Wetland Hydrology Shallow Groundwater Investigation

Part of Lot 27, Concession 10,
Township of Otonabee-South Monaghan
County of Peterborough, Ontario

Proposed Residential Development

D.M. Wills Project Number 19-10874

D.M. Wills Associates Limited
Partners in Engineering, Planning &
Environmental Services
Peterborough

May 2021

Prepared for:
Life at the Woodland Inc.
c/o Mr. Rubal Kundra

WILLS

Summary of Revisions

Revision No.	Revision Title	Date of Release	Summary of Revisions
0	Draft Submission to MNRF	September 2, 2020	N/A
1	Final Submission	May 10, 2021	No comments/edits

This report has been formatted considering the requirements of the Accessibility for Ontarians with Disabilities Act.

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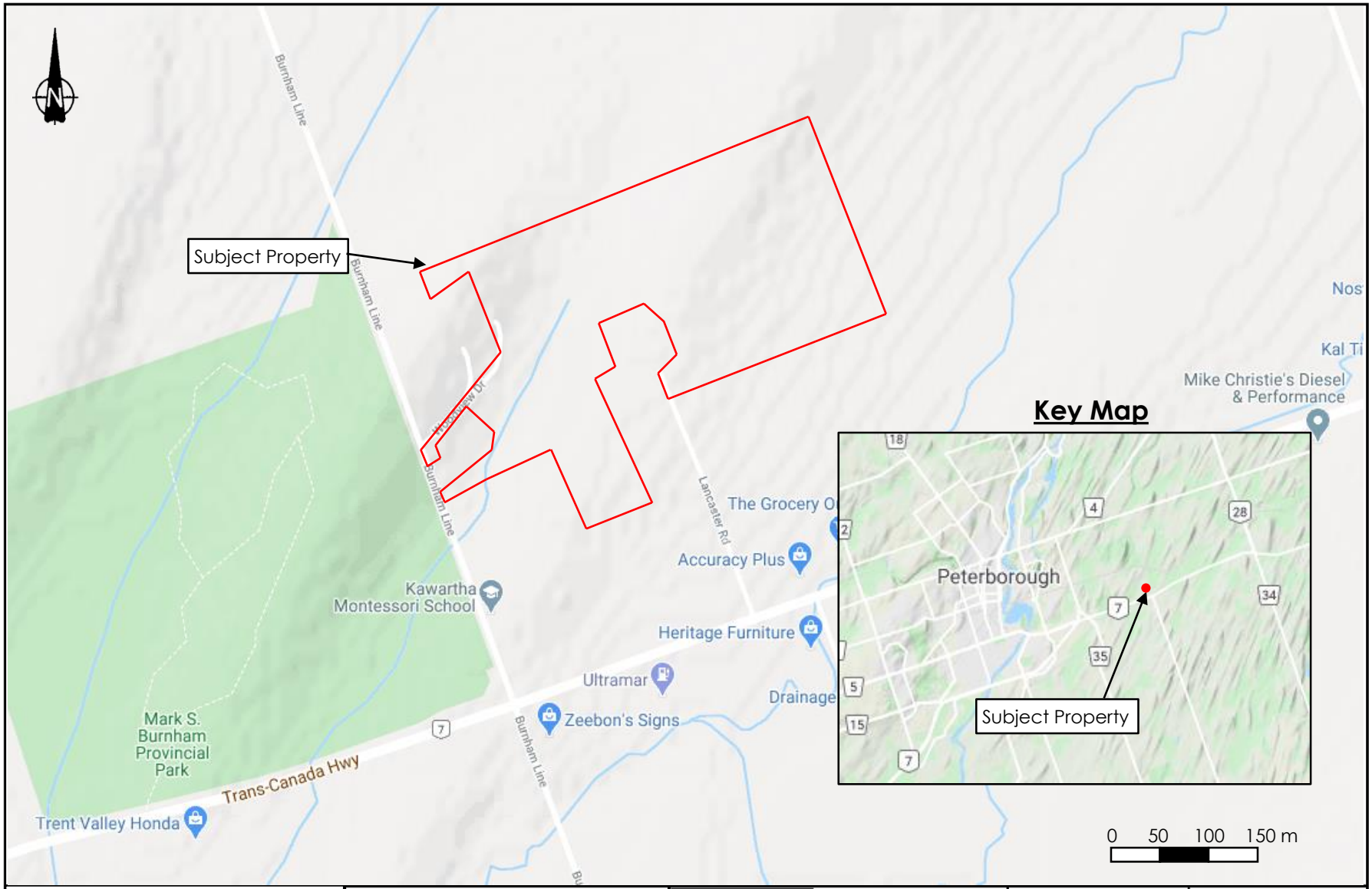
1.0 Introduction

D.M. Wills Associates Limited (Wills) was retained by Mr. Rubal Kundra of Life at the Woodland Inc. (Client) to complete a Wetland Hydrology Shallow Groundwater Investigation (Investigation) in support of a proposed residential development on the property identified as Part of Lot 27, Concession 10, Township of Otonabee-South Monaghan (Subject Property). The location of the Subject Property is shown on **Figure 1.**

Wills' Investigation was requested by the Ministry of Natural Resources and Forestry (MNRF) during a meeting between Wills and MNRF staff on November 21, 2019, and was required to supplement Wills' Species at Risk Assessment and Wetland Delineation Report completed in 2019. Wills understands that the Investigation was requested by the MNRF as input into the determination of Provincially Significant or Non-Provincially Significant designation for a wetland located on the western side of the Subject Property (Subject Wetland).

The purpose of the Investigation was to determine whether or not the Subject Wetland shares a hydraulic connection with a wetland located outside of the Subject Property to the northeast (Northeast Wetland). The relative locations of the Subject Wetland and the Northeast Wetland are shown on **Figure 2.**

Wills' Investigation included a review of available hydrogeological and water resources reports and maps; a subsurface investigation including test pits, hand augers, and monitoring well installations; topographic interpretation; data analysis; and reporting.



Legend

Subject Property Boundary

Figure 1 – Subject Property Plan

Woodland Subdivision
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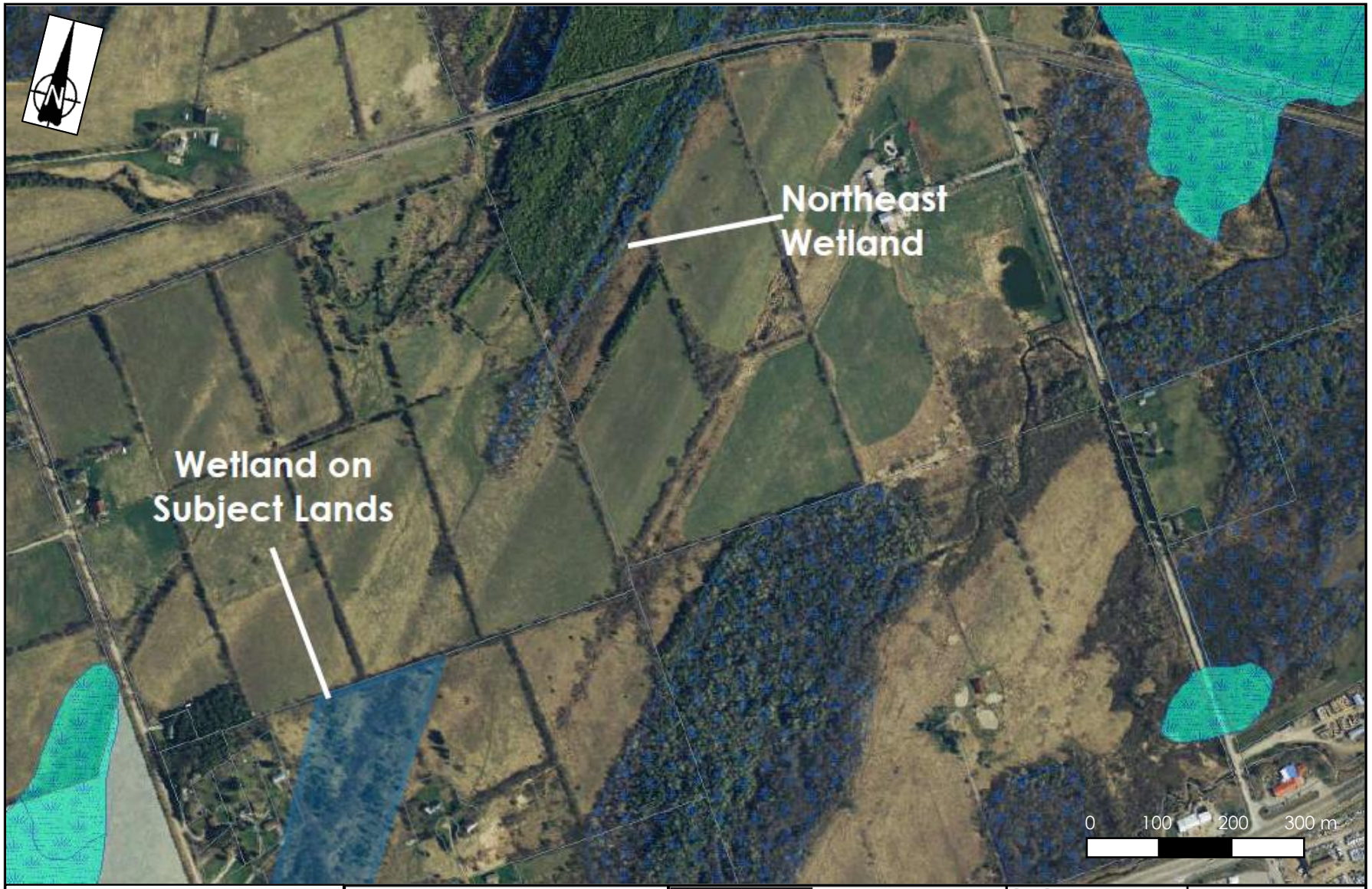
Drawn By	JC	Scale	See Scale Bar
Checked	IA	Date	August 2020
Project No.	19-10874	Drawing File No.	Figure 1



