# PRELIMINARY GEOTECHNICAL AND HYDROGEOLOGICAL STUDY FOR PROPOSED CEDAR RUN WAKEBOARD CABLE PARK, THORNBURY, ON

**Bayou Cable Park Inc. c/o C.C. Tatham & Associates**

**Draft Report**

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# 1 INTRODUCTION

WSP Canada Inc. was retained by Bayou Cable Park Inc. c/o C.C. Tatham & Associates to undertake a preliminary geotechnical and hydrogeological study for the proposed Cedar Run Wakeboard Cable Park, located at 324 Clark Street, Thornbury, Ontario.

Based on the conceptual sketch (refer Appendix A) provided to us, we understand that proposed Wakeboard Cable Park will include three artificial ponds, a pro-shop and office, maintenance building, commercial plaza and parking lots including an assessment of the stability of existing slopes. The key component of this park is the artificial Pond A which has a central island and will be provided with strategically located six towers for cable supported wakeboarding.

The purpose of this combined geotechnical and hydrogeological investigation is to characterize the subsurface soil conditions and groundwater levels at fourteen (14) boreholes and seven (7) test-pits locations and from the findings in the boreholes and test-pits to make preliminary recommendations pertaining to the geotechnical design of proposed works.

This report is provided on the basis of the terms of reference presented above and on the assumption that the design will be in accordance with the applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of this office can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for Bayou Cable Park Inc. c/o C.C. Tatham & Associates and their designers. Third party use of this report without WSP Canada Inc. consent is prohibited.

# 2 FIELD AND LABORATORY WORKS

The field investigation consisted of drilling fourteen (14) boreholes (BH16-01 to BH16-14) and advancing seven (7) test-pits (TP1 to TP7) between November 28 and December 2, 2016. For Borehole Locations and Test-Pit locations, refer to Drawing 1.

Fourteen (14) boreholes (BH16-01 to BH16-14, Appendix B) were drilled to depths ranging from 3.3 m and 9.8 m below existing ground surface. The boreholes were drilled with hollow/solid stem continuous flight auger equipment supplied by a drilling sub-contractor under the direction and supervision of WSP personnel. Samples were retrieved at regular intervals with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 624 N and dropping 760 mm in accordance with the Standard Penetration Test (SPT) method.

The soil samples were logged in the field and transported to WSP's laboratory for detailed examination by the project engineer and for laboratory testing.

Seven (7) test-pits (TP1 to TP7, Appendix C) were dug using John Deere excavator to a depth of 3.0 m below existing ground surface.

All soil samples were tested for moisture contents. Six (6) selected soil samples were subjected to grain size analysis, and results are presented on Figures C1 and C2 in Appendix D.

Water level observations were made during drilling and in the open boreholes at the completion of the drilling operations. In addition, 50 mm diameter monitoring wells were installed at BH16-03, BH16-07, BH16-09, BH16-12, BH16-13 and BH16-14 for long-term groundwater level monitoring. Remaining boreholes (BH16-01, BH16-02, BH16-04 to BH16-06, BH16-08, BH16-10 and BH16-11) were backfilled upon completion of drilling in accordance with current regulations.

The ground surface elevations of the boreholes and test-pits were estimated from the topographic survey drawing provided by client. The borehole ground surface geodetic elevations at the locations of the boreholes and test-pits are presented on the Log of Borehole sheets (Appendix B) and on the Log of Test-Pit sheets (Appendix C).

# 3 BACKGROUND INFORMATION AND SUBSURFACE CONDITIONS

The subject site is located 324 Clark Street in the Town of Thornbury, Ontario. Drawing 1 shows the location and site boundaries. It is approximately 680 m wide from the east bounding hedgerow to the western boundary along Hwy 2 and about 600m from the south boundary bordering agricultural land and Indian Brook to Clark St. Indian Brook flows along the south west corner of the subject site and meanders approximately 1 km east before discharging into Georgian Bay at Peasemarsh Park. At its closest proximity, the Georgian Bay shoreline is about 600 m northeast of the site.

Available topographic, water resource, geological and hydrogeological reports and maps were used to develop an understanding of the physical setting of the study area. A MOECC WWR database search was also conducted. Figure 1 presents the MOECC water well location map. Information from the borehole logs (Appendix A) and from the MOECC WWRs (summary included in Appendix C) was used for the interpretation of the geological and hydrogeological conditions at the site.

## 3.1 LANDUSE AND CONSTRAINT MAPPING

Current land use in the area is urban residential surrounded by special agricultural. The subject site is zoned as a Primary Settlement Area. The Grey County Official Plan (OP) indicates the following:

- portions of the subject site are designated as Hazard Lands including setbacks from Indian brook and a mapped water feature which flows through the site; an apparent unnamed feature which drains directly into Georgian Bay to the northeast;
- Schedule ‘A’ of the OP includes Primary Aggregate Mapping which shows east portions of the subject site are within a Primary Aggregate Resource Area;
- The subject site is not in a Wellhead Protection Area (WHPA) or an Intake Protection Zone (IPZ);
- The subject site is not within the Niagara Escarpment Plan Boundary;

- The subject site is not in an area with a registered active or inactive landfill;
- The subject site is not in an area with identified wetlands or significant woodlands;
- The subject site is not in an area mapped as a Special Policy Karst area; and,
- The subject site is not in an area of Natural and Scientific Interest (ANSI),.

## 3.2 REGIONAL PHYSIOGRAPHY, DRAINAGE AND GEOLOGY

The study area is entirely within the Beaver Valley physiographic region of Southern Ontario (Chapman and Putnam, 1984). The surficial soil in this area is mapped as predominantly sand and gravel with terraces along the banks of Indian Brook and a bluff across the northeast corner of the site as shown in Drawing 2 (OGS Earth, Surficial Geology). The topography of the site slopes from west to east from over 204 metres above sea level (masl) to about 185 masl. Changes in elevation across the site are generally swift, such as in the area of the bluff where an elevation change of approximately 5m observed. The majority of the site has a gentler slope.

The site is in the Indian Brook River watershed which consists of a number of tributaries that join with the Indian Brook River before draining directly into Georgian Bay. The site is well drained due to the topography and the presence of a drainage feature which flows west to east central to the site. The field investigations for the combined geotechnical and hydrogeological investigation were completed in November and December 2016, when the site was snow covered. At this time, flowing conditions were observed within the drainage feature. Artificial ponds are presently dug along the drainage channel with flow through conditions. There were no other areas of observed ponding or groundwater seepages at the site during the investigation.

### 3.2.1 BEDROCK GEOLOGY

The bedrock in the study area is mapped as consisting of shale of the Georgian Bay Formation (Upper Ordovician-aged) (MNMD Map 2341, Paleozoic Geology, Collingwood-Nottawasaga, Southern Ontario.

Based on a review of registered water wells in the area, the depth to bedrock ranges between 19 and 46 m below ground surface. Bedrock was not encountered as part of this investigation where boreholes extended to maximum depths of 10 m.

### 3.1.2 QUATERNARY GEOLOGY

Available mapping shows that overburden in the area of the site is predominantly coarse textured glaciolucustrine deposits of sand and gravel, with minor silt and clay (MNDM Map 2556 Quaternary Geology of Ontario, Southern Sheet). Drawing 2 shows the surficial geology for the study area. The results of the on-site drilling demonstrated that the site specific overburden sequence is comprised of sand to silty sand overlying a deposit of very hard silty sand to sandy silt till with gravel and cobble.

## 3.3 SOIL CONDITIONS

The borehole and test-pit locations are shown on Drawing 1. Notes on Soil Sample Descriptions are in Appendix A. The subsurface conditions at the boreholes (BH16-01 through BH16-14) are presented on the individual borehole logs in Appendix B, and of test-pit logs in Appendix C. The subsurface conditions in the boreholes and at test-pit locations are summarized in the following paragraphs.

### 3.3.1 TOPSOIL

A layer of surficial topsoil ranging in thickness from 30 to 300 mm was found at boreholes (BH16-01 to BH16-12 and BH16-04. Beneath the fill, about 180 mm and 250 mm thick buried topsoil was found at boreholes BH16-08 and BH16-13. At test-pit locations, TP2 to TP4, the topsoil thickness ranged from 300 to 400 mm. Topsoil quantities should not be calculated from the borehole and test-pit information, as large variations in depth may exist between and beyond the boreholes.

### 3.3.2 FILL

Underlying the topsoil or at surface, fill was found at boreholes BH16-08, BH16-09 and BH16-13 with thickness in general ranging from 0.8 m to 0.9 m. The fill generally consisted of sand/silt materials with inclusions of topsoil.

Standard Penetration Tests (SPT) yielded N-values ranging from 4 to 16 bows per 0.3 m of penetration, suggesting a loose to compact relative density.

Measured water content of the fill samples ranged from 9% to 16% by weight.

### 3.3.3 REWORKED/DISTURBED SOILS

A layer of reworked/disturbed soils was encountered at most of the boreholes (BH16-01 to BH16-07 and BH16-10 to BH16-12) below topsoil, extended to depths ranged from 0.8 m to 1.0 m below existing ground surface. The reworked/disturbed soils predominantly consisted of silt, sandy silt, silty sand and sand, with inclusions of rootlets. The reworked soil was typically in a loose to compact state.

### 3.3.4 NATIVE SOILS

Underlying the topsoil, fill or reworked/disturbed soils, the predominant native soils are cohesionless soils consisting of sandy silt, silt and sand, silty sand, and sand. Clayey silt layers of 0.9 m to 2.0 m in thickness were encountered in BH16-02 and BH16-04.

The grinding of augers or bouncing of hammer during drilling/sampling in various boreholes (such as BH16-02, BH16-03, BH16-06, BH16-10, BH16-12, and BH16-13) indicated that cobbles and boulders exists within the cohesionless deposits.

Two (2) tested samples of the sandy silt, and silt and sand (BH16-03/SS9 and BH16-10/SS2) contain 0 to 21% gravel, 30 to 56% sand, 40% silt and 4 to 9% clay size particles. The grain size distribution curves for the samples are presented on Drawing C1 in Appendix C.

One (1) tested sample of the clayey silt (BH16-02/SS2) contains 0% gravel, 1% sand, 77% silt and 22% clay size particles. The grain size distribution curves for the sample is presented on Drawing C2 in Appendix C.

The cohesionless soils were in a moist to very moist state, and in a loose to very dense relative density.

The cohesive soils were in a firm to hard consistency.

## 3.4 HYDROGEOLOGY

The hydrogeological conditions at the site were evaluated using both regional data collected from MOECC WWRs and the results of the on-site investigation.

### 3.4.1 MOECC WATER WELL RECORDS

The search of the MOECC WWR database focused on the area within a 500 m radius of the site. The location of the water wells are shown on Drawing 3. A summary of the data from the WWRs is included in Appendix D. A total of 19 MOECC WWRs were found, with 14 being listed as domestic water supply wells, 3 listed as abandoned and 2 without information. The wells range in depth from 18.3 m to 61.0 m below ground level. Of the 19 wells, fourteen were completed in the overburden and five were completed in the bedrock. The static water levels noted on the WWRs in the overburden ranged between 4.0 to 18.0 m below ground and in the bedrock between 11.0 to 32.3 m below ground. As noted in Section 3.1.1, bedrock was not encountered at the site during this investigation where boreholes extended to maximum depths of approximately 10 m.

### 3.4.2 GROUNDWATER CONDITIONS

At the completion of drilling, boreholes BH16-01, BH16-02, BH16-05, BH16-06, BH16-08 and BH16-10 to BH16-14 were found dry, and in the remaining boreholes (BH16-03, BH16-04, BH16-07 and BH16-09, the short-term (un-stabilized) groundwater levels ranged between 2.5 m and 4.8 m below existing grade.

The monitoring wells at Boreholes BH16-03, BH16-07, BH16-09, and BH16-12 to BH16-14 were measured and are shown on the individual Record of Borehole Sheets, as well as in the following Table 3-1.

**Table 3-1 Measured Water Level in Monitoring Wells**

| BH NO. | GROUND SURFACE ELEV. (m) | SOIL TYPE AT SCREEN LOCATION | DATE OF MEASUREMENT | WATER LEVEL DEPTH/ELEVATION (m) |
|---|---|---|---|---|
| BH16-03 | 197.1 | Sand | December 7, 2016 | 6.2 / 190.9 |
| | | | January 20, 2017 | 5.9 / 191.2 |
| BH16-07 | 189.5 | Sandy Silt | December 7, 2016 | 1.2 / 188.3 |
| | | | January 20, 2017 | 1.0 / 188.5 |
| BH16-09 | 199.6 | Sandy Silt to Silt and Sand | December 7, 2016 | 1.8 / 197.8 |
| | | | January 20, 2017 | 1.3 / 198.3 |
| BH16-12 | 191.3 | Sandy Silt to Silt and Sand | December 7, 2016 | 1.9 / 189.4 |
| | | | January 20, 2017 | 1.6 / 189.7 |
| BH16-13 | 192.5 | Sandy Silt to Silty Sand | December 7, 2016 | Dry / -- |
| | | | January 20, 2017 | 2.2 / 190.3 |
| BH16-14 | 189.0 | Sandy Silt to Silty Sand | December 7, 2016 | Dry / -- |
| | | | January 20, 2017 | Dry / -- |

It should be noted that over the long term, seasonal fluctuations in the groundwater will occur.

### 3.4.3 HYDRAULIC CONDUCTIVITY TESTING

Rising head in-situ hydraulic conductivity (K) tests were completed at monitoring wells BH16-03, BH16-07, BH16-09 and BH16-12. The testing's were completed by removing water from the well and then accurately measuring the change in head versus time. The in-situ hydraulic conductivity testing report is included in Appendix E.

The results of the in-situ hydraulic conductivity testing, along with the hydraulic conductivities estimated from the grain size analyses, are summarized in Table 3-2 below:

**Table 3-2 Summary of Hydraulic Conductivity Testing Results**

| BH NO. | IDENTIFICATION (DEPTH INTERVAL mbg) | SOIL TYPE AT SAMPLE INTERVAL | ESTIMATED HYDRAULIC CONDUCTIVITY (K) FROM GRAIN SIZE (cm/s) | MONITORING WELL SCREENED INTERVAL (mbg) | SOIL TYPE IN SCREENED INTERVAL | MEASURED IN-SITU HYDRAULIC CONDUCTIVITY (K) (cm/s) |
|---|---|---|---|---|---|---|
| BH16-02 | SS2 (0.8 – 1.2) | Clayey Silt | $8 \times 10^{-7}$ | | | |
| BH16-03 | SS9 (9.1 – 1.5) | Silt and Sand | $1 \times 10^{-5}$ | 7.4 – 8.9 | Sand | $2.8 \times 10^{-5}$ |
| BH16-07 | | | | 2.7 -4.3 | Sandy Silt | $5.8 \times 10^{-5}$ |
| BH16-09 | | | | 2.7 – 4.3 | Sandy Silt to Silt and Sand | $5.8 \times 10^{-5}$ |
| BH16-10 | SS2 (0.8 – 1.2) | Sandy Silt | $5 \times 10^{-6}$ | | | |
| BH16-12 | | | | 2.9 – 4.4 | Sandy Silt to Silt and Sand | $3.9 \times 10^{-6}$ |
| TP1 | 3.0 | Clayey Silt | $1 \times 10^{-6}$ | | | |
| TP3 | 3.0 | Clayey Silt | $9 \times 10^{-7}$ | | | |
| TP6 | 3.0 | Sandy Silt | $4 \times 10^{-6}$ | | | |

Notes:
mbg- metres below ground

### 3.4.4 INFILTRATION TESTING

In-situ infiltration testing was conducted by WSP field personnel on September 23 2017, at which time weather conditions were clear of precipitation. Site conditions were observed to be wet with surface soils saturated from snow melt and rain fall 1 day prior. To complete the investigation, WSP conducted in-situ Infiltration testing at seven (7) locations as shown in Drawing 1. Each of the seven locations included double-ring infiltrometer testing at 3.0 m bgs. within native soils. There was observed groundwater seepage into the bottom of the test pit at the TP1 location. Each of the double-ring infiltrometer tests were 15 to 30 minutes in duration with manual infiltration measurements recorded throughout the test period. Soil samples at each of the locations were retrieved from the explored depth of each test pit and tested for grain size. The results of the grain size distribution tests were used to approximate hydraulic conductivities and percolation rates for comparison to infiltration testing results.

The results of the in-situ infiltration testing, along with the infiltration rates estimated from the grain size analyses, are summarized in Appendix B.

# 4 DISCUSSION AND RECOMMENDATIONS

## 4.1 GENERAL

The final details of the proposed Wakeboard Cable Park development are not available. The proposed works based on the concept sketch provided to us will include three artificial ponds, a pro-shop and office, maintenance building, commercial plaza and parking lots including an assessment of the stability of existing slopes. The boreholes and test-pits relevant to the proposed development are summarized in Table 4-1.

**Table 4-1 Relevant Borehole Locations for Proposed Works**

| PROPOSED WORKS (APPENDIX A) | RELEVANT BOREHOLES / TEST-PITS |
|---|---|
| Pond A | BH16-07 and BH16-12 to BH16-14, TP5, and TP6 |
| Pond B | BH16-04, TP7 |
| Pond C | BH16-09, TP1 and TP2 |
| Commercial Plaza | BH16-01 |
| Pro-Shop and Office | BH16-10 |
| Over-night Accommodation | BH16-05 and BH16-06 |
| Parking Lots | BH16-01 and BH16-02 |

The key component of this park is the artificial Pond A which has a central island and will be provided with strategically located six towers for cable supported wakeboarding.

## 4.1 FOUNDATION CONSIDERATIONS

The proposed location of commercial plaza, and pro-shop and office are presented on Table 4-1. Borehole BH16-01 was drilled in the proposed commercial plaza area and BH16-10 was drilled in the proposed pro-shop and office areas. It is understood that commercial plaza, and pro-shop and office will essentially be a slab-on-grade structures.

