Hydrogeological Study in Support of Draft Plan - Phase 2

Rainsong Land Development Inc.
Barrie, Ontario

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1.0 Introduction

R.J. Burnside & Associates Limited (Burnside) has been retained by Rainsong Development Inc. to complete a hydrogeological assessment in support of a draft plan of subdivision for their Phase 2 lands. The overall Rainsong lands, are located north of Lockhart Road and west of Yonge Street in the City of Barrie, Ontario (Figure 1). The Phase 2 lands (herein referred to as the subject lands) are located on the southern portion of the Rainsong lands bounded by Lockhart Road to the south.

The subject lands are located within the Barrie Annexed Lands and the OPA 39 Hewitt's Secondary Plan Area (SPA) located on the southern boundary of the City of Barrie. In 2016, a Subwatershed Impact Study (SIS) for the Hewitt's SPA was completed for the Hewitt's Creek Landowners Group that included an assessment of regional hydrogeology (Burnside, 2016). The SIS included recommendations for additional studies to be done in support of draft plan approvals for the individual parcels within the Hewitt's SPA. The current assessment is aimed at updating information contained in the SIS and providing more detailed site-specific information in support of an application for draft plan approval for the Phase 2 lands. This report describes the geological conditions of the entire Rainsong lands but focuses on the monitoring results for the Phase 2 lands.

1.1 Scope of Work

The scope of work completed for the hydrogeological study was developed to build upon the more regional work completed for the Hewitt's SPA (Burnside, 2016) and to address requirements for hydrogeological studies in support of draft plan approval. The scope of work included completion of the following tasks:

1. Review of published geological and hydrogeological information: A review of background material for the area, including topography, surficial geology and bedrock geology mapping and existing geotechnical and hydrogeological reports was completed to assess the regional hydrogeological setting.

2. Review of the Ministry of the Environment, Conservation and Parks (MECP) water well records: The MECP maintains a database that provides geological records of water supply wells drilled in the province. A list of the available MECP water well records for local wells is provided in Appendix A and the well locations are plotted on Figure 5. It is noted that the well locations listed in the MECP records are approximations only and may not be representative of the precise well locations in the field. These well data were compiled and mapped to characterize the local groundwater resources and assess potential impacts to the local private wells from development of the subject lands.

3. Install groundwater monitoring network: Groundwater monitoring locations were established to characterize seasonal variations in the water table in both the shallow and deep aquifers. Monitoring wells were completed as part of previous studies and monitoring was completed manually and using data loggers between May 2017 and December 2020. The locations of the monitoring wells are shown on Figure 2 and monitoring well construction details are provided on the borehole logs in Appendix B.

4. Hydraulic conductivity testing: Burnside conducted single well response tests in order to determine hydraulic conductivity. Single well response tests were attempted at four groundwater monitoring wells (RS-1 and RS-3d) in 2017. The hydraulic conductivity field testing results are provided in Appendix C.

5. Monitoring of groundwater levels: Monitoring has been completed to measure the depth to the water table and assess the horizontal and vertical groundwater flow conditions. Groundwater level monitoring was completed from May 2017 to December 2020. Automatic water level recorders (dataloggers) were installed in three monitoring wells to document the range of groundwater fluctuations and the response of aquifers to precipitation events (RS-1 and RS-3d). Barometric data from a barologger installed in the vicinity of the subject lands were used for calibration of the datalogger results. The groundwater monitoring data and hydrographs are provided in Appendix D.

6. Water quality review and testing: Water quality data was collected to typify the groundwater quality in the vicinity of the subject lands. A groundwater sample was collected from RS-3s in 2017 and submitted to a qualified laboratory for analyses of general water quality indicators (e.g., pH, hardness, and conductivity), basic ions (including chloride and nitrate) and selected metals to characterize the background water quality at the property. The laboratory water quality data are provided in Appendix E.

7. Water balance calculations: Pre and post-development water balance calculations have been completed to assess the groundwater infiltration volumes across the study area. The local climate data and detailed water balance calculations are provided in Appendix F.

8. Data compilation, assessment of site conditions and reporting.

2.0 Physical Setting

2.1 Topography and Drainage

The Rainsong lands are located within the Lake Simcoe watershed and straddle the boundary between the Lovers Creek Subwatershed and Hewitt's Creek Subwatershed. The subject lands (Figure 3) are at the southern portion of the overall Rainsong lands with the majority of the subject lands being within the Lovers Creek subwatershed. The northern extremity of the subject lands is located in the Hewitt's Creek subwatershed (Figure 3). The topography of the subject lands is generally flat to gently rolling with the highest elevation generally located along the subwatershed divide of Lovers Creek and Hewitt's Creek at an elevation of 271.6 meters above sea level (masl). The lowest portion of the subject lands is located in the southwest corner at Lockhart Road at an elevation of approximately 263 masl. There are no watercourses on the subject lands.

2.2 Geology

The subject lands are located in the physiographic region known as the Peterborough Drumlin Field. The region is characterized as a rolling drumlinized till plain. The drumlins through the region are comprised of highly calcareous till (Chapman & Putnam, 1984).

The overburden was deposited as a series of advances and retreats of the Simcoe glacial ice lobe. This has resulted in drumlinized sheets of glacial till (Newmarket till), stratified glaciolacustrine deposits of sand and gravel, littoral-foreshore deposits and massive-well laminated deposits of sand and gravel. A review of the quaternary geology mapping for the area (OGS, 2010) indicates that the overburden sediments of the subject lands consist of silty to sandy glacial till with an area of glaciofluvial ice contact stratified sediments of sand and gravel found in the center of the subject lands (Figure 4).

The bedrock underlying the subject lands is mapped as the Lindsay Formation of the Simcoe Group, which consists of limestone and shale (OGS, 2007).

2.3 Regional Hydrostratigraphy

The overburden deposits of the subject lands influence groundwater occurrence and flow. The overburden has been interpreted by regional studies such as the Tier 3 Water Balance (AquaResource, 2011) and Source Water Protection Assessment Report (LSRCA, 2012) to consist of alternating sequences of coarser-grained permeable areas (aquifers) and finer-grained less permeable areas (aquitards) of varying thicknesses. The basic hydrostratigraphic sequence that was modelled in the regional studies (AquaResource, 2011) consists of four main aquifer areas (A1-A4) and four main aquitards (C1 to C4) with a confining layer (UC) over the uppermost aquifer (A1).

A description of the interpreted regional hydrostratigraphic framework is provided below (LSRCA, 2012):

- Surficial Geology Layer – This layer represents coarse grained sediments in stream beds and at surface surficial geology areas that overly the UC. The thickness ranges from 0.1 m to 3 m.
- UC – Upper Confining Layer – Represents smaller areas of less permeable surficial material. The upper confining layer has been mapped as coarse-grained lacustrine deposits which are part of a regionally extensive sand plain (LSRCA, 2012). Regional studies such as the AquaResource (2011) report indicate that the confining layer (UC) is patchy in the area of the study area.
- A1 – Represents the uppermost aquifer. Frequently exists as a surficial unconfined aquifer and is stratigraphically equivalent to the Oak Ridges Moraine. It is generally associated with coarse grained glacial and interglacial sediments mapped as ice contact stratified drift. The majority of the local domestic wells are completed within this area. The upper aquifer A1 is reported to be present throughout the larger Barrie area, and has been interpreted to occur extensively in the study area.
- C1 – Upper aquitard. Described as varved clay and silt (LRSCA, 2012).
- A2 – Intermediate aquifer which is stratigraphically equivalent to areas within the Northern Till. The aquifer is generally described as being composed of sand with some clast rich portions (LRSCA, 2012). This area is used for the Innisfil Heights water supply.
- C2 – Intermediate aquitard.
- A3 – This area constitutes the main Barrie municipal aquifer and is the source of the Stroud water supply; it is stratigraphically equivalent to the Thorncliffe deposits in the Upland regions.
- C3 – Lower aquitard.
- A4 – Lower aquifer, thin and sometimes combined with A3 where C3 is thin or absent.
- C4 – Lower aquitard but may also represent weathered bedrock.

2.4 Local Stratigraphy

Logs for boreholes completed on and in the vicinity of the subject lands were reviewed to characterize the stratigraphy of the subject lands. The reviewed logs are provided in

Appendix B and locations are shown on Figure 5. The boreholes logs indicate that the overburden stratigraphy is generally composed of layers of glacial till and sand. The till deposits were generally composed of sandy silt to silty sand with varying amounts of clay and gravel. Some lenses of finer grained sediments were encountered in the boreholes that are interpreted to be discontinuous. Silty clay was encountered below the topsoil at RS-3 and BH06-5. The clayey silt extended to depths of 0.7 m to 2.1 m. A deposit of clayey silt till was encountered at BH06-9 at a depth of 4.0 m and sandy silty clay with a thickness of approximately 0.7 m was encountered at RS-1 at a depth of 4.5 m.

To illustrate the shallow hydrostratigraphic sequence of the subject lands, schematic geologic cross-sections have been prepared by Burnside (Figures 6 and 7) using the MECP well records (Appendix A) and the soils information collected during drilling of boreholes and monitoring wells (Appendix B). The locations of the cross-sections are illustrated on Figure 5 along with the locations of water wells and boreholes used in the construction of the cross-sections. The cross-sections illustrate that the subject lands are underlain by a sandy silt to silty sand till with a thickness of approximately 5 m to 10 m. Underlying the till is a sand layer which is interpreted to form the local aquifer where supply wells are completed to depths that are generally less than 20 m to 30 m below ground surface. The sand layer is underlain by a low permeability clay silt till (Figures 6 and 7).

2.5 Hydraulic Conductivity

There are various methods that can be used to assess soil hydraulic conductivity, i.e., the ability of the soil to transmit groundwater. Grainsize data and soil characteristics can be used to provide a general estimate of hydraulic conductivity. In situ bail-down or slug-testing methods are used in groundwater monitoring wells to assess site-specific hydraulic conductivity. These methods have been used to estimate the hydraulic conductivity of the soils encountered in the study area as discussed below.

2.5.1 Grainsize Analysis

During drilling of monitoring wells, representative soil samples of soil types that were encountered were collected and submitted for grainsize analysis. Grainsize analyses from the geotechnical report (Golder, 2006) were also reviewed and included in our analysis. A summary of the grainsize analyses is provided in Table 1 (data provided in Appendix C).

Table 1: Summary of Grainsize Analyses

Sample ID	Depth of Sample (mbgs)	Soil Classification	% Fines
RS-1 SS7	4.6	Sandy Silty Clay	70
RS-3d SS13	4.6	Sand, trace silt, trace gravel	2
BH06-3-SS6	4.6	Sand	8
BH06-6-SS5	3.0	Sand	12

To estimate hydraulic conductivity based on grainsize analysis, an empirical formula method known as the Hazen estimation is used. The Hazen estimation is an approximation of hydraulic conductivity based on grainsize curves for sandy soils. The approximation does not strictly apply to finer grained materials; however, it is still considered useful to provide a general indication of the range of the hydraulic conductivity values. Hydraulic conductivity values were derived empirically using the Hazen method for representative samples from the subject lands. The grainsize distribution graphs for the selected samples are provided in Appendix C and the calculated hydraulic conductivity values are provided in Table 2.

Table 2: Estimated Hydraulic Conductivity Based on Grainsize Analyses

Sample ID	Soil Classification	Hydraulic Conductivity (cm/s)
RS-3d SS13	Sand, trace silt, trace gravel	2.7×10^{-2}
BH06-3-SS6	Sand	8.1×10^{-3}

2.5.2 Single Well Response Tests

To assess the in-situ hydraulic conductivity of the sediments, single well response tests (bail-down tests) were conducted at monitoring wells RS-1 and RS-3d. The results from the tests were plotted (Appendix C) and analyzed to calculate hydraulic conductivity of the sediments screened. A summary the calculated hydraulic conductivities is provided below in Table 3.

Table 3: Single Well Response Testing Results

Monitoring Well	Screen Interval (mbgs)*	Formation Screened	Hydraulic Conductivity (cm/sec)
RS-1	6.1 – 8.4	Sand	1.3×10^{-3}
RS-3d	8.5 – 10.7	Sand, trace silt, trace gravel	6.3×10^{-3}

*metres below ground surface

2.5.3 Hydraulic Conductivity Discussion

Grainsize analyses results indicate that the sediments within the overburden range in composition from sand with trace silt and trace gravel (2% fines) to sandy silty clay (70% fines). The amount of fines within a deposit impacts the ability of the material to transmit water and a greater amount of fines generally lowers the overall hydraulic conductivity. Groundwater flow is generally limited within fine grained sediments with lower hydraulic conductivity.

Grainsize analysis completed on the subject lands illustrates the range of sediments and associated hydraulic conductivity that are found on the subject lands. It is noted that there are some sediments with lower hydraulic conductivity, but the majority of the sediments are sand and silty sand. The hydraulic conductivities based on grainsize analyses and single well response testing were in the range of 10^{-2} to 10^{-3} cm/sec. The wells tested were all screened in the surficial sand layer which forms the local surficial aquifer.

3.0 Hydrogeology

3.1 Local Groundwater Use

The City of Barrie obtains its water from a combination of groundwater and surface water based supplies. Municipal servicing is assumed to be available for lands within the municipal city boundary which includes lands north of Mapleview Drive (Figure 2). Areas outside of municipal servicing or areas within neighbouring municipalities are assumed to have individual private water supply wells. A review of the MECP water well records indicated that there are approximately 56 water supply well records within 500 m of the subject lands. Based on the well records and interpreted hydrostratigraphy, most of these wells are completed in the surficial (local) aquifer with depths ranging from 6 m to 64 m. The locations of the MECP water well records are shown on Figure 5.

The City of Barrie groundwater supply wells are located in deep aquifers (A3 and A4 in the regional hydrostratigraphy). There are no municipal water supply wells located close to the subject lands; the municipal water supply wells are located on the west and northern sides of the City and are over six kilometers north of the subject lands. The subject lands do not fall within any wellhead protection areas or intake protection zones associated with the City of Barrie water supply systems (LSRCA, 2012) however the Stroud water supply is located approximately 1.5 km south (upgradient) of the subject lands.

3.2 Water Level Monitoring Results

Groundwater levels were monitored at the on-site monitoring wells between May 2017 and December 2020. Groundwater level data for onsite wells and wells in the vicinity of the Phase 2 lands are provided in tables and hydrographs in Appendix D. Groundwater elevations are plotted with daily precipitation data obtained from a nearby climate station – Barrie-Oro (Climate Station ID# 6117700) – which is the closest station with daily precipitation values for monitoring period. In addition to the manual water level measurements recorded at each location, automatic water level recorders were installed in RS-1 and RS-3d to record continuous water levels. The datalogger data collected are included on the hydrographs provided in Appendix D.

As part of the SIS study for the Hewitt's Creek SPA monitoring wells (MW9 and MW13) were installed in the vicinity of the subject lands (Burnside, 2016). These wells were monitored on a quarterly basis during the study period and data from these locations has been incorporated into the current study. Monitoring well logs from these studies are provided in Appendix B and locations are shown on Figure 6. Hydrographs for these wells are provided in Figures D-9 to D-10, Appendix D.

The groundwater monitoring data show the following (refer to Figure 2 for the monitoring locations and the data tables and hydrographs in Appendix D):

- Typically, in shallow wells in southern Ontario, a seasonal groundwater level pattern is apparent with highest levels occurring in the spring, declining throughout the summer and early fall and then rising again in the late fall/early winter. The seasonal variation observed at the monitoring wells on the Phase 2 lands ranged from 0.7 m to 1.4 m.

- Continuous water level data are plotted against precipitation to determine if there is a correlation between changes in water level and the occurrence of precipitation events (Figures D-1, D-3 and D-7). A response in water levels is observed at RS-3s after large precipitation events (>20 mm) (Figure D-3).
- The groundwater table is interpreted to generally reflect the topography of the area. During the monitoring period, groundwater elevations in the monitoring wells on the Phase 2 lands ranged from 261 masl to 264.8 masl. Groundwater was shallowest at MW13 with levels around 1 m below ground surface (Figure D-10, Appendix D) and deepest at RS-2 with levels around 6 to 7 m below ground surface (Figure D-2, Appendix D).

3.3 Interpreted Groundwater Flow Pattern

Groundwater flow within the shallow overburden (water table) is interpreted to be influenced by the surface topography with groundwater flow from the topographically higher areas towards topographically lower areas and surface water features. Groundwater elevation data (July 2017) obtained from the monitoring wells are shown on Figure 8, along with the interpreted groundwater elevation contours for the area. The subject lands are located at a topographical high point for the surrounding lands. Arrows perpendicular to the groundwater elevation contours shown on Figure 8 illustrate the interpreted direction of the groundwater movement.

3.4 Recharge and Discharge Conditions

Areas where water from precipitation infiltrates into the ground and moves downward (i.e., areas of downward hydraulic gradients) are known as recharge areas. These areas are generally in areas of relatively higher topographic elevation. Areas where groundwater moves upward (i.e., areas of upward hydraulic gradients) are discharge areas and these generally occur in areas of relatively lower topographic elevation, such as along watercourses.

The monitoring of groundwater levels in nested wells RS-3s/d was intended to assist with the determination of vertical hydraulic gradients and thereby to assist with the evaluation of groundwater recharge or discharge conditions in the subject lands. The water levels recorded in RS-3s/d do not show strong vertical groundwater gradients due to the similarity in the groundwater levels (Figure D-3, Appendix D). At RS-3s/d, the wells are screened in the same silty sand/sandy silt formation with a difference in the screened interval of 2.3 m (Appendix B). The absence of vertical gradient in the nested wells suggests lateral groundwater flow predominates in these areas. This is consistent with the interpretation that the groundwater flow systems in the region are topographically driven ‘local’ groundwater flow systems within each subwatershed area (Burnside, 2016). Discharge conditions (upward gradients) tend to be found in the topographically lowest areas such as along watercourse valleys. Since the subject lands are generally topographically high compared to surrounding lands, discharge areas are not expected on the subject lands.

3.5 Significant Groundwater Recharge Areas and Ecologically Significant Groundwater Recharge Areas

Significant Groundwater Recharge Areas (SGRAs) can be described as areas that can effectively move water from the surface through the unsaturated soil zone to replenish available groundwater resources (LSRCA, 2012). SGRAs were mapped by the Source Water Protection Assessment Report (LSRCA, 2012) as a requirement of the Clean Water Act, 2006 and based on guidance provided by the MECP. The delineation of these areas was completed using numerical models and analyses that included the evaluations of numerous factors including precipitation, temperature and other climate data along with land use, soil type, topography and vegetation to predict groundwater recharge, runoff and evapotranspiration. SGRAs represent areas where the annual recharge rate is greater than 115% of the average recharge of 164 mm/year across the Lake Simcoe watershed (or greater than the threshold recharge rate of 189 mm/year) (LSRCA, 2012). SGRAs within the subject lands are mapped in Figure 9.

The areas on the subject lands that are mapped as SGRAs generally correspond with areas mapped as ice contact stratified deposits on the published geology maps (Figure 4). Soils encountered during the drilling investigations generally agreed with the surficial geology mapping. Monitoring well RS-2 is located in an area mapped as a SGRA. A review of water level data from RS-2 shows that the groundwater is deep and the sand content noted in the log for RS-2 suggests a relatively high recharge capacity therefore groundwater recharge conditions are likely.

Ecologically Significant Groundwater Recharge Areas (ESGRAs) were delineated for the Barrie Creek, Lovers Creek and Hewitt's Creek subwatersheds by Earthfx (2012) using the model developed by AquaResources for the Source Protection studies. ESGRAs were identified as areas of land that are assumed to support groundwater systems or environmentally sensitive features like lakes, cold water streams and wetlands (Earthfx, 2012). ESGRAs were delineated by identifying pathways in which recharge, if it occurred, would reach an ecologically significant feature. Ecologically significant features used for the delineation of the ESRGAs included headwater streams, cold water fisheries, wetlands, and brook trout and sculpin capture sites.

ESGRAs and SGRAs are not mutually exclusive. ESGRAs are determined based on the linkage between a recharge area and an ecologically sensitive area while SGRAs are located where high volumes of recharge are assumed to occur. The locations of mapped SGRAs and ESGRAs on the subject lands are shown in Figure 9. The ESGRA locations are generally along the western and eastern boundaries of the subject lands.

The wells RS-2 and RS-3s/d are located in ESGRAs (Figure 9). The deep water table encountered at RS-2 suggests that conditions would be favourable for recharge. The lack of gradient observed at RS-3s/d (as discussed in Section 3.4) suggests that lateral flow is greater than vertical flow. ESRGAs mapped along the eastern portion of the subject lands are assumed to be supporting the St. Paul's Swamp (Figure 9) while the ESRGA mapped on the southwest portion of the subject lands is assumed to be supporting the Lovers Creek Swamp. Groundwater contours interpreted for the subject lands (Figure 8) support this interpretation.

3.6 Aquifer Vulnerability

Aquifer vulnerability refers to the susceptibility of the aquifer to potential contamination. Some degree of protection for groundwater quality from natural and human impacts is provided by the soil above the water table. The degree of protection is dependent upon the depth to the water table (for unconfined aquifers) or the depth of the aquifer (for confined aquifers) and the type of soil above the water table or aquifer. As these two properties vary over any given area, the degree of protection or vulnerability of the groundwater to contamination also varies.

The aquifer vulnerability for the subject lands was mapped in the Lake Simcoe and Couchiching-Black River SPA Part 1 Approved Assessment Report, Lake Simcoe Region Conservation Authority, 2015. The approach used by the LSRCA to create a regional vulnerability map was the aquifer vulnerability index (AVI) method. Using water well records for the area to determine the soil types and depths to aquifer an AVI was calculated for each delineated aquifer to produce a map of regional groundwater vulnerability. The high aquifer vulnerability mapping for the subject lands is provided in Figure 10. The entirety of the subject lands are mapped with a high vulnerability.

Depending on land use, runoff from urban developments may contain a variety of dilute contaminants such as suspended solids, chloride from road salt, oil and grease, metals, pesticide residues, bacteria and viruses. For groundwater, generally, with the exception of the dissolved constituents such as nitrogen and salt, most contaminants are attenuated by filtration during groundwater transport through the soils. The potential for effects on local groundwater quality from infiltration in the urban areas is therefore expected to be limited. The regional mapping can be reviewed in the context of the local site-specific information provided by the monitoring wells and interpreted as part of this study. It is noted from the geological cross sections (Figures 6 and 7) that a layer of sandy silt till overlies the surficial sand aquifer that local wells are screened in. This layer will provide some protection to the underlying sand aquifer and reduce the vulnerability based on the local information when compared to the indicated vulnerability from the regional data.

4.0 Water Quality

4.1 Groundwater Quality

Water quality data was collected monitoring well RS-3s to typify the groundwater quality in the vicinity of the subject lands. The samples were collected on August 30, 2017 and submitted to a qualified laboratory for analyses of general water quality indicators (e.g., pH, hardness, and conductivity), basic ions (including chloride and nitrate) and selected metals to characterize the background water quality.

For comparison purposes, the Ontario Drinking Water Quality Standards (ODWQS) and the Provincial Water Quality Objectives (PWQO) are provided with the results on Table E-1, Appendix E. The groundwater will not be used for drinking water however the ODWQS provides an indication of acceptable concentrations for potable water. The PWQO provide an indication of whether the groundwater on the subject lands could be discharged to surface water should pumping associated to construction be required. The groundwater testing results from the analytical laboratory are provided in Table E-1, Appendix E and discussed below:

- The results showed that the water generally met the Ontario Drinking Water Quality Standards (ODWQS).

- The sample exceeded the ODWQS for total hardness (100 mg/L) with a value of 310 mg/L (RS-3s). Hardness in groundwater is caused by dissolved calcium and magnesium and is typically related to the geologic material of the aquifer.

- The sample also exceeded the ODWQS for turbidity (5 NTU) with a value of 1310 NTU (RS-3s). This is likely a result of high silt content in the sample.

- Nitrate was detected at RS-3s at a concentration of 9.78 mg/L which is very close to the ODWQS for nitrate, 10 mg/L. Nitrate in shallow groundwater is typical of areas where agricultural activities are present.

- Total phosphorus was reported at a concentration of 0.52 mg/L which exceeds the PWQO of 0.03 mg/L. Elevated phosphorus is another indication of impacts to the groundwater from agricultural activities in the vicinity of the subject lands. Total phosphorus is a measure of all forms of phosphorus (dissolved or particulate) that are found in the water sample. There was no dissolved phosphorus (ortho-phosphate) reported in the groundwater sample suggesting the reported concentration is a result of particulate that will settle out with erosion and sediment control measures.

5.0 Water Balance

In order to assess potential land development impacts on the local groundwater conditions, a detailed water balance analysis has been completed to determine the pre-development recharge volumes (based on existing land use conditions) and the post-development recharge volumes that would be expected based on the proposed land use plan. The detailed water balance calculations are provided in Appendix F.

5.1 Water Balance Components

A water balance is planning tool that is useful as an accounting of the water resources within a given area. As a concept, the water balance is relatively simple and may be estimated from the following equation:

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

Where:
P = precipitation
S = change in groundwater storage
ET = evapotranspiration/evaporation
R = surface water runoff
I = infiltration

The components of the water balance vary in space and time and depend on climatic conditions as well as the soil and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Runoff, for example, occurs particularly during periods of snowmelt when the ground is frozen, or during intense rainfall events. Precise measurement of the water balance components is difficult and as such, approximations and simplifications are made to characterize the water balance of a property. Field observations of the drainage conditions, land cover and soil types, groundwater levels and local climatic records are important input considerations for the water balance calculations.

The groundwater balance components for the subject lands are discussed below:

Precipitation (P)

The long-term average annual precipitation for the subject lands is assumed as 933 mm based on data from the Environment Canada Barrie WPCC (Station 6110557, 44°22'33.012" N, 79°41'23.010" W, elevation 221.0 masl) for the period between 1981 and 2010. The climate station is located 6 km northeast of the subject lands and is inferred to provide data representative of the subject lands. Average monthly records of precipitation and temperature from this station have been used for the water balance calculations in this study (Appendix F).

Storage (S)

Although there are groundwater storage gains and losses on a short-term basis, the net change in groundwater storage on a long-term basis is assumed to be zero so this term is dropped from the equation.

Evapotranspiration (ET)

Evapotranspiration and evaporation components vary based on the characteristics of the land surface cover (i.e., type of vegetation, soil moisture conditions, perviousness of surfaces, etc.). Potential evapotranspiration (PET) refers to the water loss from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of evapotranspiration (AET) is generally less than the PET under dry conditions (i.e., during the summer when there is a soil moisture deficit). In this report, the PET and AET have been calculated using a soil-moisture balance approach.

Water Surplus (R + I)

The difference between the mean annual P and the mean annual ET is referred to as the water surplus. Part of the water surplus travels across the surface of the soil as surface or overland runoff (R) and the remainder infiltrates the surficial soil (I). The infiltration is comprised of two end member components: one component that moves vertically downward to the groundwater table (referred to as recharge) and a second component that moves laterally through the topsoil profile or shallow soils as interflow that re-emerges locally to surface (i.e., as runoff) at some short time following cessation of precipitation. As opposed to the “direct” component of surface runoff that occurs during precipitation or snowmelt events, interflow becomes an “indirect” component of runoff. The interflow component of surface runoff is not accounted for in the water balance equation cited above since it is often difficult to distinguish between interflow and direct (overland) runoff, however both interflow and direct runoff together form the total surface water runoff component.

5.2 Approach and Methodology

The analytical approach to calculate the water balance involves monthly soil-moisture balance calculations to determine the pre-development (based on existing land use) infiltration volumes. A soil-moisture balance approach assumes that soils do not release water as potential recharge while a soil moisture deficit exists. During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deep infiltration).

A soil moisture storage capacity of 150 mm was used for the pre-development agricultural land cover of predominantly short to moderate-rooted vegetation (Table F-1, Appendix F). A soil moisture storage capacity of 75 mm was used to represent the post-development vegetation which will be dominantly urban lawn (Table F-2, Appendix F). Tables F-1 and F-2 in Appendix F detail the monthly potential evapotranspiration calculations accounting for latitude and climate, and then calculate the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions.

The MECP SWM Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used and a corresponding runoff component was calculated for the soil moisture storage conditions. The calculated water balance components from this table are then used to assess the pre-development and post-development volumes for runoff and infiltration as presented on Table F-3 in Appendix F.

5.3 Water Balance Component Values

The detailed monthly calculations of the water balance components are provided in Tables F-1 and F-2 in Appendix F. For these calculations, it has been assumed that sandy loam soils are representative for the subject lands for estimating the soil infiltration factor. The calculations show that a water surplus is generally available from November to May. The monthly water balance calculations illustrate how infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. The monthly calculations are summed to provide estimates of the annual water balance component values (Tables F-1 and F-2, Appendix F). A summary of these values is provided in Table 4.

Table 4: Water Balance Component Values

Water Balance Component	Agricultural Lands	Urban Lawn
Average Precipitation	933 mm/year	933 mm/year
Actual Evapotranspiration	593 mm/year	555 mm/year
Water Surplus	340 mm/year	378 mm/year
Infiltration	238 mm/year	283 mm/year
Runoff	102 mm/year	94 mm/year

5.4 Pre-Development Water Balance (Existing Conditions)

The pre-development water balance calculations are presented in Table F-3 in Appendix F. As summarized on Table F-3, the total area of the subject lands is about 24.46 ha. The water balance component values from Table F-1 were used to calculate the average annual volume of infiltration across the subject lands. Based on these component values, the pre-development infiltration volume for the subject lands is calculated to be about 58,200 m^3/year (Table F-3 Appendix F).

5.5 Potential Urban Development Impacts to Water Balance

Development of an area affects the natural water balance. The most significant difference is the addition of impervious surfaces as a type of surface cover (i.e., roads, parking lots, driveways, and rooftops). Impervious surfaces prevent infiltration of water into the soils and the removal of the vegetation removes the evapotranspiration component of the natural water balance. The evaporation component from impervious surfaces is relatively minor (estimated to be 10% to 20% of precipitation) compared to the evapotranspiration component that occurs with vegetation in this area (about 64% of precipitation in the study area). So, the net effect of the construction of impervious surfaces is that most of the precipitation that falls onto impervious surfaces becomes surplus water and direct runoff. The natural infiltration components (interflow and deep recharge) are reduced.

A water balance calculation of the potential water surplus for impervious areas is shown at the bottom of Table F-1 in Appendix F. There is an evaporation component from impervious surfaces and this is typically estimated to be between about 10% and 20% of the total precipitation. For the purposes of the calculations in this study, the evaporation has been estimated to be 15% of precipitation. The remaining 85% of the precipitation that falls on impervious surfaces is assumed to become runoff. Therefore, assuming an evaporation/loss from impervious surfaces of 15% of the precipitation, there is a potential water surplus from impervious areas of 793 mm/year.

