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# A REPORT TO
# DUNPAR DEVELOPMENTS INC.

# A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

1020, 1024, 1028, 1032, AND 1042 6TH LINE,

TOWN OF OAKVILLE

REFERENCE NO. 1505-S135

DECEMBER 2022

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## 1.0 INTRODUCTION

In accordance with written authorization dated June 4, 2015, from Mr. Michael Savas of Dunpar Developments Inc., a soil investigation was carried out at 1020, 1024, 1028, 1032, and 1042 6th Line, Town of Oakville, for a proposed Residential Development. Subsequent authorization was provided by the client, dated November 7, 2022, to update the geotechnical report to incorporate the latest design.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the design and construction of the proposed project, and to establish the Long-Term Stable Slope Line (LTSSL) for the development. The findings and resulting geotechnical recommendations are presented in this Report.

## 2.0 SITE AND PROJECT DESCRIPTION

The site is situated on Halton-Peel till plain where glacial tills dominate the soil stratigraphy and overlie shale bedrock of Queenston Formation at shallow to moderate depths.

The properties consist of residences with associated asphalt-paved driveways and lawns, and scattered trees. The subject site is bounded by Queen Elizabeth Way at the east and Sixteen Mile Creek at the south, with residential properties to the north and west. The ground surface is relatively flat at the tableland, with a slope, the north valley bank of Sixteen Mile Creek, at the south limit.

According to the architectural drawings prepared by Infinity Architecture & Design, dated October 25, 2022, it is understood that the site will be constructed with eight townhouse blocks provided with paved access roadway, on-grade parking area, and municipal services.

## 3.0 FIELD WORK

The field work, consisting of 8 boreholes to depths ranging from 6.3 to 9.3 m, was performed on June 11 and 15, 2015, at the locations shown on the Borehole Location Plan, Drawing No. 1. It should be noted that 2 of the originally proposed 10 boreholes were not drilled due to access issues with property owners.

The boreholes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed “List of Abbreviations and Terms”, were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or ‘N’ values) of the subsoil. The relative density of the non-cohesive strata and the consistency of the cohesive strata are inferred from the ‘N’ values. Split-spoon samples were recovered for soil classification and laboratory testing. The field work was supervised and the findings recorded by a Geotechnical Technician.

The elevation at each of the borehole locations was surveyed using Global Navigation Satellite System (GNSS) surveying equipment.

## 4.0 SUBSURFACE CONDITIONS

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 10, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing No. 2, and the engineering properties of the disclosed soils are discussed herein.

The investigation has disclosed that beneath a layer of topsoil or in places topsoil fill and earth fill, the site is generally underlain by strata of silty sand till and silty clay till bedding onto shale bedrock. Auger refusals were encountered at Boreholes 1 and 2, located near the top of the slope, at depths of 9.1 m and 9.3 m below the prevailing ground surface. The surficial sand till is weathered to a depth of 0.9± m below the prevailing ground surface.

### 4.1 **Topsoil/Topsoil Fill** (Boreholes 1 to 5, inclusive and 8 and 9)

The revealed topsoil and topsoil fill, 15 to 30 cm thick, are contacted at the ground surface in most of the boreholes. Thicker topsoil may be found in areas beyond the borehole locations, especially in low lying areas and treed areas.

### 4.2 **Earth Fill** (Boreholes 5, 6, 8 and 9)

A layer of earth fill was encountered near the ground surface at various locations, extending to depths ranging from 1.4± to 2.1± m below the prevailing ground surface. Sample examinations show that the fill consists mainly of silty clay and sand, with a trace to some gravel and occasional topsoil and rootlets inclusions.

The obtained 'N' values range from 3 to 22, with a median of 5 blows per 30 cm of penetration, indicating that the earth fill was loosely placed on site and has partially self-consolidated. The high 'N' values are due to the presence of gravel or boulder within the fill.

The natural water content values of the earth fill were determined, and the results are plotted on the Borehole Logs; the values vary from 9% to 24%, with a median of 15%, indicating that the fill is in a damp to wet, generally moist condition.

One must be aware that the samples retrieved from boreholes may not be truly representative of the geotechnical and environmental quality of the fill and do not indicate whether topsoil was completely stripped prior to the placement of earth fill. This should be further assessed by laboratory testing and/or test pits.

### 4.3 **Silty Sand Till** (All Boreholes, except Borehole 5, 8 and 9)

The silty sand till was encountered beneath the topsoil and earth fill, extending to depths ranging from 2.1± to 2.9± m below the prevailing ground surface. It consists of a random mixture of soil particle sizes ranging from clay to gravel with sand and silt being the predominant fractions. Occasional cobbles and boulders were encountered within the till.

Sample examinations show that the surficial zone is permeated with fissures, showing it has been fractured by the weathering process. As disclosed by the boreholes, this zone extends to a depth of 0.9± m below the prevailing ground surface.

The obtained 'N' values range from 5 blows per 30 cm to 50 blows per 10 cm, with a median of 38 blows per 30 cm of penetration, showing that the relative density of the till is loose to very dense, being generally dense.

The natural water content varies from 5% to 26%, with a median of 10%, indicating that the till is damp to wet, being generally in a moist condition. Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the stratum.

Grain size analyses were performed on 3 representative samples of the till; the results are plotted on Figure 11.

The engineering properties of the silty sand till are given below:

- High frost susceptibility and moderate water erodibility.
- It will be stable in steep cuts; however, under prolonged exposure, localized sheet collapse will likely occur.

### 4.4 **Silty Clay Till** (All Boreholes)

The silty clay till was found throughout the site, beneath the earth fill and silty sand till, extending to depths ranging from 5.5± to 6.6± m. It contains occasional cobbles, boulders and sand and silt seams and layers. It is heterogeneous in structure, indicating that it is a glacial deposit. A grain size analysis was performed on 1 representative sample of the silty clay till; the results are plotted on Figure 12.

The obtained 'N' values range from 16 blows per 30 cm of penetration to 50 blows per 10 cm, with a median of 42 blows per 30 cm. This indicates that the consistency of the till is very stiff to hard, being generally hard.

Occasional hard resistance to augering was encountered, indicating the presence of cobbles, boulders and shale fragments in the till mantle. The shale fragments increase with depth and become frequent close to the bedrock. This renders delineation of the interface of the till and the shale bedrock difficult.

The Atterberg Limits of 1 representative sample and the natural water content values of all the samples were determined. The results are plotted on the Borehole Logs and summarized below:

| | |
|---|---|
| Liquid Limit | 22% |
| Plastic Limit | 14% |
| Natural Water Content | 6% to 18% (median 11%) |

The results indicate that the clay till deposit is a cohesive material with low plasticity.

The engineering properties of the silty clay till are given below:

- High frost susceptibility and low water erodibility.
- In excavations, the clay till will be stable with relatively steep slopes; however, prolonged exposure may lead to slow localized sheet sloughing.

## 4.5 **Shale Bedrock** (All Boreholes, except Borehole 3)

Shale bedrock was encountered at depths of 5.5± to 6.0± m below the prevailing ground surface. The lower zone of the silty clay till appears to be derived from a clay-shale reversion and contains occasional shale fragments. Auger refusal was encountered in Boreholes 1 and 2 at a depth of 9.1 m below the prevailing ground surface, indicating the surface of sound bedrock.

The shale is reddish-brown in colour, indicating that it is of the Queenston formation. This type of shale is thinly to thickly bedded and consists predominantly of mudstone with occasional hard, limy shale and sandstone bands. The presence of shale fragments in the lower layer of the overlying soils renders difficulty in delineating the surface of the bedrock. The shale is susceptible to disintegration and swelling upon exposure to air and water, with subsequent reversion to a clay soil, but the laminated limy and sandy layers would remain as rock slabs.

Other than at Boreholes 1 and 2, the bedrock within the investigated depth can be penetrated by power-augering with some difficulty in grinding through the hard layers. The water content values for the samples ranges from 4% to 13%, with a median of 9%. The upper layer of the shale within depths ranging from 1.0 to 3.0 m from the surface of the bedrock generally is in a weathered condition, becoming sound with depth.

The shale has low permeability, and occasional pockets of groundwater may be trapped in the fissures. Upon release through excavation, the water is likely to drain readily with a limited yield.

The weathered rock can be excavated with considerable effort by a heavy-duty backhoe equipped with a rock-ripper; however, excavation will become progressively more difficult into the sound shale. Efficient removal of the sound shale may require the aid of pneumatic hammering and/or rock blasting.

The excavated spoil may contain large amounts of hard limy and sandy rock slabs, rendering it virtually impossible to obtain uniform compaction. Therefore, unless the spoil is sorted, it is considered unsuitable for engineering applications. Limy shale fragments larger than 15 cm should either be pulverized by mechanical means or left exposed for weathering by freezing, thawing and wetting. The shale will revert to a clayey soil which can be properly compacted using mechanical means.

## 4.6 Compaction Characteristics of the Revealed Soils

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied. As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 1.

**Table 1** - Estimated Water Content for Compaction

| Soil Type | Determined Natural Water Content (%) | Water Content (%) for Standard Proctor Compaction | |
|---|---|---|---|
| | | **100% (optimum)** | **Range for 95% or +** |
| Earth Fill | 11 to 24 (median 15) | 10 | 6 to 14 |
| Silty Sand Till | 5 to 26 (median 10) | 10 | 6 to 15 |
| Silty Clay Till | 6 to 18 (median 11) | 14 | 10 to 19 |
| Broken Shale | 4 to 13 (median 9) | 17 | 13 to 22 |

Based on the above findings, the in-situ soils are generally suitable to be reused for structural backfill. However, portions of the earth fill and sand till are either too wet or on the wet side of the optimum and will therefore require aeration in the dry, warm weather or mixing with drier inorganic soil prior to compaction. Portions of the silty sand till and silty clay till are either too dry or on the dry side of the optimum and will therefore require additional water prior to compaction. The existing earth fill must be sorted free of topsoil inclusions and deleterious material and aerated prior to compaction.

The presence of boulders and large shale fragments (over 15 cm in sizes) will prevent transmission of the compactive energy into the underlying material to be compacted. They must either be sorted or must not be used for construction of engineered fill and/or structural backfill.

## 5.0 GROUNDWATER CONDITION

The groundwater and cave-in levels were measured upon completion of the boreholes; the data are plotted on the Borehole Logs and summarized in Table 2.

**Table 2** - Groundwater Levels Upon Completion

| BH No. | Borehole Depth (m) | Ground Elevation (m) | Measured Groundwater and Cave-In* Level On Completion | |
|---|---|---|---|---|
| | | | Depth (m) | El. (m) |
| 1 | 9.3 | 109.7 | 7.6 | 102.1 |
| 2 | 9.1 | 110.6 | 7.9 | 102.7 |
| 3 | 6.6 | 112.0 | 4.2/4.5* | 107.8/107.5* |
| 4 | 6.3 | 110.6 | 2.5 | 108.1 |
| 5 | 6.3 | 109.6 | Dry | - |
| 6 | 6.3 | 109.6 | 5.5 | 104.1 |
| 8 | 6.3 | 109.2 | Dry | - |
| 9 | 6.3 | 109.4 | Dry | - |

As shown above, groundwater was detected and/or cave-in occurred in 5 of the 8 boreholes at depths ranging from 2.5 to 7.9 m. The groundwater will fluctuate with season.

A Phase Two Environmental Site Assessment (Phase Two ESA) was prepared by WSP in June 2017. Groundwater monitoring wells were installed for the Phase Two ESA, where one of the monitoring well, BH 17-1, was installed near the vicinity of Borehole 2. The stabilized groundwater level in BH 17-1 was 104.5 metres above sea level (masl) on January 27, 2017. A copy of the well log of BH17-1 is attached in the Appendix.

Additional groundwater monitoring was conducted by WSP on January 22, 2018. The groundwater level at BH 17-1 is found at a depth of 6.8 m below the ground surface or at El. 103.9 m, which is slightly lower than the measurement collected in January 2017.

If groundwater is encountered in the clay till, the yield is expected to be small and limited, whereas in the silty sand till it may be some to moderate. The shale bedrock is generally considered to be a poor aquifer; therefore, the yield from the bedrock, if encountered, will be limited.

## 6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has revealed that beneath a layer of topsoil or, in places, topsoil fill and earth fill, the site is generally underlain by strata of loose to very dense, generally dense silty sand till and very stiff to hard, generally hard silty clay till. Shale bedrock was encountered at depths ranging from 5.5 to 6.0 m below the prevailing ground surface. The shale is generally weathered to a depth of 1.0 to 3.0 m below its surface.

The earth fill extends to depths ranging from 1.4± to 2.1± m below the prevailing ground surface. Sample examinations show that the fill consists mainly of silty clay and sand materials with a trace to some gravel and occasional topsoil and rootlets inclusions.

Groundwater was detected and/or cave-in occurred in 5 of the 8 drilled boreholes at depths ranging from 2.4± to 7.9± m. Based on WSP's Phase Two ESA and their additional groundwater monitoring, groundwater is recorded at El. 104.5 m and El. 103.9 m on January 2017 and January 2018, respectively.

It is understood that the site will be constructed with eight townhouse blocks provided with paved access roadway, on-grade parking area, and municipal services. The geotechnical findings which warrant special consideration are presented below:

1. The topsoil and topsoil fill are void of engineering value and, therefore, must be stripped for the project construction. They can be used for landscaping purposes only and should not be buried below any structures or deeper than 1.2 m below the finished grade. Any surplus must be removed off site.
2. The existing earth fill is unsuitable for supporting structures in its present condition. In using the fill for structural backfill, or in pavement and slab construction, it should be subexcavated, inspected, sorted free of any concentrated topsoil inclusions and deleterious materials and properly compacted. If it is impractical to sort the topsoil and other deleterious materials from the fill, the fill must be wasted and replaced with properly compacted inorganic earth fill.
3. The surficial soils are weathered in the zone extending to depths ranging from 0.9 m from the prevailing ground surface. The weathered soils are generally weak in shear strength and are not suitable for supporting foundations. They should be inspected and surface compacted prior to placement of earth fill for site grading and construction of house foundations. Where appreciable organic material is encountered within the weathered soils, it must be subexcavated and must not be placed within the proposed building envelopes.

4. The sound native soils are suitable for conventional spread and strip footing construction. The soundness of the subgrade must be assessed to ensure that the subgrade conditions are compatible with the design of the foundations.
5. A Class ‘B’ bedding, consisting of compacted 19-mm Crusher-Run Limestone (CRL) or equivalent, is recommended for the construction of underground services.
6. Construction of the underground services may require extensive rock excavation. In the weathered shale, this can be carried out by using a heavy-duty backhoe equipped with a rock-ripper but where excavation into the sound shale is required, pneumatic hammering may be required for efficient rock removal.
7. The soils contain shale fragments. Extra effort and a properly equipped backhoe will be required for excavation. Rock slabs larger than 15 cm are not suitable for structural backfill.

The recommendations appropriate for the project are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

## 6.1 Foundations

Based on the borehole information, the footings must be placed below the topsoil, existing earth fill and weathered soils onto the sound native soils or engineered fill. As a general guide, Maximum Allowable Soil Pressures (SLS) of 150 kPa and 300 kPa and Factored Ultimate Soil Bearing Pressures (ULS) of 250 kPa and 500 kPa, respectively, can be used for the design of the conventional strip and spread footings founded onto sound natural soils. The recommended pressures and corresponding founding levels are presented in Table 3.

**Table 3** - Founding Levels

| | **Recommended Maximum Allowable Soil/Rock Pressure (SLS)/ Factored Ultimate Soil/Rock Bearing Pressure (ULS) and Corresponding Founding Level** | | | |
|---|---|---|---|---|
| | **150 kPa (SLS)/250 kPa (ULS)** | | **300 kPa (SLS)/500 kPa (ULS)** | |
| **BH No.** | **Depth (m)** | **El. (m)** | **Depth (m)** | **El. (m)** |
| 1 | 1.0 or + | 108.7 or - | 1.7 or + | 108.0 or - |
| 2 | - | - | 1.2 or + | 109.4 or - |

**Table 3** - Founding Levels (cont'd)

| BH No. | Recommended Maximum Allowable Soil/Rock Pressure (SLS)/ Factored Ultimate Soil/Rock Bearing Pressure (ULS) and Corresponding Founding Level | | | |
|---|---|---|---|---|
| | 150 kPa (SLS)/250 kPa (ULS) | | 300 kPa (SLS)/500 kPa (ULS) | |
| | Depth (m) | El. (m) | Depth (m) | El. (m) |
| 3 | - | - | 1.2 or + | 110.8 or - |
| 4 | - | - | 1.2 or + | 109.4 or - |
| 5 | 2.5 or + | 107.1 or - | 3.3 or + | 106.3 or - |
| 6 | - | - | 1.7 or + | 107.9 or - |
| 8 | - | - | 1.7 or + | 107.5 or - |
| 9 | - | - | 1.7 or + | 107.7 or - |

One must be aware the recommended Maximum Allowable Soil Pressures (SLS) and corresponding founding depths are given as a guide for foundation design and must be confirmed by a subgrade inspection performed by a geotechnical engineer at each of the building locations.

The total and differential settlements of the foundations founded on soil subgrade and designed using bearing pressure at SLS are estimated to be 25 mm and 20 mm, respectively.

The footings should meet the requirements specified by the latest version of Ontario Building Code, and the structure should be designed to resist an earthquake force using Site Classification 'C' (very dense soil and soft rock).

Foundations exposed to weathering, and in unheated areas, should have at least 1.2 m of earth cover for protection against frost action or must be properly insulated.

Perimeter subdrains and damp-proofing of the foundation walls will be required. All the subdrains should be encased in a fabric filter to protect them against blockage by silting. If the proposed buildings are slab-on-grade structures without a basement, the requirement for perimeter subdrains can be omitted. The area around the slab-on-grade building must be graded to direct surface runoffs away from the foundations.

Where cut and fill is required for house foundations, it may be more economical to place engineered fill for conventional footing, storm sewer and road construction. The requirements for engineered fill construction are discussed in the following section.

## 6.2 Engineered Fill

The existing earth fill can be replaced with and/or upgraded to engineered fill, and where earth fill is required to raise the site or where extended footings are required, the engineering requirements for a certifiable fill are presented below:

1. All of the topsoil and organics must be removed, and the subgrade must be inspected and proof-rolled prior to any fill placement. The existing earth fill and badly weathered soils must be subexcavated, sorted free of topsoil inclusions and deleterious materials, if any, aerated, if necessary, and properly compacted to at least 98% Standard Proctor Dry Density (SPDD).
2. Inorganic soils must be used, and they must be uniformly compacted in lifts 20 cm thick to 98% SPDD up to the proposed lot grade and/or road subgrade. The soil moisture must be properly controlled near the optimum. If the foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% SPDD.
3. If imported fill is to be used, the hauler is responsible for its environmental quality and must provide a document to certify that the material is free of hazardous contaminants.
4. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.
5. The engineered fill must not be placed when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
6. The engineered fill should extend over the entire graded area; the engineered fill envelope and finished elevations must be clearly and accurately defined in the field, and they must be precisely documented by qualified surveyors.
7. Where the fill is to be placed on a bank steeper than 1 vertical:3horizontal, the face of the bank must be flattened to 3 + so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
8. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer.
9. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and

the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.

10. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who inspected the fill placement in order to document the locations of excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for re-certification.
11. Despite stringent control in the placement of engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the foundation constructed on the engineered fill may require continuous reinforcement with steel bars. Foundations partially on engineered fill must be reinforced and designed by a structural engineer, to properly distribute the stress induced by the abrupt differential settlement (about 20 mm) between the native soil and engineered fill.
12. In sewer construction, the engineered fill is considered to have the same structural proficiency as a native inorganic soil.

