REPORT

Hydrogeology Investigation, Terrain Analysis and Impact Assessment

Cavanagh Developments, 2596 Carp Road, Ottawa, Ontario

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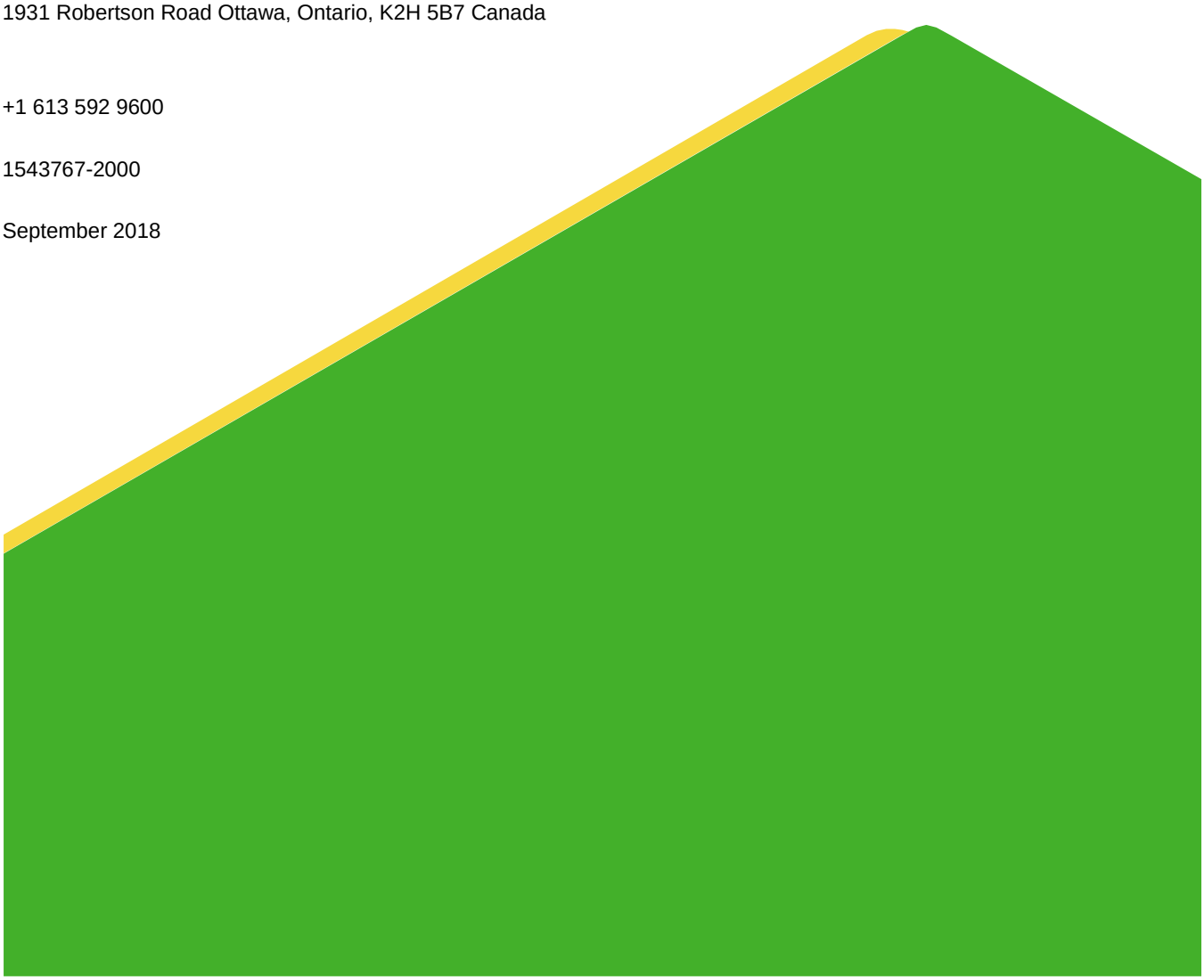

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APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Cavanagh Developments (Cavanagh) to carry out a hydrogeology investigation, terrain analysis and impact assessment in support of the proposed development of a concrete plant at 2596 Carp Road (the Site) in Ottawa, Ontario (Figure 1). The Site consists of a parcel of land measuring 28.8 hectares in size, within which the operating area of the concrete plant would measure approximately 2.6 hectares. The concrete plant would be privately serviced by two groundwater supply wells and a new septic system, while the administration building would be serviced by an existing groundwater supply well and an existing septic system. The remaining portion of the Site would remain undeveloped at this time.

The objectives of the hydrogeology investigation, terrain analysis and impact assessment were to:

- Determine the shallow subsurface soil and groundwater conditions;
- Investigate the potential quantity and quality of groundwater available from drilled wells for concrete production and for the office water supply;
- Assess the potential impact of the sewage systems in the proposed development on downgradient groundwater and/or surface water resources; and,
- Complete a water balance assessment for the proposed Site development.

1.1 Technical Guidance Documents

This study was carried out according to the following guidance documents:

- Ministry of the Environment (MOE) Procedure D-5-4. Technical Guideline for Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment (August 1996).
- Ministry of the Environment and Energy (MOEE) Hydrogeological Technical Information Requirements for Land Development Applications (TIR; April 1995).
- MOE Stormwater Management Planning and Design Manual (2003), hereafter referred to as the MOE Manual.
- Hydrogeological Assessment Submissions (Conservation Authority Guidelines for Development Applications) (2013), hereafter referred to as the CA Guidelines.
- Low Impact Development Stormwater Management Planning and Design Guide (by Credit Valley Conservation and Toronto Region Conservation), hereafter referred to as the LID Guide.
- Carp River Watershed/Subwatershed Study, Volume I – Main Report (2004). Prepared for the City of Ottawa by Robinson Consultants Inc.

2.0 SITE BACKGROUND

2.1 Site Description

In this document, the “Site” refers to the 28.8-hectare total site area, while the “proposed concrete plant site” is the area in which development is currently proposed (see Figure 1).

The Site is primarily undeveloped grassy land with sparse bushes and some fill piles. Huntley Creek flows across the northern half of the Site, roughly from southwest to northeast (see Figure 1) and the area immediately surrounding the creek is more heavily treed. Also located within the Site are one residence and one small commercial enterprise. At the southern end of the Site, there are some commercial storage buildings and associated access roads.

The current land uses with 500 metres of the Site are varied. To the southeast of the Site, along Richardson Side Road, there is commercial and industrial development, rural residential development and an undeveloped area used for storage of aggregates. To the south and southwest of the Site, along Carp Road, there is primarily commercial and industrial development. The areas north and east of the Site consist primarily of forest, rural residential development and some agricultural lands.

The topography of the Site shows that the ground surface on both sides of Huntley Creek slopes toward the creek. South of the creek, the average slope is approximately 0.02 toward the northeast. North of the creek, the average slope is approximately 0.025 to the east (Figure 1). The Site surficial drainage is interpreted to follow the topography toward Huntley Creek. The Site is located within the Carp River watershed and Huntley Creek subwatershed.

2.2 Regional Geology

2.2.1 Surficial Geology

Based on published geology maps, the surficial geology at the Site consists primarily of glaciomarine sand and gravel deposits, with a zone of glacial till in the middle of the Site (see Figure 2). These units are also mapped beyond the Site boundaries, in addition to muck and peat and fine-textured glaciomarine deposits mapped to the north of the site.

2.2.2 Bedrock Geology

Based on published mapping, the upper bedrock units at the Site are mapped as the Bobcaygeon Formation and the Verulam Formation. A bedrock fault crosses the Site from roughly west to east and separates the Bobcaygeon Formation to the south from the Verulam formation to the north (see Figure 3). As described in the Mississippi-Rideau Source Protection Region (MRSPR) Watershed Characterization Report, the Bobcaygeon Formation is limestone with varying shale content, and the thickness of the formation varies between approximately 80 to 90 metres in the northwestern portions of the MRSPR to 50 metres in the eastern portions (MRSPR, 2008). The Verulam Formation is interbedded limestone and shale, and its thickness varies from 30 metres near Ottawa to 65 metres in the east of the MRSPR (MRSPR, 2008).

2.3 Hydrogeology

2.3.1 Overburden Aquifers

Extensive deposits of coarse and permeable overburden capable of supplying sufficient quantities of groundwater do not appear on geological maps for the study area (see Figure 2). For this reason, the bedrock is considered the principal source for water supply within the vicinity of the Site for locations where municipal services are not available.

2.3.2 Bedrock Aquifers

The limestone and shale aquifer units in the MRSPR, including the Bobcaygeon and Verulam Formations that are the uppermost bedrock formations at the Site, are indicated to provide a poor or marginally moderate yield of potable water for domestic consumption (i.e., less than 10 to 15 L/min) (MRSPR, 2008). Groundwater flow in the Bobcaygeon and Verulam Formations is through bedrock fractures; however, the presence of shale content in the Verulam Formation may adversely affect the water quality and yield (MRSPR, 2008).

Regional groundwater flow is generally from southwest to northeast toward the Ottawa River (MRSPR, 2008).

2.3.3 Local Water Supply

The Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) was reviewed for water well records in the vicinity of the Site. Water well records within 500 metres of the proposed water taking locations are plotted on Figure 3. Note that the water well records for the existing Site test wells and monitoring wells are not shown on Figure 3. In addition, some water well locations were adjusted based on a review of the original well record. All 7 well records within 500 metres of the Site are for water supply wells completed in limestone bedrock at depths ranging from 20 to 87 metres. The depth to bedrock encountered in the wells was 3 to 8 metres. The overburden material overlying the bedrock at these wells was variable and included clay, sand and gravel, and hardpan (interpreted to be glacial till). Water was found at a depth of 7 to 31 metres in the bedrock wells, and the static water level ranged from 1.1 to 8.2 metres below ground. Based on these data, the available drawdown (calculated as the difference between the static water level and the total well depth) was estimated to range from 15.8 to 84.1 metres. A summary of key information from the WWIS records within 500 metres of the site is provided in Appendix A.

2.4 Proposed Site Development

The development of the concrete plant site will include a concrete batching plant with surface parking areas, a vehicle refueling area and aggregate storage areas.

The proposed water supply for the concrete plant site will be groundwater taken from two on-site water supply wells referred to as TW5 and TW6 (see Figure 4). More information on these wells is provided in Section 4.1. A Category 3 Permit to Take Water will be obtained from the MECP in order to take groundwater from TW5 and TW6. The anticipated average water taking rate at the concrete plant is 210 L/min for 12 hours/day, equivalent to 150,000L/day. Under maximum production, a taking of up to 378 L/min may be required; however, this level of production is rare. The concrete plant would also have two 10,000-L water storage tanks to supplement production. In addition to the water taking for concrete production, test wells TW5 and TW6 will provide water supply for up to 50 employees at the concrete plant (included in the rates above).

A new on-site septic system is proposed to provide treatment of all sewage flows generated from the concrete plant. Gemtec Consulting Engineers and Scientists Limited (Gemtec) has designed a new on-site septic system (to be submitted under a separate cover) which has been sized to adequately treat all sewage flows generated from the concrete mixing plant.

The stormwater management system will consist of two bioretention facilities across the site to capture stormwater runoff and provide cleansing prior to discharge into Huntley Creek. Bioretention temporarily stores, treats and infiltrates/filtrates runoff. The proposed bioretention facilities will provide enhanced quality control via infiltration/filtration of stormwater through the various treatment layers within the facility if full infiltration of the runoff volume control target (RVCT) is achieved. The stormwater management system is described in detail by Robinson Land Development under separate cover (Robinson, 2018).

The existing residence located immediately north of the concrete plant site will be repurposed as an administration building. It will be serviced by the existing water supply well for the house (referred to as House Well; see Figure 4) and the existing on-site sewage treatment system. The location of the existing septic leaching bed for the house is shown on Figure 1. It is understood that the maximum number of employees using the water supply and sewage treatment system at the house would be 36 (separate from the maximum 50 employees at the concrete plant). Therefore, assuming a daily water usage of 75 L/day/employee, the maximum water taking from the House Well is expected to be 2,700 L/day.

2.5 Additional Studies Completed by Golder

An Ontario Regulation 153/04 Phase One Environmental Site Assessment (ESA) was conducted at the site in May 2016 by Golder, as documented in Golder (2016). Two Areas of Potential Environmental Concern (APECs) were identified due to 1) the historical importation of fill of unknown quality in several locations (the nearest of which was 20 metres north of the proposed concrete plant site) and 2) actively/formerly used diesel and gasoline tanks (located approximately 140 metres northwest of the proposed concrete plant site). Golder subsequently carried out a Phase One ESA Update in August 2018, and identified no new APECs for the site (Golder, 2018a). Based on the presence of the two APECs as described above, a Phase Two ESA was required and was carried out in August/September 2018 (Golder 2018b).

The Phase Two ESA was conducted to assess soil and groundwater conditions at both APECs. Analytical data was compared to the Table 8 generic site condition standards in a potable groundwater condition within 30 meters of a water body (SCS; residential/parkland/industrial/commercial property use, coarse soil texture) presented in the MECP "*Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*", dated April 15, 2011. The analytical results from the sampling and analysis program identified the following soil and groundwater impacts:

- The cadmium concentration in crushed stone exceeded the MECP Table 8 Standard at one location near the existing residence (approximately 20 metres of the proposed concrete plant site). The exceedance appears to be limited to the imported fill used for creation of the residence's driveway and is not a Site-wide issue.
- The molybdenum concentration in soil exceeded the MECP Table 8 Standard at one location near a fill pile in the southwestern half of the Site. This exceedance is likely associated to a naturally elevated background concentration.
- Cobalt in groundwater exceeded the MECP Table 8 Standard at two locations: near the commercial enterprise north of Huntley Creek and near the commercial storage buildings at the southwest end of the site. These exceedances may be attributable to the presence of fill of poor quality but may also represent a naturally elevated background concentration.
- Petroleum hydrocarbon (PHC) Fraction F1 and PHC F2 and total xylene concentrations in soil exceeded the MECP Table 8 Standard at one location near the commercial enterprise north of Huntley Creek, approximately 140 metres from the proposed concrete plant site. In addition, ethylbenzene, PHC F2, 1-methylnaphtalene, 2-methylnaphtalene, and methylnaphtalene, 2-(1-) in groundwater exceeded the MECP Table 8 Standard in the same area. These exceedances may be due to a past petroleum hydrocarbon spill in that area.

As noted in the Phase Two ESA report (Golder, 2018b), APECs and locations where soil and groundwater impacts were identified are not located within the proposed concrete plant site.

3.0 TERRAIN ANALYSIS

3.1 Investigations by Golder (2015 to 2017)

A subsurface investigation was completed by Golder at the Site between December 7 and 8, 2015. During that time, a total of 5 boreholes (numbered 15-1, 15-2, 15-4, 15-5 and 15-6) were advanced at the approximate locations shown on Figure 4.

The boreholes were advanced using a track-mounted drill rig supplied and operated by CCC Geotechnical & Environmental Drilling of Ottawa, Ontario. The boreholes were advanced through the overburden to depths of about 4.8 to 7.4 metres below the existing ground surface. Practical auger refusal was encountered at boreholes

except BH15-5. Standard penetration tests were carried out within the overburden at regular intervals of depth. Samples of the soils encountered were recovered using split-spoon sampling equipment. The borehole logs for these boreholes are included in Appendix B.

A test pit investigation was carried out at the Site on April 25 and 26, 2017. During that time, a total of 11 test pits (numbered 17-1, 17-2, 17-4 to 17-8, and 17-19 to 17-22) were advanced at the approximate locations shown on Figure 4.

The test pits were advanced using a backhoe supplied and operated by Cavanagh. The test pits were advanced through the overburden to depths of about 2.0 to 4.0 metres below the existing ground surface. A sample of each soil type encountered in each test pit was recovered and the presence and depth of groundwater inflow was noted. The test pit logs are included in Appendix B.

The fieldwork described above was supervised by members of Golder staff who directed the test pit excavation/borehole drilling operations, logged the test pits/boreholes and samples, and took custody of the soil samples retrieved. The soil samples were transported to Golder's laboratory for further examination.

Monitoring wells were sealed into all five boreholes to allow for groundwater sampling, hydraulic response testing, and measurements of the groundwater level. The hydraulic response testing was carried out on December 22, 2015, while groundwater level measurements were collected on December 22, 2015 and April 26, 2017. Groundwater samples were collected from monitoring wells installed in BH15-1, 15-2 and 15-4 on July 19, 2018 and submitted to Eurofins Environment Testing Canada Inc. (Eurofins) for nitrate analysis.

3.2 Investigation by Gemtec (2018)

In 2018**,** Gemtec carried out a geotechnical investigation at the site, which included the drilling of 11 boreholes and the installation of 4 monitoring wells across the site. The locations of the Gemtec boreholes are indicated on Figure 4 and borehole logs are included in Appendix B.

4.0 GROUNDWATER SUPPLY INVESTIGATION

The groundwater supply investigation for the site was based on procedures for the assessment of water supplies for developments with private individual wells as described in the MOE Procedure D-5-5 (MOE, 1996a).

As described in Section 2.4, test wells TW5 and TW6 are the proposed water supply wells for the operations at the concrete plant. Water taken from these wells will be used for concrete production and water supply for employees at the concrete plant. The House Well is the proposed water supply well at the future administration building. On behalf of Cavanagh, Golder obtained PTTW 4005-B3GKCQ for the aquifer testing program (see Appendix C). This PTTW allowed a maximum taking of 340 L/min for up to 3 days at each of the three wells. As described in the following sections, test wells TW5 and TW6 were tested at this rate; however, due to the smaller required water supply rate for the administration building, the House Well was tested at a lower rate.

4.1 Test Well Construction

The two water supply wells proposed for use at the concrete plant site were drilled by Air Rock Drilling Co. Ltd. Test well TW5 was drilled on March 20, 2018 and TW6 was drilled on June 26, 2018, at the locations shown on Figure 4. Both wells were completed in the bedrock. The following table provides drilling details for TW5 and TW6:

Location	Depth to Bedrock (m)	Casing Depth (m)	Total Depth (m)	Water Bearing Zones (m)	Well Yield Estimated by Driller (L/min)
TW5	4.9	6.7	29.6	22.3, 26.5, 27.7	>75
TW6	5.5	7.3	36.6	20.7, 23.8, 34.7	>75

For reference, copies of the water well records for TW5 and TW6 are provided in Appendix D.

Prior to the pumping tests on TW5 and TW6, a step-test was performed on each well to estimate a sustainable pumping rate to use during the aquifer testing program.

The House Well was drilled at some time before this investigation began and a water well record could not be found. During the aquifer testing program, the total well depth was measured as 5.85 metres; however, this may have reflected an obstruction in the well that did not allow the measuring device to pass.

4.2 Monitoring Well Locations

4.2.1 On-Site Water Wells

Two drilled wells (TW1 and TW2) installed in 2017 were used as monitoring wells during the pumping tests at TW5 and TW6. The following table provides construction details for TW1 and TW2:

Location	Depth to Bedrock (m)	Casing Depth (m)	Total Depth (m)	Water Bearing Zones (m)	Well Yield Estimated by Driller (L/min)
TW1	7.3	9.1	91.4	54.6, 79.2	11.4
TW2	2.4	6.1	91.4	58.2, 76.2	18.9

4.2.2 Shallow Monitoring Wells

In order to monitoring the response of the Huntley Creek water level during the pumping tests at TW5 and TW6, three shallow monitoring wells (labelled MW18-1, MW18-2 and MW18-3) were installed immediately adjacent to the creek at the locations shown on Figure 4. The construction details for these shallow monitoring wells are provided in Appendix B.

4.2.3 Borehole Monitoring Wells

As described in Section 3.1, monitoring wells were sealed into five boreholes advanced by Golder across the Site. The monitoring wells nearest to the test wells TW5 and TW6 (i.e., BH15-4 and BH15-5) were monitored for water level response during the pumping tests.

Two monitoring wells (MW18-7 and MW18-11) installed as part of the Gemtec geotechnical investigation were also monitored during the pumping tests.

4.2.4 Off-Site Water Wells

As required by Condition 4.3 of PTTW 4005- B3GKCQ (see Appendix C), private well owners with 500 metres of TW5, TW6 and the House Well were notified of the proposed aquifer testing program, and written permission was requested to access their wells for the purpose of monitoring groundwater levels before, during and after the pumping tests. Golder attempted to contact the residents/tenants of the 9 residences or buildings within this area. The owner of one private well (located at 2060 Richardson Side Road) agreed to have a datalogger installed in his well for groundwater level monitoring during the pumping tests. The well record for the well was not provided.

In addition, a well drilled in 2017 (TW4) located north of Richardson Side Road that is not currently in use was monitored during the aquifer testing program. The following table provides construction details for TW4:

Location	Depth to Bedrock (m)	Casing Depth (m)	Total Depth (m)	Water Bearing Zones (m)	Well Yield Estimated by Driller (L/min)
TW4	6.1	7.9	36.9	15.2; 17.4; 34.4	75.7

4.3 Aquifer Testing Program

4.3.1 TW5 and TW6

Pumping tests were carried out at test wells TW5 and TW6 between August 22 and 30, 2018. Each pumping test consisted of a pumping phase (48.6 to 67.9 hours in duration) followed by a recovery period (up to 142 hours in duration).

The pumping tests were conducted at a rate of 340 L/min (i.e., maximum allowable rate under the PTTW) using a submersible pump supplied by Air-Rock Drilling Co. Ltd (Air-Rock). The discharge from each pumping test was directed through approximately 30 metres of flexible hose toward the east (from TW5) or northeast (from TW6). The water discharged to a well-vegetated area which was monitored to ensure that erosion did not occur.

Before, during and after the pumping tests, groundwater levels were recorded in the pumping well (TW5 or TW6) and observation wells (TW1, TW2, TW4, shallow wells MW18-1, MW18-2 and MW18-3, BH15-4, BH15-5, Gemtec wells MW18-7 and MW18-11, 2060 Richardson Side Road) at selected time intervals. The water levels were measured manually, using an electric water level tape, and electronically, using pressure transducer loggers which were set to take measurements every minute. A barometric pressure logger was left on-site for post-processing barometric compensation. It was not possible to monitor the water level at the House Well during the TW5 and TW6 pumping tests, due to the configuration of pipes and cables in the well.

4.3.2 House Well

The pumping test on the House Well was carried out on September 5, 2018, and consisted of a constant rate pumping phase (18.9 L/min for 6.2 hours) followed by a recovery period of 90 minutes. In order to complete the test, the existing pump in the House Well was removed and a submersible pump was installed by Air-Rock. The discharge from the pumping test was directed through approximately 30 metres of flexible hose toward the south. The water discharged to a well-vegetated area which was monitored to ensure that erosion did not occur.

The water level monitoring program during this pumping test was the same as described for TW5 and TW6; however, manual water level measurements were collected at only the observation wells nearest the House Well (MW18-7, TW-2, TW-5 and shallow monitoring well MW18-1).

4.4 Groundwater Quality Investigation

During the pumping tests at test wells TW5 and TW6 and at the House Well, samples of the pump discharge were collected after approximately 1.3 to 2.8 hours of pumping at a constant rate and at the end of the pumping period, just before pump shut-off (i.e. after approximately 45.5 to 66.6 hours of pumping). At the time of sampling, field testing indicated that no chlorine residual was present in the discharge water. A field-measured chlorine residual of 0.01 mg/L was measured in the two samples collected at the House Well; however, this is considered an erroneous reading given that this well was not chlorinated before the pumping test.

The samples were preserved as necessary and submitted to Eurofins Environment Testing Canada Inc. (Eurofins) for the chemical, physical and bacteriological analyses listed in the MOE Procedure D-5-5 (MOE, 1996a). The results of the Phase Two ESA (see Section 2.5) were also considered in selecting the laboratory analyses. The cadmium and molybdenum concentrations in soil exceeded MECP Table 8 at one location each; however, the soil samples with the exceedances were collected above the groundwater table. The cobalt concentration in groundwater at two locations exceeded MECP Table 8; however, this parameter does not have an ODWQS standard. For these reasons, analysis of cadmium, molybdenum and cobalt in groundwater at the test wells and House Well were not warranted. Based on the presence of some BTEX compounds (benzene, toluene, ethylbenzene and xylenes), PHCs and polycyclic aromatic hydrocarbons (PAHs) in groundwater exceeding the MECP Table 8 Standard near the commercial enterprise north of Huntley Creek, the sample collected from the House Well at the end of the pumping test was analyzed for those parameters. The results of these analyses are summarized in Tables E-1A and E-1B (Appendix E).

Field measurements of temperature, pH, conductivity, chlorine residual, hydrogen sulfide and turbidity were taken periodically during the pumping tests and at the time of sampling (Table E-2, Appendix E). All analyses were compared to the applicable maximum acceptable concentrations (MAC), interim maximum acceptable concentrations (IMAC), or aesthetic objectives (AO) found in the Technical Support Document for Ontario Drinking Water Quality Standards, Objectives and Guidelines (MOE, 2006). All laboratory method detection limits (MDLs) were less than, or equivalent to, the respective criteria. Laboratory Reports of Analysis are provided in Appendix E.

5.0 TERRAIN ANALYSIS RESULTS

5.1 Subsurface Conditions

This section provides a summary of the subsurface soils and shallow groundwater conditions on the site based on the information obtained from the test pits, boreholes and auger holes completed at the site between 2015 and 2018. Logs of the materials encountered at each investigation location are included in Appendix B. It is noted that, in some cases, the stratigraphic boundaries within the overburden represent a transition between soil types rather than an exact plane of geologic change.

In general, the subsurface conditions at the Site consist of surficial topsoil or fill, underlain by layers of sand, silty sand and clayey silt, followed by glacial till at some locations. In the southwestern portion of the Site (in the area of TP17-1, TP17-2, TP17-4 and BH15-1), there was generally fill or clayey silt from ground surface to a depth of 0.4 to 1.7 metres below ground surface (bgs), underlain by 1.1 to 1.9 metres of sand, followed by 2.2 to 2.4 metres of silty sand. At BH15-1, the silty sand was underlain by a thin (0.2 metre) layer of silt followed by silty sand and gravel starting at 6.9 metres bgs.

Just southwest of the concrete plant site (in the area of TP17-5, TP17-6, TP17-7, TP17-8, TP17-22 and BH15-2), the subsurface conditions consisted of topsoil or gravelly sand from ground surface to a depth of 0.1 to 0.7 metres bgs, underlain by 0.5 to 1.5 metres of sand or silty sand, followed by glacial till. The top of the glacial till was generally at 0.2 to 2.9 metres bgs. A layer of fill was also noted at or near ground surface and TP17-7, TP17-22 and BH15-2.

Along the northwestern and northern boundaries of the concrete plant site (in the area of TP17-19, TP17-20, TP17-21 and BH15-4), there was topsoil from ground surface to a depth of 0.1 to 0.5 metres bgs, underlain by 0.5 to 1.8 metres of sand or silty sand, followed by glacial till. The top of the glacial till was generally at 1.5 to 2.1 metres bgs. A 0.2 to 0.5 metre layer of silty clay was observed at TP17-21 and BH15-4.

At BH15-5 (located near the northeastern corner of the Site), the subsurface conditions consisted of 0.3 metre of topsoil, 0.6 metre of silty sand, 3.9 metres of silty clay, and glacial till below 4.75. At BH15-6 (located on the north side of Huntley Creek near the northern boundary of the Site), the subsurface conditions consisted of 0.3 metre of topsoil, and 4.5 metres of alternating layers of silt, silty sand, clayey silt and silty clay layers.

Bedrock was not encountered in any of the test pits, all of which were approximately 2.0 to 4.0 metres deep.

Practical refusal to augering was encountered at boreholes 15-1, 15-2, 15-4 and 15-6 at depths ranging from about 4.8 to 7.4 metres bgs. In general, these depths are consistent with the anticipated depth to bedrock in the area; however, because coring was not undertaken to prove the bedrock, auger refusal could also represent cobbles or a boulder within the fill or glacial till.

5.2 Hydrogeological Conditions

Monitoring wells were sealed into boreholes 15-1, 15-2, 15-4, 15-5 and 15-6 to allow for groundwater sampling, hydraulic response testing, and measurements of the groundwater level at the site. A summary of the groundwater levels measured in these wells and at selected Gemtec monitoring wells is provided in Appendix F. The detailed results of the hydraulic conductivity analyses are also provided in Appendix F. The groundwater levels measured in April 2017 and the estimated hydraulic conductivity values are summarized in the following table:

Well ID	Geologic Unit of Screened Interval	Depth of Screened Interval (mbgs)	Groundwater Levels April 26, 2017		Hydraulic Conductivity (m/s)
			Depth (mbgs)	Elevation (masl)	
15-1	Silty Sand over Silty Sand and Gravel	5.8 – 7.4	0.22	114.35	$5x10^{-5}$
15-2	Glacial Till	4.6 – 6.1	5.26	109.73	-
15-4	Glacial Till	3.7 – 5.3	1.52	108.79	$4x10^{-7}$
15-5	Silty Clay over Glacial Till	4.6 – 6.1	0.88	108.62	$3x10^{-7}$
15-6	Layers of Silty Sand and Silty Clay	4.1 – 5.6	3.13	106.41	$2x10^{-4}$

The groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring, as shown by the higher groundwater levels measured in April 2017.

Groundwater inflow was noted at depths of 1.5 to 1.7 mbgs at test pits TP17-1 and 17-4 located along the western boundary of the Site. Test pits TP17-19, TP17-20 and TP17-21, located along the northwestern boundary of the concrete plant site, indicated groundwater seepage at depths of 1.4 to 1.8 mbgs. Groundwater inflow was not observed in the remaining test pits.

The shallow groundwater flow direction is interpreted to be toward Huntley Creek, based on topography and groundwater level measurements collected at selected monitoring wells in August 2018 (see Figure 4).

5.3 Background Groundwater Nitrate Concentrations

Groundwater samples were collected from monitoring wells installed in BH15-1, 15-2 and 15-4 on July 19, 2017 and submitted to Eurofins for nitrate analysis. The nitrate concentration results are presented in the following table:

Monitoring Well	BH15-1	BH15-2	BH15-4
Nitrate Concentration (mg/L)	2.03	4.77	0.51

5.4 Sewage Disposal System

As previously mentioned, it is proposed to construct a new on-site septic system to provide treatment of all sewage flows generated from the concrete plant. The Gemtec design report provides details on this septic system.

The future administration building (currently used as a residence) will be serviced by the existing sewage disposal system. It is understood that the existing system was constructed in 1999. The Septic System Site Evaluation and Design Review for the existing system are included as Appendix G. Based on these documents, it is understood that the existing system was designed for a total daily design flow of 3,000 L/day. Assuming a water usage of 75 L/day/employee and a maximum of 36 employees, the maximum total flow would be 2,700 L/day, below the total daily design flow.

6.0 GROUNDWATER SUPPLY INVESTIGATION RESULTS

6.1 Groundwater Quantity

Pumping tests were carried out at test wells TW5, TW6 and the House Well between August 22 and September 5, 2018.

The results of the pumping tests are presented in the following sections. During each pumping test, the end of the discharge pipe was positioned approximately 30 metres from the pumping well to avoid ponding of the pumped groundwater in the vicinity of the pumping well. The drawdown and recovery data and the associated analyses are presented in Appendix H.

Test Well TW5

A pumping test was conducted at TW5 from August 22 to 24, 2018. The static water level before the start of the test was at 3.78 metres below the top of the casing. TW5 was pumped at a rate of 340 L/min for 48.6 hours, after which a drawdown of 2.73 metres was measured (see Figure H-1a). Approximately 200 minutes after pump shut-off, 95 percent recovery of the maximum imposed drawdown had been achieved. As shown on Figure H-1a, there was a slight increase in water level approximately 900 minutes after pumping began. It is interpreted this may have been related to slight variations in the pumping rate.

Based on data from the Environment Canada Ottawa CDA Meteorological Station (ID 6105976), located approximately 23 kilometres northeast of the Site, there was approximately 33 mm of precipitation on the day preceding and the first day of the pumping test at TW5 (August 21 and 22, 2018). There was also 1.4 mm of precipitation on August 26, 2018 (two days after pump shutoff).

During the pumping test at TW5, water levels were measured in the observation wells listed in Section 4.2 (see Figures H-1b through H-1e). The water level response noted at the observation wells is summarized as follows:

- The greatest water level drawdown, ranging from 0.58 to 0.75 metre, was observed at TW6 (proposed water supply well), TW2 (bedrock observation well) and MW15-4 (monitoring well screened in glacial till above bedrock) (see Figure H-1b). The end of the water level recovery at these wells appears to have been affected by a background decreasing water level trend (see next bullet point). As a result, the water level at TW6 achieved 95% recovery approximately 41 hours after pump shut-off, whereas the water level at TW2 and MW15-4 had not achieved 95% as of 68 hours after pump shut-off.
- Figure H-1c shows the water level response at the other overburden observation wells. At MW15-5 (screened in glacial till above bedrock), the water level appeared to respond to pumping at TW5 and exhibited approximately 0.18 m of drawdown. Monitoring wells MW18-7 (screened in glacial till above bedrock) and MW18-11 (likely screened in silty clay) did not appear to respond to pumping at TW5, based on the increasing water level trend during most of the pumping test. Starting at approximately 5 hours of before pump shut-off, these two wells exhibited a decreasing water level trend which continued for 74 hours, suggesting that there was a background decreasing trend in water level during the recovery period.
- Figure H-1d shows the water level response at the other bedrock observation wells. All three wells (TW1, TW4 and 2060 Richardson Side Road) exhibited a drawdown on the order of 0.1 metre during the pumping test at TW5, which may have been in response to the pumping from the bedrock at TW5. The water level at the supply well at 2060 Richardson Side Road was also affected by the operation of the pump in that well.
- Figure H-1e shows the water level response at the shallow monitoring wells adjacent to Huntley Creek. The datalogger installed in MW18-1 malfunctioned; therefore, only manual water level measurements were available for that well. Based on the datalogger measurements at MW18-2 and MW18-3, the shallow groundwater level did not respond to pumping at TW5 and either increased or stayed relatively consistent during the first 20 hours of the test. A decreasing trend began after 20 hours of pumping and continued until 5 hours after pump shut-off.

