August 29, 2019 Project No. 1671160

**Phil White, Quality Control**
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K0A 1B0

**GROUNDWATER TABLE ASSESSMENT IN SUPPORT OF A CATEGORY 3, CLASS A, PIT ABOVE THE WATER TABLE PROPOSED ARNOTT PIT**
**TOWNSHIP OF LANARK HIGHLANDS, ONTARIO (REVISION 1)**

Dear Mr. White,

Golder Associates Ltd. (Golder) was retained by Thomas Cavanagh Construction Limited (Cavanagh) to provide the required hydrogeological input in support of a license application under the *Aggregate Resources Act* (ARA) for a Category 3, Class A, Pit Above the Water Table. For a Category 3 aggregate license application, the scope of the required hydrogeological input is specified in Section 2.1.7 (Summary Statement) of the Report Standards, and requires a determination of the elevation of the groundwater table within the site or demonstration that the final depth of extraction is at least 1.5 metres above the groundwater table. The purpose of this submission is to satisfy the hydrogeological requirements for the Category 3 aggregate license application.

## Site Description

The proposed Arnott Pit is located on Part of Lot 3, Concession 5 in the Geographic Township of Lanark (now part of the Township of Lanark Highlands), Ontario. The general location of the site is shown on Figure 1. The proposed license area for the pit is approximately 19.5 hectares (ha) and the proposed extraction area is approximately 18.6 ha. The proposed licensed boundary and extraction boundary for the Arnott Pit is shown on Figure 2. The proposed pit would be above the water table, and no dewatering would occur at the site.

The site is located on the south side of Pine Grove Road, southwest of the intersection of Pine Grove Road and Lanark 6$^{th}$ Concession A Road, approximately 3.5 kilometres northeast of Lanark, Ontario. The current land use at the site is agricultural fields and farm operation buildings. The residential development within the vicinity of the site is light. Based on a review of the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information system (WWIS), the residences located within the vicinity of the site obtain their water supply from private wells completed in the bedrock. The residences within the vicinity of the site have been developed on private septic systems for treating wastewater.

The lands surrounding the site are primarily used for agricultural purposes, aggregate extraction (licensed pits or quarries are located to the north and west of the site), or are undeveloped and heavily vegetated (i.e., to the east and southeast of the site). The topography at the site varies between 145 metres above sea level (mASL) and 166 mASL. The ground surface is highest in the northwestern portion of the site, and slopes downward towards the south/southeast.

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## Site Investigations

Several investigations have previously been completed at the proposed Arnott Pit. The objectives of the site investigations were to assess the spatial extent of the aggregate resource at the site, and to establish the depth to the groundwater table. The first investigation, completed in November 2009, included the completion of 31 test pits across the site and beyond the site boundary to the east. The second investigation, completed in 2017, included the drilling of one borehole (BH17-1) and the installation of a monitoring well in the north-central portion of the site. In addition, during 2017, 2018 and 2019 a groundwater level monitoring program was completed at BH17-1 to provide information on the seasonal variation of the groundwater table at the site. In 2018, a second borehole (BH18-1) was drilled in the southern portion of the site. The results of the site investigations are provided below.

### 2009 Investigation – Test Pitting

During November 2009, Cavanagh completed 31 test pits at the site, or in close proximity to the site. The test pits were completed using an excavator with a maximum reach of six metres below ground surface (mbgs). Cavanagh staff familiar with aggregate materials were on-site during the test pitting to classify the materials excavated and/or exposed on the sides of the test pits through a visual and tactile examination. All test pits were then backfilled upon completion of excavation. The approximate locations of the test pits are shown on Figure 2, and the records of the materials encountered in the test pits are provided in Attachment A.

The test pit logs provide a summary of the soils encountered, as wells as the depth groundwater was encountered. Notes are also provided on the depth that bedrock was encountered, or the statement 'end of test pit' is used to indicate that the excavation continued to the maximum reach of the equipment without encountering bedrock.

Based on the test pitting results, the thickness of the sand deposit at the site is greatest in the north/northwest portion of the site where the ground surface rises. Within this portion of the site, most test pits were completed to the maximum reach of the excavation equipment without encountering bedrock (i.e., greater than 6 metres thick). The thickness of the sand deposit was also greater than 6 metres in most areas along the western boundary of the site. The sand deposit thins within the southern and eastern portions of the site. The test pits completed to the east of the proposed license boundary had limited thicknesses of sand and encountered glacial till or bedrock near surface (i.e., TP#21 through TP#25).

Groundwater was encountered in 3 of the 31 test pits (TP#11, TP#15 and TP#26). In the northern portion of the site, the groundwater table was typically beyond the reach of the excavation equipment (i.e., greater than 6 metres below ground surface). In the southern and eastern portion of the site, where the overburden thickness decreases, the groundwater table was not encountered. Within these areas, the groundwater table is interpreted to be within the bedrock. The table below summarizes the elevation of the groundwater table encountered at TP#11, TP#15 and TP#26.