Legend

- Non - Provincially Significant Wetland Evaluated
- Unevaluated Wetland

Figure 2 – Wetland Location Plan

Woodland Subdivision
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Drawn By	JC	Scale	See Scale Bar
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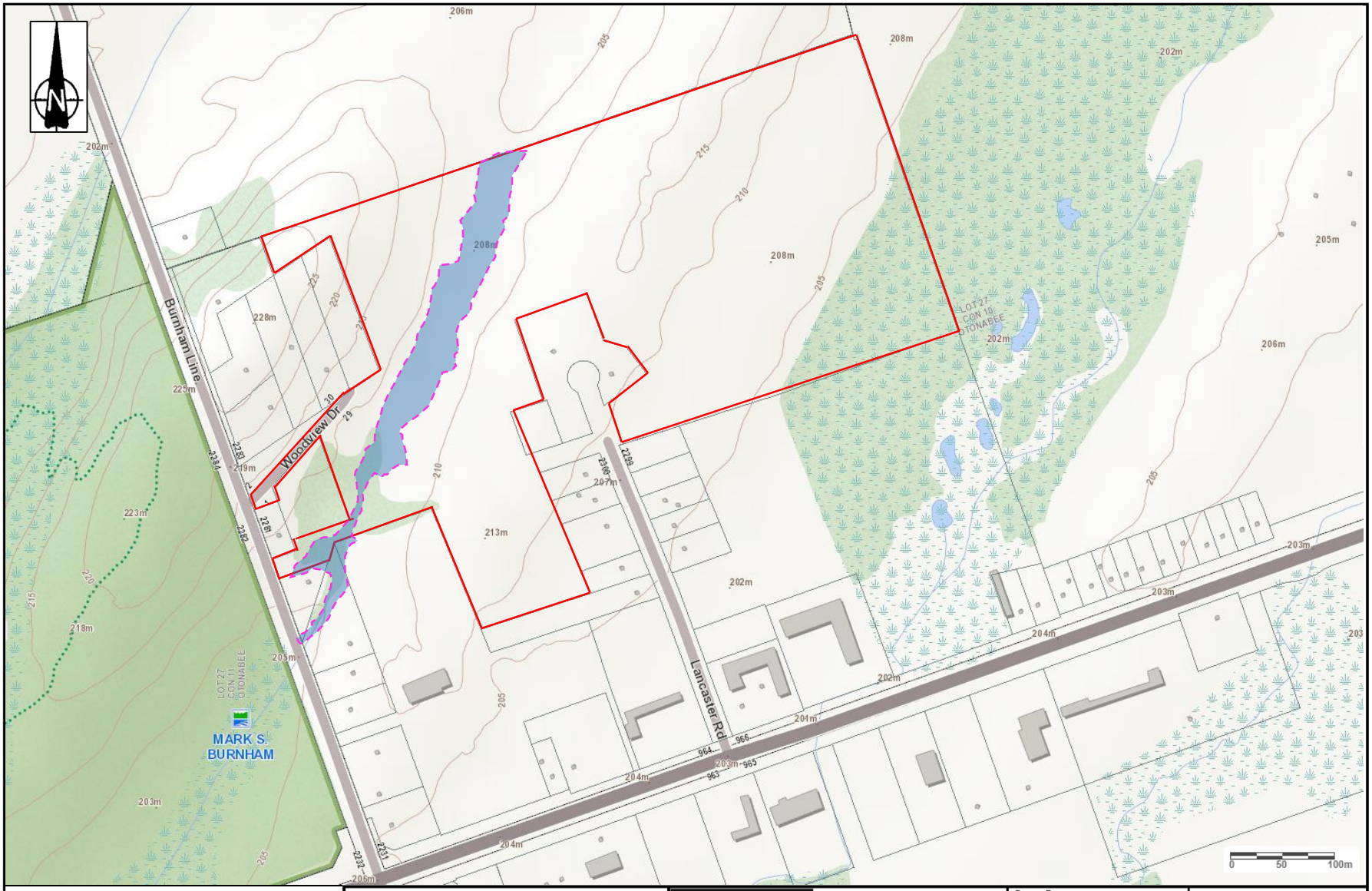
2.0 Subject Property Description

The Subject Property is located on Part of Lot 27, Concession 10 in the Township of Otonabee-South Monaghan, Peterborough County, Ontario. The Subject Property is irregular in shape, approximately 16 hectares in area, and is bound to the north by rural land, to the east by woodland and wetland areas, to the south by rural residential and institutional properties, and to the west by rural residential properties and Burnham Line.

The Subject Property is currently vacant and maintains a mixture of open grassland, coniferous and deciduous woodland, and wetland areas. The Subject Wetland is located on the western portion of the Subject Property and discharges to a culvert located beneath Burnham Line directly south of the Subject Property. The approximate location of the Subject Wetland is shown on **Figure 3**.

The Subject Property maintains a gently rolling topography associated with localized northeast trending drumlin features. Topographic highs range from approximately 225 meters above sea level (masl) to 215 masl in the northwest corner and central area respectively. Topographic lows range from approximately 205 masl in the southeast corner to 206 masl in the western area in the location of the Subject Wetland. The generalized Subject Property topography is shown on **Figure 3** and discussed in further detail in **Section 4.0**.



Legend

- Subject Property
- Subject Wetland

Figure 3 – Subject Wetland Plan

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Project No.	19 -10874	Drawing File No.	Figure 3

3.0 Geology

3.1 Physiography

The Subject Property is situated within the Peterborough Drumlin Field physiographic region (Chapman and Putnam, 1984) that is characterized by undulating till plains punctuated with northeast trending drumlin features. In addition to the well defined drumlin features, many drumlinoidal hills and surface flutings of the drift cover are present throughout this region. A Regional Physiography Map showing the Subject Property is included as **APP A-1** in **Appendix A.**

3.2 Surficial Geology

Surficial geology mapped by the Ontario Geological Survey (OGS, 2017) indicates that the Subject Property soils are comprised of Pleistocene age, stone poor, sandy silt to silty sand textured till on Paleozoic terrain beneath and adjacent to the Subject Wetland. OGS mapping suggests that coarse-textured glaciolacustrine outwash deposits of sand and gravel with minor traces of silt and clay sourced from foreshore or basinal deposits are present on the eastern side of the Subject Property, and may be associated with an off-site wetland to the east. A Surficial Geology Map showing the Subject Property is included as **APP A-2** in **Appendix A.**

3.3 Bedrock Geology

OGS (2018) indicates the bedrock geology on the Subject Property consists of Upper Ordovician-aged limestone, dolostone, shale, arkose, or sandstone from the Verulam Formation of the Simcoe Group.

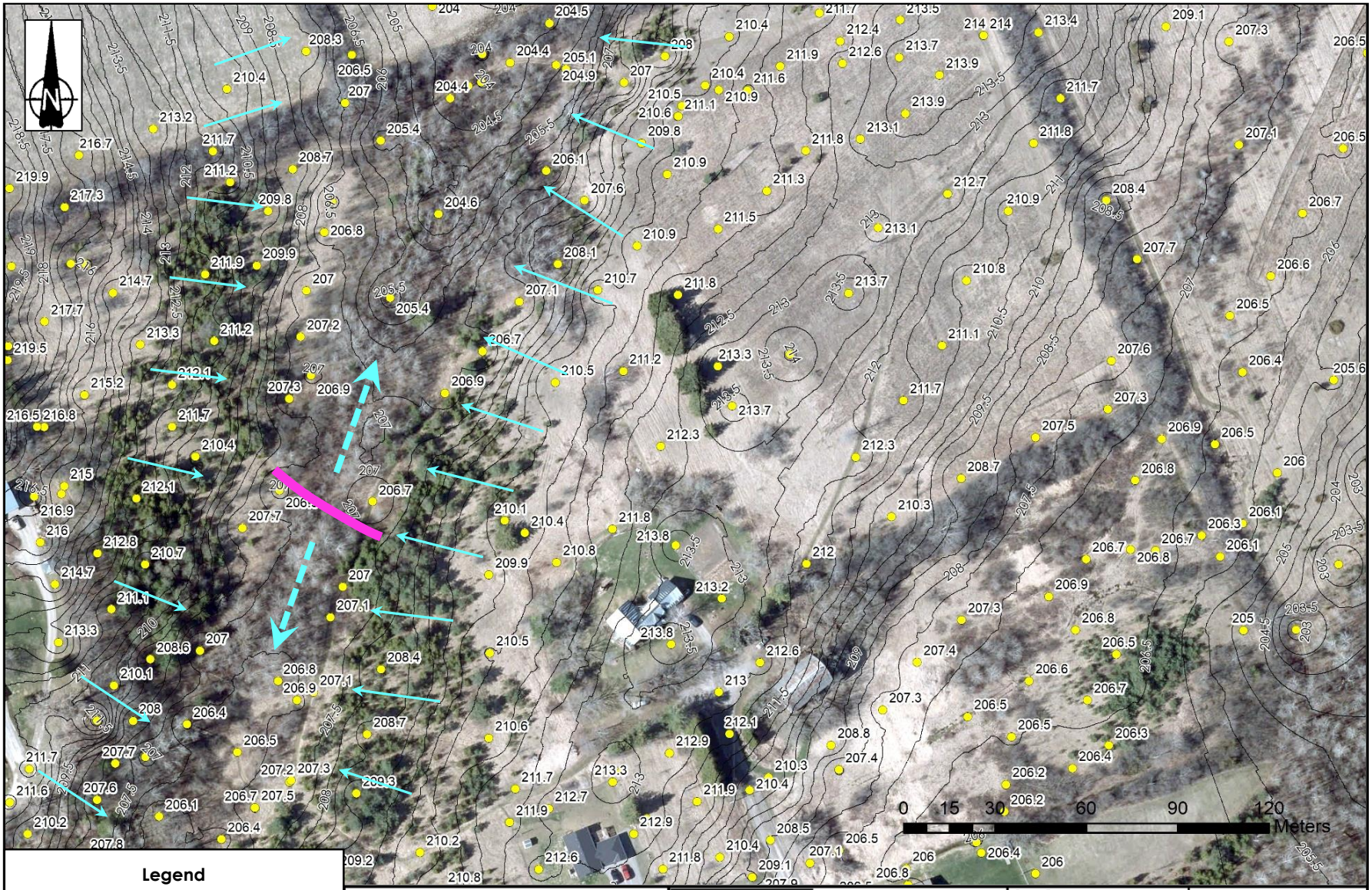
The Verulam Formation forms a broad belt south of the Bobcaygeon Formation. In general, outcrops are sparse and limited to river cuts and quarry exposures. The Verulam Formation is informally subdivided into two (2) members. The lower member consists of interbedded limestone and calcareous shale. The limestone beds are very fine to coarse grained, thin to thick bedded, nodular to tabular bedded, light to dark grey-brown and fossiliferous. The upper member is thin to thick-bedded, medium to coarse grained, cross-stratified, tan to light grey, fossiliferous, bioclastic limestone (OGS, 2019). A review of Ministry of the Environment, Conservation, and Parks (MECP) Well Records in the vicinity of the Subject property suggests underlying bedrock may be encountered at depths greater than 15 meters below existing grade (mbeg) on the Subject Property. In view of the thick and potentially hydraulically confining overburden layer, bedrock topography is not anticipated to greatly influence shallow groundwater and surface water flows on the Subject Property. A Bedrock Geology Map showing the Subject Property is included as **APP A-3** in **Appendix A.**

4.0 Topography and Drainage

A topographic survey of the Subject Property was completed by JBF Surveyors (JBF) on June 3, 2019 and is included in **Appendix B.** Based on the spot elevations measured by JBF, Wills prepared a plan showing inferred topographic contours within and adjacent to the northern portion of the Subject Wetland using Geographic Information Systems (GIS) software, and is included as **Figure 4.**

Wills' detailed topographic contours align with the generalized topography shown on **Figure 3**, which illustrates the Subject Wetland positioned along a topographic low that straddles two northeast trending drumlin features. Surface water drainage adjacent to the Subject Wetland is inferred to flow generally southeast and northwest from the crest and flanks of the drumlins towards the low-lying wetland area. Surface water flow direction within the Subject Wetland is anticipated to be controlled by the topography of the underlying and hydraulically confining glacial till material.

Based on JBF's survey data and Wills' topographic contours, a topographic high point (approximately 207 masl) was observed in the northern portion of the Subject Wetland, approximately 150 m southwest from the northern Subject Property Boundary. The approximate 207 masl elevation is relatively consistent over an approximately length of 50 m and separates lower elevation areas to the northeast and southwest. This topographic divide suggests that surface water run-off entering the Subject Wetland as overland flows will migrate away from this high point in a northeast and southwest direction, as shown on **Figure 4**. Photograph No. 19 in **Appendix C** shows surface water flowing west at the culvert outlet on Burnham Line. Photograph No. 20 in **Appendix C** shows surface water flowing north in proximity to the northern Subject Property boundary.



Legend

- Inferred Topographic Divide
- Inferred Surface Water Drainage
- Inferred Surface Water Flow Direction Within Wetland

Figure 4 – Topography and Drainage Plan

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5.0 Subsurface Field Investigation

5.1 Drive Point Well Installation

Wills installed drive-point monitoring wells (monitoring wells) within and outside of the Subject Wetland boundary on June 11, 2020 to evaluate the interaction between the surface water and shallow groundwater regime. Monitoring well locations were positioned within the northern portion of the Subject Property in order to provide information relating to potential connectivity between the Subject Wetland and the Northeast Wetland.

Two (2) monitoring locations included nested monitoring wells that were constructed with screened intervals that intersected the surficial wetland sediment/soil and the underlying glacial till material. Nested monitoring wells were designated as DP20-03A/DP20-03B, and DP20-01A/DP20-01B, and were installed at depths ranging from approximately 0.26 mbeg to 0.90 mbeg. One (1) monitoring well designated as DP20-02 was installed outside (west) of the Subject Wetland boundary at a depth of approximately 0.97 mbeg. DP20-02 was further advanced to a depth of approximately 2.03 mbeg on June 11, 2020, in an attempt to intercept the shallow groundwater table after dry conditions were encountered. Monitoring wells were constructed with a 0.25 m long stainless steel screen that was affixed to 1.25 inch outer diameter (O.D.) galvanized threaded pipe of various lengths.

Monitoring well locations are shown on **Figure 5** and **Table 1** in **Section 5.5** which summarizes the respective construction details. Furthermore, monitoring well construction details are shown on borehole logs included in **Appendix D.** Photographs showing the monitoring well locations are included in **Appendix C**. All monitoring wells installed by Wills were decommissioned on July 24, 2020.

5.2 Test Pit Investigation

Wills excavated one (1) hand-dug test pit to a depth of approximately 0.85 mbeg adjacent to DP20-02 on June 3, 2020. The test pit was designated as TP20-01 and was used to inform the depth of installation for DP20-02, as well as confirm the shallow soil stratigraphy outside of the Subject Wetland. The test pit log for TP20-01 is included in **Appendix D** and the test pit location is shown on **Figure 5**.

The encountered soil stratigraphy in TP20-01 included a thin layer of topsoil underlain by dark brown silty sand with organic material, and a basal layer of light brown silty sand till with some clay, trace gravel, and occasional cobbles. Photographs showing the test pit and encountered stratigraphy are included in **Appendix C**.

5.3 Hand Auger Investigation

Wills advanced two (2) boreholes adjacent to the nested well locations on June 11, 2020 to confirm shallow soil stratigraphy adjacent to the screened intervals. Boreholes were advanced using a 2 ¼ inch O.D. hand auger and were designated as HA20-01

and HA20-02, and were positioned beside DP20-03A/B and DP20-01A/B respectively. HA20-01 and HA20-02 were advanced to a depth of approximately 1.05 mbeg. Borehole locations are shown on **Figure 5** and borehole logs are included in **Appendix D.**

In general, the encountered stratigraphy consisted of a thin (0.25 m thick) layer of dark brown silty sand and organic material with underlying glacial till that was described as silty sand, some clay, and trace gravel. Boreholes were advanced within the Subject Wetland boundary and all encountered soils were described as saturated to much wetter than the plastic limit at the time of the investigation.

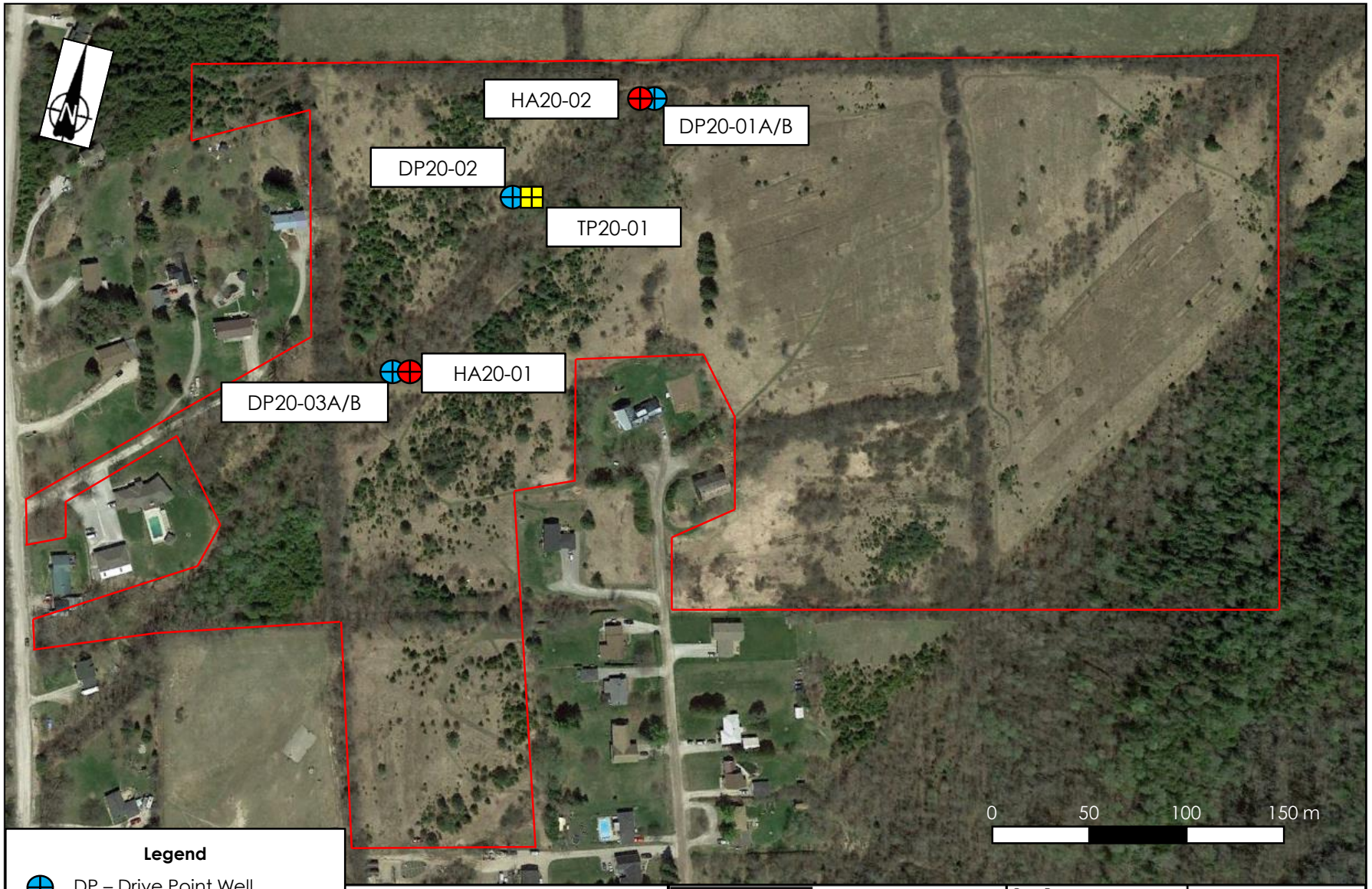

Figure 5 – Subsurface Investigation Plan

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5.4 Elevation Survey

Ground elevations and top of pipe elevations for the monitoring well location were surveyed by Wills staff on June 24, 2020 using a Sokkia GCX3 GPS and survey rod. Elevations measured by Wills were used to determine groundwater elevations from the static water level measurements recorded at the monitoring well locations.

5.5 Shallow Groundwater Elevations

Static groundwater levels were measured at the five (5) monitoring wells on June 3, June 11, June 26, July 21, and July 24, 2020, using a Solinst electronic water level tape and recorded to the nearest 0.01 m**.** Static water levels and elevations are summarized in **Table 1**.

Table 1 – Groundwater Level Summary

				Date:	**June 3, 2020**	**June 11, 2020**	**June 26, 2020**	**July 21, 2020**	**July 24, 2020**
Monitoring Well ID	**Well Depth (mbtop)**	**Well Depth (mbeg)**	**Stick up (m)**	**Ground Elevation (masl)**	**Groundwater Elevation (masl)**				
DP20-01A	1.58	0.90	0.68	204.23	203.64	203.97	203.84	Dry	Dry
DP20-01B	0.96	0.28	0.68	204.24	204.28	204.28	Dry	Dry	Dry
DP20-02	2.70	2.03	0.67	207.26	-	Dry	Dry	205.44	Dry
DP20-03A	1.58	0.88	0.70	206.31	205.91	206.38	205.71	Dry	Dry
DP20-03B	0.96	0.26	0.70	206.31	206.36	206.37	Dry	Dry	Dry

mbtop - meters below top of well pipe
mbeg - meters below existing grade
masl - meters above sea level
Dry - no water present in the well

5.5.1 Hydraulic Gradient

Vertical hydraulic gradients were calculated for each of the nested wells using static groundwater levels measured on June 3, 2020 and June 11, 2020. Hydraulic gradients were calculated using the distance between the mid-point of each nested well screen and the respective change in hydraulic head. Negative vertical hydraulic gradients indicate a downward flow direction and positive values indicate an upward flow direction at the nested monitoring well locations. **Table 2** summarizes the results of Wills' vertical hydraulic gradient calculations.

Table 2 – Vertical Hydraulic Gradients

Date:	June 3, 2020	June 11, 2020
Monitoring Well ID	**Vertical Hydraulic Gradient**	
DP20-01A	- 0.99	- 0.48
DP20-01B		
DP20-03A	- 1.52	0.02
DP20-03B		

In summary, the measured gradients generally indicate a downward flow direction with the exception of DP20-03A/B on June 11, 2020. It should be noted that the static water levels measured in DP20-03A/B were very similar and the inferred upward flow direction (positive hydraulic gradient) may be attributed to one of the screens becoming dislodged, resulting in an equilibrated static water level within the monitoring well stand-pipes.

The negative hydraulic gradients calculated for the Subject Wetland suggest a recharge system in which the net flow is downward. The downward flow direction indicates that surface water entering the wetland either percolates into the underlying glacial till, or moves out of the wetland as surface water flows or shallow groundwater flows through the wetland sediment. These results do not suggest that a discharge system (i.e. artesian conditions) is present on the northern side of the Subject Wetland, which would indicate a potential connectivity or input from other groundwater regimes.

5.5.2 Hydraulic Conductivity

Based on the stratigraphy encountered in Wills' subsurface investigation, the Subject Wetland was inferred to consist of a thin organic rich layer of silty sand with organics, and was underlain by silty sand till with varying amounts of clay and gravel. Based on Table 2 in the 2012 Ontario Building Code (OBC) (Percolation Time and Soil Descriptions), the overlying silty sand unit generally aligns with the S.M. soil envelope description (silty sands, sand silt mixtures) and the underlying till generally aligns with either the S.M. or S.C. (clayey sands, sand-clay mixtures) was underlain by a basal layer of silty sand till (ML) description.

On the basis of Table 2 OBC, the upper silty sand material is estimated to have a coefficient of permeability between 10^{-3} – 10^{-5} centimeters per second (cm/s) and the underlying silty sand till material is estimated to have a coefficient of permeability between 10^{-5} - 10^{-6} cm/s. In view of the relative compactness and poorly sorted nature of the basal till material, the coefficient of permeability is anticipated to be on the low end of the provided range, and the two encountered soil units are expected to have a coefficient of permeability greater than an order of magnitude in difference. The inferred difference in permeability suggests that overland surface water flows within the

wetland may be the driving factor for net water movement where slope gradients permit.

6.0 Climate Data

The Environment Canada climate database was consulted for historical precipitation and climate information pertaining to the Subject Property. The information provided below was generated from the Peterborough Trent University climatology station located approximately 8 km northwest of the Subject Property. Climate normal for the years 1981-2010 are included in **Table 3** (Environment Canada, 2019). This data represents the most current data available.

Table 3 – Climate Normals (Peterborough Trent University 1981-2010)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Daily Temp (°C)	-8.4	-6.5	-1.3	6.3	12.8	18.0	20.7	19.4	15.0	8.4	2.4	-4.0
Rainfall (mm)	22.4	23.1	34.0	60.9	88.7	83.0	73.6	87.0	92.4	75.7	73.3	35.0
Snowfall (mm)	38.9	28.8	23.7	6.1	0.0	0.0	0.0	0.0	0.0	1.4	13.9	34.3
Precipitation (mm)	57.3	48.8	56.5	66.4	88.7	83.0	73.6	87.0	92.4	77.0	85.5	66.0

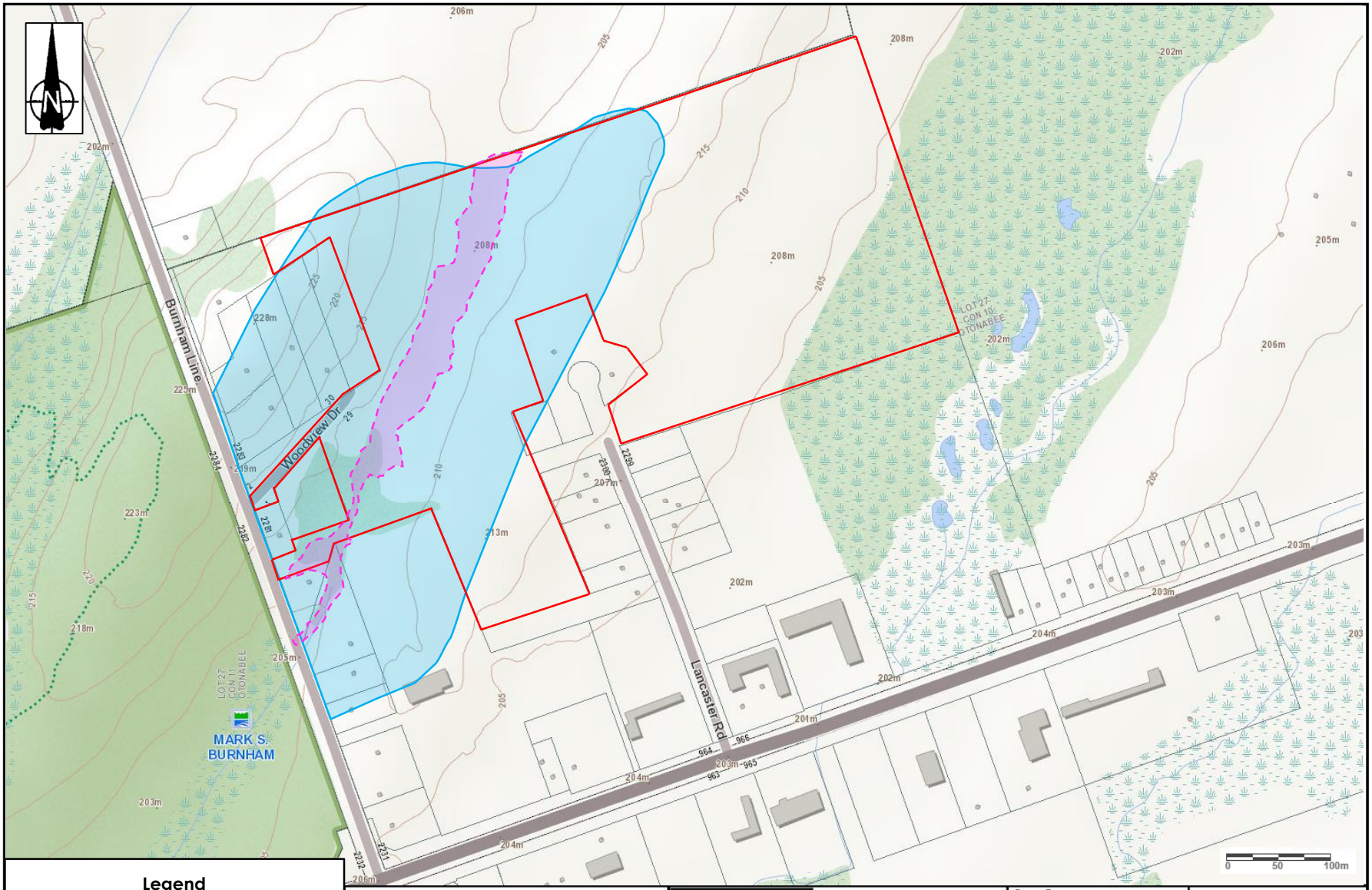
7.0 Interpreted Water Budget

Based on the topographic mapping contours, the catchment area for the Subject Wetland was interpreted, and is shown on **Figure 6**. This was completed by identifying areas that slope towards the wetland and which would thereby supply overland flows into the Subject Wetland. It is noted that the northernmost section of the wetland is not included in the catchment area in view of the topographic divide that separates low elevation areas to the northeast and southwest. Surface water on the northern side of this topographic divide is interpreted to flow northeast towards the Northeast Wetland, and surface water on the southern side is interpreted to flow southwest through the Subject Wetland.

Following are the Subject Wetland Characteristics:

Elevation = approximately 206 masl
Estimated Catchment Area (Error! Reference source not found.**6**) = 136,750 m^2

Wills collected temperature and precipitation data from the Peterborough Trent University Climatological Station to calculate monthly annual precipitation and monthly annual surplus after evapotranspiration (Thornthwaite method), which informed the amount of available overland flows that could supply the Subject Wetland. Temperature and precipitation data are summarized in **Table 4**.



Legend

- Subject Property
- Approximate Wetland Catchment Area
- Wetland Area

Figure 6 - Capture Area

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Checked: IA	Date: Sept. 2020
Project No.: 19 -10874	Drawing File No.: Figure 6

Table 4 – Water Budget

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Daily Temp (°C)	0	0	0	6.3	12.8	18.0	20.7	19.4	15.0	8.4	2.4	0
Evapotranspiration (mm)	0.0	0.0	0.0	32.4	62.9	114.0	133.6	126.5	88.5	40.7	9.5	0.0
Precipitation (mm)	57.3	48.8	56.5	66.4	88.7	83.0	73.6	87.0	92.4	77.0	85.5	66.0
Surplus (mm)	57.3	48.8	56.5	34.0	25.8	-31.0	-60.6	-39.5	3.9	36.3	76.0	66.0

The following information is provided based on the Peterborough Trent University climatology station information summarized in **Table 4**:

Total Annual Precipitation: 882.2 mm

Total Annual Surplus after evapotranspiration: 273.5 mm (Thornthwaite method)

Maximum Monthly Deficit: approximately 61 mm (in July)

An assumption was made that the water within the catchment area has the ability to flow into the Subject Wetland. The following was completed to calculate the Total Recharge conditions:

Catchment Area (136,750 m^2) x Surplus (0.274 m) = 37,470m^3

Total Annual Recharge = 37,470 m^3

The Total Annual Recharge available to the Subject Wetland was estimated to be approximately 37,470 m^3.

8.0 Wetland Hydrology and Shallow Hydrogeology

The Subject Wetland was estimated to be approximately 15,850 m^2 in area on the Subject Property. Based on the measured depth of the saturated wetland soils (organic rich silty sand material, approximately 0.25 m thick) an approximate volume of water contained on average within the Subject Wetland was estimated to be 3,963 m^3 and is conservative. Water volumes within the Subject Wetland are anticipated to fluctuate seasonally and in response to precipitation and snow/ice melt events.

In view of Wills' estimated water volume contained within the Subject Wetland, the total estimated annual recharge of volume 37,470 m^3 (approximately 9.5 X the estimated volume of water contained within the Subject Wetland) is considered sufficient to provide adequate recharge during months where snowmelt or precipitation can occur. During Wills' field investigations, it was noted that the Subject Wetland within the investigated areas was dry underfoot during the late June and July site visits. This observation aligns with the monthly deficits provided in **Table 4**, suggesting that the annual recharge of 37,470 m^3 is the primary source of water into the Subject Wetland, and may contribute to wetland recharge during approximately six (6) months of the

year (March through November, excluding months with water deficits). Although surface water flow modelling (i.e. flow rates) was beyond the scope of Wills investigation, the total annual surplus available to the Subject Wetland is considered significant in view of Wills' conservative Subject Wetland volume estimate.

Wills' inferred water budget supports the idea that the Subject Wetland is recharged by overland flows originating on and directly adjacent to the Subject Property from areas of higher elevation during precipitation and melt events. Surface water that enters the Subject Wetland generally flows southwest, away from the topographic high point (270 masl) identified on the northern end of Subject Wetland, as shown on **Figure 4**. Some surface water flows leave the Subject Property through the culvert beneath Burnham Line, and some water infiltrates into the underlying glacial till material as recharge to the local groundwater system. Conversely, a smaller percentage of surface water entering the Subject Wetland is expected to flow northeast from the topographic high towards the northern boundary of the Subject Property. Assessment of wetland hydrology outside of the Subject Property boundary was beyond the scope of Wills' investigation and the ultimate fate of the northeast flowing water in the north end of the Subject Wetland is unknown.

In summary, the Subject Wetland is interpreted to include two hydrologic regimes; both of which appear to be recharged by localized overlands flows on the Subject Property. The one (1) regime includes northeast flows at the northern end of the Subject Wetlands. The other regime, which accounts for the majority of the Subject Wetland, flows in a southwest direction and does not appear to share a hydraulic connection with the Northeast Wetland.

9.0 Conclusions

Based on Wills' Investigation, the following conclusions are provided:

- Shallow soils in the the vicinity of the Subject Wetland included a surficial layer of wetland sediment/soil (silty sand with organics) underlain by more hydraulically confining glacial till material (silty sand with varying amounts of clay and gravel).
- Nested wells were installed within the Subject Wetland boundary to assist in characterizing the shallow hydrologic regime. Static water level measurements and vertical hydraulic gradients measured at the nested well locations suggest a net downward movement of water within the Subject Wetland.
- Based on the net downward water movement, the Subject Wetland is considered a recharge system that dissipates accumulated water through lateral movement within the saturated wetland sediments (or surface water flows) and through infiltration into the underlying glacial till material.
- Wills' evaluation of the local topography suggests that surface water drainage into the Subject Wetland appears to be the primary source of recharge into the wetland.

- Wills' inferred water budget estimates a total annual recharge of 37,470 m^3 that is assumed to enter the Subject Wetland as overland flows resulting from ice/snow melt and precipitation events.
- Wills' estimated the average volume of water contained within the Subject Wetland to be approximately 3,963 m^3.
- Although detailed surface water modelling (i.e. flow rates) was not included in Wills' scope of work, the total annual recharge is considered sufficient to support the observed water levels within the Subject Wetland.
- Based on Wills' topographic evaluation and field observations, surface water (and shallow groundwater) within the Subject Wetland flow in a northeast and southwest direction away from a topographic high point (270 masl) in the northern area of the Subject Wetland. These two flow directions are considered separate hydrologic regimes, although they are both inferred to be recharged from a shared catchment area.
- Northeast flows may leave the Subject Property through a shallow groundwater connection; however, surface water flows away from the Subject Property to the north were not observed during Wills' Investigation. The ultimate fate of the northeast flows on the Subject Property are unknown, and are considered relatively insignificant with respect to the dominant southwest flow direction.
- Net water movement within the Subject Wetland is inferred to be predominantly in a southwest direction. Based on Wills' subsurface investigation and evaluation, the Subject Wetland associated with this hydrologic regime does not share a connection with the Northeast Wetland.

10.0 Closing

Wills' Wetland Hydrology Shallow Groundwater Investigation Report was prepared based on a review of available hydrogeological and water resources reports and maps, a subsurface investigation including test pits, hand augers, and monitoring well installations, topographic interpretation, and data analysis including an interpreted water budget.

The conclusions presented in this report reflect Wills' best understanding of the hydrology and shallow hydrogeology with respect to the Subject Wetland, using available information and investigative methods.

The following Statement of Limitations is an integral part of this report and should be read carefully.

We trust that the information contained in and appended to this report meet your current needs. Do not hesitate to contact the undersigned if you have any questions or concerns.

Respectfully submitted,

Prepared by: _____
Ian Ames, M.Sc., P.Geo.
Project Geoscientist

Reviewed by: _____
Michael J. Lord, B.A., Dipl. ET
Manager, Environmental Services

AT/IA/MJL/bam

11.0 Statement of Limitations

This report is intended solely for Life at the Woodlands Inc. (Client) in assessing wetland hydrology and shallow hydrogeological conditions on the property identified as Part Lot 27, Concession 10, Township of Otonabee-South Monaghan, County of Peterborough, and is prohibited for use by others without Wills' prior written consent. This report is considered Wills' professional work product and shall remain the sole property of D.M. Wills Associates Limited. Any unauthorized reuse, redistribution of or reliance on this report shall be at the Client and recipient's sole risk, without liability to Wills. The Client shall defend, indemnify and hold Wills harmless from any liability arising from or related to the Client's unauthorized distribution of the report. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include supporting drawings and appendices.

The recommendations made in this report are based on Wills' present understanding of the project, the current and proposed site use, ground and subsurface conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with the level of care and skill ordinarily exercised by members of geoscience or engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

The conclusion, recommendations and comments made in this report are based on our investigations and resulting understanding of the project, as defined at the time of the assignment. Wills should be retained to review our recommendations when the final or any modified design drawings and specifications are complete. Without this review, Wills shall not be liable for any misunderstanding of our recommendations or their application.

Appendix A

Regional Maps

Legend

Verulam – Limestone and shale

Subject Property Boundary

Bedrock Geology Map

Woodland Subdivision
Part of Lot 27, Concession 10
Peterborough County

D.M. Wills Associates Limited
150 Jameson Drive
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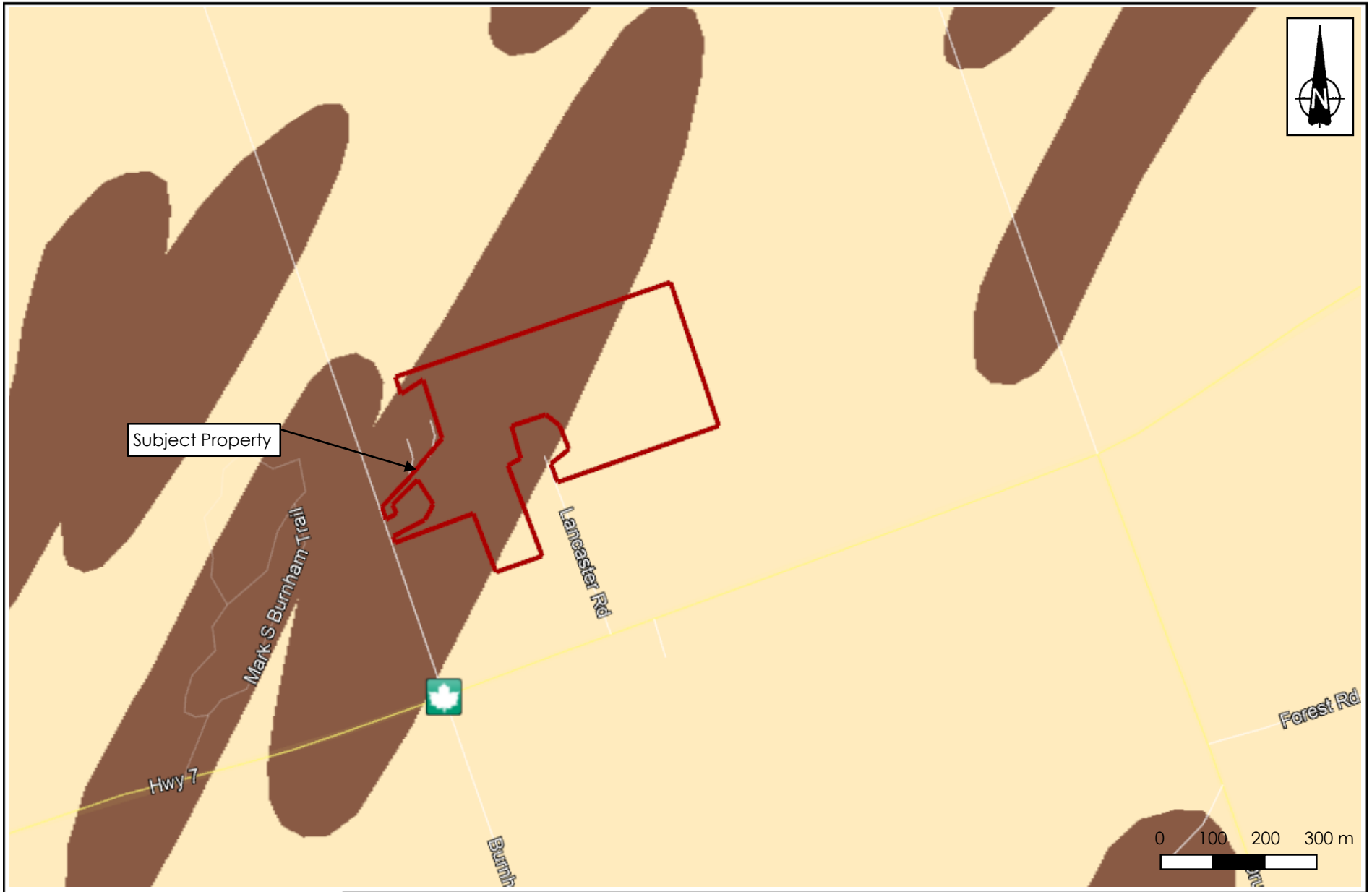
E. wills@dmwills.com

Drawn By	JC	Scale	See Scale Bar
Checked	IA	Date	Sept, 2020
Project No.	19-10872	Drawing File No.	APP A-3



Legend

- Till Plains (Undrumlinized)
- Till plains (Drumlinized)
- Subject Property Boundary

Physiography Map

Woodland Subdivision
Part of Lot 27, Concession 10
Peterborough County

WILLS

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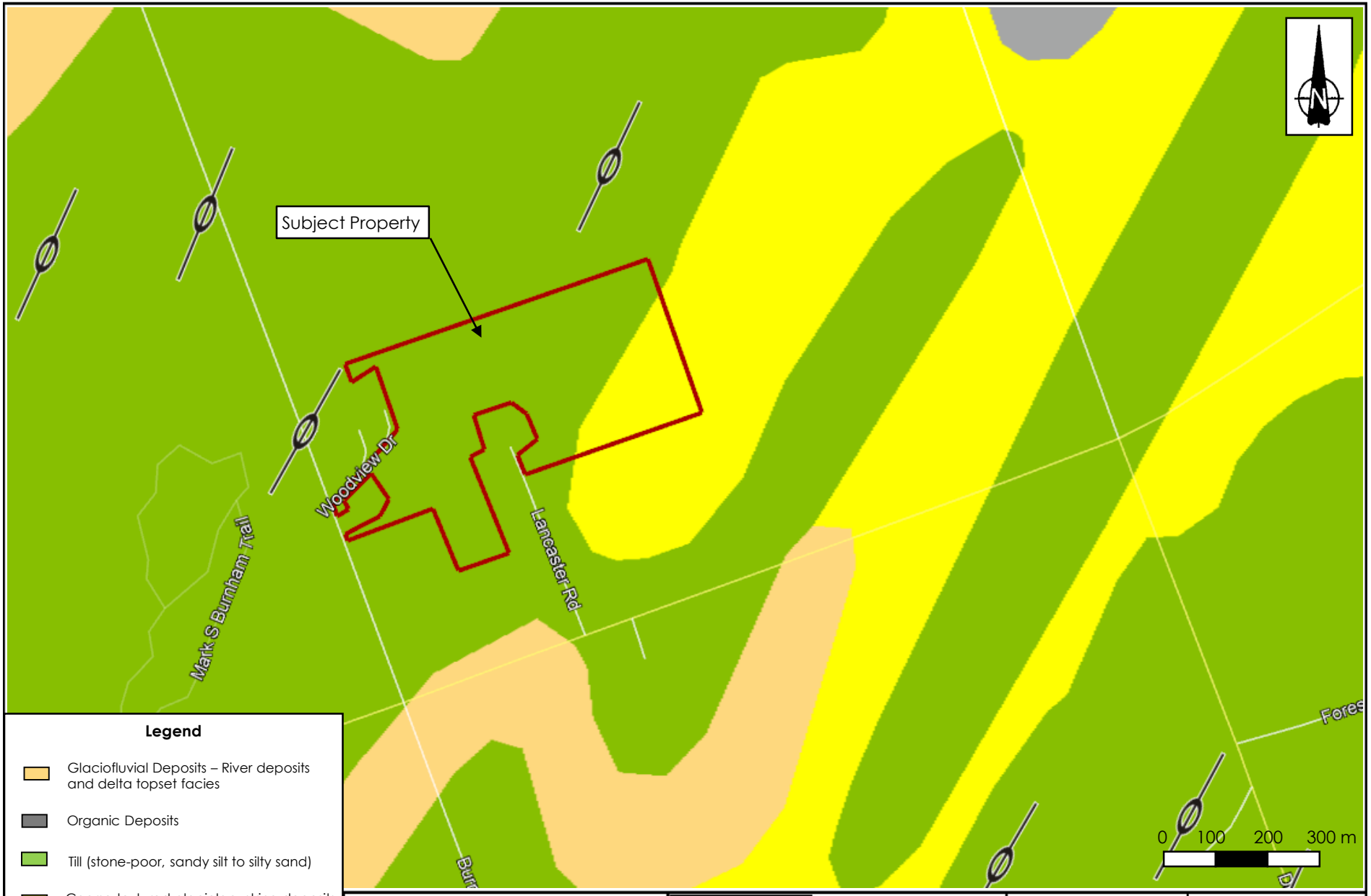
Drawn By	JC	Scale	See Scale Bar
Checked	IA	Date	Sept, 2020
Project No.	19-10872	Drawing File No.	APP - A1



Surficial Geology Map

Woodland Subdivision
Part of Lot 27, Concession 10
Peterborough County

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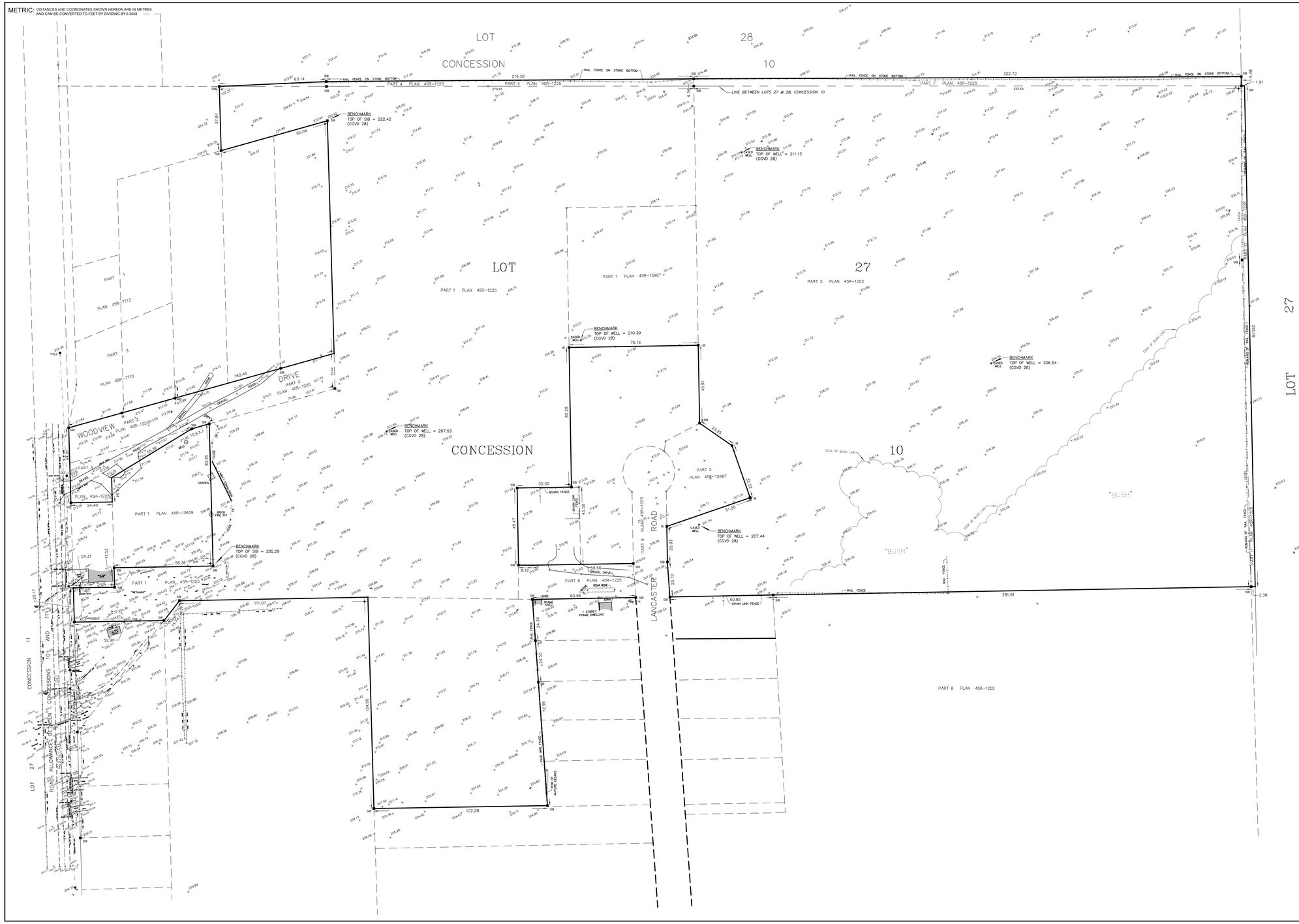
Drawn By: JC	Scale: See Scale Bar
Checked: IA	Date: Sept, 2020
Project No.: 19-10872	Drawing File No.: APP - A2

Appendix B

Topographic Survey

METRIC: DISTANCES AND COORDINATES SHOWN HEREON ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

CAUTION: THIS IS NOT A PLAN OF SURVEY



TOPOGRAPHIC DETAIL OF
WOODLAND SUBDIVISION
TOWNSHIP OF OTONABEE-SOUTH MONAGHAN
COUNTY OF PETERBOROUGH

0 15 45 75

SCALE: 1:750

DATE: 13 JANUARY 2020

LEGEND

■ . . . . . DENOTES SURVEY MONUMENT FOUND
INV. . . . . DENOTES INVERT
202.82 × . . . . . DENOTES SPOT ELEVATION CGVD 28
CGVD(28) . . . . . DENOTES CANADIAN GEODETIC VERTICAL DATUM OF 1928

LEGAL DESCRIPTION

PART OF LOTS 27 & 28
CONCESSION 10
GEOGRAPHIC TOWNSHIP OF OTONABEE
TOWNSHIP OF OTONABEE-SOUTH MONAGHAN

JBF SURVEYORS
44 CLEMENTI ST., BOX 70
LAKEFIELD, ON K0L 2H0
PHONE: 705-652-6198
INFO@JBFSURVEYORS.COM

PROJ. # 7369

Appendix C

Photographic Logs

Client Name:	**Site Location:**
Life at the Woodlands Inc.	Part of Lot 27, Concession 10, Burnham Line, Township of Otonabee-South Monaghan, County of Peterborough, Ontario

Photograph No.: 1
Date: May 30, 2019
Direction: East
Description: Subject Wetland near southern Subject Property boundary

Photograph No.: 2
Date: May 30, 2019
Direction: North
Description: Subject Wetland adjacent to Burnham Line

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Photograph No.: 3
Date: April 28, 2020
Direction: North
Description: Inlet of culvert at Burnham Line.

Photograph No.: 4
Date: June 03, 2020
Direction: West
Description: Drive-point DP20-03A and DP20-03B

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P. 705.742.2297 **F**. 705.748.9944 **E**. wills@dmwills.com

Photograph No.: 5
Date: June 03, 2020
Direction: East
Description: DP20-02 with backfilled test pit TP20-01 in background

Photograph No.: 6
Date: June 03, 2020
Direction: Down
Description: Test pit stratigraphy in TP20-01

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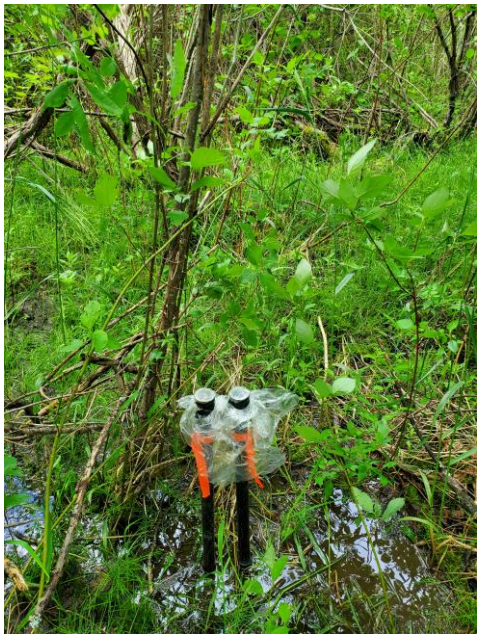
Photograph No.: 7
Date: June 03, 2020
Direction: North
Description: Drive-point DP20-01A and DP20-01B

Photograph No.: 8
Date: June 11, 2020
Direction: West
Description: Drive-point DP20-03A and DP20-03B

Photograph No.: 9
Date: June 11, 2020
Direction: West
Description: Advancing auger hole HA20-01

Photograph No.: 10
Date: June 11, 2020
Direction: West
Description: Drive-point DP20-01A and DP20-01B



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Photograph No.: 11
Date: June 11, 2020
Direction: N/A
Description: Glacial till material in auger hole HA20-02

Photograph No.: 12
Date: June 11, 2020
Direction: North
Description: Advancing drive-point DP20-02

Photograph No.: 13
Date: June 24, 2020
Direction: West
Description: Drive-point DP20-03A and DP20-03B

Photograph No.: 14
Date: June 24, 2020
Direction: West
Description: Drive-point DP20-01A and DP20-01B

D.M. Wills Associates Limited
150 Jameson Drive, Peterborough, Ontario, Canada K9J 0B9
P. 705.742.2297 **F**. 705.748.9944 **E**. wills@dmwills.com

Photograph No.: 15
Date: June 24, 2020
Direction: South
Description: Drive-point DP20-02, backfilled test pit TP20-01 location visible to the left

Photograph No.: 16
Date: July 21, 2020
Direction: West
Description: Drive-point DP20-03A and DP20-03B

D.M. Wills Associates Limited
150 Jameson Drive, Peterborough, Ontario, Canada K9J 0B9
P. 705.742.2297 **F**. 705.748.9944 **E**. wills@dmwills.com

Photograph No.: 17
Date: July 21, 2020
Direction: West
Description: Drive-point DP20-01A and DP20-01B

Photograph No.: 18
Date: July 21, 2020
Direction: East
Description: Drive-point DP20-02 Adjacent to backfilled test pit TP20-01

D.M. Wills Associates Limited
150 Jameson Drive, Peterborough, Ontario, Canada K9J 0B9
P. 705.742.2297 **F**. 705.748.9944 **E**. wills@dmwills.com

Photograph No.: 19
Date: May 30, 2020
Direction: West
Description: Surface water flowing west from culvert beneath Burnham Line.

Photograph No.: 20
Date: June 03, 2020
Direction: Northwest
Description: Surface water flowing north at northern side of Subject Wetland. Finger points in direction of flow, as indicated by vegetation orientation and movement.

Appendix D

Subsurface Investigation Logs

DRIVE-POINT DP20-1A

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 3, 2020

BOREHOLE TYPE: 1.25" OD drive-point well | **PREPARED BY:** JC

UTM: 17 T 0718310 E 4909317 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE TYPE (#)	SAMPLE 'N' VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE VAPOUR (ppm)	"N" VALUE / SHEAR STRENGTH (10 20 30 40 50)	WATER CONTENT % (10 20 30) W_P W_L	REMARKS
0											WELL DETAILS: – 1.25" OD WELL INSTALLED TO 0.65m – SCREEN INTERVAL: 0.65m TO 0.90m – STEEL STICK UP OF 0.68m STATIC WATER LEVEL: JUNE 3, 2020 1.27mBTP JUNE 11, 2020 0.94mBTP JUNE 26, 2020 1.07mBTP
0.5											
0.90											
1	DRIVE–POINT WELL INSTALLED TO 0.90 M										
1.5											
2											
2.5											
3											
3.5											
4											
4.5											
5											

DRIVE-POINT DP20-1B

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 3, 2020

BOREHOLE TYPE: 1.25" OD drive-point well | **PREPARED BY:** JC

UTM: 17 T 0718310 E 4909317 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE: TYPE (#)	SAMPLE: 'N' VALUE	SAMPLE: % WATER	SAMPLE: % RECOVERY	SAMPLE: VAPOUR (ppm)	"N" VALUE 10 20 30 40 50 / SHEAR STRENGTH	WATER CONTENT % 10 20 30 (W_P – W_L)	REMARKS
0											WELL DETAILS: – 1.25" OD WELL INSTALLED TO 0.03m – SCREEN INTERVAL: 0.03m TO 0.28m – STEEL STICK UP OF 0.68m STATIC WATER LEVEL: JUNE 3, 2020 0.64mBTP JUNE 11, 2020 0.63mBTP JUNE 26, 2020 DRY
0.28											
0.5	DRIVE–POINT WELL INSTALLED TO 0.28 M										
1											
1.5											
2											
2.5											
3											
3.5											
4											
4.5											
5											

DRIVE-POINT DP20-2

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 3, 2020

BOREHOLE TYPE: 1.25" OD drive-point well | **PREPARED BY:** JC

UTM: 17 T 0718320 E 4909235 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE: TYPE (#)	SAMPLE: 'N' VALUE	SAMPLE: % WATER	SAMPLE: % RECOVERY	SAMPLE: VAPOUR (ppm)	"N" VALUE 10 20 30 40 50 / SHEAR STRENGTH	WATER CONTENT % 10 20 30 (W_P – W_L)	REMARKS
0											INSTALLATION DETAILS: JUNE 3, 2020 –1.25" OD WELL INSTALLED TO 0.72m –SCREEN INTERVAL: 0.72m TO 0.97m – STELL STICK UP OF 0.62m JUNE 11, 2020 –ADVANCED 1.25" OD WELL INSTALLED TO 1.78m – ADVANCED SCREEN INTERVAL: 1.78m TO 2.03m – STEEL STICK UP OF 0.67m STATIC WATER LEVEL: JUNE 3, 2020 DRY JUNE 11, 2020 DRY JUNE 26, 2020 DRY
0.5											
1											
1.5											
2	2.03										
2.5	DRIVE–POINT WELL INSTALLED TO 2.03 M										
3											
3.5											
4											
4.5											
5											

DRIVE-POINT DP20-3A

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 3, 2020

BOREHOLE TYPE: 1.25" OD drive-point well | **PREPARED BY:** JC

UTM: 17 T 0718280 E 4909122 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE: TYPE (#)	SAMPLE: 'N' VALUE	SAMPLE: % WATER	SAMPLE: % RECOVERY	SAMPLE: VAPOUR (ppm)	"N" VALUE 10 20 30 40 50 / SHEAR STRENGTH	WATER CONTENT % 10 20 30 (W_P – W_L)	REMARKS
0											WELL DETAILS: – 1.25" OD WELL INSTALLED TO 0.63m – SCREEN INTERVAL: 0.63m TO 0.88m – STEEL STICK UP OF 0.70m STATIC WATER LEVEL: JUNE 3, 2020 1.105mBTP JUNE 11, 2020 0.63mBTP JUNE 26, 2020 1.30mBTP
0.5											
0.88											
1	DRIVE–POINT WELL INSTALLED TO 0.90 M										
1.5											
2											
2.5											
3											
3.5											
4											
4.5											
5											

DRIVE-POINT DP20-3B

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 3, 2020

BOREHOLE TYPE: 1.25" OD drive-point well | **PREPARED BY:** JC

UTM: 17 T 0718280 E 4909122 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE: TYPE (#)	SAMPLE: 'N' VALUE	SAMPLE: % WATER	SAMPLE: % RECOVERY	SAMPLE: VAPOUR (ppm)	"N" VALUE 10 20 30 40 50 / SHEAR STRENGTH	WATER CONTENT % 10 20 30 / W_P W_L	REMARKS
0											
0.26											WELL DETAILS: – 1.25" OD WELL INSTALLED TO 0.01m – SCREEN INTERVAL: 0.01m TO 0.26m – STEEL STICK UP OF 0.70m STATIC WATER LEVEL: JUNE 3, 2020 0.65mBTP JUNE 11, 2020 0.64mBTP JUNE 26, 2020 DRY
	DRIVE–POINT WELL INSTALLED TO 0.26 M										
0.5											
1											
1.5											
2											
2.5											
3											
3.5											
4											
4.5											
5											

WILLS

Test Pit Log – TP20-01

Depth (mbeg)	Soil Description
0.0 – 0.6	Topsoil – Dark brown silty sand, rootlets, occasional cobble, moist.
0.6 – 0.7	Dark brown silty sand, organics, wet.
0.7 – 0.85	Till – Light brown silty sand, some clay, trace gravel, occasional cobble, saturated.

Grab Sample Summary

- GS-01 collected at approximately 0.50 mbeg.
- GS-02 collected at approximately 0.65 mbeg.
- GS-03 collected at approximately 0.80 mbeg.

Groundwater

- Grab sample saturated at 0.80 mbeg.

Additional Notes

- Test pit terminated at 0.85 mbeg.
- Test pit backfilled and compacted using shovel following completion of stratigraphic logging and sampling.

Test Pit Photos

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BOREHOLE HA20-01

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 11, 2020

BOREHOLE TYPE: 2.25" Diameter Hand Auger | **PREPARED BY:** JC

UTM: 17 T 0718280 E 4909122 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE TYPE (#)	SAMPLE 'N' VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE VAPOUR (ppm)	"N" VALUE / SHEAR STRENGTH (10 20 30 40 50)	WATER CONTENT % (10 20 30) W_P W_L	REMARKS
0											
0.25	SANDY SILT: DARK BROWN SANDY SILT, ORGANICS, SATURATED										
0.5	SILTY SAND TILL: LIGHT GREY BROWN WITH ORANGE MOTTLING, SILTY SAND TILL, SOME CLAY, TRACE GRAVEL, SATURATED			AS-1							
	– DECREASING GRAVEL CONTENT			AS-2							
1	– SOME SILT, TRACE CLAY, SATURATED.			AS-3							–DIFFICULTY AUGERING AT 0.8 m DUE TO COMPACTNESS OF MATERIAL
1.05	BOREHOLE TERMINATED AT 1.05m IN SILTY SAND TILL. BOREHOLE OPEN, GROUNDWATER AT SURFACE.										
1.5											
2											
2.5											
3											
3.5											
4											
4.5											
5											

BOREHOLE HA20-02

PROJECT NAME: Woodland Subdivision | **PROJECT NO.:** 20-10874

CLIENT: Life at the Woodland Inc. | **DATE:** June 11, 2020

BOREHOLE TYPE: 2.25" Diameter Hand Auger | **PREPARED BY:** JC

UTM: 17 T 0718310 E 4909317 N | **REVIEWED BY:** IA

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STATIC WATER LEVEL	MONITOR DETAILS	SAMPLE TYPE (#)	SAMPLE 'N' VALUE	SAMPLE % WATER	SAMPLE % RECOVERY	SAMPLE VAPOUR (ppm)	"N" VALUE / SHEAR STRENGTH (10 20 30 40 50)	WATER CONTENT % (10 20 30) W_P W_L	REMARKS
0											
	SANDY SILT: DARK BROWN SANDY SILT, ORGANICS, SATURATED										
0.25											
	SILTY SAND TILL: LIGHT GREY WITH ORANGE MOTTLING, SILTY SAND TILL, SOME CLAY, TRACE GRAVEL, SATURATED			AS-1							
0.5											
	– MOTTLED BROWN TO GREY BROWN, SILT AND SAND, SOME CLAY TO CLAYEY. MWTPL.			AS-2							
1				AS-3							
1.05											
	BOREHOLE TERMINATED AT 1.05m IN SILTY SAND TILL BOREHOLE OPEN, WATER AT SURFACE										
1.5											
2											
2.5											
3											
3.5											
4											
4.5											
5											