## 6.3 Slab-On-Grade

The subgrade for slab-on-grade construction must consist of sound native soils or properly compacted inorganic earth fill. The exposed subgrade should be inspected and assessed by proof-rolling prior to slab-on-grade construction. Where weathered soils or soft/loose subgrade is detected, it should be subexcavated, sorted free of any deleterious materials, aerated and uniformly compacted to 98% SPDD.

The slab should be constructed on a granular base 20 cm thick, consisting of 19-mm CRL, or equivalent, compacted to 100% SPDD.

A Modulus of Subgrade Reaction of 35 MPa/m is recommended for the design of the floor slab.

## 6.4 Garages, Driveways, Sidewalks and Interlocking Stone Pavement

Due to the high frost susceptibility of some of the underlying soils, heaving of the pavement is expected to occur during the cold weather. The driveways at the entrances to the garages should be backfilled with non-frost-susceptible granular material, with a frost taper at a slope of 1 vertical:1 horizontal. The garage floor slab and interior garage foundation walls must be insulated with 50-mm Styrofoam, or equivalent.

The outdoor structures in open areas should be designed to tolerate frost heave and the grading must be designed such that it directs runoff away from the structures.

Interlocking stone pavement and the sidewalks in areas which are sensitive to frost-induced ground movement, such as entrances, must be constructed on a free-draining, non-frost-susceptible granular material such as Granular ‘B’. It must extend to 0.3 to 1.2 m, depending on the degree of tolerance to ground movement, below the slab or pavement surface and be provided with positive drainage such as weeper subdrains connected to manholes or catch basins. Alternatively, the sidewalks and the interlocking stone pavement should be properly insulated with 50-mm Styrofoam, or equivalent, as approved by a geotechnical engineer.

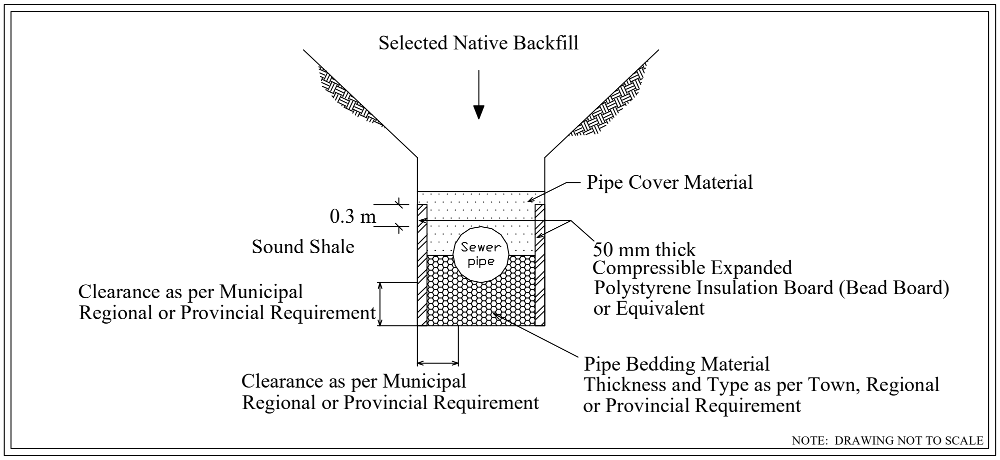
## 6.5 **Underground Services**

The subgrade for the underground services should consist of sound native soils or properly compacted inorganic earth fill. Depending on the depth, underground services construction may require excavation in shale.

A Class ‘B’ bedding is recommended for the underground services construction. The bedding material should consist of compacted 19-mm CRL, or equivalent, as approved by a geotechnical engineer. The bedding material must meet the requirements prescribed by the Ontario Provincial Standards (OPS), Region of Halton and Town of Oakville.

Where the pipe is to be placed in the sound shale bedrock, the trench sides should be slightly sloped rather than vertical due to the residual stress relief and the swelling characteristics of the shale. The side slopes should be no steeper than 2 vertical: 1 horizontal. The rock face can be lined with a cushioning layer such as Styrofoam, then backfilled with fine sand to 0.3 m above the crown of the pipe and flooded. The recommended scheme is illustrated in Diagram 1.

**Diagram 1** - Sewer Installation in Sound Shale



In order to prevent pipe flotation when the trench is deluged with water, an earth cover at least equal in thickness to the outside diameter of the pipe should be in place at all times after installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent blockage by silting.

Since the silty clay till have moderately high corrosivity to buried metal, the pipes should be protected against corrosion. In determining the mode of protection, an anode weight meeting the Municipality standard should be used.

## 6.6 Trench Backfilling

The on-site inorganic soils are suitable for trench backfill. However, they should be sorted free of large pieces (over 15 cm in size) of limy shale, rock slabs and shale fragments, or the large pieces must be broken into sizes suitable for structural compaction.

In normal construction practice, the problem areas of road settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. The lumpy clays and broken shale are generally difficult to compact in these close quarters; it is recommended that a sand backfill should be used and compacted using light equipment.

In the zone within 1.0 m below the underside of the granular base of the floor slab or pavement subgrade, the backfill should be compacted to at least 98% SPDD with the moisture content 2% to 3% drier than the optimum. In the lower zone, 95% SPDD is considered to be adequate. The lifts of each backfill layer should be limited to a thickness of 20 cm, or to a suitable thickness as determined by test strips to be carried out at the time of compaction.

One must be aware of possible consequences during trench backfilling and exercise caution as described below.

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in-situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing conditions, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as when the trench box is removed, or when the backfill consists of shale mixture. The above will invariably cause backfill settlement that may become evident within 1 to several years, depending on the depth of the trench which has been backfilled.
- In areas where the underground services construction is carried out during the winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to the final surfacing of the new pavement.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1 vertical: 1.5 + horizontal, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.
- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand. In a trench stabilized by a trench box, the void left after the removal of the box will be filled by the backfill. It is necessary to backfill this sector with sand, and the compacted backfill must be flooded for 1 day, prior to the placement of the backfill above this sector, i.e., in the upper slope trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of

the backfill in the upper section. In areas where groundwater movement is expected in the sand fill mantle, anti-seepage collars should be provided.

## 6.7 **Pavement Design**

The inorganic native soils are suitable for road subgrade. Knowing that the subgrade will consist predominantly of silty clay material, the recommended pavement designs for local residential roads without bus traffic meeting the standards from the Town of Oakville are provided in Table 4.

**Table 4** - Pavement Design

| Course | Thickness (mm) | OPS Specifications |
|---|---|---|
| Asphalt Surface | 40 | HL-3 |
| Asphalt Surface | 50 | HL-8 |
| Granular Base | 150 | Granular 'A' or equivalent |
| Granular Sub-base | 350 | Granular 'B' or equivalent |

In preparation of the subgrade, the subgrade surface should be proof-rolled; any soft subgrade, organics and deleterious materials should be subexcavated and replaced by organic-free earth fill or granular material compacted to at least 98% SPDD in lifts no more than 20 cm thick.

All the granular bases should be compacted to 100% of their maximum Standard Proctor dry density.

In order to prevent infiltrated precipitation from seeping into the granular bases, since this may inflict frost damage on the pavement, a swale or an intercept subdrain system should be installed along the perimeter where surface runoff may drain onto the pavement. In the paved areas, catch basins should be provided; they should drain into the storm sewer manholes through filter-sleeved weeper subdrains and be backfilled with free-draining granular material such as Granular 'B'. The invert of the subdrains should be at least 0.3 m beneath the underside of the granular sub-base and should be backfilled with free-draining granular material.

The subgrade will suffer a strength regression if water is allowed to saturate the mantle. The following measures should, therefore, be incorporated in the construction procedures and road design:

- If the road construction does not immediately follow the trench backfilling, the subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- Lot areas adjacent to the roads should be properly graded to prevent ponding of large amounts of water. Otherwise, the water will seep into the subgrade mantle and induce a regression of the subgrade strength with costly consequences for the pavement construction.
- In extreme cases during the wet seasons, the wet/weak subgrade can be replaced by compacted granular material. This can be assessed during construction.
- Fabric filter-encased curb subdrains will be required by the Town of Oakville.

## 6.8 Slope Stability Analysis

A valley slope was identified at the south limit of the property, which is the northern valley bank of Sixteen Mile Creek. The slope has an overall height of 20.0 to 24.0 m, measured from the bottom of slope to the top of slope, with gradients ranging from 1 vertical:0.77 to 1.63 horizontal.

Visual inspection of the slope at the time of the report preparation revealed that it is wooded and the ground is covered with leaves. Active erosion was noted at the south end of the investigated area where the edge of creek is at the bottom of slope. The creek was flowing at the time of inspection with an approximate width of 8.0 m.

At the locations for the slope, the investigation, based on the subsurface information collected from Boreholes 1 and 2, has disclosed that beneath a veneer of topsoil, the slope area is underlain by strata of silty sand till and silty clay till bedding onto shale bedrock at a depth of 6.0 m below the prevailing ground surface. The highest stabilized groundwater was recorded at El. 104.5 m by WSP in January 2017.

Seven cross-sections, Cross-Sections A-A to G-G, were selected for analysis to provide a comprehensive overview of the slope profile and condition. The locations of the cross-sections are shown on Drawing No. 3. The surface profile of each cross-section is interpreted from the contour lines shown on the topographic plan prepared by Rady-Pentek & Edward Surveying Limited. The subsurface profile is interpreted from the soil findings at Boreholes 1 and 2. The cross-sections of the existing slopes are shown on Drawing Nos. 4 to 10, inclusive.

The slope stability was analyzed using force-moment-equilibrium criteria of the Bishop Method and the soil strength parameters provided in Table 6, Section 6.9. Detail explanation on the soil strength parameters are provided in a Letter Report dated January 24, 2018 and was reviewed with the conservation authority.

In order to address the comment from the conservation authority, an elevated groundwater level of El. 105.5 m will be used for the slope stability analysis. It is our opinion that the water level is not anticipated to rise above El. 105.5 m due to the low permeable characteristics of the subsoil, even during the wet seasons. Infiltrated precipitation may, in places, be trapped in the soil fissures, and in the sand and silt layers embedded in the tills, rendering the occurrence of perched groundwater at shallower depths. Its yield, if any, will generally be limited and it will often dissipate in dry seasons. Thus, the water level in the analysis is reasonable and is on the conservative side, comparing to the recorded level in the monitoring wells.

The results of the analyses indicate that the Factor of Safety (FOS) for the existing slope at the locations of Cross-Sections A-A to G-G (excluding D-D) ranges from 1.058 to 1.280, which does not meet the Ontario Ministry of Natural Resources (OMNR) guideline requirement for active land use (minimum FOS of 1.3 against elevated groundwater level). The analytical result for Cross Section D-D yields a FOS of 1.689, meeting the OMNR guideline requirement. The results of the stability analyses for the existing condition of the slope are presented on Drawing Nos. 4 to 10, inclusive.

Stable slope gradients of 1 vertical:1.4 horizontal within the shale bedrock and 1 vertical: 1.7 to 2.0 horizontal within the silty sand till and silty clay till stratum are recommended to establish the LTSSL. Further, since the east section of the slope is located immediately next to the creek, and toe erosion was observed, a toe erosion allowance of 5.0 m in shale bedrock must be considered wherever the distance from the creek to the bottom of the slope is less than 5.0 m.

The remodelled slope incorporating the stable slope gradient with or without toe erosion allowance, depending on the distance between the creek and the bottom of slope, at Cross-Sections A-A to G-G (excluding D-D), yields a FOS ranging from 1.507 to 1.677, which satisfies the OMNR requirements. The results of the remodelled cross-sections are presented on Drawing Nos. 11 to 16, inclusive.

The resulting factors of safety against deep-seated failure are given in the Table 5.

**Table 5 -** Factors of Safety Against Slope Failure

| Cross-Section | Factor of Safety | |
|---|---|---|
| | **Existing Slope** | **Long-Term Stable Slope** |
| A-A* | 1.109 (Local); 1.288 (Global) | 1.547 |
| B-B | 1.135 (Local); 1.354 (Global) | 1.564 |
| C-C | 1.058 (Local); 1.340 (Global) | 1.567 |
| D-D | 1.689 | - |
| E-E | 1.228 (Local); 1.574 (Global) | 1.550 |
| F-F | 1.280 (Local); 1.582 (Global) | 1.677 |
| G-G* | 1.108 (Local); 1.357 (Global) | 1.507 |

The LTSSL, incorporating the specified stable gradient component and toe erosion allowance, is established and illustrated on Drawing No. 3.

A development setback for man-made and environmental degradation of the slope will be required. This is subject to the discretion of the Halton Region Conservation Authority.

In order to prevent the occurrence of localized surface slides and to enhance the stability of the slope, the following geotechnical constraints should be stipulated:

1. The prevailing vegetative cover must be maintained, since its extraction would deprive the slope of the rooting system that acts as reinforcement against soil erosion by weathering. If for any reason the vegetation cover is stripped, it must be reinstated to its original, or better than its original, protective condition.
2. The leafy topsoil cover on the slope face should not be disturbed, since this provides insulation and screen against frost wedging and rainwash erosion.
3. Grading of the land adjacent to the slope must be such that concentrated runoff is not allowed to drain onto the slope face. Landscaping features, which may cause runoff to pond at the top of the slope, such as infiltration trenches, as well as soil saturation at the tableland must not be permitted.
4. Where development is carried out near the top of the slope, there are other factors to be considered related to possible human environmental abuse. These include soil saturation from frequent watering to maintain of landscaping features, stripping of topsoil or vegetation, and dumping of loose fill and material storage close to the top of slope; none of these should be permitted.

## 6.9 Soil Parameters

The recommended soil parameters for the project design are given inTable 6.

**Table 6** - Soil Parameters

**Unit Weight and Bulk Factor**

|  | Bulk Unit Weight (kN/m$^3$) | Estimated Bulk Factor |  |
|---|---|---|---|
|  |  | Loose | Compacted |
| Earth Fill | 20.5 | 1.20 | 1.00 |
| Silty Clay Till | 22.0 | 1.33 | 1.03 |
| Silty Sand Till | 22.5 | 1.33 | 1.03 |
| Weathered Shale | 23.0 | 1.50 | 1.00 |

**Effective Cohesion and Internal Friction Angle**

|  | Effective Cohesion, c' (kPa) | Effective Internal Friction Angle, Φ' |
|---|---|---|
| Earth Fill | 0 | 26° |
| Silty Clay Till | 5 | 30° |
| Silty Sand Till | 2 | 31° |
| Weathered Shale | 20 | 40° |
| Shale | Impenetrable |  |

**Lateral Earth Pressure Coefficients**

|  | Active, $K_a$ | At Rest, $K_o$ | Passive, $K_p$ |
|---|---|---|---|
| Compacted Earth Fill/Silty Clay Till | 0.40 | 0.55 | 2.50 |
| Silty Sand Till | 0.33 | 0.45 | 3.00 |
| Shale Bedrock | 0.20 | 0.35 | 5.00 |

**Estimated Coefficient of Permeability (K) and Percolation Time (T)**

|  | K (cm/sec) | T (min/cm) |
|---|---|---|
| Silty Clay Till | $10^{-7}$ | Over 80 |
| Silty Sand Till | $10^{-4}$ to $10^{-5}$ | 12 to 20 |

**Estimated California Bearing Ratio**

|  |  |
|---|---|
| Silty Clay Till | Less than 3% |
| Silty Sand Till | 10% |

**Table 6** - Soil Parameters (cont'd)

| | |
|---|---|
| **Coefficients of Friction** | |
| Between Concrete and Granular Base | 0.50 |
| Between Concrete and Sound Native Soils | 0.35 |

## 6.10 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. For excavation purposes, the types of soils are classified in Table 7.

**Table 7** - Classification of Soils for Excavation

| Material | Type |
|---|---|
| Sound Shale Bedrock | 1 |
| Sound Tills and weathered Shale Bedrock | 2 |
| Existing Earth Fill and weathered Soils | 3 |

In shale bedrock, a cut steeper than 1 vertical:1 horizontal may be allowed, provided that the bedding plane of the rock is horizontal and loose rocks protruding from the excavation are removed for safety. The weathered shale or the hard and very dense tills containing boulders and shale fragments will require extra effort for excavation using mechanical means, and a rock-ripper will be required to facilitate the excavation. This method can generally be employed to excavate the weathered shale to a depth of 1.0 to 3.0 m below the bedrock surface. Efficient removal of the sound shale may require the aid of pneumatic hammering.

If groundwater is encountered in the clay till, the yield is expected to be small and limited, whereas in the silty sand till, it may be some to moderate. The shale bedrock is generally considered to be a poor aquifer; therefore, the yield from the bedrock, if encountered, will be limited. In some places, the fissures of the weathered shale contain pockets of groundwater which may sometimes be under moderate artesian pressure. Upon release through excavation, this water is expected to drain readily with continuous pumping from sumps.

## 7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Dunpar Developments Inc., for review by the designated consultants, financial institutions, and government agencies. The material in the report reflects the judgment of Kin Fung Li, P.Eng., and Yinglin Xiao, EIT., in light of the information available to it at the time of preparation.

