Geotechnical Studies
West Carleton Environmental Centre

August 2015

Prepared for:
Waste Management of Canada Corporation
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Project No. 131-19416-00

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1. Summary

All geotechnical studies which were completed between 2011 and 2014 for the proposed landfill expansion at the West Carleton Environmental Centre (WCEC) have been assembled herein, in support of the Waste Management of Canada Corporation (WM) Site Plan Control application. The Site Plan Control approval is required by the City of Ottawa before the proposed site development, in addition to the Environmental Compliance Approval (ECA) by Ontario Ministry of the Environment and Climate Change (MOECC). WM applied for an ECA approval in September 2014 and their application is under review.

Details of the proposed landfill expansion are outlined in the Development and Operations Report dated July 2014, by WSP Canada Inc.

Assembled by:

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Appendix A.1

Seismic Slope Stability Analysis, prepared by AECOM, dated August 2012 (part of Supporting Document #4, Facility Characteristics Report)

Appendix A. Seismic Slope Stability Analysis

1. Purpose

The purpose of the slope stability analyses presented in this appendix is to assess the potential effect of ground motion due to seismic activity on the slope stability of the landfill and liner system of the proposed new landfill at the West Carlton Environmental Centre (WCEC). The site is located on Lots 3 and 4, Concession 3 in the former Township of Huntley, formerly in the Township of West Carleton, now the City of Ottawa near the intersection of Carp Road and Highway 417.

2. Background

Unlike plate boundary regions where the rate and size of seismic activity is directly correlated with plate interaction, eastern Canada is part of the stable interior of the North American Plate. Seismic activity in areas like these seems to be related to the regional stress fields, with the earthquakes concentrated in regions of crustal weakness. In the Western Quebec Seismic Zone, pattern of historical seismic activity recorded by the Canadian seismograph network since the beginning of the century shows the earthquakes concentrating in two sub-zones: one along the Ottawa River and a second along a more active Montreal-Maniwaki axis. (Natural Resources Canada, 2011a)

The damage potential of an earthquake is determined by how the ground moves. Expected ground motion can be calculated on the basis of probability, and the expected ground motions are referred to as seismic hazard. The seismic hazard at a given site is determined from numerous factors. Canada has been divided into earthquake source regions based on past earthquake activity and tectonic structure. The relationship between earthquake magnitude and the average rate of occurrence for each region is weighed, along with variations in the attenuation of ground motion with distance. In calculating seismic hazard, scientists consider all earthquake source regions within a relevant distance of the proposed site (Natural Resources Canada, 2011b).

Ground motion probability values are given in terms of probable exceedance, that is the likelihood of a given horizontal acceleration or velocity being exceeded during a particular period. The probability used in the 2010 National Building Code of Canada is 0.000404 per annum, equivalent to a 2-per-cent probability of exceedance over 50 years. This means that over a 50-year period there is a 2-per-cent chance of an earthquake causing ground motion greater than the given expected value.

3. Methodology

A conventional method to evaluate the slope stability of municipal solid waste landfill is the pseudo-static factor of safety approach (US EAP, 1995). In this method, a seismic coefficient is specified to represent the effect of the inertial forces imposed by the earthquake upon the potential failure mass and a factor of safety is defined in the conventional manner as the ratio of the ultimate shear strength of the slope elements to the maximum shear stresses induced in those elements by seismic and static loadings.

The computer software SLOPE/W (version 2007), developed by GEO-SLOPE International, was used to perform the slope stability assessment. GEO-SLOPE software is used in more than 100 countries. SLOPE/W, in one form, or another has been used since 1977. SLOPE/W was the very first geotechnical software product available commercially for analyzing slope stability. The initial code was developed by Professor D.G. Fredlund at the University of Saskatchewan. Currently, thousands of professionals both in education and in practice used the software (GEO-SLOPE, 2007).

4. Model Input Parameters

The peak ground acceleration at the site was determined using the 2010 National Building Code Seismic Hazard Calculator of Natural Resources Canada. The National Building Code peak ground acceleration at the site is 0.31 g. To examine the effect of seismic hazard on the slope stability of the landfill the peak ground acceleration was used in the SLOPE/W pseudo-static analysis.

The geometry of the landfill in the slope stability analyses was according to the Figures FCR-3 and FCR-10 in the Facility Characteristics Report. The slope of the landfill at the northeast corner adjacent to the proposed surface water ponds is the highest and was used in the analysis.

The typical configuration of the landfill liner system is shown in Figure FCR-11 in the Facility Characteristics Report. There are many layers and interfaces of adjacent layers. The shear of the weakest interface may govern the stability of the slope. The strength of the layers and interfaces depend on the specific materials selected for each of the components. Published data was used in this preliminary slope stability analysis and the input parameters are presented in the attached Table SS1. In the detailed design of the landfill, the stability assessment will be based on properties and strength of the materials selected for the liner system.

If the composite liner has a smooth geomembrane, the shear strength of its interface is generally lowest and is the critical interface on slope stability. The liner system is modelled in the slope stability analyses as two layers. The top layer represents the primary leachate collection system plus the geotextile and geomembrane directly beneath. The strength of this layer is assumed to be controlled by the critical interface. The rest of the liner system below is modelled as another layer.

The key input parameters to SLOPE/W are presented in Table SS1. For a liner system with a smooth geomembrane, the critical interface shear strength is assumed to be 8 degrees based on published data. Sensitivity analyses were carried assuming the strength is increased by 50% to 12 degrees which also corresponds to published specific value from a manufacturer. The strength of the waste was based on values established by Sukhmander, Singh, and Murphy using results of laboratory testing, back-calculations from field load test and performance records, and in situ testing (Singh and Murphy, 1990). The effect of variation on the waste strength on the results was examined in sensitivity analyses for the smooth geomembrane cases. Slope stability analyses were performed with and without seismic condition.

Slope stability analyses, with and without seismic condition, were also performed for a liner system with a textured geomembrane instead of a smooth membrane. Textured geomembrane generally has a significantly higher interface shear strength than smooth geomembrane. The critical interface friction angle that gave a slope stability factor of safety greater than 1.0 under seismic condition was determined by back-calculations. In the above cases, the critical slip surface was determined by SLOPE/W as a composite slip surface. Additional cases were analyzed for the critical slip surface being circular as in conventional rotational analyses.

5. Results of Slope Stability Analyses

The results of SLOPE/W are summarised in the attached Table SS2, figures showing the critical slip surface and the corresponding calculated factor of safety for each case, and the plots of results of the sensitivity analyses.

The results showed that the factor of safety on slope stability is lower when the effect of seismic hazard is considered (see attached Table SS2). The seismic condition is based on the peak ground acceleration at the site according to the 2010 National Building Code. For a smooth geomembrane the calculated factors of safety under seismic condition were generally less than half of the corresponding results without seismic loading (Cases PD2A and PD2B versus Case PD1). Similar differences were found for the cases with a textured geomembrane as shown in Table SS2 (Case PD4B versus Case PD3, and Case PS2Bversus Case PS1).

With a smooth geomembrane, the calculated factors of safety under seismic condition were all well below 1.0 for the ranges of input parameters considered. These pseudo-static analyses results suggested that the calculated factor of safety on slope stability under the seismic condition for a liner system with a smooth geomembrane at the critical slip surface is inadequate. The results are summarized in Cases PD2A and PD2B in Table SS2 and in the plots of the sensitivity analyses results.

For the scenarios considered, Cases PD4A, PD4B, PS2A and PS2B, the back-calculations suggested that under seismic condition, the critical interface shear strength has to be approximately 25 degrees or greater for a calculated factor of safety above 1.0.

6. Discussion and Conclusions

Published generalized friction angle of texture HDPE geomembrane with non-woven, needle-punched or heat-bonded, geotextile showed values between 28 to 32 degrees (Koerner, 2005). The data by Koerner also suggested that the interface fraction between a texture HDPE geomembrane and soil could also be over 25 degrees. Furthermore, the use of peak ground acceleration with a pseudo-static factor of safety of 1.0 has been shown to give conservative assessments of slope performance in earthquakes (US EPA, 1995). With the selection of appropriate liner materials, the seismic slope stability analyses results suggested that the slope stability of the landfill and liner system can have adequate factor of safety under seismic condition with peak ground acceleration up to 0.31 g. This value of 0.31 g corresponds to the peak ground acceleration at the site for an earthquake with probability of exceedance of 2-percent over 50 years according to the 2010 National Building Code.

Detailed assessment of stability of the landfill and liner system shall be carried out using updated input parameters in the detailed design of the landfill to confirm that appropriate materials are selected and ensure that adequate factor of safety is achieved.

7. References

GEO-SLOPE International Ltd., 2007:
Stability Modelling with SLOPE/W 200, An Engineering Methodology, 2nd Edition, May 2007.

Koerner, R.M, 2005:
Designing with Geosynthetics, 5th Edition, Pearson Prentice Hall.

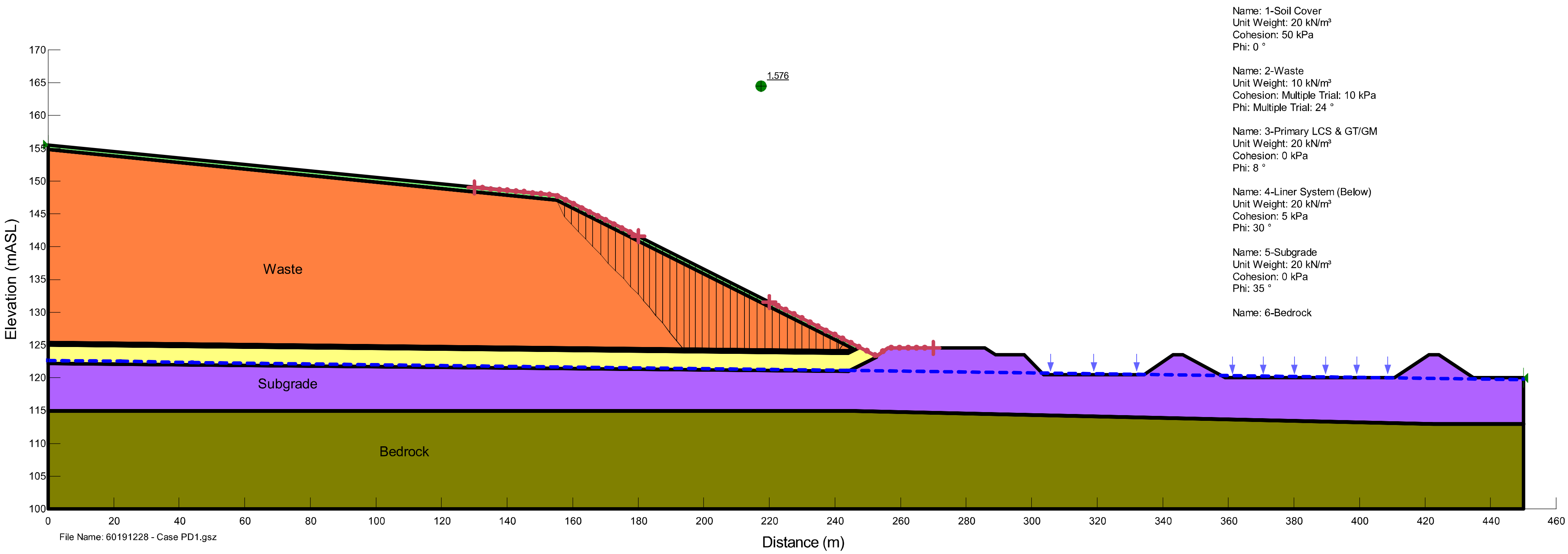
Natural Resources Canada, 2011a:
Earthquake Zones in Eastern Canada, Date Modified 2011-11-07
http://earthquakescanada.nrcan.gc.ca/zones/eastcan-eng.php#WQSZ

Natural Resources Canada, 2011b:
Seismic hazard Calculations, Date Modified 2011-11-07
http://earthquakescanada.nrcan.gc.ca/hazard-alea/zoning-zonage/haz-eng.php

Singh, S. and Murphy. B.J., 1990:
Evaluation of the Stability of Sanitary Landfills in “Geotechnical of Waste Fills – Theory and Practice”, ASTM STP 1070, ASTM.

United Stated Environmental Protection Agency (US EAP), 1995:
RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities. EPA/600/R-95/051 April 1995.

Name: Case PD1



Name: 1-Soil Cover
Unit Weight: 20 kN/m^3
Cohesion: 50 kPa
Phi: 0 °

Name: 2-Waste
Unit Weight: 10 kN/m^3
Cohesion: Multiple Trial: 10 kPa
Phi: Multiple Trial: 24 °

Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m^3
Cohesion: 0 kPa
Phi: 8 °

Name: 4-Liner System (Below)
Unit Weight: 20 kN/m^3
Cohesion: 5 kPa
Phi: 30 °

Name: 5-Subgrade
Unit Weight: 20 kN/m^3
Cohesion: 0 kPa
Phi: 35 °

Name: 6-Bedrock

File Name: 60191228 - Case PD1.gsz

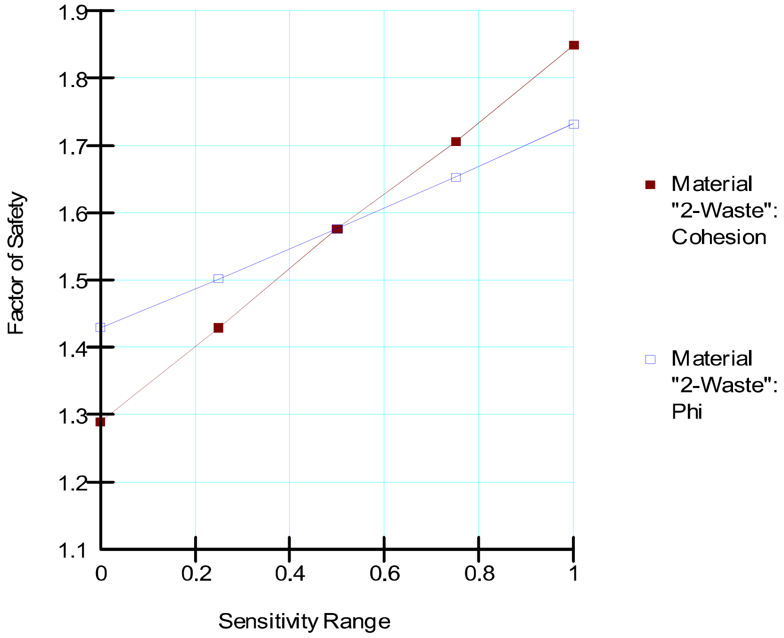
Project Name: **West Carleton Environmental Centre**
Project No.: **60242342**
Task: **Preliminary Seismic Slope Stability Analysis**
Date: **Jan-2012**

Sensitivity Analysis

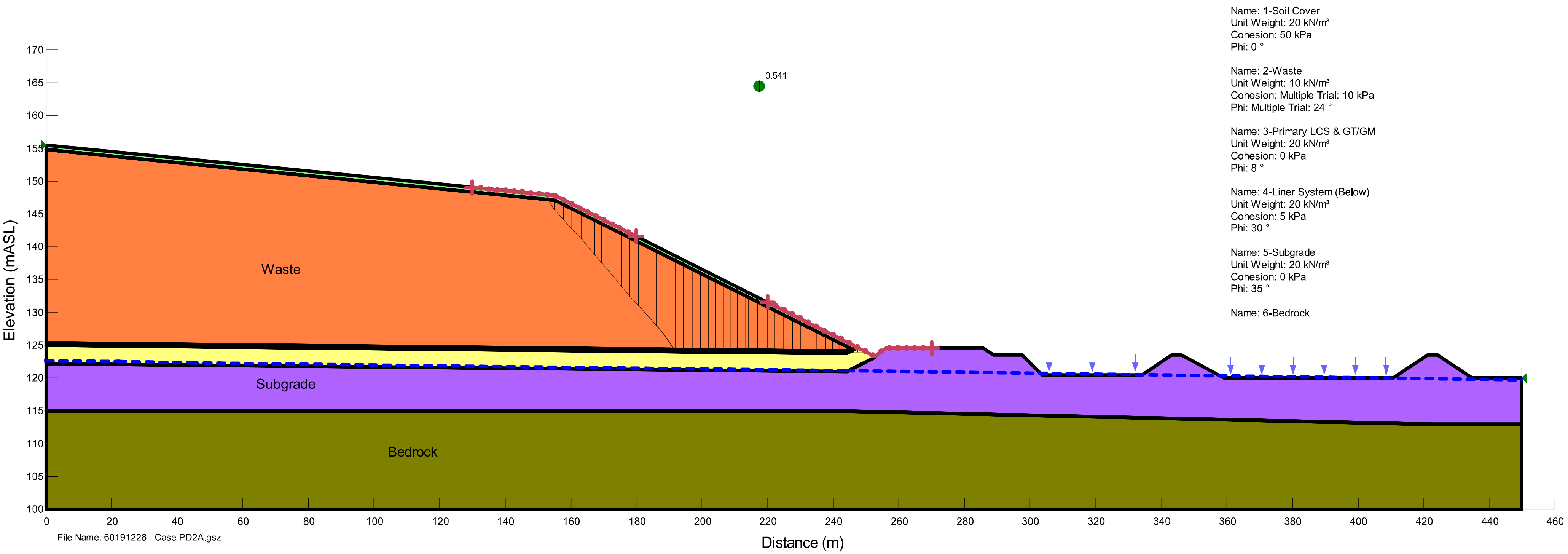
Case PD1

(Critical Interface Friction Angle ϕ: 8 Degree)

Input Data		
Sensitivity Range	Corresponding "2-Waste" Cohension Value (kPa)	Corresponding "2-Waste" Phi Value (Degree)
0	0	20
0.25	5	22
0.5	10	24
0.75	15	26
1	20	28



Name: Case PD2A



Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °

Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: Multiple Trial: 10 kPa
Phi: Multiple Trial: 24 °

Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 8 °

Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °

Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °

Name: 6-Bedrock

File Name: 60191228 - Case PD2A.gsz

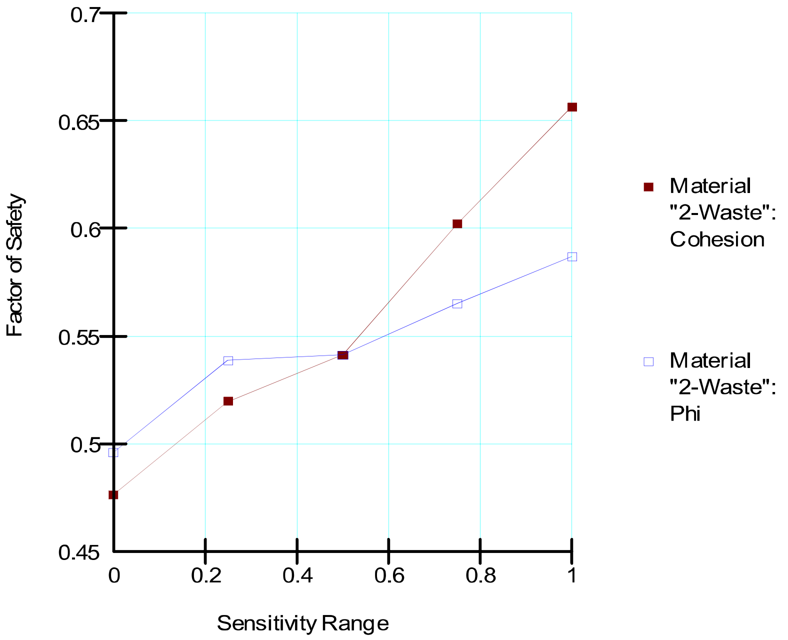
Project Name: **West Carleton Environmental Centre**
Project No.: **60242342**
Task: **Preliminary Seismic Slope Stability Analysis**
Date: **Jan-2012**

Sensitivity Analysis

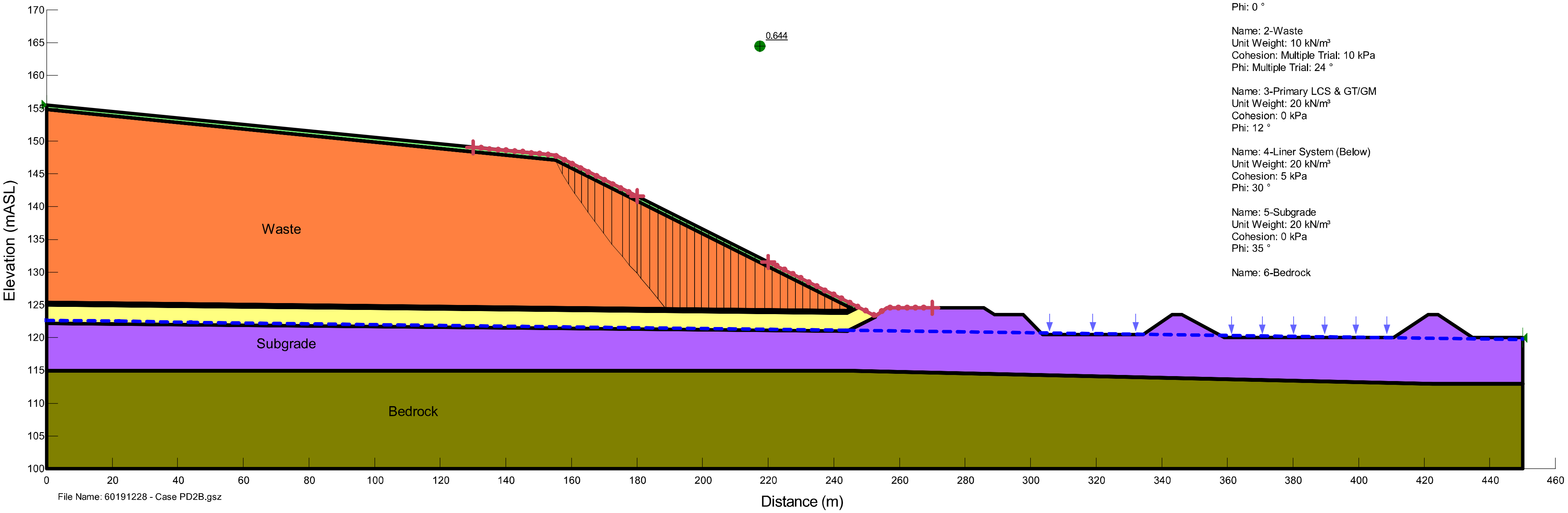
Case PD2A

(Critical Interface Friction Angle ϕ: 8 Degree)

Input Data		
Sensitivity Range	Corresponding "2-Waste" Cohension Value (kPa)	Corresponding "2-Waste" Phi Value (Degree)
0	0	20
0.25	5	22
0.5	10	24
0.75	15	26
1	20	28



Name: Case PD2B



Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °

Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: Multiple Trial: 10 kPa
Phi: Multiple Trial: 24 °

Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 12 °

Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °

Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °

Name: 6-Bedrock

File Name: 60191228 - Case PD2B.gsz

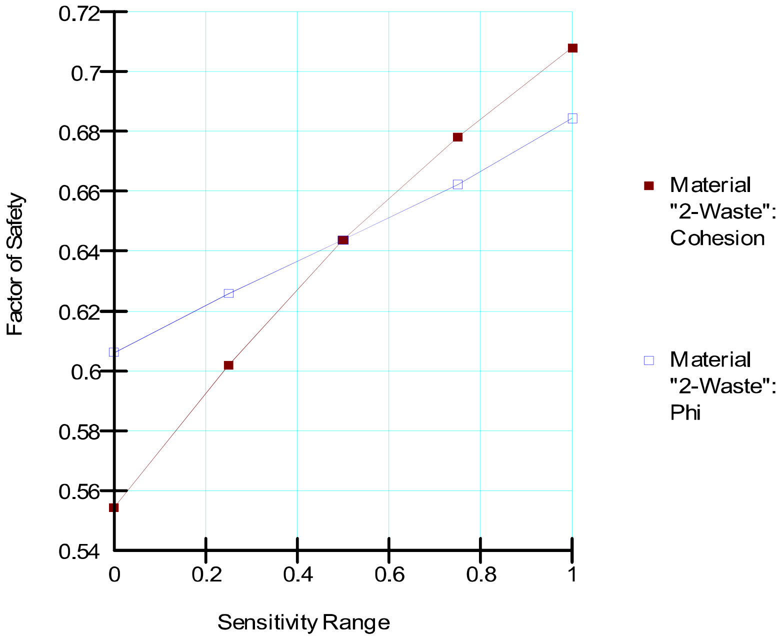
Project Name: **West Carleton Environmental Centre**
Project No.: **60242342**
Task: **Preliminary Seismic Slope Stability Analysis**
Date: **Jan-2012**

Sensitivity Analysis

Case PD2B

(Critical Interface Friction Angle ϕ: 12 Degree)

Input Data		
Sensitivity Range	Corresponding "2-Waste" Cohension Value (kPa)	Corresponding "2-Waste" Phi Value (Degree)
0	0	20
0.25	5	22
0.5	10	24
0.75	15	26
1	20	28



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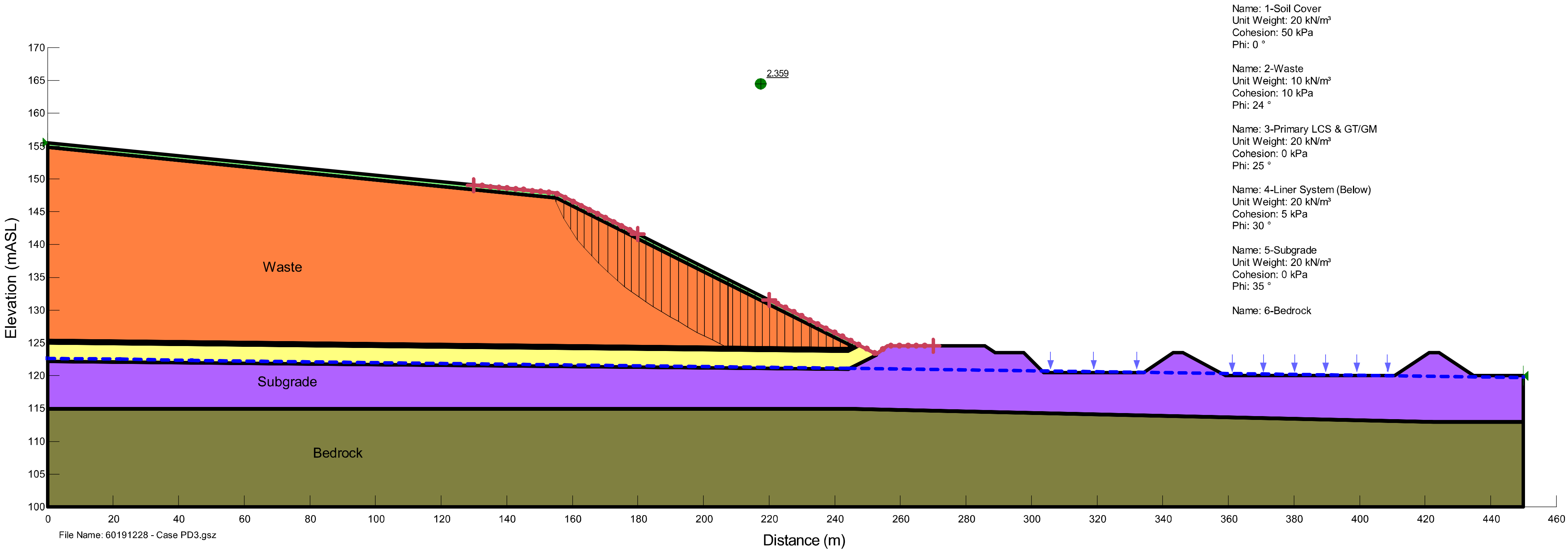
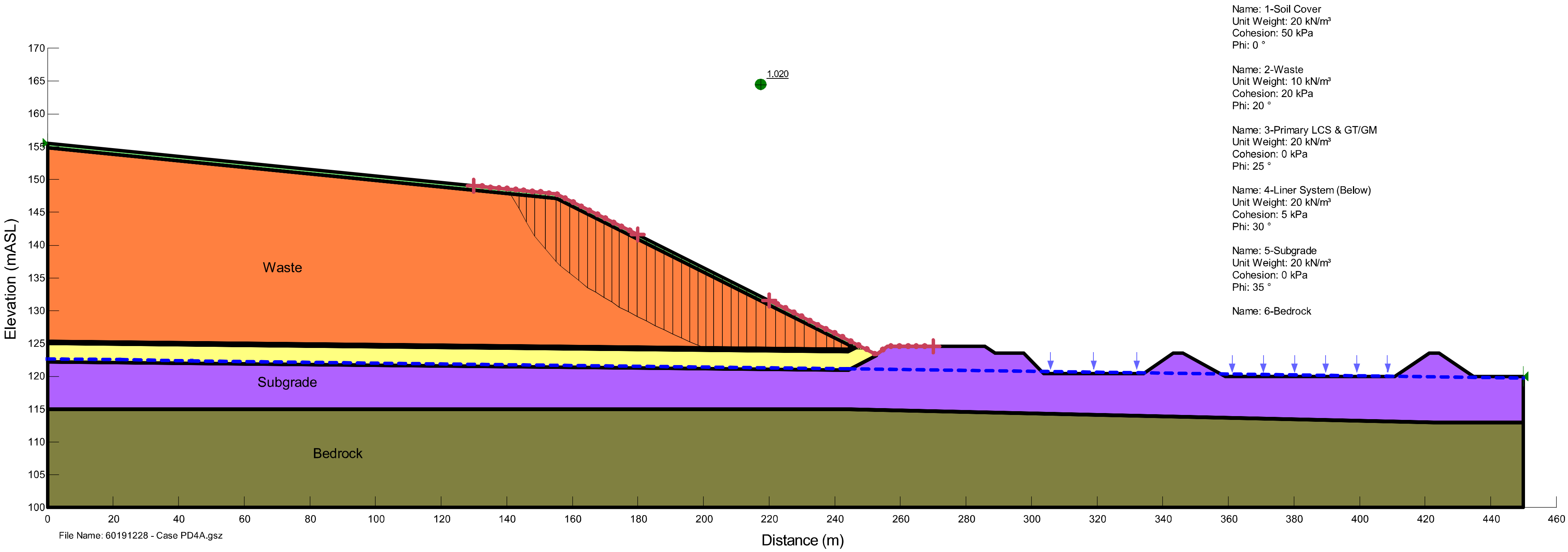


Name: Case PD4A



Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °

Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 20 kPa
Phi: 20 °

Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °

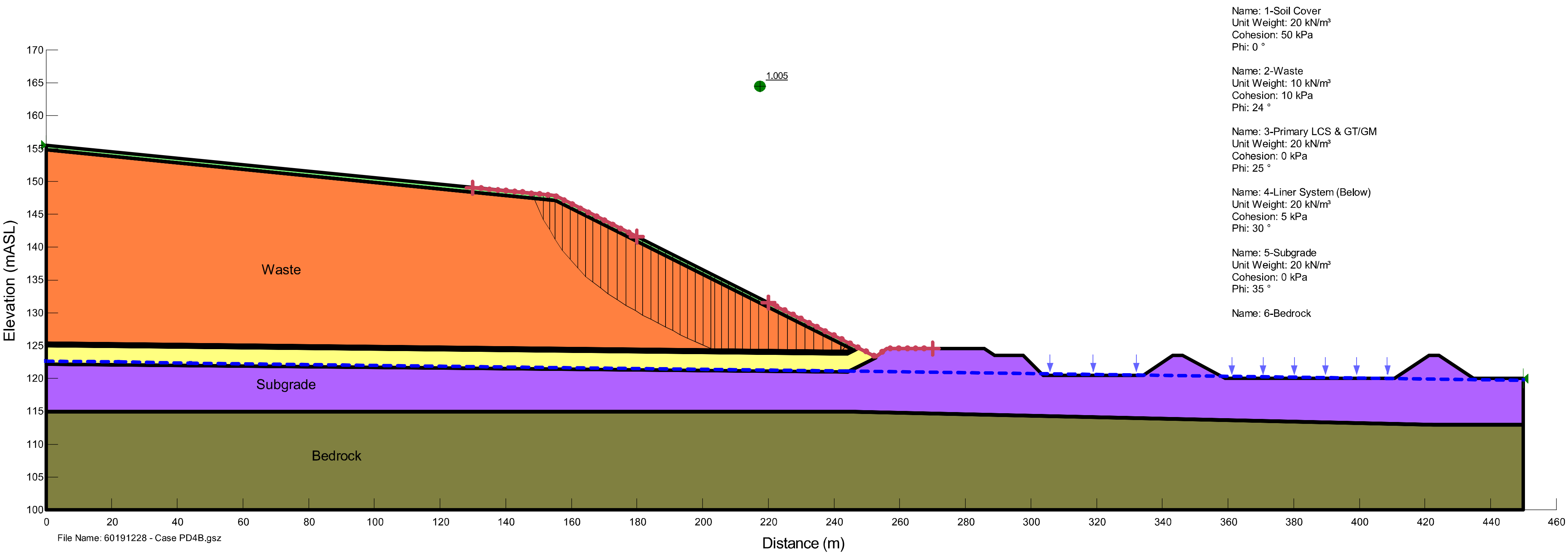
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °

Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °

Name: 6-Bedrock

File Name: 60191228 - Case PD4A.gsz

Name: Case PD4B



Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °

Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 10 kPa
Phi: 24 °

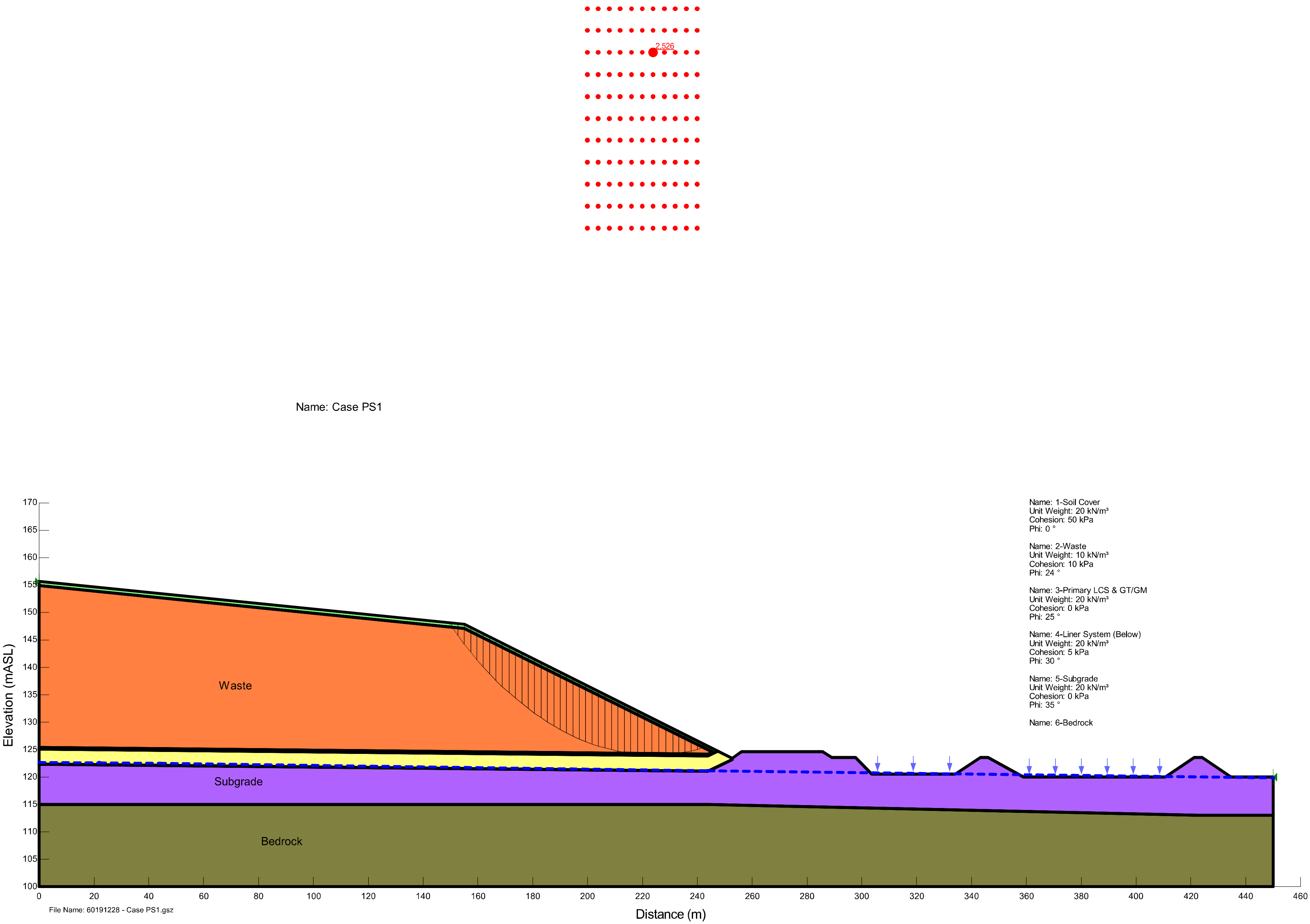
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °

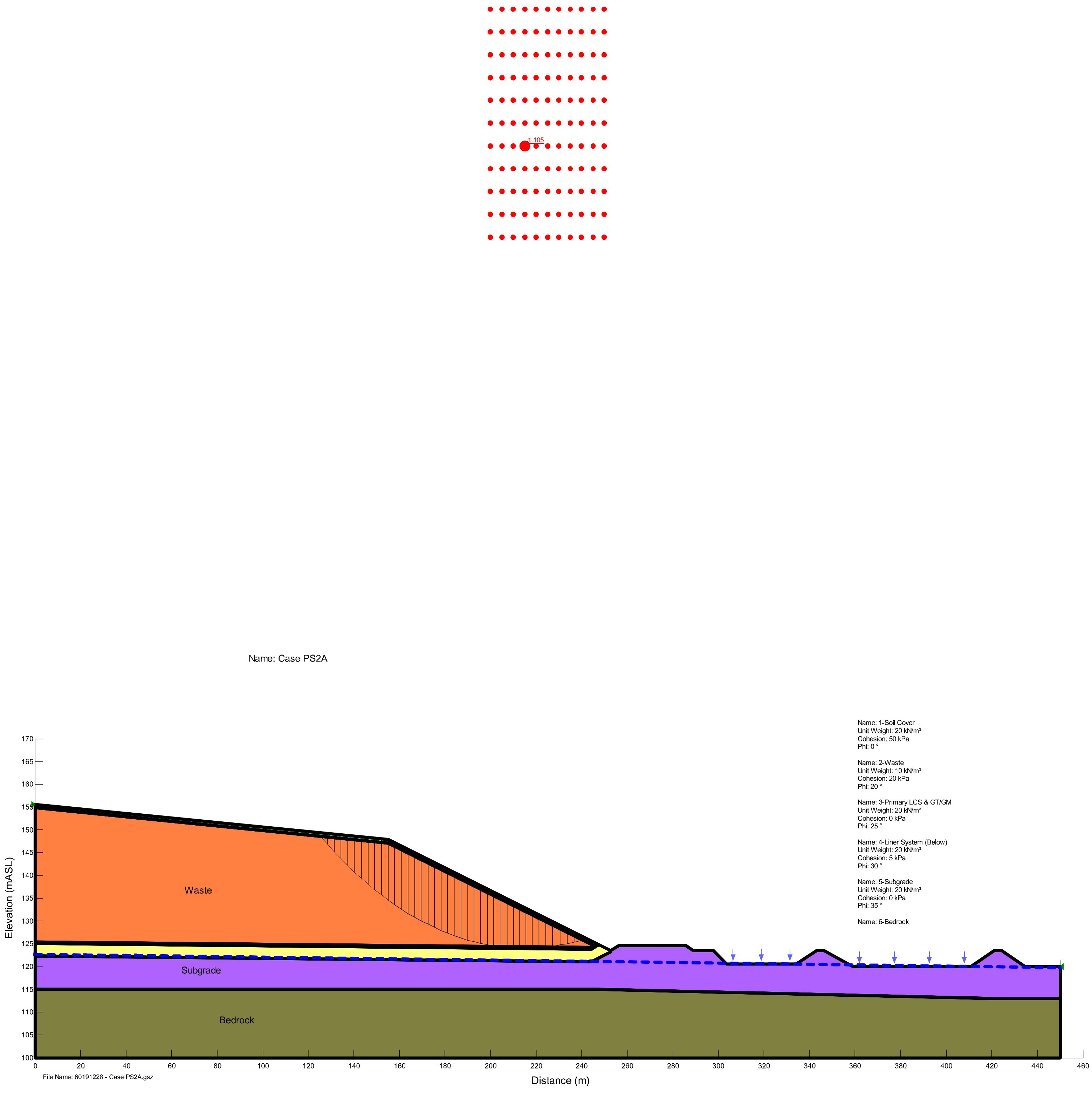
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °

Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °

Name: 6-Bedrock

File Name: 60191228 - Case PD4B.gsz


2.526
Name: Case PS1
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 10 kPa
Phi: 24 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
Waste
Subgrade
Bedrock
Elevation (mASL)
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
Distance (m)
File Name: 60191228 - Case PS1.gsz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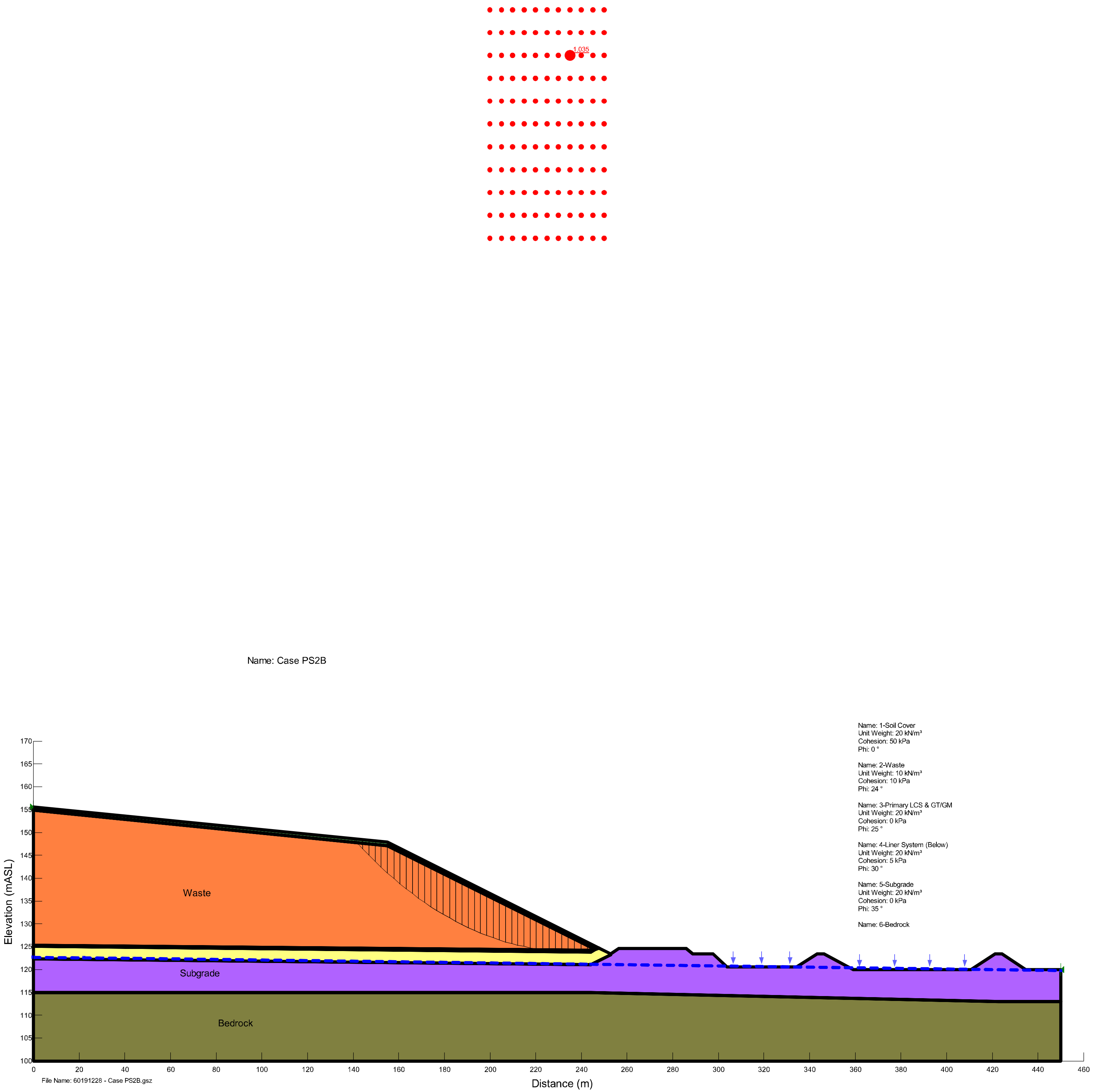
Name: Case PS2A
Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °
Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 20 kPa
Phi: 20 °
Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °
Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °
Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °
Name: 6-Bedrock
Waste
Subgrade
Bedrock
Elevation (mASL)
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
Distance (m)
File Name: 60191228 - Case PS2A.gsz

Name: Case PS2B



Name: 1-Soil Cover
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 0 °

Name: 2-Waste
Unit Weight: 10 kN/m³
Cohesion: 10 kPa
Phi: 24 °

Name: 3-Primary LCS & GT/GM
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 25 °

Name: 4-Liner System (Below)
Unit Weight: 20 kN/m³
Cohesion: 5 kPa
Phi: 30 °

Name: 5-Subgrade
Unit Weight: 20 kN/m³
Cohesion: 0 kPa
Phi: 35 °

Name: 6-Bedrock

File Name: 60191228 - Case PS2B.gsz

Table SS1. Key Input Parameters

Project Name: **West Carleton Environmental Centre**
Project Number: **60242342**
Task: **Preliminary Seismic Slope Stability Analyses**
Date: **January 2012**

Parameters	Preliminary Values Assumed	Unit	Notes
Subgrade			Source - Alston Associates Inc Report Aug 2, 2011 "Preliminary Geotechnical Evaluation, Proposed New Landfill Mound, Waste Management, Carp, Ontatio (Revised)".
Friction Angle	35	degree	The effective friction angle measured by direct shear test on a sample of the silty sand soil of 39^{o} is higher than would be predicted on the basis of penetration index values measured by in situ testing (CPT and DCPT) according to the report.
Cohesion	0	kPa	
Density	16.5	kN/m^3	Density based on the initial water contents and dry densities before the direct shear test on the sample of silty sand soil.
Liner System			The G2 liner system from the primary compacted clay liner down is modelled as a single unit.
Friction Angle	30	degree	
Cohesion	5	kPa	
Density	20	kN/m^3	
Primary Leachate Collection System, Geotextile and Geomembrane			All the Interfaces from the bottom of the waste to top of the primary clay liner is modelled as a single unit. The shear strength of the weakest interface shall govern the shear strength of this unit. The interface shear strength will depend on the actual construction materials used.
Friction Angle (smooth HDPE)	8	degree	Geotextile/Geomembrane interface assumed critical. Generalized interface shear strength based on Robert Koerner "Design with Geosynthetics" 5th Edition, for a smooth High Density Polyethylene (HDPE) geomembrane and a non-woven needle-punched geotextile .
Friction Angle (textured HDPE)	25	degree	Critical interface depends on the actual construction materials used, and may be at a geotextile interface or a geomembrane interface. For the preliminary analysis, the assumed critical shear strength assumed is not less than those showed in Robert Koerner's book "Design with Geosynthetics" 5th Edition. The soil, geotextile and textured geomembrane shall be selected in the detailed design to ensure adequate factor of safety.
Cohesion	0	kPa	
Density	20	kN/m^3	
Waste			Assumed preliminary strength parameters based on Singh S and Murphy B, "Evaluation of the Stability of Sanitary Landfills" in “Geotechnical of Waste Fills – Theory and Practice”ASTM STP 1070, 1990.
Friction Angle	24, (20 to 28 sensitivity analysis)	degree	
Cohesion	10, (0 to 20 sensitivity analysis)	kPa	
Density	10	kN/m^3	
Final Cover			Strength based on generalized unconfined compression strength based on Karl Terzaghi and Ralph Peck "Soil Mechanics in Engineering Practice" 2nd Edition, for a clay with medium consistency .
Friction Angle	0	degree	
Cohesion	50	kPa	
Density	20	kN/m^3	

Notes
1. *All these preliminary input parameters to be updated in the detailed design.*
2. *The parameters and values will depend on the actual type of construction materials selected.*
3. *Dry condition was assumed for all cases.*

Table SS2: Summary of Slope Stability Results

Project Name: **West Carleton Environmental Centre**
Project No.: **60191228**
Task: **Preliminary Seismic Slope Stability Analysis**
Date: **Jan-2012**

Summary of the Factor of Safety

	Results	Inputs				
Case ID	**Factor of Safety**	**Waste Strength**		**Critical Interface Friction Angle ø (degree)**	**Seismic**	**Critical Slip Surface Type**
		Cohesion C (kPa)	**Friction Angle ø (degree)**			
PD1	**1.576**	10	24	8	No	Composite
PD2A	**0.541**	10	24	8	0.31g (horz)	Composite
PD2B	**0.644**	10	24	12	0.31g (horz)	Composite
PD3	**2.359**	10	24	25	No	Composite
PD4A	**1.020**	20	20	25	0.31g (horz)	Composite
PD4B	**1.005**	10	24	25	0.31g (horz)	Composite
PS1	**2.526**	10	24	25	No	Circular
PS2A	**1.105**	20	20	25	0.31g (horz)	Circular
PS2B	**1.035**	10	24	25	0.31g (horz)	Circular

Notes:

1. Input parameters see Table SS1.

2. Critical Interface Friction Angles for Cases PD1, PD2A, and PD2B were assumed for a smooth geomembrane. A textured geomem

3. Critical slip surfaces and calculation of Factor of Safety shown as attached.

4. Sensitivity analysis conducted for Cases PD1, PD2A, and PD2B, the plots of the results are shown as attached.

Appendix A.2

Geotechnical Investigations, Proposed Landfill Expansion, West Carleton Environmental Centre, Carp, Ontario, prepared by Alston Associates Inc., dated July 27, 2015

alston associates inc.
consulting engineers

geotechnics
construction materials testing

GEOTECHNICAL INVESTIGATIONS
PROPOSED LANDFILL EXPANSION
WEST CARLETON ENVIRONMENTAL CENTRE
CARP, ONTARIO

REPORT REF. NO. 15-022
July 27, 2015

Prepared For:
WSP Canada Inc.
1450 1st Avenue, Suite 101
Owen Sound, ON N4K 6W2

Prepared By:
Alston Associates Inc.
Toronto

Distribution:

Electronic copy	-	WSP Canada Inc.
1 copy	-	Alston Associates Inc.

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APPENDICES

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1.0 Introduction

Alston Associates Inc. (AAI) was retained by Waste Management (WM) to carry out geotechnical investigation studies for the proposed landfill expansion located at West Carleton Environmental Centre (WCEC) in Carp, Ontario. Four geotechnical reports were prepared during the period between 2011 and 2014 by **AAI**. Copies of the four reports which comprise Appendices 1 through 4 of this report were submitted by WSP to the City of Ottawa in support of Waste Management of Canada Corporation Site Control Plan Application.

We understand that upon preliminary review of the geotechnical reports, the City of Ottawa, commented that the provided reports addressed separate issues as well as some of the same issues and requested that the reports be consolidated into one report that combines the sections that cover the same general information and provide one set of conclusions and recommendations.

The following report consolidates the four reports.

2.0 Preliminary Geotechnical Evaluation, Proposed New Landfill Mound, Waste Management, Carp, Ontario, (Revised), ref. No. 11-066, dated August 2, 2011

A preliminary geotechnical evaluation of the study site was carried out by **AAI** in 2011. This work involved excavating five test pits within the footprint of the proposed landfill mound, and excavating a sixth test pit at a location north of the proposed mound to provide information on the near surface soil deposits in that area of the site; the purpose of the sixth test pit was to make a preliminary evaluation of that area of the site as a source of borrow material.

The test pits which were excavated to depths ranging from 2.3 to 5.2 m below the existing ground surface, revealed that soil deposits within the proposed landfill mound generally consisted of an upper layer of gravelly sand; 0.5 to 1.2 m in thickness followed by silty sand with a trace of gravel, which included traces of boulders. The compactness condition of both granular soil deposits was determined to be compact becoming dense with depth. Groundwater was contacted at depths ranging from 1.5 to 2 m below grade.

The results of a set of direct shear tests performed on a sample of the silty sand provided an effective friction angle of the soil of 39^{o}.

2.1 CONCLUSION

The report concluded that the in situ soil will provide competent support for construction of the landfill mound and that construction of the mound was unlikely to result in slope instability in the side of the mound as a result of failure surface undercutting the supporting native soil deposits. The probable settlement of the base of the mound was expected to be modest as a result of the dense condition of much of the sand deposits.
It should be noted that this study was preliminary in nature and did not include any analyses.

A copy of this report comprises Appendix 1 of this document.

3.0 Geotechnical Investigation, Waste Management, Carp Road, Carp, Ontario ref. No. 13-107, dated December 3, 2013

Based on the findings of the preliminary evaluation, **AAI** was retained by Waste Management in 2013 to carry out a detailed geotechnical analysis of the proposed expansion.

A detailed description of the hydrogeology of the site had been developed by WESA; presented in their report for the proposed site development regarding the Geology and Hydrogeology, existing conditions. A copy of the plan which shows the positions of the WESA boreholes and records of the borehole data which are relevant to the geotechnical design were provided to **AAI** for use for this study.

The fieldwork for this geotechnical study involved advancing a total of twelve sampled boreholes at the site. Those data were complemented by the results of two soundings advanced using a Marchetti Flat Plate Dilatometer (DMT) and one sounding by the Dynamic Cone Penetration test (DCPT) method. Further information relating to procedures followed during the fieldwork may be found in Section 3.0 of the report attached in Appendix 2.

Eight boreholes; Boreholes numbered 1, 2, 3, 6, 7, 9, 10 and 11 were located within the footprint of the proposed landfill site. The remaining four boreholes; Boreholes Numbered 4, 5, 8 and 12, which were instrumented with 50 mm diameter monitoring wells were located within the area of proposed infiltration basins. The locations of these boreholes were chosen by WESA.

