Hydrogeological Addendum Report for the East Half of Lot 3, Concession 2, Orangeville, ON

Revised Report

Prepared for:
Orangeville Highlands Ltd.
c/o Venta Investments Limited

Prepared by:
Azimuth Environmental
Consulting, Inc.

April 2019

AEC 11-237b

AZIMUTH ENVIRONMENTAL
CONSULTING, INC.

Environmental Assessments & Approvals

April 10, 2019 AEC 11-237b

Orangeville Highlands Ltd.
c/o Venta Investments Limited
9-2458 Dundas Street West
Mississauga, ON
L5K 1R8

Attention: Carmen Jandu

Re: **Revised Hydrogeological Addendum Report for the East Half of Lot 3, Concession 2, West of Hurontario Street, Geographic Township of Mono, in the Town of Orangeville, County of Dufferin**

Dear Ms. Jandu:

Azimuth Environmental Consulting (Azimuth) is pleased to submit our updated and revised Hydrogeological Report for the property described above. This report was prepared in order to address a number of outstanding issues identified in the September 23, 2011 letter from the Credit Valley Conservation Authority (CVC) as well as subsequent comments from a previous submission of this report which was submitted in May 2018. These include comments from the Town of Orangeville, Town of Mono and the Credit Valley Conservation Authority (CVC). Overall, the report summarizes newly collected water level and stream flow data in addition to providing an updated assessment based on that initially presented in the Jagger Hims in 2007 (***Supplemental Monitoring & Hydrogeological Assessment - Proposed Orangeville Highlands Development, Phase II***), utilizing the most recent development plan.

We would like to thank you for opportunity to complete this project. Please contact me if you have any questions or comments.

Yours truly,
AZIMUTH ENVIRONMENTAL CONSULTING, INC.

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1.0 INTRODUCTION

The purpose of this report is to summarize newly acquired hydrogeological data to satisfy some remaining issues presented by Michael Crechiolo of the Credit Valley Conservation Authority (CVC) in a September 23, 2011 letter to the Director of Planning with the City of Orangeville, as well as comments received by the CVC, Town of Orangeville and Town of Mono from a previous submission of this report in May 2018. The subject property has previously been referred to as the ***Orangeville Highland Development – Phase 2*** and is located on Part of East Half Lot 3, Concession 2, W.H.S, Formerly in the Township of Mono, currently the Town of Orangeville, County of Dufferin.

Specifically, the following issues were raised and have been addressed in subsequent sections of this report.

- Measurement of high ground water levels in the areas of the proposed SWMP and retaining walls. New monitoring wells are to target these areas and be monitored in conjunction with the existing monitoring network;
- Seasonal contributions of ground water discharge to terrestrial features and Middle Monora Creek are to be characterized. Describe how those features will be maintained post-development;
- Updated feature based water balance incorporating the ground water level monitoring;
- Clarification of the description of the highest measured water levels presented by Jagger Hims;
- Presentation of ground water elevation and flow mapping in relation to site grading, subsurface infrastructure, retaining wall depths, SWMP / outlets and basement depths;
- A discussion of the implications of site grading on recharge potential of the site;
- Proposed construction and post construction monitoring program;
- Discussion regarding the quality and quantity impacts resulting from increased impermeable area and mitigation measures proposed to address these potential impacts such that impacts to adjacent private wells are prevented.

It should be noted that this report represents an addendum to the previous Hydrogeological Investigation completed by Jagger Hims Ltd in 2007. As such, for reference the reader is directed to review this report (Appendix E) for a more detailed description of the geological and hydrogeological conditions at the site.

2.0 2013 & 2017 FIELD WORK

In order to address a few of the items noted above, field work upon at the site was undertaken beginning in April 2013 where a number of geotechnical boreholes (14) were constructed by Soil-Mat Engineers and Consultants (Soil Mat). Three of these boreholes (MW-1, 2 & 3) were equipped with monitoring wells in accordance with O. Reg. 903 to establish water table elevations in the areas of the proposed SWMP and proposed retaining walls (Figure 2).

A review of the borehole logs (Appendix C) indicates the shallow soils encountered (>7 mbgs) were described as fine sand / fine sandy silt across the site, which is generally similar to what was observed in the original boreholes installed in 2005 as part of the Jagger Hims original Hydrogeological Investigation. However, it is noted that the historic logs provide slightly more detailed descriptions which include a greater degree of stratification with sand at surface, transitioning into a silt till at most of the locations. The fact the Soil Mat logs indicate finer grained sand and silt is likely a function of these wells being located at lower elevations at the Site such that they are intersecting the glacial till found deeper as noted in the Jagger Hims logs.

As these new monitoring wells were installed to determine water table elevations, including establishment of high water table conditions at the site, water level monitoring began immediately following the installation of the new wells and included supplemental water level monitoring of the historical monitoring wells at the Site. In order to correlate the ground water elevation data between the new constructed and historical monitoring wells, the new wells were surveyed by Soil-Mat and Azimuth tied these elevations into the existing monitoring well network.

In addition to the monitoring wells discussed above, one additional ground water monitoring point (MW-10) was installed adjacent to the south branch of the Middle Monora Creek (Figure 2). This monitoring well was a shallow standpipe installed by hand to a depth of 1.8 mbgs. The purpose of this monitoring point was to establish shallow ground water levels relative to ground surface to establish whether the area adjacent to the creek represents a ground water discharge area. The soils observed during this installation were mainly fine grained sand, similar to what is described in Site borehole logs.

This water level monitoring program also included the installation of two dataloggers at MW-2 and MW-10 to provide continuous (30 minute interval) water level measurements for the monitoring period, which are illustrated in Appendix B.

The monitoring program also included measurement of stream flow at both the Middle Monora Creek to the north of the Site and the Lower Monora Creek to the south. Stream flow measurements were completed on three separate dates during 2013 in conjunction with the water level monitoring program and included collection of both up and downstream flows for both water courses, with the purpose of establishing potential variability in baseflow. Follow-up measurements of both flow and water levels were also completed in 2017 in order to update the database.

3.0 RESULTS

3.1 Ground Water Elevations

As illustrated in Table 1 (Appendix B), the recent ground water elevations within the historical wells show similar results to those measured historically and although only three measurements were collected, similar seasonal trending is observed with ground water levels declining at all locations following the spring freshet. However, it was noted that the springtime ground water elevations measured during April 2013 were lower than those observed during 2005 and 2006 with the exception of BH05-F I/II which indicated elevations similar during both periods. Given this location showed limited seasonal variability compared to the other locations, the lack of variance is not surprising.

Based on the difference in seasonal data between the 2013 /2017 and historical data, a comparison was completed between these two data sets to estimate a high ground water elevation mark for the three new monitoring wells. This was done by looking at the variance at the closest historical monitoring well to each of the new monitoring wells. The following table summarizes this comparison for each location. It is noted that the historical high elevation utilized the values on May 8, 2006 as this represented the monitoring event with the most locations with a maximum value.

MW-1

Closest Historical Monitoring Well	**BH05-A-I**
Historical GW Elevation at closest well	429.2 (May, 2006)
2013 GW Elevation	428.43 (May, 2013)
Difference	0.77 m
2013 MW-1 GW Elevation	426.66 (April, 2013)
Estimated GW Elevation High at MW-1	**427.43**

* - All elevations in masl

MW-3

Closest Historical Monitoring Well	**BH05-E-I**
Historical GW Elevation at closest well	421.75 (May, 2006)
2013 GW Elevation	421.55 (April, 2013)
Difference	0.20 m
2013 MW-3 GW Elevation	420.35 (April, 2013)
Estimated GW Elevation High at MW-3	**420.55**

* - All elevations in masl

No estimate was calculated for MW-2 as the 2013 ground water elevations at MW05-F-I (closest historical monitoring well) were more elevated during 2013 than in 2005/06.

Ground water elevations have been plotted on Figure 3 to establish ground water flow direction. As expected, ground water flow direction generally follows the topography of the Site towards the east, which matches historical representations of ground water flow patterns. It is noted that the contours were generated with AutoCAD using point ground water elevation data for each monitoring well. These contours were reviewed to ensure appropriateness given the local topography and environmental setting.

As indicated in the review comments, some clarification was requested with respect to the discussion on highest measured ground water levels as it was indicated that the report focused on the 2005 data, while the most elevated levels were noted during 2006. A review of the historical and more recent ground water elevation data indicates that there is some variability in seasonal ground water elevations. The wells located at lower elevations to the east of the property were shown to be more elevated in 2006 while the western locations are topographically higher and indicated higher ground water elevations in 2005. It is likely this variance is a function of climatic response and timing of the measurements following rainfall events. This variance is illustrated in the hydrograph for the continuous water level monitoring at BH05-E (Figure 9, Jagger Hims, 2006) (Appendix E) and Figure 3 which illustrates continuous ground water elevations at MW-2.

The high water table elevation contours were also presented on the Site grading plan completed by Urbantech as part of their FSR. Proposed grading ensures that basements and retaining walls will be situated at minimum 0.5 m above the maximum observed water table. Similarly, all proposed LID's have been proposed to be constructed at an elevation of greater than 1.0 m above the water table (Appendix D). In addition, the wet portion of the storm water management pond and forebay are designed to be below the water table, while the remaining components are near the high water table elevation. As such, the pond and forebay are proposed to be lined, which would limit the hydraulic connection between the pond and underlying aquifer. The servicing details for the property are not known to date, however, may intersect the water table in certain areas of the property depending on the elevations required. Temporary dewatering may be required in these areas to create a dry working area during installation, or may be possibly avoided if the work is completed during the summer when the water table is depressed. No permanent alterations will be expected as a result of these installations; however, it is recommended that trench plugs could be used to eliminate permanent dewatering along these servicing trenches in the areas where the utility trenches are below the high water table. Similarly, as the wet portion of the pond and forebay are designed to be below the water table, temporary dewatering may be required to facilitate construction of the facility.

Although not surveyed, water levels in MW-10 were measured to establish whether the area adjacent to the stream represents a ground water discharge area. The continuous water level measurements (Appendix B) indicated much more consistent water levels than those observed within the upland area of the property. Despite saturated ground conditions noted in the area, upward (artesian) vertical gradients were not observed with the water levels remaining consistent approximately 0.2 mbgs. These measurements support field observations made during this monitoring period that no pooled areas with outflow or other flow channels were observed during these Site visits indicating no specific ground water seep or springs are present in the valley. Despite this, the shallow water levels at MW10 would indicate that there likely is a hydraulic connection between the shallow water table and creek, which would support the creek as a potential ground water discharge feature. However, it is also noted that the differential between the fluctuation in ground water levels in the upland sections of the Site (up to 0.7 m during 2013) and the valley area (<0.1 m) indicates that contributions beyond the Site area likely have more influence than that from the Site itself, which is supported by the fact the developable area of the Site is approximately 40 times smaller than the watershed area for adjacent creeks.

3.2 Stream Flow

Stream flow measurements were collected at both the middle and lower Monora Creek at both upstream and downstream locations to establish whether an increase in baseflow is observed in the area of the subject property as a result of ground water discharge. Flow measurements were determined through the use of a Global Water Flow Probe meter to establish velocity over a measured cross-section of the watercourse at a location where turbulence or eddy effects would be minimal (i.e. relatively uniform streambed and free of debris).

The stream flow measurements are summarized in the following table and indicate that there is an increase in baseflow downstream of the subject property, which would be attributable to ground water discharge as the small additional tributaries (SW1a & SW2a) measured during the 2017 field measurements do not contribute a meaningful amount of flow to these features. Of the two features, the Middle Monora Creek is interpreted to represent a more dominant ground water receptor than Lower Monora Creek due to both the elevated flows and downstream differential. It is also noted that the degree of baseflow contribution is seasonal as the there is a decline in both overall flow, as well as the increase in downstream flow during the summer. It is noted that these results contradict those collected by Jagger Hims in 2005, which indicated more consistent flows between up and downstream locations (Section 4.8, Appendix E). As the Jagger Hims measurements were collected in the spring time (April), the degree of baseflow may have been muted by higher flows derived from upstream sources. This is supported by the fact the recent flow measurements indicated a seasonal increase in baseflow in June, 2013 & 2017.

Table 1: Stream Flow Measurements

	Stream Flow Measurements (m^3/sec)							
Location	**29-Apr-13**		**24-May-13**		**26-Jun-13**		**7-Jun-17**	
SW-1 (Upstream)	0.0082		0.0038		0.0010		0.0048	
SW-1a (mid location)	Not Measured		Not Measured		Not Measured		0.0005	
SW-1 (Downstream)	0.0202		0.0126		0.0051		0.0208	
Difference	***0.0120***	***145%***	***0.0088***	***232%***	***0.0041***	***410%***	***0.0165***	***343%***
SW-2 (Upstream)	0.0399		0.0280		0.0218		0.0638	
SW-2a (mid location)	Not Measured		Not Measured		Not Measured		0.0127	
SW-2 (Downstream)	0.0590		0.0372		0.0305		0.0833	
Difference	***0.0191***	***48%***	***0.0092***	***33%***	***0.0087***	***40%***	***0.0322***	***50%***

* - Locations identified on Figure 2

4.0 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). It is noted that the approach and variables have generally been maintained from the previous submission as the approach was endorsed by the CVC in their review comments. The "pre-development" case is based on the existing conditions, i.e. undeveloped. This method evaluated 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 approach used by many individuals in examining infiltration resets the 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 Orangeville, Ontario between 1969 and 2015 (Orangeville Climate Station – Station ID 6155790). The calculations are based on the average conditions during this period. The average precipitation was 896 millimeters (mm), rainfall was 675 mm, evapotranspiration was 502 mm, and the surplus was 393 mm per year. It is noted that this climate station was closed at the end of 2015, as such; the dataset is as complete as can be with the available data. Despite a lack of more recent data, the extended period of record makes it appropriate when looking at long term climate averages.

Infiltration rates for the Site were estimated taking into account site specific soils data collected during both the Jagger Hims Hydrogeological Assessment and Soil Mat Geotechnical Investigation (borehole logs in Appendix C & E), local topography and ground cover. These variables for the infiltration factor were based on Table 2 of the Ministry of Environment, Conservation & Parks (MECP) Hydrogeological Technical Information Requirements for Land Development Applications (1995). The infiltration factors utilized in this assessment are 0.70 and 0.75 and are based on the following.

Table 2: Infiltration Factors

Factor	**Classification**	**Value of Factor**			
		Pre-Development		**Post-Development**	
		Cultivated / Grasslands	**Forested**	**Cultivated / Grasslands**	**Forested**
Topography	Flat Land, <0.6m per km	0.25	0.25	0.25	0.25
Soils	Med. / Fine Sand to Silty Sand	0.30	0.30	0.30	0.30
Cover	Forested		0.20		0.20
	Cultivated / Grasslands	0.15		0.15	
Total		**0.70**	**0.75**	**0.70**	**0.75**

By multiplying the annual average surplus amount (393 mm) by the soil infiltration rates (70 & 75%), infiltration is estimated to be approximately 275 & 295 mm/year for the

Site. It is noted that infiltration factors between pre and post development will be kept consistent as the Site is currently cultivated / grasslands, while the post-development scenario will maintain this in all pervious sections within the developed portion of the site. Similarly, grading will not significantly alter the overall Site topography such that the infiltration factor has not been adjusted in the post-development scenario; however, from a ground water infiltration perspective, the reduction in overall relief across the site to facilitate construction would enhance the potential for infiltration.

As this water balance is being presented as a feature based assessment, the areas were divided into three catchments which are based on topography, ground water flow direction as well as the presence of a *Wellhead Protection Area (WHPA Q1/2)* at the eastern end of the property. It is noted that these areas were established in communication with the CVC in December 2018. More discussion related to the WHPA area is provided in Section 5.0, although it is noted that the WHPA area catchment matches the boundary established in the Source Water Protection Area mapping. The second catchment area represents the area interpreted to contribute to the water course and associated wetland feature at the north end of the Site and is based more on the localized topographic relief in the northern section of the Site. The final area is the remainder of the which based on ground water flow mapping (Figure 3) indicates a defined easterly flow path generally correlating to the easterly slope of the Site. For reference, these catchment areas are illustrated on Figure 2.

The 2018 water balance submission included informal ground water infiltration mitigation measures such as discharge of rooftop runoff to adjacent yards. However, with additional information provided by Urbantech as part of their 2019 Functional Servicing Report (FSR), the majority of ground water infiltration mitigation will be completed as part of formal LID's (infiltration trenches). The details relating to these features are provided in the following section, while design information can be referenced in the FSR.

4.1 Low Impact Design (LID) Mitigation Measures

Based on previous comments received by the CVC, it is understood that previously provided ground water infiltration deficits (38%) did not meet requirements established by the CVC and that the deficit needs to be reduced through the creation of additional mitigation measures. As presented in the FSR, as well as illustrated in the LID drainage plan provided in Appendix D, Urbantech has identified a number of locations for potential LID features as well as their associated sizing details. As a result, the water balance has incorporated these volumes in order to show the potential for a much closer match in each of the catchments / features summarized in the following sections.

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 Orangeville Climate station. Rainfall events over the past 6 years (2010 – 2015) 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 (675 mm) utilized in the overall water balance to obtain an annual average amount / depth for the various intervals.

Table 3: Rainfall Frequency Evaluation

	Total	25 mm	20mm	15mm	12mm	10mm	9mm	8mm	7mm	6mm	5mm	4mm
Total Depth (mm)	4,446	4,065	3,904	3,594	3,307	3,063	2,914	2,748	2,551	2,326	2,072	1,789
Percent of Total Rainfall	100%	91%	88%	81%	74%	69%	66%	62%	57%	52%	47%	40%
Rainfall Depth (mm)	**675**	**617**	**593**	**546**	**502**	**465**	**442**	**417**	**387**	**353**	**315**	**272**

* - Rainfall depths are cumulative with increasing rainfall event size.

It is noted that the above breakdown does not extend beyond the 25 mm event, although some of the LID's are proposed to capture larger events. As the annual amount for the larger (>25 MM) storm events represent only 9% of the total rainfall, a more detailed breakdown was not completed and the 25 mm event was utilized for all sizing above this threshold. As such, it is noted that this does add a level of conservancy to the evaluation.

As each of the LID's have different rainfall event sizing (Appendix D), infiltration values were established for each LID independently and totaled for each feature / catchment. It is noted that these boundaries are based on topographic relief and policy boundaries (WHPA Q1/Q2) area such that ground water recharge and flow would not follow these exact boundaries. As such, variance associated with this overlap is not seen as significant enough to provide a meaningful enough change in the values, such that the infiltration volumes have been assumed to be incorporated into the feature / catchment where the LID is located. In the case of LID 9 and LID 10, a percentage of the total for each was taken to represent a portion going to both the Middle Medora Creek and Tableland catchment / feature areas.

In order to quantify the annual infiltration volumes for each LID, the annual rainfall depth discussed above is multiplied by the catchment area for that specific LID, while a 20% evaporation loss factor was employed for runoff collected on all impervious surfaces. It is noted that this factor is a common assumption in water balance assessments and is based on standards presented in *Conservation Guidelines for Hydrogeological Assessments* (Cuddy & Chan, 2013). For capture of runoff from pervious surfaces, infiltration and evapotranspiration were considered such that the runoff was calculated as a percentage of surplus (17% or 118 mm/year).

Finally, it is noted that added conservancy is reflected in these numbers through discounting of snow melt. Although difficult to quantify due to seasonal storage and movement (i.e. snow banks, snow dumps), it can provide a potential meaningful contribution as it represents ~31% of total precipitation.

4.2 Feature Based Water Balance Assessment

Using the climate model data, calculations and LID measures mentioned above, the following pre- and post-development infiltration values have been determined for each of the feature catchments.

Table 4: Water Balance Summary – WHPA Q1/Q2 Area

Parameter		Pre-Development	Post-Development No Mitigation	Post-Development With Mitigation
Annual Rainfall (mm)		675	675	675
Annual Surplus (mm)		393	393	393
Infiltration Factor (Grassland)*		0.7	0.7	0.7
Infiltration Factor (Forest)*		0.75	0.75	0.75
Feature Area (m^2)		38,400	38,400	38,400
Total Non-Hard Surface Area (pervious) (m^2)		38,400	25,400	25,400
Total Hard Surface Area (impervious) (m^2)		0	13,000	13,000
Infiltration Gain From LID's		0	0	1,705
Annual Infiltration (m^3/year)		10,758	7,116	8,821
Infiltration Reduction	m^3/year	0	3,642	1,937
	%	0%	34%	18%
	mm/m^2	0	95	50

* - infiltration factor for non-hard surface areas

The results for this feature indicate a 34% (3,642 m^3) loss in ground water infiltration post development, with no mitigation measures employed. However, with the inclusion of LID's, this loss is reduced to 18% (1,937 m^3). Further, it is noted that the eastern boundary intersects LID 13, such that if infiltration from this LID were to be accounted for in this feature, the deficit would be reduced to 12% or 1,242 m^3/year. Overall, this deficit is not viewed as significant given the conservancy factors utilized in this assessment, such that this deficit would likely be overcome through snowmelt contributions to the LID.

Table 5: Water Balance Summary – Middle Medora Creek Area

Parameter		Pre-Development	Post-Development No Mitigation	Post-Development With Mitigation
Annual Rainfall (mm)		675	675	675
Annual Surplus (mm)		393	393	393
Infiltration Factor (Grassland)*		0.7	0.7	0.7
Infiltration Factor (Forest)*		0.75	0.75	0.75
Feature Area (m^2)		56,000	56,000	56,000
Total Non-Hard Surface Area (pervious) (m^2)		56,000	50,700	50,700
Total Hard Surface Area (impervious) (m^2)		0	5,300	5,300
Infiltration Gain From LID's		0	0	758
Annual Infiltration (m^3/year)		16,300	14,757	15,515
Infiltration Reduction	m^3/year	0	1,543	784
	%	0%	9%	5%
	mm/m^2	0	28	14

* - infiltration factor for non-hard surface areas

The results for this feature indicate a 9% (1,543 m^3) loss in ground water infiltration post development with no mitigation measures employed. However, with the inclusion of LID's, this loss is reduced to 5% (784 m^3). Overall, this deficit is not viewed as significant given the conservancy factors utilized in this assessment, such that this deficit would likely be overcome through snowmelt contributions the LID.

Table 6: Water Balance Summary – Tableland (remaining) Area

Parameter		Pre-Development	Post-Development No Mitigation	Post-Development With Mitigation
Annual Rainfall (mm)		675	675	675
Annual Surplus (mm)		393	393	393
Infiltration Factor (Grassland)*		0.7	0.7	0.7
Infiltration Factor (Forest)*		0.75	0.75	0.75
Feature Area (m^2)		85,300	85,300	85,300
Total Non-Hard Surface Area (pervious) (m^2)		85,300	23,900	23,900
Total Hard Surface Area (impervious) (m^2)		0	61,400	61,400
Infiltration Gain From LID's		0	0	16,998
Annual Infiltration (m^3/year)		23,466	6,575	23,573
Infiltration Reduction	m^3/year	0	16,891	-107
	%	0%	72%	0%
	mm/m^2	0	198	-1

* - infiltration factor for non-hard surface areas
negative value indicates increase

The results for this feature indicate a 72% (16,891 m^3) loss in ground water infiltration post development with no mitigation measures employed. However, with the inclusion of LID's, reduced surplus is generated to create an overall increase of 107 m^3. However, it is noted that if LID 13 is removed from this catchment and added to the WHPA catchment, the actual reduction would be 3% (588 m^3). Regardless of the inclusion of LID 13, this deficit is not viewed as significant given the conservancy factors utilized in this assessment, such that this deficit would likely be overcome through snowmelt contributions to the LID.

Table 7: Water Balance Summary – Total Site

Parameter		Pre-Development	Post-Development No Mitigation	Post-Development With Mitigation
Annual Rainfall (mm)		675	675	675
Annual Surplus (mm)		393	393	393
Infiltration Factor (Grassland)*		0.70	0.7	0.7
Infiltration Factor (Forest)*		0.75	0.75	0.75
Total Non-Hard Surface Area (pervious) (m^2)		179,700	100,000	100,000
Total Hard Surface Area (impervious) (m^2)		0	79,700	79,700
Infiltration Gain From LID's (m^3/year)		0	0	19,461
Annual Infiltration (m^3/year)		50,524	28,448	47,909
Infiltration Change	m^3/year	0	22,076	2,615
	%	0%	44%	5%
	mm/m^2	0	123	15

* - infiltration factor for non-hard surface areas

Despite the feature based assessment which was required by the CVC, it is still important to look at the water balance at a site level as entire site is ultimately contributing to the Middle Medora Creek through ground water discharge.

Post-development infiltration rates will be affected by the presence of impervious surfaces (i.e., building rooftops and asphalt roads/driveways), which based on the proposed development plan will comprise approximately 64% of the development area of the property or 44% of the entire property. Upon completion of the site development, it is estimated that there will be a loss of approximately 44% in ground water infiltration between the pre-development and post-development conditions, assuming no mitigation strategies are employed. If LID mitigation measures are employed as outlined in the Urbantech FSR, an overall recovery in ground water infiltration of approximately 19,461 m^3/year would be expected, for a net loss of approximately 5%. The deficit is re-directed to Middle Monora Creek so that it remains within the same watershed. As the deficit mainly occurs during spring and fall (periods of high water), the net effect is minimized. Finally, this deficit equates to only approximately 15 mm/year/m^2, which is insignificant relative to pre-development infiltration rate of 275 mm. A reduction of infiltration by this amount will theoretically reduce the on-site water table elevation by 0.005 to 0.015 metre, which is within the existing seasonal fluctuations, which have been shown at some monitoring wells to vary between 1.5 to 2 m, therefore is not considered to be significant.

5.0 SOURCE WATER PROTECTION

A review of the Source Water Protection Areas as identified on the MOECC Source Protection Information Atlas website indicates that the Site is not located within a *Wellhead Protection Area [WHPA (A, B, C or D)]* for quality threats or within a *Significant Groundwater Recharge Area (SGRA)*. However, the Site is situated within a *High Vulnerability Aquifer Area,* as well as partially within a *Wellhead Protection Area (WHPA Q1/2)* for quantity threat. Despite this, it is noted that only a small area of the property intersects the *WHPA Q1/2* boundary, which as illustrated on Figure 2 is mostly being maintained as parkland such that only a very small (5%) developable area encroaches in this area, which only a portion of would represent hard surface area. As stated previously, mitigation measures are proposed to help compensate for any infiltration loss resulting from the proposed development.

6.0 LOCAL PRIVATE WELL WATER SUPPLIES

It is noted that much of the surrounding area is municipally serviced through the Town of Orangeville's municipal water supply. Similarly, the proposed development will be municipally serviced for both water and sewage such that no supply wells and sewage treatment facilities are being proposed at the Site. The closest private water well supplies are noted to the north of the property along Starview Cres., Brucedale Blvd., Victoria Heights Ave., and Dodd's Crt. Most of these properties are more than 200 m from the development limits; however, some properties along Brucedale Blvd. and Victoria Heights Ave. are noted to be as close as 70 m. A detailed well survey was not completed as part of this report; however, a review of local water well records indicate that the majority of these wells target the underlying bedrock with depths of approximately 20 m. The fact the majority of wells target this deeper unit would provide protection from surficial influences or localized ground water recharge. Despite this, there were some more shallow well constructions targeting shallower depths within the overburden (~12 m) noted in the area, but do not represent the primary target aquifer.

Impacts from the proposed development are limited due to the fact the proposed development is municipally serviced such that no permanent water taking will be occurring to facilitate water supply to the new residential units. Similarly, as noted in the above water balance, the LID measures proposed in the FSR (i.e. infiltration trenches) will provide mitigation to the loss of infiltration on the impervious surfaces (i.e. roads, rooftops) created as part of the development. Finally, the entire development is located south of Middle Monora Creek, which provides a hydraulic separation between the development and the private wells to the north.

With respect to water quality, the proposed development would have limited sources of contaminants which would contribute to the impairment of the shallow ground water in the area. Potential influences would be limited to road salt application along the roads servicing the Site properties. However, as these roadways are not main arterial roads, the winter maintenance is more limited than what would be applied locally on roads such as Highway 10 or Hansen Blvd. As indicated in the FSR, all surface runoff from the main Site roadways will be directed into the lined storm water management pond such that it would be released to the adjacent surface water feature rather than infiltrated. The only LID areas which potentially will receive road salt application will be the access laneways and parking area in the southern apartment blocks. Overall, exclusively “clean” or non roadway runoff will represent 50% of the LID capture volume (8,432 m^3) (LID’s 1 – 10), while the remaining LID’s represent approximately 50% capture from roadway or parking areas. As such, the overall ground water infiltration from roadway or parking areas is estimated to represent approximately 10% of the overall post development infiltration. Given this limited contribution, it is not expected that road salt would create a meaningful contribution to the ground water quality beneath the Site compared to what is already being applied within the entire watershed for the adjacent creeks, which is approximately 40 times larger than the developable area of the Site.

Finally, there would be similar protection to the private wells to the north due to the hydraulic separation of the creek and the upslope / upgradient location of these private wells from the creek. It is also noted that the predominant ground water flow path at the Site, as illustrated in Figure 3 is to the east. This is further supported by the more regional topographic dip in this direction. As a result, any water quality impairments as a result of the development would be directed east within a municipally serviced area and not north towards the private water wells.

7.0 CONCLUSIONS

Based upon our interpretation of the available data, the proposed development will not have a significant impact on the existing hydrogeological conditions of the area, including the adjacent wetland features associated with Middle Monora Creek. It has been determined that these features are likely ground water discharge areas. Although no defined seeps or springs were identified in the field, saturated ground conditions within the wetland areas and measured increases in baseflow downstream of the site indicate base flow contributions to the wetlands.

The water balance assessment completed for the proposed development plan indicates that approximately 2,615 m^3/year, or 5% of pre-development infiltration would be re-directed from infiltration to runoff, assuming that all proposed LID’s in the FSR are developed. This equates to an average of approximately 15 mm/year over the development property. A reduction of infiltration by this amount will theoretically reduce the on-site water table elevation by less than 0.5 metre, which is within the existing seasonal fluctuations, which have been shown at some monitoring wells to vary between 1.5 to 2 m, therefore is not considered to be significant.

Finally, it is also noted that the development, as well the existing surrounding development is municipally serviced, such that there are no potential for impairment of local water wells. Private wells are noted to be present along and off of Starview Crescent to the North of the Site; however, given the limited impacts to the water table resulting from the proposed development and these wells being hydraulically separated from the development by the Middle Monora Creek, a more detailed assessment of these private wells was not completed and is not proposed to be completed given the monitoring program outlined below will provide ground water level data during and post construction.

8.0 PROPOSED MONITORING PROGRAM

As required by the CVC in their review comments of the previous submission, a monitoring program is being proposed to allow for the collection of ground water and base flow data prior to, during and post construction.

This monitoring program is proposed to align with the monitoring program already completed, but with focus on Middle Medora Creek and understanding that monitoring wells will be decommissioned over much of the site to facilitate construction. It is recommended that ground water levels be monitored at MW-1, MW-3 (if monitor can be retained) as well as a replacement drivepoint peizometer in the area of MW-10 as this monitor was noted to have been destroyed. Even with the potential absence of MW-3 post construction, MW-1 and MW-10 provide strategic monitoring locations to assess ground water conditions closest to the creek such that would be most reflective of the contributions to this feature. It is proposed that dataloggers could be installed to obtain continuous data thus reducing the need for more frequent site visits to seasonal (spring, summer, fall).

In addition to the ground water monitoring, stream flow and creek water levels could be monitored with installation of stilling wells at an upstream and downstream location with installation of dataloggers at both to record continuous water level data similar to the monitoring wells. Seasonal stream flow measurements could be collected in conjunction with the manual ground water level measurements.

Implementation of this monitoring program will be scheduled prior to construction and continue throughout construction and for one year following the completion of construction.