Use of this report is subject to the conditions and limitations of the contractual agreement. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

**SOIL ENGINEERS LTD.**

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KFL/YX

LICENSED PROFESSIONAL ENGINEER
Dec 8, 2022
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PROVINCE OF ONTARIO

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Yinglin Xiao, EIT

# LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

## SAMPLE TYPES

| | |
|---|---|
| AS | Auger sample |
| CS | Chunk sample |
| DO | Drive open (split spoon) |
| DS | Denison type sample |
| FS | Foil sample |
| RC | Rock core (with size and percentage recovery) |
| ST | Slotted tube |
| TO | Thin-walled, open |
| TP | Thin-walled, piston |
| WS | Wash sample |

## PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—●—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

| | |
|---|---|
| WH | Sampler advanced by static weight |
| PH | Sampler advanced by hydraulic pressure |
| PM | Sampler advanced by manual pressure |
| NP | No penetration |

## SOIL DESCRIPTION

Cohesionless Soils:

| 'N' (blows/ft) | Relative Density |
|---|---|
| 0 to 4 | very loose |
| 4 to 10 | loose |
| 10 to 30 | compact |
| 30 to 50 | dense |
| over 50 | very dense |

Cohesive Soils:

| Undrained Shear Strength (ksf) | 'N' (blows/ft) | Consistency |
|---|---|---|
| less than 0.25 | 0 to 2 | very soft |
| 0.25 to 0.50 | 2 to 4 | soft |
| 0.50 to 1.0 | 4 to 8 | firm |
| 1.0 to 2.0 | 8 to 16 | stiff |
| 2.0 to 4.0 | 16 to 32 | very stiff |
| over 4.0 | over 32 | hard |

Method of Determination of Undrained Shear Strength of Cohesive Soils:

| | |
|---|---|
| x 0.0 | Field vane test in borehole; the number denotes the sensitivity to remoulding |
| △ | Laboratory vane test |
| ☐ | Compression test in laboratory |

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

## METRIC CONVERSION FACTORS

1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

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GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE

**JOB NO:** 1505-S135

# LOG OF BOREHOLE NO: 1

**FIGURE NO: 1**

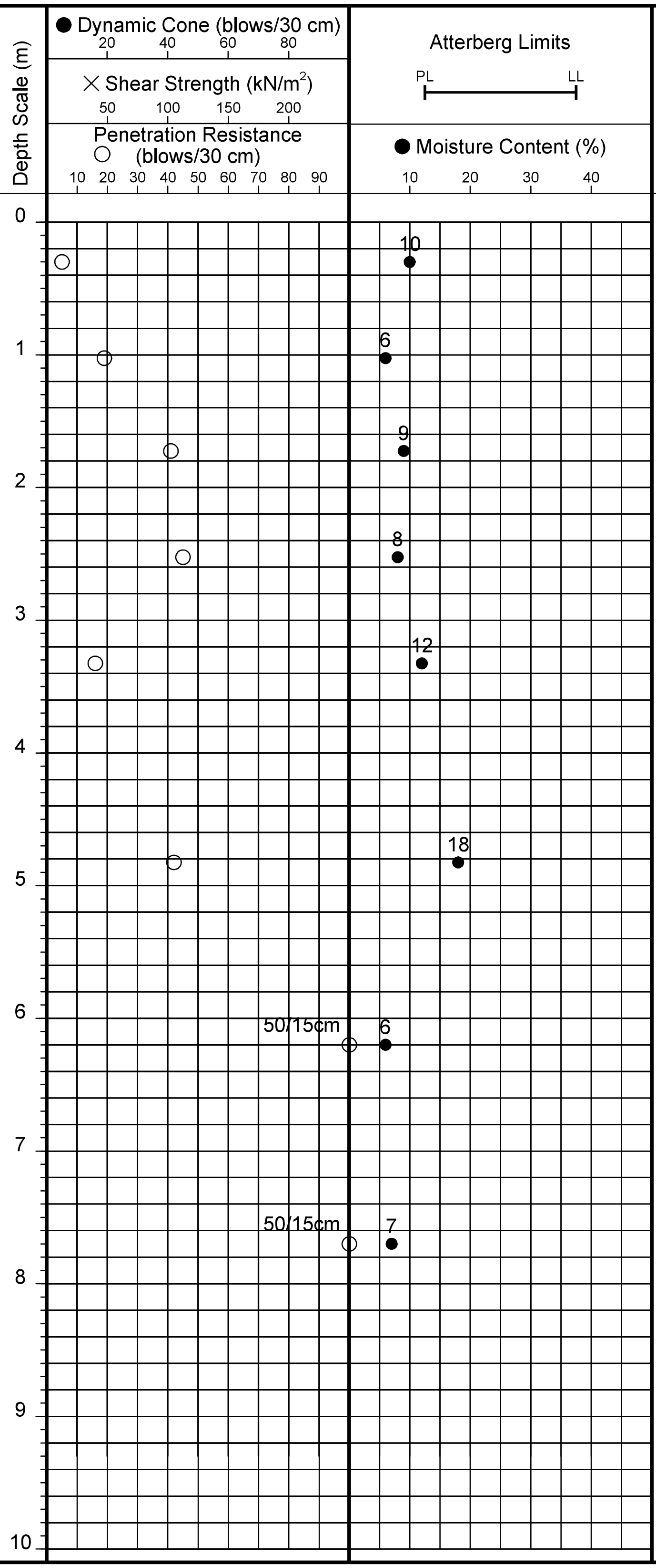
**JOB DESCRIPTION:** Proposed Residential Development

**JOB LOCATION:** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

**METHOD OF BORING:** Flight-Auger

**DATE:** June 11, 2015

| Depth<br>Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | Type | N-Value |
|---|---|---|---|---|
| 0.0 | Ground Surface | | | |
| 109.7 | **25 cm TOPSOIL** | | | |
| | Reddish-brown, loose to dense<br>**SILTY SAND, Till**<br>weathered<br>a trace to some gravel<br>occ. cobbles and boulders | 1 | DO | 5 |
| | | 2 | DO | 19 |
| | | 3 | DO | 41 |
| | | 4 | DO | 45 |
| 2.9<br>106.8 | Grey, very stiff to hard<br>**SILTY CLAY, Till**<br>some sand and gravel<br>occ. cobbles, boulders<br>and shale fragments | 5 | DO | 16 |
| | | 6 | DO | 42 |
| 6.0<br>103.7 | Reddish-brown, weathered<br>**SHALE BEDROCK** | 7 | DO | 50/15 |
| | | 8 | DO | 50/15 |
| 9.3<br>100.4 | **END OF BOREHOLE**<br>Auger refusal @ El. 100.4m | 9 | DO | NP |



WATER LEVEL

cave in @ EL. 102.1 m on completion

**Soil Engineers Ltd.**

***JOB NO:*** 1505-S135

# LOG OF BOREHOLE NO: 2

***FIGURE NO: 2***

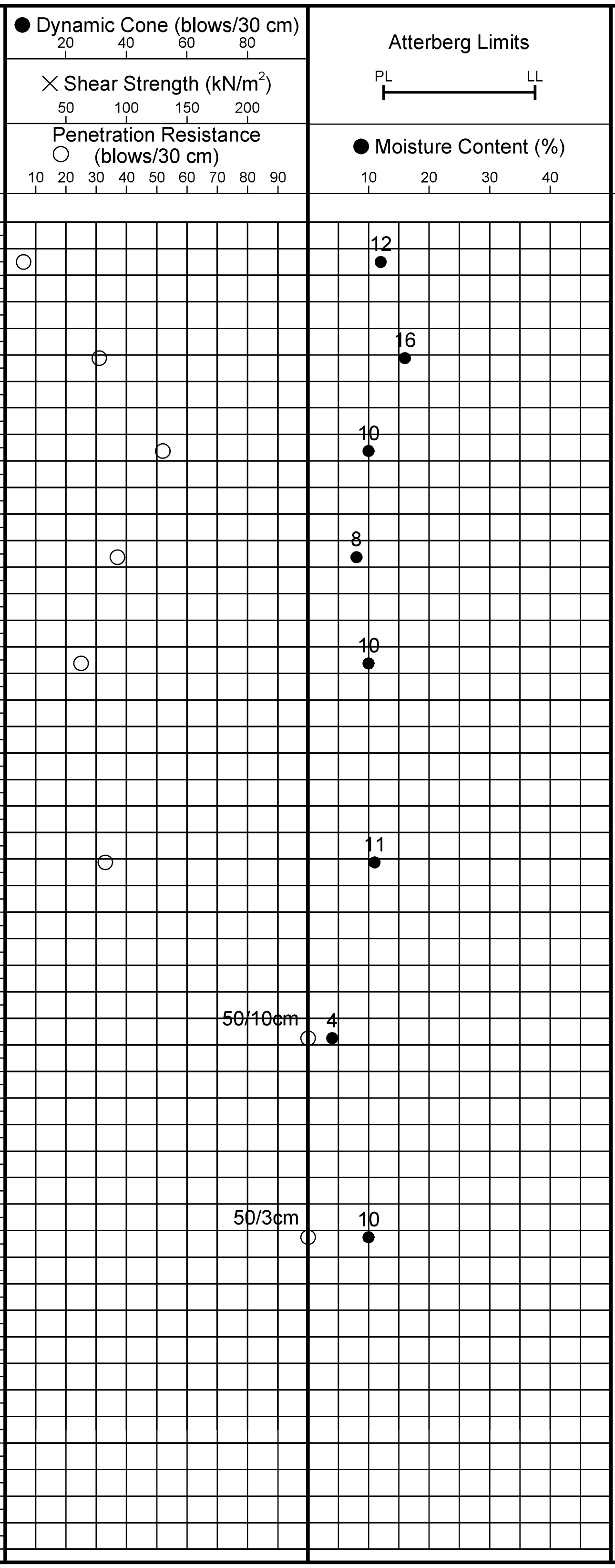
***JOB DESCRIPTION:*** Proposed Residential Development

***JOB LOCATION:*** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

***METHOD OF BORING:*** Flight-Auger

***DATE:*** June 11, 2015

| Depth<br>Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | Type | N-Value | Depth Scale (m) |
|---|---|---|---|---|---|
| 0.0 | Ground Surface | | | | 0 |
| 110.6 | **25 cm TOPSOIL** | | | | |
| | Redish-brown, loose to very dense<br>**SILTY SAND, Till**<br>some gravel<br>occ. cobbles and boulders<br>topsoil and rootlet inclusion to 1.0 m | 1 | DO | 6 | |
| | weathered | 2 | DO | 31 | 1 |
| | | 3 | DO | 52 | 2 |
| | shale fragments<br>sand pockets | 4 | DO | 37 | |
| 2.9<br>107.7 | Very stiff to hard<br>**SILTY CLAY, Till**<br>some sand and gravel<br>occ. cobbles, boulders<br>and shale fragments | 5 | DO | 25 | 3 |
| | brown<br>grey | | | | 4 |
| | | 6 | DO | 33 | 5 |
| 6.0<br>104.6 | Reddish-brown, weathered<br>**SHALE BEDROCK** | 7 | DO | 50/<br>10 | 6 |
| | | 8 | DO | 50/<br>3 | 7 |
| 9.1<br>101.5 | **END OF BOREHOLE**<br>Auger refusal @ El. 101.5m | 9 | DO | NP | 9 |



WATER LEVEL

cave in @ EL. 102.7 m on completion

**Soil Engineers Ltd.**

**JOB NO:** 1505-S135

# LOG OF BOREHOLE NO: 3

**FIGURE NO: 3**

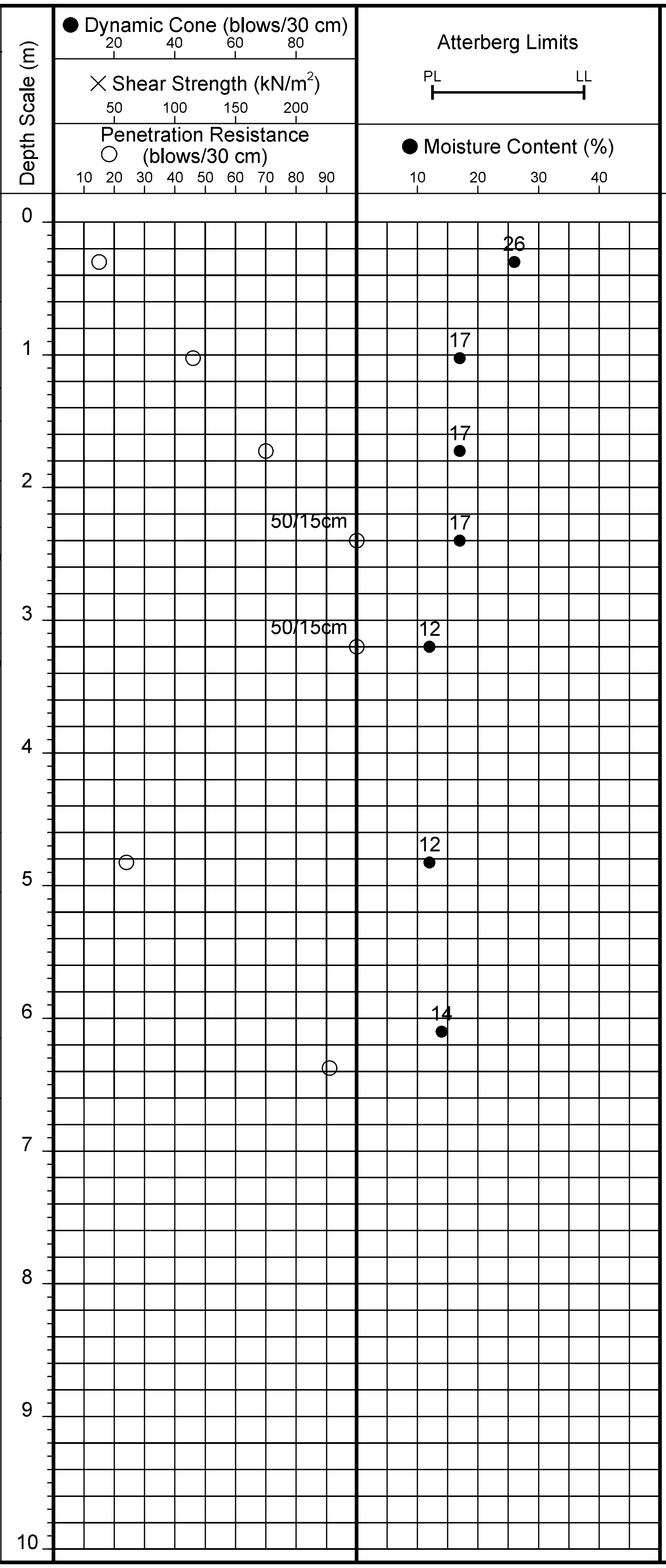
**JOB DESCRIPTION:** Proposed Residential Development

**JOB LOCATION:** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

**METHOD OF BORING:** Flight-Auger

**DATE:** June 15, 2015

| Depth<br>Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | Type | N-Value |
|---|---|---|---|---|
| 0.0 | Ground Surface | | | |
| 112.0 | **15 cm TOPSOIL** | | | |
| | Brown, compact to very dense<br>**SILTY SAND, Till**<br>some gravel to gravelly<br>occ. cobbles and boulders | 1 | DO | 15 |
| | weathered<br>rootlets | 2 | DO | 46 |
| | | 3 | DO | 70 |
| 2.2<br>109.8 | Very stiff to hard<br>**SILTY CLAY, Till**<br>some to gravelly<br>occ. cobbles, boulders<br>and shale fragments | 4 | DO | 50/<br>15 |
| | | 5 | DO | 50/<br>15 |
| | brown<br>grey | 6 | DO | 24 |
| | | 7 | DO | 91 |
| 6.6<br>105.4 | **END OF BOREHOLE** | | | |



WATER LEVEL

∇

W.L.@ EL. 107.8 m on completion
cave in @ EL. 107.5 m on cpmletion

**Soil Engineers Ltd.**

**JOB NO:** 1505-S135

# LOG OF BOREHOLE NO: 4

**FIGURE NO: 4**

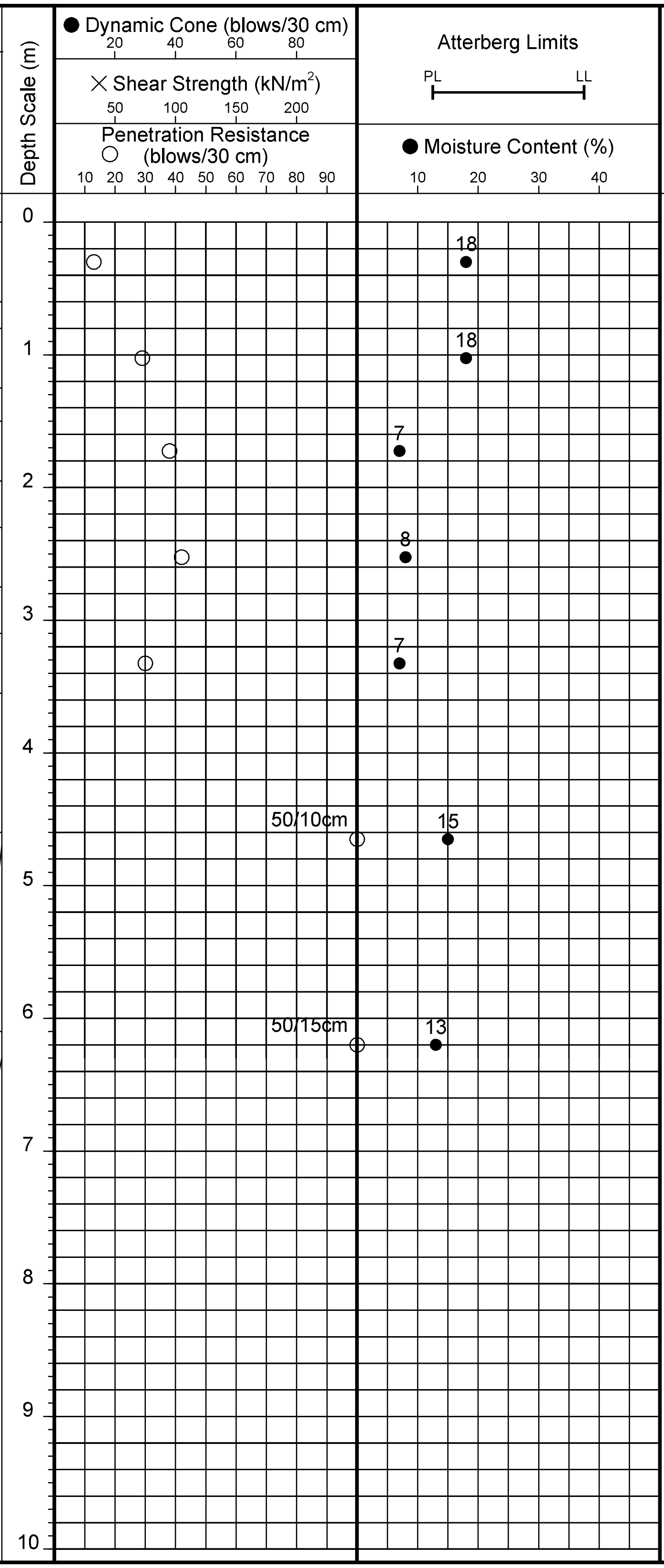
**JOB DESCRIPTION:** Proposed Residential Development

**JOB LOCATION:** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

**METHOD OF BORING:** Flight-Auger

**DATE:** June 15, 2015

| Depth<br>Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | Type | N-Value |
|---|---|---|---|---|
| 0.0 | Ground Surface | | | |
| 110.6 | **15 cm TOPSOIL** | | | |
| | Brown, compacted to dense<br>**SILTY SAND, Till**<br>some gravel to gravelly<br>occ. cobbles and boulders | 1 | DO | 13 |
| | weathered | 2 | DO | 29 |
| | | 3 | DO | 38 |
| | | 4 | DO | 42 |
| 2.9<br>107.7 | Very stiff to hard<br>**SILTY CLAY, Till**<br>a trace of gravel<br>occ. cobbles, boulders<br>and shale fragments | | | |
| | brown<br>grey | 5 | DO | 30 |
| | | 6 | DO | 50/<br>10 |
| 5.8<br>104.8 | Reddish-brown, weathered<br>**SHALE BEDROCK** | 7 | DO | 50/<br>15 |
| 6.3<br>104.3 | **END OF BOREHOLE** | | | |



WATER LEVEL ▼

W.L. and cave in @ EL. 108.1 m on completion

**Soil Engineers Ltd.**

***JOB NO:*** 1505-S135

# LOG OF BOREHOLE NO: 5

***FIGURE NO: 5***

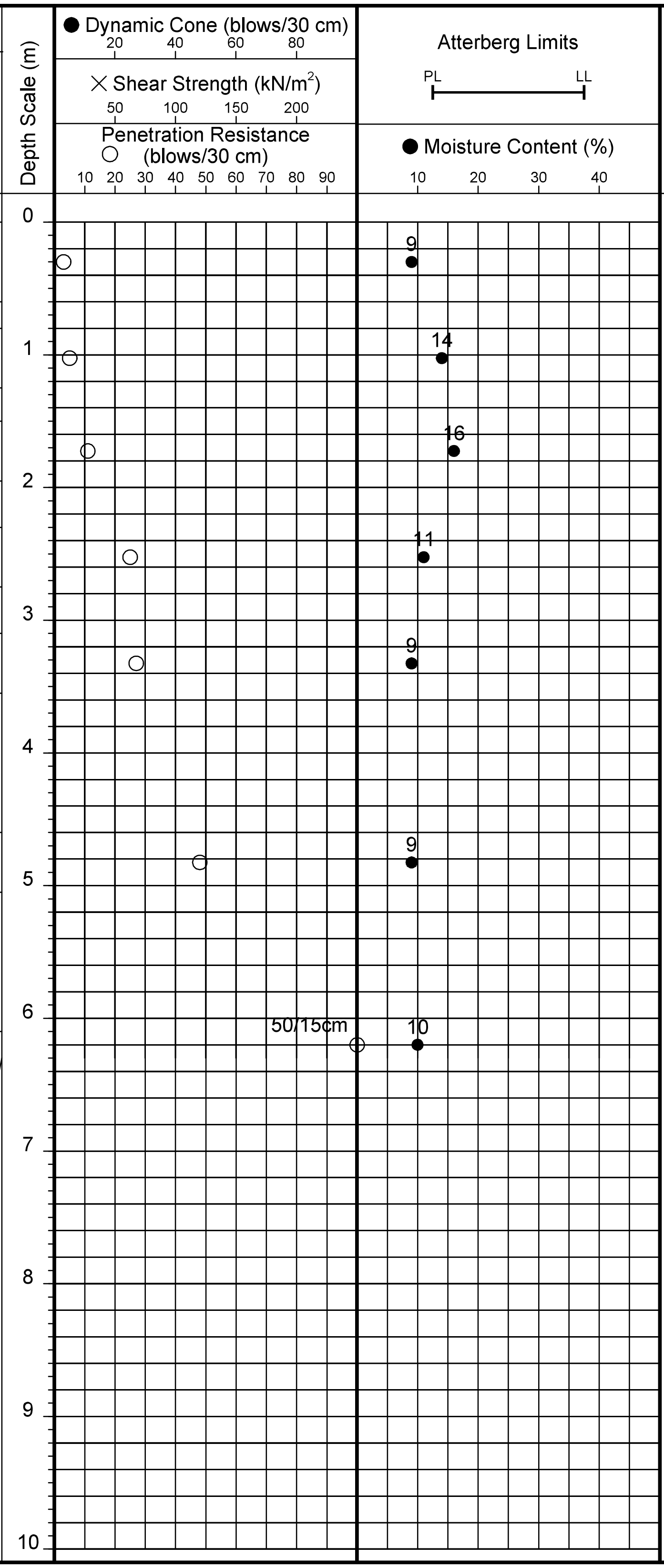
***JOB DESCRIPTION:*** Proposed Residential Development