It is noted that the proposed development will be serviced by municipal water supply and wastewater services. Therefore, there will be no impact on the water balance and local groundwater or surface water quantity and quality conditions related to any on-site groundwater supply pumping or disposal of septic effluent.

5.6 Post-Development Water Balance with No Mitigation

To assess potential development impacts on infiltration, the post-development infiltration volumes have been calculated for the subject lands on Table F-3 in Appendix F. The land use areas and the associated percentage imperviousness were based on the current design layout provided by the design engineers (SCS Consulting Group, December 2021).

The infiltration and runoff components for the post-development land uses have been calculated using the MECP SWM Planning and Design Manual (2003) methodology based on topography, soil type and land cover as shown on Table F-1 in Appendix F. In summary from these appendix tables, the average calculated post-development infiltration volume (without mitigation) is about 17,800 m^3/year.

Comparing the pre- and post-development infiltration volumes, shows that development has the potential to reduce the average infiltration on the subject lands from 58,200 m^3/year to 17,800 m^3/year, i.e., a reduction of about 40,400 m^3/year or 69%. These calculations assume no low impact development (LID) measures for stormwater management are in place.

It is noted that stormwater management for the subject lands have been included in the overall stormwater strategy for the Hewitt’s SPA that was outlined in the SIS (Burnside, 2016).

5.7 Recommended Mitigation Strategies for Infiltration

The water balance calculations suggest that, without mitigation, the subject lands will receive about 31% of the current amount of average annual groundwater infiltration after development.

It is recommended to minimize the potential development impacts to infiltration through the use of ‘low impact development’ (LID) measures for stormwater management to ensure the post-development groundwater infiltration volume is maintained as close to the pre-development infiltration volume as possible. As outlined in the SIS (Burnside, 2016), stormwater management for the subject lands is to be managed in collaboration with adjacent lands.

The Functional Servicing Report (FSR) completed by SCS Consulting Ltd (SCS, 2022) provides an evaluation of potential LID measures and their feasibility on the subject lands. Given the soil conditions and groundwater levels observed on the subject lands, infiltration based LIDs are considered feasible in certain areas.

The FSR indicates that the selection of LIDs and quantification of proposed recharge achieved by them will be determined at the detailed design stage. Potential LIDs to be implemented on the subject lands include a centralized infiltration gallery (on Mattamy Lockhart lands) and rain gardens (SCS, 2022).

To demonstrate that pre-development infiltration can be achieved with the proposed LIDs, preliminary calculations have been completed based on details provided in the FSR (Table F-4, Appendix F). The calculations show that proposed LID measures can overcome the estimated deficit and potentially increase infiltration by 8%.

Infiltration rates of soils in the area of proposed LIDs should be confirmed with in-situ testing as part of detailed design.

6.0 Development Considerations

6.1 Construction Below the Water Table

Based on groundwater level data collected as part of this study water table on the subject lands ranges from 1 m to 7 m below ground surface.

The construction of buried services below the water table has the potential to capture and redirect groundwater flow through more permeable fill materials typically placed in the base of excavations. Groundwater may also infiltrate into joints in storm sewers and manholes. Over the long-term, these impacts can lower the groundwater table across the development area. To mitigate this effect, services to be installed below the water table should be constructed to prevent redirection of groundwater flow. This will involve the use of anti-seepage collars or clay plugs surrounding the pipes to provide barriers to flow and prevent groundwater flow along granular bedding material and erosion of the backfill materials.

Should excavations during construction of servicing extend below the water table the local soils may need to be dewatered. The undertaking of dewatering according to industry standards and in accordance with a MECP processes will ensure that adequate attention is paid to potential adverse impacts to the environment. Currently the MECP allows for construction dewatering of less than 400,000 L/d to proceed under the Environmental Activity Sector Registry (EASR) process. If dewatering is to be above this threshold, then the standard Permit to Take Water (PTTW) process applies. In both cases, a scientific study is required in support of EASR registration or PTTW application. This scientific study must review the potential for environmental impacts and provide mitigation and monitoring measures to the satisfaction of the MECP or other review agency. The requirements for construction dewatering will be confirmed by geotechnical/hydrogeological investigations completed in support of detailed design.

6.2 Local Groundwater Supply Wells

The area surrounding the subject lands is not currently serviced and residences are supplied by private wells. A water well survey has been completed on behalf of the Hewitt's Landowners Group to identify private water supply wells within 300 m of the Hewitt's SPA area (Burnside, 2019). The survey confirmed the location of private wells along Mapleview Drive, Yonge Street and Lockhart Road. Within 300 m of the subject lands, there were several shallow dug wells identified. A monitoring program for high-risk wells (shallow wells) has been commissioned by the Hewitt's Landowner Group starting in 2019. An impact contingency and mitigation plan for private well impacts has also been implemented (Burnside, 2019). The plan provides a mechanism for interference complaints to be addressed and for a temporary alternate water supply to be provided.

6.3 Well Decommissioning

Prior to or during construction, it is necessary to ensure that all inactive wells within the development footprint have been located and properly decommissioned by a licensed water well contractor according to Ontario Regulation 903. This regulation applies private domestic wells and to the groundwater observation wells installed for this study unless they are maintained throughout the construction for monitoring purposes.

7.0 References

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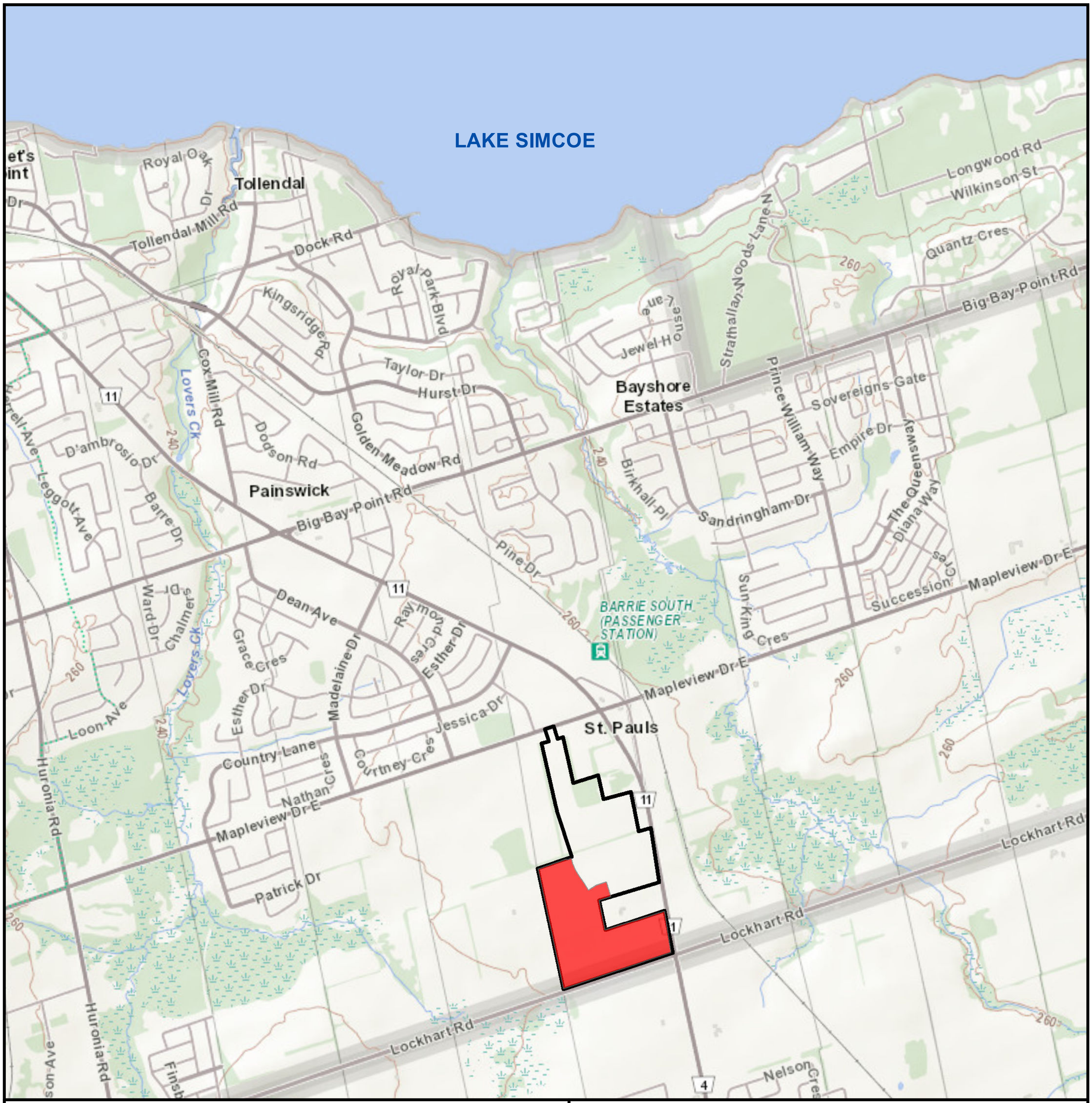
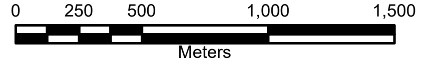
Figures

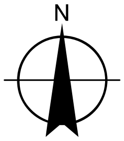


LEGEND

🟥 PHASE 2 LANDS

☐ RAINSONG LANDS





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RAINSONG LAND DEVELOPMENT INC.
BARRIE, ONTARIO

HYDROGEOLOGICAL ASSESSMENT
PHASE 2 LANDS

Figure Title:

SITE LOCATION

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LEGEND

🟥	PHASE 2 LANDS
⬛	RAINSONG LANDS
—	WATERCOURSE
●	MONITORING WELL (RJB, 2014)
●	MONITORING WELL (GOLDER, 2017)

Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario
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N

0 100 200 300 400
Metres

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PHASE 2 LANDS

Figure Title

SITE PLAN

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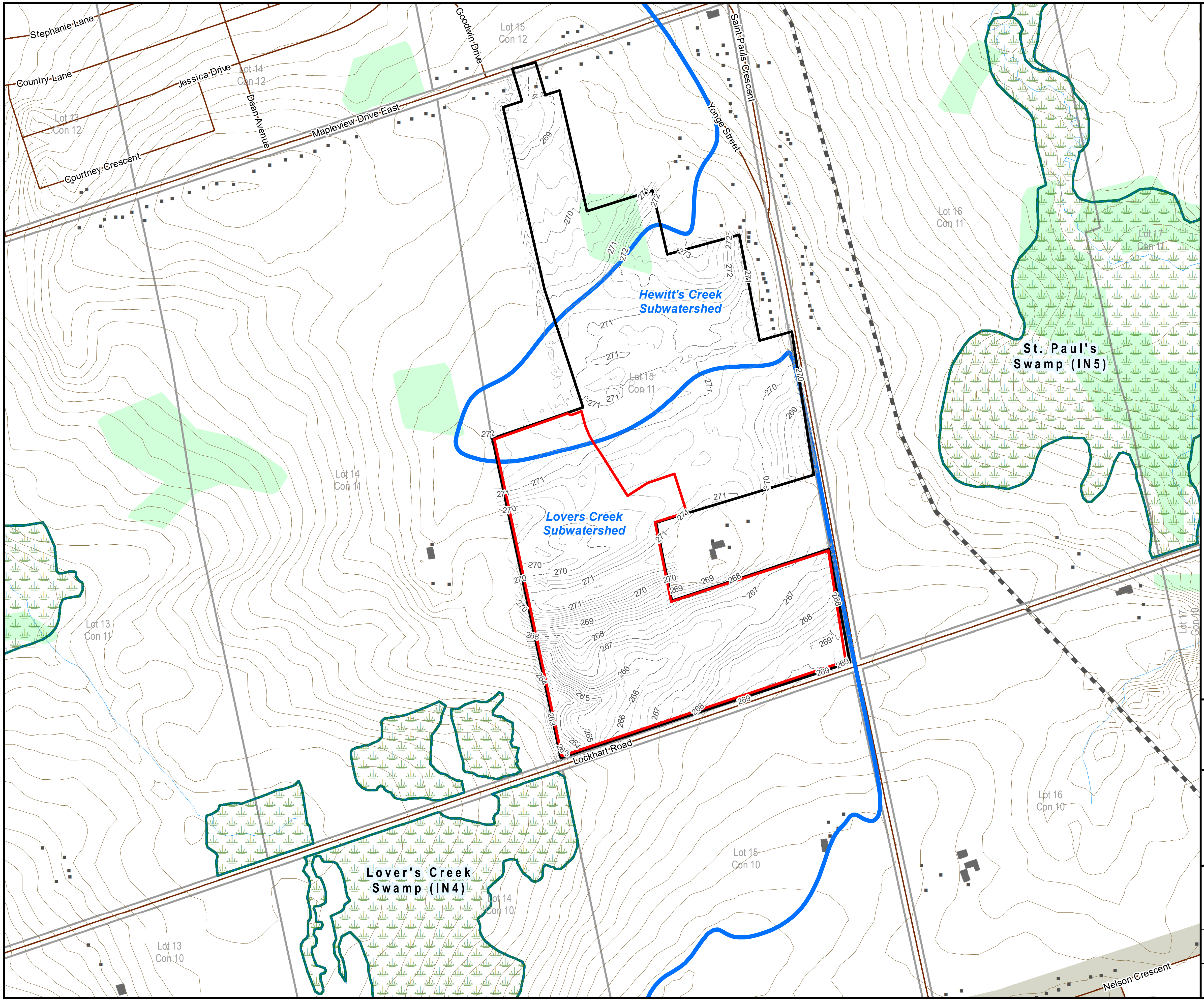

LEGEND

🟥	PHASE 2 LANDS
⬛	RAINSONG LANDS
—	CONTOUR (0.25m intervals)
—	SUBWATERSHED BOUNDARY
▬	RAILWAY
—	WATERCOURSE: PERMANENT
- -	WATERCOURSE: INTERMITTENT
—	ROADWAY
—	CONTOUR (1m intervals - masl)
—	CONTOUR (REGIONAL)
■	BUILDING
▨	WETLAND
▭	PROVINCIALLY SIGNIFICANT WETLAND
🟩	WOODED AREA

Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario
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0 100 200 300 400 500 600
Metres

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PHASE 2 LANDS

Figure Title

TOPOGRAPHY AND DRAINAGE

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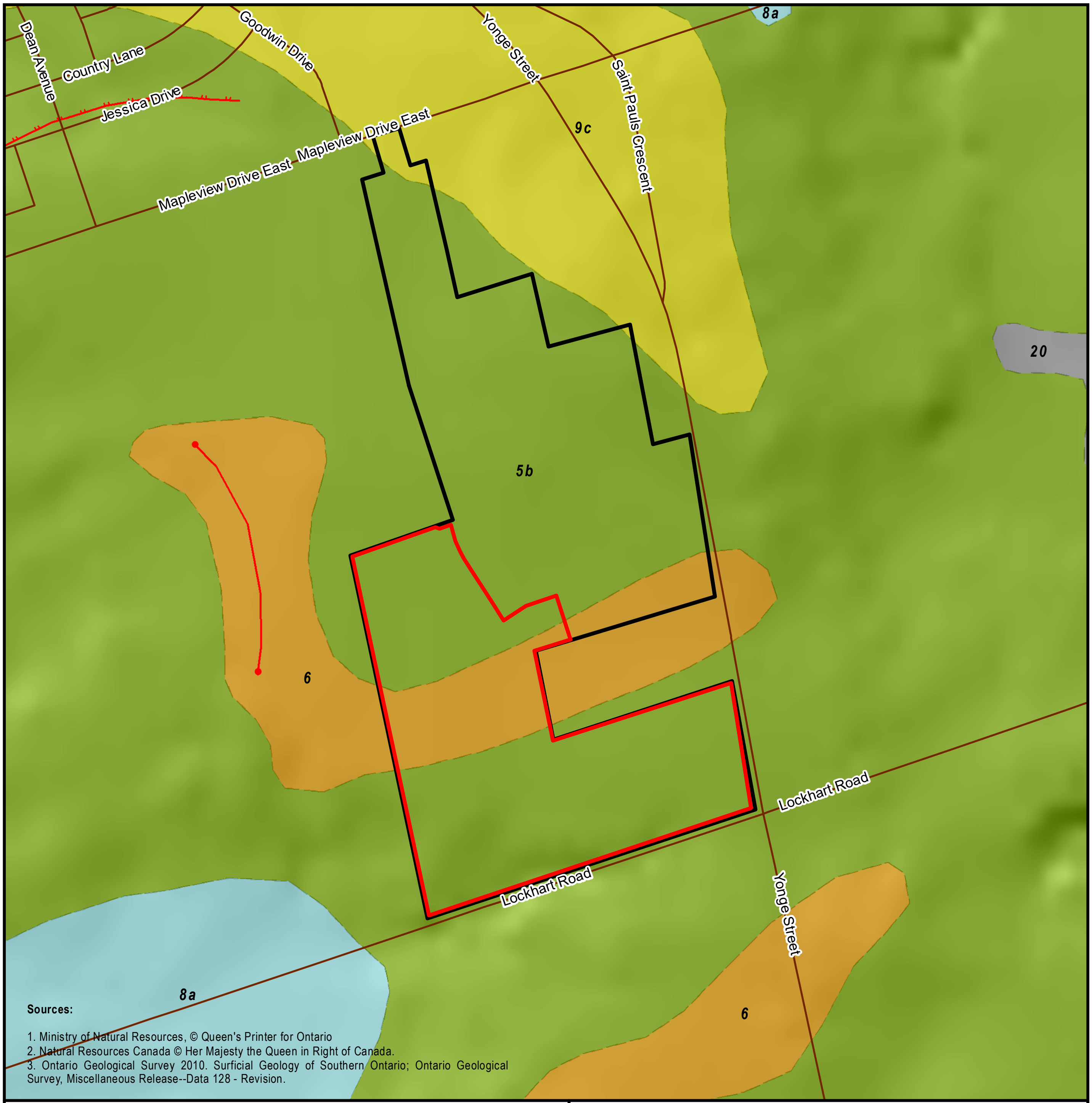


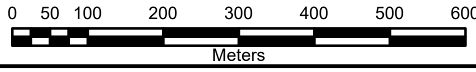
Sources:

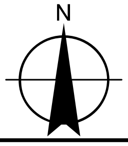
1. Ministry of Natural Resources, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.
3. Ontario Geological Survey 2010. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128 - Revision.

LEGEND

🟥 PHASE 2 LANDS
⬛ RAINSONG LANDS
— ROADWAY
🟩 5b: sandy silt to silty sand-textured till
🟧 6: sand and gravel, minor silt, clay and till
🟦 8a: silt and clay, minor silt and gravel
🟨 9c: sand, gravel, minor silt and clay
⬜ 20: organic deposits

●—● Beach
—┴— Bluff





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BARRIE, ONTARIO

HYDROGEOLOGICAL ASSESSMENT
PHASE 2 LANDS

Figure Title:

SURFICIAL GEOLOGY

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🟥	PHASE 2 LANDS
☐	RAINSONG LANDS
—	WATERCOURSE
⊕	MONITORING WELL (RJB, 2014)
⊕	MONITORING WELL (RJB, 2017)
⊕	MONITORING WELL (SOIL ENG., 2017)
⊕	BOREHOLE (SOIL ENG., 2017)
⊕	BOREHOLE (GOLDER, 2006)
+	MECP WELL RECORD LOCATION
A A'	CROSS-SECTION LOCATION KEY

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Metres

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PHASE 2 LANDS

Figure Title

WELL LOCATION PLAN

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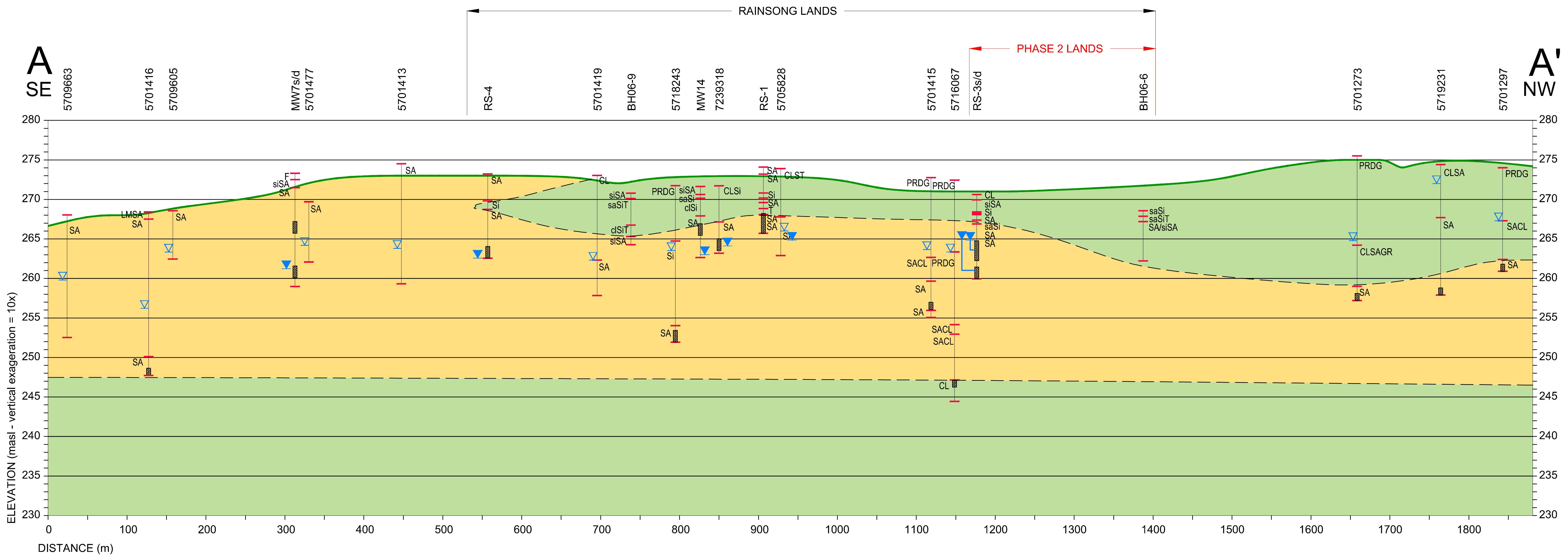

LEGEND

BH1 WELL NUMBER / ID

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

▼ MEASURED WATER LEVEL (SEASONAL HIGH)

▽ STATIC WATER LEVEL (MECP WELL RECORD)

▨ WELL SCREEN

si	SILTY
sa	SANDY
cl	CLAYEY
GR	GRAVEL
SA	SAND
Si	SILT
CL	CLAY
T	TILL
PRDG	PREDUG

- - - - - INTERPRETED STRATIGRAPHY

🟨 SAND / SILT

🟩 SILT / CLAY / TILL

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BARRIE, ONTARIO
HYDROGEOLOGICAL ASSESSMENT
PHASE 2 LANDS

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION A-A'

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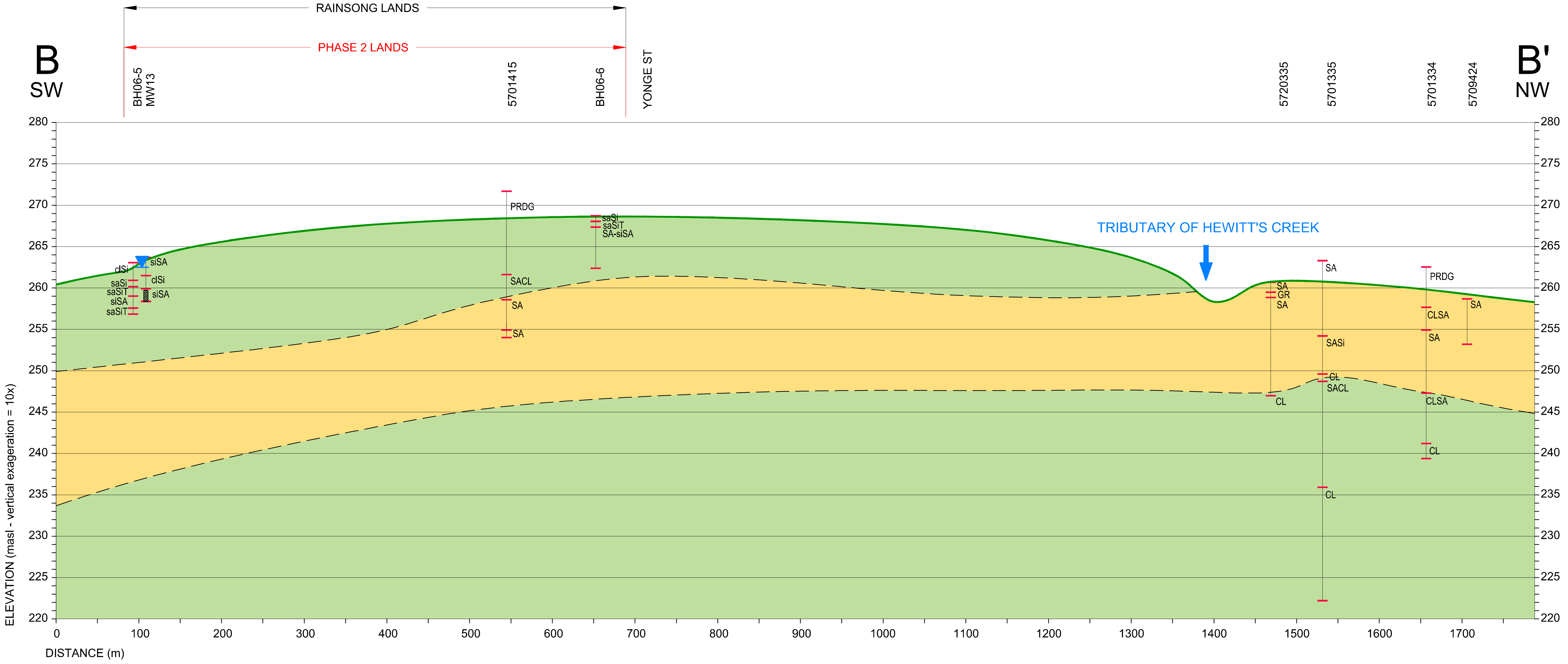

LEGEND

BH1 WELL NUMBER / ID

EXISTING GROUND PROFILE

GEOLOGICAL CONTACT

▼ MEASURED WATER LEVEL (SEASONAL HIGH)

▽ STATIC WATER LEVEL (MECP WELL RECORD)

▨ WELL SCREEN

si	SILTY
sa	SANDY
cl	CLAYEY
GR	GRAVEL
SA	SAND
Si	SILT
CL	CLAY
T	TILL
PRDG	PREDUG

- - - - INTERPRETED STRATIGRAPHY

🟨 SAND / SILT

🟩 SILT / CLAY / TILL

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BARRIE, ONTARIO
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PHASE 2 LANDS

Figure Title

INTERPRETED GEOLOGICAL CROSS-SECTION B-B'

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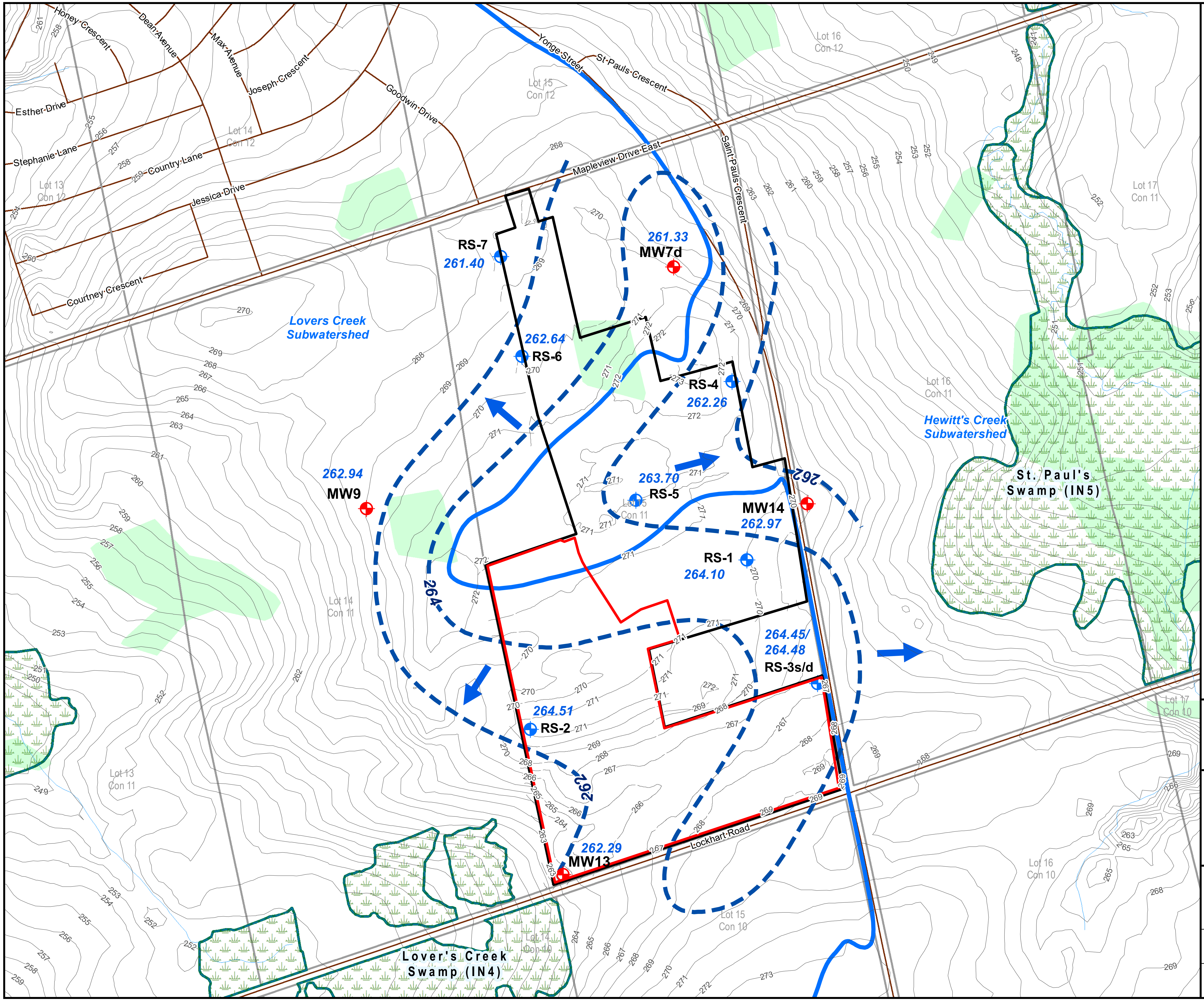

LEGEND

- 🟥 PHASE 2 LANDS
- ⬛ RAINSONG LANDS
- SUBWATERSHED BOUNDARY
- CONTOUR (1m intervals - masl)
- WATERCOURSE: PERMANENT
- WATERCOURSE: INTERMITTENT
- ROADWAY
- WETLAND
- PROVINCIALLY SIGNIFICANT WETLAND
- 🟩 WOODED AREA
- MONITORING WELL (RJB, 2014)
- MONITORING WELL (RJB, 2017)
- INTERPRETED GROUNDWATER CONTOUR (masl)
- 262.64 MEASURED WATER LEVEL (JULY, 2017)
- INTERPRETED GROUNDWATER FLOW DIRECTION

Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario
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3. Contours derived from Ontario Ministry of Natural Resources and Forestry, Provincial Digital Elevation Model Version 3.0, 2013.