The proposed buildings supported by conventional spread and strip footings founded on the undisturbed native soils can be designed for a geotechnical reaction of 150 kPa at the Serviceability Limit States (SLS), and a factored geotechnical resistance of 225 kPa at the Ultimate Limit States (ULS), at or below 0.8 m from the existing grade.

The base of all footings must be inspected by this office to ensure of their placement on the competent native soil.

Variations in the soil conditions are expected in between and beyond the borehole locations, and during construction. As such, the soil bearing pressures must be confirmed by the Geotechnical Engineer.

Provided that the founding soil is undisturbed during construction, total and differential settlements of foundations designed and constructed in accordance with the specified design bearing values should not exceed 25 mm and 19 mm respectively.

Where it is necessary to place footings at different levels, the upper footing must be founded below an imaginary 10 horizontal to 7 vertical line drawn up from the base of the lower footing. The lower footing must be installed first to help minimize the risk of undermining the upper footing. The new footings must match the existing footing level when founded adjacent to the existing footing, otherwise it will require underpinning.

In the vicinity of the existing buried utilities, all footings must be lowered to undisturbed native soils, or alternatively the services must be structurally bridged.

The floor slab of the building can be supported on grade provided, the subgrade is thoroughly proof rolled with heavy roller in the supervision of WSP. Any loose / soft spots must be sub excavated and replaced with suitable selected inorganic fill compacted to 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

A moisture barrier consisting of at least 200 mm of Granular 'A' or 19 mm clear crushed stone should be installed under the floor slab (Drawing 9).

If the floor slab is more than about 150 mm higher than the exterior grade, perimeter drainage is not considered to be necessary.

## 4.2 WAKEBOARD CABLE PARK POND A

Boreholes BH16-07 and BH16-12 to BH16-14 and test-pits TP5 and TP6 were advanced within the footprint of the proposed pond. The locations of sections across pond are shown on Drawing 1, and pond profiles are shown on Drawings 4 and 5. The design pond water elevations are not available till the writing of this report.

In summary, proposed pond will be constructed in cut and fill. The pond sides (both upstream and downstream) will have a slope inclination of 3 H : 1 V. The bottom of the pond is proposed to be at an elevation of 187.7 masl, which will about 1.8 m below perimeter berm crest level and about 3.8 m below the centre island crest level. The perimeter berm crest will be 3 m wide. The base of the pond and sides (other than fill berm) will be provided with a clay liner of 1 m thickness, to minimize seepage losses.

### 4.2.1 SITE PREPARATION

The foundation of the berm area should be stripped and prepared for at least 2 m beyond the footprint of the berm. All vegetation, topsoil, boulders over 100 mm, soft or loose earth fill, reworked soil and other unsuitable soils (where required) be removed from the proposed pond and berm envelope. After stripping, the exposed subgrade should be proof-rolled. Any soft spots revealed during proof rolling must be sub-excavated and re-engineered in the presence of a qualified geotechnical personnel.

### 4.2.2 BERM FILL

In order to retain water in the pond and to limit seepage/piping and groundwater intrusion into the berm, the berm fill should consist of inorganic low permeability material (clayey silt/silty clay). Earth fill for the berm should be placed in loose lifts not exceeding 150 mm. Each lift should be uniformly compacted to at least 98 % of the material's Standard Proctor Maximum Dry Density (SPMDD). The berm fill should contain minimum 20% clay (finer than 0.002 mm) and have a plasticity index (PI) of minimum 6.0. Any cobbles or boulders greater than 100 mm in size should be excluded from the earth berm fill. The materials shall be placed and compacted at a water content of between 2 percent dry and 3 percent wet of the optimum moisture content. This is required to ensure that the material is compacted to a homogenous mass, and does not remain as distinct "clods" or "clumps".

Berm construction should be in accordance with OPSS 501 and to the satisfaction of the geotechnical engineer. The fill must be placed and compacted under the supervision of qualified geotechnical personnel. It is recommended that a test section be incorporated in the berm during construction. Field tests should be performed on the test section and field compaction curves developed for the equipment used.

Under no condition should frozen materials be placed in the berm. If construction proceeds under winter conditions, then adequate protection against frost penetration must be provided (e.g. straw bales, tarping, heating).

During the first 2 to 3 years the berm surface cover of topsoil and seeding may require periodic maintenance on slopes (due to surface erosion), until the vegetation becomes well established. Erosion netting or mulch could reduce the amount of maintenance.

Based on the borehole information, local excavated clayey silt to silty clay materials are generally suitable for re-use as the berm fill, to be confirmed by laboratory tests (grain size and Atterberg Limits tests) of the materials during the construction stage.

### 4.2.3 LINER CONSIDERATIONS

The berm should consist of clayey silt to silty clay fill as per the requirements presented in Section 4.2.2 of this report. Clay liner is required at the bottom and sides of the pond.

Due to the relatively high permeability of the cohesionless deposits at the bottom and lower portion of the pond slopes, any water in the pond will gradually infiltrate into the cohesionless deposits if a liner is not installed. It is recommended that a liner be constructed to limit seepage/piping and groundwater intrusion into the berm.

The liner may consist of a clay liner or a synthetic membrane liner (such as a High Density Polyethylene, Geo-synthetic Clay Liner, or PVC). A clay liner may be preferable based on the following considerations:

- Low permeability clayey silt to silty clay materials are generally available locally for the construction of the liner.
- A clay liner is readily constructed using locally available construction equipment and manpower.
- A synthetic liner requires more elaborate design and construction considerations with respect to fabrication and protection of the completed liner.

It is suggested that a clay liner, with a minimum 0.5 m thickness, be adopted for this pond.

The clay liner must be constructed of low permeability material (clayey silt to silty clay) compacted to at least 98% SPMDD. The liner fill should contain minimum 20% clay (finer than 0.002 mm) and have a plasticity index (PI) of minimum 6.0. Any cobbles or boulders greater than 100 mm in size should be excluded from the earth berm fill. The materials shall be placed and compacted at a water content of between 2 percent dry and 3 percent wet of the optimum moisture content.

Pond side slopes should confirm to the requirements for berm stability under the latest version of the Lakes and Rivers Improvement Act (LRIA). In general, the berm/side slope below the permanent water level should be 4 H : 1 V or flatter

### 4.2.4 OHSA SOIL CLASSIFICATION

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the reworked soils, fill (if any), compact sand/silt soils are classified as Type 3 soils above groundwater and Type 4 soils below groundwater level.

## 4.3 PONDS B AND C

The footprints and design details of Pons A and B are not available till the writing of this report. Comments will be provided once the details are available.

## 4.4 PARKING LOTS

The recommended pavement structures provided in Table 4-2 are based upon an estimate of the subgrade soil properties determined from visual examination, textural classification of the soil samples. Consequently,

the recommended pavement structures should be considered for preliminary design purposes only. A functional design life of eight to ten years has been used to establish the pavement recommendations. This represents the number of years to the first rehabilitation, assuming regular maintenance is carried out. If required, a more refined pavement structure design can be performed based on specific traffic data and design life requirements and will involve specific laboratory tests to determine frost susceptibility and strength characteristics of the sub grade soils, as well as specific data input from the client.

**Table 4-2 Recommended Minimum Pavement Structure Thicknesses for New Parking Lots**

| PAVEMENT LAYER | COMPACTION REQUIREMENTS | LIGHT DUTY PARKING |
|---|---|---|
| Asphaltic Concrete | 92.0 to 96.5 MRD* | 40 mm OPSS HL 3<br>50 mm OPSS HL 8 |
| OPSS Granular A Base (Crushed Limestone) | 100% SPMDD** | 150 mm |
| OPSS Granular B Sub-base (Crushed Limestone) | 100% SPMDD | 250 mm |
| **Notes:**<br>* MRD - Maximum Relative Density<br>** SPMDD - Denotes Standard Proctor Maximum Dry Density, ASTM-D698<br>The sub grade must be compacted to 98% SPMDD for at least the upper 300 mm unless accepted by WSP | | |

The long term performance of the pavement structure is highly dependent upon the subgrade support and drainage conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. The finished pavement surface and underlying subgrade should be free of depressions and should be sloped (preferably at a minimum grade of 2%) to provide effective surface drainage toward catch basins or ditches. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Subdrains should be installed to intercept excess subsurface moisture and prevent subgrade softening.

Additional comments on the construction of parking areas and access roadways are as follows:

1. The exposed surface should be proof rolled. Any soft spots revealed during proof rolling must be sub-excavated. Engineered fill can then be placed using approved inorganic material compacted to 98% Standard Proctor Maximum Dry Density throughout. The subgrade must be covered with geo-grid/filter fabric, if needed.
2. The locations and extent of sub-drainage required within the paved areas should be reviewed by this office in conjunction with the proposed lot grading. Assuming that satisfactory cross falls in the order of two percent have been provided, sub drains extending from and between catch basins may be satisfactory. In the event that shallower cross falls are considered, a more extensive system of sub-drainage may be necessary and should be reviewed by WSP.
3. The most severe loading conditions on light-duty pavement areas and the sub grade may occur during construction. Consequently, special provisions such as restricted access lanes, half-loads during paving, etc., may be required, especially if construction is carried out during unfavourable weather.
4. It is recommended that WSP be retained to review the final pavement structure designs and drainage plans prior to construction to ensure that they are consistent with the recommendations of this report.

## 4.5 FROST PROTECTION

All footings exposed to seasonal freezing conditions should be provided with at least 1.2 m of earth cover or equivalent thermal insulation against frost.

## 4.6 SLOPE STABILITY ASSESSMENT

The site was visited by WSP on December 7, 2016 and the existing site area and slope conditions, primarily the slope on west side of proposed Ponds A and B was visually reviewed. General information pertaining to the existing slope features such as slope profile, slope drainage, water course features, vegetation cover, erosion features and slope slide features was obtained during this reconnaissance. A brief summary of the results of the visual inspection is presented below.

Two boreholes BH16-03 and BH16-10 were drilled near the slope crest and two boreholes BH16-04 and BH16-11 were drilled near the toe of the slope to assess the subsurface soil and groundwater conditions comprising the subject slope. The boreholes reveals that the overburden consists of dense to very dense sand/ silty sand/ sand and silt/ sandy silt soils and stiff to hard clayey silt.

The topographic information of the site was provided by the client. Three (3) cross sections (Section C-C, Section D-D and Section E-E) were inferred from the topographic information provided and our field observations. The cross-section location was selected on the basis of the slope height and inclination to represent the critical slope condition present within the study area. The section included a portion of the tableland extending across the slope down to a relatively flat ground. The location of the selected slope cross-section is presented on Drawing No. 1, and slope profile details are included on Drawing No. 4.

The slope at the subject location varies between 4 and 8 m in height with average slope inclination ranging from 3.3 horizontal : 1 vertical to 5.1 horizontal : 1 vertical. The slope surface is very well vegetated with grass and weed growth. There were no obvious signs of slope instability.

There is no watercourse situated within 15 m of the slope toe within the study area. Therefore, the subject slope is not subjected to toe erosion.

Based on the visual inspection, available topography, borehole information, and our experience with slope stability analysis of similar slopes in the general area, it is our opinion that the existing slope in its current condition is considered stable in terms of long term stability.

Additional comments related to construction of recreational ponds, in terms of slope stability are as follows:

- A sediment control fence must be erected and maintained during construction to isolate work area from the adjoining slope
- The existing slope vegetation should be maintained. Any slope areas disturbed by construction should be restored with suitable native vegetation

## 4.7 HYDROGEOLOGICAL COMMENTS AND RECOMMENDATIONS

### 4.7.1 GROUNDWATER CONDITIONS

As discussed in Section 3.4.2, the observed groundwater levels in the sand, silty sand and sandy silt deposit encountered at the site were approximately 1.0 to 5.9 m below ground, with elevations ranging from 188.5 masl (BH16-9) to 198.3 masl (BH16-7). Groundwater flow is directed eastward with a horizontal gradient of

0.03 and appears to be a subdued reflection of the topography, corresponding to the flow of surface water. Based on in-situ hydraulic conductivity (k) testing results, the k of the sand, silty sand and sandy silt deposit is estimated in the range of 5.0 x $10^{-6}$ to 5.0 x $10^{-5}$ cm/s.

In the southeast sections of the site within the vicinity of Indian Brook, it is expected that groundwater levels locally decline to surface water elevations along the stream. Evidence of the streams influence on ground water levels is observed at monitoring well BH16-14 which has remained dry since installation. In this location, groundwater levels appears to be lower than the well screen with a bottom elevation of 185.0 masl.

### 4.7.2 CONSTRUCTION GROUNDWATER CONTROL

Excavation of the proposed pond A will extend below the ground water table and into the sand, silty sand and sandy silt deposit encountered between surface and 5.0 m below ground in BH16-07, BH16-11, BH16-12, BH16-13 and BH16-14. A surficial sand and gravel layer approximately 2.0 m thick was observed at test pit location TP5. Observed water levels in this area of the site range between 1.0 and 2.2 m bgs. As a result, groundwater control will be required during the construction of the proposed pond. Groundwater control is expected to be managed by sumps in sand, silty sand and sandy silt, but may require additional efforts while excavating through saturated sand and gravel deposits. Groundwater control in the sand and gravel is expected to be managed by the excavation of drainage pits to the base of the sand and gravel deposit. The drainage pits could be constructed of a 0.6 m diameter perforated culvert, installed vertically into the pits, with a sump pump located inside, at the base, of the culvert. Placing stone (e.g. 1" crushed lime stone) in the pits will prevent the pits from filling/caving in. To decrease removal of fine soils from the dewatering discharge the submerged portion of the culverts should be wrapped in a filter cloth and aggregate placed inside with the sump pump.

Based on the data from the borehole drilling and monitoring well testing, daily pumping volumes are expected to be below the MOECC requirement of 400 $m^3$/day requirement for a Permit To Take Water (PTTW). A conservative estimate of daily pumping volumes is expected to be greater than 50 $m^3$/day. As a result, construction dewatering should be registered on the Environmental Activity and Sit Registry (EASR). The calculation used to estimate dewatering pumping rates is as follows:

Q = K * i * A = 60 $m^3$/day, where;

Q = flow rate ($m^3$/day);

K = hydraulic conductivity of the silty sand (5 x $10^{-5}$cm/s (0.04 m/day);

i = an estimated hydraulic gradient of 1.5; and,

A = 500 m x 2 m (length of pond x excavation depth below the water table).

The above scenario will be applicable to all areas of the pond. Where the sand and gravel formation is present, additional pumping volumes are expected. Also, a contingency of 50% is typical to account for precipitation and variations in hydraulic conductivity.

Considerations to reduce the potential removal of the fine grained soil particles with the groundwater pumping will need to be incorporated into the design in order to reduce the potential for settlement along the perimiter of the pond. This will be required both during construction and for the long-term operation of the pond.

### 4.7.3 WATER SUPPLY FOR LONG-TERM POND OPERATION

It is recommended that ponds be designed with liners so that a consistent water level can be maintained. To supplement losses due to evaporation, seepage and losses during circulation, a source of water to supplement and maintain water levels within the pond is required. Reliance on groundwater seepage into proposed ponds is not possible. A significant groundwater supply was not encountered at the site during onsite drilling where boreholes extended to maximum depths of approximately 10 m, however, based on a review of domestic water well records found within 500 m of the site, there appears to be some potential for groundwater supply for long-term pond operation.

To explore an alternative water supply for long-term pond operation, flow monitoring along the drainage feature central to the site was conducted to estimate the volume of water. Seasonal monitoring of flow within the feature will be completed as an ongoing monitoring program. With seasonal data, the suitability of the feature as a potential water supply can be assessed.

# 5 LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP Canada Inc.at the time of preparation. Unless otherwise agreed in writing by WSP Consultants Limited, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

# SIGNATURES

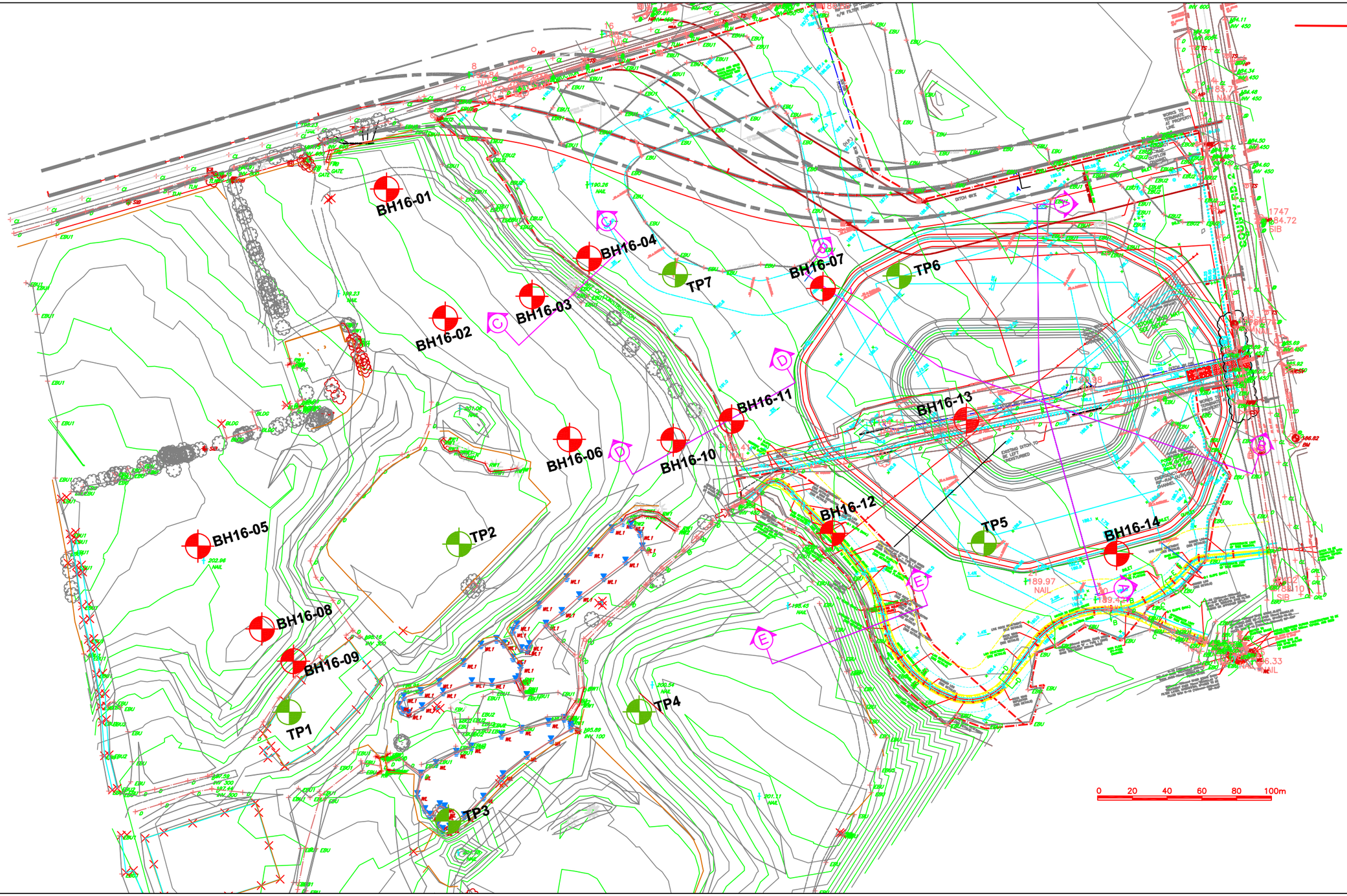
Kulbir Singh, M.Eng., P.Eng

Fanyu Zhu, Ph.D., P.Eng.