***JOB LOCATION:*** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

***METHOD OF BORING:*** Flight-Auger

***DATE:*** June 11, 2015

| Depth Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | SAMPLES Type | SAMPLES N-Value |
|---|---|---|---|---|
| 0.0 | Ground Surface | | | |
| 109.6 | **30 cm TOPSOIL** | | | |
| | Redish-brown, very loose to compact, weathered<br>**EARTH Fill**<br>silty sand with some gravel occ. cobbles and topsoil and rootlet inclusions | 1 | DO | 3 |
| | | 2 | DO | 5 |
| | | 3 | DO | 11 |
| 2.1<br>107.5 | Very stiff to hard<br>**SILTY CLAY, Till**<br>a trace of gravel occ. cobbles, boulders and shale fragments<br>reddish-brown / brown<br>sand pockets | 4 | DO | 25 |
| | | 5 | DO | 27 |
| | brown / grey | 6 | DO | 48 |
| 5.5<br>104.1 | Reddish-brown, weathered<br>**SHALE BEDROCK** | 7 | DO | 50/15 |
| 6.3<br>103.3 | **END OF BOREHOLE** | | | |



WATER LEVEL

Dry upon completion

**Soil Engineers Ltd.**

**JOB NO:** 1505-S135

# LOG OF BOREHOLE NO: 6

**FIGURE NO: 6**

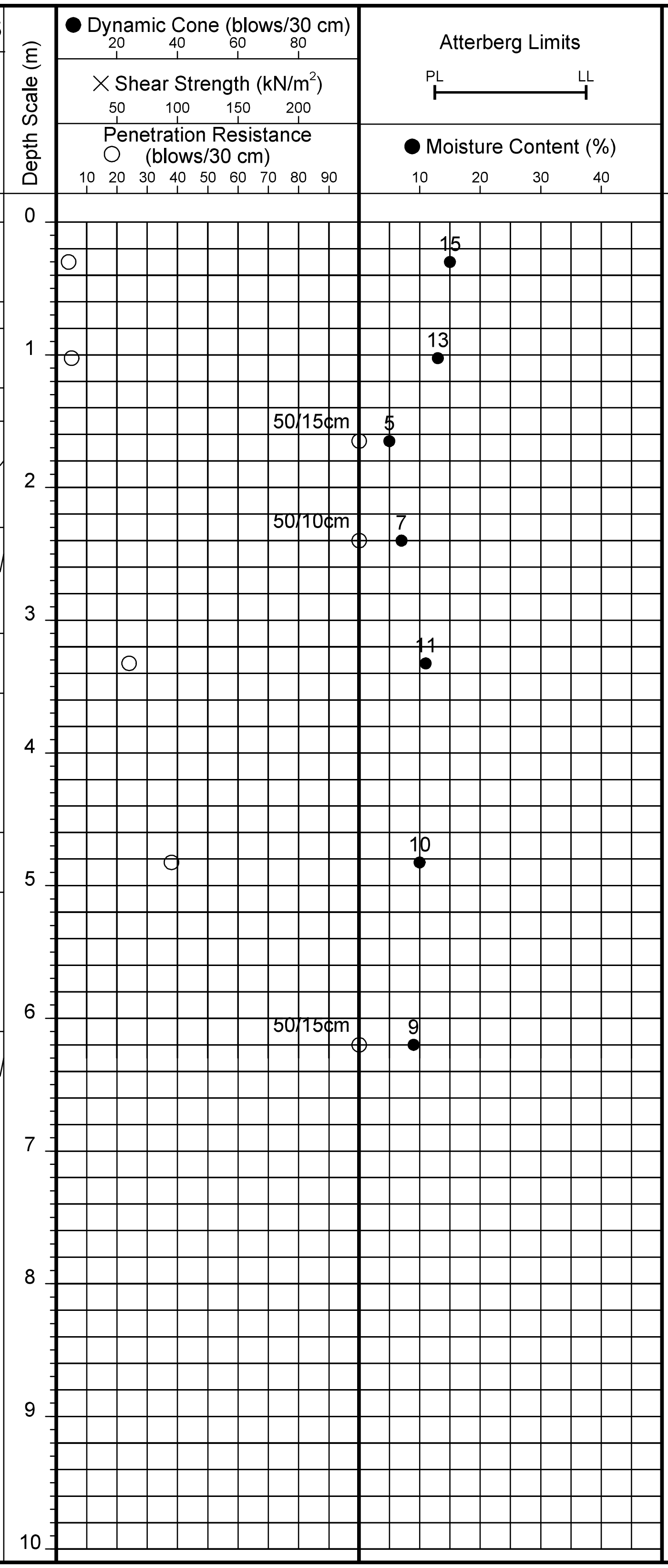
**JOB DESCRIPTION:** Proposed Residential Development

**JOB LOCATION:** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

**METHOD OF BORING:** Flight-Auger

**DATE:** June 11, 2015

| Depth<br>Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | Type | N-Value |
|---|---|---|---|---|
| 0.0 | Ground Surface | | | |
| 109.6 | Brown<br>**EARTH Fill**<br>silty clay with some sand and gravel occ. topsoil and rootlets inclusions | 1<br>2 | DO<br>DO | 4<br>5 |
| 1.4<br>108.2 | Brown, very dense<br>**SILTY SAND, Till**<br>some gravel to gravelly occ. cobbles and boulders | 3<br>4 | DO<br>DO | 50/15<br>50/10 |
| 2.9<br>106.7 | Grey, very stiff to hard<br>**SILTY CLAY, Till**<br>a trace of gravel occ. cobbles, boulders and shale fragments | 5<br>6 | DO<br>DO | 24<br>38 |
| 5.5<br>104.1 | Reddish-brown, weathered<br>**SHALE BEDROCK** | 7 | DO | 50/15 |
| 6.3<br>103.3 | **END OF BOREHOLE** | | | |



WATER LEVEL

∇

cave in @ EL. 104.1 m on completion

**Soil Engineers Ltd.**

***JOB NO:*** 1505-S135

# LOG OF BOREHOLE NO: 7

***FIGURE NO: 7***

***JOB DESCRIPTION:*** Proposed Residential Development

***JOB LOCATION:*** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

***METHOD OF BORING:***

***DATE:***

| Depth<br>Elev.<br>(m) | SOIL DESCRIPTION | SAMPLES<br>Number | SAMPLES<br>Type | SAMPLES<br>N-Value | Depth Scale (m) | ● Dynamic Cone (blows/30 cm) 20 40 60 80<br>× Shear Strength (kN/m²) 50 100 150 200<br>Penetration Resistance ○ (blows/30 cm) 10 20 30 40 50 60 70 80 90 | Atterberg Limits PL LL<br>● Moisture Content (%) 10 20 30 40 | WATER LEVEL |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Surface | | | | | | | |
| 0.0 | Borehole not drilled due access issue with property owner<br>**END OF BOREHOLE** | | | | 0 | | | |
| | | | | | 1 | | | |
| | | | | | 2 | | | |
| | | | | | 3 | | | |
| | | | | | 4 | | | |
| | | | | | 5 | | | |
| | | | | | 6 | | | |
| | | | | | 7 | | | |
| | | | | | 8 | | | |
| | | | | | 9 | | | |
| | | | | | 10 | | | |

**JOB NO:** 1505-S135

# LOG OF BOREHOLE NO: 8

**FIGURE NO: 8**

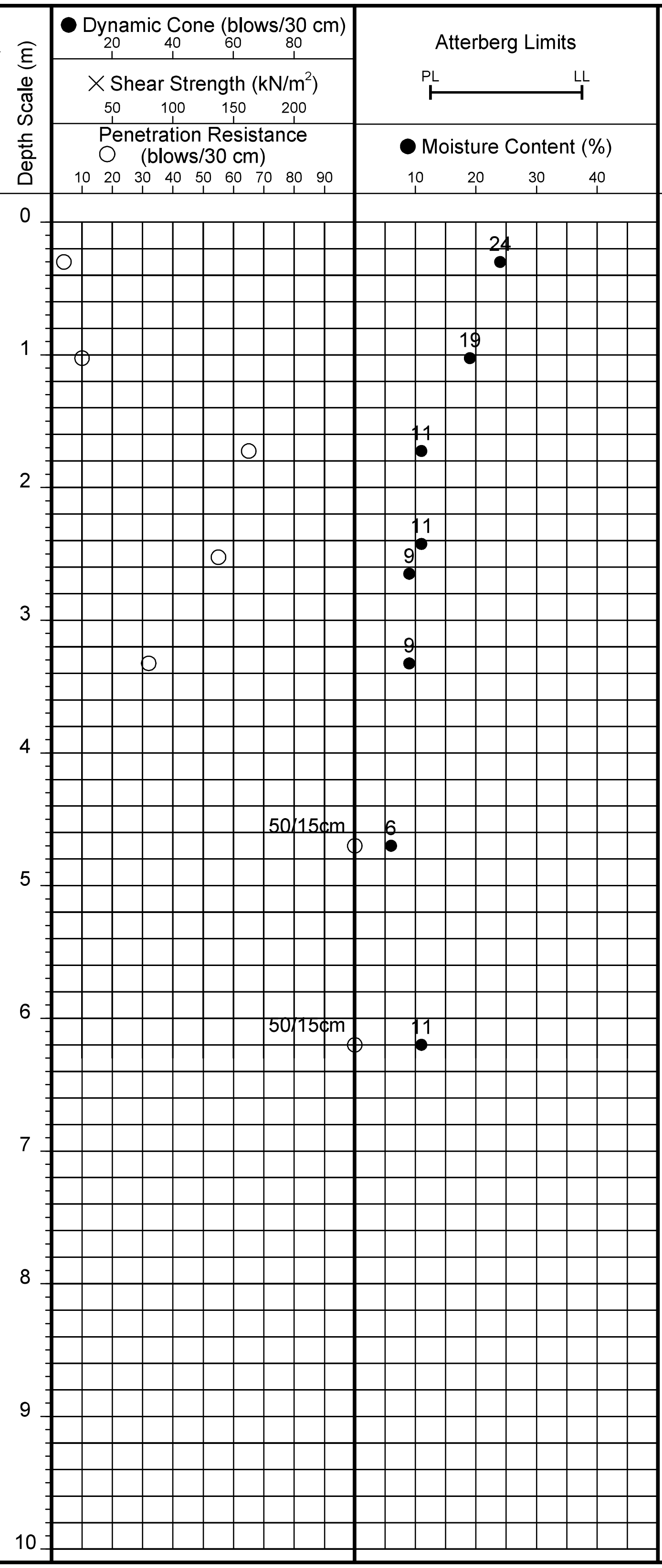
**JOB DESCRIPTION:** Proposed Residential Development

**JOB LOCATION:** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

**METHOD OF BORING:** Flight-Auger

**DATE:** June 15, 2015

| Depth<br>Elev.<br>(m) | SOIL DESCRIPTION | SAMPLES Number | SAMPLES Type | SAMPLES N-Value |
|---|---|---|---|---|
| 0.0<br>109.2 | Ground Surface<br>**15 cm TOPSOIL Fill** | | | |
| | Brown<br>**EARTH Fill**<br>silty clay with some sand and gravel<br>occ. topsoil and rootlets inclusions | 1 | DO | 4 |
| | | 2 | DO | 10 |
| 1.4<br>107.8 | Hard<br>**STILTY CLAY, Till**<br>some gravel<br>occ. cobbles, boulders<br>and shale fragments | 3 | DO | 65 |
| | reddish-brown | 4A | DO | 55 |
| | grey | 4B | | |
| | | 5 | DO | 32 |
| | | 6 | DO | 50/<br>15 |
| 5.5<br>103.7 | Reddish-brown, weathered<br>**SHALE BEDROCK** | 7 | DO | 50/<br>15 |
| 6.3<br>102.9 | **END OF BOREHOLE** | | | |



WATER LEVEL

Dry upon completion

**JOB NO:** 1505-S135

# LOG OF BOREHOLE NO: 9

**FIGURE NO: 9**

**JOB DESCRIPTION:** Proposed Residential Development

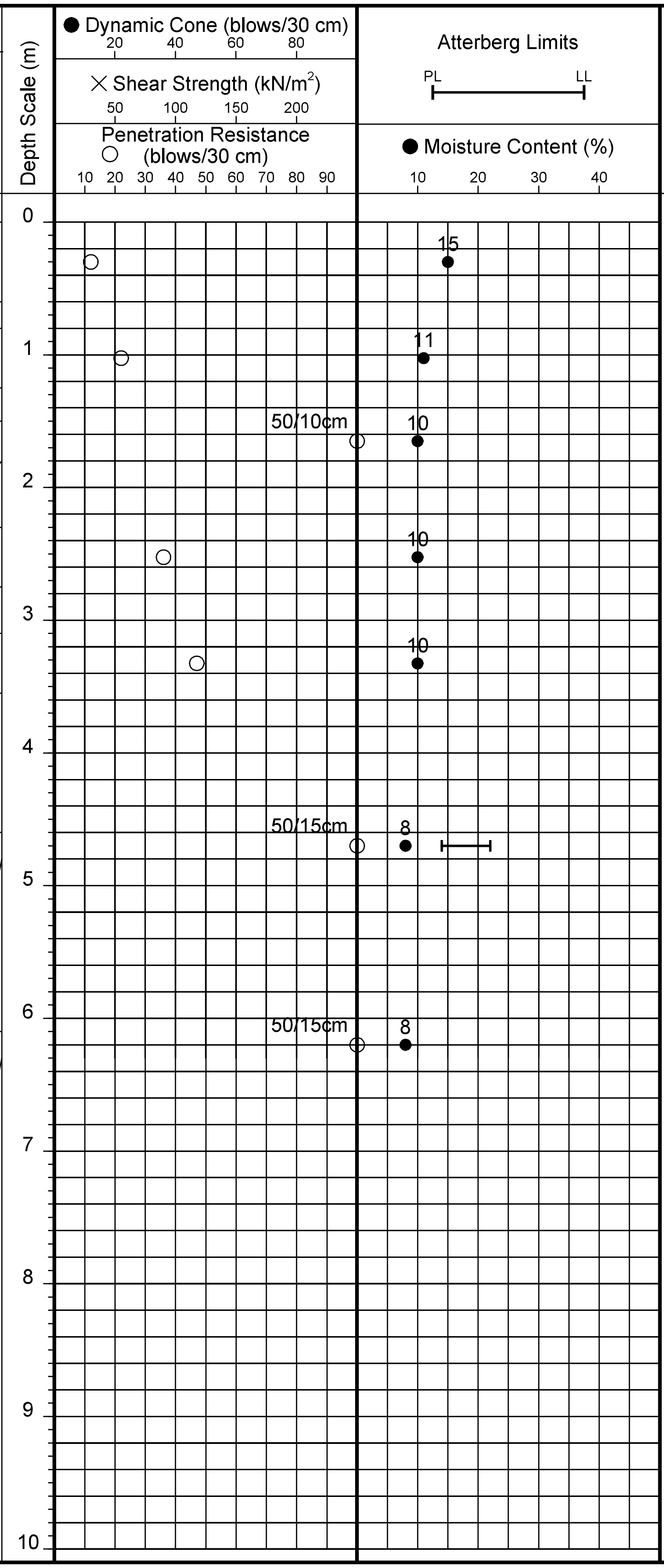
**JOB LOCATION:** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

**METHOD OF BORING:** Flight-Auger

**DATE:** June 15, 2015

| Depth<br>Elev. (m) | SOIL DESCRIPTION |
|---|---|
| 0.0 | Ground Surface |
| 109.4 | **15 cm TOPSOIL Fill** |
| | Brown<br>**EARTH Fill**<br>silty clay with some sand and gravel<br>occ. topsoil and rootlets inclusions |
| 1.4<br>108.0 | Hard<br>**STILTY CLAY, Till**<br>some gravel<br>occ. cobbles, boulders<br>and shale fragments<br>reddish-brown<br>grey |
| 5.8<br>103.6 | Reddish-brown, weathered<br>**SHALE BEDROCK** |
| 6.3<br>103.1 | **END OF BOREHOLE** |

| SAMPLES Number | Type | N-Value |
|---|---|---|
| 1 | DO | 12 |
| 2 | DO | 22 |
| 3 | DO | 50/10 |
| 4 | DO | 36 |
| 5 | DO | 47 |
| 6 | DO | 50/15 |
| 7 | DO | 50/15 |



WATER LEVEL

Dry upon completion

**Soil Engineers Ltd.**

***JOB NO:*** 1505-S135

# LOG OF BOREHOLE NO: 10

***FIGURE NO: 10***

***JOB DESCRIPTION:*** Proposed Residential Development

***JOB LOCATION:*** 1020, 1024, 1028, 1032, and 1042 Sixth Line, Town of Oakville

***METHOD OF BORING:***

***DATE:***

| Depth<br>Elev. (m) | SOIL DESCRIPTION | SAMPLES Number | SAMPLES Type | SAMPLES N-Value | Depth Scale (m) | ● Dynamic Cone (blows/30 cm) 20 40 60 80<br>× Shear Strength (kN/m$^2$) 50 100 150 200<br>○ Penetration Resistance (blows/30 cm) 10 20 30 40 50 60 70 80 90 | Atterberg Limits PL ⊢—⊣ LL<br>● Moisture Content (%) 10 20 30 40 | WATER LEVEL |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Surface | | | | | | | |
| 0.0 | Borehole not drilled due access issue with property owner<br>**END OF BOREHOLE** | | | | 0 | | | |
| | | | | | 1 | | | |
| | | | | | 2 | | | |
| | | | | | 3 | | | |
| | | | | | 4 | | | |
| | | | | | 5 | | | |
| | | | | | 6 | | | |
| | | | | | 7 | | | |
| | | | | | 8 | | | |
| | | | | | 9 | | | |
| | | | | | 10 | | | |