A composite drawdown plot showing the water level drawdown at the pumping well and selected observation wells is provided as Figure H-1f. This plot shows drawdown vs. t/r2, where t=time since pumping began and r=distance from the pumping well. The drawdown in any observation well in the water supply aquifer that responded to pumping at TW5 should have the same slope as the pumping well drawdown. Aquifer transmissivity of the pumped bedrock aquifer was estimated as $3x10^{-3}$ m^2/s using the Cooper and Jacob drawdown (Cooper and Jacob, 1946) based on the slope of the drawdown on the composite plot. The recovery data from the pumping well were also analyzed using the Theis recovery (Theis, 1935) method and yielded a transmissivity estimate of $4x10^{-3}$ m^2/s (see Figure H-1g). Although the assumptions on which these methods are based are not strictly met, these methods provide a reasonable estimate of aquifer transmissivity (T).

The composite plot also confirmed that the water level in the shallow monitoring wells adjacent to Huntley Creek (MW18-2 and MW18-3) did not respond to pumping at TW5.

Test Well TW6

A pumping test was conducted at TW6 from August 27 to 30, 2018. The static water level before the start of the test was at 3.33 metres below the top of the casing. TW6 was pumped at a rate of 340 L/min for 67.9 hours, after which a drawdown of 1.91 metres was measured (see Figure H-2a). Approximately 65 hours after pump shut-off, 91 percent recovery of the maximum imposed drawdown had been achieved. The water level then remained relatively steady for the next 77 hours. The fact that the water level did not fully recover suggests that there was a background decreasing water level trend throughout the pumping test, as discussed below.

Based on data from the Environment Canada Ottawa CDA Meteorological Station (ID 6105976), located approximately 23 kilometres northeast of the Site, there was approximately 1.4 mm of precipitation on the day preceding the pumping test at TW6 (August 26, 2018). There was also 4.0 mm of precipitation on September 2, 2018 (three days after pump shutoff).

During the pumping test at TW6, water levels were measured in the observation wells listed in Section 4.2 (see Figures H-2b through H-2e). The water level response noted at the observation wells is summarized as follows:

- The greatest water level drawdown, ranging from 0.61 to 0.93 metre, was observed at TW5 (proposed water supply well), TW2 (bedrock observation well) and MW15-4 (monitoring well screened in glacial till above bedrock) (see Figure H-2b). The end of the water level recovery at these wells appears to have been affected by a background decreasing water level trend (see next bullet point). As a result, the water level at these three wells had not achieved 95% as of 142 hours after pump shut-off.
- Figure H-2c shows the water level response at the other overburden observation wells. At MW15-5 (monitoring well screened in glacial till above bedrock), the water level appeared to respond to pumping at TW6 and exhibited approximately 0.19 m of drawdown. Monitoring wells MW18-7 (screened in glacial till above bedrock) and MW18-11 (likely screened in silty clay) did not appear to respond to pumping at TW6, based on the decreasing water level trend that was apparent before the test began and continued after the end of the pumping test. It appears that there was a background decreasing trend in water level during the recovery period.
- Figure H-2d shows the water level response at the other bedrock observation wells. All three wells (TW1, TW4 and 2060 Richardson Side Road) exhibited a drawdown on the order of 0.1 to 0.4 metre during the pumping test at TW6, which may have been in response to the pumping from the bedrock at TW6. The water level at the supply well at 2060 Richardson Side Road was also affected by the operation of the pump in that well.
- Figure H-2e shows the water level response at the shallow monitoring wells adjacent to Huntley Creek. The datalogger installed in MW18-1 malfunctioned; therefore, only manual water level measurements were available for that well. Based on the datalogger measurements at MW18-2 and MW18-3, the shallow groundwater level was exhibiting a background decreasing trend in response to precipitation that began before the TW6 test and continued until 33 hours into the test. The water level then became steady and remained so for approximately 100 hours until it again appeared to respond to precipitation on September 2, 2018.

A composite drawdown plot showing the water level drawdown at the pumping well and selected observation wells is provided as Figure H-2f. This plot shows drawdown vs. t/r2, where t=time since pumping began and r=distance from the pumping well. The drawdown in any observation well in the water supply aquifer that responded to pumping at TW5 should have the same slope as the pumping well drawdown. Aquifer transmissivity of the pumped bedrock aquifer was estimated as $4x10^{-3}$ m^2/s using the Cooper and Jacob drawdown (Cooper and

Jacob, 1946) based on the slope of the drawdown on the composite plot. The recovery data from the pumping well were also analyzed using the Theis recovery (Theis, 1935) method and yielded a transmissivity estimate of $8x10^{-3}$ m^2/s (see Figure H-2g); however, as previously discussed, it is interpreted that the water level recovery at TW6 was likely affected by a background decreasing trend in groundwater level. Although the assumptions on which these methods are based are not strictly met, these methods provide a reasonable estimate of aquifer transmissivity (T).

The composite plot also confirmed that the water level in the shallow monitoring wells adjacent to Huntley Creek (MW18-2 and MW18-3) did not respond to pumping at TW6.

House Well

A pumping test was conducted at the House Well on September 5, 2018. The static water level before the start of the test was at 2.56 metres below the top of the casing. The House Well was pumped at a rate of 18.9 L/min for 6.2 hours, after which a drawdown of 0.31 metre was measured (see Figure H-3a). Approximately 90 minutes after pump shut-off, 93 percent recovery of the maximum imposed drawdown had been achieved.

During the pumping test at the House Well, water levels were measured in the observation wells listed in Section 4.2 (see Figures H-3b through H-3e). It is noted that in some of the observation wells, a sudden increase and decrease in water level was observed after approximately 385 minutes of pumping. At this time, there was a sudden increase in barometric pressure recorded at the site during the passage of a brief thunderstorm. The apparent change in water level is due to the change in barometric pressure reading used to correct the raw water level. The water level response noted at the observation wells is summarized as follows:

- Figure H-3b shows the water level response at the bedrock wells nearest the House Well (TW2, TW5 and TW6). Figure H-3c shows the water level response at the overburden wells (MW15-4, MW15-5, MW18-7, MW18-11). Both the bedrock well and overburden wells showed variations within 0.03 metre of the static level during the test, likely reflecting a background water level trend.
- Figure H-3d shows the water level response at the bedrock wells further from the House Well (TW1 and TW4). These wells did not appear to respond to pumping at the House Well.
- Figure H-3e shows the water level response at the shallow monitoring wells adjacent to Huntley Creek. The datalogger installed in MW18-1 malfunctioned; therefore, only manual water level measurements were available for that well. Based on the datalogger measurements, the shallow groundwater level at MW18-2 may have decreased by 0.01 metre during the pumping test, although this variation is within the range of measurement error. The water level at MW18-3 appeared to respond to precipitation events but not to pumping.

6.2 Groundwater Quality

The field observations and the results of the laboratory chemical, physical and bacteriological analyses for the groundwater samples collected from TW5, TW6 and the House Well are summarized in Tables E-1A and E-1B following the text of this report. The certificates of laboratory analyses are also included in Appendix E. Field measurements of temperature, pH, conductivity, chlorine residual and turbidity collected periodically during the pumping tests are presented in Table E-2.

All laboratory results were compared to the applicable maximum acceptable concentrations (MAC), interim maximum acceptable concentrations (IMAC), aesthetic objectives (AO) and operational guidelines (OG) found in the Technical Support Document for Ontario Drinking Water Quality Standards (ODWQS) (MOE, 2006).

Test Wells TW5 and TW6

Based on the analytical results, test wells TW5 and TW6 have similar groundwater quality. Exceedances of the ODWQS at these wells included chloride concentration in the 1.3-hour sample at TW6 (but not the 66.6-hour sample), the hydrogen sulphide concentration in the 2.8-hour and 45.5-hour samples at TW5, and the TDS concentration in all samples from TW5 and TW6; all of these concentrations exceeded the applicable AO. The hydrogen sulphide concentrations at TW5 were below the treatability limit established in Procedure D-5-5. There is no treatability limit for TDS. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for all of the samples from TW5 and TW6, which ranged from 0.1 to 0.6. These LSI values are within or just beyond the range generally considered stable (between -0.5 and +0.5) and indicate that corrosion or encrustation problems are unlikely (see Appendix E).

In addition, total coliforms were detected at both TW5 and TW6 (at concentrations of 51 ct/100 mL and 5 ct/100 mL, respectively, at or above the applicable MAC of 0 ct/100 mL and the 5 ct/100 mL level used to evaluate non-disinfected private water supplies (as described in Procedure D-5-5; MOE, 1996).

The hardness in all samples from TW5 and TW6 exceeded the applicable OG but is treatable by conventional water softening equipment.

There were no other exceedances of the applicable MACs, AOs or OGs for the parameters tested (see Table E-1).

Test wells TW5 and TW6 will be used to supply water for concrete production and for employees at the concrete plant. If the ODWQS exceedances for total coliform are found to persist, an alternative source of drinking water at the concrete plant will be necessary (e.g., bottled water).

House Well

Based on the analytical results for the House Well, the colour and TDS concentrations in both the 2.2-hour and 4.7-hour samples exceeded the applicable AOs. The colour concentrations were at or below the treatability limit established in Procedure D-5-5. There is no treatability limit for TDS. The potential for corrosion or encrustation problems associated with elevated TDS was assessed by calculating the Langelier Saturation Indices (LSI) for 2.2-hour and 4.7-hour samples, which were 0.8 and 0.6, respectively. These LSI values are within or just beyond the range generally considered stable (between -0.5 and +0.5) and showed a decreasing trend, indicating that corrosion or encrustation problems are unlikely (see Appendix E).

In addition, the total coliform concentrations (4 and 10 ct/100 mL after 2.2 and 4.7 hours, respectively) exceeded the applicable MAC of 0 ct/100 mL, and the latter sample exceeded the 5 ct/100 mL level used to evaluate non-disinfected private water supplies (as described in Procedure D-5-5; MOE, 1996). Similarly, the E. coli concentration in the 4.7-hour sample (1 ct/100mL) exceeded the applicable MAC of 0 ct/100 mL.

The hardness in both samples exceeded the applicable OG but is treatable by conventional water softening equipment.

The House Well was resampled for bacteriological parameters on September 11, 2018. The sample was collected from an outside tap at the residence. The E. coli concentration was 0 ct/100 mL. The total coliform and fecal coliform concentrations were both 1 ct/100 mL. After the sample was collected on September 11, 2018, the House Well was chlorinated and the pipes in the house were filled with chlorinated water and allowed to sit for 12 hours. Afterward, the chlorinated water was flushed from the system. The House Well was resampled on September 13, 2018 at the outside tap. The results indicated that the total coliform, fecal coliform and E. coli concentrations were 0 ct/100 mL and that free chlorine residual was not detected. On the basis of the September 13, 2018 results, it is interpreted that the chlorination and flushing of the House Well was effective in addressing the bacteriological exceedances.

There were no other exceedances of the applicable MACs, AOs or OGs for the parameters tested (see Table E-1).

The House Well will be used to supply water to the future administration building.

7.0 WATER BALANCE

A water balance assessment for current and proposed land uses, with and without LID mitigation measures, was carried out for the Site. The assessment was carried out with due consideration of the MOE Manual, the CA Guidelines and the LID Guide as described in Section 1.1. Golder also referred to the stormwater management design prepared by Robinson (2018).

The water balance assessment was based on land use data, existing soil types and meteorological data. The water surplus for the site was based on water budget data from the Environment Canada Ottawa CDA Meteorological Station (ID 6105976), located approximately 23 kilometres northeast of the Site, from 1945 to 2013. The raw water budget data from Environment Canada (EC) are included in Appendix I.

Water balance calculations are based on the following equation:

$$P = S + ET + R + I$$

Where: P = precipitation
S = change in soil water storage
ET = evapotranspiration
R = surface runoff
I = infiltration (groundwater recharge)

Precipitation data for the Ottawa CDA station indicate a mean annual precipitation (P) of 885 mm/yr.

Evapotranspiration (ET) refers to water lost to the atmosphere from vegetated surfaces. The term combines evaporation (i.e., water lost from soil or water surfaces) and transpiration (i.e., water lost from plants and trees) because of the difficulties in measuring these two processes separately. Potential evapotranspiration refers to the loss of water from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of evapotranspiration is typically less than the potential rate under dry conditions (e.g., during the summer months when there is a moisture deficit). The mean annual potential evapotranspiration for the study area is approximately 615 mm/yr based on data provided by EC.

Annual water surplus is the difference between precipitation and the actual evapotranspiration. The water surplus represents the total amount of water available for either surface runoff (R) or groundwater infiltration (I) on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snow-melt, and maximum soil or snow pack storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use. Short-term or seasonal changes in soil water storage (S) occur as demonstrated by the dry conditions in the summer months and the wet or flooded conditions in the winter and spring. Long-term changes (e.g., year-to-year) in soil water storage are considered to be negligible.

The site-specific data required to use the water balance equation described above depend on soil type, land use, topography and vegetative cover. Soil type and land use are used to determine WHC based on Table 3.1 from the MOE Manual (2003), which in turn is used to determine actual evapotranspiration. Soil type, topography and ground cover are used to estimate an infiltration factor which represents the approximate annual percentage of surplus which can be infiltrated in an area with a sufficient downward groundwater gradient. Wetlands and water bodies are assumed to have a negligible downward gradient, resulting in all surpluses being contained in these areas, which provide increased evaporation and typically limited infiltration. Runoff is calculated as the difference between surplus and infiltration.

7.1 Pre-Development Conditions

The following data sources and assumptions were used in determining the infiltration factors for the water balance under pre-development conditions:

- For the purpose of determining WHC, land use at the Site under existing conditions was identified from Google Earth imagery (dated September 2016) and Golder's Site visits. In keeping with the vegetation cover types described in the MOE Manual (2003), land use was classified as follows (see Figure 5):
  - The lawn area immediately surrounding the existing residence was classified as "Urban Lawn".
  - Huntley Creek was assumed to measure 3 metres wide along its path within the Site and was classified as "Open Water".
  - The treed area on either side of Huntley Creek was classified as "Mature Forest", with the boundary of this area estimated based on Google Earth imagery.
  - The roadways and disturbed areas across the Site were classified as "Impervious Surface". These areas generally consist of a gravel surface, which is considered relatively impervious for the purpose of the water balance assessment.
  - The rest of the Site area was classified as "Pasture/Shrub", based on the presence of tall grasses and shrubs.
- For impervious surfaces, an infiltration factor of zero indicating no infiltration occurring on these surfaces was applied. It was assumed that 20% of precipitation on impervious surfaces would evaporate, while 80% would become runoff (Cuddy et al., 2013).
- Based on the results of the borehole and testpit investigations at the Site (refer to Section 5.0), the main surficial soils at the Site consist of surficial topsoil or fill, underlain by layers of sand, silty sand and clayey silt. For comparison to the MOE Manual (2003), this soil type was classified as sand loam, based on the U.S. Department of Agriculture classification system and the relative percentages of sand, silt and clay.
- Based on the average ground surface slope of 0.02 to 0.025, the topography was considered "hilly", as defined in the MOE Manual (2003).
- For the purpose of determining the infiltration factor, the type of cover was classified as "woodland" for the treed area along Huntley Creek and "cultivated land" for the urban lawn. The areas classified as "Pasture/Shrub" were assumed to have a land cover equivalent to the average between cultivated land use and woodland.
- Due to their small area relative to the overall Site area, the rooves of the existing residence and other commercial buildings on Site were not separately assessed as impermeable surfaces in the water balance.
- Water holding capacities (WHC) – WHC were taken from Table 3.1 of the MOE manual.
- The surplus to Huntley Creek was estimated as precipitation minus potential evapotranspiration. As described in the previous section, wetlands and water bodies are assumed to have a negligible downward gradient, resulting in all surpluses being contained in these areas, which provide increased evaporation and typically limited infiltration. Therefore, an infiltration factor of zero, indicating no infiltration occurring on this surface, was applied.

The following table presents the results of the water balance under pre-development conditions for average annual conditions.

Pre-Development Annual Water Balance Results

Land Use	Area (ha)	Precipitation *(mm/yr)* m³/yr	Evapo-transpiration *(mm/yr)* m³/yr	Surplus *(mm/yr)* m³/yr	Infiltration *(mm/yr)* m³/yr	Runoff *(mm/yr)* m³/yr
Impervious Surfaces	2.383	*(885)* 21,090	*(177)* 4,218	*(708)* 16,872	*(0)* 0	*(708)* 16,872
Water	0.501	*(885)* 4,434	*(615)* 3,081	*(270)* 1,353	*(0)* 0	*(270)* 1,353
Urban Lawn	0.410	*(885)* 3,629	*(534)* 2,189	*(351)* 1,439	*(211)* 865	*(140)* 574
Pasture/Shrub	19.938	*(885)* 176,451	*(579)* 115,441	*(306)* 61,010	*(199)* 39,677	*(107)* 21,334
Mature Forest	5.543	*(885)* 49,056	*(585)* 32,427	*(300)* 16,629	*(210)* 11,640	*(90)* 4,989
Total	**28.775**	**254,660**	**157,356**	**97,303**	**52,182**	**45,122**

The total estimated average annual pre-development runoff from the site is approximately 45,122 m^3 and the estimated infiltration is approximately 52,182 m^3.

Additional details of the hydrologic water balance are presented in Appendix I.

Based on site topography, it is interpreted that the shallow groundwater flow direction mirrors the topography and the surface water drainage. That is, shallow groundwater flow is toward Huntley Creek.

7.2 Proposed Post-Development Conditions

The post-development water balance excludes the LID features (bioretention facilities) proposed for the concrete plant site, which are addressed in the following section. The water balance was completed for the Site under post-development conditions using the same method presented for the pre-development conditions. The assumptions for post-development conditions were the same as described in the previous section for pre-development conditions, with the following exception:

- Within the area of the concrete plant site (approximately 2.6 ha), the land use was changed from “Urban Lawn” or “Pasture/Shrub” to “Impervious Surface” (see Figure 6).

The following table presents the results of the water balance under post-development conditions for average annual conditions.

Post-Development Annual Water Balance Results

Land Use	Area (ha)	Precipitation *(mm/yr)* m³/yr	Evapo-transpiration *(mm/yr)* m³/yr	Surplus *(mm/yr)* m³/yr	Infiltration *(mm/yr)* m³/yr	Runoff *(mm/yr)* m³/yr
Impervious Surfaces	4.975	*(885)* 49,750	*(177)* 8,806	*(708)* 35,223	*(0)* 0	*(708)* 35,223
Water	0.501	*(885)* 4,434	*(615)* 3,081	*(270)* 1,353	*(0)* 0	*(270)* 1,353
Urban Lawn	0.337	*(885)* 2,982	*(534)* 1,800	*(351)* 1,183	*(211)* 711	*(140)* 472
Pasture/Shrub	17.419	*(885)* 154,158	*(579)* 100,856	*(306)* 53,302	*(199)* 34,664	*(107)* 18,638
Mature Forest	5.543	*(885)* 49,056	*(585)* 32,427	*(300)* 16,629	*(210)* 11,640	*(90)* 4,989
Total	**28.775**	**254,659**	**146,970**	**107,690**	**47,015**	**60,675**

The total estimated average annual post-development runoff from the site is approximately 60,675 m^3 and the estimated infiltration is approximately 47,015 m^3.

Additional details of the hydrologic water balance are presented in Appendix I.

Under post-development conditions, it is assumed that shallow groundwater flow is toward Huntley Creek. Between pre- and post-development conditions, the infiltration on the site is estimated to decrease by 10% and the runoff is estimated to increase by 34%.

7.3 Mitigated Development Condition

The main LID feature consists of two bioretention facilities that will capture stormwater runoff and provide cleansing prior to discharge into Huntley Creek. The RVC_T (runoff volume control target) to be infiltrated by these facilities is 27 mm (i.e., this feature has been designed to capture runoff from the concrete plant site for precipitation events under 27 mm or the first 27 mm of higher intensity precipitation events). This precipitation amount corresponds to the 90th percentile rainfall event (Robinson, 2018). Therefore, as per the Robinson stormwater management design, 90% of the annual surplus from the concrete plant site (2.59 ha) will be available for infiltration through the bioretention facilities.

The following table presents the results of the water balance within the study area under post-development mitigated conditions for average annual conditions.

Mitigated Post-Development Annual Water Balance Results

Land Use	Area (ha)	Precipitation *(mm/yr)* m^3/yr	Evapo-transpiration *(mm/yr)* m^3/yr	Surplus *(mm/yr)* m^3/yr	Infiltration *(mm/yr)* m^3/yr	Runoff *(mm/yr)* m^3/yr
Impervious Surfaces – Other than Concrete Plant	2.383	*(885)* 21,090	*(177)* 4,218	*(708)* 16,872	*(0)* 0	*(708)* 16,872
Impervious Surfaces – Concrete Plant	2.592	*(885)* 22,939	*(177)* 4,588	*(708)* 18,351	*(637)* 16,516	*(71)* 1,835
Water	0.501	*(885)* 4,434	*(615)* 3,081	*(270)* 1,353	*(0)* 0	*(270)* 1,353
Urban Lawn	0.337	*(885)* 2,982	*(534)* 1,800	*(351)* 1,183	*(211)* 711	*(140)* 472
Pasture/Shrub	17.419	*(885)* 154,158	*(579)* 100,856	*(306)* 53,302	*(199)* 34,664	*(107)* 18,638
Mature Forest	5.543	*(885)* 49,056	*(585)* 32,427	*(300)* 16,629	*(210)* 11,640	*(90)* 4,989
Total	**28.775**	**254,659**	**146,970**	**107,690**	**63,531**	**44,159**

The total estimated overall annual mitigated development runoff from the site is approximately 44,159 m^3 and the estimated infiltration is approximately 63,531 m^3. Between pre- and post-development mitigated conditions, the infiltration on the site is estimated to increase by 22% and the runoff is estimated to decrease by 2%.

Additional details of the hydrologic water balance are presented in Appendix I.

8.0 IMPACT ASSESSMENT

8.1 Hydrogeological Sensitivity

The site is not considered hydrogeologically sensitive, as none of the following have been identified: karstic areas, areas of thin soil cover, or areas of highly permeable soils. As discussed in Sections 3.0 and 4.0, at least 2.0 metres of overburden was encountered in all Site boreholes, test pits and test wells. The overburden material generally consists of surficial topsoil or fill, underlain by layers of sand, silty sand and clayey silt, followed by glacial till at some locations.

8.2 Water Quantity Impacts

This section addresses potential impacts to groundwater and surface water quality due to groundwater pumping at TW5, TW6 and House Well. As discussed in Section 2.4, the maximum water taking from TW5 and TW6 for concrete production and water supply would be 378 L/min under extreme conditions, while the average taking would be approximately 210 L/min. The maximum taking from the House Well would be 2,700 L/day.

8.2.1 Well Interference

The potential impact of pumping at TW5 or TW6 (for concrete production/water supply) and at the House Well (for water supply at the administration building) on off-site water supply wells was investigated by calculating the potential cumulative drawdown at the nearest supply well, which was identified as the well at the commercial/industrial building located north of Huntley Creek, approximately 70 metres west of the House Well (within the Site boundary). The cumulative drawdown was calculated using the Cooper and Jacob equation (Cooper and Jacob, 1946) with an aquifer transmissivity of $4x10^{-3}$ m^2/s and an assumed storativity of $1x10^{-4}$.

The combined pumping rate from TW5 and TW6 was assumed to be 378 L/min and the pumping rate at the House Well was assumed to be 2,700 L/day. A time of 20 years was used in the calculation. Calculations are provided in Appendix J.

A cumulative potential drawdown of 1.82 metres was calculated for the well at the commercial/industrial building located north of Huntley Creek, essentially entirely due to the larger pumping rate at TW5 and TW6. As discussed in Section 2.3.3, the available drawdown in the water supply wells within 500 metres of the site ranges from 15.8 to 84.1 metres. Assuming that the nearest well at the commercial/industrial building would have an available drawdown similar to those wells, this level of cumulative drawdown is considered acceptable with respect to the total drawdown available to the well.

8.2.2 Shallow Groundwater and Surface Water

The potential impact on the shallow groundwater and surface water levels at Huntley Creek due to groundwater pumping at the site was assessed based on the water level response at the shallow monitoring wells adjacent to the creek during the aquifer testing program.

As discussed in Section 6.1, the shallow groundwater level at MW18-2 and MW18-3 did not exhibit a response to pumping at TW5, TW6 or the House Well. The composite drawdown plot also confirmed that the water level in these did not respond to pumping at TW5 or TW6. The concrete supply wells TW5 and TW6 were each pumped at 340 L/min for at least 48 hours, which represents a higher taking than the anticipated average total pumping rate of 210 L/min for 12 hours/day. Therefore, the pumping rates used in the aquifer testing program are considered to represent a conservative water taking rate relative to the long-term average taking. Based on these results, it is not anticipated that the water taking from the bedrock aquifer for the operation of the concrete plant will adversely impact shallow groundwater levels or surface water level in the vicinity of Huntley Creek.

8.2.3 Water Balance

Based on the results of the water balance assessment, with mitigation measures proposed, the proposed site development is projected to increase the average annual infiltration by approximately 22% and decrease the average annual runoff by approximately 2% compared to existing conditions. In terms of LID infiltration targets, it is generally recommended that any post-development reduction in infiltration be within 10% of pre-development conditions. In this case, infiltration is projected to increase from pre-development to post-development.

8.3 Water Quality Impacts

8.3.1 Nitrate Attenuation

The assessment of potential groundwater impact due to the use of the existing on-site sewage system at the future administration building and the new on-site sewage system at the concrete plant site was based on the MOE Guideline entitled “Technical Guideline for Individual On-site Sewage Systems: Water Quality Impact Risk Assessment”, dated August 1996 (Guideline D-5-4). This guideline was developed for the assessment of privately serviced subdivisions. The groundwater impact assessment for the site followed the predictive assessment method (i.e., the nitrate dilution calculation). The following assumptions were made to apply this method:

- The shallow groundwater is interpreted to flow from the septic system toward Huntley Creek. Therefore, all water infiltrating at the Site under mitigated post-development conditions (Section 7.3) on the south side of Huntley Creek was considered dilution water. This volume is 63,531 m^3/year.
- The daily sewage flow was estimated as 6,450 L/day, based on an individual rate of 75 L/day per employee and 86 employees (50 at the concrete plant and 36 at the administration building).

- The nitrate input was estimated as $9.417x10^7$ mg/year (40 mg/L x 6,450 L/day x 365 days/yr).
- The downgradient nitrate concentration is equal to the nitrate input divided by the volume of dilution water.

Based on these assumptions, the theoretical nitrate concentration at the location where the shallow groundwater discharges to Huntley Creek was calculated as 1.5 mg/L. As such, the proposed development complies with the requirements of Procedure D-5-4 related to nitrate impacts.

8.3.2 Surface Water Quality Impacts

The shallow groundwater flow direction is interpreted to be toward Huntley Creek, based on topography and groundwater level measurements collected at selected monitoring wells in August 2018 (see Figure 4). Therefore, effluent from the on-site sewage disposal systems will ultimately flow via shallow groundwater toward Huntley Creek. As described in the previous section, the on-site nitrate attenuation satisfies the requirements of Procedure D-5-4. With regards to other potential parameters found in domestic sewage (e.g. phosphate), the new sewage systems will be constructed at an appropriate setback from the creek in accordance with the Ontario Building Code and City of Ottawa requirements. Therefore, adverse water quality impacts to surface water are not anticipated.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Based on the hydrogeology investigation, terrain analysis and impact assessment carried out by Golder at the Site, the following conclusions are provided:

a) Pumping tests carried out at test wells TW5 and TW6 suggest that both wells can provide at least 340 L/min for concrete production, which represents a higher taking than the anticipated average pumping rate of 210 L/min for 12 hours/day. The pumping test carried out at the House Well indicates that the well can provide at least 18 L/min, which is greater than the anticipated water use at the future administration building of 75 L/day/employee (or 2,700 L/day).

b) Based on the analytical results, test wells TW5 and TW6 have exceedances of the ODWQS for chloride, hydrogen sulphide, TDS, hardness and total coliforms. Test wells TW5 and TW6 will be used to supply water for concrete production and for employees at the concrete plant. If the ODWQS exceedances for total coliform are found to persist, an alternative source of drinking water at the concrete plan will be necessary (e.g., bottled water).

c) Based on the analytical results, the House Well has exceedances of the ODWQS for colour and TDS. It also had exceedances for total coliforms, fecal coliforms and E.coli. However, the post-chlorination results indicated that the total coliform, fecal coliform and E. coli concentrations were 0 ct/100 mL. Therefore, the House Well is considered to satisfy the ODWQS for bacteriological parameters. The House Well will be used to supply water to the future administration building.

d) The shallow groundwater levels in the vicinity of Huntley Creek did not respond to pumping at TW5, TW6 and the House Well. Based on these results, it is not anticipated that the water taking for the operation of the concrete plant will adversely impact shallow groundwater levels or surface water level in the vicinity of Huntley Creek.

e) The use of the test wells and the House Well for the Site water supply is not anticipated to result in a significant impact on the available drawdown at nearby water supply wells.

f) Based on the results of the water balance assessment, with mitigation measures proposed, the proposed site development is projected to increase the average annual infiltration by approximately 22% and decrease the average annual runoff volume by approximately 2% compared to existing conditions.

g) The theoretical nitrate concentration at the location of groundwater discharge to Huntley Creek was calculated as 1.5 mg/L. As such, the proposed development complies with the requirements of Procedure D-5-4 related to nitrate impacts. With regards to other potential parameters found in domestic sewage (e.g. phosphate), the new sewage system will be constructed at an appropriate setback from the creek in accordance with the Ontario Building Code and City of Ottawa requirements. Therefore, adverse water quality impacts to surface water are not anticipated.

9.2 Recommendations

a) Cavanagh is advised that treatment for colour, hydrogen sulphide and hardness in the groundwater supply may be desirable. Cavanagh is also advised of the following potential effects caused by natural groundwater quality or by water treatment equipment:

- The sodium concentration in groundwater samples at the site exceeded 20 mg/L. Accordingly, the Local Medical Officer of Health should be informed and individuals on sodium-restricted diets should consult their physicians before using the well water as a potable water source;
- Treating water for hardness using a conventional sodium ion exchange water softener may increase the sodium content of the water; and,
- If untreated, elevated sulphide concentrations may result in an unpleasant odour.

b) Regular water quality testing of all wells used to supply drinking water is recommended.

c) Septic systems at the site must be constructed in accordance with the Ontario Building Code (OBC, O.Reg. 350/06), which indicates minimum clearances between wells and septic system components (treatment units and distribution piping). The septic system designer and constructor shall ensure that the necessary approvals are obtained.

10.0 LIMITATIONS

This report was prepared for the exclusive use of Cavanagh Developments. 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 properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in 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 report as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

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.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on 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 based on this report.

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, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

11.0 CLOSURE

We trust this report meets your current requirements. If you have any questions regarding this report, please contact the undersigned.

Golder Associates Ltd.

Loren Bekeris, M.Sc., P.Eng.
Environmental Engineer

Brian Byerley, M.Sc., P.Eng.
Senior Hydrogeologist/Principal

LEB/BTB/sg
n:\active\2015\3 proj\1543767 cavanagh industrial subdivision carp\04_reporting\hydrogeology\water balance and terrain analysis\1543767-r-rev 0-hydrogeology investigation 2596 carp road_19sep2018.docx

12.0 REFERENCES

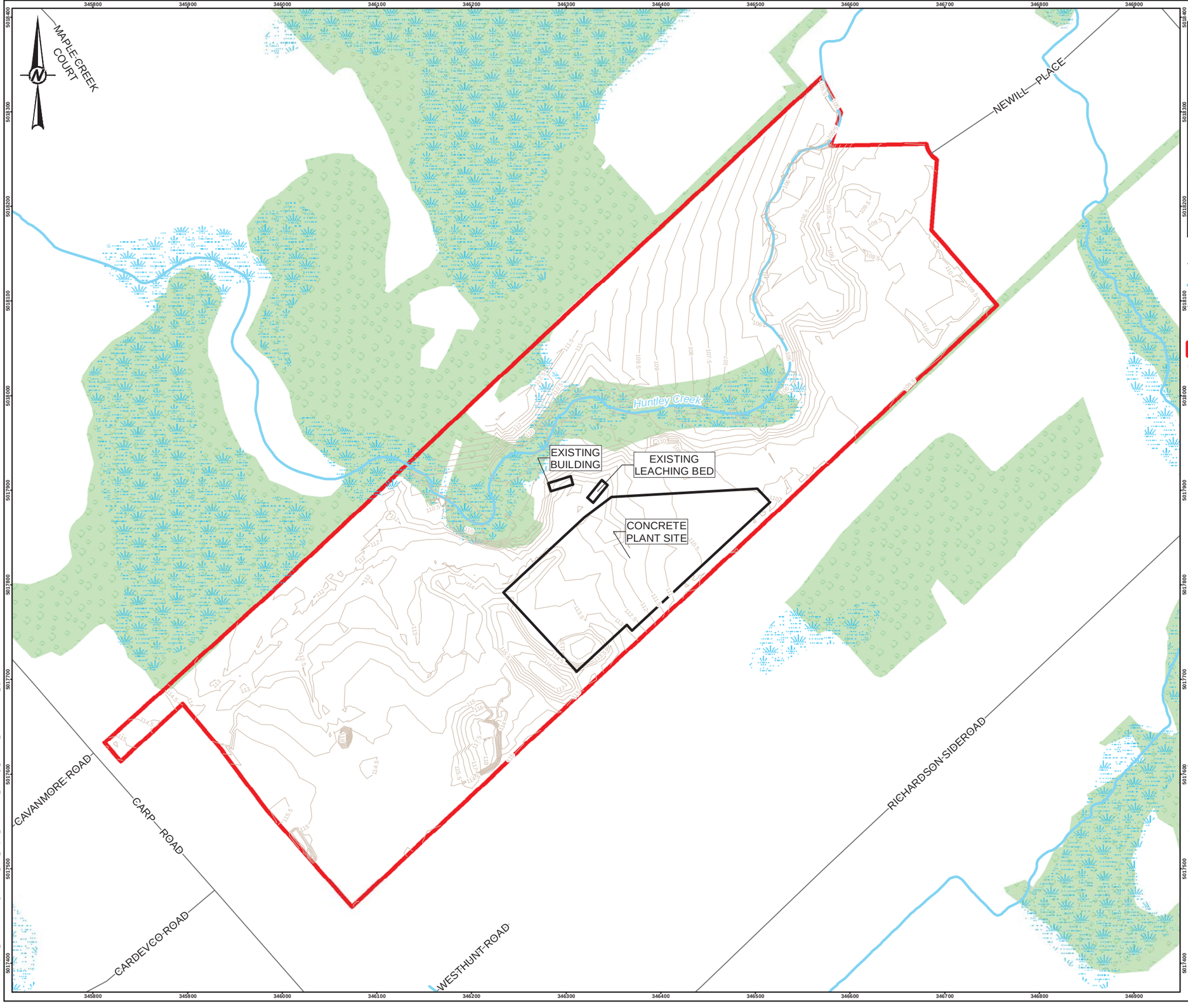
Golder Associates Ltd. 2016. Phase One Environmental Site Assessment, Part of Lot 6, Concession 2, Township of Huntley, Ottawa, Ontario. Project No. 1543767, May 2016.