Shabbir Bandukwala, P.Eng.

# Drawings

BOREHOLE AND SLOPE LOCATION PLAN (DRAWING 1)
SURFICIAL GEOLOGY MAP (DRAWING 2)
MOECC WATER WELL RECORD MAP (DRAWING 3)
CROSS SECTIONS A-A TO E-E (DRAWINGS 4 TO 8)
DRAINAGE AND BACKFILL RECOMMENDATIONS (DRAWING 9)




**LEGEND**

Slope Location

Approximate Location of Previous Borehole by Naylor

| | | | | | |
|---|---|---|---|---|---|
| Client: | C.C Tatham & Associates Ltd. | | | Project No.: 161-15484-00 | Drawing No.: 1 |
| Drawn: ZMO | | Approved: KS | | Title: Borehole and Slope Location Plan | |
| Date: January 26, 2017 | | Scale: As Shown | | Project: Geotechnical and Hydrogeologlcal Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON | |
| Original Size: Tabloid | | Rev: N/A | | WSP 51 Constellation Court Toronto, Ontario M9W 1K4 | |

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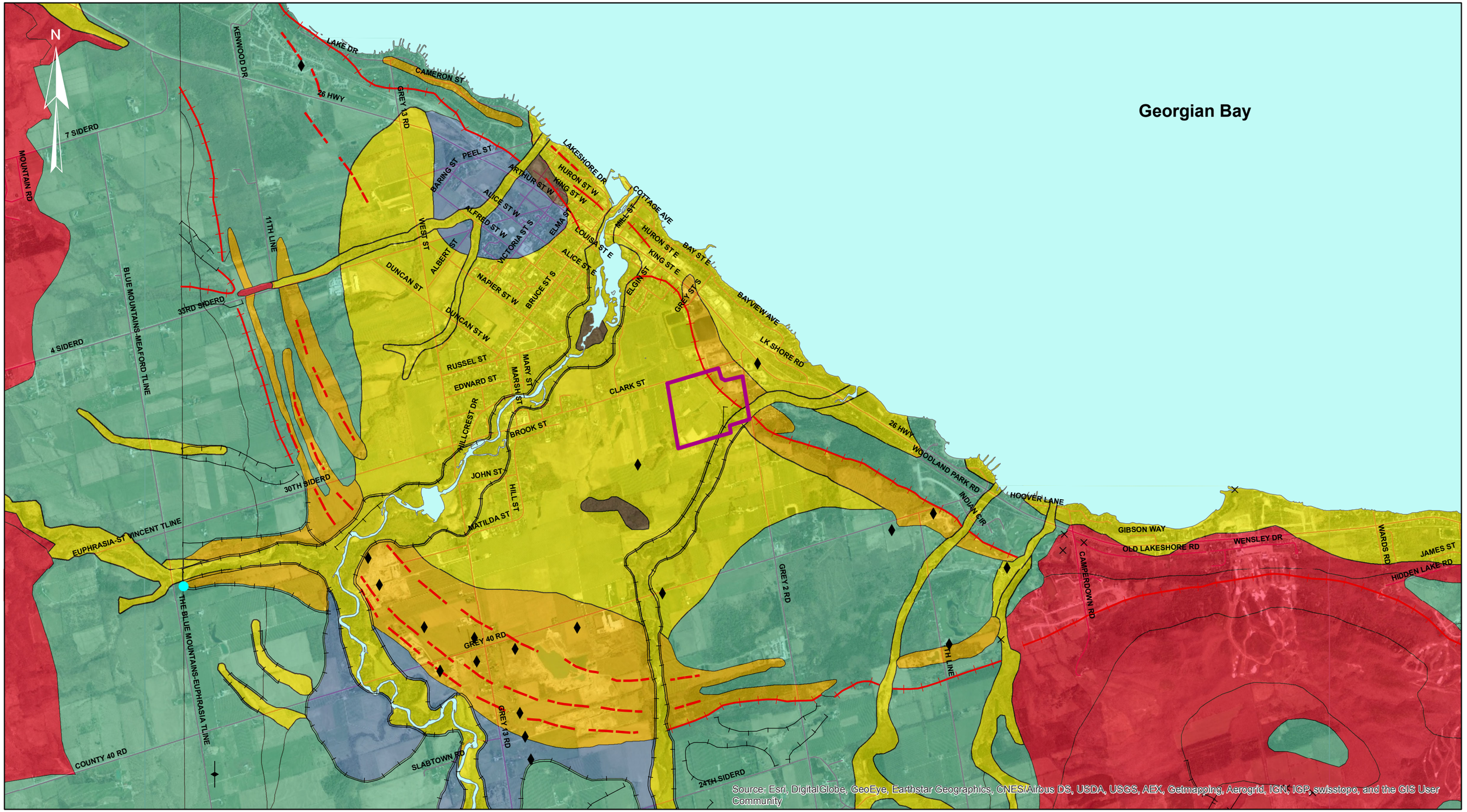


**Legend**

- Site Boundary
- Paleozoic Bedrock
- Diamicton
- Gravel
- Organic Deposits
- Sand
- Silt
- Beach
- Bluff
- Terrace
- Drumlin
- Bedrock Outcrop
- rcdate
- Sand and/or Gravel Pit

0 250 500 750 1,000 1,250 Meters

| | | | |
|---|---|---|---|
| Client: Cedar Run Wakeboard Park | | Project No.: 161-07991-00 | Drawing No.: 2 |
| Drawn: SW | Approved: GJ | Title: SURFICIAL GEOLOGY MAP | |
| Date: February 2017 | Scale: As Shown | Project: GEOTECHNICAL AND HYDROGEOLOGICAL ASSESSMENT CEDAR RUN WAKEBOARD PARK, THORNBURY, ONTARIO | |
| Original Size: Tabloid | Rev: 0 | | |

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www.wspgroup.ca





## Legend

- Site Boundary
- 500 m Site Buffer
- MOECC Registered Water Wells

0 100 200 300 400 500 Meters

| | | | |
|---|---|---|---|
| Client: Cedar Run Wakeboard Park | | Project No.: 161-07991-00 | Drawing No.: 3 |
| Drawn: SW | Approved: GJ | Title: SITE LOCATION AND MOECC WATER WELL MAP | |
| Date: February 2017 | Scale: As Shown | Project: GEOTECHNICAL AND HYDROGEOLOGICAL ASSESSMENT CEDAR RUN WAKEBOARD PARK, THORNBURY, ONTARIO | |
| Original Size: Tabloid | Rev: 0 | | |

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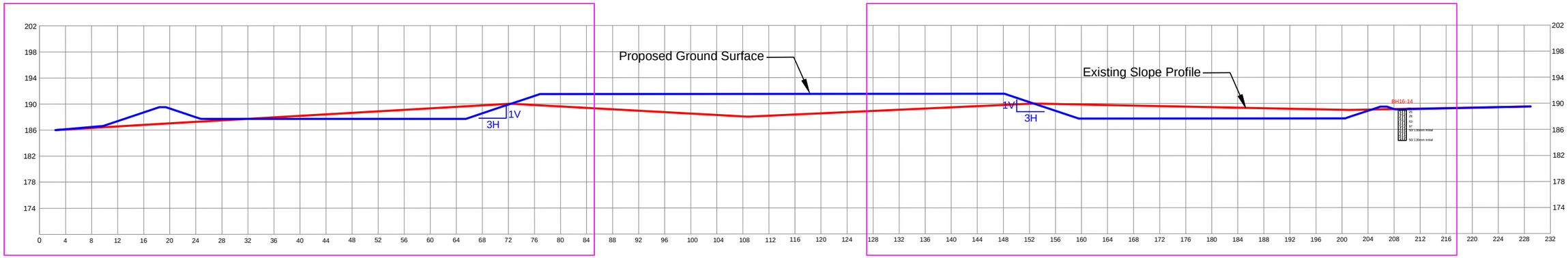


See Drawing 2A - Detail A

See Drawing 2B - Detail B

Cross Section A-A

LEGEND

Topsoil | Sand | Clayey Silt

Sandy Silt | Sandy Silt Till | Clayey Silty Sand

| | | | | | |
|---|---|---|---|---|---|
| Client: | C.C Tatham & Associates Ltd. | | | Project No.: 161-15484-00 | Drawing No.: 4 |
| Drawn: ZMO | | Approved: KS | | Title: Cross Section A-A | |
| Date: January 26, 2017 | | Scale: As Shown | | Project: Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON | |
| Original Size: Tabloid | | Rev: N/A | | WSP 51 Constellation Court Toronto, Ontario M9W 1K4 | |

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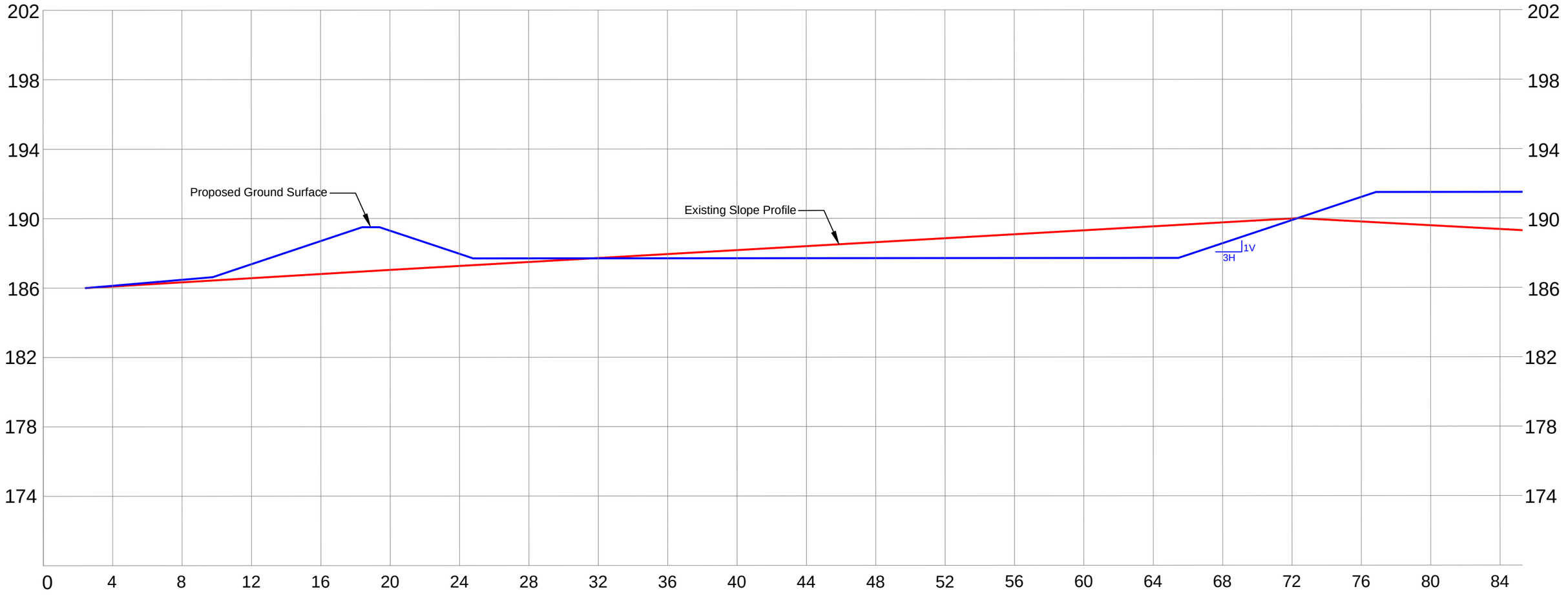


Detail A

| | | | | | |
|---|---|---|---|---|---|
| Client: | **C.C Tatham & Associates Ltd.** | | | Project No.: **161-15484-00** | Drawing No.: **4A** |
| Drawn: **ZMO** | | Approved: **KS** | | Title: | **Detail A for Cross Section A-A** |
| Date: **January 26, 2017** | | Scale: **As Shown** | | Project: | **Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON** |
| Original Size: **Tabloid** | | Rev: **N/A** | | WSP | 51 Constellation Court<br>Toronto, Ontario<br>M9W 1K4 |

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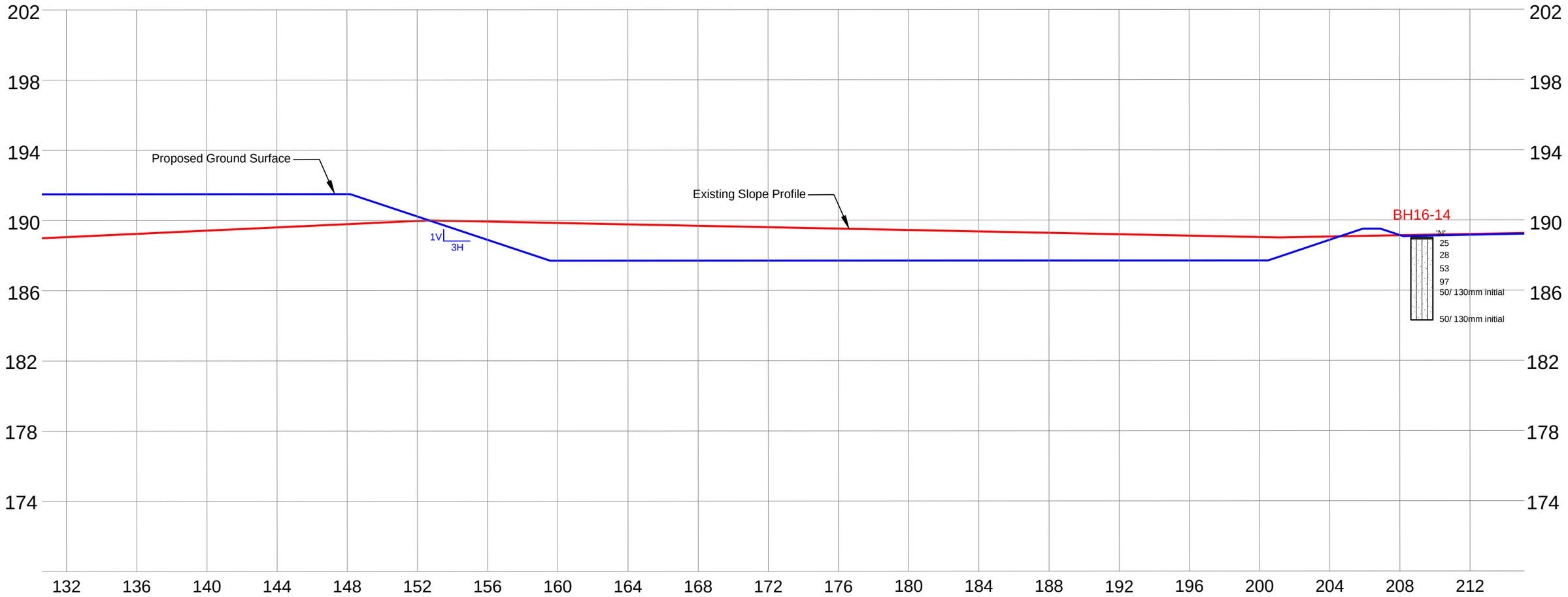


Detail B

LEGEND

Topsoil | Sand | Clayey Silt

Sandy Silt | Sandy Silt Till | Clayey Silty Sand

| | | | | | |
|---|---|---|---|---|---|
| Client: | C.C Tatham & Associates Ltd. | | | Project No.: 161-15484-00 | Drawing No.: 4B |
| Drawn: ZMO | | Approved: KS | | Title: Detail B for Cross Section A-A | |
| Date: January 26, 2017 | | Scale: As Shown | | Project: Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON | |
| Original Size: Tabloid | | Rev: N/A | | WSP 51 Constellation Court Toronto, Ontario M9W 1K4 | |

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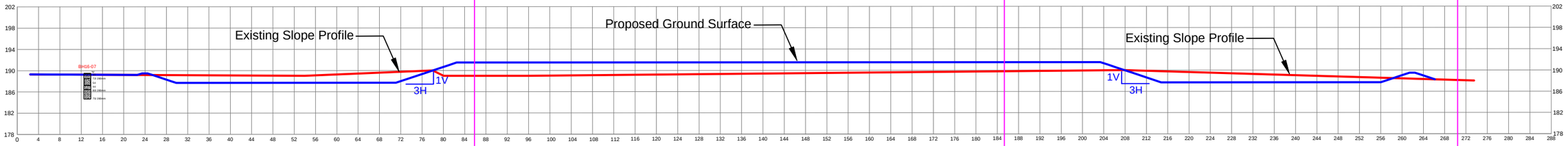