**Table 1: Groundwater Table Elevation in Test Pits**

| Location | Ground Surface Elevation (mASL) | Groundwater Table Elevation (mASL) |
|---|---|---|
| TP#11 | 149.43 | 146.43 |
| TP#15 | 151.00 | 147.00 |
| TP#26 | 151.37 | 146.37 |

Based on the results of the November 2009 test pitting, the total thickness of the aggregate deposit, and the depth to the groundwater table in the northern portion of the site was unknown.

## 2017 Investigation – Borehole Drilling and Monitoring Well Installation

As part of the 2017 investigation, one borehole (BH17-1) was drilled in the northern portion of the site. The objective of the borehole drilling was to determine the total thickness of the aggregate resource, and to allow for the installation of a monitoring well to confirm the depth of the groundwater table in the northern portion of the site. The approximate location of BH17-1 is shown on Figure 2. BH17-1 was completed on September 7 and 8, 2017, and was drilled using a CME55 track mounted drill rig supplied and operated by CCC Geotechnical and Environmental Drilling Ltd of Ottawa, Ontario.

The total depth of BH17-1 was 17.58 metres. Details regarding the drilling of BH17-1 are present on the borehole log in Attachment B. The upper 14.33 metres of BH17-1 was drilled using hollow stem augers, and continuous split-spoon sampling was completed to classify the overburden material with depth. The upper 12.80 metres of material encountered at BH17-1 consists of sand varying from fine to coarse grained. Cobbles and boulders were encountered at 12.80 mbgs, and the augers could not be advanced beyond 14.33 mbgs. The remaining 3.24 metres of BH17-1 was completed using rotary core drilling techniques (HQ-size). Due to the coarse nature of the cobbles and boulders material, water pressure/circulation could not be maintained during rotary drilling, and the borehole could not be advanced beyond 17.58 mbgs. Based on observations from the Lanark Pit/Quarry located immediately to the north of the site, the cobbles and boulders layer is typically encountered close to the bedrock surface. All samples collected from BH17-1 prior to the start of coring were observed to be dry indicating that the groundwater table at the time of drilling was greater than 14.33 mbgs.

Upon completion of the borehole drilling, a single monitoring well was installed at BH17-1. The monitoring well was constructed of 32-millimetre diameter, PVC slot #10 screen and risers. Silica sand was used in the borehole around the screened portion of the monitor (i.e., granular filter) and bentonite was used to provide a seal above the monitoring interval, and to provide a seal at ground surface. A protective casing with lockable lid was installed over the monitoring well. A survey of the monitoring well location elevations (i.e., ground surface and top of monitoring pipe) was completed by Cavanagh. The monitoring well completion details are provided on the borehole log in Attachment B.

## 2018 Investigation – Borehole Drilling

As part of the 2018 investigation, one borehole (BH18-1) was drilled in December 2018. The objective of the borehole drilling was to determine the depth to the water table in the southern portion of the site. The approximate location of BH18-1 is shown on Figure 2. Bedrock was encountered at ground surface at BH18-1, and the borehole was completed as a 0.10-metre diameter open hole. A borehole log for BH18-1 is provided in Attachment B.

## 2017, 2018 and 2019 Groundwater Table Monitoring

Between September 2017 and August 2019 groundwater levels were collected 14 times at BH17-1 to provide information on the seasonal variability of the groundwater table at the site. The table below summarizes the groundwater elevation data collected from BH17-1. For reference, the top of pipe elevation at BH17-1 is 163.05 mASL.

**Table 2: Groundwater Elevation Data for BH17-1**

| Date | Groundwater Level (mbtop) | Groundwater Elevation (mASL) |
|---|---|---|
| September 8, 2017 | 14.93 | 148.12 |
| September 19, 2017 | 14.71 | 148.34 |
| October 5, 2017 | 14.81 | 148.24 |
| November 24, 2017 | 14.69 | 148.36 |
| February 27, 2018 | 14.91 | 148.14 |
| May 1, 2018 | 15.04 | 148.01 |
| July 4, 2018 | 15.63 | 147.42 |
| September 11, 2018 | 15.58 | 147.47 |
| October 1, 2018 | 15.46 | 147.59 |
| December 13, 2018 | 15.54 | 147.51 |
| February 7, 2019 | 15.49 | 147.56 |
| June 17, 2019 | 14.86 | 148.19 |
| July 8, 2019 | 14.90 | 148.15 |
| August 7, 2019 | 15.04 | 148.01 |

**Notes:** mbtop – metres below top of pipe

The groundwater elevation data for BH17-1 are presented on Figure C1 in Attachment C. The available groundwater level data collected to date at BH17-1 indicates that the groundwater table at this location varies between 147.42 mASL and 148.36 mASL. Based on the available groundwater level data, there is minimal seasonal variation in the groundwater table at BH17-1 (i.e., less than 1 metre).