Golder Associates Ltd. 2018a. Ontario Regulation 153/04 Phase One Environmental Site Assessment Update, 2596 Carp Road, Ottawa, Ontario. Project No. 1543767, September 2018.

Golder Associates Ltd. 2018b. Phase Two Environmental Site Assessment, 2596 Carp Road, Ottawa, Ontario. Project No. 1543767, September 2018.

Mississippi-Rideau Source Protection Region (MRSPR). 2008. Watershed Characterization Report. March 2008.

Robinson Land Development. 2018. 2596 Carp Road, Ottawa, Ontario, Industrial Development Servicing and Stormwater Management Report. Project No. 19047, September 2018.



KEY MAP

SCALE 1:100,000

LEGEND

- WATERCOURSE
- ROADWAY
- WETLAND
- SITE BOUNDARY

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. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
SITE PLAN

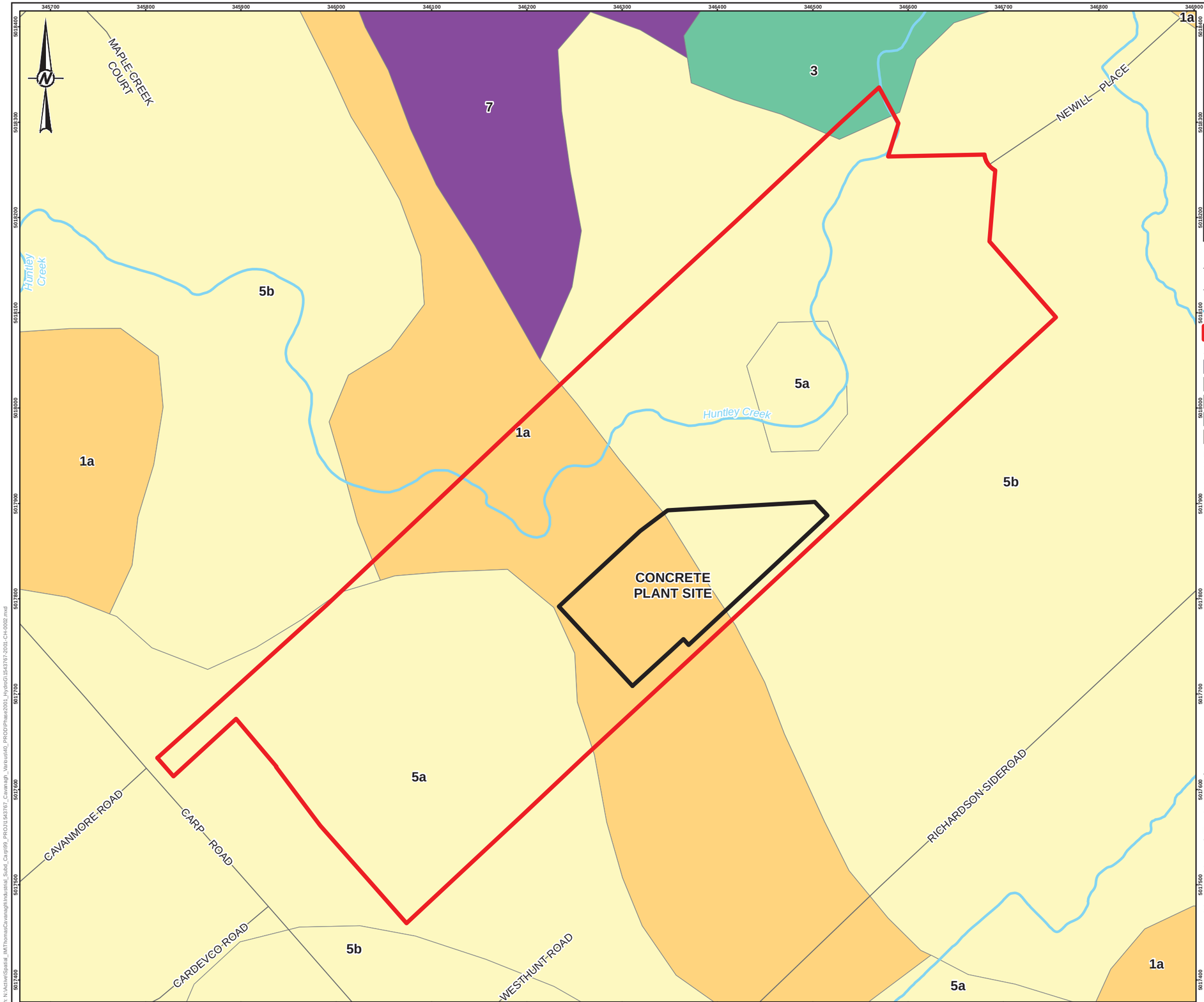
CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	1

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

Path: N:\Active\Spatial_IM\Thomas\Cavanagh\Industrial_Subd_Carp\99_PROJ\1543767_Cavanagh_Variou\s40_PROD\Phase2001_Hydro\G154\3767-22001-CH-0001.mxd



KEY MAP

SCALE 1:100,000

LEGEND

- ROADWAY
- WATERCOURSE
- SITE BOUNDARY

SURFICIAL GEOLOGY

- 7. ORGANIC DEPOSITS: MUCK & PEAT
- 5a: NEARSHORE SEDIMENTS: GRAVEL, SAND & BOULDERS
- 5b: NEARSHORE SEDIMENTS: FINE TO MEDIUM GRAINED SAND
- 3. OFFSHORE MARINE DEPOSITS: CLAY, SILTY CLAY & SILT
- 1a. TILL, PLAIN WITH LOCAL RELIEF <5 m

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. BÉLANGER, J. R. 2008 URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE 5311, 1 DVD.
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160
1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
SURFICIAL GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	**2**

Path: N:\Active\Spatial \MAT\Thomas\Cavanagh\Industrial_Subd_Carp\99_PROJ\1543767_Cavanagh_Various\40_PROD\Phase2001_Hydro\G\1543767-2001-CH-0002.mxd

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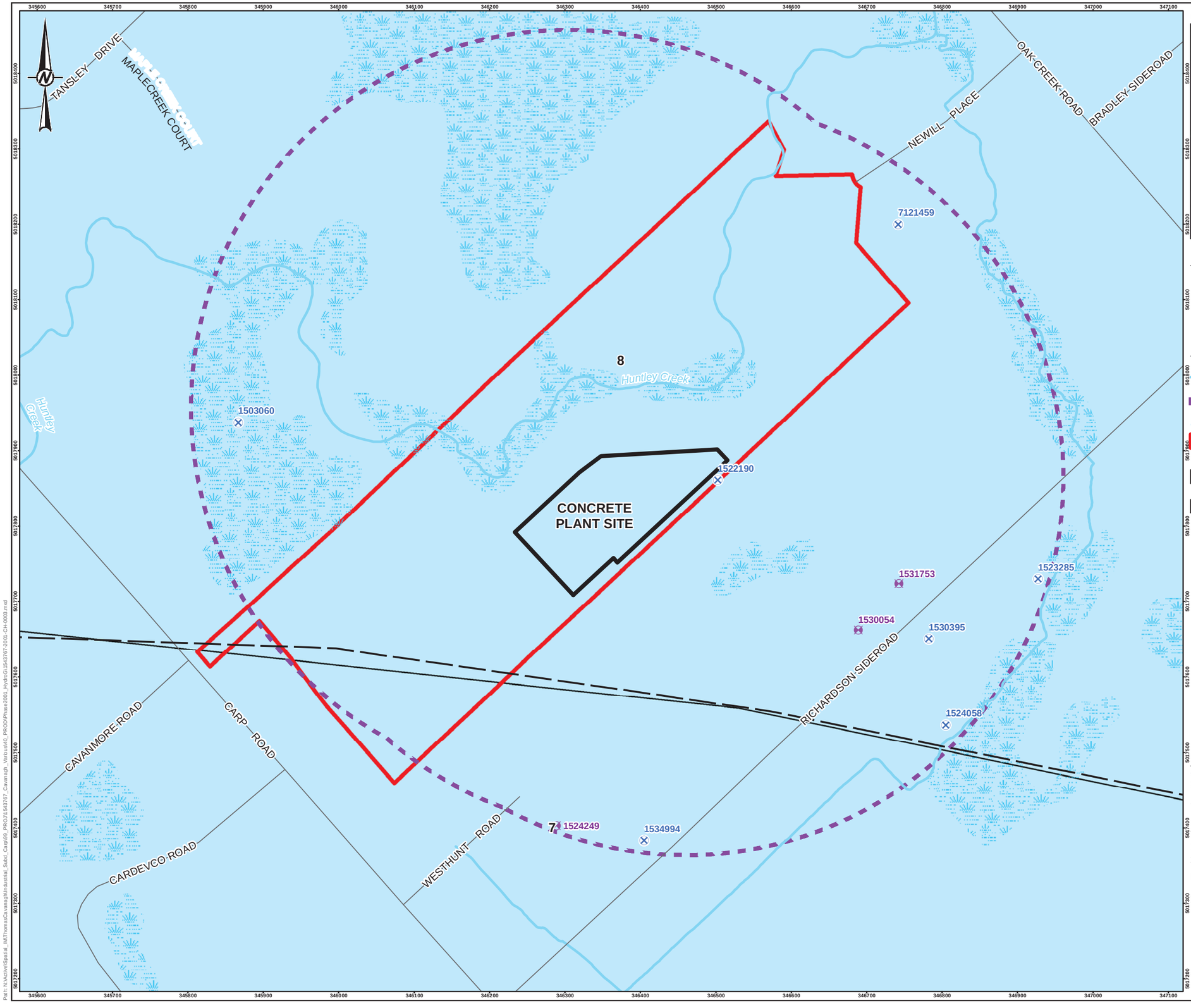

KEY MAP

SCALE 1:100,000

LEGEND

- MECP LISTED WATER WELL (LOCATION ADJUSTED)
- MECP LISTED WATER WELL
- FAULT
- ROADWAY
- WATERCOURSE
- 500 m BUFFER FROM TEST WELLS
- WETLAND
- SITE BOUNDARY

BEDROCK GEOLOGY

- 8. VERULAM FORMATION: INTERBEDDED BIOCLASTIC LIMESTONE, SUBLITHOGRAPHIC TO FINE CRYSTALLINE LIMESTONE
- 7. BOBCAYGEON FORMATION: INTERBEDDED SILTY DOLOMITE, LITHOGRAPHIC TO FINE CRYSTALLINE LIMESTONE, OOLITIC LIMESTONE, SHALE, AND FINE-GRAINED CALCAREOUS QUARTZ SANDSTONE

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. BÉLANGER, J. R., URBAN GEOLOGY OF THE NATIONAL CAPITAL AREA, GEOLOGICAL SURVEY OF CANADA, OPEN FILE D3256, 2001
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 50 100 200
1:5,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
BEDROCK GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	3

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

KEY MAP

SCALE 1:100,000

LEGEND

99.99	OVERBURDEN GROUNDWATER ELEVATION, mASL (Aug. 22, 2018)
99.99	BEDROCK GROUNDWATER ELEVATION, mASL (Aug. 22, 2018)
	APPROXIMATE BOREHOLE LOCATION, GEMTEC, 2018
	APPROXIMATE TEST WELL LOCATION
	APPROXIMATE TEST WELL (MONITORING WELL) LOCATION
	APPROXIMATE TEST PIT LOCATION
	APPROXIMATE SHALLOW MONITORING WELL LOCATION
	APPROXIMATE BOREHOLE LOCATION
	SITE BOUNDARY

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. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
FIELD INVESTIGATION LOCATIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	**4**

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

SCALE 1:100,000

LEGEND

- INFILTRATION AREA
- SITE BOUNDARY

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. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
WATER BALANCE - PRE-DEVELOPMENT CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	**5**

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

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KEY MAP

SCALE 1:100,000

LEGEND

- INFILTRATION AREA
- SITE BOUNDARY

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. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

0 40 80 160

1:4,000 METRES

CLIENT
CAVANAGH DEVELOPMENTS

PROJECT
HYDROGEOLOGY INVESTIGATION
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
WATER BALANCE - POST-DEVELOPMENT CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-08-01
DESIGNED	----
PREPARED	ABD
REVIEWED	LEB
APPROVED	BTB

PROJECT NO.	PHASE	REV.	FIGURE
1543767	2001	0	6

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

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APPENDIX A

MECP Water Well Record Summary

MECP Water Well Record Summary

Well ID	Easting	Northing	Elevation (m)	Date Completed	Well Type	Depth to Bedrock (ft)	Depth to Bedrock (m)	Well Depth (m)	Water found depth (ft)	Water Found Depth (m)	Static Water Level (m)	Overburden Type	Bedrock Type	UTMRC
7121459	424330	5017008	107.9	06-Feb-09	Bedrock	N/A	6.1	86.7	N/A	N/A	2.6	sandy clay/clay	limestone	3
1524249	424085	5016674	109.2	16-Oct-89	Bedrock	16	4.9	45.7	28; 87	8.5; 26.5	4.3	sand and gravel/hardpan	limestone	9
1530054	424085	5016674	109.2	05-May-98	Bedrock	15	4.6	30.5	80-95	24.3 - 29.0	1.5	sandy clay/sand and gravel	limestone	9
1531753	424081	5016676	109.2	19-Feb-01	Bedrock	12	3.7	30.5	26; 89	7.9; 27.1	1.1	sandy clay	limestone	9
1524058	424381	5016344	109.5	03-Nov-89	Bedrock	21	6.4	20.4	65	19.8	4.6	clay	limestone	5
1530395	424361	5016458	110.0	25-Sep-98	Bedrock	22	6.7	33.5	100	30.5	3.4	clay fill/sand	limestone	5
1523285	424507	5016535	108.1	11-Mar-89	Bedrock	26	7.9	25.9	83	25.3	8.2	sand and gravel/clay	limestone	5

Notes: N/A - not applicable
N/D - no data

APPENDIX B

Borehole and Test Pit Logs

PROJECT: 1543767

RECORD OF BOREHOLE: 15-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 7, 2015

DATUM: CGVD28

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		114.57							
0	Power Auger 200 mm Diam. (Hollow Stem)	(ML) CLAYEY SILT, some sand and gravel; dark brown; non-cohesive, moist, loose to compact		0.00							
1					1	SS	7				
				112.89							
		(SP) SAND, some gravel, trace fines; brown; non-cohesive, moist to wet, compact		1.68	2	SS	19				
2											
					3	SS	16				Cuttings
				111.67							
3		(SP) SAND, trace gravel; grey, contains cobbles; non-cohesive, wet, compact		2.90							
					4	SS	19				
				110.76							
4		(SM) SILTY SAND; brown; non-cohesive, wet, compact		3.81	5	SS	11				
5					6	SS	14				Bentonite Seal
					7	SS	17				Silica Sand
6											
					8	SS	17				
				107.95							51 mm Diam. PVC #10 Slot Screen
		(ML) SILT, some sand and gravel; grey; non-cohesive, wet, compact		6.62							
				107.71							
7		(SM/GM) SILTY SAND and GRAVEL; grey brown; non-cohesive, wet, compact		6.86	9	SS	>50				
				107.19							
		End of Borehole Auger Refusal		7.38							W.L. in Screen at Elev. 106.41 m on April 26, 2017
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 7, 2015

DATUM: CGVD28

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. +, 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		114.99							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SP) gravelly SAND, angular; grey; non-cohesive, moist, loose		0.00							
1					1	SS	7				Cuttings
				113.62							
		(SM) SILTY SAND, trace gravel; red brown; non-cohesive, moist, loose			2	SS	7				Bentonite Seal
2				112.86							
		(SM) SILTY SAND, some gravel; grey brown; non-cohesive, moist to wet, compact		2.13	3	SS	16				
				112.09							
3		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		2.90	4	SS	>50				Silica Sand
4					5	SS	71				
					6	SS	56				
5											51 mm Diam. PVC #10 Slot Screen
					7	SS	60				
6					8	SS	>50				Silica Sand
				108.61							
		End of Borehole Auger Refusal		6.38							W.L. in Screen at Elev. 109.74 m on April 26, 2017
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 12, 2015

DATUM: CGVD28

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. +, 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		112.02							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, moist		0.00 / 111.33							
		(SM) SILTY SAND; brown; non-cohesive, moist, compact		0.69 / 111.03							Cuttings
1		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		0.99	1	SS	14				
					2	SS	47				Bentonite Seal
2											Silica Sand
					3	SS	86				
3											51 mm Diam. PVC #10 Slot Screen
					4	SS	>50				
				108.21							
4		End of Borehole Auger Refusal		3.81							W.L. in Screen at Elev. 111.74 m on April 26, 2017
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 7, 2015

DATUM: CGVD28

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. +, 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		110.31							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist		0.00 / 109.90							
		(SM) SILTY SAND to sandy SILT; brown; non-cohesive, moist		0.41 / 109.55							
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.76 / 0.91	1	SS	10				
1		(SM) SILTY SAND, fine, trace gravel; brown, contains organics; non-cohesive, moist, compact									Cuttings
					2	SS	17				
2		(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		108.25 / 2.06							
					3	SS	30				Bentonite Seal
3				107.26							
		(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL)		3.05	4	SS	53				Silica Sand
4					5	SS	82				
											51 mm Diam. PVC #10 Slot Screen
					6	SS	41				
5				105.05							
		End of Borehole Auger Refusal		5.26							W.L. in Screen at Elev. 108.79 m on April 26, 2017
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2015

DATUM: CGVD28

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	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		109.50									
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, fine; dark brown; non-cohesive, moist		0.00									
				109.19									
		(SM) SILTY SAND; brown; non-cohesive, moist		0.31									
				108.59									
1		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.91	1	SS	6						
					2	SS	15						Cuttings
2													
					3	SS	3						
				106.76									
3		(CI/CH-ML) SILTY CLAY to CLAYEY SILT, trace sand; grey; cohesive, w>PL, firm to stiff		2.74				⊕	+				
								⊕	+				
													Bentonite Seal
4					4	SS	WH						
													Silica Sand
				104.75									
5		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, dense to compact		4.75	5	SS	31						
													51 mm Diam. PVC #10 Slot Screen
					6	SS	25						
6				103.40									
		End of Borehole		6.10									W.L. in Screen at Elev. 108.62 m on April 26, 2017
7													
8													
9													
10													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

PROJECT: 1543767

RECORD OF BOREHOLE: 15-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2015

DATUM: CGVD28

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. +, 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		109.54							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00 / 109.23							
		(SM) SILTY SAND; brown; non-cohesive, moist, compact		0.31	1	SS	8				Cuttings
1				108.24							
		(SM) SILTY SAND; grey brown; non-cohesive, moist, compact		1.30	2	SS	25				
2				107.25							
		(ML,CL & SM) layered SILT, CLAYEY SILT, SILTY CLAY and SILTY SAND; grey; brown; non-cohesive, moist, very loose		2.29	3	SS	2				Bentonite Seal
3				106.49							
		(SM) SILTY SAND, fine; brown; non-cohesive, moist to wet, loose		3.05	4	SS	4				Silica Sand
				105.73							
4		(CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL, very stiff		3.81	5	SS	WH				51 mm Diam. PVC #10 Slot Screen
				105.12							
		(SM) SILTY SAND, fine, some gravel; grey; non-cohesive, wet, compact		4.42	6	SS					
				104.72							
5		End of Borehole Auger Refusal		4.82							W.L. in Screen at Elev. 106.41 m on April 26, 2017
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: HEC

CHECKED: WAM

MIS-BHS 001 1543767.GPJ GAL-MIS.GDT 09/12/18 JEM

RECORD OF BOREHOLE 18-1

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		112.90						
		TOPSOIL		0.05						
		Brown SAND, trace silt		112.49	1	GS			M	
		Grey SILTY SAND, trace clay		0.41	2	GS				
1										
2				110.77						
		End of borehole		2.13						
3										
4										
5										

PENETRATION RESISTANCE (N), BLOWS/0.3m ●
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m ▲
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P W W_L
10 20 30 40 50 60 70 80 90

Bentonite seal
Filter sand
51 mm diametre, 1.52 m long well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/17	0.69 ▽	112.21

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-2

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		114.17					10 20 30 40 50 60 70 80 90		
		TOPSOIL FILL		0.03							
		Dark brown sandy silt, some clay, trace gravel (FILL MATERIAL)			1	GS			○	M	Backfilled with soil cuttings
1					2	GS					Groundwater seepage oberved in open borehole
				112.65							
		End of borehole		1.52							
2											
3											
4											
5											

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/08	1.35 ▽	112.82

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-3

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (+ NATURAL, ⊕ REMOULDED) / WATER CONTENT, % (W_P, W, W_L)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		114.76							
		TOPSOIL FILL		114.71 / 0.05	1	GS					
		Brown sandy silt, trace gravel and clay, with debris (rebar) (FILL MATERIAL)			2	GS					Backfilled with soil cuttings
1											
				113.24							No groundwater seepage observed upon completion of borehole
		End of borehole		1.52							
2											
3											
4											
5											

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL, ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-4

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		113.88							
		TOPSOIL FILL		0.05							
		Brown sandy silt, trace gravel and clay, with possible cobbles and boulders (FILL MATERIAL)			1	GS			○	M	Backfilled with soil cuttings
1											
		End of borehole		112.36 1.52							No groundwater seepage observed upon completion of borehole
2											
3											
4											
5											

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL, ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-5

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		113.91							
		TOPSOIL FILL		0.03							
		Grey to brown sandy silt, some clay, trace gravel (FILL MATERIAL)			1	GS					Backfilled with soil cuttings
1					2	GS					
		End of borehole		112.39 / 1.52							No groundwater seepage observed upon completion of borehole
2											
3											
4											
5											

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL, ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-6

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m ● / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m ▲	SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		110.86								
		TOPSOIL		0.05								
		Dark brown SILTY SAND		110.56	1	GS						
		Brown SAND, trace silt and gravel		0.30 / 110.35	2	GS						
1		Grey brown SILTY SAND		0.51	3	GS					M	
2				108.73								
		End of borehole		2.13								
3												
4												
5												

10 20 30 40 50 60 70 80 90

Bentonite seal
Filter sand
51 mm diametre, 1.52 m long well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/17	1.25 ▽	109.61

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

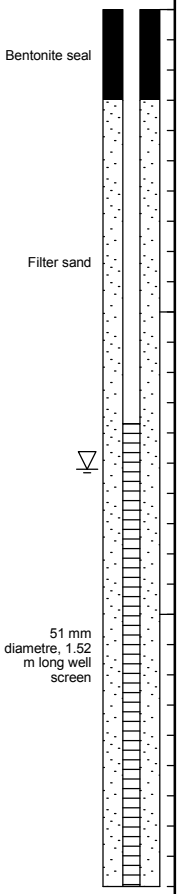
RECORD OF BOREHOLE 18-7

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		112.68						
		TOPSOIL		0.05						
		Loose, brown SILTY SAND, trace gravel			1 1B	SS SS	430	7	M	
1		very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)		111.61 1.07	2	SS	480	10		
2					3	SS	610	54		
					4	SS	410	>50 for 150 mm		
3		End of borehole Auger refusal on inferred bedrock		109.78 2.90						
4										
5										

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/17	1.52 ▽	111.16

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-8

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (NATURAL, REMOULDED) / WATER CONTENT, % (W_P, W, W_L)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		111.57							
		TOPSOIL		0.05							
	Power Auger / Hollow Stem Auger (210mm OD)	Very loose, brown SILTY SAND, trace gravel			1A 1B	SS SS	480	4			Soil moist at about 0.8 metres below ground surface
				110.81							
1		Compact to very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)		0.76	2	SS	460	21			Backfilled with soil cuttings
					3	SS	510	54		MH	
2					4	SS	510	>50 for 100 mm			
				108.88							
		End of borehole Auger refusal on inferred bedrock		2.69							
3											
4											
5											

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-9

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	111.79						
		TOPSOIL	0.05	1	SS	305	7		Soil moist at about 0.8 metres below ground surface
1		Loose to compact, brown SILTY SAND, trace gravel	110.72	2	SS	560	15		
		Compact to very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)	1.07	3	SS	560	58		Backfilled with soil cuttings
2				4	SS	530	>50 for 130 mm		
3		End of borehole Auger refusal on inferred bedrock	108.92 2.87						
4									
5									

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P W W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-10

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		110.28						
		TOPSOIL		110.20 / 0.08						
		Very loose to loose dark brown to brown SANDY SILT, trace clay			1	SS	510	3		
1					2	SS	585	9	M	Soil moist at about 0.8 metres below ground surface
				108.76 / 1.52						Backfilled with soil cuttings
2		Compact to very dense, grey brown silty sand, trace to some gravel with possible cobbles and boulders (GLACIAL TILL)			3	SS	560	18		
					4	SS	280	>50 for 80 mm		
3		End of Borehole Auger refusal on inferred bedrock		107.38 / 2.90						
4										
5										

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

RECORD OF BOREHOLE 18-11

CLIENT: Cavanagh Developments
PROJECT: 2596 Carp Road
JOB#: 61318.20
LOCATION: See Borehole Location Plan, Figure 2

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Aug 8 2018

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (+ NATURAL, ⊕ REMOULDED) / WATER CONTENT, % (W_P, W, W_L)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		110.87							
		Soil conditions not logged									Bentonite seal
1											Filter sand
2											51 mm diametre, 1.52 m long well screen
				108.08							
3		End of Borehole Auger refusal on inferred bedrock		2.79							
4											
5											

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
18/08/18	1.47 ▽	109.40

GEMTEC
Consulting Engineers and Scientists

LOGGED: K.H.
CHECKED: B.W.

GEO - BOREHOLE LOG 61318.20_GINT_V01_2018-08-08.GPJ GEMTEC 2018.GDT 30/8/18

TP17-1	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.4	FILL - (GP) sandy GRAVEL; grey; non-cohesive, moist	SA-1 (0.3 m)
	0.4 – 2.0	(SP) SAND, some gravel; brown, contains cobbles; non-cohesive, moist to wet	SA-2 (1.5 m)
	2.0	End of test pit; groundwater seepage into test pit at 1.5 m, test pit caving	

TP17-2	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.5	FILL - (SP) gravelly SAND, some fines; grey; non-cohesive, moist	SA-1 (0.3 m)
	0.5 – 1.8	(SP) SAND, some gravel; brown; non-cohesive, moist	SA-2 (1.2 m)
	1.8 - 4.0	(SM) SILTY SAND; grey; non-cohesive, wet	SA-3 (3.0 m)
	4.0	End of test pit; no groundwater inflow noted	

TP17-4	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	(SM) SILTY SAND, some gravel; contains rootlets; non-cohesive	SA-1 (0.4 m)
	0.1 – 0.5	(ML) CLAYEY SILT, some sand, trace gravel; non-cohesive, moist	SA-2 (1.0 m)
	0.5 – 2.4	(SP) SAND, trace gravel; brown; non-cohesive, moist to wet	SA-3 (2.0 m)
	2.4	End of test pit; water at 1.7 m in test pit	

TP17-5	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.4	TOPSOIL - (SP) gravelly SAND, some fines; dark brown; non-cohesive	SA-1 (0.2 m)
	0.4 – 1.5	(SP) SAND, some fines, trace gravel; brown; non-cohesive, moist	SA-2 (1.0 m)
	1.5 – 2.0	(SM) SILTY SAND, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-3 (2.0 m)
	2.0	End of test pit; no groundwater inflow noted	

TP17-6	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.3	(SP) gravelly SAND, some fines; brown, contains organic matter; non-cohesive, moist	SA-1 (0.2 m)
	0.3 – 0.8	(SM) SILTY SAND, trace gravel; brown; non-cohesive, moist	SA-2 (0.7 m)
	0.8 – 2.0	(SM) SILTY SAND, some gravel; brown (GLACIAL TILL): non-cohesive, moist	SA-3 (1.6 m)
	2.0	End of test pit; no groundwater inflow noted	

TP17-7	Depth (m)	Description	Sample
	0.0 – 0.7	TOPSOIL - (SP) SAND, trace fines and gravel; dark	SA-1 (0.2 m)
25-Apr-17	0.7 - 1.4	FILL - (SP) SAND, some fines and gravel; brown, contains debris; non-cohesive, moist	SA-2 (1.2 m)
	1.4 - 2.8	(SM) SILTY SAND, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-3 (1.9 m)
	2.8	End of test pit; no groundwater inflow noted	

TP17-8	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.2	TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown; non-cohesive, moist	SA-1 (0.1 m)
	0.2 - 2.0	(SM) SILTY SAND, some gravel; grey brown, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-2 (1.5 m)
	2.0	End of test pit; no groundwater inflow noted	

TP17-19	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	TOPSOIL - (SM) SILTY SAND, some gravel; non-cohesive	SA-1 (0.3 m)
	0.1 - 1.6	(SP) SAND, trace fines and gravel; brown; non-cohesive, moist	SA-2 (1.0 m)
	1.6 - 2.1	(SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, wet	SA-3 (2.0 m)
	2.1	End of test pit; groundwater seepage into test pit at 1.4 m, water level in pit at 2.0 m	

TP17-20	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	TOPSOIL - (SM) SILTY SAND, some gravel; dark brown; non-cohesive, moist	SA-1 (0.1 m)
	0.1 - 1.5	(SP-SM) SAND, some fines to SILTY, trace gravel; red brown; non-cohesive, moist to wet	SA-2 (1.0 m)
	1.5 - 2.0	(SM) SILTY SAND, some gravel; grey brown, contains cobbles (GLACIAL TILL); non-cohesive, moist	SA-2 (1.7 m)
	2.0	End of test pit; groundwater seepage into test pit at 1.4 m, water level in pit at 1.9 m	

TP17-21	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.5	TOPSOIL - (SM) SILTY SAND, some gravel; dark brown; non-cohesive, moist	SA-1 (0.1 m); SA2 (0.3 m)
	0.5 - 1.0	(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown (WEATHERED CRUST); cohesive, w>PL	SA-3 (0.7 m)
	1.0 - 1.3	(SP) SAND, some fines, trace gravel; brown, non-cohesive, moist	SA-4 (1.1 m)
	1.3 - 2.8	(SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, moist to wet	SA-5 (1.7 m)
	2.8	End of test pit; groundwater seepage into test pit at 1.8 m, water level in pit at 2.7 m	

TP17-22	Depth (m)	Description	Sample
25-Apr-17	0.0 – 0.1	FILL/TOPSOIL - (SM) SILTY SAND, some gravel; brown; non-cohesive, moist	SA-1 (0.1 m)
	0.1 - 1.8	FILL - (SM) SILTY SAND, some gravel; brown, contains cobbles and boulders; non-cohesive, moist	SA-2 (1.0 m)
	1.8 - 2.4	(SM) SILTY SAND, some gravel; brown, contains cobbles; non-cohesive, moist	SA-3 (2.0 m); SA-4 (2.2 m)
	2.4	End of test pit; no groundwater inflow noted	

MW18-1	Depth (m)	Description	Ground Surface Elevation (m)
13-Aug-18	0.00 – 0.39	SAND, some gravel and cobbles; brown.	107.782

MW18-2	Depth (m)	Description	Ground Surface Elevation (m)
13-Aug-18	0.00 – 0.59	SAND, some gravel and cobbles; brown.	107.093

MW18-3	Depth (m)	Description	Ground Surface Elevation (m)
13-Aug-18	0.00 – 0.45	SAND, some gravel and cobbles; brown.	106.552

All monitoring wells were constructed using 19-mm PVC pipe. The wells were screened from the bottom of the well to approximately 8 cm below ground surface and sealed with bentonite between 8 cm below ground and ground surface.

APPENDIX C

Permit to Take Water 4005-B3GKCQ

PERMIT TO TAKE WATER
Ground Water
NUMBER 4005-B3GKCQ

Pursuant to Section 34.1 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:

1384341 Ontario Ltd.
9094 Cavanagh Rd Ashton
Ottawa, Ontario, K0A 1B0
Canada

For the water taking from: Pumping Test Wells TW5, TW6, and a House Well (approximately 20 metres from Huntley Creek) for future long-term ready-mix concrete production at the proposed Cavanagh Developments, Ready-mix Concrete Plant

Located at: 2596 Carp Rd
Ottawa

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

DEFINITIONS

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34.1, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment, Conservation and Parks.

(d) "District Office" means the Ottawa District Office.

(e) "Permit" means this Permit to Take Water No. 4005-B3GKCQ including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.

(f) "Permit Holder" means 1384341 Ontario Ltd..

(g) "OWRA " means the *Ontario Water Resources Act,* R.S.O. 1990, c. O. 40, as amended.

You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated July 19, 2018 and signed by Jeff Cavanagh, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

2. General Conditions and Interpretation

2.1 Inspections

The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act* , R.S.O. 1990, the *Pesticides Act* , R.S.O. 1990, or the *Safe Drinking Water Act,* S. O. 2002.

2.2 Other Approvals

The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act* , and the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 **Expiry**

This Permit expires on **February 20, 2019**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

Table A

	Source Name / Description:	Source: Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken per Year:	Zone/ Easting/ Northing:
1	TW5	Well Drilled	Pumping Test	Miscellaneous	340	24	489,600	3	18 423975 5016711
2	TW6	Well Drilled	Pumping Test	Miscellaneous	340	24	489,600	3	18 424043 5016678
3	House Well	Well Drilled	Pumping Test	Miscellaneous	340	24	489,600	3	18 423888 5016774
						Total Taking:	489,600		

3.3 Purpose of Pumping Test

Water taken by the Permit Holder shall be used solely for the purpose of pumping tests in order to assess hydrogeological conditions.

4. Monitoring

4.1 Monitoring of Water Takings

The Permit Holder shall maintain a record of all water takings. This record shall include the dates and times of water takings, and the total measured amounts of water taken per day for each day that water is taken under the authorization of this Permit. A separate record shall be maintained for each source. The Permit Holder shall keep all required records up to date and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request.

4.2 Type of Water Taking Measurement

The total amounts of water taken shall be measured using a calibrated flow meter and totalizer.

4.3 Area of Study

The Permit Holder shall contact all well owners within 500 metres of the test well(s) prior to commencing the pumping test and seek written permission to access their well(s).

4.4 Required Groundwater Pumping Test Results
Where written permission sought under Condition 4.3 has been obtained, the Permit Holder shall measure and record static water levels prior to the pumping test, pumping water levels at an appropriate frequency to allow for the calculation of aquifer conductivity and storativity values and water levels during the recovery period in the well(s) until 95% recovery occurs or for a period of time equal to the duration of the pumping test, whichever is less.

4.5 The Permit Holder shall monitor groundwater levels as described in Item #1 and Item #2, Schedule A of this Permit.

4.6 Water Interference Contingency Plan
Prior to commencing the pumping test, the Permit Holder shall develop a contingency plan to compensate other water users in the event that this water taking negatively impacts the area's water supply. The Permit Holder shall implement this contingency plan upon the validation of any water interference complaint and this plan shall remain in effect until the affected water supply recovers to a sustainable quality and quantity that may be considered usable for the normal use of the water.

5. Impacts of the Water Taking

5.1 Notification
The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 For Groundwater Takings
If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

5.3 Notification of the Director

The Permit Holder must immediately report to the Director all groundwater and surface water interference and surface water discharge impacts and adverse effects associated with the pumping test.

5.4 Prevention of Damage To Structures
The Permit Holder shall take all measures necessary to prevent damage to buildings, structures, roads and/or railway lines that may be impacted by this taking.

5.5 Discharge of Water Taken
The discharge of water shall be controlled in such a way as to avoid erosion and sedimentation in the receiving stream.

5.6 The Permit Holder shall ensure that any water discharged to the natural environment does not result in scouring, erosion or physical alteration of stream channels or banks and that there is no flooding in the receiving area or water body, downstream water bodies, ditches or properties caused or worsened by this discharge.

5.7 Any discharge to the land surface shall use a multi-barrier approach to control erosion and run-off and the discharge shall be to a well vegetated area to promote infiltration prior to entering Huntley Creek or any other watercourse.

5.8 The Permit Holder shall not discharge turbid water to any watercourse. Turbid water shall be defined as any discharge water or diverted water with a maximum increase of 8 NTUs above the receiving stream's background levels.

5.9 Siltation control measures shall be installed at the discharge site(s) and shall be sufficient to control the volumes. Continuous care shall be taken to properly maintain the siltation control devices.

6. Director May Amend Permit
The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing,

conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

*In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written notice served upon me, the Environmental Review Tribunal and the Environmental Commissioner, **Environmental Bill of Rights**, R.S.O. 1993, Chapter 28, within 15 days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 101 of the Ontario Water Resources Act, as amended provides that the Notice requiring a hearing shall state:*

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

a. The name of the appellant;
b. The address of the appellant;
c. The Permit to Take Water number;
d. The date of the Permit to Take Water;
e. The name of the Director;
f. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 326-5370
Email:
ERTTribunalsecretary@ontario.ca

AND

The Environmental Commissioner
1075 Bay Street
6th Floor, Suite 605
Toronto, Ontario M5S 2W5

AND

The Director, Section 34.1,
Ministry of the Environment,
Conservation and Parks
1259 Gardiners Rd, PO Box 22032
Kingston, ON
K7P 3J6

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by Telephone at	by Fax at	by e-mail at
(416) 212-6349	(416) 326-5370	www.ert.gov.on.ca
Toll Free 1(866) 448-2248	Toll Free 1(844) 213-3474	

*This instrument is subject to Section 38 of the **Environmental Bill of Rights** that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek to appeal for 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry, you can determine when the leave to appeal period ends.*

Dated at Kingston this 16th day of August, 2018.

Peter Taylor
Director, Section 34.1

Ontario Water Resources Act , R.S.O. 1990

Schedule A

This Schedule “A” forms part of Permit To Take Water 4005-B3GKCQ, dated August 16, 2018.

Item #1

Section 2.6.5, Proposed Monitoring Program, of the report titled "Category 2 Permit To Take Water Application Proposed Cavanagh Ready-Mix Concrete Plant, Ottawa, Ontario", signed and stamped by Loren Bekeris, M.Sc., P.Eng., and signed by Kris Marentette, M.Sc., P.Geo., on July 20, 2018.

Item #2

Figure 1, Site Plan, Rev. A, dated July 16, 2018, of the report titled "Category 2 Permit To Take Water Application Proposed Cavanagh Ready-Mix Concrete Plant, Ottawa, Ontario", signed and stamped by Loren Bekeris, M.Sc., P.Eng., and signed by Kris Marentette, M.Sc., P.Geo., on July 20, 2018.

APPENDIX D

Water Well Records for TW5 and TW6

Ontario — Ministry of the Environment and Climate Change

Well Tag#: A240646 (ow)

A240646

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Measurements recorded in: ☐ Metric ☒ Imperial

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed ☐ Well Owner
1384341	ONTARIO LIMITED	c/o Colnaugh Const	

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
9094 Colnaugh Road	Ashton	Ont	K0A1B0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
#2596 CARP ROAD	West Carleton P	L6	2

County/District/Municipality	City/Town/Village	Province	Postal Code
Ottawa-Carleton	Carp	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	423975	5016711	RP 4R-1165 Part 1	TW#5

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
	Clay Gravel			0'	16'
	Grey Limestone (Broken)			16'	97'

* TEST WELL #5 *

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
22'	0'	Neat Cement Slurry	10.92

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	Depth (m/ft) To
6¼"	Steel	.188"	+2'	22'
6"	Open hole		22'	97'

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* ____

Construction Record - Screen

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

Water Details

Water found at Depth	Kind of Water	Hole Diameter Depth From	Depth To	Diameter (cm/in)
73 (m/ft) ☐ Gas	☐ Fresh ☒ Untested ☐ Other, *specify* ____	0'	22'	9¾"
87 (m/ft) ☐ Gas	☐ Fresh ☒ Untested ☐ Other, *specify* ____	22'	97'	6"
91 (m/ft) ☐ Gas	☐ Fresh ☒ Untested ☐ Other, *specify* ____			

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify* ____

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 80'

Pumping rate (l/min / GPM): 20

Duration of pumping: 1 hrs 0 min

Final water level end of pumping (m/ft): 12'

If flowing give rate (l/min / GPM): X

Recommended pump depth (m/ft): 80'

Recommended pump rate (l/min / GPM): 20

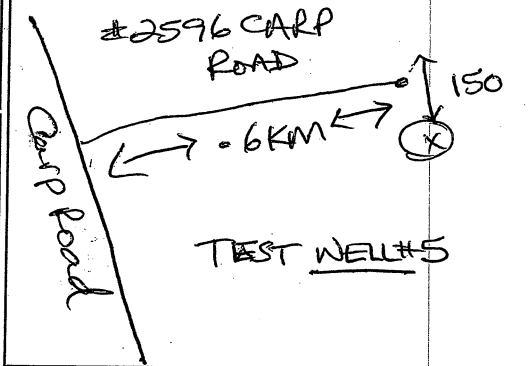
Well production (l/min / GPM): 20

Disinfected? ☒ Yes ☐ No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	11'2"			12'
1	12'		1	11'2"
2	12'		2	11'2"
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: 1/2HP-10GPM @ 80'

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
AIR ROCK DRILLING CO LTD	1119

Business Address (Street Number/Name)	Municipality	Province	Postal Code	Business E-mail Address
RR#1	Richmond	ONT	K0A2Z0	

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)	Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
6138382170	HANNA JEREMY	T3632		2018 03 30

Well owner's information package delivered: ☒ Yes ☐ No

Date Package Delivered: 2018 03 30

Date Work Completed: 2018 03 30

Ministry Use Only

Audit No. Z237000

Received

0506E (2014/11)

Ministry's Copy

Ontario — Ministry of the Environment and Climate Change

Measurements recorded in: ☐ Metric ☒ Imperial

Tag#: A229149 (Below)

A229149

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	1384341 Ontario Limited (c/o Cavanagh Const)		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
9094 Cavanagh Road	Ashton	On	K0A 1B0	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
2596 Carp Road	West Carleton	P/L 6	2

County/District/Municipality	City/Town/Village	Province	Postal Code
Ottawa-Carleton	Carp	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	424043	5016678	RP-4R-1165	Part 1 - TEST WELL 6

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
	Sandy	Clay,	Gravel & Sand	0'	18'
Grey	Limestone			18'	68'
Grey	Limestone			68'	78'
Grey	Limestone			78'	114'
Grey	Limestone			114'	120'
		TEST WELL # 6			

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/cf)
24'	14'	Neat cement	12.5
14'	0'	Bentonite slurry	8.4

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	Depth (m/ft) To
6 1/4"	Steel	.188"	+2'	24'
6"	Open Hole		24'	120'

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) 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	Hole Diameter Depth From	Depth To	Diameter (cm/in)
68	☐	☐ Fresh ☒ Untested ☐ Other, specify ____	0'	24'	9 3/4"
78	☐	☐ Fresh ☒ Untested ☐ Other, specify ____	24'	120'	6"
114	☐	☐ Fresh ☒ Untested ☐ Other, specify ____			

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify Not tested

If pumping discontinued, give reason: X

Pump intake set at (m/ft): 100

Pumping rate (l/min / GPM): 20

Duration of pumping: 1 hrs + 0 min

Final water level end of pumping (m/ft): 11.2'

If flowing give rate (l/min / GPM): X

Recommended pump depth (m/ft): 100'

Recommended pump rate (l/min / GPM): 20

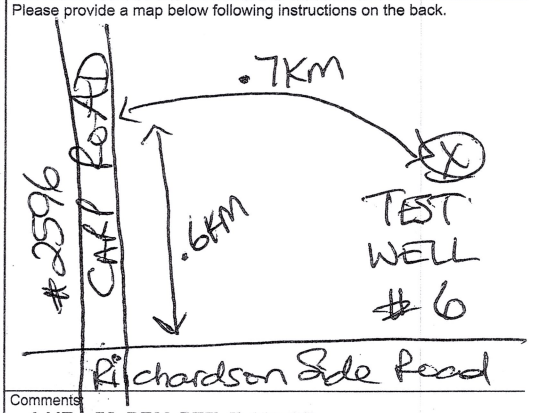
Well production (l/min / GPM): 20+

Disinfected? ☒ Yes ☐ No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level		10'.7"		11.2'
1	11.2		1	10.7
2	11.2		2	10.7
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: 1 HP - 20 GPM SET @ 100 FT

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Air Rock Drilling Co. Ltd.	1119

Business Address (Street Number/Name)	Municipality
6059 Frankford Road, RR#1	Richmond

Province	Postal Code	Business E-mail Address
ON	K0A 2Z0	air-rock@sympatico.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
6138382170	Hanna, [redacted] Jeremy

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted (Y Y Y Y M M D D)
T3632		2018 06 29

Well owner's information package delivered	Date Package Delivered (Y Y Y Y M M D D)	Ministry Use Only
☒ Yes ☐ No	2018 06 27	Audit No. Z276961
	Date Work Completed: 2018 06 26	Received

0506E (2014/11) Ministry's Copy

APPENDIX E

Water Quality Results

TABLE E-1A
GROUNDWATER QUALITY DATA
LABORATORY RESULTS

PARAMETER	ODWQS	TREATABILITY LIMIT [a]	TW5		TW6		House Well				MW15-1	MW15-2	MW15-4
			22-Aug-18	24-Aug-18	27-Aug-18	30-Aug-18	5-Sep-18	5-Sep-18	11-Sep-18	13-Sep-18	19-Jul-17	19-Jul-17	19-Jul-17
			2.8 hr	45.5 hr	1.3 hr	66.6 hr	2.2 hr	4.7 hr	--	--	--		--
Alkalinity (as $CaCO_3$)	30-500 (OG)	--	300	306	314	281	378	280	--	--	--	--	--
Ammonia (as N)	--	--	0.07	0.12	0.05	0.06	0.03	0.04	--	--	--	--	--
Calcium	--	--	124	140	142	149	114	115	--	--	--	--	--
Chloride	250 (AO)	250	210	218	**262**	246	120	118	--	--	--	--	--
Chlorine Residual	--	--	0.04	0.00	0.03	0.00	0.01*	0.01*	--	<0.04	--	--	--
Colour (TCU)	5 (AO)	7	3	2	<2	3	7	6	--	--	--	--	--
Conductivity (field) (uS/cm)	--	--	1452	1451	1680	1500	1015	965	--	--	--	--	--
Conductivity (lab) (uS/cm)	--	--	1440	1440	1630	1530	956	956	--	--	--	--	--
Dissolved Organic Carbon	5 (AO)	10	1.3	1.7	2.0	3.1	2.5	2.5	--	--	--	--	--
Fluoride	1.5 [b] (MAC)	--	0.20	0.20	0.14	0.23	0.12	0.12	--	--	--	--	--
Hardness (as $CaCO_3$)	80-100 [c] (OG)	--	413	444	458	479	363	365	--	--	--	--	--
Iron	0.30 (AO)	10	0.18	0.05	0.03	<0.03	0.10	0.07	--	--	--	--	--
Magnesium	--	--	25	23	25	26	19	19	--	--	--	--	--
Manganese	0.05 (AO)	1	0.02	0.01	<0.01	<0.01	<0.01	<0.01	--	--	--	--	--
Nitrate (as N)	10 [d] (MAC)	--	1.18	1.27	1.90	1.41	0.19	0.19	--	--	2.03	4.77	0.51
Nitrite (as N)	1 [d] (MAC)	--	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	--	--	--	--	--
pH (field)	6.5-8.5 (OG)	--	7.33	7.55	7.63	7.86	7.90	7.87	--	--	--	--	--
pH (lab)	6.5-8.5 (OG)	--	8.01	8.19	7.72	7.82	7.97	7.99	--	--	--	--	--
Phenols	--	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	--	--	--	--	--
Potassium	--	--	4	3	4	4	2	2	--	--	--	--	--
Sodium	200 [e] (AO)	200	114	111	160	142	67	68	--	--	--	--	--
Sulphate	500 [f] (AO)	500	87	114	149	130	45	44	--	--	--	--	--
Sulphide (lab)	0.05 (AO)	2.5	0.07	0.06	<0.01	<0.01	<0.01	<0.01	--	--	--	--	--
Tannin and Lignin	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	--	--	--	--
Temperature (field)	15 (AO)	--	11.7	13.1	18.1	11.1	17.7	16.7	--	--	--	--	--
Total Dissolved Solids	500 (AO)	--	936	936	1060	994	621	621	--	--	--	--	--
Total Kjeldahl Nitrogen	--	--	0.3	0.4	0.3	0.3	0.1	0.1	--	--	--	--	--
Turbidity - field (NTU)	5 [g] (AO)	5	3.30	0.65	0.75	0.50	1.80	1.95	--	--	--	--	--
Turbidity - lab (NTU)	5 [g] (AO)	5	2.6	2.8	0.9	0.2	1.6	0.4	--	--	--	--	--
Total Coliforms (ct/100ml)	not detected [h] (MAC)	--	--	51	--	5	4	10	1	0	--	--	--
Escherichia coli (ct/100ml)	not detected (MAC)	--	--	0	--	0	0	1	0	0	--	--	--
Fecal Coliforms (ct/100ml)	--	--	--	0	--	1	0	0	1	0	--	--	--
Heterotrophic Plate Count (ct/ml)	--	--	--	34	--	43	89	176	>500	18	--	--	--

Notes:
* = measurement considered erroneous
Criteria from "Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines",
Ministry of the Environment, June 2003, Revised June 2006
OG = operational guideline
AO = aesthetic objective
MAC = maximum acceptable concentration
Values are reported in mg/L unless otherwise noted
nd = below detection limit
-- = not measured or no value derived

	Exceeds ODWQS (MAC or AO)
Bold	Exceeds Treatability Limit (MOE Guideline D-5-5)

a - Treatability Limit from MOE Guideline D-5-5
b - Where fluoride is added to drinking water, it is recommended that the concentration be adjusted to 0.5 – 0.8 mg/L, the optimum level for control of tooth decay. Where supplies contain naturally occurring fluoride at levels higher than 1.5 mg/L but less than 2.4 mg/L, the Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposure to fluoride from other sources.
c - Hardness in excess of 500 mg/L in drinking water is unacceptable for most domestic purposes.
d – Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
e -The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.
f - When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.
g - Applicable for all waters at the point of consumption.
h - For private water wells Total Coliform counts of less than 6 per 100 ml of sample are considered indicative of acceptable water quality (Table 1 of MOE Guideline D-5-5).

GROUNDWATER QUALITY DATA
LABORATORY RESULTS

PARAMETER	ODWQS	House Well
		05-Sep-18
		4.7 hr
F1 (C6-C10)	--	<20
F1-BTEX (C6-C10)	--	<20
F2 (C10-C16)	--	<20
F3 (C16-C34)	--	<50
F4 (C34-C50)	--	<50
Benzene	1 (MAC)	<0.5
Toluene	60 (MAC)	<0.5
Ethylbenzene	140 (MAC)	<0.5
m/p-Xylene	--	<0.4
o-Xylene	--	<0.4
Xylene, total	90 (MAC)	<0.5
1+2-Methylnaphthalene	--	<0.1
1-Methylnaphthalene	--	<0.1
2-Methylnaphthalene	--	<0.1
Acenaphthene	--	<0.1
Acenaphthylene	--	<0.1
Anthracene	--	<0.1
Benzo(a)anthracene	--	<0.1
Benzo(a)pyrene	0.01 (MAC)	<0.01
Benzo(g,h,i)perylene	--	<0.1
Benzo(k)fluoranthene	--	<0.05
Benzo(b)fluoranthene	--	<0.05
Chrysene	--	<0.05
Dibenzo(a,h)anthracene	--	<0.1
Fluoranthene	--	<0.1
Fluorene	--	<0.1
Indeno(1,2,3-c,d)pyrene	--	<0.1
Naphthalene	--	<0.1
Phenanthrene	--	<0.1
Pyrene	--	<0.1

Notes:
* = value in parentheses is from duplicate sample
Criteria from "Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines", Ministry of the Environment, June 2003, Revised June 2006
OG = operational guideline
AO = aesthetic objective
MAC = maximum acceptable concentration
Values are reported in ug/L unless otherwise noted
nd = below detection limit
-- = not measured or no value derived

	Exceeds ODWQS (MAC or AO)
Bold	Exceeds Treatability Limit (MOE Guideline D-5-5)

a - Treatability Limit from MOE Guideline D-5-5
b - Where fluoride is added to drinking water, it is recommended that the concentration be adjusted to 0.5 – 0.8 mg/L, the optimum level for control of tooth decay. Where supplies contain naturally occurring fluoride at levels higher than 1.5 mg/L but less than 2.4 mg/L, the Ministry of Health and Long Term Care recommends an approach through local boards of health to raise public and professional awareness to control excessive exposure to fluoride from other sources.
c - Hardness in excess of 500 mg/L in drinking water is unacceptable for most domestic purposes.
d – Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
e -The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.
f - When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.
g - Applicable for all waters at the point of consumption.
h - For private water wells Total Coliform counts of less than 6 per 100 ml of sample are considered indicative of acceptable water quality (Table 1 of MOE Guideline D-5-5).

TABLE E-2A
GROUNDWATER QUALITY DATA
FIELD-MEASURED RESULTS

Test Well	Date	Time (hr)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Chlorine Residual (mg/L)	Sample
TW5	22-Aug-18	2.8	7.33	11.7	1452	3.30	0.04	SA#1
TW5	22-Aug-18	22.4	7.59	11.8	1430	0.85	0.04	
TW5	22-Aug-18	45.5	7.55	13.1	1451	0.65	0.00	SA#2

Test Well	Date	Time (hr)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Total Chlorine (mg/L)	Sample
TW6	27-Aug-18	1.3	7.63	18.1	1680	0.75	0.03	SA#3
TW6	28-Aug-18	20.6	7.65	16.0	1550	0.68	0.05	
TW6	29-Aug-18	47.1	7.75	14.6	1525	0.62	0.00	
TW6	30-Aug-18	66.6	7.86	11.1	1520	0.50	0.00	SA#4

Test Well	Date	Time (min)	pH	Temp (°C)	Cond (µs/cm)	Turb (ntu)	Total Chlorine (mg/L)	Sample
House	05-Sep-18	2.2	7.90	17.7	1015	1.80	0.01[(1)]	SA#5
House	05-Sep-18	4.7	1.87	16.7	965	1.95	0.01[(1)]	SA#6

Notes:
1 Reading considered erroneous as there was no chlorination before pumping.

LANGELIER SATURATION INDEX CALCULATIONS

Sample	pH	TDS (mg/L)	Temp (deg C)	Ca (mg/L)	Ca as CaCO3 (mg/L)	Alkalinity as CaCO3 (mg/L)	A	B	C	D	pHs	Langelier Saturation Index (pH-pHs)	Comment
TW5 2.8 hr	7.33	936	11.7	124	310	300	0.197128	2.348436	2.091362	2.477121	7.277081	0.1	Acceptable Range
TW5 45.5 hr	7.55	936	13.1	140	350	306	0.197128	2.320486	2.144068	2.485721	7.187824	0.4	Acceptable Range
TW6 1.3 hr	7.63	1060	18.1	142	355	314	0.202531	2.221766	2.150228	2.49693	7.077139	0.6	Outside Acceptable Range
TW6 66.6 hr	7.86	994	11.1	149	372.5	281	0.199739	2.360457	2.171126	2.448706	7.240363	0.6	Outside Acceptable Range
House Well 2.2 hr	7.90	621	17.7	114	285	378	0.179309	2.229601	2.054845	2.577492	7.076574	0.8	Outside Acceptable Range
House Well 4.7 hr	7.87	621	16.7	115	287.5	280	0.179309	2.249236	2.058638	2.447158	7.222749	0.6	Outside Acceptable Range

An acceptable range is -0.5 to +0.5

Notes:

$LSI = pH - pH_s$

$pH_s = (9.3 + A + B) - (C + D)$

$A = (Log_{10}[TDS] - 1) / 10$

$B = -13.12 \times Log_{10}(^{o}C + 273) + 34.55$

$C = Log_{10}[Ca^{2+} \text{ as } CaCO_3] - 0.4$

$D = Log_{10}[\text{alkalinity as } CaCO_3]$

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815371
Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Rebecca Koshy 2018.08.30 18:45:57 -04'00'

Rebecca Koshy, Project Manager

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Eurofins(Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

eurofins | Environment Testing

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				Lab I.D.	1383513
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-27
				Sample I.D.	SA#3
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	262*
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.90
	SO4	1	mg/L	AO 500	149
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	314
	Colour	2	TCU	AO 5	<2
	Conductivity	5	uS/cm		1630
	F	0.10	mg/L	MAC 1.5	0.14
	pH	1.00		6.5-8.5	7.72
	S2-	0.01	mg/L	AO 0.05	<0.01
	TDS (COND - CALC)	1	mg/L	AO 500	1060*
	Turbidity	0.1	NTU	AO 5.0	0.9
Hardness	Hardness as CaCO3	1	mg/L	OG 100	458*
Indices/Calc	Ion Balance	0.01			0.96
Metals	Ca	1	mg/L		142
	Fe	0.03	mg/L	AO 0.3	0.03
	K	1	mg/L		4
	Mg	1	mg/L		25
	Mn	0.01	mg/L	AO 0.05	<0.01
	Na	2	mg/L	AO 200	160
Subcontract	DOC	0.5	mg/L	AO 5	2.0
	N-NH3	0.01	mg/L		0.05
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.3

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

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COC #: 199022

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 342797 **Analysis/Extraction Date** 2018-08-30 **Analyst** H D **Method** C SM2120C			
Colour	<2 TCU	99	90-110
Run No 351667 **Analysis/Extraction Date** 2018-08-28 **Analyst** AET **Method** EPA 200.8			
Iron	<0.03 mg/L	92	91-109
Manganese	<0.01 mg/L	97	92.9-107
Run No 351752 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	100	90-110
SO4	<1 mg/L	105	90-110
Run No 351793 **Analysis/Extraction Date** 2018-08-30 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	100	80-120
N-NO3	<0.10 mg/L	97	80-120
Run No 351794 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	108	87-113

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
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MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

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COC #: 199022

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Magnesium	<1 mg/L	97	76-124
Sodium	<2 mg/L	96	82-118
Run No 351800 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	113	
Run No 351819 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	96	90-110
Conductivity	<5 uS/cm	100	90-110
F	<0.10 mg/L	106	90-110
pH		100	90-110
Run No 351820 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			
Run No 351838 **Analysis/Extraction Date** 2018-08-30 **Analyst** R K **Method** SUBCONTRACT P			
DOC	<0.5 mg/L	78	

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815371
Date Submitted: 2018-08-27
Date Reported: 2018-08-30
Project: 1543767-5000
COC #: 199022

QC Summary

Analyte	Blank	QC % Rec	QC Limits
N-NH3	<0.01 mg/L	100	
Phenols	<0.001 mg/L	92	
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	97	
Run No 351840 **Analysis/Extraction Date** 2018-08-30 **Analyst** R K **Method** C SM2130B			
Turbidity	0.1 NTU		70-130

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Addrine Thomas 2018.09.01 10:46:25 -04'00'

APPROVAL: _____

Addrine Thomas, Inorganics Supervisor

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

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Certificate of Analysis

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Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

				Lab I.D.	1382734
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-22
				Sample I.D.	SA #1
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	210
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.18
	SO4	1	mg/L	AO 500	87
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	300
	Colour	2	TCU	AO 5	3
	Conductivity	5	uS/cm		1440
	F	0.10	mg/L	MAC 1.5	0.20
	pH	1.00		6.5-8.5	8.01
	S2-	0.01	mg/L	AO 0.05	0.07*
	TDS (COND - CALC)	1	mg/L	AO 500	936*
	Turbidity	0.1	NTU	AO 5.0	2.6
Hardness	Hardness as CaCO3	1	mg/L	OG 100	413*
Indices/Calc	Ion Balance	0.01			0.96
Metals	Ca	1	mg/L		124
	Fe	0.03	mg/L	AO 0.3	0.18
	K	1	mg/L		4
	Mg	1	mg/L		25
	Mn	0.01	mg/L	AO 0.05	0.02
	Na	2	mg/L	AO 200	114
Subcontract-Inorg	DOC	0.5	mg/L	AO 5	1.3
	N-NH3	0.01	mg/L		0.07
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.3

Guideline = ODWSOG *** = Guideline Exceedence**

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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 351242 **Analysis/Extraction Date** 2018-08-31 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	100	90-110
Run No 351471 **Analysis/Extraction Date** 2018-08-24 **Analyst** YH **Method** C SM2130B			
Turbidity	<0.1 NTU	103	70-130
Run No 351479 **Analysis/Extraction Date** 2018-08-24 **Analyst** SKH **Method** EPA 200.8			
Iron	<0.03 mg/L	93	91-109
Manganese	<0.01 mg/L	102	92.9-107
Run No 351517 **Analysis/Extraction Date** 2018-08-27 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	123	
Run No 351634 **Analysis/Extraction Date** 2018-08-27 **Analyst** AET **Method** SUBCONTRACT P-INORG			
DOC	<0.5 mg/L	89	
N-NH3	<0.01 mg/L	100	
Phenols	<0.001 mg/L	88	69-132
Tannin & Lignin	<0.1 mg/L	80	

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Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Total Kjeldahl Nitrogen	<0.1 mg/L	101	81-126
Run No 351673 **Analysis/Extraction Date** 2018-08-28 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	96	90-110
Conductivity	<5 uS/cm	100	90-110
F	<0.10 mg/L	110	90-110
pH		102	90-110
Run No 351723 **Analysis/Extraction Date** 2018-08-29 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	93	80-120
N-NO3	<0.10 mg/L	88	80-120
Run No 351794 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	108	87-113
Magnesium	<1 mg/L	97	76-124
Sodium	<2 mg/L	96	82-118
Run No 351871 **Analysis/Extraction Date** 2018-08-31 **Analyst** H F **Method** SM 4110			

Guideline = ODWSOG *** = Guideline Exceedence**

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PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815147
Date Submitted: 2018-08-23
Date Reported: 2018-09-01
Project: 1543767
COC #: 198679

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Chloride	<1 mg/L	100	90-110
SO4	<1 mg/L	105	90-110
Run No 351975 **Analysis/Extraction Date** 2018-09-01 **Analyst** AET **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Addrine Thomas 2018.09.04 15:25:58 -04'00'

Addrine Thomas, Inorganics Supervisor

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

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Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

				Lab I.D.	1383039
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-24
				Sample I.D.	SA#2
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	218
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.27
	SO4	1	mg/L	AO 500	114
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	306
	Colour	2	TCU	AO 5	2
	Conductivity	5	uS/cm		1440
	F	0.10	mg/L	MAC 1.5	0.20
	pH	1.00		6.5-8.5	8.19
	S2-	0.01	mg/L	AO 0.05	0.06*
	TDS (COND - CALC)	1	mg/L	AO 500	936*
	Turbidity	0.1	NTU	AO 5.0	2.8
Hardness	Hardness as CaCO3	1	mg/L	OG 100	444*
Indices/Calc	Ion Balance	0.01			0.94
Metals	Ca	1	mg/L		140
	Fe	0.03	mg/L	AO 0.3	0.05
	K	1	mg/L		3
	Mg	1	mg/L		23
	Mn	0.01	mg/L	AO 0.05	0.01
	Na	2	mg/L	AO 200	111
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		0
	Faecal Streptococcus	0	ct/100mL		0
	Heterotrophic Plate Count	0	ct/1mL		34
	Total Coliforms	0	ct/100mL	MAC 0	51*

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Certificate of Analysis

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Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

				Lab I.D.	1383039
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-24
				Sample I.D.	SA#2
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Subcontract	DOC	0.5	mg/L	AO 5	1.7
	N-NH3	0.01	mg/L		0.12
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.4

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

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1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 351242 **Analysis/Extraction Date** 2018-08-31 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	100	90-110
Run No 351495 **Analysis/Extraction Date** 2018-08-26 **Analyst** DRA **Method** AMBCOLM1			
Escherichia Coli			
Faecal Coliforms			
Faecal Streptococcus			
Heterotrophic Plate Count			
Total Coliforms			
Run No 351517 **Analysis/Extraction Date** 2018-08-27 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	123	
Run No 351521 **Analysis/Extraction Date** 2018-08-27 **Analyst** YH **Method** C SM2130B			
Turbidity	<0.1 NTU	103	70-130
Run No 351667 **Analysis/Extraction Date** 2018-08-28 **Analyst** AET **Method** EPA 200.8			
Iron	<0.03 mg/L	92	91-109

Guideline = ODWSOG *** = Guideline Exceedence**

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Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Manganese	<0.01 mg/L	97	92.9-107
Run No 351673 **Analysis/Extraction Date** 2018-08-29 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	96	90-110
Conductivity	<5 uS/cm	100	90-110
F	<0.10 mg/L	110	90-110
pH		102	90-110
Run No 351794 **Analysis/Extraction Date** 2018-08-30 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	99	90-110
Potassium	<1 mg/L	108	87-113
Magnesium	<1 mg/L	97	76-124
Sodium	<2 mg/L	96	82-118
Run No 351799 **Analysis/Extraction Date** 2018-08-30 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	100	80-120
N-NO3	<0.10 mg/L	102	80-120
Run No 351841 **Analysis/Extraction Date** 2018-08-28 **Analyst** R K **Method** SUBCONTRACT P			

Guideline = ODWSOG *** = Guideline Exceedence**

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K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815262
Date Submitted: 2018-08-24
Date Reported: 2018-09-04
Project: 1543767-5000
COC #: 198680

QC Summary

Analyte	Blank	QC % Rec	QC Limits
DOC	<0.5 mg/L	90	
N-NH3	<0.01 mg/L	100	
Phenols	<0.001 mg/L	92	
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	101	
Run No 351979 **Analysis/Extraction Date** 2018-08-31 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	102	90-110
SO4	<1 mg/L	107	90-110
Run No 352013 **Analysis/Extraction Date** 2018-09-04 **Analyst** AET **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Rebecca Koshy
2018.09.05
06:12:07 -04'00'

APPROVAL: _____

Rebecca Koshy, Project Manager

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Certificate of Analysis

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Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

				Lab I.D.	1384434
				Sample Matrix	Water
				Sample Type	
				Sampling Date	2018-08-30
				Sample I.D.	SA#4
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	1	mg/L	AO 250	246
	N-NO2	0.10	mg/L	MAC 1.0	<0.10
	N-NO3	0.10	mg/L	MAC 10.0	1.41
	SO4	1	mg/L	AO 500	130
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500	281
	Colour	2	TCU	AO 5	3
	Conductivity	5	uS/cm		1530
	F	0.10	mg/L	MAC 1.5	0.23
	pH	1.00		6.5-8.5	7.82
	S2-	0.01	mg/L	AO 0.05	<0.01
	TDS (COND - CALC)	1	mg/L	AO 500	994*
	Turbidity	0.1	NTU	AO 5.0	0.2
Hardness	Hardness as CaCO3	1	mg/L	OG 100	479*
Indices/Calc	Ion Balance	0.01			1.03
Metals	Ca	1	mg/L		149
	Fe	0.03	mg/L	AO 0.3	<0.03
	K	1	mg/L		4
	Mg	1	mg/L		26
	Mn	0.01	mg/L	AO 0.05	<0.01
	Na	2	mg/L	AO 200	142
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		1
	Heterotrophic Plate Count	0	ct/1mL		43
	Total Coliforms	0	ct/100mL	MAC 0	5*
Subcontract	DOC	0.5	mg/L	AO 5	3.1

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

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Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
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Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. 1384434 Water 2018-08-30 SA#4
Subcontract	N-NH3	0.01	mg/L		0.06
	Phenols	0.001	mg/L		<0.001
	Tannin & Lignin	0.1	mg/L		<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.3

Guideline = ODWSOG *** = Guideline Exceedence**

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K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1815697
Date Submitted: 2018-08-30
Date Reported: 2018-09-05
Project: 1543767-5000
COC #: 199029

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 351242 **Analysis/Extraction Date** 2018-08-31 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	100	90-110
Run No 351795 **Analysis/Extraction Date** 2018-08-31 **Analyst** L V **Method** AMBCOLM1			
Escherichia Coli			
Faecal Coliforms			
Heterotrophic Plate Count			
Total Coliforms			
Run No 351800 **Analysis/Extraction Date** 2018-08-30 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	113	
Run No 351840 **Analysis/Extraction Date** 2018-08-30 **Analyst** R K **Method** C SM2130B			
Turbidity	0.1 NTU		70-130
Run No 351871 **Analysis/Extraction Date** 2018-08-31 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	100	90-110
N-NO2	<0.10 mg/L	108	90-110

Guideline = ODWSOG *** = Guideline Exceedence**

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
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PO#:
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Report Number: 1815697
Date Submitted: 2018-08-30
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COC #: 199029

QC Summary

Analyte	Blank	QC % Rec	QC Limits
SO4	<1 mg/L	105	90-110
Run No 351898 **Analysis/Extraction Date** 2018-08-31 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO3	<0.10 mg/L	97	80-120
Run No 351901 **Analysis/Extraction Date** 2018-08-31 **Analyst** AET **Method** EPA 200.8			
Iron	<0.03 mg/L	94	91-109
Manganese	<0.01 mg/L	99	92.9-107
Run No 351940 **Analysis/Extraction Date** 2018-08-31 **Analyst** AET **Method** SM2320,2510,4500H/F			
Alkalinity (CaCO3)	<5 mg/L	99	90-110
Conductivity	<5 uS/cm	101	90-110
F	<0.10 mg/L	108	90-110
pH		100	90-110
Run No 352001 **Analysis/Extraction Date** 2018-09-04 **Analyst** H F **Method** M SM3120B-3500C			
Calcium	<1 mg/L	100	90-110
Potassium	<1 mg/L	107	87-113
Magnesium	<1 mg/L	97	76-124

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QC Summary

Analyte	Blank	QC % Rec	QC Limits
Sodium	<2 mg/L	108	82-118
Run No 352034 **Analysis/Extraction Date** 2018-09-04 **Analyst** R K **Method** SUBCONTRACT P			
DOC	<0.5 mg/L	110	
N-NH3	<0.01 mg/L	111	
Phenols	<0.001 mg/L	80	
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	102	
Run No 352035 **Analysis/Extraction Date** 2018-09-05 **Analyst** R K **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Rebecca Koshy
2018.09.10
19:08:03 -04'00'

APPROVAL: _____

Rebecca Koshy, Project Manager

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

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Certificate of Analysis

eurofins | Environment Testing

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
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K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1385665 GW 2018-09-05 SA#5	1385666 GW 2018-09-05 SA#6
Anions	Cl	1	mg/L	AO 250		120	118
	F	0.10	mg/L	MAC 1.5		0.12	0.12
	N-NO2	0.10	mg/L	MAC 1.0		<0.10	<0.10
	N-NO3	0.10	mg/L	MAC 10.0		0.19	0.19
	SO4	1	mg/L	AO 500		45	44
General Chemistry	Alkalinity as CaCO3	5	mg/L	OG 500		378	280
	Colour	2	TCU	AO 5		7*	6*
	Conductivity	5	uS/cm			956	956
	pH	1.00		6.5-8.5		7.97	7.99
	S2-	0.01	mg/L	AO 0.05		<0.01	<0.01
	TDS (COND - CALC)	1	mg/L	AO 500		621*	621*
	Turbidity	0.1	NTU	AO 5.0		1.6	0.4
Hardness	Hardness as CaCO3	1	mg/L	OG 100		363*	365*
Hydrocarbons	F1 (C6-C10)	20	ug/L				<20
	F1-BTEX (C6-C10)	20	ug/L				<20
	F2 (C10-C16)	20	ug/L				<20
	F3 (C16-C34)	50	ug/L				<50
	F4 (C34-C50)	50	ug/L				<50
Indices/Calc	Ion Balance	0.01				0.86	1.05
Metals	Ca	1	mg/L			114	115
	Fe	0.03	mg/L	AO 0.3		0.10	0.07
	K	1	mg/L			2	2
	Mg	1	mg/L			19	19
	Mn	0.01	mg/L	AO 0.05		<0.01	<0.01
	Na	2	mg/L	AO 200		67	68

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Report Number: 1816061
Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

Group	Analyte	MRL	Units	Guideline	1385665 GW 2018-09-05 SA#5	1385666 GW 2018-09-05 SA#6
	Lab I.D.				1385665	1385666
	Sample Matrix				GW	GW
	Sample Type					
	Sampling Date				2018-09-05	2018-09-05
	Sample I.D.				SA#5	SA#6
Microbiology	Escherichia Coli	0	ct/100mL	MAC 0	0	1*
	Faecal Coliforms	0	ct/100mL		0	0
	Heterotrophic Plate Count	0	ct/1mL		89	176
	Total Coliforms	0	ct/100mL	MAC 0	4*	10*
PAH	1+2-methylnaphthalene	0.1	ug/L			<0.1
	1-methylnaphthalene	0.1	ug/L			<0.1
	2-methylnaphthalene	0.1	ug/L			<0.1
	Acenaphthene	0.1	ug/L			<0.1
	Acenaphthylene	0.1	ug/L			<0.1
	Anthracene	0.1	ug/L			<0.1
	Benzo(a)anthracene	0.1	ug/L			<0.1
	Benzo(a)pyrene	0.01	ug/L	MAC 0.01		<0.01
	Benzo(b)fluoranthene	0.05	ug/L			<0.05
	Benzo(g,h,i)perylene	0.1	ug/L			<0.1
	Benzo(k)fluoranthene	0.05	ug/L			<0.05
	Chrysene	0.05	ug/L			<0.05
	Dibenzo(a,h)anthracene	0.1	ug/L			<0.1
	Fluoranthene	0.1	ug/L			<0.1
	Fluorene	0.1	ug/L			<0.1
	Indeno(1,2,3-c,d)pyrene	0.1	ug/L			<0.1
	Naphthalene	0.1	ug/L			<0.1
	Phenanthrene	0.1	ug/L			<0.1
	Pyrene	0.1	ug/L			<0.1
PHC Surrogate	Alpha-androstrane	0	%			103
Subcontract-Inorg	DOC	0.5	mg/L	AO 5	2.5	2.5

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Certificate of Analysis

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Report Number: 1816061
Date Submitted: 2018-09-06
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Project: 1543767
COC #: 835480

Group	Analyte	MRL	Units	Guideline	1385665 GW 2018-09-05 SA#5	1385666 GW 2018-09-05 SA#6
	Lab I.D.				1385665	1385666
	Sample Matrix				GW	GW
	Sample Type					
	Sampling Date				2018-09-05	2018-09-05
	Sample I.D.				SA#5	SA#6
Subcontract-Inorg	N-NH3	0.01	mg/L		0.03	0.04
	Phenols	0.001	mg/L		<0.001	<0.001
	Tannin & Lignin	0.1	mg/L		<0.1	<0.1
	Total Kjeldahl Nitrogen	0.1	mg/L		0.1	0.1
VOCs Surrogates	Toluene-d8	0	%			94
Volatiles	Benzene	0.5	ug/L	MAC 1		<0.5
	Ethylbenzene	0.5	ug/L	MAC 140		<0.5
	m/p-xylene	0.4	ug/L			<0.4
	o-xylene	0.4	ug/L			<0.4
	Toluene	0.5	ug/L	MAC 60		<0.5
	Xylene; total	0.5	ug/L	MAC 90		<0.5

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Date Submitted: 2018-09-06
Date Reported: 2018-09-10
Project: 1543767
COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 208523 **Analysis/Extraction Date** 2018-09-10 **Analyst** C M **Method** P 8270			
1+2-methylnaphthalene			
Run No 352169 **Analysis/Extraction Date** 2018-09-07 **Analyst** DRA **Method** AMBCOLM1			
Escherichia Coli			
Faecal Coliforms			
Heterotrophic Plate Count			
Total Coliforms			
Run No 352177 **Analysis/Extraction Date** 2018-09-06 **Analyst** Z S **Method** C SM4500-NO3-F			
N-NO2	<0.10 mg/L	100	80-120
N-NO3	<0.10 mg/L	103	80-120
Run No 352188 **Analysis/Extraction Date** 2018-09-06 **Analyst** SKH **Method** EPA 200.8			
Manganese	<0.01 mg/L	100	92.9-107
Run No 352206 **Analysis/Extraction Date** 2018-09-07 **Analyst** H F **Method** SM 4110			
Chloride	<1 mg/L	100	90-110

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QC Summary

Analyte	Blank	QC % Rec	QC Limits
SO4	<1 mg/L	105	90-110
Run No 352239 **Analysis/Extraction Date** 2018-09-07 **Analyst** AET **Method** C SM4500-S2-D			
S2-	<0.01 mg/L	110	
Run No 352240 **Analysis/Extraction Date** 2018-09-07 **Analyst** C F **Method** C SM2130B			
Turbidity	<0.1 NTU	100	70-130
Run No 352250 **Analysis/Extraction Date** 2018-09-07 **Analyst** SKH **Method** EPA 200.8			
Iron	<0.03 mg/L	94	91-109
Run No 352289 **Analysis/Extraction Date** 2018-09-07 **Analyst** AET **Method** SM 2320B			
Alkalinity (CaCO3)	<5 mg/L	101	95-105
Conductivity	<5 uS/cm	99	95-105
F	<0.10 mg/L	106	90-110
pH	5.99	100	90-110
Run No 352312 **Analysis/Extraction Date** 2018-09-06 **Analyst** TJB **Method** V 8260B			
Benzene	<0.5 ug/L	91	60-130

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Date Submitted: 2018-09-06
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QC Summary

Analyte	Blank	QC % Rec	QC Limits
Ethylbenzene	<0.5 ug/L	85	60-130
Petroleum Hydrocarbons F1	<20 ug/L	93	60-140
Petroleum Hydrocarbons F1-BTEX			
m/p-xylene	<0.4 ug/L	89	60-130
o-xylene	<0.4 ug/L	88	60-130
Toluene	<0.5 ug/L	92	60-130
Run No 352313 **Analysis/Extraction Date** 2018-09-10 **Analyst** TJB **Method** V 8260B			
Xylene Mixture			
Run No 352318 **Analysis/Extraction Date** 2018-09-10 **Analyst** YH **Method** C SM2120C			
Colour	<2 TCU	105	90-110
Run No 352321 **Analysis/Extraction Date** 2018-09-07 **Analyst** C M **Method** P 8270			
Methlynaphthalene, 1-	<0.1 ug/L	66	50-140
Methlynaphthalene, 2-	<0.1 ug/L	54	50-140
Acenaphthene	<0.1 ug/L	62	50-140
Acenaphthylene	<0.1 ug/L	64	50-140
Anthracene	<0.1 ug/L	70	50-140

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QC Summary

Analyte	Blank	QC % Rec	QC Limits
Benz[a]anthracene	<0.1 ug/L	60	50-140
Benzo[a]pyrene	<0.01 ug/L	64	50-140
Benzo[b]fluoranthene	<0.05 ug/L	78	50-140
Benzo[ghi]perylene	<0.1 ug/L	62	50-140
Benzo[k]fluoranthene	<0.05 ug/L	78	50-140
Chrysene	<0.05 ug/L	71	50-140
Dibenz[a h]anthracene	<0.1 ug/L	64	50-140
Fluoranthene	<0.1 ug/L	64	50-140
Fluorene	<0.1 ug/L	62	50-140
Indeno[1 2 3-cd]pyrene	<0.1 ug/L	62	50-140
Naphthalene	<0.1 ug/L	58	50-140
Phenanthrene	<0.1 ug/L	54	50-140
Pyrene	<0.1 ug/L	64	50-140
Run No 352371 **Analysis/Extraction Date** 2018-09-10 **Analyst** RRK **Method** CCME O.Reg 153/04			
Petroleum Hydrocarbons F2	<20 ug/L	80	60-140
Petroleum Hydrocarbons F3	<50 ug/L	80	60-140
Petroleum Hydrocarbons F4	<50 ug/L	80	60-140

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COC #: 835480

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 352380 **Analysis/Extraction Date** 2018-09-10 **Analyst** SKH **Method** M SM3120B-3500C			
Calcium	<1 mg/L	107	90-110
Potassium	<1 mg/L	95	87-113
Magnesium	<1 mg/L	101	76-124
Sodium	<2 mg/L	91	82-118
Run No 352387 **Analysis/Extraction Date** 2018-09-07 **Analyst** SDC **Method** SUBCONTRACT P-INORG			
DOC	<0.5 mg/L	102	
N-NH3	<0.01 mg/L	99	
Phenols	<0.001 mg/L	84	69-132
Tannin & Lignin	<0.1 mg/L	80	
Total Kjeldahl Nitrogen	<0.1 mg/L	94	81-126
Run No 352388 **Analysis/Extraction Date** 2018-09-10 **Analyst** R K **Method** C SM2340B			
Hardness as CaCO3			
Ion Balance			
TDS (COND - CALC)			

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1931 Robertson Road
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K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1816448
Date Submitted: 2018-09-11
Date Reported: 2018-09-13
Project: 1543767
COC #: 199103

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: Krista Quantrill 2018.09.13 14:14:42 -04'00'

Krista Quantrill, Microbiology Supervisor

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

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Attention: Ms. Loren Bekeris
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Report Number: 1816448
Date Submitted: 2018-09-11
Date Reported: 2018-09-13
Project: 1543767
COC #: 199103

Group	Analyte	MRL	Units	Guideline	Lab I.D. 1386680 Sample Matrix Water Sample Type Sampling Date 2018-09-11 Sample I.D. 2596 Carp
Microbiology	Heterotrophic Plate Count	0	ct/1mL		>500
Others	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		1
	Total Coliforms	0	ct/100mL	MAC 0	1*

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Analytical Method: AMBCOLM1
additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1816624
Date Submitted: 2018-09-13
Date Reported: 2018-09-17
Project: 1543767
COC #: 199023

Dear Loren Bekeris:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: _____
Krista Quantrill, Microbiology Supervisor

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Eurofins (Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required.

eurofins | Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Loren Bekeris
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1816624
Date Submitted: 2018-09-13
Date Reported: 2018-09-17
Project: 1543767
COC #: 199023

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. 1387247 GW 2018-09-13 2596 Carp Road
General Chemistry	Chlorine (free)	0.04	mg/L		<0.04
	Chlorine (total)	0.04	mg/L		0.09
Microbiology	Heterotrophic Plate Count	0	ct/1mL		18
Others	Escherichia Coli	0	ct/100mL	MAC 0	0
	Faecal Coliforms	0	ct/100mL		0
	Total Coliforms	0	ct/100mL	MAC 0	0

Guideline = ODWSOG *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Analytical Method: AMBCOLM1
additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX F

Water Level Measurements and Rising Head Test Analyses

Well ID	Ground Surface Elevation	Top of Casing Elevation	Geologic Unit of Screened Interval	Depth of Screened Interval	Groundwater Levels						Hydraulic Conductivity (m/s)
					22-Dec-15		26-Apr-17		22-Aug-18		
	(masl)	(masl)		(mbgs)	Depth (mbtoc)	Elevation (masl)	Depth (mbtoc)	Elevation (masl)	Depth (mbtoc)	Elevation (masl)	
15-1	114.57	115.45	Silty Sand over Silty Sand and Gravel	5.8 – 7.4	2.32	113.13	1.10	114.35	-	-	$5x10^{-5}$
15-2	114.99	115.79	Glacial Till	4.6 – 6.1	Dry	Dry	6.06	109.73	-	-	-
15-4	110.31	111.24	Glacial Till	3.7 – 5.3	3.60	107.64	2.45	108.79	3.43	107.81	$4x10^{-7}$
15-5	109.50	110.33	Silty Clay over Glacial Till	4.6 – 6.1	2.55	107.78	1.71	108.62	2.693	107.64	$3x10^{-7}$
15-6	109.54	110.34	Layers of Silty Sand and Silty Clay	4.1 – 5.6	4.16	106.18	3.93	106.41	-	-	$2x10^{-4}$
Gemtec 18-7	112.68	113.63	Glacial Till	1.4 - 2.9	-	-	-	-	2.795	110.84	-
Gemtec 18-11	110.87	111.82	Glacial Till	1.4 - 2.9	-	-	-	-	2.57	109.25	-
MW18-1 (Shallow)	107.782	109.391	Sand	0.1 - 0.39	-	-	-	-	1.7	107.69	-
MW18-2 (Shallow)	107.093	108.665	Sand	0.1 - 0.59	-	-	-	-	1.605	107.06	-
MW18-3 (Shallow)	106.552	108.182	Sand	0.1 - 0.45	-	-	-	-	1.6	106.58	-
TW1	-	-	Limestone Bedrock	9.1 - 91.4	-	-	-	-	4.153	-	-
TW2	-	-	Limestone Bedrock	6.1 - 91.4	-	-	-	-	4.178	-	-
TW4	111.513	112.109	Limestone Bedrock	7.9 - 36.9	-	-	-	-	3.943	108.17	-
TW5	111.215	111.785	Limestone Bedrock	6.7 - 29.6	-	-	-	-	3.61	108.18	-
TW6	110.414	111.034	Limestone Bedrock	7.3 - 36.6	-	-	-	-	3.16	107.87	-
House Well	-	110	Unknown	Unknown	-	-	-	-	-	-	-

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 15-1

INTERVAL (metres below ground surface)

Top of Interval =	**5.84**
Bottom of Interval =	**7.37**

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

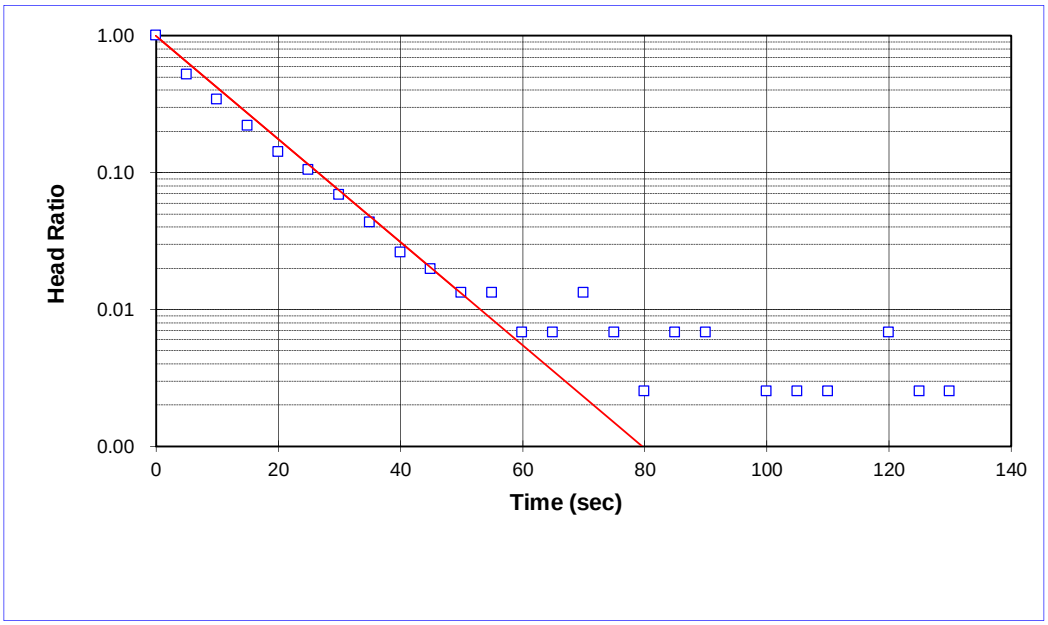
where:

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 =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**50**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.01**

RESULTS

K=	**5E-05**	**m/sec**
K=	**5E-03**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 15-1

INTERVAL (metres below ground surface)

Top of Interval =	**5.84**
Bottom of Interval =	**7.37**

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

where:

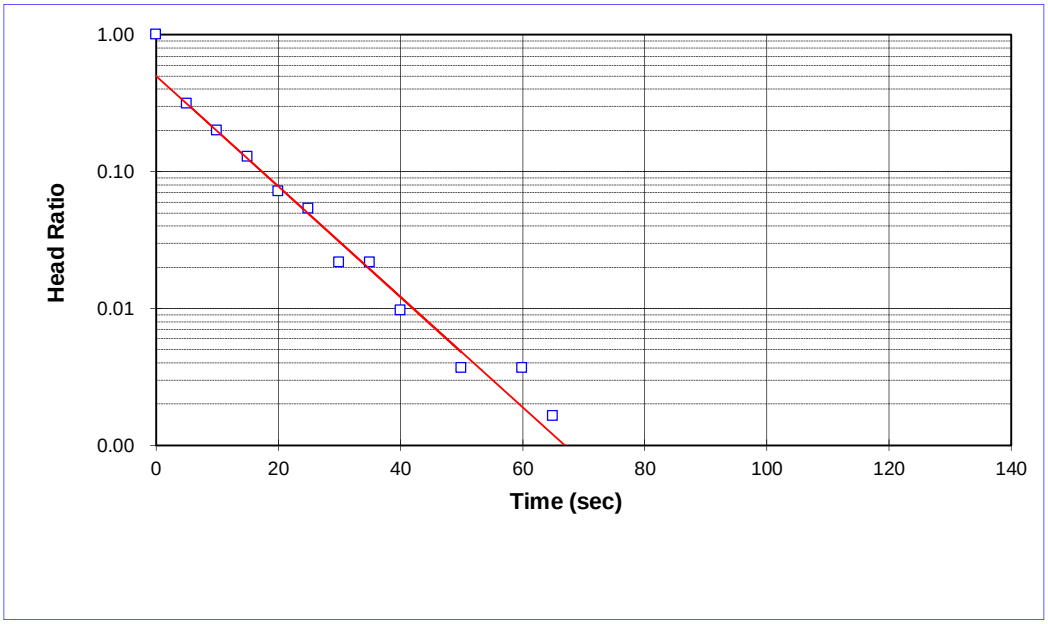
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**5**
t_2 =	**50**
h_1/h_0 =	**0.31**
h_2/h_0 =	**0.00**

RESULTS

K=	**5E-05**	**m/sec**
K=	**5E-03**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 15-4

INTERVAL (metres below ground surface)

Top of Interval =	**3.73**
Bottom of Interval =	**5.26**

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

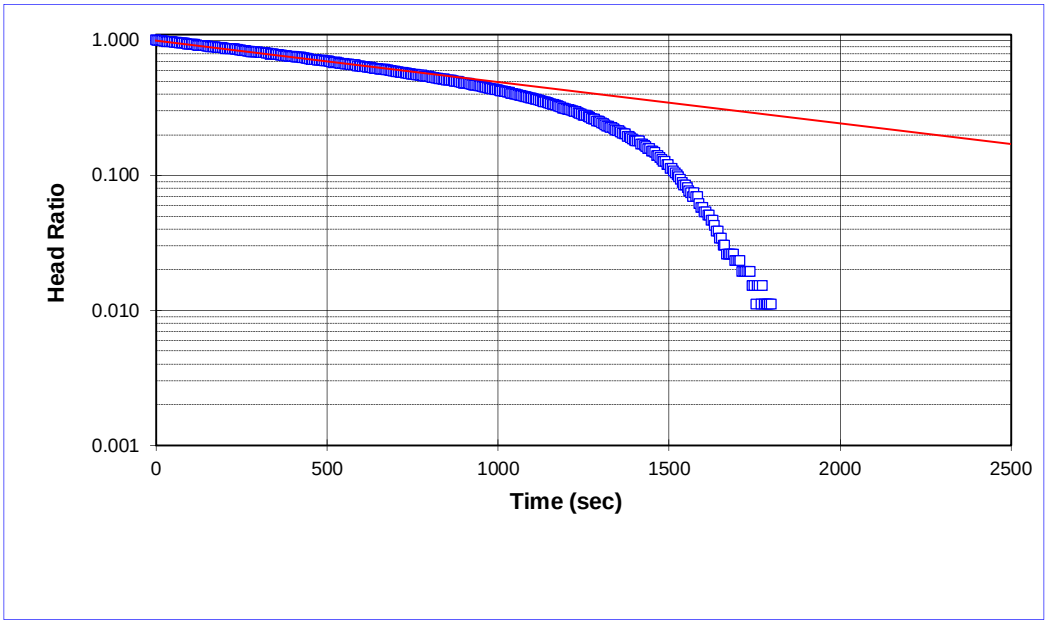
where:

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 =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**400**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.75**

RESULTS

K=	**4E-07**	**m/sec**
K=	**4E-05**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 15-5

INTERVAL (metres below ground surface)

Top of Interval =	**4.57**
Bottom of Interval =	**6.10**

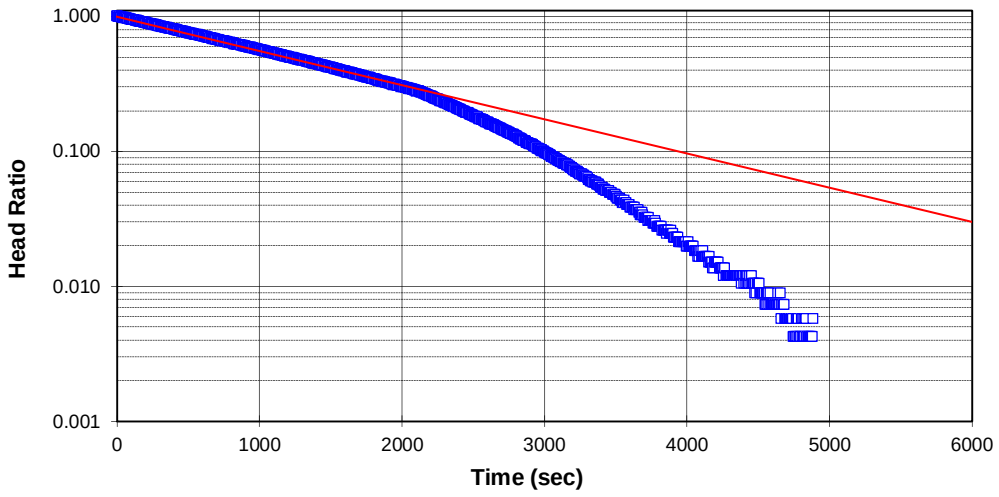
$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

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 =	**0.025**
R_e =	**0.102**
L_e =	**1.5**
t_1 =	**165**
t_2 =	**1475**
h_1/h_0 =	**0.91**
h_2/h_0 =	**0.42**

RESULTS

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



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/2015

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

Golder Associates Ltd.

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-6

INTERVAL (metres below ground surface)

Top of Interval =	**3.30**
Bottom of Interval =	**4.82**

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln\frac{y_0}{y_t}$$

where K=m/sec

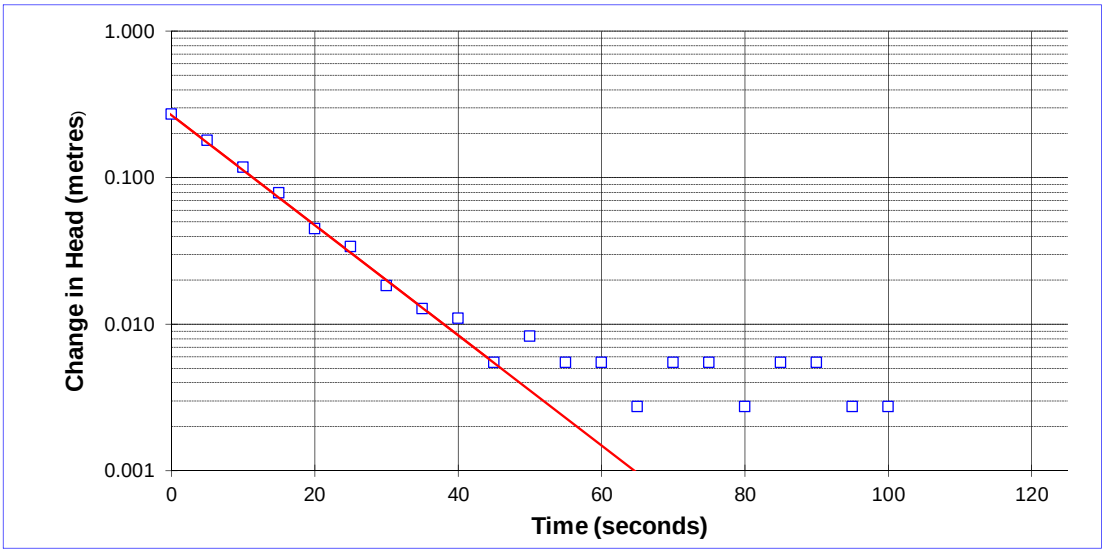
where:

r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS	
r_c =	**0.060**
r_w =	**0.102**
L_e =	**1.47**
$\ln(R_e/r_w)$	**1.97**
y_0 =	**0.27**
y_t =	**0.01**
t =	**45.0**

RESULTS

K=	**2E-04**	**m/sec**
K=	**2E-02**	**cm/sec**



Project Name: Cavanagh/Carp Road
Project No.: 1543767
Test Date: 12/22/15

Analysis By: CWT
Checked By: LEB
Analysis Date: 12/23/2015

APPENDIX G

Septic System Information

WEST CARLETON

SEPTIC SYSTEM SITE EVALUATION

- ☐ CLASS 2 LEACHING PIT
- ☐ CLASS 3 CESS POOL
- ☒ CLASS 4 SYSTEMS
- ☒ ABSORPTION TRENCH CONVENTIONAL
- ☐ ABSORPTION TRENCH RAISED
- ☐ FILTER BED (ATTACH GRADING CERTIFICATE)
- ☐ PROPRIETARY SYSTEM

DESCRIBE

- ☐ CLASS 5 HOLDING TANK

TYPE OF ALARM ☐ AUDIO ☐ VISUAL

PUMP OUT CONTRACT ☐ ATTACH DOCUMENTATION

NAME Ken White Const LTD
(Name of Individual Preparing Site Evaluation)

ADDRESS P.O. Box 296

CITY Carp Ont

POSTAL CODE K0A 1L0

PHONE O ( ) 839-5460 H ( )

LICENCE # L1998-1654

DESIGN PARAMETERS

☐ NUMBER OF BEDROOMS - EXIST _____ PROPOSED 3

☐ BUILDING AREA GROSS

TOTAL ALL FLOORS - LIVING AREA 339 M²

☐ WATER SUPPLY - DUG WELL ☐

- SAND POINT ☐

- CASED WELL (min 6M) ☒ Proposed

SEPTIC SYSTEM DESIGN

6000L TANK SIZE

_____ PROPRIETARY TREATMENT SYSTEM

DESCRIBE _____
(ATTACH MANUFACTURERS INFORMATION)

18.75 LENGTH DISTRIBUTION PIPING EACH RUN

8 NUMBER OF RUNS

150 TOTAL LENGTH OF DISTRIBUTION PIPING

3000L DAILY FLOW RATE

MINIMUM LOADING AREA

MINIMUM CONTACT AREA

TANK TYPE CONCRETE ☐ MANUFACTURER

PLASTIC ☐ Boucher Pre-Cast

OTHER ☐ MODEL

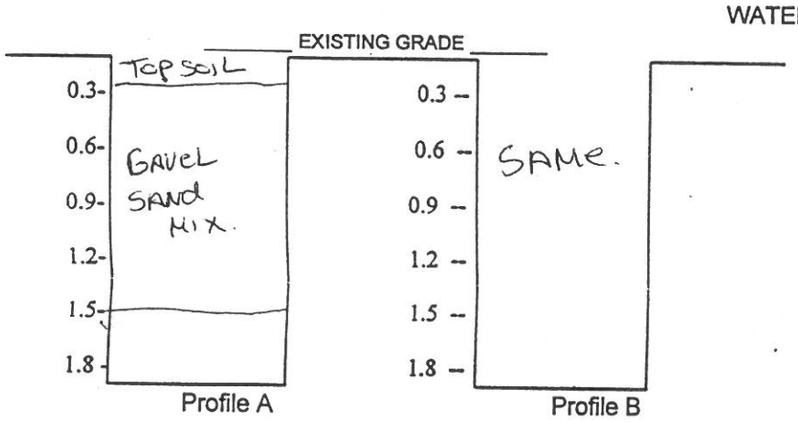
DESCRIBE _____

☐ PUMP REQUIRED MANUFACTURER
(ATTACH MANUFACTURER SPECS AND INSTALLATION INSTRUCTIONS)

PLUMBING FIXTURES	EXIST	PROPOSED		FIXTURE UN
Bathroom Group (3 PCs)		3	X 6	18
Bathtub/Shower		0	X 1.5	
Basin (Lavatory)		0	X 1.5	
Toilet		0	X 4	
Bidet		0	X 1.0	
Sink		1	X 1.5	1.5
Dishwasher		1	X 1.5	1.5
Laundry Tub		1	X 1.5	1.5
Auto Washer		1	X 1.5	1.5
Water Softener		0	X	
Other				
TOTALS		7		24

NOTICE: Depth to bedrock/watertable and description of soil type are to be shown for both profiles. TWO test locations are required of BURIED beds.

SOIL PROFILES



IDENTIFY SOIL TYPE, LAYERS AND DEPTHS, WATER TABLE AND ROCK

The percolation rate shall be determined by test **OR** soil classification, according to the unified soil classification syste

T Time .....

Native Soil .....10.....

Imported Soil .....10.....