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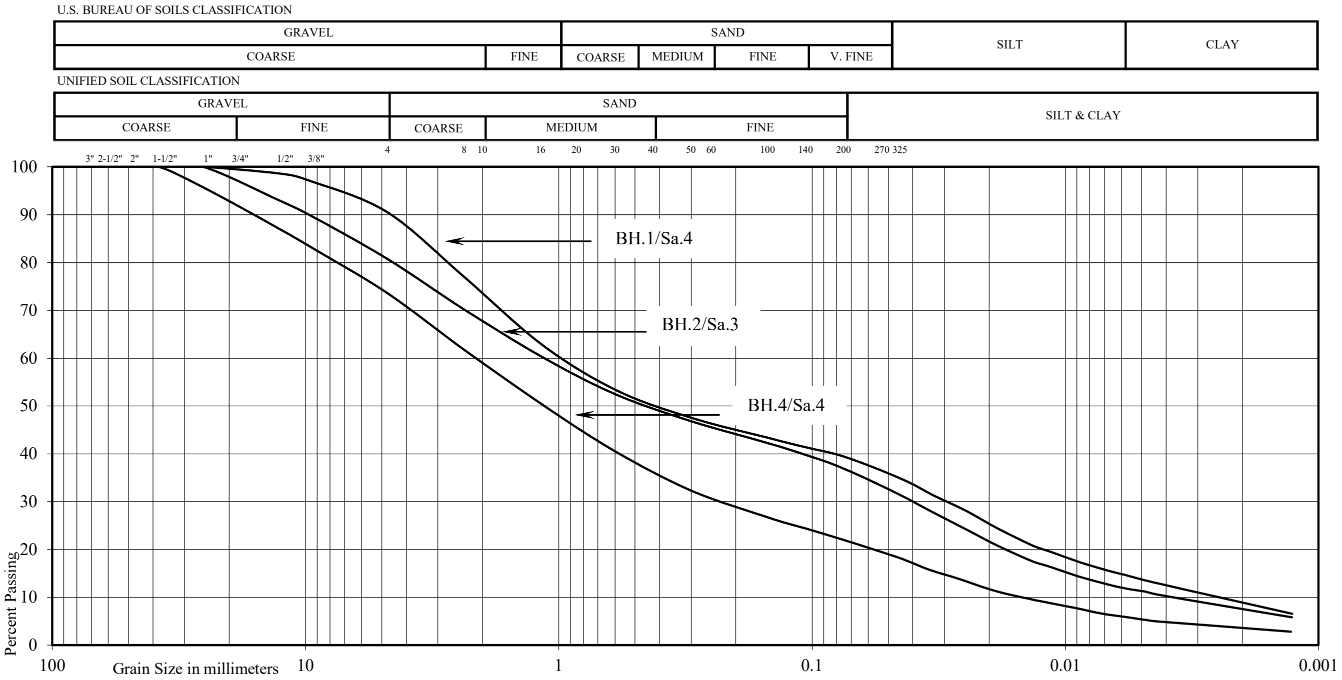
# GRAIN SIZE DISTRIBUTION

Reference No: 1505-S135



Project: Proposed Residential Development

Location: 1020, 1024, 1028, 1032 and 1042 6th Line, Town of Oakville

| | | | |
|---|---|---|---|
| Borehole No: | 1 | 2 | 4 |
| Sample No: | 4 | 3 | 4 |
| Depth (m): | 2.5 | 1.7 | 2.5 |
| Elevation (m): | 107.2 | 108.9 | 108.1 |

| BH./Sa. | 1/4 | 2/3 | 4/4 |
|---|---|---|---|
| Liquid Limit (%) = | - | - | - |
| Plastic Limit (%) = | - | - | - |
| Plasticity Index (%) = | - | - | - |
| Moisture Content (%) = | 8 | 10 | 8 |
| Estimated Permeability (cm./sec.) = | $10^{-5}$ | $10^{-5}$ | $10^{-4}$ |

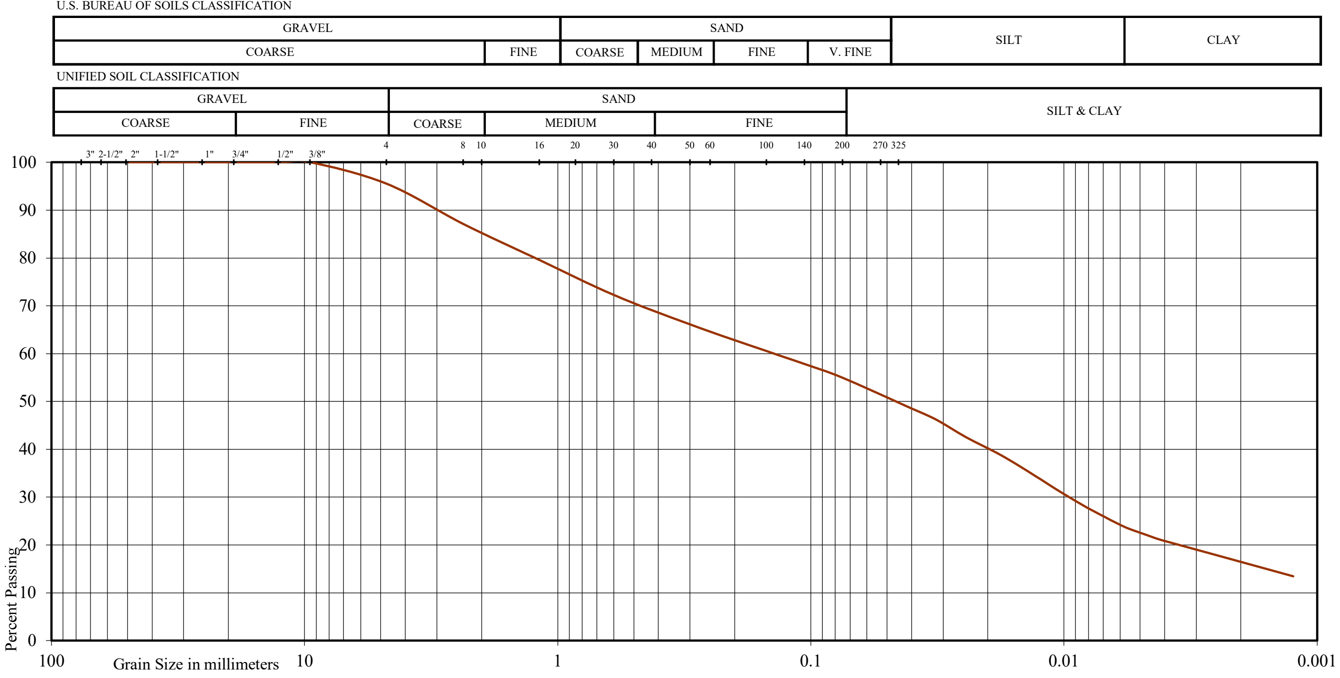
Classification of Sample [& Group Symbol]: SILTY SAND, Till
a tr. to some gravel, some silt and a tr. of clay

Figure: 11

**Soil Engineers Ltd.**

# GRAIN SIZE DISTRIBUTION

Reference No: 1505-S135



Project: Proposed Residential Development

Location: 1020, 1024, 1028, 1032 and 1042 6th Line, Town of Oakville

Liquid Limit (%) = 22

Plastic Limit (%) = 14

Borehole No: 9

Plasticity Index (%) = 8

Sample No: 5

Moisture Content (%) = 10

Depth (m): 3.3

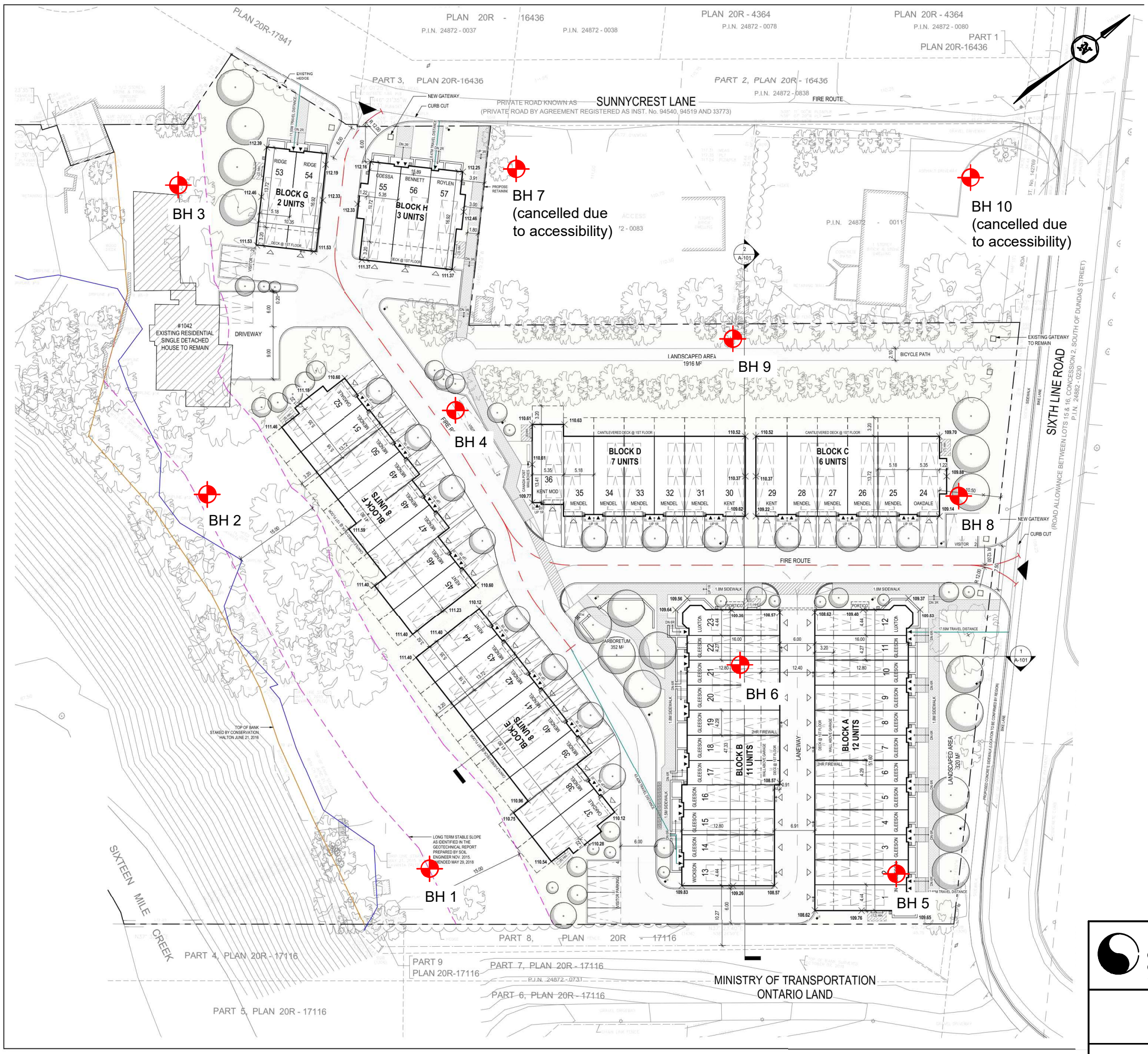
Estimated Permeability

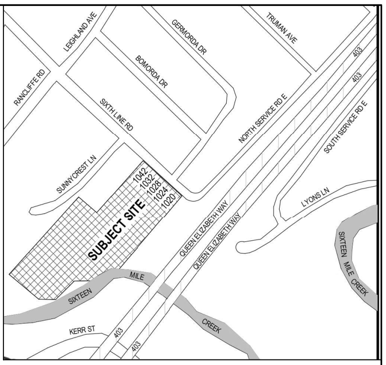
Elevation (m): 106.1

(cm./sec.) = $10^{-7}$

Classification of Sample [& Group Symbol]: SILTY CLAY, Till
sandy, a tr. of gravel

Figure: 12





Key Plan (N.T.S)

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## Borehole Location Plan

**SITE:** 1020, 1024, 1028, 1032, and 1042 6th Line, Town of Oakville

| | | | |
|---|---|---|---|
| **DESIGNED BY:** X.Y, | **CHECKED BY:** K.L. | **DWG NO.:** 1 | |
| **SCALE:** 1:1000 | **REF. NO.:** 1505-S135 | **DATE:** November 2022 | **REV** - |

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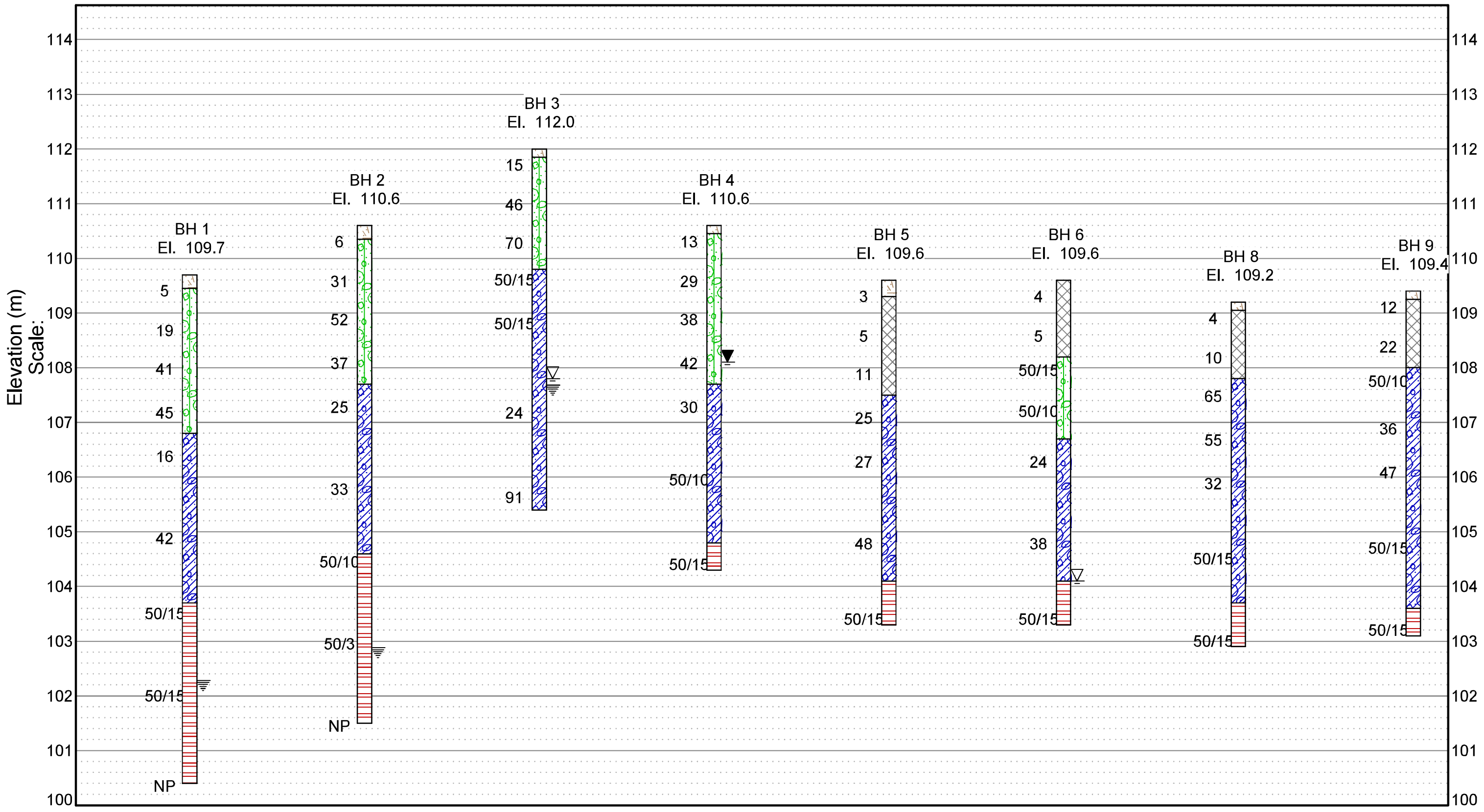
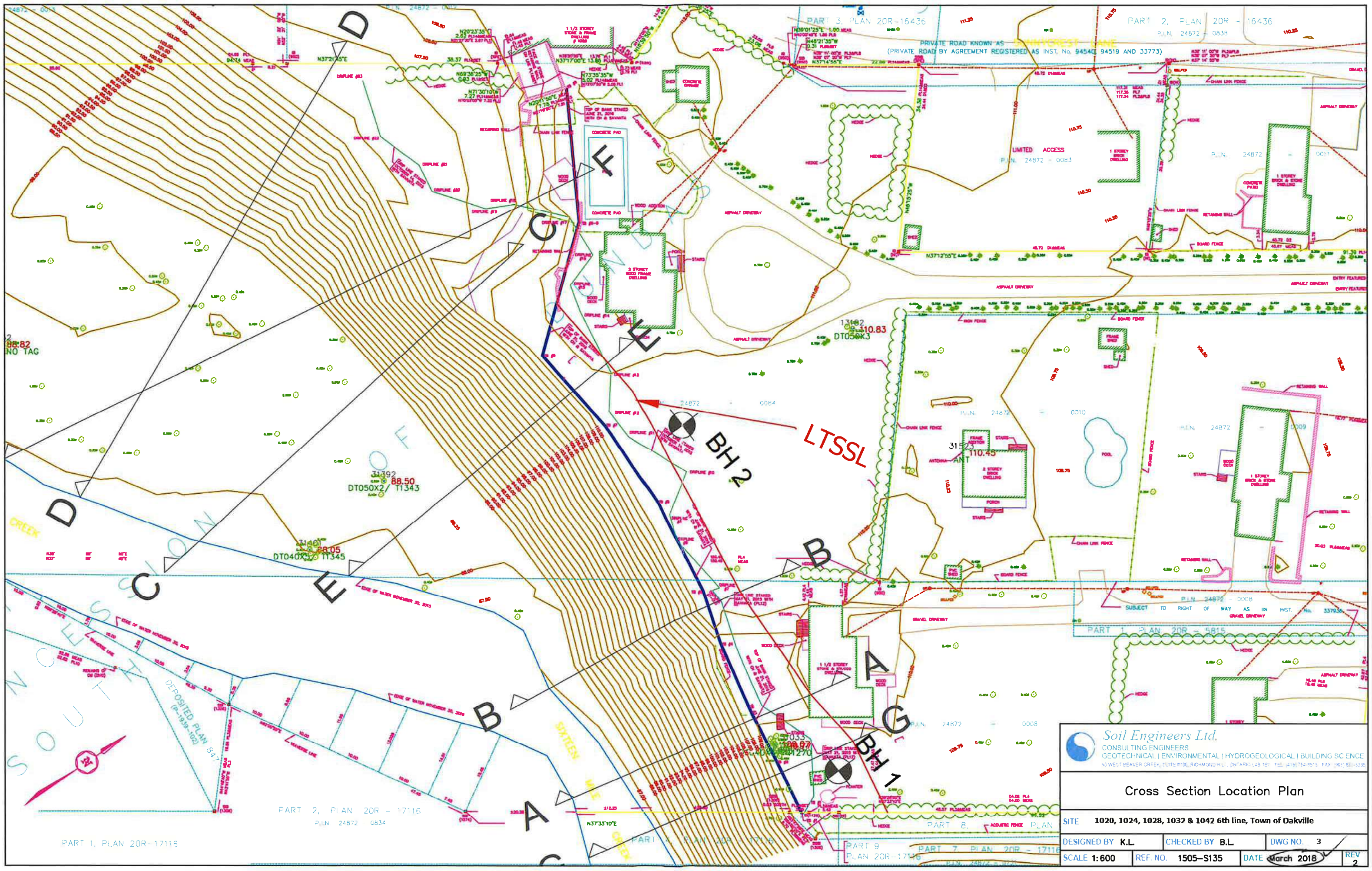
# SUBSURFACE PROFILE
## DRAWING NO.: 2
## SCALE: AS SHOWN