The groundwater level at BH18-1 was measure on January 10, 2019. At that time, the groundwater level at BH18-1 was 9.27 metres below ground surface (142.81 mASL).

## Groundwater Level Assessment

Based on the available information from the test pitting completed in November 2009 and the groundwater level monitoring program completed at BH17-1 in 2017, 2018 and 2019, when encountered, the groundwater table in the overburden at the site varies between 146.37 mASL (TP#26) and 148.36 mASL (BH17-1 in November 2017). Based on the available groundwater level data for BH18-1, the water table in the bedrock in the southern portion of the site is well below the bedrock surface and was measured at 142.81 mASL.

Based on the available groundwater level data, the proposed extraction area was divided into Zone A and Zone B. In the northern portion of the site, based on the elevation of the groundwater encountered at BH17-1, and allowing for a 1.5 metre separation between the proposed pit floor elevation and the position of the groundwater table, the proposed base elevation for the Arnott Pit at the north end of Zone A (i.e., where the topography is the highest) is approximately 149.9 mASL. Based on the elevation of the groundwater encountered at TP#26 (146.37) and TP#11 (146.43), the water table slopes downward within Zone A as the topography decreases to the south and southeast. Allowing for a 1.5 metre separation between the proposed pit floor elevation and the position of the groundwater table at TP#26 and TP#11, the proposed base elevation for the Arnott Pit on the southeastern side and at the southern end of Zone A is approximately 147.9 mASL. As such, the pit floor in Zone A would vary between 147.9 mASL and 149.9 mASL and would generally slope downward towards the south and southeast.
For reference, the boundary for Zone A is shown on Figure 2.

Based on the 2009 test pit information, the water table was not encountered in the test pits completed within Zone B, and the groundwater table is interpreted to be found within the underlying bedrock. As such, it is proposed that for Zone B, the base of the pit would be the bedrock surface, which varies in elevation between 145.4 mASL (TP#17) and 151.75 mASL (TP#4). For reference, the boundary for Zone B is shown on Figure 2. Based on the measured water table elevation at BH18-1 (142.81 mASL), the groundwater table within the bedrock in Zone B is expected to be greater than 1.5 metres below the bedrock surface.

Based on the proposed pit development plan (i.e., pit floor to remain a minimum of 1.5 m above the groundwater table), the operation of the pit will not result in alteration (lowering) of the groundwater table in the overburden or the bedrock. Consequently, there is no potential for the pit operation to negatively impact existing water supply wells or septic systems in the vicinity of the site.

### Recommendations

It is recommended that the site plan accompanying the application for the Arnott Pit license include the following condition:

> *"The Licensee will periodically excavate test pits in the immediate area of active extraction. These periodic test pits would be used to further define the position of the groundwater table in close proximity to the active extraction area to ensure that extraction operations remain at least 1.5 metres above the groundwater table. Should, during extraction operations, the groundwater table be encountered, excavation at that location shall cease and the area backfilled and subsequent excavation will terminate at least 1.5 metres above the groundwater table."*

### Qualifications and Experience of the Report Authors

The qualifications and experience of the report authors are presented in Attachment D.

## Limitations

This letter was prepared for the exclusive use of Thomas Cavanagh Construction Limited. The letter, which specifically includes all tables, figures and attachments, is based on data and information collected by Golder and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder as described in this letter.

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The findings and conclusions of this letter are valid only as of the date of this letter. If new information is discovered in future work, including excavations, borings, or other studies, Golder should be requested to re-evaluate the conclusions of this letter, and to provide amendments as required.

## Closure

If you have any questions, please contact the undersigned.

Yours truly,

**Golder Associates Ltd.**

PROFESSIONAL GEOSCIENTIST
JAIME P. A. OXTOBEE
PRACTISING MEMBER
1095
Aug. 29/2019
ONTARIO

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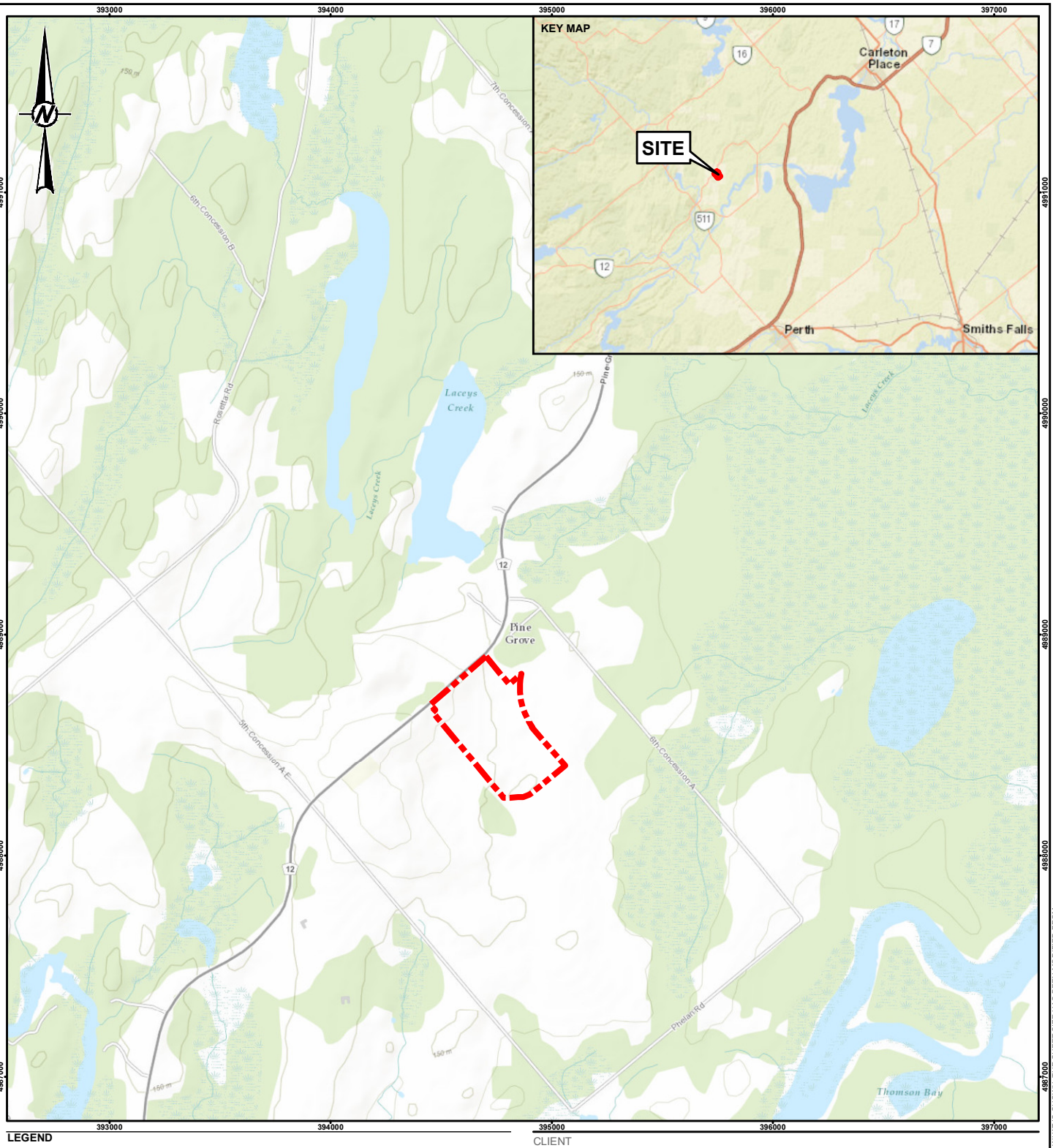
*Senior Hydrogeologist/Principal*

JPAO/KAM/sg
n:\active\2016\3 proj\1671160 cavanagh arnott pit ara licensing\reports\1671160 groundwater table assessment (no effect on private wells).docx

Attachments: Figure 1 – Key Plan
Figure 2 – Site Plan
Attachment A – Test Pit Logs
Attachment B – Borehole Logs (BH17-1 and BH18-1)
Attachment C – Groundwater Elevation Data (BH17-1)
Attachment D – Qualifications and Experience of the Report Authors




**LEGEND**

SITE

0 250 500 1,000

1:25,000 METRES

**NOTE(S)**

1. ALL LOCATIONS ARE APPROXIMATE

**REFERENCE(S)**

1. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
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2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 18 VERTICAL DATUM: CGVD28

CLIENT
THOMAS CAVANAGH CONSTRUCTION LIMITED

PROJECT
GROUNDWATER TABLE ASSESSMENT
PROPOSED ARNOTT PIT, LANARK HIGHLANDS, ONTARIO

TITLE
**KEY PLAN**

CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2018-10-01 |
| DESIGNED | ---- |
| PREPARED | BR |
| REVIEWED | JPAO |
| APPROVED | KAM |

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 1671160 | 0005 | 0 | 1 |

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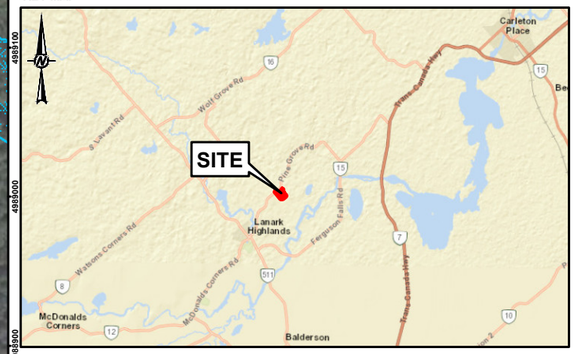
**KEY MAP**




SCALE 1:400,000

**LEGEND**

- BOREHOLE/MONITORING WELL LOCATION
- TEST PIT LOCATION
- (148.42) GROUND SURFACE ELEVATION
- PROPOSED LICENSE BOUNDARY
- PROPOSED EXTRACTION BOUNDARY
- CAVANAGH PROPERTY BOUNDARY
- ZONE A AND ZONE B BOUNDARY
- ROADWAY
- TOPOGRAPHIC CONTOUR, METRES
- WATERCOURSE
- PROVINCIALLY SIGNIFICANT WETLAND (PSW)

**REFERENCE(S)**

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. IMAGE OBTAINED FROM GOOGLE EARTH © 2018 GOOGLE INC. USED WITH PERMISSION. GOOGLE AND GOOGLE LOGO ARE REGISTERED TRADEMARKS OF GOOGLE INC.
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4. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18, VERTICAL DATUM: CGVD28

0 50 100 200

1:4,000 METRES

CLIENT
THOMAS CAVANAGH CONSTRUCTION LIMITED

PROJECT
GROUNDWATER TABLE ASSESSMENT
PROPOSED ARNOTT PIT, LANARK HIGHLANDS, ONTARIO

TITLE
**SITE PLAN**

CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2019-08-28 |
| DESIGNED | ---- |
| PREPARED | BR |
| REVIEWED | JPAO |
| APPROVED | KAM |

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 1671160 | 0005 | 0 | 2 |

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

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**ATTACHMENT A**

# Test Pit Logs

## Record of Test Pits

| TEST PIT NUMBER | DEPTH (mbgs) | DESCRIPTION |
|---|---|---|
| TP#1 | 0.00 – 0.15 | Topsoil |
| (153.23 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 6.0 | Fine sand |
| | | End of test pit – no water encountered |
| TP#2 | 0.00 – 0.20 | Topsoil |
| (149.98 mASL) | 0.20 – 0.60 | Red fine sand |
| | 0.60 – 2.4 | Silty sand to clay |
| | 2.4 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#3 | 0.00 – 0.10 | Topsoil |
| (153.12 mASL) | 0.10 – 0.60 | Red fine sand |
| | 0.60 – 2.00 | Clayey sand |
| | 2.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#4 | 0.00 – 0.20 | Topsoil |
| (151.95 mASL) | 0.20 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#5 | 0.00 – 0.20 | Topsoil |
| (148.42 mASL) | 0.20 – 0.60 | Red fine sand |
| | 0.60 – 1.50 | Silty sand |
| | 1.50 – 3.00 | Clayey sand |
| | 3.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#6 | 0.00 – 0.15 | Topsoil |
| (149.55 mASL) | 0.15 – 0.45 | Red fine sand |
| | 0.45 – 1.00 | Clayey sand |
| | 1.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#7 | 0.00 – 0.15 | Topsoil |
| (148.91 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 1.50 | Silty sand |
| | 1.50 – 2.40 | Clayey sand |
| | 2.40 | Refusal/bedrock encountered |
| | | No water encountered |

| TEST PIT NUMBER | DEPTH (mbgs) | DESCRIPTION |
|---|---|---|
| TP#8 | 0.00 – 0.15 | Topsoil |
| (149.66 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 3.30 | Silty sand |
| | 3.30 – 3.60 | Sandy silt |
| | 3.60 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#9 | 0.00 – 0.15 | Topsoil |
| (149.84 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 4.30 | Silty sand |
| | 4.30 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#10 | 0.00 – 0.15 | Topsoil |
| (147.47 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 3.00 | Silty sand |
| | 3.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#11 | 0.00 – 0.15 | Topsoil |
| (149.43 mASL) | 0.15 – 0.45 | Red sand mix |
| | 0.45 – 3.00 | Silty sand with clay |
| | 3.00 | Refusal/bedrock encountered |
| | | Water encountered and 3 m |
| TP#12 | 0.00 – 0.15 | Topsoil |
| (153.33 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 6.00 | Silty sand |
| | | End of test pit – no water encountered |
| TP#13 | 0.00 – 0.20 | Topsoil |
| (164.79 mASL) | 0.20 – 0.60 | Red fine sand |
| | 0.60 – 6.00 | Clean fine sand |
| | | End of test pit – no water encountered |
| TP#14 | 0.00 – 0.15 | Topsoil |
| (156.49 mASL) | 0.15 – 0.50 | Red fine sand |
| | 0.50 – 2.00 | Coarse sand with gravel |
| | 2.00 – 6.00 | Gravel with cobbles |
| | | End of test pit – no water encountered |
| TP#15 | 0.00 – 0.15 | Topsoil |
| (151.00 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 4.00 | Silty sand |
| | | Water encountered at 4 m |

| TEST PIT NUMBER | DEPTH (mbgs) | DESCRIPTION |
|---|---|---|
| TP#16 | 0.00 – 0.20 | Topsoil |
| (149.62 mASL) | 0.20 – 0.50 | Sandy clay |
| | 0.50 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#17 | 0.00 – 0.15 | Topsoil |
| (150.37 mASL) | 0.15 – 0.50 | Red fine sand |
| | 0.50 – 5.00 | Silty sand |
| | | End of test pit – no water encountered |
| TP#18 | 0.00 – 0.15 | Topsoil |
| (147.54 mASL) | 0.15 – 2.40 | Red sand mix |
| | 2.40 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#19 | 0.00 – 0.15 | Topsoil |
| (148.50 mASL) | 0.15 – 3.00 | Sandy silt |
| | 3.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#20 | 0.00 – 0.25 | Topsoil and red sand |
| (148.47 mASL) | 0.25 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#21 | 0.00 – 0.00 | Bedrock at Surface |
| (148.35 mASL) | 0.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#22 | 0.00 – 0.15 | Topsoil |
| (148.32 mASL) | 0.15 – 0.50 | Red fine sand |
| | 0.50 – 2.50 | Silty sand |
| | 2.50 – 3.00 | Till |
| | 3.00 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#23 | 0.00 – 0.15 | Black peat |
| (146.60 mASL) | 0.15 – 0.50 | Red fine sand |
| | 0.50 – 3.00 | Till |
| | 3.00 | Refusal till encountered |
| | | No water encountered |
| TP#24 | 0.00 – 0.15 | Topsoil |
| (145.15 mASL) | 0.15 – 0.45 | Red fine sand |
| | 0.45 – 2.00 | Sandy silt/till |
| | 2.00 | Refusal/bedrock or till encountered |
| | | No water encountered |

| TEST PIT NUMBER | DEPTH (mbgs) | DESCRIPTION |
|---|---|---|
| TP#25 | 0.00 – 0.15 | Topsoil |
| (147.44 mASL) | 0.15 – 0.25 | Silty sand |
| | 0.25 | Refusal/bedrock encountered |
| | | No water encountered |
| TP#26 | 0.00 – 0.15 | Topsoil |
| (151.37 mASL) | 0.15 – 0.60 | Red silty sand |
| | 0.60 – 6.00 | Water level at 0.10 mbgs |
| | | End of test pit |
| | | Water encountered at 5 m |
| TP#27 | 0.00 – 0.15 | Topsoil |
| (154.69 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 6.00 | Fine clean sand |
| | | End of test pit |
| | | No water encountered |
| TP#28 | 0.00 – 0.15 | Topsoil |
| (158.47 mASL) | 0.15 – 0.60 | Red fine sand |
| | 0.60 – 2.00 | Silty sand |
| | 2.00 – 4.00 | Sand and gravel |
| | 4.00 – 6.00 | Silty sand |
| | | End of test pit |
| | | No water encountered |
| TP#29 | 0.00 – 0.20 | Topsoil |
| (162.93 mASL) | 0.20 – 0.45 | Red fine sand |
| | 0.45 – 3.00 | Sand and gravel |
| | 3.00 – 6.00 | Fine silty sand |
| | | End of test pit |
| | | No water encountered |
| TP#30 | 0.00 – 0.25 | Topsoil |
| (158.63 mASL) | 0.25 – 0.70 | Red fine sand |
| | 0.70 – 6.00 | Fine silty sand |
| | | End of test pit |
| | | No water encountered |
| TP#31 | 0.00 – 0.25 | Topsoil |
| (157.22 mASL) | 0.25 – 0.60 | Red fine sand |
| | 0.60 – 6.00 | Fine clean sand |
| | | End of test pit |
| | | No water encountered |

**ATTACHMENT B**

# Borehole Logs (BH17-1 and BH18-1)

PROJECT: 1671160

# RECORD OF BOREHOLE: 17-1

SHEET 1 OF 2

LOCATION: N 4988810.0 ;E 394601.0

BORING DATE: September 7 and 8, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

| 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 | | 162.16 | | | | | | | |
| 0 | Power Auger 200 mm Diam. (Hollow Stem) | TOPSOIL - SAND; dark brown | | 0.05 | | | | | | | |
| | | SAND, fine; brown; loose | | | 0 | SS | 5 | | | | Bentonite Seal |
| 1 | | | | | 1 | SS | 4 | | | | |
| | | | | 161.04 | | | | | | | |
| | | SAND, fine to medium; brown; firm | | 1.12 | | | | | | | |
| | | | | | 2 | SS | 23 | | | | |
| | | | | 160.33 | | | | | | | |
| 2 | | SAND, fine to medium; brown, contains occasional gravel; compact | | 1.83 | | | | | | | |
| | | | | | 3 | SS | 56 | | | | |
| | | | | | 4 | SS | 35 | | | | |
| 3 | | | | 159.11 | | | | | | | |
| | | SAND, fine; light brown; compact | | 3.05 | | | | | | | |
| | | | | | 5 | SS | 28 | | | | |
| | | | | | 6 | SS | 34 | | | | |
| 4 | | | | | | | | | | | |
| | | | | | 7 | SS | 26 | | | | |
| | | | | | 8 | SS | 66 | | | | |
| 5 | | | | | | | | | | | Native Cave |
| | | | | | 9 | SS | 45 | | | | |
| | | | | | 10 | SS | 36 | | | | |
| 6 | | | | | | | | | | | |
| | | | | | 11 | SS | 36 | | | | |
| 7 | | | | 154.84 | | | | | | | |
| | | SAND, fine to medium; light brown; compact | | 7.32 | | | | | | | |
| | | | | | 12 | SS | 46 | | | | |
| | | | | 154.24 | | | | | | | |
| 8 | | SAND, fine; light brown; compact | | 7.92 | | | | | | | |
| | | | | | 13 | SS | 38 | | | | |
| | | | | | 14 | SS | 30 | | | | |
| 9 | | | | | | | | | | | |
| | | | | 152.71 | 15 | SS | 38 | | | | |
| | | SAND, fine to coarse; brown; compact | | 9.45 | | | | | | | |
| | | | | | 16 | SS | 27 | | | | |
| 10 | | | | | | | | | | | |
| | | *CONTINUED NEXT PAGE* | | | | | | | | | |

DEPTH SCALE

1 : 50

GOLDER

LOGGED: CA

CHECKED: JPAO

MIS-BHS 001 1671160.GPJ GAL-MIS.GDT 5/9/18 ZS

PROJECT: 1671160

# RECORD OF BOREHOLE: 17-1

SHEET 2 OF 2

LOCATION: N 4988810.0 ;E 394601.0

BORING DATE: September 7 and 8, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

| DEPTH SCALE METRES | BORING METHOD | DESCRIPTION | STRATA PLOT | ELEV. DEPTH (m) | 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 ---* | | | | | | | | | |
| 10 | Power Auger 200 mm Diam. (Hollow Stem) | SAND, fine to coarse; brown; compact | | 151.80 | 16 | SS | 27 | | | | Native Cave |
| | | SAND, medium to coarse; brown, contains occasional gravel; compact | | 10.36 | 17 | SS | 44 | | | | |
| 11 | | | | | 18 | SS | 37 | | | | Bentonite Seal |
| | | | | 150.58 | | | | | | | |
| | | SAND, medium to coarse; brown, contains gravel; compact | | 11.58 | 19 | SS | 45 | | | | |
| 12 | | | | | 20 | SS | 48 | | | | |
| | | | | 149.36 | | | | | | | |
| | | COBBLES and BOULDERS | | 12.80 | 21 | SS | >50 | | | | |
| 13 | | | | | | | | | | | |
| | | | | | | | | | | | Silica Sand |
| 14 | | | | | | | | | | | |
| | Rotary Drill HQ Core | | | | 22 | RC | DD | | | | |
| 15 | | | | | | | | | | | |
| | | | | | | | | | | | 32 mm Diam. PVC #10 Slot Screen |
| 16 | | | | | 23 | RC | DD | | | | |
| | | | | 144.58 | | | | | | | |
| 17 | | End of Borehole | | 17.58 | | | | | | | |
| | | | | | | | | | | | WL in Screen at Elev. 148.36 m on Nov. 24, 2017 |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

DEPTH SCALE

1 : 50

GOLDER

LOGGED: CA

CHECKED: JPAO

MIS-BHS 001 1671160.GPJ GAL-MIS.GDT 5/9/18 ZS

PROJECT: 1671160

# RECORD OF BOREHOLE: 18-1

SHEET 1 OF 2

LOCATION: N 4988335.0 ;E 394922.0

BORING DATE: December 2018

DATUM: Geodetic

| DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE: DESCRIPTION | STRATA PLOT | ELEV. / DEPTH (m) | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: BLOWS/0.30m | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) | SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, 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 | | 152.08 | | | | | | | | | |
| 0 | Air-track / Open Hole | Amphibolite | | 0.00 | | | | | | | | | |
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | |
| 10 | | *CONTINUED NEXT PAGE* | | | | | | | | | | | |

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PW

CHECKED: JPAO

MIS-BHS 001 1671160.GPJ GAL-MIS.GDT 8/29/19 ZS

PROJECT: 1671160

# RECORD OF BOREHOLE: 18-1

SHEET 2 OF 2

LOCATION: N 4988335.0 ;E 394922.0

BORING DATE: December 2018

DATUM: Geodetic

| DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE: DESCRIPTION | STRATA PLOT | ELEV. / DEPTH (m) | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: 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 ---* | | | | | | | | | |
| 10 | Air-track Open Hole | Amphibolite | | | | | | | | | |
| 11 | | | | 141.08 | | | | | | | |
| | | End of Borehole | | 11.00 | | | | | | | |
| 12 | | | | | | | | | | | |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

DEPTH SCALE

1 : 50

GOLDER

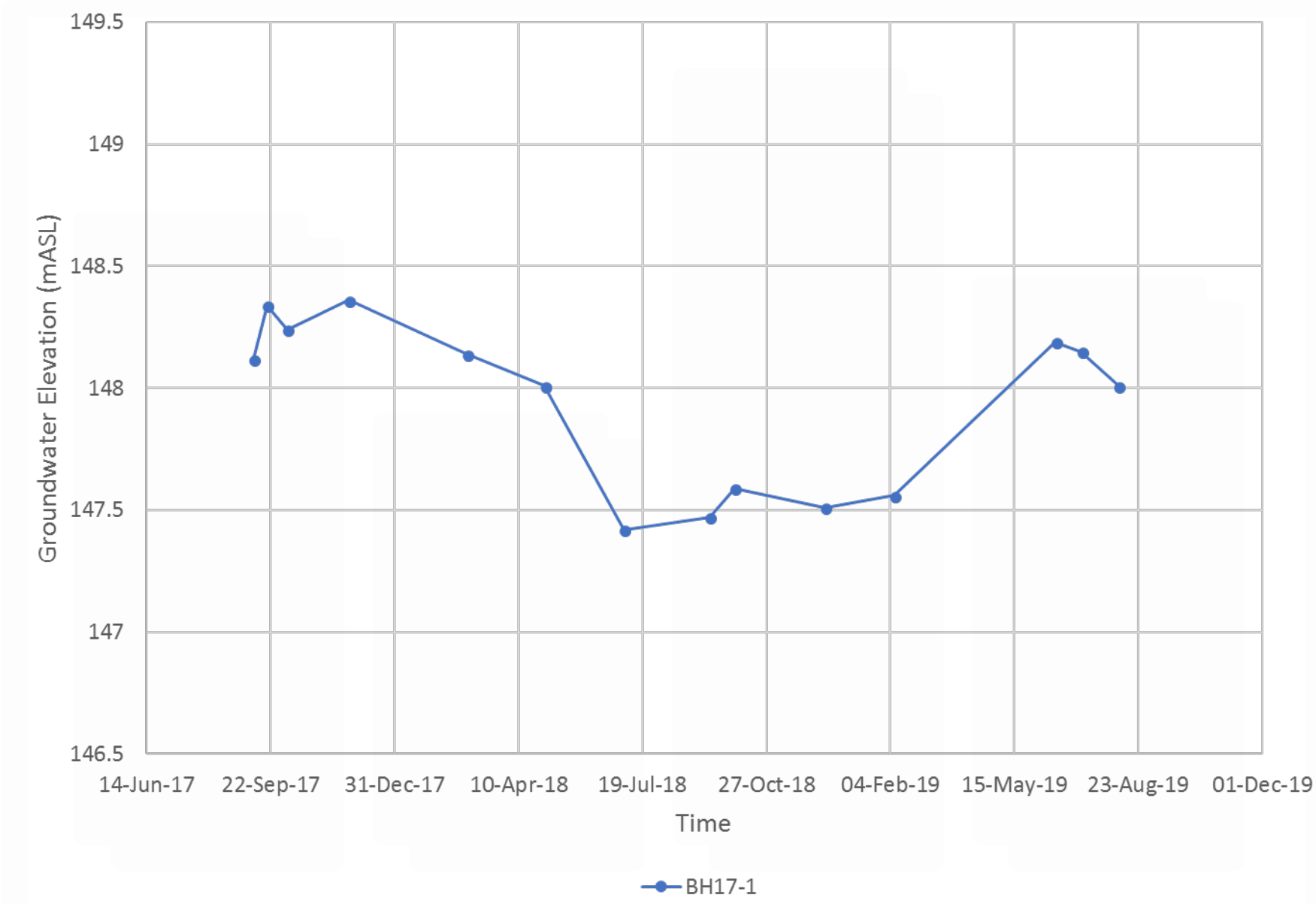
LOGGED: PW

CHECKED: JPAO

MIS-BHS 001 1671160.GPJ GAL-MIS.GDT 8/29/19 ZS

**ATTACHMENT C**

# Groundwater Elevation Data (BH17-1)




| | | | |
|---|---|---|---|
| GOLDER | Date: Aug 2019 Drawn: JPAO<br>Project: 1671160 Checked: KAM | BH17-1 Groundwater Elevations September 2017 Through August 2019 | FIGURE C1 |

**ATTACHMENT D**

# Qualifications and Experience of the Report Authors

**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. Jaime 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. Jaime 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. Jaime 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. Jaime 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. 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