See Drawing 3A - Detail C

See Drawing 3B - Detail D

Cross Section B-B

LEGEND

Topsoil | Sand | Clayey Silt

Sandy Silt | Sandy Silt Till | Clayey Silty Sand

| | | | | | |
|---|---|---|---|---|---|
| Client: | C.C Tatham & Associates Ltd. | | | Project No.: 161-15484-00 | Drawing No.: 5 |
| Drawn: ZMO | | Approved: KS | | Title: Cross Section B-B | |
| Date: January 26, 2017 | | Scale: As Shown | | Project: Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON | |
| Original Size: Tabloid | | Rev: N/A | | WSP 51 Constellation Court Toronto, Ontario M9W 1K4 | |

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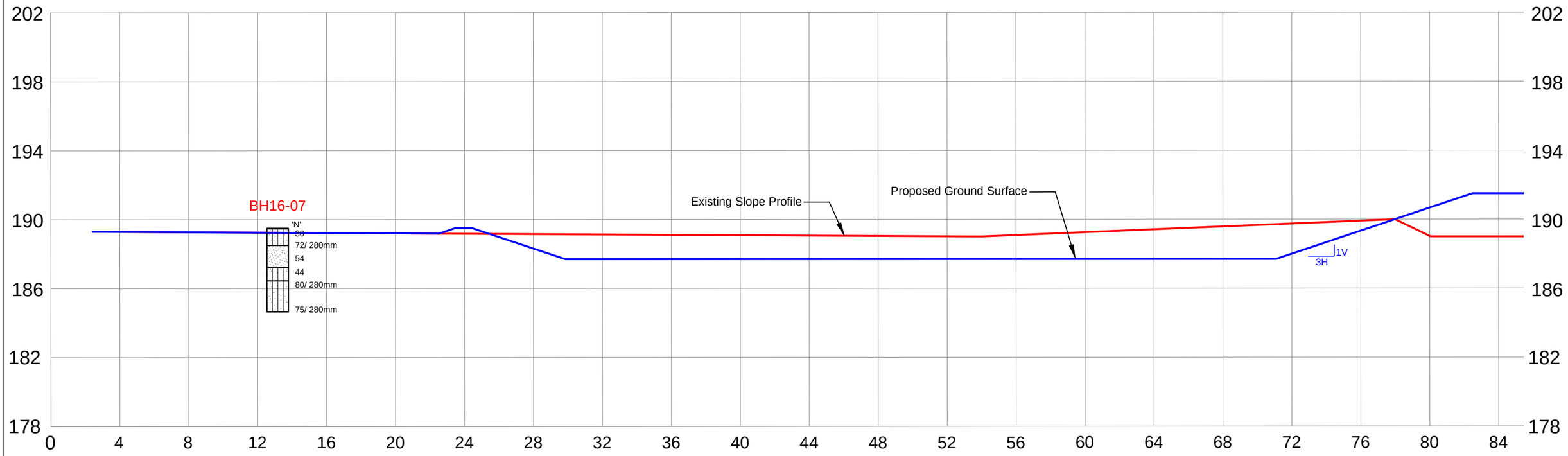


Detail C

LEGEND

Topsoil | Sand | Clayey Silt

Sandy Silt | Sandy Silt Till | Clayey Silty Sand

| | | | | | |
|---|---|---|---|---|---|
| Client: | **C.C Tatham & Associates Ltd.** | | | Project No.: **161-15484-00** | Drawing No.: **5A** |
| Drawn: **ZMO** | | Approved: **KS** | | Title: | **Detail C for Cross Section B-B** |
| Date: **January 26, 2017** | | Scale: **As Shown** | | Project: | **Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON** |
| Original Size: **Tabloid** | | Rev: **N/A** | | WSP | 51 Constellation Court<br>Toronto, Ontario<br>M9W 1K4 |

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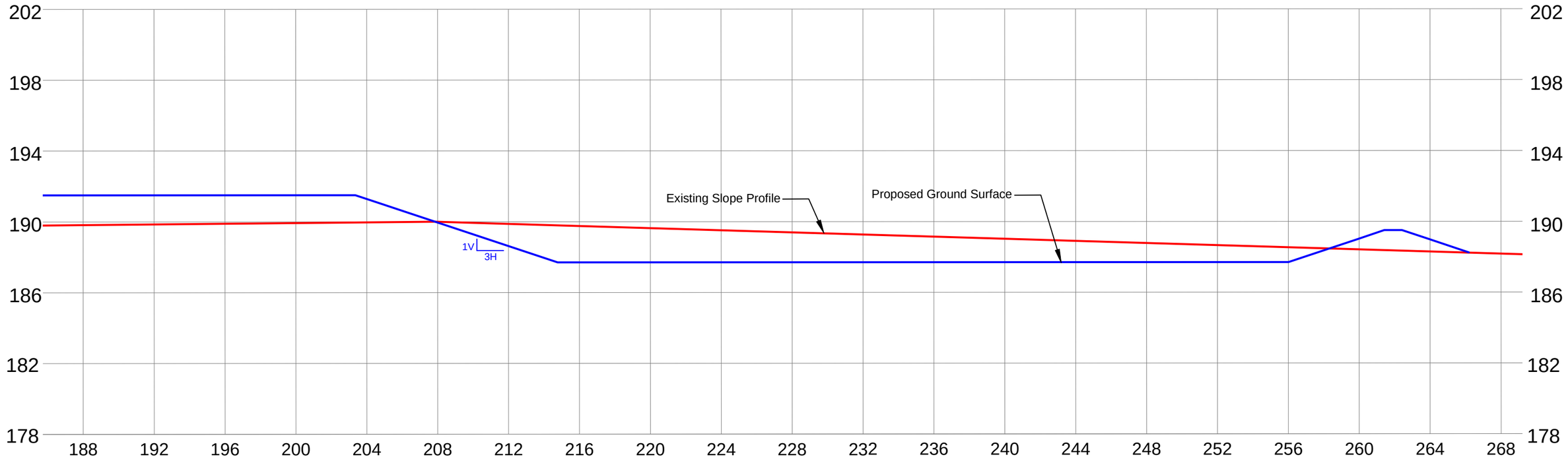


Detail D

| | | | | | |
|---|---|---|---|---|---|
| Client: | **C.C Tatham & Associates Ltd.** | | | Project No.: **161-15484-00** | Drawing No.: **5B** |
| Drawn: **ZMO** | | Approved: **KS** | | Title: | **Detail D for Cross Section B-B** |
| Date: **January 26, 2017** | | Scale: **As Shown** | | Project: | **Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON** |
| Original Size: **Tabloid** | | Rev: **N/A** | | WSP | 51 Constellation Court<br>Toronto, Ontario<br>M9W 1K4 |

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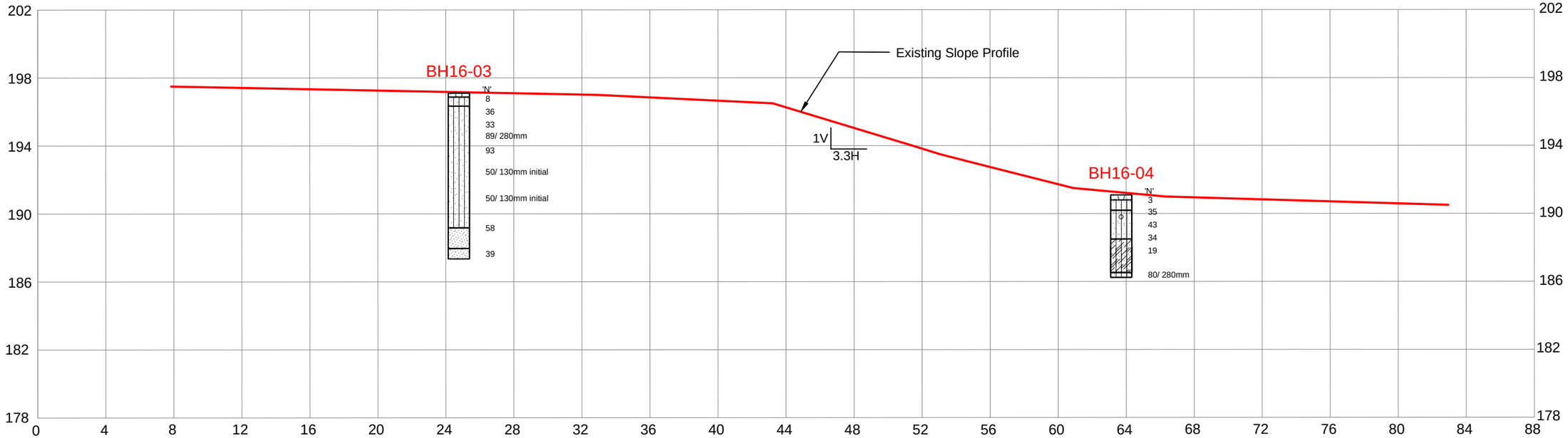


Cross Section C-C

LEGEND

Topsoil | Sand | Clayey Silt | Sandy Silt | Sandy Silt Till | Clayey Silty Sand

| | | | |
|---|---|---|---|
| Client: C.C Tatham & Associates Ltd. | | Project No.: 161-15484-00 | Drawing No.: 6 |
| Drawn: ZMO | Approved: KS | Title: Cross Section C-C | |
| Date: January 26, 2017 | Scale: As Shown | Project: Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON | |
| Original Size: Tabloid | Rev: N/A | WSP 51 Constellation Court Toronto, Ontario M9W 1K4 | |

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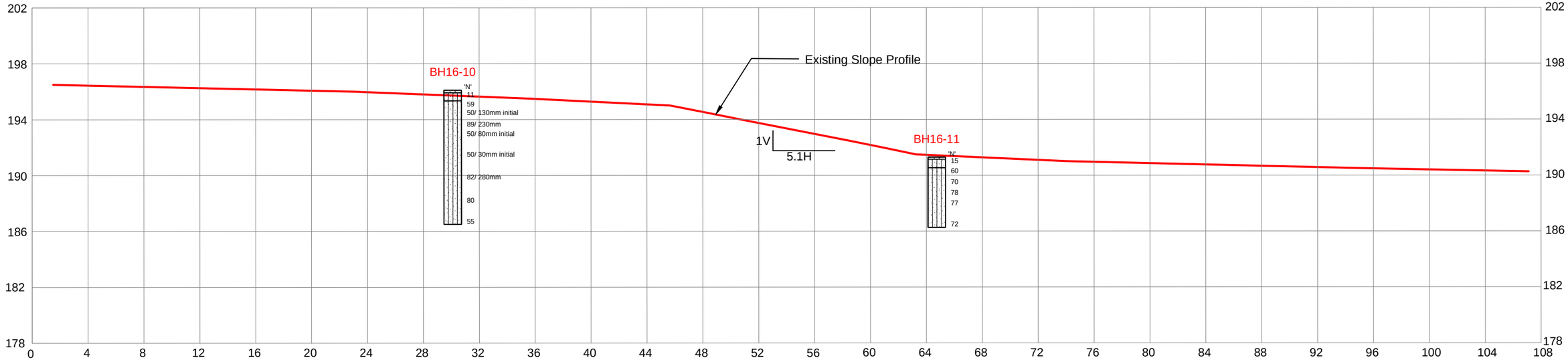


Cross Section D-D

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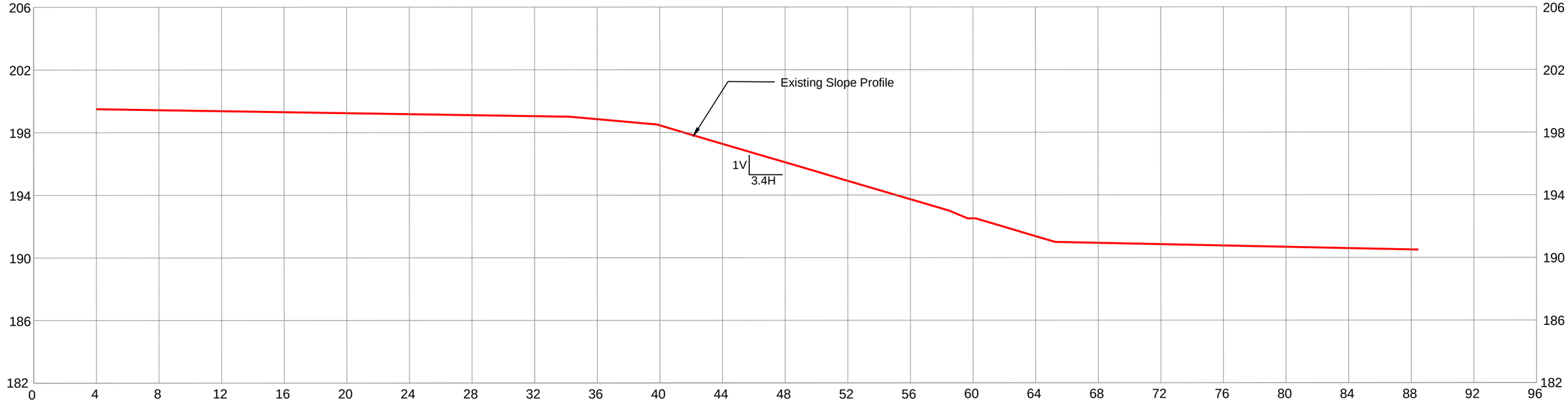
| | | | | | |
|---|---|---|---|---|---|
| Client: | C.C Tatham & Associates Ltd. | | | Project No.: 161-15484-00 | Drawing No.: 7 |
| Drawn: | ZMO | Approved: | KS | Title: | Cross Section D-D |
| Date: | January 26, 2017 | Scale: | As Shown | Project: | Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON |
| Original Size: | Tabloid | Rev: | N/A | WSP | 51 Constellation Court<br>Toronto, Ontario<br>M9W 1K4 |




Cross Section E-E

| | | | | | |
|---|---|---|---|---|---|
| Client: | **C.C Tatham & Associates Ltd.** | | | Project No.: **161-15484-00** | Drawing No.: **8** |
| Drawn: **ZMO** | | Approved: **KS** | | Title: | **Cross Section E-E** |
| Date: **January 26, 2017** | | Scale: **As Shown** | | Project: | **Geotechnical and Hydrogeological Study - Proposed Cedar Run Wakeboard Cable Park, Thornbury, ON** |
| Original Size: **Tabloid** | | Rev: **N/A** | | WSP | 51 Constellation Court<br>Toronto, Ontario<br>M9W 1K4 |

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# Appendix A

**NOTES ON SAMPLE DESCRIPTIONS**
**LOG OF BOREHOLES (BH16-01 TO BH16-14)**

# LOG OF BOREHOLE BH16-01

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Nov/28/2016

REF. NO.: 161-15484-00
ENCL. NO.: 1

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | BLOWS 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 197.5 | Ground Surface | | | | | | | | | | | |
| 0.0 / 197.2 | **TOPSOIL:** 280mm | | | | | | | | | | | |
| 0.3 / 196.7 | **SANDY SILT (reworked/disturbed):** trace clay, trace gravel, trace rootlets, brown, moist, loose to compact | | 1 | SS | 10 | | 197 | | | | | |
| 0.8 | **SANDY SILT TO SILT AND SAND:** trace to some gravel, trace clay, stratified, brown, moist, compact | | 2 | SS | 17 | | | | | | | |
| 1 | ---------- oxidized stains, dense | | 3 | SS | 31 | | 196 | | | | | |
| 2 | ---------- grey, very dense | | 4 | SS | 86 | | 195 | | | | | |
| 3 | | | 5 | SS | 77/ 280mm | | | | | | | |
| 194.2 | | | | | | | | | | | | |
| 3.3 | **END OF BOREHOLE:** Notes: 1. Borehole was open and dry upon completion | | | | | | | | | | | hammer bouncing |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-02

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Nov/28/2016

REF. NO.: 161-15484-00
ENCL. NO.: 2

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 198.2 | Ground Surface | | | | | | | | | | | |
| 0.0 / 197.9 | **TOPSOIL:** 300mm | | 1 | SS | 13 | | 198 | | | | | |
| 0.3 / 197.4 | **CLAYEY SILT (reworked/ disturbed):** trace sand, trace gravel, trace rootlets, brown, moist, stiff | | | | | | | | | | | |
| 0.8 / 196.5 | **CLAYEY SILT:** trace sand, trace gravel, stratified, brown, moist, stiff to hard | | 2 | SS | 10 | | 197 | | | | | 0 1 77 22 |
| 1.7 / 195.9 | **SANDY SILT TO SILT AND SAND:** some gravel, trace clay, grey, dense | | 3 | SS | 33 | | | | | | | |
| 2.3 / 194.5 | very dense<br>---<br>(inferred cobbles/boulders) | | 4 | SS | 77 | | 196 | | | | | hammer bouncing |
| | | | 5 | SS | 73 | | 195 | | | | | |
| 3.7 | **END OF BOREHOLE:**<br>Notes:<br>1. Borehole was open and dry upon completion | | | | | | | | | | | |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

# LOG OF BOREHOLE BH16-03

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Nov/28/2016

REF. NO.: 161-15484-00
ENCL. NO.: 3

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 197.1 | Ground Surface | | | | | | | |
| 0.0 / 196.9 | **TOPSOIL:** 230mm | | | | | | 197 | |
| 0.2 / 196.3 | **SANDY SILT (reworked/disturbed):** trace clay, trace gravel, trace rootlets, brown, moist, loose | | 1 | SS | 8 | | | |
| 0.8 | **SANDY SILT TO SILT AND SAND:** trace to some gravel, trace clay, brown, moist, dense | | 2 | SS | 36 | | 196 | |
| | trace broken stone pieces, oxidized stains | | 3 | SS | 33 | | 195 | |
| | (inferred cobbles/boulders, moved borehole, see Note 1) | | 4 | SS | 89/ 280mm | | | hammer bouncing |
| | occasional thin sand seams | | 5 | SS | 93 | | 194 | |
| | | | 6 | SS | 50/ 130mm initial | | 193 | hammer bouncing |
| | | | 7 | SS | 50/ 130mm initial | | 192 | hammer bouncing |
| 189.2 | | | | | | | 191 | |
| 7.9 | **SAND:** some silty to silty, trace clay, trace gravel, grey, wet, very dense | | 8 | SS | 58 | | 190 | |
| 188.0 | | | | | | | 189 | |
| 9.1 | **SILT AND SAND:** trace clay, grey, wet, dense | | 9 | SS | 39 | | 188 | 0 56 40 4 |
| 187.4 | | | | | | | | |
| 9.8 | **END OF BOREHOLE:** | | | | | | | |

Notes:
1. At 2.1 mbg, auger grinding, could not get through obstruction (inferred cobbles/boulders), moved 1m North
2. 50 mm dia. monitoring well installed in the borehole upon completion of drilling

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

Continued Next Page

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$. Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

PROJECT: Geotechnical Investigation & Hydrogeological Assessment

CLIENT: C.C. Tatham & Associates Ltd.

PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury

DATUM: Geodetic

BH LOCATION: See Drawing 1

**DRILLING DATA**

Method: Hollow Stem Auger

Diameter: 200 mm

Date: Nov/28/2016

REF. NO.: 161-15484-00

ENCL. NO.: 3

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | | | | | | | GR SA SI CL |
| | Continued | | | | | | | | | | | |
| | 3. Water Level Measurements in Monitoring Well:<br>Date W.L. Depth (m) W.L. Elev. (m)<br>upon completion 2.5 194.6<br>December 7, 2016 6.2 190.9<br>January 20, 2017 5.9 191.2 | | | | | | | | | | | |

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

# LOG OF BOREHOLE BH16-04

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/01/2016

REF. NO.: 161-15484-00
ENCL. NO.: 4

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 191.1 | Ground Surface | | | | | | | |
| 0.0 / 190.8 | **TOPSOIL:** 300mm | | 1 | SS | 3 | | 191 | |
| 0.3 / 190.2 | **SANDY SILT (reworked/disturbed):** trace clay, trace rootlets, brown, moist, very loose | | 2 | SS | 35 | | 190 | |
| 0.9 / 188.5 | **SANDY SILT:** trace to some gravel, trace clay, grey, moist, dense | | 3 | SS | 43 | | 189 | |
| 2.6 / 186.5 | **CLAYEY SILT:** sandy, trace gravel, grey, very moist, very stiff to hard | | 4 | SS | 34 | | 188 | |
| 4.6 / 186.3 | **SANDY SILT:** some clay, grey, saturated, dilatant, very dense | | 5 | SS | 19 | | 187 | |
| 4.9 | **END OF BOREHOLE:** Notes: 1. Borehole caved to 3.5 mbg and was wet at 2.5 mbg upon completion. | | 6 | SS | 80/ 280mm | | | hammer bouncing |

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%) (10 20 30)
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-05

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Nov/29/2016

REF. NO.: 161-15484-00
ENCL. NO.: 5

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 203.0 | Ground Surface | | | | | | | | | | | |
| 0.0 / 202.8 | **TOPSOIL:** 250mm | | | | | | | | | | | |
| 0.3 / 202.2 | **SANDY SILT (reworked/disturbed):** trace clay, trace gravel, trace rootlets, brown, moist, compact | | 1 | SS | 24 | | | | | | | |
| 0.8 | **SANDY SILT TO SILT AND SAND:** some gravel, trace clay, grey, moist, very dense | | 2 | SS | 63 | | 202 | | | | | |
| | | | 3 | SS | 82/ 250mm | | | | | | | hammer bouncing |
| | | | 4 | SS | 58 | | 201 | | | | | |
| | | | 5 | SS | 51 | | 200 | | | | | |
| 199.5 | | | | | | | | | | | | |
| 3.5 | **END OF BOREHOLE:** Notes: 1. Borehole was dry and open upon completion. | | | | | | | | | | | |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

# LOG OF BOREHOLE BH16-06



PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Nov/29/2016

REF. NO.: 161-15484-00
ENCL. NO.: 6

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | BLOWS / 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 198.0 | Ground Surface | | | | | | | |
| 0.0 / 197.8 | **TOPSOIL:** 230mm | | | | | | | |
| 0.2 / 197.2 | **SANDY SILT (reworked/disturbed):** trace clay, trace gravel, trace rootlets, brown, moist, loose | | 1 | SS | 7 | | | |
| 0.8 / 195.7 | **SANDY SILT TO SILT AND SAND:** trace clay, stratified, oxidized stains, brown, moist, dense | | 2 | SS | 43 | | 197 | |
| | | | 3 | SS | 43 | | 196 | |
| 2.3 | some gravel, grey, very dense<br>---<br>(inferred cobbles/boulders) | | 4 | SS | 90/ 280mm | | | hammer bouncing |
| | | | 5 | SS | 93/ 280mm | | 195 | hammer bouncing |
| | | | | | | | 194 | auger grinding |
| 193.0 | | | 6 | SS | 96/ 250mm | | | hammer bouncing |
| 5.0 | **END OF BOREHOLE:**<br>Notes:<br>1. Borehole was open and dry upon completion. | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED
● QUICK TRIAXIAL
+ FIELD VANE & Sensitivity
× LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$

WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

# LOG OF BOREHOLE BH16-07

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Nov/30/2016

REF. NO.: 161-15484-00
ENCL. NO.: 7

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | BLOWS 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 189.5 / 0.0 | Ground Surface | | | | | | | | | | | |
| 189.5 / 0.0 | **TOPSOIL:** 30mm | | | | | | | | | | | |
| | **SILTY SAND TO SAND (reworked/disturbed):** trace clay, trace rootlets, brown, moist, compact to very dense | | 1 | SS | 30 | | 189 | | | | | |
| 188.5 / 1.0 | **SAND:** some silt, trace clay, trace gravel, grey, wet, very dense | | 2 | SS | 72/ 280mm | | | | | | | |
| | 250mm sand and gravel layer | | 3 | SS | 54 | | 188 | | | | | |
| 187.2 / 2.3 | **SANDY SILT:** trace clay, grey, moist, dense | | 4 | SS | 44 | | 187 | | | | | |
| | 150mm saturated sand layer at 2.4 m | | | | | | | | | | | |
| 186.5 / 3.1 | stratified, very dense | | 5 | SS | 80/ 280mm | | 186 | | | | | hammer bouncing |
| 184.7 / 4.9 | **END OF BOREHOLE:** | | 6 | SS | 75/ 280mm | | 185 | | | | | hammer bouncing |

Notes:
1. 50 mm dia. monitoring well installed in the borehole upon completion of drilling
2. Water Level Measurements in Monitoring Well:

| Date | W.L. Depth (m) | W.L. Elev. (m) |
|---|---|---|
| upon completion | 4.8 | 184.7 |
| December 7, 2016 | 1.2 | 188.3 |
| January 20, 2017 | 1.0 | 188.5 |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-08



PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Nov/29/2016

REF. NO.: 161-15484-00
ENCL. NO.: 8

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 203.8 | Ground Surface | | | | | | | |
| 0.0 / 203.6 | **TOPSOIL:** 230mm | | | | | | | |
| 0.2 | **FILL:** sandy silt to silt, trace clay, brown, moist, compact | | 1 | SS | 12 | | | |
| 202.8 | | | 2 | SS | 10 | | 203 | |
| 1.0 | **BURIED TOPSOIL:** 180mm | | | | | | | |
| 202.3 | | | | | | | | |
| 1.5 | **SANDY SILT TO SILTY SAND:** trace clay, trace gravel, brown, moist, stratified, compact | | 3 | SS | 21 | | 202 | |
| 201.5 | | | | | | | | |
| 2.3 | very dense | | 4 | SS | 50 | | | |
| 200.8 | | | | | | | 201 | |
| 3.1 | oxidized stains | | 5 | SS | 73 | | | |
| | | | | | | | 200 | |
| | | | 6 | SS | 78 | | 199 | |
| 197.7 | | | | | | | | |
| 6.1 | some clay, grey, very moist, compact | | 7 | SS | 17 | | 198 | |
| | | | | | | | 197 | |
| 196.2 | | | | | | | | |
| 7.6 | trace clay, some gravel, very dense<br>---<br>(inferred cobbles/boulders) | | 8 | SS | 87/ 230mm | | 196 | hammer bouncing |
| 194.6 | | | | | | | 195 | |
| 9.2 | **END OF BOREHOLE:**<br>Notes:<br>1. Borehole caved to 8.5 mbg and was dry upon completion. | | 9 | SS | 50/ 50mm initial | | | hammer bouncing |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ $\varepsilon_f$=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-09



PROJECT: Geotechnical Investigation & Hydrogeological Assessment

CLIENT: C.C. Tatham & Associates Ltd.

PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury

DATUM: Geodetic

BH LOCATION: See Drawing 1

**DRILLING DATA**

Method: Hollow Stem Auger

Diameter: 200 mm

Date: Nov/29/2016

REF. NO.: 161-15484-00

ENCL. NO.: 9

| ELEV / DEPTH (m) | DESCRIPTION | NUMBER | TYPE | BLOWS 0.3 m "N" | ELEVATION |
|---|---|---|---|---|---|
| 199.6 / 0.0 | Ground Surface | | | | |
| 199.6 / 0.1 | **TOPSOIL:** 50mm | | | | |
| 199.2 / 0.5 | **FILL:** sand, trace silt, trace rootlets, brown, moist, compact | 1 | SS | 16 | |
| 198.8 / 0.8 | **FILL:** sandy silt, trace clay, brown, moist, compact | | | | |
| | **SANDY SILT TO SILT AND SAND:** trace clay, stratified, brown, moist, compact to loose | 2 | SS | 24 | |
| | ---------- loose | 3 | SS | 9 | |
| 197.3 / 2.3 | grey | 4 | SS | 18 | |
| 196.3 / 3.4 | trace to some gravel | 5 | SS | 16 | |
| 194.6 / 5.0 | **END OF BOREHOLE:** | 6 | SS | 12 | |

Notes:
1. 50 mm dia. monitoring well installed in the borehole upon completion of drilling
2. Water Level Measurements in Monitoring Well:

| Date | W.L. Depth (m) | W.L. Elev. (m) |
|---|---|---|
| upon completion | 3.7 | 195.9 |
| December 7, 2016 | 1.8 | 197.8 |
| January 20, 2017 | 1.3 | 198.3 |

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE

PLASTIC LIMIT $w_P$ — NATURAL MOISTURE CONTENT $w$ — LIQUID LIMIT $w_L$

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%) — GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-10

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Nov/30/2016

REF. NO.: 161-15484-00
ENCL. NO.: 10

| ELEV / DEPTH (m) | DESCRIPTION | NUMBER | TYPE | BLOWS / 0.3 m "N" | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|
| 196.1 / 0.0 | Ground Surface | | | | | |
| 196.0 / 0.2 | **TOPSOIL:** 180mm | | | | | |
| 195.3 / 0.8 | **SANDY SILT (reworked/disturbed):** trace clay, trace gravel, trace rootlets, brown, moist, compact | 1 | SS | 11 | 196 | |
| | **SANDY SILT:** some gravel to gravelly, trace clay, stratified, moist, very dense | 2 | SS | 59 | 195 | 21 30 40 9 |
| | (inferred cobble/boulder, see Note 1) | 3 | SS | 50/ 130mm initial | | hammer bouncing |
| | | | | | 194 | auger grinding |
| | | 4 | SS | 89/ 230mm | | auger grinding |
| | (inferred cobble/boulder, see Note 1) | 5 | SS | 50/ 80mm initial | 193 | hammer bouncing auger grinding |
| | | | | | 192 | |
| | | 6 | SS | 50/ 30mm initial | | hammer bouncing |
| | | | | | 191 | auger grinding |
| | | 7 | SS | 82/ 280mm | 190 | hammer bouncing |
| | | | | | 189 | auger grinding |
| | | 8 | SS | 80 | 188 | auger grinding |
| | | 9 | SS | 55 | 187 | |
| 186.5 / 9.6 | **END OF BOREHOLE:** Notes: 1. At 1.5 mbg, hammer bouncing and auger grinding, cannot get through obstruction (inferred boulder), moved 1m to West, hit boulder again, moved 3m Southwest made it down to 3mbg and hit another boulder, moved | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%): 10 20 30
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)
GROUND WATER CONDITIONS

Continued Next Page

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

PROJECT: Geotechnical Investigation & Hydrogeological Assessment

CLIENT: C.C. Tatham & Associates Ltd.

PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury

DATUM: Geodetic

BH LOCATION: See Drawing 1

**DRILLING DATA**

Method: Solid Stem Auger

Diameter: 150 mm

Date: Nov/30/2016

REF. NO.: 161-15484-00

ENCL. NO.: 10

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $W_P$ / NATURAL MOISTURE CONTENT $W$ / LIQUID LIMIT $W_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | | | | | | | GR SA SI CL |
| | Continued<br>about 6m Southwest<br>2. Borehole was open and dry upon completion. | | | | | | | | | | | |

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

# LOG OF BOREHOLE BH16-11

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/01/2016

REF. NO.: 161-15484-00
ENCL. NO.: 11

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $W_P$ / NATURAL MOISTURE CONTENT $W$ / LIQUID LIMIT $W_L$ WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 191.3 | Ground Surface | | | | | | | | | | | |
| 191.2 / 0.0 | **TOPSOIL:** 150mm | | | | | | | | | | | |
| 0.2 / 190.5 | **SANDY SILT (reworked/disturbed):** some clay, trace gravel, trace rootlets, brown, moist, compact | | 1 | SS | 15 | | 191 | | | | | hammer bouncing |
| 0.8 | **SANDY SILT TO SILT AND SAND:** trace to some gravel, trace clay, stratified, grey, very dense | | 2 | SS | 60 | | | | | | | |
| | | | 3 | SS | 70 | | 190 | | | | | |
| | 100mm sand seam at 2.4 mbg | | 4 | SS | 78 | | 189 | | | | | |
| | | | 5 | SS | 77 | | 188 | | | | | |
| | | | 6 | SS | 72 | | 187 | | | | | |
| 186.3 / 5.0 | **END OF BOREHOLE:** Notes: 1. Borehole was open and dry upon completion. | | | | | | | | | | | |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-12

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Dec/01/2016

REF. NO.: 161-15484-00
ENCL. NO.: 12

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 191.3 | Ground Surface | | | | | | | |
| 0.0 / 191.1 | **TOPSOIL:** 250mm | | 1 | SS | 4 | | 191 | |
| 0.3 / 190.5 | **SANDY SILT (reworked/disturbed):** trace to some clay, trace gravel, trace rootlets, brown, moist, loose | | | | | | | |
| 0.8 | **SANDY SILT TO SILT AND SAND:** trace to some gravel, trace clay, stratified, brown, moist, compact to dense | | 2 | SS | 19 | | | |
| | | | 3 | SS | 43 | | 190 | |
| | ---------- (inferred cobble/boulder) | | 4 | SS | 50/ 50mm initial | | 189 | hammer bouncing |
| | ---------- (inferred cobble/boulder) | | 5 | SS | 74/ 230mm | | 188 | hammer bouncing |
| | | | | | | | 187 | |
| 186.5 | | | 6 | SS | 97/ 230mm | | | hammer bouncing |
| 4.8 | **END OF BOREHOLE:** | | | | | | | |

Notes:
1. 50 mm dia. monitoring well installed in the borehole upon completion of drilling
2. Water Level Measurements in Monitoring Well:

| Date | W.L. Depth (m) | W.L. Elev. (m) |
|---|---|---|
| upon completion | dry | -- |
| December 7, 2016 | 1.9 | 189.4 |
| January 20, 2017 | 1.6 | 189.7 |

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%) (10 20 30)
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ε=3%: Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-13

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Nov/30/2016

REF. NO.: 161-15484-00
ENCL. NO.: 13

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | BLOWS 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|
| 192.5 | Ground Surface | | | | | | | |
| 0.0 / 191.6 | **FILL:** sand to silty sand, trace clay, trace rootlets, trace organics, brown, very moist, compact to loose | | 1 | SS | 16 | | 192 | |
| 1 0.9 / 191.0 | **BURIED TOPSOIL:** 250mm | | 2 | SS | 4 | | | |
| 1.5 / 190.2 | **SAND:** trace silt, trace organics, brown, very moist, loose | | 3 | SS | 4 | | 191 | |
| 2 2.3 / 189.5 | **SANDY SILT/SILTY SAND:** trace clay, some gravel, grey, moist, very dense (inferred cobble/boulder) | | 4 | SS | 50/ 230mm | | 190 | hammer bouncing |
| 3 3.1 / 188.7 | trace gravel | | 5 | SS | 50 | | 189 | |
| 3.8 | **END OF BOREHOLE:** | | | | | | | |

Notes:
1. Auger grinding at 3.81 mbg.
2. 50 mm dia. monitoring well installed in the borehole upon completion of drilling
3. Water Level Measurements in Monitoring Well:

| Date | W.L. Depth (m) | W.L. Elev. (m) |
|---|---|---|
| upon completion | dry | -- |
| December 7, 2016 | dry | -- |
| January 20, 2017 | 2.2 | 190.3 |

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
PLASTIC LIMIT $W_P$ | NATURAL MOISTURE CONTENT $W$ | LIQUID LIMIT $W_L$
WATER CONTENT (%) (10 20 30)
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# LOG OF BOREHOLE BH16-14

PROJECT: Geotechnical Investigation & Hydrogeological Assessment
CLIENT: C.C. Tatham & Associates Ltd.
PROJECT LOCATION: Cedar Run Wakeboard Cable Park, Thornbury
DATUM: Geodetic
BH LOCATION: See Drawing 1

**DRILLING DATA**
Method: Hollow Stem Auger
Diameter: 200 mm
Date: Dec/02/2016

REF. NO.: 161-15484-00
ENCL. NO.: 14

| (m) ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS / 0.3 m "N" | ELEVATION |
|---|---|---|---|---|---|
| 189.0 | Ground Surface | | | | |
| 188.9 / 0.1 | **TOPSOIL:** 80mm | | | | |
| | **SANDY SILT TO SILTY SAND:** trace clay, trace gravel, brown, moist, compact | 1 | SS | 25 | |
| 1 | ---------- stratified | 2 | SS | 28 | 188 |
| | ---------- very dense | 3 | SS | 53 | |
| 2 | grey | | | | 187 |
| | | 4 | SS | 97 | |
| 3 | | 5 | SS | 50/ 130mm initial | 186 |
| 4 | | | | | 185 |
| 184.3 / 4.7 | **END OF BOREHOLE:** | 6 | SS | 50/ 130mm initial | |

Notes:
1. 50 mm dia. monitoring well installed in the borehole upon completion of drilling
2. Water Level Measurements in Monitoring Well:

| Date | W.L. Depth (m) | W.L. Elev. (m) |
|---|---|---|
| upon completion | dry | -- |
| December 7, 2016 | dry | -- |
| January 20, 2017 | dry | -- |

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)
REMARKS AND GRAIN SIZE DISTRIBUTION (%) — GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ $\varepsilon_f$=3% Strain at Failure

WSP SOIL LOG 161-15484-00 BH LOGS.GPJ SPL.GDT 2/9/17

# Appendix B

**TEST-PIT LOGS**

**Test Pits and Infiltration Testing Summary Table**
**Cedar Run**
**Project # 161-15484-00**

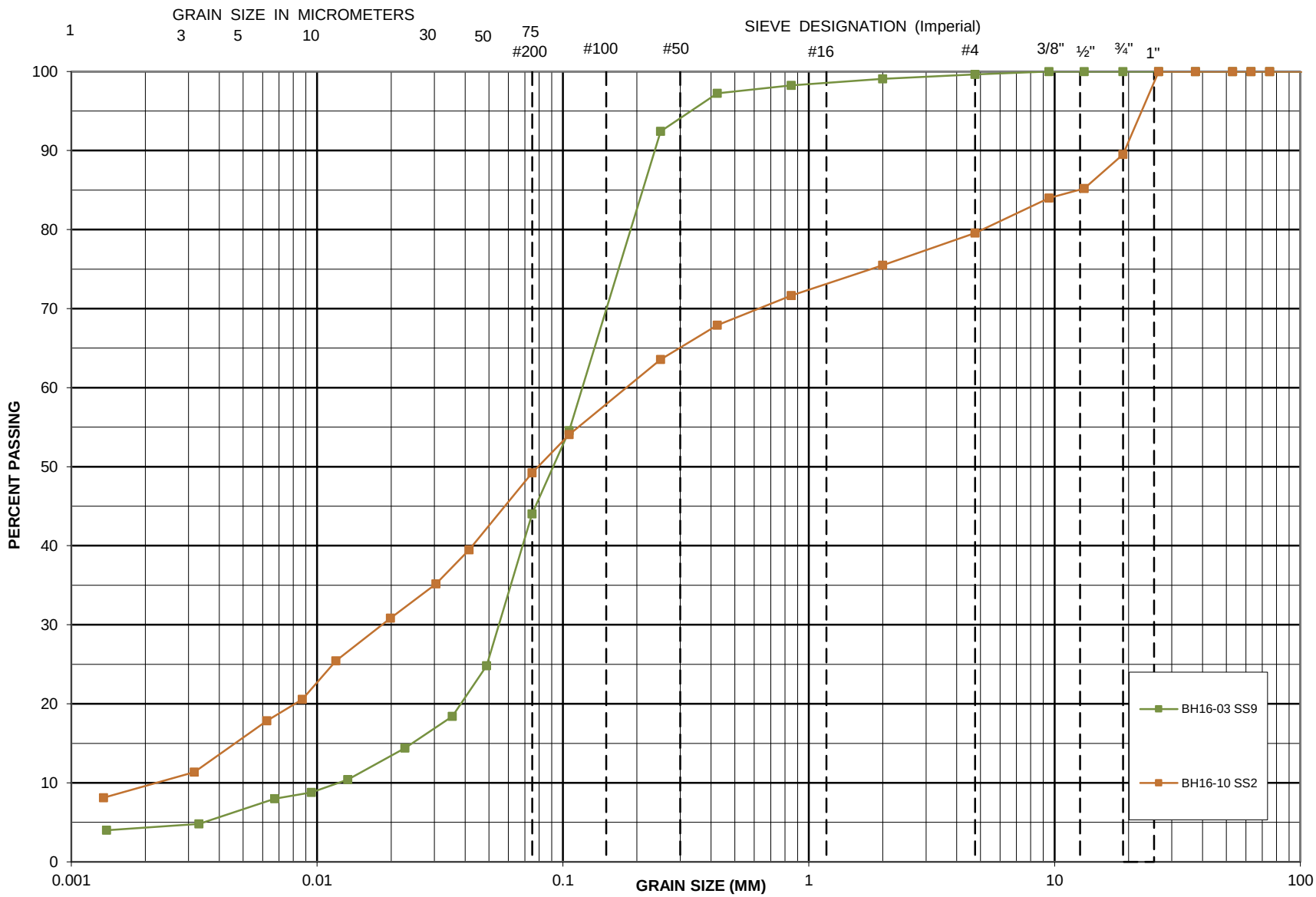
| Test Location | Soil Type at Test Depth | Test Pit Depth interval (m bgs) | Infiltration Test - Double-Ring Infiltrometer | | Infiltration Rate Approximated by Grain Size * |
|---|---|---|---|---|---|
| | | | Infiltration Test Depth (m bgs) | Measured Infiltration Rate (mm/hr) | (cm/s) |
| **TP 1**<br>**Surface Elevation 199.2 m** | **Sand** - silty sand, disturbed, Br | 0 – 0.3 | - | - | - |
| | **Fill** - clayey silt with some sand, some layering with grey silt, moist, Br, wet | 0.9 – 3.0 | 3.0 | 8 / 12 | 14.5 |
| **TP 2**<br>**Surface Elevation 199.6 m** | **Top Soil** - sand, rootlets, organics, loose, Br | 0 – 0.4 | - | - | - |
| | **Silty Sand** - very compact, stratified, moist, Br | 0.4 – 3.0 | 3.0 | 15 / 18 | - |
| **TP 3**<br>**Surface Elevation 199.5 m** | **Topsoil** - silt loam, rootlets, organics, Br | 0 – 0.3 | - | - | - |
| | **Silty Sand** - disturbed, loose, moist, Br | 0.3 - 2.0 | - | - | - |
| | **Clayey Silt** - trace sand, varved with some oxidized layering, dense, moist, Br to Gr | 2.0 – 3.0 | 3.0 | 8 / 6 | 13.2 |
| **TP 4**<br>**Surface Elevation 196.4 m** | **Topsoil** - silt loam, rootlets, organics, Br | 0 – 0.4 | - | - | - |
| | **Silty Sand** - disturbed, loose, moist, Br | 0.4 - 1.8 | - | - | - |
| | **Till** - sandy silt with gravel and cobble/boulders, trace clay, very compact, moist, Gr | 1.8 – 3.0 | 3.0 | 14 / 12 | - |
| **TP 5**<br>**Surface Elevation 189.8 m** | **Sand & Gravel**- with silt and cobble/boulders, wet, loose, Gr | 0 – 2.0 | - | - | - |
| | **Till** - sandy silt with gravel and cobble/boulders, trace clay, very compact, moist, Gr | 2.0 – 3.0 | 3.0 | 10 / 15 | - |
| **TP 6**<br>**Surface Elevation 188.1 m** | **Silty Sand** - with gravel and cobble/boulders, moist, loose, Br | 0 – 0.5 | - | - | - |
| | **Till** - sandy silt with gravel and cobble/boulders, trace clay, very compact, moist, Gr | 0.5 – 3.0 | 3.0 | 12 / 15 | 19.6 |
| **TP 7**<br>**Surface Elevation 190.4 m** | **Sand & Gravel**- with cobble/boulders, moist, loose, Gr | 0 – 1.8 | - | - | - |
| | **Till** - sandy silt with gravel and cobble/boulders, trace clay, very compact, moist, Gr | 1.8 – 3.0 | 3.0 | 14 / 14 | - |

# Appendix C

## GRAIN SIZE DISTRIBUTION TEST RESULTS

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |




WSP

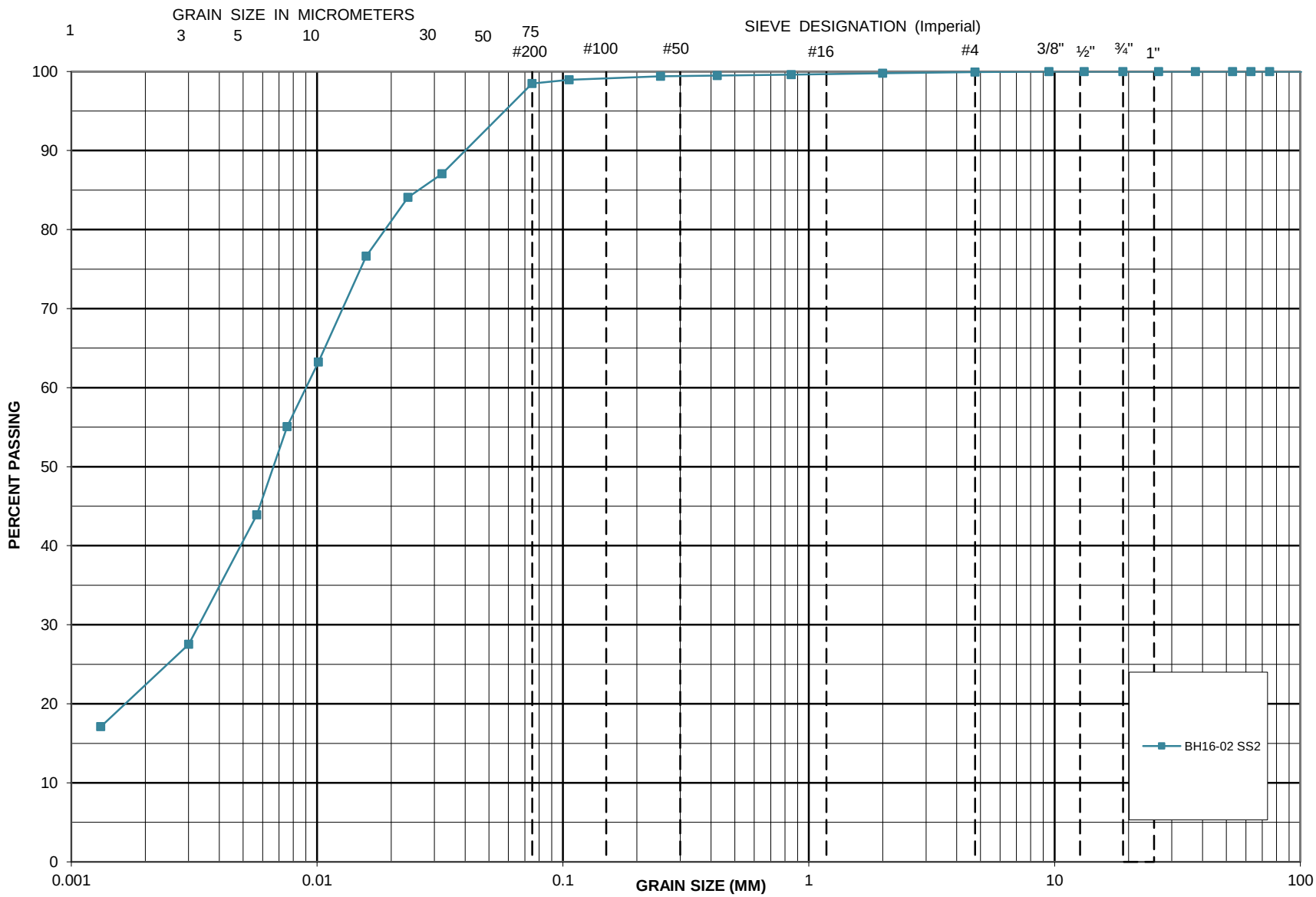
# GRAIN SIZE DISTRIBUTION

Sand and Silt

| | |
|---|---|
| Figure No: | C1 |
| Project No. | 161-15484-00 |
| Date : | December, 2016 |

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |




WSP

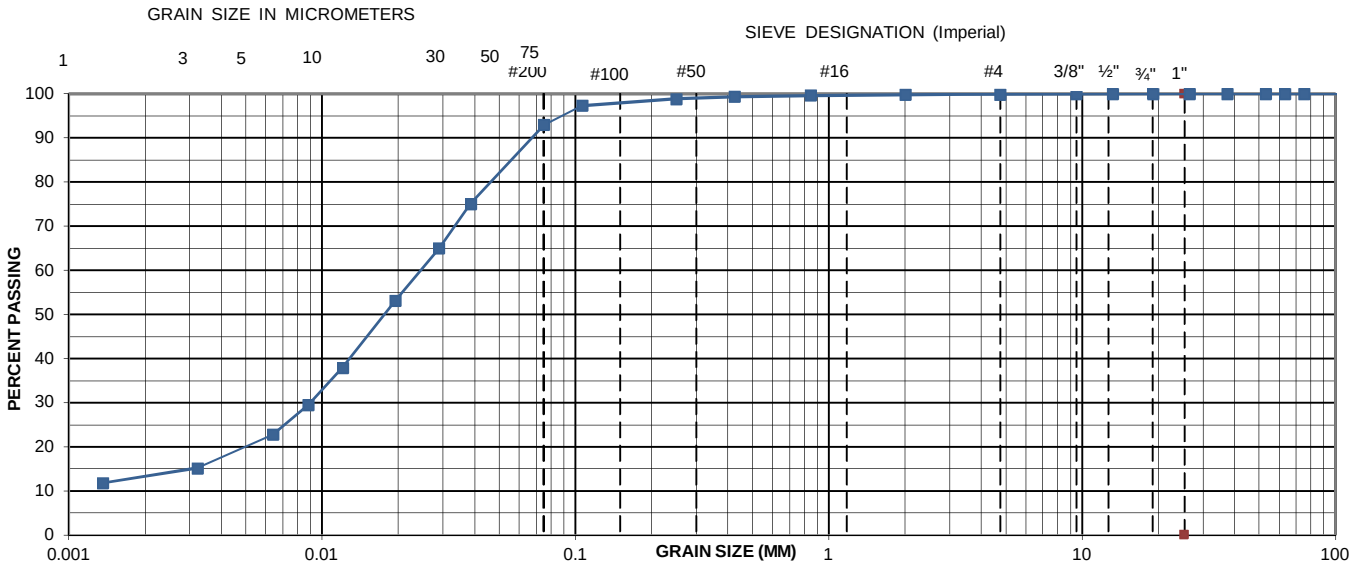
GRAIN SIZE DISTRIBUTION

Clayey Silt

| | |
|---|---|
| Figure No: | C2 |
| Project No. | 161-15484-00 |
| Date : | December, 2016 |

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |




# TP1

| GRAIN SIZE | SIEVE SIZES (mm) | PERCENT PASSING | PERCENT COMPOSITION |
|---|---|---|---|
| Gr | 150 | 100.0 | 0.1 |
| | 106 | 100.0 | |
| | 75 | 100.0 | |
| | 63 | 100.0 | |
| | 53 | 100.0 | |
| | 37.5 | 100.0 | |
| | 26.5 | 100.0 | |
| | 19 | 100.0 | |
| | 13.2 | 100.0 | |
| | 9.5 | 100.0 | |
| | 4.75 | 99.9 | |
| Sa | 2 | 99.8 | 6.9 |
| | 0.85 | 99.7 | |
| | 0.425 | 99.4 | |
| | 0.25 | 98.9 | |
| | 0.106 | 97.3 | |
| | 0.075 | 93.0 | |
| Si | 0.0385 | 75.1 | 77.8 |
| | 0.0289 | 65.0 | |
| | 0.0195 | 53.2 | |
| | 0.0121 | 38.0 | |
| | 0.0088 | 29.5 | |
| | 0.0064 | 22.8 | |
| | 0.0032 | 15.2 | |
| Cl | 0.0013 | 11.8 | 15.2 |

## Soil Classification

**Soil Description:**
clayey silt, some sand

**Coefficients:**

| | |
|---|---|
| D90 | 0.0689 |
| D85 | 0.0587 |
| D60 | 0.0249 |
| D50 | 0.0179 |
| D30 | 0.0090 |
| D15 | 0.0031 |
| D10 | 0.0012 |

**Properties:**

| | |
|---|---|
| Estimated Hydraulic Conductivity, K ($D10^2$) ( cm/sec) | 1.E-06 |
| Approximated Infiltration Rate (mm/hour) | 14.5 |
| Approximated Percolation Time, T (min/cm) | 41.3 |

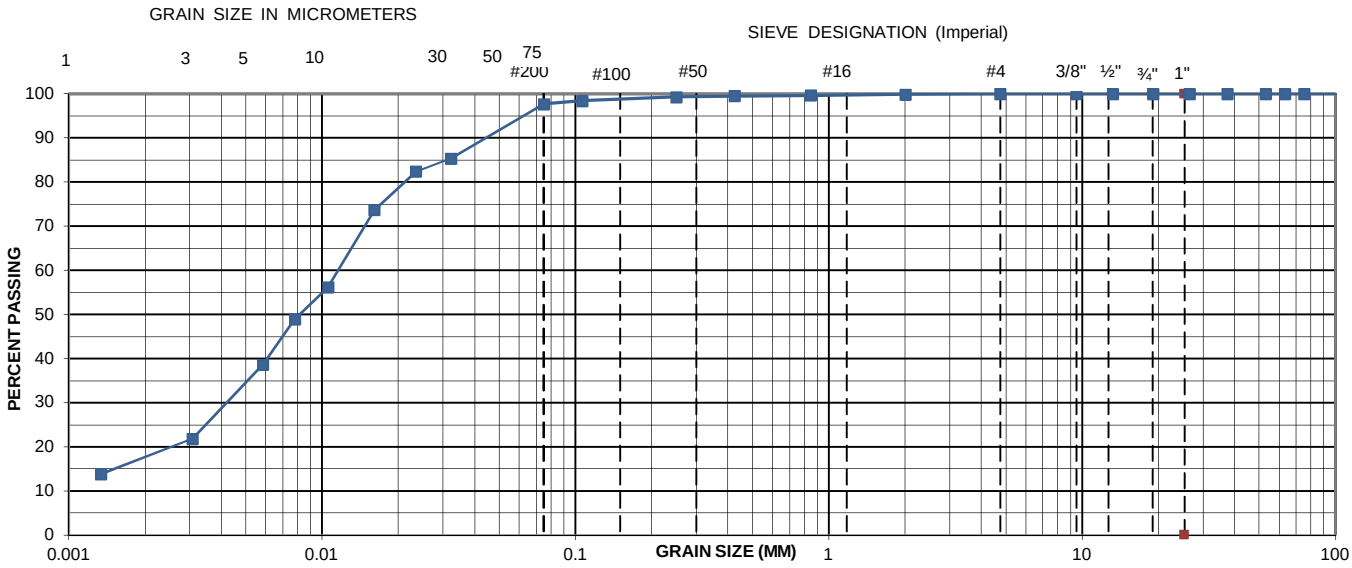
WSP

GRAIN SIZE DISTRIBUTION
AND SOIL CHARACTERISTICS


Project No. 161-15484-00
Date : January 24, 2017

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |




## TP3

| GRAIN SIZE | SIEVE SIZES (mm) | PERCENT PASSING | PERCENT COMPOSITION |
|---|---|---|---|
| Gr | 150 | 100.0 | 0.0 |
| | 106 | 100.0 | |
| | 75 | 100.0 | |
| | 63 | 100.0 | |
| | 53 | 100.0 | |
| | 37.5 | 100.0 | |
| | 26.5 | 100.0 | |
| | 19 | 100.0 | |
| | 13.2 | 100.0 | |
| | 9.5 | 100.0 | |
| | 4.75 | 100.0 | |
| Sa | 2 | 99.9 | 2.3 |
| | 0.85 | 99.7 | |
| | 0.425 | 99.5 | |
| | 0.25 | 99.3 | |
| | 0.106 | 98.4 | |
| | 0.075 | 97.7 | |
| Si | 0.0322 | 85.4 | 75.9 |
| | 0.0235 | 82.4 | |
| | 0.0161 | 73.7 | |
| | 0.0106 | 56.2 | |
| | 0.0078 | 48.9 | |
| | 0.0058 | 38.7 | |
| | 0.0031 | 21.9 | |
| Cl | 0.0013 | 13.9 | 21.9 |

### Soil Classification

**Soil Description:**
clayey silt, trace sand

**Coefficients:**

| | |
|---|---|
| D90 | 0.0483 |
| D85 | 0.0312 |
| D60 | 0.0118 |
| D50 | 0.0082 |
| D30 | 0.0044 |
| D15 | 0.0016 |
| D10 | 0.0010 |

**Properties:**

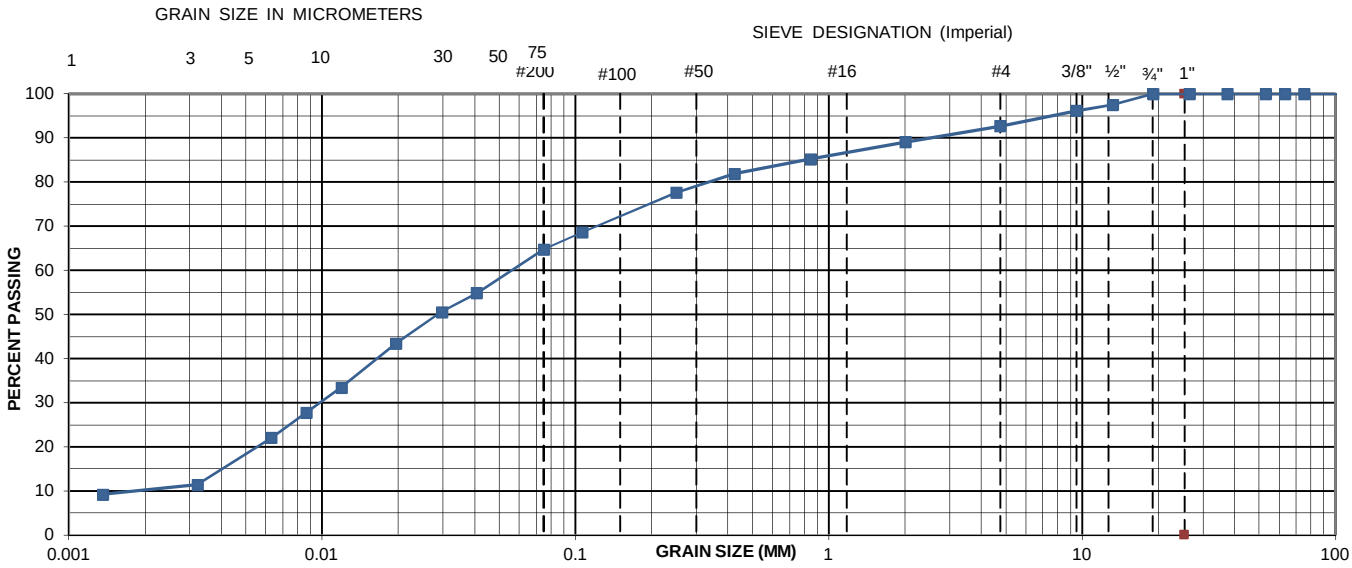
| | |
|---|---|
| Estimated Hydraulic Conductivity, K ($D10^2$) ( cm/sec) | 9.E-07 |
| Approximated Infiltration Rate (mm/hour) | 13.2 |
| Approximated Percolation Time, T (min/cm) | 45.3 |

WSP

GRAIN SIZE DISTRIBUTION
AND SOIL CHARACTERISTICS

UNIFIED SOIL CLASSIFICATION SYSTEM

| CLAY AND SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|
| | Fine | Medium | Coarse | Fine | Coarse |




# TP6

| GRAIN SIZE | SIEVE SIZES (mm) | PERCENT PASSING | PERCENT COMPOSITION |
|---|---|---|---|
| Gr | 150 | 100.0 | 7.3 |
| | 106 | 100.0 | |
| | 75 | 100.0 | |
| | 63 | 100.0 | |
| | 53 | 100.0 | |
| | 37.5 | 100.0 | |
| | 26.5 | 100.0 | |
| | 19 | 100.0 | |
| | 13.2 | 97.5 | |
| | 9.5 | 96.2 | |
| | 4.75 | 92.7 | |
| Sa | 2 | 89.1 | 28.0 |
| | 0.85 | 85.2 | |
| | 0.425 | 81.9 | |
| | 0.25 | 77.6 | |
| | 0.106 | 68.6 | |
| | 0.075 | 64.7 | |
| Si | 0.0322 | 54.9 | 53.3 |
| | 0.0235 | 50.6 | |
| | 0.0161 | 43.5 | |
| | 0.0106 | 33.5 | |
| | 0.0078 | 27.8 | |
| | 0.0058 | 22.1 | |
| | 0.0031 | 11.4 | |
| Cl | 0.0013 | 9.3 | 11.4 |

## Soil Classification

**Soil Description:**
sandy silt , some clay

**Coefficients:**

| | |
|---|---|
| D90 | 2.7083 |
| D85 | 0.8208 |
| D60 | 0.0586 |
| D50 | 0.0288 |
| D30 | 0.0099 |
| D15 | 0.0043 |
| D10 | 0.0020 |

**Properties:**

| | |
|---|---|
| Estimated Hydraulic Conductivity, K ($D10^2$) ( cm/sec) | 4.E-06 |
| Approximated Infiltration Rate (mm/hour) | 19.6 |
| Approximated Percolation Time, T (min/cm) | 30.7 |

WSP

GRAIN SIZE DISTRIBUTION
AND SOIL CHARACTERISTICS


Project No. 161-15484-00
Date : January 24, 2017

# Appendix D

**MOECC WATER WELL RECORD SUMMARY**

**Summary of Available MOECC Water Well Records (500m radius)**

| MOE Water Well ID | Easting | Northing | Elevation | Total Depth | Top Depth | Thickness | Stratigraphy | | | | Static Level | Water Found | Water Kind | Date Completed | Status | Water Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (m) | (m) | (m) | (m) | Colour | Material #1 | Material #2 | Material #3 | (m) | | | | | |
| 2506034 | 543664 | 4932873 | 205.74 | 27.74 | 0.00 | 0.30 | Black | Loam | - | - | 11.0 | 25.3 | Fresh | 27-Apr-77 | Water Supply | Domestic |
| | | | | | 0.30 | 3.05 | Brown | Sand | Clay | Packed | | | | | | |
| | | | | | 3.35 | 2.13 | Blue | Clay | Stones | Cemented | | | | | | |
| | | | | | 5.49 | 14.33 | Grey | Clay | Stones | - | | | | | | |
| | | | | | 19.81 | 5.49 | Grey | Gravel | Silt | Boulder | | | | | | |
| | | | | | 25.30 | 1.22 | Brown | Sand | - | Sand | | | | | | |
| | | | | | 26.52 | 1.22 | Brown | Sand | Gravel | - | | | | | | |
| 2500552 | 544114 | 4932823 | 198.12 | 32.90 | 0.00 | 24.38 | - | Clay | Gravel | Hard Pan | 7.6 | 27.43 | Fresh | 3-Aug-67 | Water Supply | Domestic |
| | | | | | 24.38 | 6.10 | - | Fine Sand | Gravel | - | | | | | | |
| | | | | | 30.48 | 2.44 | - | Coarse Sand | Gravel | - | | | | | | |
| 2503360 | 545074 | 4932323 | 207.26 | 18.30 | 0.00 | 0.61 | Brown | Fill | - | - | 9.4 | 17.68 | Fresh | 13-Nov-70 | Water Supply | Domestic |
| | | | | | 0.61 | 5.79 | Brown | Clay | Gravel | Stones | | | | | | |
| | | | | | 6.40 | 10.06 | Grey | Clay | Medium Sand | - | | | | | | |
| | | | | | 16.46 | 1.22 | Grey | Medium Sand | Clay | - | | | | | | |
| | | | | | 17.68 | 0.61 | Brown | Medium Sand | Gravel | - | | | | | | |
| 2503553 | 543864 | 4933053 | 210.31 | 23.80 | 0.00 | 0.30 | - | Loam | - | - | 18.0 | 23.1648 | Fresh | 5-Oct-71 | Water Supply | Domestic / Livestock |
| | | | | | 0.30 | 1.83 | Brown | Clay | - | - | | | | | | |
| | | | | | 2.13 | 7.62 | Grey | Clay | Gravel | - | | | | | | |
| | | | | | 9.75 | 13.41 | Grey | Gravel | Clay | - | | | | | | |
| | | | | | 23.16 | 0.61 | Grey | Gravel | - | - | | | | | | |
| 2509205 | 543729 | 4932948 | 198.12 | 27.70 | 0.00 | 2.44 | - | Loam | Sand | LTCL | - | 26.5176 | Fresh | 25-Sep-87 | Water Supply | Domestic / Livestock |
| | | | | | 2.44 | 11.58 | Grey | Clay | - | - | | | | | | |
| | | | | | 14.02 | 3.05 | Grey | Hard Pan | Stones | - | | | | | | |
| | | | | | 17.07 | 7.32 | Grey | Sand | Clay | Gravel | | | | | | |
| | | | | | 24.38 | 3.35 | - | Gravel | Sand | - | | | | | | |
| 2500543 | 545139 | 4932373 | 192.02 | 29.30 | 0.00 | 10.67 | - | Boulder | Gravel | - | 12.2 | 27.43 | Fresh | 18-May-65 | Water Supply | Domestic |
| | | | | | 10.67 | 13.72 | - | Hard Pan | Clay | Gravel | | | | | | |
| | | | | | 24.38 | 4.88 | - | Medium Sand | Gravel | - | | | | | | |

**Summary of Available MOECC Water Well Records (500m radius)**

| MOE Water Well ID | Easting | Northing | Elevation | Total Depth | Top Depth | Thickness | Stratigraphy | | | | Static Level | Water Found | Water Kind | Date Completed | Status | Water Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (m) | (m) | (m) | (m) | Colour | Material #1 | Material #2 | Material #3 | (m) | | | | | |
| 2500550 | 544829 | 4932248 | 201.17 | 20.10 | 0.00 | 7.92 | - | Coarse Sand | Stones | - | 4.0 | 20.12 | Fresh | 25-Jun-47 | Water Supply | Domestic |
| | | | | | 7.92 | 12.19 | - | Coarse Sand | Fine Sand | - | | | | | | |
| 2500551 | 543864 | 4932873 | 198.12 | 61 | 0.00 | 1.52 | - | Loam | - | - | 12.1999998 | 45.72 | Mineral | 13-Nov-58 | Water Supply | Domestic / Livestock |
| | | | | | 1.52 | 7.62 | - | Medium Sand | Clay | - | | | | | | |
| | | | | | 9.14 | 6.10 | - | Quick Sand | - | - | | | | | | |
| | | | | | 15.24 | 6.10 | - | Gravel | Medium Sand | - | | | | | | |
| | | | | | 21.34 | 21.34 | - | Quick Sand | - | - | | | | | | |
| | | | | | 42.67 | 3.05 | Brown | Hard Pan | - | - | | | | | | |
| | | | | | 45.72 | 15.24 | - | Shale | - | - | | | | | | |
| 2514599 | 544102 | 4933363 | - | 36 | 0.00 | 2.74 | Brown | Clay | Stones | - | 32.2999992 | 32.6136 | Fresh | 16-May-01 | - | - |
| | | | | | 2.74 | 9.75 | Blue | Stones | Clay | Silt | | | | | | |
| | | | | | 12.50 | 6.71 | Grey | Silt | Stones | - | | | | | | |
| | | | | | 19.20 | 0.61 | Blue | Shale | - | - | | | | | | |
| | | | | | 19.81 | 8.23 | Grey | Limestone | Shale | - | | | | | | |
| | | | | | 28.04 | 4.57 | Black | Limestone | - | - | | | | | | |
| | | | | | 32.61 | 3.35 | Brown | Limestone | - | - | | | | | | |
| 2505547 | 544907 | 4932137 | 208.79 | 21.2999992 | 0.00 | 0.30 | - | - | - | - | 9.1000004 | 20.4216 | Fresh | 30-Oct-75 | Water Supply | Domestic |
| | | | | | 0.30 | 2.74 | Brown | - | - | - | | | | | | |
| | | | | | 3.05 | 8.23 | Blue | Stones | - | - | | | | | | |
| | | | | | 11.28 | 10.06 | Blue | Sand | Clay | - | | | | | | |
| 2505238 | 544240 | 4933046 | 201.78 | 24.3999996 | 0.00 | 22.86 | - | Clay | Gravel | - | 5.1999998 | 22.86 | Fresh | 15-Jul-75 | Water Supply | Domestic |
| | | | | | 22.86 | 1.52 | - | Sand | Gravel | - | | | | | | |
| 2509443 | 544298 | 4933180 | 213.36 | 34.7000008 | 0.00 | 0.30 | - | Loam | LTCL | Soft | 11 | 28.956 | Fresh | 9-Mar-88 | Water Supply | Domestic |
| | | | | | 0.30 | 3.35 | Grey | Hard Pan | Stones | Soft | | | | | | |
| | | | | | 3.66 | 8.53 | Grey | Clay | Sand | Soft | | | | | | |
| | | | | | 12.19 | 11.89 | Grey | Clay | Gravel | Soft | | | | | | |
| | | | | | 24.08 | 10.06 | Grey | Shale | Hard | Soft | | | | | | |
| | | | | | 34.14 | 0.61 | Grey | Clay | Soft | Soft | | | | | | |

**Summary of Available MOECC Water Well Records (500m radius)**

| MOE Water Well ID | Easting | Northing | Elevation | Total Depth | Top Depth | Thickness | Stratigraphy | | | | Static Level | Water Found | Water Kind | Date Completed | Status | Water Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (m) | (m) | (m) | (m) | Colour | Material #1 | Material #2 | Material #3 | (m) | | | | | |
| 2509868 | 543807 | 4932892 | 213.36 | 23.2000008 | 0.00 | 3.05 | - | Clay | Gravel | - | 11.8999996 | 23.1648 | Fresh | 14-Mar-89 | Water Supply | Domestic |
| | | | | | 3.05 | 8.53 | Brown | Gravel | Sand | - | | | | | | |
| | | | | | 11.58 | 3.05 | Grey | Sand | Stones | Gravel | | | | | | |
| | | | | | 14.63 | 5.18 | Grey | Clay | Gravel | - | | | | | | |
| | | | | | 19.81 | 1.83 | Grey | Gravel | Clay | Sand | | | | | | |
| | | | | | 21.64 | 0.61 | Brown | Gravel | Sand | - | | | | | | |
| | | | | | 22.25 | 0.91 | - | Coarse Gravel | - | - | | | | | | |
| 2514463 | 543858 | 4932953 | - | 54.2999992 | 0.00 | 0.30 | - | Loam | | | - | - | - | 6-Dec-00 | Abandoned | Domestic Supply |
| | | | | | 0.30 | 4.88 | Brown | Sand | Gravel | | | | | | | |
| | | | | | 5.18 | 6.71 | Grey | Silt | Gravel | | | | | | | |
| | | | | | 11.89 | 5.18 | Grey | Silt | - | | | | | | | |
| | | | | | 17.07 | 5.49 | Grey | Gravel | Clay | | | | | | | |
| | | | | | 22.56 | 1.22 | Grey | Gravel | Silt | | | | | | | |
| | | | | | 23.77 | 7.32 | Grey | Gravel | Stones | Clay | | | | | | |
| | | | | | 31.09 | 9.45 | Grey | Limestone | Shale | | | | | | | |
| | | | | | 40.54 | 4.88 | Black | Limestone | - | | | | | | | |
| | | | | | 45.42 | 3.05 | Grey | Limestone | - | | | | | | | |
| | | | | | 48.46 | 0.61 | Brown | Limestone | - | | | | | | | |
| | | | | | 49.07 | 5.18 | Black | Limestone | - | | | | | | | |
| 2515067 | 544102 | 4933363 | - | 27.3999996 | 0.00 | 0.30 | - | Loam | - | - | 17.3999996 | 25.908 | Fresh | 10-Jul-02 | Water Supply | Domestic |
| | | | | | 0.30 | 8.53 | Brown | Sand | Stoney | - | | | | | | |
| | | | | | 8.84 | 5.79 | Grey | Clay | Stones | - | | | | | | |
| | | | | | 14.63 | 10.67 | - | Clay | Sand | Gravel | | | | | | |
| | | | | | 25.30 | 2.13 | - | Gravel | Sand | - | | | | | | |

**Summary of Available MOECC Water Well Records (500m radius)**

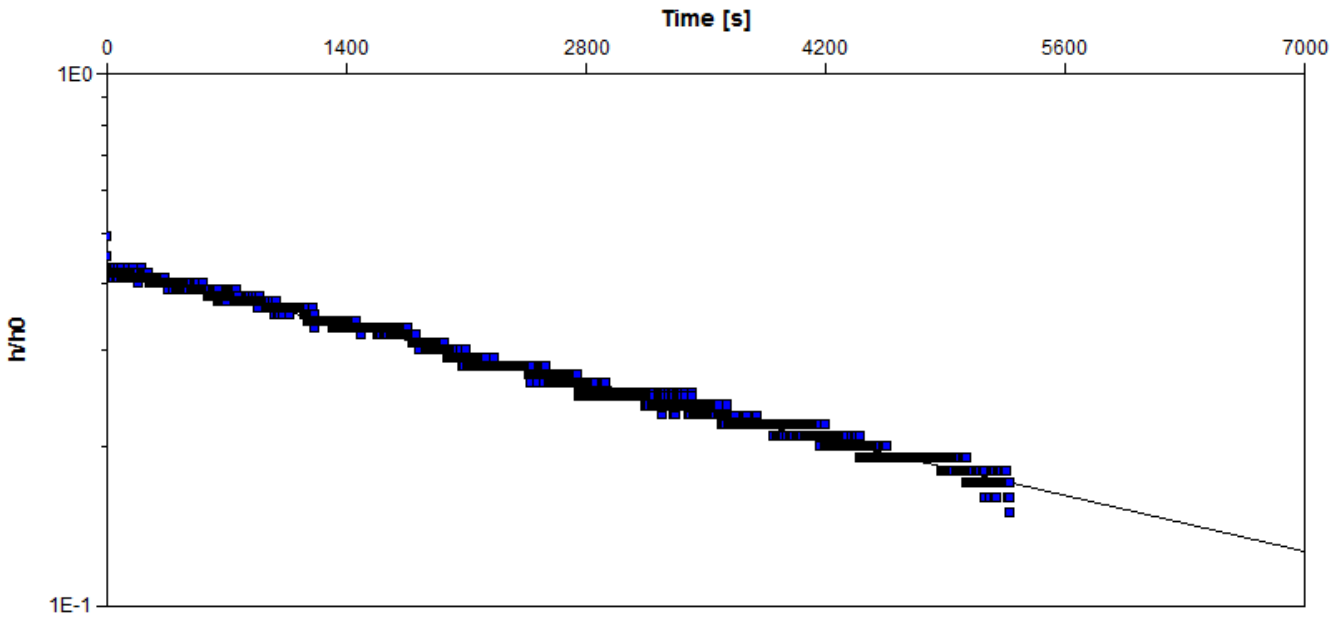
| MOE Water Well ID | Easting | Northing | Elevation | Total Depth | Top Depth | Thickness | Stratigraphy | | | | Static Level | Water Found | Water Kind | Date Completed | Status | Water Use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (m) | (m) | (m) | (m) | Colour | Material #1 | Material #2 | Material #3 | (m) | | | | | |
| 7123132 | 545137 | 4932669 | - | 13.3999996 | 0.00 | 0.30 | Brown | Loam | Stones | - | - | - | - | 15-Apr-09 | Abandoned | Domestic Supply |
| | | | | | 0.30 | 0.61 | Brown | Sand | Gravel | - | | | | | | |
| | | | | | 0.91 | 2.74 | Brown | Clay | Stones | - | | | | | | |
| | | | | | 3.66 | 5.18 | Grey | Clay | Stones | Hard | | | | | | |
| | | | | | 8.84 | 1.52 | Grey | Silt | - | - | | | | | | |
| | | | | | 10.36 | 2.44 | Grey | Clay | - | - | | | | | | |
| | | | | | 12.80 | 0.15 | Grey | Gravel | - | - | | | | | | |
| | | | | | 12.95 | 0.46 | Grey | Shale | - | - | | | | | | |
| 7152421 | 545033 | 4932520 | - | 19.7999992 | 0.00 | 0.61 | Brown | Loam | - | - | 8.1000004 | 19.2024 | Fresh | 29-Jul-10 | Water Supply | - |
| | | | | | 0.61 | 4.57 | Brown | Clay | - | - | | | | | | |
| | | | | | 5.18 | 1.52 | Grey | Clay | - | - | | | | | | |
| | | | | | 6.71 | 3.66 | Grey | Clay | - | - | | | | | | |
| | | | | | 10.36 | 8.84 | Grey | Gravel | - | - | | | | | | |
| | | | | | 19.20 | 0.61 | Grey | Gravel | - | - | | | | | | |
| 7156294 | 544278 | 4932330 | - | 45.7000008 | 0.00 | 0.30 | - | Loam | - | - | - | - | - | 17-Aug-10 | Abandoned | not used |
| | | | | | 0.30 | 5.79 | - | Clay | Sandy | - | | | | | | |
| | | | | | 6.10 | 7.01 | - | Clay | - | Soft | | | | | | |
| | | | | | 13.11 | 14.33 | - | Clay | Gravel | - | | | | | | |
| | | | | | 27.43 | 18.29 | Brown | Shale | - | - | | | | | | |
| 7247236 | 544067 | 4932822 | - | - | - | - | - | - | - | - | - | - | - | 28-May-15 | - | - |

# Appendix E

## HYDRAULIC CONDUCTIVITY TEST RESULTS

| | |
|---|---|
| WSP | **Slug Test Analysis Report** |
| | Project: Cedar Run |
| | Number: 161-15484-00 |
| | Client: C.C Tatham & Associates |

| | | |
|---|---|---|
| Location: Thornbury, ON | Slug Test: BH 16-03 | Test Well: BH 16-03 |
| Test Conducted by: Scott W | | Test Date: 07/12/2016 |
| Analysis Performed by: Scott W | Bouwer & Rice | Analysis Date: 23/01/2017 |
| Aquifer Thickness: 5.00 m | | |

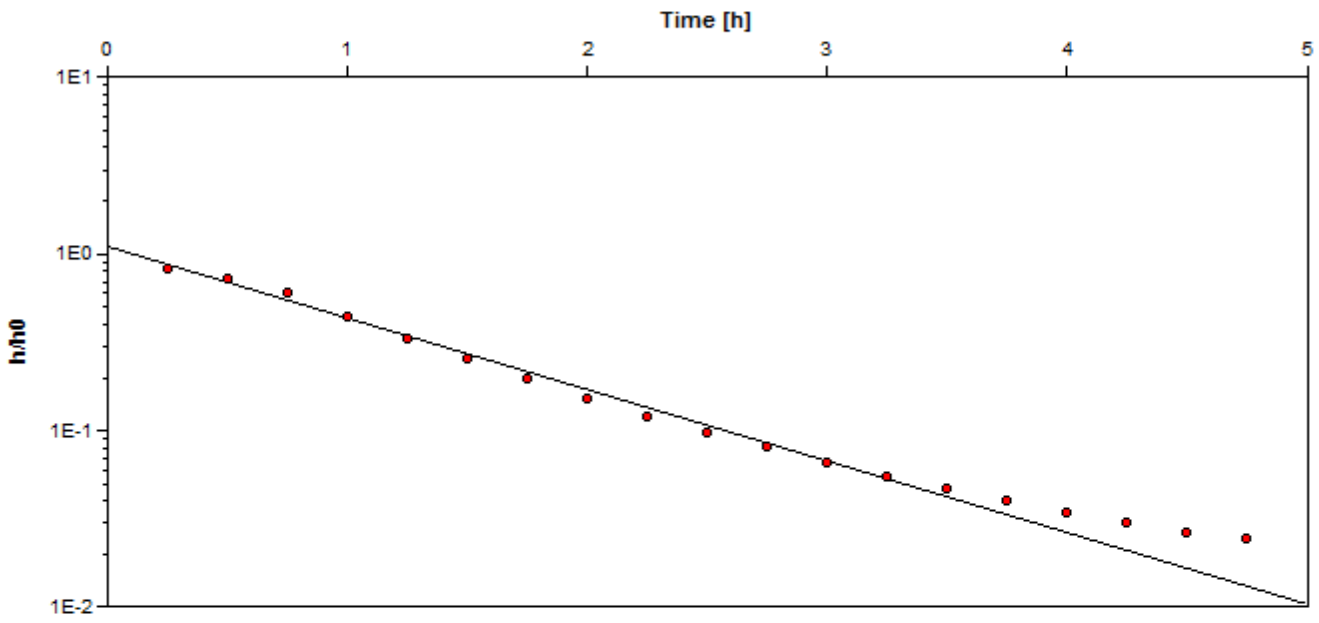



Calculation using Bouwer & Rice

| Observation Well | Hydraulic Conductivity [cm/s] | |
|---|---|---|
| BH 16-03 | $2.76 \times 10^{-5}$ | |

| | |
|---|---|
| WSP | **Slug Test Analysis Report** |
| | Project: Cedar Run |
| | Number: 161-15484-00 |
| | Client: C.C Tatham & Associates |

| | | |
|---|---|---|
| Location: Thornbury, ON | Slug Test: BH 16-07 | Test Well: BH 16-07 |
| Test Conducted by: Scott W | | Test Date: 07/12/2016 |
| Analysis Performed by: Scott W | Bouwer & Rice | Analysis Date: 23/01/2017 |
| Aquifer Thickness: 5.00 m | | |

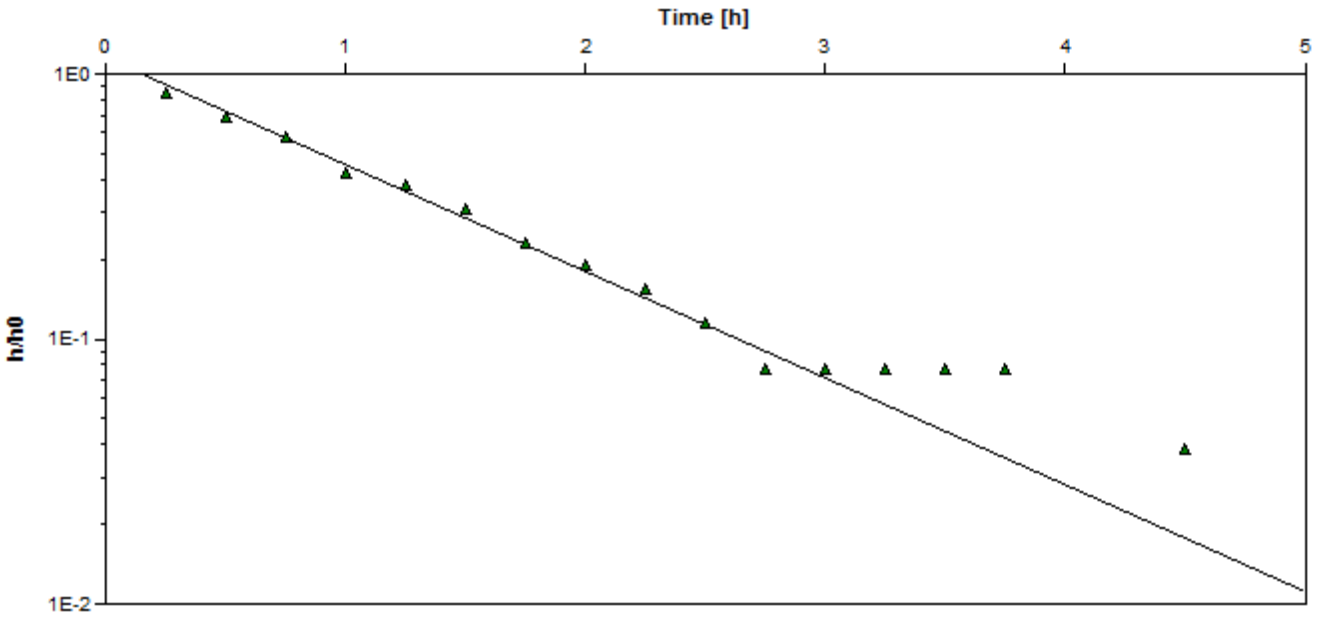



Calculation using Bouwer & Rice

| Observation Well | Hydraulic Conductivity [cm/s] | |
|---|---|---|
| BH 16-07 | $5.80 \times 10^{-5}$ | |

| | |
|---|---|
| | **Slug Test Analysis Report** |
| | Project: Cedar Run |
| | Number: 161-15484-00 |
| | Client: C.C Tatham & Associates |

| | | |
|---|---|---|
| Location: Thornbury, ON | Slug Test: BH 16-09 | Test Well: BH 16-09 |
| Test Conducted by: Scott W | | Test Date: 23/01/2017 |
| Analysis Performed by: Scott W | Bouwer & Rice | Analysis Date: 23/01/2017 |
| Aquifer Thickness: 5.00 m | | |

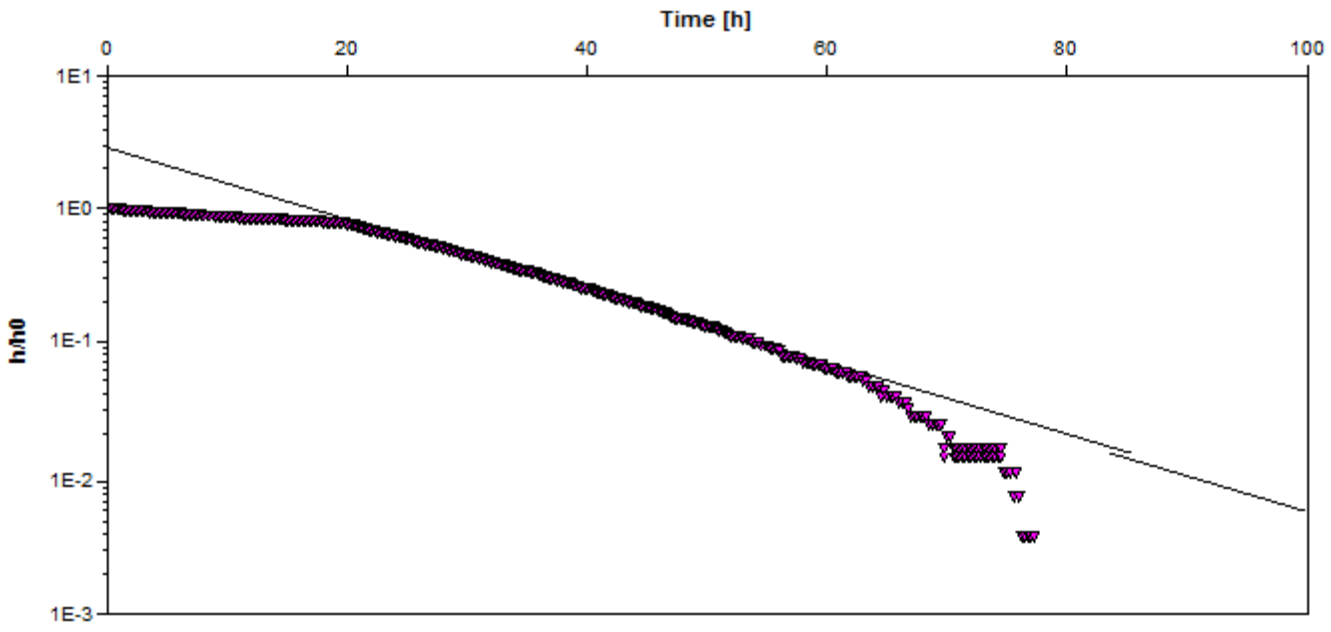



Calculation using Bouwer & Rice

| Observation Well | Hydraulic Conductivity [cm/s] | |
|---|---|---|
| BH 16-09 | $5.75 \times 10^{-5}$ | |

| | |
|---|---|
| **Slug Test Analysis Report** | |
| Project: Cedar Run | |
| Number: 161-15484-00 | |
| Client: C.C Tatham & Associates | |

| | | |
|---|---|---|
| Location: Thornbury, ON | Slug Test: BH 16-12 | Test Well: BH 16-12 |
| Test Conducted by: Scott W | | Test Date: 23/01/2017 |
| Analysis Performed by: Scott W | Bouwer & Rice | Analysis Date: 23/01/2017 |
| Aquifer Thickness: 5.00 m | | |




Calculation using Bouwer & Rice

| Observation Well | Hydraulic Conductivity [cm/s] | |
|---|---|---|
| BH 16-12 | $3.85 \times 10^{-5}$ | |