**JOB NUMBER:** 1505-S135
**REPORT DATE:** November 2015
**JOB LOCATION:** 1020, 1024, 1028, 1032 & 1042 6th Line,
Town of Oakville
**JOB DESCRIPTION:** Proposed Residential Development

**LEGEND**

- ▽ Water Level (End of Drilling)
- ≡ Cave-In
- ▼ Water Level (Stabilized)
- ▨ Topsoil/Topsoil Fill
- ▨ Silty Sand Till
- ▨ Silty Clay Till
- ▤ Shale
- ▩ Fill





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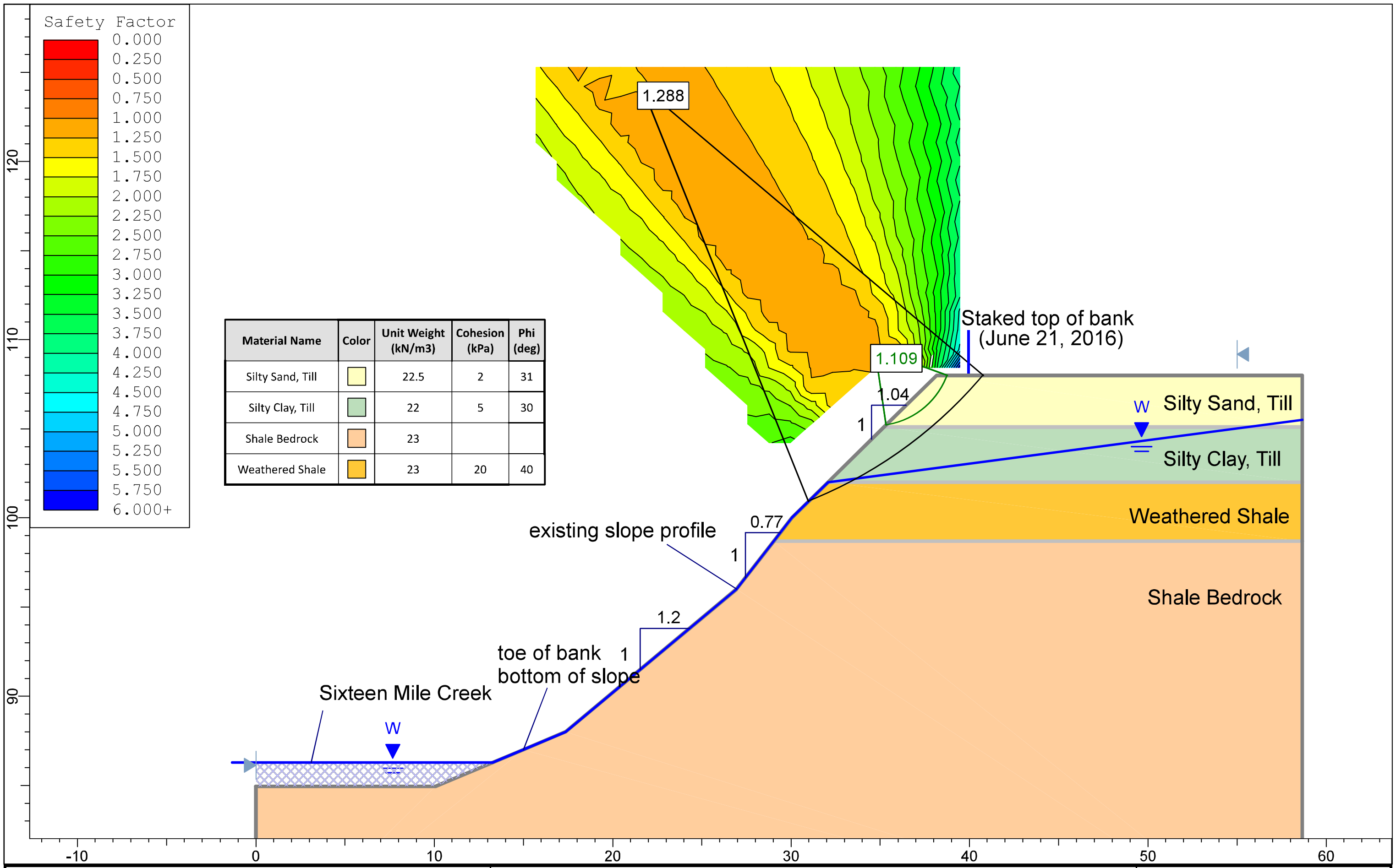
## Cross Section Location Plan

| | | | | | |
|---|---|---|---|---|---|
| SITE | 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville | | | | |
| DESIGNED BY K.L. | | CHECKED BY B.L. | | DWG NO. 3 | |
| SCALE 1:600 | REF. NO. 1505–S135 | | DATE March 2018 | | REV 2 |



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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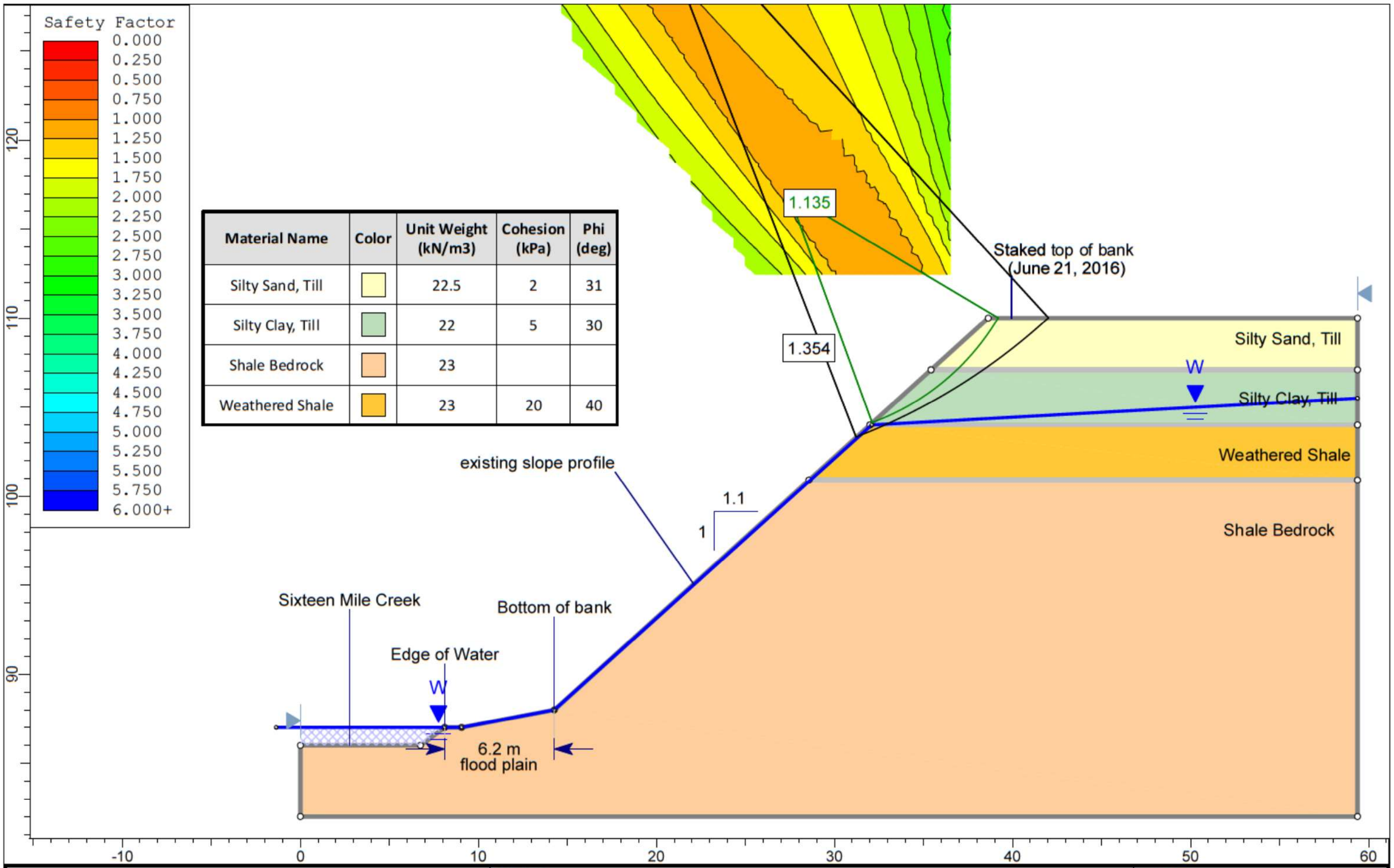
Project Title
Slope Stability Analysis - Cross Section A-A

Load Case
Existing Slope

Location
1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville

Drawn By KL
Checked By BL
Scale 1:300
Revision -
Date November 2017
Reference No. 1505-S135
Drawing No. 4



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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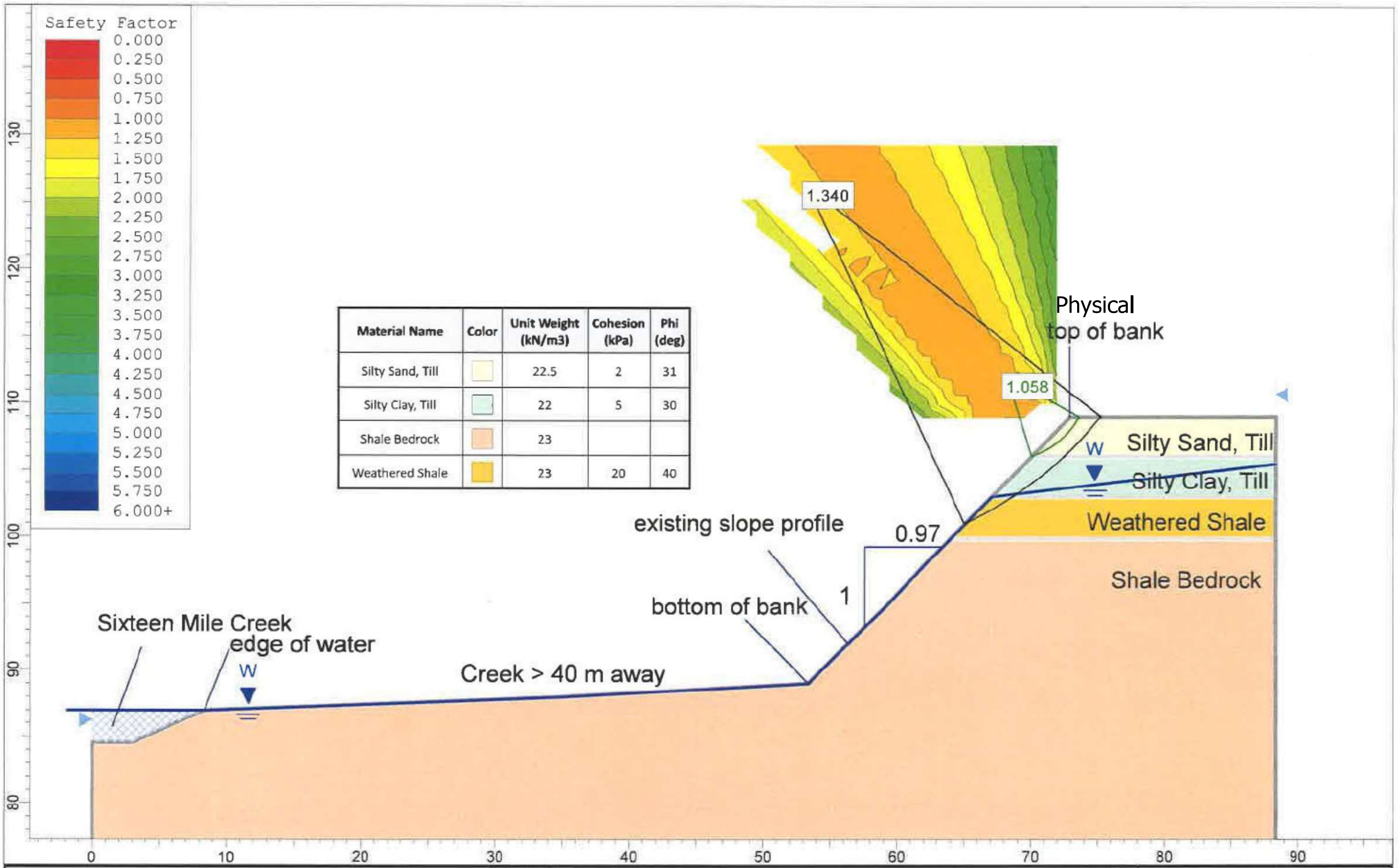
Project Title: Slope Stability Analysis - Cross Section B-B
Load Case: Exisiting Slope
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: KL
Checked By: BL
Scale: 1:300
Revision: -
Date: November 2017
Reference No.: 1505-S135
Drawing No.: 5



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | ⬜ | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟦 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟨 | 23 | 20 | 40 |

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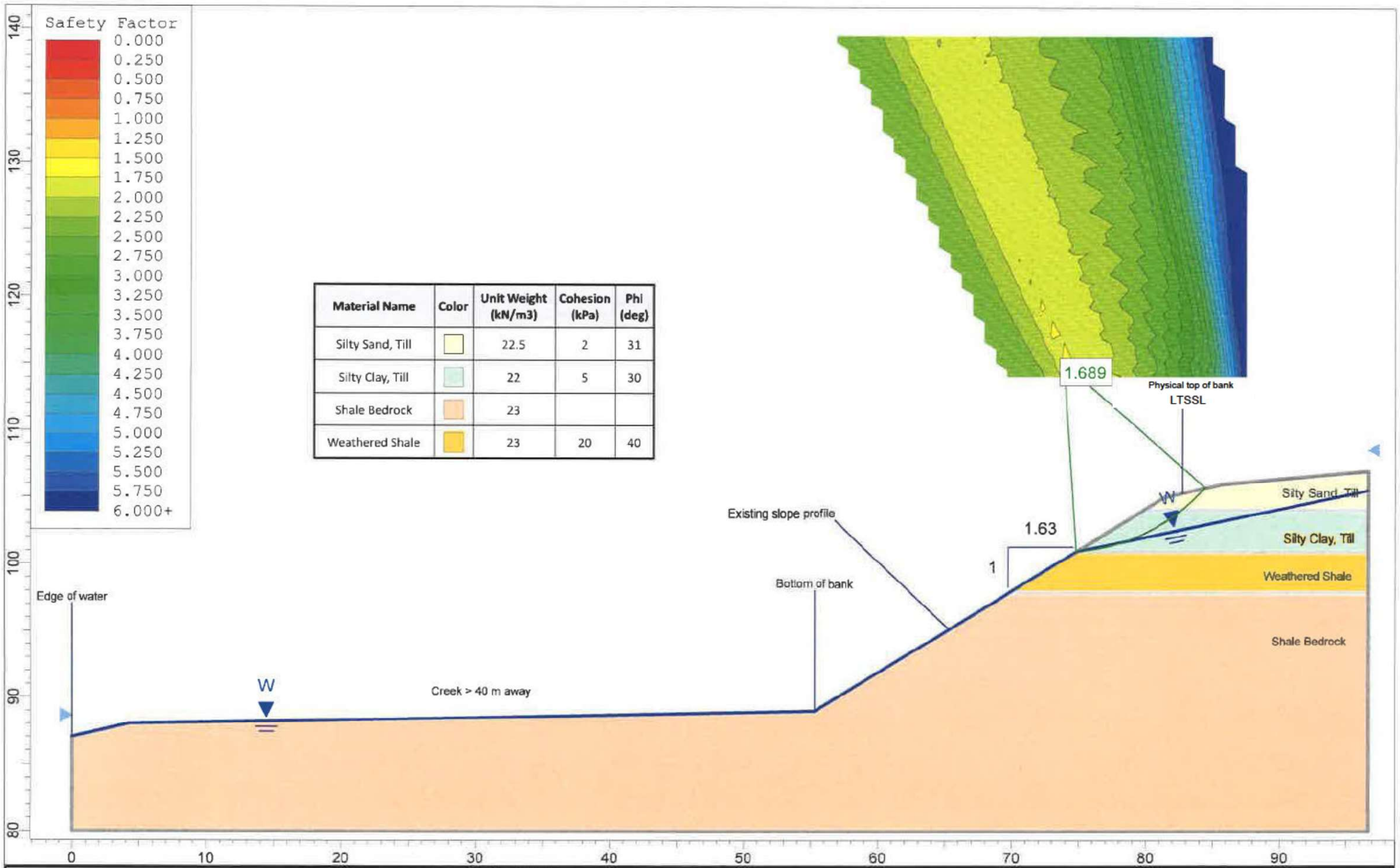
Project Title: Slope Stability Analysis - Cross Section C-C
Load Case: Exisiting Slope
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: PH
Checked By: BL
Scale: 1:400
Revision: -
Date: November 2017
Reference No.: 1505-S135
Drawing No.: 6



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟦 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟨 | 23 | 20 | 40 |

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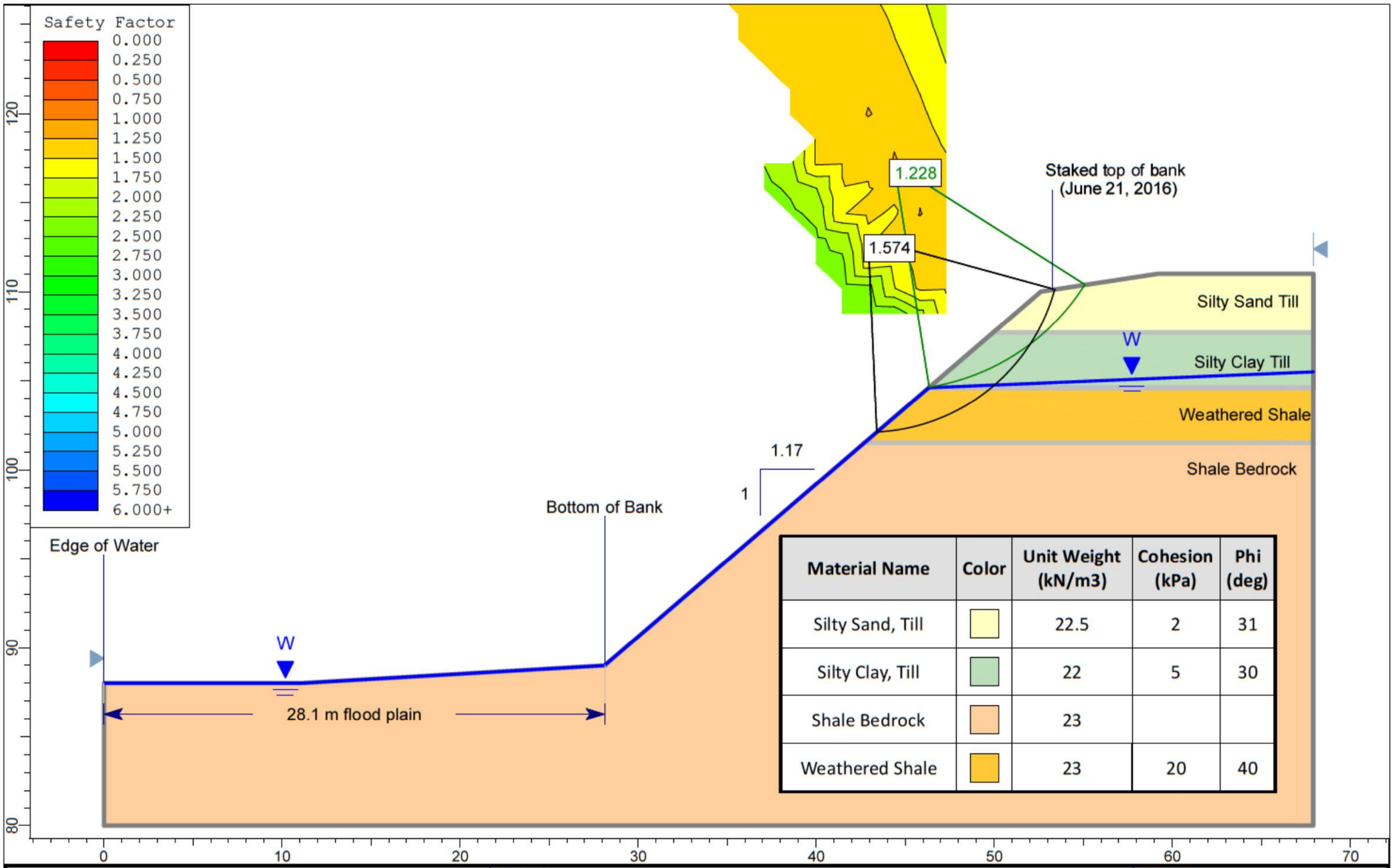
Project Title: Slope Stability Analysis - Cross Section D-D
Load Case: Existing Slope
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: KL
Checked By: BL
Scale: 1:400
Revision: -
Date: November 2017
Reference No.: 1505-S135
Drawing No.: 7