9.0 REFERENCES

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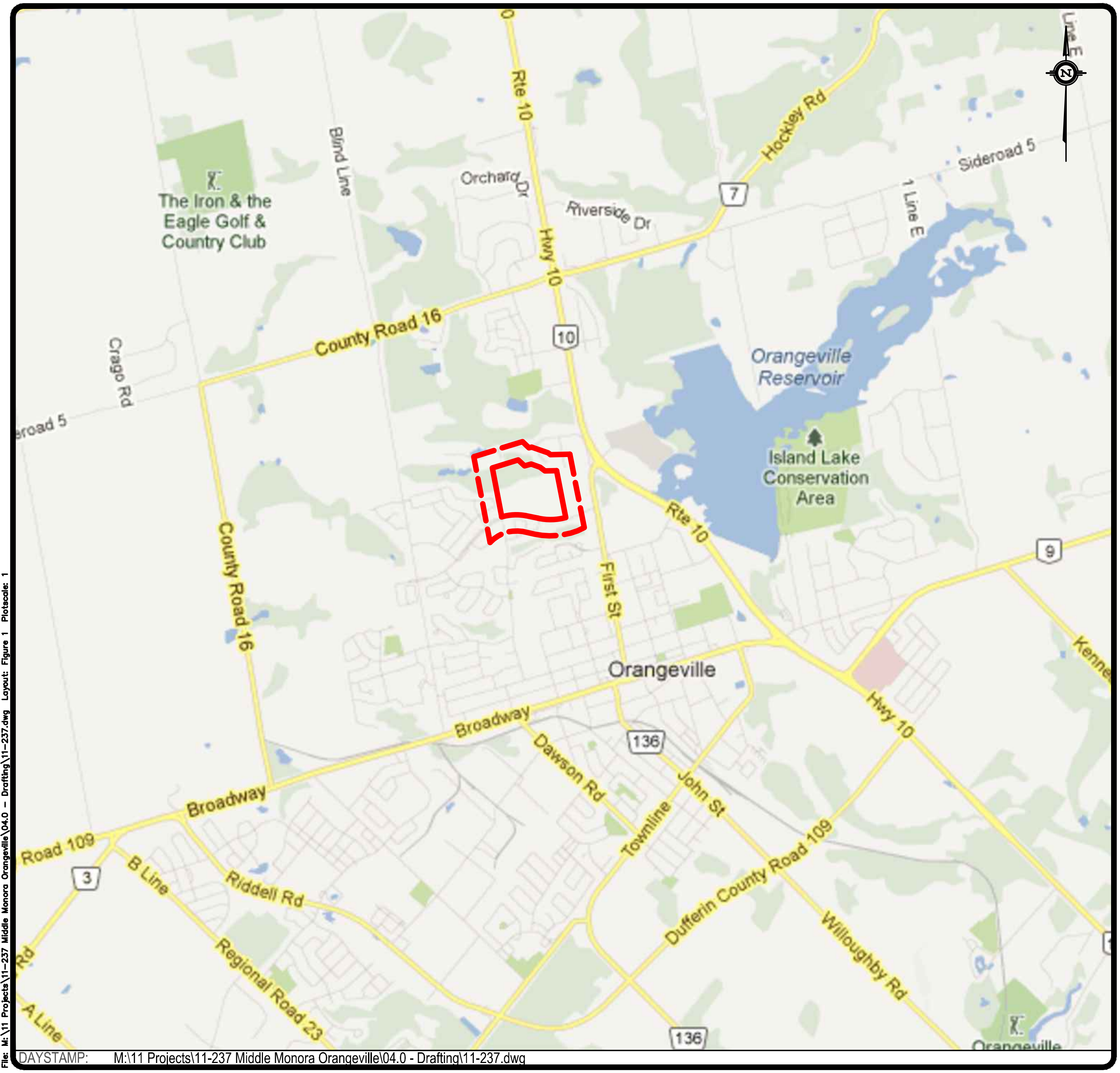
APPENDICES

Appendix A: Figures
Appendix B: Ground Water Elevations
Appendix C: Borehole Logs
Appendix D: LID Plan and Details
Appendix E: 2007 Jagger Hims Hydrogeological Assessment

APPENDIX A

Figures



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LEGEND:

- Approx. Property Boundary
- Study Area

600m 0 1200m

HORIZONTAL SCALE 1: 40,000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Study Area

Orangeville Highlands Phase 2
Orangeville, ON

DATE ISSUED: March 2018	Figure No.
CREATED BY: JLM	1
PROJECT NO.: 11-237	
REFERENCE: Google Maps	

Plotted by: JMCCARTNEY on March 14, 2018 at 10:29am Layout: Figure 1 Plotscale: 1
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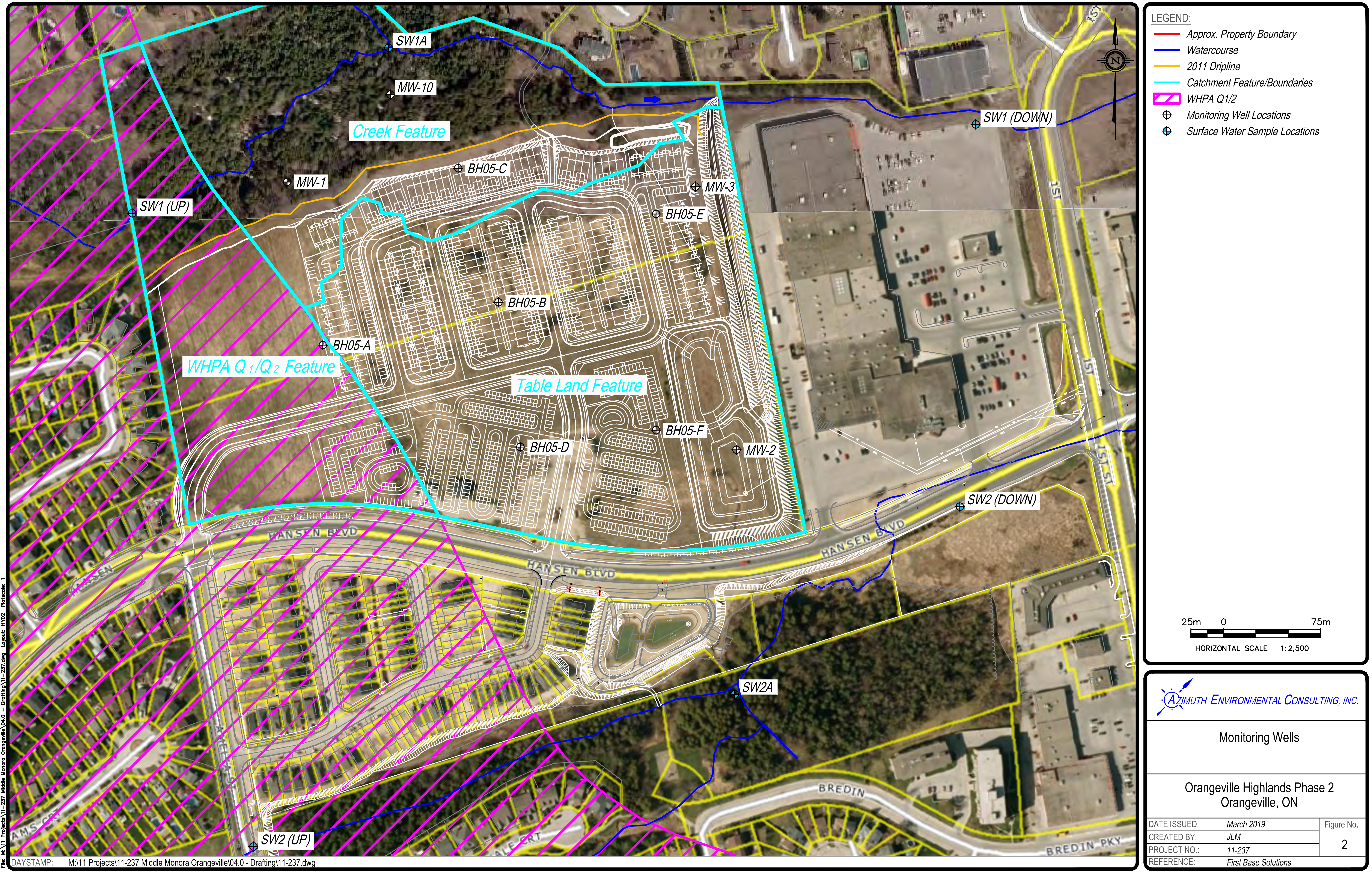

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File: M:\11 Projects\11-237 Middle Monora Orangeville\04.0 - Drafting\11-237.dwg Layout: HYD2 Plotscale: 1

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

Monitoring Wells

Orangeville Highlands Phase 2
Orangeville, ON

DATE ISSUED:	March 2019	Figure No. 2
CREATED BY:	JLM	
PROJECT NO.:	11-237	
REFERENCE:	First Base Solutions	

Plotted by: JMCCARTNEY on April 4, 2019 at 11:13am Layout: HYD3 Plotscale: 1
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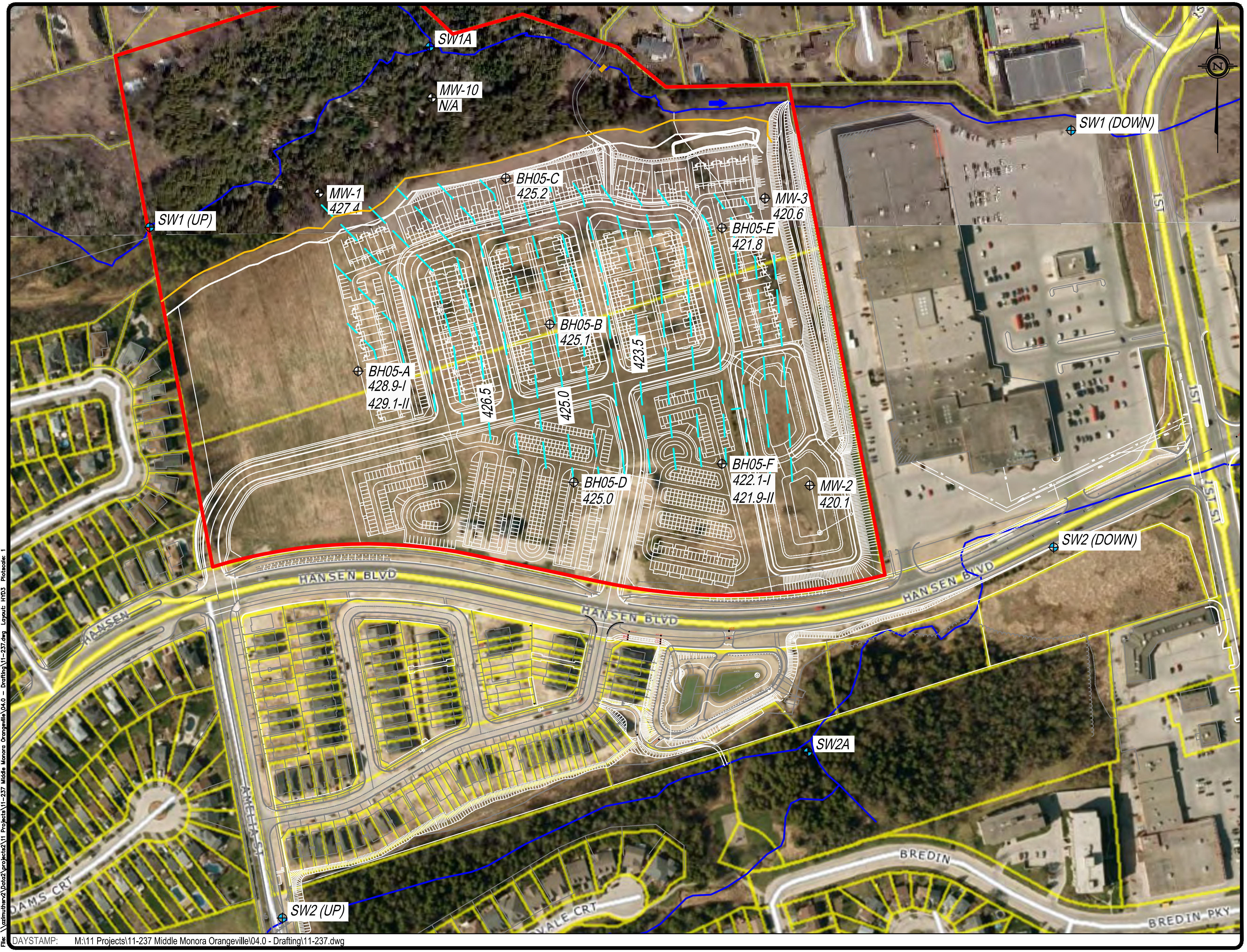

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LEGEND:

- 🟥 *Approx. Property Boundary*
- 🟦 *Watercourse*
- 🟧 *2011 Dripline*
- ⊕ *Monitoring Well Locations*
- ⊕ *Surface Water Sample Locations*
- 421.55 *Ground Water Elevation* (May 2006)*
- *Inferred Ground Water Contours*

** MW-1, MW-2, MW-3 ground water elevations extrapolated from difference between May 2016, and June 2013 at adjacent locations.*

25m 0 75m
HORIZONTAL SCALE 1:2,500

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

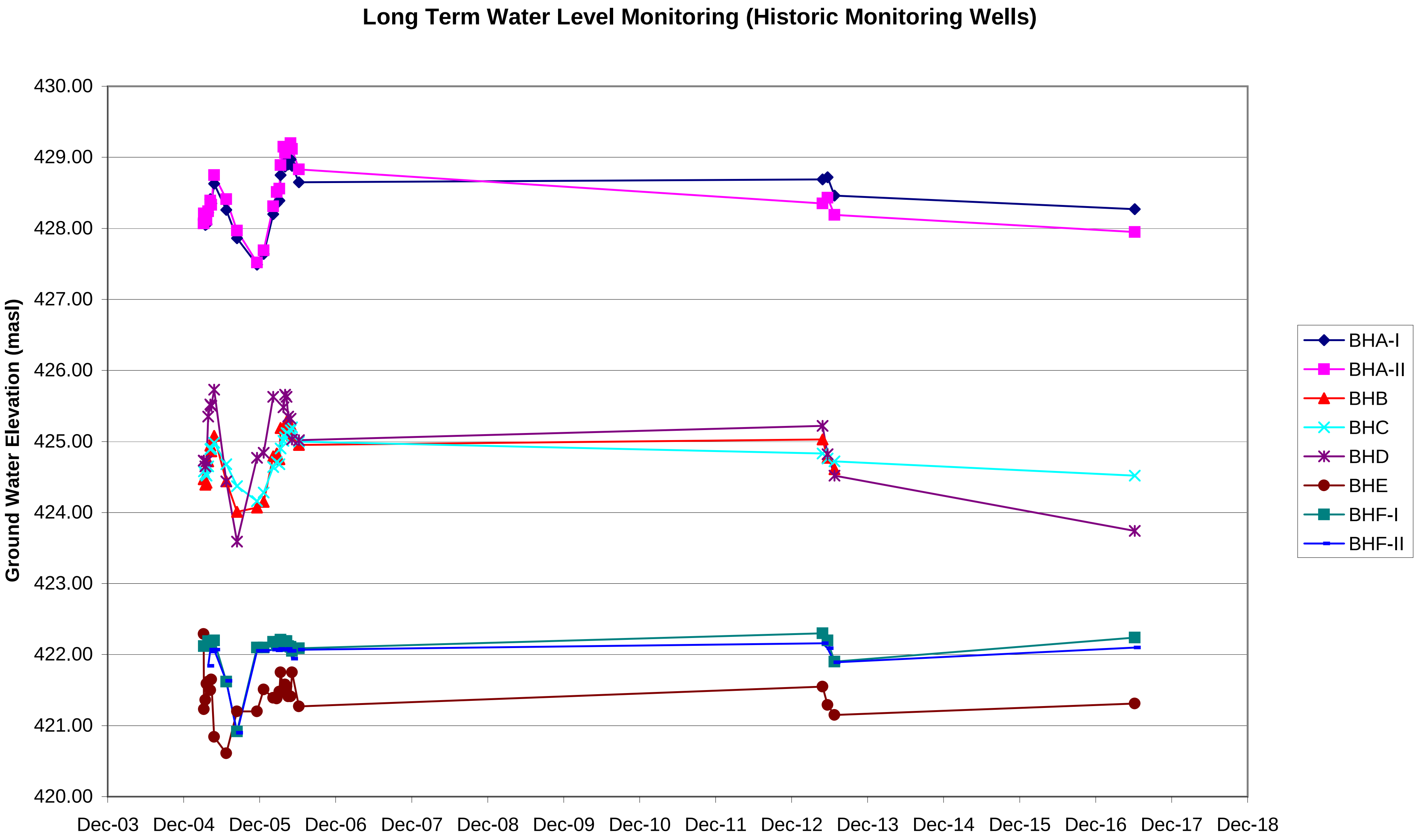
Ground Water Elevations and Contours (High Water Table Conditions)

Orangeville Highlands Phase 2
Orangeville, ON

DATE ISSUED:	March 2019	Figure No.
CREATED BY:	JLM	3
PROJECT NO.:	11-237	
REFERENCE:	First Base Solutions	

APPENDIX B

Ground Water Elevations


Long Term Water Level Monitoring (Historic Monitoring Wells)
Ground Water Elevation (masl)
430.00
429.00
428.00
427.00
426.00
425.00
424.00
423.00
422.00
421.00
420.00
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
BHA-I
BHA-II
BHB
BHC
BHD
BHE
BHF-I
BHF-II

Continuous Water Levels

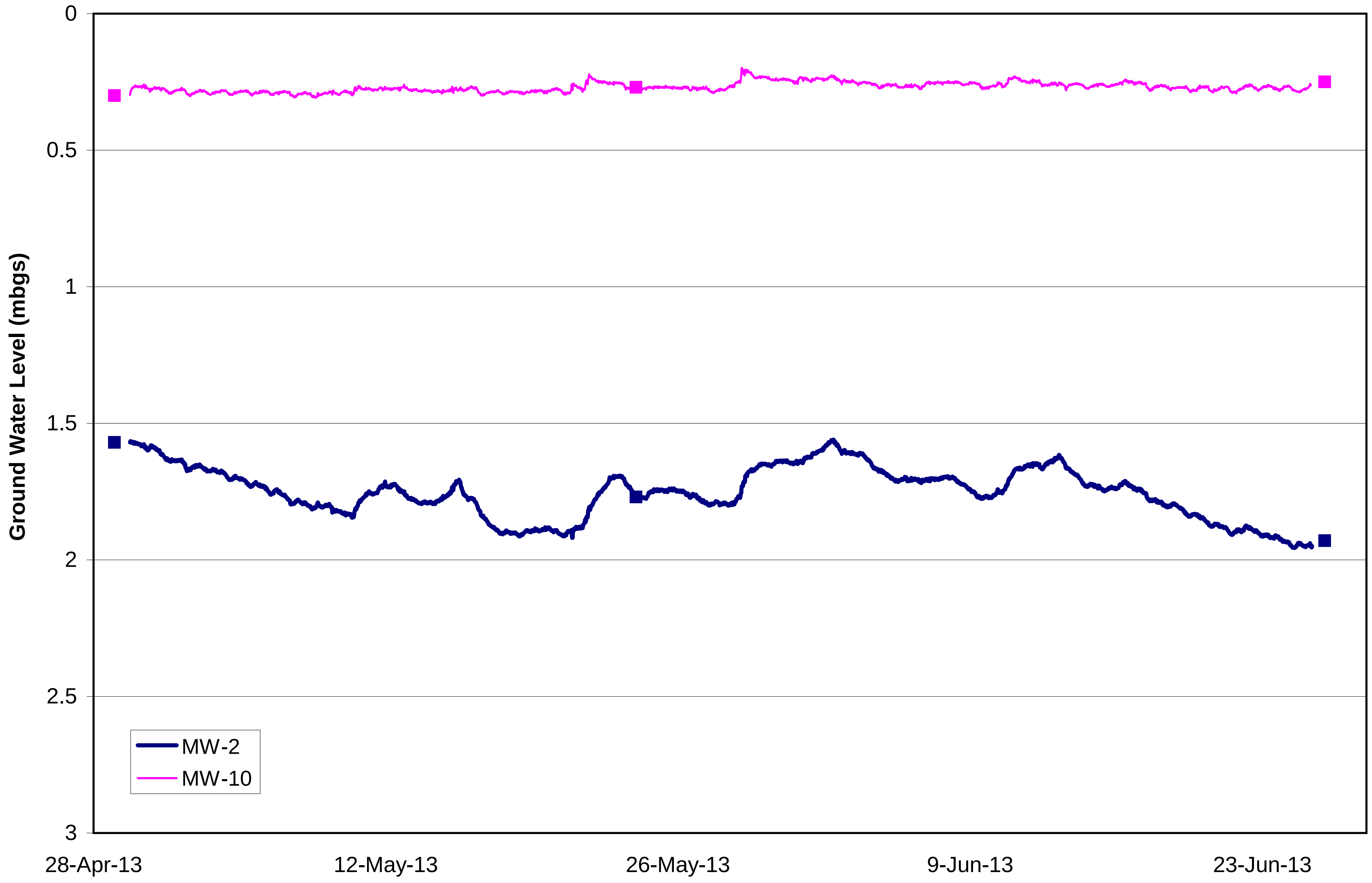


Table 2 - Historical Ground Water Elevations

BH-A-I		BH-A-II		BH-B		BH-C		BH-D		BH-E		BH-F-I		BH-F-II	
Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)	Date	Ground Water Elevation (masl)
10-Mar-05	428.12	10-Mar-05	428.07	10-Mar-05	424.47	11-Mar-05	424.58	10-Mar-05	424.73	10-Mar-05	422.29	11-Mar-05	422.12	11-Mar-05	
11-Mar-05	428.14	11-Mar-05	428.21	11-Mar-05	424.47	18-Mar-05	424.54	11-Mar-05	424.73	11-Mar-05	421.23	18-Mar-05		18-Mar-05	
18-Mar-05	428.05	18-Mar-05	428.14	18-Mar-05	424.39	24-Mar-05	424.52	18-Mar-05	424.65	18-Mar-05	421.36	24-Mar-05		24-Mar-05	
24-Mar-05	428.06	24-Mar-05	428.12	24-Mar-05	424.42	1-Apr-05	424.65	24-Mar-05	424.72	24-Mar-05	421.59	1-Apr-05	422.19	1-Apr-05	421.84
1-Apr-05	428.22	1-Apr-05	428.24	1-Apr-05	424.72	11-Apr-05	424.89	1-Apr-05	425.35	1-Apr-05	421.62	11-Apr-05	422.18	11-Apr-05	422.07
11-Apr-05	428.41	11-Apr-05	428.39	11-Apr-05	424.94	15-Apr-05	424.90	11-Apr-05	425.52	11-Apr-05	421.50	15-Apr-05	422.14	15-Apr-05	422.04
15-Apr-05	428.35	15-Apr-05	428.33	15-Apr-05	424.86	29-Apr-05	424.98	15-Apr-05	425.50	15-Apr-05	421.65	29-Apr-05	422.20	29-Apr-05	422.07
29-Apr-05	428.63	29-Apr-05	428.75	29-Apr-05	425.08	27-Jun-05	424.68	29-Apr-05	425.73	29-Apr-05	420.84	27-Jun-05	421.62	27-Jun-05	421.63
27-Jun-05	428.26	27-Jun-05	428.41	27-Jun-05	424.44	17-Aug-05	424.37	27-Jun-05	424.44	27-Jun-05	420.61	17-Aug-05	420.92	17-Aug-05	420.90
17-Aug-05	427.86	17-Aug-05	427.97	17-Aug-05	424.01	21-Nov-05	424.16	17-Aug-05	423.59	17-Aug-05	421.20	21-Nov-05	422.10	21-Nov-05	422.05
21-Nov-05	427.49	21-Nov-05	427.52	21-Nov-05	424.07	23-Dec-05	424.28	21-Nov-05	424.77	21-Nov-05	421.20	23-Dec-05	422.10	23-Dec-05	422.05
23-Dec-05	427.64	23-Dec-05	427.69	23-Dec-05	424.15	7-Feb-06	424.64	23-Dec-05	424.84	23-Dec-05	421.51	7-Feb-06	422.18	7-Feb-06	422.07
7-Feb-06	428.20	7-Feb-06	428.31	7-Feb-06	424.79	24-Feb-06	424.71	7-Feb-06	425.63	7-Feb-06	421.39	24-Feb-06	422.14	24-Feb-06	422.06
24-Feb-06	428.35	24-Feb-06	428.51	24-Feb-06	424.83	9-Mar-06	424.68	24-Feb-06		24-Feb-06	421.38	9-Mar-06	422.18	9-Mar-06	422.08
9-Mar-06	428.39	9-Mar-06	428.56	9-Mar-06	424.75	14-Mar-06	424.90	9-Mar-06		9-Mar-06	421.48	14-Mar-06	422.21	14-Mar-06	422.07
14-Mar-06	428.75	14-Mar-06	428.89	14-Mar-06	425.19	28-Mar-06	425.01	14-Mar-06		14-Mar-06	421.75	28-Mar-06	422.16	28-Mar-06	422.07
28-Mar-06	428.90	28-Mar-06	429.15	28-Mar-06	425.19	5-Apr-06	425.06	28-Mar-06	425.48	28-Mar-06	421.48	5-Apr-06	422.19	5-Apr-06	422.07
5-Apr-06	428.87	5-Apr-06	429.06	5-Apr-06	425.23	12-Apr-06	425.12	5-Apr-06	425.66	5-Apr-06	421.58	12-Apr-06	422.19	12-Apr-06	422.08
12-Apr-06	428.94	12-Apr-06	429.13	12-Apr-06	425.28	20-Apr-06	425.11	12-Apr-06	425.63	12-Apr-06	421.55	20-Apr-06	422.12	20-Apr-06	422.05
20-Apr-06	428.90	20-Apr-06	429.13	20-Apr-06	425.19	1-May-06	425.16	20-Apr-06	425.35	20-Apr-06	421.41	1-May-06	422.11	1-May-06	422.05
1-May-06	428.97	1-May-06	429.20	1-May-06	425.23	8-May-06	425.20	1-May-06	425.32	1-May-06	421.41	8-May-06	422.05	8-May-06	421.94
8-May-06	428.88	8-May-06	429.12	8-May-06	425.09	10-Jun-06	425.00	8-May-06	425.03	8-May-06	421.75	10-Jun-06	422.09	10-Jun-06	422.07
10-Jun-06	428.65	10-Jun-06	428.83	10-Jun-06	424.95	29-Apr-13	424.83	10-Jun-06	425.02	10-Jun-06	421.27	29-Apr-13	422.30	29-Apr-13	422.16
29-Apr-13	428.69	29-Apr-13	428.35	29-Apr-13	425.03	24-May-13	424.76	29-Apr-13	425.22	29-Apr-13	421.55	24-May-13	422.20	24-May-13	422.09
24-May-13	428.72	24-May-13	428.43	24-May-13	424.77	26-Jun-13	424.72	24-May-13	424.82	24-May-13	421.29	26-Jun-13	421.90	26-Jun-13	421.89
26-Jun-13	428.46	26-Jun-13	428.19	26-Jun-13	424.61	7-Jun-17	424.52	26-Jun-13	424.52	26-Jun-13	421.15	7-Jun-17	422.24	7-Jun-17	422.10
7-Jun-17	428.27	7-Jun-17	427.95					7-Jun-17	423.74	7-Jun-17	421.31				

Table 1 - Ground Water Monitor Details and Elevations

Monitoring Well	Stickup (m)	Total Depth (mbtoc)	TOC Elevation (masl)	Ground Elevation (masl)	Ground Water Levels (mbtoc)				Ground Water Levels (mbgs)				Ground Water Elevation (masl)			
					29-Apr-13	24-May-13	26-Jun-13	7-Jun-17	29-Apr-13	24-May-13	26-Jun-13	7-Jun-17	29-Apr-13	24-May-13	26-Jun-13	7-Jun-17
MW-1	0.50	8.10	432.91	432.41	6.25	6.31	6.36	7.78	5.75	5.81	5.86	7.28	426.66	426.60	426.55	425.13
MW-2	0.66	7.36	422.36	421.70	2.23	2.43	2.59	NA	1.57	1.77	1.93	NA	420.13	419.93	419.77	NA
MW-3	0.65	7.25	422.35	421.70	2.00	2.19	2.21	2.17	1.35	1.54	1.56	1.52	420.35	420.16	420.14	420.18
MW-A-I	0.73	10.51	433.17	432.26	4.48	4.45	4.71	4.90	3.75	3.72	3.98	4.17	428.69	428.72	428.46	428.27
MW-A-II	0.68	6.22	433.15	432.26	4.80	4.72	4.96	5.20	4.12	4.04	4.28	4.52	428.35	428.43	428.19	427.95
MW-B	0.75	9.29	431.09	430.18	6.06	6.32	6.48	NA	5.31	5.57	5.73	NA	425.03	424.77	424.61	NA
MW-C	0.77	7.22	429.77	428.80	4.94	5.01	5.05	5.25	4.17	4.24	4.28	4.48	424.83	424.76	424.72	424.52
MW-D	0.59	4.36	426.74	425.88	1.52	1.92	2.22	3.00	0.93	1.33	1.63	2.41	425.22	424.82	424.52	423.74
MW-E	0.96	4.55	423.30	422.25	1.75	2.01	2.15	1.99	0.79	1.05	1.19	1.03	421.55	421.29	421.15	421.31
MW-F-I	0.80	8.68	423.10	422.19	0.80	0.90	1.20	0.86	0.00	0.10	0.40	0.06	422.30	422.20	421.90	422.24
MW-F-II	0.74	3.56	422.99	422.02	0.83	0.90	1.10	0.89	0.09	0.16	0.36	0.15	422.16	422.09	421.89	422.10
MW-10*	0.90	2.69	NA	NA	1.20	1.17	1.15	NA	0.30	0.27	0.25	NA	NA	NA	NA	NA

*MW-10 is piezometer installed by hand in wetland

Bold and Italics indicates new wells installed in 2013

NA - not accessible

APPENDIX C

Borehole Logs

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 1

Project Manager: John Monkman, P. Eng.

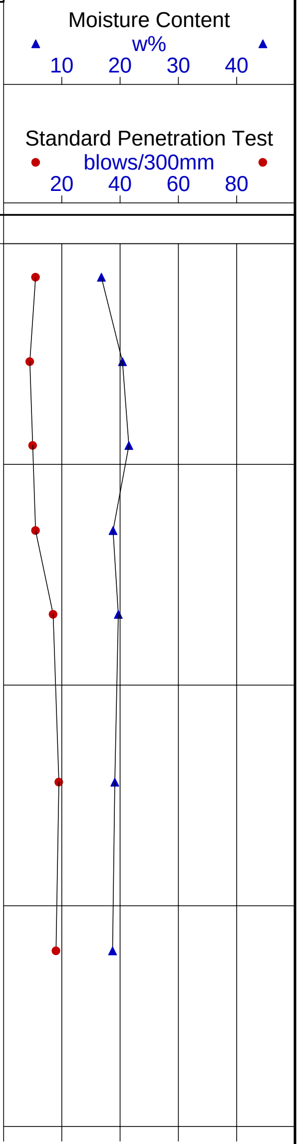
Borehole Location: See Drawing No. 1

: ::

Soil-Mat

SUBSURFACE PROFILE / SAMPLE

Depth (ft / m)	Elevation [m]	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	98.35		Ground Surface								
			Topsoil Approximately 150 millimetres of topsoil.		SS	1	5,5,6,7	11	▨		
			Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel, occasional silt seams, loose to compact		SS	2	3,3,6,8	9	▨		
					SS	3	4,5,5,8	10	▨		
					SS	4	4,5,6,8	11	▨		
					SS	5	4,7,10,12	17	▨		
					SS	6	5,7,12,17	19	▨		
					SS	7	3,4,4,5	8	▨		
	91.65		End of Borehole								



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'caved' at a depth of 2.0 metres upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

SOIL-MAT ENGINEERS & CONSULTANTS LTD.
130 Lancing Drive, Hamilton, ON L8W 3A1
Phone: (905) 318-7440 Fax: (905) 318-7455
e-mail: info@soil-mat.on.ca

Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 2

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

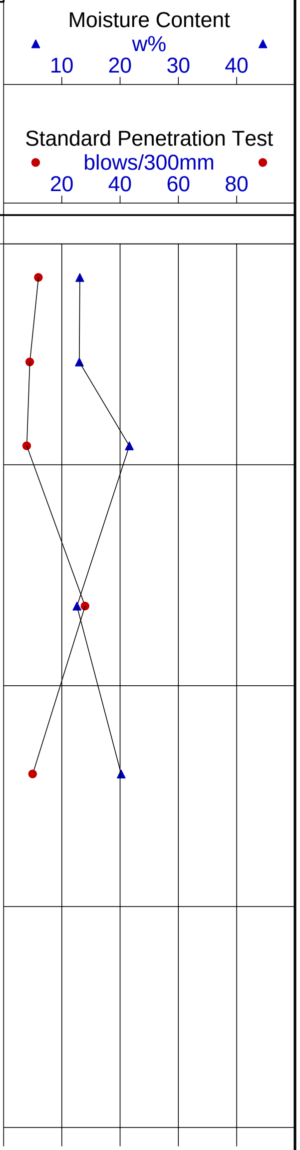
: **::**

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Elevation [m]	Description
0	0	98.75	Ground Surface
0	0		**Topsoil** Approximately 150 millimetres of topsoil.
			Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel, traces of organic staining at shallower depths, loose to compact
		95.25	Coarse layer at approximately 3.5 meters
		92.05	End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	3,5,7,8	12	▨		
SS	2	5,4,5,8	9	▨		
SS	3	2,2,6,9	8	▨		
SS	4	9,10,18	28	▨		
SS	5	4,4,6	10	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'wet' at a depth of 2.3 metres upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

SOIL-MAT ENGINEERS & CONSULTANTS LTD.
130 Lancing Drive, Hamilton, ON L8W 3A1
Phone: (905) 318-7440 Fax: (905) 318-7455
e-mail: info@soil-mat.on.ca

Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 3

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

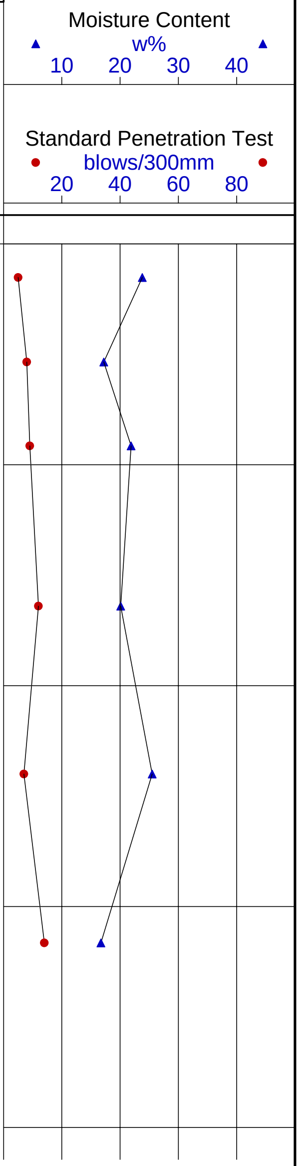
: **::**

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Elevation [m]	Description
0	0	97.78	Ground Surface
0–2.3	0–0.7	97.08	**Topsoil** Approximately 700 millimetres of topsoil.
2.3–21.7	0.7–6.6	91.18	**Fine Sand/ Fine Sandy Silt** Brown to greyish brown, interbedded, traces of fine gravel, organic staining at shallower depths, loose to compact
21.7			End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	3,2,3,5	5	▨		
SS	2	2,3,5,8	8	▨		
SS	3	2,4,5,6	9	▨		
SS	4	3,4,8	12	▨		
SS	5	2,2,5	7	▨		
SS	6	6,7,7	14	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 6.6 metres.

2. Borehole was recorded as 'wet' at a depth of 1.5 metres upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 4

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

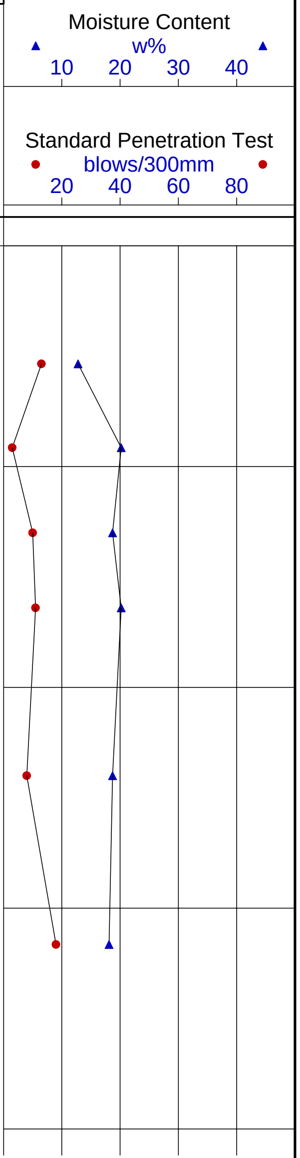
: ::

SUBSURFACE PROFILE

Depth	Elevation [m]	Symbol	Description	Well Data
ft 0 / m 0	102.71		Ground Surface	
		~	**Topsoil** Approximately 150 millimetres of topsoil.	
		⁙	**Fine Sand/ Fine Sandy Silt** Brown to greyish brown, interbedded, traces of fine gravel, traces of oxidation at shallower depths, very loose to compact	
	96.11		End of Borehole	

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	5,7,6,5	13	▨		
SS	2	1,1,2,3	3	▨		
SS	3	2,4,6,6	10	▨		
SS	4	4,5,6	11	▨		
SS	5	2,3,3	8	▨		
SS	6	5,7,11	18	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 6.6 metres.

2. Borehole was recorded as 'caved' at a depth of 1.8 metres upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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e-mail: info@soil-mat.on.ca

Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 5

Project Manager: John Monkman, P. Eng.

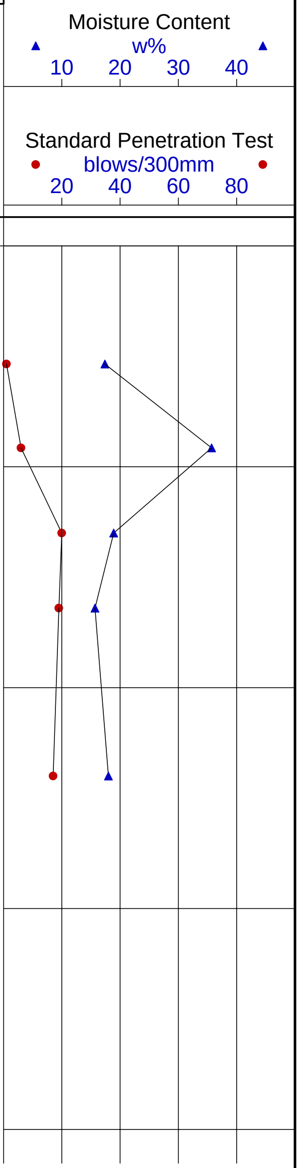
Borehole Location: See Drawing No. 1

: ::

SUBSURFACE PROFILE / SAMPLE

Depth	Elevation [m]	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
ft m 0 0	104.46		Ground Surface								
	104.26		**Topsoil** Approximately 200 millimetres of topsoil.								
			Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel, occasional silt seams, very loose to compact		SS	1	1,0,1,1	1	▨		
					SS	2	0,1,2,4	6	▨		
	102.64		Clay-rich layer at approximately 1.8 meters		SS	3	3,5,9,11	20	▨		
					SS	4	4,8,11	19	▨		
					SS	5	5,8,9	17	▨		
	99.46		End of Borehole								

Depth scale: ft 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32; m 0, 2, 4, 6, 8



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 5.0 metres.

2. Borehole was recorded as 'dry' upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Phone: (905) 318-7440 Fax: (905) 318-7455
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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 6

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

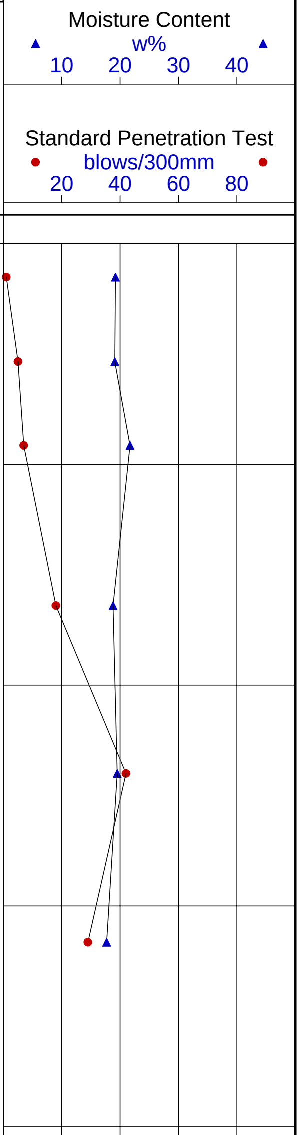
: ::

SUBSURFACE PROFILE

Elevation [m]	Symbol	Description	Well Data
105.69		Ground Surface	
105.49	~~	**Topsoil** Approximately 200 millimetres of topsoil.	
99.09	⁝⁝	**Fine Sand/ Fine Sandy Silt** Brown to greyish brown, interbedded, traces of fine to coarse gravel, organic staining at shallower depths, very loose to dense	
		End of Borehole	

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	0,1,0,0	1	▒		
SS	2	2,3,2,3	5	▒		
SS	3	2,3,4,7	7	▒		
SS	4	6,8,10	18	▒		
SS	5	11,18,24	42	▒		
SS	6	7,12,17	29	▒		



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 6.6 metres.

2. Borehole was recorded as 'wet' at a depth of 5.3 meters upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 7

Project Manager: John Monkman, P. Eng.

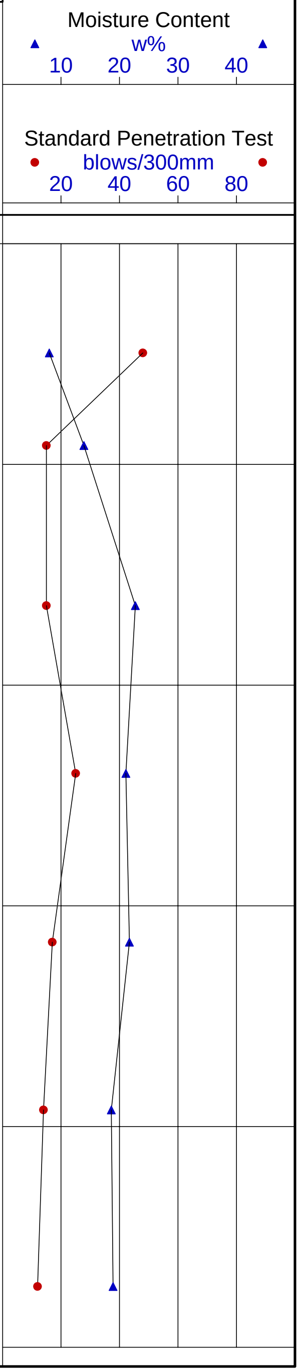
Borehole Location: See Drawing No. 1

: ::

SUBSURFACE PROFILE / SAMPLE

Depth (ft / m)	Elevation [m]	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
0 / 0	103.77		Ground Surface								
	103.57		***Topsoil*** Approximately 200 millimetres of topsoil.								
			Fine Sand/ Fine Silty Sand Brown to greyish brown, interbedded, traces of fine gravel throughout, some coarse gravel at shallower depths, assumed cobble at approximately 0.9 meters, compact to dense		SS	1	6,20,28	48			
					SS	2	3,7,8,8	15			
					SS	3	4,7,8	15			
					SS	4	4,11,14	25			
					SS	5	0,1,5,12	17			
					SS	6	2,4,10	14			
					SS	7	2,4,8,12	12			
	93.97		End of Borehole								

Depth scale: ft 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32; m 0, 2, 4, 6, 8



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 9.8 metres.

2. Borehole was recorded as 'wet' at a depth of 3.5 meters upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 8

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

: ::

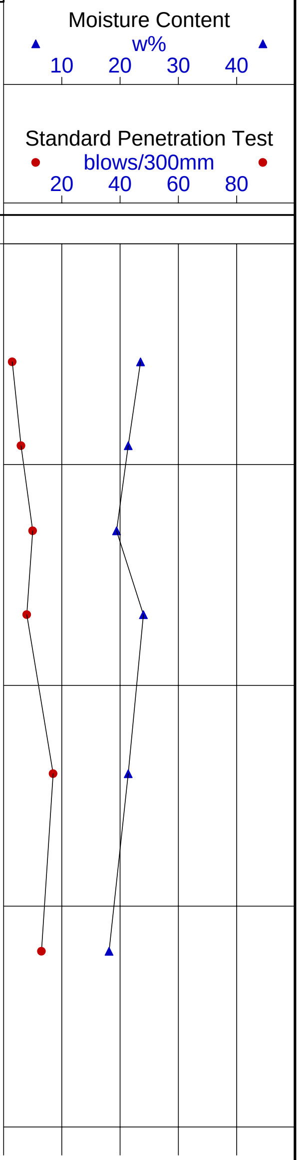
Soil-Mat

SUBSURFACE PROFILE

Depth (m)	Elevation [m]	Description
0	102.15	Ground Surface
0 – 0.15		**Topsoil** Approximately 150 millimetres of topsoil.
0.15 – 6.7		**Fine Sand/ Fine Sandy Silt** Brown to greyish brown, interbedded, traces of fine gravel, occasional silt seams, loose to compact
6.7	95.45	End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	1,1,2,3	3			
SS	2	2,2,4,8	6			
SS	3	3,4,6,6	10			
SS	4	3,3,5,7	8			
SS	5	4,7,10	17			
SS	6	2,5,8,11	13			



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 25, 2013 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'wet' at a depth of 1.8 meters upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 25, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 9

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

: **::**

Soil-Mat

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Elevation [m]	Description
0	0	99.42	Ground Surface
			Topsoil Approximately 150 millimetres of topsoil.
			Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel, occasional silt seams, loose to compact
32		89.67	End of Borehole

Depth scale: ft 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32; m 0, 2, 4, 6, 8

NOTES:

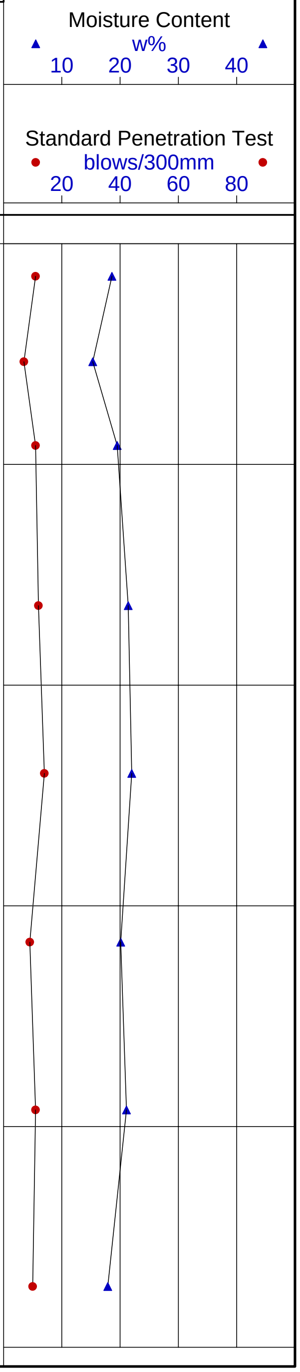
1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 9.8 metres.

2. Borehole was recorded as 'caved' at a depth of 1.8 meters upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	4,4,7	11			
SS	2	2,3,4,5	7			
SS	3	3,5,6,10	11			
SS	4	3,5,7	12			
SS	5	3,5,9	14			
SS	6	4,3,6	9			
SS	7	4,5,6	11			
SS	8	5,6,4,6	10			



Drill Method: Solid-Stem Auger

Drill Date: April 26, 2013

Hole Size: 150mm

Drill Contractor: Geo Environmental

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Phone: (905) 318-7440 Fax: (905) 318-7455
e-mail: info@soil-mat.on.ca

Datum: Ground Surface

Field Logged by: Kyle Fletcher

Checked by: JM

Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 10

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

: **::**

Soil-Mat

SUBSURFACE PROFILE

Depth

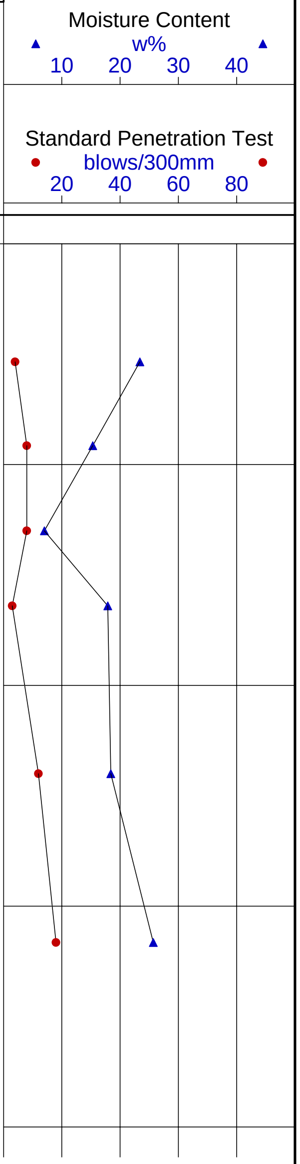
ft: 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32

m: 0 2 4 6 8

Elevation [m]	Symbol	Description	Well Data
104.29		Ground Surface	
104.09		**Topsoil** Approximately 200 millimetres of topsoil.	
		Fine Sand/ Fine Sandy Silt Brown to greyish brown, traces of fine gravel, occasional silt seams, very loose to compact	
97.69		End of Borehole	

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	2,2,2,3	4			
SS	2	2,4,4,6	8			
SS	3	3,4,4,5	8			
SS	4	3,2,1	3			
SS	5	2,4,8	12			
SS	6	4,7,11	18			



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 6.6 metres.

2. Borehole was recorded as 'caved' at a depth of 3.7 meters and 'wet' at a depth of 3.5 meters upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 26, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 11

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

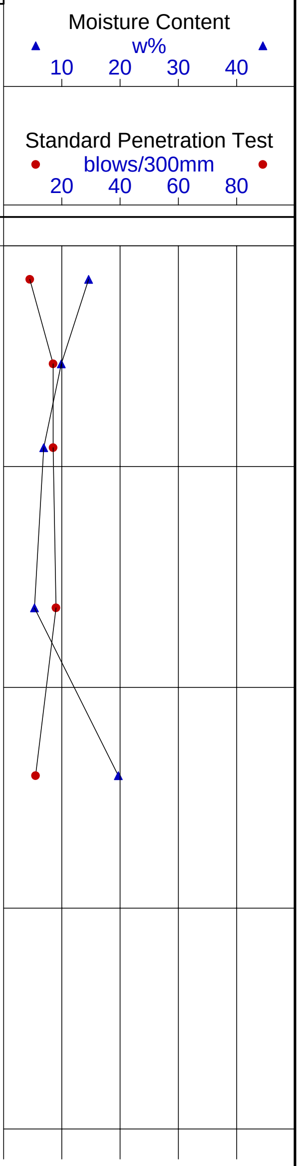
: **::**

SUBSURFACE PROFILE

Depth (m)	Elevation [m]	Description
0	104.56	Ground Surface
0.2	104.36	***Topsoil*** Approximately 200 millimetres of topsoil.
		Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel throughout, some coarse gravel at shallower depths, loose to compact
5.0	99.56	End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	1,2,7,10	9	▨		
SS	2	9,10,7,12	17	▨		
SS	3	4,8,9,10	17	▨		
SS	4	6,8,10	18	▨		
SS	5	6,5,6	11	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 5.0 metres.

2. Borehole was recorded as 'dry' upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid-Stem Auger
Drill Date: April 26, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 12 [MW-1]

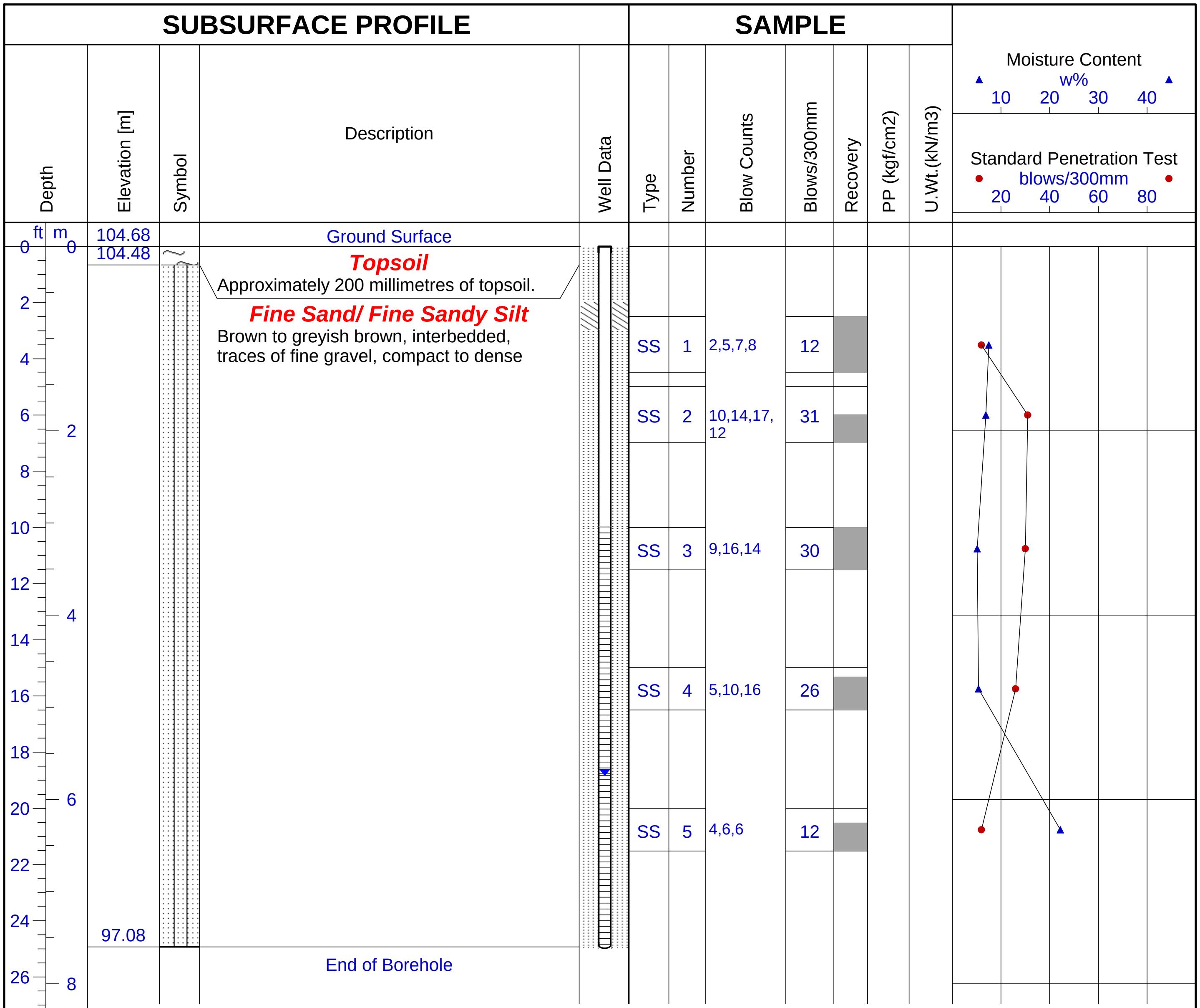
Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

: **::**

Soil-Mat

SUBSURFACE PROFILE / SAMPLE



Elevation [m]	Description	Type	Number	Blow Counts	Blows/300mm
104.68	Ground Surface				
104.48	**Topsoil** Approximately 200 millimetres of topsoil.				
	Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel, compact to dense	SS	1	2,5,7,8	12
		SS	2	10,14,17, 12	31
		SS	3	9,16,14	30
		SS	4	5,10,16	26
		SS	5	4,6,6	12
97.08	End of Borehole				

NOTES:

1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 7.6 metres.

2. A monitoring well was installed upon the completion of drilling and a following free groundwater level of 5.75 metres was measured by a representative of Azimuth Environmental Consulting Inc. on April 29, 2013.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Hollow-Stem Auger
Drill Date: April 26, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 13 [MW-2]

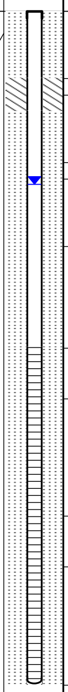
Project Manager: John Monkman, P. Eng.

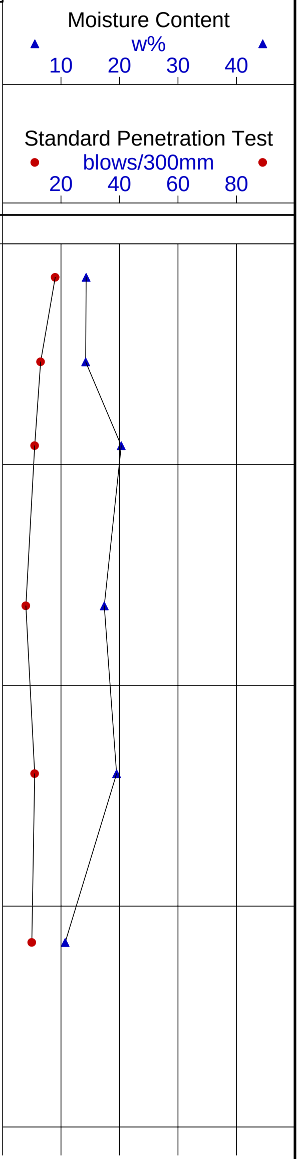
Borehole Location: See Drawing No. 1

: **::**

Soil-Mat

SUBSURFACE PROFILE			SAMPLE						
Elevation [m]	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
93.97	Ground Surface								
93.77	**Topsoil** Approximately 200 millimetres of topsoil.		SS	1	5,6,12,12	18	▨		
	Fine Sand/ Fine Sandy Silt Brown to greyish, interbedded, traces of fine gravel, traces of organic staining at shallower depths, occasional silt seams, loose to compact		SS	2	5,8,5,6	13	▨		
			SS	3	3,4,7,10	11	▨		
			SS	4	2,3,5	8	▨		
			SS	5	4,5,6	11	▨		
			SS	6	3,4,4,6	10	▨		
87.27	End of Borehole								





Depth: ft 0–32, m 0–8

NOTES:

1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 6.7 metres.

2. A monitoring well was installed upon the completion of drilling and a following free groundwater level of 1.57 metres was measured by a representative of Azimuth Environmental Consulting Inc. on April 29, 2013.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Hollow-Stem Auger
Drill Date: April 26, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

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Datum: Ground Surface
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Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 14 [MW-3]

Project Manager: John Monkman, P. Eng.

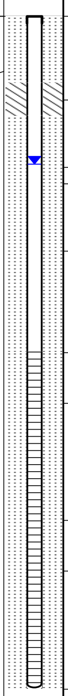
Borehole Location: See Drawing No. 1

: **::**

Soil-Mat

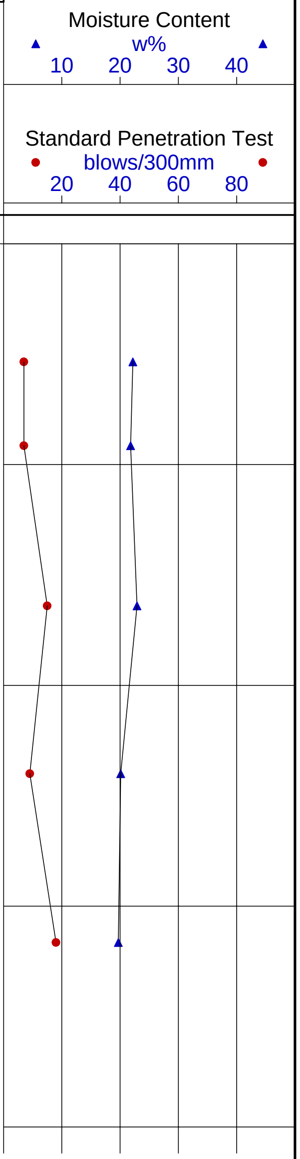
SUBSURFACE PROFILE

Depth (ft / m)	Elevation [m]	Symbol	Description
0 / 0	93.97		Ground Surface
0 / 0			***Topsoil*** Approximately 500 millimetres of topsoil.
	93.47		***Fine Sand/ Fine Sandy Silt*** Brown to greyish brown, interbedded, traces of fine gravel, traces of organic staining at shallower depths, loose to compact
	87.37		End of Borehole



SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	5,8,5,6	7	▨		
SS	2	3,4,7,10	7	▨		
SS	3	2,3,5	15	▨		
SS	4	4,5,6	9	▨		
SS	5	3,4,4,6	18	▨		



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 6.6 metres.

2. A monitoring well was installed upon the completion of drilling and a following free groundwater level of 1.35 metres was measured by a representative of Azimuth Environmental Consulting Inc. on April 29, 2013.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Hollow-Stem Auger
Drill Date: April 26, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

SOIL-MAT ENGINEERS & CONSULTANTS LTD.
130 Lancing Drive, Hamilton, ON L8W 3A1
Phone: (905) 318-7440 Fax: (905) 318-7455
e-mail: info@soil-mat.on.ca

Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

Project No: SM135031-G

Project: Orangeville Highlands Phase II

Location: Hansen Bvld., Orangeville, ON

Client: Country Green Homes Ltd.

Log of Borehole No. 15

Project Manager: John Monkman, P. Eng.

Borehole Location: See Drawing No. 1

: **::**

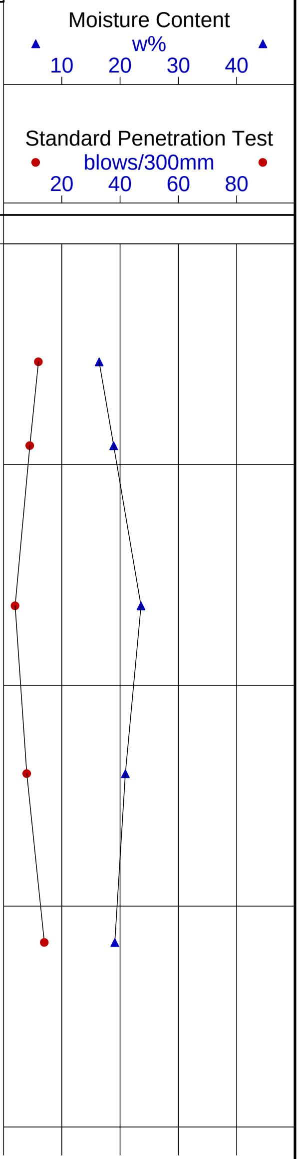
Soil-Mat

SUBSURFACE PROFILE

Depth (ft / m)	Elevation [m]	Description
0 / 0	93.97	Ground Surface
	93.52	***Topsoil*** Approximately 450 millimetres of topsoil.
		Fine Sand/ Fine Sandy Silt Brown to greyish brown, interbedded, traces of fine gravel, organic staining at shallower depths, very loose to compact
	88.77	End of Borehole

SAMPLE

Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)
SS	1	4,5,7,7	12			
SS	2	4,5,4,5	9			
SS	3	1,1,3,5	4			
SS	4	2,3,5	8			
SS	5	4,7,7,9	14			



NOTES:

1. Borehole was advanced using solid stem auger equipment on April 26, 2013 to termination at a depth of 5.2 metres.

2. Borehole was recorded as 'caved' at a depth of 1.5 metres upon completion of drilling and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.

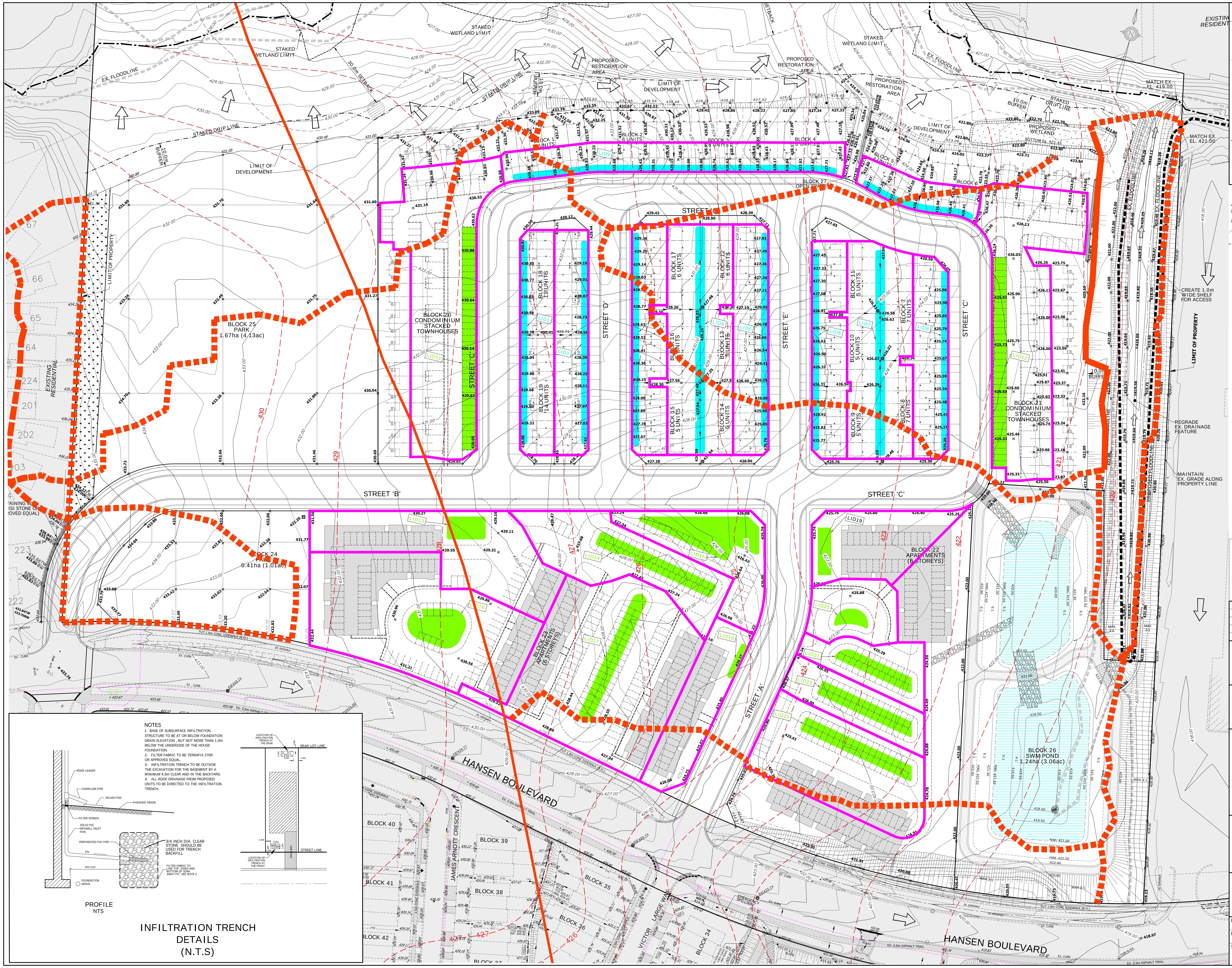
Drill Method: Solid-Stem Auger
Drill Date: April 26, 2013
Hole Size: 150mm
Drill Contractor: Geo Environmental

SOIL-MAT ENGINEERS & CONSULTANTS LTD.
130 Lancing Drive, Hamilton, ON L8W 3A1
Phone: (905) 318-7440 Fax: (905) 318-7455
e-mail: info@soil-mat.on.ca

Datum: Ground Surface
Field Logged by: Kyle Fletcher
Checked by: JM
Sheet: 1 of 1

APPENDIX D

LID Plan and Details

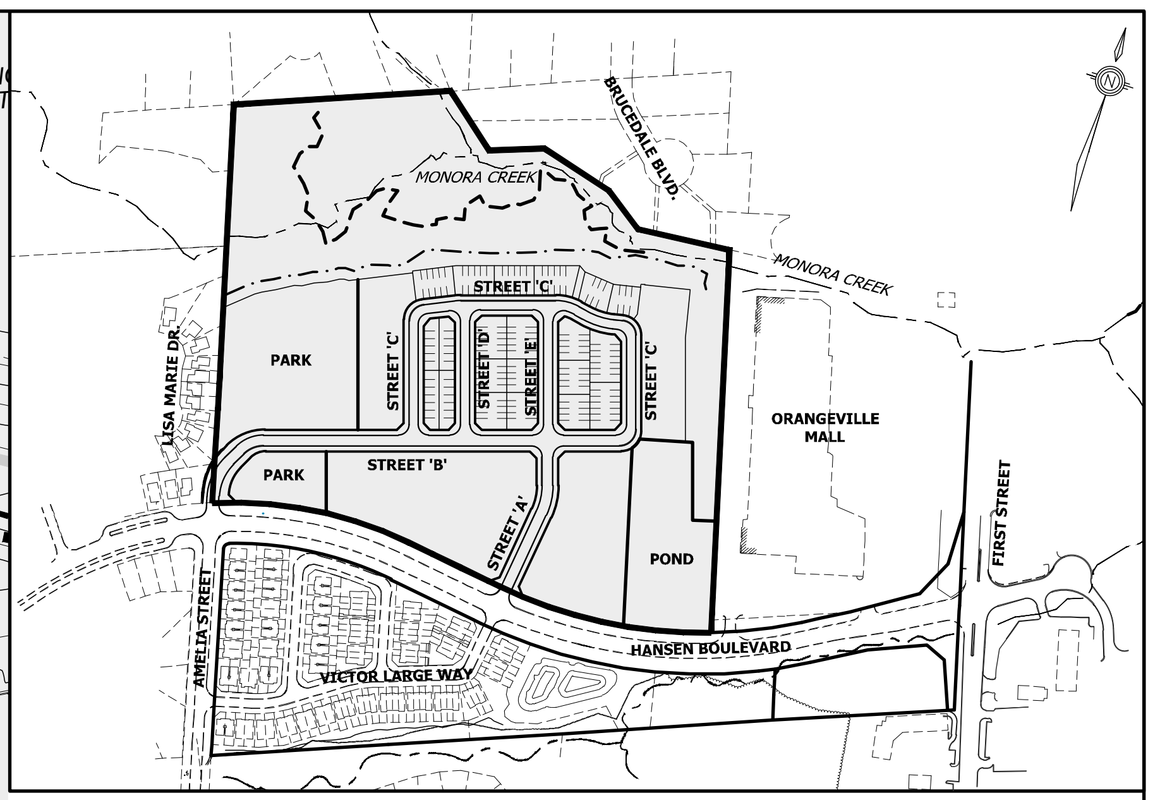


PROFILE
NTS

NOTES

1. BASE OF SUBSURFACE INFILTRATION STRUCTURE TO BE AT OR BELOW FOUNDATION DRAIN ELEVATION , BUT NOT MORE THAN 1.0m BELOW THE UNDERSIDE OF THE HOUSE FOUNDATION.
2. FILTER FABRIC TO BE TERRAFIX 270R OR APPROVED EQUAL.
3. INFILTRATION TRENCH TO BE OUTSIDE THE EXCAVATION FOR THE BASEMENT BY A MINIMUM 4.5m CLEAR AND IN THE BACKYARD.
4. ALL ROOF DRAINAGE FROM PROPOSED UNITS TO BE DIRECTED TO THE INFILTRATION TRENCH.

INFILTRATION TRENCH
DETAILS
(N.T.S)



KEY PLAN
NTS

LEGEND

429.03	PROPOSED GRADE (m)
426.24	EXISTING ELEVATION (m)
421.50	GROUND ELEVATION (m)
422.00	HIGH GROUND WATER ELEVATION CONTOUR (m)
⇦	EXISTING OVERLAND FLOW ROUTE
⬅	PROPOSED OVERLAND FLOW ROUTE
▨	INFILTRATION TRENCH LOCATED IN PRIVATE FRONT/REAR YARD (REFER TO DETAIL, THIS DWG)
🟦	POTENTIAL LOCATION OF PRIVATE LID FEATURE (TO BE DETERMINED THROUGH FUTURE SITE PLAN APPLICATION)
☐	CONTRIBUTION DRAINAGE AREA TO LID FEATURE

LID#	DRAINAGE AREA (m^2)	STORAGE VOL (m^3)
LID1	1378	35.1
LID2	1384	35.1
LID3	1410	40.3
LID4	2778	86.4
LID5	1484	43.2
LID6	1363	40.5
LID7	2532	108.0
LID8	1283	50.4
LID9	1842	108.0
LID10	694	36.0
LID11	3959	207.7
LID12	3582	392.0
LID13	2624	15.6
LID14	2043	32.4
LID15	1575	57.0
LID16	4166	65.1
LID17	4784	41.9
LID18	1336	4.6
LID19	1489	66.0
LID20	943	47.8
LID21	994	80.2
LID22	1085	102.8
LID23	2665	121.8

BENCHMARK

STATION: 00819688502 ELEVATION: 417.719
502-68: ONE STOREY BROWN BRICK MORTUARY (FOREST LAWN MORTUARY) ON EAST SIDE OF HWY 10 AND 24, 1.9 KM NORTH OF NORTH JCT OF HWYS 9, 10 AND 24 AT ORANGEVILLE. 1.4 KM SOUTH OF MONO TWP SIDEROAD 5 (DUFFERIN CTY RD 7) AND 301.8 M EAST OF CENTERLINE OF HWY 10 AND 24 ALONG CEMETERY RD. TABLET IS SET HORIZONTALLY IN NORTH FACE OF CONCRETE FOUNDATION, 2.59 M EAST OF N.W. CORNER AND 43 CM BELOW BRICKWORK.

No.	REVISION	DATE
4		
3		
2		
1		

ORANGEVILLE HIGHLANDS PHASE 2
FUNCTIONAL SERVICING

Orangeville
Historic Charm Dynamic Future

Corporation of the
Town of Orangeville
Ontario, Canada

REVIEWED BY
THE TOWN OF
ORANGEVILLE

DATE

DIRECTOR OF PUBLIC WORKS

urbantech
Urbantech® Consulting, A Division of Leighton-Zec Ltd.
3760 14th Avenue, Suite 301 Markham ON L3R 3T7
tel: 905.946.9461 fax: 905.946.9595
www.urbantech.com

S.B. RIEMER
100214712
APRIL 2019

LID DRAINAGE PLAN

DESIGNED: D.Z.	CHECKED: D.Z.	PROJECT No.: 06-233-PH2
DRAWN: V.P.	DATE: MARCH 2019	FIGURE No.:
SCALE: H 1:750		FIG 5B

File: P:\Projects\06-233-Phase 2\FSR\F5B-FSR LID WATER BALANCE.dwg - Revised by <DFAN> : Mon, Apr 01 2019 - 4:36pm

TABLE: LID PERFORMANCE AND ON-SITE RETENTION

LID	TYPE	TOTAL DRAINAGE AREA (m^2)	IMPERVIOUS DRAINAGE AREA (m^2)	TOTAL LID SURFACE AREA (m^2)	AVG GROUNDWATER DEPTH (m)	AVERAGE LID DEPTH (m)	TOTAL LID VOL (m^3)	TOTAL STORAGE VOL (m^3)	EQUIV RAINFALL DEPTH (mm)
1	INFILTRATION TRENCH	1378	1034	58.5	2.5	1.50	87.8	35.1	25.5
2	INFILTRATION TRENCH	1384	1038	58.5	2.5	1.50	87.8	35.1	25.4
3	INFILTRATION TRENCH	1410	1058	72.0	2.4	1.40	100.8	40.3	28.6
4	INFILTRATION TRENCH	2778	2083	144.0	2.5	1.50	216.0	86.4	31.1
5	INFILTRATION TRENCH	1484	1113	72.0	2.5	1.50	108.0	43.2	29.1
6	INFILTRATION TRENCH	1363	1023	67.5	2.5	1.50	101.3	40.5	29.7
7	INFILTRATION TRENCH	2532	1899	135.0	3.0	2.00	270.0	108.0	42.7
8	INFILTRATION TRENCH	1283	962	63.0	3.0	2.00	126.0	50.4	39.3
9	INFILTRATION TRENCH	1842	1381	108.0	3.5	2.50	270.0	108.0	58.6
10	INFILTRATION TRENCH	694	520	36.0	3.5	2.50	90.0	36.0	51.9
11	TBD AT SITE PLAN DESIGN STAGE	3959	3563	519.3	2.0	1.00	519.3	207.7	52.5
12	TBD AT SITE PLAN DESIGN STAGE	3582	3224	490.1	3.0	2.00	980.1	392.0	109.4
13	TBD AT SITE PLAN DESIGN STAGE	2624	2362	155.7	1.3	0.25	38.9	15.6	5.9
14	TBD AT SITE PLAN DESIGN STAGE	2043	1839	324.0	1.3	0.25	81.0	32.4	15.9
15	TBD AT SITE PLAN DESIGN STAGE	1575	1418	570.0	1.3	0.25	142.5	57.0	36.2
16	TBD AT SITE PLAN DESIGN STAGE	4166	3749	325.7	1.5	0.50	162.8	65.1	15.6
17	TBD AT SITE PLAN DESIGN STAGE	4784	4306	349.1	1.3	0.30	104.7	41.9	8.8
18	TBD AT SITE PLAN DESIGN STAGE	1336	1202	38.1	1.3	0.30	11.4	4.6	3.4
19	TBD AT SITE PLAN DESIGN STAGE	1489	1340	110.0	2.5	1.50	165.0	66.0	44.3
20	TBD AT SITE PLAN DESIGN STAGE	943	849	79.6	2.5	1.50	119.4	47.8	50.6
21	TBD AT SITE PLAN DESIGN STAGE	994	894	200.5	2.0	1.00	200.5	80.2	80.7
22	TBD AT SITE PLAN DESIGN STAGE	1085	977	257.0	2.0	1.00	257.0	102.8	94.8
23	TBD AT SITE PLAN DESIGN STAGE	2665	2398	304.5	2.0	1.00	304.5	121.8	45.7
								1817.9	

APPENDIX E

2007 Jagger Hims Hydrogeological Assessment

SUPPLEMENTAL MONITORING AND HYDROGEOLOGIC ASSESSMENT PROPOSED ORANGEVILLE HIGHLANDS DEVELOPMENT, PHASE 2 PART OF EAST HALF OF LOT 3, CONCESSION 2 W.H.S FORMERLY IN THE TOWNSHIP OF MONO TOWN OF ORANGEVILLE, COUNTY OF DUFFERIN

Prepared for:
Orangeville Highlands Ltd.

January 2007

File 021508.03

Distribution:
8 c Urbantech
1 c File

This report contains recycled fibre

JAGGER HIMS LIMITED
Environmental Consulting Engineers

JAGGER HIMS
LIMITED
Environmental Consulting Engineers

1091 Gorham Street, Suite 301
Newmarket, Ontario
Canada L3Y 8X7

Tel 905 853-3303
800 263-7419
Fax 905 853-1759

January 8, 2007

Orangeville Highlands Ltd.
c/o Mr. Paul A. Sytsma, Principal
Urbantech
25 Royal Crest Court, Suite 201
Markham, Ontario
L3R 9X4

Dear Mr. Sytsma:

Re: Supplemental Monitoring and Hydrogeologic Assessment
Proposed Orangeville Highlands Development, Phase 2
Part of East Half of Lot 3, Concession 2 W.H.S
Formerly in the Township of Mono
Town of Orangeville, County of Dufferin
File 021508.03

As requested, Jagger Hims Limited is pleased to provide the supplemental hydrogeologic report on the Phase 2 area of the proposed Orangeville Highlands residential development, which expands upon our 2003 infiltration study. The fieldwork components included borehole drilling, groundwater monitor installation, groundwater level monitoring, and watercourse flow monitoring.

The information provided herein can be used in support of the design of the general development layout. We understand that a copy of this document will be provided to Credit Valley Conservation for their review and approval.

We understand that Urbantech has replaced Metropolitan Consulting for managing development at this site. We look forward to continuing to provide our services for this site under direction of Urbantech. If our firm can be of further assistance, please contact us.

Yours truly,
JAGGER HIMS LIMITED

AG Hims

Andrew G. Hims, P.Eng.
Consulting Engineer
BDT:nah

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FIGURES

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TABLES

1.0 BACKGROUND

1.1 PROPOSED DEVELOPMENT

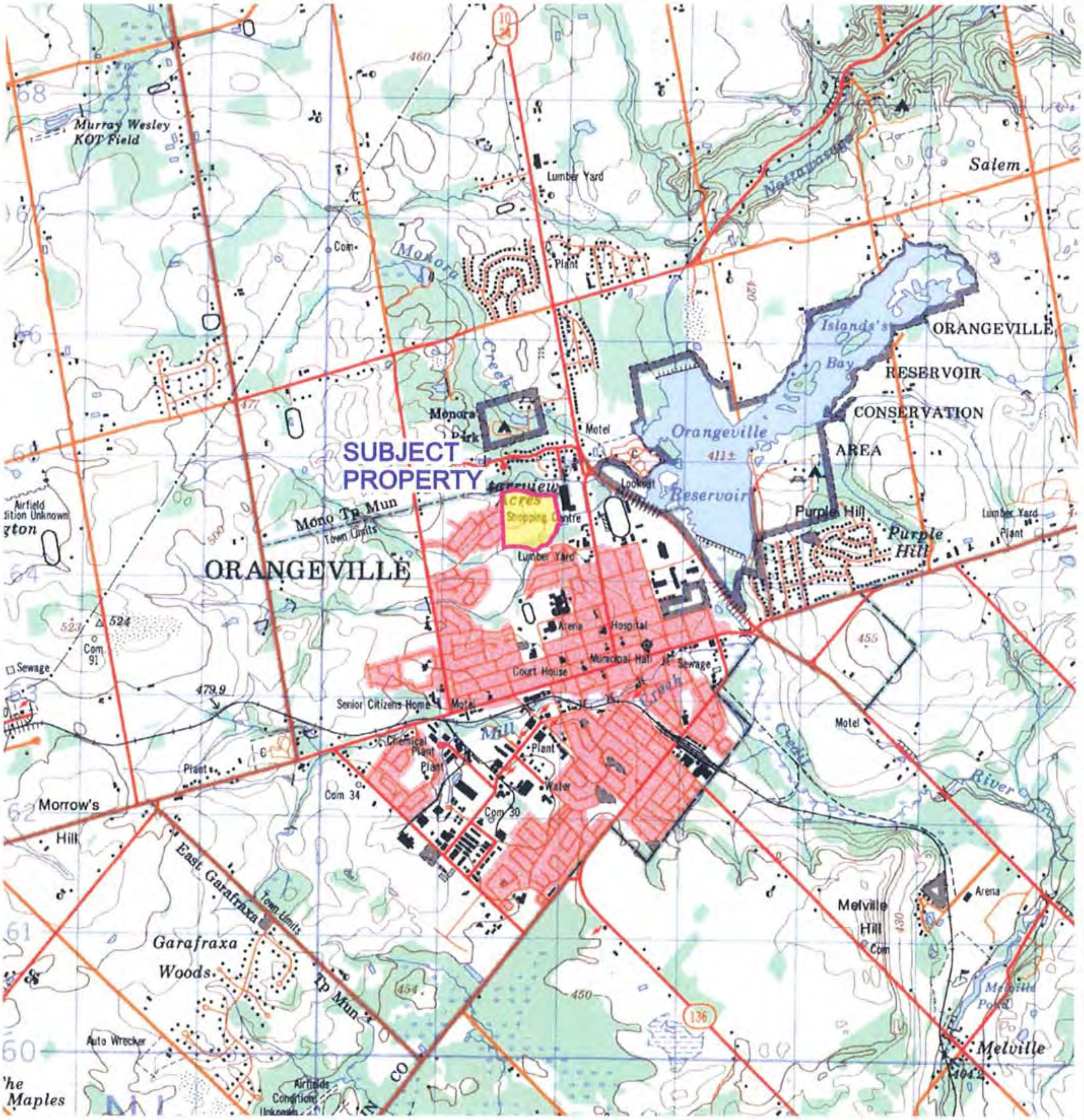
Orangeville Highlands Ltd. is proposing to construct a residential development in an area located in the northern part of the Town of Orangeville, in the County of Dufferin, as shown on Figure 1. The total property area is 22.39 ha (55.33 acres), which will be developed in two phases as follows, as illustrated in Figure 2.

- Phase 1 that is located south of Hansen Boulevard and east of Amelia Street, and extends over approximately 5.1 ha (12.6 acres).
- Phase 2 (site) that is located north of Hansen Boulevard, and extends over an area of approximately 18.01 ha (44.5 acres).

Phase 2 is the subject of this report and has a total area of 18 ha, of which approximately 13 ha (32.2 acres) is potentially available for development; the northern portion along the Middle Monora valley will be preserved. The development concept for Phase 2 will be prepared when the constraints, as partially determined from the results of this study, are finalized.

Jagger Hims Limited previously carried out a test pit investigation and infiltration study of the site (Jagger Hims Limited, 2003).

Full municipal services will be provided to the proposed development, including water supply and sewage disposal. It is proposed that stormwater will be collected by stormwater management systems to be directed to two stormwater management ponds on site, which will subsequently discharge to the Middle and Lower Monora Creeks.



LEGEND

🟨 APPROXIMATE LOCATION OF SUBJECT PROPERTY

N
W E
S

MAP SOURCE:
NTS SHEET 40P/16 ORANGEVILLE

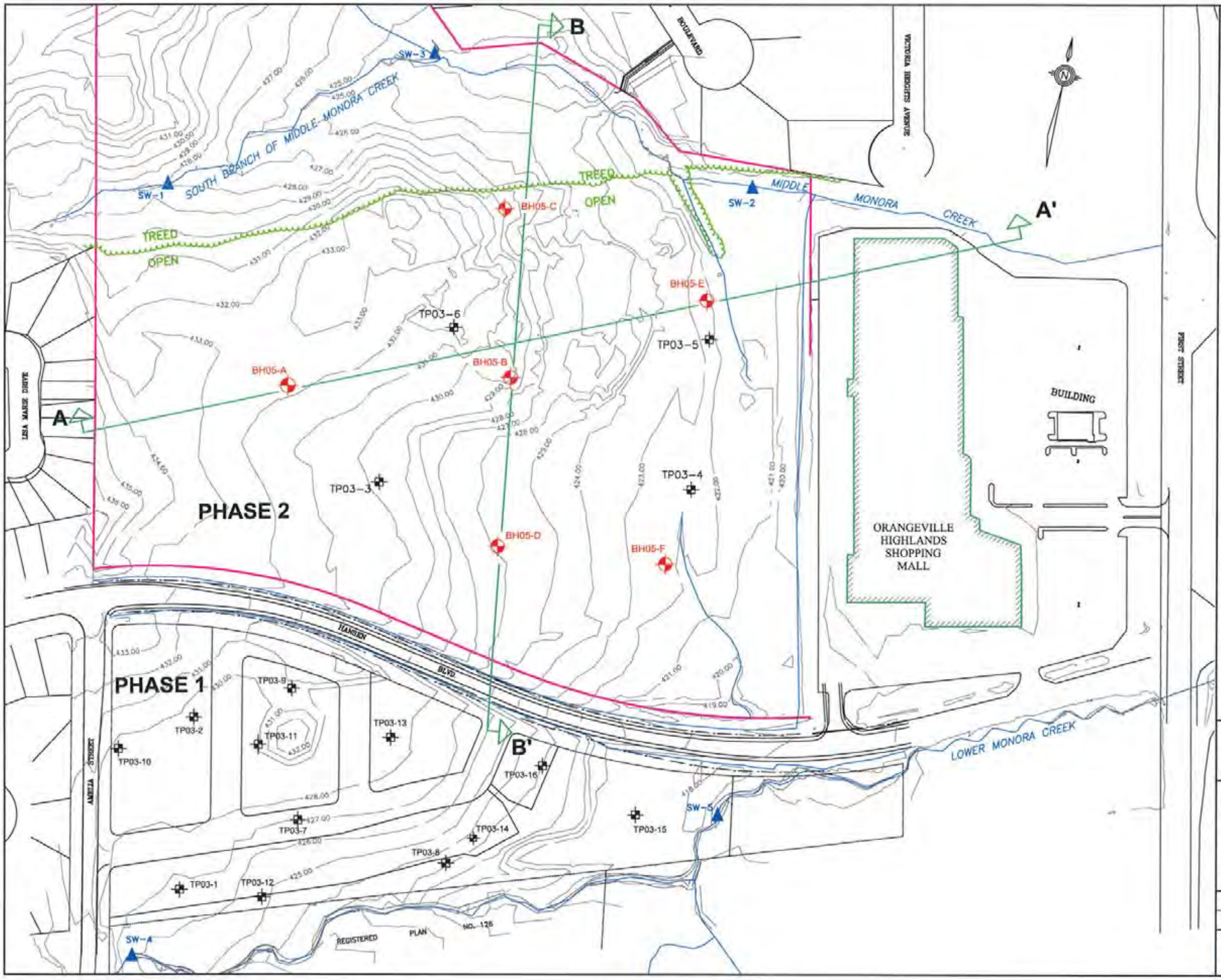
SITE LOCATION PLAN

SUPPLEMENTAL MONITORING
AND HYDROGEOLOGICAL ASSESSMENT
PROPOSED ORANGEVILLE HIGHLANDS
DEVELOPMENT, PHASE 2
for Orangeville Highlands Ltd.

DATE: JULY 2006	SCALE: 1:50,000
PROJECT: 021508.03	REF. NO.: 0-02150803F1-LM

JAGGER HIMS
LIMITED
Environmental Consulting Engineers

FIGURE
1



Legend

🟥	SITE PROPERTY BOUNDARY
BH05-A	JAGGER HIMS LIMITED BOREHOLE AND MONITOR, LOCATION AND DESIGNATION
TP03-16	JAGGER HIMS LIMITED TEST PIT LOCATION AND DESIGNATION
▲ SW-A	SURFACE WATER MONITORING STATION
423.00	TOPOGRAPHIC CONTOUR (mASL)
	SURFACE WATER COURSE
	BOUNDARY OF TREED AREA
A	LINE OF HYDROSTRATIGRAPHIC CROSS SECTION AS SHOWN ON FIGURE 4

10 0 20 metres

NOTES:

1. CONTOURS OF EXISTING GRADE PROVIDED BY METROPOLITAN CONSULTING INC.

2. LOCATIONS OF MONITORS SURVEYED BY METROPOLITAN CONSULTING INC. LOCATIONS OF TEST PITS IN PHASE 2 ARE ESTIMATED BASED ON GPS.

3. BASED ON MAP BY METROCON, N-05001 SURVEY, JUNE 2005 AND AERIAL PHOTOGRAPHY.

DETAILED SITE PLAN

SUPPLEMENTAL MONITORING AND HYDROGEOLOGICAL ASSESSMENT PROPOSED ORANGEVILLE HIGHLANDS DEVELOPMENT, PHASE 2
for Orangeville Highlands Ltd.

DATE: JULY 2006
SCALE: 1:2,500
PROJECT: 021508.03
FILE NO.: 0-02150803F2-SP

JAGGER HIMS LIMITED
Environmental Consulting Engineers

Figure 2

1.2 ENVIRONMENTAL OBJECTIVES

The site is situated within the catchments of two local watercourses that include (1) the north branch of Lower Monora Creek that is located to the south of Phase 1, and (2) the Middle Monora Creek that is located to the north of Phase 2. In the present undeveloped condition, on-site infiltration recharges the shallow groundwater regime through pervious soils exposed at surface over the entire area of the site. Discharges from the shallow groundwater regime contribute a portion of the base flow in both watercourses.

The proposed residential development will include construction of relatively impervious surfaces over pervious soils that are exposed in the present pre-construction condition. Examples of impervious surfaces include paved roads, driveways, and dwelling footprints. In post-construction, such impervious surfaces will intercept incident precipitation and that water will be conveyed to a stormwater management pond. Impervious surfaces reduce the total amount of recharge to the shallow groundwater regime that can consequently reduce the volume of base flow in receiving watercourses.

Several environmental studies were carried out on the site area for the Town of Orangeville, private developers, and Credit Valley Conservation (ESG International Inc. August, 2002; Aquafor Beech Ltd et al, 1997; Aquafor Beech Ltd., 2001). The following relevant conclusions and objectives were derived from those studies.

- Base flows in the adjacent watercourses are provided by shallow and deeper groundwater flow systems.
- The primary source of water to groundwater systems is recharge within the local and regional areas.
- Base flow is significant for supporting the ecological functions of those watercourses.

- Most of the Phase 2 property is designated as a "high" groundwater recharge area.

- The Lower and Middle Monora Creeks are Level One Riparian Corridors.

- It will be necessary to provide, "...emulation or enhancement of existing recharge, taking into account local groundwater divides" (Aquafor Beech, 1997).

In summary, environmental reviews of the site area indicate that development should proceed in a manner such that the rate of infiltration for post-construction conditions will be similar to the rate of infiltration that presently occurs for pre-construction conditions.

1.3 STUDY OBJECTIVES AND SCOPE

The objective of this study was to assess aspects of the relationship between the groundwater regime and the proposed development, which included the following components.

1) Determine the elevation of shallow groundwater.
2) Characterize temporal changes of groundwater elevations, including for peak annual conditions.
3) Interpret areas of groundwater recharge and discharge.
4) Assess the distribution of areas with shallower groundwater that could affect development design components.
5) Determine the direction of groundwater movement to assess contributions by the site to the local watercourses.
6) Assess subsurface conditions with respect to the capability to support artificial infiltration systems that will maintain local watercourse base flows.

This information will provide input to planning of the residential development, including the distribution of lots, artificial infiltration measures, and the design of subsurface municipal servicing infrastructure. We understand that the elevation of the groundwater level can constrain the design and placement of dwellings, basements, buried utility infrastructure, and artificial infiltration systems.

The scope of work included completion of the following tasks.

- Completion of drilling explorations to determine subsurface soil conditions at six locations.
- Installation of a network of groundwater monitors to assess groundwater levels, consisting of eight monitors at six locations.
- Performance of a monitoring program to observe seasonal groundwater level elevations and trends, including for two spring seasons.
- Measurement of base flows in local watercourses
- Assessment of hydrogeologic effects potentially resulting from development at the site.
- Provision of this report.

2.0 METHODOLOGY

2.1 BOREHOLE AND MONITOR INSTALLATION PROGRAM

A program of borehole drilling and groundwater monitor installation was carried out during March 7 to 11, 2005. Work was performed at six (6) locations on the site, with boreholes and groundwater monitors designated as BH05-A through BH05-F. The locations of boreholes and groundwater monitors are shown on Figure 2.

Borehole locations were selected to provide good areal coverage for the interpretation of soil and groundwater conditions across the site. The selection of locations also considered the probable presence of groundwater divides, including between the surface water catchments of Middle Monora Creek and Lower Monora Creek, a local swale, and a ridge. The drilling locations were submitted to and approved by Credit Valley Conservation prior to commencing the field program.

Lantech Drilling Services Inc. of Mount Albert, Ontario was the drilling contractor who provided the drilling equipment and operating crew. The work program was supervised in the field by a Jagger Hims Limited technician.

The depth of exploratory boreholes resulting from the drilling ranged from 4.4 to 11.3 metres below ground level (m bgl). Boreholes were drilled using the hollow stem auger method and soil samples were collected using a standard 0.6 metre (m) long split spoon sampler. Samples were generally collected every 0.76 m, with reduced sampling frequencies at less critical depths as determined by the project geoscientist.

A groundwater monitor was installed within the exploratory borehole at each location. At locations BH05-A and BH05-F, an adjacent, unsampled borehole was advanced and a relatively shallower monitor was installed to determine the position of the groundwater table and the vertical hydraulic gradient.

Each groundwater monitor was constructed using environmental grade, PVC, 51 millimetre (mm) diameter, thread-connected riser pipe. Each monitor was equipped with a machine-slotted well screen with an open length of 1.4 m. The bottom of the monitor was fitted with a slotted end cap. The annulus at the screened zone was backfilled with sand to provide a filter pack. The annulus above the screened zone was backfilled with a low permeability bentonite seal that continued to ground surface. Locked protective casings were installed over each riser pipe. Summaries of monitor construction details are provided in Tables A-1 and A-2 of Appendix A.

Groundwater monitors were surveyed for location and elevation by Metropolitan Consulting Inc. The elevation references were the rim of PVC riser casing and adjacent ground level at each monitor. Elevation data is provided on Table A-2 of Appendix A.

The Well Tag Number that is registered with the Ministry of the Environment for the monitors installed on this site is No. A011143.

Test pits were excavated on the site by Jagger Hims Limited (Jagger Hims Limited, 2003), with designations of TP03-3, TP03-4, TP03-5, and TP03-6. Locations are shown on Figure 2. Standpipes were installed in TP03-3 and TP03-4, and the standpipe at TP03-3 was functional and used for monitoring in 2005/2006.

2.2 GROUNDWATER LEVEL MONITORING

Groundwater levels were measured in the groundwater monitors and in the test pit standpipe using a Solinst® brand electric water level tape. The reference level at each monitor was the rim of the PVC casing.

Historic measurements of groundwater levels were obtained at test pits TP03-4 and TP03-5 in January and June 2003.

In 2005, groundwater levels were measured in groundwater monitors at locations BH05-A through BH05-F, and at TP03-4. Monitoring events were carried out on the dates indicated on Table 1, which are summarized as follows.

- Spring 2005, including 7 events from March 11 to April 29, 2005.
- Other 2005, including 4 events between June 27 and December 23, 2005.
- Spring 2006, including 11 events from February 7 to June 10, 2006.

TABLE 1
Record of Groundwater Levels
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Monitor	Ground Surface	Top of Tube	Date	Static Water Levels		
	m ASL	m ASL		m bmp	m ASL	m bgl
BH05-A-i	432.26	433.17	10-Mar-05	5.055	428.12	4.14
			11-Mar-05	5.035	428.14	4.13
			18-Mar-05	5.12	428.05	4.21
			24-Mar-05	5.11	428.06	4.20
			1-Apr-05	4.95	428.22	4.04
			11-Apr-05	4.76	428.41	3.85
			15-Apr-05	4.82	428.35	3.91
			29-Apr-05	***4.54***	***428.63***	***3.63***
			27-Jun-05	4.91	428.26	4.00
			17-Aug-05	5.31	427.86	4.40
			21-Nov-05	5.68	427.49	4.77
			23-Dec-05	5.53	427.64	4.62
			7-Feb-06	4.97	428.20	4.06
			24-Feb-06	4.82	428.35	3.91
			9-Mar-06	4.78	428.39	3.87
			14-Mar-06	4.42	428.75	3.51
			28-Mar-06	4.27	428.90	3.36
			5-Apr-06	4.30	428.87	3.39
			12-Apr-06	4.23	428.94	3.32
			20-Apr-06	4.27	428.90	3.36
			1-May-06	***4.20***	***428.97***	***3.29***
			8-May-06	4.29	428.88	3.38
			10-Jun-06	4.53	428.65	3.61
BH05-A-ii	432.26	433.15	10-Mar-05	5.08	428.07	4.19
			11-Mar-05	4.94	428.21	4.05
			18-Mar-05	5.01	428.14	4.12
			24-Mar-05	5.03	428.12	4.14
			1-Apr-05	4.91	428.24	4.02
			11-Apr-05	4.76	428.39	3.87
			15-Apr-05	4.82	428.33	3.93
			29-Apr-05	***4.40***	***428.75***	***3.51***
			27-Jun-05	4.74	428.41	3.85
			17-Aug-05	5.18	427.97	4.29
			21-Nov-05	5.63	427.52	4.74
			23-Dec-05	5.46	427.69	4.57
			7-Feb-06	4.84	428.31	3.95
			24-Feb-06	4.64	428.51	3.75
			9-Mar-06	4.59	428.56	3.70
			14-Mar-06	4.26	428.89	3.37
			28-Mar-06	4.00	429.15	3.11
			5-Apr-06	4.09	429.06	3.20
			12-Apr-06	4.03	429.13	3.13
			20-Apr-06	4.02	429.13	3.13
			1-May-06	***3.95***	***429.20***	***3.06***
			8-May-06	4.03	429.12	3.14
			10-Jun-06	4.33	428.83	3.44

TABLE 1
Record of Groundwater Levels
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Monitor	Ground Surface m ASL	Top of Tube m ASL	Date	Static Water Levels m bmp	m ASL	m bgl
BH05-B	430.18	431.09	10-Mar-05	6.62	424.47	5.71
			11-Mar-05	6.62	424.47	5.71
			18-Mar-05	6.70	424.39	5.79
			24-Mar-05	6.67	424.42	5.76
			1-Apr-05	6.37	424.72	5.46
			11-Apr-05	6.15	424.94	5.24
			15-Apr-05	6.23	424.86	5.32
			29-Apr-05	***6.01***	***425.08***	***5.10***
			27-Jun-05	6.65	424.44	5.74
			17-Aug-05	7.08	424.01	6.17
			21-Nov-05	7.02	424.07	6.11
			23-Dec-05	6.94	424.15	6.03
			7-Feb-06	6.30	424.79	5.39
			24-Feb-06	6.26	424.83	5.35
			9-Mar-06	6.34	424.75	5.43
			14-Mar-06	5.90	425.19	4.99
			28-Mar-06	5.90	425.19	4.99
			5-Apr-06	5.86	425.23	4.95
			12-Apr-06	***5.82***	***425.28***	***4.91***
			20-Apr-06	5.90	425.19	4.99
			1-May-06	5.86	425.23	4.95
			8-May-06	6.00	425.09	5.09
			10-Jun-06	6.15	424.95	5.24
BH05-C	428.80	429.77	11-Mar-05	5.195	424.58	4.23
			18-Mar-05	5.235	424.54	4.27
			24-Mar-05	5.25	424.52	4.28
			1-Apr-05	5.12	424.65	4.15
			11-Apr-05	4.88	424.89	3.91
			15-Apr-05	4.87	424.90	3.90
			29-Apr-05	***4.79***	***424.98***	***3.82***
			27-Jun-05	5.09	424.68	4.12
			17-Aug-05	5.40	424.37	4.43
			21-Nov-05	5.61	424.16	4.64
			23-Dec-05	5.49	424.28	4.52
			7-Feb-06	5.13	424.64	4.16
			24-Feb-06	5.06	424.71	4.09
			9-Mar-06	5.09	424.68	4.12
			14-Mar-06	4.87	424.90	3.90
			28-Mar-06	4.76	425.01	3.79
			5-Apr-06	4.71	425.06	3.74
			12-Apr-06	4.65	425.12	3.68
			20-Apr-06	4.66	425.11	3.69
			1-May-06	4.61	425.16	3.64
			8-May-06	***4.57***	***425.20***	***3.60***
			10-Jun-06	4.78	425.00	3.81

TABLE 1
Record of Groundwater Levels
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Monitor	Ground Surface	Top of Tube	Date	Static Water Levels		
	m ASL	m ASL		m bmp	m ASL	m bgl
BH05-D	425.88	426.74	10-Mar-05	2.01	424.73	1.15
			11-Mar-05	2.01	424.73	1.15
			18-Mar-05	2.09	424.65	1.23
			24-Mar-05	2.02	424.72	1.16
			1-Apr-05	1.39	425.35	0.53
			11-Apr-05	1.22	425.52	0.36
			15-Apr-05	1.24	425.50	0.38
			29-Apr-05	***1.01***	***425.73***	***0.15***
			27-Jun-05	2.30	424.44	1.44
			17-Aug-05	3.15	423.59	2.29
			21-Nov-05	1.97	424.77	1.11
			23-Dec-05	1.90	424.84	1.04
			7-Feb-06	1.11	425.63	0.25
			24-Feb-06	0.90 to ice		
			9-Mar-06	0.90 to ice		
			14-Mar-06	0.85 to ice		
			28-Mar-06	1.26	425.48	0.40
			5-Apr-06	***1.08***	***425.66***	***0.22***
			12-Apr-06	1.11	425.63	0.25
			20-Apr-06	1.39	425.35	0.53
			1-May-06	1.42	425.32	0.56
			8-May-06	1.71	425.03	0.85
			10-Jun-06	1.73	425.02	0.87
BH05-E	422.25	423.30	11-Mar-05	1.015	422.29	-0.04
			18-Mar-05	2.07	421.23	1.02
			24-Mar-05	1.94	421.36	0.89
			1-Apr-05	1.71	421.59	0.66
			11-Apr-05	1.68	421.62	0.63
			15-Apr-05	1.80	421.50	0.75
			29-Apr-05	***1.65***	***421.65***	***0.60***
			27-Jun-05	2.46	420.84	1.41
			17-Aug-05	2.69	420.61	1.64
			21-Nov-05	2.10	421.20	1.05
			23-Dec-05	2.10	421.20	1.05
			7-Feb-06	1.79	421.51	0.74
			24-Feb-06	1.91	421.39	0.86
			9-Mar-06	1.92	421.38	0.87
			14-Mar-06	***1.55***	***421.75***	***0.50***
			28-Mar-06	1.82	421.48	0.77
			5-Apr-06	1.72	421.58	0.67
			12-Apr-06	1.76	421.55	0.70
			20-Apr-06	1.89	421.41	0.84
			1-May-06	1.89	421.41	0.84
			8-May-06	***1.55***	***421.75***	***0.50***
			10-Jun-06	2.03	421.27	0.98

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TABLE 1
Record of Groundwater Levels
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Monitor	Ground Surface	Top of Tube	Date	Static Water Levels		
	m ASL	m ASL		m bmp	m ASL	m bgl
BH05-F-i	422.19	423.10	11-Mar-05	0.985	422.12	0.07
			18-Mar-05	1.00 to ice		0.07 to ice
			24-Mar-05	1.07 to ice		0.14 to ice
			1-Apr-05	0.91	422.19	0.00
			11-Apr-05	0.92	422.18	0.01
			15-Apr-05	0.96	422.14	0.05
			29-Apr-05	***0.90***	***422.20***	***-0.01***
			27-Jun-05	1.48	421.62	0.57
			17-Aug-05	2.18	420.92	1.27
			21-Nov-05	1.00	422.10	0.09
			23-Dec-05	1.00	422.10	0.09
			7-Feb-06	0.92	422.18	0.01
			24-Feb-06	0.96	422.14	0.05
			9-Mar-06	0.92	422.18	0.01
			14-Mar-06	***0.89***	***422.21***	***-0.02***
			28-Mar-06	0.94	422.16	0.03
			5-Apr-06	0.91	422.19	0.00
			12-Apr-06	0.92	422.19	0.00
			20-Apr-06	0.98	422.12	0.07
			1-May-06	0.99	422.11	0.08
			8-May-06	1.05	422.05	0.14
			10-Jun-06	1.01	422.09	0.10
BH05-F-ii	422.02	422.99	11-Mar-05	Frozen		
			18-Mar-05	0.895 to ice		-0.08 to ice
			24-Mar-05	0.96 to ice		-0.01 to ice
			1-Apr-05	1.15	421.84	0.18
			11-Apr-05	***0.92***	***422.07***	***-0.05***
			15-Apr-05	0.95	422.04	-0.02
			29-Apr-05	***0.92***	***422.07***	***-0.05***
			27-Jun-05	1.36	421.63	0.39
			17-Aug-05	2.09	420.90	1.12
			21-Nov-05	0.94	422.05	-0.03
			23-Dec-05	0.94	422.05	-0.03
			7-Feb-06	0.92	422.07	-0.05
			24-Feb-06	0.93	422.06	-0.04
			9-Mar-06	***0.91***	***422.08***	***-0.06***
			14-Mar-06	0.92	422.07	-0.05
			28-Mar-06	0.92	422.07	-0.05
			5-Apr-06	0.92	422.07	-0.05
			12-Apr-06	***0.92***	***422.08***	***-0.06***
			20-Apr-06	0.94	422.05	-0.03
			1-May-06	0.94	422.05	-0.03
			8-May-06	1.05	421.94	0.08
			10-Jun-06	0.93	422.07	-0.05

Notes:

1. "m bmp" indicates metres below measurement point (top of PVC casing).
2. "m ASL" indicates metres above sea level.
3. "m bgl" indicates metres below ground level.
4. Shaded values are minimum observed for location.
5. Bold and italic values are maximum observed for location for year.

The spring events were completed to observe water level trends during the spring freshet period, when groundwater levels were anticipated to correspond with maximum annual values. Other events in June to December were used to monitor seasonal variation.

In addition to manual measurements, shorter-term fluctuations of the groundwater level were measured by a computerized datalogger instrument that was installed in groundwater monitors. The instrument used was a Solinst® Levelogger® that includes an automated data logger and transducer. A Levelogger was installed in groundwater monitor BH05-D, which obtained readings at 10 minute intervals, between March 18 and April 29, 2005. A Levelogger was installed in groundwater monitor BH05-A-ii, which obtained readings at 10 minute intervals, between March 9 and May 1, 2006. The Solinst® Barologger®, which is a similar instrument to the Levelogger, was installed above ground on site, and its record was used to filter out barometric effects to the Levelogger record.

2.3 WATERCOURSE BASE FLOW MEASUREMENT

Base flows in the north branch of Lower Monora Creek and in the south branch of Middle Monora Creek were estimated using the stream profiling method. The cross-section of each watercourse was subdivided into segments, and the flow velocity and the sectional geometry within each segment was measured. Flow velocity was measured using the Marsh-McBirney Flo-mate instrument, which is an electromagnetic flow meter. One flow measurement event was completed on April 15, 2005, which was timed to occur several days after the most recent precipitation event.

2.4 CLIMATE MONITORING

Data for climate conditions for the duration of the field program were based on reports from local Environment Canada climate monitoring stations. Long-term monthly climatic averages of total precipitation and average daily temperature were based on the record for the Orangeville MOE Climate Station between 1971 and 2000. Assessment of effects during the spring monitoring periods required data of daily precipitation and daily temperature, most of which were obtained from the Orangeville MOE Climate Station (80°5' W, 43°55' N, Elevation = 411 metres above sea level (m ASL)).

Due to incomplete monitoring at the Orangeville MOE climate station that is located nearest to the site, supplemental data were required from other stations. Missing daily precipitation data were obtained from the Sandhill Climate Station (79°49' W, 43°49' N, Elevation = 274 m ASL), and missing daily temperature data were obtained from the Borden AWOS Climate Station (79°54' W, 44°16' N, Elevation = 222 m ASL).

2.5 HYDRAULIC CONDUCTIVITY

The in-situ hydraulic conductivity of soil was determined using rising-head tests at the two deeper groundwater monitors of BH05-A and BH05-F on December 23, 2005.

The rising head tests involved the removal of standing water within the groundwater monitors which was followed by measurement of the recovery of the water level over time. Hydraulic conductivity was interpreted from the water level versus time data using the Bouwer-Rice analytical method. Graphical presentations of the tests are provided in Appendix A.

3.0 SITE CONDITIONS

3.1 EXISTING FEATURES

The southern and central portions of Phase 2, at the times of inspection in 2003 and 2005, consisted for the most part of fallow pasture lands vegetated with wild grass and isolated trees. The northern portion consisted of the watercourse and adjacent wooded area. Buildings or other structures were absent from the site.

The land usage immediately surrounding Phase 2 consists of the following types, as shown on Figure 2:

- North: A woodlot along the valley containing the south branch of Middle Monora Creek, and further north was a neighbourhood of single-family residential dwellings.
- East: Commercial development consisting of a shopping mall with an extensive paved parking area.
- South: Hansen Boulevard, which is a two-lane asphalt paved road. Further south is the yet-to-be-developed Phase 1 land that consists primarily of grassy pasture.
- West: A neighourhood of single-family residential dwellings, including residences with addresses along Lisa Marie Drive and Hansen Boulevard.

Residential and commercial areas that are located downgradient of the proposed development are on municipal servicing, and there are no identified water supply wells that could be affected by infiltration at the site.

3.2 TOPOGRAPHY AND GRADE

The maximum elevation within the Phase 2 property is above 437.7 m ASL at a location near the southwest corner, and the minimum elevation is below 419 m ASL at a location in a ditch near the northeast corner at Middle Monora Creek, indicating a vertical range for the site of about 18 m.

Phase 2 can be divided into five topographic features, as follows.

- Western upland, which extends from the western property line to approximately 180 m eastward, and from Hansen Boulevard to approximately 180 m northward. In general, the western upland includes lands higher than approximately 430 m ASL. Existing grades are toward the east and northeast.
- Northern valley, which is a portion of a wooded valley that contains the south branch of Middle Monora Creek and its floodplain, with existing grades on site sloping northward to the watercourse.
- Broad swale, which is located in the south-central portion of the site. Existing grades are toward the west-to-east trending axis of the swale.
- Fill stockpile, which forms a hummocky hill in the central area of the site. The stockpile hill generally grades towards the east and to the northeast. The topography of native ground beneath the fill is not known.
- Eastern lowland, which is a relatively flatter area with grades less than approximately 5%, with steeper slopes that grade toward internal ditches or to the adjacent shopping mall. In general, the eastern lowland includes lands lower than an elevation of 423 m ASL.

The origin of the soil stockpile is believed to be from development of the Orangeville Highlands Mall property that is located to the east of the site. Site mapping shows the presence of the soil stockpile on-site in 1991.

3.3 DRAINAGE

The site is situated within the surface water catchments of two local watercourses. In pre-construction conditions, the majority of the site is located within the catchment of the south branch of Middle Monora Creek and connecting ditches. A minor portion of the site is located within the catchment of the north branch of Lower Monora Creek. The watercourses and the catchment divide between them are indicated on Figure 3.

Middle Monora Creek and Lower Monora Creek flow eastward and confluence east of First Street, and then discharge into the Orangeville Reservoir. The reservoir drains both to the Credit River (south) and to the Nottawasaga River (north). Both Lower Monora Creek and Middle Monora Creek are considered tributaries of the Credit River, within Subwatershed 19 of the Credit Valley Conservation plan (Aquafor Beech Ltd., 1997).

The north branch of Middle Monora Creek confluences with the south branch of Middle Monora Creek on the site, at a location that is approximately 250 m east of the western property line.

A 250 m long south-to-north trending ditch, designated herein as "Ditch #1", is located within the eastern portion of the eastern lowland and discharges to the south branch of Middle Monora Creek.

A 180 m long south-to-north trending constructed ditch, designated herein as "Ditch #2", is located within the northern portion of the eastern lowland, between the soil stockpile and Ditch #1, and discharges to the south branch of Middle Monora Creek.

A 120 m long west-to-east trending ditch, designated herein as "Ditch #3", is located north of the sidewalk adjacent to Hansen Boulevard, and discharges to a 0.91 m diameter culvert that is located near the intersection of Hansen Boulevard and the western driveway entrance to the Orangeville Highlands Mall.

A 450 m long west-to-east trending constructed swale, designated herein as "Ditch #4", is located between the sidewalk and the paved asphalt of Hansen Boulevard, and discharges to a catchbasin located near the intersection of Hansen Boulevard and the western driveway entrance to the Orangeville Highlands Mall.

A 170 m long north-to-south trending ditch, designated as "Ditch #5", is located within the southern portion of the eastern lowland, and discharges to Ditch #3.

Water from Ditch #3 and Ditch #4 is conveyed through storm sewers that include a culvert at Hansen Boulevard that eventually is conveyed to discharge at Lower Monora Creek.

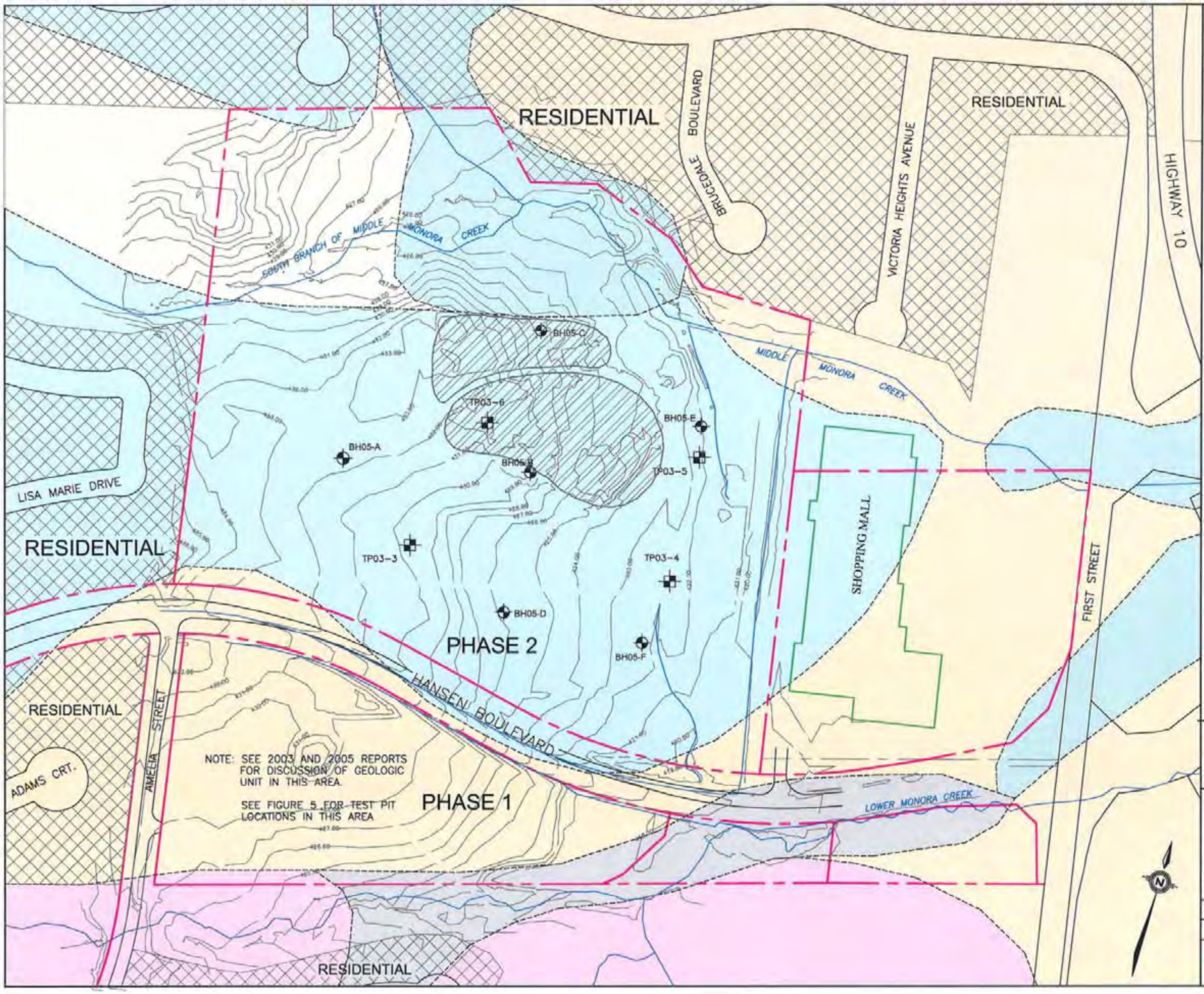
Water flow in site ditches is seasonal and in response to antecedent precipitation events.

3.4 SURFICIAL GEOLOGIC MAPPING

Surficial geologic mapping characterizes the site and area as being dominated by overburden soils. Bedrock beneath the proposed development is located approximately 15 metres below ground level (m bgl) or deeper (Ontario Department of Mines, 1969) and is not a significant influence with respect to infiltration or watercourse base flow aspects.

Published mapping indicates that surficial geology at the site is generally complex, as shown on Figure 4. The proposed development is located within the Orangeville Moraine landform (ESG International Inc, 2002; Aquafor Beech, 2001). The surficial geology map that covers this area (Ontario Department of Mines, 1973) indicates that the units at the site include the following.

- Ice-contact stratified drift, comprised of sand and gravel, and also including some glacial till or silt soils. This unit covers the vast majority of the site.
- Glaciofluvial outwash, comprised of gravel and gravelly sand, frequently overlain by several metres of sand or silt. This unit is exposed in the extreme northeast and southeast corners of the site.
- Glaciofluvial outwash, comprised of sand, with minor gravel. This unit is exposed in the northwest corner of the site.
- Bog deposits, comprised of peat, muck, and marl. This unit is exposed in the north-central portion of the site.



Legend

— · —	SUBJECT PROPERTY BOUNDARY
☒	RESIDENTIAL AREA
	MAPPED SURFICIAL GEOLOGIC UNITS:
☐	MODERN ALLUVIUM: SILT, SAND, GRAVEL
☐	BOG DEPOSITS: PEAT, MUCK, MARL
☐	GLACIOLACUSTRINE OR LOCAL POND SEDIMENTS: MAINLY FINE TO VERY FINE SAND
☐	GLACIOFLUVIAL OUTWASH SAND, MINOR GRAVEL
☐	GLACIOFLUVIAL OUTWASH GRAVEL AND GRAVELLY SAND, FREQUENTLY OVERLAIN BY SEVERAL FEET OF SAND OR SILT
☐	ICE-CONTACT STRATIFIED DRIFT: SAND AND GRAVEL INCLUDING SOME TILL OR SILT
▨	TOPSOIL STOCKPILE
BH05-E	BOREHOLE AND MONITOR LOCATION AND DESIGNATION (JAGGER HIMS LIMITED)
TP03-5	TEST PIT LOCATION AND DESIGNATION (JAGGER HIMS LIMITED)
420.00	TOPOGRAPHIC ELEVATION CONTOUR (mASL)

50 0 100 metres

NOTES:
1. LOCATIONS OF TEST PITS ARE APPROXIMATE, BASED ON GPS, LOCATIONS OF BOREHOLES WERE SURVEYED BY METROPOLITAN CONSULTING.
2. LOCATION OF TOPSOIL STOCKPILE IS ESTIMATED FROM YARDUN ENGINEERING (1991).
3. GEOLOGY FROM QUATERNARY GEOLOGY ORANGEVILLE AREA, PRELIMINARY MAP P.848, ONTARIO DIVISION OF MINES, MINISTRY OF NATURAL RESOURCES.

SURFICIAL GEOLOGY

SUPPLEMENTAL MONITORING AND
HYDROGEOLOGICAL ASSESSMENT
PROPOSED ORANGEVILLE HIGHLANDS
DEVELOPMENT, PHASE 2
for Orangeville Highlands Ltd.

DATE: JULY 2006	SCALE: 1:3,000
PROJECT: 021508.03	FILE NO.: 0-02150803F4-GE
JAGGER HIMS LIMITED Environmental Consulting Engineers	Figure 4

With the exception of the bog deposits, the surficial geologic materials present on site consist of granular soil materials that are anticipated to be well drained. Glacial till and silt materials, where present at depth, would be relatively poorly drained.

Site mapping indicates the presence of the fill stockpile with a reported volume of approximately 50,000 m^3 (Yardun Engineering Inc, 1991) at the approximate location shown on Figure 4.

4.0 OBSERVATIONS

4.1 CLIMATE

The source of infiltration and surface runoff is from climatic moisture surplus, which is the remainder of precipitation minus the evapotranspiration component. The average moisture surplus for the site was calculated based on long-term climate averages as recorded at the Orangeville MOE Climate Station, for the time period between 1971 and 2000; this station is the nearest Environment Canada station to the proposed development. Evapotranspiration losses were estimated from average monthly temperatures as input to the Thornthwaite method, with a daylight correction for latitude. Long-term averages of monthly climate data are provided on Table C-1 of Appendix C. The calculations indicate that the long-term average annual moisture surplus is 0.322 m/year. The moisture surplus is available for either infiltration or surface runoff, depending on site conditions.

A key objective for the monitoring program was to characterize the response of the shallow groundwater regime in the Phase 2 area to the spring snowmelt, also known as the spring freshet. Groundwater elevations are anticipated to be at or close to annual maximums during the freshet. Spring freshet usually occurs when the ambient air temperature ascends above the freezing point, the ground surface thaws, and the snow pack melts. Graphs of daily temperatures, including maximums, minimums, and averages for the spring monitoring periods of 2005 and 2006, are presented as Figures C-1 and C-2 of Appendix C, respectively. Graphs of daily precipitation for the spring monitoring period of 2005 and 2006 are presented as Figure C-3 and C-4, respectively. Tables of snow pack data for spring 2005 and 2006 are provided as Table C-2 and C-3, respectively.

4.1.1 Spring Freshet of 2005

The climatic record for 2005 indicates that the spring freshet occurred during late March to early April, as indicated by several climate parameters.

- "Snow on Ground" observations indicated that the main winter snow pack had completely melted by March 23 to 27, with a brief snow pack accumulation between April 2 and 5.
- Temperature was above the freezing point for some period of the day from at least March 19 onwards as indicated in the barometric logger air temperature data.
- The average daily temperature remained mainly above the freezing point from March 29 onwards according to Environment Canada climate stations, and from March 24 onwards as indicated in the barometric logger air temperature data. Most thawing of the frozen ground surface probably occurred after this date.

The precipitation record indicated that two periods of more-significant precipitation activity occurred during the monitoring period between mid-March and late April. The first significant period of precipitation occurred between March 31 to April 3, with a total of 49.8 mm provided during those days; the peak of 22 mm occurred on April 2. The second significant period of precipitation occurred between April 20 and April 29, with a total of at least 42.9 mm provided during those days; the peak of 21 mm occurred on April 23. Note precipitation data were not reported for the Orangeville or Sandhill climate stations for April 25. Other smaller events also occurred, as shown on Figure C-3, Appendix C.

4.1.2 Spring Freshet of 2006

The climatic record for 2006 indicates that the spring freshet occurred during late March, as indicated by several climate parameters.

- "Snow on Ground" observations indicated that the main winter snow pack had completely melted by March 12.
- Temperature was above the freezing point for some period of the day from at least March 23.
- The average daily temperature remained mainly above the freezing point from March 27 onwards. Most thawing of the frozen ground surface probably occurred after this date.

The precipitation record indicated that three periods of more significant precipitation activity occurred during the datalogger monitoring period between early-March and the start of May. There were cumulative precipitations on March 8 to 14, April 2 to 5 and April 21 to 24 of 56.3, 30.3 and 40.8 mm, respectively. Other single-day events also occurred, as shown on Figure C-4, Appendix C.

4.2 SITE GEOLOGY

Surficial geologic mapping indicates that the site is situated upon primarily granular sand and gravel textured soil units.

Subsurface geology of the site was investigated using boreholes and test pits. Detailed soil information at boreholes is provided in the borehole records of Appendix A, and details of test pits excavated are provided on Table B-1 of Appendix B and are also reported in Jagger Hims Limited (2003).

The borehole and test pits advanced on site indicate that the subsurface consists of two primary native soil layers, as follows.

- Sand - A fine to medium sand layer occurs across most of the drilled area of the site. The thickness of the sand layer ranges from 1.2 m at BH05-D to 4.0 m at BH05-E. At most locations the sand layer is the upper layer that overlies a lower layer of glacial till. At some locations the sand layer was buried beneath fill.

- Silt Till - A layer of glacial till, with dominant grain size texture ranging from "sand and silt" to "silt with some sand", including a trace clay component, was intercepted at most boreholes. The observed depth to till ranges from 1.8 to 8.2 m bgl, depending on location. The unit was not encountered at BH05-C to the depth of exploration at 6.0 m bgl.

In addition to the above units, other units were encountered at specific locations, including the following layers.

- Native topsoil - This layer occurs sporadically across the site. This unit was encountered at BH05-A and BH05-D with an approximate thickness of 0.6 m. This unit was absent at other locations and is likely buried beneath the fill at some locations.

- Fill, including organic soil fill and sandy silt fill - This layer is located within the central area of the site. This layer was encountered at BH05-B and BH05-C, with thicknesses of 3.0 and 2.1 m, respectively. These boreholes were located nearer to the edges of the topsoil stockpile as indicated on provided mapping, and a greater thickness of fill may be anticipated toward the centre of the stockpile. Also, test pit TP03-5 indicated granular fill with brick pieces with a layer thickness of 1.2 m, indicating that fill extends beyond the indicated stockpile perimeter to occur on portions of the eastern lowland.

- Sand with Silt - A layer of sand with some silt to silty fine sand was present at BH05-F. The layer was 2.2 m thick and occurred beneath the sand layer and above the silt till.

- Layered Sand and Silt - A layered sequence of dominantly silt and dominantly sand units was encountered at BH05-A and BH05-B. The thickness of the sequence was 6.7 m and 2.2 m, respectively. The layer is located above the silt till in the western area of the site.

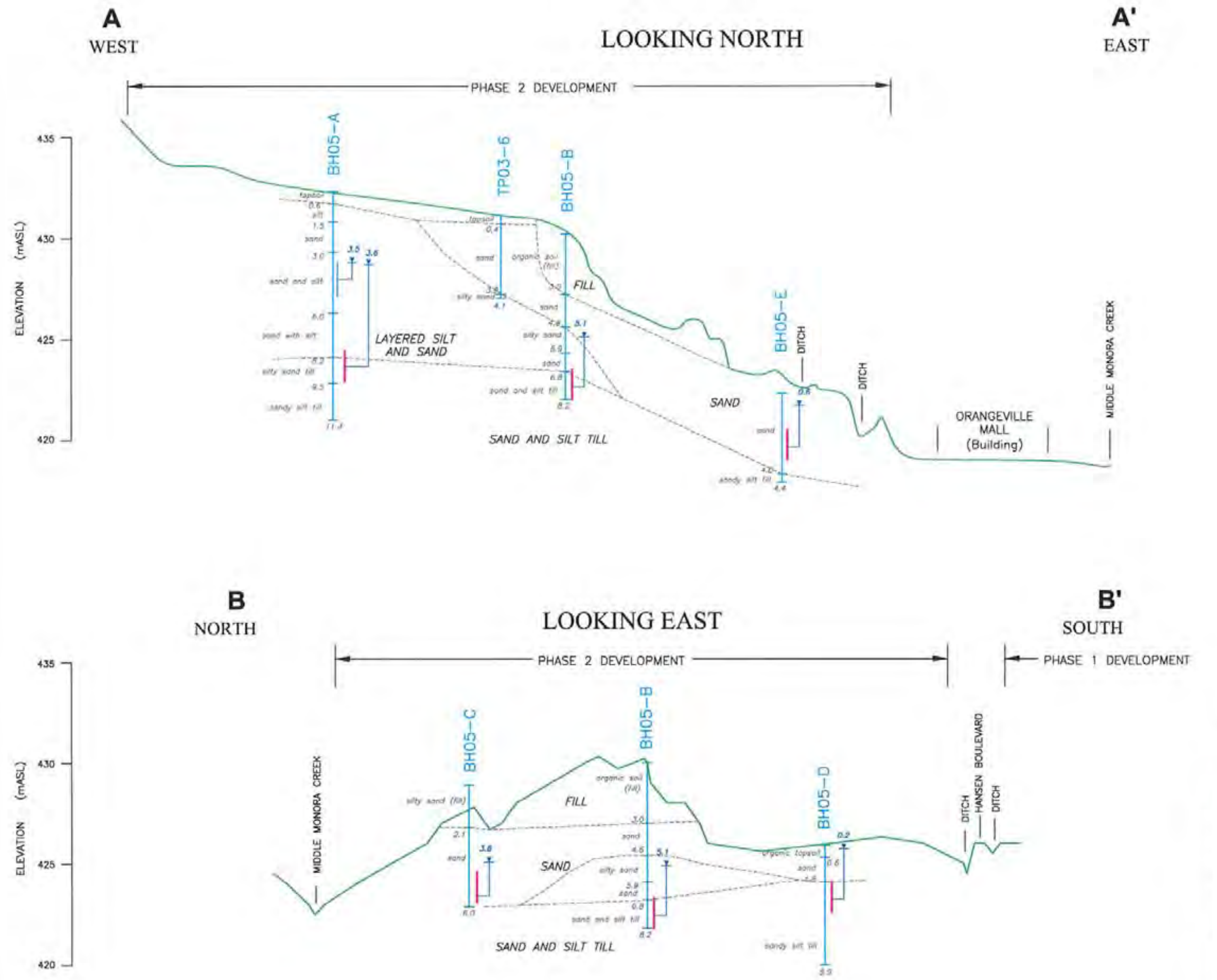
Two hydrostratigraphic cross sections were prepared that show the general relationship between these layers, based on available borehole and test pit data, as shown on Figure 5.

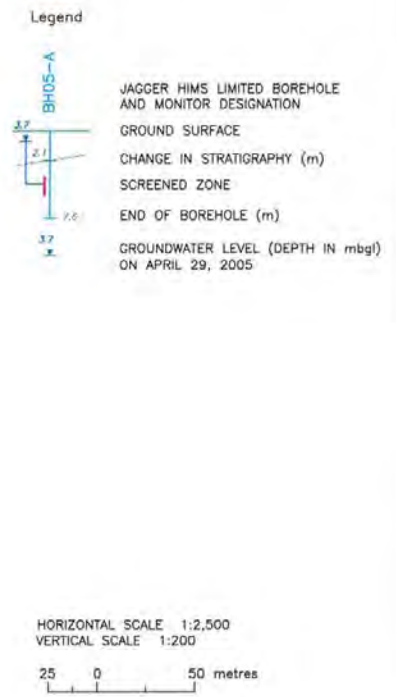
Two soil samples from the 2003 test pit program were submitted for laboratory analysis of the particle size distribution. Particle size distribution curves are provided as Figures B-1 and B-2 of Appendix B. The curves indicate fine sand with trace silt occurs at TP03-4 and TP03-6.

4.3 SHALLOW GROUNDWATER REGIME

Observations of groundwater levels at the site are provided on Table 1, for the measurement dates indicated in Section 2.2.

The following discussion focuses on the shallow groundwater levels that were observed on April 29, 2005, which provide the maximum observed elevation for Phase 2 during spring





STRATIGRAPHY NOTE:

THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE BOREHOLE LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS.

HYDROSTRATIGRAPHIC CROSS SECTIONS A-A' AND B-B'

SUPPLEMENTAL MONITORING AND
HYDROGEOLOGICAL ASSESSMENT
PROPOSED ORANGEVILLE HIGHLANDS
DEVELOPMENT, PHASE 2
for Orangeville Highlands Ltd.

DATE: JULY 2006	SCALES: AS SHOWN
PROJECT: 021508.03	FILE NO.: 0-02150803F5-CR
JAGGER HIMS LIMITED Environmental Consulting Engineers	Figure 5

freshet of 2005. Comments on the groundwater response to the spring freshet 2006 are provided at the end of this section. The observed groundwater levels for April 29, 2005 are posted on Figure 3.

Contours for the maximum groundwater elevation condition were interpreted based on observations at monitors, an estimated "surface" computed with the Golden Software "Surfer" program, and interpretations by a Professional Geoscientist. The Surfer program used observations at Phase 1 standpipes and Phase 2 monitors for April 29, 2005, and also assumed that groundwater elevations were similar to grade at Middle Monora Creek. Note that groundwater contours shown are considered as established at groundwater monitor locations only, and conditions in between groundwater monitors and beyond the network are estimated.

The maximum elevation of shallow groundwater directly observed at the site was 428.75 m ASL at shallow monitor BH05-A-ii that is located in the western area of the site. It is probable that the groundwater elevations increase at lands west of this monitor, based on the general correlation of site topography and groundwater elevation trends.

The minimum elevation of shallow groundwater directly observed at the site was 421.65 m ASL at monitor BH05-E that is located in the eastern lowland. It is probable that the shallow groundwater occurs at lower elevations in the area east of this monitor, which is toward Ditch #1 and Ditch #5, based on the general correlation of site topography and groundwater elevation trends.

The depth to shallow groundwater level below existing grade varies across the site. The maximum observed depth was 5.10 m bgl at BH05-B in the central area. The minimum observed depth was 0.05 m above ground level at BH05-F, indicating sufficient hydrostatic pressure at the screen to raise the water above existing grade (artesian conditions).

Depths to maximum groundwater level were interpreted for the site based on a comparison of a maximum groundwater surface and the existing pre-construction grade. The maximum groundwater surface was estimated as described above. The surface for the existing ground elevation was generated by the Surfer program using the 1-m contours of Phases 1 and 2, as provided by Metropolitan Consulting Inc. The depth to maximum groundwater level was calculated by subtracting the maximum groundwater level surface from the ground elevation surface. A colour-classified map of the results is presented on Figure 5. Various depth ranges are highlighted that may be relevant to different requirements for infrastructure components with respect to the maximum groundwater level. Shaded areas indicate the following ranges of maximum groundwater level: greater than 2.0 m bgl, between 0.5 and 2.0 m bgl, between 0.0 and 0.5 m bgl grade, and above grade.

The findings indicate that maximum groundwater levels occurs in relatively close proximity to pre-construction existing grade within the eastern portion of Phase 2, particularly at the eastern lowland, the broad swale, and adjacent to watercourses. In the eastern lowland, groundwater levels that are less than 1.0 m bgl probably occur on a year-round basis. Hydrophilic vegetation and surface water at the base of ditches in the eastern lowland are interpreted to indicate a shallow water table in that area. The construction of ditches suggests the requirement for water management near to grade.

In general, the depth to water table or shallow groundwater will vary naturally with position across the proposed development, with season, and in response to constructed drainage measures and proposed artificial infiltration systems.

4.4 DISCHARGE AND RECHARGE AREAS

Discharge areas occur where the water table intersects the ground surface, and where the vertical hydraulic gradient and groundwater movement are upward. Discharge areas may be expressed as springs, seeps, or direct discharge to surface water bodies. If sufficient permeability is available in weathered soils that are near-to-surface and the discharge rate is relatively low, the discharge may move horizontally in soils below ground surface, with no surface expression.

Recharge areas occur where the vertical hydraulic gradient and groundwater movement is downward. In general, infiltration at grade does not contribute to groundwater systems in a discharge area, but it does contribute in a recharge area.

Areas of the site where the depths to maximum groundwater were at or higher than existing grade are interpreted to be discharge areas, as shown on Figure 5. Discharge areas occur in the eastern lowland, the broad swale, and likely at the base of Middle Monora Creek valley. The discharge areas are expressed by relatively denser vegetation and relatively wetter soils, with inundated conditions in ditches.

Localized springs and seeps of groundwater, as expressed by a wet area with continuous drainage away from the wet area that would suggest continuous discharge, were not observed in the areas of the site with shallow groundwater. Some areas of wet ground or small shallow ponds less than 20 cm deep without inflow and outflow drainage were present in some areas of the eastern lowland, the broad swale, and the valley floor of Middle Monora Creek. Some shallow ponds may be due to containment by micro-topography. Observed areas of wet ground are shown on Figure 5 as observed at the site in Spring 2006, based on reconnaissance mapping of Phase 1 and 2 areas. Other areas of wet ground could conceivably be present in portions of the site that were not visited, and wet conditions at some areas may have been obscured beneath the thick grass vegetation. The areas of wet ground and shallow ponds are temporary seasonal seeps. Those discharges are likely seasonal as they were not observed during site visits of the summer and late fall.

At Phase 2, the areas mapped on Figure 5 that have a maximum groundwater level that is deeper than 0.5 m below grade will likely function as perennial recharge areas. Perennial recharge areas occur at the soil stockpile and western upland areas.

Areas where the maximum shallow groundwater is located between ground surface and 0.5 m below are uncertain with respect to discharge and recharge conditions. The areal extent of discharge areas and recharge areas at a site can vary in response to seasonal climatic conditions, relatively wetter or drier years, and other factors. Seasonal conditions and minor topographic variations will be more significant in this zone.

The boundary between recharge areas and discharge areas will shift in response to seasonal conditions. As example, as the groundwater level declines through the summer/fall period, the extent of discharge areas will decrease and possible temporarily cease. There are areas where there is seasonal conversion from recharge area to discharge area and back, depending on the fluctuating water table elevation.

The amount of recharge that can occur per unit area depends on the presence of a downward hydraulic gradient, climatic moisture surplus, soil type, ground slope, vegetation, proportion of impervious cover, and other factors. Under pre-construction conditions, the proposed development portion of the site has variable ground slopes and soil types and the rate of infiltration will vary with location.

4.5 GROUNDWATER LEVEL TEMPORAL FLUCTUATIONS

The elevation of shallow groundwater will vary seasonally in response to moisture received at the overlying ground surface. Shallow groundwater usually increases in elevation in response to additions of moisture, such as from incident precipitation, runoff from upland areas, and/or a melting snow pack. During drier periods, when there is little or no surplus moisture available, the elevation of shallow groundwater decreases as the groundwater regime loses water to discharges at adjacent local watercourses.

The observed water levels during the 2005 and 2006 monitoring periods are graphed on Figures 6, 7, and 8, respectively. The water levels are presented as elevations and metres below existing grade on Table 1.

Figure 6: Hydrograph for Monitors BH05-A AND BH05-B
Orangeville Highlands, Phase 2 Area

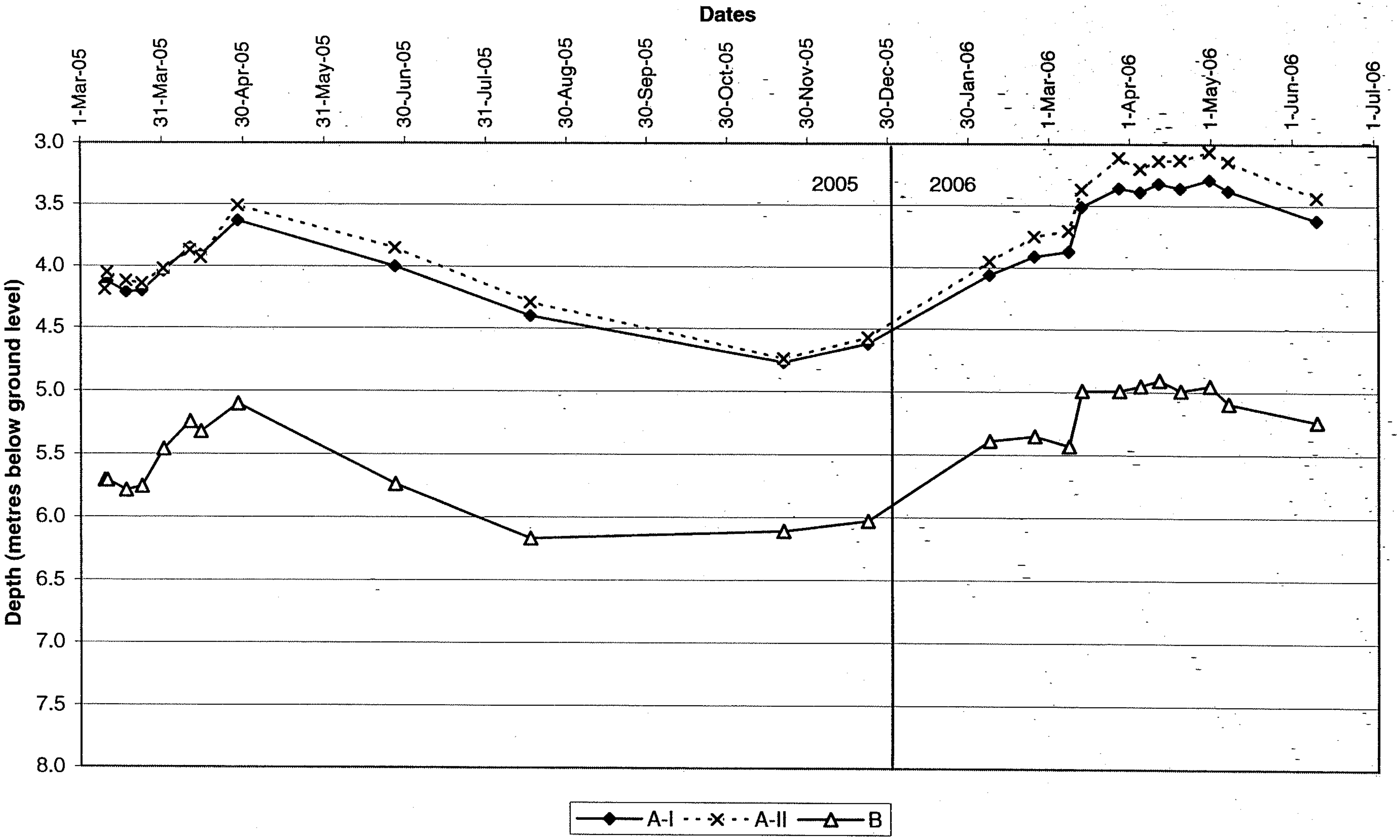


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Figure 7: Hydrograph for Monitors BH05-C AND BH05-D
Orangeville Highlands, Phase 2 Area

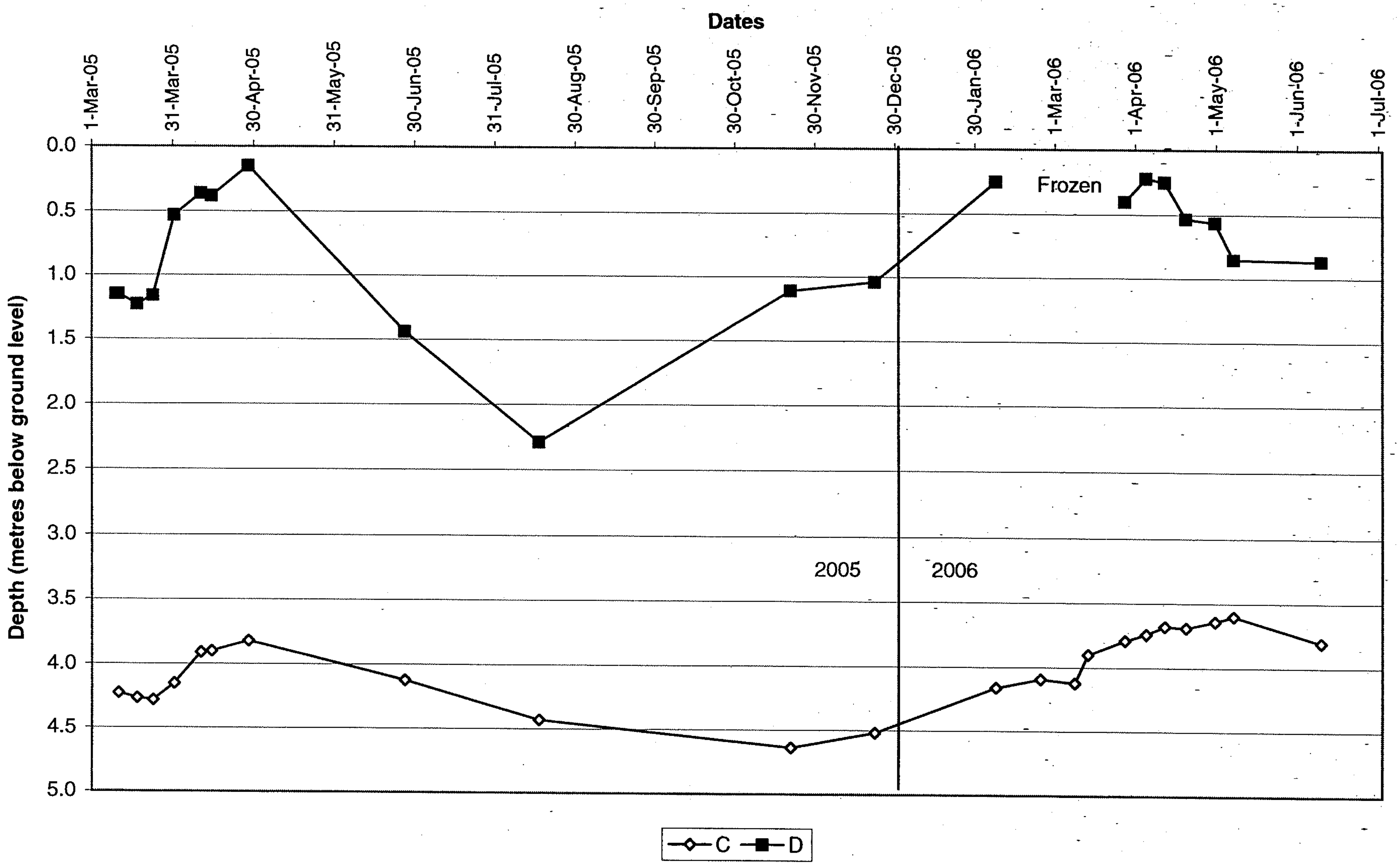

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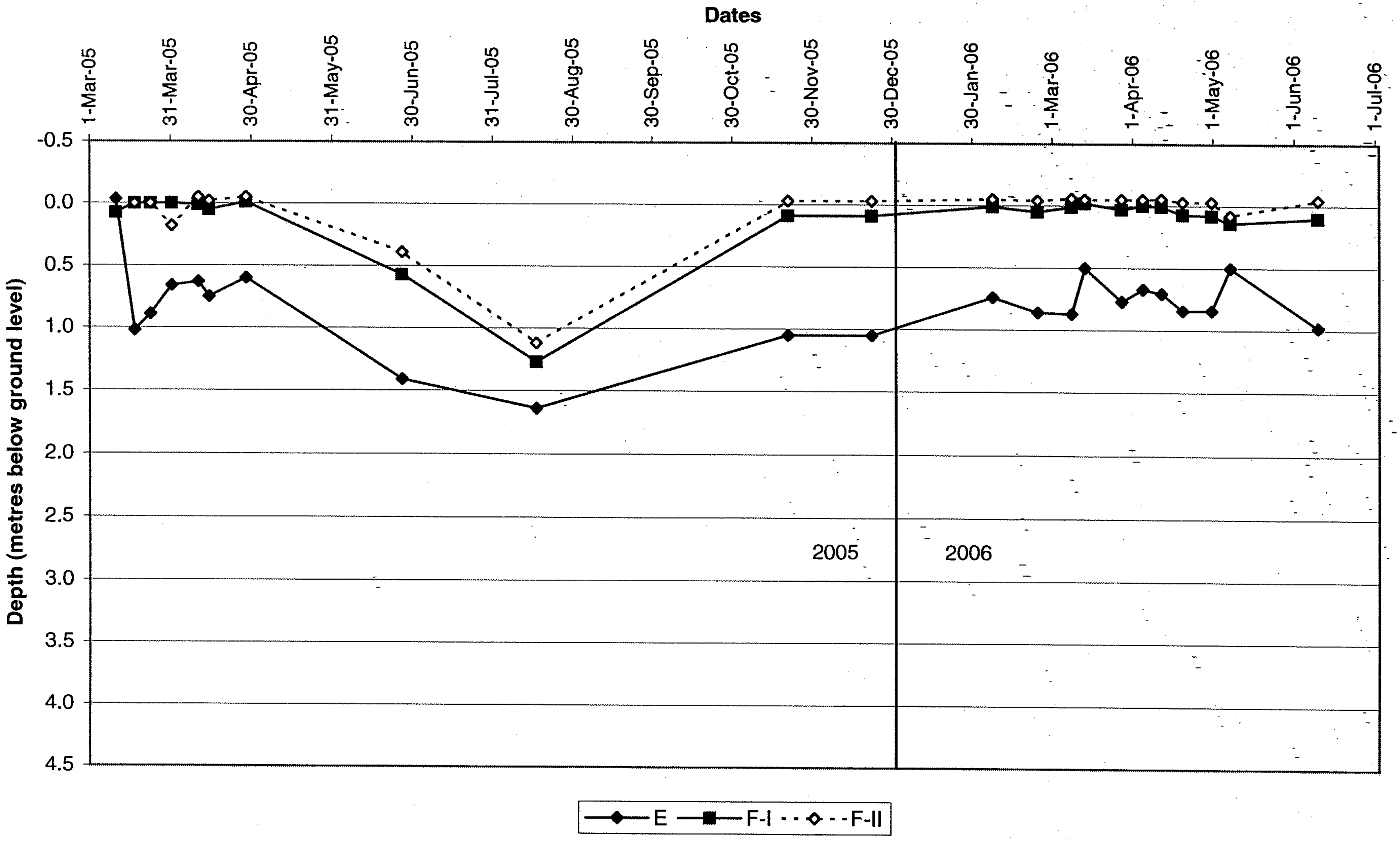
Figure 8: Hydrograph for Monitors BH05-E AND BH05-F Orangeville Highlands, Phase 2 Area



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4.5.1 Data Logger Observations at Eastern Lowland, 2005

As described in Section 2.2, an automated water level recorder was installed in BH05-E between March 18 and April 29, 2005 to monitor response of the groundwater level to the spring freshet in the Eastern Lowland area. The recorded hydrograph is provided on Figure 9. For comparison, temperature and precipitation data for that observation period are provided on Figures C-1 and C-3 of Appendix C, respectively.

The hydrograph for BH05-E indicates that the groundwater level elevation exhibited the following trends during the period of observation.

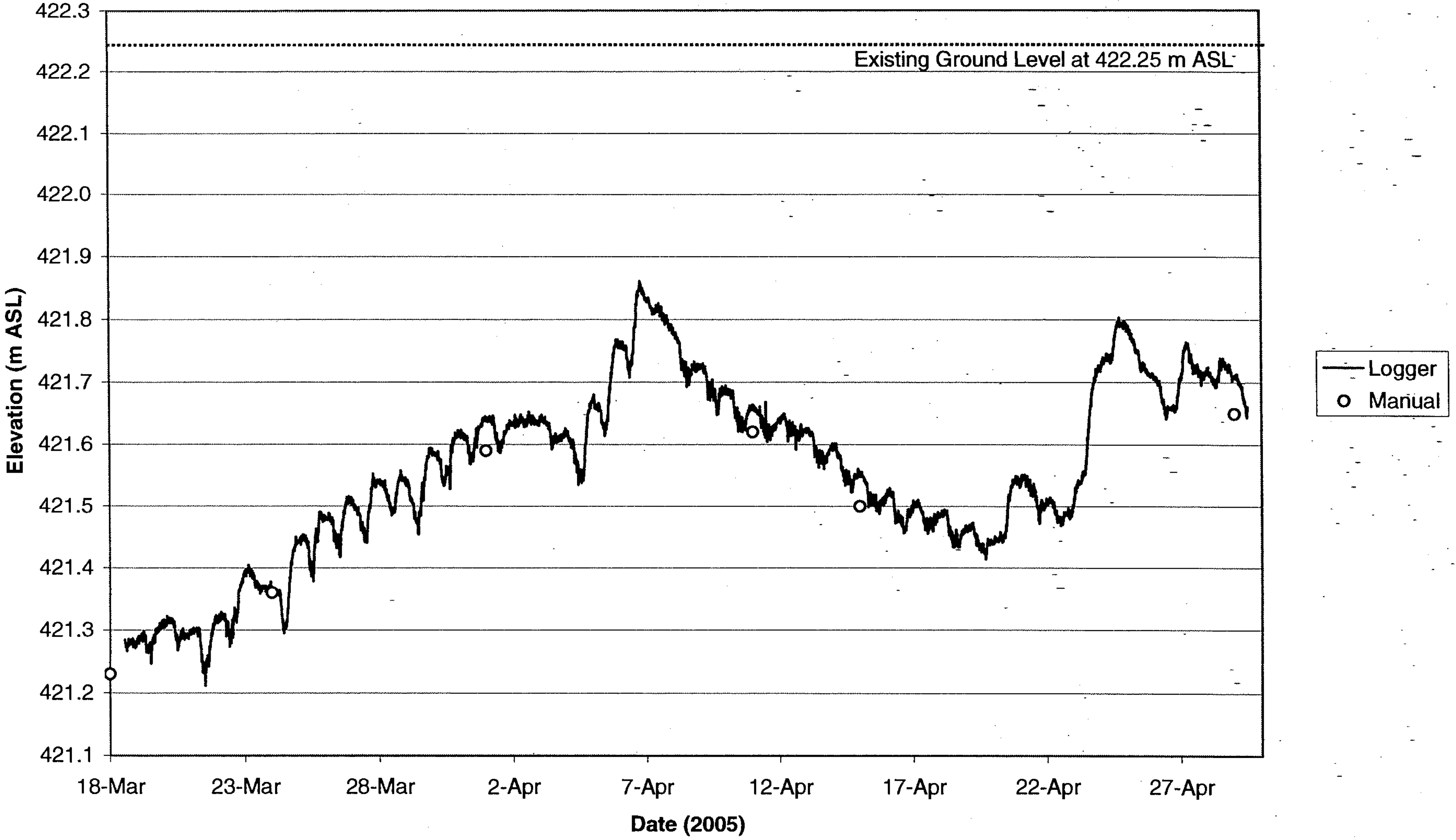
- The groundwater level has a regular diurnal fluctuation, with a magnitude on the order of 0.05 to 0.1 m. Within the cycle, the groundwater level usually increases to its highest elevation by mid-morning. This cyclical effect is negligible in magnitude and should have not any effects on the development.

- The groundwater level varied in elevation by 0.65 m during the logger monitoring period. Manual observations at this groundwater monitor indicate a historic elevation range of 1.6 m.

- The groundwater level elevation increased by approximately 0.3 m between March 19 and April 1, 2005. The increase likely was in response to partial melting of the overlying snow pack, thawing of ground frost, and some contribution by the total 10 mm of precipitation that fell during March 19 and 20.

- The groundwater level elevation increased by 0.3 m between April 4 and April 6. That increase is interpreted to be a result of the April 2 to 5 snow melt that resulted from warmer air temperatures during that period. No precipitation events occurred during that period. The peak groundwater elevation in response to the spring freshet occurred during this period, on April 6, 2005.

FIGURE 9: Logger Hydrograph of Monitor BHO5-E
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments



- No increase occurred in response to the total 48.6 mm of precipitation that fell during April 1 to 3. The lack of response to the relatively large amount of precipitation is attributed to a frozen ground surface at the time of precipitation, which would be relatively impermeable to recharge. The precipitation may have been temporarily stored in the snow pack and released during April 4 to 6.

- The groundwater level gradually declined between April 7 and 20. This decline occurred during a dry period and after the snow pack had melted, 'such that there were no sources to recharge the shallow groundwater. The groundwater level elevation declined at a rate of approximately 26 mm/day.

- The groundwater level increased by 0.4 m between April 20 and 24, with peaks on April 27 and 28. This marked increase is attributed to the total 35.7 mm of precipitation that fell during that period. The groundwater level elevation was sustained over the next few days as precipitation events of approximately 2 mm/day continued. At that time the ground surface would probably have thawed, allowing recharge of the underlying groundwater. The observations indicate that the groundwater level can increase by at least 0.3 m over a few days in response to a wetter climatic period.

It is noted that the magnitude of response to freshet observed at BH05-E is probably close to the maximum response for the site, as this monitor is located within a low area that receives runoff and snowmelt water from higher areas. Upland areas are anticipated to exhibit a lesser magnitude of responses to additions of moisture, as discussed in Section 4.5.2.

4.5.2 Data Logger Observations at Western Upland, 2006

As described in Section 2.2, an automated water level recorder was installed in BH05-A-ii between March 9 and May 1, 2006 to monitor response of the groundwater level to the spring freshet in the Western Upland area. The recorded hydrograph is provided on Figure 10. For comparison, temperature and precipitation data for that observation period are provided on Figures C-2 and C-4 of Appendix C, respectively.

The hydrograph for BH05-A-ii indicates that the groundwater level elevation exhibited the following events and patterns during the period of observation:

- The groundwater level has a regular fluctuation with a magnitude of about 0.01 m. This cyclical pattern is negligible in magnitude and is less than the diurnal fluctuation observed at BH05-E.

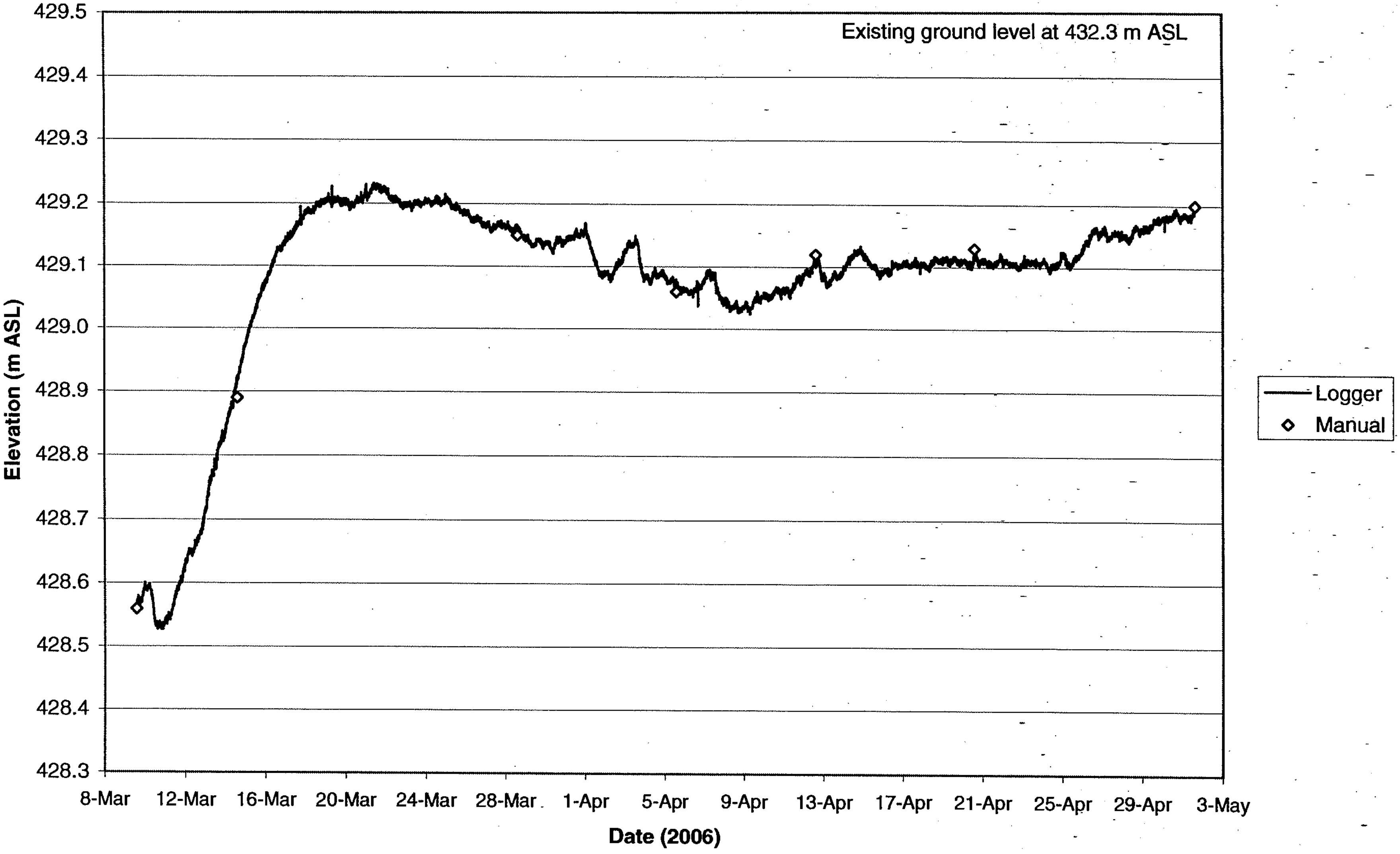
- The groundwater level varied in elevation by 0.70 m during the logger monitoring period. Manual observations at this groundwater monitor indicate a historic elevation range of 1.7 m.

- The groundwater level elevation increased by approximately 0.68 m between March 10 and March 19, 2006. Some of the increase likely was in response to melting of the overlying snow pack between March 9 and 11 and the cumulative 56.3 mm of precipitation that fell during March 8 and 14, 2006.

- The groundwater level elevation reached its highest value of 429.23 m ASL on March 21, 2006.

- The groundwater level generally decreased from March 21 to April 9, 2006. The snow pack had melted, precipitation events were fewer, and temperatures were

FIGURE 10: Logger Hydrograph of Monitor BH05-A-II
Orangeville Highlands, Phase 2, Supplemental Monitoring and Hydrogeologic Assessment



7/5/2006 2:49 PM h:\proj\02\1508\02\Loggers\A-II Mar9-May1 06 Comp.xls relatively cold to maintain partially frozen ground conditions, indicating fewer sources of moisture to groundwater.

- The groundwater level generally increased from April 9 to May 1, 2006. The temperature was relatively warmer during this period, which would have promoted thawing of the ground and thus infiltration of precipitation to groundwater. A second peak groundwater elevation in response to the spring freshet occurred close to May 1, 2006, as indicated by manual measurements and the levelogger record.

- The response to precipitation events generally is less than about 0.1 m above the general trend. This magnitude of response in BH05-A-ii is less than in BH05-E, as indicated by leveloggers. The location of BH05-A-ii in the western uplands area receives less runoff from upgrade areas than does BH05-E the eastern lowland area, as discussed in Section 4.5.1.

4.5.3 Manual Measurement Observations

As described in Section 2.2, a series of groundwater level measurement events were performed at Phase 2 groundwater monitors to measure the response to the spring freshet and the maximum groundwater level during 2005 and 2006. Observations are provided in Table 1.

The observations indicate that the groundwater level at each monitor varies over time. The vertical range between maximum and minimum groundwater levels at Phase 2 monitors varies between 1.0 m (at BH05-C) and 2.1 m (at BH05-D), with an average range of about 1.5 m. There is no apparent spatial pattern with respect to areas of the site that exhibited a consistent lower or higher range of shallow groundwater fluctuations.

During some monitoring events, some groundwater monitors developed a frozen ice plug that prevented measurement of the water level. The depth to ice indicates the water level at the time it was frozen. It is possible that groundwater pressure at the time of measurement was at a higher or lower elevation than the ice plug.

In southern Ontario, the maximum shallow groundwater elevation commonly occurs during the spring freshet. The leveloggers in BH05-E indicated that the 2005 maximum groundwater elevation occurred on April 6. The maximum groundwater elevation in 2005 as observed in Phase 2 monitors by manual measurements occurred towards the end of April. The elevated groundwater on that date was in response to a series of precipitation events that provided at least 42.9 mm in late April and those events were superimposed on relatively higher groundwater base level due to spring freshet conditions.

In southern Ontario, the minimum groundwater level elevation commonly occurs in late summer to early fall. The lowest observed groundwater level elevation at the site occurred for the August or November 2005 measurement events, depending on location. The lowest elevation of the groundwater elevation cycle is not a controlling factor with respect to construction design of the proposed residential development.

The monitoring record for 2006 suggests that the timing of maximum shallow groundwater elevation can vary by location across the site. As example, the peak elevation was as early as March 9 in BH05-F-ii and as late as May 8 in BH05-C and BH05-E. It is noted that the 2006 peak groundwater elevations ranged from 0.07 m deeper at BH05-D than in 2005 to 0.45 m higher at BH05-A-ii than in 2005, with most elevations being slightly higher in 2006.

4.5.4 Interpretations

The information presented indicates the following patterns can be anticipated with respect to the shallow groundwater elevation at Phase 2.

- Shallow groundwater elevation increases in response to the spring melt and sustained precipitation events. The increase in elevation generally is in proportion to the magnitude of the precipitation events, with some variation to be expected resulting from antecedent moisture conditions and the occurrence of frozen soils. Shallow groundwater elevations generally do not increase in response to a snowfall event, or to a precipitation event on frozen ground.
- The maximum shallow groundwater elevation occurs at the time of spring freshet, commonly occurring in March to April.
- The combination of a relatively high shallow groundwater elevation due to spring freshet and a heavier rainfall period can result in similar or higher groundwater level elevations than occur for the response to freshet alone.
- Shallow groundwater declines in elevation between rainfall events, at a rate that ranges from to 11 mm/day at BH05-A to approximately 26 mm/day at BH05-E.
- The lowest shallow groundwater is anticipated to occur in late summer to early fall, after a sustained period when natural recharge is limited.
- The elevation of the shallow groundwater gradually increases during the late-fall through to spring during months with positive moisture surplus.

4.6 HYDRAULIC CONDUCTIVITY

Hydraulic conductivity is a measure of the ability of a soil to transmit water. Higher values of hydraulic conductivity indicate that a relatively higher amount of water can be transmitted under the same hydraulic gradient conditions, and these soils will allow greater infiltration from incident precipitation or artificial infiltration systems. Hydraulic conductivity in a soil is controlled by the grain size texture of constituent particles, compaction of soils, degree of weathering, and other factors.

Hydraulic conductivity values determined from in-situ rising head tests in groundwater monitors provide properties of soils that are immediately adjacent to the monitors tested.

In situ hydraulic conductivity results at two locations on site are provided in Appendix B. The test completed at BH05-A, which was screened across two units that were dominantly sand with silt, indicated a hydraulic conductivity of 3 x 10^{-6} m/s. The test completed at BH05-F, which was screened across a glacial silt till, indicated a hydraulic conductivity of 2 x 10^{-7} m/s.

A grain-size distribution curve can be used with the Hazen formula to estimate the hydraulic conductivity. This method applies to soils where the finest 10% of the soil particles (the D10 value) are within the sand size range. Grain-size distribution tests were performed on two samples from Phase 2, with results provided as Figures B-1 and B-2 of Appendix B. The D10 value for those samples was approximately 0.09 mm, for which the Hazen formula estimates a hydraulic conductivity of approximately $8x10^{-5}$ m/s. This result represents conditions in shallower soil units than were tested by the rising head tests.

The data logger record at monitors BH05-A-ii BH05-E indicates that the average rates of decline during a dry period were approximately 11 and 26 mm/day, respectively. This is a similar magnitude to the infiltration rate for Phase 1 observed in the 2003 study, which was an average of 28 mm/day. The rate suggests that drainage from the shallow groundwater system in portions of Phase 2 may be partially controlled by deeper, less permeable materials.

Drilling and other information indicates variable soils at the site, with different fine particle content and density with location and depth. Thus, a range of hydraulic conductivity values will occur with depth and location at the site. The variability in permeability that occurs on site indicates that design of artificial infiltration systems, if required, should include tests of infiltration capacity at the elevations and locations of proposed infiltration systems.

4.7 GROUNDWATER MOVEMENT

4.7.1 Horizontal Groundwater Movement

A review of the direction of movement of shallow groundwater is pertinent since it demonstrates connection between the groundwater regime on site with adjacent watercourses. Such a connection also demonstrates that groundwater recharged by artificial infiltration systems on site would move to contribute base flow in local watercourses.

The surface of shallow groundwater that is shown on Figure 3 was used to interpret directions of groundwater movement. Groundwater tends to move in a direction that is perpendicular and downward from groundwater elevation contours. The results indicate that groundwater within the site moves within two main groundwater subcatchments, with divides shown on Figure 3 and as discussed below.

- A northern groundwater subcatchment that is located from along a broad ridge to Middle Monora Creek, and occupies approximately 28% of the site. Much of this catchment is covered by treed areas that will be conserved following construction of the site. Shallow groundwater in this area is higher than the adjacent Middle Monora Creek, such that some recharge within this area discharges to that watercourse. Interpreted groundwater contours indicate a slight northeast direction of movement in this area. The measurement of base flow in the watercourse, as discussed in Section 4.8, indicates that the contribution is relatively low.

- A central groundwater subcatchment that is located south of the northern groundwater subcatchment, and occupies approximately 65% of the site. Interpreted groundwater contours indicate an eastward direction of movement in this area. A portion of shallow groundwater is seasonally captured by Ditches #1, #2, and #5 that are tributaries to Lower Monora Creek, and Middle Monora Creek. It is considered probable that the majority of shallow groundwater in this subcatchment moves eastward off site toward the Orangeville Highlands Mall property.

The above areas account for about 93% of the site. Shallow groundwater movement in the remaining minor portion the site includes the following.

- Approximately 4% of the site, located in the extreme southeast corner, is eastward toward the Orangeville Highlands Mall property.
- Approximately 2% of the site, located in the extreme southwest corner, is toward Lower Monora Creek.
- Less than 1% of the site, located along the southern property line, is eastward toward Ditches #3 and #4.

Some local complexities in groundwater movement may occur from those shown, such as adjacent to the broad swale, the hummocky fill area, and near to ditches.

It is expected that the Orangeville Highlands Mall is equipped to manage shallow groundwater. The mall is located lower than eastern lowlands of the site that has shallow depth to groundwater, and it is probable that the mall area also has shallow depth to groundwater. The mall is also located near to watercourses, where groundwater will also tend to be shallow. The groundwater control measures at the mall may include foundation drains, sump pumps, and/or other mechanisms. These systems must have an outlet. Thus, it is probable that most groundwater moving off site is captured by groundwater control measures and discharges to a local watercourse and/or storm sewer system that discharge to other surface water features.

The magnitude of the horizontal gradient of shallow groundwater is relatively consistent over most of the site, with a range of approximately 0.02 to 0.03 m/m.

The rate of groundwater movement can be estimated using the Darcy approach. The groundwater observations indicate a horizontal hydraulic gradient of approximately 0.025 m/m. The rising head tests indicated a hydraulic conductivity of 2 x 10^{-7} m/s in the glacial till to 3 x 10^{-6} m/s in the sand and silt layer. The probable porosity is about 0.35. These input parameters indicate that the rates of horizontal movement are about 0.5 m/year within the glacial till to about 7 m/year within the sand with silt layer. Rates of movement will vary along the flow path depending on changes in gradient, soil material, and other factors.

In summary, infiltration within the recharge areas of the site replenishes the shallow groundwater. Recharge at the northern and southern groundwater subcatchments moves through the groundwater system and eventually discharges to watercourses. Recharge at the central groundwater subcatchment moves eastward, with a portion discharging at ditches that drain to Middle Monora Creek or Lower Monora Creek, while a significant portion likely moves further east of the site. A portion of shallow groundwater may move downward to recharge deeper groundwater systems that discharge at distance from the site.

4.7.2 Vertical Groundwater Movement

The vertical movement of groundwater is indicated by the relative difference in groundwater elevations between the shallow and deep groundwater monitors at an individual monitoring location. A higher groundwater elevation in a shallow monitor indicates downward groundwater movement, while a lower elevation in the shallow monitor indicates upward movement.

The vertical hydraulic gradient was measured at groundwater monitor nest BH05-A. The observations to date indicated a fluctuating gradient, ranging from a minimum of -0.010 m/m in an upward direction to a maximum of 0.044 m/m in a downward direction. The average condition is downward and the groundwater level is consistently several metres below grade, indicating the location of BH05-A, and by inference the western uplands and central area, can be classified as a recharge area.

The vertical hydraulic gradient was measured at groundwater monitor nest BH05-F. The observations to date indicated a fluctuating gradient, ranging from a minimum of -0.053 m/m in an upward direction to a maximum of 0.002 m/m in a downward direction. The average condition is upward and the groundwater level is consistently close to existing grade, indicating that the location of BH05-F, and by inference the eastern lowland, can be classified as a discharge area. Seasonal recharge conditions may occur.

Vertical hydraulic gradients were not determined at other locations. Based on topographic relationships, it is expected that the soil stockpile area is a recharge area and that the broad swale and Middle Monora Creek valley are discharge areas.

4.8 WATERCOURSE BASE FLOW OBSERVATIONS

Phase 2 is located within the catchments of two watercourses, the north branch of Lower Monora Creek and the south branch of Middle Monora Creek. Development on the property has the potential to affect base flow rates in those watercourses.

Flow rates were measured near upstream and downstream locations of the site boundaries adjacent to both watercourses, such that the difference would indicate base flow contributions by the site, within the accuracy of the measurement method. In addition, the flow rate was measured at the north branch of the Middle Monora Creek to account for contributions by this tributary to the south branch. The locations of stations, designated as "SW-# ", are shown on Figure 2.

Flow measurements at each station were obtained on April 15, 2005. That event was timed to occur after a relatively dry climatic period such that flow in the watercourses was comprised primarily of base flow, without a significant component of response to a recent precipitation event, nor to snowmelt. The most recent precipitation event antecedent to the flow measurement event was a rainfall of 1.6 mm that occurred on April 7, 2005, which was 8 days previous.

For the north branch of Lower Monora Creek, the calculated flow rates for the upstream station SW-4 and downstream station SW-5 were 33.4 and 39.0 L/s, respectively. Thus, assuming similar accuracy of flow measurements, the flow rate increased by 5.6 L/s across the Phase 1 site. The increased flow was likely a result of groundwater discharge adjacent to Phase 1, which would have originated from recharge in portions of the catchment area that are located to the south and north of the watercourse. The results confirm that recharge at Phase 1 and a portion of Phase 2 probably contributes to discharge that is received by the north branch of Lower Monora Creek.

For the south branch of Middle Monora Creek, the measured flow rates for the upstream station SW-1 at the south branch and the pre-confluence station SW-2 at the north branch were 9.4 and 0.5 L/s, respectively. The flow rate measured at the downstream station SW-3 was 10.0 L/s. Thus, assuming similar accuracy of flow measurements, the flow rate increased by 0.1 L/s across the Phase 2 site. This difference is probably less than the accuracy of the measurement method. Due to the configuration of higher groundwater levels to the south of the watercourse and general hydrogeologic principles, some groundwater discharge toward Middle Monora Creek that originates from on-site recharge is probable. Based on the one flow measurement, discharges from the catchment areas north and south of the watercourse along the site have a volume that is less than 1% of the base flow carried in this watercourse, which is negligible. This measurement was performed during seasonal high groundwater level conditions when base flow values would be anticipated to be close to annual maximum.

5.0 CONSIDERATIONS FOR CONSTRUCTION

5.1 WATER TABLE EFFECTS TO INFRASTRUCTURE

Effects to dwellings, buried servicing, and other infrastructure are possible if these components are constructed below the perennial water table, or are temporarily affected by vertical fluctuations of the water table.

As an example of an effect to a dwelling, if the high groundwater level ascends to the elevation of the foundation, wet basement conditions may result. Also, susceptibility to frost heave may result if high groundwater levels freeze. Wet seepage conditions are possible in lawn areas. Therefore dwellings should be constructed above the maximum groundwater level.

As an example of an effect to buried piped municipal servicing, such as water mains and sanitary sewage lines, a high groundwater level condition may require dewatering during construction and/or design of special drainage measures, among other requirements.

High groundwater levels can affect the vertical position of individual lot soakaway chambers, if installed to supplement recharge that is reduced due to development

The backfilled portions of buried utility trenches are often more permeable than adjacent native soils and if the utility trenches and lines are located below the water table, drainage of adjacent formations is possible with water moving down the utility alignment. To reduce this effect, trench plugs should be installed at adequate spacing. With trench plugs installed, shallow groundwater will be able to move laterally across trenches and so the shallow groundwater elevation and direction will be maintained similar to pre-construction conditions. Plugs can be constructed of compacted low permeability materials, such as local clayey soils or bentonite.

Construction of buried services, basements, and site grading should consider the potential for temporary inundation and artesian water pressures at some areas of the site.

It is possible that a pattern of warming and larger individual precipitation events could occur that may result in higher groundwater level elevations than observed to date. For the purpose of draft design planning, the highest annual shallow groundwater elevation for Phase 2 should be assumed as being 0.5 m above the maximum elevations indicated on Figure 5 and as observed at groundwater monitors.

Metropolitan Consulting Inc. indicated that all proposed dwellings or other buildings will be constructed with foundations and foundation drains that are located above the maximum annual groundwater elevation. Buried trenches should be equipped with trench plugs to inhibit movement of groundwater along the trenches. With the measures of foundations above the maximum groundwater level and trench plugs, the direction of groundwater movement will be similar for pre-construction and post-construction conditions at Phase 2.

While the elevations of building foundations will be designed to be above the water table, drains should be installed. Drains for foundations and subsurface walls must be properly designed, sized, and constructed. The drains must be able to accommodate and convey away from the structure the surplus moisture resulting from surface runoff, and rare and short-term "spike" elevation increases in shallow groundwater elevations that are conceivable, with no effects to the residences. Drainage infrastructure should be installed in compliance with the Ontario Building Code.

5.2 GROUNDWATER RECHARGE

Under pre-construction conditions, the Phase 2 area has perennial and seasonal recharge areas that contribute to base flows of the adjacent watercourses. Under the proposed development plan, impervious surfaces will be constructed that will occlude a portion of existing permeable surfaces and thereby reduce the total volume of recharge occurring on site (Jagger Hims Limited, 2003). Reduction of infiltration/recharge will similarly reduce the total volume of groundwater discharges that contribute to base flow in the creek, unless mitigation measures are implemented.

On-site flow measurements indicate that contributions by the site to the base flow of the Middle Monora Creek are negligible, as discussed in Section 4.8. It is recommended studies for the draft design phase include additional monitoring of base flow to confirm the interpretation of a negligible contribution. If contributions to base flow are negligible, then mitigation measures for compensating base flow in some parts of the site probably are not necessary, subject to discussion with the Conservation Authority.

The proposed development will result in construction of relatively impervious surfaces that, if left unmitigated, would reduce the amount of groundwater recharge, which could translate into a decrease in the base flow of adjacent surface water courses. Previous reports have discussed the feasibility of using artificial infiltration options (Jagger Hims Limited, 2003) to promote recharge to post-construction rates that are similar to pre-construction rates. The likely preferred option for implementation at Phase 2 is a soakaway pit system for roof rainwater leaders.

5.3 EFFECTS OF CUTTING AND FILLING

As we understand, re-grading of the site is a probable step for construction, including cutting and filling. The cutting and filling will affect the permeability of soils in which artificial infiltration systems will be placed. Cutting and filling will also affect the proximity to the maximum water table that affects the location of artificial infiltration systems, the design of buried utilities, house basements, and other infrastructure.

Re-grading by cutting will affect the infiltration rate that is available for artificial infiltration systems. The site generally has more-permeable granular soils at shallow depth under pre-construction conditions. Cutting will reduce the depth to soils that are denser and finer grained, such as the glacial till layer, which will provide less permeability. Cutting will also decrease the depth to the shallow groundwater level and the proportion of site area with shallow depth to groundwater, if being considered.

Re-grading by filling will increase the distance between the constructed ground elevation and the maximum groundwater level, at the fill areas. The fill thickness should be designed for sufficient vertical distance to allow installation of artificial infiltration systems and other infrastructure considerations. It is recommended that fill thickness be sufficient to raise foundation grades to elevations above the maximum water table elevations, where required. Fills will decrease the proportion of site area with shallow depth to groundwater.

Areas of filling where the pre-construction ground surface is perennially above the maximum groundwater level would continue to function as perennial recharge areas after construction. Areas of filling where there are pre-construction discharge areas will result in a groundwater level within the fill layer as a water table in post-construction. Filling of pre-construction discharge areas will increase the amount of recharge area at the site in post-construction. Groundwater that would have discharged in the discharge area will instead remain as groundwater as it moves toward the watercourse, where it will then discharge. Filling will not reduce the total amount of water reaching the watercourses.

The topography of the proposed development should be designed to maintain surface grades in the same general directions as pre-construction existing conditions, to maintain a similar direction of shallow groundwater movement.

Re-grading by filling will affect the infiltration rate that is available for artificial infiltration systems. If the fill material has a higher proportion of fine grained silt and clay, and/or is compacted to higher density than occurs in soils at surface in pre-construction conditions, then the fill will be less permeable in post-construction conditions. To prevent reduced permeability in post-construction, fill at this site should be sourced and placed in a manner that maintains or increases the groundwater recharge rate that occurs during pre-construction conditions. The permeability of fill will be significantly controlled by the finer grained components of the soil texture, thus the fill source for use at this site should be equivalent to or coarser than the native material. The texture of native soils at this site should be characterized by sampling of at least eight widely separated locations within Phase 2 that are within areas proposed to be filled. Those samples should be submitted to a laboratory for grain-size and hydrometer analysis. The results should be analysed to determine the average D10 and D50 values. The D10 value represents the grain size for which 10 percent is finer, and the D50 represents the median 50% passing grain size. Fill materials for Phase 2 should be sourced from soils that have D10 and D50 values that are equal or coarser than the average D10 and D50 of native soils.

5.4 PREFERRED GREEN SPACE DEVELOPMENT

As we understand, the Town of Orangeville Official Plan designates part of the western upland area of the site as parkland (green space). Based on the interpreted hydrogeologic conditions at the site, we recommend consideration of the eastern lowland area as the preferred location of green space, due to the following factors.

- Vegetation tends to grow more rapidly in areas of shallow water table, which is the condition at the eastern lowland and does not occur at the western upland.
- Green space along the eastern lowland could be directly connected to the wooded area along Middle Monora Creek valley.
- Green space along the eastern lowland would provide a visual buffer between the mall and residences in Phase 2.
- The eastern lowland currently has three ditches. The ditch system could be re-constructed to permit improved continuous drainage to watercourses, increasing the volume of base flow. Re-alignment of ditches could also result in aesthetic improvement and increases in ecologic habitat.

- The western upland is a preferred area for development because of reduced costs associated for construction in areas of deep water table. Areas with shallow water table will likely require the importation of fill.

6.0 MAINTENANCE OF GROUNDWATER MONITOR NETWORK

The location and number of monitors in the groundwater monitor network was considered to be sufficient for draft level planning for the proposed development. Significant re-grading of the site is probable, including removal of the soil stockpile. Groundwater information should be reviewed in comparison to the proposed final design grade elevations and additional monitors should be installed, if necessary.

The existing groundwater monitoring network should remain in functional condition until the final design of the development is approved. Once the network is no longer required, the monitors should be abandoned by a licensed water well contractor in accordance with Regulation 903 as amended by Regulation 128.

7.0 CONCLUSIONS

Detailed monitoring of the groundwater was completed for Phase 2 groundwater monitors. The shallow groundwater response to spring freshets over two years was observed.

The depth to maximum annual shallow groundwater elevation was mapped for the Phase 2 area.

Shallow groundwater generally moves toward the east, a portion of which seasonally discharges to ditches that are a tributary to either the south branch of Middle Monora Creek or the north branch of Lower Monora Creek.

The depth of the shallow groundwater below existing grade varies with location. The observed depth of the maximum groundwater level ranged from about 5 metres below ground surface, to portions of the site where artesian conditions are present at shallow depth. Groundwater levels will vary seasonally and in response to climatic events.

During pre-construction conditions, areas with relatively shallow groundwater conditions were prevalent over approximately one-third of the property, with some seasonal variation. During post-construction, areas with relatively shallow groundwater conditions will depend on grading plans, including cuts and fills.

The maximum shallow groundwater elevation occurs at the time of spring freshet, commonly occurring in March or April.

A combination of high shallow groundwater due to spring freshet and a wet rainfall period can result in similar or higher shallow groundwater elevations than occur for the response to the freshet itself.

Measurements indicate that recharge from Phase 2 is not a significant contributor to the base flow volume in Middle Monora Creek. Analysis of interpreted groundwater subcatchments suggest that Phase 2 is not a significant contributor to the base flow volume of Lower Monora Creek.

The maximum elevation of the shallow groundwater should be assumed to be 0.5 m above that indicated by the maximum groundwater level contours that are shown on Figure 5.

We trust that this information is satisfactory to your requirements. Should you have any questions please call our office.

Yours truly,
JAGGER HIMS LIMITED

Brian D. Theimer

Brian D. Theimer, M.Sc., P.Geo
Project Hydrogeologist

BDTjec

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APPENDICES

APPENDIX A

JAGGER HIMS LIMITED BOREHOLE RECORDS

TABLE A-1
Groundwater Monitor Construction Details: Depths
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Monitor Designation	Stick Up m agl	Bottom of Borehole m bgl	Bottom of Monitor m bgl	Length of Monitor m	Screen		Sand Pack		Bentonite Seals	
					Bottom of m bgl	Top of m bgl	Bottom of m bgl	Top of m bgl	Bottom of m bgl	Top of m bgl
BH05-A-i	0.91	11.28	9.60	10.51	9.45	8.08	9.60	7.62	7.62	0.00
BH05-A-ii	0.89	5.49	5.33	6.22	5.18	3.81	5.33	3.35	3.35	0.00
BH05-B	0.91	8.38	8.38	9.29	8.23	6.86	8.38	6.40	6.40	0.00
BH05-C	0.97	6.25	6.25	7.22	6.10	4.73	6.25	3.96	3.96	0.00
BH05-D	0.86	5.94	3.50	4.36	3.35	1.98	3.50	1.37	1.37	0.00
BH05-E	1.05	4.42	3.50	4.55	3.35	1.98	3.50	1.52	1.52	0.00
BH05-F-i	0.91	7.77	7.77	8.68	7.62	6.25	7.77	5.79	5.79	0.00
BH05-F-ii	0.97	3.05	2.59	3.56	2.44	1.07	2.59	0.61	0.61	0.00

Notes:

1) "m agl" indicates metres above ground level. 2) "m bgl" indicates metres below ground level. 3) "m" indicates metres

TABLE A-2
Groundwater Monitor Construction Details: Elevations
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Monitor Designation	Top of Pipe m ASL	Existing Grade m ASL	Bottom of Borehole m ASL	Bottom of Monitor m ASL	Screen		Sand Pack		Bentonite Seals	
					Bottom of m ASL	Top of m ASL	Bottom of m ASL	Top of m ASL	Bottom of m ASL	Top of m ASL
BH05-A-i	433.17	432.26	420.98	422.66	422.81	424.18	422.66	424.64	424.64	432.26
BH05-A-ii	433.15	432.26	426.77	426.93	427.08	428.45	426.93	428.91	428.91	432.26
BH05-B	431.09	430.18	421.80	421.80	421.95	423.32	421.80	423.78	423.78	430.18
BH05-C	429.77	428.80	422.55	422.55	422.70	424.07	422.55	424.84	424.84	428.80
BH05-D	426.74	425.88	419.94	422.38	422.53	423.90	422.38	424.51	424.51	425.88
BH05-E	423.30	422.25	417.83	418.75	418.90	420.27	418.75	420.73	420.73	422.25
BH05-F-i	423.10	422.19	414.42	414.42	414.57	415.94	414.42	416.40	416.40	422.19
BH05-F-ii	422.99	422.02	418.97	419.43	419.58	420.95	419.43	421.41	421.41	422.02

Notes:

1) "m ASL" indicates metres above sea level.

7/5/2006 3:00 PM h:\proj\02\1508\03\tech\Monitor Construction Details.xls

BOREHOLE LOG EXPLANATION FORM

This explanatory section provides the background to assist in the use of the borehole logs. Each of the headings used on the borehole log, is briefly explained.

DEPTH

This column gives the depth of interpreted geologic contacts in metres below ground surface.

STRATIGRAPHIC DESCRIPTION

This column gives a description of the soil based on a tactile examination of the samples and/or laboratory test results. Each stratum is described according to the following classification and terminology.

Soil Classification *	
Clay	<0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2 mm
Gravel	2 to 60 mm
Cobbles	60 to 200 mm
Boulders	>200 mm

Terminology	Proportion
"trace" (eg. trace sand)	<10%
"some" (eg. some sand)	10% - 20%
adjective (eg. sandy)	20% - 35%
"and" (eg. and sand)	35% - 50%
noun (eg. sand)	>50%

* Extension of MIT Classification system unless otherwise noted.

The use of the geologic term "till" implies that both disseminated coarser grained (sand, gravel, cobbles or boulders) particles and finer grained (silt and clay) particles may occur within the described matrix.

The compactness of cohesionless soils and the consistency of cohesive soils are defined by the following:

COHESIONLESS SOIL		COHESIVE SOIL	
Compactness	Standard Penetration Resistance "N", Blows / 0.3 m	Consistency	Standard Penetration Resistance "N", Blows / 0.3 m
Very Loose	0 to 4	Very Soft	0 to 2
Loose	4 to 10	Soft	2 to 4
Compact	10 to 30	Firm	4 to 8
Dense	30 to 50	Stiff	8 to 15
Very Dense	Over 50	Very Stiff	15 to 30
		Hard	Over 30

The moisture conditions of cohesionless and cohesive soils are defined as follows.

COHESIONLESS SOILS

Dry
Moist
Wet
Saturated

COHESIVE SOILS

DTPL - Drier Than Plastic Limit
APL - About Plastic Limit
WTPL - Wetter Than Plastic Limit
MWTPL - Much Wetter Than Plastic Limit

STRATIGRAPHY

Symbols may be used to pictorially identify the interpreted stratigraphy of the soil and rock strata.

MONITOR DETAILS

This column shows the position and designation of standpipe and/or piezometer ground water monitors installed in the borehole. Also the water level may be shown for the date indicated.

▲ Standpipe and Designation

● Piezometer and Designation

■ Gas Monitor and Designation

▧ Borehole Seal (Peltonite, Bentonite or Hole Plug)

▨ Cement Seal

░ Granular Pack

▒ Granular Backfill

□ Native Soil Backfill/Cave

Where monitors are placed in separate boreholes, these are shown individually in the "Monitor Details" column. Otherwise, monitors are in the same borehole. For further data regarding seals, screens, etc., the reader is referred to the summary of monitor details table.

SAMPLE

These columns describe the sample type and number, the "N" value, the water content, the percentage recovery, and Rock Quality Designation (RQD), of each sample obtained from the borehole where applicable. The information is recorded at the approximate depth at which the sample was obtained. The legend for sample type is explained below.

SS = Split Spoon
ST = Thin Walled Shelby Tube
AS = Auger Flight Sample
CC = Continuous Core

GS = Grab Sample
CS = Channel Sample
WS = Wash Sample
RC = Rock Core

$$\%\ \text{Recovery} = \frac{\text{Length of Core Recovered Per Run}}{\text{Total Length of Run}} \times 100$$

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundness of the rock mass. It is obtained from the rock cores by summing the length of core recovered, counting only those pieces of sound core that are 100 mm or more in length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification	RQD (%)
Very poor quality	< 25
Poor quality	25 - 50
Fair quality	50 - 75
Good quality	75 - 90
Excellent quality	90 - 100

TEST DATA

The central section of the log provides graphs which are used to plot selected field and laboratory test results at the depth at which they were carried out. The plotting scales are shown at the head of the column.

Dynamic Penetration Resistance - The number of blows required to advance a 51 mm diameter, 60° steel cone fitted to the end of 45 mm OD drill rods, 0.3 m into the subsoil. The cone is driven with a 63.5 kg hammer over a fall of 750 mm.

Standard Penetration Resistance - Standard Penetration Test (SPT) "N" Value - The number of blows required to advance a 51 mm diameter standard split-spoon sampler 300 mm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 750 mm. In cases where the split spoon does not penetrate 300 mm, the number of blows over the distance of actual penetration in millimetres is shown as $\frac{x \text{ Blows}}{\text{mm}}$

Water Content -	The ratio of the mass of water to the mass of oven-dry solids in the soil expressed as a percentage.
w_P -	Plastic Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.
w_L -	Liquid Limit of a fine-grained soil expressed as a percentage as determined from the Atterberg Limit Test.

REMARKS

The last column describes pertinent drilling details, field observations and/or provides an indication of other field or laboratory tests that were performed.

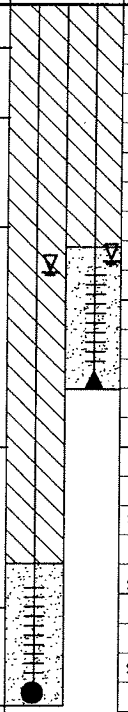
BOREHOLE NO. BH05-A

PAGE 1 OF 1

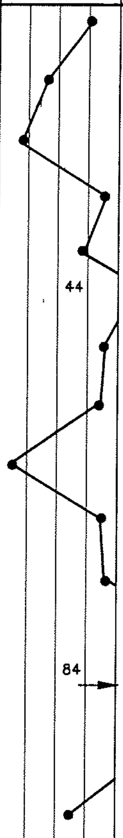
PROJECT NAME: ORANGEVILLE HIGHLANDS, PHASE 2
PROJECT NO.: 021508.03
CLIENT: ORANGEVILLE HIGHLANDS LTD.
DATE: MARCH 10, 2005
BOREHOLE TYPE: HOLLOW STEM AUGER
SUPERVISOR: BTC
GROUND ELEVATION: 432.26 m ASL
REVIEWER: BDT

DEPTH (m)	STRATIGRAPHIC DESCRIPTION	STRATIGRAPHY	SAMPLE TYPE	'N' VALUE	% WATER	% RECOVERY	RQD (%)	REMARKS
0.6	TOPSOIL: DARK BROWN ORGANIC SOIL WITH SILT, TRACE MEDIUM SAND, DAMP TO WET.		SS1	30		58		FROZEN SOILS NEAR SURFACE
1.5	SILT: MEDIUM TO DARK BROWN SILT, TRACE MEDIUM SAND, TRACE GRAVEL, SATURATED, COMPACT.		SS2	17		29		
3.0	SAND: MEDIUM BROWN FINE TO MEDIUM SAND, TRACE TO SOME SILT, DAMP. LOOSE TO DENSE.		SS3	9		54		
			SS4	34		67		STATIC WATER LEVELS ON APRIL 29, 2005 WERE: i 3.63 mBGL ii 3.51 mBGL
6.0	SILT AND SAND: MEDIUM BROWN SILT AND FINE SAND TO FINE TO MEDIUM SANDY SILT, DAMP, SATURATED BELOW 3.8 m, COMPACT TO DENSE.		SS5	29		63		
			SS6	44		88		
			SS7	36		100		
			SS8	34		100		
8.2	SAND WITH SILT: MEDIUM BROWN MEDIUM SAND SOME SILT, SATURATED, LOOSE TO DENSE.		SS9	5		92		
			SS10	34		67		
			SS11	36		92		
9.5	SILTY SAND: BROWN SILTY FINE TO COARSE SAND, SATURATED, VERY DENSE. LENS OF DARK RUSTY BROWN COARSE SAND AT 9.3 m.		SS12	84		92		
11.3	SANDY SILT TILL: GREY SANDY SILT TILL, TRACE CLAY, COMPACT.		SS13	24		67		
	BOREHOLE TERMINATED IN SANDY SILT TILL AT 11.3 m.							

MONITOR DETAILS



"N" VALUE



WATER CONTENT %

10 20 30

WP WL

BOREHOLE NO. BH05-B

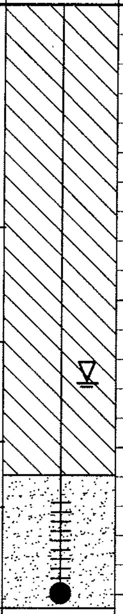
PAGE 1 OF 1

PROJECT NAME: ORANGEVILLE HIGHLANDS, PHASE 2
PROJECT NO.: 021508.03
CLIENT: ORANGEVILLE HIGHLANDS LTD.
DATE: MARCH 9, 2005
BOREHOLE TYPE: HOLLOW STEM AUGER
SUPERVISOR: BTC
GROUND ELEVATION: 430.18 mASL
REVIEWER: BDT

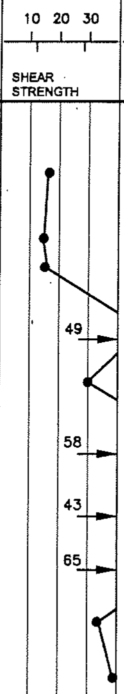
DEPTH (m)	STRATIGRAPHIC DESCRIPTION
0 – 3.0	ORGANIC SOIL FILL: DARK BROWN ORGANIC SOIL FILL WITH TRACE FINE TO MEDIUM SAND, TRACE TO SOME SILT, ROOTS, MOIST, COMPACT.
3.0 – 4.6	SAND: MOTTLED DARK BROWN TO YELLOW FINE TO MEDIUM SAND, SOME GRAVEL, SOME SILT, DAMP TO MOIST, DENSE. -SILTY ORGANIC SOIL AT 3.8 m.
4.6 – 5.9	UNKNOWN: NO SAMPLE RECOVERED, HARD, TRACE OF SILTY SAND ON SPOON.
5.9 – 6.8	SAND: MEDIUM BROWN FINE TO MEDIUM SAND, TRACE SILT, DAMP, VERY DENSE.
6.8 – 8.2	SAND AND SILT TILL: MEDIUM BROWN FINE SAND AND SILT TILL, SATURATED, DENSE.
8.2	BOREHOLE TERMINATED IN SAND AND SILT TILL AT 8.2 m.

TYPE	'N' VALUE	% WATER	% RECOVERY	RQD (%)
SS1	16		17	
SS2	15		17	
SS3	15		50	
SS4	49		54	
SS5	30		75	
SS6	58		0	
SS7	43		0	
SS8	65		88	
SS9	33		92	
SS10	39		96	

MONITOR DETAILS



"N" VALUE



WATER CONTENT %
10 20 30
W_P W_L

REMARKS

STATIC WATER LEVEL ON APRIL 29, 2005 WAS 5.10 mBGL.

BOREHOLE NO. BH05-C

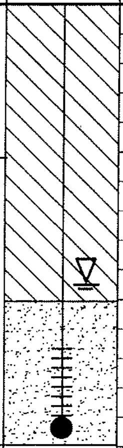
PAGE 1 OF 1

PROJECT NAME: ORANGEVILLE HIGHLANDS, PHASE 2
PROJECT NO.: 021508.03
CLIENT: ORANGEVILLE HIGHLANDS LTD.
DATE: MARCH 11, 2005
BOREHOLE TYPE: HOLLOW STEM AUGER
SUPERVISOR: BTC
GROUND ELEVATION: 428.80 mASL
REVIEWER: BDT

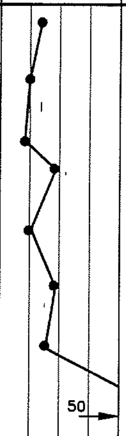
DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE TYPE	'N' VALUE	% WATER	% RECOVERY	RQD (%)	REMARKS
0	SILTY SAND FILL: MOTTLED GREY SILTY MEDIUM SAND FILL MIXED WITH DARK BROWN ORGANIC SOIL, OCCASIONAL GRAVEL, DRY TO WET, LOOSE TO COMPACT.	SS1	13		33		
		SS2	10		58		
2.1		SS3	8		54		
	SAND: BROWN FINE TO MEDIUM SAND, TRACE SILT, ROOTS TO 2.9 m, DRY TO DAMP, LOOSE TO DENSE. –SATURATED BELOW 4.1 m.	SS4	17		54		
		SS5	10		63		STATIC WATER LEVEL ON APRIL 29, 2005 WAS 3.82 mBGL.
		SS6	18		88		
		SS7	15		92		
6.0		SS8	50		100		
	BOREHOLE TERMINATED IN SAND AT 6.0 m.						

STRATIGRAPHY

MONITOR DETAILS



"N" VALUE



WATER CONTENT %
10 20 30
W_P W_L

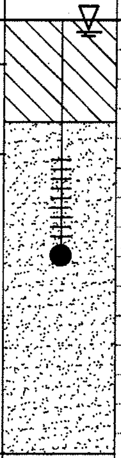
Depth scale (m): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20

BOREHOLE NO. BH05-D

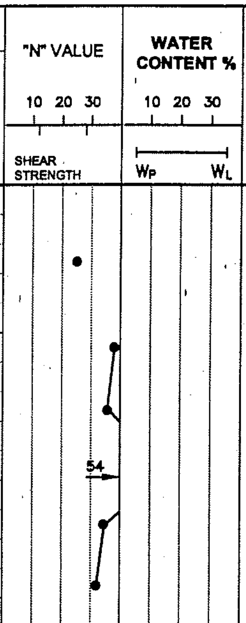
PAGE 1 OF 1

PROJECT NAME: ORANGEVILLE HIGHLANDS, PHASE 2
PROJECT NO.: 021508.03
CLIENT: ORANGEVILLE HIGHLANDS LTD.
DATE: MARCH 9, 2005
BOREHOLE TYPE: HOLLOW STEM AUGER
SUPERVISOR: BTC
GROUND ELEVATION: 425.88 mASL
REVIEWER: BDT

DEPTH (m)	STRATIGRAPHIC DESCRIPTION
0 – 0.6	ORGANIC TOPSOIL: DARK BROWN ORGANIC TOPSOIL WITH MEDIUM TO COARSE SAND, GRAVEL, ROOTS, MOIST.
0.6 – 1.8	SAND: BROWN COARSE SAND, TRACE TO SOME FINE TO COARSE GRAVEL, MOIST.
1.8 – 5.9	SANDY SILT TILL: MEDIUM BROWN FINE TO MEDIUM SANDY SILT TO SILT WITH SOME FINE SAND, WET TO SATURATED, DENSE.
5.9	BOREHOLE TERMINATED IN SANDY SILT AT 5.9 m.



TYPE	'N' VALUE	% WATER	% RECOVERY	RQD (%)
SS9	46		63	
SS10	48		71	
SS1	25+		20	
SS11	120		83	
SS2	–		0	
SS3	37		67	
SS4	36		67	
SS5	54		75	
SS6	34		100	
SS7	32		67	



REMARKS

STATIC WATER LEVEL ON APRIL 29, 2005 WAS 0.15 m BGL

FROZEN SOIL NEAR SURFACE

SS9 TO SS11 OBTAINED IN AN ADJACENT HOLE

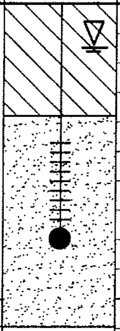
Revision 2/ Aug 2003

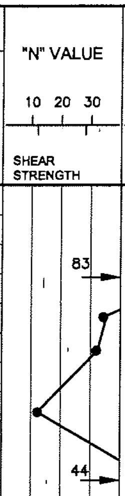
JAGGER HIMS LIMITED

BOREHOLE NO. BH05-E

PAGE 1 OF 1

PROJECT NAME: ORANGEVILLE HIGHLANDS, PHASE 2
PROJECT NO.: 021508.03
CLIENT: ORANGEVILLE HIGHLANDS LTD.
DATE: MARCH 8, 2005
BOREHOLE TYPE: HOLLOW STEM AUGER
SUPERVISOR: BTC
GROUND ELEVATION: 422.25 mBGL
REVIEWER: BDT





DEPTH (m)	STRATIGRAPHIC DESCRIPTION	SAMPLE TYPE	'N' VALUE	% WATER	% RECOVERY	RQD (%)	WATER CONTENT % 10 20 30 Wp WL	REMARKS
0	SAND: BROWN FINE TO MEDIUM SAND, TRACE TO SOME SILT, DAMP, SATURATED BELOW 1.6 m, COMPACT TO DENSE.							FROZEN NEAR SURFACE
		SS1	83		29			STATIC WATER LEVEL ON APRIL 29, 2005 WAS 0.60 mBGL.
2		SS2	34		58			
		SS3	31		83			
		SS4	12		71			
4.0	SANDY SILT TILL: BROWNISH GREY SANDY SILT, TRACE CLAY, WTPL, HARD.	SS5	44		92			
4.4	BOREHOLE TERMINATED IN SANDY SILT TILL AT 4.4 m.							
6								
8								
10								
12								
14								
16								
18								
20								

Revision 2/ Aug 2003

JAGGER HIMS LIMITED

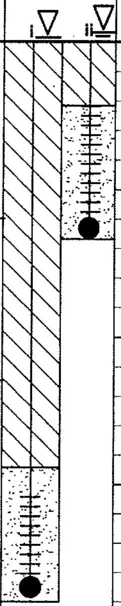
BOREHOLE NO. BH05-F

PAGE 1 OF 1

PROJECT NAME: ORANGEVILLE HIGHLANDS, PHASE 2
PROJECT NO.: 021508.03
CLIENT: ORANGEVILLE HIGHLANDS LTD.
DATE: MARCH 7, 2005
BOREHOLE TYPE: HOLLOW STEM AUGER
SUPERVISOR: BTC
GROUND ELEVATION: 422.10 mASL
REVIEWER: BDT

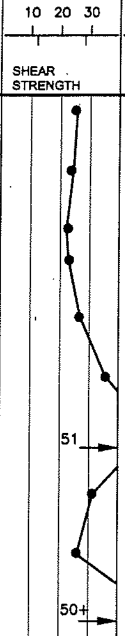
DEPTH (m)	STRATIGRAPHIC DESCRIPTION
0 – 2.4	SAND: BROWN FINE TO MEDIUM SAND, TRACE TO SOME SILT, MOIST, WET TO SATURATED, COMPACT.
2.4 – 4.6	SAND WITH SILT: BROWN TO GREY BROWN FINE SAND, SOME SILT TO SILTY FINE SAND, TRACE CLAY, WTPL, VERY STIFF TO HARD.
4.6 – 7.6	SILT TILL: GREY–BROWN SILT TILL, SOME FINE SAND TO SANDY, TRACE TO SOME CLAY, WTPL, VERY STIFF TO HARD.
7.6	BOREHOLE TERMINATED IN SILT TILL AT 7.6 m.

MONITOR DETAILS



SAMPLE TYPE	'N' VALUE	% WATER	% RECOVERY	RQD (%)
SS1	24		46	
SS2	23		83	
SS3	22		91	
SS4	22		71	
SS5	26		–	
SS6	35		92	
SS7	51		83	
SS8	31		83	
SS9	26		79	
SS10	50+		71	

"N" VALUE



WATER CONTENT %

10 20 30

Wp WL

REMARKS

STATIC WATER LEVELS ON APRIL 29, 2005 WERE
i 0.01 mAGL
ii 0.05 mAGL

(ARTESIAN)

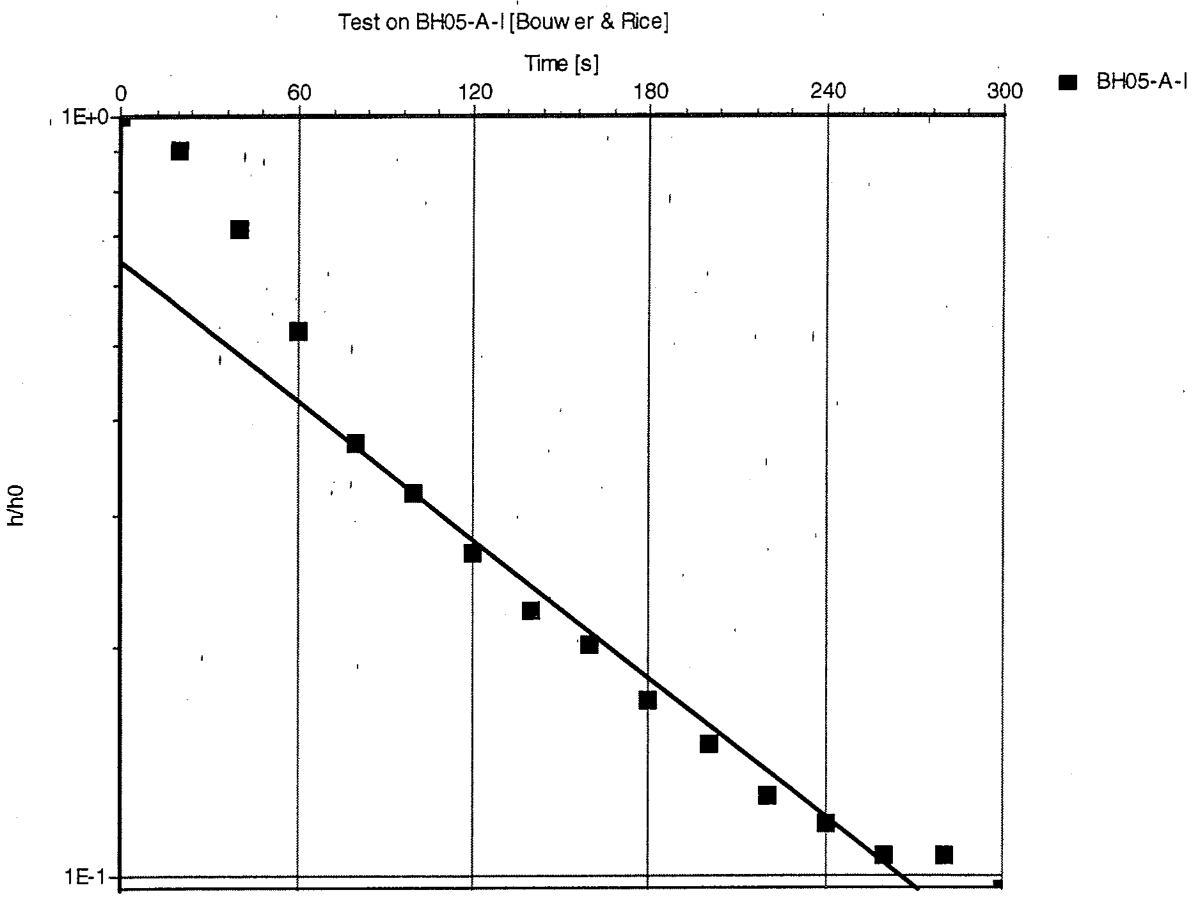
mAGL = METRES ABOVE GROUND LEVEL

Revision 2/ Aug 2003

JAGGER HIMS LIMITED

Waterloo Hydrogeologic Inc.
180 Columbia St. Unit 1104
Waterloo, Ontario, Canada
Phone 519 746-1798

Slug Test Analysis Report	
Project:	Orangeville Highlands Phase 2
Number:	021508.02
Client:	Orangeville Highlands Ltd.



Slug Test: **Test on BH05-A-I**

Analysis Method: **Bouwer & Rice**

Analysis Results: Conductivity: 3.11E-6 [m/s]

Test parameters:	Test Well:	BH05-A-I	Aquifer Thickness:	8 [m]
	Casing radius:	0.0254 [m]	Gravel Pack Porosity (%)	25
	Screen length:	1.4 [m]		
	Boring radius:	0.105 [m]		
	r(eff):	0.057 [m]		

Comments:

Evaluated by: BDT
Evaluation Date: 2/6/2006

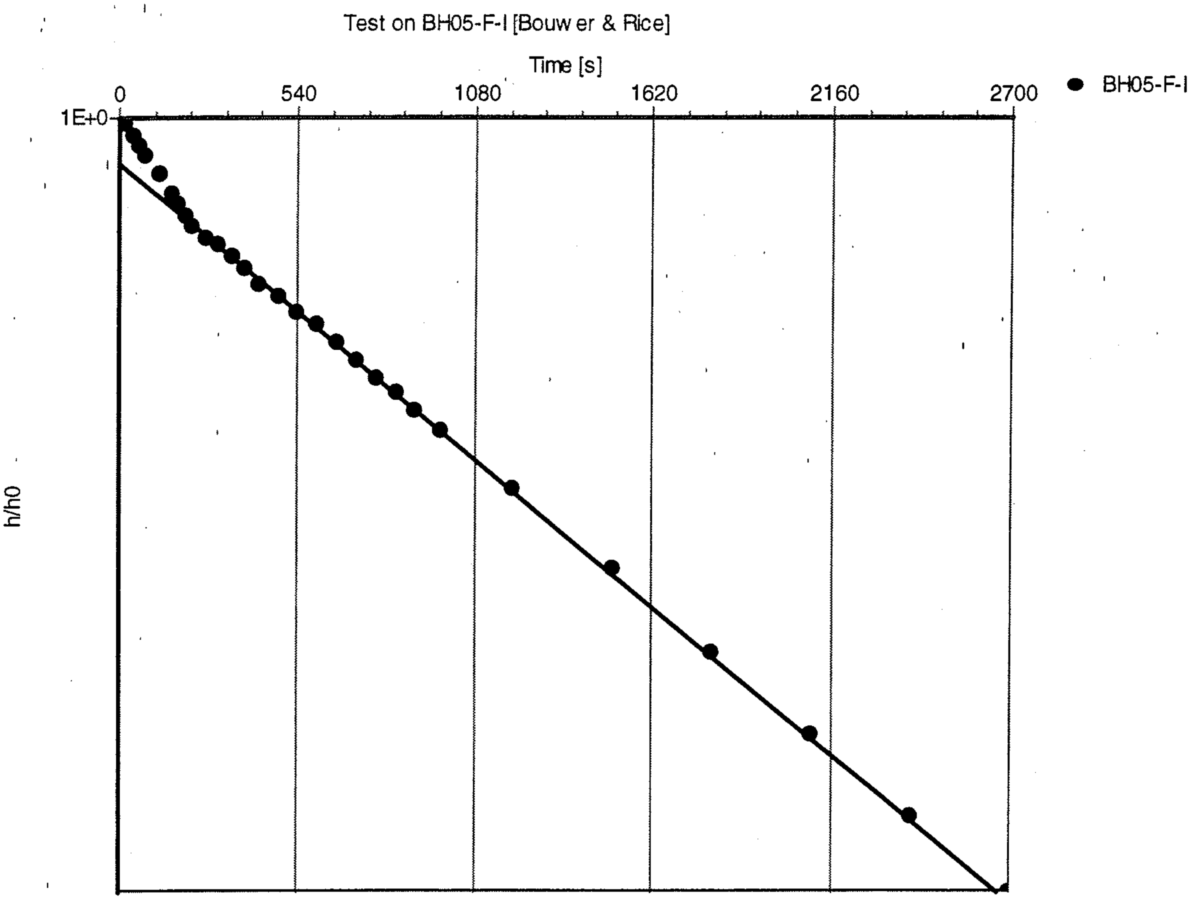
Waterloo Hydrogeologic Inc.
180 Columbia St. Unit 1104
Waterloo, Ontario, Canada
Phone 519 746-1798

Slug Test Analysis Report

Project: Orangeville Highlands Phase 2

Number: 021508.02

Client: Orangeville Highlands Ltd.



Slug Test: **Test on BH05-F-I**

Analysis Method: **Bouwer & Rice**

Analysis Results:		Conductivity:	2.45E-7 [m/s]

Test parameters:	Test Well:	BH05-F-I	Aquifer Thickness:	10.6 [m]
	Casing radius:	0.0245 [m]	Gravel Pack Porosity (%)	25
	Screen length:	1.4 [m]		
	Boring radius:	0.105 [m]		
	r(eff):	0.057 [m]		

Comments:

Evaluated by: BDT

Evaluation Date: 2/6/2006

APPENDIX B

JAGGER HIMS LIMITED TEST PITS

TABLE B-1

TEST PIT LOGS

TP03-3

Depth Interval (m)	Soil Description
0.0 – 0.25	Topsoil, with silt, organic silt, and fine sand. Dark brown to black. Grass roots. Frozen.
0.25 – 0.6	Fine Sand, trace organic silt. Dark brown. Damp.
0.6 – 1.4	Fine to Medium Sand, fine to coarse gravelly, occasional cobble and boulder. Grey brown. Dry to damp.
1.4 – 3.5	Silt, trace fine sand, trace clay, occasional rounded coarse gravel. Grading to medium grey brown Silt, some fine sand. Moist.
4.1 – 4.2	Silt, some fine sand, trace clay. Grey brown. Damp.

- No seepage observed to base.
- No standpipe installed.
- Soil samples taken at 1.0, 2.5, and 4.2 m bgl.

TP03-4

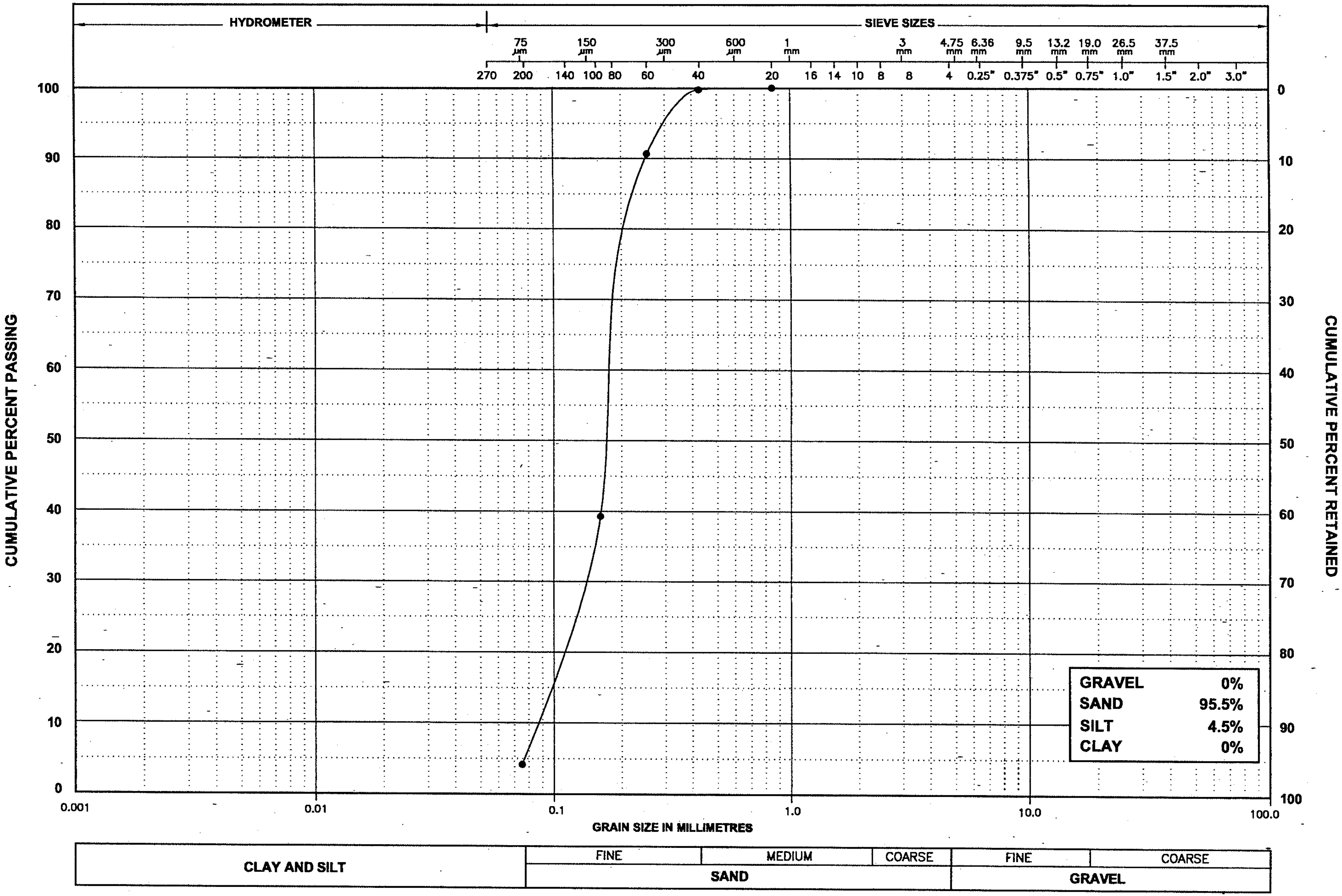
Depth Interval (m)	Soil Description
0.0 – 0.25	Topsoil, with silt, organic silt, and some fine sand. Dark brown to black. Grass roots. Frozen.
0.25 – 1.2	Fine Sand, trace silt. Well sorted. Medium grey brown. Moist.
1.2 – 2.5	Grading to Silt and Fine Sand to Silty Fine Sand. Grey-brown. Damp.
2.5 – 3.8	Grading to Silty Fine Sand. Grey-brown. Wet.

- Seepage at 1.1 m. Seepage stopped below 1.3 metres.
- Standpipe installed.
- Standpipe stick up = 1.3 m agl. Base = 2.1 m bgl.
- Frequent collapse of pit walls.
- Soil samples taken at 0.7 and 2.5 m bgl.
- Static water level is 0.89 m bmp on June 26, 2003.

Depth Interval (m)	Soil Description
TP03-5	
0.0 – 0.2	Topsoil, with Organic Silt and Silt. Grass roots. Dark brown to black. Frozen.
0.2 – 0.3	Fill. Fine to Medium Sand. Roots. Grey-brown. Damp.
0.3 – 1.2	Fill. Fine Sand, some silt. With brick pieces, grass turf, occasional cobble and boulder. Mottled medium brown and dark brown. Moist.
1.2 – 4.0	Fine to Medium Sand, trace silt. Light grey brown, and medium grey brown below 3.0 m bgl. Moist, and wet to saturated below 3.0 m bgl. ➢ No seepage observed. ➢ Standpipe installed. ➢ Standpipe stick up = 0.6 m agl. Base = 3.4 m bgl. ➢ Soil samples taken at 0.9, 2.2, 3.2, and 4.0 m bgl. ➢ Static water level is 1.98 m bmp on June 26, 2003.
TP03-6	
0.0 – 0.4	Topsoil, with fine to medium sand, fine to medium gravel, organic silt. Black. Frozen.
0.4 – 0.7	Fine to Medium Sand, trace to some fine to coarse gravel, occasional cobble and boulder. Grey brown. Damp.
0.7 – 1.2	Fine Sand, trace fine gravel, trace silt. Light grey brown. Damp.
1.2 – 1.5	Sand and Gravel.
1.5 – 1.7	Fine to Medium Sand, trace fine gravel. Light grey brown. Damp.
1.7 – 2.4	Fine to Medium Sand, trace fine to coarse gravel, occasional boulder. Grey brown. Damp.
2.4 – 3.9	Fine to Medium Sand. Grey brown. Damp.
3.9 – 4.1	Fine Sand and Silt. Medium grey. Moist. ➢ No seepage observed to base. ➢ No standpipe installed. ➢ Soil samples taken at 0.9, 2.2, and 4.0 m bgl

JAGGER HIMS LIMITED
Environmental Consulting Engineers

PARTICLE SIZE DISTRIBUTION



GRAVEL	0%
SAND	95.5%
SILT	4.5%
CLAY	0%

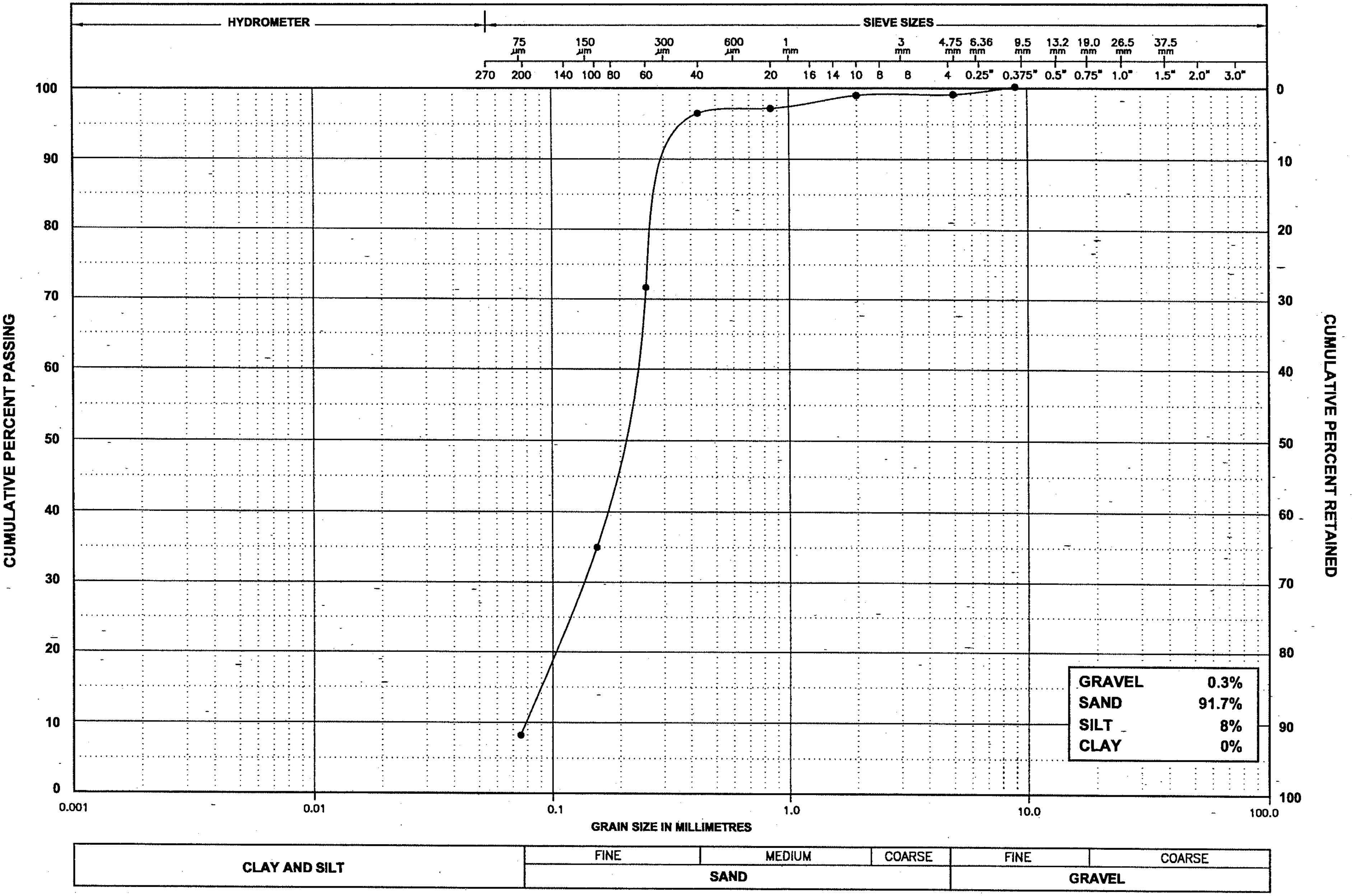
UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: ORANGEVILLE HIGHLANDS **PROJECT No:** 021508.00 **HOLE No:** 03-4 **SAMPLE No:**

DEPTH: 0.7 m bgl **REMARKS:** Fine sand, trace silt **FIGURE:** B-1

JAGGER HIMS LIMITED
Environmental Consulting Engineers

PARTICLE SIZE DISTRIBUTION



UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: ORANGEVILLE HIGHLANDS **PROJECT No:** 021508.03 **HOLE No:** 03-6 **SAMPLE No:**

DEPTH: 1.0 m bgl **REMARKS:** Fine sand, trace silt **FIGURE:** B-2

APPENDIX C

CLIMATIC DATA

TABLE C-1
Climatic Water Budget: 1971 - 2000
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

MONTH	Mean Temperature (°C)	Heat Index	Evapo-trans. (mm)	Daylight Correction Factor	Adjusted Evap. (mm)	Total Precipitation (mm)	Surplus (mm)	Deficit (mm)
January	-8.0	0.0	0.0	0.73	0.0	65.2	65.2	0.0
February	-7.3	0.0	0.0	0.85	0.0	50.9	50.9	0.0
March	-2.3	0.0	0.0	0.98	0.0	65.8	65.8	0.0
April	4.9	1.0	24.7	1.13	27.9	69.9	42.0	0.0
May	11.8	3.7	59.8	1.26	75.4	79.3	3.9	0.0
June	16.5	6.1	83.8	1.33	111.7	83.9	0.0	27.8
July	19.1	7.6	97.1	1.31	126.7	75.3	0.0	51.4
August	18.3	7.1	93.0	1.20	111.1	95.6	0.0	15.5
September	14.0	4.7	71.0	1.06	74.9	83.7	8.8	0.0
October	7.8	2.0	39.4	0.91	35.8	71.0	35.2	0.0
November	1.6	0.2	8.0	0.78	6.2	81.8	75.6	0.0
December	-4.7	0.0	0.0	0.71	0.0	69.3	69.3	0.0
TOTALS (mm)					**569.8**	**891.7**	**416.7**	**94.7**
						569.8		
				Water Surplus		**321.9**	**mm**	

NOTES:
1) Evapotrans. = Evapotranspiration
2) Water budget based on Thornthwaite Method. Adjusted for latitude and daylight.
3) (°C) - Represents calculated mean of daily temperatures for the month.
4) Data from the Orangeville MOE Climatological Station located at latitude 43°55'N, longitude 80°5'W.
5) Water surplus is calculated as total precipitation minus adjusted evapotranspiration

TABLE C-2
Snow On Ground, 2005
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Date	Snow Pack Depth (cm)	
	Orangeville MOE	Sandhill
1-Mar-05	15	25
2-Mar-05	13	30
3-Mar-05	16	31
4-Mar-05	12	30
5-Mar-05	NR	28
6-Mar-05	NR	22
7-Mar-05	12	19
8-Mar-05	9	11
9-Mar-05	NR	11
10-Mar-05	12	15
11-Mar-05	NR	16
12-Mar-05	NR	12
13-Mar-05	NR	17
14-Mar-05	12	15
15-Mar-05	12	12
16-Mar-05	11	10
17-Mar-05	7	13
18-Mar-05	3	10
19-Mar-05	NR	9
20-Mar-05	NR	8
21-Mar-05	13	10
22-Mar-05	3	7
23-Mar-05	NR	6
24-Mar-05	NR	8
25-Mar-05	NR	5
26-Mar-05	NR	3
27-Mar-05	NR	1
28-Mar-05	Trace	Trace
29-Mar-05	0	Trace
30-Mar-05	0	0
31-Mar-05	0	0

Date	Snow Pack Depth (cm)	
	Orangeville MOE	Sandhill
1-Apr-05	0	NR
2-Apr-05	20	Trace
3-Apr-05	NR	5
4-Apr-05	22	3
5-Apr-05	4	0
6-Apr-05	Trace	0
7-Apr-05	0	0
8-Apr-05	0	0
9-Apr-05	0	0
10-Apr-05	NR	0
11-Apr-05	0	0
12-Apr-05	0	0
13-Apr-05	0	0
14-Apr-05	0	0
15-Apr-05	0	0
16-Apr-05	NR	0
17-Apr-05	NR	0
18-Apr-05	0	0
19-Apr-05	0	0
20-Apr-05	0	0
21-Apr-05	0	0
22-Apr-05	0	0
23-Apr-05	0	0
24-Apr-05	NR	0
25-Apr-05	NR	NR
26-Apr-05	0	0
27-Apr-05	NR	0
28-Apr-05	NR	0
29-Apr-05	NR	0
30-Apr-05	NR	0

Note

NR = not recorded

TABLE C-3
Snow On Ground, 2006
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

Date	Snow Pack Depth (cm)	
	Orangeville MOE	Sandhill
1-Feb-06	0	0
2-Feb-06	0	0
3-Feb-06	2	0
4-Feb-06	NR	0
5-Feb-06	NR	17
6-Feb-06	25	17
7-Feb-06	41	19
8-Feb-06	35	17
9-Feb-06	31	17
10-Feb-06	28	16
11-Feb-06	NR	17
12-Feb-06	NR	17
13-Feb-06	25	15
14-Feb-06	29	14
15-Feb-06	23	12
16-Feb-06	23	22
17-Feb-06	22	15
18-Feb-06	NR	17
19-Feb-06	NR	16
20-Feb-06	22	16
21-Feb-06	21	16
22-Feb-06	24	16
23-Feb-06	23	12
24-Feb-06	30	13
25-Feb-06	NR	17
26-Feb-06	NR	17
27-Feb-06	37	16
28-Feb-06	36	16
1-Mar-06	36	15
2-Mar-06	37	15
3-Mar-06	37	15
4-Mar-06	NR	14
5-Mar-06	NR	14
6-Mar-06	25	12
7-Mar-06	25	12
8-Mar-06	NR	11
9-Mar-06	29	10
10-Mar-06	11	7
11-Mar-06	NR	2
12-Mar-06	NR	0
13-Mar-06	0	0
14-Mar-06	NR	0
15-Mar-06	1	1
16-Mar-06	NR	0
17-Mar-06	NR	0
18-Mar-06	NR	0
19-Mar-06	NR	0
20-Mar-06	0	0
21-Mar-06	0	0
22-Mar-06	0	0
23-Mar-06	0	0
24-Mar-06	NR	0
25-Mar-06	NR	1
26-Mar-06	NR	0
27-Mar-06	0	0
28-Mar-06	0	0
29-Mar-06	0	0
30-Mar-06	NR	0
31-Mar-06	NR	0
1-Apr-06	NR	0
2-Apr-06	NR	0
3-Apr-06	0	0
4-Apr-06	0	0
5-Apr-06	2	0
6-Apr-06	0	0
7-Apr-06	NR	0
8-Apr-06	NR	0
9-Apr-06	NR	0
10-Apr-06	0	0
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13-Apr-06	0	0
14-Apr-06	NR	0
15-Apr-06	NR	0
16-Apr-06	NR	0
17-Apr-06	0	0
18-Apr-06	0	0
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21-Apr-06	0	0
22-Apr-06	NR	0
23-Apr-06	NR	0
24-Apr-06	0	0
25-Apr-06	NR	0
26-Apr-06	0	0
27-Apr-06	0	0
28-Apr-06	NR	0
29-Apr-06	NR	0
30-Apr-06	NR	0

Note

NR = not recorded

FIGURE C-1, Air Temperatures for Spring Monitoring Period, 2005
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

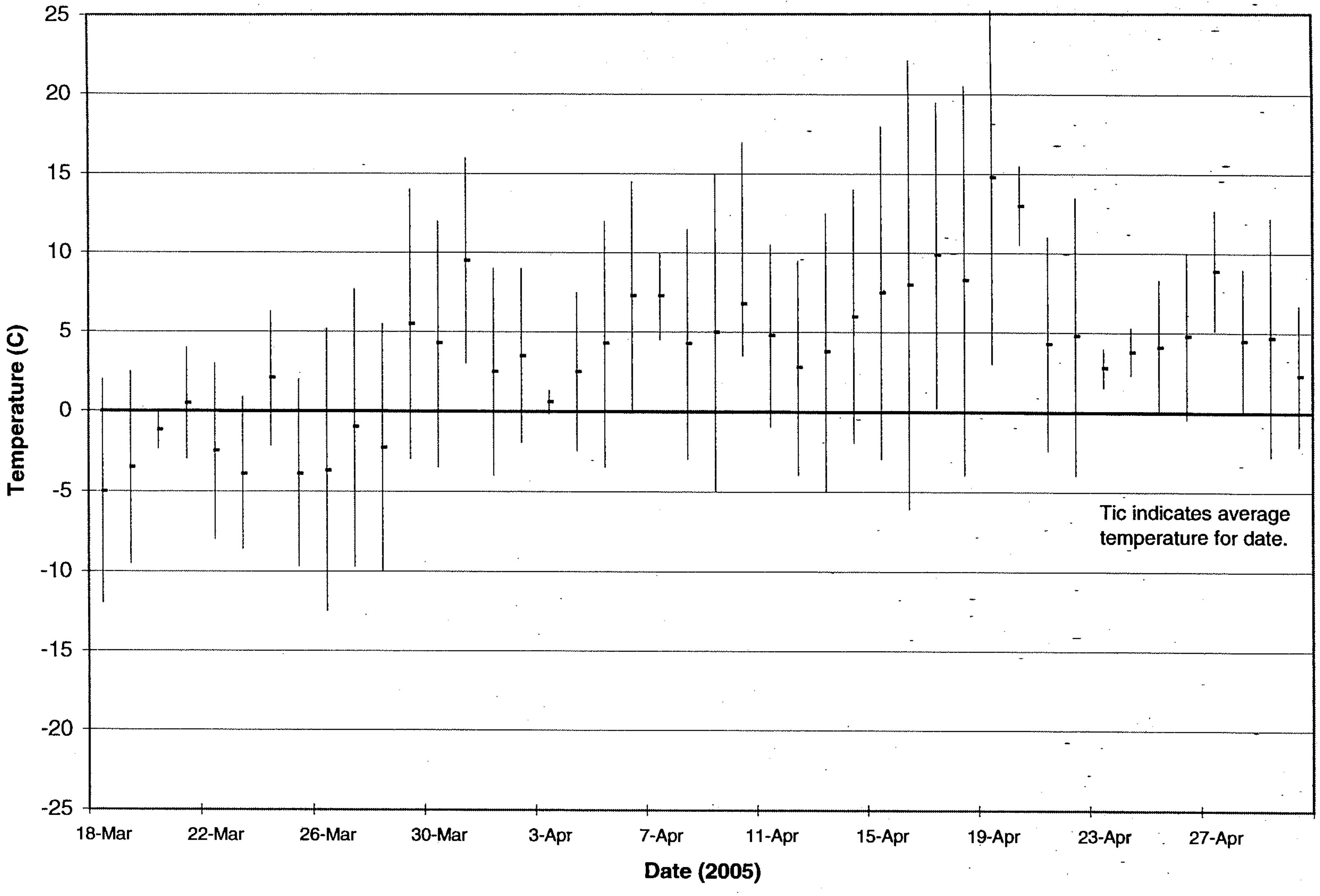

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FIGURE C-2, Air Temperatures for Spring Monitoring Period, 2006
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

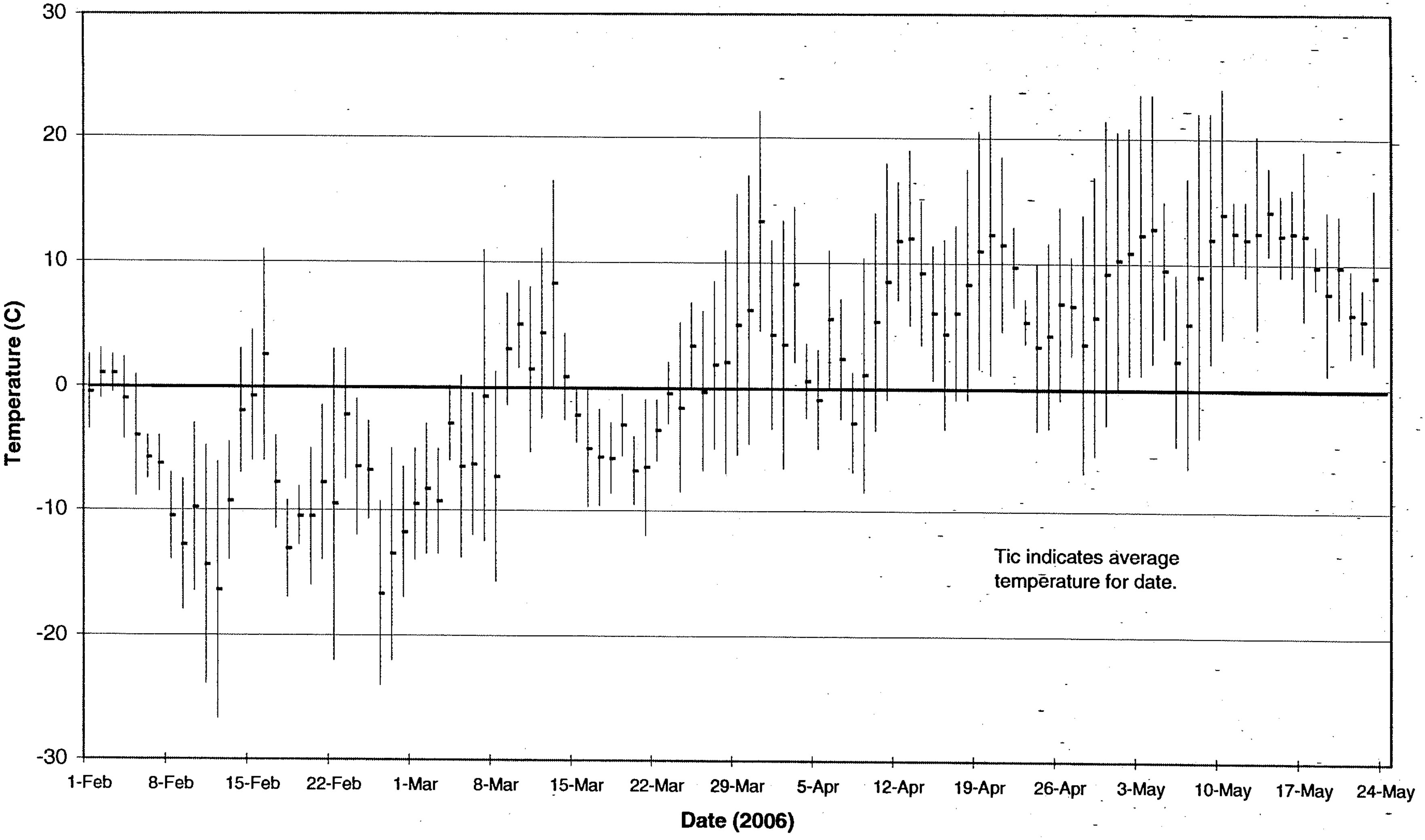
Tic indicates average temperature for date.

FIGURE C-3: Daily Precipitation for Spring Monitoring Period, 2005
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments

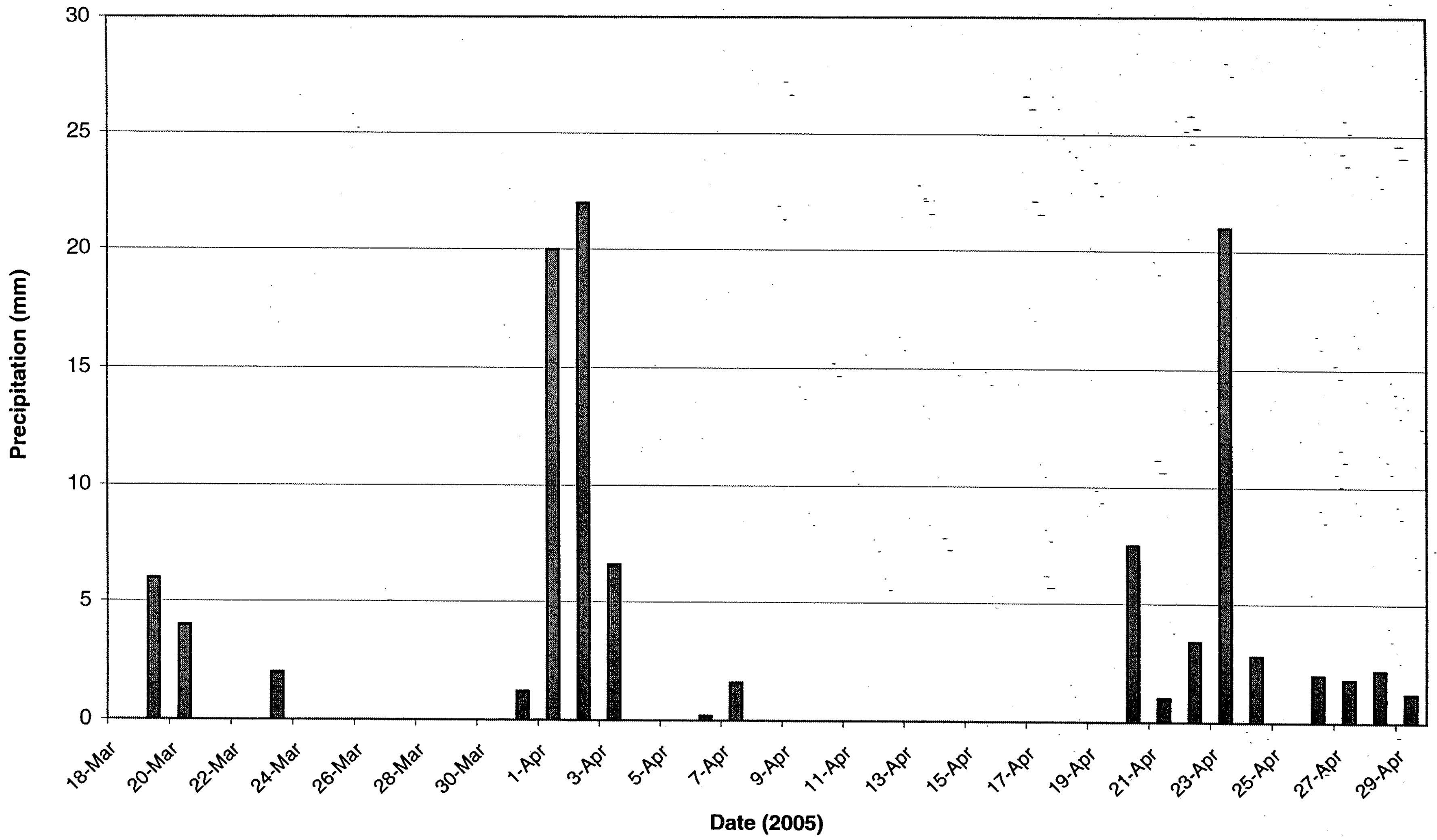

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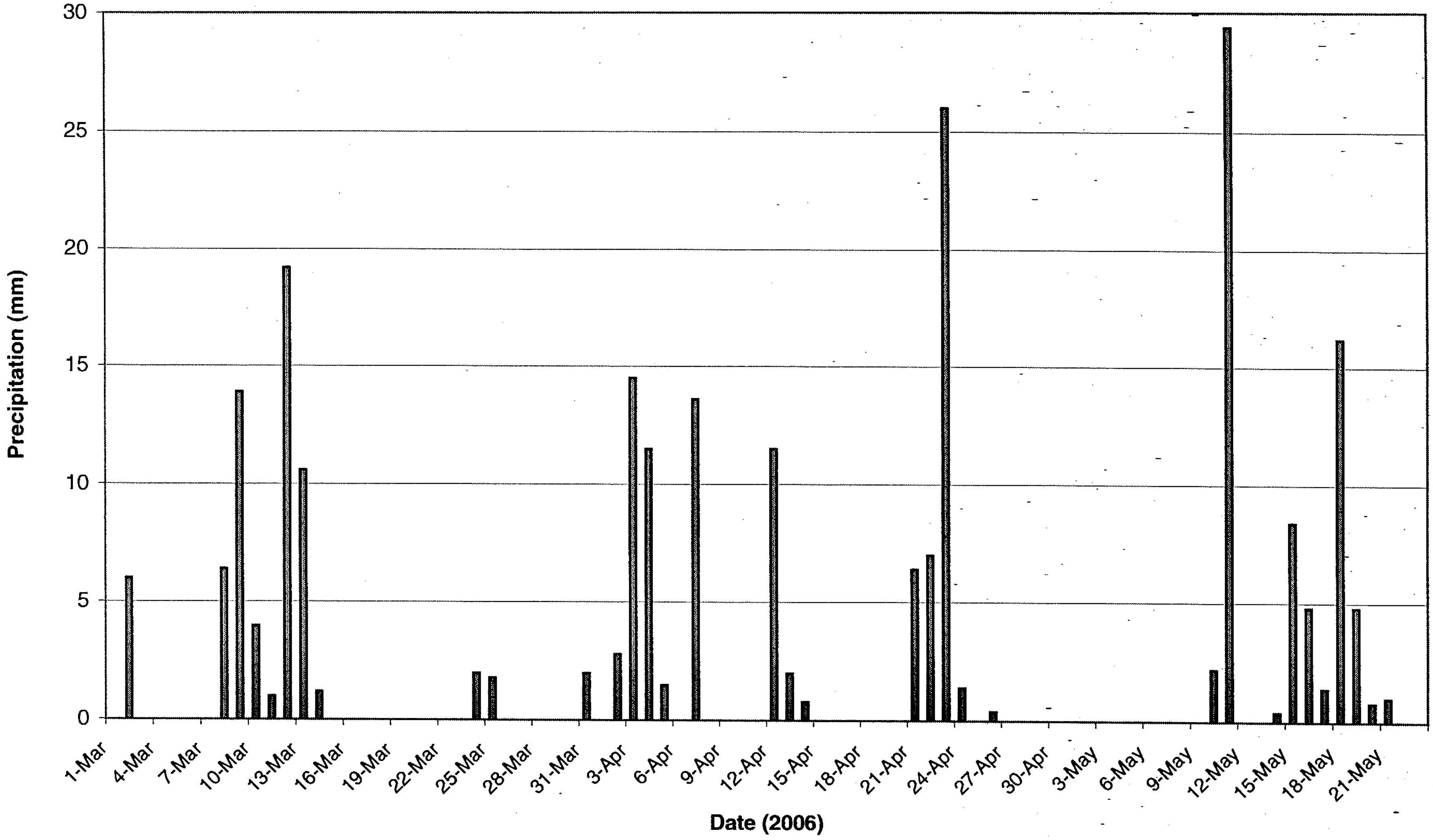
FIGURE C-4: Daily Precipitation for Spring Monitoring Period, 2006
Orangeville Highlands, Phase 2, Supplemental Monitoring and Assessments



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