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Metres

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BARRIE, ONTARIO

HYDROGEOLOGICAL ASSESSMENT
PHASE 2 LANDS

Figure Title

INTERPRETED GROUNDWATER FLOW

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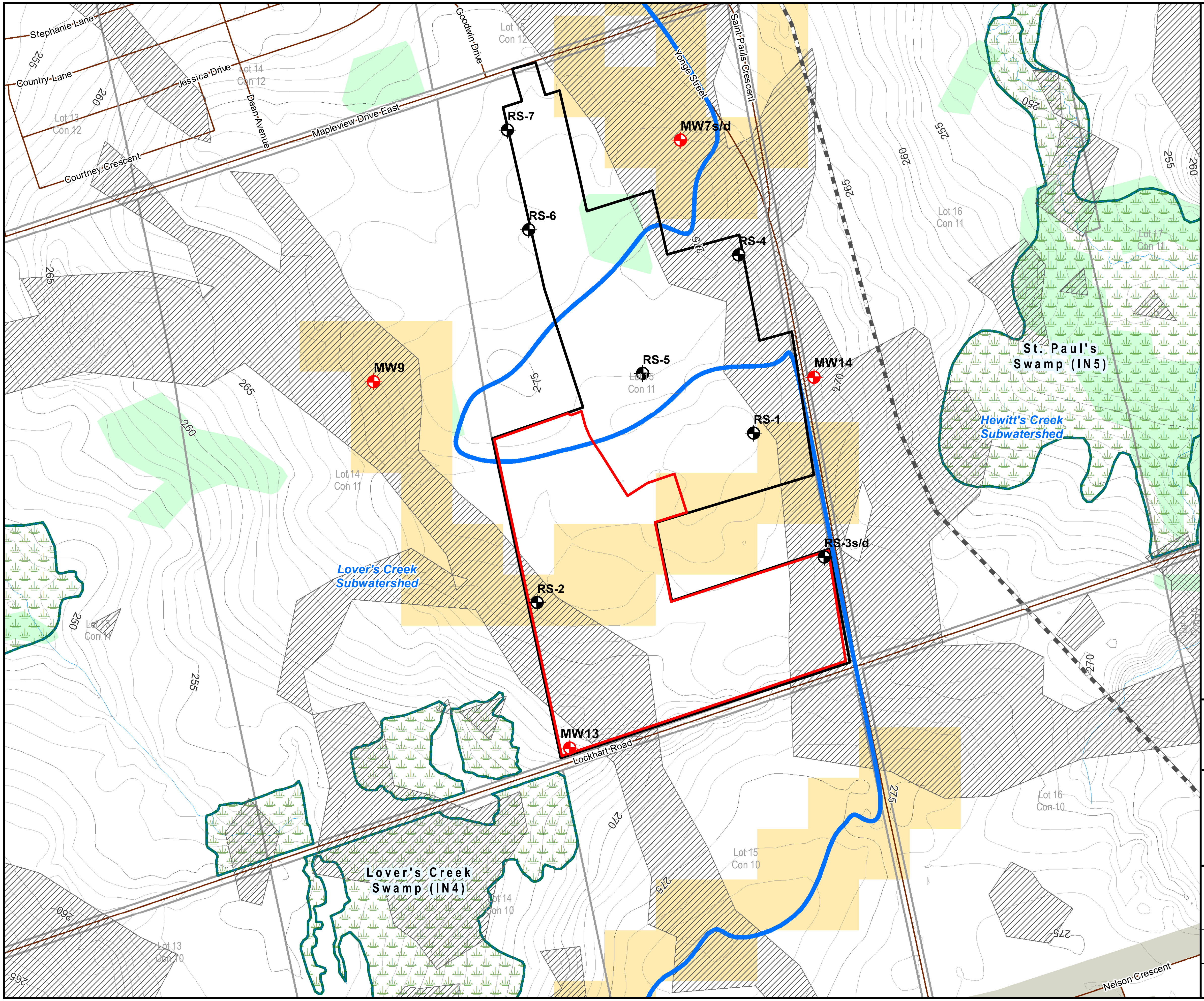

LEGEND

🟥 PHASE 2 LANDS
⬛ RAINSONG LANDS
SUBWATERSHED BOUNDARY
CONTOUR (5m intervals - masl)
CONTOUR (1m intervals)
RAILWAY
▨ ECOLOGICALLY SIGNIFICANT GROUNDWATER RECHARGE AREAS (ESGRA, LSRCA)
🟨 SIGNIFICANT GROUNDWATER RECHARGE AREAS (SGRA, LSRCA)
WATERCOURSE: PERMANENT
WATERCOURSE: INTERMITTENT
ROADWAY
WETLAND
🟩 PROVINCIALLY SIGNIFICANT WETLAND
🟩 WOODED AREA
● MONITORING WELL (RJB, 2014)
● MONITORING WELL (GOLDER, 2017)

Sources:

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3. Contours derived from Ontario Ministry of Natural Resources and Forestry, Provincial Digital Elevation Model Version 3.0, 2013.
4. Recharge Area mapping provided by Lake Simcoe Region Conservation Authority

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0 100 200 300 400 500 600
Metres

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BARRIE, ONTARIO

HYDROGEOLOGICAL ASSESSMENT
PHASE 2 LANDS

Figure Title

RECHARGE AREAS

Drawn	Checked	Date	Figure No.
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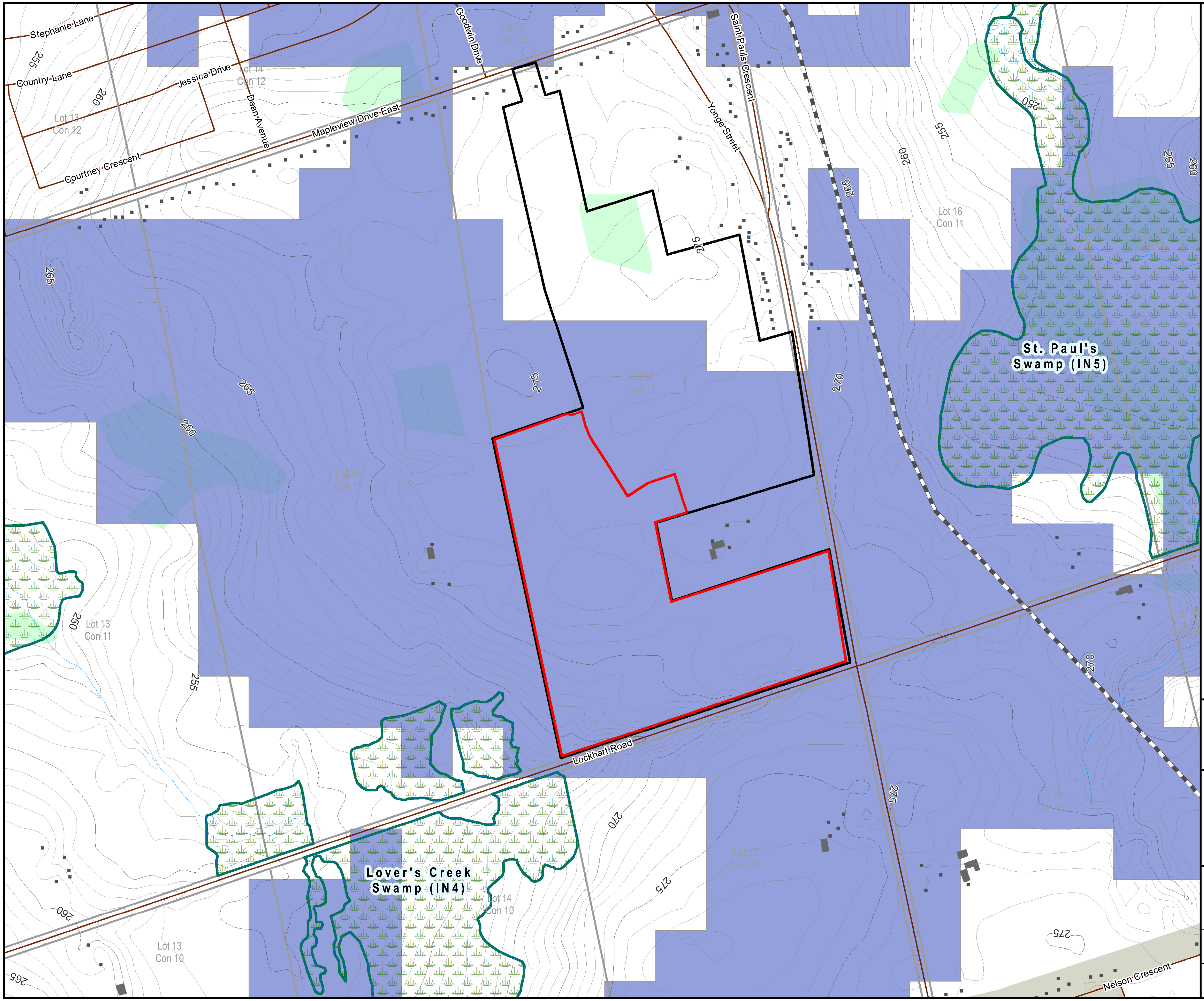

LEGEND

- 🟥 PHASE 2 LANDS
- ☐ RAINSONG LANDS
- CONTOUR (5m intervals - masl)
- CONTOUR (1m intervals)
- RAILWAY
- 🟦 HIGH AQUIFER VULNERABILITY
- WATERCOURSE: PERMANENT
- WATERCOURSE: INTERMITTENT
- ROADWAY
- ▪ BUILDING
- WETLAND
- 🟩 PROVINCIALLY SIGNIFICANT WETLAND
- 🟩 WOODED AREA

Sources:

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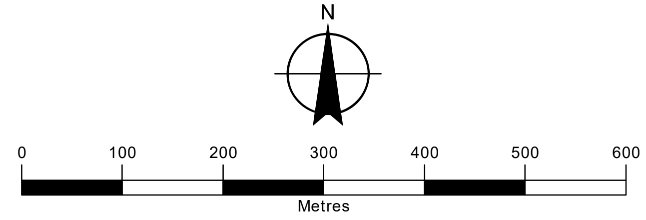
3. Contours derived from Ontario Ministry of Natural Resources and Forestry, Provincial Digital Elevation Model Version 3.0, 2013.
4. Aquifer Vulnerability mapping provided by Lake Simcoe Region Conservation Authority



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BARRIE, ONTARIO

HYDROGEOLOGICAL ASSESSMENT
PHASE 2 LANDS

Figure Title

AQUIFER VULNERABILITY AREAS

Drawn	Checked	Date	Figure No.
SK	SC	February 2022	10
Scale		Project No.	
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[THE DIFFERENCE IS OUR PEOPLE]

Appendix A

MECP Water Well Records

Water Well Records

Tuesday, December 12, 2017

10:35:43 AM

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
INNISFIL TOWNSHIP	17 609712 4910766 W	2014/04 6809	2			TH	0022 5	7239318 (Z175927) A152307	BRWN CLAY SILT 0015 BRWN CSND 0028
INNISFIL TOWNSHIP	17 609573 4911539 W	2016/06 6946	2			MO	0010 10	7266357 (Z232472) A189646	BRWN SAND SILT LOOS 0020
INNISFIL TOWNSHIP CON 10 014	17 608937 4909842 W	1973/06 4816						5710909 () A	CLAY SAND 0028 SAND CLAY 0045 GRVL CLAY 0087 SAND GRVL 0098 CLAY SILT 0174 CLAY GRVL 0226 CLAY 0267 MSND 0273 CLAY SILT 0315
INNISFIL TOWNSHIP CON 10 015	17 609732 4909940 W	1962/10 2514	6	FR 0054	35/57/5/1:0	ST DO	0057 3	5701273 ()	PRDG 0037 BRWN CLAY MSND GRVL 0054 MSND 0060
INNISFIL TOWNSHIP CON 10 016	17 609941 4909800 W	1963/01 2514	6	FR 0040	22/40/5/1:30	ST DO	0040 3	5701297 ()	PRDG 0022 MSND CLAY 0038 MSND 0043
INNISFIL TOWNSHIP CON 10 016	17 609914 4909873 W	1984/04 3203	5	FR 0022	8/40/10/1:0	DO	0051 3	5719231 ()	LOAM 0002 BRWN CLAY SAND 0022 BRWN SAND 0054
INNISFIL TOWNSHIP CON 11 014	17 608866 4911234 W	1966/03 1510	4	FR 0060	30/40/10/2:0	DO	0056 4	5701406 ()	PRDG 0020 MSND 0060
INNISFIL TOWNSHIP CON 11 014	17 608774 4911233 W	1968/08 3203	5	FR 0054	/52/6/2:0	DO	0061 6	5705950 ()	LOAM 0001 YLLW CLAY MSND 0016 YLLW MSND 0054 GREY FSND 0068
INNISFIL TOWNSHIP CON 11 014	17 608786 4911188 W	1966/09 3203	5	FR 0058	35/60/6/2:0	DO	0066 3 0069 3	5701409 ()	PRDG 0020 YLLW MSND 0058 GREY FSND 0072
INNISFIL TOWNSHIP CON 11 014	17 608741 4911198 W	1966/06 3203	5	FR 0037	33/49/1/1:0	DO	0061 3	5701407 ()	BRWN CLAY 0003 BLDR 0005 BRWN CLAY 0023 BRWN CLAY MSND 0029 BRWN MSND 0051 BRWN FSND 0065
INNISFIL TOWNSHIP CON 11 014	17 608914 4911273 W	1971/07 4610	5	FR 0047	20/36/12/1:30	DO	0054 6 0060 3	5708200 ()	PRDG 0005 BRWN MSND GRVL 0028 BRWN GRVL MSND CLAY 0047 BRWN FSND CSND 0064
INNISFIL TOWNSHIP CON 11 014	17 608901 4911229 W	1965/10 1614	6	FR 0072	29/65/3/4:0	DO	0076 4	5701405 ()	FILL 0033 MSND 0070 FSND 0080
INNISFIL TOWNSHIP CON 11 014	17 608606 4911142 W	1965/05 1510	4	FR 0065	35/50/5/2:0	DO	0060 5	5701404 ()	PRDG 0035 FSND CLAY 0060 FSND 0065
INNISFIL TOWNSHIP CON 11 014	17 608606 4911162 W	1964/04 2514	6					5701403 () A	PRDG 0042 YLLW FSND 0060 GREY FSND CLAY 0073 BLUE CLAY 0127
INNISFIL TOWNSHIP CON 11 014	17 608666 4911158 W	1962/08 4102	30	FR 0030	20//2/:	DO		5701402 ()	BRWN CLAY 0030 MSND 0038
INNISFIL TOWNSHIP CON 11 014	17 608431 4911086 W	1966/07 2514	6	FR 0046	30/45/9/:	DO	0049 3	5701408 ()	PRDG 0002 BRWN CLAY MSND BLDR 0020 BLUE CLAY MSND BLDR 0046 YLLW FSND MSND 0049 MSND CSND 0052
INNISFIL TOWNSHIP CON 11 014	17 608798 4910589 L	1989/08 1583	6 5	FR 0116	32//12/1:0	DO	0109 2	5725420 (64384)	BRWN CLAY TILL SNDY 0040 BLUE CLAY 0073 GREY CLAY GRVL STNS 0103 BRWN FSND 0118 GREY CLAY 0125

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
INNISFIL TOWNSHIP CON 11 014	17 608798 4910589 L	1990/09 3660	6	FR 0032	32/57/4/1:0	DO	0064 5	5728430 (87995)	BLCK LOAM 0001 GREY GRVL 0008 GREY CLAY HARD 0032 BRWN SAND SILT WBRG 0070 GREY SAND SILT CLAY 0075
INNISFIL TOWNSHIP CON 11 014	17 608634 4911215 W	1988/03 3135	5	FR 0205	90/150/5/1:30	DO	0208 3	5723078 (31559)	CLAY 0025 CLAY SAND 0050 SILT CLAY 0095 CLAY 0195 CLAY SAND 0205 SAND 0211
INNISFIL TOWNSHIP CON 11 014	17 608639 4911216 W	1988/03 3135	5	FR 0205	90/150/5/1:30	DO	0208 3	5723077 (31559)	CLAY 0025 CLAY SAND 0050 SILT CLAY 0095 CLAY 0195 CLAY SAND 0205 SAND 0211
INNISFIL TOWNSHIP CON 11 015	17 609571 4911277 W	1963/01 4102	30	FR 0018	18//2/:	DO		5701477 ()	CSND 0025
INNISFIL TOWNSHIP CON 11 015	17 609575 4910893 W	1967/01 4608	30	FR 0035	35//2/:	DO		5701419 ()	BRWN CLAY 0035 MSND 0050
INNISFIL TOWNSHIP CON 11 015	17 609314 4911423 W	1970/02 1510	4	FR 0062	38/48/10/1:0	DO	0058 4	5707053 ()	PRDG 0028 RED MSND 0050 GREY MSND 0062
INNISFIL TOWNSHIP CON 11 015	17 609372 4911182 W	1959/10 1510	2	FR 0045	35/40/5/2:0	DO	0040 5	5701412 ()	CSND 0050
INNISFIL TOWNSHIP CON 11 015	17 609231 4911256 W	1958/06 1637	4	FR 0058	30/50/6/2:0	DO		5701411 ()	CLAY LOAM 0012 MSND 0063
INNISFIL TOWNSHIP CON 11 015	17 609446 4911438 W	1956/07 1637	4	FR 0054	32/50/7/4:0	DO	0060 5	5701410 ()	LOAM GRVL 0018 FSND 0032 GRVL 0042 FSND 0054 CSND 0060 GRVL 0066
INNISFIL TOWNSHIP CON 11 015	17 609366 4911388 W	1966/03 1510	4	FR 0070	40/58/3/1:0	DO	0066 4	5701417 ()	PRDG 0035 HPAN 0060 FSND 0072
INNISFIL TOWNSHIP CON 11 015	17 609614 4910663 W	1968/09 4608	30	FR 0025	26///:	DO		5705828 ()	BRWN CLAY STNS 0020 MSND 0036
INNISFIL TOWNSHIP CON 11 015	17 609461 4911448 W	1966/01 1510	4	FR 0068	40/45/10/2:0	DO	0065 3	5701416 ()	LOAM MSND 0003 RED MSND 0060 CSND 0068
INNISFIL TOWNSHIP CON 11 015	17 609361 4911398 W	1966/03 1510	4	FR 0072	40/50/10/2:0	DO	0047 4	5701418 ()	LOAM MSND 0003 MSND GRVL 0047 CSND 0072
INNISFIL TOWNSHIP CON 11 015	17 609414 4911273 W	1982/03 2514	6	FR 0058	34/56/15/1:0	CO DO	0058 4	5718447 ()	LOAM DKCL 0001 BRWN SAND SILT 0012 YLLW MSND 0056 YLLW SAND SILT 0058 YLLW FSND 0062 GREY SAND 0062
INNISFIL TOWNSHIP CON 11 015	17 609488 4911138 W	1959/10 1510	2	FR 0045	35/40/5/1:30	DO	0040 5	5701413 ()	CSND 0050
INNISFIL TOWNSHIP CON 11 015	17 609572 4910457 W	1965/08 2514	6	FR 0043	30/52/3/2:30	ST DO	0052 3	5701415 ()	PRDG 0033 MSND CLAY 0043 MSND 0055 FSND 0058
INNISFIL TOWNSHIP CON 11 015	17 609054 4911333 W	1972/12 3203	5	FR 0030	30/40/5/1:0	DO	0059 3	5709510 ()	PRDG 0026 BRWN SAND 0055 GREY SAND 0062
INNISFIL TOWNSHIP CON 11 015	17 609484 4911423 W	1973/01 4608	30	FR 0017	17/28/3/1:0	IN		5709605 ()	BLCK LOAM 0001 GREY SAND 0020
INNISFIL TOWNSHIP CON 11 015	17 609379 4910783 L	1999/03 2513	6	FR 0064	26/58/9/1:0	DO	0060 6	5734439 (195331)	LOAM 0001 YLLW SAND 0004 YLLW SILT 0018 YLLW SAND 0027 YLLW SAND SILT CLAY 0052 YLLW SAND 0064 YLLW CLAY 0064

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
INNISFIL TOWNSHIP CON 11 015	17 608971 4911290 W	1962/07 1614	6	FR 0060	29/55/10/1:30	DO	0055 4	5701414 ()	CLAY LOAM 0018 MSND 0060
INNISFIL TOWNSHIP CON 11 015	17 609514 4911473 W	1980/09 3135	5	UK 0040	14/33/4/2:0	DO	0042 4	5717401 ()	SAND 0018 SILT SAND CLAY 0040 FSND 0046
INNISFIL TOWNSHIP CON 11 015	17 609376 4910783 L	2004/04 2513	6.28	FR 0085	36/55/2/1:0	DO	0086 6	5738721 (Z00199) A000103	BRWN SAND SILT STNS 0014 YLLW SAND 0062 BLUE SAND SILT CLAY 0085 GREY SAND SILT CMTD 0092
INNISFIL TOWNSHIP CON 11 015	17 609665 4911082 W	2008/01 2514	6.25	FR 0055	25/51/4/1:0	DO	0051 8	7102395 (Z54565) A048085	BLCK SAND GRVL LOAM 0001 GREY CLAY SAND LOOS 0049 GREY SAND PORS 0059
INNISFIL TOWNSHIP CON 11 015	17 609561 4911397 W	2010/04 3413	6 5	FR 0030	16/40/30/1:0	CO	0046 3	7146493 (Z111542) A092764	BRWN SAND 0050 GREY SILT 0056
INNISFIL TOWNSHIP CON 11 015	17 609564 4910423 W	1979/04 3203	6 5	FR 0060	30/75/2/6:10	DO	0080 3	5716067 ()	PRDG 0030 PRDR 0060 BRWN SAND CLAY 0064 GREY SAND CLAY LYRD 0083 GREY CLAY 0092
INNISFIL TOWNSHIP CON 11 016	17 609611 4911278 W	1997/05 5528	5 5	FR 0042	16/32/4/2:0	DO	0042 4	5732723 (155258)	LOAM 0001 BRWN SAND 0004 STNS GRVL 0005 BRWN SAND MGRD 0023 BRWN FSND 0049 BRWN SILT CLAY 0052
INNISFIL TOWNSHIP CON 11 016	17 609971 4910979 L	1997/10 1851	6	FR 0044	17/48/4/1:0	DO	0044 6	5733085 (187561)	BLCK LOAM 0001 BRWN SAND 0004 GREY SAND 0010 BRWN SAND WBRG 0015 BRWN CLAY SLTY 0044 BRWN SAND WBRG 0050
INNISFIL TOWNSHIP CON 11 016	17 609682 4911066 W	2016/04 1851	6.25	FR 0063	29/56/4/1:30	DO	0063 5	7261373 (Z164616) A063855	BRWN CLAY 0018 GREY CLAY SAND 0053 GREY SAND DRTY 0063 BRWN SAND 0068
INNISFIL TOWNSHIP CON 11 016	17 609686 4910964 W	2002/06 2513	7	FR 0067	23/59/8/1:0	DO	0062 5	5736948 (246396)	BLCK LOAM 0001 BRWN SILT SAND 0017 YLLW SAND 0060 GREY SAND VERY 0067
INNISFIL TOWNSHIP CON 11 016	17 609621 4911258 W	1997/06 5528	6 5	FR 0046	16/38/6/1:0	DO	0046 4	5732836 (155265)	BRWN SAND GRVL 0040 BRWN SAND 0050
INNISFIL TOWNSHIP CON 11 016	17 609694 4911024 W	1965/10 4102	30	FR 0026	26//6/:	DO		5701421 ()	BRWN CLAY 0012 CSND 0040
INNISFIL TOWNSHIP CON 11 016	17 609714 4910823 W	1983/08 2514	6 5	FR 0060	27/70/6/1:30	DO	0071 4	5718813 ()	FILL 0003 BRWN CLAY SAND 0040 YLLW SAND CLAY GRVL 0060 GREY FSND VERY 0075
INNISFIL TOWNSHIP CON 11 016	17 609714 4910923 W	1974/10 3203	5	FR 0023	23/44/7/1:0	DO		5711629 ()	LOAM 0002 BRWN CLAY 0016 BRWN SAND CLAY 0023 GREY SAND 0058
INNISFIL TOWNSHIP CON 11 016	17 609714 4910823 W	1982/11 3660	5	FR 0058	21/45/6/2:0	DO	0062 3	5718243 ()	PRDG 0023 BRWN SILT 0058 GREY MSND 0065
INNISFIL TOWNSHIP CON 11 016	17 609623 4911154 W	1965/11 2514	6	FR 0043	24/43/4/2:0	DO	0043 3	5701420 ()	PRDG 0028 MSND CLAY 0035 BRWN MSND 0046 FSND 0049
INNISFIL TOWNSHIP CON 12 015	17 609230 4911464 W	1964/04 1510	4	FR 0055	40/50/3/2:0	DO	0058 4	5701482 ()	MSND STNS 0025 FSND CLAY 0055 CSND 0062

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
INNISFIL TOWNSHIP CON 12 015	17 609240 4911479 W	1964/04 1510	4	FR 0055	40/50/3/2:0	DO	0058 4	5701483 ()	PRDG 0020 MSND STNS 0025 FSND CLAY 0055 CSND 0062
INNISFIL TOWNSHIP CON 12 015	17 608966 4911382 W	1967/06 1510	4	FR 0062	35/45/10/2:0	DO	0058 4	5701486 ()	PRDG 0040 HPAN 0055 CSND 0062
INNISFIL TOWNSHIP CON 12 015	17 609404 4911543 W	1973/01 1204	5	FR 0034	27/35/5/1:0	DO	0048 3	5709663 ()	BRWN SAND 0051
INNISFIL TOWNSHIP CON 12 015	17 608949 4911393 W	1973/04 3203	5	FR 0035	8/15/0/:	DO	0051 6	5709921 ()	BLCK LOAM 0001 BRWN CLAY STNS 0020 BRWN CLAY SAND STNS 0035 BRWN CSND 0057
INNISFIL TOWNSHIP CON 12 015	17 608964 4911373 W	1978/05 3203	5	FR 0020	18/40/6/2:0	DO	0056 3	5715208 ()	BRWN CLAY SAND 0014 BRWN SAND 0059
INNISFIL TOWNSHIP CON 12 016	17 609552 4911601 W	1967/05 4608	30	FR 0018	18//2/:	DO		5701488 ()	LOAM 0001 BRWN CLAY 0007 GRVL 0011 MSND 0030
INNISFIL TOWNSHIP CON 12 016	17 610084 4911763 W	1976/02 2514	30 6	FR 0096	45/100/7/2:0	ST DO	0096 8	5713067 ()	PRDG 0040 BRWN CLAY PCKD 0051 BRWN CLAY SAND GRVL 0069 BRWN CLAY HARD 0090 YLLW SILT PCKD 0096 YLLW FSND PCKD 0109

Notes:
UTM: UTM in Zone, Easting, Northing and Datum is NAD83; L: UTM estimated from Centroid of Lot; W: UTM not from Lot Centroid
DATE CNTR: Date Work Completedand Well Contractor Licence Number
CASING DIA: .Casing diameter in inches
WATER: Unit of Depth in Fee. See Table 4 for Meaning of Code

PUMP TEST: Static Water Level in Feet / Water Level After Pumping in Feet / Pump Test Rate in GPM / Pump Test Duration in Hour : Minutes
WELL USE: See Table 3 for Meaning of Code
SCREEN: Screen Depth and Length in feet
WELL: WEL (AUDIT #) Well Tag . A: Abandonment; P: Partial Data Entry Only
FORMATION: See Table 1 and 2 for Meaning of Code

1. Core Material and Descriptive terms

Code	Description	Code	Description	Code	Description	Code	Description	Code	Description
BLDR	BOULDERS	FCRD	FRACTURED	IRFM	IRON FORMATION	PORS	POROUS	SOFT	SOFT
BSLT	BASALT	FGRD	FINE-GRAINED	LIMY	LIMY	PRDG	PREVIOUSLY DUG	SPST	SOAPSTONE
CGRD	COARSE-GRAINED	FGVL	FINE GRAVEL	LMSN	LIMESTONE	PRDR	PREV. DRILLED	STKY	STICKY
CGVL	COARSE GRAVEL	FILL	FILL	LOAM	TOPSOIL	QRTZ	QUARTZITE	STNS	STONES
CHRT	CHERT	FLDS	FELDSPAR	LOOS	LOOSE	QSND	QUICKSAND	STNY	STONEY
CLAY	CLAY	FLNT	FLINT	LTCL	LIGHT-COLOURED	QTZ	QUARTZ	THIK	THICK
CLN	CLEAN	FOSS	FOSILIFEROUS	LYRD	LAYERED	ROCK	ROCK	THIN	THIN
CLYY	CLAYEY	FSND	FINE SAND	MARL	MARL	SAND	SAND	TILL	TILL
CMTD	CEMENTED	GNIS	GNEISS	MGRD	MEDIUM-GRAINED	SHLE	SHALE	UNKN	UNKNOWN TYPE
CONG	CONGLOMERATE	GRNT	GRANITE	MGVL	MEDIUM GRAVEL	SHLY	SHALY	VERY	VERY
CRYS	CRYSTALLINE	GRSN	GREENSTONE	MRBL	MARBLE	SHRP	SHARP	WBRG	WATER-BEARING
CSND	COARSE SAND	GRVL	GRAVEL	MSND	MEDIUM SAND	SHST	SCHIST	WDFR	WOOD FRAGMENTS
DKCL	DARK-COLOURED	GRWK	GREYWACKE	MUCK	MUCK	SILT	SILT	WTHD	WEATHERED
DLMT	DOLOMITE	GVLY	GRAVELLY	OBDN	OVERBURDEN	SLTE	SLATE		
DNSE	DENSE	GYPS	GYPSUM	PCKD	PACKED	SLTY	SILTY		
DRTY	DIRTY	HARD	HARD	PEAT	PEAT	SNDS	SANDSTONE		
DRY	DRY	HPAN	HARDPAN	PGVL	PEA GRAVEL	SNDY	SANDYOAPSTONE		

2. Core Color

Code	Description
WHIT	WHITE
GREY	GREY
BLUE	BLUE
GREN	GREEN
YLLW	YELLOW
BRWN	BROWN
RED	RED
BLCK	BLACK
BLGY	BLUE-GREY

3. Well Use

Code	Description	Code	Description
DO	Domestic	OT	Other
ST	Livestock	TH	Test Hole
IR	Irrigation	DE	Dewatering
IN	Industrial	MO	Monitoring
CO	Commercial	MT	Monitoring TestHole
MN	Municipal		
PS	Public		
AC	Cooling And A/C		
NU	Not Used		