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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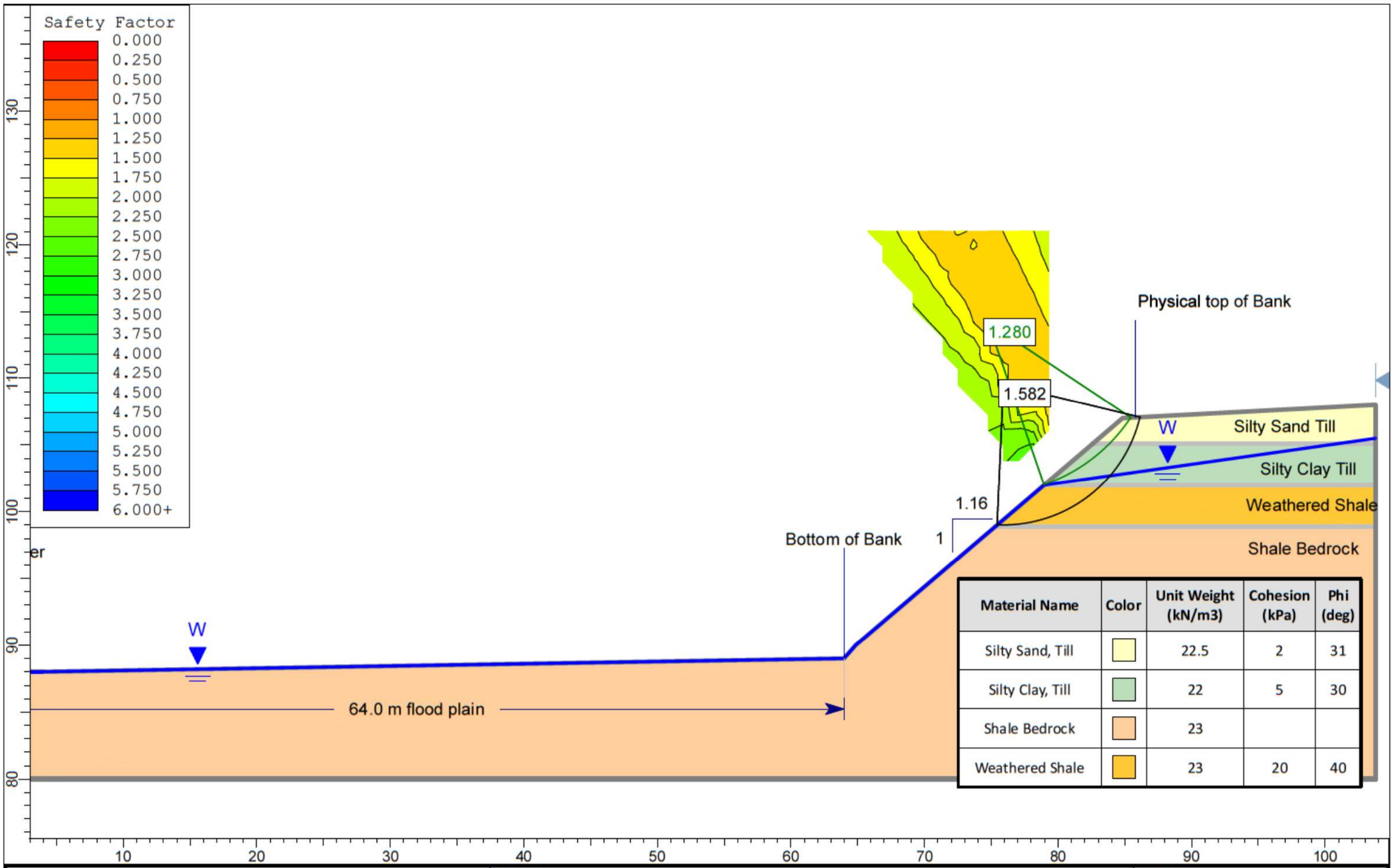
Project Title: Slope Stability Analysis - Cross Section E-E
Load Case: Exisiting Slope
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: PH
Checked By: BL
Scale: 1:300
Revision: -
Date: January 2018
Reference No.: 1505-S135
Drawing No.: 8



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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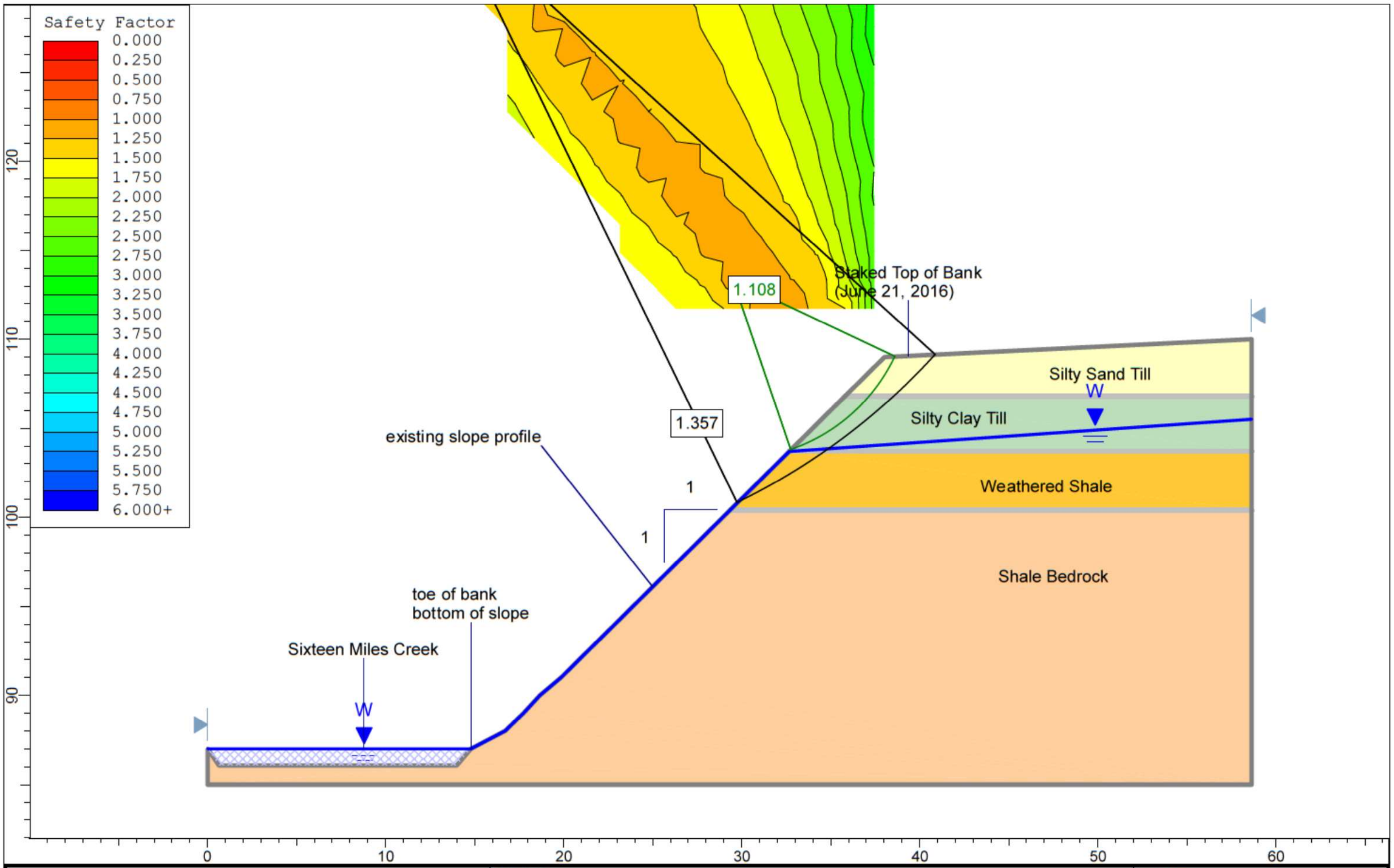
| | | | | | |
|---|---|---|---|---|---|
| Project Title | Slope Stability Analysis - Cross Section F-F | | | Load Case | Exisiting Slope |
| Location | 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville | | | | |
| Drawn By | PH | Checked By | BL | Scale | 1:400 |
| Revision | - | | | | |
| Date | January 2018 | Reference No. | 1505-S135 | Drawing No. | 9 |



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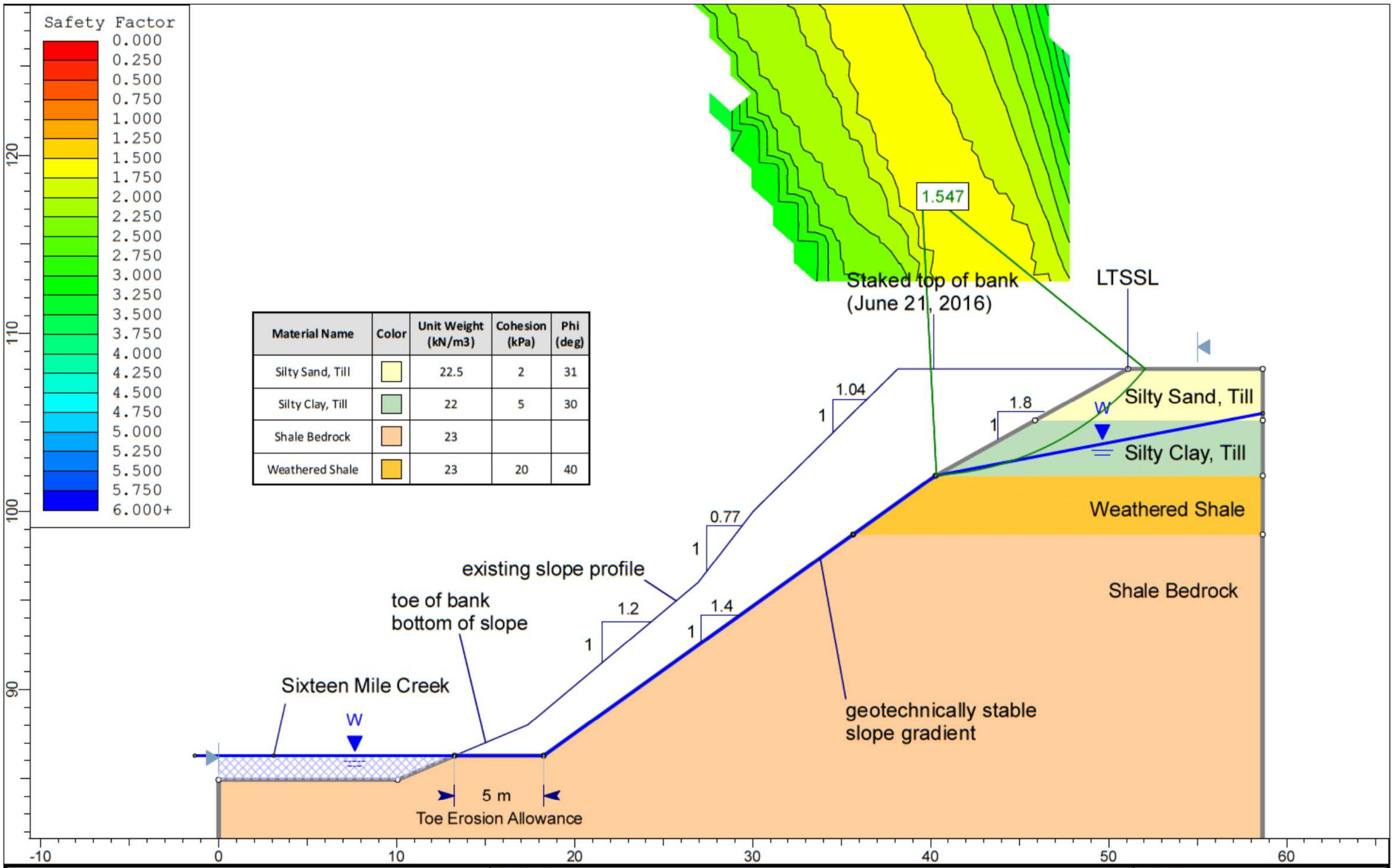
Project Title: Slope Stability Analysis - Cross Section G-G
Load Case: Existing Condition
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: PH
Checked By: BL
Scale: 1:300
Revision: -
Date: March 2018
Reference No.: 1505-S135
Drawing No.: 10



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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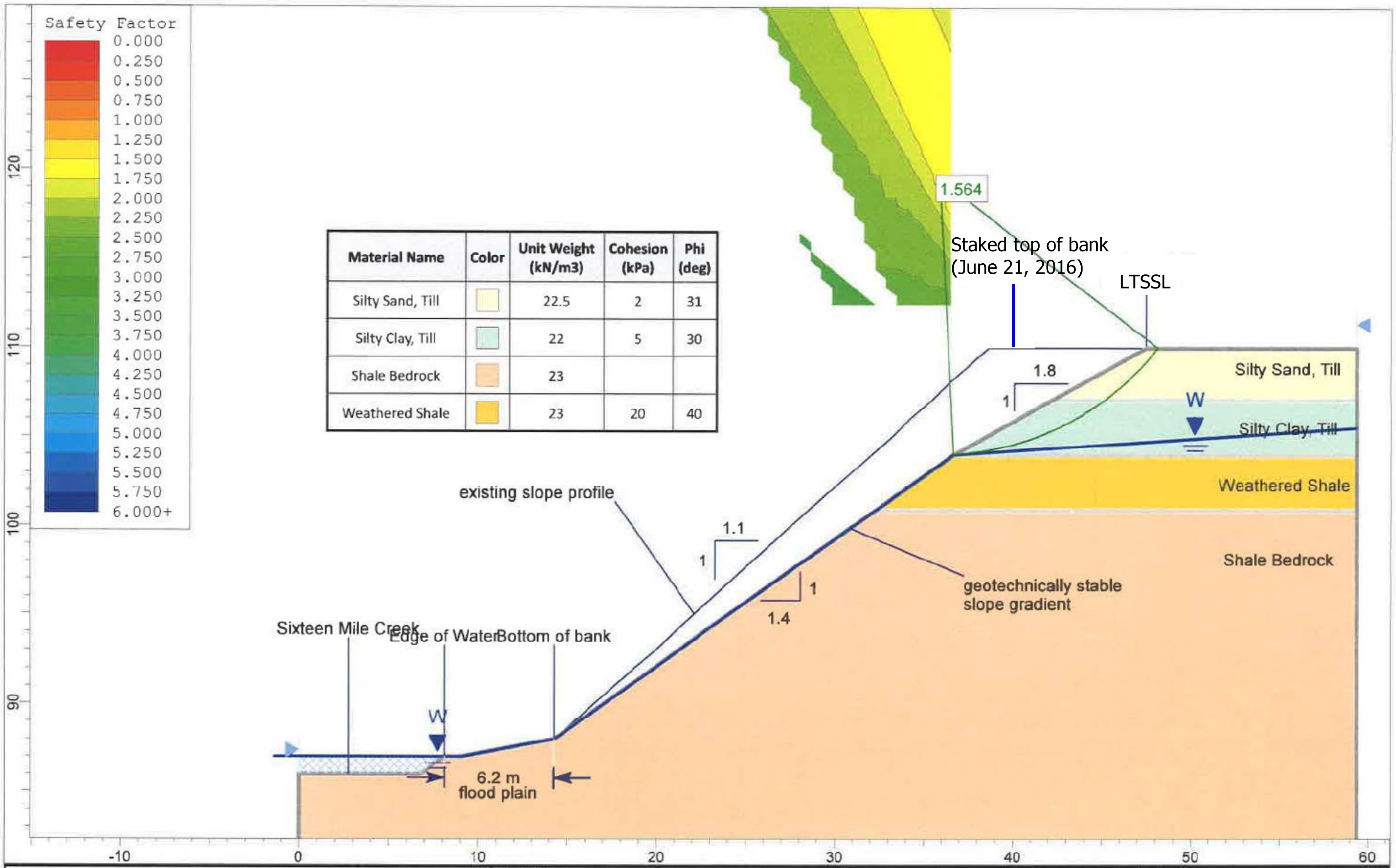
Project Title: Slope Stability Analysis - Cross Section A-A
Load Case: Stable Condition
Location: 1020, 1024, **1028**, 1032 & 1042 6th line, Town of Oakville
Drawn By: KL
Checked By: BL
Scale: 1:300
Revision: -
Date: March 2018
Reference No.: 1505-S135
Drawing No.: 11



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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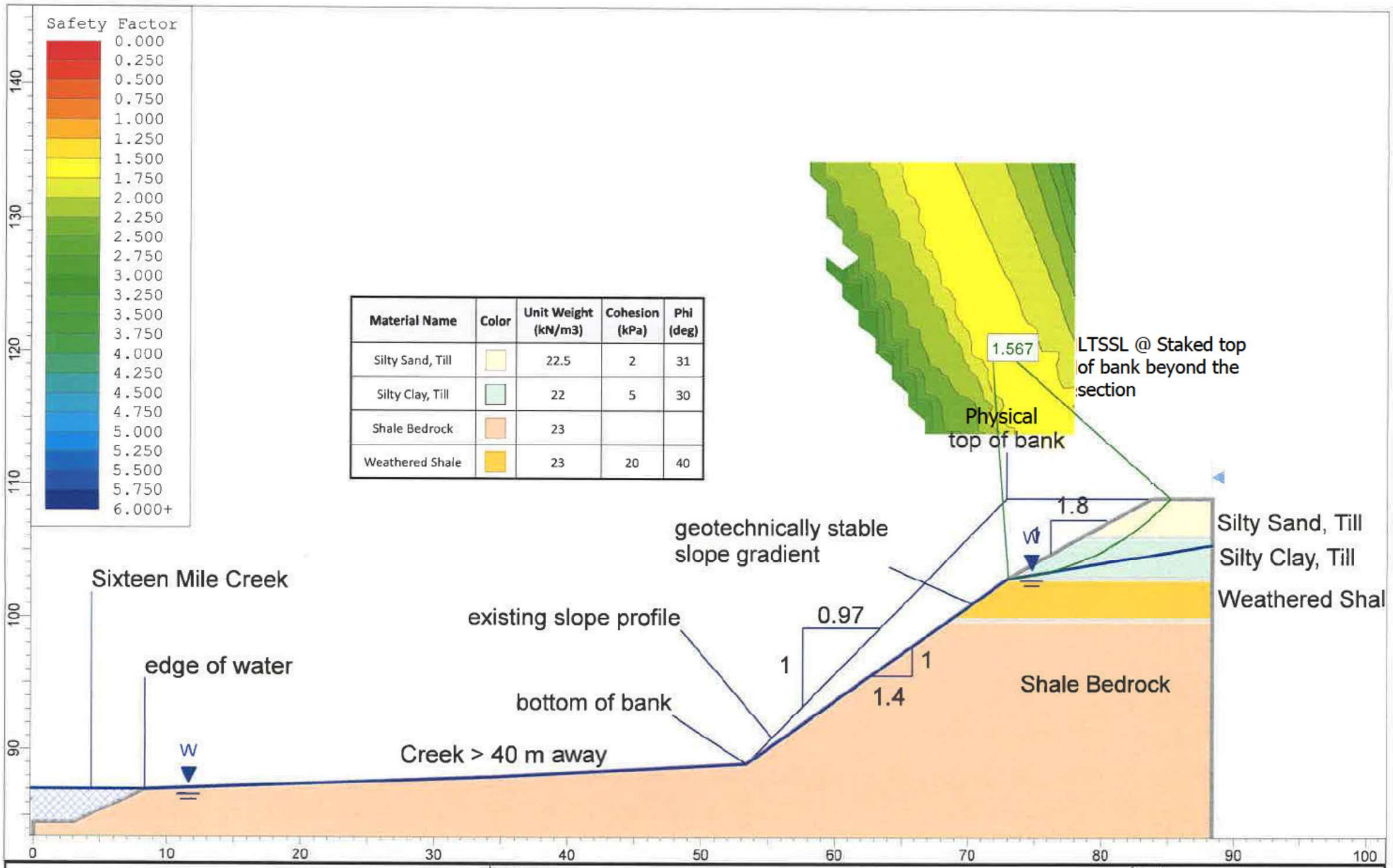
Project Title: Slope Stability Analysis - Cross Section B-B
Load Case: Stable Condition
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: KL
Checked By: BL
Scale: 1:300
Revision: -
Date: November 2017
Reference No.: 1505-S135
Drawing No.: 12