TOWNSHIP OF WEST CARLETON

DESIGN REVIEW
CLASS 4 SEPTIC SYSTEM

Permit No. 99-0249 **Date** July 2/99
Plan review By T. USHER
Owner R. RUMP
Applicant copy _____ Office copy ✓

Calculate daily design flow Additional flows

1 bedroom 750 litre
2 bedroom 1100 litre
(3) bedroom 1600 litre
4 bedroom 2000 litre
5 bedroom 2500 litre
Daily design flow
< 10,000 litre/ day ✓ > 10,000 litre/ day _____

additional bedrooms 500 litre each
additional bldg area exceeding 200m2 100 litre / 10m2
additional fixture unite exceeding 20 50 litre each fixture unit

Number of bedrooms 3 1600 litres
Additional Flows Building Area 139 m2 1400 litres 339 m² > 200 m²
Additional Flows Fixture Units 4 FU 200 litres
24 > 20
1600 + 1400

✓2 Size treatment unit septic tank **Proposed** 6000
2 x daily design flow res ✓ 3x non-res ___

1 **Total daily design flow** 3000 litres

2 **Min Septic tank size** 6000 litres

3 **Type of leaching bed** (check one)
Absorption trench
Raised bed _ Partially raised bed _ (Buried Bed) _ Raised bed _ Partially raised bed _ Buried bed _

Filter media
Proprietary treatment units
Manufacturers installation Instructions or Ministry Guidelines, BMEC or Buildings Branch Opinion

✓4 Size distribution pipe
T time > 2 < 20 min / cm T time >20 < 50 min / cm
L = QT / 200 (T=10) L = QT / 300
Length of distribution pipe 150 m

Daily design flow
<5000 litre/ day _____ > 5000 litre/ day ___

Daily design flow
< 3000 litre > 3000 litre Secondary or tertiary treatment ___
Minimum 2 beds

5 Bed loading 6 litre / m2 **Bed loading Area** **Proposed** ____m2 500 m²
✓6 Bed size **No. of runs** 8
Length of runs 18.75 m

✓7 Distribution piping > 150 metres
requires dosing pump and chamber
Determine dosage volume 75% of distribution piping Volume dia. X length
PROPOSED 150m > 130m
Dosage Volume _____ litres

4 Size bed effective area
Maximum 75 litre/ m2/ day ___ Maximum 50 litre/ m2/ day ___
proposed _____m2 **Min bed area** _____m2
Bed size minimum 10 m2 maximum 50 m2 area

✓8 Required / Proposed

	Proposed
900 mm to rock, water table or impervious soil	900 mm
40 metre minimum total piping length	150 mm
30 metre maximum run length	18.75 mm
500mm to 1000mm trench width	500 mm
600 to 900 depth of trench	600 mm
1.6 metre minimum trench spacing	1.6 mm

5 Size contact area A= QT / 850 **Minimum contact area** _____m2

6 750 mm x min bed area **Size volume of filter sand** _____m3
45.36 kg per ft3 1602kg per m3 _____kg
7 **Size mantel contact area** Daily design flow / 4 litre / m2 _____m2

Raised beds fill material mantel T time minimum 75 % of leaching bed soil

8 Distribution piping maximum spacing 1.2 metre evenly spaced with ½ space at bed edges
_____mm 750 mm filter sand below stone
_____mm 250 mm material depth below filter sand where on rock or impervious soil

BURIED BED

~~9 Raised beds mantel minimum 15 metre extension in direction of natural drainage~~
~~250 mm depth of material~~ ~~Length of Mantle Extension~~ _____m

10

300 to 600 mm topsoil over stone	300 mm	
Paper over stone	YES	
50 mm stone over tiles	50 mm	
75 mm minimum tile diameter	75 mm	
150 mm minimum stone depth below tile	150 mm	
Slope of pipe minimum 30 mm maximum 50 mm / 10 metre	56.25 mm to 93.75 mm	No slope required on filter beds

~~11 Increase clearances for raised beds~~ 2 x _____ _____ m

12 Clearances Required / Clearances Actual

Treatment unit to structure	1.5 metre		1.5 m
2 x bed height above existing grade			
Treatment unit to potable water supply	drilled wells cased to 6 metre	15 metres	15 m
	Surface wells sand points and dug wells	15 metres	~~15~~ m
Tile bed to water supply	drilled wells	15 ~~30~~ metres	15 m
	Surface wells, sand points and dug wells	30 metres	~~_____~~ m
Tile bed to Property lines	3 metres		3 m
Tile bed to Bodies of water	15 metres		15 m
Tile bed to Trees	3 metres		3 m
Tile bed to structures	5 metres		5 m
~~Mantel slopes minimum 4:1~~ BURIED			_____ m
		Total Mantel width	_____ m

13 Design conforms to regulation ✓ Design does not conform to regulation _____

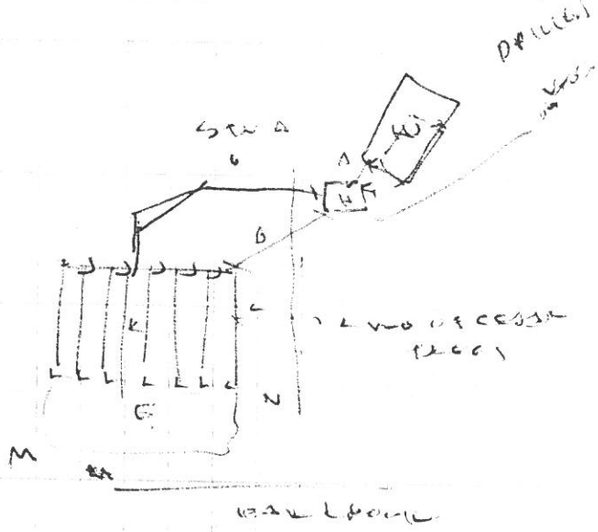
14 Required inspections
(1) Test pit
2 Scarify clay
(3) Septic system installation
(4) Final grading

RUNS
CARD ROSS
DEC 6/99

CARD ROSS

TANK [redacted]
MAX COLL
MANH BOULDER
SIZE [illegible]
BAFFLES

DISTANCE TO TANK TOP MH
6 RUNS
- CHECK OF TILE 16.6m



A	HOUSE TO TANK	4.16m
B	TANK TO TW	13.94m
C	TW TO TREES	6.1m
D	TANK TO WALL	155m +-
G	MANTEE EXT	+ NOT INSTALLED

SLOPE RB 1E 6
3 5
56.4 90.0
56.4 – 90.0m RANGE

END OF TW 1.035
HEADER 0.96
.075m

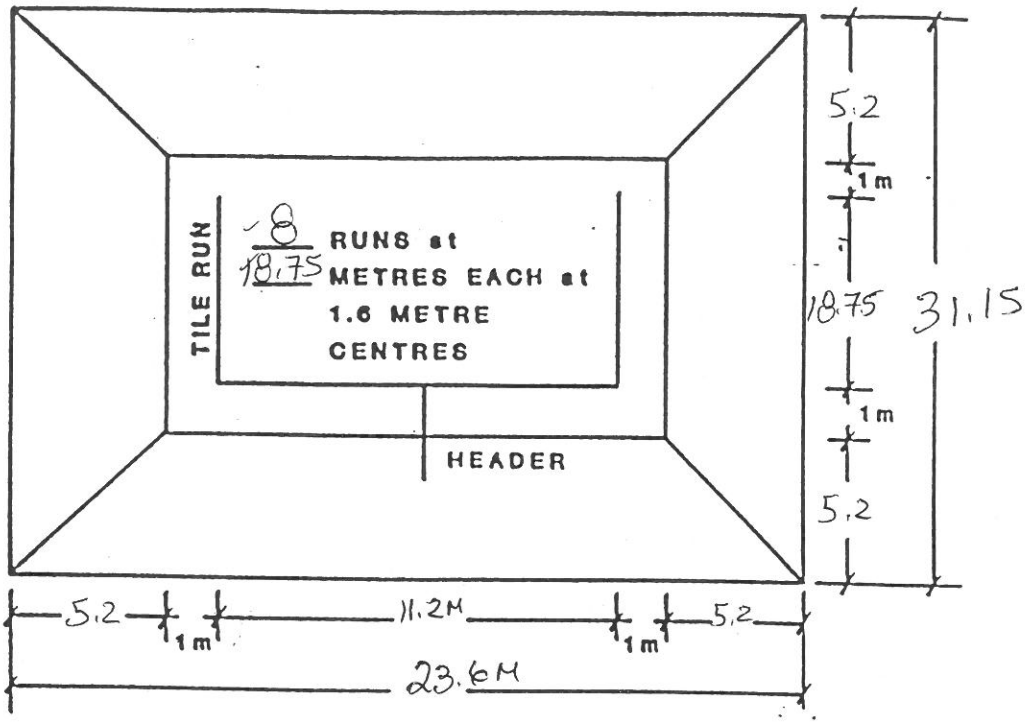
F	TOP RUN	0.47
G	TOP INLET	– NOT INSTALLED
H	TOP TANK	0.64
I	TOP OUTLET	0.675
J	POST HEADER	0.96
K	TOP SEW BOX	1.235
L	TOP END TW	1.035
N	TOP EXIST. GRASS	2.46
V	EXIST. GRND	1.965

DEPTH OF SEW
AT ST GRASS 2.76
TO BOTTOM 1.235
1.245 ...

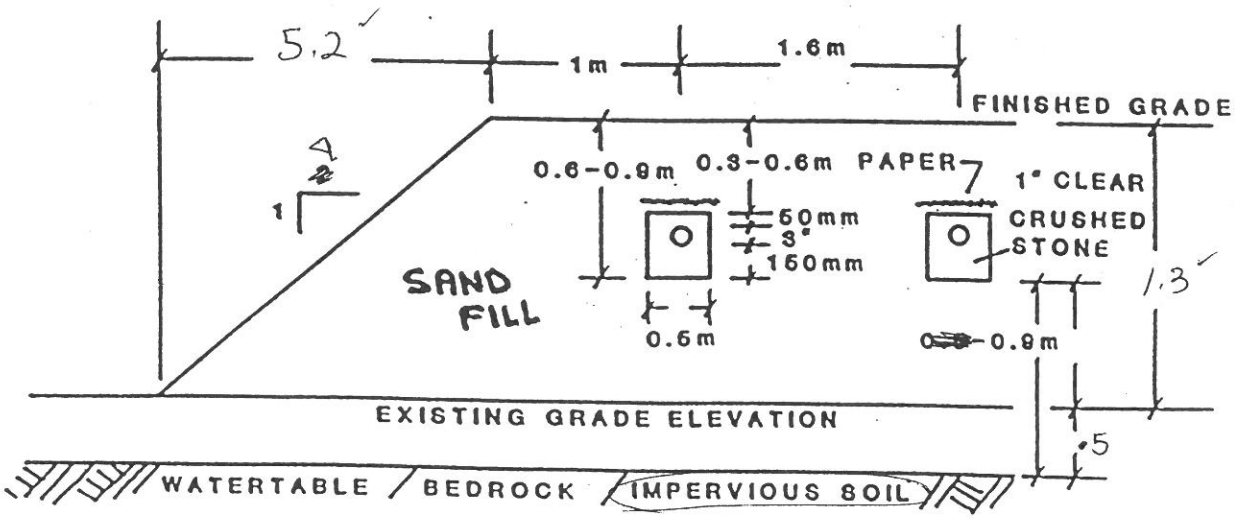
IS NO MANTEE EXT
ALLOWS TO TANK LOWS FROM
INLET PIPE TO TANK
BREAK IN TW

TYPICAL DRAWING B
RAISED TILE BED – ABSORPTION TRENCH METHOD

PLAN



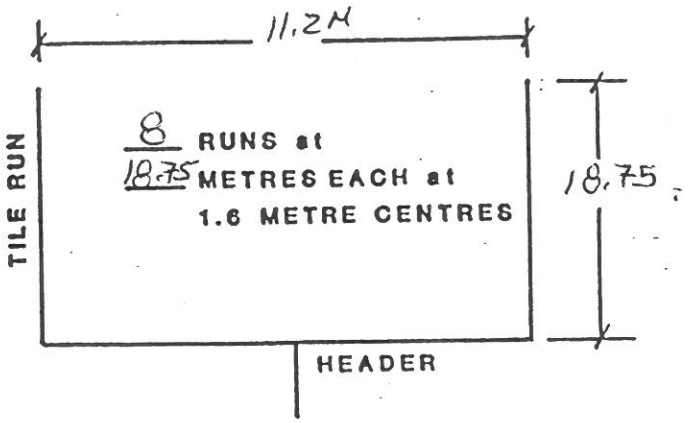
PROFILE



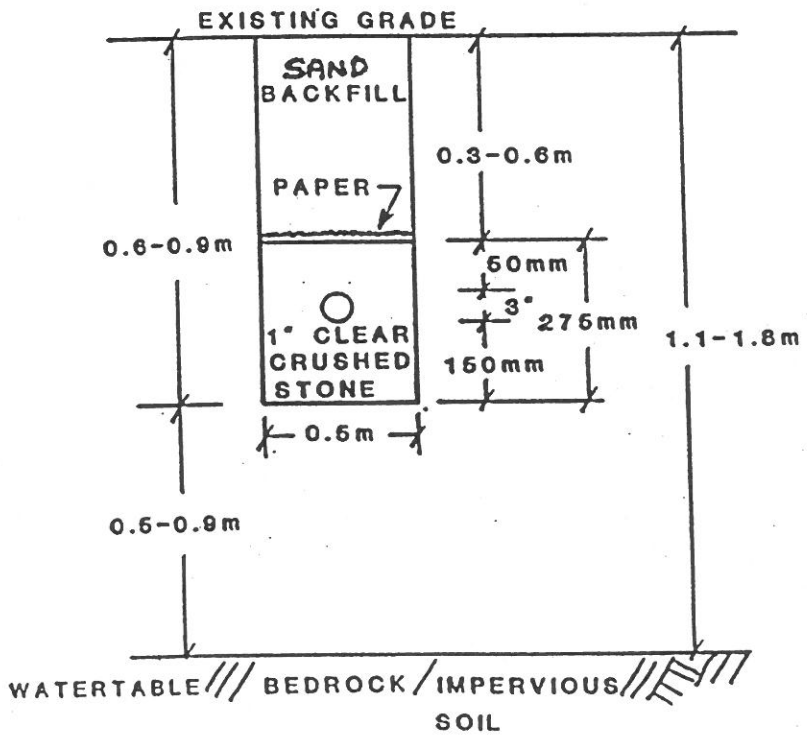
TYPICAL DRAWING A

BURIED BED-ABSORPTION TRENCH METHOD

PLAN



PROFILE



END VIEW

TOWNSHIP OF WEST CARLETON

Construction Site Inspection Report

Permit Number 99-0249 Date of Inspection DEC. 8, 1999
Civic Address 2596 CARP RD. Owner RUMP
Contractor K. WHITE CONST. LTD. Inspector R. MOORE
Weather _____ Time 9^45

Inspection

Building		Plumbing		Septic		Other	
Site	☐	Underground	☐	Site	☐	Pool Enclosure	☐
Excavation	☐	Sanitary Sewer	☐	Scarification	☐	Wood Appliance	☐
Foundation	☑ RO	Rough In	☐	Installation	☑	Chimney	☐
Framing	☐	Completion	☐	Final Grading	☐	Heating	☐
Insulation	☐						
Progress	☐						
Occupancy	☐						
Final	☐						

Inspection Status

Passed	☐
Passed with Conditions	☑ SEPTIC
Not passed	☑ FOUND
Do Not Cover	☐
Call For Reinspection	☐

832-5644 (224)

Inspection Remarks

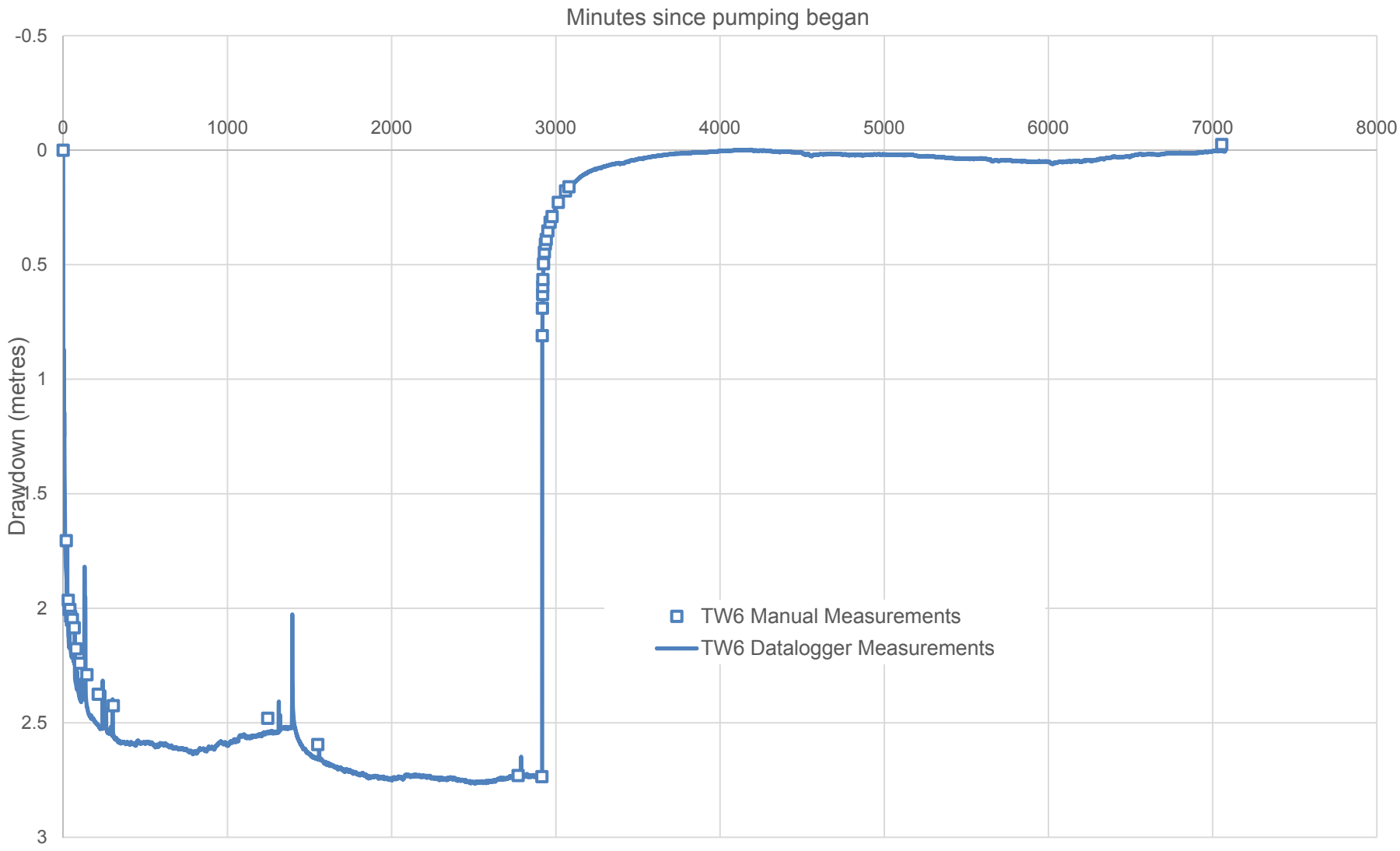
1. FOUNDATION INSPECTION NOT PASSED
ITEMS NOTED AUG 20/99 OUTSTANDING
2 ENG DWGS SIDE WALL OPENING
3 FILLING HONEYCOMBED CONCRETE
4 DAMPROOFING NOT INSTALLED
4 DRAINAGE TILE INSTALLATION
5 FROST PROTECTION FOOTING @ SIDE ENTRY

2 SEPTIC - MANTEL EXTENSION ISN
3 ACCESS TO TANK - LIDS FROZEN
4 PAPER ON TILE
5 INLET PIPE TO TANK NOT INSTALLED - FULLY BED, INSPECTION PRIOR TO COVER

BB.

APPENDIX H

Pumping Test Results and Analysis



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

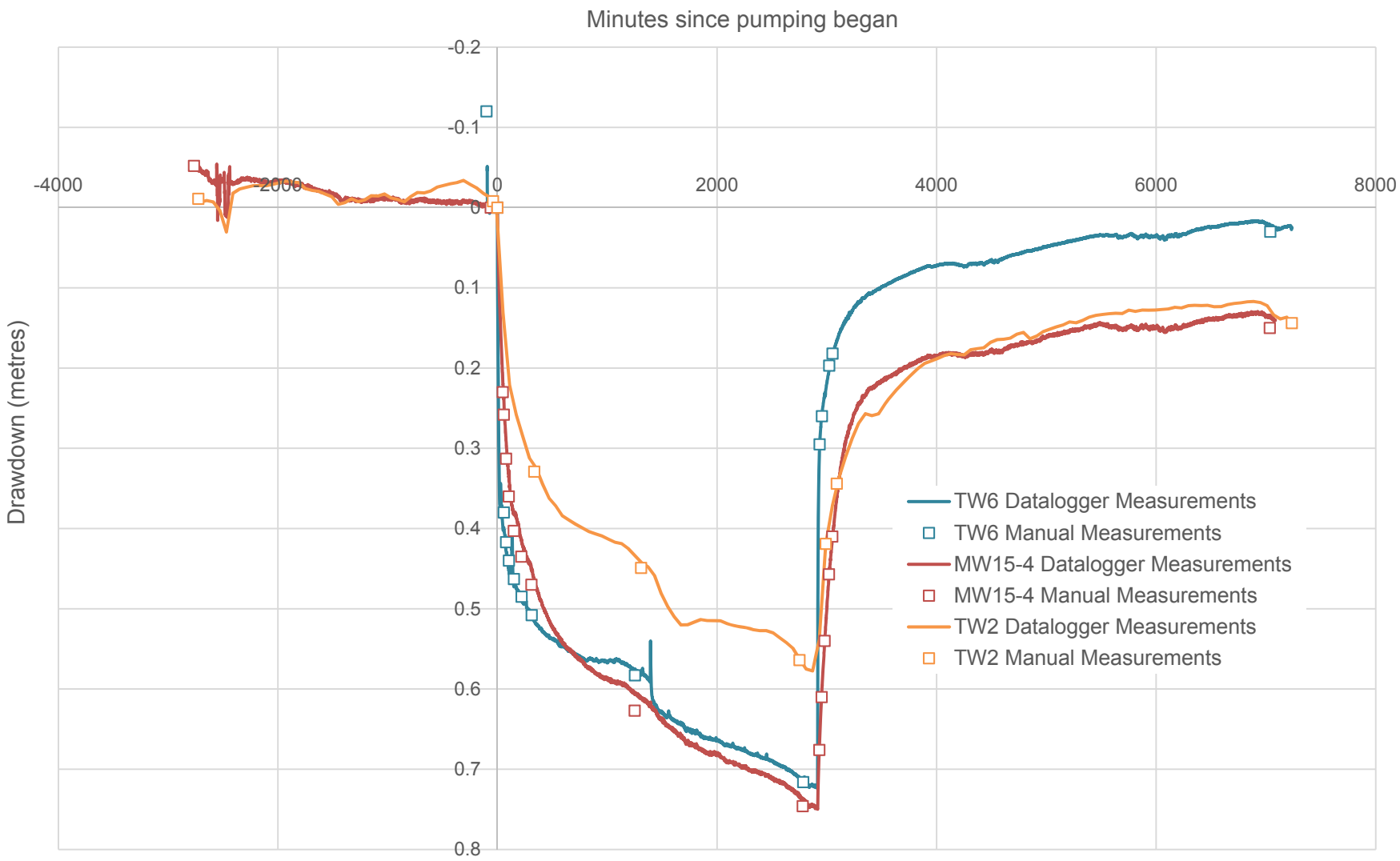
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (PUMPING WELL)

PROJECT No.
1543767

Rev.

FIGURE
H-1a



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CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

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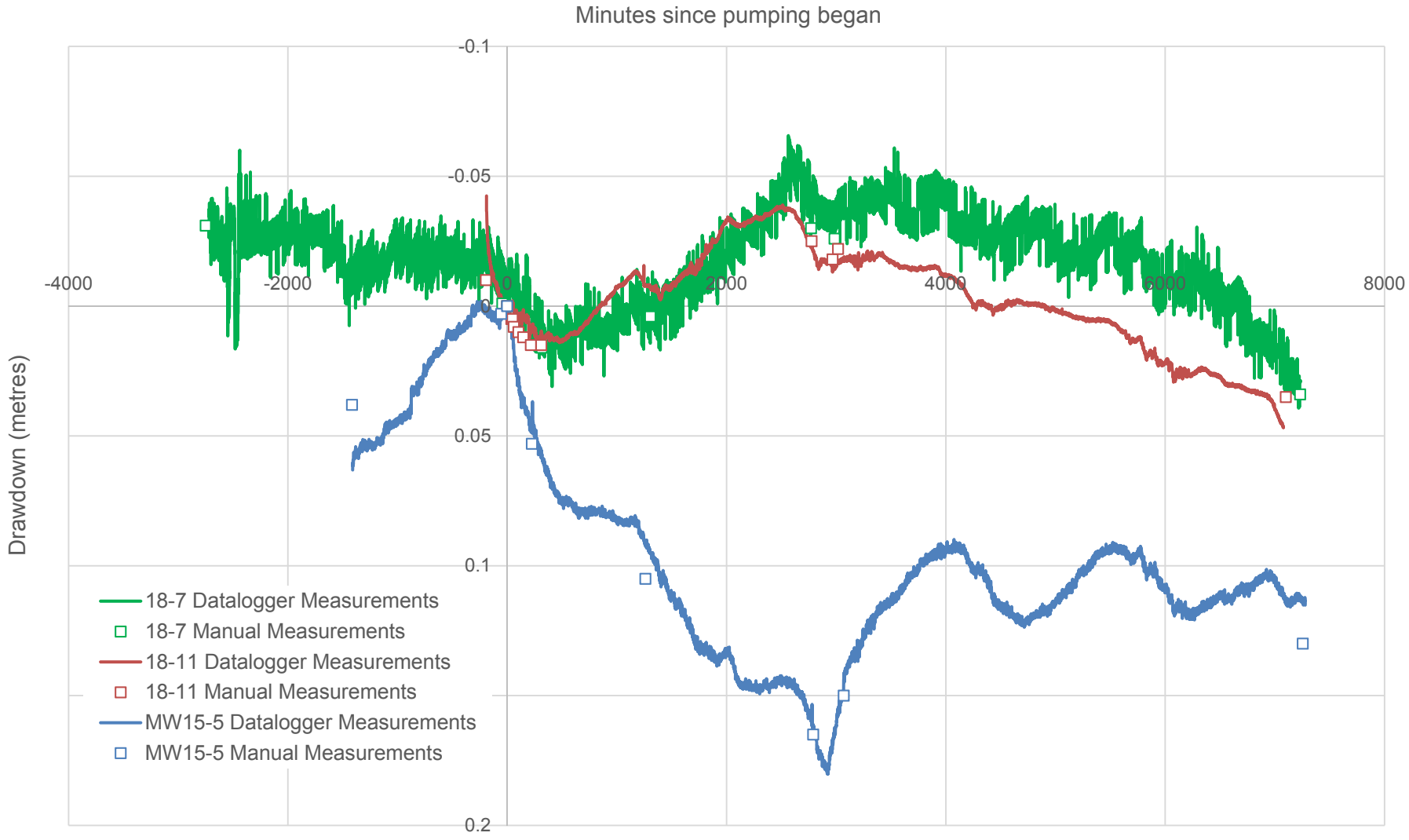
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (TW2, TW6 AND MW15-4)

PROJECT No. **1543767**
Rev.
FIGURE **H-1b**



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CAVANAGH DEVELOPMENTS

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GOLDER

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DESIGN	
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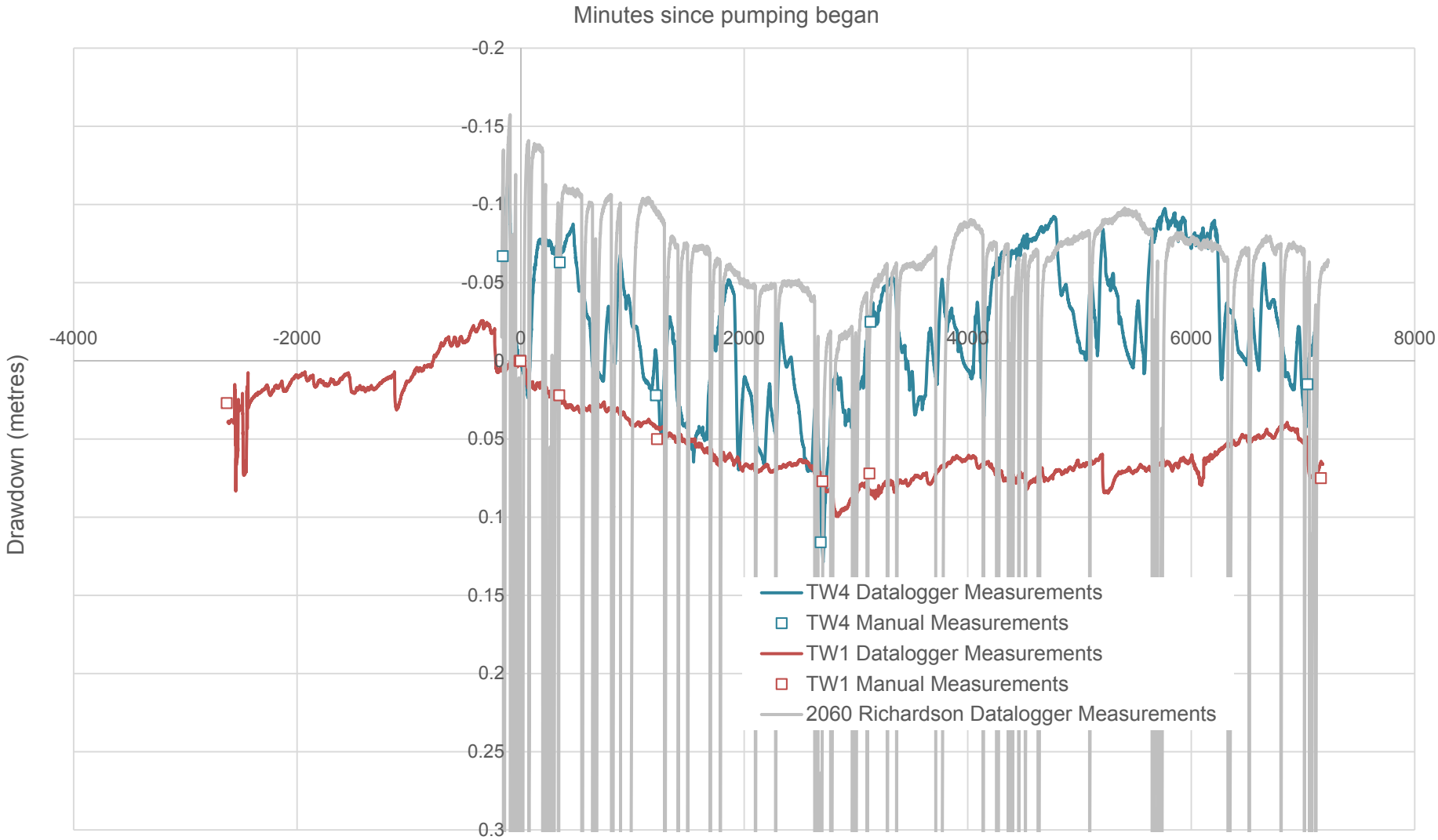
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (MW18-7, MW18-11 AND MW15-5)

PROJECT No. **1543767**
Rev.
FIGURE **H-1c**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

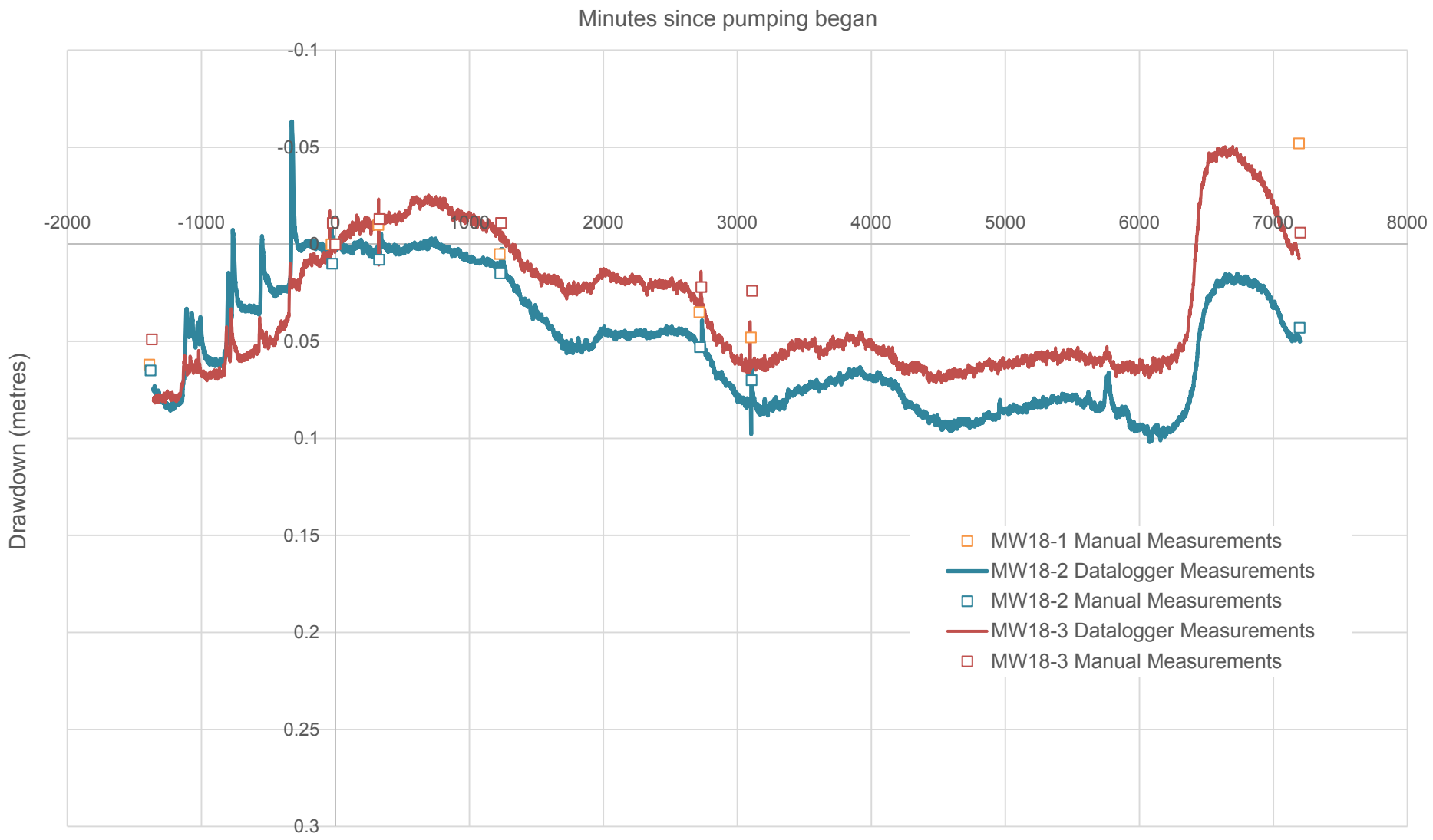
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (TW1, TW4 AND 2060 RICHARDSON SIDE ROAD)

PROJECT No. **1543767**
Rev.
FIGURE **H-1d**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

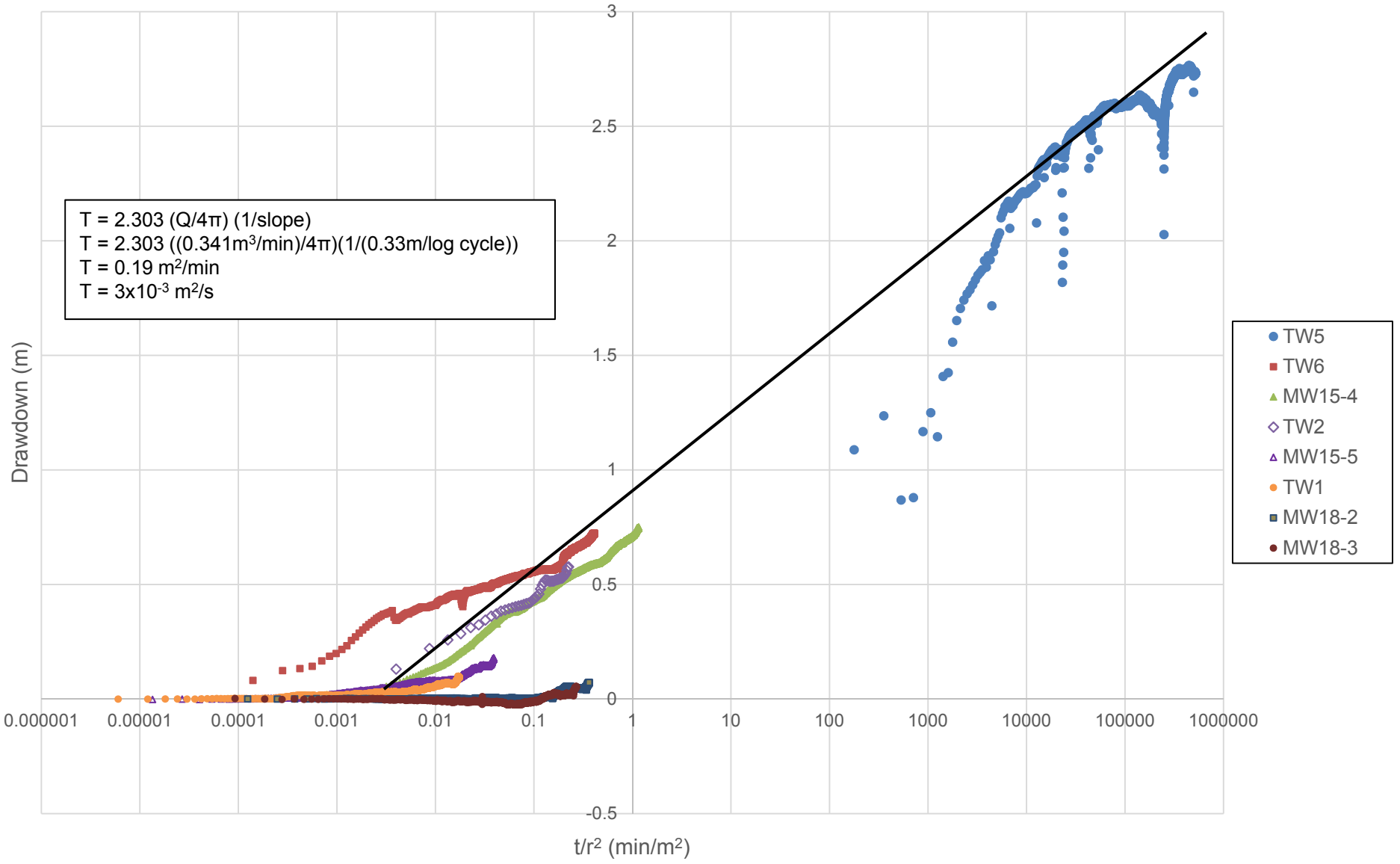
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW5 (SHALLOW MONITORS MW18-1, MW18-2, MW18-3)

PROJECT No. **1543767**

Rev.

FIGURE **H-1e**



CLIENT
CAVANAGH DEVELOPMENTS

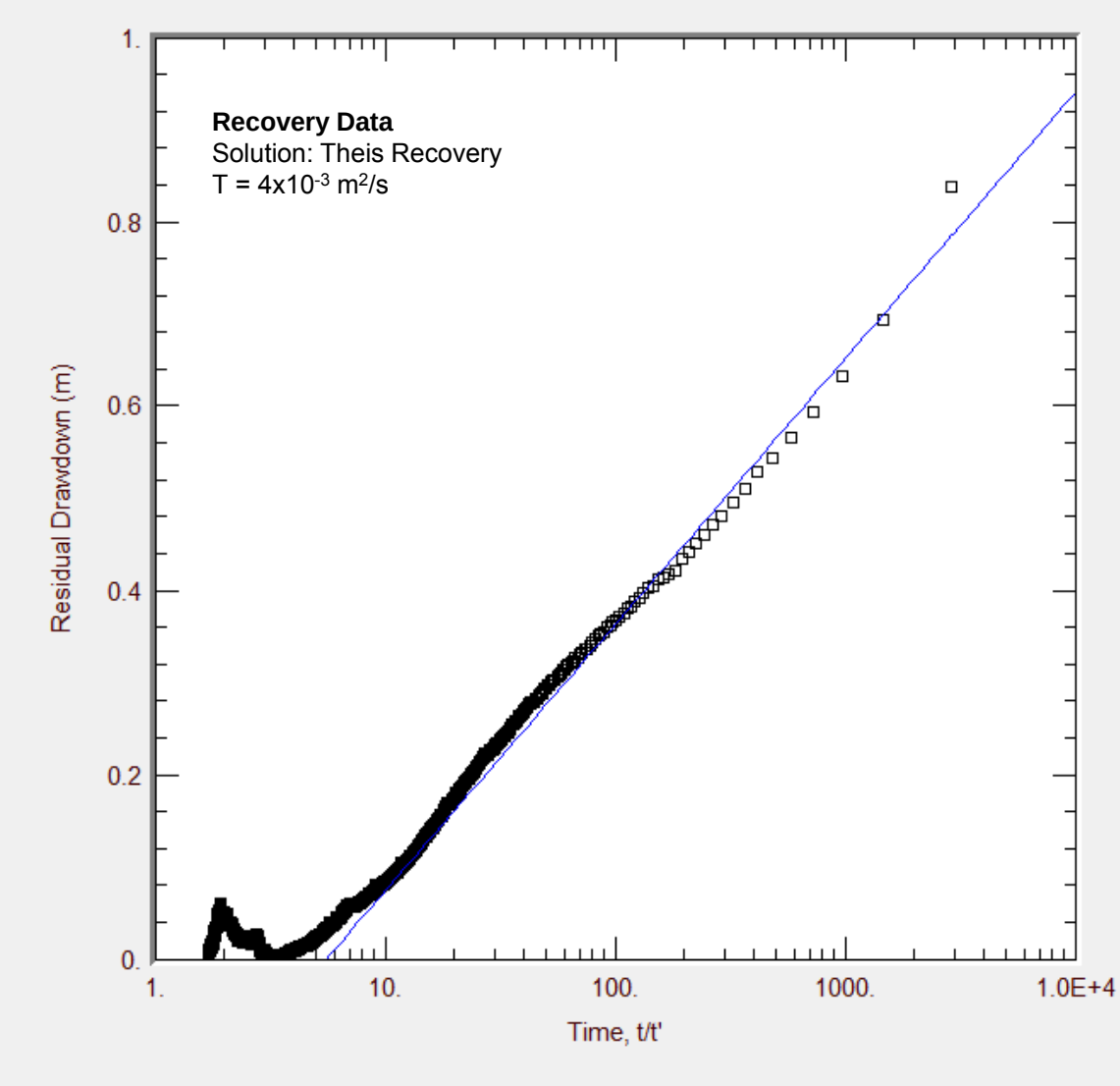
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
COOPER-JACOB STRAIGHT-LINE COMPOSIT ANALYSIS
WATER LEVEL RESPONSE DURING PUMPING AT TW5

PROJECT No. **1543767**
Rev.
FIGURE **H-1f**



CLIENT
CAVANAGH DEVELOPMENTS

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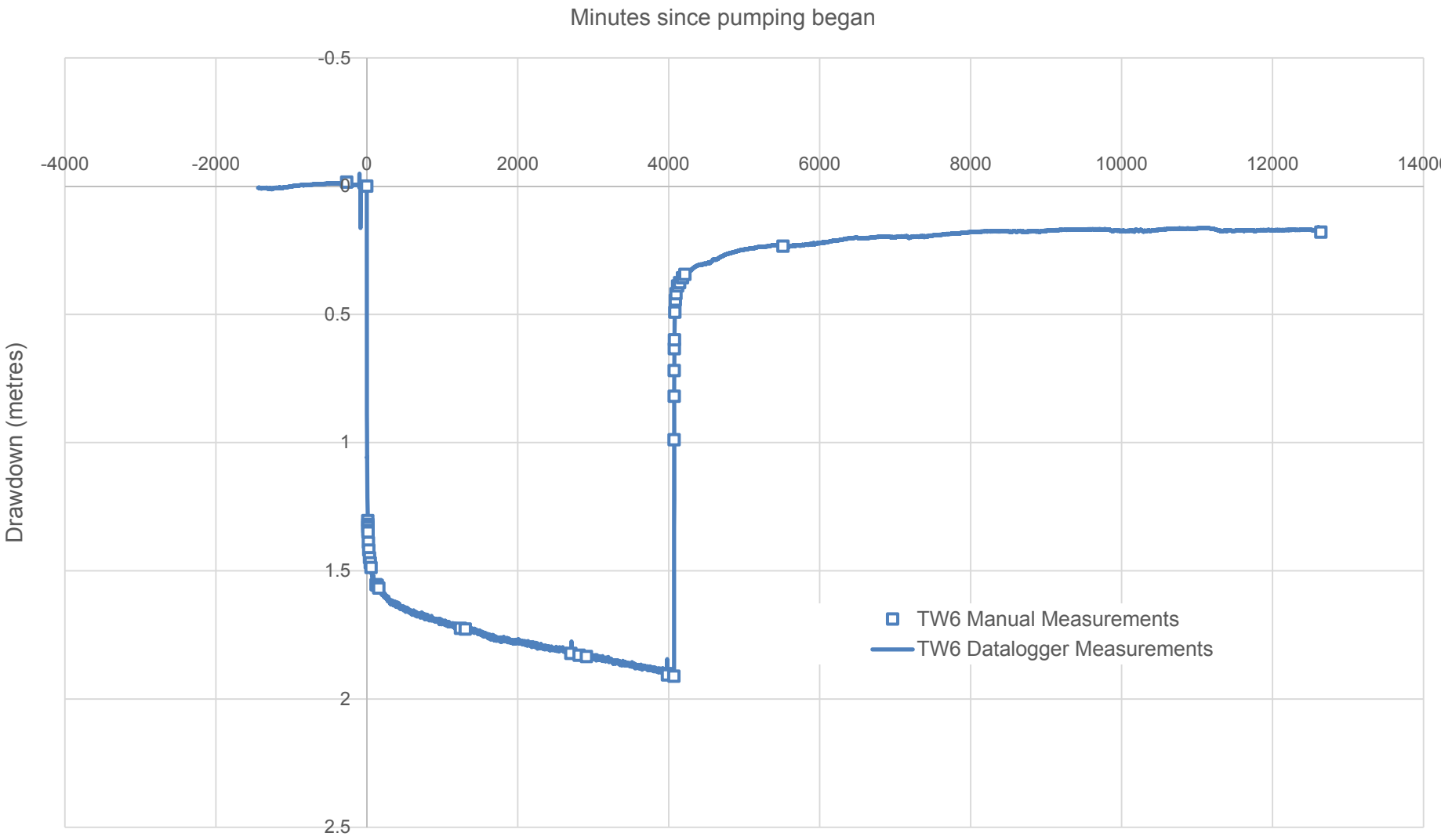
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
RECOVERY DATA ANALYSIS
PUMPING AT TW5

PROJECT No. **1543767**
Rev.
FIGURE **H-1g**



CLIENT
CAVANAGH DEVELOPMENTS

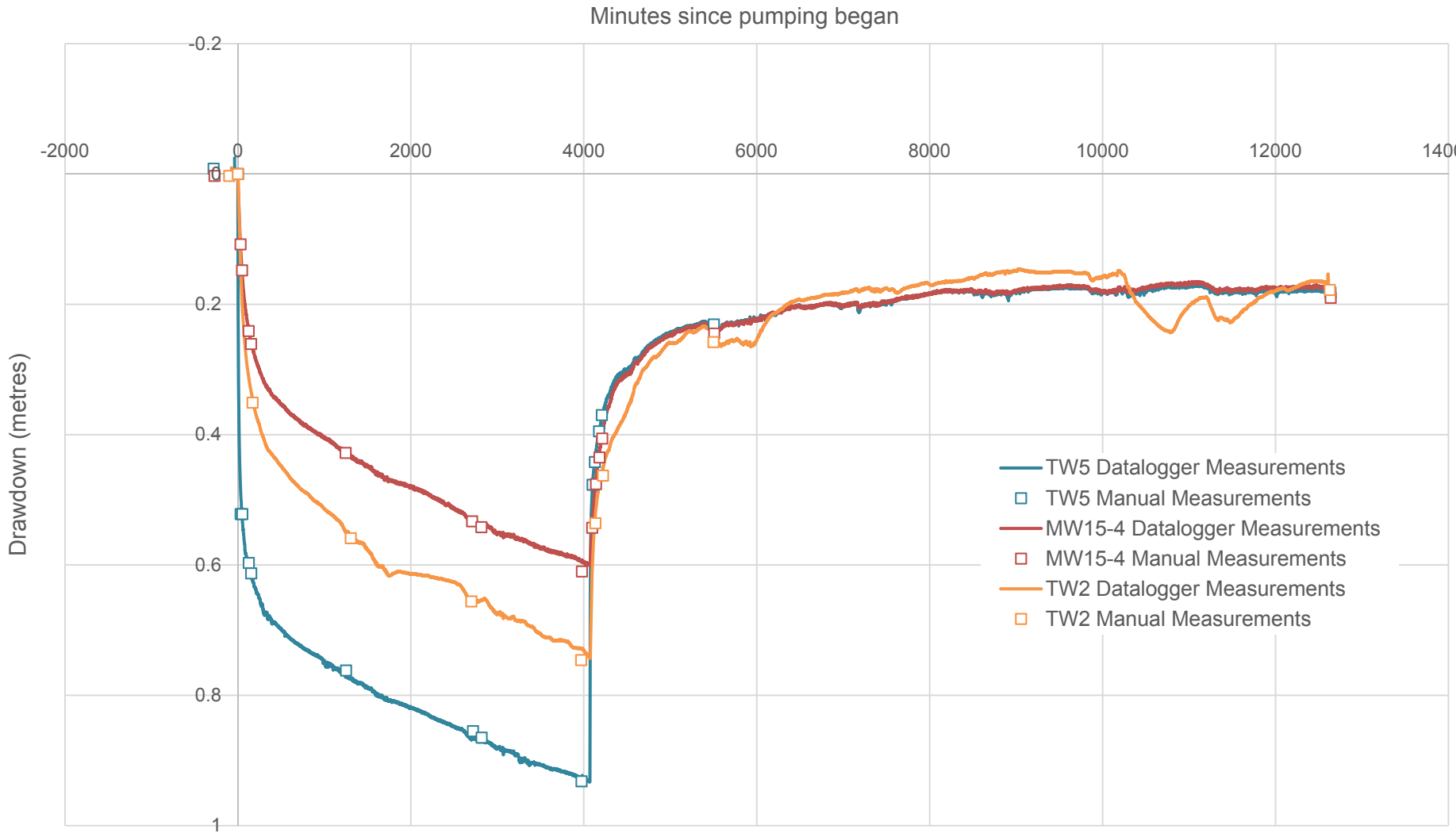
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (PUMPING WELL)

PROJECT No. **1543767**
Rev.
FIGURE **H-2a**



CLIENT
CAVANAGH DEVELOPMENTS

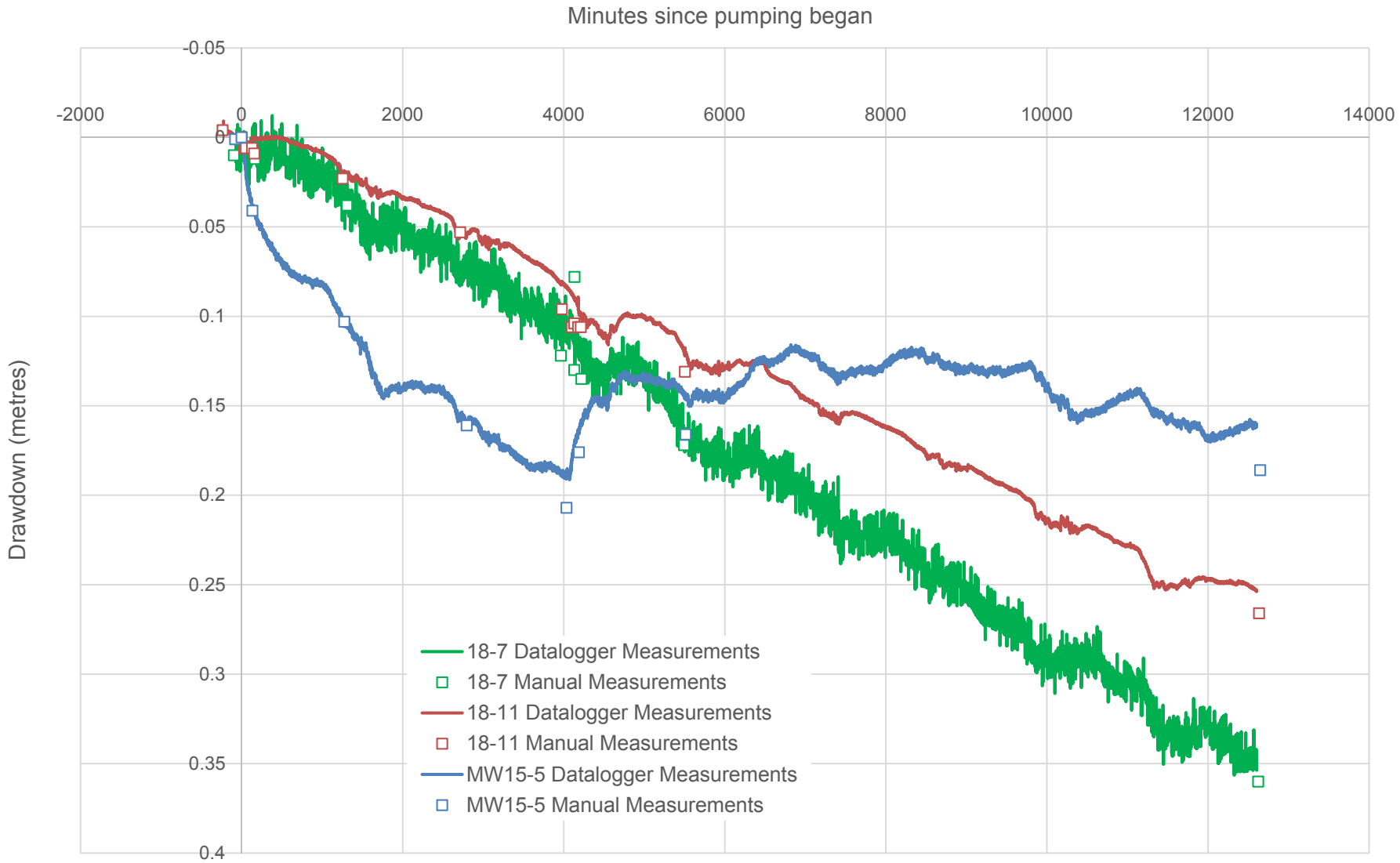
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (TW2, TW6 AND MW15-4)

PROJECT No. **1543767**
Rev.
FIGURE **H-2b**



CLIENT
CAVANAGH DEVELOPMENTS

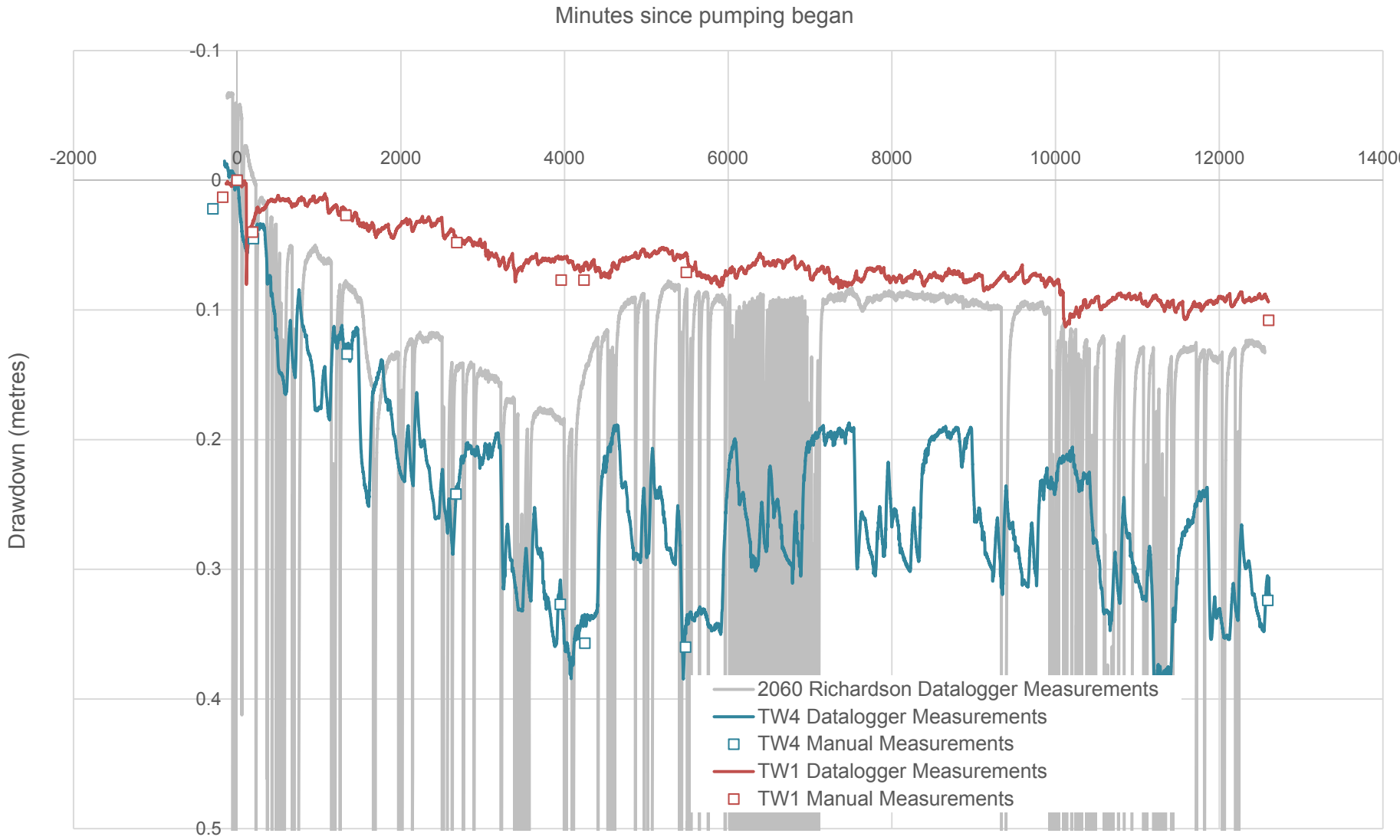
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (MW18-7, MW18-11 AND MW15-5)

PROJECT No. **1543767** | Rev. | FIGURE **H-2c**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

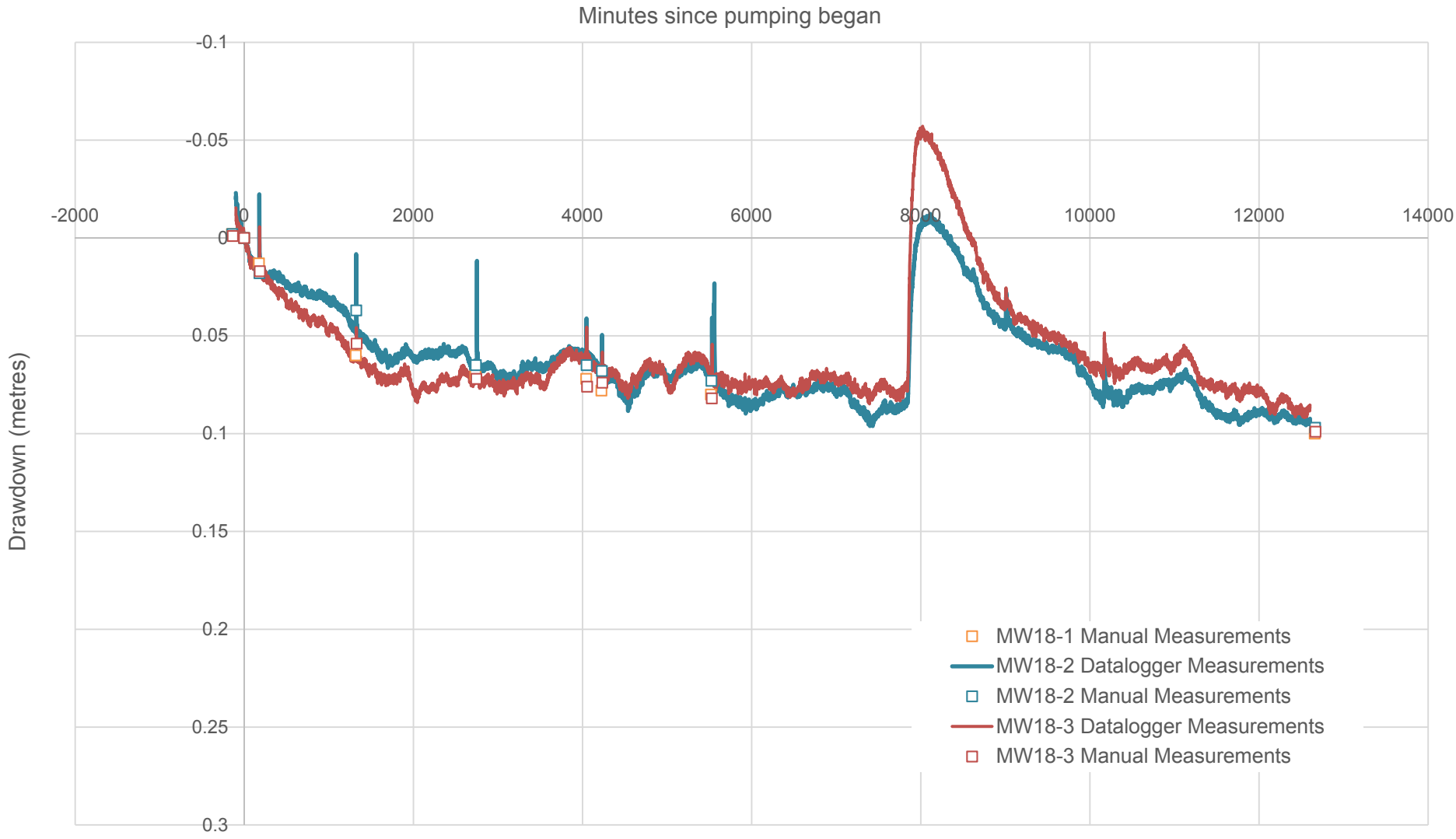
YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (TW1, TW4 AND 2060 RICHARDSON SIDE ROAD)

PROJECT No. **1543767**
Rev.
FIGURE **H-2d**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



CLIENT
CAVANAGH DEVELOPMENTS

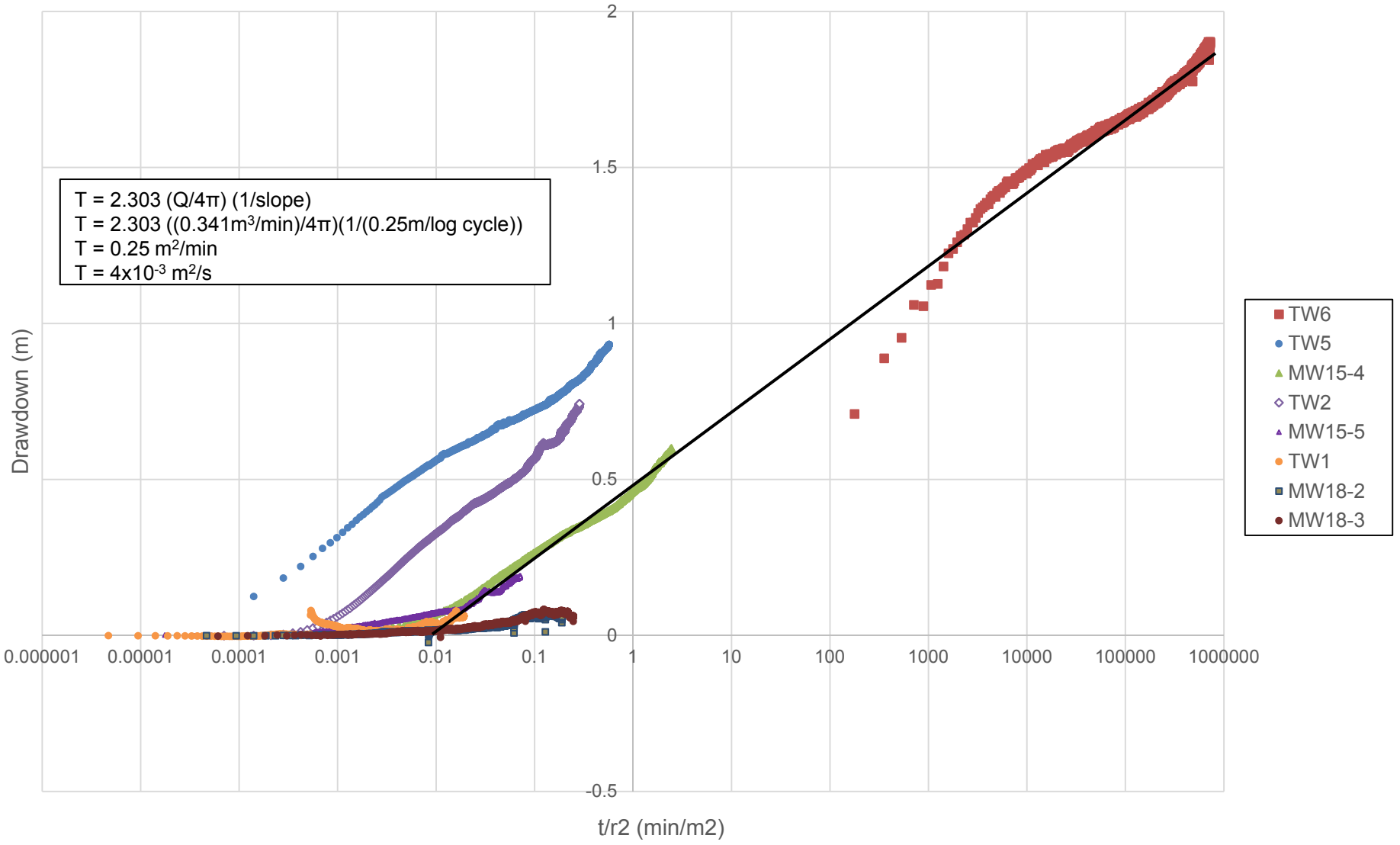
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT TW6 (SHALLOW MONITORS MW18-1, MW18-2, MW18-3)

PROJECT No. **1543767**
Rev.
FIGURE **H-2e**



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CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
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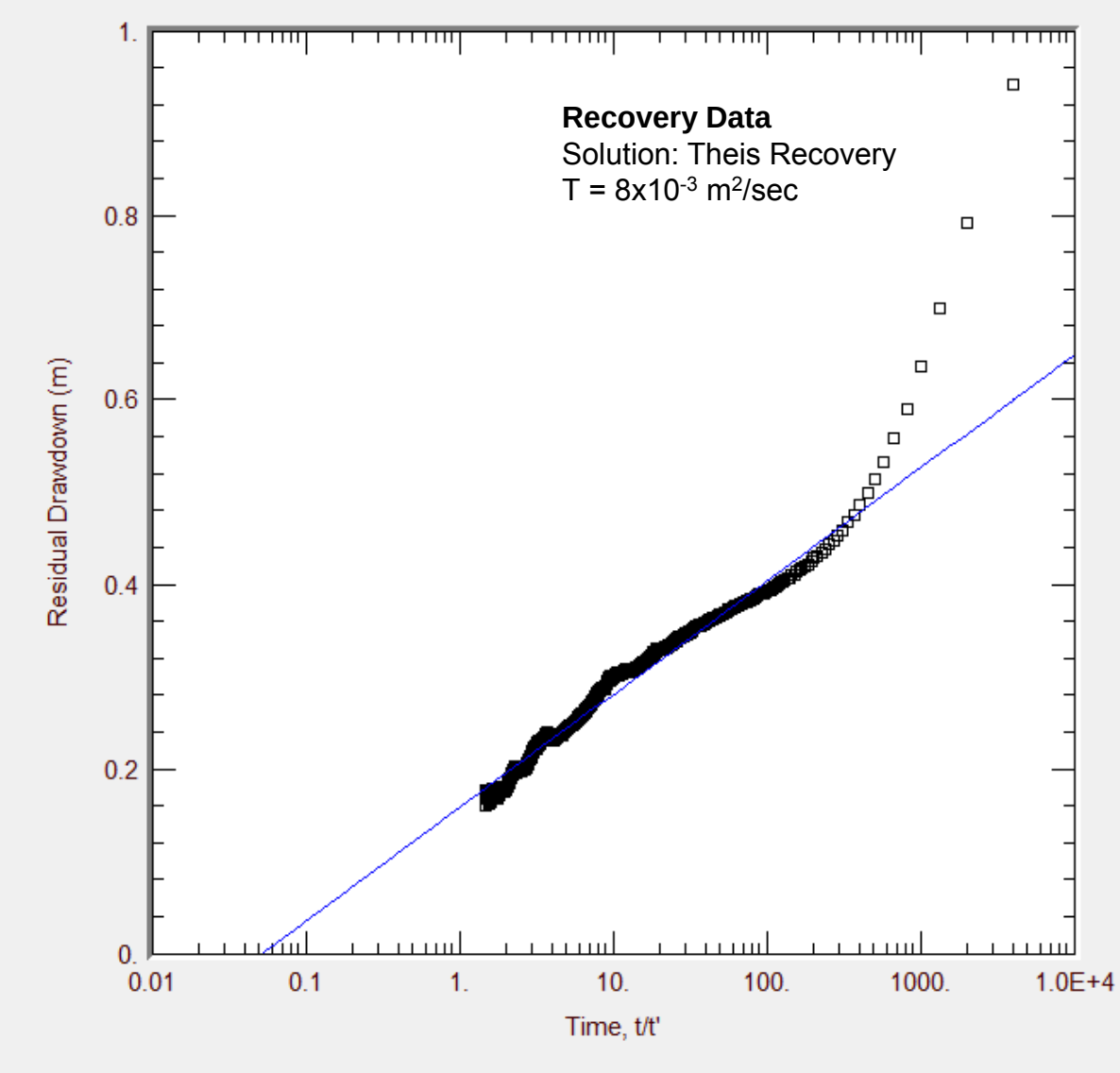
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
COOPER-JACOB STRAIGHT-LINE COMPOSIT ANALYSIS
WATER LEVEL RESPONSE DURING PUMPING AT TW6

PROJECT No. **1543767**
Rev.
FIGURE **H-2f**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
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REVIEW	BTB
APPROVED	BTB

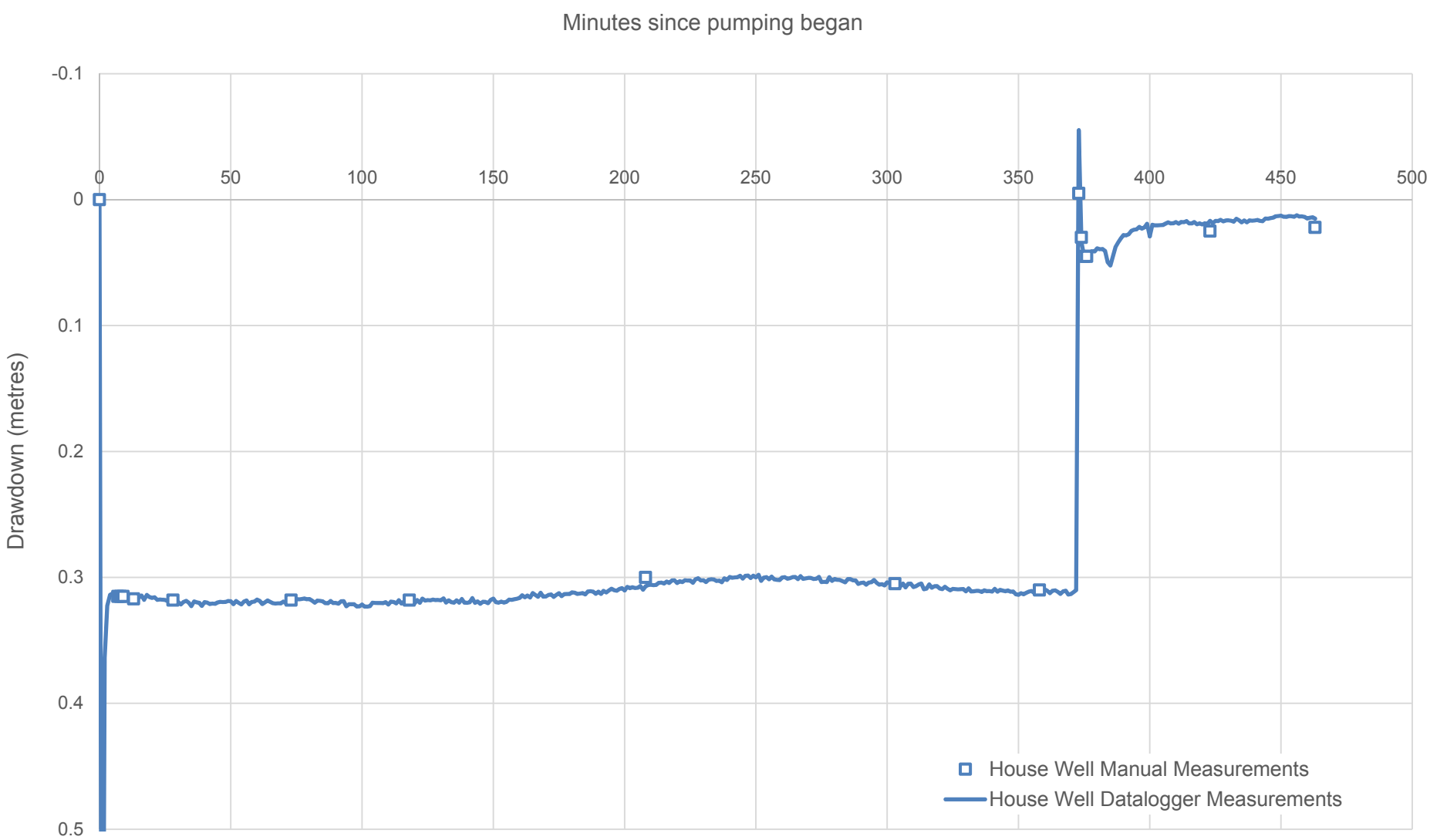
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
RECOVERY DATA ANALYSIS
PUMPING AT TW6

PROJECT No. **1543767**

Rev.

FIGURE **H-2g**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
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REVIEW	BTB
APPROVED	BTB

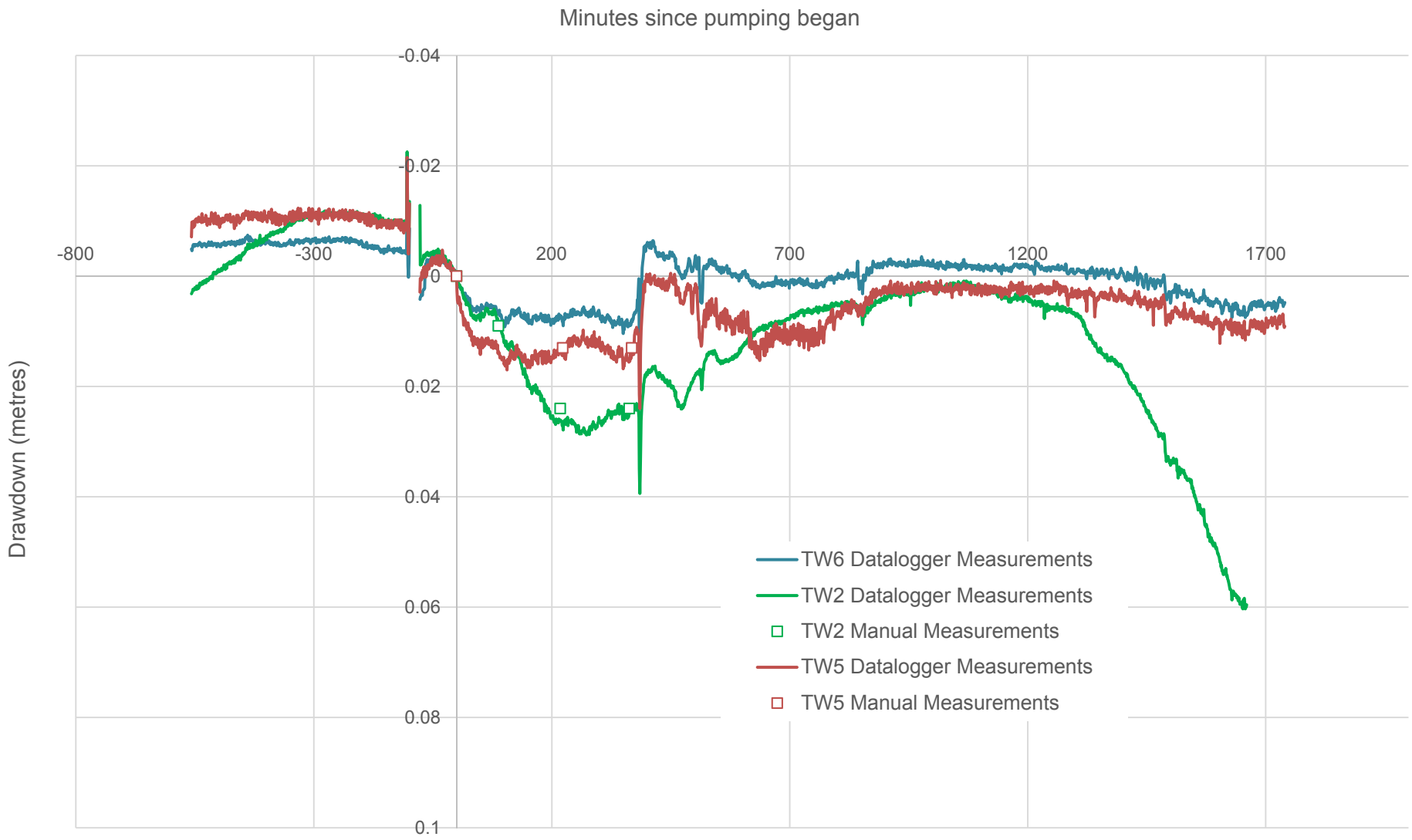
PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (PUMPING WELL)

PROJECT No. **1543767**

Rev.

FIGURE **H-3a**



CLIENT
CAVANAGH DEVELOPMENTS

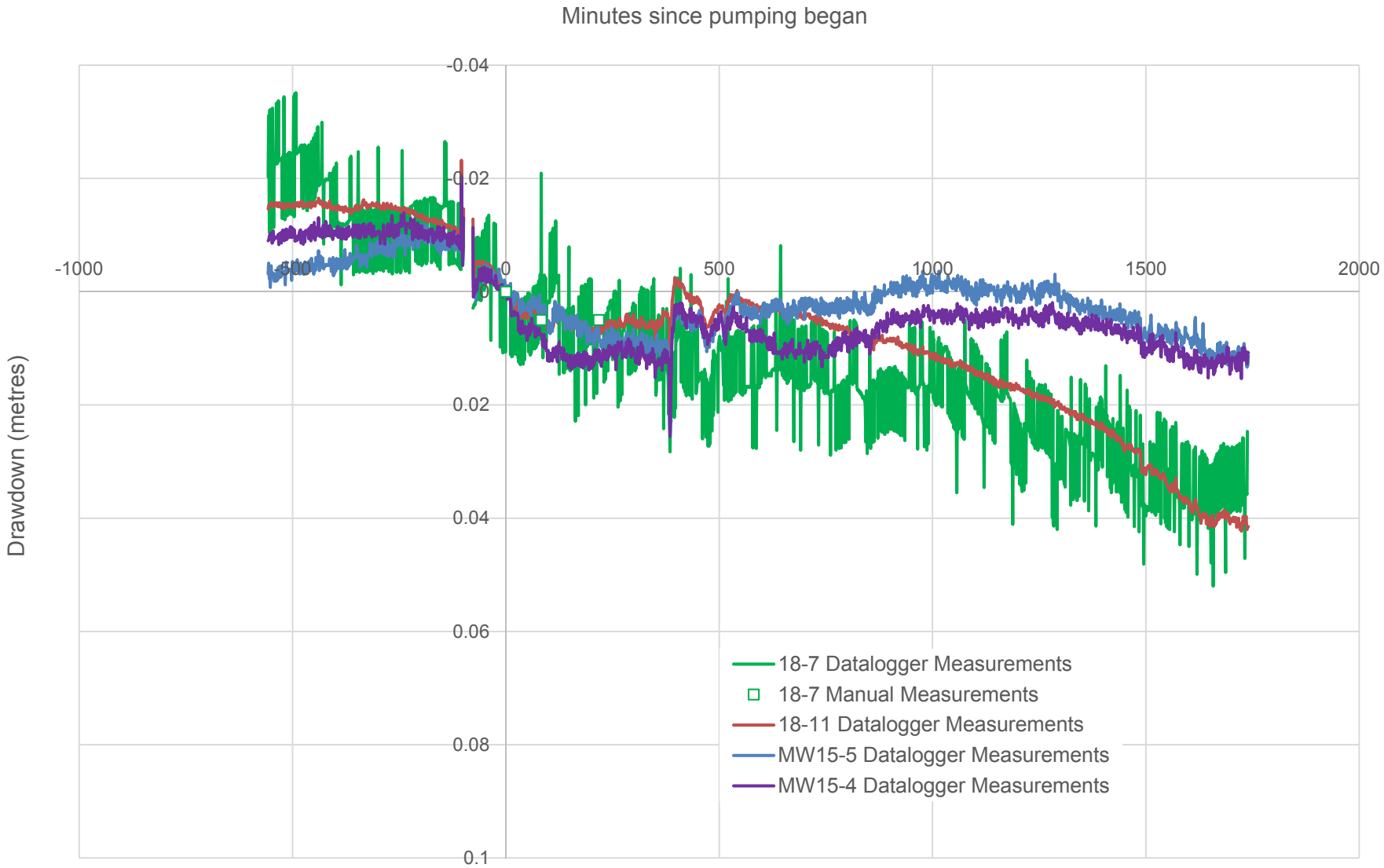
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (TW2, TW5, TW6)

PROJECT No. **1543767**
Rev.
FIGURE **H-3b**



CLIENT
CAVANAGH DEVELOPMENTS

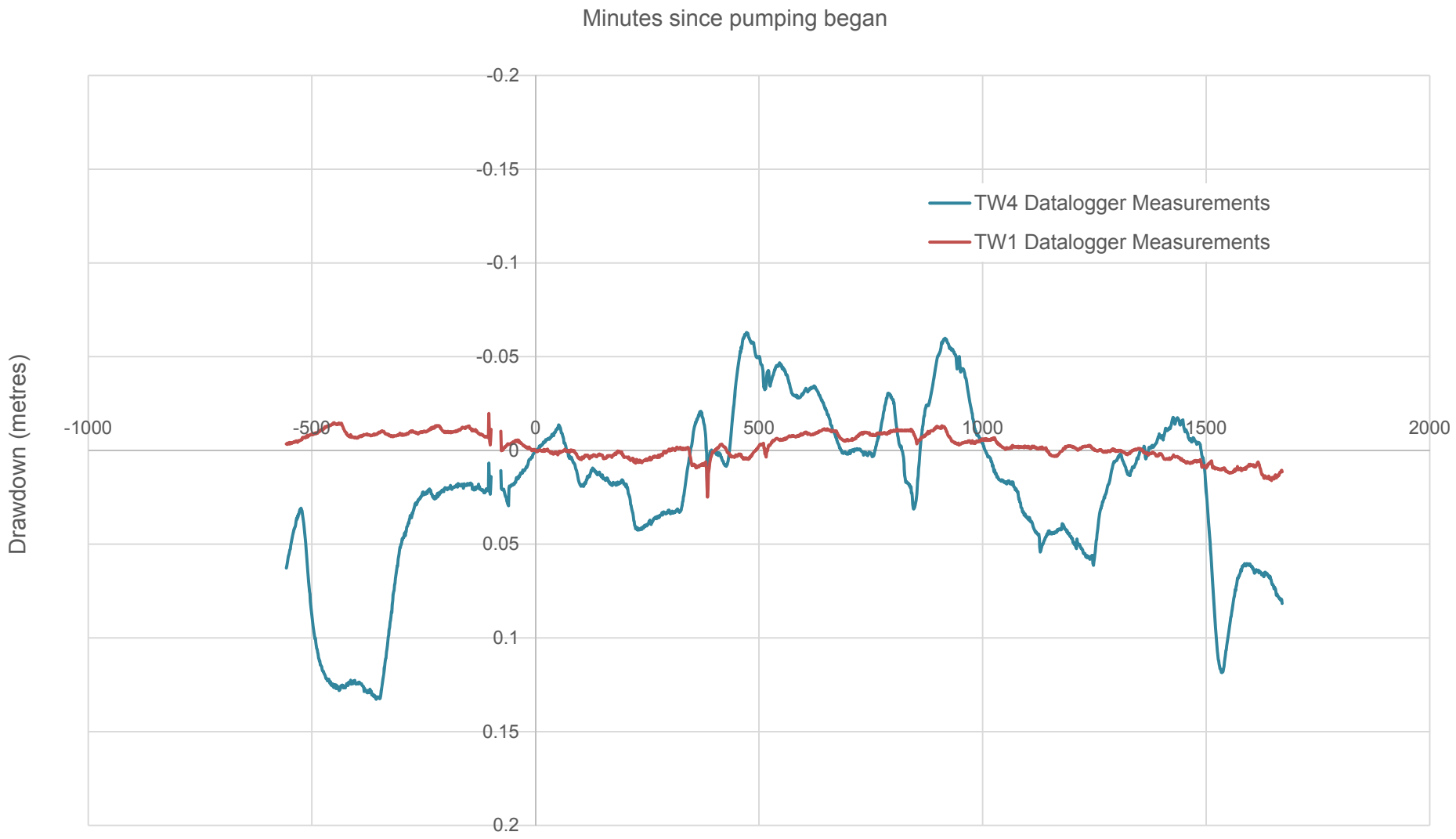
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (MW18-7, MW18-11, MW15-4 AND MW15-5)

PROJECT No. **1543767**
Rev.
FIGURE **H-3c**



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CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (TW1 AND TW4)

PROJECT No. **1543767**
Rev.
FIGURE **H-3d**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0

CLIENT
CAVANAGH DEVELOPMENTS

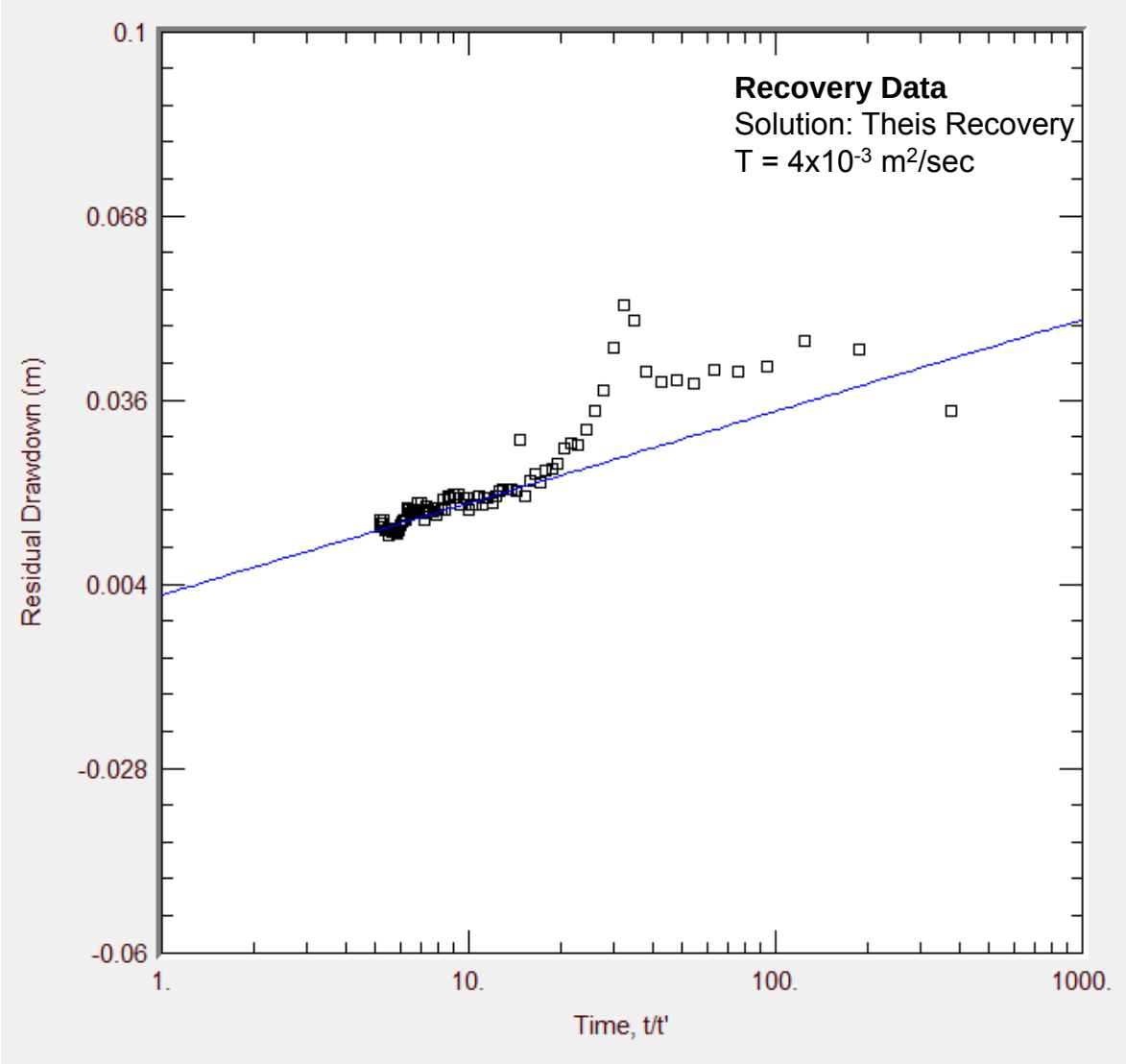
CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
GROUNDWATER LEVEL RESPONSE DURING PUMPING AT HOUSE WELL (SHALLOW MONITORS MW18-1, MW18-2, MW18-3)

PROJECT No. **1543767**
Rev.
FIGURE **H-3e**



CLIENT
CAVANAGH DEVELOPMENTS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-11
PREPARED	LEB
DESIGN	
REVIEW	BTB
APPROVED	BTB

PROJECT
HYDROGEOLOGY INVESTIGATION,
TERRAIN ANALYSIS AND IMPACT ASSESSMENT
2596 CARP ROAD, OTTAWA, ONTARIO

TITLE
RECOVERY DATA ANALYSIS
PUMPING AT HOUSE WELL

PROJECT No. **1543767**
Rev.
FIGURE **H-3f**

APPENDIX I

Water Balance Analysis

Table I-1: Environment Canada Precipitation and Surplus Data
Ottawa CDA Meteorological Station

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 75 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 45 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1	-10.4	59	11	16	0	0	0	26	71	74	284
28- 2	-8.8	52	10	18	1	1	0	27	94	75	335
31- 3	-2.5	61	31	74	6	6	0	99	50	75	396
30- 4	6	70	67	53	32	32	0	88	0	74	466
31- 5	13.1	77	77	0	80	80	0	14	0	58	542
30- 6	18.3	85	85	0	117	108	-8	3	0	32	627
31- 7	20.8	86	86	0	136	105	-30	1	0	11	714
31- 8	19.6	85	85	0	117	85	-33	1	0	11	798
30- 9	14.9	85	85	0	76	68	-8	3	0	26	883
31-10	8.6	75	75	0	38	37	-1	13	0	51	75
30-11	1.8	76	61	7	11	11	0	38	7	70	151
31-12	-6.6	73	25	16	1	1	0	35	39	75	224
AVE/TTL	6.3	885	698	184	615	534	-80	348			

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 100 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 60 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1	-10.4	59	11	16	0	0	0	25	71	98	284
28- 2	-8.8	52	10	18	1	1	0	27	94	99	335
31- 3	-2.5	61	31	74	6	6	0	98	50	100	396
30- 4	6	70	67	53	32	32	0	88	0	99	466
31- 5	13.1	77	77	0	80	80	0	14	0	83	542
30- 6	18.3	85	85	0	117	113	-4	3	0	52	627
31- 7	20.8	86	86	0	136	115	-20	1	0	21	714
31- 8	19.6	85	85	0	117	88	-30	1	0	18	798
30- 9	14.9	85	85	0	76	69	-7	2	0	33	883
31-10	8.6	75	75	0	38	37	-1	9	0	62	75
30-11	1.8	76	61	7	11	11	0	30	7	90	151
31-12	-6.6	73	25	16	1	1	0	32	39	97	224
AVE/TTL	6.3	885	698	184	615	553	-62	330			

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 150 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 90 MM A..... 1.085

Date	Temprature (˚C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1 -	10.4	59	11	16	0	0	0	21	71	145	284
28- 2	-8.8	52	10	18	1	1	0	25	94	147	335
31- 3	-2.5	61	31	74	6	6	0	97	50	150	396
30- 4	6	70	67	53	32	32	0	88	0	149	466
31- 5	13.1	77	77	0	80	80	0	14	0	133	542
30- 6	18.3	85	85	0	117	116	0	3	0	98	627
31- 7	20.8	86	86	0	136	127	-8	1	0	56	714
31- 8	19.6	85	85	0	117	98	-19	1	0	42	798
30- 9	14.9	85	85	0	76	70	-6	2	0	56	883
31-10	8.6	75	75	0	38	37	0	7	0	87	75
30-11	1.8	76	61	7	11	11	0	19	7	125	151
31-12	-6.6	73	25	16	1	1	0	25	39	140	224
AVE/TTL	6.3	885	698	184	615	579	-33	303			

Table I-1: Environment Canada Precipitation and Surplus Data
Ottawa CDA Meteorological Station

Date	Temprature	Precipiation	Rain	Melt	Potential Evaporation	Actual Evaporation	Deficit	Surplus	Snow	Soil	Accumulated Precipiation

Ottawa CDA Combined, ON WATER BUDGET MEANS FOR THE PERIOD 1945-2013 DC20492
LAT.... 45.38 WATER HOLDING CAPACITY... 300 MM HEAT INDEX... 37.10
LONG... 75.72 LOWER ZONE..... 1280 MM A..... 1.085

Date	Temprature (°C)	Precipiation (mm)	Rain (mm)	Melt (mm)	Potential Evaporation (mm)	Actual Evaporation (mm)	Deficit (mm)	Surplus (mm)	Snow (mm)	Soil (mm)	Accumulated Precipiation (mm)
31- 1	-10.4	59	11	16	0	0	0	17	71	280	284
28- 2	-8.8	52	10	18	1	1	0	20	94	288	335
31- 3	-2.5	61	31	74	6	6	0	89	50	298	396
30- 4	6	70	67	53	32	32	0	87	0	299	466
31- 5	13.1	77	77	0	80	80	0	14	0	283	542
30- 6	18.3	85	85	0	117	117	0	3	0	248	627
31- 7	20.8	86	86	0	136	135	0	1	0	198	714
31- 8	19.6	85	85	0	117	114	-3	1	0	168	798
30- 9	14.9	85	85	0	76	74	-2	2	0	178	883
31-10	8.6	75	75	0	38	38	0	7	0	208	75
30-11	1.8	76	61	7	11	11	0	15	7	251	151
31-12	-6.6	73	25	16	1	1	0	19	39	272	224
AVE/TTL	6.3	885	698	184	615	609	-5	275			

Table I-2: Estimation of Annual Water Balance Rates
2596 Carp Road
Ottawa, Ontario

Assigned Water Holding Capacity					
Soil Type	Fine Sandy Loam	Fine Sandy Loam	Fine Sandy Loam	Fine Sandy Loam	
Vegetation Type	Pasture/Shrub	Urban Lawn	Mature Forest	Gravel Surface	
Water Holding Capacity (mm)	150	75	300	10	

Annual Rates by Water Holding Capacity					
Water Holding Capacity (mm)	**Impervious**	**Water**	**75**	**150**	**300**
Precipitation	885	885	885	885	885
Actual Evapotranspiration	177	615	534	579	585
Surplus	708	270	351	306	300

Pre-Development - Estimated Infiltration Factor					
Land use		**Topography**	**Soils**	**Cover**	**Infiltration Factor**
Impervious Surfaces	n/a	n/a	0.00	0.00	0.00
Water	n/a	n/a	0.00	0.00	0.00
Urban Lawn	Fine Sandy Loam	0.1	0.40	0.10	0.60
Pasture/Shrub	Fine Sandy Loam	0.1	0.40	0.15	0.65
Mature Forest	Fine Sandy Loam	0.1	0.40	0.20	0.70

Post-Development - Estimated Infiltration Factor					
Land use		**Topography**	**Soils**	**Cover**	**Infiltration Factor**
Impervious Surfaces	n/a	n/a	0.00	0.00	0.00
Water	n/a	n/a	0.00	0.00	0.00
Urban Lawn	Fine Sandy Loam	0.1	0.40	0.10	0.60
Pasture/Shrub	Fine Sandy Loam	0.1	0.40	0.15	0.65
Mature Forest	Fine Sandy Loam	0.1	0.40	0.20	0.70

Pre-Development - Estimated Average Annual Infiltration Rates						
Land use	**Surficial Soil**	**WHC (mm)**	**Surplus (mm/a)**	**Infiltration Factor**	**Infiltration (mm/a)**	**Run-Off (mm/a)**
Impervious Surfaces	n/a	n/a	708	n/a	0	708
Water	n/a	n/a	270	0.00	0	270
Urban Lawn	Fine Sandy Loam	75	351	0.60	211	140
Pasture/Shrub	Fine Sandy Loam	150	306	0.65	199	107
Mature Forest	Fine Sandy Loam	300	300	0.70	210	90

Post-Development - Estimated Average Annual Infiltration Rates						
Land use	**Surficial Soil**	**WHC (mm)**	**Surplus (mm/a)**	**Infiltration Factor**	**Infiltration (mm/a)**	**Run-Off (mm/a)**
Impervious Surfaces	n/a	n/a	708	n/a	0	708
Water	n/a	n/a	270	0.00	0	270
Urban Lawn	Fine Sandy Loam	75	351	0.60	211	140
Pasture/Shrub	Fine Sandy Loam	150	306	0.65	199	107
Mature Forest	Fine Sandy Loam	300	300	0.70	210	90

Table I-3: Water Balance Calculation
2596 Carp Road
Ottawa, Ontario

Land use	Surficial Soil	Water Holding Capacity	Area	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(mm)	(m^2)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)
Impervious Surfaces	n/a	n/a	23,830	885	21,090	177	4,218	708	16,872	0	0	708	16,872
Water	n/a	n/a	5,010	885	4,434	615	3,081	270	1,353	0	0	270	1,353
Urban Lawn	Fine Sandy Loam	75	4,100	885	3,629	534	2,189	351	1,439	211	865	140	574
Pasture/Shrub	Fine Sandy Loam	150	199,380	885	176,451	579	115,441	306	61,010	199	39,677	107	21,334
Mature Forest	Fine Sandy Loam	300	55,430	885	49,056	585	32,427	300	16,629	210	11,640	90	4,989
TOTAL			**287,750**		**254,660**		**157,356**		**97,303**		**52,182**		**45,122**

Post-Development - Estimated Annual Average Water Balance

Land use	Surficial Soil	Water Holding Capacity	Area	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(mm)	(m^2)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)
Impervious Surfaces	n/a	n/a	49,750	885	44,029	177	8,806	708	35,223	0	0	708	35,223
Water	n/a	n/a	5,010	885	4,434	615	3,081	270	1,353	0	0	270	1,353
Urban Lawn	Fine Sandy Loam	75	3,370	885	2,982	534	1,800	351	1,183	211	711	140	472
Pasture/Shrub	Fine Sandy Loam	150	174,190	885	154,158	579	100,856	306	53,302	199	34,664	107	18,638
Mature Forest	Fine Sandy Loam	300	55,430	885	49,056	585	32,427	300	16,629	210	11,640	90	4,989
TOTAL			**287,750**		**254,659**		**146,970**		**107,690**		**47,015**		**60,675**
			% Change				-7%		11%		-10%		34%

Mitigated Post-Development - Estimated Annual Average Water Balance

Land use	Surficial Soil	Water Holding Capacity	Area	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(mm)	(m^2)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)	(mm/a)	(m^3/a)
Impervious Surfaces - Other than Concrete Plant	n/a	n/a	23,830	885	21,090	177	4,218	708	16,872	0	0	708	16,872
Impervious Surfaces - Concrete Plant	n/a	n/a	25,920	885	22,939	177	4,588	708	18,351	637	16,516	71	1,835
Water	n/a	n/a	5,010	885	4,434	615	3,081	270	1,353	0	0	270	1,353
Urban Lawn	Fine Sandy Loam	75	3,370	885	2,982	534	1,800	351	1,183	211	711	140	472
Pasture/Shrub	Fine Sandy Loam	150	174,190	885	154,158	579	100,856	306	53,302	199	34,664	107	18,638
Mature Forest	Fine Sandy Loam	300	55,430	885	49,056	585	32,427	300	16,629	210	11,640	90	4,989
TOTAL			**287,750**		**254,659**		**146,970**		**107,690**		**63,531**		**44,159**
			% Change				-7%		11%		22%		-2%

APPENDIX J

Well Interference Assessment

S (-)	1.00E-04
t (years)	20
t (d)	7300
T (m^2/sec)	4.00E-03
T (m^2/day)	3.46E+02

s = (0.183*(Q/T))*LOG((2.25*T*t)/(S*r^2))

Drawdown due to TW5/TW6 pumping:

Q (L/day)	544320
Q (m^3/day)	544.32
r (m)	175
Drawdown (m)	**1.81**

Drawdown due to House Well pumping:

Q (L/day)	2700
Q (m^3/day)	2.7
r (m)	70
Drawdown (m)	**0.01**

Total Drawdown (m) **1.82**

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