4. Water Detail

Code	Description	Code	Description
FR	Fresh	GS	Gas
SA	Salty	IR	Iron
SU	Sulphur		
MN	Mineral		
UK	Unknown		

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix B

Borehole Logs

LOG OF DRILLING OPERATIONS

RS-1

BURNSIDE

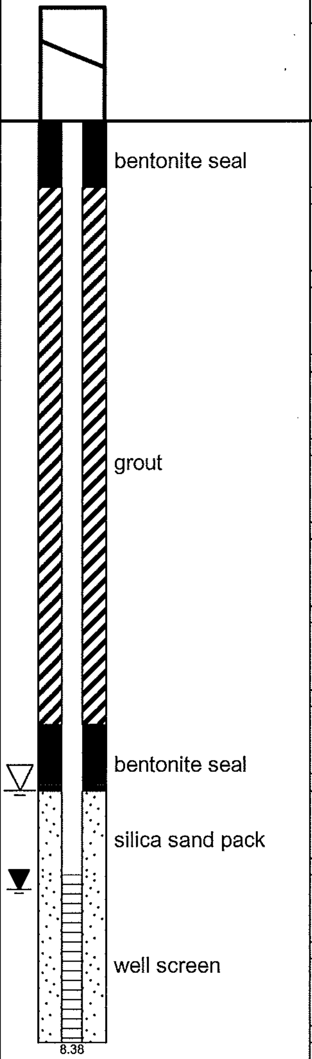
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **270.19**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/23/2017**	Static Water Level Depth (m): **6.09**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/23/2017**	Sand Pack Depth (m) : **6.10 - 8.38**

Surface Elevation (m): **270.19**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, damp, rootlets throughout	0.24
SAND, trace clay, trace silt brown, damp, soft	0.91
SAND, trace gravel, trace silt light brown, damp, very stiff	3.28
SILT, trace sand, trace clay light brown to grey, damp, very stiff	3.91
SAND, trace silt grey, damp, dense	4.50
SANDY SILTY CLAY, occasional silt and sand inclusions grey, damp, very stiff	5.26
-sand seam at 4.90m	6.02
SAND, trace silt, trace clay grey, damp, dense	
SAND uniform, light brown to grey, wet, dense -at 6.86m saturated -clay seam at 6.96m -occasional <1cm rounded gravel at 7.62m	8.99



Num.	Type	Int.	N.Val.
1	SS	☒	4
2	SS	☒	14
3	SS	☒	31
4	SS	☒	53
5	SS	☒	55
6	SS	☒	55
7	SS	☒	34
8	SS	☒	57
9	SS	☒	107
10	SS	☒	>59/12"
11	SS	☒	122
12	SS	☒	127

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC ■ Auger Cutting — SS ☒ Split Spoon
▽ Static Water Level - 7/26/2017	Screen: **51 mm dia. PVC #10 slot**	CS Continuous — AR ▨ Air Rotary
		RC Rock Core — WC Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\300 JOBS\300040647-RAINSONG\300040647_BARRIE-RAINSONG (BONNIE DRAFT).GPJ TEMPLATE.GDT 1/11/18

LOG OF DRILLING OPERATIONS

RS-2

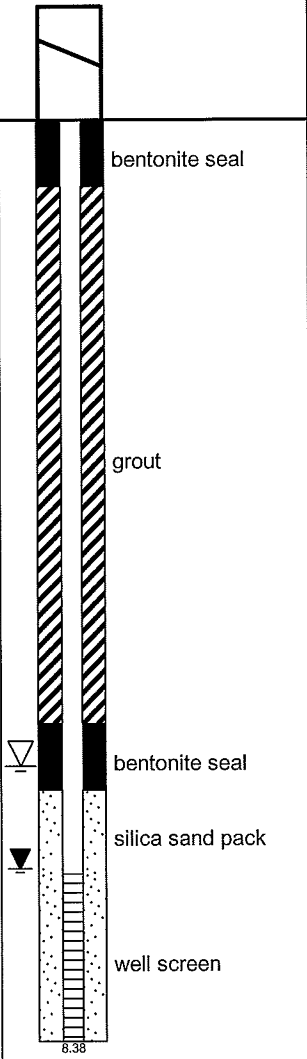
BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **270.51**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/23/2017**	Static Water Level Depth (m): **5.88**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/23/2017**	Sand Pack Depth (m) : **6.10 - 8.38**

Surface Elevation (m): **270.51**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, moist, soft, rootlets throughout	0.35
SAND, trace gravel light brown, dry to moist, loose	0.86
SANDY SILT, trace clay and gravel light brown to grey, moist, low plasticity, stiff	1.45
SAND, trace silt, trace clay, trace gravel grey, moist, stiff, -coarse sand seam at 1.55m -3cm saturated seam at 3.05m -with depth increasing gravel content -10cm saturated seam at 3.81m	3.91
SAND, trace gravel light brown, dry, dense -at 5.94m grey and damp -at 6.10m saturated	8.99



Num.	Type	Int.	N.Val.
1	SS	☒	5
2	SS	☒	8
3	SS	☒	18
4	SS	☒	36
5	SS	☒	54
6	SS	☒	81
7	SS	☒	82
8	SS	☒	93
9	SS	☒	81/11"
10	SS	☒	86
11	SS	☒	71
12	SS	☒	54

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level - 7/26/2017

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE					
AC	◧	Auger Cutting	SS	☒	Split Spoon
CS	◫	Continuous	AR	▨	Air Rotary
RC	⛰	Rock Core	WC	〜	Wash Cuttings

LOG OF DRILLING OPERATIONS

RS-3d

BURNSIDE

R.J. Burnside & Associates Limited
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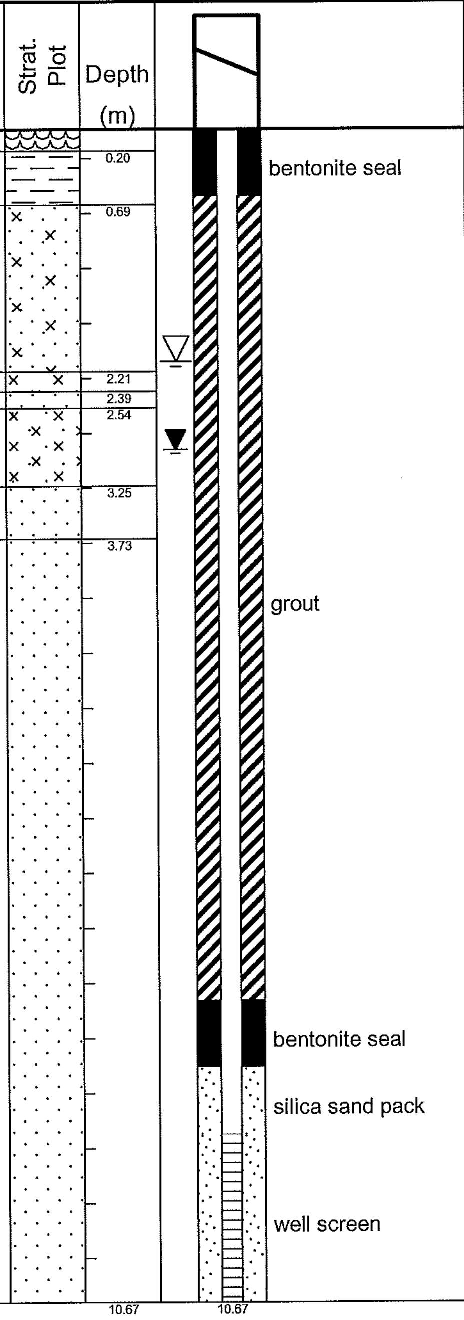
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **266.77**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/24/2017**	Static Water Level Depth (m): **2.12**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/24/2017**	Sand Pack Depth (m) : **8.53 - 10.67**

Surface Elevation (m): 266.77

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, damp, rootlets throughout	0.20
CLAY, with silt brown, dry, low plasticity, medium hardness	0.69
SILTY SAND, trace clay, trace gravel light brown, damp, medium hardness	2.21
SILT, with clay, trace gravel light brown, wet, soft,	2.39
SAND, trace silt light brown, saturated, loose	2.54
SANDY SILT, trace clay, trace gravel light brown, wet	3.25
SAND, with silt and gravel light brown, damp, medium hardness	3.73
SAND, trace gravel, trace silt light brown, medium hardness, saturated -silt seams at 5.5m-5.9m and 6.48-6.57m , trace fine sand, light brown, saturated, very stiff	10.67



SAMPLE

Num.	Type	Int.	N.Val.
1	SS	☒	12
2	SS	☒	12
3	SS	☒	24
4	SS	☒	35
5	SS	☒	41
6	SS	☒	27
7	SS	☒	53
8	SS	☒	56
9	SS	☒	65
10	SS	☒	17
11	SS	☒	28
12	SS	☒	57
13	SS	☒	48
14	SS	☒	32

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA		SAMPLE TYPE					
▼ Water found @ time of drilling	Pipe:	**51 mm dia. PVC**	AC	▮	Auger Cutting	SS	☒	Split Spoon
▽ Static Water Level - 7/26/2017	Screen:	**51 mm dia. PVC #10 slot**	CS	☐	Continuous	AR	▨	Air Rotary
			RC	^^^	Rock Core	WC	~	Wash Cuttings

LOG OF DRILLING OPERATIONS

RS-3s

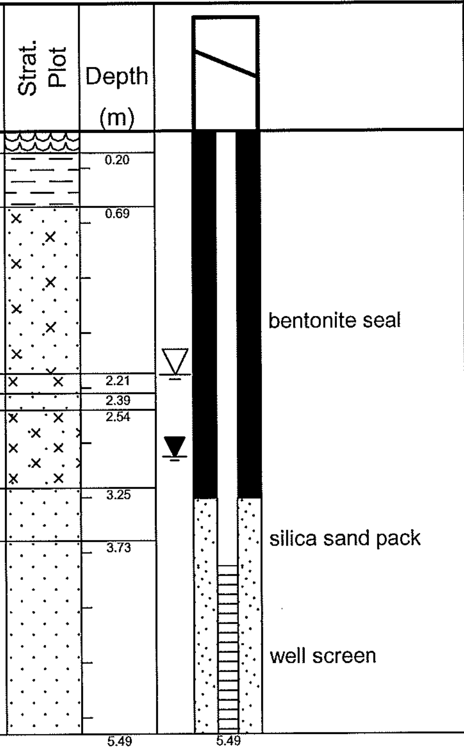
BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **266.84**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/24/2017**	Static Water Level Depth (m): **2.22**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/24/2017**	Sand Pack Depth (m) : **3.35 - 5.49**

Surface Elevation (m): **266.84**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, damp, rootlets throughout	
CLAY, with silt brown, dry, low plasticity, medium hardness	0.20
SILTY SAND, trace clay, trace gravel light brown, damp, medium hardness	0.69
SILT, with clay, trace gravel light brown, wet, soft,	2.21
SAND, trace silt light brown, saturated, loose	2.39
SANDY SILT, trace clay, trace gravel light brown, wet	2.54
SAND, with silt and gravel light brown, medium hardness, wet	3.25
SAND, trace gravel light brown, medium hardness, saturated	3.73
	5.49



SAMPLE Num.	Type	Int.	N.Val.
1	SS	☒	12
2	SS	☒	12
3	SS	☒	24
4	SS	☒	35
5	SS	☒	41
6	SS	☒	27
7	SS	☒	53

Depth Scale (ft) (m): 5.0, 10.0, 15.0 (ft); 1.0, 2.0, 3.0, 4.0, 5.0 (m)

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level - 7/26/2017	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\300 JOBS\300040647-RAINSONG\300040647_BARRIE-RAINSONG (BONNIE DRAFT).GPJ TEMPLATE.GDT 1/11/18

LOG OF DRILLING OPERATIONS

RS-4

BURNSIDE

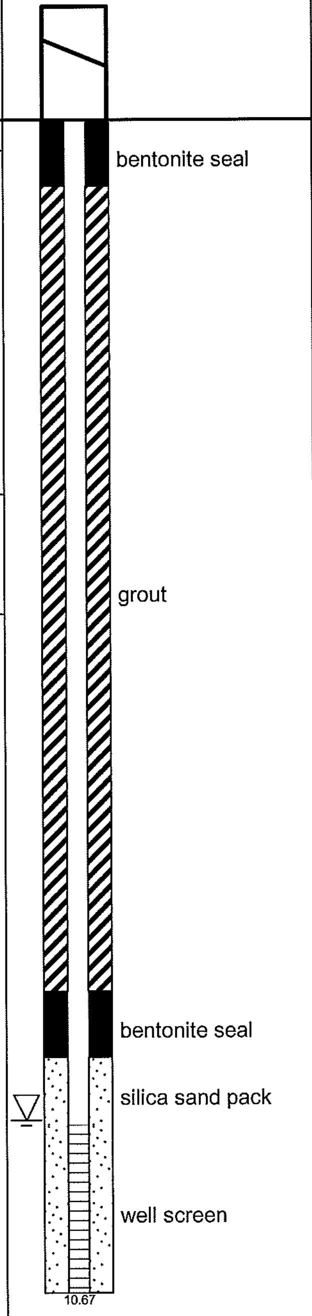
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **271.37**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/26/2017**	Static Water Level Depth (m): **9.1**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/26/2017**	Sand Pack Depth (m) : **8.53 - 10.67**

Surface Elevation (m): **271.37**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, damp, trace gravel, rootlets throughout	0.28
SAND, trace silt, trace gravel brown, damp, soft -at 1.52m becomes light brown to grey	3.41
SILT, with sand, trace clay, trace gravel light brown to grey, dry to damp -at 3.91m and 4.31m fine sand seam	4.50
SAND uniform, light brown, damp, hard -at 4.57-5.41m trace silt -at 6.53-6.74m silt seam, uniform, light brown, wet to saturated -at 9.14m saturated, some silt, trace clay	11.28



SAMPLE Num.	Type	Int.	N.Val.
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2	SS	☒	8
3	SS	☒	31
4	SS	☒	32
5	SS	☒	40
6	SS	☒	62
7	SS	☒	94/11"
8	SS	☒	89/11"
9	SS	☒	100
10	SS	☒	105/9"
11	SS	☒	114/11"
12	SS	☒	147
13	SS	☒	130/9"
14	SS	☒	75
15	SS	☒	66

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level - 7/26/2017	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\300 JOBS\300040647-RAINSONG\300040647_BARRIE-RAINSONG (BONNIE DRAFT).GPJ TEMPLATE.GDT 1/11/18

LOG OF DRILLING OPERATIONS

RS-5

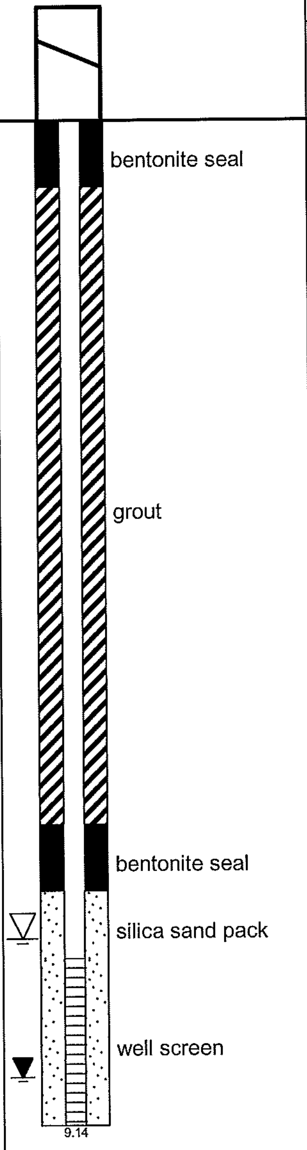
BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **271.15**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/26/2017**	Static Water Level Depth (m): **7.44**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/26/2017**	Sand Pack Depth (m) : **7.01 - 9.14**

Depth Scale (ft) (m)	Stratigraphic Description Surface Elevation (m): **271.15**	Depth (m)
	TOPSOIL dark brown, damp to wet, rootlets throughout	0.23
	SANDY SILT/SILTY SAND, trace clay, trace gravel light brown to grey, damp, soft	1.45
	SAND, trace silt, trace gravel -light brown, damp, very dense -at 2.29-2.48m silty sand seam -at 7.62m saturated -at 8.68m silty clay seam	9.75

Depth Scale (ft): 5.0, 10.0, 15.0, 20.0, 25.0, 30.0
Depth Scale (m): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0



SAMPLE Num.	Type	Int.	N.Val.
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2	SS	☒	11
3	SS	☒	57
4	SS	☒	62
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6	SS	☒	91/10"
7	SS	☒	100/10"
8	SS	☒	88
9	SS	☒	97/10"
10	SS	☒	111
11	SS	☒	109/8"
12	SS	☒	88
13	SS	☒	37

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level - 7/26/2017

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE					
AC	◧	Auger Cutting	SS	☒	Split Spoon
CS	▯	Continuous	AR	▨	Air Rotary
RC	▦	Rock Core	WC	▭	Wash Cuttings

BURNSIDE

R.J. Burnside & Associates Limited
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telephone (519) 823-4995 fax (519) 836-5477

LOG OF DRILLING OPERATIONS

RS-6

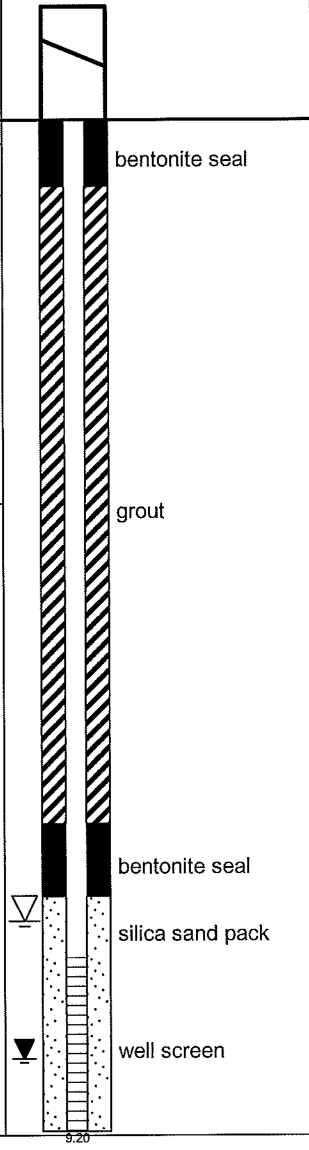
Page 1 of 1

Client: **Rainsong Land Development Inc.**	Project Name: **Hydrogeology Study**	Logged by: **B.W.**
Project No.: **300040647**	Location: **Barrie, ON**	Ground (m amsl): **269.93**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **5/25/2017**	Static Water Level Depth (m): **7.29**
Drilling Method: **Hollow Stem Auger**	Date Completed: **5/25/2017**	Sand Pack Depth (m) : **7.07 - 9.20**

Depth Scale (ft) (m)

Stratigraphic Description — Surface Elevation (m): **269.93**

Stratigraphic Description	Depth (m)
TOPSOIL dark brown, damp, soft, rootlets throughout	0.22
SILTY CLAY, trace sand, trace gravel brown, damp, medium plastisity, soft	0.69
SILTY SAND/SANDY SILT, some clay, trace gravel light brown, damp, friable, medium to stiff -at 1.52-2.13m increasing clay content	3.50
SAND, trace silt, trace to some gravel light brown, dry, very dense -at 5.48m 15cm fine sand seam -at 7.62m saturated	9.24



SAMPLE

Num.	Type	Int.	N.Val.
1	SS	☒	6
2	SS	☒	16
3	SS	☒	32
4	SS	☒	43
5	SS	☒	65
6	SS	☒	29
7	SS	☒	62
8	SS	☒	92
9	SS	☒	125
10	SS	☒	97
11	SS	☒	100/10"
12	SS	☒	88
13	SS	☒	50/4"

Depth Scale (ft) (m)

Prepared By: **B.W.** Checked By: **SC** Date Prepared: **7/27/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level - 7/26/2017	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

RS-7

Golder-

Ontario Ministry of the Environment

Measurements recorded in: ☑ Metric ☑ Imperial

Well Tag No. *(Place Sticker and/or Print Below)*
A108863

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name / Last Name / Organization: Rainsong Land Development inc

E-mail Address:

☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name): 3751 Victoria pk ave

Municipality: tor

Province: ONT

Postal Code: M1W3Z4

Telephone No. *(inc. area code)*: 4167742175

Well Location

Address of Well Location (Street Number/Name): Yonge/Mapleview

Township: InnisFil

Lot:

Concession:

County/District/Municipality: Barrie

City/Town/Village:

Province: **Ontario**

Postal Code:

UTM Coordinates NAD 83 Zone 17 Easting 609012 Northing 4911269

Municipal Plan and Sublot Number:

Other:

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	To
Brown	Silty Clay	gravel, sand	loose	0	2'6"
Brown	Clay silt	sand, some grvl	hard	2'6"	8'
Brown	sand	gravel, silt, cobbles	very dense	8'	30'

Annular Space

Depth Set at *(m/ft)* From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
30'	18'	3mm sand	3.4
18	0'	3/8" holeplug	5

Results of Well Yield Testing

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

If pumping discontinued, give reason:

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping ____ hrs + ____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

Well production *(l/min / GPM)*

Disinfected? ☐ Yes ☐ No

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

Method of Construction

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

Well Use

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

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth *(m/ft)* From	To
1 7/8"	plastic		0	29'

Status of Well

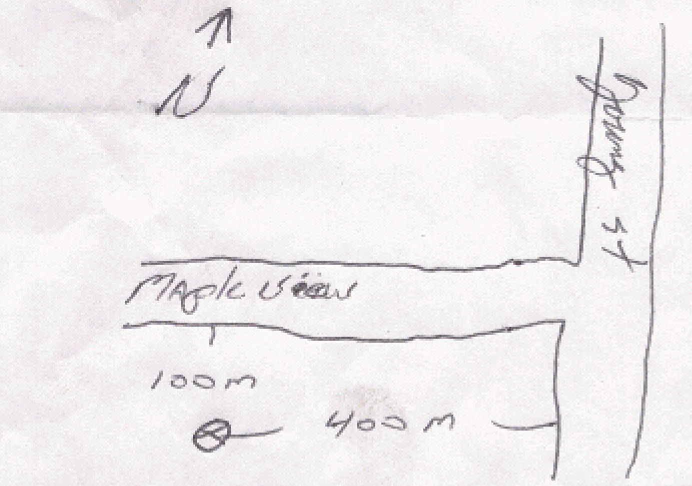
☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☑ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth *(m/ft)* From	To
2"	plastic	10	29'	19'

Map of Well Location

Please provide a map below following instructions on the back.



Water Details

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

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

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

Hole Diameter

Depth *(m/ft)* From	To	Diameter *(cm/in)*
0	30'	8"

Well Contractor and Well Technician Information

Business Name of Well Contractor: Canadian Soil Drilling

Well Contractor's Licence No.: 7075

Business Address (Street Number/Name): 12493 #27 Midhurst

Municipality:

Province: Ont

Postal Code: L0L1X0

Business E-mail Address: Sales@CanadianSoil.CA

Bus.Telephone No. *(inc. area code)*: 7057289872

Name of Well Technician (Last Name, First Name): Whittle Ken

Well Technician's Licence No.: 2592

Signature of Technician and/or Contractor: K Whittle

Date Submitted: 20110708

Comments:

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: YYYYMMDD

Date Work Completed: 20110621

Ministry Use Only

Audit No. Z125663

Received AUG 16 2011

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Ministry's Copy

LOG OF DRILLING OPERATIONS

MW7d

BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Hewitt's Creek Landowners Group**	Project Name: **Hewitt's Secondary Plan Area**	Logged by: **C. Dinulescu**
Project No.: **300033110**	Location: **Barrie, ON**	Ground (m amsl): **273.20**
Drilling Co.: **Lantech Drilling**	Date Started: **3/20/2014**	Static Water Level Depth (m): **10.35**
Drilling Method: **Hollow Stem Auger**	Date Completed: **3/20/2014**	Sand Pack Depth (m) : **11.10-13.23**

Stratigraphic Description

Surface Elevation (m): **273.20**

FILL
Brown coarse sand, loose, damp, trace gravel, well graded, cobbles, boulders.

SAND Silty
Light brown, fine, compact, damp, uniform trace clay, trace gravel rounded (<2 cm diam.), trace iron stains

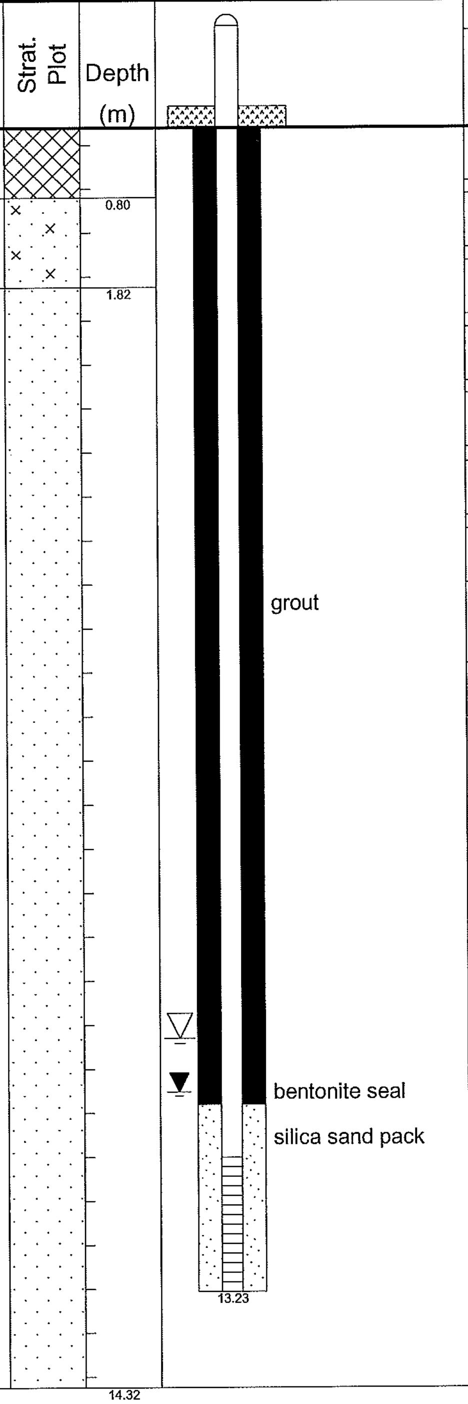
SAND
Light brown, fine to medium, loose, damp, well graded, trace silt, trace rounded gravel (<2 cm diam.), occasional spots of very coarse sand

at 2.8 m - 15 cm thick fine to coarse sand, loose, well graded

at 3.8 m - fine to very coarse

from 6.1 m to 10.2 m - fine to medium, uniform, milimetric seams of dark brown sand

from 10.2 to 14.3 m - medium to coarse, layered with fine to medium sand, well graded, saturated



SAMPLE Num.	Type	Int.	N.Val.
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2	SS	☒	12
3	SS	☒	48
4	SS	☒	66
5	SS	☒	97/20"
6	SS	☒	80/12"
7	SS	☒	100
8	SS	☒	80/12"
9	SS	☒	80/20"
10	SS	☒	90/11"
11	SS	☒	90/11"
12	SS	☒	122/24"
13	SS	☒	110/24"

Prepared By: **C. Dinulescu** Checked By: **D. Smikle** Date Prepared: **7/14/2014**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level - 6/9/2014

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE					
AC	▮	Auger Cutting	SS	☒	Split Spoon
CS	▯	Continuous	AR	▨	Air Rotary
RC	⁂	Rock Core	WC	⌒	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW9

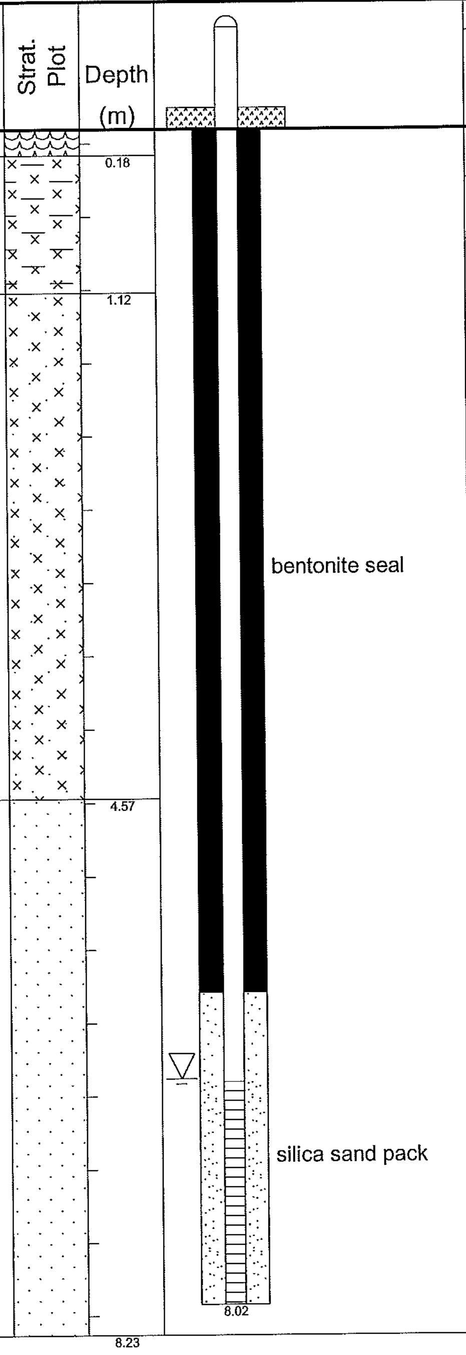
BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Hewitt's Creek Landowners Group**	Project Name: **Hewitt's Secondary Plan Area**	Logged by: **K. Churcher**
Project No.: **300033110**	Location: **Barrie, ON**	Ground (m amsl): **271.60**
Drilling Co.: **Lantech Drilling**	Date Started: **3/18/2014**	Static Water Level Depth (m): **6.48**
Drilling Method: **Hollow Stem Auger**	Date Completed: **3/18/2014**	Sand Pack Depth (m) : **5.89 - 8.02**

Stratigraphic Description Surface Elevation (m): **271.60**	Depth (m)
TOPSOIL	0.18
CLAYEY SILT, some fine sand, moist, firm, cohesive, brown, plastic	1.12
SANDY SILT, fine to medium grained, some small to medium gravel, trace clay, dry, firm, not cohesive, brown/gray, not plastic - gravel becoming larger - becoming moist - rusty brown mottling throughout	4.57
SAND, fine to medium grained, some small gravel, trace silt, uniform, moist, loose, not cohesive, brown - wet, becoming more dense	8.23



SAMPLE Num.	Type	Int.	N.Val.
1	SS	☒	10
2	SS	☒	52
3	SS	☒	62
4	SS	☒	43
5	SS	☒	57
6	SS	☒	>100
7	SS	☒	>100
8	SS	☒	88

Depth Scale (ft) (m): 5.0, 10.0, 15.0, 20.0, 25.0 (ft); 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0 (m)

Prepared By: **K. Churcher** Checked By: **D. Smikle** Date Prepared: **4/14/2014**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
- ▼ Water found @ time of drilling
- ▽ Static Water Level - 6/9/2014

MONITORING WELL DATA
- Pipe: **51 mm dia. PVC**
- Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE
- AC ■ Auger Cutting
- CS ☐ Continuous
- RC ▨ Rock Core
- SS ☒ Split Spoon
- AR ▨ Air Rotary
- WC ☐ Wash Cuttings

LOG OF DRILLING OPERATIONS

MW13

BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Hewitt's Creek Landowners Group**	Project Name: **Hewitt's Secondary Plan Area**	Logged by: **C. Dinulescu**
Project No.: **300033110**	Location: **Barrie, ON**	Ground (m amsl): **263.80**
Drilling Co.: **Lantech Drilling**	Date Started: **3/21/2014**	Static Water Level Depth (m): **1.07**
Drilling Method: **Hollow Stem Auger**	Date Completed: **3/21/2014**	Sand Pack Depth (m) : **2.72 - 5.31**

Surface Elevation (m): **263.80**

Stratigraphic Description	Depth (m)	Num.	Type	Int.	N.Val.
TOPSOIL Dark brown loam	0.35	1	SS	☒	14
No Sample	1.52				
Clayey SILT Brown, soft wet, mottled with grey silty clay, some sand, occasional spots with wet sand, trace iron staining, weakly plastic, medium dilatant.	2.20	2	SS	☒	13
Sandy SILT Till like, brown, very soft, wet, medium dilatant, weakly plastic, trace gravel subrounded to subangular (<2 cm diam.), trace iron stains, cobbles	3.73	3 4	SS SS	☒ ☒	10 64/8"
Silty SAND Brown, fine to coarse, compact, saturated, trace to some clay, trace gravel subangular to subrounded (<2 cm diam.), well graded. at 5.18 m - 5 cm thick seam of very coarse sand	5.31	5 6	SS SS	☒ ☒	55/10" 50

Prepared By: **C. Dinulescu** Checked By: **D. Smikle** Date Prepared: **7/14/2014**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
- ▼ Water found @ time of drilling
- ∇ Static Water Level - 6/9/2014

MONITORING WELL DATA
- Pipe: **51 mm dia. PVC**
- Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE
- AC Auger Cutting
- CS Continuous
- RC Rock Core
- SS ☒ Split Spoon
- AR ▨ Air Rotary
- WC Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\300 JOBS\300033110 BARRIE\300033110 BARRIE - CARMEN'S.GPJ TEMPLATE.GDT 11/10/15

LOG OF DRILLING OPERATIONS
MW14

BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

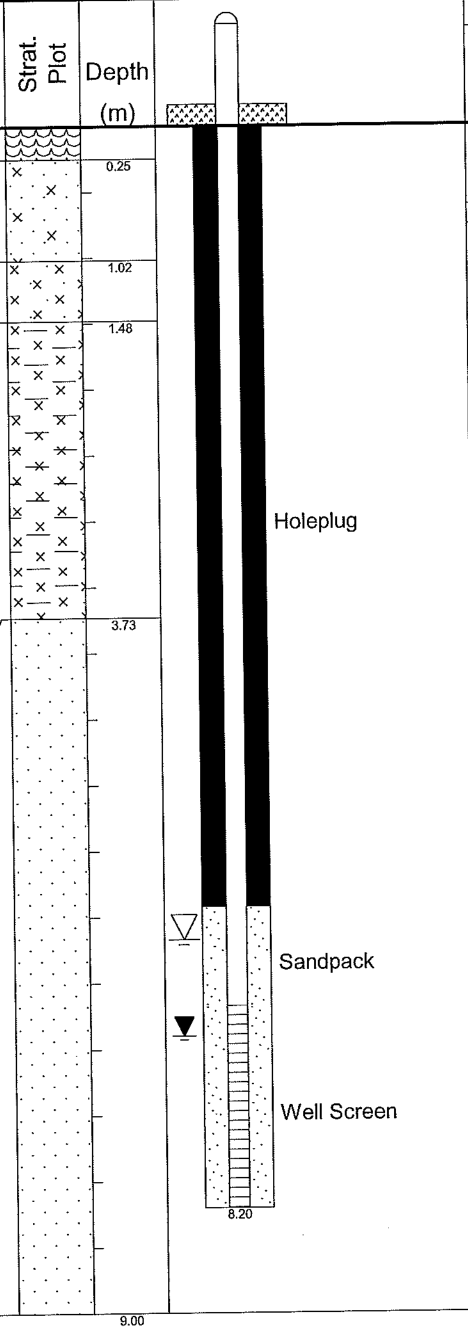
Client: **Hewitt's Creek Landowners Group**	Project Name: **Hewitt's Secondary Plan Area**	Logged by: **C. Dinulescu**
Project No.: **300033110**	Location: **Barrie, ON**	Ground (m amsl): **271.50**
Drilling Co.: **Lantech Drilling**	Date Started: **4/9/2014**	Static Water Level Depth (m): **6.17**
Drilling Method: **Hollow Stem Auger**	Date Completed: **4/9/2014**	Sand Pack Depth (m) : **5.92 - 8.20**

Depth Scale (ft) (m)

Stratigraphic Description
Surface Elevation (m): **271.50**

Stratigraphic Description	Depth (m)
TOPSOIL Dark brown loam	0.25
Silty SAND brown, fine to coarse, loose, moist, well graded, trace clay, trace gravel	1.02
Sandy SILT Brown, soft, moist, weakly plastic, some clay, trace small gravel	1.48
Clayey SILT Brown, soft, moist to damp, weakly plastic, some fine to medium sand, trace gravel subangular to subrounded (<1 cm diam.)and between 3.05 m and 3.65 m - milimetric seams of medium to coarse sand, gravel <3 cm diam. and cobbles	3.73
SAND Brown, fine to medium, loose, dry, well graded, trace silt, trace small gravel, seasonal laminations uniform from 4.57 m moist to wet from 6.1 m saturated from 7.3 m	9.00

Depth Scale (ft): 5.0, 10.0, 15.0, 20.0, 25.0
Depth Scale (m): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0



SAMPLE

Num.	Type	Int.	N.Val.
1	SS	☒	5
2	SS	☒	9
3	SS	☒	6
4	SS	☒	88
5	SS	☒	81/18"
6	SS	☒	75/8"
7	SS	☒	77/8"
8	SS	☒	92/10"
9	SS	☒	82/10"
10	SS	☒	

Prepared By: **C. Dinulescu** Checked By: **D. Smikle** Date Prepared: **7/14/2014**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC ◧ Auger Cutting SS ☒ Split Spoon
▽ Static Water Level - 6/9/2014	Screen: **51 mm dia. PVC #10 slot**	CS ▯ Continuous AR ▨ Air Rotary RC ⩓ Rock Core WC ⌒ Wash Cuttings

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-1

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 25, 2006

DATUM: GEODETIC

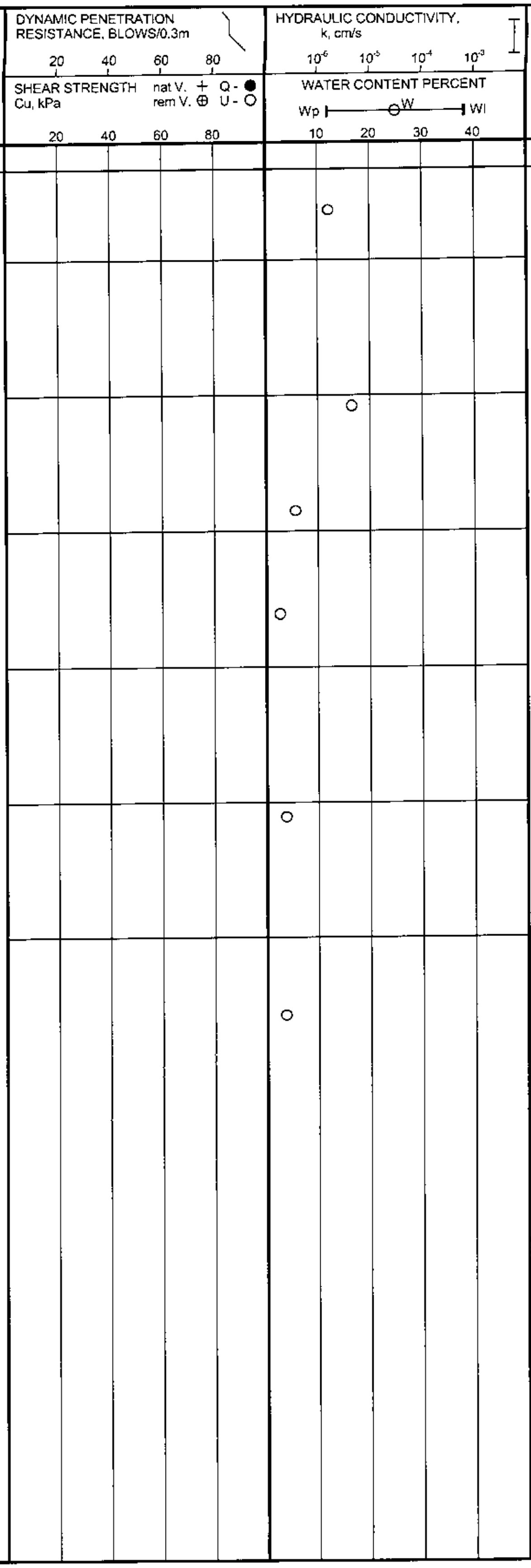
SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION UTMs: 609188 m E, 4911338 m N	ELEV. DEPTH (m)
GROUND SURFACE	268.67
TOPSOIL	0.00
Firm to very stiff, brown CLAYEY SILT, trace to some sand	0.20
Compact, brown, moist sandy SILT, trace to some clay, trace gravel. Contains zones of clayey silt (TILL) Becoming very dense at 2.3 m	267.30 1.37
Very dense, brown, damp to moist SAND, trace silt to SILTY SAND, trace gravel	265.77 2.90
END OF BOREHOLE	262.29 6.38

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	50 DO	16
2	50 DO	7
3	50 DO	14
4	50 DO	60
5	50 DO	57
6	50 DO	50/.10
7	50 DO	25/.13



INSTALLATION AND GROUNDWATER OBSERVATIONS

Borehole caved to a depth of 5.2 m upon completion of drilling, Sept. 25/06

Borehole dry upon completion of drilling, Sept. 25/06

LDN_BHS 06-1189-510.GPJ GLDR_LDN.GDT 22/11/06 DATA INPUT: JLJ 2006'09

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PM
CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-2

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 25, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

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 : 10 20 30 40

UTMs: 609189 m E, 4910877 m N

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
0	TRACK-MOUNTED POWER AUGER 115 mm Solid Stem Augers	GROUND SURFACE	271.19						
		TOPSOIL	0.00						
		Compact, grey SILTY SAND, some gravel, trace clay (TILL)	270.93 0.26	1	50 DO	11	271		
1		Becomes very dense at 0.8 m		2	50 DO	72	270	MH	
				3	50 DO	78			
2		Very dense, brown, moist SAND, trace silt to SILTY SAND, trace to some gravel. Contains gravel and/or boulders	269.06 2.13	4	50 DO	50/.10	269		
3				5	50 DO	50/.13	268		
4				6	50 DO	50/.13	267		
5							266		
6				7	50 DO	50/.10	265		
		END OF BOREHOLE	264.84 6.35						Borehole caved to a depth of 4.7 m upon completion of drilling, Sept. 25/06
7									
8									
9									
10									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PM
CHECKED: KN

LDN_BHS 06-1189-510.GPJ GLDR_LDN.GDT 22/11/06 DATA INPUT: JLJ 2006'09

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-3

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 25, 2006

DATUM: GEODETIC

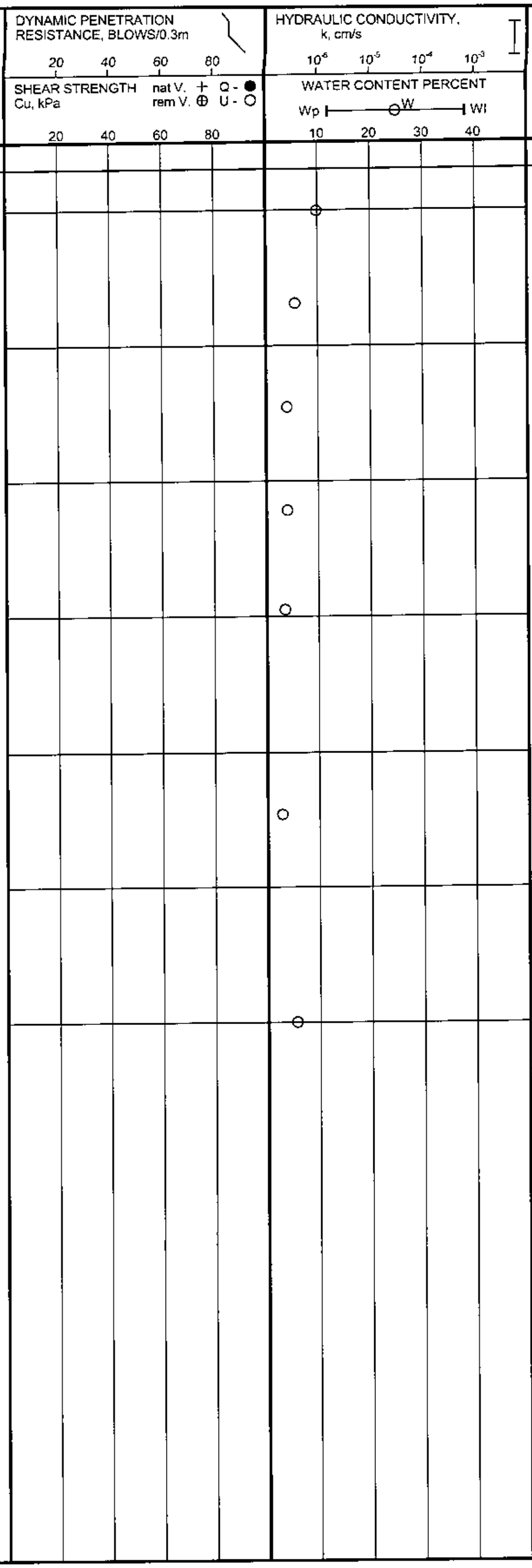
SAMPLER HAMMER, 63.5kg; DROP, 760mm

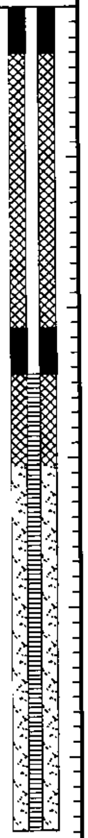
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

SOIL PROFILE — DESCRIPTION — UTMs: 609102 m E, 4910692 m N

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
0	GROUND SURFACE	271.30						
	TOPSOIL	0.00						Bentonite Seal
	Compact, brown, damp to moist SANDY SILT, trace clay and gravel	271.04 0.26	1	50 DO	17	271		
1			2	50 DO	23			Cuttings
	Compact to dense, brown, moist SAND, trace silt to SILTY SAND, trace gravel	269.93 1.37				270		
2			3	50 DO	26			Bentonite Seal
			4	50 DO	43	269		Cuttings
3	Becomes very dense below 3 m		5	50 DO	50/ .10	268		
4						267		Silica Sand Filter
5			6	50 DO	50/ .08	266	M	
6		264.80	7	50 DO	50/ .10	265		
	END OF BOREHOLE	6.50						Borehole caved to a depth of 5.5 m upon completion of drilling, Sept. 25/06 Borehole dry upon completion of drilling, Sept. 25/06 Piezometer dry on Sept. 29/06
7								
8								
9								
10								





DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-4

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 25, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

UTMs: 609143 m E, 4910372 m N

BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	270.61
TOPSOIL	0.00
Compact, brown, moist SANDY SILT, trace to some clay. Contains organic staining in upper 0.5 m	270.38 0.23
Compact to dense, brown, moist SANDY SILT, trace to some clay, trace gravel. Contains zones of CLAYEY SILT, some sand and gravel (TILL) Becomes very dense at 2.3 m	269.92 0.69
Very dense, brown, moist SAND, some silt to SILTY SAND, trace gravel	267.71 2.90
END OF BOREHOLE	264.11 6.50

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	50 DO	17
2	50 DO	22
3	50 DO	30
4	50 DO	85
5	50 DO	74
6	50 DO	50/.15
7	50 DO	50/.10

DEPTH SCALE METRES: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

ELEVATION: 270, 269, 268, 267, 266, 265

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 10 20 30 40

ADDITIONAL LAB. TESTING

INSTALLATION AND GROUNDWATER OBSERVATIONS:

Borehole caved to a depth of 5.5 m upon completion of drilling, Sept. 26/06

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-5

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 25, 2006

DATUM: GEODETIC

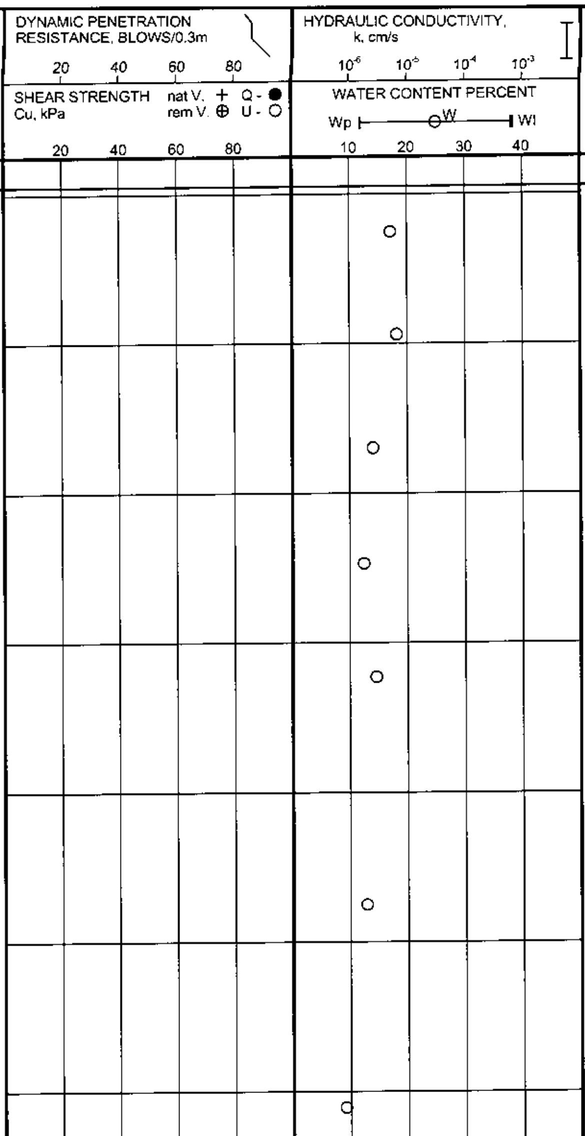
SAMPLER HAMMER, 63.5kg; DROP, 760mm

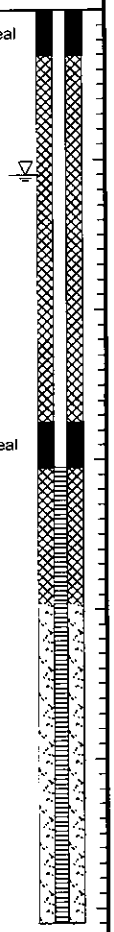
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

UTMs: 609204 m E, 4910053 m N

BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	INSTALLATION AND GROUNDWATER OBSERVATIONS
GROUND SURFACE	263.05				
TOPSOIL	0.00	1	50 DO	10	Bentonite Seal
Firm to stiff, brown CLAYEY SILT, some sand, trace gravel. Contains organic staining to approximately 0.8 m	262.70 0.35	2	50 DO	8	Cuttings
		3	50 DO	13	
Compact, grey, moist SANDY SILT, trace clay and gravel	260.92 2.13	4	50 DO	11	
Compact, grey, moist SANDY SILT, trace to some clay, trace gravel (TILL)	260.15 2.90	5	50 DO	22	Bentonite Seal Cuttings
Dense, grey, moist SILTY SAND, trace gravel	259.01 4.04	6	50 DO	45	Silica Sand Filter
Very dense, grey, moist SANDY SILT, trace to some clay, trace gravel (TILL)	257.56 5.49	7	50 DO	50/ .13	
END OF BOREHOLE	256.83 6.22				





Water encountered during drilling at a depth of 3.1 m, Sept. 25/06

Water level measured in borehole at a depth of 2.1 m upon completion of drilling, Sept. 25/06

Water level measured in piezometer at a depth of 2.0 m bgs, Sept. 26/06

Water level measured in piezometer at a depth of 1.1 m bgs, Sept. 29/06

LDN_BHS 06-1189-510.GPJ GLDR_LDN.GDT 22/11/06 DATA INPUT: JLJ 2006'09

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

PROJECT: 06-1189-510

LOCATION: SEE FIGURE 2

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE BH 06-6

BORING DATE: September 25, 2006

SHEET 1 OF 1

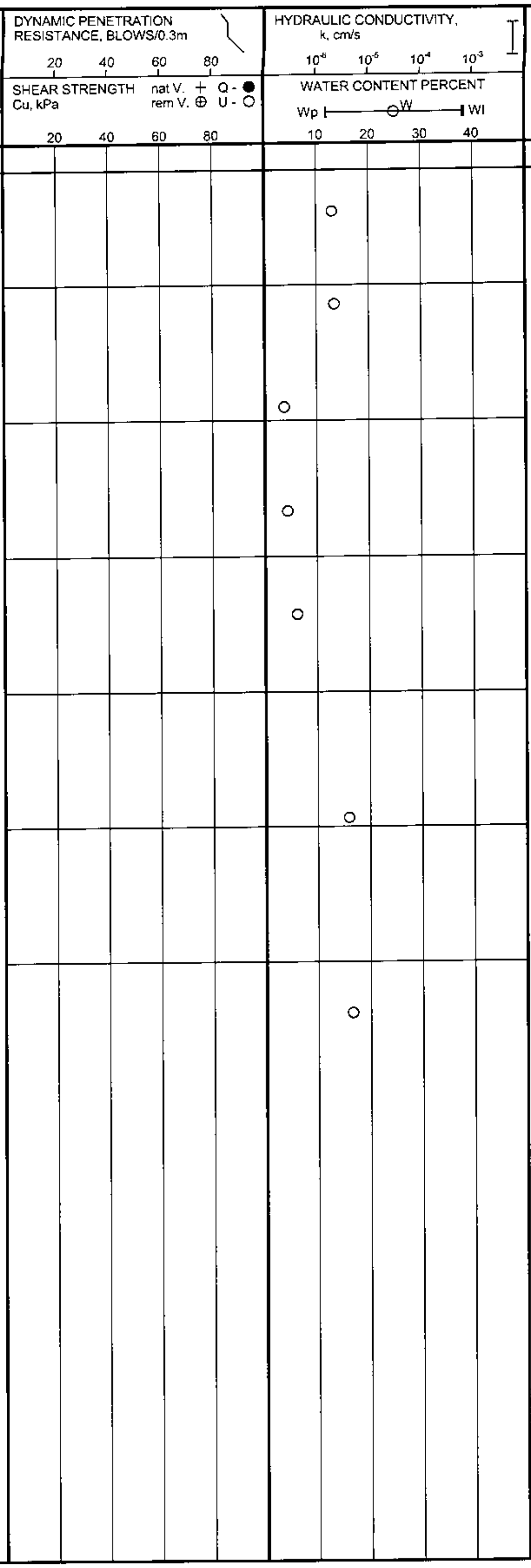
DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

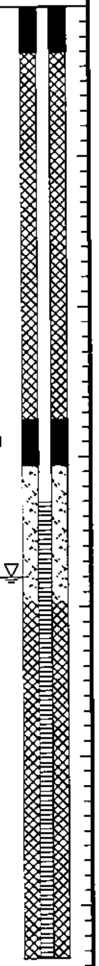
BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

UTMs: 609733 m E, 4910209 m N

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	268.85				
TOPSOIL	0.00	1	50 DO	17	
Compact, brown, moist SANDY SILT. Contains organic staining to 0.6 m	268.52 0.33				
Compact, brown, moist SANDY SILT, trace to some clay, trace gravel (TILL)	268.16 0.69	2	50 DO	22	
Dense to very dense, brown, moist SAND, some silt to SILTY SAND, trace gravel	267.48 1.37	3	50 DO	41	
		4	50 DO	48	
Becomes wet below 3 m		5	50 DO	56	M
		6	50 DO	92/.28	
Becomes grey and grades to a SILT and SAND below at 6 m		7	50 DO	50/.10	
END OF BOREHOLE	262.50 6.35				



INSTALLATION AND GROUNDWATER OBSERVATIONS



Borehole caved to a depth of 4.0 m upon completion of drilling, Sept. 25/06

Water level measured in piezometer at a depth of 3.8 m bgs, Sept. 26/06

Water level measured in piezometer at a depth of 3.8 m bgs, Sept. 29/06

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-7

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 26, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

UTMs: 609453 m E, 4910338 m N

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 10 20 30 40

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ELEVATION	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
0		GROUND SURFACE	268.05						
		TOPSOIL	0.00				268		
			267.70 0.35	1	50 DO	5			
		Loose, brown to dark brown SANDY SILT, trace to some clay. Contains rootlets and organic staining to approximately 0.8 m							
1				2	50 DO	8	267		
				3	50 DO	8			
2			265.92 2.13				266		
		Compact, brown, moist SILTY SAND, trace clay		4	50 DO	11			
3	TRACK-MOUNTED POWER AUGER 115 mm Solid Stem Augers			5	50 DO	25	265		
4							264		
		Becomes dense at 4.6 m		6	50 DO	73/.28			
5							263		
6							262		
		Becomes wet at 6.1 m	261.70	7	50 DO	50/.10			
		END OF BOREHOLE	6.35						Water encountered during drilling at a depth of 5.2 m, Sept. 26/06 Borehole caved to a depth of 4.1 m upon completion of drilling, Sept. 26/06 Trace amount of water present in open portion of borehole upon completion of drilling, Sept. 26/06
7									
8									
9									
10									

LDN_BHS 06-1189-510.GPJ GLDR_LDN.GDT 22/11/06 DATA INPUT: JLJ 2006'09

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-8

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

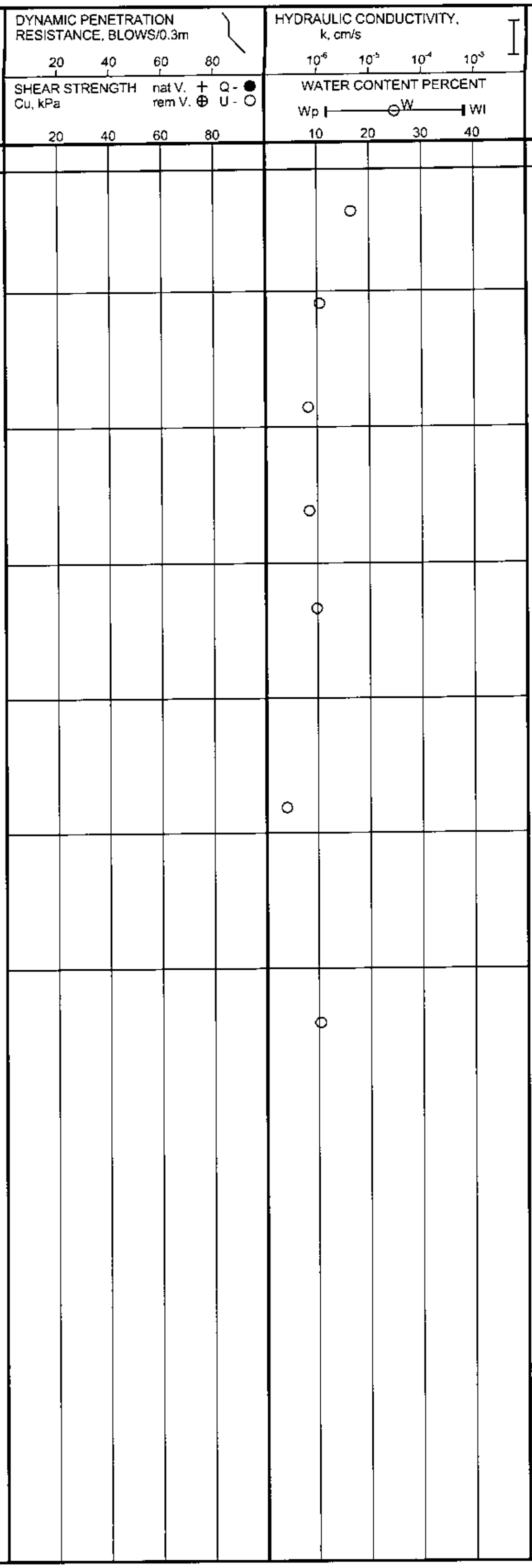
BORING DATE: September 26, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION UTMs: 609464 m E, 4910524 m N	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ELEVATION	INSTALLATION AND GROUNDWATER OBSERVATIONS
		GROUND SURFACE	270.90					
0	TRACK-MOUNTED POWER AUGER 115 mm Solid Stem Augers	TOPSOIL	0.00					
			270.55 0.35	1	50 DO	7		
		Loose, dark brown, moist SANDY SILT, trace clay, trace gravel. Contains organic staining to approximately 0.6 m	270.29 0.61					
1		Compact, grey, moist SANDY SILT, trace to some clay, trace gravel. Contains sand interlayers (TILL)		2	50 DO	22	270	
		Becomes very dense below 1.5 m		3	50 DO	51	269	
2				4	50 DO	93		
3		Hard, grey CLAYEY SILT, some sand, trace gravel (TILL)	268.00 2.90	5	50 DO	85/.23	268	
4		Very dense, brown, moist SILTY SAND	266.79 4.11	6	50 DO	50/.13	267 266	
5								
6				7	50 DO	90/.25	265	
		END OF BOREHOLE	264.40 6.50					Borehole open and dry upon completion of drilling, Sept. 26/06
7								
8								
9								
10								



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PM
CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-9

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 26, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

UTMs: 609645 m E, 4910867 m N

BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

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 10 20 30 40

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ELEVATION	INSTALLATION AND GROUNDWATER OBSERVATIONS
0	GROUND SURFACE	270.08				270	
	TOPSOIL	0.00					
	Compact, brown, moist SILTY SAND, trace clay. Contains organic staining to approximately 5.5 m	269.83 0.25	1	50 DO	10		
1	Compact to dense, grey, damp to moist SANDY SILT, trace clay, trace gravel. Contains sand interlayers (TILL)	269.39 0.69	2	50 DO	36	269	
2			3	50 DO	28	268	
			4	50 DO	44		
3	Becomes very dense below 3 m		5	50 DO	50	267	
4	Hard, grey CLAYEY SILT, some sand and gravel (TILL)	266.04 4.04				266	
5			6	50 DO	80/ .28	265	
6	Very dense, grey, damp to moist SILTY SAND, trace gravel	264.59 5.49				264	
			7	50 DO	81/ .28		
7	END OF BOREHOLE	263.55 6.53					Borehole caved to a depth of 5.8 m upon completion of drilling, Sept. 26/06
8							
9							
10							

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PM
CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-10

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 26, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

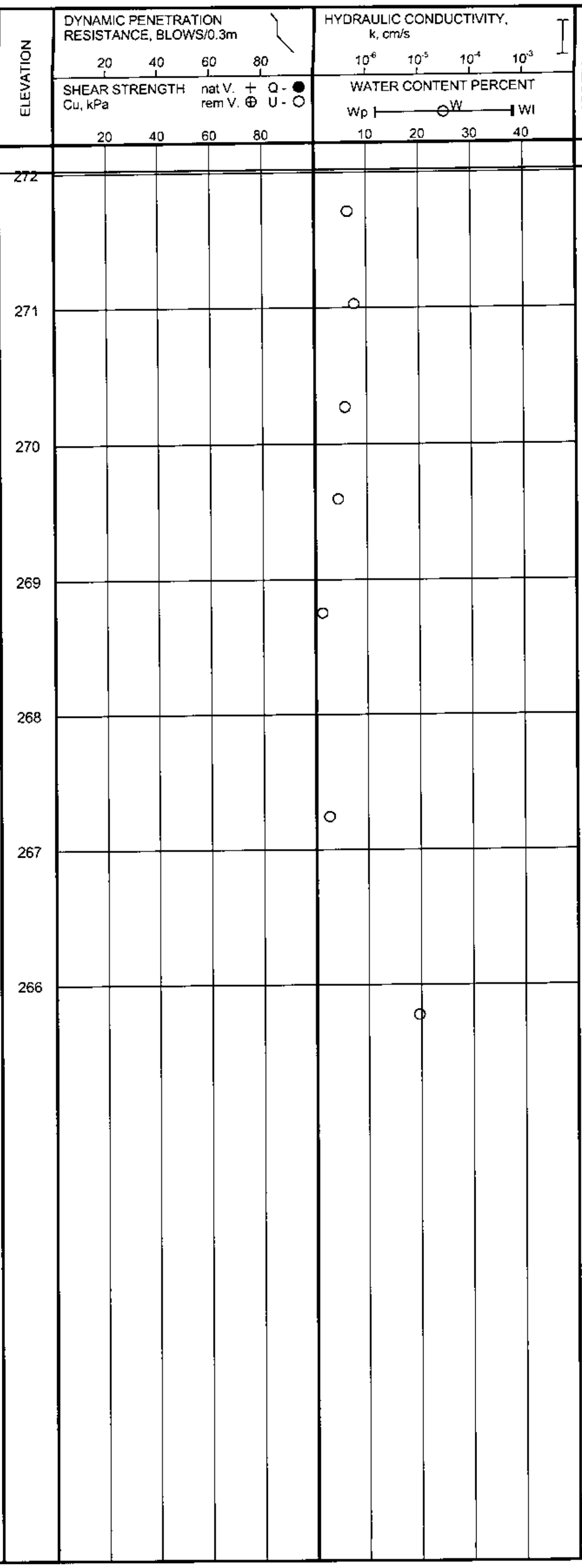
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

UTMs: 609370 m E, 4911008 m N

BORING METHOD: TRACK-MOUNTED POWER AUGER
115 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	272.02
TOPSOIL	0.00
Compact, brown, damp to moist SANDY SILT, trace gravel	271.72 0.30
Dense to very dense, grey, moist SANDY SILT, trace to some clay, trace gravel. Contains sand interlayers (TILL)	271.33 0.69
Very dense, grey, moist SAND, some silt to SILTY SAND, trace gravel	269.89 2.13
Very dense, grey, moist SILT	266.30 5.72
END OF BOREHOLE	265.64 6.38

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	50 DO	10
2	50 DO	28
3	50 DO	58
4	50 DO	50/ .13
5	50 DO	90/ .28
6	50 DO	84/ .25
7	50 DO	50/ .13



ADDITIONAL LAB. TESTING

INSTALLATION AND GROUNDWATER OBSERVATIONS

Water encountered during drilling at a depth of 6.38 m, Sept. 26/06

Borehole caved to a depth of 5.8 m upon completion of drilling, Sept. 26/06

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

PROJECT: 06-1189-510

RECORD OF BOREHOLE BH 06-11

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: September 26, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

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; 10 20 30 40

ADDITIONAL LAB. TESTING

BORING METHOD: TRACK-MOUNTED POWER AUGER, 115 mm Solid Stem Augers

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

SOIL PROFILE DESCRIPTION UTMs: 609280 m E, 4911036 m N	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ELEVATION	INSTALLATION AND GROUNDWATER OBSERVATIONS
GROUND SURFACE	268.72					
TOPSOIL	0.00 268.37	1	50 DO	8		
Loose, brown, moist SANDY SILT	0.35 268.03					
Compact, grey, moist SANDY SILT, trace to some clay, trace gravel (TILL)	0.69 267.35	2	50 DO	16	268	
Dense to very dense, grey, moist SAND, some silt to SILTY SAND, trace gravel	1.37	3	50 DO	48	267	
		4	50 DO	65	266	
		5	50 DO	80/ .28	265	
		6	50 DO	90/ .28	264	
					263	
	262.24	7	50 DO	85/ .23		
END OF BOREHOLE	6.48					Borehole open and dry upon completion of drilling, Sept. 26/06

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PM

CHECKED: KN

BURNSIDE

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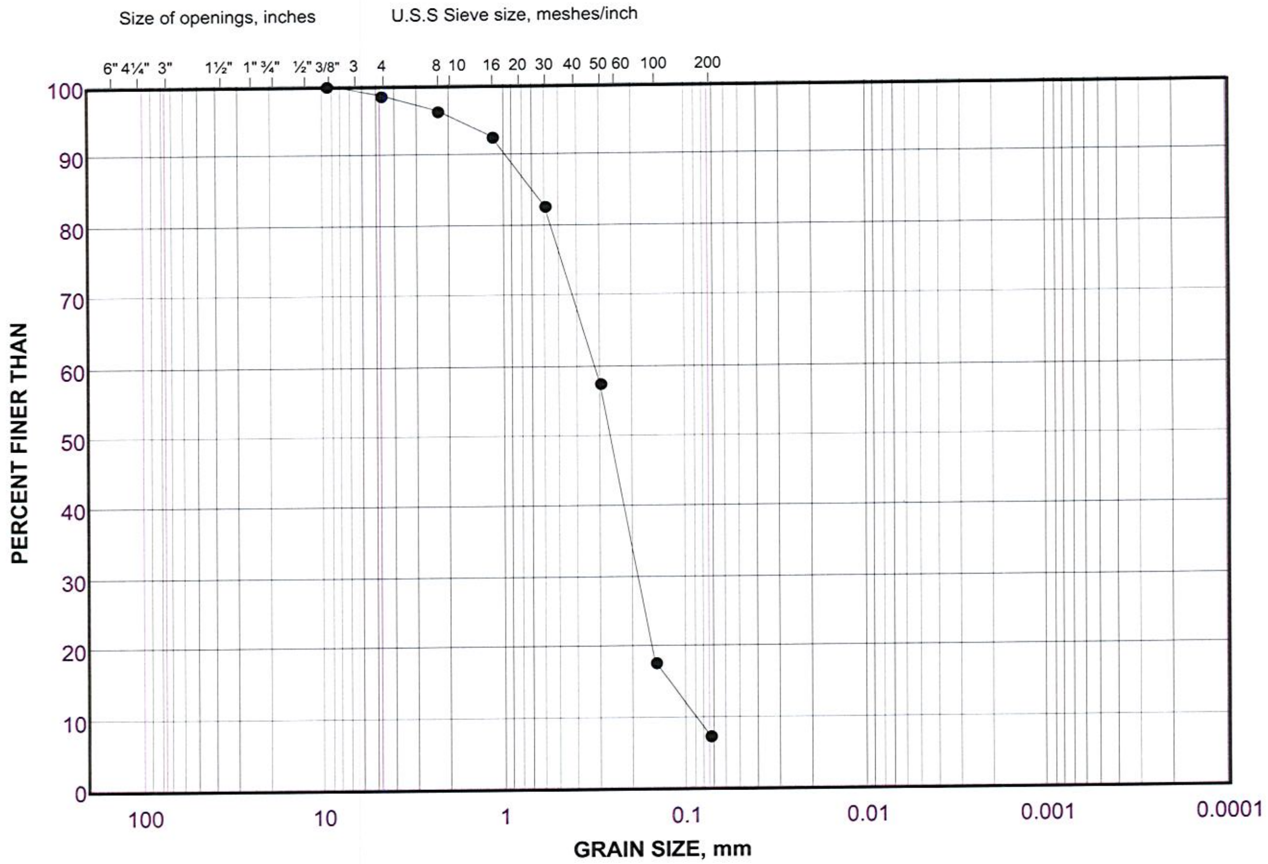
Appendix C

Hydraulic Conductivity Data

GRAIN SIZE DISTRIBUTION
SAND

FIGURE 4



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	06-3	6	4.6 - 5.0

Project Number: 06-1189-510

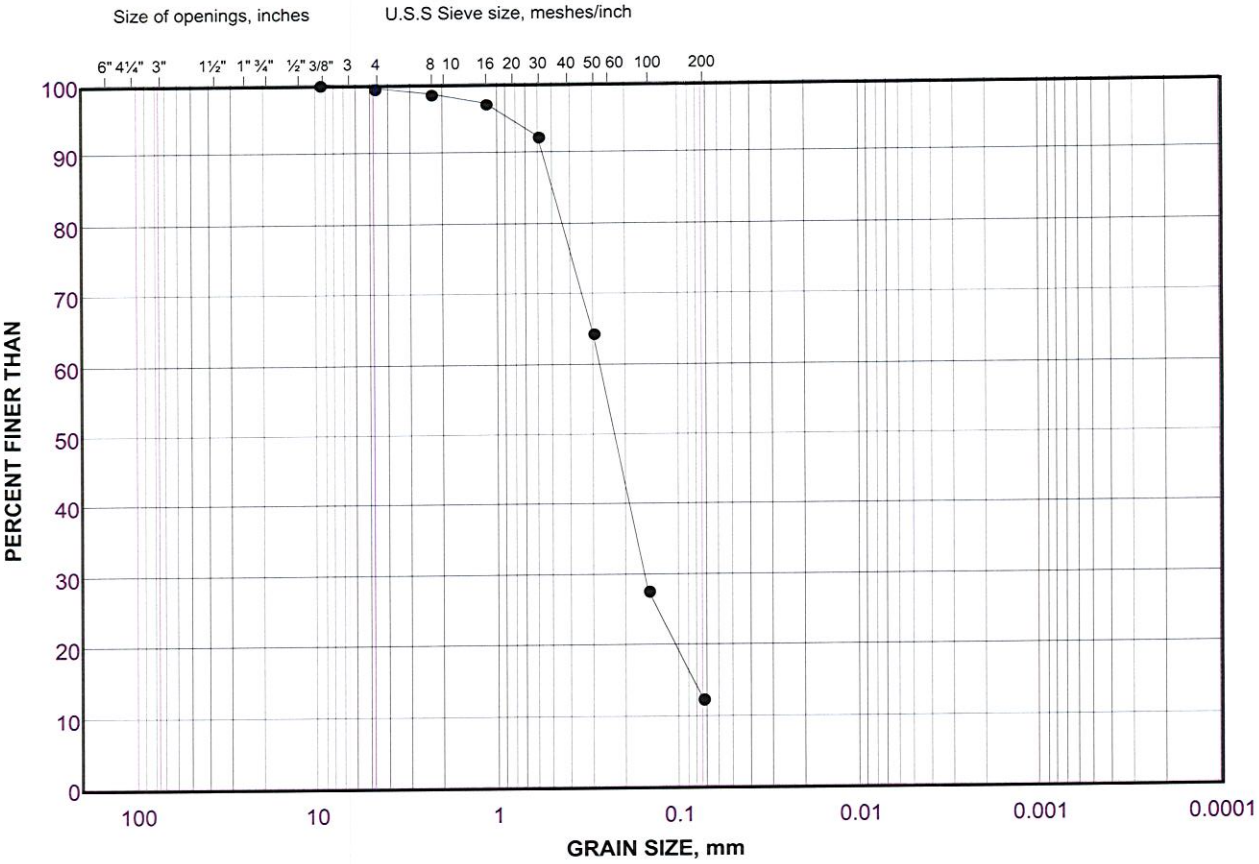
Checked By:

Golder Associates

Date: 06-Oct-06

GRAIN SIZE DISTRIBUTION
SAND

FIGURE 5



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	06-6	5	3.0 - 3.5

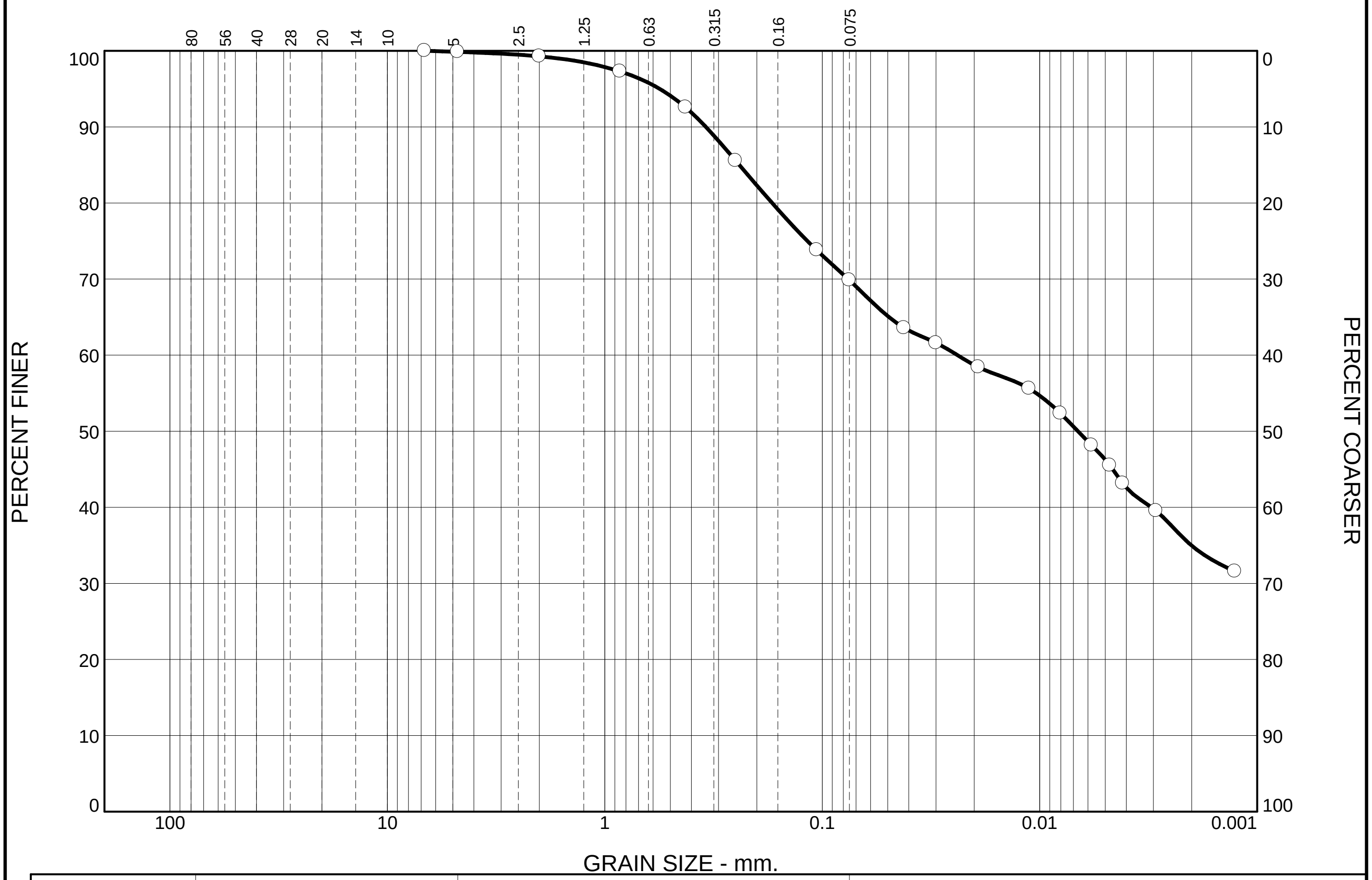
Project Number: 06-1189-510

Checked By:

Golder Associates

Date: 06-Oct-06

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	1	6	23	35	35

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2408	0.0239	0.0067					

Material Description	USCS	AASHTO
○ SANDY SILTY CLAY		

Project No. 18-001 **Client:** R.J. Burnside & Associates Limited

Project: Laboratory testing

Burnside File 300039257, Rainsong

○ **Location:** 15.0 ft - 17.0 ft **Sample Number:** RS-1, Sample SS-7

Remarks:

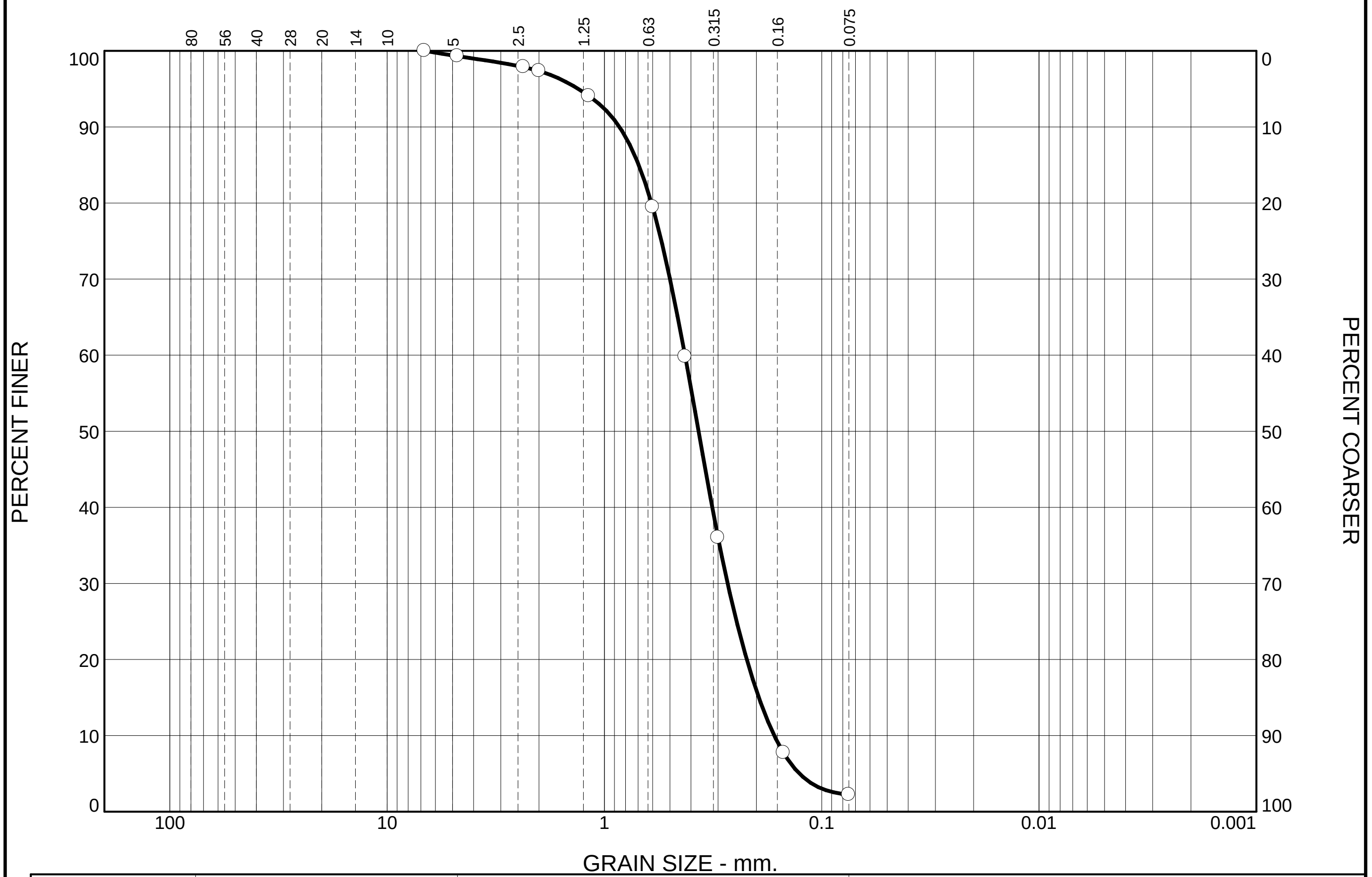
Alston Associates

Geotechnical Division of Terrapex

Figure 1

Tested By: VP **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	1	2	37	58	2	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.6957	0.4262	0.3689	0.2711	0.1948	0.1653	1.04	2.58

Material Description	USCS	AASHTO
○ SAND, trace silt, trace gravel	SP	

Project No. 18-001 **Client:** R.J. Burnside & Associates Limited

Project: Laboratory testing

Burnside File 300039257, Rainsong

○ **Location:** 30 ft - 32 ft **Sample Number:** RS-3d, Sample SS-13

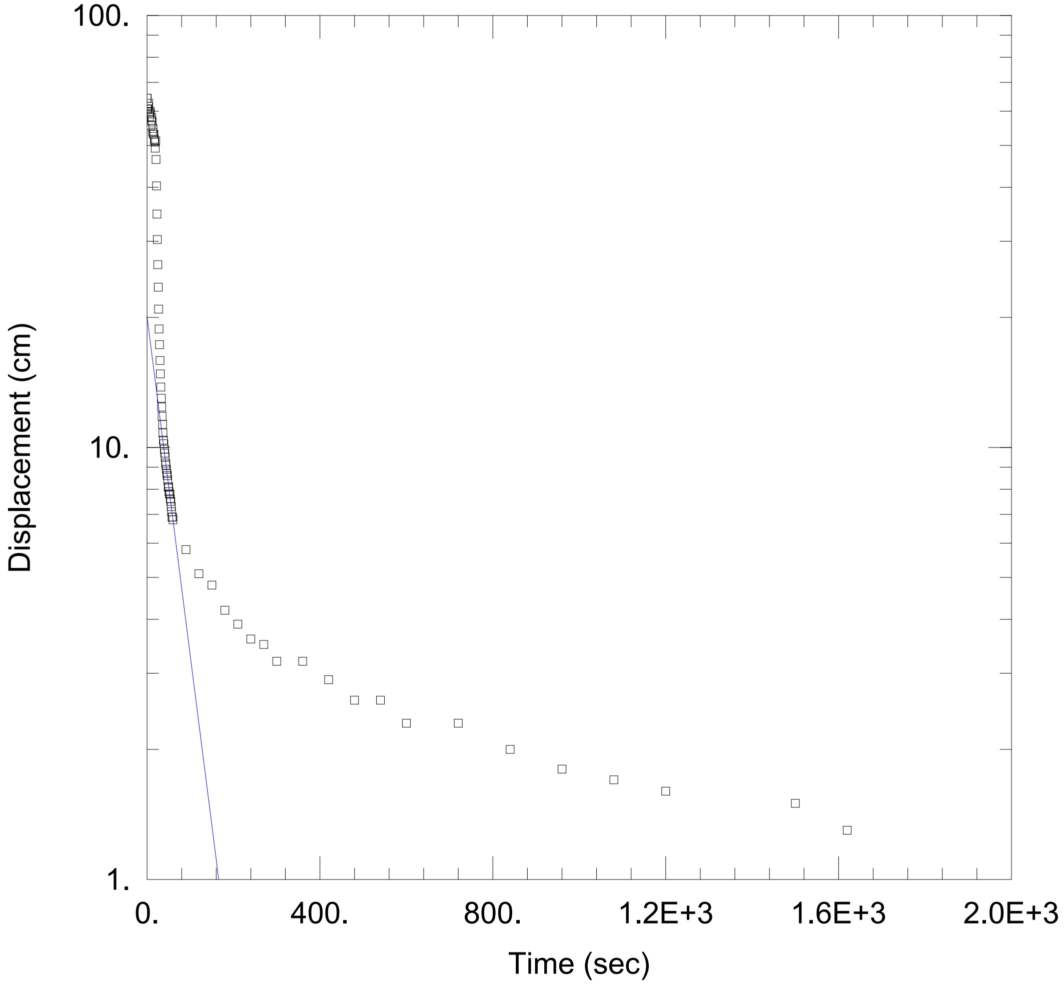
Remarks:

Alston Associates

Geotechnical Division of Terrapex

Figure 2

Tested By: VP **Checked By:** JB



HYDRAULIC CONDUCTIVITY TEST AT RS-1(SCREENED IN SAND)

PROJECT INFORMATION

Company: R.J Burnside
Client: Rainsong
Project: 300039257
Location: Barrie
Test Well: RS-1
Test Date: October 26, 2017

AQUIFER DATA

Saturated Thickness: 173. cm
Anisotropy Ratio (Kz/Kr): 0.1

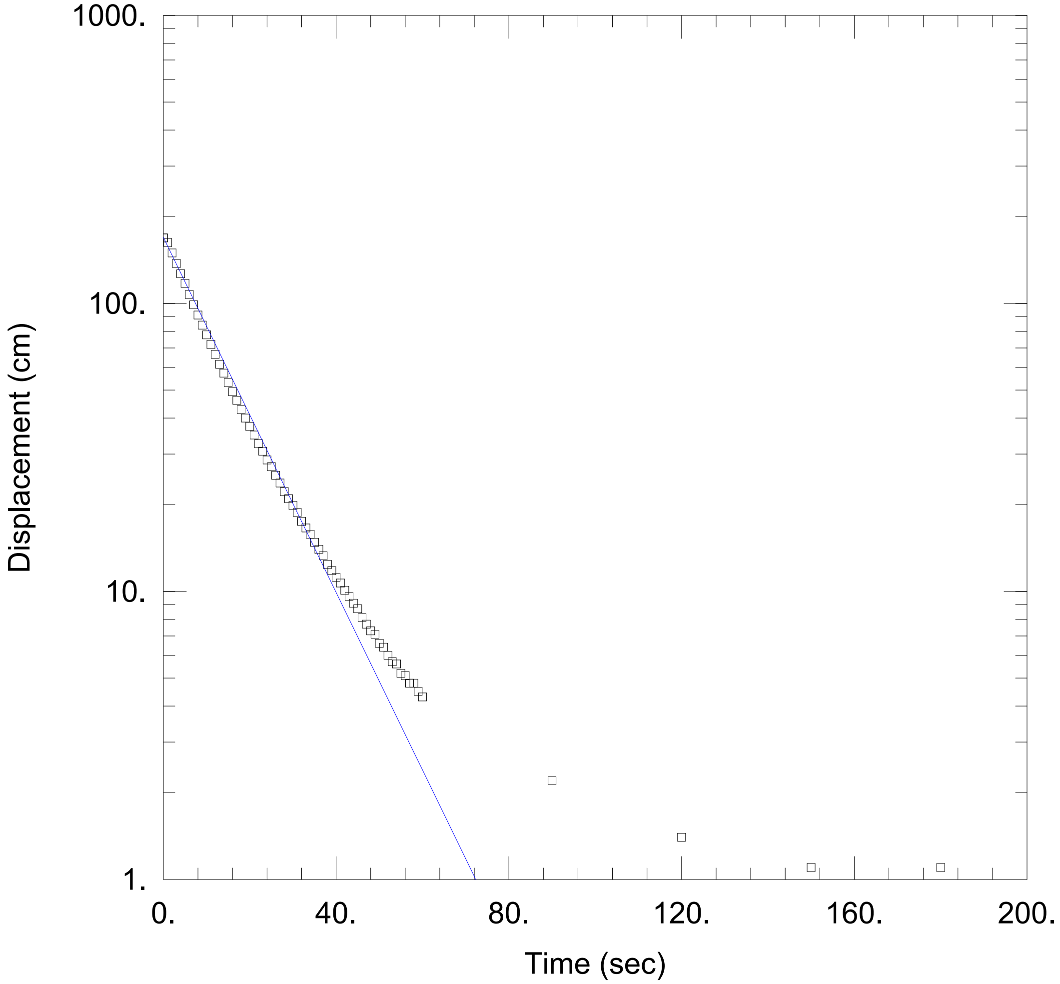
WELL DATA (RS-1)

Initial Displacement: 64.3 cm
Total Well Penetration Depth: 173. cm
Casing Radius: 2.54 cm
Static Water Column Height: 173. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.001252 cm/sec
y0 = 20.07 cm



HYDRAULIC CONDUCTIVITY TEST AT RS-3D (SCREENED IN SAND)

PROJECT INFORMATION

Company: R.J Burnside
Client: Rainsong
Project: 300039257
Location: Barrie
Test Well: RS-3d
Test Date: October 26, 2017

AQUIFER DATA

Saturated Thickness: 780. cm
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (RS-3d)

Initial Displacement: 168.8 cm
Total Well Penetration Depth: 780. cm
Casing Radius: 2.54 cm
Static Water Column Height: 0. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.006291 cm/sec
y0 = 169.5 cm

BURNSIDE

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Appendix D

Groundwater Level Data

Appendix D

Table D-1
Groundwater Elevations

Monitoring Well	Well Depth (mbgl)	Ground Surface Elevation (masl)	May 23-27, 2017		5-Jul-2017		26-Jul-2017		30-Aug-2017		27-Sep-2017		26-Oct-2017	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
RS-1	**8.34**	**270.19**	6.05	264.14	6.09	264.10	6.16	264.03	6.18	264.01	6.46	263.73	6.61	263.58
RS-2	**8.31**	**270.51**	5.88	264.63	5.88	264.63	6.00	264.51	6.32	264.19	6.36	264.15	6.49	264.02
RS-3s	**5.68**	**266.84**	2.00	264.84	2.22	264.62	2.39	264.45	2.64	264.20	2.83	264.01	2.99	263.85
RS-3d	**10.70**	**266.77**	1.91	264.86	2.12	264.65	2.29	264.48	2.55	264.22	2.73	264.04	2.90	263.87
RS-4	**10.81**	**271.37**	-	-	9.10	262.27	9.11	262.26	9.25	262.12	9.36	262.01	9.48	261.89
RS-5	**9.16**	**271.15**	7.63	263.52	7.44	263.71	7.45	263.70	7.58	263.57	7.69	263.46	7.83	263.32
RS-6	**9.20**	**269.93**	7.48	262.45	7.29	262.64	7.29	262.64	7.42	262.51	7.53	262.40	7.66	262.27
RS-7	**8.92**	**268.49**	7.24	261.25	7.06	261.43	7.09	261.40	7.22	261.28	7.32	261.17	7.46	261.03
MW7s	**7.61**	**271.24**	-	-	Dry	Dry	-	-	-	-	-	-	Dry	Dry
MW7d	**13.23**	**271.24**	-	-	9.91	261.33	-	-	-	-	-	-	10.21	261.03
MW9	**8.02**	**268.86**	-	-	5.93	262.94	-	-	-	-	-	-	6.51	262.36
MW13	**5.31**	**263.14**	-	-	0.85	262.29	-	-	-	-	-	-	1.13	262.01
MW14	**8.20**	**268.89**	-	-	5.92	262.97	-	-	-	-	-	-	6.39	262.50

"-" denotes data unavailable

Table D-1
Groundwater Elevations

Monitoring Well	Well Depth (mbgl)	Ground Surface Elevation (masl)	24-Nov-2017		19-Dec-2017		26-Jan-2018		23-Feb-2018		23-Mar-2018		27-Apr-2018	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
RS-1	**8.34**	**270.19**	6.75	263.44	6.82	263.37	6.93	263.26	6.84	263.35	6.81	263.38	6.77	263.42
RS-2	**8.31**	**270.51**	6.56	263.95	6.65	263.86	6.65	263.86	6.60	263.91	6.74	263.77	6.43	264.08
RS-3s	**5.68**	**266.84**	2.97	263.87	3.10	263.74	2.85	263.99	2.90	263.94	3.05	263.79	2.29	264.55
RS-3d	**10.70**	**266.77**	2.89	263.88	3.01	263.76	2.78	263.99	2.79	263.98	2.95	263.82	2.25	264.52
RS-4	**10.81**	**271.37**	9.59	261.78	9.66	261.71	9.82	261.55	9.84	261.53	9.68	261.69	9.69	261.68
RS-5	**9.16**	**271.15**	8.33	262.82	8.08	263.07	8.27	262.88	8.26	262.89	8.11	263.04	8.21	262.94
RS-6	**9.20**	**269.93**	7.81	262.12	7.91	262.02	8.08	261.85	8.09	261.84	8.06	261.87	8.08	261.85
RS-7	**8.92**	**268.49**	7.60	260.89	7.69	260.80	7.84	260.65	7.66	260.83	7.76	260.73	7.75	260.74
MW7s	**7.61**	**271.24**	-	-	-	-	-	-	-	-	Dry	Dry	Dry	Dry
MW7d	**13.23**	**271.24**	-	-	-	-	-	-	-	-	10.53	260.71	10.49	260.75
MW9	**8.02**	**268.86**	-	-			-	-	6.75	262.12	6.79	262.08	6.38	262.49
MW13	**5.31**	**263.14**	-	-	-	-	-	-	0.78	262.36	1.05	262.09	0.64	262.50
MW14	**8.20**	**268.89**	-	-	-	-	-	-	6.56	262.33	6.43	262.46	6.37	262.52

"-" denotes data unavailable

Table D-1
Groundwater Elevations

Monitoring Well	Well Depth (mbgl)	Ground Surface Elevation (masl)	17-May-2018		28-Jun-2018		14-Aug-2018		24-Oct-2018		17-Dec-2018	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
RS-1	**8.34**	**270.19**	6.45	263.74	6.45	263.74	6.68	263.51	6.99	263.20	7.02	263.17
RS-2	**8.31**	**270.51**	6.28	264.23	6.37	264.14	6.61	263.90	6.49	264.02	6.72	263.79
RS-3s	**5.68**	**266.84**	2.51	264.33	2.74	264.10	3.02	263.82	3.36	263.48	3.13	263.71
RS-3d	**10.70**	**266.77**	2.40	264.37	2.64	264.13	2.92	263.85	3.26	263.51	3.03	263.74
RS-4	**10.81**	**271.37**	9.51	261.86	9.33	262.04	9.51	261.86	9.48	261.89	9.90	261.47
RS-5	**9.16**	**271.15**	7.96	263.19	7.77	263.38	7.95	263.20	8.24	262.91	8.41	262.74
RS-6	**9.20**	**269.93**	7.77	262.16	7.64	262.29	7.80	262.13	8.06	261.87	8.23	261.70
RS-7	**8.92**	**268.49**	7.48	261.01	7.39	261.10	7.57	260.92	7.81	260.68	7.98	260.51
MW7s	**7.61**	**271.24**	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
MW7d	**13.23**	**271.24**	10.23	261.01	10.08	261.16	10.28	260.96	10.54	260.70	10.68	260.56
MW9	**8.02**	**268.86**	-	-	6.42	262.45	6.69	262.18	Removed	Removed	Removed	Removed
MW13	**5.31**	**263.14**	0.91	262.23	1.08	262.06	0.75	262.39	1.09	262.05	0.88	262.26
MW14	**8.20**	**268.89**	6.05	262.84	6.23	262.66	6.49	262.40	6.77	262.12	6.66	262.23

"-" denotes data unavailable

Table D-1
Groundwater Elevations

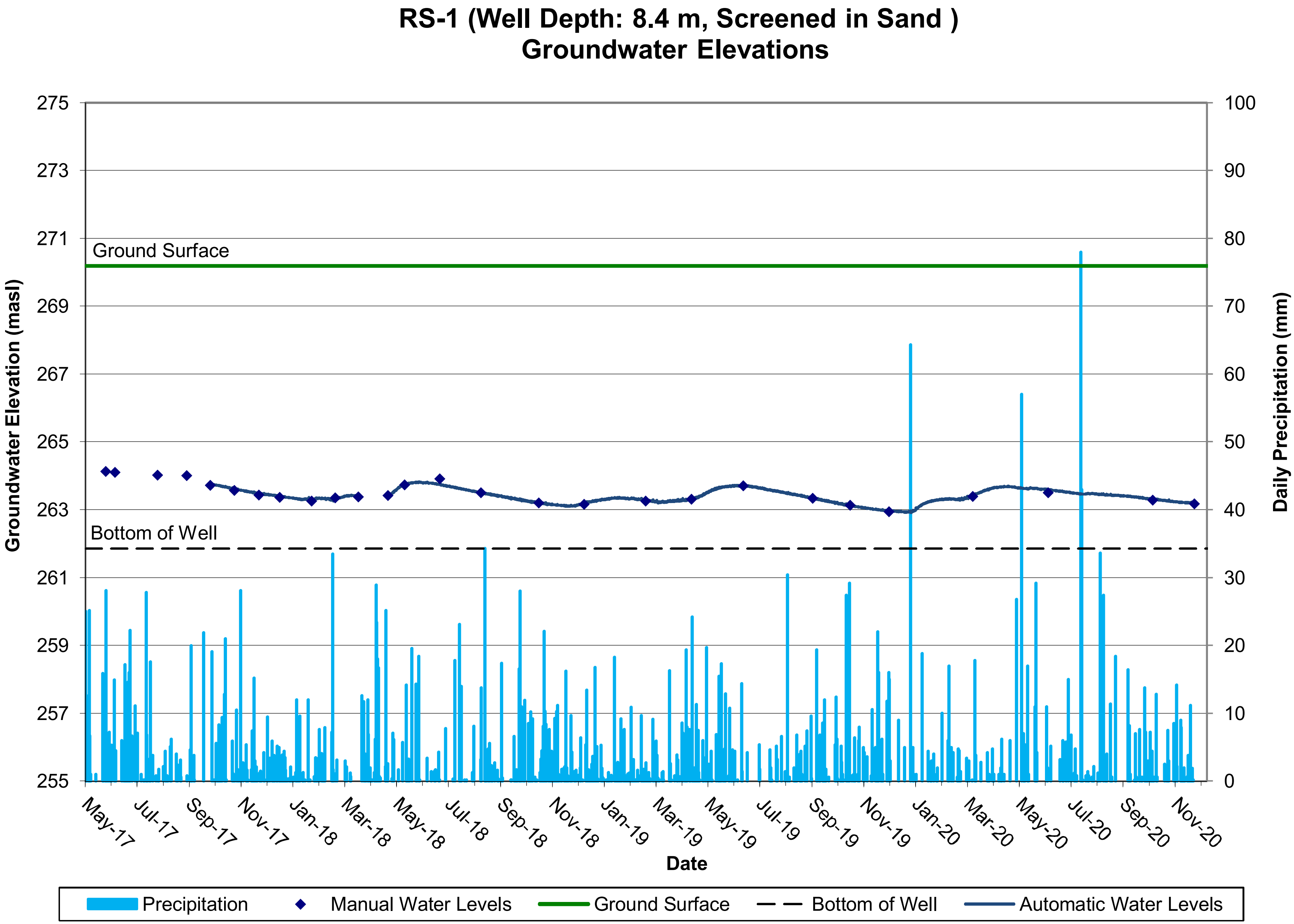
Monitoring Well	Well Depth (mbgl)	Ground Surface Elevation (masl)	1-Mar-2019		25-Apr-2019		26-Jun-2019		17-Sep-2019		31-Oct-2019		17-Dec-2019	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
RS-1	**8.34**	**270.19**	6.93	263.26	6.87	263.32	6.48	263.71	6.85	263.34	7.26	262.93	7.25	262.94
RS-2	**8.31**	**270.51**	N/A	N/A	6.66	263.85	6.47	264.04	6.86	263.65	-	-	7.01	263.50
RS-3s	**5.68**	**266.84**	3.20	263.64	2.86	263.98	2.76	264.08	3.28	263.56	-	-	3.41	263.43
RS-3d	**10.70**	**266.77**	3.11	263.66	2.78	263.99	2.65	264.12	3.18	263.59	-	-	3.31	263.46
RS-4	**10.81**	**271.37**	9.85	261.52	9.74	261.63	9.44	261.93	9.67	261.70	9.83	261.54	10.00	261.37
RS-5	**9.16**	**271.15**	8.26	262.89	8.16	262.99	7.90	263.25	8.13	263.02	8.36	262.79	8.50	262.65
RS-6	**9.20**	**269.93**	8.16	261.77	8.05	261.88	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
RS-7	**8.92**	**268.49**	7.89	260.60	7.80	260.69	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
MW7s	**7.61**	**271.24**	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	-	-	-	-
MW7d	**13.23**	**271.24**	10.72	260.52	10.56	260.68	10.26	260.98	10.51	260.73	-	-	-	-
MW9	**8.02**	**268.86**	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
MW13	**5.31**	**263.14**	1.04	262.10	0.76	262.38	0.99	262.15	1.37	261.77	-	-	-	-
MW14	**8.20**	**268.89**	6.67	262.22	6.57	262.32	6.26	262.63	-	-	6.71	262.18	6.93	261.96

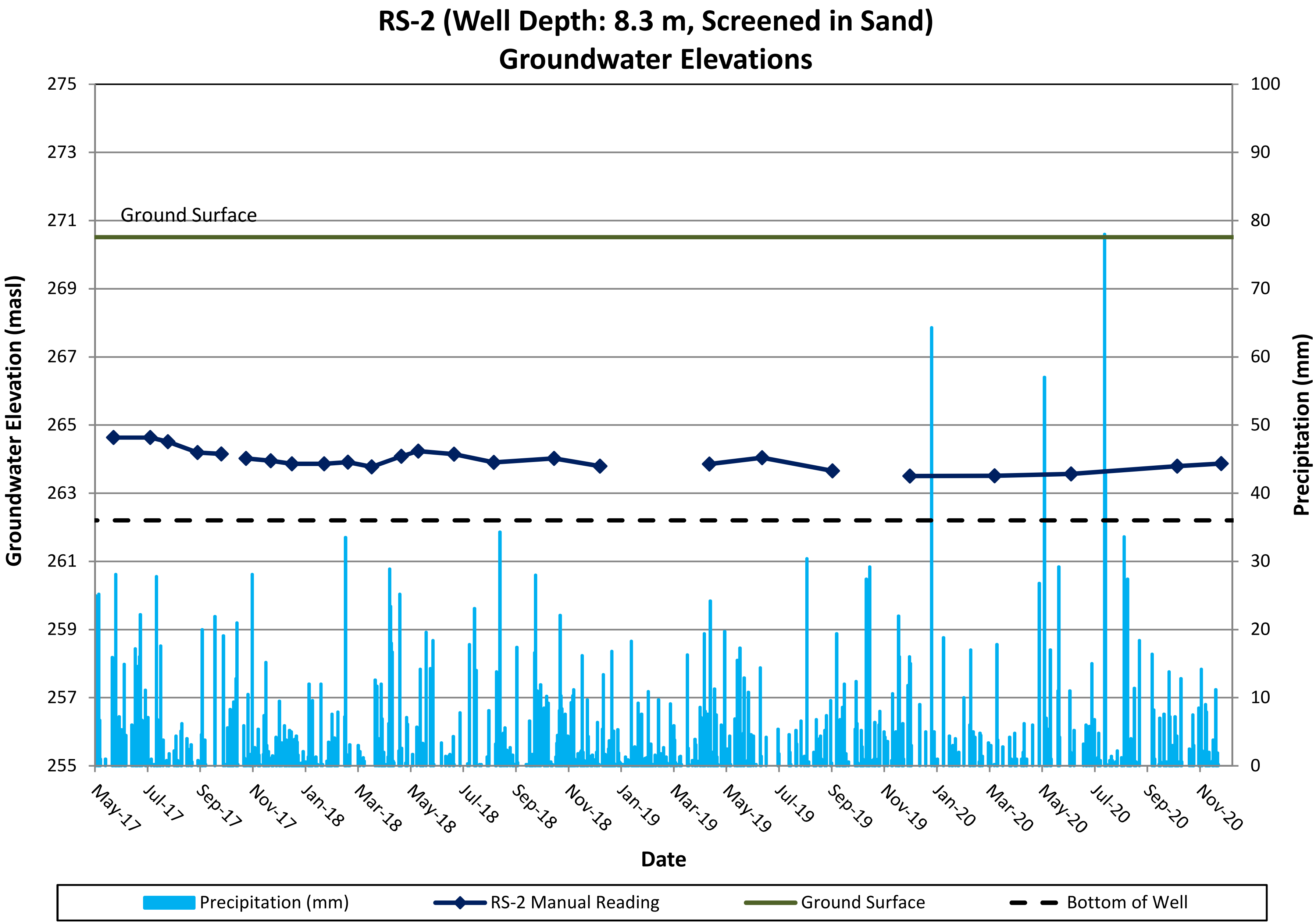
"-" denotes data unavailable

Table D-1
Groundwater Elevations

Monitoring Well	Well Depth (mbgl)	Ground Surface Elevation (masl)	26-Mar-2020		24-Jun-2020		27-Oct-2020		16-Dec-2020	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
RS-1	**8.34**	**270.19**	6.80	263.39	6.68	263.51	6.90	263.29	7.01	263.18
RS-2	**8.31**	**270.51**	7.00	263.51	6.95	263.56	6.72	263.79	6.64	263.87
RS-3s	**5.68**	**266.84**	2.71	264.13	2.77	264.07	3.18	263.66	2.96	263.88
RS-3d	**10.70**	**266.77**	2.62	264.15	2.67	264.10	3.09	263.68	2.89	263.88
RS-4	**10.81**	**271.37**	9.85	261.52	9.57	261.80	9.82	261.55	9.91	261.46
RS-5	**9.16**	**271.15**	8.28	262.87	8.05	263.10	8.17	262.98	8.41	262.74
RS-6	**9.20**	**269.93**	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
RS-7	**8.92**	**268.49**	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
MW7s	**7.61**	**271.24**	Dry	Dry	Dry	Dry	Dry	Dry	-	-
MW7d	**13.23**	**271.24**	10.75	260.49	10.46	260.78	10.76	260.48	-	-
MW9	**8.02**	**268.86**	Removed	Removed	Removed	Removed	Removed	Removed	Removed	Removed
MW13	**5.31**	**263.14**	0.71	262.43	0.84	262.30	0.66	262.48	0.80	262.34
MW14	**8.20**	**268.89**	6.44	262.45	6.40	262.49	6.66	262.23	6.73	262.16

"-" denotes data unavailable


RS-1 (Well Depth: 8.4 m, Screened in Sand)
Groundwater Elevations
Groundwater Elevation (masl)
Daily Precipitation (mm)
275
273
271
269
267
265
263
261
259
257
255
100
90
80
70
60
50
40
30
20
10
0
Ground Surface
Bottom of Well
May-17
Jul-17
Sep-17
Nov-17
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18
Jan-19
Mar-19
May-19
Jul-19
Sep-19
Nov-19
Jan-20
Mar-20
May-20
Jul-20
Sep-20
Nov-20
Date
Precipitation
Manual Water Levels
Ground Surface
Bottom of Well
Automatic Water Levels


RS-2 (Well Depth: 8.3 m, Screened in Sand)
Groundwater Elevations
Groundwater Elevation (masl)
275
273
271
269
267
265
263
261
259
257
255
Precipitation (mm)
100
90
80
70
60
50
40
30
20
10
0
Ground Surface
May-17
Jul-17
Sep-17
Nov-17
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18
Jan-19
Mar-19
May-19
Jul-19
Sep-19
Nov-19
Jan-20
Mar-20
May-20
Jul-20
Sep-20
Nov-20
Date
Precipitation (mm)
RS-2 Manual Reading
Ground Surface
Bottom of Well

RS-3s (Well Depth: 5.5 m, Screened in Sand)
RS-3d (Well Depth: 10.7 m, Screened in Sand)
Groundwater Elevations

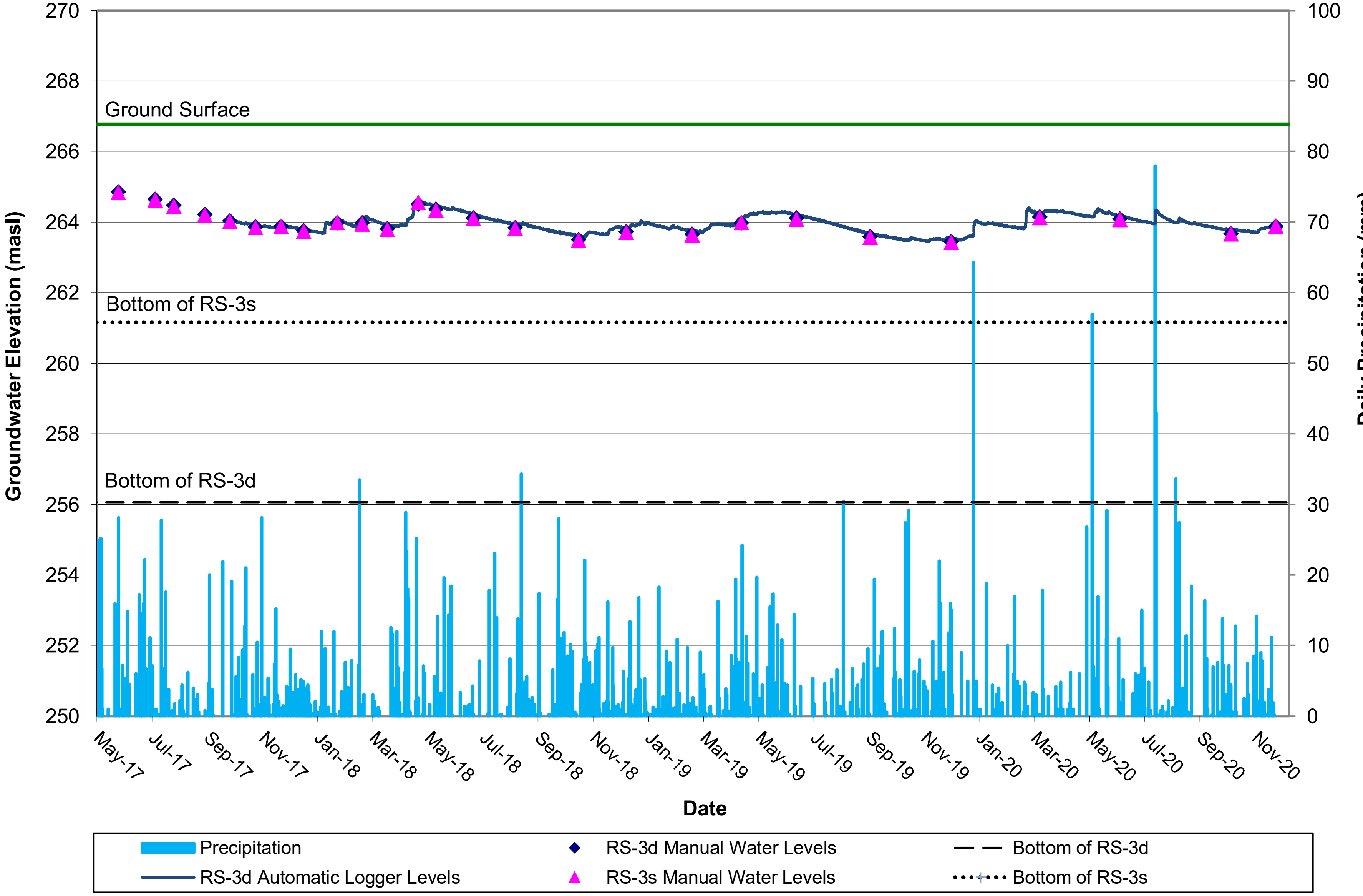
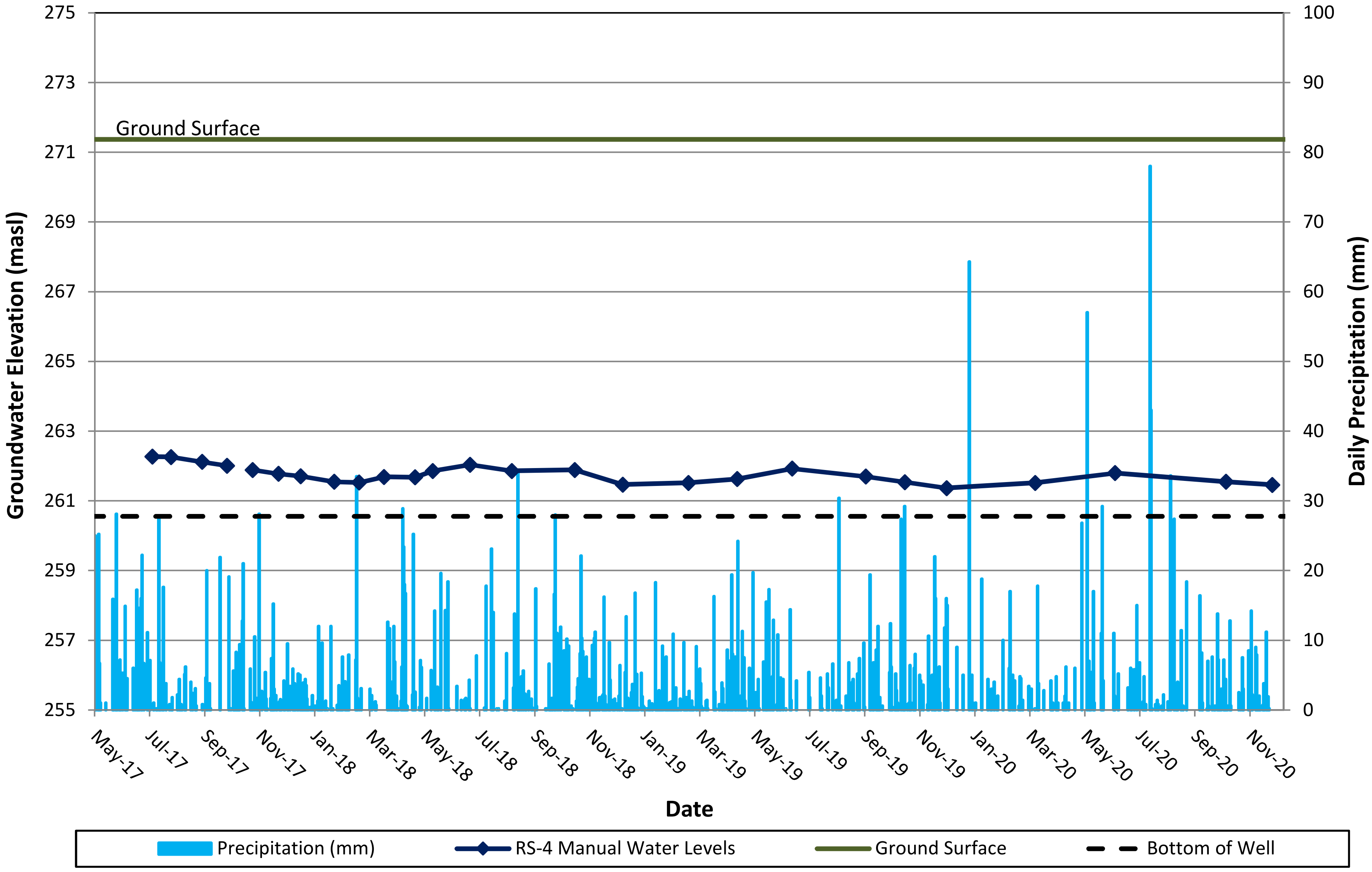


Figure D-3

RS-4 (Well Depth: 10.8 m, Screened in Sand)
Groundwater Elevations



RS-5 (Well Depth 9.1 m, Screened in Sand)
Groundwater Elevations

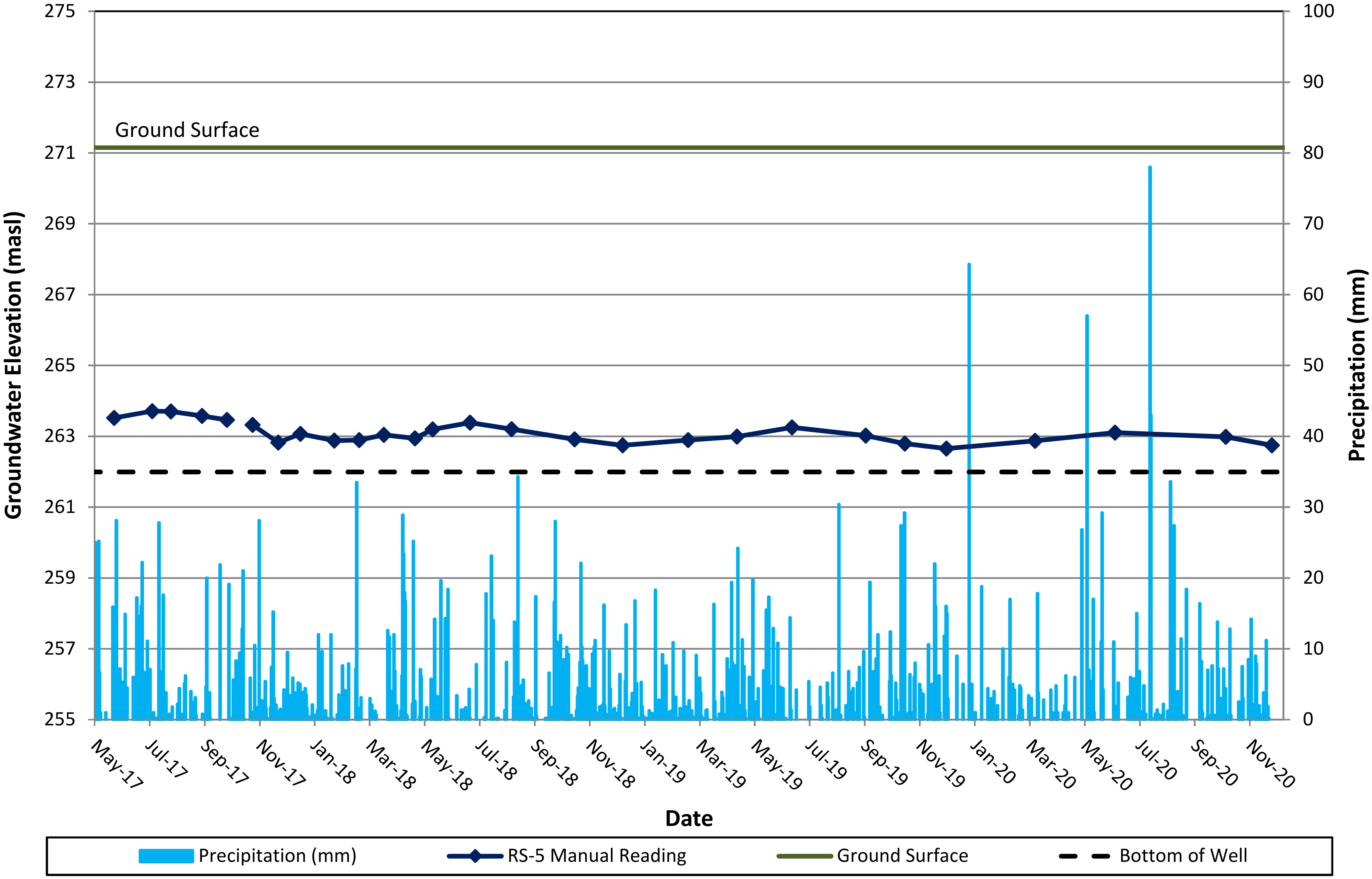
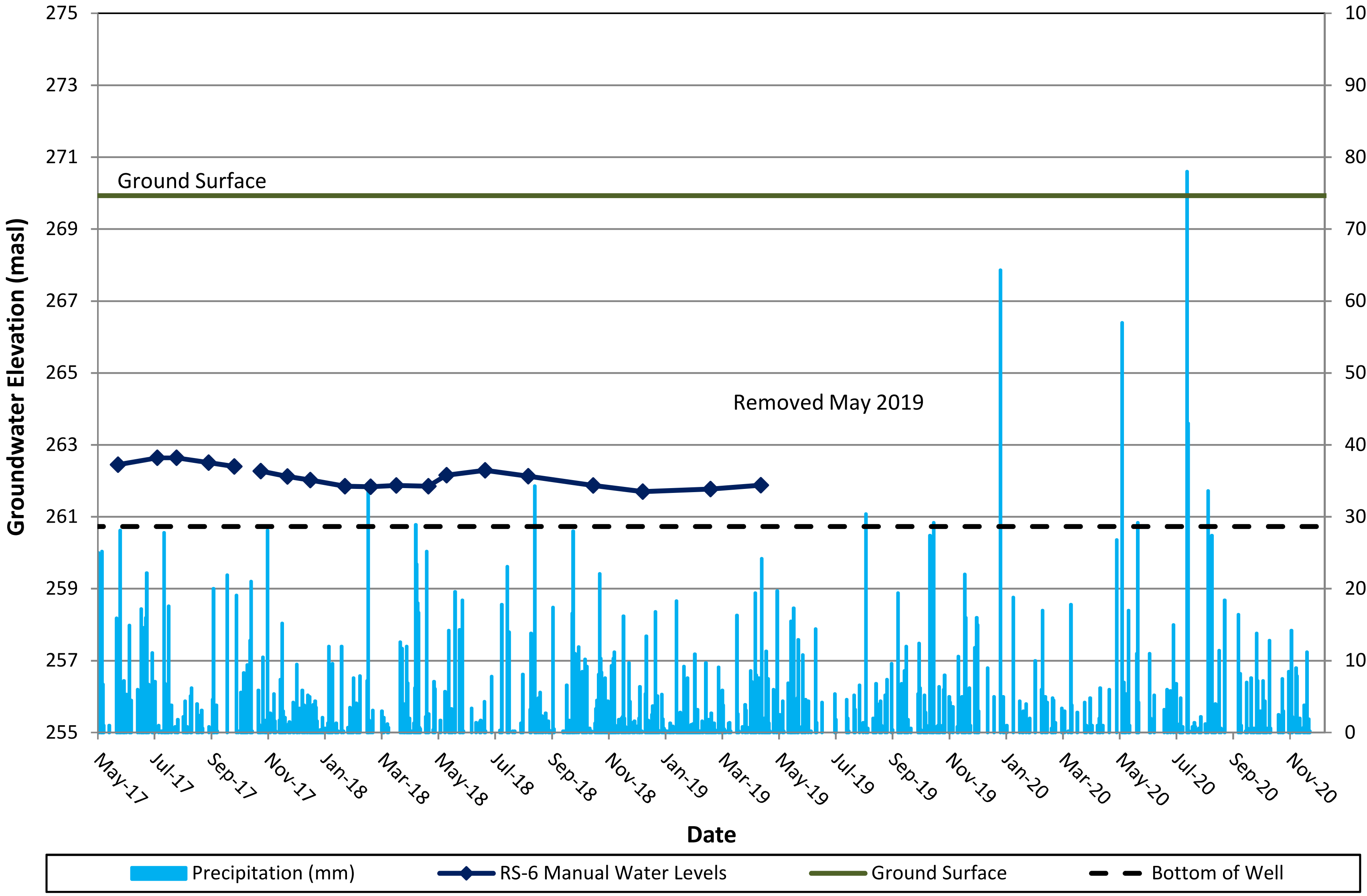
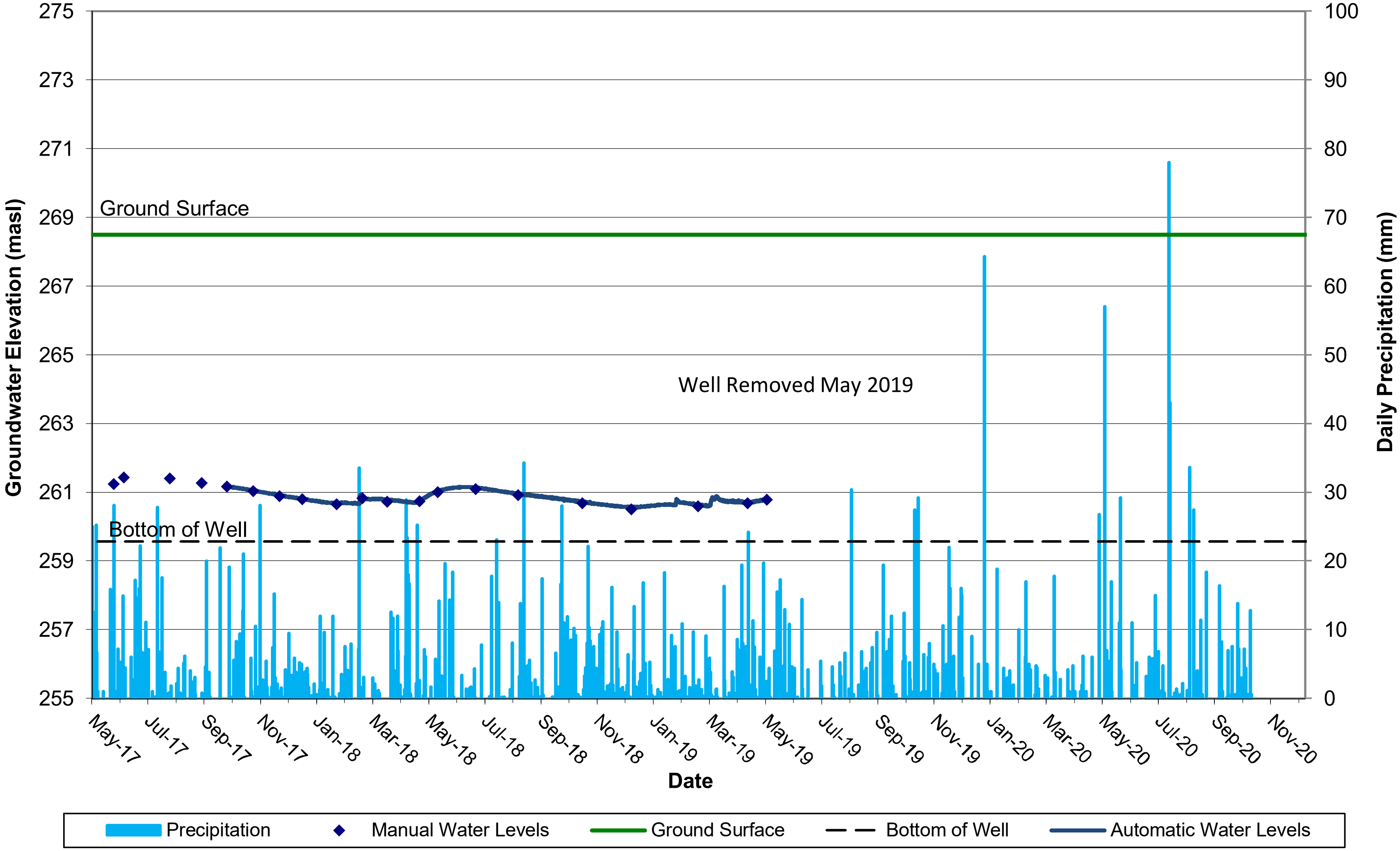


Figure D-5

RS-6 (Well Depth: 9.2 m, Screened in Sand)
Groundwater Elevations



RS-7 (Well Depth: 9.7m, Screened in Sand Till)
Groundwater Elevations



MW7d (Well Depth: 14.2 m, Screened in Sand)
Groundwater Elevations

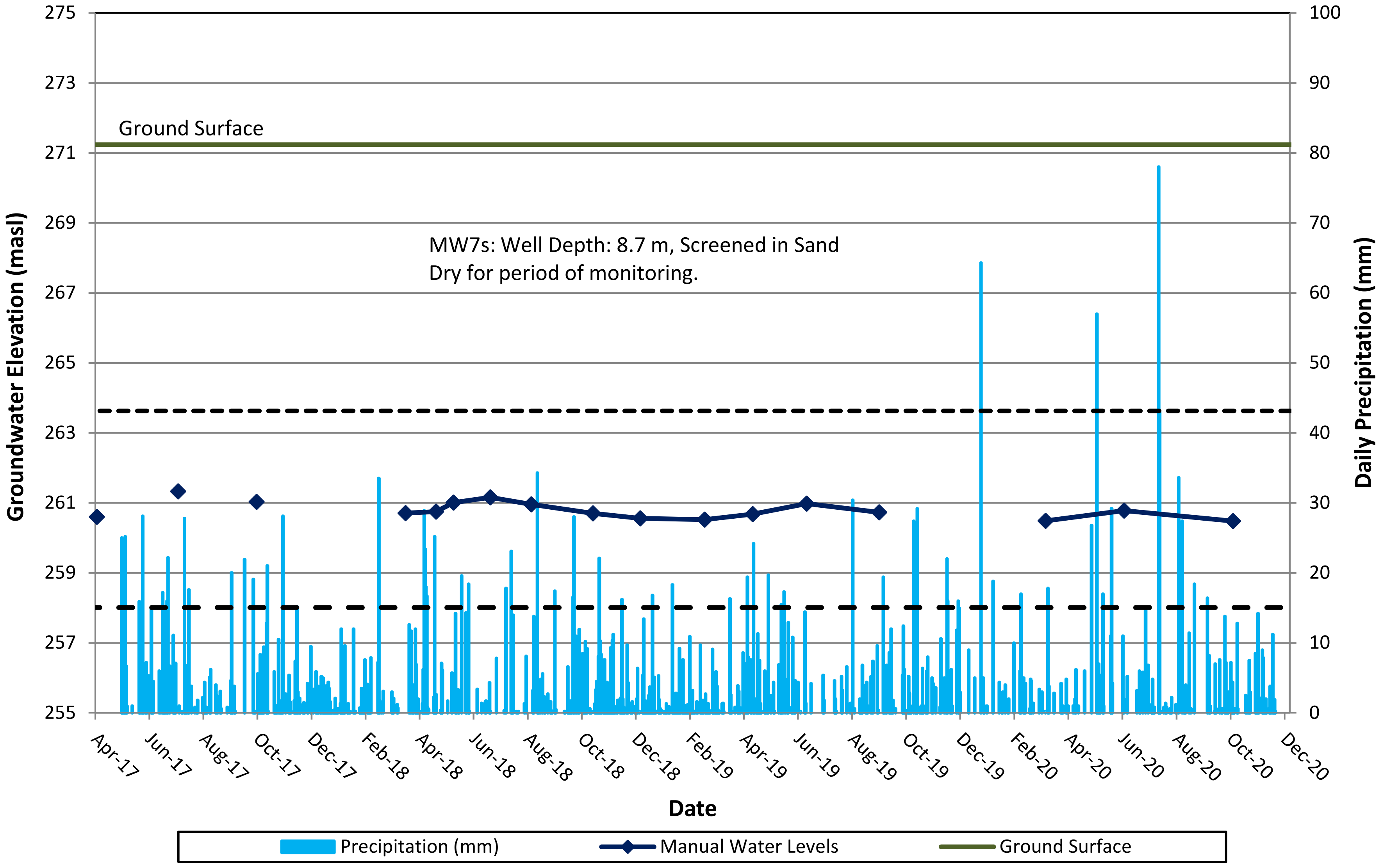


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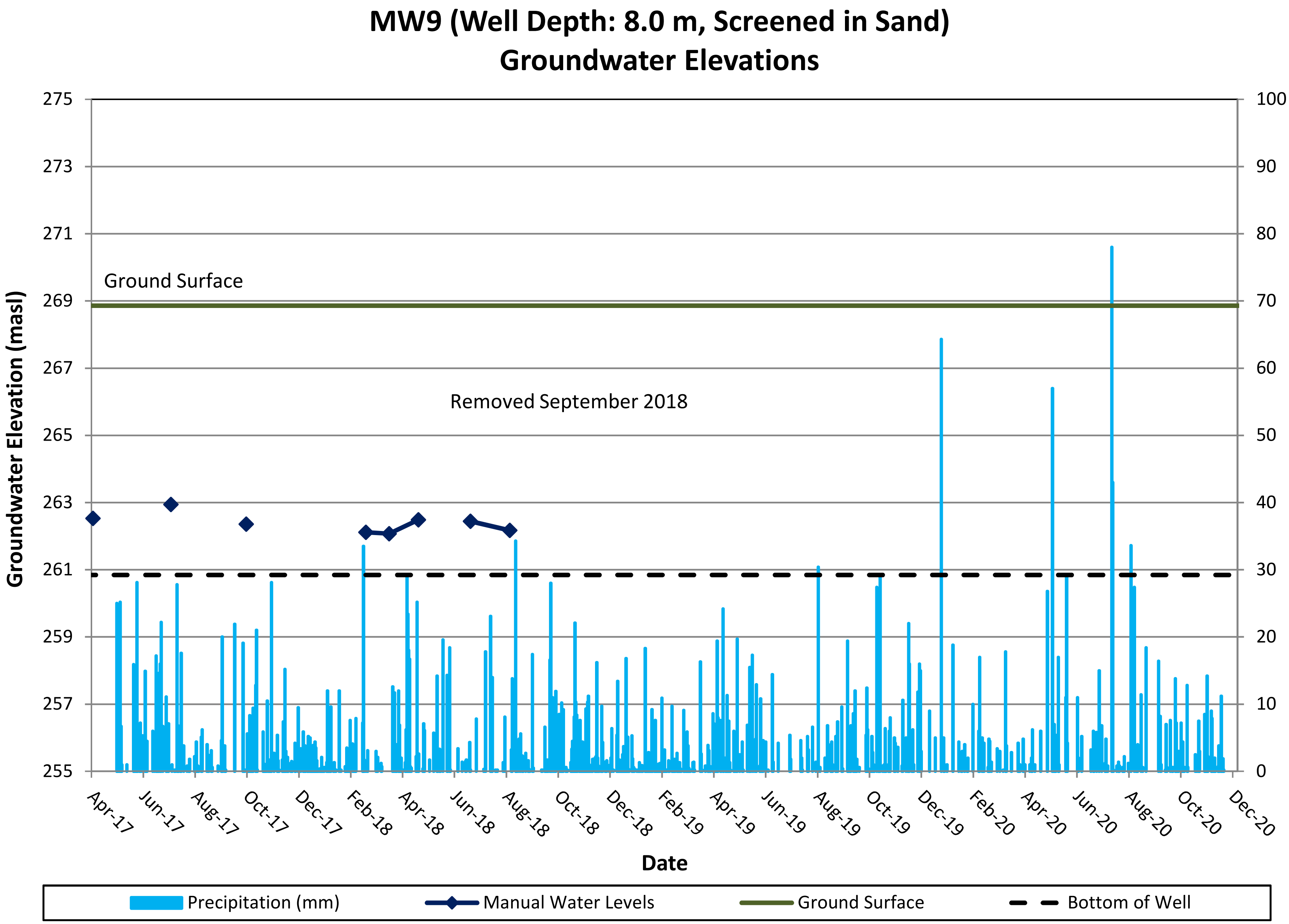
Figure D-8


MW9 (Well Depth: 8.0 m, Screened in Sand)
Groundwater Elevations
Groundwater Elevation (masl)
275
273
271
269
267
265
263
261
259
257
255
Daily Precipitation (mm)
100
90
80
70
60
50
40
30
20
10
0
Ground Surface
Removed September 2018
Apr-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Oct-18
Dec-18
Feb-19
Apr-19
Jun-19
Aug-19
Oct-19
Dec-19
Feb-20
Apr-20
Jun-20
Aug-20
Oct-20
Dec-20
Date
Precipitation (mm)
Manual Water Levels
Ground Surface
Bottom of Well

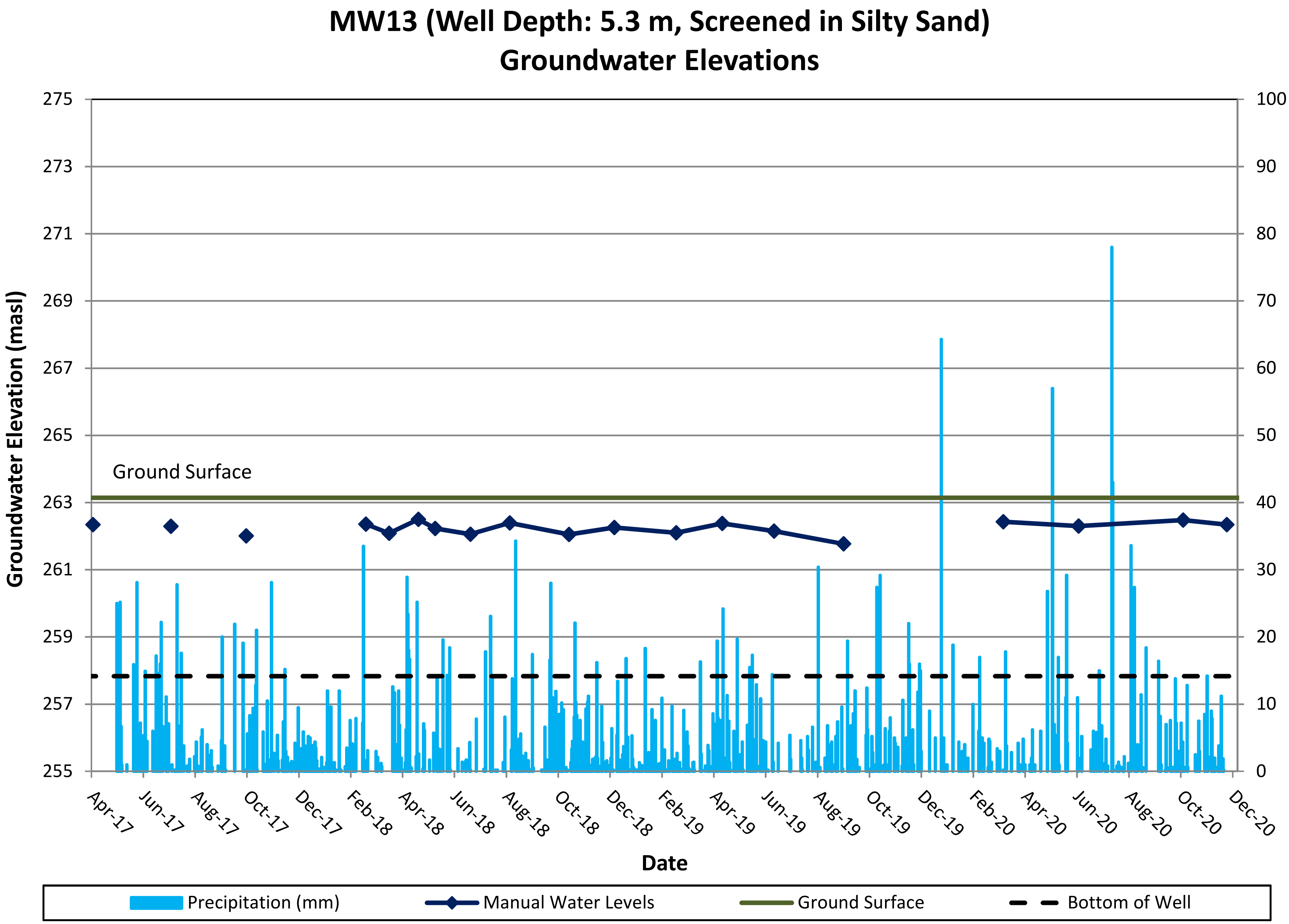


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Figure D-10

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Appendix E

Water Quality Data

Table E-1
Groundwater Quality

Monitoring Well					**RS-3s**
Date Sampled					**30-Aug-17**
Parameter	**Unit**	**RDL**	**ODWQS**	**PWQO**	
Electrical Conductivity	uS/cm	2			575
pH	pH Units	NA	(6.5-8.5)	(6.5-8.5)	8.14
Saturation pH					6.97
Langelier Index					1.17
Total Hardness (as CaCO3)	mg/L	0.5	(80-100)		**310**
Total Dissolved Solids	mg/L	20	500		304
Alkalinity (as CaCO3)	mg/L	5	(30-500)		250
Bicarbonate (as CaCO3)	mg/L	5			244
Carbonate (as CaCO3)	mg/L	5			6
Hydroxide (as CaCO3)	mg/L	5			<5
Fluoride	mg/L	0.25	1.5		<0.05
Chloride	mg/L	0.50	250		16.3
Nitrate as N	mg/L	0.25	10.0		9.78
Nitrite as N	mg/L	0.25	1.0		<0.05
Bromide	mg/L	0.25			<0.05
Sulphate	mg/L	0.50	500		13.2
Ortho Phosphate as P	mg/L	0.50			0.1
Reactive Silica	mg/L	0.10			14.5
Ammonia as N	mg/L	0.02			<0.02
Total Phosphorus	mg/L	0.05		0.03	0.52
Total Organic Carbon	mg/L	0.5			3.5
Colour	TCU	5	5		<5
Turbidity	NTU	0.5	5		**1310**
Calcium	mg/L	0.05			110
Magnesium	mg/L	0.05			8.5
Sodium	mg/L	0.05	20 (200)		6.9
Potassium	mg/L	0.05			1.01
Aluminum	mg/L	0.004	0.1	0.075	0.017
Antimony	mg/L	0.003	0.006		<0.003
Arsenic	mg/L	0.003	0.025	1	<0.003
Barium	mg/L	0.002	1		0.034
Beryllium	mg/L	0.001			<0.001
Boron	mg/L	0.010	5	2	0.01
Cadmium	mg/L	0.001	0.005	0.0002	<0.001
Chromium	mg/L	0.003	0.05	0.009	<0.003
Cobalt	mg/L	0.001			<0.001
Copper	mg/L	0.003	1	0.005	<0.003
Iron	mg/L	0.010	0.3	0.3	<0.010
Lead	mg/L	0.002	0.01	0.001	<0.002
Manganese	mg/L	0.002	0.05		<0.002
Mercury	mg/L	0.0001	0.001	0.0002	<0.0001
Molybdenum	mg/L	0.002		0.04	<0.002
Nickel	mg/L	0.003		0.025	<0.003
Selenium	mg/L	0.004	0.01	0.01	<0.004
Silver	mg/L	0.002		0.002	<0.002
Strontium	mg/L	0.005			0.186
Thallium	mg/L	0.006		0.0003	<0.006
Tin	mg/L	0.002			<0.002
Titanium	mg/L	0.002			<0.002
Tungsten	mg/L	0.010			<0.010
Uranium	mg/L	0.002	0.02	0.005	<0.002
Vanadium	mg/L	0.002			<0.002
Zinc	mg/L	0.005	5	0.03	<0.005
Zirconium	mg/L	0.004			<0.004
% Difference/ Ion Balance	%	NA			0.69

ODWQS - Ontario Drinking Water Quality Standards

PWQO - Provincial Water Quality Objectives

RDL - Reported Detection Limit

Bold indicates an exceedance of the ODWQS

Underlined indicates an exceedance of the PWQO

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Appendix F

Water Balance Calculations

WATER BALANCE CALCULATIONS
Rainsong Land Development Inc.
Barrie, ON

PROJECT No.300040647

TABLE F-1

Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 150 mm (short to moderate rooted crops in sandy loam soils)

Precipitation data from Barrie WPCC Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	**6.9**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	**36.8**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	25.18	58.76	88.02	103.48	97.59	74.33	40.47	11.47	0.00	**499**
Adjusting Factor for U (Latitude 44° 22' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	83	62	58	62	82	85	77	90	94	78	89	74	**933**
Potential Evapotranspiration (PET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
P - PET	83	62	58	34	8	-29	-57	-27	17	39	80	74	**340**
Change in Soil Moisture Storage	0	0	0	0	0	-29	-57	-27	17	39	58	0	**0**
Soil Moisture Storage max 150 mm	150	150	150	150	150	121	64	37	53	92	150	150	
Actual Evapotranspiration (AET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
Soil Moisture Deficit max 150 mm	0	0	0	0	0	29	86	113	97	58	0	0	
Water Surplus - available for infiltration or runoff	83	62	58	34	8	0	0	0	0	0	22	74	**340**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	58	43	41	24	5	0	0	0	0	0	16	52	**238**
Potential Direct Surface Water Runoff (independent of temperature)	25	19	17	10	2	0	0	0	0	0	7	22	**102**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	933	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	140	mm/year											
P-PE (surplus available for runoff from impervious areas)	793	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 150 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations
topography - rolling land 0.2 <-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - sandy loam 0.4 <-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - predominantly cultivated land 0.1 <-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor 0.7

Latitude of site (or climate station) 44 ° N.

WATER BALANCE CALCULATIONS
Rainsong Land Development Inc.
Barrie, ON

PROJECT No.300040647

TABLE F-2

Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 75 mm (urban lawn in sandy loam soils)

Precipitation data from Barrie WPCC Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-7.7	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	**6.9**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	**36.8**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	25.18	58.76	88.02	103.48	97.59	74.33	40.47	11.47	0.00	**499**
Adjusting Factor for U (Latitude 44° 22' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	83	62	58	62	82	85	77	90	94	78	89	74	**933**
Potential Evapotranspiration (PET)	0	0	0	28	75	114	135	117	77	38	9	0	**593**
P - PET	83	62	58	34	8	-29	-57	-27	17	39	80	74	**340**
Change in Soil Moisture Storage	0	0	0	0	0	-29	-46	0	17	39	19	0	**0**
Soil Moisture Storage max 75 mm	75	75	75	75	75	46	0	0	17	56	75	75	
Actual Evapotranspiration (AET)	0	0	0	28	75	114	123	90	77	38	9	0	**555**
Soil Moisture Deficit max 75 mm	0	0	0	0	0	29	75	75	58	19	0	0	
Water Surplus - available for infiltration or runoff	83	62	58	34	8	0	0	0	0	0	60	74	**378**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	58	43	41	24	5	0	0	0	0	0	42	52	**265**
Potential Direct Surface Water Runoff (independent of temperature)	25	19	17	10	2	0	0	0	0	0	18	22	**113**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	933	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	140	mm/year											
P-PE (surplus available for runoff from impervious areas)	793	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 75 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations
topography - rolling land 0.2 <-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - sandy loam 0.4 <-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawn 0.1 <-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor 0.7

Latitude of site (or climate station) 44 ^{O} N.

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WATER BALANCE CALCULATIONS
Rainsong Land Development Inc.
Barrie, ON

PROJECT No.300040647

TABLE F-3

Water Balance for Pre- and Post-Development Land Use Conditions in Rainsong Phase 2 (with no SWM/LID measures in place)

Land Use Description	Approx. Land Area* (m^2)	Estimated Impervious Fraction for Land Use*	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration from Pervious Area** (m/a)	Infiltration Volume from Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Exising Land Use												
Agricultural	244,600	0	0	0.793	0	244,600	0.102	24,928	0.238	58,166	24,928	58,166
TOTAL PRE-DEVELOPMENT	**244,600**		**0**		**0**	**244,600**		**24,928**		**58,166**	**24,928**	**58,166**
Post-Development Land Use (with no LID measures in place)												
Single Detached Residential	91,800	0.67	61,506	0.793	48,772	30,294	0.113	3,435	0.265	8,016	52,207	8,016
Semi-Detached (18m ROW)	26,400	0.69	18,216	0.793	14,445	8,184	0.113	928	0.265	2,165	15,373	2,165
Semi-Detached (24m ROW)	10,200	0.70	7,140	0.793	5,662	3,060	0.113	347	0.265	810	6,009	810
Street Towns (18m ROW)	7,000	0.69	4,830	0.793	3,830	2,170	0.113	246	0.265	574	4,076	574
Street Towns (24m ROW)	18,100	0.70	12,670	0.793	10,047	5,430	0.113	616	0.265	1,437	10,663	1,437
Back to Back Towns	24,600	0.79	19,434	0.793	15,410	5,166	0.113	586	0.265	1,367	15,996	1,367
School Block	58,800	0.79	46,452	0.793	36,835	12,348	0.113	1,400	0.265	3,267	38,235	3,267
Servicing Block	100	1.00	100	0.793	79	0	0.113	0	0.265	0	79	0
Road Widening and Reserves	6,300	0.90	5,670	0.793	4,496	630	0.113	71	0.265	167	4,568	167
Future Development and Daylighting	1,300	0.90	1,170	0.793	928	130	0.113	15	0.265	34	943	34
TOTAL POST-DEVELOPMENT	**244,600**		**177,188**		**140,504**	**67,412**		**7,644**		**17,837**	**148,148**	**17,837**
										% Change from Pre to Post	594	69
										Effect of development (with no mitigation)	5.9 times increase in runoff	69% reduction of infiltration

* data provided by SCS Consulting Group (Dec, 2021)

** figures from Tables F-1 and F-2.

To balance pre- to post-,
the infiltration target (m^3/a)= **40,329**

WATER BALANCE CALCULATIONS
Rainsong Land Development Inc.
Barrie, ON

PROJECT No.300040647

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TABLE F-4

Water Balance for Existing Condition and Post-Development with Mitigation

		Approx. Land Area* (m^2)	**Estimated Impervious Fraction***	**Estimated Impervious Area (m^2)**	**Runoff from Impervious Area** (m/a)**	**Runoff Volume from Impervious Area (m^3/a)**	**Estimated Pervious Area (m^2)**	**Runoff from Pervious Area** (m/a)**	**Runoff Volume from Pervious Area (m^3/a)**	**Infiltration from Pervious Area** (m/a)**	**Infiltration Volume from Pervious Area (m^3/a)**	**Total Runoff Volume (m^3/a)**	**Total Infiltration Volume (m^3/a)**
Exising Land Use													
Agricultural		244,600	0	0	0.793	0	244,600	0.102	24,928	0.238	58,166	24,928	58,166
TOTAL PRE-DEVELOPMENT		**244,600**		**0**		**0**	**244,600**		**24,928**		**58,166**	**24,928**	**58,166**
Post-Development Land Use*													
Catchment 201 without School Block	Land area draining to Rain Gardens	2,600	0.74	1,924	0.793	1,526	676	0.113	77	0.265	179	993	179
	Rain Gardens - designed to capture 6 mm storm; 6 mm storms account for approximately 50% of total rainfall^a (38% of total precipitation); so assume 38% of runoff total will infiltrate)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	609	0	609
	Lands draining to SWMF #4	28,400	0.74	21,016	0.793	16,665	7,384	0.113	837	0.265	1,954	9,579	1,954
Catchment 202 without School Block	Lands draining to Infiltration Facility	96,600	0.69	66,654	0.793	52,854	29,946	0.113	3,396	0.265	7,924	13,500	7,924
	Mattamy Lockhart Infiltration Facility - designed to capture 80 mm and 100% of total rainfall (76% of total precipitation); so assume 76% of runoff total will infiltrate)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	42,750	0	42,750
Catchment 203 without School Block	Land area draining to Rain Gardens	3,300	0.74	2,442	0.793	1,936	858	0.113	97	0.265	227	1,281	227
	Rain Gardens - designed to capture 5 mm storm; 5 mm storms account for approximately 48% of total rainfall^a (37% of total precipitation); so assume 37% of runoff total will infiltrate)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	752	0	752
	Lands draining to SWMF #3	43,400	0.74	32,116	0.793	25,467	11,284	0.113	1,280	0.265	2,986	26,746	2,986
Catchment 205	Residential	6,500	0.74	4,810	0.793	3,814	1,690	0.113	192	0.265	447	2,524	447
	Rain Gardens - designed to capture 5 mm storm; 5 mm storms account for approximately 48% of total rainfall^a (37% of total precipitation); so assume 37% of runoff total will infiltrate)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,482	0	1,482
Catchment 204 & 203 (School Block Portion)		63,800	0.79	50,402	0.793	39,967	13,398	0.113	1,519	0.265	3,545	41,486	3,545
TOTAL POST-DEVELOPMENT		**244,600**		**179,364**		**142,229**	**65,236**		**7,398**		**62,855**	**96,110**	**62,855**
% Change from Pre to Post												386	-8
Effect of development (with mitigation)												3.9 times increase in runoff	8% increase in infiltration

* data provided in FSR by SCS Consulting Group (Feb, 2022)

** figures from Tables F-1 and F-2.

Increase in infiltration with LIDs (m^3/a)= **4,689**

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