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟨 | 23 | 20 | 40 |

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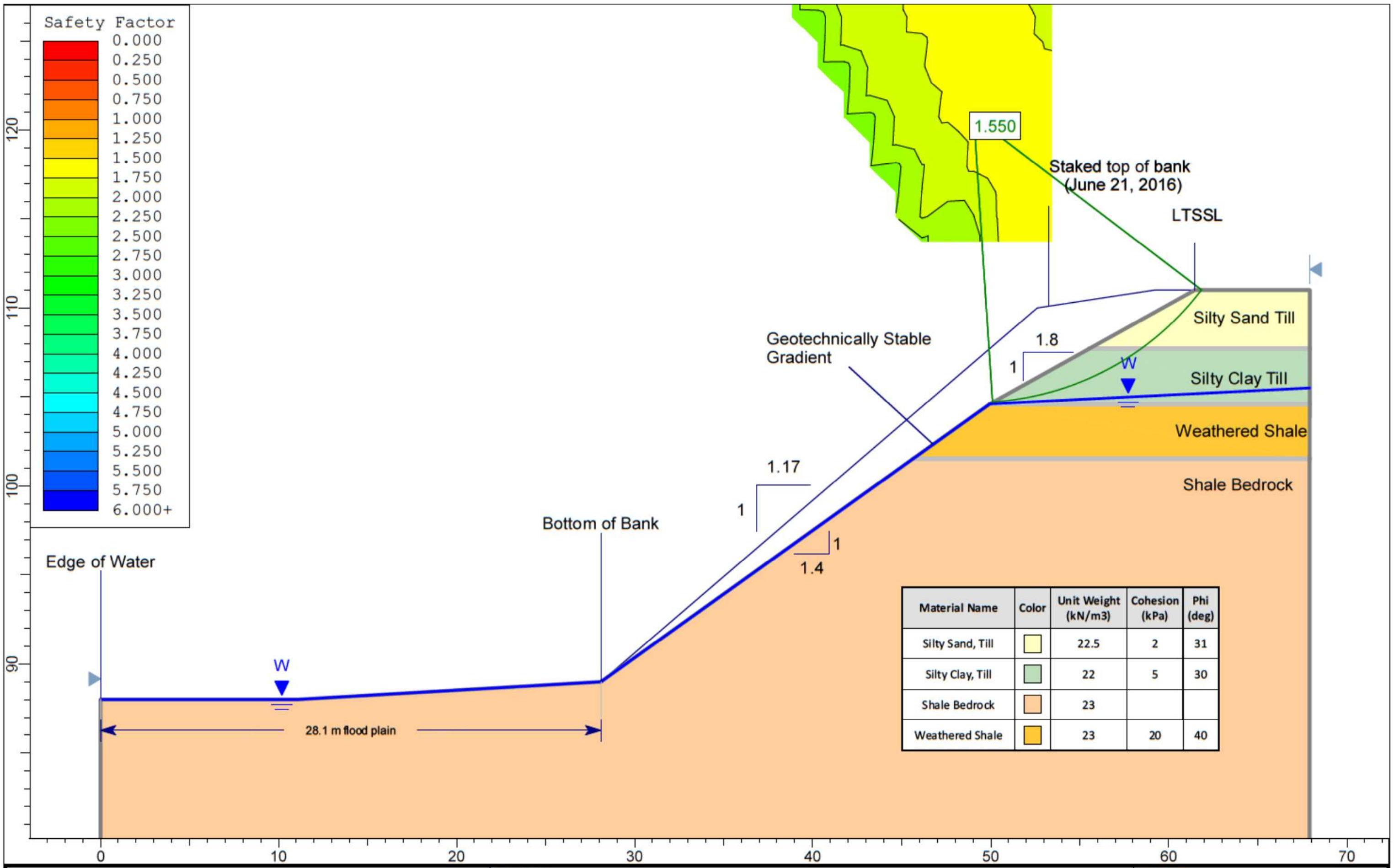
Project Title: Slope Stability Analysis - Cross Section C-C
Load Case: Stable Condition
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: PH
Checked By: BL
Scale: 1:400
Revision: -
Date: November 2017
Reference No.: 1505-S135
Drawing No.: 13



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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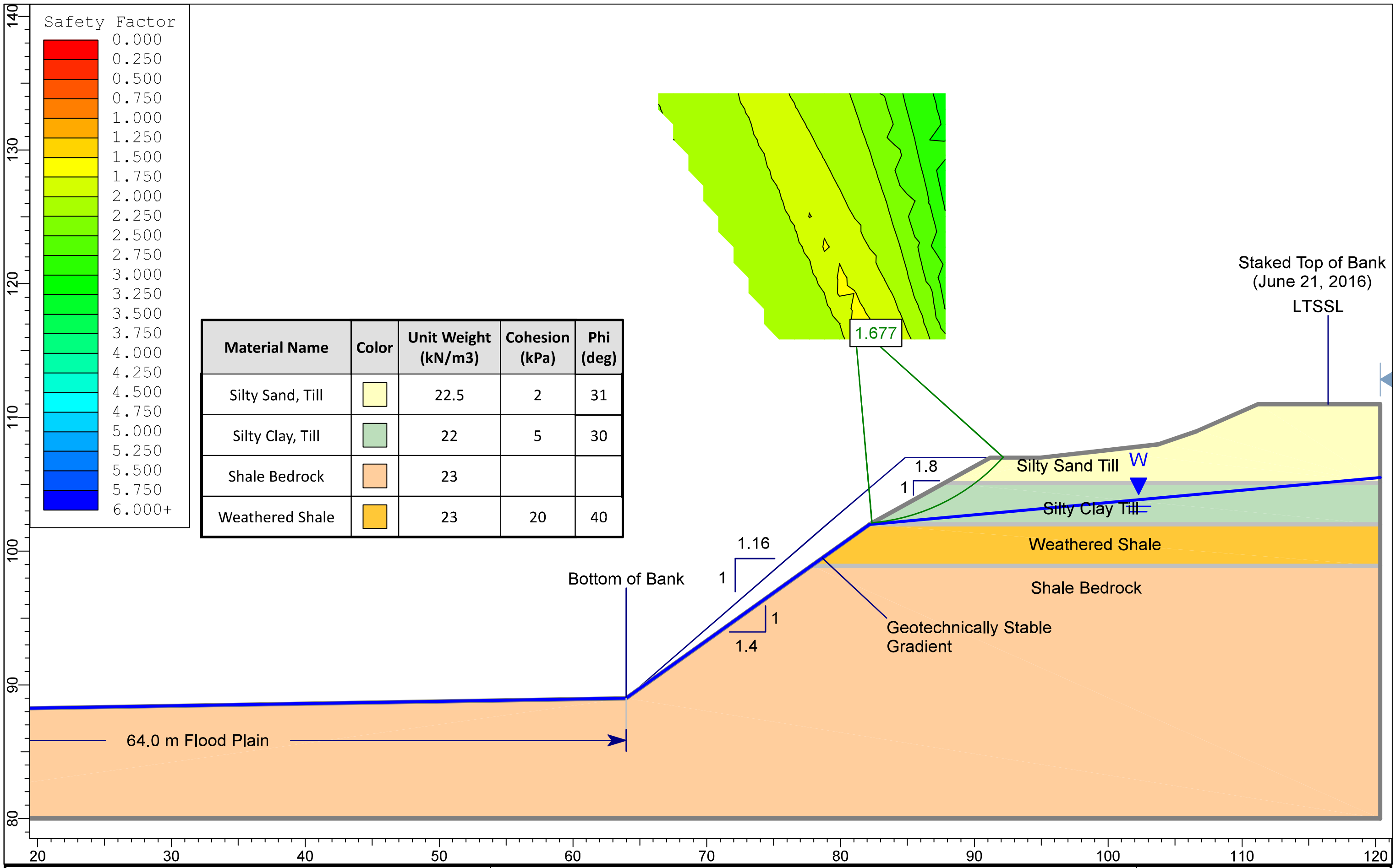
Project Title: Slope Stability Analysis - Cross Section E-E
Load Case: Stable Condition
Location: 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville
Drawn By: PH
Checked By: BL
Scale: 1:300
Revision: -
Date: January 2018
Reference No.: 1505-S135
Drawing No.: 14



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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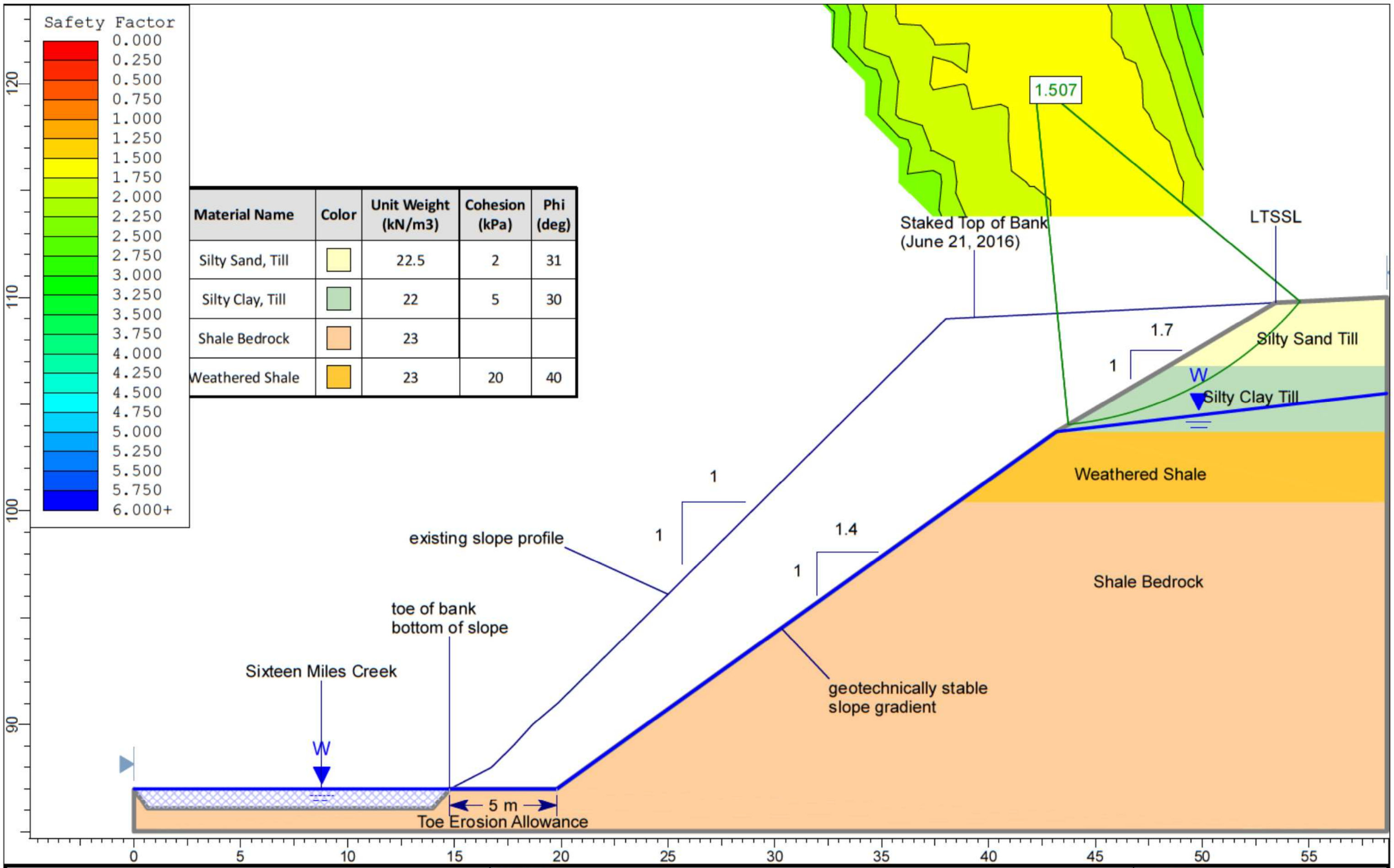
| | | | |
|---|---|---|---|
| Project Title | Slope Stability Analysis - Cross Section F-F | Load Case | Stable Condition |
| Location | 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville | | |
| Drawn By PH | Checked By BL | Scale 1:400 | Revision - |
| Date May 2018 | | Reference No. 1505-S135 | Drawing No. 15 |



| Material Name | Color | Unit Weight (kN/m3) | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|
| Silty Sand, Till | 🟨 | 22.5 | 2 | 31 |
| Silty Clay, Till | 🟩 | 22 | 5 | 30 |
| Shale Bedrock | 🟧 | 23 | | |
| Weathered Shale | 🟧 | 23 | 20 | 40 |

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| | | | |
|---|---|---|---|
| Project Title | Slope Stability Analysis - Cross Section G-G | Load Case | Stable Condition |
| Location | 1020, 1024, 1028, 1032 & 1042 6th line, Town of Oakville | | |
| Drawn By PH | Checked By BL | Scale 1:250 | Revision - |
| Date March 2018 | | Reference No. 1505-S135 | Drawing No. 16 |

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# APPENDIX

## MONITORING WELL LOG (BH17-1) BY WSP

## REFERENCE NO. 1508-S135

WSP

# MONITORING WELL DRILLING RECORD : **BH17-1**

Project Number: **161-03136-00**

1042 Sixth Line, Oakville, Ontario
Phase Two Environmental Site Assessment
Dunpar

**DRILLING DETAILS**

| | |
|---|---|
| Date (Start): | 18/01/2017 |
| Date (End): | 18/01/2017 |
| Drilling Company: | Landshark Drilling |
| Drilling Equipment: | B57 |
| Drilling Method: | Hollow Stem Auger |
| Borehole Diameter: | 203 mm |
| Drilling Fluid: | None |
| Sampling Method: | Split Spoon |

**SURVEY DETAILS**

| | |
|---|---|
| Easting: | 605571.866 m |
| Northing: | 4811945.432 m |
| Surface Elevation: | 110.704 masl |
| Top of Well Elevation: | masl |

**ODOUR**
L - Light
M - Medium
S - Strong

**VISUAL**
D - Dispersed with Product
S - Saturated with Product

**SAMPLE TYPE**
DC - Diamond Corer
SS - Split Spoon
MA - Manual Auger
TR - Trowel
ST - Shelby Tube
DT - Dual Tube
MC - Macro Core

**CHEMICAL ANALYSIS**

| | |
|---|---|
| Metals | Sb As Ba Be B Cd Cr Co Cu Pb Mo Ni Se Ag Tl U V Zn |
| Inorg. | Inorganic Compounds |
| PHC | Petroleum Hydrocarbons (F1-F4) |
| BTEX | Benzene, Toluene, Ethylbenzene, Xylene |
| VOC | Volatile Organic Compounds |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PCB | Polychlorinated Biphenyl |
| D/F | Dioxins & Furans |
| Phenol | Phenolic Compounds |
| GSA | Grain-size Analysis |

| (m) DEPTH / ELEVATION (masl) | LITHOLOGY / GEOLOGY: DESCRIPTION | OBSERVATIONS: PID / CGD (ppm) | ODOUR (L M S) | VISUAL (D S) | SAMPLES: SAMPLE TYPE & No. | % RECOVERY | N (Blow/15cm) | CHEMICAL ANALYSIS | DUPLICATE |
|---|---|---|---|---|---|---|---|---|---|
| 0.00 / 110.70 | **TOPSOIL**: 4" topsoil on the surface | | | | | | | | |
| 110.61 | **FILL**: reddish brown, sandy silt, mixed organics, some cobbles and seams of coarse sand | 4.2 | | | SS1 | % | 4 | | |
| | | 4.7 | | | SS2 | % | 35 | | |
| 1.52 / 109.18 | **SILTY SAND**: dry, reddish brown, with some cobbles. | 4.7 | | | SS3 | % | 43 | | |
| | *seams of coarse sand at 2.4 mbgs* | 3.8 | | | SS4 | % | 34 | | |
| 3.05 / 107.66 | **SANDY SILT TILL**: dry to moist, grey | 1.1 | | | SS5 | % | 16 | | |
| | | 1.4 | | | SS6 | % | 9 | | |
| 6.10 / 104.61 | **SILT**: reddish brown, with shale fragments | 1.3 | | | SS7 | % | 50 / 75 mm | | |
| 7.62 / 7.75 / 103.08 / 102.96 | **WEATHERED SHALE**: inferred | 1.3 | | | SS8 | % | 100 / 125 mm | | |

*END OF BOREHOLE*

*Nores:*

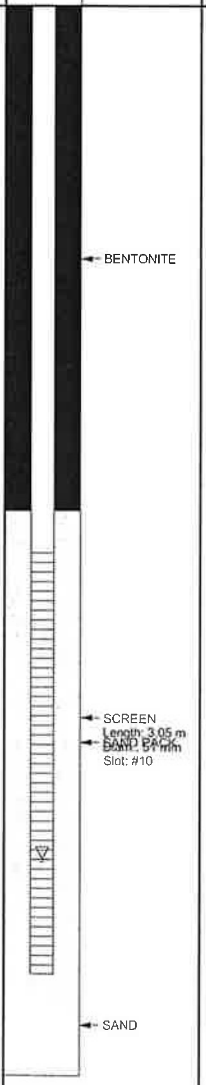
*1) Auger refusal at 7.6 mbgs*

*2) 50mm dia. monitoring well installed upon completion.*

*3) Water Level Readings in monitoring well:*

| *Date* | *W. L. Depth (mbgs)* |
|---|---|
| *Jan 27, 17* | *6.2* |

**MONITORING WELL**



WATER MARKER
Depth : 6.2 m
Elev. : m
Date : 27/01/2017

REMARKS

Project : TEMPLATE_MASTER - IMPERIAL.GPJ   Report : WSP_EN_WELL-ENVIRONMENTAL   19/6/2017

Prepared by:
Reviewed by: