Hydrogeological Assessment

969 - 989 Mapleview Drive East, Barrie Ontario

Sandy Creek Estates Phase 1 Lands

Prepared for:
Sandy Creek Estates

Prepared by:
Azimuth Environmental
Consulting, Inc.

February 2022

AEC 18-295

February 2, 2022 AEC 18-295

Sandy Creek Estates Inc.
2031 James Street
Burlington, Ontario
L7R 1H2

Re: **Preliminary Hydrogeological Assessment**
Phase 1 Lands, 969, 979 & 989 Mapleview Drive East, City of Barrie

Azimuth Environmental Consulting, Inc. (Azimuth) is pleased to provide our Hydrogeological Assessment for the property located at 969, 979 & 989 Mapleview Drive East within the City of Barrie, Ontario (the "Site"). This evaluation was focused on the existing soil and ground water regime underlying the Site, specifically the Phase I section of the Site.

Should you have any questions or wish to discuss the report in greater detail, please do not hesitate to contact the undersigned.

Yours truly,

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

PROFESSIONAL GEOSCIENTIST
COLIN ROSS
PRACTISING MEMBER
2055
ONTARIO

Colin Ross, B.Sc., P.Geo
Senior Hydrogeologist

Table of Contents

List of In-Text Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

Azimuth Environmental Consulting, Inc. ("Azimuth") has been retained by Sandy Creek Estates Inc. to conduct a Preliminary Hydrogeological Assessment for the proposed residential and commercial development located at 969, 979 & 989 Mapleview Drive East within the City of Barrie, Ontario (Figure 1).

The proposed Sandy Creek Estates Subdivision is approximately 19.7 hectares (ha) in size and is located on the south side of Mapleview Drive East, approximately 600 m west of the Mapleview Drive East and 20th Sideroad intersection (Figure 2). The parcel historically contained a rural residence and farm as well as an existing residential property at the northwestern corner of the Site.

The is part of the City of Barrie's Annex Lands and is therefore separated into a 4.68 ha parcel immediately south of Mapleview Drive East (Phase 1 Lands), and a 15.0 ha parcel located south of a tributary of Sandy Cove Creek (Phase 3 lands). The current assessment focuses on Parcel 1 lands (the "Site"). The current assessment provides a summary of the existing environmental conditions as it relates to the soil and ground water regime at the Site.

2.0 BACKGROUND

The following documents were reviewed as part of the current assessment:

- Cambium Inc. 2018. Draft Geotechnical Investigation Report, Sandy Cove Creek, Barrie, Ontario. Reference No.: 7975-001;
- R. J. Burnside & Associates Limited. 2016. Hewitt's Secondary Plan Area, Hydrogeological Assessment, Part 1 – Existing Conditions;
- Soil Engineers Ltd. 2006. A Soil Investigation For Proposed Residential Development, 1657 Mapleview Road, Town of Innisfil. Reference No. 0611-S047; and
- Soil Engineers Ltd. 2017. Proposed Residential Subdivision, Southwest Corner of Mapleview Drive East and 20th Sideroad, City of Barrie. Reference No.: 1610-S116.
- Hunt Design Associates Inc., 2022. Conceptual Site Plan- Crystal Homes – 221033.

3.0 ENVIRONMENTAL SETTING

3.1 Soil

The soil map of Simcoe County (Soil Survey Report No. 29, Scale 1:63,360) shows the uppermost soil at the Site to be composed of a mixture of material, including Sargent gravelly sandy loam, Bondhead sandy loam, Vasey sandy loam, and Muck associated with the valley of Sandy Cove Creek. These materials are classified within hydrologic soil group A, AB, or B soils. Group A soils represent material with low runoff potential and high infiltration rates even when thoroughly wetted. Group B soils represent material with moderate infiltration rates when thoroughly wetted.

3.2 Physiography

The Ontario Geologic Survey (Chapman and Putnam, 1984) describes the area as being located within the Peterborough Drumlin Field Physiographic region. The Peterborough Drumlin Field is a rolling till plain which contains approximately 3,000 good drumlins in addition to many drumlinoid hills and surface flutings of the till sheet. The general orientation of the drumlin axes is from north east to south west.

3.3 Topography and Drainage

According to local topographic mapping and the information reviewed in Appendix B, the Site is found at an elevation of 251 – 261 masl (Figure 2). The Site slopes from north to south from Mapleview Drive East toward Sandy Cove Creek. Sandy Cove Creek flows east, eventually draining into Lake Simcoe.

Figure 3 displays the presence of any watercourse, wooded area, or wetland feature in the vicinity of the Site.

3.4 Bedrock Geology

The Ontario Geologic Survey (OGS) Earth Database shows that the uppermost bedrock unit at the subject property consists of limestone and shale of the Simcoe Group of the Verulam Formation (OGS, 2017). The Verulam Formation is Middle Ordovican in age. Bedrock is sufficiently deep (55m+) and does not influence the shallow hydrogeology of the Site.

3.5 Quaternary Geology

The mapped surficial material for the north portion of the Site is composed of ice-contact stratified deposits consisting of sand and gravel with minor silt, clay, and till. The southern portion of the Site is composed of stone-poor till consisting of a sandy silt to silty sand textured matrix. (OGS, 2017). The quaternary geology of the Site and surrounding area is shown on Figure 4.

The Site was included as part of the Hewitt's Secondary Plan Area Hydrogeological Assessment completed by R. J. Burnside in 2016. This program included collecting surface water and ground water measurements across the Hewitt's Creek Secondary

Area. Excerpts from Burnside (2016) are included in Appendix C. Two cross sections A-A' and C-C' intersect the Site, and show a schematic of the anticipated subsurface conditions. The conditions at the Site therefore show a discontinuous surficial sand/gravel unit overlying a regional clay/silt /till unit overlying a regional sand/gravel unit. On the eastern portion of the cross section there is a thin confined lense of sand/gravel within the clay/silt/till unit. This cross section suggests this represents a localized confined aquifer within the regional aquitard in the vicinity of the Site.

3.6 Hydrogeology

The Ontario Ministry of Environment, Conservation, and Parks (MECP)'s Water Well Records (Appendix D) were referenced for any recorded well information within the vicinity (~ 500 m) of the Site (GIN, 2018, Table 1). The development will be serviced with public utilities; however historic well records can be used to gain subsurface information which can provide insight into the geological formations within the area. All wells within 500 m of the Site are provided on Figure 5.

Table 1: MECP Water Well Database Summary

Well No.	Distance from the Site (m)	Direction from the Site	Elevation (m)	Date Drilled	Well Type	Well Depth (m)	Water Level (m)	Primary Use
7051426	-	-	-	2007-09-15	-	-	-	Abandoned
7051427	-	-	-	2007-09-15	-	-	-	Abandoned
5701423	-	-	259	1965-09-15	Overburden	13.4	4.6	Livestock
7283336	35	E		2016-11-17	-	-	-	-
5701494	50	N	261	1964-11-09	Overburden	12.8	7.9	Domestic
5708961	140	NE	260	1972-06-20	Overburden	21.3	6.7	Domestic
5738770	300	NW	-	2004-04-10	Overburden	57.9	15.5	Domestic
5740741	330	W	-	2006-05-18	Overburden	5.5	-	Abandoned
7239317	375	NW	-	2014-04-07	Overburden	7.6	-	Monitoring

The well records included within Table 1 were advanced primarily for domestic, livestock, or monitoring use, with three records listed as abandoned. The wells were drilled between 5.5 and 57.9 mbgs, with corresponding water levels ranging between 4.6 and 15.5 mbgs. In general, the overburden material is composed of surficial sand overlying a clay unit. However one record listed clay at the surface. None of the well records encountered bedrock, indicating it is found at a depth greater than 58 mbgs in the vicinity of the Site.

4.0 SOURCE WATER PROTECTION

A review of the Source Water Protection Areas as identified on the MECP Source Protection Information Atlas website indicates a portion of the Site is considered a Significant Ground Water Recharge Area (SGRA) and a Highly Vulnerable Aquifer

(HVA). The Site is not located within a Wellhead Protection Area (WHPA) or an Intake Protection Zone (IPZ). The mapping is illustrated in Appendix K

5.0 MONITORING

5.1 Drilling Program

Azimuth conducted a drilling program at the Site between October 9th and 12th 2018. As part of the program, five (5) boreholes were advanced across the Site, including beyond the Phase 1 area which is targeted for this assessment to depths between 3.1 and 8.4 mbgs. The soil drilling and monitoring well installation was completed by Orbit Garant, a licensed well contractor in the Province of Ontario. The field work was completed under the guidance and supervision of an Azimuth field technician, who logged the soil conditions encountered during borehole advancement. Additional monitoring wells were also installed within test pits utilized for the infiltration testing across the Site (Phase 1 and Phase 3) summarized in Section 4.2. In each of these test pits, monitoring wells were installed by field staff. The location of each borehole / test pit for Phase 1 are found on Figure 6. The complete borehole logs can be found in Appendix E.

Each monitoring well consisted of a 50.0 mm diameter PVC pipe and contained an above ground, steel monument-type protective casing. The monitoring wells were installed in accordance with Ontario Regulation (O. Reg.) 903 (Wells Regulation), with all wells deeper than 3 m being installed by a licensed well contractor / technician.

5.1.1 Subsurface Conditions

<u>Topsoil</u> (all locations): A layer of sandy topsoil was encountered in all boreholes and ranged between 0.2 to 0.5m thick. The topsoil was dark brown, contained roots, was in a loose condition, and moist.

<u>Sand:</u> Beneath the topsoil, a layer of medium sand was encountered at BH102 and BH103A/B. Sand was also encountered at a depth of 6.1m at BH109 beneath the finer grained units described below. The sand was brown to grey, loose to compact, and moist to saturated. The material had some gravel in addition to thin clay layers at BH103A/B. The material was fully saturated at BH109, and exhibited significant flowing artesian conditions.

<u>Silty clay</u>: A layer of silty clay was encountered beneath the topsoil at BH109, and beneath the sand at BH103A/B. This material was brown to grey, loose to compact, and moist to wet. This material contained wet sand seams at BH109.

Silty clay till: Beneath the topsoil, a layer of silty clay till was encountered at BH101. The till was brown to grey, compact to very dense, and moist to wet. The material has occasional cobbles and boulders.

Silty sand till: A layer of silty sand till was encountered beneath the silty clay till at BH101, and beneath the silty clay at BH103A/B and BH109. The till was grey, loose to dense, and contained occasional cobbles and boulders. This material was fully saturated at BH101, exhibiting flowing conditions.

It should be noted that during drilling, artesian conditions were noted at BH103A and BH109, therefore a nested pair of monitoring wells (MW103A & MW103B) were installed. A shallow standpipe (TP109B) was also installed in the vicinity of BH109 to create a nested location as well. The two nested locations will be used to isolate the depth at which artesian conditions are present.

The location of each borehole is found on Figure 6. The complete borehole logs can be found in Appendix E.

5.2 Infiltration Testing

The current Infiltration Assessment focused on LID measures within Phase 1 of the development. The purpose of this assessment was to assess the existing soil beneath the proposed LID locations, and determine a suitable infiltration rate for use in detailed design.

5.2.1 Methodology

A field program was conducted by Azimuth staff on October 30th, 2018 between the hours of 7:30 am and 4:00 pm during which the weather was 10 °C and sunny. Test pits were advanced at five (5) locations across the Site, each corresponding to a potential LID location (Table 2). The test pits were advanced using an excavator rented and operated by Eisses Brother Excavating. The location of each test pit was marked in the field and surveyed prior to the field program. The test pit base elevation was therefore determined based on the ground elevation and test pit depth.

Table 2: Summary of Test Pit Locations

Test Pit ID	Target LID	Base of Test Pit Elevation (masl)	Approximate Coordinates	
			Latitude	Longitude
TP-1	NA	257.0	44.354628	-79.598959
TP-2	NA	257.5	44.354912	-79.597237
TP-3	NA	253.5	44.354508	-79.596471
TP-4	NA	254.5	44.354195	-79.598329
TP-5	NA	253.5	44.353722	-79.599494

The Infiltration Assessment was completed in accordance with Appendix C of the *Low Impact Development Stormwater Management Planning and Design Guide* (TRCA 7 CVC, 2010).

Each test pit was advanced to an elevation approximately 1 m below the base of each LID. A hand auger was then used within the test pit to remove approximately 0.5 m of additional soil. The infiltration assessment was therefore completed 1.5 m below the base of the proposed LID.

Test pits were typically about 2 m wide and 4 m long. However, in some instances the target elevation was significantly below (3m+) the graded surface, and a larger test pit area was required to ensure the side wall stability was sufficient for access.

The Guelph Permeameter Model 2800K1 (Soil Moisture Equipment Corp.) was used to measure the in-situ hydraulic conductivity as per the *Guelph Permeameter Operating Instructions* (Soil Moisture, 2012). The two head method utilizing a combined reservoir was utilized. Two tests were completed with varying well head heights. The results of each of the tests were averaged to determine a representative value.

One soil sample was collected from each test pit at the approximate elevation of infiltration testing for laboratory grain size and T-Time analysis. The soil sample analysis was used to confirm the in-situ results. After the infiltration tests were completed, the test pits were refilled with the original soil material.

5.2.2 Test Results

The results of the infiltration assessment are included in Table 3 below. The raw infiltration test results are included in Appendix F. The material encountered within each test pit varied across the Site, and included sand and silty sand till with varying amounts of clay and gravel. The grain size and T-Time results for each sample are included in Appendix F.

No ground water was encountered in any of the test pits, with the exception of TP-5. An initial test pit was advanced to an elevation of 253.5 masl, however ground water was noted seeping through the very bottom of the pit. One of the side walls of the initial test pit was therefore extended horizontally, so that the base of the extension was level with 253.6 masl, approximately 0.10 m above the initial level. No ground water was encountered at this depth, indicating the unstabilized ground water table to be found at 253.5 masl.

The Guelph Permeameter generates a result as a hydraulic conductivity (K_{fs}) value. As per Table C1 from CVC & TRCA (2010), the K_{fs} values from the Guelph Permeameter and percolation rate (T-Time) values from the grain size analysis have been converted to an infiltration rate (1/T).

Based on the information provided in Table 3 above, the measured in-situ infiltration rate at the Site ranged between 45 and 202 mm/hr. These rates are consistent with values expected from a sand or silty sand till soil. All of the locations produced medium rates of infiltration (between 45 and 77 mm/hr) with the exception of TP-2 which produced a high rate of 202 mm/hr. The high rate of infiltration observed at TP-2 is likely associated with the gravel observed within the sand at this location. The in-situ testing results and the estimate based on the grain size analysis appear to be somewhat correlated.

Table 3: Results of Infiltration Assessment

Test Pit ID	Soil Type at Depth[1]	Guelph Permeameter Results			Estimated Infiltration Rate from Soil Sample[3] (mm/hr)
		Test # 1 Infiltration Rate[2] (mm/hr)	Test # 2 Infiltration Rate[2] (mm/hr)	Geometric Mean Infiltration Rate (mm/hr)	
TP-1	Silty sand till, some clay, trace gravel	83	70	77	30
TP-2	Sand, trace gravel, trace fines	212	192	202	100
TP-3	Sand, some fines	41	48	45	50
TP-4	Silty sand till, some clay, trace gravel	50	69	59	30
TP-5	Silty sand till, some gravel, trace clay	50	65	58	30

Notes
1 Soil type as per Central Earth Engineering Letter Report dated November 12, 2018 titled T-Time Analyses, Ref. No. 18-295
2 Guelph Permeameter results are converted from K_{fs} to 1/T according to Table C1 from TRCA & CVC (2010)
3 Soil sample collection results are converted from T-Time to 1/T according to Table C1 from TRCA & CVC (2010)

5.2.3 Recommendations

As per TRCA & CVC (2010), the infiltration rate used to design infiltration LIDs must incorporate a safety correction factor that compensates for potential reductions in soil permeability due to compaction or smearing during construction, gradual accumulation of fine sediments over the lifespan of the LID, and an uncertainty in measured values when less permeable soil horizons exist. A safety correction factor of 2.5 was used as per TRCA & CVC (2010). Table 4 summarizes the recommended design infiltration rate for the six locations investigated:

Table 4: Summary of Design Infiltration Rates

Test Pit ID	Soil Type at Depth	Infiltration Rate (mm/hr)	Safety Correction Factor	Design Infiltration Rate (mm/hr)
TP-1	Silty sand till, some clay, trace gravel	77	2.5	31
TP-2	Sand, trace gravel, trace fines	202	2.5	81
TP-3	Sand, some fines	45	2.5	18
TP-4	Silty sand till, some clay, trace gravel	59	2.5	24
TP-5	Silty sand till, some gravel, trace clay	58	2.5	23

After applying a correction factor of 2.5, the design infiltration rates for the Site are 23 to 81 mm/hr. The highest design infiltration rate is found at TP-2, which is 81 mm/hr and found in the north east portion of the Site. The remaining design infiltration rates are all between 18 - 31 mm/hr.

5.3 Ground Water Level Monitoring

Five monitoring wells were installed as part of the drilling program, and six standpipes were installed as part of the infiltration assessment. The water levels at each of the monitoring locations were measured periodically between October 2018 and June 2021 such that seasonal water table fluctuations could be established. In order to establish spring high water table conditions, events were targeted in April & May 2019, March 2020 and March, April, May and June 2021. As a result of this data, the high water table conditions are best represented by the May 2019 data (Appendix H), which are illustrated on Figure 8 and summarized in the following table.

Table 5: Summary of Monitoring Well & High Water Table Conditions (May 2019)

Location ID	Ground Elevation (masl)	Approximate Screen Interval (mbgs)	Water Level (mbgs)	Water Level (masl)
MW 101	259.86	5.3 – 8.3	1.95	257.91
MW 102	259.90	4.8 – 7.9	5.10	254.80
MW 103A*	252.95	5.3 – 6.8	-0.89	253.84
MW 103B	252.95	1.5 – 3.0	0.55	252.40
MW 109*	252.64	2.8 – 5.8	-1.76	254.40
TP 109B	252.64	0.5 – 2.0	0.44	252.20
TP 1	260.55	1.4 – 2.9	2.04	258.51
TP 2	259.28	0.2 – 1.7	1.72	257.66
TP 3	254.55	0.4 – 1.9	1.10	253.45
TP 4	258.14	1.1 – 2.6	2.56	255.58
TP 5	254.83	0 – 1.4	0.20	254.63

* - not included in high water table mapping as wells target a deeper confined aquifer unit

The measured high water table level at the Site ranged from 252.2 to 258.5 masl in May, 2019. .

In general, the available data shows the shallow ground water flow matches the local topography and is south east toward Sandy Cove Creek. Two locations contained a nested pair of monitoring depths (MW103A and 103B, and MW109 and TP109B). At each location, the deeper monitoring point contained artesian conditions, while the shallow monitoring point contains a water level below the existing ground surface. This indicates the presence of a confined aquifer at the Site. Based on the subsurface geology and relative elevations, the confined aquifer encountered at the Site may correlate to the localized sand and gravel lense noted in cross-section A-A' and C-C' discussed in Section 3.5. Information regarding this unit derived from Burnside, 2016 confirms its presence in the area, although it is shown not to be regional aquifer unit. Given the installation into the deeper, confined unit, MW103A and MW109 locations were excluded from the high water table evaluation as they are not representative of water table conditions at the Site.

Additional monitoring was completed with the use of pressure transducer dataloggers, which were installed at select locations to measure continuous data (hourly) to supplement the above noted manual measurements. The data collected is illustrated in a hydrograph (Appendix H) and indicates more detailed seasonal and shorter term climatic response, with an evident drought response during the summer of 2019, relative to more stable conditions in 2020. Continuous water level monitoring was also completed at Sandy Cove Creek, which is also illustrated in the hydrograph. The response is very similar to that of the shallow ground water levels, which would indicate hydraulic connection between these two units.

5.4 Hydraulic Conductivity Testing

In order to understand the hydraulic characteristics of the underlying overburden, transient slug tests were performed at three (3) monitoring wells constructed at the Site.

A slug test involves the instantaneous injection or withdrawal of a volume or slug of water or solid cylinder of known volume. This is accomplished by adding or displacing a known volume to/from a well and measuring water level response time to return to equilibrium. Water level measurements were recorded both manually and with automatic dataloggers, which were programmed to record the pressure of water above the data logger on a 1 second interval. Data was analyzed using the Hvorslev Method (1951), which assumes a homogeneous, isotropic medium in which soil and water are incompressible. Hydraulic testing results are summarized in Table 6.

Table 6: Hydraulic Testing Results

Monitoring Well	Log Hydraulic Conductivity (m/s)	Soil Description
MW-102	7.4×10^{-4}	Sand
MW-103B	2.1×10^{-6}	Sand / Silty Clay
MW-109	7.4×10^{-6}	Sand / Silty Sand Till

Notes: Values rounded off for presentation purposes

Slug test data indicates that the hydraulic conductivity of the deposits range between 2.1×10^{-6} to 7.4×10^{-4} m/s. These results show the difference between hydraulic conductivities of the overburden across the Site, mainly reflecting the varying silt and clay content in the deeper soils. The results of each of the slug tests are included in Appendix I.

6.0 WATER BALANCE

In order to determine the potential changes to the natural ground water recharge conditions, a pre- and post-development water balance assessment has been completed using the Thornthwaite and Mather method (1957). This method evaluates evapotranspiration based on precipitation and temperature. Residual soil saturation is a function of topography and soil type. Monthly data are tabulated from daily average temperature and precipitation, and the water budget is a continuous calculation over the period of record. To clarify, the method and the approach used by many individuals in examining infiltration resets annual conditions (moisture deficit, snow storage, etc) over the winter months because of the general lack of infiltration during the frost period. However, we maintain those records and carry them forward from month to month during the entire period of record.

Values were determined on a monthly basis, compiled from daily Environment Canada meteorological data station located in Barrie, Ontario between 1970 and 2020 (Station ID 6110557). The calculations are based on the average conditions during this period; the average precipitation was 909 mm, rainfall was 655 mm, evapotranspiration was 479 mm and the surplus was 430 mm.

6.1 Lane Use

6.1.1 Pre-Development

The pre-development Site area was classified according to land use/vegetation type. Land within the pre-development area is provided in Table 7.

Table 7: Pre Development Area Classification

Land Use	Land Area (m^2)
Agricultural	44,950
Structure	235
Driveway	135
Landscaped	1,480
TOTAL	**46,800**

Land within the pre-development scenario is considered 1% impervious.

6.1.2 Post-Development

The land classification in the post-development scenario was classified based on the Phase 1 Draft Plan (Appendix B). Land within the post-development Site is summarized in the below Table 8:

Table 8: Post Development Area Classification

Land Use	Land Area (m^2)
Structures / Rooftops	9,300
Roads / Driveways	18,350
Landscaped	16,550
Stormwater Pond (impervious)	2,600
TOTAL	**46,800**

Land within the post-development scenario is considered 63% impervious.

6.2 Infiltration

Infiltration is generated one of two ways: (1) directly from rainfall impact on pervious surfaces; and (2) indirectly when runoff from impervious surfaces is diverted into adjacent naturalized areas.

Infiltration factors for the Site were estimated based on the underlying soil, local topography, and ground cover as per Table 2 of the Ministry of Environment and Energy (MOEE) Hydrogeological Technical Information Requirements for Land Development Applications (1995).

The soil variable factor was determined by taking into account information obtained from the regional geologic mapping (Section 3.0) and the field work programs completed for the Site (Section 5.0). This information suggests that the surficial material at the Site is primarily composed of sand and silty sand till. The infiltration factors utilized in the water balance assessment are summarized in Table 9 below.

Table 9: Summary of Pervious Land Infiltration Factor

Scenario	Land Use	Infiltration Factor	Assumption
Pre-Development	Agricultural	0.60	Rolling land (0.2) silt and sand soil (0.3), cultivated (0.1)
Post-Development	Landscaped	0.60	Rolling land (0.2) silt and sand soil (0.3), landscaped (0.1)

6.2.1 Pre-Development Infiltration

Pre-development infiltration was determined by multiplying the annual average surplus amount, the area of each land use, and the infiltration factor for each land use. The pre-development annual infiltration is therefore 11,979 m^3/year (Appendix G).

6.2.2 Post-Development Infiltration

Post-development infiltration (without mitigation) was determined by multiplying the annual average surplus amount, the area of each land use, and the infiltration factor for each land use. The post-development annual direct infiltration is therefore 4,270 m^3/year. There is therefore a decrease in infiltration of 7,709 m^3/year from pre- to post-development without mitigation measures employed.

The post-development drainage plan includes low impact development (LID) to promote infiltration. An infiltration gallery will be included in the storm water design to collect rooftop runoff from Block 10 & 11, while an infiltration trench will be located north of the road separating Blocks 10 & 11 from 12 & 13 which will collect runoff from a 1 ha area including paved, rooftop and landscaped surfaces. The infiltration gallery is designed for capture of a 25 mm storm event, while the infiltration trench is sized for capture of a 19 mm storm event. The details for this feature are outlined in the Tatham, 2022 Functional Servicing Report. In order to correlate event based rainfall data, for which the LID's are designed (i.e. 25 mm rainfall event), to annual averages, as is what is utilized in water balances, an event based assessment has been completed for the Barrie Climate station. Rainfall events over an 8 year period (2012-2019) were broken down by event size, such that total volumes for each of these events could be calculated. These totals were then related to the total volume over the same period to obtain a percentage. This percentage is then multiplied by the annual average value (655 mm) utilized in the overall water balance to obtain an annual average amount / depth for the various intervals. It was determined that an event rainfall depth of 25 mm represented an average annual rainfall total of 614 mm or 94% of the rainfall events, while an event rainfall depth of 19 mm represented an average annual rainfall total of 582 mm or 89% of the rainfall events over this period of record. It is noted that these represent cumulative amounts for all rainfall amounts less than the stated event size. In order to quantify the annual infiltration volumes for the LID, the annual rainfall depth (event equivalent) discussed above is multiplied by the capture areas, which have the “Trench” or “Soakaway” designation in water balance summary table (Appendix F). This results in an increase in infiltration of 4,124 m^2. It is noted that the contributions from the landscaped areas are the remaining surplus value once surface infiltration has been accounted for. After incorporating this infiltration into the Site, the post-development infiltration value is 8,394 m^3/year. The pre- to post-development deficit is therefore 3,585 m^3/year or a reduction of 30% from the predevelopment configuration.

6.3 Water Balance Summary

Using the climate model data and calculations mentioned above, the water balance was completed for pre-development, post-development, and post-development with mitigation (Appendix G).

The pre-development infiltration volume is 11,979 m^3/year. This assumes the Site is covered in agricultural land and a single residential lot. The post-development without mitigation infiltration volume is 4,270 m^3/year, which is a deficit of 7,709 m^3/year. This assumes the Site is composed of structures, landscaped grass, and storm water management pond, and other impervious areas (i.e. sidewalk, road, driveways). An additional 4,124 m^3/year of infiltration can be obtained by surface runoff into LID’s including an infiltration trench and soakaway pit. The post-development with mitigation volume is therefore 8,394 m^3/year which represents a reduction of 3,585 m^3/year or 30% reduction from the pre-development volume.

7.0 DEWATERING ASSESSMENT

The proposed development will include the construction of a residential and commercial development and associated underground servicing and storm water management pond. The details for which have been included in the Tatham Engineering storm water design and servicing plan (Appendix L) were reviewed to assess areas where servicing would extend below the water table (high water table – Figure 8). Sections which were noted to extend beneath the water table were the north west and south west condo roads, north / south connections for those roads, the central road alignment and the base of the storm water management pond (dry cell). The vertical encroachment distances in these areas have been used to provide an estimate for potential dewater demands at the Site based on the soils and water table.

Shallow excavations into the ground water table can typically be controlled by conventional sump pump technologies. If the required drawdown is greater than 1.5 m, or the servicing alignments are in close proximity to surface water bodies, the use of shallow well points or eductor systems may be required. The exact dewatering methodology will depend on Site specific conditions and will be determined by the dewatering contractor if determined to be required.

The Site is located within an area which is currently being developed from agricultural to urban land use; however, given the limited storm water infrastructure in place in the area, all dewatering discharge will be outletted to the Sandy Cove Creek located south of the Phase I development area, within the overall property boundary.

7.1 Drawdown Conditions

The dewatering assessment was broken down into the various alignments noted above based on the various vertical water table encroachment depths, as well as the storm water management pond. Details for these items included location, width, and length of each construction excavation to determine the maximum drawdown required for construction in relation to the water table conditions for the Site as illustrated in Figure 8.

For underground servicing, Azimuth targeted the sanitary servicing alignments as they were the deepest infrastructure proposed and were divided based on varying depths below water table. The dewatering area for the storm water management pond was assumed to be one section (75 m x 30 m), which relates to the bottom area of the pond which is located below the water table.

Based on the high ground water table and the servicing depths, ground water lowering during construction will range between 1.0 and 5.0 m. This is based on the following assumptions:

- Construction ground water lowering will target a depth of 1 m below the base of the storm water management pond and lowest sanitary servicing invert elevations to ensure dry working conditions;
- The hydraulic conductivity values utilized in the calculations is assumed to be a half order of magnitude higher than the measured value from the hydraulic testing completed at the Site monitoring wells. This was done to account for possible more permeable soils or variability across the Site;
- The most elevated ground water elevation / depth of ground water was assumed for each item / section; and
- All items / sections will done as single dewatering undertakings installed at one time;

The actual drawdown will depend on construction timing. It is therefore recommended that excavation is completed in the dry summer months such that dewatering for some items may be reduced or not required (*i.e.* storm water management pond).

7.2 Approximate Dewatering Volumes

Two dewatering equations were used, one for the trench dewatering and one for the structure dewatering. For the trench dewatering, the steady state method from Powers *et al*. (2007) for estimating flow from a line source from an unconfined aquifer was utilized. This method assumes since the excavation is long and narrow, equivalent slot plane flow is the dominant flow regime, and radial flow from the side of the excavation is considered negligible.

The following equation was used:

$$Q = 2*[a*K*(H^2-h^2)/(2R_o)]* 86400*1000$$

(Ref: Powers *et al*. (2007)

For the storm water management pond dewatering, calculations for the dewatering rate / volume were completed using the steady state method from Powers et al. (2007) for estimating radial flow to an excavation in an unconfined aquifer.

The following equation was used:

$$Q = \{[(\pi* K)*(H^2-h^2)] / [ln(R_o/r)] * 86400*1000$$

(Ref: Powers *et al*. (2007)

The full dewatering assessment can be found in Appendix L, while the details are also summarized in Table 9 below.

Based on the information provided in Table 9, the dewatering required for the construction of the storm water management pond is 9,000 L/day. The dewatering volume for the sanitary sewers ranges between 221,000 and 586,000 L/day to facilitate construction. A 3x safety factor can then be applied to each of the above volumes for a conservative estimate (Table 10). These values are based on worst case spring season ground water values. The dewatering volume is anticipated to be lower during dry summer months.

Any construction dewatering between 50,000 L/day and 400,000 L/day can be completed after registration under the Environmental Activity and Sector Registry (EASR). Any active construction dewatering above 400,000 L/day requires a Permit To Take Water (PTTW). As noted above, the magnitude of dewatering required will vary on the timing of construction and less dewatering could be needed in the summer drought conditions. Peak ground water elevation typically occurs between mid April and the end of May. Based on the calculated values, a PTTW would be required to facilitate dewatering at the Site, although sections could possibly be undertaken with an EASR if shorter alignments were utilized. Potential dewatering requirements can be minimized if work is completed during the drier summer months when the water table may be up to 1 m lower than the seasonal high elevations included in Section 5.3. It is also noted that if target elevations are shallower than those assumed in the above assessment, there may be a reduced need for dewatering for some or all items.

Table 10: Summary of Dewatering Conditions

Variable	NW Condo Road Sanitary	SW Condo Road Sanitary	North / South Condo Road Sanitary	Main Entrance Road Sanitary	Storm Water Management Pond (dry cell)
Estimate of Equivalent Radius **[r_e]** (m)	55	42	23	25	33
Hydraulic Conductivity **[K]** (m/s)	7.4×10^{-4}	7.4×10^{-4}	7.4×10^{-4}	7.4×10^{-4}	7.4×10^{-6}
Maximum Required Drawdown **[H-h]** (m)	5.0	2.0	3.5	4.0	1.0
Saturated Thickness Before Pumping **[H]** (m)	5.0	2.0	3.5	4.0	1.0
Depth of Water During Pumping **[h]** (m)	0	0	0	0	0
length of excavation **[a]** (m)	170	130	70	76	75
width of excavation **[b]** (m)	3	3	3	3	30
Radius of Influence **[R]** (m) [1]	463	206	309	352	42
Discharge **[Q]** (L/day)	588,710	161,730	177,500	221,120	9,000
Discharge [Q] (L/day) 3 X Safety Factor Applied	**1,760,130**	**485,190**	**532,500**	**663,360**	**27,000**

7.3 Impact Assessment

Based on the information provided in Table 10, the largest zone of influence is 463 m from the dewatering zone which corresponds to the building foundation; however this is the maximum distance where any measurable water table decline is observed (~1-5 cm). In reality, more significant decline in ground water levels (1 m) will be contained within ~25 m from the dewatering area.

The well record review completed in Section 3.6 identified five water supply wells within 500 m of the Site; however, only two developed properties remain within 500 m owing to redevelopment in the area such, which are >100 m from the proposed dewatering area. Given these distances, there is not expected to be a meaningful impact to the wells (<0.5 m of drawdown).

The closest surface water feature is Sandy Cove Creek, which is located immediately south of the Phase I area. The closest dewatering area is for the storm water management pond; however, the rates from this area will be quite limited such that limited influence is expected to be observed in the Creek and will be overcome of dewatering discharge being directed into the feature. Similarly, the increased distance of the creek from the more significant takings would limit the influence in this feature, while dewatering discharge would be directed back into the feature such that no decline in water levels would be expected.

7.4 Water Quality Results

A water sample was collected from MW103B on August 15th, 2019 to determine the onsite ground water quality in preparation for potential dewatering activities. The results are included in Appendix J and have been compared to the Provincial Water Quality Objectives (PWQO) when available. All parameters met the PWQO with the exception of aluminum, which is marginally (0.09 mg/L) above PWQO (0.075 mg/L). Aluminum is an earth element such that elevated concentrations are not surprising. Given Sandy Cove Creek has been interpreted to be hydraulically connected to the shallow water table, aluminum concentrations are likely already elevated in the Creek. As such any potential dewatering effluent discharge into the Creek would not represent any impact to the quality of the adjacent drainage swale; however concentrations from dewatering effluent and the creek could be collected prior to discharge to confirm more elevated concentrations or larger differentials between the ground water and surface water do not exist.

8.0 SUMMARY AND CONCLUSIONS

Azimuth was retained by Sandy Creek Estates Inc. to conduct a Preliminary Hydrogeological Assessment for the Phase 1 portion of the proposed Sandy Creek Lakes Subdivision located at 969, 979 & 989 Mapleview Drive East within the City of Barrie, Ontario. The proposed development is approximately 19.7 ha in size and is located on the south side of Mapleview Drive East, approximately 600 m west of the Mapleview Drive East and 20th Sideroad intersection. The parcel is currently composed of undeveloped agricultural land as well as a single residential lot at the northwest corner. The current assessment focuses on the Parcel 1 lands (4.68 ha) located immediately south of Mapleview Drive East.

The Site is found at an elevation of 251 – 261 masl and slopes from north to south toward Sandy Cove Creek, which is located parallel to the south Phase 1 boundary. The surficial geology in the vicinity of the Site is reportedly composed of a mixture of ice-stratified sand and gravel in addition to sandy silt to silty sand till. A drilling program was conducted at the Site in October of 2018 to advance 5 boreholes with monitoring well completion. The program encountered topsoil overlying sand, silty clay, silty clay till, and silty sand till. Surficial material varied between sand and the more fined grained silty clay till.

A test pit program was conducted in October of 2018 to measure the in-situ infiltration rate of the soils and install shallow standpipes in potential LID areas. The design infiltration rates for the tested locations ranged between 23 to 81 mm/hr. The highest infiltration rates were found in the north east portion of the Site.

Manual ground water measurements were collected from the monitoring well and shallow standpipes installed at the Site. The measured water levels at the Site ranged from 249.5 to 257.9 masl with levels fluctuating seasonally as evidenced with data collected between 2018 and 2021. Ground water flow direction is south towards Sandy Cove Creek following local topography. Artesian conditions were noted at the base of the slope in MW103A and MW 109, indicating the presence of a localized confined aquifer. Based on the subsurface geology and relative elevations, the localized confined aquifer encountered at the Site correlates to the thin sand and gravel lense noted in cross-section A-A' and C-C' discussed in Section 3.5. Monitoring of water levels in Sandy Cove Creek were also completed continuously in 2019, which noted a correlation to ground water level trends in the water table aquifer, indicating a likely hydraulic connection.

Hydraulic (slug) testing was completed at three (3) of the monitoring wells to characterize the hydraulic conductivity of the soils associated with the shallow water table aquifer. The hydraulic conductivity ranged between 2.1×10^{-6} to 7.4×10^{-4} m/s. These results show the difference between hydraulic conductivities of the overburden across the Site, mainly reflecting the varying silt and clay content in the deeper soils.

One ground water quality samples were collected from MW102 was analyzed for a general water quality package. All parameters met the PWQO with the exception of aluminum, which is a natural earth element. Given Sandy Cove Creek has been interpreted to be hydraulically connected to the shallow water table, aluminum concentrations are likely already elevated in the Creek. As such any potential dewatering effluent discharge into the Creek would not represent any impact to the quality of the adjacent drainage swale; however concentrations from dewatering effluent and the creek could be collected prior to discharge to confirm more elevated concentrations or larger differentials between the ground water and surface water do not exist.

A water balance was completed for the Site. The pre-development infiltration volume is 11,979 m^3/year. This assumes the entire site is covered in agricultural land and a single residential lot. The post-development without mitigation infiltration volume is 4,270 m^3/year, which is a deficit of 7,709 m^3/year. This assumes the Site is composed of structures, landscaped grass, and storm water management pond, and other impervious areas (i.e. sidewalk, road, driveways). An additional 4,124 m^3/year of infiltration can be obtained by surface runoff into LID's including an infiltration trench and soakaway pit. The post-development with mitigation volume is therefore 8,394 m^3/year which represents a reduction of 3,585 m^3/year or 30% reduction from the pre-development volume.

It is noted that the Site is mapped as only being partially within a significant ground water recharge area and partially within lands subject to Lake Simcoe Protection Plan (LSPP) 4.8-DP. As such the calculated infiltration deficit in the post-development scenario does not trigger the LSPP Water Balance Offsetting Policy as is understood from previous completed projects within LSRCA. Regardless, the proposed development and associated water balance deficit is not anticipated to create adverse impacts to the aquifer recharge area given the small Site area and incomplete presence within the surrounding mapped Significant Ground Water Recharge Area (SGRA) (Appendix K).

Although it is interpreted that shallow ground water discharges to Sandy Cove Creek immediately south of Phase I, the overall deficit is overcome by an increase in surface runoff which will be directed back to the creek via a storm water management pond such that quality and quantity controls are in place to mitigate this increase in runoff. It is also noted the Phase I Site area represents approximately 4% of the watershed for this branch of Sandy Cove Creek such that the abovementioned alterations to the ground and surface water contributions are unlikely to have a significant impact on the overall function of the Creek.

The proposed development will include the construction of a underground servicing and a storm water management pond, which will encroach beneath the water table at various depths and locations across the Site. The Site soils are varied, but elevated permeability such that ground water controls for below water table work will be required to facilitate servicing construction. The preliminary dewatering assessment indicated that water taking rates range between 27,000 and 1.7 million L/day, which will require obtaining a PTTW to support construction. However, potential dewatering requirements can be more limited, or sections potentially not requiring dewatering if work is completed during the drier summer months when the water table may be up to 1 m lower than the seasonal high elevations measured.

9.0 REFERENCES

Barnett, P.J., Cowan, W.R. and Henry, A.P. 1991. Quaternary Geology of Ontario, Ontario Geological Survey, Map 2556, Scale 1:1,000,000.

Chapman L.J., and D.F. Putnam, 1984. The Physiography of Southern Ontario. 3rd Edition, OGS Special Volume 2, Ministry of Natural Resources.

Golder Associates Ltd. (Golder). 2004. North Simcoe Municipal Groundwater Study Draft Report.

Hoffman, D.W. & N.R. Richards, 1962. Soil Survey of Simcoe County. Report No. 29 of the Ontario Soil Survey.

Ontario Geological Survey (OGS).2017. OGS Earth Mapping. Obtained from: https://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth

Ontario Ministry of the Environment and Climate Change (MOECC), 1995. MOEE Hydrogeological Technical Information Requirements for Land Development Applications.

R. J. Burnside & Associates Limited. 2016. Hewitt's Secondary Plan Area, Hydrogeological Assessment, Part 1 – Existing Conditions.

Soil Engineers Ltd. 2006. A Soil Investigation For Proposed Residential Development, 1657 Mapleview Road, Town of Innisfil. Reference No. 0611-S047

Soil Moisture Equipment Corp. (Soil Moisture). 2012. Guelph Permeameter Operating Instructions. Model 2800K1.

Tatham Engineering, 2022. Functional Servicing Report 969, 979 & 989 Mapleview Drive East.

Thornthwaite, C.W., and Mather, J.R., 1957. Instructions and tables for computing potential evapotranspiration and the water balance. Climatology, vol. 10.

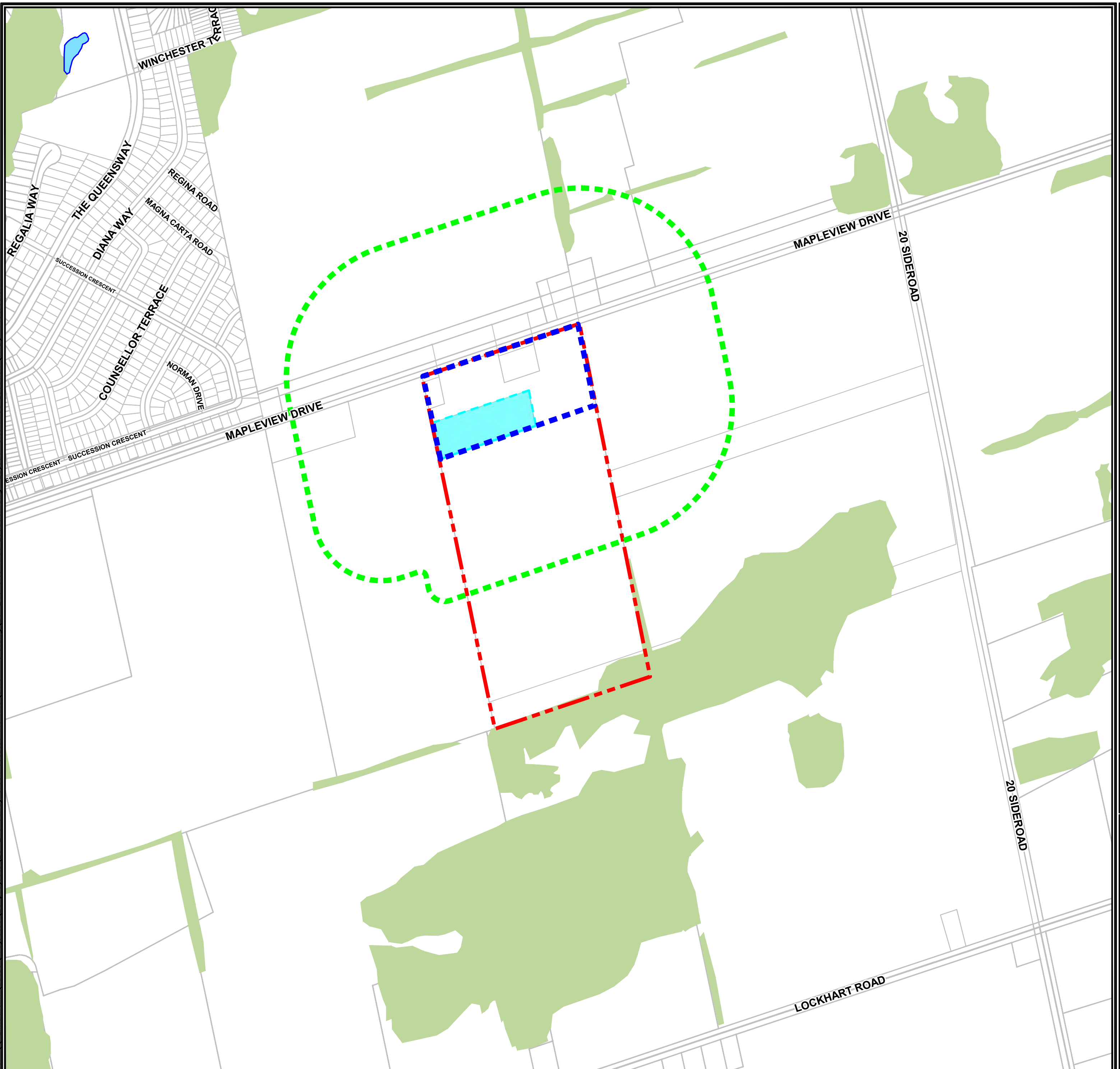
Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC). 2010. Low Impact Development Stormwater Management Planning And Design Guide. Version 1.

APPENDICES

Appendix A: **Figures**
Appendix B: **Engineering Drawings**
Appendix C: **Burnside (2016) Excerpts**
Appendix D: **MECP Well Records**
Appendix E: **Borehole Logs**
Appendix F: **Infiltration Test Results**
Appendix G: **Water Balance Information**
Appendix H: **Ground Water Elevation Data**
Appendix I: **Slug Testing Analysis**
Appendix J: **Water Quality Data**
Appendix K: **Source Water Protection Mapping**
Appendix L: **Dewatering Assessment Information**

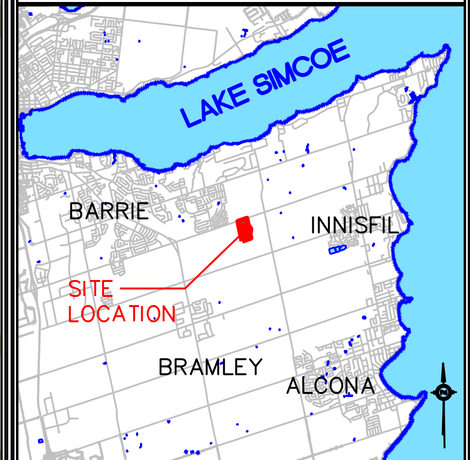
APPENDIX A

Figures



LEGEND:

- APPROX. PROPERTY BOUNDARY
- STUDY AREA – PHASE 1 LANDS
- 120m STUDY AREA LIMIT
- STORMWATER MANAGEMENT POND BLOCK



REGIONAL MAP

SCALE 1:250000

0 250 500

HORIZONTAL SCALE 1:10000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

SITE AREA LOCATION

SANDY CREEK ESTATES INC. NHE
BARRIE, ON

DATE ISSUED: *JANUARY 2022*	Figure No. 1
CREATED BY: *A.L.*	
PROJECT NO.: *20-243*	
REFERENCE: *SIMCOE COUNTY*	

Plotted by: ALIU on January 27, 2022 at 5:14pm
File: \\Azimuthsrv\data3\Projects3\20 projects\20-243 sandy creek estates inc nhe\04.0 – drafting\20-243 Site Area Location.dwg Layout: Site Area Location (HYD) Plotscale: 1

LEGEND:
- Approx. Property Boundary
- Approx. Phase One Boundary
- Watercourse

15m 0 30m

HORIZONTAL SCALE 1:1,000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

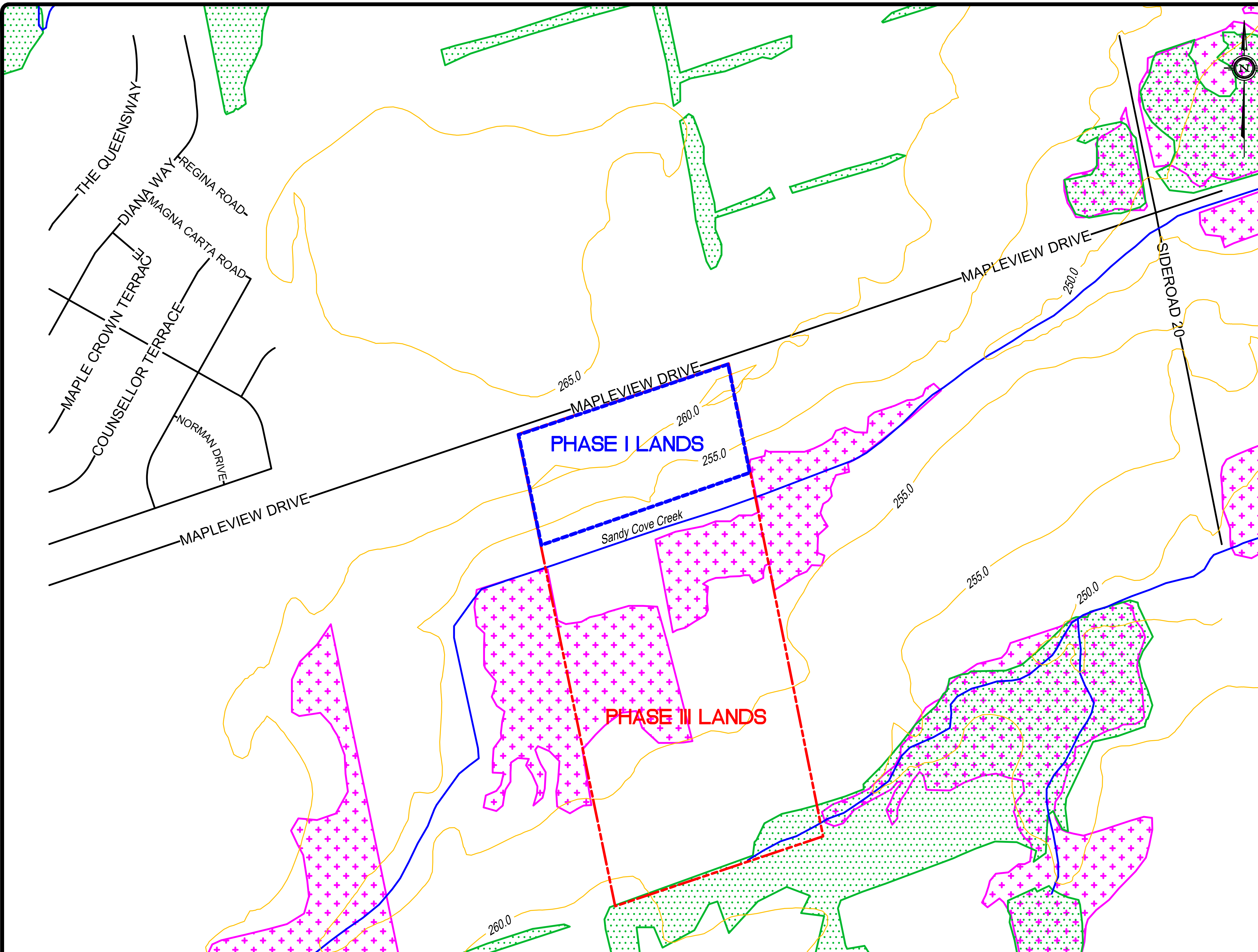
Site Layout
Finger Lakes Phase One

Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM	2
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

Plotted by: AJU on January 27, 2022 at 5:15pm Layout: HYD2 Plotscale: 1
File: P:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 – Drafting\18-295.dwg



LEGEND:

- Approx. Property Boundary
- Approx. Phase One Boundary
- Watercourse
- 5m OBM Contours
- Unevaluated Wetland
- Woodland

75m 0 150m

HORIZONTAL SCALE 1:5,000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Natural Features Map
Finger Lakes Phase One

Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM	3
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

LEGEND:

- Approx. Property Boundary
- Approx. Phase One Boundary
- Watercourse
- Quaternary Geology Boundary
- Till
  Stone-poor, sandy silt to silty sand-textured till on Paleozoic terrain
- Ice-contact stratified deposits
  sand and gravel, minor silt, clay and till

30m 0 60m

HORIZONTAL SCALE 1: 2,000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Quaternary Geology Map
Finger Lakes Phase One

Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM	4
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

Plotted by: AJU on January 27, 2022 at 5:16pm Layout: HYD4 Plotscale: 1
File: P:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

LEGEND:

- Approx. Property Boundary
- Approx. Phase One Boundary
- Watercourse
- 500m Study Area
- GIN Water Well Locations

Note:
Well locations are based on MOECC well records and/ or GIN (2018) mapping.

75m 0 150m

HORIZONTAL SCALE 1:5,000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

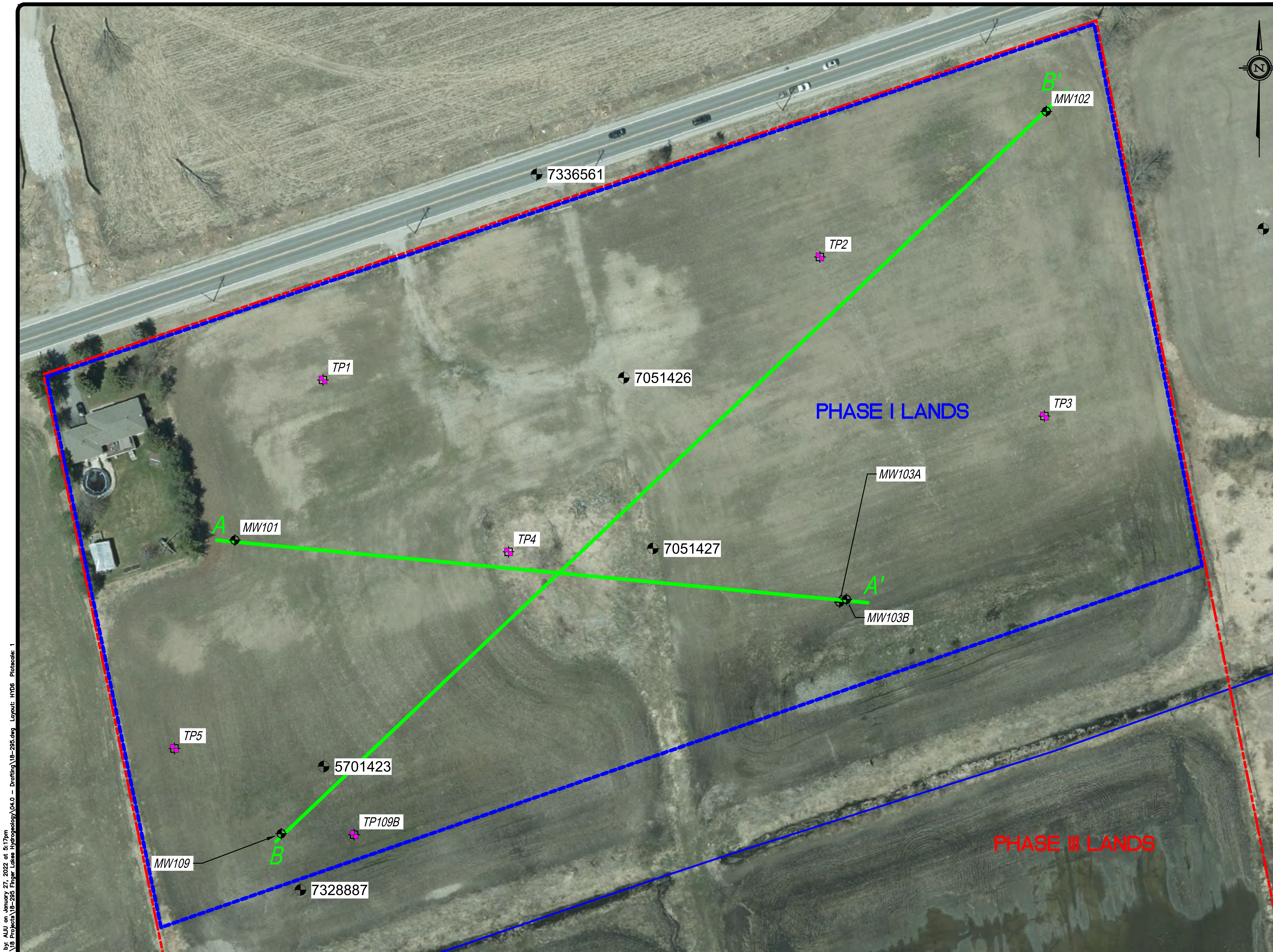
MECP Well Records
Finger Lakes Phase One

Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM	5
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

Plotted by: ALIU on January 27, 2022 at 5:16pm
File: P:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg Layout: HYD5 Plotscale: 1



LEGEND:
- Approx. Property Boundary
- Approx. Phase One Boundary
- Watercourse
- Cross Section Locations
- Monitoring Well Locations
- Test Pit Locations

15m 0 30m

HORIZONTAL SCALE 1:1,000

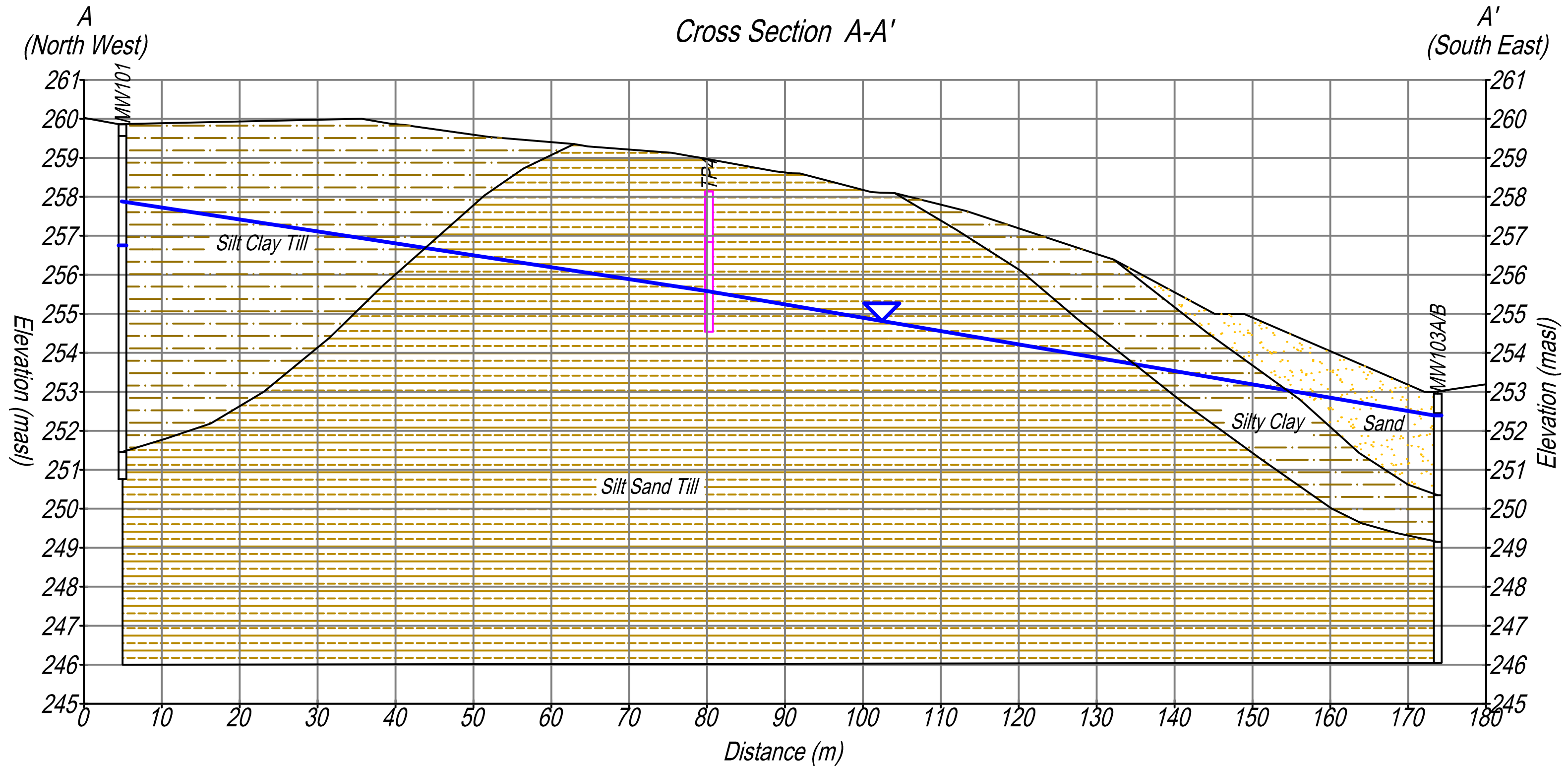
AZIMUTH ENVIRONMENTAL CONSULTING, INC.

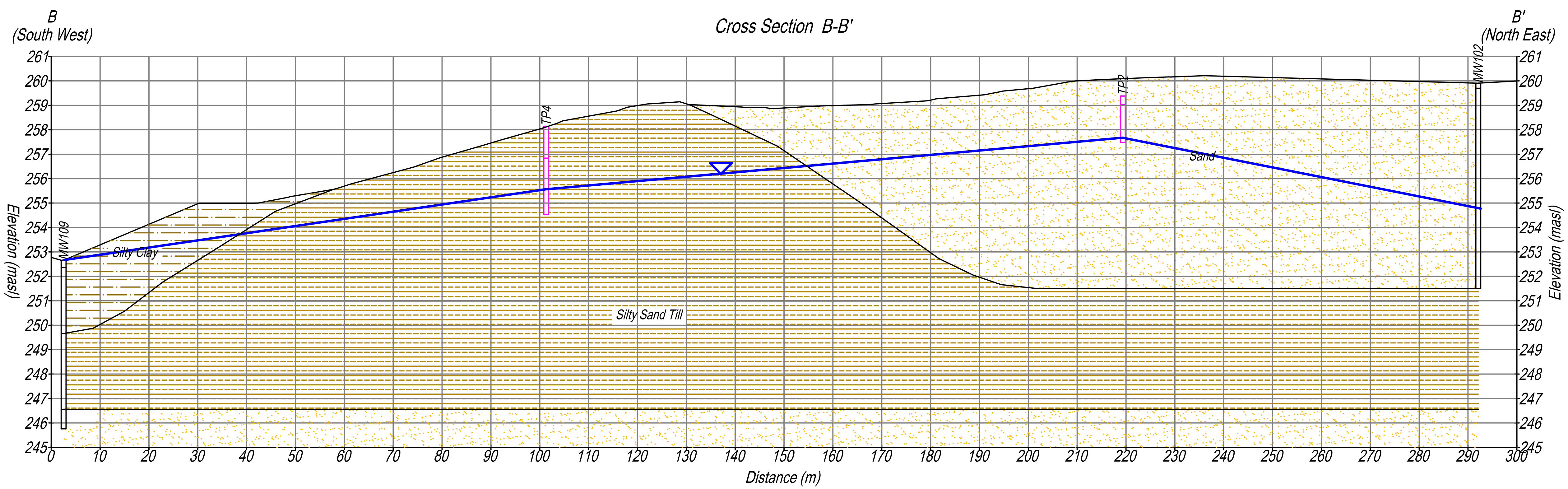
Field Testing Locations
Finger Lakes Phase One

Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM	6
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg





LEGEND:

Water Table May 7, 2019

Not to Scale
10x Vertical Exaggeration

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Cross Sections
Finger Lakes Phase One

Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM	7
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

LEGEND:

- Approx. Property Boundary
- Approx. Phase One Boundary
- Watercourse
- 0.5m Ground Water Contours
- 253.2 Ground Water Elevation (May 7, 2019)
- Monitoring Well Locations
- Test Pit Locations

15m 0 30m

HORIZONTAL SCALE 1:1,250

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Interpreted Ground Water Flow Map
Finger Lakes Phase One

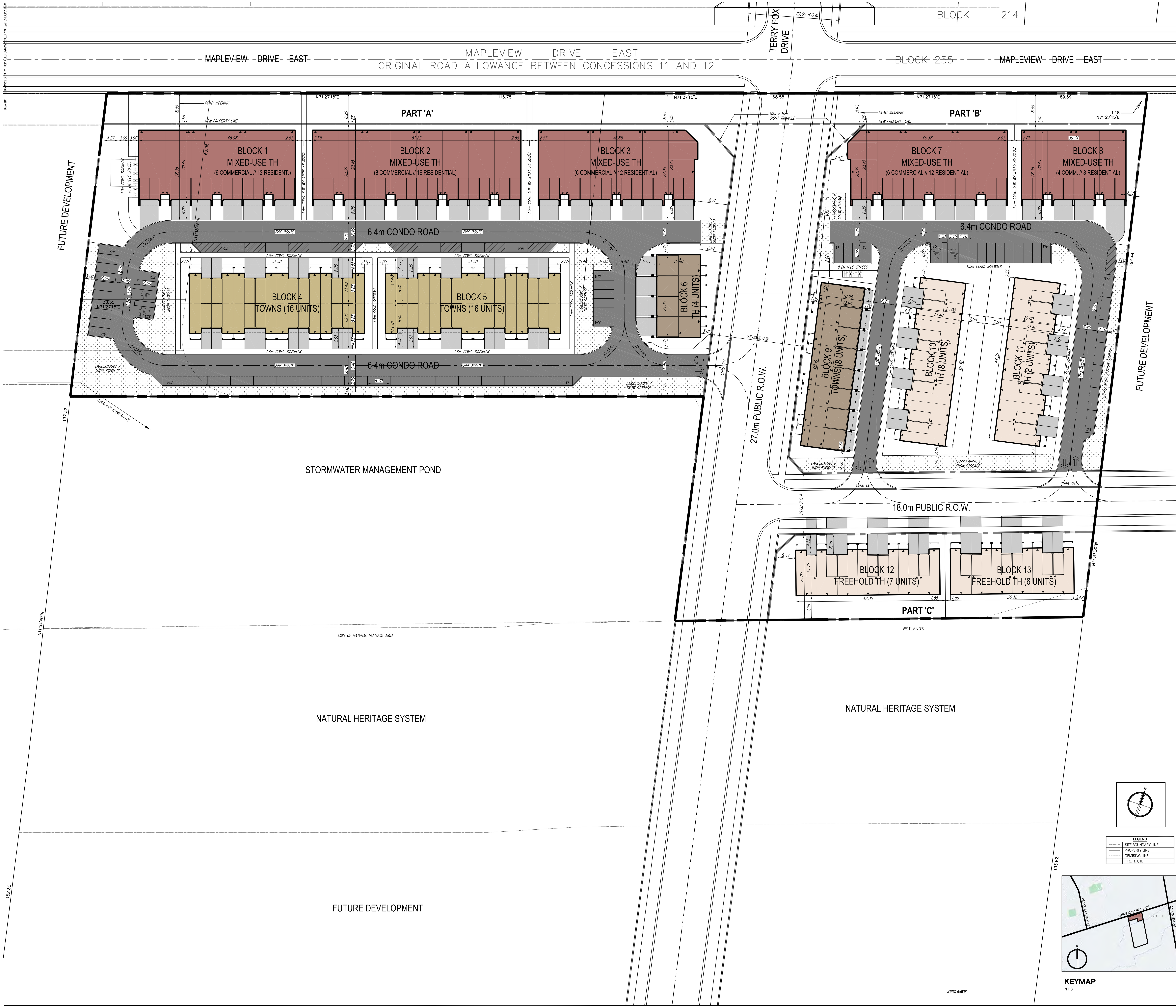
Finger Lakes Hydrogeology,
Barrie, ON

DATE ISSUED:	January 2022	Figure No.
CREATED BY:	JLM/AL	8
PROJECT NO.:	18-295	
REFERENCE:	Simcoe County Maps	

DAYSTAMP: M:\18 Projects\18-295 Finger Lakes Hydrogeology\04.0 - Drafting\18-295.dwg

APPENDIX B

Engineering Drawings



SITE STATISTICS - SITE TOTALS

1. SITE AREAS

	HECTARE	ACRE
PART 'A' - MIXED-USE CONDO TH	1.4896	3.6809
PART 'B' - MIXED-USE CONDO TH	0.9363	2.3136
PART 'C' - FREEHOLD TH	0.2303	0.5690
NET DEV. AREA	**2.6561**	**6.5634**

2. UNIT COUNT

UNIT TYPE	#
TYPE 'A' - 3 STOREY, 7.62M MIXED-USE STACKED TOWNHOUSE	
COMMERCIAL G.F.A. : 48 SM PER MODULE MAX	30
RESIDENTIAL G.F.A. : SUITE 1	30
RESIDENTIAL G.F.A. : SUITE 2	30
TYPE 'B' - 3 STOREY, 6.4M BACK-TO-BACK TOWNHOUSE	32
TYPE 'C' - 3 STOREY, 6.0M REAR-LANE DECK TOWNHOUSE	12
TYPE 'D' - 3 STOREY, 6.0M CONVENTIONAL TOWNHOUSE	29
TOTAL	**163**

3. DENSITY

	UNITS / HECTARE	UNITS / ACRE
# OF UNITS / NET DEV. AREA	61.37	24.83

4. COMMERCIAL G.F.A.

PART	COMMERCIAL UNIT COUNT	G.F.A. (48 SM PER COMM. UNIT)
PART 'A'	20	960 SM
PARTS 'B' + 'C'	10	480 SM
TOTAL	**30**	**1,440 SM**

5. COMMERCIAL FSI

	REQUIRED	PROVIDED (COMM. G.F.A. / LOT AREA)
PART 'A'	0.27	960 SM / 14,896 SM = **0.06**
PARTS 'B' + 'C'	0.27	480 SM / 11,665 SM = **0.04**

SITE STATISTICS - PART A

1. SITE AREAS

	HECTARE	ACRE
PART 'A' - MIXED-USE CONDO TH	1.4896	3.6809
NET DEV. AREA	**1.4896**	**3.6809**

2. UNIT COUNT

UNIT TYPE	#
TYPE 'A' - 3 STOREY, 7.62M MIXED-USE STACKED TOWNHOUSE	
COMMERCIAL G.F.A. : 48 SM PER MODULE MAX	20
RESIDENTIAL G.F.A. : SUITE 1	20
RESIDENTIAL G.F.A. : SUITE 2	20
TYPE 'B' - 3 STOREY, 6.4M BACK-TO-BACK TOWNHOUSE	32
TYPE 'C' - 3 STOREY, 6.0M REAR-LANE DECK TOWNHOUSE	4
TYPE 'D' - 3 STOREY, 6.0M CONVENTIONAL TOWNHOUSE	0
TOTAL	**96**

3. DENSITY

	UNITS / HECTARE	UNITS / ACRE
# OF UNITS / NET DEV. AREA	64.45	26.08

4. RESIDENT PARKING

UNIT TYPE	REQUIRED (1.5)	PROVIDED
TYPE 'A' - SUITE 1 (2 SP. PER UNIT PROV.)	30.00	40.00
TYPE 'A' - SUITE 2 (2 SP. PER UNIT PROV.)	30.00	40.00
TYPE 'B' (2 SP. PER UNIT PROV.)	48.00	64.00
TYPE 'C' (2 SP. PER UNIT PROV.)	6.00	8.00
TYPE 'D' (2 SP. PER UNIT PROV.)	0.00	0.00
TOTAL	**114.00**	**152.00**

5. VISITOR PARKING

UNIT TYPE	REQUIRED	PROVIDED
TYPE 'A' - COMMERCIAL (1 SP / 24 sm REQ'D)	40	40.00
RESIDENTIAL UNITS	-	4.00
TOTAL	**40**	**44.00**

OTHER REQUIREMENTS

1. BICYCLE PARKING

PART A

REQUIRED:

A) MIN. 0.2 SPACES PER APARTMENT UNIT (MIXED-USE RESIDENTIAL UNITS)
0.2 * 40 UNITS = 8 SPACES REQUIRED

B) ADDITIONAL 1 SPACE FOR EVERY 7% OF REQUIRED COMMERCIAL PARKING
7% * 40 COMMERCIAL PARKING REQ'D = 3 SPACES REQUIRED

TOTAL = 11 SPACES REQUIRED

PROVIDED = 16 SPACES PROPOSED

PART B

REQUIRED:

A) MIN. 0.2 SPACES PER APARTMENT UNIT (MIXED-USE RESIDENTIAL UNITS)
0.2 * 20 UNITS = 4 SPACES REQUIRED

B) ADDITIONAL 1 SPACE FOR EVERY 7% OF REQUIRED COMMERCIAL PARKING
7% * 20 COMMERCIAL PARKING REQ'D = 2 SPACES REQUIRED

TOTAL = 6 SPACES REQUIRED

PROVIDED = 8 SPACES PROPOSED

2. SNOW STORAGE

PART A

PAVED ROADWAY AND STREET PARKING AREA: 3601 SM
PROPOSED SNOW STORAGE AREA: 1564 SM (43.4%)

PART B

PAVED ROADWAY AND STREET PARKING AREA: 1871 SM
PROPOSED SNOW STORAGE AREA: 742 SM (39.7%)

PAVED ROADWAY AND STREET PARKING AREA

PROPOSED SNOW STORAGE AREA

SITE STATISTICS - PART B

1. SITE AREAS

	HECTARE	ACRE
PART 'B' - MIXED-USE CONDO TH	0.9363	2.3136
NET DEV. AREA	**0.9363**	**2.3136**

2. UNIT COUNT

UNIT TYPE	#
TYPE 'A' - 3 STOREY, 7.62M MIXED-USE STACKED TOWNHOUSE	
COMMERCIAL G.F.A. : 48 SM PER MODULE MAX	10
RESIDENTIAL G.F.A. : SUITE 1	10
RESIDENTIAL G.F.A. : SUITE 2	10
TYPE 'B' - 3 STOREY, 6.4M BACK-TO-BACK TOWNHOUSE	0
TYPE 'C' - 3 STOREY, 6.0M REAR-LANE DECK TOWNHOUSE	8
TYPE 'D' - 3 STOREY, 6.0M CONVENTIONAL TOWNHOUSE	16
TOTAL	**54**

3. DENSITY

	UNITS / HECTARE	UNITS / ACRE
# OF UNITS / NET DEV. AREA	57.68	23.34

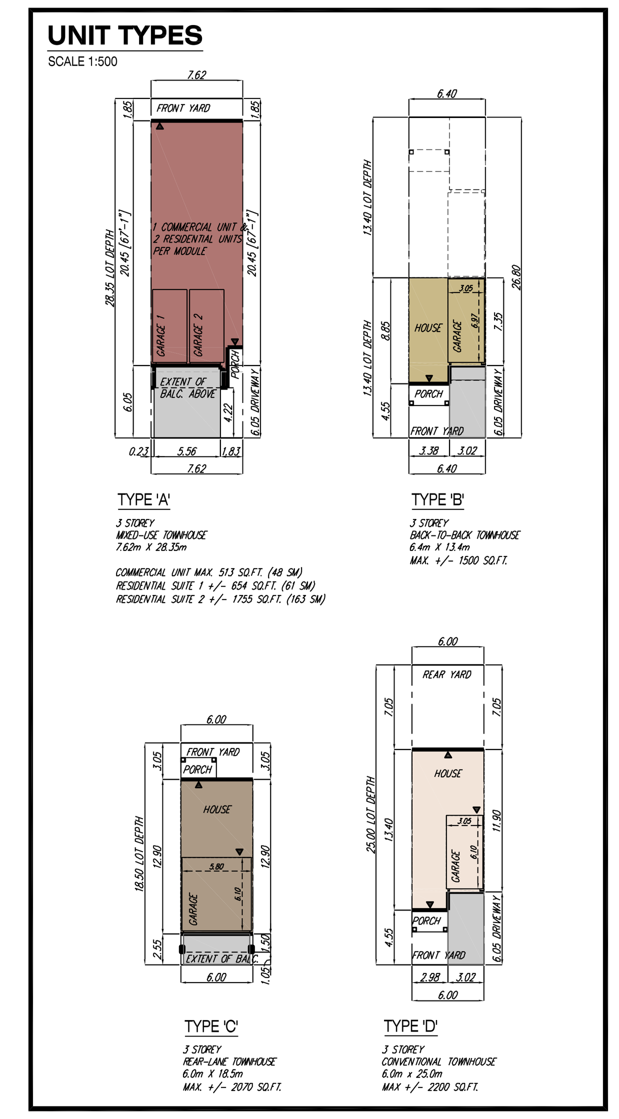
4. RESIDENT PARKING

UNIT TYPE	REQUIRED (1.5)	PROVIDED
TYPE 'A' - SUITE 1 (2 SP. PER UNIT PROV.)	15.00	20.00
TYPE 'A' - SUITE 2 (2 SP. PER UNIT PROV.)	15.00	20.00
TYPE 'B' (2 SP. PER UNIT PROV.)	0.00	0.00
TYPE 'C' (2 SP. PER UNIT PROV.)	12.00	16.00
TYPE 'D' (2 SP. PER UNIT PROV.)	24.00	32.00
TOTAL	**66.00**	**88.00**

5. VISITOR PARKING

UNIT TYPE	REQUIRED	PROVIDED
TYPE 'A' - COMMERCIAL (1 SP / 24 sm REQ'D)	20.00	20.00
RESIDENTIAL UNITS	-	3.00
TOTAL	**20**	**23.00**

UNIT TYPES



SITE STATISTICS - PART C

1. SITE AREAS

	HECTARE	ACRE
PART 'C' - FREEHOLD TH	0.2303	0.5690
NET DEV. AREA	**0.2303**	**0.5690**

2. UNIT COUNT

UNIT TYPE	#
TYPE 'A' - 3 STOREY, 7.62M MIXED-USE STACKED TOWNHOUSE	
COMMERCIAL G.F.A. : 48 SM PER MODULE MAX	0
RESIDENTIAL G.F.A. : SUITE 1	0
RESIDENTIAL G.F.A. : SUITE 2	0
TYPE 'B' - 3 STOREY, 6.4M BACK-TO-BACK TOWNHOUSE	0
TYPE 'C' - 3 STOREY, 6.0M REAR-LANE DECK TOWNHOUSE	0
TYPE 'D' - 3 STOREY, 6.0M CONVENTIONAL TOWNHOUSE	13
TOTAL	**13**

3. DENSITY

	UNITS / HECTARE	UNITS / ACRE
# OF UNITS / NET DEV. AREA	56.46	22.85

4. RESIDENT PARKING

UNIT TYPE	REQUIRED (1.5)	PROVIDED
TYPE 'A' - SUITE 1 (2 SP. PER UNIT PROV.)*	0.00	0.00
TYPE 'A' - SUITE 2 (2 SP. PER UNIT PROV.)	0.00	0.00
TYPE 'B' (2 SP. PER UNIT PROV.)	0.00	0.00
TYPE 'C' (2 SP. PER UNIT PROV.)	0.00	0.00
TYPE 'D' (2 SP. PER UNIT PROV.)	19.50	26.00
TOTAL	**19.50**	**26.00**

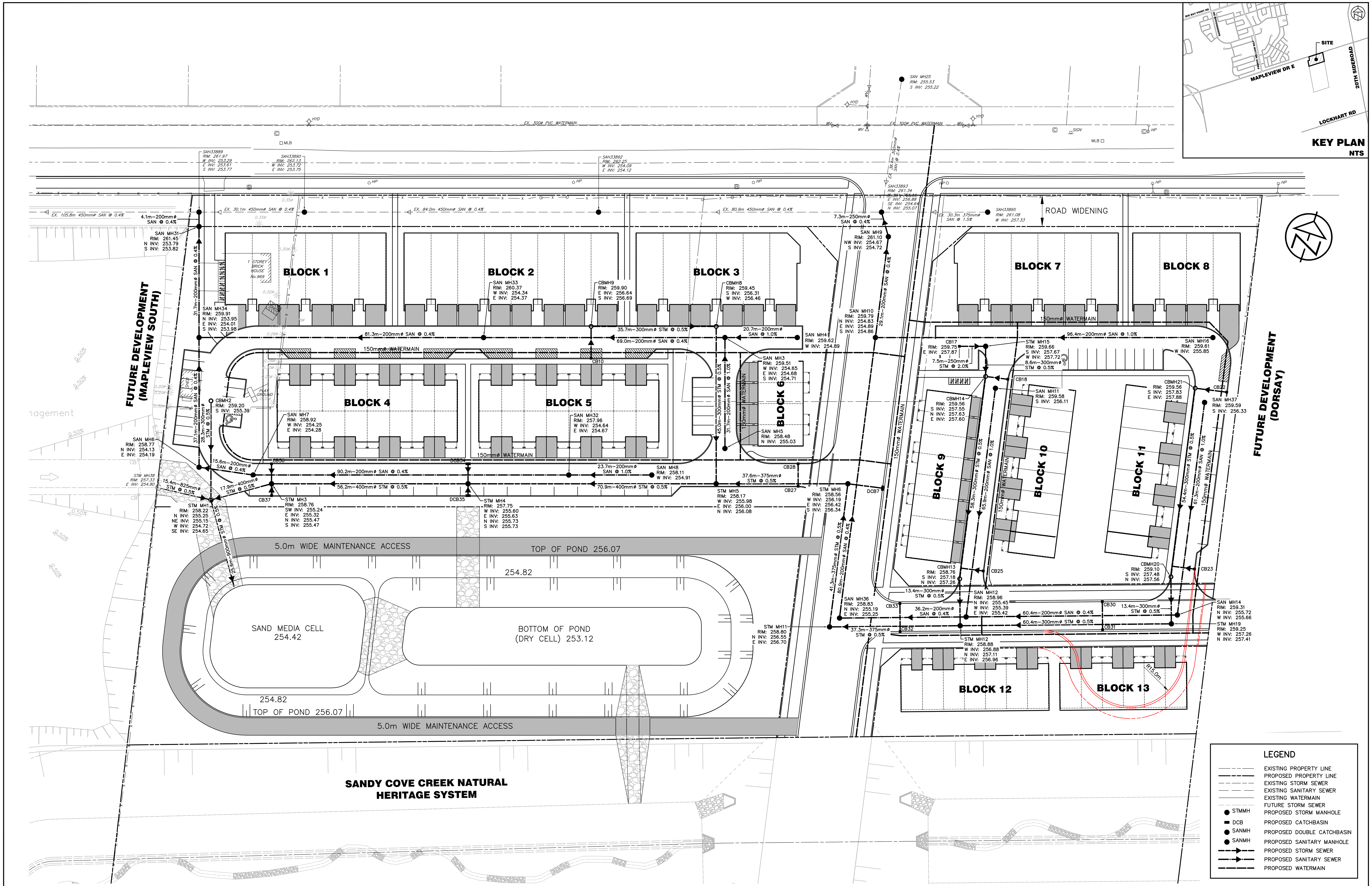
5. VISITOR PARKING

NOT REQUIRED FOR FREEHOLD LOTS

HUNT DESIGN ASSOCIATES INC.
www.huntdesign.ca

CRYSTAL HOMES - 221033
MAPLEVIEW, BARRIE, ON
8966 Woodbine Ave, Markham, ON L3R 0J7 ■ T 905.737.5133 ■ F 905.737.7326 ■ JAN. 2022 ■ JA ■

CONCEPTUAL SITE PLAN
1:500
221033DSP01



DISCLAIMER AND COPYRIGHT

CONTRACTOR MUST VERIFY ALL DIMENSIONS AND BE RESPONSIBLE FOR SAME. ANY DISCREPANCIES MUST BE REPORTED TO THE ENGINEER BEFORE COMMENCING WORK. DRAWINGS ARE NOT TO BE SCALED.

DRAWING REFERENCES

SITE PROPERTY LINES SHOWN BASED ON PLAN 51R-33948 PREPARED BY HOLDING JONES VANDERVEEN INC., O.L.S., DATED FEBRUARY 13, 2008. EXISTING PROPERTY LINES SHOWN ARE APPROXIMATE BASED ON SIMCOE COUNTY GIS.

TOPOGRAPHIC INFORMATION SHOWN BASED ON SURVEY COMPLETED BY HOLDING JONES VANDERVEEN INC., O.L.S., JULY 27, 2015.

SITE PLAN SHOWN PREPARED BY HUNT DESIGN ASSOCIATES INC., MAY 2021.

BENCHMARKS

TBM#1 ELEV. 261.551 m
CITY OF BARRIE BENCHMARK #03120110020

TBM#2 ELEV. 268.852 m
CITY OF BARRIE BENCHMARK #03120110016

No.	REVISION DESCRIPTION	DATE

ENGINEER STAMP

DRAFT

SANDY CREEK ESTATES INC.
PHASE 1
CITY OF BARRIE

TATHAM ENGINEERING

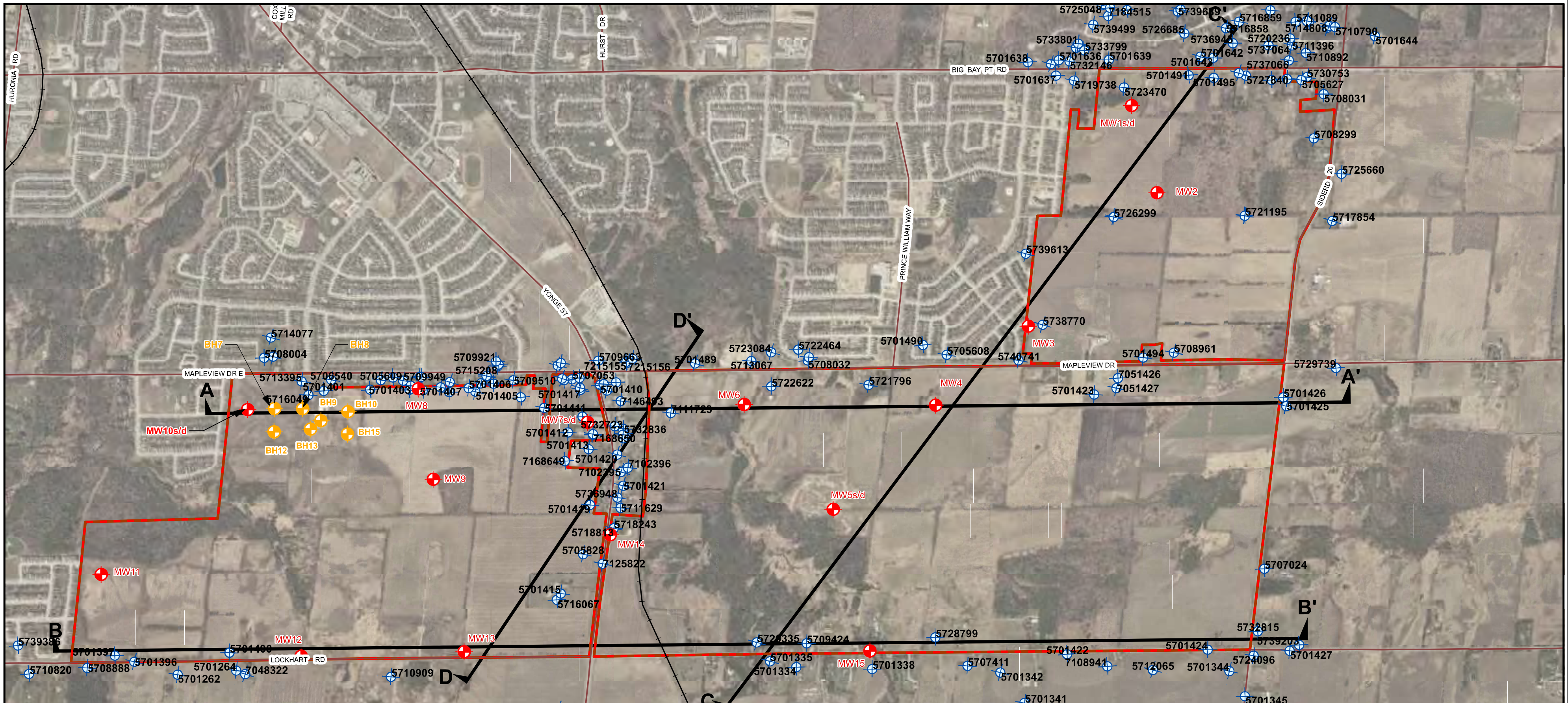
GENERAL SERVICING PLAN

DESIGN: LC	FILE: 420406-1	DWG:
DRAWN: LC	DATE: AUGUST 2021	**SS-01**
CHECK: NM	SCALE: 1:500	

Drawing Name: 420406-SS01.dwg, Plotted: Jan 24, 2022

APPENDIX C

Burnside (2016) Excerpts



Legend

- HEWITT'S SECONDARY PLAN AREA (STUDY AREA)
- RAILWAY
- ROADWAY
- MONITORING WELL (RJB, 2014)
- MONITORING WELL (PML, 2013)
- MECP WELL RECORD LOCATION
- CROSS SECTION LOCATION KEY

Sources:

1. Ministry of Natural Resources, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.
3. County of Simcoe WebServices
4. Satellite Image: Simcoe County online maps, Public/Ortho_2012
http://maps.simcoe.ca/arcgis/services © The Corporation of the County of Simcoe

N

0 250 500 750 1,000 1,250

Metres

BURNSIDE

Client / Report

HEWITT'S CREEK LANDOWNERS GROUP
BARRIE, ONTARIO

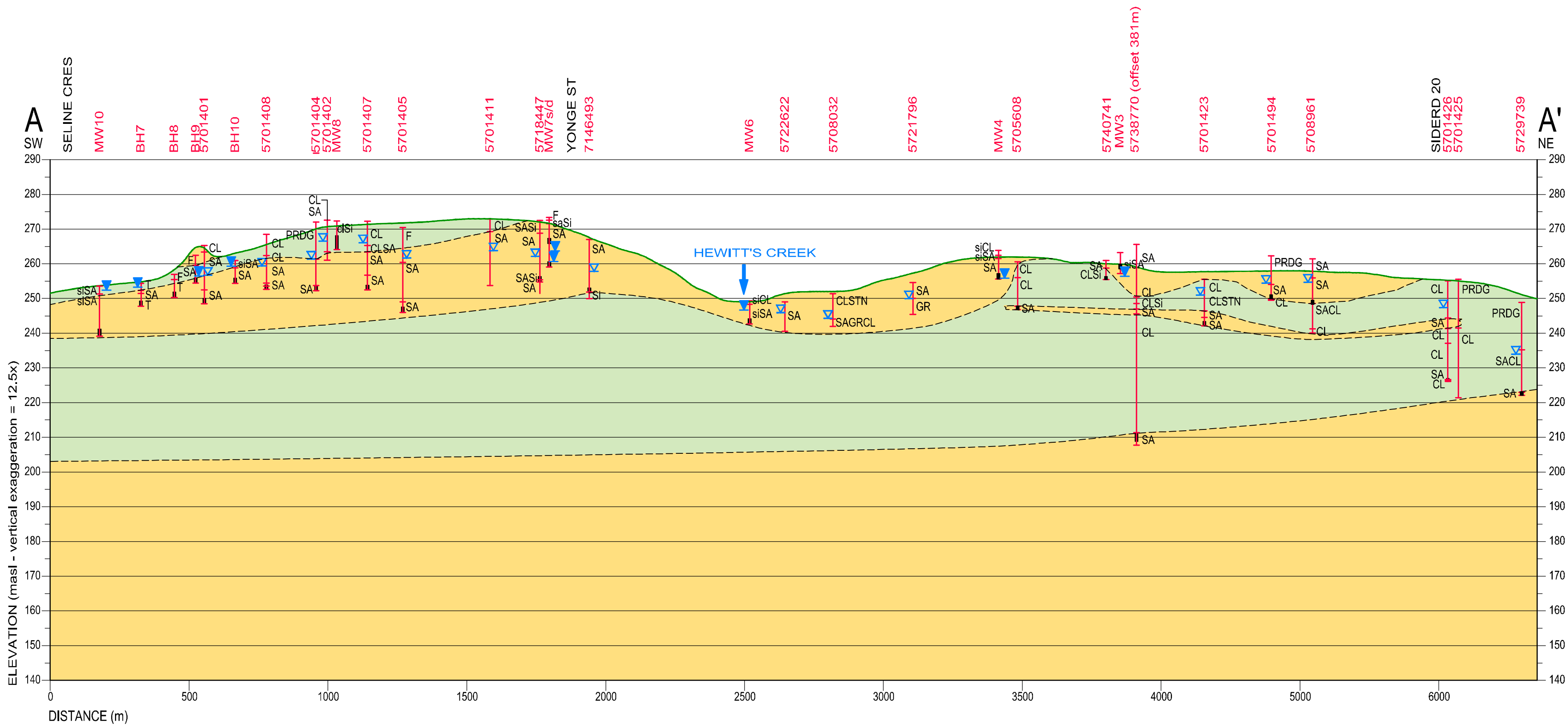
HEWITT'S SPA WELL SURVEY REPORT

Figure Title

CROSS SECTION LOCATION PLAN

Drawn	Checked	Date	Figure No.
SK	SC	October 2018	4
Scale		Project No.	
1:18,000		300042101.0000	

File Path: Nigel/Shared Work Areas/A:\042101 Hewitt\042101 Cross-Section Locations.mxd Print Date: 2018/11/01 Time: 01:08 PM



LEGEND

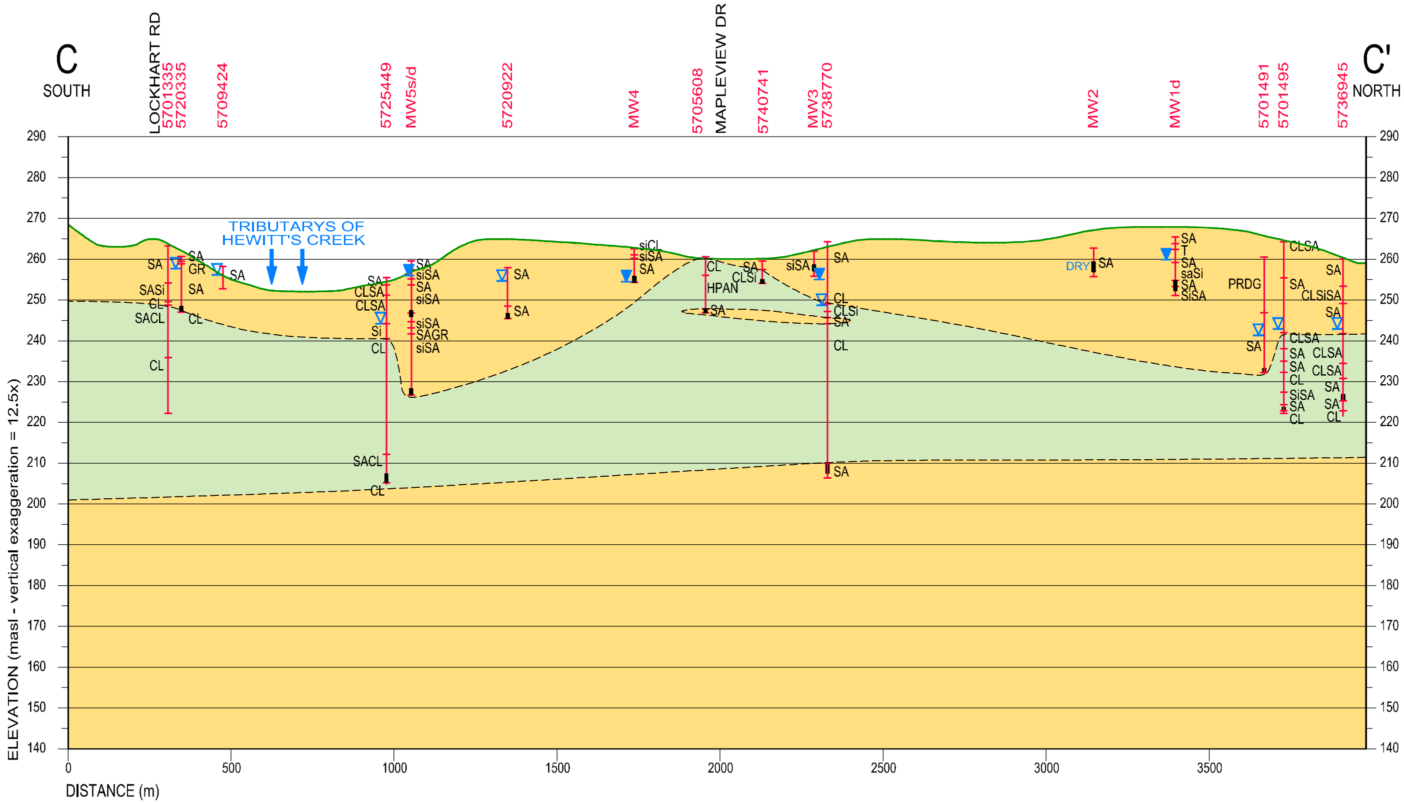
4901807 MW10	WELL / BOREHOLE ID		CLAY / SILT / TILL	si	SILTY
	MOE WELL RECORD NUMBER		SAND / GRAVEL	cl	CLAYEY
	WELL		INTERPRETED GEOLOGICAL CONTACT	sa	SANDY
CLGR	GEOLOGICAL STRATIGRAPHY		WATERCOURSE CROSSING	F	FILL
	STATIC WATER LEVEL (REPORTED ON MOE WELL RECORD)			T	TILL
	MEASURED WATER LEVEL (APRIL 6, 2015)			SA	SAND
	WELL SCREEN			Si	SILT
				GR	GRAVEL
				CL	CLAY
				PRDG	PREDUG

BURNSIDE

Client
HEWITT'S CREEK LANDOWNERS GROUP
BARRIE, ONTARIO
HEWITT'S SPA WELL SURVEY REPORT

Figure Title
SCHEMATIC GEOLOGICAL CROSS SECTION A-A'

Drawn	Checked	Date	Figure No.
SK	SC	October 2018	5
Scale		Project No.	
1:15,000		300042101.0000	



LEGEND

- WELL / BOREHOLE ID
- MOE WELL RECORD NUMBER
- WELL
- GEOLOGICAL STRATIGRAPHY
- STATIC WATER LEVEL (REPORTED ON MOE WELL RECORD)
- MEASURED WATER LEVEL (APRIL 6, 2015)
- WELL SCREEN

- CLAY / SILT / TILL
- SAND / GRAVEL
- ---- INTERPRETED GEOLOGICAL CONTACT
- WATERCOURSE CROSSING

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

BURNSIDE

Client
HEWITT'S CREEK LANDOWNERS GROUP
BARRIE, ONTARIO
HEWITT'S SPA WELL SURVEY REPORT

Figure Title
SCHEMATIC GEOLOGICAL CROSS SECTION C-C'

Drawn	Checked	Date	Figure No.
SK	SC	October 2018	7
Scale		Project No.	
1:15,000		300042101.0000	

File Name:Nigel/Shared Work Areas/042101 Hewitt/ 042101 Cross-Sections.dwg Date Plotted: November 1, 2018 - 1:07 PM

APPENDIX D

MECP Well Records

UTM 17 Z 611 642 E
4949 N 4911887 N

Elev. 0850

Basin 22

57 № 1423

B

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District SIMCOE Township, Village, Town or City Innisfil

Con. XI Lot E/219 Date completed 15 (day) Sept (month) 65 (year)

[redacted]ess RR 4 BARRIE

Casing and Screen Record	
Inside diameter of casing	4"
Total length of casing	40'
Type of screen	Cook #16 SLOT.
Length of screen	4'
Depth to top of screen	40'
Diameter of finished hole	4"

Pumping Test	
Static level	15'
Test-pumping rate	10 G.P.M.
Pumping level	17'
Duration of test pumping	2 HRS.
Water clear or cloudy at end of test	CLEAR.
Recommended pumping rate	5 G.P.M.
with pump setting of	30' feet below ground surface

Well Log: Overburden and Bedrock Record	From ft.	To ft.	Water Record: Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
BROWN CLAY	0	3		
" " + STONES	3	30		
FINE SAND	30	36	30	FRESH
COARSE "	36	44		

For what purpose(s) is the water to be used? FARM

Is well on upland, in valley, or on hillside? ✓

Drilling or Boring Firm

Address A. CAMERON. R.R.1 MIDHURST.

Licence Number 1659.

Name of Driller or Borer SAME.

Address

Date Dec. 8/65

Alf Cameron

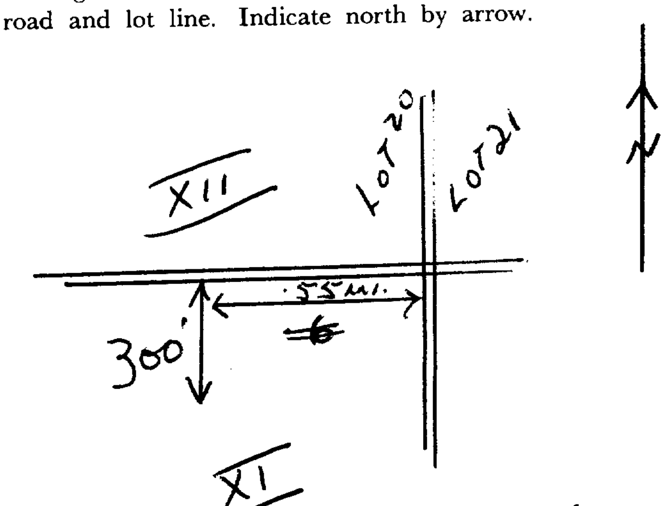
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



LOW BRICK HOUSE BARN BEHIND.

CSS.58

UTM 17 z 611806 E

Con 5 XII 4912121 N

Elev. LOT 20 50855

The Ontario Water Resources Commission Act

WATER WELL RECORD

WATER RESOURCES DIVISION 57 № 1494 JUN 10 1965 ONTARIO WATER RESOURCES COMMISSION

3

Basin VV County or District Simcoe Township, Village, Town or City Innisfil

Con. 12 Lot ~~19~~ 20 NE Date completed 9 (day) Nov. (month) 1964 (year)

[redacted]ess RR#4 BARRIE.

Casing and Screen Record

Inside diameter of casing 6¼"

Total length of casing 28 ft.

Type of screen 6" Johnson Stainless slot 16

Length of screen 3 ft.

Depth to top of screen 38 ft.

Diameter of finished hole 6¼" 10"

Pumping Test

Static level 26

Test-pumping rate 2½ G.P.M.

Pumping level 39 ft.

Duration of test pumping 1 hr.

Water clear or cloudy at end of test clear

Recommended pumping rate 2½ G.P.M.

with pump setting of 39 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Water Record: Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Dug well	0	27		
sand	27	38		
medium yellow sand	38	41	38	fresh
brown clay	41			

For what purpose(s) is the water to be used? House

Is well on upland, in valley, or on hillside? upland

Drilling or Boring Firm H. Hammers Well Driller

Address RR#3 Barrie, Ont.

Licence Number 1303

Name of Driller or Borer A. Hammers

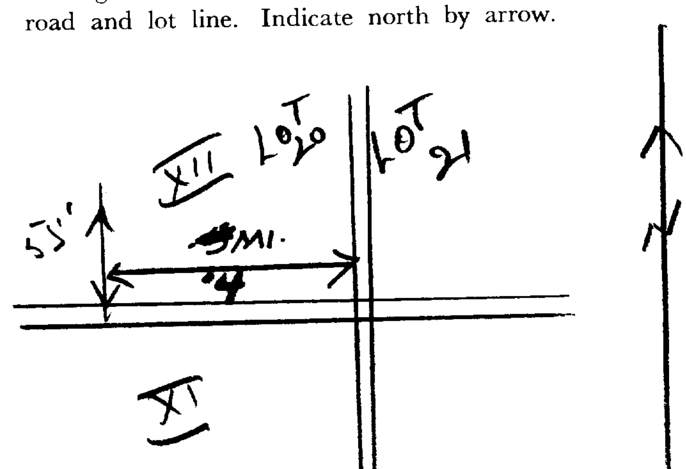
Address RR#5 Barrie, Ont.

Date Nov 11/64

Henry Hammers
(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 7 15M-60-4138

OWRC COPY

CSS.S8

The Ontario Water Resources Commission Act

WATER WELL RECORD

310/5E

Water management in Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

5708961 | MUNICIP. 57005 | CON. CON | 12

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
SIMCOE	INNISFIL	12	020

[redacted] RR#4 Barrie Ontario

DATE COMPLETED: DAY 20 MO. 06 YR. 72

ELEVATION | BASIN CODE

[redacted] 12188 4 852 5 22 MAR 26, 1975 52

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH – FEET FROM	TO
BLACK	TOPSOIL			0	1
YELLOW	SAND		FINE TO MED	1	18
"	"		MED TO C	18	42
"	SAND	CLAY		42	66
GREY	CLAY			66	70

31: 0001802 | 0018528 | 0042509 | 0066528 05 | 0070205

32

41 WATER RECORD

WATER FOUND AT – FEET	KIND OF WATER
0042	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH – FEET FROM	TO
05	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	188	0	~~39~~ 0039
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
012	05 INCHES	03 FEET

MATERIAL AND TYPE: ~~JOHNSON~~ S.S. | DEPTH TO TOP OF SCREEN: 0039 FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT – FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☐ PUMP 2 ☒ BAILER

PUMPING RATE: 0006 GPM.

DURATION OF PUMPING: 01 HOURS 00 MINS.

1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
022 FEET	036 FEET	036	036	036	036 FEET

IF FLOWING, GIVE RATE: — GPM.

PUMP INTAKE SET AT: — FEET

WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☒ DEEP

RECOMMENDED PUMP SETTING: 040 FEET

RECOMMENDED PUMPING RATE: 0005 GPM.

0004 GPM./FT. SPECIFIC CAPACITY

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

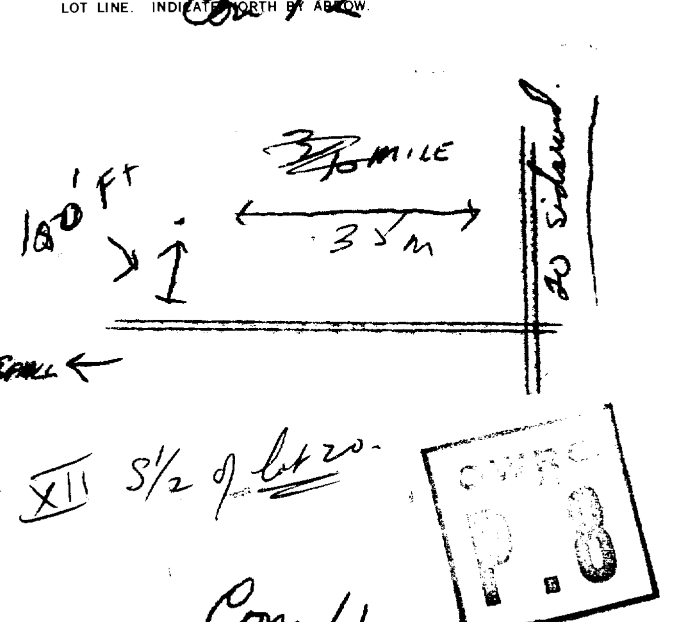
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING

1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

OWRC P.8

CONTRACTOR

NAME OF WELL CONTRACTOR: KNELSEN WATER WELLS | LICENCE NUMBER: 3203

ADDRESS: RR#1 BARRIE ONT

NAME OF DRILLER OR BORER: SAME | LICENCE NUMBER:

SIGNATURE OF CONTRACTOR: [signature]

SUBMISSION DATE: DAY 4 MO. 7 YR. 72

OFFICE USE ONLY

DATA SOURCE: 1 | CONTRACTOR: 3203 | DATE RECEIVED: 030872

DATE OF INSPECTION: | INSPECTOR: C

REMARKS: CSS.S8

WI

OWRC COPY

Ontario Ministry of the Environment

Well Tag I A 006238 below)
A006238

Well Record
Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

[redacted]

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
GEORGE PATTERSON	INNISFIL		

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
1640 MAPLEVIEW DRIVE EAST	INNISFIL	

GPS Reading: NAD 83; Zone 17; Easting 611227; Northing 4912344; Unit Make/Model MERIDIAN GOLD UTM; Mode of Operation: ☐ Undifferentiated ☑ Averaged ☐ Differentiated, specify ______

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth Metres From	Depth Metres To
BLACK	TOP SOIL			0	.3048
BROWN	SAND			.3048	15.24
GREY	CLAY			15.24	17.07
GREY	CLAY	SILT		17.07	18.60
BROWN	SAND			18.60	20.11
GREY	CLAY		HARD	20.11	54.25
BROWN	SAND			54.25	57.91

Hole Diameter

Depth Metres From	Depth Metres To	Diameter Centimetres
0	54.25	22.23
54.25	56.69	15.55

Water Record

Water found at Metres	Kind of Water
55 m	☐ Gas ☑ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Other:
___ m	☐ Gas ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Other:
___ m	☐ Gas ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Other:

After test of well yield, water was: ☑ Clear and sediment free ☐ Other, specify

Chlorinated ☑ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth Metres From	Depth Metres To
Casing				
16.33	☑ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	0.48	+60.96	54.25
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized		SCREEN ON 4' LEADER	
Screen (Outside diam)		Slot No.		
15.23	☑ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	8	54.25	56.69
No Casing or Screen	☐ Open hole			

Test of Well Yield

Pumping test method: PUMPED

Pump intake set at - (metres): 48.5[illegible]

Pumping rate - (litres/min): [illegible]

Duration of pumping ___hrs + ___ min: [illegible]

Final water level end of pumping ___ metres: [illegible]

Recommended pump type. ☐ Shallow ☑ Deep

Recommended pump depth. [illegible] metres

Recommended pump rate. (litres/min)

If flowing give rate - (litres/min)

If pumping discontinued, give reason.

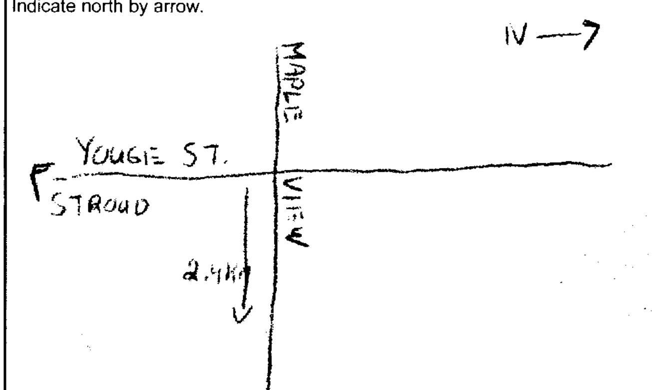
Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Static Level	15.54		
1	[illegible]	1	[illegible]
2	[illegible]	2	[illegible]
3	[illegible]	3	[illegible]
4	20.60	4	[illegible]
5	21.06	5	[illegible]
10	[illegible]	10	[illegible]
15	[illegible]	15	
20	[illegible]	20	
25	[illegible]	25	
30	[illegible]	30	
40	[illegible]	40	
50	[illegible]	50	
60	[illegible]	60	

Plugging and Sealing Record ☑ Annular space ☐ Abandonment

Depth set at - Metres From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
0	9.14	BENTONITE (BENSEAL SLURRY)	

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Method of Construction

☐ Cable Tool ☑ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

Water Use

☑ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☐ Municipal ☐ Public Supply ☐ Not used ☐ Cooling & air conditioning ☐ Other

Final Status of Well

☑ Water Supply ☐ Observation well ☐ Test Hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Unfinished ☐ Dewatering ☐ Replacement well ☐ Abandoned, (Other)

Audit No. Z 06336

Date Well Completed YYYY 04 MM 04 DD 10

Was the well owner's information package delivered? ☑ Yes ☐ No

Date Delivered YYYY 04 MM 04 DD 15

Well Contractor/Technician Information

Name of Well Contractor: DOWNTERRE DRILLING — Well Contractor's Licence No. 7178

Business Address (street name, number, city etc.): 44 MITCHELL AVE ALLISTON L9R 1C2

Name of Well Technician (last name, first name): PETTIFER DONALD — Well Technician's Licence No. 2955

Signature of Technician/Contractor: x Donald Pettifer — Date Submitted YYYY 04 MM 04 DD 21

Ministry Use Only

Data Source — Contractor 7178

Date Received MAY 0 6 2004 — Date of Inspection YYYY MM DD

Remarks CSS ES — Well Record Number 5738770

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐ *Cette formule est disponible en français*

Maple Court Barrie

Ontario Ministry of the Environment

Well Tag Number (Place sticker and print number below)

A035742

Well Record

Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only		
MUN	CON	LOT

Well Owner's Information and Location of Well Information

First Name	Last Name	Mailing Address (Street Number/Name, RR, Lot, Concession)
Con Drain /	Atlas Corporation	111 Ortona Court

County/District/Municipality	Township/City/Town/Village	Province	Postal Code	Telephone Number (include area code)
Vaughan	Vaughan	Ontario	L4K 3M3	905-669-6825

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
Molson Park Drive and Prince (Maple Court Subdivision) Richard	Barrie		

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
	Barrie	

GPS Reading	NAD	Zone	Easting	Northing	Unit Make/Model	Mode of Operation
	83	17	491152	6111272	Garmin	Etrex ☐ Undifferentiated ☒ Averaged ☐ Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth From	Metres To
brown	sand		moist.	0	2
browngrey	clay	silt, coarse gravel	moist.	2	5.5

Notes:
95 Wellpoints
4 MW close alignment
+4 MW on Perimeter.

MW1 - Molson Park Drive + Southeast Corner Subdivision.
MW2 - Mapna Cartet + Counsellor Rds.
MW3 - Queensway + Empire Rds.
MW4 - Empire + Stuart Rds

Hole Diameter

Depth From	Metres To	Diameter Centimetres
0	5.5m	12"

Water Record

Water found at Metres	Kind of Water
___ m	☒ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
___ m	☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
___ m	☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:

After test of well yield, water was
☐ Clear and sediment free
☐ Other, specify

Chlorinated ☒ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth From	Metres To
Casing				
1.8"	☐ Steel ☐ Fibreglass ☒ Plastic ☐ Concrete ☐ Galvanized	.1"	0	5.5m
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	PVC	Sched.	40
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen				
Outside diam 2"	☐ Steel ☐ Fibreglass ☒ Plastic ☐ Concrete ☐ Galvanized	Slot No. 20	PVC/40 4.5m	5.5m
No Casing or Screen				
	☐ Open hole			

Test of Well Yield

N/A

Pumping test method	Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Pump intake set at - (metres)	Static Level			
Pumping rate - (litres/min)	1		1	
Duration of pumping ___hrs + ___ min	2		2	
Final water level end of pumping ___ metres	3		3	
Recommended pump type. ☐ Shallow ☐ Deep	4		4	
Recommended pump depth. ___ metres	5		5	
Recommended pump rate. (litres/min)	10		10	
	15		15	
If flowing give rate - (litres/min)	20		20	
	25		25	
If pumping discontinued, give reason.	30		30	
	40		40	
	50		50	
	60		60	

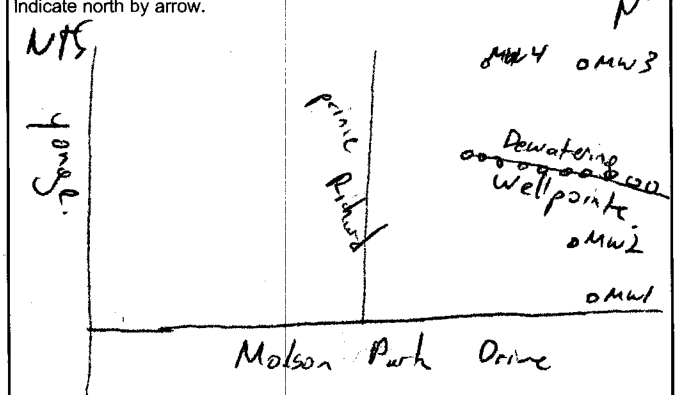
Plugging and Sealing Record

TBC ☐ Annular space ☒ Abandonment

Depth set at - Metres From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Method of Construction

☐ Cable Tool	☐ Rotary (air)	☐ Diamond	☐ Digging
☒ Rotary (conventional)	☐ Air percussion	☒ Jetting	☐ Other
☐ Rotary (reverse)	☐ Boring	☐ Driving	

Water Use

☐ Domestic	☐ Industrial	☐ Public Supply	☐ Other
☐ Stock	☐ Commercial	☒ Not used	
☐ Irrigation	☐ Municipal	☐ Cooling & air conditioning	

Final Status of Well

☐ Water Supply	☐ Recharge well	☐ Unfinished
☐ Observation well	☐ Abandoned, insufficient supply	☒ Dewatering
☐ Test Hole	☐ Abandoned, poor quality	☐ Replacement well

☒ Abandoned, (Other) O.Reg. 903 To Be.

Audit No. Z 45901

Date Well Completed YYYY 2006 MM 05 DD 18

Was the well owner's information package delivered? ☐ Yes ☐ No

Date Delivered YYYY MM DD

Well Contractor/Technician Information

Name of Well Contractor	Well Contractor's Licence No.
Atlas Corporation	6926

Business Address (street name, number, city etc.)
111 Ortona Court, Concord ON L4K 3M3

Name of Well Technician (last name, first name)	Well Technician's Licence No.
Emma, Nick	04-869

Signature of Technician/Contractor	Date Submitted
X	YYYY 2006 MM 5 DD 19

Ministry Use Only

Data Source	Contractor 6926
Date Received MAY 24 2006	Date of Inspection YYYY MM DD
Remarks	Well Record Number

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐

Cette formule est disponible en français

Ontario Ministry of the Environment

Well Tag No. *(Place Sticker and/or Print Below)*
A060735
A 060735

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name	E-mail Address	
Finger Lake	Estates Inc		☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name, RR)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
8600 Dufferin St	York	Ont	L4K5PS	4167981127

Part A Construction and/or Major Alteration of a Well

Address of Well Location (Street Number/Name, RR)	Township	Lot	Concession
1657 Mapleview Dr.	Innisfil	19	11

County/District/Municipality	City/Town/Village	Province	Postal Code
Simcoe	Innisfil	Ontario	

UTM Coordinates	Zone	Easting	Northing	GPS Unit Make	Model	Mode of Operation:
NAD 83	17	611739	4912217	Garmin	Etrex	☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify ____

Overburden and Bedrock Materials *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (Metres) From	To
	Previously filled in dug well				

Annular Space/Abandonment Sealing Record

Depth Set at (Metres) From	To	Type of Sealant Used (Material and Type)	Volume Placed (Cubic Metres)
0	1.21	Brown Sand Clay Fill	
1.21	1.52	Bentonite Hole Plug	0.156308
1.52	3.96	Brown Sand Clay Fill	0.603251
3.96	4.26	Bentonite Hole Plug	0.058615

Method of Construction

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

Water Use

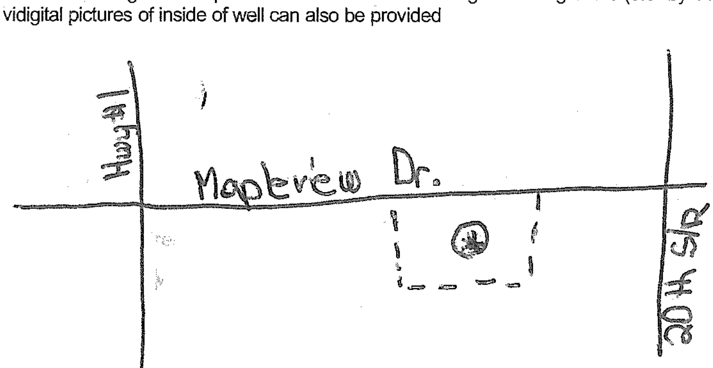
☐ Public ☐ Commercial ☒ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, specify ____

Status of Well

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

Location of Well

Please provide a map below showing:
- all property boundaries, and measurements sufficient to locate the well in relation to fixed points,
- an arrow indicating the North direction
- detailed drawings can be provided as attachments no larger than legal size (8.5" by 14")
- vidigital pictures of inside of well can also be provided



Date Well Completed (yyyy/mm/dd)	Was the well owner's information package delivered?	Date the Well Record and Package Delivered to Well Owner (yyyy/mm/dd)
2007/09/15	☐ Yes ☒ No	2007/09/15

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Hal Calvin Merklinger Well Drilling	7219

Business Address (Street No./Name, number, RR)	Municipality
4131 - 15th line RR#3 Cookstown	Innisfill

Province	Postal Code	Business E-mail Address
Ont	L0L1L0	

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
7054358791	Merklinger Calvin

Well Technician's Licence No.	Signature of Technician	Date Submitted (yyyy/mm/dd)
T2387	Calvin Merklinger	2007/10/16

Results of Well Yield Testing

Check box if after test of well yield, water was:	Draw Down Time (Min)	Water Level (Metres)	Recovery Time (Min)	Water Level (Metres)
☐ Clear and sand free ☐ Cannot develop to sand-free state	Static Level	Dry	Static Level	
If pumping discontinued, give reason:	1		1	
	2		2	
Pumping test method	3		3	
Pump intake set at (Metres)	4		4	
Pumping rate (Litres/min)	5		5	
Duration of pumping ____ hrs + ____ min	10		10	
Final water level end of pumping (Metres)	15		15	
	20		20	
Recommended pump type ☐ Shallow ☐ Deep	25		25	
Recommended pump depth ____ Metres	30		30	
Recommended pump rate (Litres/min)	40		40	
If flowing give rate (Litres/min)	50		50	
	60		60	

Water Details

Water found at Depth	Kind of Water
____ Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals
____ Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals
____ Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Casing Used	Screen Used	Casing and Well Details
☐ Galvanized	☐ Galvanized	Diameter of the Hole (Centimetres)
☐ Steel	☐ Steel	Depth of the Hole (Metres)
☐ Fibreglass	☐ Fibreglass	Wall Thickness (Metres)
☐ Plastic	☐ Plastic	Inside Diameter of the Casing (Metres)
☐ Concrete	☐ Concrete	Depth of the Casing (Metres)

No Casing and Screen Used

☐ Open Hole

Disinfected? ☒ Yes ☐ No

Ministry Use Only

Audit No.	Well Contractor No.
Z67263	

Date Received (yyyy/mm/dd)	Date of Inspection (yyyy/mm/dd)
OCT 25 2007	

Remarks

Ontario Ministry of the Environment

Well Tag No. *(Place Sticker and/or Print Below)*
A060738
A 060738

Well Record

Regulation 903 Ontario Water Resources Act

Page ______ of ______

Well Owner's Information

First Name	Last Name	E-mail Address	☐ Well Constructed by Well Owner
Finger Lake Estates Inc.			

Mailing Address (Street Number/Name, RR)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
8600 Dufferin St.	York	Ont	L4K5P5	4167981127

Part A Construction and/or Major Alteration of a Well

Address of Well Location (Street Number/Name, RR)	Township	Lot	Concession
1657 Mapleview Dr	Innisfil	19	11

County/District/Municipality	City/Town/Village	Province	Postal Code
Simcoe	Innisil	Ontario	

UTM Coordinates	Zone	Easting	Northing	GPS Unit Make	Model	Mode of Operation:
NAD 83	17	611747	4912170	Garmin	Etrex	☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify ______

Overburden and Bedrock Materials *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth *(Metres)* From	To

Annular Space/Abandonment Sealing Record

Depth Set at *(Metres)* From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(Cubic Metres)*
0	10.05	Bentonite Hole Plug	0.07854

Results of Well Yield Testing

Check box if after test of well yield, water was:
☐ Clear and sand free
☐ Cannot develop to sand-free state

If pumping discontinued, give reason:

Pumping test method

Pump intake set at *(Metres)*

Pumping rate *(Litres/min)*

Duration of pumping
____ hrs + ____ min

Final water level end of pumping *(Metres)*

Recommended pump type
☐ Shallow ☐ Deep

Recommended pump depth
________ Metres

Recommended pump rate *(Litres/min)*

If flowing give rate *(Litres/min)*

Draw Down Time *(Min)*	Water Level *(Metres)*	Recovery Time *(Min)*	Water Level *(Metres)*
Static Level	Flow	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 ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Rotary (Air) ☐ Digging
☐ Air percussion ☐ Boring
☐ Other, *specify* ______

Water Use

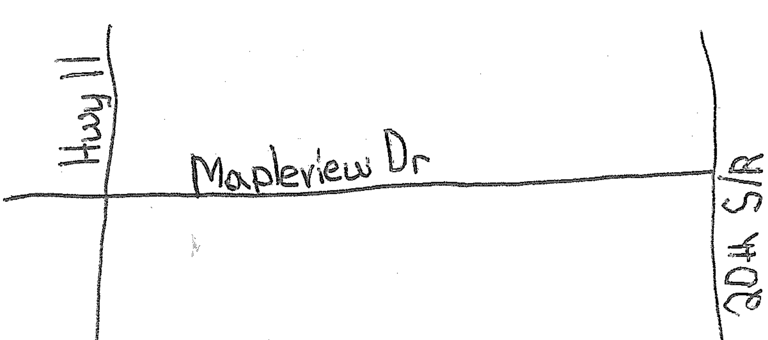
☐ Public ☐ Commercial ☑ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* ______

Status of Well

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

Location of Well

Please provide a map below showing:
- all property boundaries, and measurements sufficient to locate the well in relation to fixed points,
- an arrow indicating the North direction
- detailed drawings can be provided as attachments no larger than legal size (8.5" by 14")
- vidigital pictures of inside of well can also be provided



Water Details

Water found at Depth	Kind of Water
____ Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals
____ Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals
____ Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Casing Used	Screen Used	Casing and Well Details
☐ Galvanized	☐ Galvanized	Diameter of the Hole *(Centimetres)*: 10.16
☑ Steel	☐ Steel	Depth of the Hole *(Metres)*: 10.05
☐ Fibreglass	☐ Fibreglass	Wall Thickness *(Metres)*: .250
☐ Plastic	☐ Plastic	Inside Diameter of the Casing *(Metres)*: 10.16
☐ Concrete	☐ Concrete	Depth of the Casing *(Metres)*

No Casing and Screen Used
☐ Open Hole

Disinfected?
☑ Yes ☐ No

Date Well Completed *(yyyy/mm/dd)*	Was the well owner's information package delivered?	Date the Well Record and Package Delivered to Well Owner *(yyyy/mm/dd)*
2007/09/15	☐ Yes ☑ No	2007/09/15

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
H2O Calvin Merklinger Well Drilling	7219

Business Address (Street No./Name, number, RR)	Municipality
431 - 15th line RR#3 Cookstown	Innisfil

Province	Postal Code	Business E-mail Address
Ont	L0L1L0	

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
7054358791	Merklinger Calvin

Well Technician's Licence No.	Signature of Technician	Date Submitted *(yyyy/mm/dd)*
2887	Calvin Merklinger	2007/10/16

Ministry Use Only

Audit No.	Well Contractor No.
Z 67264	

Date Received *(yyyy/mm/dd)*	Date of Inspection *(yyyy/mm/dd)*
OCT 25 2007	

Remarks

0506E (11/2006) Ministry's Copy

Ontario Ministry of the Environment

Measurements recorded in: ☐ Metric ☑ Imperial

Tag#: A152305

Well Tag No. (Place Sticker and/or Print Below) A152305

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

Well Owner's Information

First Name	Last Name / Organization	E-mail Address		☐ Well Constructed by Well Owner
2121191 Ontario Inc. / LM Barrie c/o R.J. Burnside & Associates Ltd				
Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
292 Speedvale Ave. W., Unit 20	Guelph	Ontario	N1H 1C4	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
Mapleview Dr. E.			
County/District/Municipality	City/Town/Village	Province	Postal Code
Simcoe	Barrie	Ontario	
UTM Coordinates Zone 17 Easting 611266 Northing 4912314 NAD 83	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
Black	Topsoil			Ø	7'
Brown	Silty Clay	Sand		7'	12'
Brown	Sandy Till	Stones		12'	25'

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
Ø	18'	Bentonite	
18'	25'	Silica Sand	

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

Well Use

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

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
2"	PVC	Sch. 40	Ø	20'

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"	PVC	0.010	20'	25'

Map of Well Location

Please provide a map below following instructions on the back.

See Attached

Water Details

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

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

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

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
Ø	25'	8"

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Lantech Drilling Services Inc.	6809
Business Address (Street Number/Name)	Municipality
3661 Mt. Albert Road	Sharon
Province / Postal Code / Business E-mail Address	
Ontario / L0G 1V0	
Bus. Telephone No. (inc. area code) / Name of Well Technician (Last Name, First Name)	
9054782243 / Dan Sinden	
Well Technician's Licence No. / Signature of Technician and/or Contractor	Date Submitted
3166	20140609

Comments:

Well owner's information package delivered ☐ Yes ☑ No

Date Package Delivered YYYYMMDD

Date Work Completed 20140407

Ministry Use Only

Audit No. Z175928

Received APR 08 2015

C-6805 Z175928

APPENDIX E

Borehole Logs

Azimuth Environmental Consulting, Inc.

Environmental Assessments & Approvals

Project: Finger Lakes	**Project Number:** 18-295	**Client:** Trinison	**Borehole ID:** 101
Project Location: 1657 Mapleview Drive East Barrie		**Drilling Contractor:** Orbit Garant	**Drilling Method:** CME 556
Logged By: Jenn Thompson	**Date:** October 9th 2018	**Stickup (m):** 0.9	**Well Depth (mbgs):** 8.37
UTM Coordinates (17T)	**Ground Elevation (masl):** 259.86	**Water Level (mbgs):** 4.3	**Well Diameter (mm):** 50.8
Easting: 611632 **Northing** 4912172	**Well Screen Type:** 10-Slot PVC, schedule 40	**Riser Pipe Type:** schedule 40 PVC	**Well Screen Length (m):** 3.05

Lithology Description

Soil Group Name: grain size,color, density/consistency, moisture, stratification, other descriptors

Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

Sample Type	Sample Number	Sample Recovery (%)
SS	1	100
SS	2	100
SS	3	100
SS	4	100
SS	5	100
SS	6	100
SS	7	100
SS	8	40
SS	9	100
SS	10	100
SS	11	50
SS	12	60

Depth Below Ground Surface (mbgs): 2, 4, 6, 8, 10, 12

Lithology	Description
Topsoil	dark brown sandy topsoil, roots, loose, moist
Silty Clay Till	0.3 - 8.4m brown silty clay, trace sand, occasional cobbles and boulders, compact to very dense, moist to wet, homogeneous - fine sand layer at 0.3m - brown to grey at 1.5m - becomes blue-grey at 6.6m - flowing sand at 8.4m
Silty Sand Till	8.4 - 9.1m grey silty sand till, grey, dense, wet
	end of borehole

Ground Water Level Upon Well Completion (mbgs)

Seal (grout / hole plug)

Silica Sand Pack

Well Screen

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

Project: Finger Lakes	Project Number: 18-295	Client: Trinison	Borehole ID: 102
Project Location: 1657 Mapleview Drive East Barrie		Drilling Contractor: Orbit Garant	Drilling Method: CME 556
Logged By: Jenn Thompson	Date: October 9th 2018	Stickup (m): 0.85	Well Depth (mbgs): 7.96
UTM Coordinates (17T)	Ground Elevation (masl): 259.90	Water Level (mbgs): 5.28	Well Diameter (mm): 50.8
Easting: 611855 Northing 4912290	Well Screen Type: 10-Slot PVC, schedule 40	Riser Pipe Type: schedule 40 PVC	Well Screen Length (m): 3.05

Lithology Description

Soil Group Name: grain size,color, density/consistency, moisture, stratification, other descriptors

Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

Depth Below Ground Surface (mbgs)	Sample Type	Sample Number	Sample Recovery (%)
	SS	1	100
	SS	2	100
2	SS	3	100
	SS	4	100
	SS	5	100
4	SS	6	100
	SS	7	100
6	SS	8	100
	SS	9	100
	SS	10	100
8	SS	11	100
10			
12			

Topsoil dark brown sandy topsoil, roots, loose, moist

Sand 0.2 - 8.4m brown to grey medium sand, loose to compact, wet to saturated, laminated,

- brown to grey at 1.5m

- wet to saturated at 5.3m

end of borehole

Ground Water Level Upon Well Completion (mbgs)

Seal (grout / hole plug) Silica Sand Pack Well Screen

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

Project: Finger Lakes	Project Number: 18-295	Client: Trinison	Borehole ID: 103A
Project Location: 1657 Mapleview Drive East Barrie		Drilling Contractor: Orbit Garant	Drilling Method: CME 556
Logged By: Jenn Thompson	Date: October 12th 2018	Stickup (m): 0.89	Well Depth (mbgs): 6.91
UTM Coordinates (17T)	Ground Elevation (masl): 252.95	Water Level (mbgs): -0.44	Well Diameter (mm): 50.8
Easting: 611799 Northing 4912155	Well Screen Type: 10-Slot PVC, schedule 40	Riser Pipe Type: schedule 40 PVC	Well Screen Length (m): 1.52

Sample Type	Sample Number	Sample Recovery (%)
SS	1	100
SS	2	100
SS	3	100
SS	4	100
SS	5	100
SS	6	100
SS	7	100
SS	8	100
SS	9	100

Depth Below Ground Surface (mbgs): 2, 4, 6, 8, 10, 12

Lithology | Monitoring Well Construction

Lithology Description

Soil Group Name: grain size,color, density/consistency, moisture, stratification, other descriptors

Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

Topsoil	dark brown silty sand topsoil, roots, loose, moist
Sand	0.5 - 2.6m brown to grey medium sand, some gravel, loose, moist to saturated - brown to grey at 0.75m, thin clay layers at 2.1m
Silty Clay	2.6 - 3.8m grey silty clay, loose to compact, moist
Silty Sand Till	3.8 - 6.9m grey silty sand, occasional cobbles and boulders, loose to compact, moist, wet seams
	end of borehole

Ground Water Level Upon Well Completion (mbgs)

Seal (grout / hole plug) | Silica Sand Pack | Well Screen

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

Project: Finger Lakes	**Project Number:** 18-295	**Client:** Trinison	**Borehole ID:** 103B
Project Location: 1657 Mapleview Drive East Barrie		**Drilling Contractor:** Orbit Garant	**Drilling Method:** CME 556
Logged By: Jenn Thompson	**Date:** October 12th 2018	**Stickup (m):** 0.88	**Well Depth (mbgs):** 3.11
UTM Coordinates (17T)	**Ground Elevation (masl):** 252.95	**Water Level (mbgs):** 0.87	**Well Diameter (mm):** 50.8
Easting: 611800 **Northing** 4912156	**Well Screen Type:** 10-Slot PVC, schedule 40	**Riser Pipe Type:** schedule 40 PVC	**Well Screen Length (m):** 1.52

Lithology Description

Soil Group Name: grain size,color, density/consistency, moisture, stratification, other descriptors

Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

Depth Below Ground Surface (mbgs)	Sample Type	Sample Number	Sample Recovery (%)	Lithology	Monitoring Well Construction	Lithology Description
	SS	1	100			**Topsoil** dark brown silty sand topsoil, roots, loose, moist
	SS	2	100			**Sand** 0.5 - 2.6m brown to grey medium sand, some gravel, loose, moist to saturated - brown to grey at 0.75m, thin clay layers at 2.1m
2	SS	3	100			
	SS	4	100			**Silty Clay** 2.6 - 3.8m grey silty clay, loose to compact, moist
	SS	5	100			
4	SS	6	100			**Silty Sand Till** 3.8 - 6.9m grey silty sand, occasional cobbles and boulders, loose to compact, moist, wet seams
	SS	7	100			
	SS	8	100			
6	SS	9	100			
						end of borehole (soil descriptions from 103A)
8						
10						
12						

Ground Water Level Upon Well Completion (mbgs)

Seal (grout / hole plug) Silica Sand Pack Well Screen

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

Project: Finger Lakes	**Project Number:** 18-295	**Client:** Trinison	**Borehole ID:** 109
Project Location: 1657 Mapleview Drive East Barrie		**Drilling Contractor:** Orbit Garant	**Drilling Method:** CME 556
Logged By: Jenn Thompson	**Date:** October 12th 2018	**Stickup (m):** 1.76	**Well Depth (mbgs):** 5.83
UTM Coordinates (17T)	**Ground Elevation (masl):** 252.64	**Water Level (mbgs):** -1.7	**Well Diameter (mm):** 50.8
Easting: 611645 **Northing** 4912091	**Well Screen Type:** 10-Slot PVC, schedule 40	**Riser Pipe Type:** schedule 40 PVC	**Well Screen Length (m):** 3.05

Depth Below Ground Surface (mbgs)	Sample Type	Sample Number	Sample Recovery (%)
	SS	1	100
	SS	2	100
2	SS	3	100
	SS	4	100
	SS	5	100
4	SS	6	100
	SS	7	65
6	SS	8	65
	SS	9	100
8			
10			
12			

Lithology | Monitoring Well Construction

Lithology Description

Soil Group Name: grain size,color, density/consistency, moisture, stratification, other descriptors

Rock Description: modifier, color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.

Topsoil	dark brown clayey topsoil, roots, loose, moist
Silty Clay	0.3 - 3.0m brown to grey silty clay with occassional wet sand seams, loose, wet - brown to grey at 1.5m
Silty Sand Till	3.0 - 6.1m grey silty sand, occasional cobbles and boulders, loose to compact, wet - flowing sand noted at 6.1m
Sand	6.1 - 6.9m grey sand, compact, saturated, homogeneous
	end of borehole

Ground Water Level Upon Well Completion (mbgs)

Seal (grout / hole plug) | Silica Sand Pack | Well Screen

Azimuth Environmental Consulting, Inc.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Finger Lakes	**Project Address**	1657 Mapleview Drive East, Barrie	**Date**	October 30th 2018
Test Pit Number	TP-1	**Contractor**	Eisses Brothers Excavating	**Elevation**	260.55
Equipment	Excavator JD 245	**Test Pit Size**	2.0 x 4.0 (L x W)	**Datum**	Ground Surface
Temperature	10^{o}C	**Weather**	Sunny	**Sample Type**	Soil

Depth		Soil description	Samples		Headspace Combustible Vapour Concentration (ppm)	Remarks / Chemical Analysis
From (m)	To (m)		No.	Depth (mbgs)		
0.0	0.30	Topsoil Dark brown sandy topsoil, roots, loose, dry	NA			-
0.30	0.90	Sand Light brown medium sand, compact, layered, dry	NA			-
0.90	3.60	Silty sand till Light brown silty sand till, compact to dense, dry	NA			Sample collected at base for grain size analysis. In-situ testing completed using a Guelph Permeameter.

Test Pit Terminated at 3.6 mbgs

Comments	***Water Conditions in Test Pit***
Standpipe installed upon completion. Contains a 5ft screen. Latitude: 44.354628 Longitude: -79.598960	☐ Wet upon completion ☑ Dry upon completion

JOB No. 18-295
TEST PIT No. TP-1
FIELD STAFF I. Acheson & J. Thompson

Azimuth Environmental Consulting, Inc.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Finger Lakes	**Project Address**	1657 Mapleview Drive East, Barrie	**Date**	October 30th 2018
Test Pit Number	TP-2	**Contractor**	Eisses Brothers Excavating	**Elevation**	257.5
Equipment	Excavator JD 245	**Test Pit Size**	2.0 x 4.0 (L x W)	**Datum**	Ground Surface
Temperature	10°C	**Weather**	Sunny	**Sample Type**	Soil

Depth		Soil description	Samples		Headspace Combustible Vapour Concentration (ppm)	Remarks / Chemical Analysis
From (m)	To (m)		No.	Depth (mbgs)		
0.0	0.35	Topsoil Dark brown sandy topsoil, roots, loose, dry	NA			
0.35	1.90	Sand Light brown medium/fine sand, compact, dry	NA			Sample collected at base for grain size analysis. In-situ testing completed using a Guelph Permeameter.

Test Pit Terminated at 1.9 mbgs

Comments	***Water Conditions in Test Pit***
Standpipe installed upon completion. Contains a 5ft screen. Latitude: 44.354912 Longitude: -79.597237	☐ Wet upon completion ☑ Dry upon completion

JOB No. 18-295
TEST PIT No. TP-2
FIELD STAFF I. Acheson & J. Thompson

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Finger Lakes	**Project Address**	1657 Mapleview Drive East, Barrie	**Date**	October 30th 2018
Test Pit Number	TP-3	**Contractor**	Eisses Brothers Excavating	**Elevation**	254.55
Equipment	Excavator JD 245	**Test Pit Size**	2.0 x 4.0 (L x W)	**Datum**	Ground Surface
Temperature	10^{o}C	**Weather**	Sunny	**Sample Type**	Soil

Depth		Soil description	Samples		Headspace Combustible Vapour Concentration (ppm)	Remarks / Chemical Analysis
From (m)	To (m)		No.	Depth (mbgs)		
0.0	0.35	Topsoil Dark brown sandy topsoil, roots, loose, dry	NA			-
0.35	1.90	Sand Light reddish brown medium sand, becoming silty with depth, compact, moist	NA			Sample collected at 253.5 masl for grain size analysis. In-situ testing completed at this depth using a Guelph Permeameter.

Test pit initially dug to 1.05 mbgs for infiltration testing. Test pit dug a further 1m to investigate depth of sand. Test pit terminated at 2.0 mbgs

Comments	*Water Conditions in Test Pit*
Standpipe installed upon completion. Contains a 5ft screen. Latitude: 44.354508 Longitude: -79.596471	☐ Wet upon completion ☑ Dry upon completion

JOB No.	18-295
TEST PIT No.	TP-3
FIELD STAFF	I. Acheson & J. Thompson

Azimuth Environmental Consulting, Inc.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Finger Lakes	**Project Address**	1657 Mapleview Drive East, Barrie	**Date**	October 30th 2018
Test Pit Number	TP-4	**Contractor**	Eisses Brothers Excavating	**Elevation**	258.14
Equipment	Excavator JD 245	**Test Pit Size**	2.0 x 4.0 (L x W)	**Datum**	Ground Surface
Temperature	10°C	**Weather**	Sunny	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Headspace Combustible Vapour Concentration (ppm)**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.0	1.30	Topsoil Dark brown sandy topsoil and fill, roots, loose, dry, with bricks, concrete, and misc. garbage inclusions	NA			-
1.30	3.60	Silty sand till Light brown silty sand till, blocky, dense to very dense, dry	NA			Sample collected at base for grain size analysis. In-situ testing completed using a Guelph Permeameter.

Test pit terminated at 3.6 mbgs

Comments	***Water Conditions in Test Pit***
Standpipe installed upon completion. Contains a 5ft screen. Latitude: 44.354195 Longitude: -79.598329	☐ Wet upon completion ☑ Dry upon completion

JOB No.	18-295
TEST PIT No.	TP-4
FIELD STAFF	I. Acheson & J. Thompson

Azimuth Environmental Consulting, Inc.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Finger Lakes	**Project Address**	1657 Mapleview Drive East, Barrie	**Date**	October 30th 2018
Test Pit Number	TP-5	**Contractor**	Eisses Brothers Excavating	**Elevation**	253.5
Equipment	Excavator JD 245	**Test Pit Size**	2.0 x 4.0 (L x W)	**Datum**	Ground Surface
Temperature	10^oC	**Weather**	Sunny	**Sample Type**	Soil

Depth		Soil description	Samples		Headspace Combustible Vapour Concentration (ppm)	Remarks / Chemical Analysis
From (m)	To (m)		No.	Depth (mbgs)		
0.0	0.30	Topsoil Dark brown sandy topsoil, roots, loose, dry	NA			-
0.30	0.95	Sand Light brown layered sand, loose, dry	NA			-
0.95	1.35	Silty sand till Grey silty sand till, blocky, very dense, dry to wet	NA			Sample collected at base for grain size analysis. In-situ testing completed using a Guelph Permeameter.

Test Pit Terminated at 1.35 mbgs

No ground water was in the test pit upon completion. After 1.5 hours about 3cm of water had accumulated in the base of the pit. The Guelph Permeameter testing was therefore completed by extending one of the side walls so that the base of the extension was level with 253.6 masl, about 0.10m above the initial base.

Comments	*Water Conditions in Test Pit*
Standpipe installed upon completion. Contains a 5ft screen. Latitude: 44.353722 Longitude: -79.599494	☑ Wet upon completion ☐ Dry upon completion

JOB No.	18-295
TEST PIT No.	TP-5
FIELD STAFF	I. Acheson & J. Thompson

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

TEST PIT LOG

Project Name/ Project Client	Finger Lakes	**Project Address**	1657 Mapleview Drive East, Barrie	**Date**	October 30th 2018
Test Pit Number	TP-109B	**Contractor**	Eisses Brothers Excavating	**Elevation**	252.64
Equipment	Excavator JD 245	**Test Pit Size**	2.0 x 4.0 (L x W)	**Datum**	Ground Surface
Temperature	10^{o}C	**Weather**	Sunny	**Sample Type**	Soil

Depth		**Soil description**	**Samples**		**Headspace Combustible Vapour Concentration (ppm)**	**Remarks / Chemical Analysis**
From (m)	**To (m)**		**No.**	**Depth (mbgs)**		
0.0	0.20	Topsoil Dark brown sandy topsoil, roots, loose, moist	NA			-
0.20	1.20	Sand Light brown layered sand, loose, moist to saturated, seeps at the bottom of the unit	NA			-
0.95	1.35	Silty clay Grey silty clay, mottled brown, blocky, very dense, moist	NA			-

Test Pit Terminated at 2.1 mbgs

Comments	***Water Conditions in Test Pit***
Standpipe installed upon completion. Contains a 5ft screen. Latitude: NA Longitude: NA	☑ Wet upon completion ☐ Dry upon completion

JOB No.	18-295
TEST PIT No.	TP-109B
FIELD STAFF	I. Acheson & J. Thompson

APPENDIX F

Infiltration Test Results

Summary Table - Test Pit Results from Guelph Permeameter Testing

	Kfs 1 (cm/s)	Infiltration Rate (mm/hr)	Kfs 2 (cm/s)	Infiltration Rate (mm/hr)	Avg Kfs (cm/s)	Average Infiltation Rate (mm/hr)	Design Infiltration Rate (mm/hr)
TP-1	9.17E-04	83	4.80E-04	70	6.99E-04	77	31
TP-2	3.11E-02	212	2.14E-02	192	2.62E-02	202	81
TP-3A	6.43E-05	41	1.13E-04	48	8.84E-05	45	18
TP-3B		0		0	3.13E-04	0	0
TP-4	1.27E-04	50	4.36E-04	69	2.81E-04	59	24
TP-5	1.31E-04	50	3.61E-04	65	2.46E-04	58	23

Guelph Permeameter Calculations for TP-1

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	8
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropores, etc

Steady State Rate of Water Level Change ("R" in cm/min): 1.2000

Res Type	35.22
H	8
a	3
H/a	2.667
a*	0.12
C0.01	1.072
C0.04	1.128
C0.12	1.11
C0.36	1.11
C	1.11
R	1.200
Q	0.704
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.109993

$Q =$ 0.7044

$K_{fs} =$ 9.17E-04 cm/sec; 5.50E-02 cm/min; 9.17E-06 m/sec; 2.17E-02 inch/min; 3.61E-04 inch/sec

$\Phi_m =$ 7.64E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	5
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropores, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.4500

Res Type	35.22
H	5
a	3
H/a	1.666667
a*	0.12
C0.01	0.809485
C0.04	0.842059
C0.12	0.803154
C0.36	0.803154
C	0.803154
R	0.450
Q	0.26415
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.803154

$Q =$ 0.26415

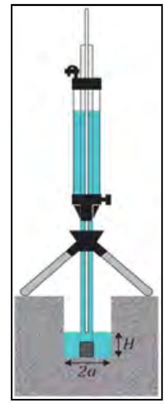
$K_{fs} =$ 4.80E-04 cm/sec; 2.88E-02 cm/min; 4.80E-06 m/ses; 1.13E-02 inch/min; 1.89E-04 inch/sec

$\Phi_m =$ 4.00E-03 (cm^2/min)

Average

$K_{fs} =$ 6.99E-04 cm/sec; 4.19E-02 cm/min; 6.99E-06 m/s; 1.65E-02 inch/min; 2.75E-04 inch/sec

$\Phi_m =$ 5.82E-03 (cm^2/min)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Permeameter Calculations for TP-2

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 0.5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 11.4000

Res Type	35.22
H	0.5
a	3
H/a	0.167
a*	0.12
C0.01	0.182
C0.04	0.183
C0.12	0.149
C0.36	0.149
C	0.149
R	11.400
Q	6.692
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.148581

$Q =$ 6.6918

$K_{fs} =$

3.11E-02	cm/sec
1.87E+00	cm/min
3.11E-04	m/sec
7.35E-01	inch/min
1.23E-02	inch/sec

$\Phi_m =$ 2.59E-01 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 1
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 9.6000

Res Type	35.22
H	1
a	3
H/a	0.333333
a*	0.12
C0.01	0.288332
C0.04	0.291896
C0.12	0.249183
C0.36	0.249183
C	0.249183
R	9.600
Q	5.6352
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.249183

$Q =$ 5.6352

$K_{fs} =$

2.14E-02	cm/sec
1.28E+00	cm/min
2.14E-04	m/ses
5.05E-01	inch/min
8.42E-03	inch/sec

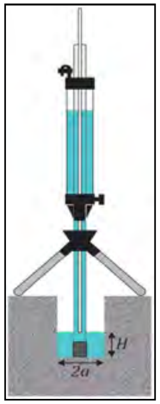
$\Phi_m =$ 1.78E-01 (cm^2/min)

Average

$K_{fs} =$

2.62E-02	cm/sec
1.57E+00	cm/min
2.62E-04	m/s
6.20E-01	inch/min
1.03E-02	inch/sec

$\Phi_m =$ 2.19E-01 (cm^2/min)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

SOILMOISTURE

Guelph Permeameter Calculations for TP-3A

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): **1**
Enter water Head Height ("H" in cm): **20**
Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.2000**

Res Type	35.22
H	20
a	3
H/a	6.667
a*	0.12
C0.01	1.755
C0.04	1.903
C0.12	1.98
C0.36	1.98
C	1.98
R	0.200
Q	0.117
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.980192

$Q =$ 0.1174

$K_{fs} =$ 6.43E-05 cm/sec; 3.86E-03 cm/min; 6.43E-07 m/sec; 1.52E-03 inch/min; 2.53E-05 inch/sec

$\Phi_m =$ 5.36E-04 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): **1**
Enter water Head Height ("H" in cm): **22.5**
Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.4000**

Res Type	35.22
H	22.5
a	3
H/a	7.5
a*	0.12
C0.01	1.855823
C0.04	2.022368
C0.12	2.118308
C0.36	2.118308
C	2.118308
R	0.400
Q	0.2348
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 2.118308

$Q =$ 0.2348

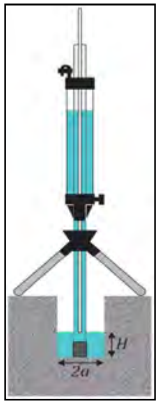
$K_{fs} =$ 1.13E-04 cm/sec; 6.75E-03 cm/min; 1.13E-06 m/ses; 2.66E-03 inch/min; 4.43E-05 inch/sec

$\Phi_m =$ 9.38E-04 (cm^2/min)

Average

$K_{fs} =$ 8.84E-05 cm/sec; 5.31E-03 cm/min; 8.84E-07 m/s; 2.09E-03 inch/min; 3.48E-05 inch/sec

$\Phi_m =$ 7.37E-04 (cm^2/min)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Permeameter Calculations for TP-3

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 5
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropores, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	35.22
H	5
a	3
H/a	1.667
a*	0.12
C0.01	0.809
C0.04	0.842
C0.12	0.803
C0.36	0.803
C	0.803
R	0.200
Q	0.117
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 0.803154

$Q =$ 0.1174

$K_{fs} =$ 2.14E-04 cm/sec
1.28E-02 cm/min
2.14E-06 m/sec
5.04E-03 inch/min
8.41E-05 inch/sec

$\Phi_m =$ 1.78E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropores, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.6500

Res Type	35.22
H	10
a	3
H/a	3.333333
a*	0.12
C0.01	1.21841
C0.04	1.290234
C0.12	1.287543
C0.36	1.287543
C	1.287543
R	0.650
Q	0.38155
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.287543

$Q =$ 0.38155

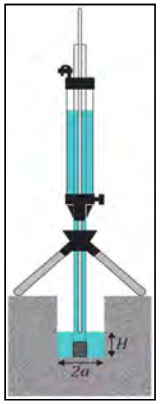
$K_{fs} =$ 4.13E-04 cm/sec
2.48E-02 cm/min
4.13E-06 m/ses
9.77E-03 inch/min
1.63E-04 inch/sec

$\Phi_m =$ 3.45E-03 (cm^2/min)

Average

$K_{fs} =$ 3.13E-04 cm/sec
1.88E-02 cm/min
3.13E-06 m/s
7.40E-03 inch/min
1.23E-04 inch/sec

$\Phi_m =$ 2.61E-03 (cm^2/min)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

Guelph Permeameter Calculations for TP-4

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): **1**

Enter water Head Height ("H" in cm): **10**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **0.2000**

Res Type	35.22
H	10
a	3
H/a	3.333
a*	0.12
C0.01	1.218
C0.04	1.29
C0.12	1.288
C0.36	1.288
C	1.288
R	0.200
Q	0.117
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.287543

$Q =$ 0.1174

$K_{fs} =$	1.27E-04	cm/sec
	7.63E-03	cm/min
	1.27E-06	m/sec
	3.00E-03	inch/min
	5.01E-05	inch/sec

$\Phi_m =$ 1.06E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): **1**

Enter water Head Height ("H" in cm): **15**

Enter the Borehole Radius ("a" in cm): **3**

Enter the soil texture-structure category (enter one of the below numbers): **3**

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): **1.0000**

Res Type	35.22
H	15
a	3
H/a	5
a*	0.12
C0.01	1.518269
C0.04	1.629144
C0.12	1.666893
C0.36	1.666893
C	1.666893
R	1.000
Q	0.587
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.666893

$Q =$ 0.587

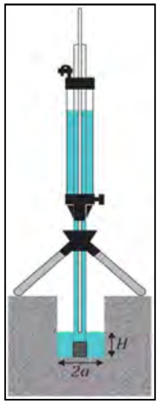
$K_{fs} =$	4.36E-04	cm/sec
	2.61E-02	cm/min
	4.36E-06	m/ses
	1.03E-02	inch/min
	1.72E-04	inch/sec

$\Phi_m =$ 3.63E-03 (cm^2/min)

Average

$K_{fs} =$	2.81E-04	cm/sec
	1.69E-02	cm/min
	2.81E-06	m/s
	6.65E-03	inch/min
	1.11E-04	inch/sec

$\Phi_m =$ 2.35E-03 (cm^2/min)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm), H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Permeameter Calculations for TP-5

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	15
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.3000

Res Type	35.22
H	15
a	3
H/a	5
a*	0.12
C0.01	1.518
C0.04	1.629
C0.12	1.667
C0.36	1.667
C	1.667
R	0.300
Q	0.176
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.666892939

$Q =$ 0.1761

$K_{fs} =$	1.31E-04	cm/sec
	7.84E-03	cm/min
	1.31E-06	m/sec
	3.09E-03	inch/min
	5.15E-05	inch/sec

$\Phi_m =$ 1.09E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir):	1
Enter water Head Height ("H" in cm):	18
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 1.0000

Res Type	35.22
H	18
a	3
H/a	6
a*	0.12
C0.01	1.666091
C0.04	1.799739
C0.12	1.86136
C0.36	1.86136
C	1.86136
R	1.000
Q	0.587
pi	3.1415

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.861360466

$Q =$ 0.587

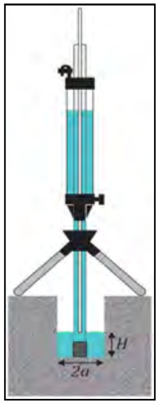
$K_{fs} =$	3.61E-04	cm/sec
	2.16E-02	cm/min
	3.61E-06	m/ses
	8.52E-03	inch/min
	1.42E-04	inch/sec

$\Phi_m =$ 3.00E-03 (cm^2/min)

Average

$K_{fs} =$	2.46E-04	cm/sec
	1.47E-02	cm/min
	2.46E-06	m/s
	5.80E-03	inch/min
	9.67E-05	inch/sec

$\Phi_m =$ 2.05E-03 (cm^2/min)



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	$\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

APPENDIX G

Water Balance Information

Table A: Pre-Development - Phase 1

Catchment Designation	Site: Agricultural	Site: Landscaped Grass	Site: Driveway	Site: Structure	Total
Area (m^2)	44,950	1,480	135	235	46,800
Pervious Area (m^2)	44,950	1,480	0	0	46,430
Impervious Area (m^2)	0	0	135	235	370
Infiltration Factors					
Topography Infiltration Factor	0.2	0.2	0	0	
Soil Infiltration Factor	0.3	0.3	0	0	
Land Cover Infiltration Factor	0.1	0.1	0	0	
Infiltration Factor	0.6	0.6	0	0	
Run-Off Coefficient	0.4	0.4	1	1	
Run-Off From Impervious Surfaces	0.8	0.8	0.8	0.8	
Inputs (Per Unit Area)					
Precipitation (mm/yr)	909	909	909	909	909
Rainfall (mm/yr)	655	655	655	655	655
Run-On (mm/yr)	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0
Total Inputs (mm/yr)	**909**	**909**	**909**	**909**	909
Outputs (Per Unit Area)					
Precipitation Surplus (mm/yr)	430	430	727	727	432
Net Surplus (mm/yr)	430	430	727	727	432
Evapotranspiration (mm/yr)	479	479	182	182	477
Infiltration (mm/yr)	258	258	0	0	256
Surplus Infiltration (mm/yr)	0	0	0	0	0
Total Infiltration (mm/yr)	258	258	0	0	256
Run-Off Pervious Areas (mm/yr)	172	172	0	0	171
Run-Off Impervious Areas (mm/yr)	0	0	727	727	6
Total Run-Off (mm/yr)	172	172	727	727	176
Total Outputs (mm/yr)	**909**	**909**	**909**	**909**	**909**
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**
Inputs (Volumes)					
Precipitation (m^3/yr)	40,860	1,345	123	214	42,541
Run-On (m^3/yr)	0	0	0	0	0
Other Inputs (m^3/yr)	0	0	0	0	0
Total Inputs (m^3/yr)	**40,860**	**1,345**	**123**	**214**	**42,541**
Outputs (Volumes)					
Precipitation Surplus (m^3/yr)	19,329	636	98	171	20,234
Net Surplus (m^3/yr)	19,329	636	98	171	20,234
Evapotranspiration (m^3/yr)	21,531	709	25	43	22,307
Infiltration (m^3/yr)	11,597	382	0	0	11,979
Surplus Infiltration (m^3/yr)	0	0	0	0	0
Total Infiltration (m^3/yr)	***11,597***	***382***	***0***	***0***	**11,979**
Run-Off Pervious Areas (m^3/yr)	7,731	255	0	0	7,986
Run-Off Impervious Areas (m^3/yr)	0	0	98	171	269
Total Run-Off (m^3/yr)	7,731	255	98	171	8,255
Total Outputs (m^3/yr)	40,860	1,345	123	214	42,541
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**

Table B: Post-Development (no mitigation) - Phase 1

Catchment Designation	Landscaped Grass	Roads / Driveways	SWMP	Structures	Total
Area (m^2)	16,550	18,350	2,600	9,300	46,800
Pervious Area (m^2)	16,550	0	0	0	16,550
Impervious Area (m^2)	0	18,350	2,600	9,300	30,250
Infiltration Factors					
Topography Infiltration Factor	0.2	0	0	0	
Soil Infiltration Factor	0.3	0	0	0	
Land Cover Infiltration Factor	0.1	0	0	0	
Infiltration Factor	0.6	0	0	0	
Run-Off Coefficient	0.4	1	1	1	
Run-Off From Impervious Surfaces	0.8	0.8	0.8	0.8	
Inputs (Per Unit Area)					
Precipitation (mm/yr)	909	909	909	909	909
Rainfall (mm/yr)	655	655	655	655	655
Run-On (mm/yr)	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0
Total Inputs (mm/yr)	**909**	**909**	**909**	**909**	**909**
Outputs (Per Unit Area)					
Precipitation Surplus (mm/yr)	430	727	727	727	622
Net Surplus (mm/yr)	430	727	727	727	622
Evapotranspiration (mm/yr)	479	182	182	182	287
Infiltration (mm/yr)	258	0	0	0	91
Surplus Infiltration (mm/yr)	0	0	0	0	0
Total Infiltration (mm/yr)	258	0	0	0	91
Run-Off Pervious Areas (mm/yr)	172	0	0	0	61
Run-Off Impervious Areas (mm/yr)	0	727	727	727	470
Total Run-Off (mm/yr)	172	727	727	727	531
Total Outputs (mm/yr)	**909**	**909**	**909**	**909**	**909**
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**
Inputs (Volumes)					
Precipitation (m^3/yr)	15,044	16,680	2,363	8,454	42,541
Run-On (m^3/yr)	0	0	0	0	0
Other Inputs (m^3/yr)	0	0	0	0	0
Total Inputs (m^3/yr)	**15,044**	**16,680**	**2,363**	**8,454**	**42,541**
Outputs (Volumes)					
Precipitation Surplus (m^3/yr)	7,117	13,344	1,891	6,763	29,114
Net Surplus (m^3/yr)	7,117	13,344	1,891	6,763	29,114
Evapotranspiration (m^3/yr)	7,927	3,336	473	1,691	13,427
Infiltration (m^3/yr)	4,270	0	0	0	4,270
Surplus Infiltration (m^3/yr)	0	0	0	0	0
Total Infiltration (m^3/yr)	***4,270***	***0***	***0***	***0***	***4,270***
Run-Off Pervious Areas (m^3/yr)	2,847	0	0	0	2,847
Run-Off Impervious Areas (m^3/yr)	0	13,344	1,891	6,763	21,998
Total Run-Off (m^3/yr)	2,847	13,344	1,891	6,763	24,844
Total Outputs (m^3/yr)	15,044	16,680	2,363	8,454	42,541
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**

Table C: Post-Development (with mitigation) - Phase 1

Catchment Designation	Landscaped Grass (Trench)	Landscaped Grass	Roads / Driveways (Trench)	Roads / Driveways	SWMP	Rooftop (Trench)	Rooftop (Soakaway)	Rooftop	Total
Area (m^2)	5,500	11,050	2,341	16,009	2,600	2,159	1,218	5,923	46,800
Pervious Area (m^2)	5,500	11,050	0	0	0	0	0	0	16,550
Impervious Area (m^2)	0	0	2,341	16,009	2,600	2,159	1,218	5,923	30,250
Infiltration Factors									
Topography Infiltration Factor	0.2	0.2	0	0	0	0	0	0	
Soil Infiltration Factor	0.3	0.3	0	0	0	0	0	0	
Land Cover Infiltration Factor	0.1	0.1	0	0	0	0	0	0	
Infiltration Factor	0.6	0.6	0	0	0	0	0	0	
Run-Off Coefficient	0.4	0.4	1	1	1	1	1	1	
Run-Off From Impervious Surfaces	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
Inputs (Per Unit Area)									
Precipitation (mm/yr)	909	909	909	909	909	909	909	909	909
Rainfall (mm/yr)	655	655	655	655	655	655	655	655	655
Run-On (mm/yr)	0	0	0	0	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0	0	0	0	0
Total Inputs (mm/yr)	**909**	**909**	**909**	**909**	**909**	**909**	**909**	**909**	909
Outputs (Per Unit Area)									
Precipitation Surplus (mm/yr)	430	430	727	727	727	727	727	727	622
Net Surplus (mm/yr)	430	430	727	727	727	727	727	727	622
Evapotranspiration (mm/yr)	479	479	182	182	182	182	182	182	287
Infiltration (mm/yr)	258	258	0	0	0	0	0	0	91
Surplus Infiltration (mm/yr)	138	0	582	0	0	582	614	0	88
Total Infiltration (mm/yr)	396	258	582	0	0	582	614	0	179
Run-Off Pervious Areas (mm/yr)	34	172	0	0	0	0	0	0	45
Run-Off Impervious Areas (mm/yr)	0	0	145	727	727	145	113	727	398
Total Run-Off (mm/yr)	34	172	145	727	727	145	113	727	443
Total Outputs (mm/yr)	**909**	**909**	**909**	**909**	**909**	**909**	**909**	**909**	**909**
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Inputs (Volumes)									
Precipitation (m^3/yr)	5,000	10,044	2,128	14,552	2,363	1,963	1,107	5,384	42,541
Run-On (m^3/yr)	0	0	0	0	0	0	0	0	0
Other Inputs (m^3/yr)	0	0	0	0	0	0	0	0	0
Total Inputs (m^3/yr)	**5,000**	**10,044**	**2,128**	**14,552**	**2,363**	**1,963**	**1,107**	**5,384**	**42,541**
Outputs (Volumes)									
Precipitation Surplus (m^3/yr)	2,365	4,752	1,702	11,642	1,891	1,570	886	4,307	29,114
Net Surplus (m^3/yr)	2,365	4,752	1,702	11,642	1,891	1,570	886	4,307	29,114
Evapotranspiration (m^3/yr)	2,635	5,293	426	2,910	473	393	221	1,077	13,427
Infiltration (m^3/yr)	1,419	2,851	0	0	0	0	0	0	4,270
Surplus Infiltration (m^3/yr)	757	0	1,362	0	0	1,257	748	0	4,124
Total Infiltration (m^3/yr)	***2,176***	***2,851***	***1,362***	***0***	***0***	***1,257***	***748***	***0***	**8,394**
Run-Off Pervious Areas (m^3/yr)	189	1,901	0	0	0	0	0	0	2,090
Run-Off Impervious Areas (m^3/yr)	0	0	340	11,642	1,891	313	138	4,307	18,631
Total Run-Off (m^3/yr)	189	1,901	340	11,642	1,891	313	138	4,307	20,721
Total Outputs (m^3/yr)	5,000	10,044	2,128	14,552	2,363	1,963	1,107	5,384	42,541
Difference (Inputs - Outputs)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table D: Water Balance Summary Table - Phase 1

Characteristic	Site						
	Pre-Development	Post-Development	Change (Pre to Post)		Post-Development with Mitigation	Change (Pre to Post with Mitigation)	
Inputs (Volume)							
Precipitation (m^3/yr)	42,541	42,541	0	0%	42,541	0	0%
Run-On (m^3/yr)	0	0	0	NA	0	0	NA
Other Inputs (m^3/yr)	0	0	0	NA	0	0	NA
Total Inputs (m^3/yr)	42,541	42,541	0	0%	42,541	0	0%
Outputs (Volume)							
Precipitation Surplus (m^3/yr)	20,234	29,114	8,880	44%	29,114	8,880	44%
Net Surplus (m3/yr)	20,234	29,114	8,880	44%	29,114	8,880	44%
Evapotranspiration (m^3/yr)	22,307	13,427	-8,880	-40%	13,427	-8,880	-40%
Infiltration (m^3/yr)	11,979	4,270	-7,709	-64%	4,270	-7,709	-64%
LID Infiltration (m^3/yr)	0	0	0	NA	4,124	4,124	NA
Total Infiltration (m^3/yr)	***11,979***	**4,270**	***-7,709***	**-64%**	**8,394**	***-3,585***	**-30%**
Run-Off Pervious Areas (m^3/yr)	7,986	2,847	-5,139	-64%	2,090	-5,896	-74%
Run-Off Impervious Areas (m^3/yr)	269	21,998	21,729	8076%	18,631	18,362	6824%
Total Run-Off (m^3/yr)	8,255	24,844	16,589	201%	20,721	12,466	151%
Total Outputs (m^3/yr)	**42,541**	**42,541**	**0**	**0%**	**42,541**	**0**	**0%**

APPENDIX H

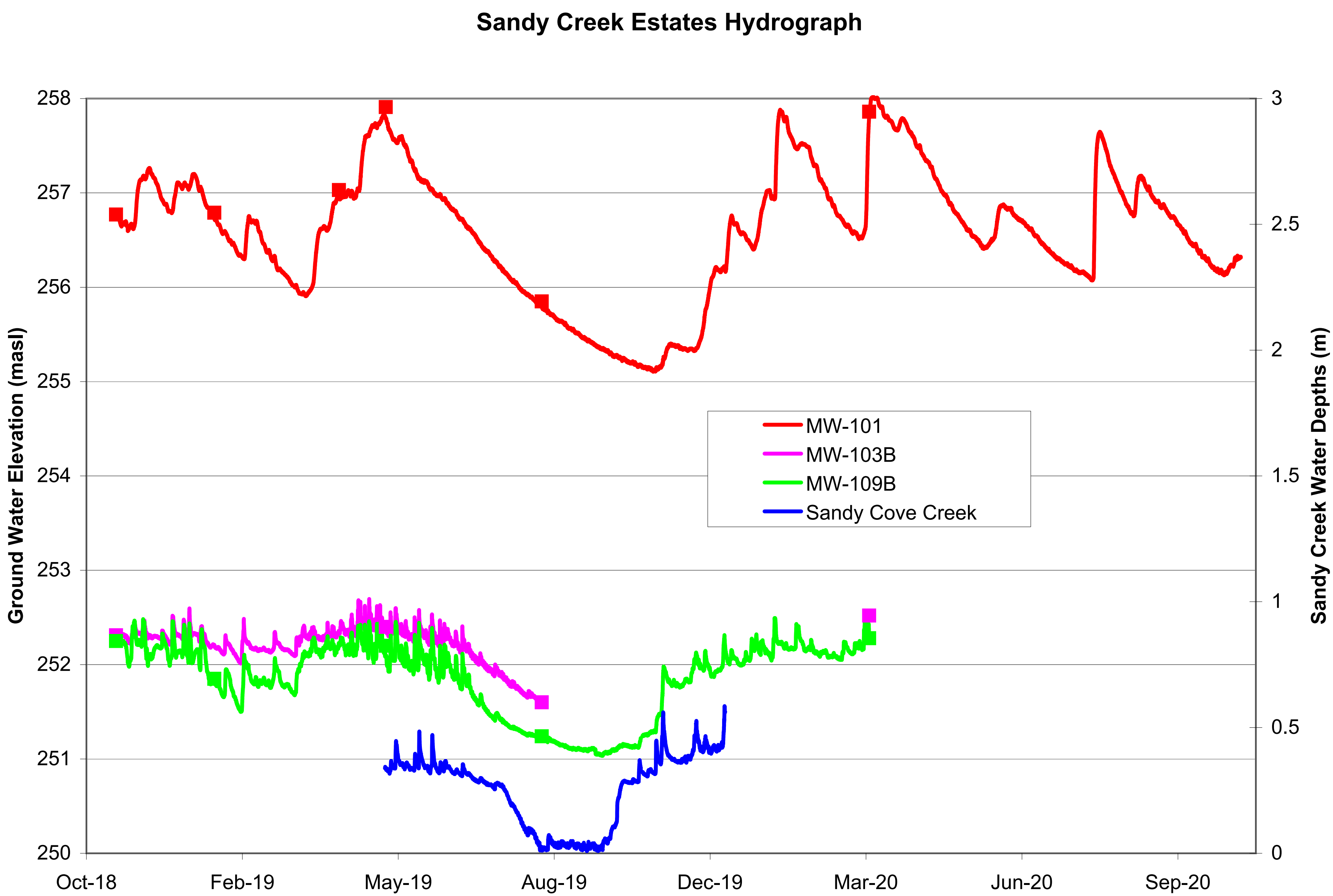
Ground Water Elevation Data

Phase I Monitoring Well & Ground Water Level / Elevation Summary

Location ID	Ground Elevation	Total Depth	Stick Up	Manual Water Level (mbgs)										
	(masl)	(mbgs)	(m)	15-Oct-18	19-Nov-18	17-Jan-19	07-Apr-19	07-May-19	15-Aug-19	12-Mar-20	19-Mar-21	16-Apr-21	31-May-21	22-Jun-21
MW-101	259.86	8.37	0.90	4.30	3.09	3.07	2.83	1.95	4.01	2.00	2.64	2.90	3.56	3.89
MW-102	259.9	7.96	0.85	5.28	5.33	5.20	5.25	5.10	5.18	4.94	4.83	4.90	4.64	4.65
MW-103A	252.95	6.91	0.89	-0.44	frozen	frozen	-0.89	-0.89	-0.69	-0.55	-0.89	-0.89	Flowing	Flowing
MW-103B	252.95	3.11	0.88	0.87	0.64	frozen	frozen	0.55	1.35	0.43	0.55	frozen	0.73	0.85
MW-109	252.64	5.83	1.76	-1.70	frozen	frozen	1.76 (flowing)	-1.76	-1.76 (flowing)	-1.76 (flowing)	Flowing	Flowing	Flowing	Flowing
TP-109B	252.64	2.04	0.61	-	0.39	0.79	frozen	0.44	1.4	0.36	Destroyed	Destroyed	Destroyed	Destroyed
TP-1	260.55	2.93	1.03	-	2.64	dry	2.86	2.04	dry		2.41	2.88	2.89	2.93
TP-2	259.38	1.74	0.68	-	dry	dry	1.73	1.72	dry	dry	1.75	1.75	1.75	1.75
TP-3	254.55	1.95	0.53	-	1.31	1.46	1.2	1.1	1.61	0.82	1.17	1.21	1.25	1.37
TP-4	258.14	2.6	1.62	-	dry	dry	2.58	2.56	dry	2.54	2.52	2.53	2.52	2.54
TP-5	254.83	1.44	1.38	-	0.16	0.85	frozen	0.2	1.38	0.12	0.52	0.54	1.11	1.28

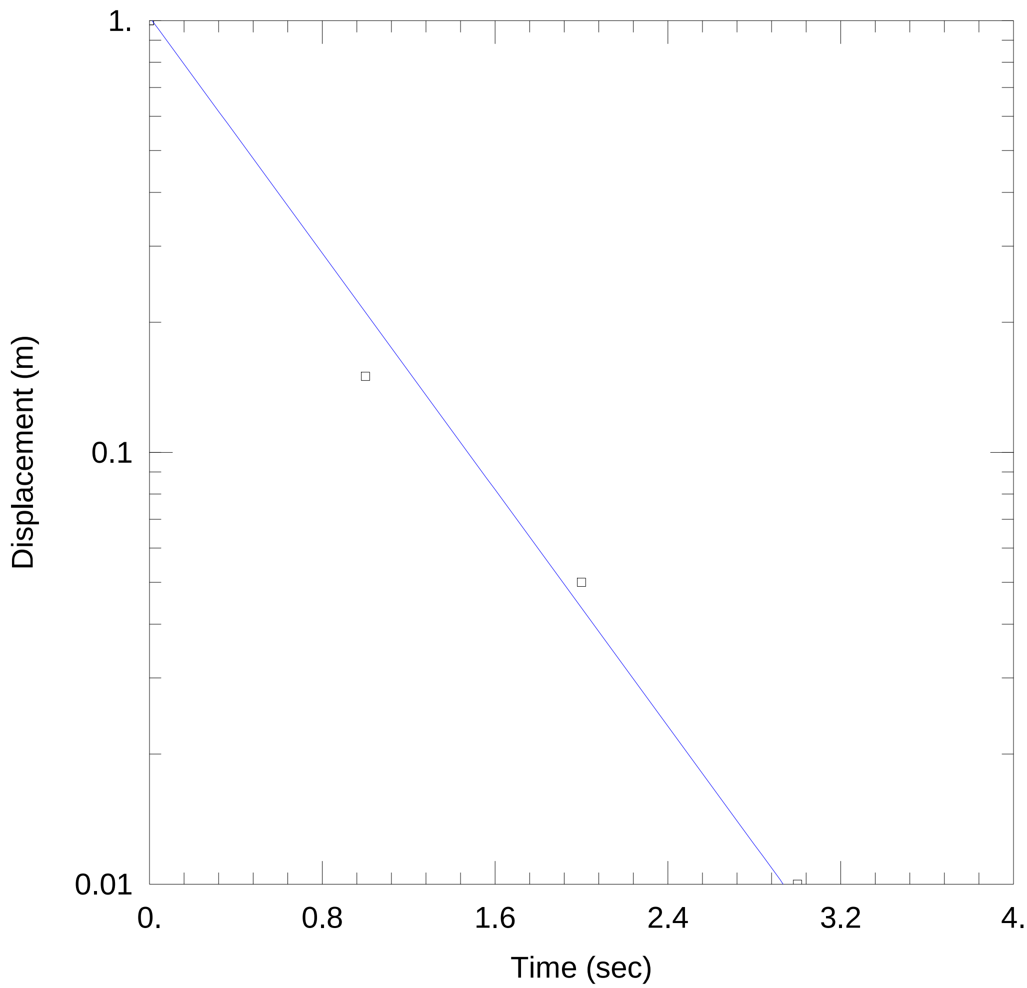
Phase I Monitoring Well & Ground Water Level / Elevation Summary

Location ID	Ground Elevation	Total Depth	Stick Up	Manual Water Level (masl)										
	(masl)	(mbgs)	(m)	15-Oct-18	15-Nov-18	17-Jan-19	07-Apr-19	07-May-19	15-Aug-19	12-Mar-20	19-Mar-21	16-Apr-21	31-May-21	22-Jun-21
MW-101	259.86	8.37	0.90	255.56	256.77	256.79	257.03	257.91	255.85	257.86	257.22	256.96	256.30	255.97
MW-102	259.9	7.96	0.85	254.62	254.57	254.70	254.65	254.80	254.72	254.96	255.07	255.00	255.26	255.25
MW-103A	252.95	6.91	0.89	253.39	frozen	frozen	253.84	253.84	253.64	253.50	253.84	253.84	Flowing	Flowing
MW-103B	252.95	3.11	0.88	252.08	252.31	frozen	frozen	252.40	251.60	252.52	252.40	Frozen	252.22	252.10
MW-109	252.64	5.83	1.76	254.34	frozen	frozen	Flowing	254.40	Flowing	Flowing	Flowing	Flowing	Flowing	Flowing
TP-109B	252.64	2.04	0.61		252.25	251.85		252.2	251.24	252.28				
TP-1	260.55	2.93	1.03	-	257.91	dry	257.69	258.51	dry		258.14	257.67	257.66	257.62
TP-2	259.38	1.74	0.68	-	dry	dry	257.65	257.66	dry	dry	257.63	257.63	257.63	257.63
TP-3	254.55	1.95	0.53	-	253.24	253.09	253.35	253.45	252.94	253.73	253.38	253.34	253.30	253.18
TP-4	258.14	2.6	1.62	-	dry	dry	255.56	255.58	dry	255.6	255.62	255.61	255.62	255.60
TP-5	254.83	1.44	1.38	-	254.67	253.98	frozen	254.63	253.45	254.71	254.31	254.29	253.72	253.55


Sandy Creek Estates Hydrograph
Ground Water Elevation (masl)
Sandy Creek Water Depths (m)
258
257
256
255
254
253
252
251
250
3
2.5
2
1.5
1
0.5
0
Oct-18
Feb-19
May-19
Aug-19
Dec-19
Mar-20
Jun-20
Sep-20
MW-101
MW-103B
MW-109B
Sandy Cove Creek

APPENDIX I

Slug Testing Analysis



SANDY CREEK ESTATES

Data Set: L:\projects2\18 Projects\18-295 Finger Lakes Hydrogeology\03.0 - Data\BH102 Slug Test.aqt
Date: 01/12/22 Time: 12:51:46

PROJECT INFORMATION

Company: Azimuth Environmental
Project: 18-295
Test Well: BH102
Test Date: August 15, 2019

AQUIFER DATA

Saturated Thickness: 2.78 m Anisotropy Ratio (Kz/Kr): 1.

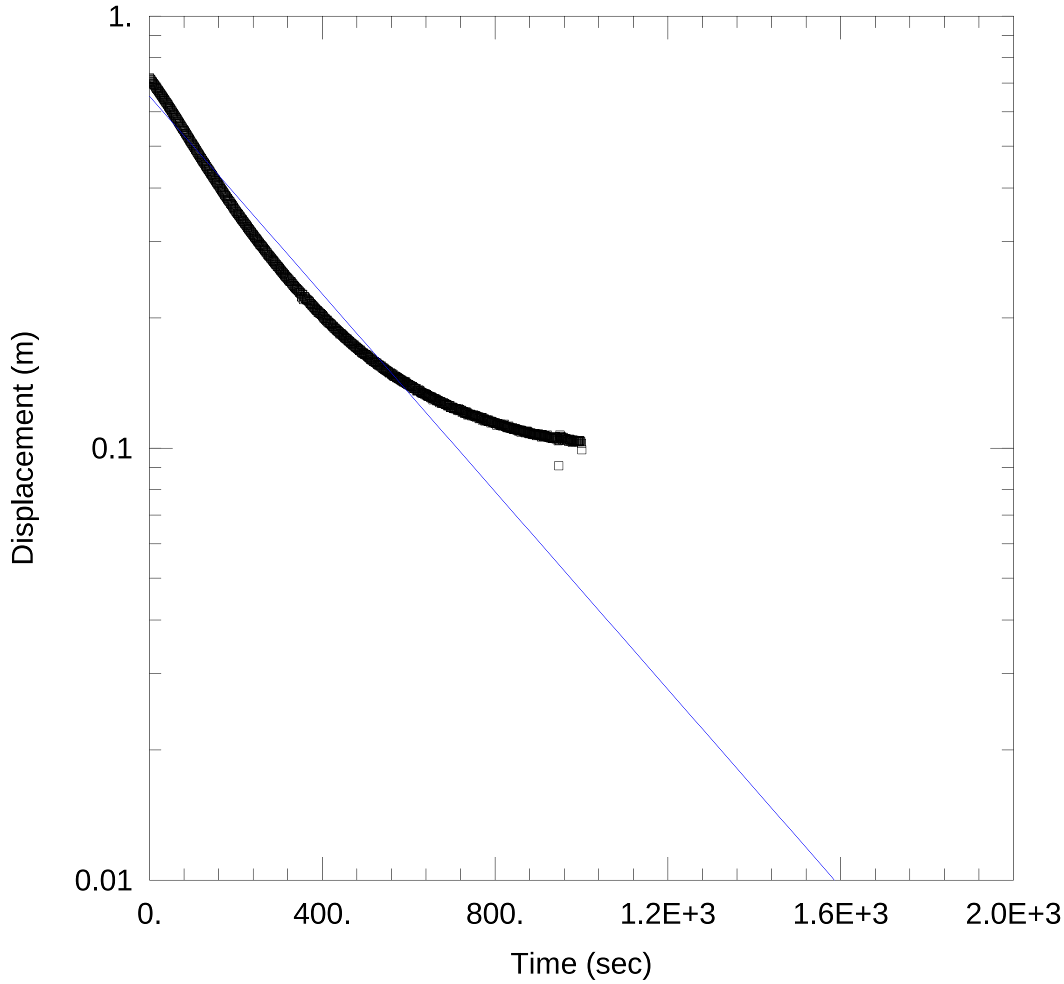
WELL DATA (BH102)

Initial Displacement: 1. m
Total Well Penetration Depth: 2.78 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.78 m
Screen Length: 3. m
Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 0.0007428 m/sec y0 = 1.02 m



SANDY CREEK ESTATES

Data Set: L:\...\BH103B Slug Test.aqt
Date: 01/12/22 Time: 13:03:43

PROJECT INFORMATION

Company: Azimuth Environmental
Project: 18-295
Test Well: BH103B
Test Date: August 15, 2019

AQUIFER DATA

Saturated Thickness: 1.76 m Anisotropy Ratio (Kz/Kr): 1.

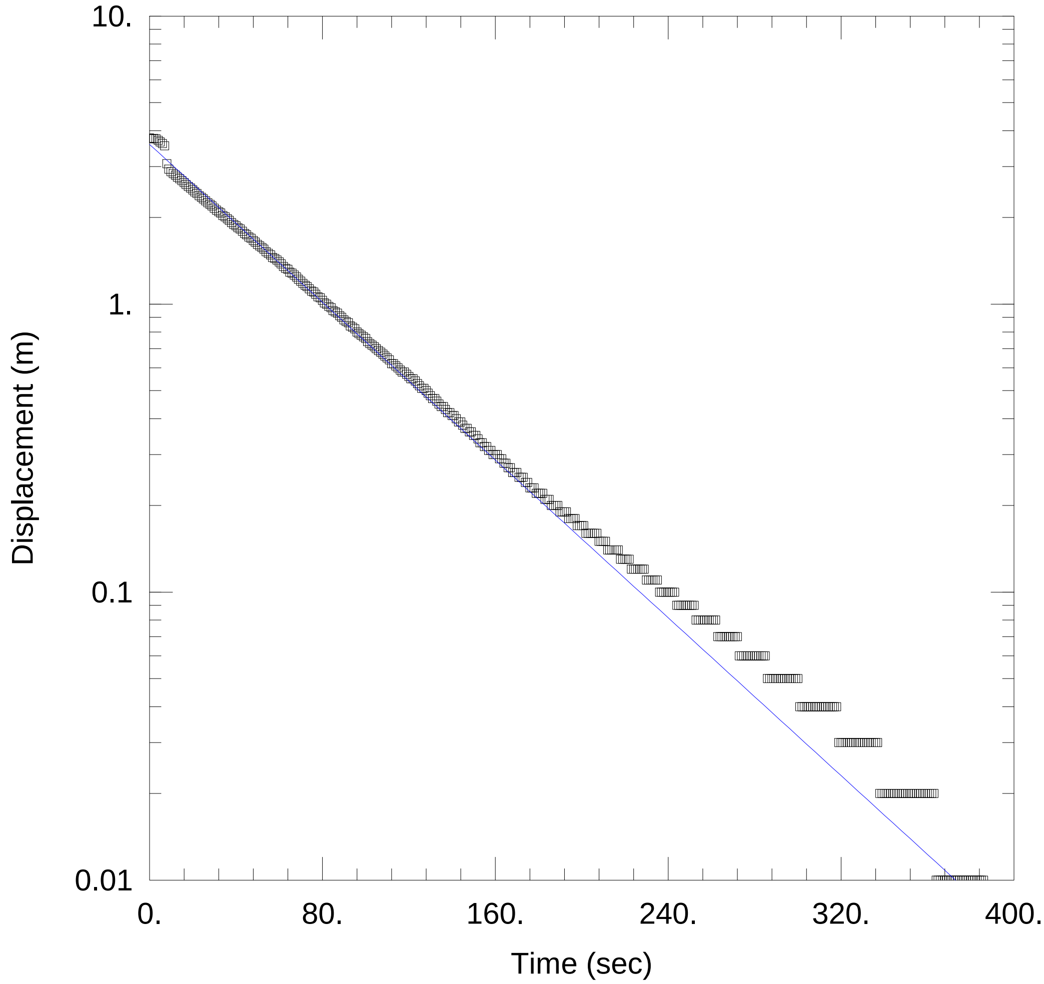
WELL DATA (BH103B)

Initial Displacement: 0.7187 m Static Water Column Height: 1.76 m
Total Well Penetration Depth: 1.76 m Screen Length: 1.5 m
Casing Radius: 0.0254 m Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 2.091E-6 m/sec y0 = 0.6523 m



SANDY CREEK ESTATES

Data Set: L:\projects2\18 Projects\18-295 Finger Lakes Hydrogeology\03.0 - Data\BH109 Slug Test.aqt
Date: 01/12/22 Time: 13:13:24

PROJECT INFORMATION

Company: Azimuth Environmental
Project: 18-295
Test Well: BH109
Test Date: August 15, 2019

AQUIFER DATA

Saturated Thickness: 7.6 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH109)

Initial Displacement: 3.77 m Static Water Column Height: 7.6 m
Total Well Penetration Depth: 7.6 m Screen Length: 3. m
Casing Radius: 0.0254 m Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 7.431E-6 m/sec y0 = 3.582 m

APPENDIX J

Water Quality Results

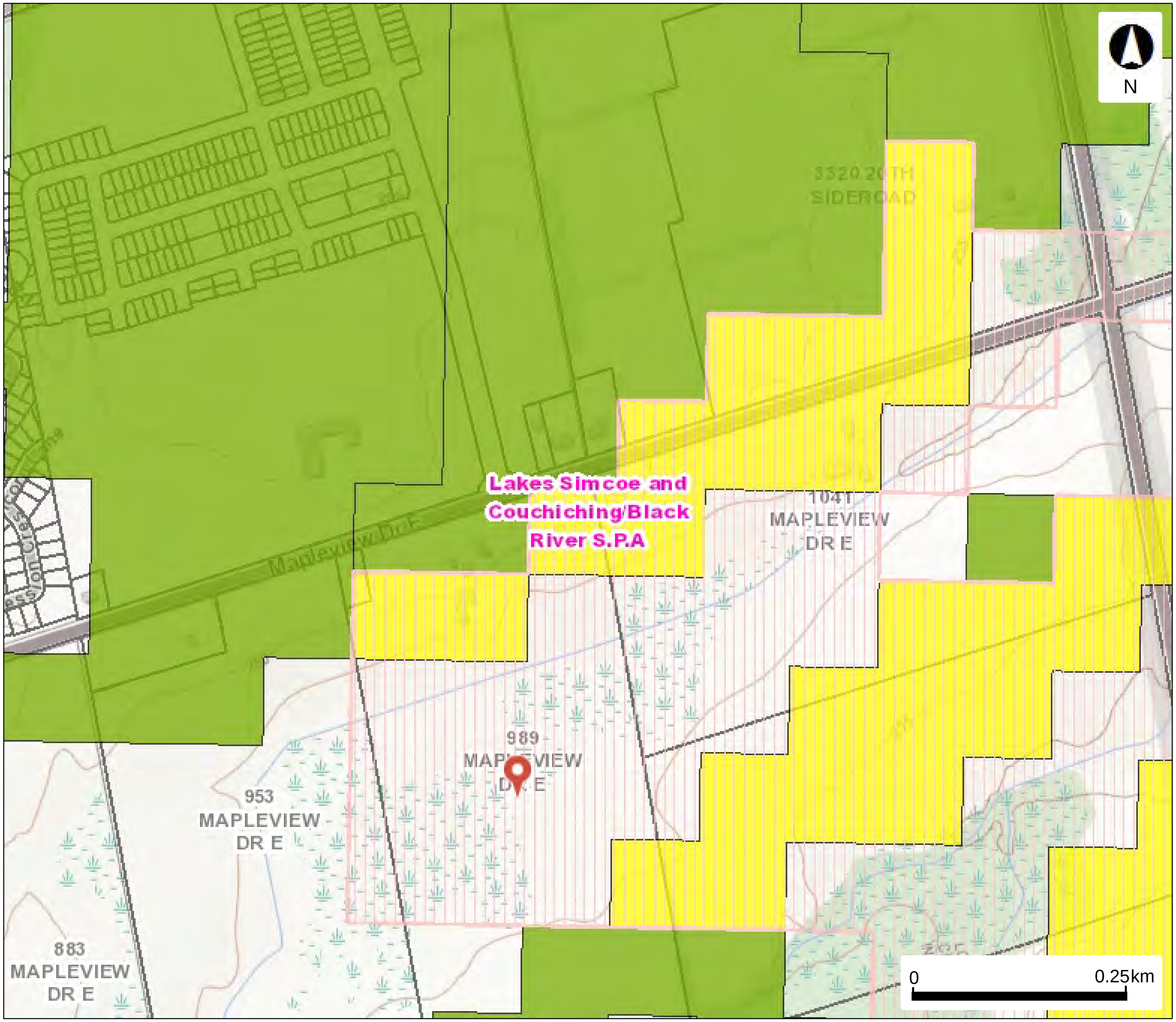
Summary of Water Quality Data

			Provincial Water Quality Objectives (1994)	MW - 103B **Sampled on:** 2019-08-15 **Sampled by:** Azimuth **Analyzed by:** Caduceon
Parameter	**Symbol**	**Units**	**Objective**	
Saturation pH			-	
pH (lab)			6.5-8.5	7.93
Langelier Saturation Index			-	1.11
Alkalinity (4.2) (as Calcium Carbonate)		mg/L	-	253
Conductivity		μS/cm	-	1390
Fluoride	F^-	mg/L	-	0.4
Chloride	Cl^-	mg/L	-	331
Nitrate (as Nitrogen)	NO_3-N	mg/L	-	0.6
Nitrite (as Nitrogen)	NO_2-N	mg/L	-	<0.1
Sulphate	SO_4^{-2}	mg/L	-	24
Calcium	Ca	mg/L	-	181
Magnesium	Mg	mg/L	-	41.6
Sodium	Na	mg/L	-	46.4
Potassium	K	mg/L	-	3.3
Total Ammonia (as Nitrogen)	NH_3-N	mg/L	-	0.01
Phosphate (ortho)	PO_4^{-3}	mg/L	-	0.012
Turbidity			-	227
Aluminum	Al	mg/L	0.075	**0.09**
Arsenic	As	mg/L	0.1	0.0005
Boron	B	mg/L	0.2	0.017
Cadmium	Cd	mg/L	0.0005	<0.0000015
Chromium	Cr	mg/L	0.0089	<0.001
Copper	Cu	mg/L	0.005	0.0017
Iron	Fe	mg/L	0.3	0.031
Lead	Pb	mg/L	0.005	0.00004
Manganese	Mn	mg/L	-	0.038
Molybdenum	Mo	mg/L	0.04	0.0003
Nickel	Ni	mg/L	0.025	<0.010
Selenium	Se	mg/L	0.1	<0.001
Silver	Ag	mg/L	0.0001	<0.0001
Thallium	Tl	mg/L	0.0003	<0.00005
Uranium	U	mg/L	0.005	0.00085
Vanadium	V	mg/L	0.006	<0.005
Zinc	Zn	mg/L	0.02	<0.005
Total Dissolved Solids	TDS	mg/L	-	782
Hardness (as Calcium Carbonate)		mg/L	-	623
% Difference / Ion Balanace			-	1.34

APPENDIX K

Source Water Protection Mapping

18-295



Legend

- Source Protection Areas
- Intake Protection Zone Q
- Wellhead Protection Area Q2
- Issue Contributing Areas
- Highly Vulnerable Aquifers
- Significant Groundwater Recharge Area
  - 0
  - 2
  - 4
  - 6
- WHPA Groundwater Under Direct Influence (WHPA-E)
- Wellhead Protection Area
  - A
  - B
  - C
  - C1
  - D
  - F
- Intake Protection Zone 1
- Event Based Areas
- Intake Protection Zone 2
- Assessment Parcel with Addre

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Environment, Conservation and Parks (MECP) shall not be liable in any way for the use or any information on this map. of, or reliance upon, this map.

Ontario

Map Created: 1/13/2022
Map Center: 44.35512 N, -79.59631 W

APPENDIX L

Dewatering Assessment Information

														Radial Flow	Plane Flow			
Type	**ID**	**Length (m)**	**Width (m)**	**Effecitve Radius[1] (m)**	**Hydraulic Conductivity (m/s)**	**Hydraulic Conductivity (m/day)**	**Initial Depth of Water (static head) prior to dewatering (m)**	**H^2**	**Depth of Water in the well while pumping (m)**	**h^2**	**H^2-h^2**	**Radius of Influence[2] (m)**	**Ro/r**	**Discharge Into Ends [3] (m^3/day)**	**Plane Discharge [4] (m^3/day)**	**Total Discharge (m^3/day)**	**Total Discharge (L/day)**	**Total Discharge x 3 Safety Factor (L/day)**
		a	**b**	**re**	**k**	**k**	**H**		**h**			**Ro**		**Q**	**Q**	**Q**	**Q**	**Q**
Sanitary	Northwest Condo Road	170	3	55	7.40E-04	6.39E+01	5.0	25	0.0	0.0	25	463	8.4	0.0	587	587	586,710	1,760,130
Sanitary	Southwest Condo Road	130	3	42	7.40E-04	6.39E+01	2.0	4	0.0	0.0	4	206	4.9	0.0	162	162	161,730	485,190
Sanitary	Noth / South Connections	70	3	23	7.40E-04	6.39E+01	3.5	12	0.0	0.0	12	309	13.3	0.0	177	177	177,500	532,500
Sanitary	Main Entrance Road	76	3	25	7.40E-04	6.39E+01	4.0	16	0.0	0.0	16	352	14.0	0.0	221	221	221,120	663,360
Storm Pond	Dry Cell	75	30	33	7.40E-06	6.39E-01	1.0	1	0.0	0.0	1	42	1.2	9.2	0.0	9.2	9,000	27,000
Total														9.2	1,147	1,156	1,156,060	3,468,180

Notes

[1] *$r_e = (a+b) / \pi$ - assuming a/b >1.5, (Driscoll, 1986)*

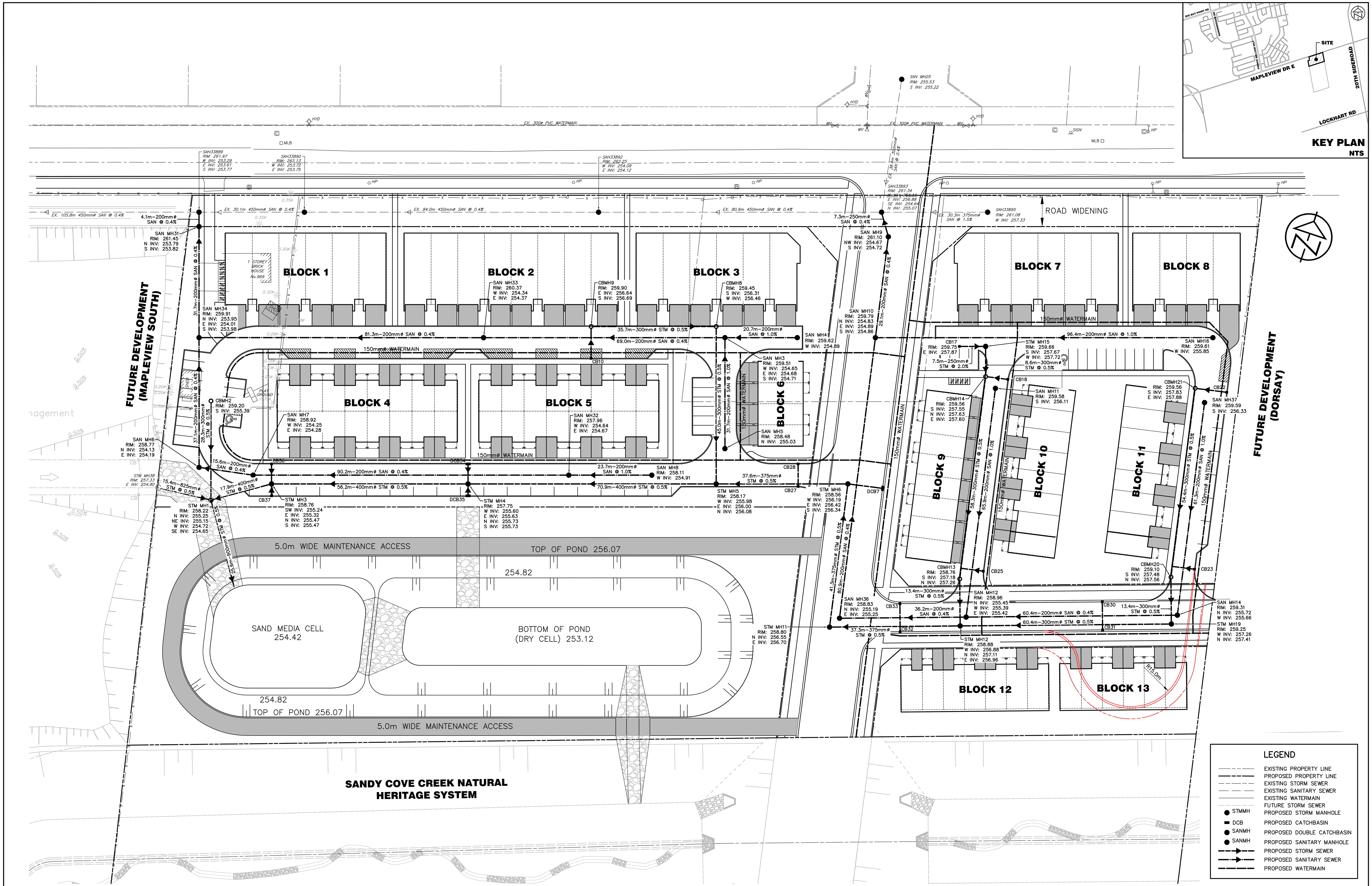
[2] *$Ro = r_e + 3000 * (H-h) * \sqrt{k}$ - Sichardts Formula, (Cashman and Preene, 2001)*

[3] *$Q = [(\pi * K)*(H^2 - h^2)] / [\ln(R_o/r)]$ (Powers et al., 2007)*

[4] *$Q = 2*[a*K*(H^2 - h^2)/(2R_o)]$ (Powers et al., 2007)*

* servicing lengths and depths based on Tatham 2022 SS-01

**For trench dewatering, only plane discharge is counted since the trench is only 2m wide so in most cases a>>b. Radial flow for the buildings and the stormtech chamber was determined since they are more proportional



DISCLAIMER AND COPYRIGHT	DRAWING REFERENCES	BENCHMARKS
CONTRACTOR MUST VERIFY ALL DIMENSIONS AND BE RESPONSIBLE FOR SAME. ANY DISCREPANCIES MUST BE REPORTED TO THE ENGINEER BEFORE COMMENCING WORK. DRAWINGS ARE NOT TO BE SCALED. TATHAM ENGINEERING LIMITED CLAIMS COPYRIGHT TO THIS DRAWING WHICH MAY NOT BE USED FOR ANY PURPOSE OTHER THAN THAT PROVIDED IN THE CONTRACT BETWEEN THE OWNER/CLIENT AND THE ENGINEER WITHOUT THE EXPRESS CONSENT OF TATHAM ENGINEERING LIMITED.	SITE PROPERTY LINES SHOWN BASED ON PLAN 51R-33948 PREPARED BY HOLDING JONES VANDERVEEN INC., O.L.S., DATED FEBRUARY 13, 2008. EXISTING PROPERTY LINES SHOWN ARE APPROXIMATE BASED ON SIMCOE COUNTY GIS. TOPOGRAPHIC INFORMATION SHOWN BASED ON SURVEY COMPLETED BY HOLDING JONES VANDERVEEN INC., O.L.S., JULY 27, 2015. SITE PLAN SHOWN PREPARED BY HUNT DESIGN ASSOCIATES INC., MAY 2021.	**TBM#1 ELEV. 261.551 m** CITY OF BARRIE BENCHMARK #03120110020 **TBM#2 ELEV. 268.852 m** CITY OF BARRIE BENCHMARK #03120110016

No.	REVISION DESCRIPTION	DATE

ENGINEER STAMP

DRAFT

SANDY CREEK ESTATES INC.
PHASE 1
CITY OF BARRIE

TATHAM ENGINEERING

GENERAL SERVICING PLAN

DESIGN: LC	FILE: 420406-1	DWG:
DRAWN: LC	DATE: AUGUST 2021	**SS-01**
CHECK: NM	SCALE: 1:500	

Drawing Name: 420406-SS01.dwg, Plotted: Jan 24, 2022