Description of the site and subsurface soil and groundwater conditions, along with the results of the laboratory testing is provided in Section 4, sub-sections 4.1 through 4.8 of the report (Appendix 2).

The preliminary target density for the emplaced landfill material given in the development prospectus is 7.8 kN/m³. That density has been adopted for geotechnical analysis of facility design.

3.1 Conclusions and Recommendations

Measurements of the stabilized groundwater table elevation at the site show that mostly, the water table lies at shallow depth. For ease of site preparation it is proposed that the base of the landfill will be positioned above the groundwater table. Site preparation for the proposed 30 m high above landfill mound would require the following operations:

- Remove topsoil and fill materials beneath landfill footprint;
- Compact the exposed subgrade to a dry density of not less than 98% of the material's standard Proctor maximum dry density (SPMDD);
- Lay fill materials as required by landfill design in lifts appropriate to the compaction equipment, and thoroughly and uniformly compact the fill materials to 98% SPMDD.

Analyses have been carried out to assess the stability of the side slopes of the completed landfill facility following final profiling of the slopes immediately prior to closure. Those analyses show a factor of safety under a static loading condition with respect to global stability of more than the required design value of 1.5, which is satisfactory. A copy of the stability analysis for the final side slope is attached in Appendix 'E' of the report attached in Appendix 2. The soil parameters adopted for design evaluation is based on interpreted in situ and laboratory test data, and is given in the analysis sheets.

It is proposed to complete the construction of the liner, including the 2.5 m high slope at a 25% (IV:4H) gradient, at the liner perimeter. This slope must be stable in the period prior to placement of landfill as well as in service life. The relevant selected geotechnical parameters are given below:

- Compacted clay landfill liner and attenuation layer unit weight 19.5 kN/m^3, cohesion intercept nil, effective angle of internal friction 28°;
- Interface friction angle between non-woven geotextile and compacted day line 28°;
- Interface friction angle between non-woven geotextile and granular drainage layer, 36°;
- Interface friction angle between non-woven geotextile and textured geomembrane 36°;
- Interface friction angle between textured geomembrane and compacted clay landfill liner 28°.

The listed parameters show that the critical layers for slope instability are the compacted clay liners; the clay material governs the interface properties. Thus, presuming that the critical failure mode will be sliding, the factor of safety with respect to slope instability is more than 2 for the static condition, which is satisfactory.

An analysis of the expected settlement which will occur in the soils which underlie the landfill has been carried out using values of deformation (constrained) modulus measured by DMT. The results of analysis show that the maximum expected settlement in the native soils is less than 20 mm. Copies of settlement analyses in both east-west and north-south directions and which show estimated settlement along the length of the selected sections are attached in Appendix ‘F’ of the document attached in Appendix 2. On the basis that the soil profile consists of predominantly granular type soils, the rate of settlement is expected to be relatively rapid following load application.

Numerous building developments are anticipated at the site. However, those building locations have not been finalized. Based on the results of the boreholes advanced at the site, it is anticipated that conventional footing foundations applying a bearing pressure at Serviceability Limit States of 120 kPa at a depth below the ground surface of not less than 1.5 m (for heated buildings) may be adopted for preliminary design. It is anticipated that the site classification with respect to seismic site response will be Class ‘D’ with regard to building developments. Specific recommendations will be prepared when the site layout has been finalized.

A copy of this report comprises Appendix 2 of this document.

4.0 Addendum to report, Geotechnical Investigation, Waste Management, Carp Road, Carp, Ontario ref. No. 13-107a, dated December 16, 2013

Analyses carried out in the December 3, 2013 report summarized in Section 3 above with regards to the stability of the side slopes of the completed landfill and the settlement characteristics of the supporting soil profile were made on the basis of conventional (conservative) parameters for shear strength and unit weight of the landfill materials, and were intended to support the conceptual design of the landfill.

We understand that it is the intention of Waste Management that the municipal waste materials be compacted to a dense condition, similar to that achieved on other current landfill sites in Ontario, which are operated by Waste Management.

This report addendum updates the geotechnical design of the landfill. This study presents the results of detailed analysis of side slope stability for both static and seismic loading as well as anticipated settlement which will occur under the completed landfill site.

Selection of soil parameters for assessment of stability presented in this report is based on the results of the testing work carried out to determine the shear strength of samples of densely compacted municipal waste material on samples excavated from the Richmond Landfill site in Napanee, Ontario.

Denser compaction of the waste material has resulted in a higher unit weight of the fill, and improved shear strength characteristics. Work carried out to determine the geotechnical parameters of landfilled municipal waste excavated from the Waste Management Richmond Landfill site shows the following representative soil parameters.

Age of Municipal Solid Waste	Cohesion Intercept C’ (kPa)	Effective Angle of Internal ø’
6 months old	27	26°
1 year old	32	28°
16 years old	9	37°

Records for the Richmond Landfill indicate that the representative unit weight of the compacted waste, including daily cover, is 14 kN/m³.

Reference to the foregoing test results shows that in general, the shear strength characteristics of the landfilled municipal waste increase with time. This is attributed to a denser state of packing of the materials and increased interlock between rigid particles included in the waste fill.

Comparison was made of the recorded results with data reported by other researchers the test data for the Richmond site have been shown to be reasonably consistent with test results reported by others.

It is proposed that the landfill liner will consist of a double composite liner as required by the Ontario Ministry of the Environment. This consists of the following components:

- Landfill leachate collection system embedded in 0.3 m thick layer of granular material;
- Needle punched nonwoven geotextile;
- 1.5 mm thick HDPE liner;
- 0.75 m thick engineered clay liner;
- Needle punched nonwoven geotextile;
- 0.3 m thick granular secondary leachate collection layer;
- Needle punched nonwoven geotextile;
- 2 mm thick HDPE liner;
- 0.75 m thick engineered clayey secondary liner;
- 1 m thick attenuation layer consisting or natural of constructed low permeability soil.

In order to enhance the adhesion between the HDPE liner and both the overlying nonwoven geotextile, as well as the underlying engineered clayey liner, it is proposed that the HDPE be a textured material. Reference to published literature shows that the friction angle between non-woven geotextile and textured HDPE ranges from 32 to 38°. The friction angle between textured HDPE and compacted clay has been found to be more than 40°. The friction angle of the granular material in the drainage layer is expected to exceed 35° for hard, durable stone.

On the basis of the given data, the controlling shear strength parameters of the composite double liner system are governed by the properties of the compacted clay layer.

On the basis of these data a conservative effective friction angle of 28° has been selected for static stability analysis; an undrained shear strength of the compacted clay layer of 120 kPa is of the liner is assumed. This value will be part of the specification for liner construction.

An analysis has been carried out with regards to the stability of the side slopes of the completed landfill using the soil parameters given above. Those results show a factor of safety with respect to global shear failure of more than 2 for both 1 year old and 16 year old municipal waste. The analysis results are attached in Appendices ‘AA’ and ‘BB’, respectively of the document attached in Appendix 3 of this report. This exceeds the Ministry of the Environment requirement value of 1.5 and is satisfactory.

A seismic load of 0.42 g has been adopted for analysis of slope stability under seismic loads. The results of the stability analysis for the 1 year old and 16 year old waste are given in Appendices ‘CC’ and ‘DD’, respectively of the document attached in Appendix 3 of this report. The results of analysis show a factor of safety of more than 1.1 which is satisfactory.

The settlement of the base of the liner under the full loads of the landfilled municipal waste have been calculated on the basis of deformation modulus values measured in the course of undertaking DMT soundings. The results of the analyses showing estimated settlement in both north-south and east-west directions are attached in Appendices ‘EE’ and ‘FF’ of the document attached in Appendix 3 of this report. These analyses show that the maximum deformation of the landfill base under full load (30 m landfill height) is expected to be in the range 25 to 30 mm. The calculated settlement profile beneath the landfill is given in Page 5 of each reported analysis.

A copy of this report comprises Appendix 3 of this document.

5.0 Supplemental Geotechnical Investigation, Proposed Landfill Expansion, West Carleton Environmental Centre, Carp, Ontario, ref. No. 13-182, dated March 12, 2014

AAI was subsequently retained by Waste Management to carry out a supplemental geotechnical investigation. The purpose of this investigation was to characterize the subsurface soil and groundwater conditions, to determine the relevant geotechnical properties of encountered soils, and to provide geotechnical recommendations for:

- Structural design of proposed paved and granular-surfaced roads, including recommendations for placement of subgrade and components of the various pavement structures which included a paved access road extending from the southwest corner of the proposed landfill site to the proposed Carp Road widening, a granular-surfaced maintenance/service road surrounding the perimeter of the proposed landfill, and repaving the existing gravel road at the southwest corner of the proposed landfill site.

- Geotechnical support and guidance in design of infiltration basins, including recommendations relating to percolation rate of the in-situ soils and design of above grade containment berms;
- Recommendations relating to the design and construction of two proposed lined SWM ponds;
- Design recommendations required for paving the existing gravel road to the transfer station at the southwest corner of the Waste Management (WM) property; and
- Recommendations regarding installation of various utilities, including suitability of native soils and requirements for imported soils as bedding and backfill material.

The fieldwork for this investigation was carried out during the period between December 16 and 20, 2013, and consisted of twenty (20) exploratory boreholes, numbered 201 to 220 inclusive.

Description of the subsurface soil and groundwater conditions, along the existing gravel road, the proposed infiltration basins and the two proposed stormwater management ponds is provided in Section 5, sub-sections 5.1 through 5.5 of the report attached in Appendix 4 of this report.

5.1 Roadway Pavement Recommendations

It is understood that new roads are proposed for construction to provide access for the new landfill expansion. The proposed roads will include:

- a new paved access road extending from the southwest corner of the proposed landfill site to the proposed Carp Road widening
- new granular-surfaced maintenance/service road (ring road) surrounding the perimeter of the proposed landfill
- pave the existing gravel road at the southwest corner of the proposed landfill site

According to Section 7.3 of Supporting Document 4, Facility Characteristics Report prepared by AECOM, truck traffic associated with the landfill operation will include hauling waste to the site as well as haulage of construction materials.

Based on Drawing No. 131-19416-00 – SK10 prepared by WM / WSP Canada Inc., the indications are that with the exception of the existing gravel road extending north from the existing waste transfer building, the grades along all remaining proposed roads will be raised by as much as 8 m.

The following recommendations regarding placement of fill under proposed roads should be adhered to during the construction stage:

- All exposed topsoil and organic soils must be removed, and the underlying subgrade soils compacted prior to any new fill placement.
- Fill operations should be monitored and compaction tests should be performed to ensure that the materials are being adequately compacted.

- Material used as fill should be free of organics and/or other unsuitable material, and must be placed in lifts suitable for the material and size of compactor being used, and compacted to at least 96% SPMDD.
- If fill is required adjacent to sloped banks (> 3:1, horizontal to vertical), it is imperative that the fill is placed in stepped planes in order to avoid a plane weakness.
- The fill operation should take place in favorable climatic conditions. If the work is carried out in months where freezing temperatures may occur, all frost affected material must be removed prior to the placement of frost-free fill.

In general, the soil strata at the site consist of compact sandy silt underlain by very dense sandy silt soil which rests on bedrock. Deformation of these soils under application of up to 8 m of fill (approximately 160 kPa) will be minimal and likely be completed within a few weeks upon completion of placement of fill.

Based on information provided by WSP Canada Inc., we understand that the roadways throughout the site should be designed for a service life of 25 years and the following anticipated traffic:

Section of the main road from the landfill entrance to the turnaround near SW corner of the expansion area:

- Average annual daily traffic (AADT) – 700
- 55% packer and roll-off trucks (3-4 axles)
- 26% tractor trailers (7-9 axles)
- 19% small passenger cars and pickups

Section of road from the turnaround to Waste Transfer Processing Facility

- AADT - 138
- 80% roll off trucks (3-4 axles)
- 20% tractor trailers (7-9 axles)

Ring road surrounding waste disposal area

The ring road surrounding the proposed waste disposal area will be used by internal site traffic which may include rock trucks.

We also understand that as loaded tractor trailers may keep down liftable axles and apply additional stress on pavement on all 90 degree turns.

Based on a design life of 25 years, the anticipated usage provided above, and a CBR of 4 for the compacted fill subgrade, the following pavement designs are recommended for the gravel and paved roads.

Section of the main road from the landfill entrance to the turnaround near SW corner of the expansion area:

- Asphaltic concrete surface course – 50 mm HL3 High Stability or Superpave 12.5 Level D with PG 64-28 asphalt cement

- Asphaltic concrete base course – 100mm (2 layers) HL8 Heavy Duty Binder Course or Superpave 19 Level D with PG 64-28 asphalt cement
- Granular base course – 150 mm of Granular 'A'
- Granular sub-base course – 550 mm of Granular 'B' Type II

As an alternate to the asphaltic concrete pavement recommended above, in areas where trucks are to repeatedly stop and go, such as at gates, as well as make sharp turns, a Portland cement concrete pavement may be considered. The concrete pavement should consist of:

- Concrete – 250 mm
- Granular base course – 150 mm of Granular 'A'
- Granular sub-base course – 300 mm of Granular 'B' Type II

The concrete must be air entrained, and possess minimum compressive and flexural strengths of 35 MPa and 4.8 MPa respectively.

Section of road from the turnaround to Waste Transfer Processing Facility

- Asphaltic concrete surface course – 40 mm HL3 High Stability or Superpave 12.5 Level D with PG 64-28 asphalt cement
- Asphaltic concrete base course – 80mm (2 layers) HL8 Heavy Duty Binder Course or Superpave 19 Level D with PG 64-28 asphalt cement
- Granular base course – 150 mm of Granular 'A'
- Granular sub-base course – 400 mm of Granular 'B' Type II

The in situ granular soil along the existing gravel road north of the transfer station may be left in place, and overlain with a minimum of 150 mm thick Granular 'A' base prior to placement of the asphaltic concrete layers recommended above.

Ring road surrounding waste disposal area

- Granular surface course – 300 mm of Granular 'A'
- Granular base course – 450 mm of Granular 'B' Type II

It should be noted that all proposed roadways will be suitable for use by fire trucks.

The subgrade must be compacted to at least 98% SPMDD for at least the upper 600 mm and 96% below this level. Where fine-grained clay soils are used for subgrade upfill, the degree of compaction specification alone cannot ensure distress free subgrade. Proof-rolling of the roadway subgrade must be carried out and witnessed by **AAI** personnel for final recommendations of sub-base.

The granular pavement structure materials should be placed in lifts not exceeding 150 mm thick and be compacted to a minimum of 100% SPMDD. Asphaltic concrete materials should be rolled and compacted as per OPSS 310. The granular and asphaltic concrete pavement materials and their placement should conform to OPSS 310, 501, 1010 and 1150.

The long-term performance of the proposed pavement structures is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over-emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be crowned and sloped (at a minimum crossfall of 2% for both the pavement surface and the subgrade) to provide effective drainage. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Sub-drains or roadside drainage ditches must be provided to facilitate effective and assured drainage of the pavement structures as required to intercept excess subsurface moisture and minimize subgrade softening. The invert of sub-drains and drainage ditches should be maintained at least 0.3 m below subgrade level.

In the event that the near surface subgrade soil cannot be maintained dry by providing good ditches and sub drains, then the fill within the uppermost 900 mm should consist of Select Subgrade Material (sandy soil).

5.2 Infiltration Basin Recommendations

Details of the proposed Infiltration Basins No. 1 and No. 2 are provided in Drawing No. 131-19416-00 – SK10 prepared by WM / WSP Canada Inc. dated November 21, 2013.

According to this drawing, the proposed base elevation of Infiltration Basin No. 1 is 123.00 m, and of Infiltration Basin No. 2 is 122.00 m. The proposed grades at the top of the basins (containment berms) would range between 126.7 and 128 m at Infiltration Basin 1 and between 124.5 and 126.3 m at Infiltration Basin No. 2. The side slopes of both infiltration basin embankments would be 3H to 1V.

The existing site grades within the bases of the proposed infiltration basins range between 122 and 122.5 m, and between 117.5 to 124.5 m, at Basins 1 and 2 respectively. On this basis, the existing site grades will be raised to achieve the design base elevations of both infiltration basins.

Our recommendations regarding the construction of the proposed infiltration basins are:

- The existing topsoil, organic soil and any fill materials present within the footprints of the infiltration basins must be removed down to the native soil stratum.
- Soil possessing the design infiltration rate should be placed loosely within the base of both basins to the proposed grades of 122 m and 123 m.
- Fill placed within the containment berms of the basins should consist of clayey soils and compacted to a minimum 98% SPMDD.
- The uppermost at least 600 mm depth of the clayey soil placed within the berms should have the following properties:
  - Plasticity Index between 7 and 65.
  - 100 percent of the particles passing 75 mm sieve.

- Not less than 70 percent of the particles, by weight, passing the 0.075 mm sieve.
- Not less than 20 percent of the particles, by weight, passing the 0.002 mm sieve.
- Placed in maximum 300 mm lifts and compacted to a minimum of 98% SPMDD.
- Placed at or slightly above optimum moisture content.

The permeability of the 5 soil samples retained from the footprint of Infiltration Basin 1 are estimated to be in the range of $5x10^{-2}$ to $2.3x10^{-4}$ cm/sec, corresponding to approximate percolation times of 3 to 10 min/cm respectively.

The permeability of the 4 soil samples retained from the footprint of Infiltration Basin 2 (Boreholes 202, 203, 204 and 4) are estimated to be in the range of $4x10^{-2}$ to $1.6x10^{-5}$ cm/sec, corresponding to approximate percolation times of 3 to 20 min/cm respectively. The silty clay present in Borehole 205, situated in the southeast quadrant of the footprint of Infiltration Basin 2 is considered to be impervious, with an estimated permeability of less than 10^{-7} cm/sec and corresponding percolation time in excess of 50 min/cm.

5.3 Proposed Stormwater Management Pond Recommendations

Details of the proposed SWM ponds which are provided in Drawing No. 131-19416-00 – SK10 prepared by WM / WSP Canada Inc. dated November 21, 2013 are summarized as follows:

	Proposed Base Elevation (m)	Existing Base Elevation (m)	Proposed top of Berm Elevation (m)	Existing top of Berm Elevation (m)
SWM Pond 1	124.0	122.5 to 124.0	126.75 to 129.0	122.0 to 125.0
SWM Pond 2	122.8	117.5 to 122.5	126.3 to 126.8	117.5 to 125.0

The waterside slopes of the containment berms of the ponds would be 4H:1V and the landside or downstream slopes of the embankments would be 3H:1V. The top width of the berms will be approximately 3 m.

Three boreholes, numbered 12, 210 and 211, were advanced within the footprint of the proposed SWM Pond No. 1. Fill is present at all three boreholes. The fill consists of sandy silt at Borehole 210, silty sand with some gravel at Borehole 211, and sand with trace organics at Borehole 12. The fill extends to an approximate depth of 3 m at Borehole 210 and 12, and 0.7 m at Borehole 211. The in situ test results indicate that the compactness condition of the fill is very loose to compact. Underlying the fill, a sand and gravel unit with inclusions of rock fragments was contacted in Borehole 210 extending to the explored depth of the borehole. Sand to silty sand soils are present below the fill in Boreholes 211 and BH12. At Borehole 211, the upper section of the silty sand deposit is brown, changing to grey below an approximate depth of 5.6 m. The grey sand unit is a glacial deposit; with inclusions of trace gravel and rock fragments.

Two boreholes, numbered 5 and 201 were advanced at the location of the proposed SWM Pond No. 2. The boreholes revealed that 100 to 200 mm thick layer of topsoil is present at all three boreholes. At Borehole 201, the topsoil is underlain by an approximately 400 mm thick layer of fill consisting of gravelly sand, with some organics and traces of silt and clay. The fill at Borehole 201, and the topsoil at Boreholes 5 are underlain by native soil. The native soil present at Borehole 201 consists of sand with inclusions of rock fragments. In Borehole 5 the native soil consists of medium to coarse sand and gravel.

The groundwater table across the area of the ponds is situated below elevation 120 m and is not anticipated to impact construction and continued performance of the ponds, as the bases of the ponds would be set above elevation 122.8 m.

Based on the available information, the bases of the ponds would be raised by as much as 5 m, and the containment berms would be raised by as much as 7 m. The soil present within the bases and side slopes of SWM Pond 1 consist of up to 3 m of loose fill underlain by sandy and gravelly soils. The soil that is present within the bases and side slopes of SWM Pond 2 consist of a thin (less than 400 mm thick) layer of topsoil or fill underlain by sand and gravelly sand soil.

Based on the above considerations the following recommendations are provided for construction of the proposed ponds:

- The existing topsoil, organic soil and any fill materials present within the footprints of the stormwater ponds must be removed down to the native soil stratum.
- Fill placed within the bases and containment berms of the pond should consist of clayey soils and compacted to a minimum 98% SPMDD.
- The uppermost at least 600 mm depth of the clayey soil placed within the pond base and sidewalls should have the following properties:
    - Plasticity Index between 7 and 65.
    - 100 percent of the particles passing 75 mm sieve.
    - Not less than 70 percent of the particles, by weight, passing the 0.075 mm sieve.
    - Not less than 20 percent of the particles, by weight, passing the 0.002 mm sieve.
    - Placed in maximum 300 mm lifts and compacted to a minimum of 98% SPMDD.
    - Placed at or slightly above optimum moisture content.

Alternatively a geosynthetic liner may be used. However since the bases and containment berms are to be raised using earth fill, installation of a compacted clay liner is considered to be more economical. Installation of a compacted clay liner is also more standard construction practice as compared to the more specialized procedures/specifications for geosynthetic liners. From a geotechnical perspective, a compacted clay liner is considered to be the preferred option.

5.4 Slope Stability Analyses

Analyses have been carried out to assess the stability of the side slopes of the completed infiltration basins and stormwater management ponds. Those analyses show a minimum factor of safety under a static loading condition with respect to global stability of 1.90; more than the required value of 1.5, which is satisfactory. Copies of the stability analyses for various sections and loading conditions are attached in Appendix ‘F’ of the document attached in Appendix 4. The soil parameters adopted for design evaluations are based on interpreted in situ and laboratory test data, as well as conservative values for the proposed fills, and are given in the analysis sheets.

The proposed containment berm gradients within the ponds and basins will remain stable against any sliding failure. The minimum Safety Factor of the global stability of the embankments; 1.90, is well over the minimum specified factor of 1.5, for any of the loading conditions.

5.5 Excavation, Backfill and Dewatering

Based on the field results, excavation of the soils at this site above the bedrock can be carried out with heavy hydraulic excavators.

All excavations must be carried out in accordance with Occupational Health and Safety Act (OHSA). The soil profile at the site generally consists of an upper layer of fill which is of variable quality and variable condition. On the basis of our inspection of the soil samples, it should be assumed that the fill materials will conform to Type 3 or Type 4 classification, as given in the Occupational Health and Safety Regulations. The compact to dense sand soils stiff silty clay which lie above the water table are expected to conform to Type 2 or Type 3 classification; below the water table the sand can be expected to behave as a flowing soil unless the soil is dewatered. Temporary excavation side-slopes should not exceed 1.0 horizontal to 1.0 vertical. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation. Locally, where very loose or soft soil is encountered at shallow depths or within zones of persistent seepage, it will be necessary to flatten the side slopes as necessary to achieve stable conditions. Excavation side-slopes should not be left exposed to inclement weather. Excavation slopes consisting of sandy soils will be prone to gullying in periods of wet weather, unless the slopes are properly sheeted with tarpaulins.

Where workers must enter excavations extending deeper than 1.2 m below grade, the excavation side-walls must be suitably sloped and/or braced in accordance with the Occupational Health and Safety Act and Regulation for Construction Projects. The design of temporary shoring should be in accordance with the earth pressure diagram (Figure 26.8) from the Canadian Foundation Engineering Manual.

It is anticipated that proposed sewer pipe inverts and proposed manhole chambers will be situated above the groundwater level and as such dewatering should not be necessary. Surface water should be directed away from open excavations.

Based on the existing topography at the subject site and proposed grades, it is anticipated that significant cut and fill operations will be required for development of the property.

On-site excavated inorganic native soils are considered suitable for reuse as backfill material or engineered fill, provided their water content is within 2% of their optimum moisture content (OMC) as determined by Standard Proctor test, and the materials are effectively compacted with heavy vibratory pad-type rollers (cohesive soils) and smooth drum rollers (cohesionless soils). The compactors must be of sufficient size and energy to break down the lumps and to knead the soil into a homogeneous mass as water and compaction effort is applied. If the equipment does not have sufficient energy to break down the lumps, there is a tendency to bridging and post construction settlements. In areas of narrow trenches or confined spaces such as around foundations, foundation walls, etc., the use of aggregate fill such as Granular 'B' (OPSS 1010) is required if there is to be post-construction grade integrity.

New fill placed to raise the existing grade must be compacted to the specified compaction requirements recommended in the preceding paragraphs. It is best to schedule deep fill placement as far in advance of finish surfacing as possible for best grade integrity.

If construction is carried out in inclement weather, there is a likelihood that some amount of road sub-base supplement may be required (i.e. some sub-excavation followed by granular replacement).

Should construction proceed during the winter season, it is imperative to ensure that frozen material is not utilized as trench backfill, beneath pavements or ponds.

5.6 Bedding for Sewers and Water Mains

The undisturbed natural soils at the site are suitable for supporting water mains, sewer pipes, manholes, catch basins and other related structures. Based on the present site grades, sewer pipes and water mains will probably be supported on the engineered fill, or undisturbed native soil deposits.

The type of bedding depends mainly on the strength of the subgrade immediately below the invert levels.

Normal Class 'B' bedding is recommended for underground utilities. Granular 'A' or 19 mm crusher-run limestone can be used as bedding material. The bedding material should be compacted to a minimum of 96% SPMDD.

Pipe bedding and backfill for flexible pipes should be undertaken in accordance with OPSD 802.010, 802.013, and 802.014. Pipe embedment and cover for rigid pipes should be undertaken in accordance with OPSD 802.030, 802.031, 802.032, 802.033 and 802.034.

Fine sand may be used as bedding material for HDPE pipes.

If unsuitable bedding conditions occur, careful preparation and strengthening of the trench bases prior to sewer installation will be required. The subgrade may be strengthened by placing a thick mat consisting of 50 mm crusher-run limestone. Field conditions will determine the depth of stone required. Geotextiles and/or geogrids may be helpful and these options should be reviewed by AAI on a case by case basis.

Sand cover material should be placed as backfill to at least 300 mm above the top of pipes. Placement of additional granular material (thickness dictated by the type of compaction equipment) as required or use of smaller compaction equipment for the first few lifts of native material above the pipe will probably be necessary to prevent damage to the pipe during the trench backfill compaction.

Where necessary, especially within and in close proximity of ponds and pond embankments, plugs should be provided within the bedding materials to prevent water seepage through bedding material.

It is recommended that service trenches be backfilled with on-site native materials such that at least 96% of Standard Proctor Maximum Dry Density (SPMDD) is obtained in the lower zone of the trench and 98% of SPMDD for the upper 600 mm. However, prior to building the roads, the subgrade should be thoroughly proof-rolled and re-compacted to 98% of SPMDD to ensure uniformity in subgrade strength and support.

Yours truly,
alston associates inc.

LICENSED PROFESSIONAL ENGINEER
V. NERSESIAN
33778705
27/07/15
PROVINCE OF ONTARIO

Vic Nersesian, P. Eng.
Vice President, Geotechnical Services

APPENDIX 1

PRELIMINARY GEOTECHNICAL EVALUATION, PROPOSED NEW LANDFILL MOUND, WASTE MANAGEMENT, CARP, ONTARIO, (REVISED), REF. NO. 11-066, DATED AUGUST 2, 2011

PRELIMINARY GEOTECHNICAL EVALUATION
PROPOSED NEW LANDFILL MOUND
WASTE MANAGEMENT
CARP, ONTARIO
(Revised)

Ref. No. 11-066
2 August 2011

Prepared for:

AECOM
300 Town Centre Boulevard
Suite 300
Markham, Ontario
L3R 5Z6

Distribution:

4 Copies - AECOM
2 Copies - Alston Associates Inc.

2 August 2011

Ref. No. 11-066

AECOM
300 Town Centre Boulevard
Suite 300
Markham, Ontario
L3R 5Z6

Att: Mark Sungaila
Project Manager

Subject: Preliminary Geotechnical Evaluation
Proposed New Landfill Mound
Waste Management
Carp, Ontario
(Revised)

Following authorization from your office, a preliminary geotechnical evaluation of the study site was carried out by Alston Associates Inc. This work involved excavating five test pits within the footprint of the proposed new landfill mound, and excavating a sixth test pit exploration at a location north of the proposed mound to provide information on the near surface soil deposits in that area of the site; the purpose of the sixth test pit was to make a preliminary evaluation of that area of the site as a source of borrow material. The test pits were excavated to depths ranging from 2.3 to 5.2 m below the existing ground surface. Soil samples were taken at frequent depth intervals in the excavations to provide information regarding classification of the soils, and their engineering characteristics. Assessment of the compactness condition of the in situ soils was made using hand operated dynamic cone penetration test (DCPT) equipment. This equipment meets the requirements of DIN Standard 4094 (DPL energy). The results of the DCPT soundings can be correlated with standard penetration test N-values to give an assessment of in situ soil condition. Additional testing was carried out using hand operated static cone penetration test (CPT) equipment to measure the cone penetration resistance value of the soils.

Subsurface Conditions

The site is overlain with a layer of topsoil which ranges in thickness from 200 to 500 mm. Generally, the site is grass covered, with some areas of mature tree growth. A layer of disturbed soil underlies the topsoil at the locations of Test Pit N1. This soil unit consists of material which likely originates from the underlying sand and gravel layer.

The mineral soil deposits at the site generally consist of an upper layer of gravelly sand which is generally in the range 0.5 to 1.2 m thick. The upper sand and gravel to gravelly sand is underlain by a soil deposit consisting of silty sand with a trace of gravel, and with some zones which include an increased gravel fraction (some gravel); the silty sand includes occasional cobble and boulder sizes. The compactness condition of both granular soil deposits is compact becoming dense, as evidenced by equivalent standard penetration test N-values in the range 6 to 30 blows/300 mm in the upper 2 m of the soil profile and more than 30 blows/300 mm in the lower zone. Static cone penetrometer readings in the range 10 to 30 kg/cm^2 were recorded in the upper 1 to 1.5 m of the soil profile.

The water content of the sand was found to range from 8 to 21%, this range represents differences in soil composition and saturation of the soil samples. The results of grain size distribution tests carried out on representative soil samples of the upper and lower soil deposits are given in Figures 1 and 2, respectively. Falling head permeability tests were carried out on two samples of the granular soil, and the test results are reported in Figures 3 and 4. These results show a soil with a permeability in the range 10^{-4} to 10^{-5} cm/s, which is lower than would be predicted from the results of grain size distribution tests. The results of a set of direct shear tests carried out on a sample of the silty sand soil are given in Figure 5. These indicate an effective friction angle of the soil of 39°, which is somewhat higher than would be predicted on the basis of penetration index values measured by in situ testing (CPT and DCPT).

Generally, groundwater was contacted at a depth of about 1.5 to 2 m below the existing ground surface. However, it was found possible to dig beyond the depth of saturation up to a depth of more than 4 m without resort to excessive construction expedients. Seasonal variations in groundwater level should be anticipated; it should be noted that the field test program for this study was carried out following an unusually wet spring season.

Discussion

The results of the test pit excavation program have shown that the site is underlain by a deposit of gravelly sand overlying silt and fine sand soil, which extends to a depth of more than 5 m. The compactness condition of the sand is generally "compact" in the near surface sub-unit of the sand soil deposit, and "dense" in the underlying portion of the deposit which is shown by in situ testing together with the results of laboratory direct shear testing of the soil. Groundwater at the time of the site exploration was found to lie at a depth of about 1.5 to 2 m.

The compact, becoming dense condition of the sand soil deposit which underlies the site indicates that this layer will provide competent support for construction of a landfill mound. Thus, construction of a mound is unlikely to result in a slope instability in the side of the mound as a result of a failure surface undercutting the mound and intersecting the supporting native soil deposits. The design side slope gradient of the mound will be governed by regulatory requirements and the condition of the stored landfill material, not by the supporting base.

The probable settlement of the base of the mound is expected to be modest as a result of the dense condition of much of the sand deposit. Excessive settlements are not anticipated in the foundation soil.

A limitation on the depth of excavation required to construct the base of the mound will be provided in a practical sense, by the depth to the water table at the site.

Consideration should be given to utilizing the local silty sand material amended by the addition of powdered bentonite to provide low permeability layers in the base liner of the landfill, as an alternative to silty clay borrow material.

Limitations of Report

This report provides preliminary information with regard to the geotechnical characteristics of the local soil deposit. The test pit explorations were widely spaced and extended to limited depth. It will be necessary to conduct a detailed geotechnical evaluation of the site to provide high quality design data for detailed geotechnical design of the development.

A description of limitations inherent in carrying out conventional geotechnical report is given in Appendix 'A', which is an integral part of this report.

Yours very truly,
ALSTON ASSOCIATES INC.

Colin Alston, P.Eng.

/jt

APPENDIX 'A'

Appendix 'A'

LIMITATIONS OF REPORT

The conclusions and recommendations in this report are based on information determined at the test hole locations. Soil 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 soil investigation.

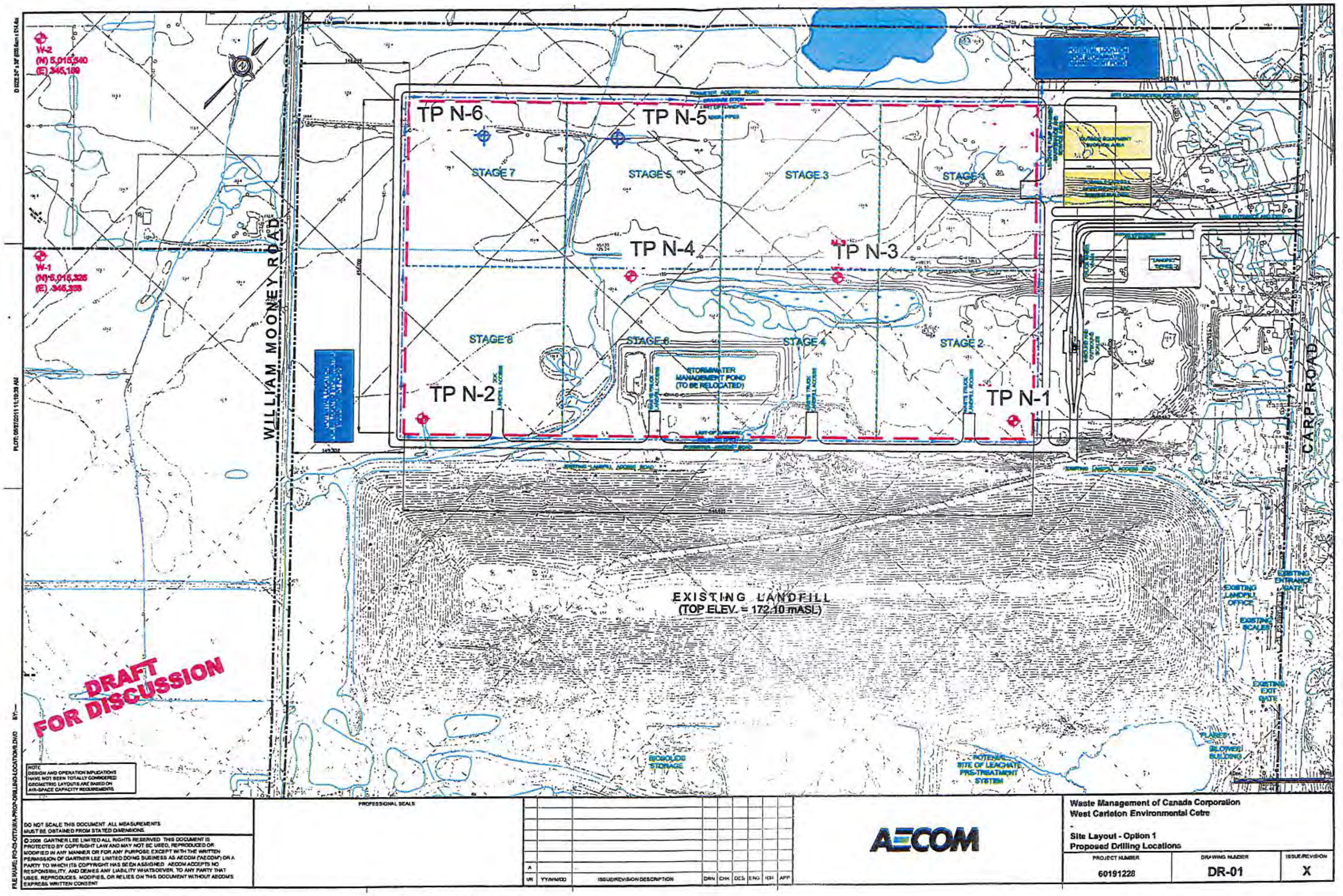
The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made as set out in this report. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

This report was prepared for AECOM by Alston Associates Inc. The material in it reflects Alston Associates Inc. judgement in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions which the Third Party may make based on it, are the sole responsibility of such Third Parties.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the test holes. In cases where these recommendations are not followed, the company's responsibility is limited to accurately interpreting the conditions encountered at the test holes, only.

The comments given in this report on potential construction problems and possible methods are intended for the guidance of the design engineer, only. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. 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.

ENCLOSURES



UTM Co-ordinates for each location shown on Test Pit Log Sheets

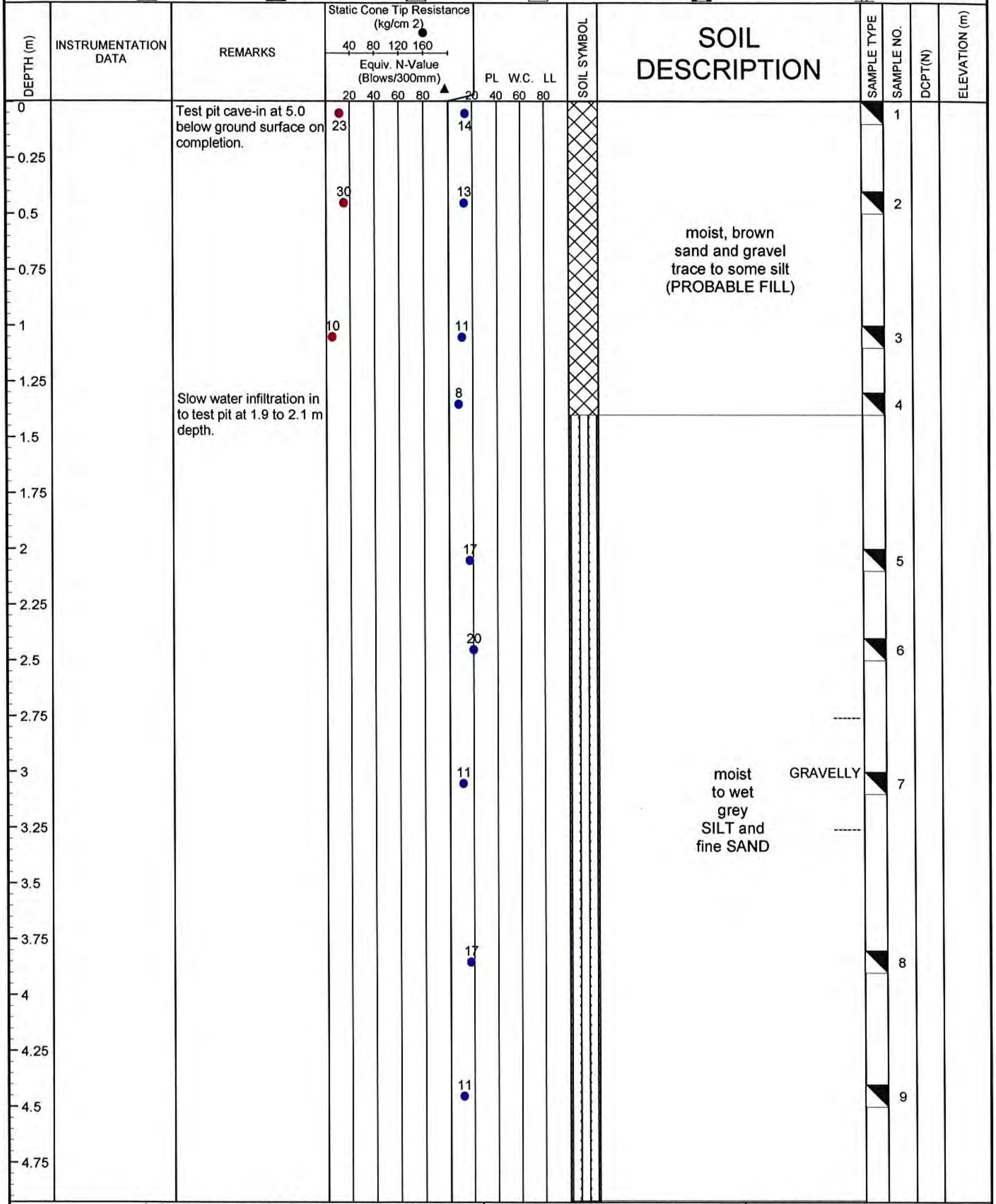
TEST PIT LOCATION PLAN
CARP LANDFILL
CARP, ONTARIO

Drawing No. 1
Ref. No. 11-066
June 2011
Scale: n.t.s.

TP No.: N1

CLIENT: AECOM
METHOD: Track Mounted Excavator
PROJECT: Carp Landfill
PROJECT ENGINEER: CA
ELEV. (m)
LOCATION: Carp Road at Highway 417
NORTHING: 5015067
EASTING: 0424059
PROJECT NO.: 11-066

SAMPLE TYPE: AUGER · DRIVEN · CORING · DYNAMIC CONE · SHELBY · SPLIT SPOON



Test pit cave-in at 5.0 below ground surface on completion.

Slow water infiltration in to test pit at 1.9 to 2.1 m depth.

moist, brown
sand and gravel
trace to some silt
(PROBABLE FILL)

moist
to wet
grey
SILT and
fine SAND

GRAVELLY

alston associates inc.
consulting engineers

LOGGED BY: KC
DRILLING DATE: 31 May 2011
REVIEWED BY: DM

CLIENT: AECOM
METHOD: Track Mounted Excavator
PROJECT: Carp Landfill
PROJECT ENGINEER: CA
ELEV. (m)

TP No.: N1

LOCATION: Carp Road at Highway 417
NORTHING: 5015067
EASTING: 0424059
PROJECT NO.: 11-066

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Static Cone Tip Resistance (kg/cm 2) 40 80 120 160 ● Equiv. N-Value (Blows/300mm) 20 40 60 80 ▲	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
5		Side walls caving at 5.0 m depth.	9 ●			see bottom of previous page	◣	10		
						END OF BOREHOLE				

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consulting engineers

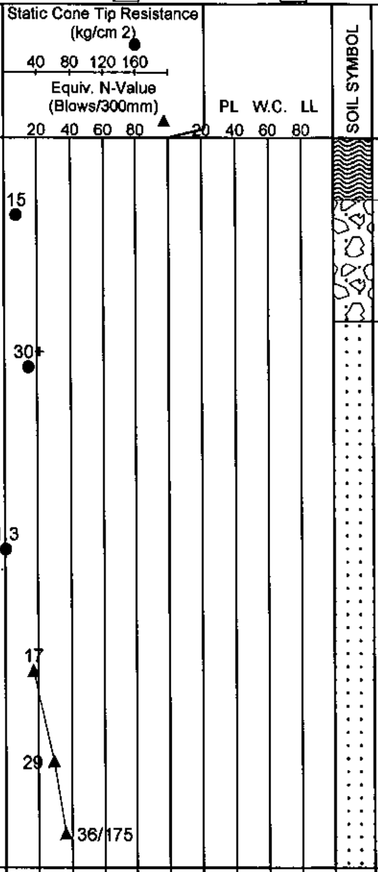
LOGGED BY: KC
DRILLING DATE: 31 May 2011
REVIEWED BY: DM

CLIENT: AECOM
PROJECT: Carp Landfill
LOCATION: Carp Road at Highway 417
METHOD: Track Mounted Excavator
PROJECT ENGINEER: CA
ELEV. (m)
NORTHING: 5014562
EASTING: 0423450

TP No.: N2

PROJECT NO.: 11-066

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Water level at 1.2 m and side walls of excavation sloughing from 1.2 m depth to base of exdcavation on completion.	200 mm TOPSOIL	DRIVEN	1		
0.25			moist, brown SAND and GRAVEL trace silt	DRIVEN	2		
0.75			moist	DRIVEN	3		
1.25	▼	Fast water infiltration in to test pit at 1.2 m depth. Dynamic Cone penetration test advanced from 1.4 to 2.4 m depth.	----- brown fine to medium SAND trace gravel trace silt	DRIVEN	4		
1.75			wet compact			17	
2				DRIVEN	5		
			------			29	
2.25			dense			36/175	
		Refusal to advancement of dynamic cone test, probable boulder.	END OF BOREHOLE				

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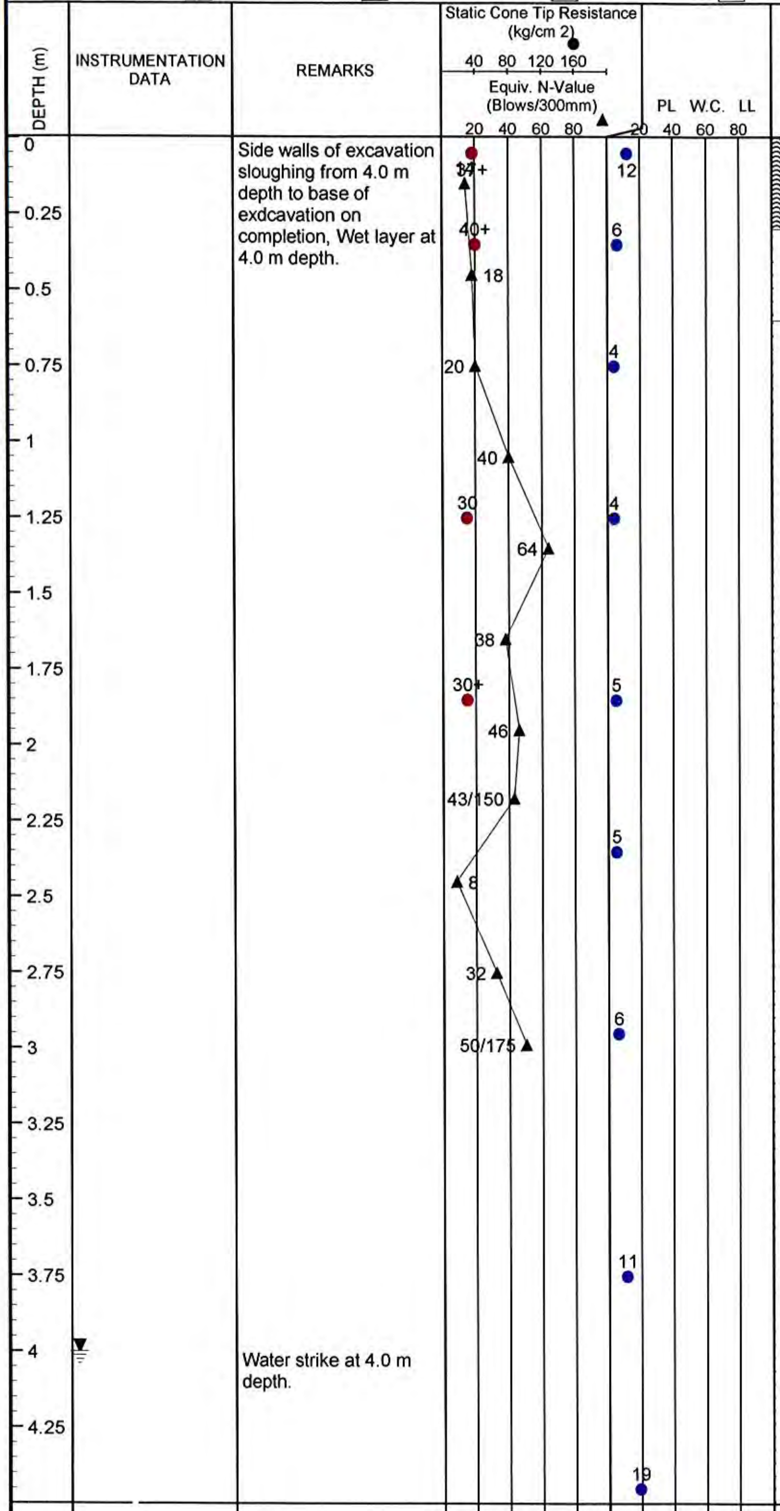
LOGGED BY: KC
REVIEWED BY: DM
DRILLING DATE: 31 May 2011
Page 1 of 1

CLIENT: AECOM	METHOD: Track Mounted Excavator		**TP No.: N3**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5015120	EASTING: 0423765	PROJECT NO.: 11-066

SAMPLE TYPE ▮ AUGER ◩ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▯ SHELBY Ⅰ SPLIT SPOON



REMARKS: Side walls of excavation sloughing from 4.0 m depth to base of exdcavation on completion, Wet layer at 4.0 m depth.

Water strike at 4.0 m depth.

SOIL DESCRIPTION

300 mm TOPSOIL

moist, brown
SAND
some gravel

compact

------

dense

damp
to
moist

greyish brown
fine to
medium SAND
trace silt

------

wet

END OF BOREHOLE

SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
◩	1	14	
◩	2	18	
◩	3	20	
		40	
◩	4	64	
		38	
◩	5	46	
		43/ 150	
◩	6	8	
		32	
◩	7	50/ 175	
◩	8		
◩	9		

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	REVIEWED BY: DM	Page 1 of 1

CLIENT: AECOM	METHOD: Track Mounted Excavator	**TP No.: N4**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)
LOCATION: Carp Road at Highway 417	NORTHING: 5014894	EASTING: 0423507
		PROJECT NO.: 11-066

SAMPLE TYPE ▯ AUGER ◢ DRIVEN ⧗ CORING ▬ DYNAMIC CONE ▮ SHELBY ‖ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Static Cone Tip Resistance (kg/cm 2) ● 40 80 120 160 Equiv. N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Test pit cave-in at 1.8 m and water level at 1.8 m below ground surface on completion.	● 17		400 mm TOPSOIL	◢	1		
0.25									
0.5			30 ●		damp to moist brown SAND some gravel	◢	2		
0.75									
1			30+ ●			◢	3		
1.25					moist greyish brown SILT and fine SAND	◢	4		
1.5		Boulder contacted at 1.5 m depth.							
1.75	▽	Water quickly infiltrating at 1.8 m depth.	30+ ●			◢	5		
2									
2.25									
2.5						◢	6		
2.75									
3					wet, brown fine to medium SAND	◢	7		
					END OF BOREHOLE				

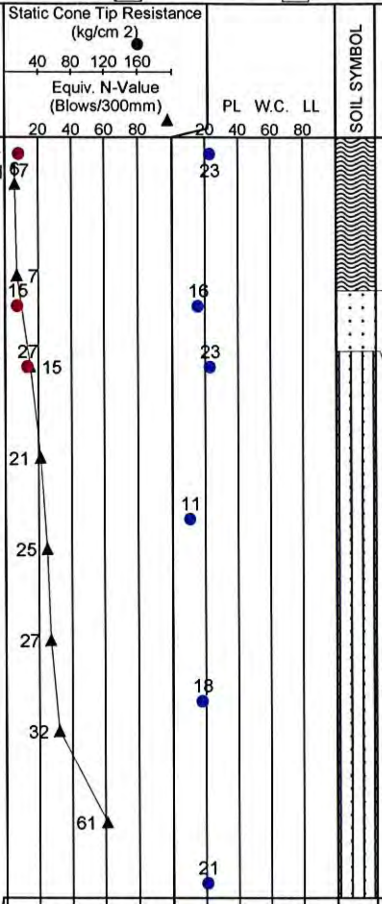
alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 31 May 2011
	REVIEWED BY: DM	Page 1 of 1

CLIENT: AECOM	METHOD: Rubber Tire Backhoe		**TP No.: N5**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5015006	EASTING: 0423376	PROJECT NO.: 11-066

SAMPLE TYPE ▮ AUGER ◪ DRIVEN ⧓ CORING ▬ DYNAMIC CONE ▯ SHELBY Ⅱ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS
0		Test pit side wallls cave-in at 1.2 m below ground surface on completion.
0.75	▼	DCPT rods wet at 0.8 m depth.
2.4		Very slow water infiltration at 2.4 m depth.

Depth scale (m): 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25



SOIL DESCRIPTION

500 mm TOPSOIL

loose, moist, brown SAND, some gravel trace to some silt

moist to wet brown SILT and fine SAND

compact

------

dense

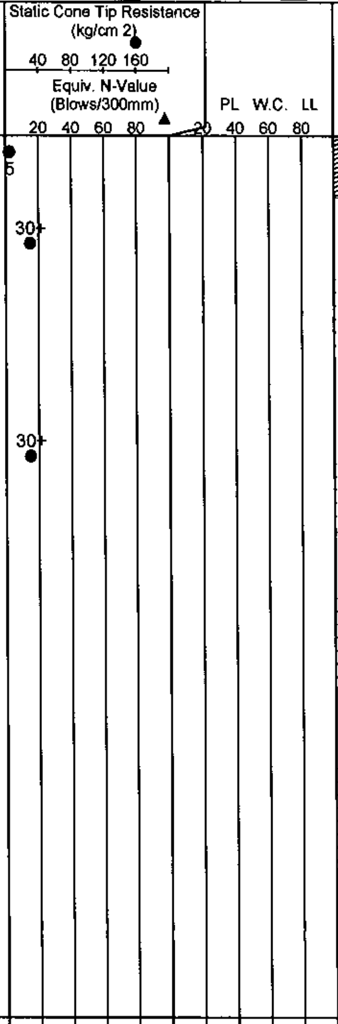
END OF BOREHOLE

SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
◪	1		
		6	
		7	
◪	2		
◪	3	15	
		21	
◪	4		
		25	
		27	
◪	5		
		32	
		61	
◪	6		

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 1 June 2011
	REVIEWED BY: DM	Page 1 of 1

CLIENT: AECOM	METHOD: Rubber Tire Backhoe	**TP No.: N6**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5014917 EASTING: 0423264	PROJECT NO.: 11-066

SAMPLE TYPE ▮ AUGER ◣ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ‖ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Test pit dry and open on completion.	≋	200 mm TOPSOIL	◣	1		
0.25 0.5 0.75 1			⁚	grey to brown damp to moist SAND some silt some gravel	◣ ◣	2 3		
1.25 1.5 1.75 2 2.25 2.5 2.75			⁚	damp, grey SILTY fine to medium SAND trace gravel	◣ ◣ ◣	4 5 6		
				END OF BOREHOLE				

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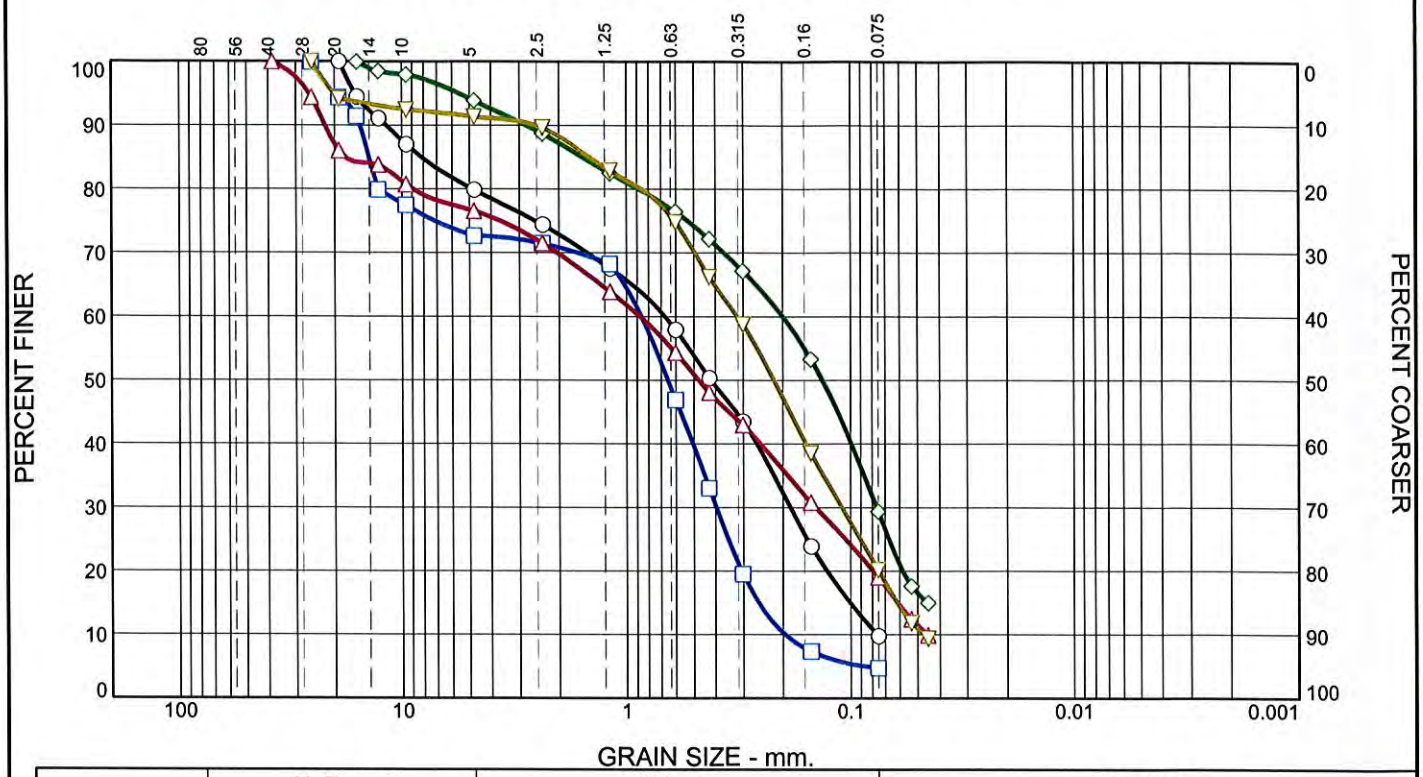
consulting engineers

LOGGED BY: KC
REVIEWED BY: DM
DRILLING DATE: 1 June 2011

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	20	7	23	40	10	
□	0	6	21	2	38	28	5	
△	0	14	9	7	22	29	19	
◇	0	0	6	7	15	43	29	
▽	0	6	3	3	22	46	20	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			8.1624	0.6693	0.4174	0.1856	0.1006	0.0761	0.68	8.80
□			14.0059	0.8551	0.6480	0.3943	0.2548	0.1939	0.94	4.41
△			17.8450	0.8651	0.4728	0.1427	0.0608	0.0452	0.52	19.16
◇			1.5512	0.1985	0.1334	0.0761				
▽			1.4459	0.3171	0.2181	0.1097	0.0613	0.0469	0.81	6.76

Material Description	USCS	AASHTO
○ SAND, some gravel to GRAVELLY, trace to some silt		
□ GRAVELLY SAND, trace silt		
△ GRAVELLY SAND, some silt		
◇ SILTY SAND, trace gravel		
▽ SAND, some silt to SILTY, trace gravel		

Project No. 11-066 **Client:** AECOM

Project: Carp Landfill

○ **Sample Number:** TP N1, Sample 2

□ **Sample Number:** TP N3, Sample 2

△ **Sample Number:** TP N6, Sample 2

◇ **Sample Number:** TP N5, Sample 2

▽ **Sample Number:** TP N6, Sample 5

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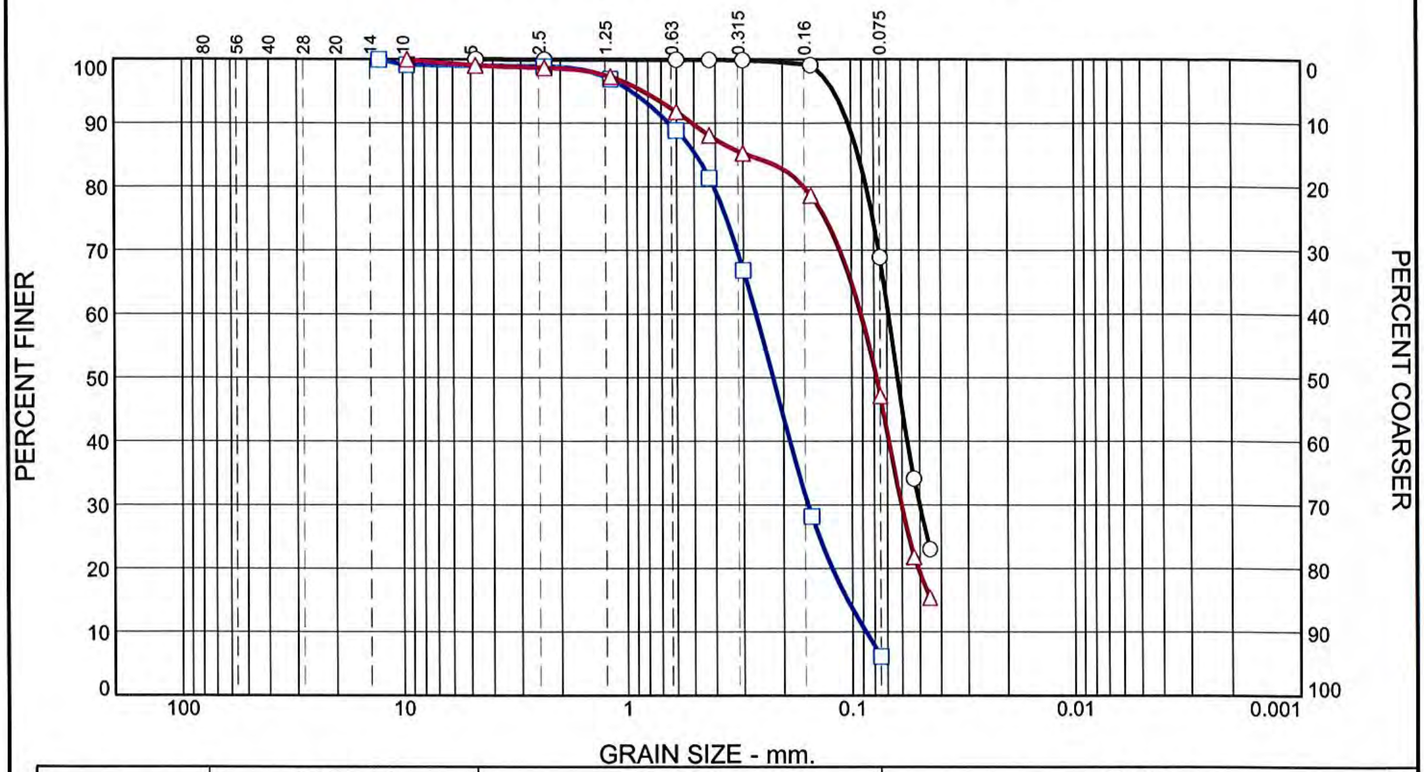
consulting engineers

Remarks:

Figure 1

Tested By: ○ RP □ GP △ RP ◇ GP ▽ RP **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	0	31	69	
□	0	0	1	0	18	75	6	
△	0	0	1	0	11	41	47	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0932	0.0686	0.0625	0.0502				
□			0.4862	0.2642	0.2226	0.1555	0.1049	0.0873	1.05	3.03
△			0.2843	0.0912	0.0780	0.0602				

Material Description	USCS	AASHTO
○ SANDY SILT		
□ SAND, trace silt		
△ SILT and fine SAND		

Project No. 11-066 **Client:** AECOM

Project: Carp Landfill

○ **Sample Number:** TP N1, Sample 5

□ **Sample Number:** TP N3, Sample 4

△ **Sample Number:** TP N5, Sample 5

Remarks:

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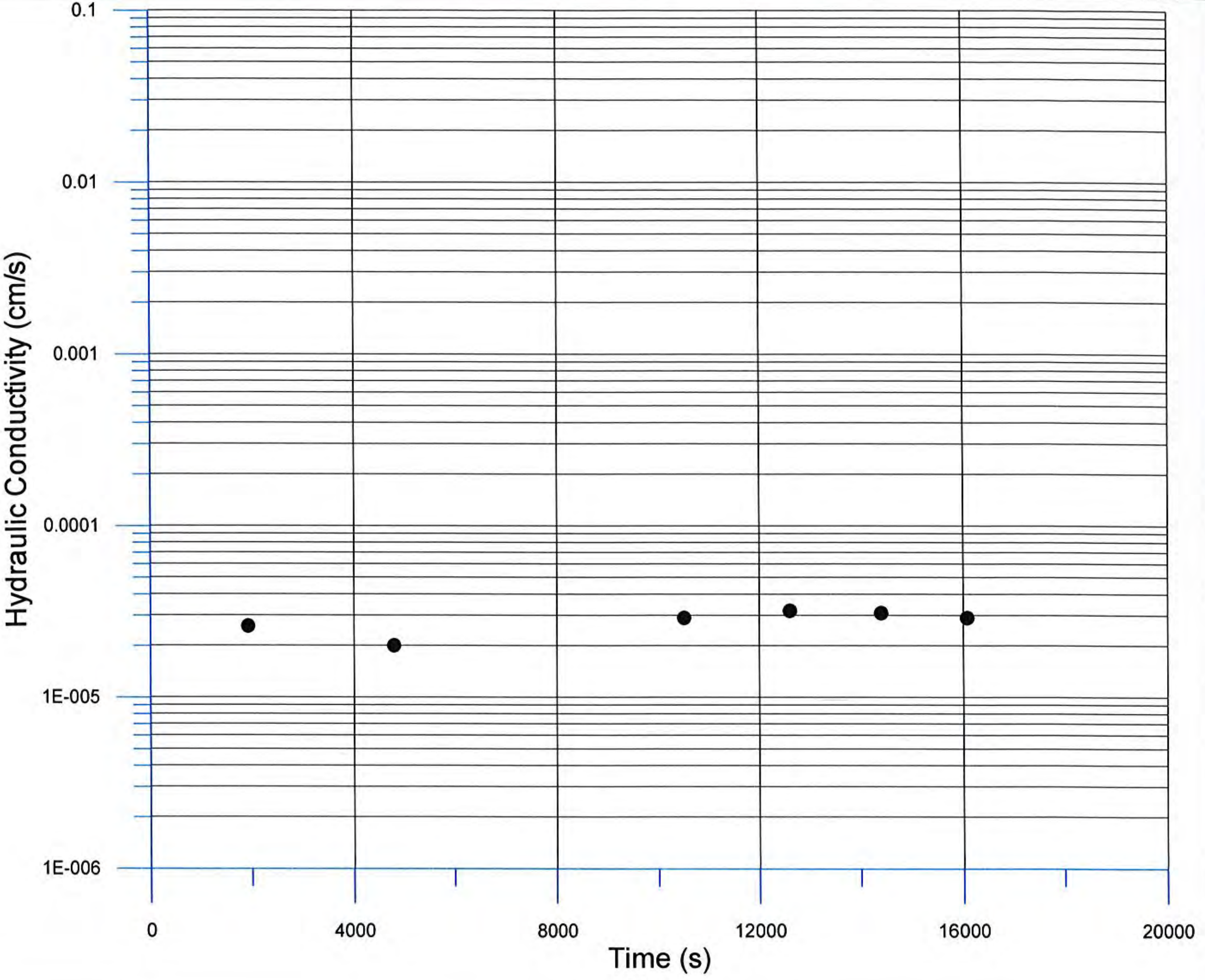
consulting engineers

Figure 2

Tested By: ● GP ■ GP ▲ RP **Checked By:** JB

HYDRAULIC CONDUCTIVITY TEST REPORT



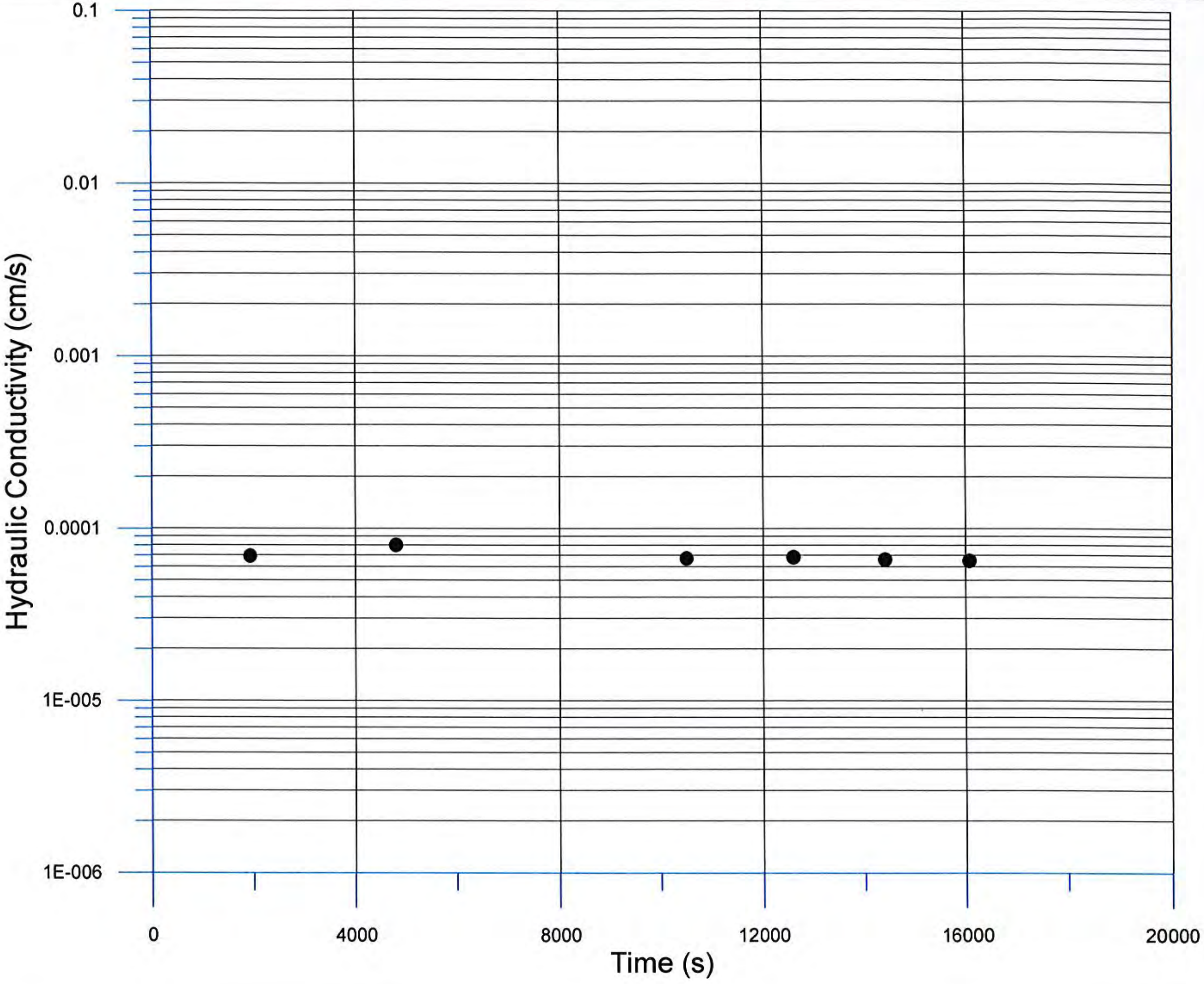
Client: AECOM
Project: Carp Landfill Extension
Alston Associates Inc. Ref. No.: 11-066
Material Description: Silty Sand to Sandy Silt
Sample Location: Test Pit N5, Sample 3
Final Hydraulic Conductivity Reading (cm/s): 2.9 x 10^{-5}

Remarks:

alston associates inc.

Figure No. 3

HYDRAULIC CONDUCTIVITY TEST REPORT

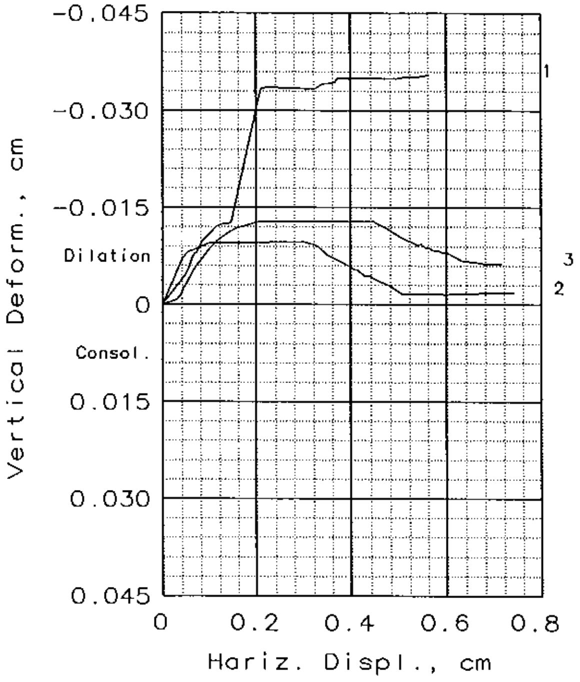


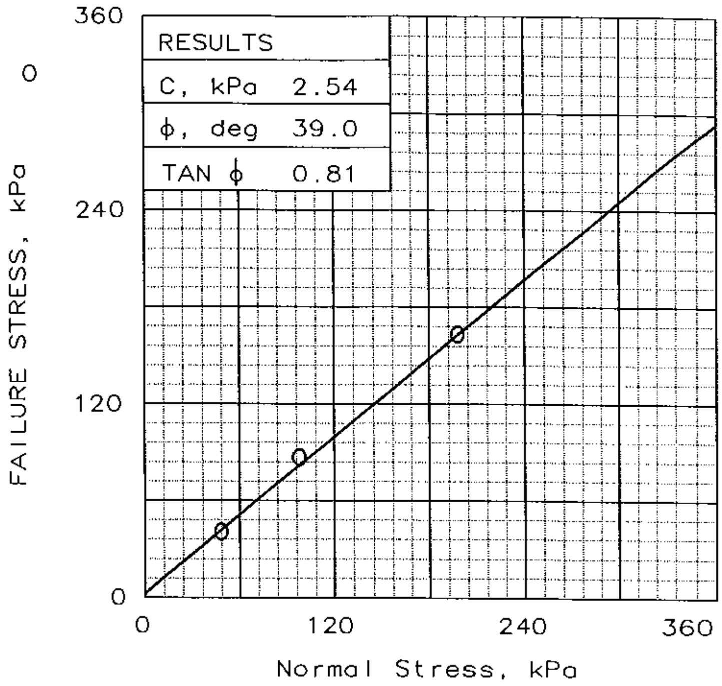
Client: AECOM
Project: Carp Landfill Extension
Alston Associates Inc. Ref. No.: 11-066
Material Description: Silty Sand to Sandy Silt
Sample Location: Test Pit N1, Sample 4
Final Hydraulic Conductivity Reading (cm/s): 6.5 x 10^{-5}

Remarks:

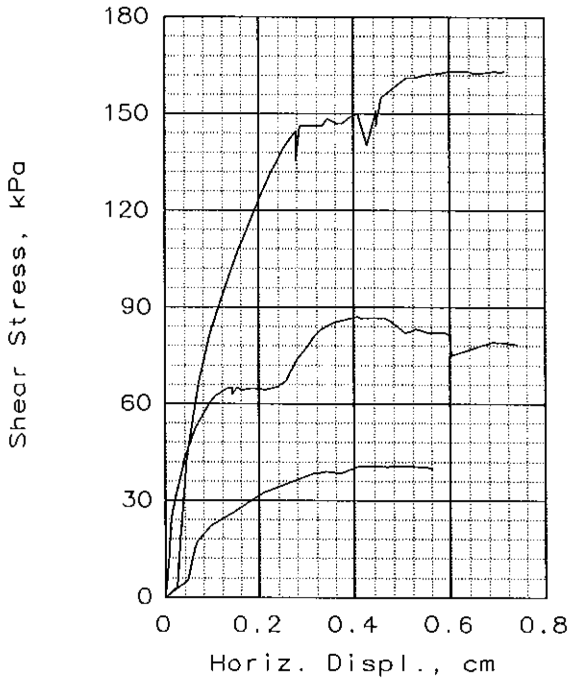
alston associates inc.

Figure No. 4





RESULTS	
C, kPa	2.54
φ, deg	39.0
TAN φ	0.81



	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	19.7	19.7	19.7
	DRY DENSITY, kg/cu.m	1656.9	1704.8	1690.6
	SATURATION, %	84.7	91.3	89.3
	VOID RATIO	0.630	0.584	0.597
	DIAMETER, cm	5.00	5.00	5.00
	HEIGHT, cm	2.40	2.40	2.40
AT TEST	WATER CONTENT, %	18.3	19.5	19.2
	DRY DENSITY, kg/cu.m	1671.8	1735.3	1709.1
	SATURATION, %	80.4	94.7	89.6
	VOID RATIO	0.615	0.556	0.580
	DIAMETER, cm	5.00	5.00	5.00
	HEIGHT, cm	2.38	2.36	2.37
	NORMAL STRESS, kPa	50	100	200
	FAILURE STRESS, kPa	41	87	163
	DISPLACEMENT, cm	0.41	0.41	0.60
	ULTIMATE STRESS, kPa	41	87	163
	DISPLACEMENT, cm	0.41	0.41	0.60
	Strain rate, cm/min	0.0016	0.0016	0.0016

SAMPLE TYPE: Bulk Sample
DESCRIPTION: Silt and fine SAND

SPECIFIC GRAVITY= 2.7
REMARKS:

CLIENT: AECOM

PROJECT: Carp Landfill Expansion

SAMPLE LOCATION: Test Pit N1, Sample 4
1.4 m depth

PROJ. NO.: 11-066 DATE: 27 June 2011

DIRECT SHEAR TEST REPORT

alston associates inc.

Fig. No.: 5

APPENDIX 2

GEOTECHNICAL INVESTIGATION, WASTE MANAGEMENT, CARP ROAD, CARP, ONTARIO REF. NO. 13-107, DATED DECEMBER 3, 2013

GEOTECHNICAL INVESTIGATION
WASTE MANAGEMENT
CARP ROAD
CARP, ONTARIO

Ref. No. 13-107
3 December 2013

AECOM Canada
300 Town Centre Blvd.
Markham, Ontario
L3R 5Z6

Distribution:

8 Copies	-	AECOM Canada
1 Copy	-	Alston Associates Inc.

Ref. No. 13-107

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1.0 INTRODUCTION

Alston Associates Inc. has been retained by AECOM Canada on behalf of Waste Management of Canada Corporation to carry out a geotechical investigation at the site of a proposed landfill development located in Carp, Ontario. The development site lies immediately north of a closed landfill site which, in turn lies north of Highway 417 and west of Carp Road. Authorization to proceed with this study was given by Larry Fedec of AECOM Canada.

The purpose of this study has been to develop geotechnical data for the site and to present geotechnical design recommendations for the landfill facility.

2.0 BACKGROUND

Borehole data for the site have been developed by Water and Earth Science Associates (WESA), who have advanced several boreholes which fully penetrate the soil profile and extend into the underlying bedrock stratum. Those data include a detailed reporting of the groundwater levels at the site. A detailed description of the hydrogeology of the site has been developed by WESA and is presented in their report for the proposed site development regarding the Geology and Hydrogeology, existing conditions. A copy of the location plan which shows the positions of the WESA boreholes and records of the borehole data which are relevant to the geotechnical design of the proposed copies of landfill are attached in Appendix ‘B’.

A preliminary geotechnical evaluation of the site was carried out by Alston Associates Inc. in 2011 and the results of that preliminary investigation were presented in report Ref. No. 11-066. Copies of the location plan, test pit logs and laboratory test results from that study are attached in Appendix ‘C’.

3.0 FIELDWORK

The fieldwork for the current geotechnhical study of the proposed landfill site involved advancing a total of twelve sampled boreholes at the site. Those data are complemented by the results of two soundings advanced using a Marchetti Flat Plat Dilatometer (DMT) and one sounding by the Dynamic Cone Penetration test (DCPT) method.

Eight boreholes; Boreholes numbered 1, 2, 3, 6, 7, 9, 10 and 11 were located within the footprint of the proposed landfill site. The remaining four boreholes; Boreholes Numbered 4, 5, 8 and 12, which were instrumented with 50 mm diameter monitoring wells were located within the area of proposed infiltration basins. The locations of these boreholes were chosen by WESA.

Standard penetration tests were carried out at frequent intervals of depths in the sampled boreholes to take representative soil samples and to measure the penetration index values (N-values) of the in situ soils. Each of the boreholes was advanced to the depth of refusal to further advancement of the boreholes. At locations where shallow refusal was encountered (Boreholes 4 and 5), a second boring was advanced in close proximity to the borehole to confirm the depth of refusal.

The Marchetti Flat Dilatometer (DMT) features a thin blade shape probe which incorporates a pressure cell. The probe is advanced into the ground and at 200 mm depth increments, the downward progress is arrested. At each arrest point the cell is activated to record the enclosing soil pressure and the force required to deform the enclosing soils. From these direct, operator independent measurements are interpreted the traditional geotechnical parameters of unit weight, angle of internal friction and constrained (defamation) modulus. The engineering behaviour of the soil is interpreted from the measurements, as well.

The Dynamic Cone Penetration test (DCPT) involves driving a 50 mm outside diameter cone into the ground continuously using standard penetration test (DPSH) energy. The number of blows of the driving hammer taken to advance the cone through successive 300 mm depth increments is recorded as an index value. For practical purposes, this approximates to the standard penetration test N-value.

The fieldwork for this study was supervised on a full-time basis by an experienced field supervisor from this office who exercised geotechnical control over the sampling and in situ testing operations. The supervisor recorded groundwater conditions occurring in the boreholes at the time of their advancement. The groundwater observations are a complement to but do not supercede the data reported and described by WESA.

4.0 SITE AND SUBSURFACE CONDITION

Full details of the subsurface conditions contacted in the current geotechnical explorations are given on the log sheets of Borehole Nos. 1 through 12, DMT’s 101 and 102 and DCPT 12A.

Interpreted stratigraphic profiles along the northern and southern limits of the proposed landfill development are given in Figures 1 and 2, respectively. A summary of the standard penetration test N-values plotted against depth is given in Figures 3 and 4; the plot for the in situ test results from Boreholes 6 and 7 is shown in Figure 4 to provide comparison with DMT data.

The following paragraphs present a description of the engineering characteristics of the various soil materials contacted in the boreholes.

4.1 Site Description

The site lies immediately north of the existing closed Carp landfill site which was operated by Waste Management. The study site area is presently used for agricultural purposes and is undeveloped, however, it is noted that prior excavations which lie at the eastern limit of the site have been backfilled to provide a level ground surface.

There is a limestone quarry operation lying on the east side of Carp Road.

The area of the proposed landfill site slopes down gently from the southwest to the northeast; the ground surface elevations ranging from a high of 127.5 m at Borehole 9, to 123.3 m at Borehole 3. There are no salient surface features which would affect the proposed site development. The ground surface elevations at the locations of Boreholes 4 and 5; 118.6 m and 117.5 m respectively are relatively lower than the remaining boreholes.

4.2 Fill

A surficial layer of fill materials was contacted in Boreholes 4, 8 and 12. The fill consists of sand in Borehole 8 and a mixture of sand and topsoil with wood pieces in Borehole 12.

Borehole 4 was advanced through a site access road and at this location, the fill consists of sand and gravel.

Standard penetration tests carried out in the fill layer recorded N-values ranging from 2 to 47 blows/300 mm, and more commonly in the range 2 to 7 blows/300 mm. The high measured N-value is attributed to the sampling spoon striking a larger particle embedded within the fill and is not considered representative of the general condition of the fill soils. Based on the measured N-values, it is interpreted that the fills are very loose to loose and that the materials were placed without selection or dense compaction. It is understood that fills were placed to provide a level surface in areas previously occupied by lagoon features, which are located at the eastern limit of the site.

The water content of the fill material was found to range from 4 to 8%. These test results indicate that the organic content in the fill is relatively minor.

4.3 Topsoil

Topsoil covers the site through most of the proposed development area. Typically the topsoil is relatively thin, ranging from about 70 to 200 mm in thickness.

4.4 Silt and Fine Sand

The site cover layers are underlain by a layer of silt and fine sand, the soil fractions are present in varying proportions (sandy silt to silty fine sand) with a trace of clay at the location of Boreholes 6, 7, 9, 10, 11 and 12. In general the soil deposit is brown in the near surface zone and below a depth of about 1 to 1.5 m, the soil colouration is grey. In several boreholes, the near surface soils were found to be disturbed; it is probable that the disturbance is a result of agricultural activity.

Standard penetration tests carried out in the silt to sand soil deposit measured N-values ranging from 6 to 75 blows/300 mm which represents a range of soil condition from loose to very dense. In general the low N-values were measured at shallow depths; below a depth of about 1 m, the in situ test results indicate that the soils are compact to dense.

The results of grain size distribution tests carried out on samples of the silt to sand soil are given in Figures 5 and 6, which are attached to this report. Previous laboratory testing shows a similar soil gradation. Permeability tests carried out on the soil show coefficient values ranging from about 3 to 6 x 10 $^{-5}$ cm/s. A laboratory shear test carried out on a sample of this soil measured an angle of internal friction of 39°, refer to Appendix ‘C’.

4.5 Silt and Sand (Till)

Below the silt to sand soil deposit in the above noted boreholes and below the surficial soil layers in the balance of the site, a soil deposit consisting of silt and sand with some gravel, cobbles and boulders and a trace of clay was encountered. The unsorted character of this soil stratum indicates that it is likely of glacial origin and may therefore be referred to as a till. Generally, the soil colour is grey. Occasional lenses of silty clay soil are included within this soil stratum, which extends to the bedrock surface.

Standard penetration tests carried out in the silt to sand till material measured N-values ranging from 14 to more than 100/blows 300 mm. Typically the progression in soil compactness condition is compact in the near surface zone of the stratum, rapidly becoming dense then very dense.

The water content values of the till soils were found to range from 5% to 10%, which is consistent with the gradation and density of the soils. A water content value of 26% was measured on a sample of an included silty clay lens (or layer).

The results of grain size distribution tests carried out on samples of the silt to sand till soil are given on Figures 7 and 8.

Boreholes 4A and 5A were advanced in the area of prior site excavations. The remaining thickness of the soil profile at the explorations is about 1.5 to 2.5 m, the depth of auger refusal is at an elevation comparable with rockhead as given on WESA Boreholes 65 and 73 which shows that bedrock in this area was at a depth ranging from about 7 to 12 m.

4.6 Bedrock

Boreholes advanced by WESA were carried into the bedrock stratum. A full description of the profile of rockhead and the condition of the bedrock is given in the companion report by WESA.

4.7 Results of Soundings

Soundings were carried out by using the Flat Plate Dilatometer in the central portion of the development area. The interpreted results of the soundings show that the shear strength characteristics of the soil are represented by friction angles generally in the range 37° to 41° and deformation modulus of generally more than 150 MPa (1500 bars) below the loose, near surface subunit of the soil profile. The interpreted values of angle of internal friction from the DMT soundings are comparable with the laboratory direct shear test results.

4.8 Groundwater

Groundwater was contacted in all boreholes and was found to lie at depths ranging between about 1 and 4.5 m at the time of undertaking this investigation. Measurements of stabilized groundwater table elevation have been taken by WESA who have also prepared an analysis of the hydrogeological data, including the direction of flow at the site.

5.0 DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a landfill on the study site which will be up to about 30 m high above the existing ground surface. Site preparation will involve removal of the topsoil layer and any shallow fill materials which lie beneath the footprint of the landfill, and construction of a fill pad to provide the design base profile.

The preliminary target density for the emplaced landfill material given in the development prospectus is 7.8 kN/m³. That density has been adopted for geotechnical analysis of facility design.

Drawings illustrating the layout and construction of the landfill are given in Drawing Nos. FCR-02-03-10 and -11 by AECOM. It is proposed that the design should meet the current "generic design" for landfills by the Ontario Ministry of the Environment. Copies of the referenced drawings are attached in Appendix 'D'.

5.1 Site Preparation

Measurements of the stabilized groundwater table elevation at the site show that mostly, the water table lies at shallow depth. For ease of site preparation it is proposed that the base of the landfill will be positioned above the groundwater table. Site preparation will involve removing topsoil and shallow fill materials and adjusting the elevation of the subgrade by laying engineered fill materials as required by the profile design. Base preparation will involve the following operations:

- *Remove topsoil and fill materials beneath landfill footprint;*

- *Compact the exposed subgrade to a dry density of not less than 98% of the material's standard Proctor maximum dry density;*

- *Lay fill materials as required by landfill design in lifts appropriate to the compaction equipment, and thoroughly and uniformly compact the fill materials to 98% SPMDD.*

Based on the results of test pit and borehole data for the site, the local soil materials may be used as engineered fills for adjustment of base grade and profile. Based on a review of the gradation of the soil, it is anticipated that efficient compaction of engineered fill material will be sensitive to placement water content; some moisture conditioning of the material is expected.

5.2 Landfill Liner

It is noted that a generic Ministry of the Environment liner is to be constructed on the site. This will involve importing suitable compactible low permeability silty clay materials which are laid and compacted to meet the project specifications. The proposed design is shown on Drawing SK5 by Genivar, refer to Appendix 'G'.

It is noted that the local silt to sand till material and the local silt to fine sand soils possess a gradation which is appropriate for amendment with Bentonite materials to provide a low permeability liner, should this be advantageous to the proposed development.

5.3 Slope Stability Analysis - Final Design

Analyses have been carried out to assess the stability of the side slopes of the completed landfill facility following final profiling of the slopes immediately prior to closure. Those analyses show a factor of safety under a static loading condition with respect to global stability of more than the required design value of 1.5, which is satisfactory. A copy of the stability analysis for the final side slope is attached in Appendix ‘E’. The soil parameters adopted for design evaluation are based on interpreted in situ and laboratory test data, and are given in the analysis sheets.

The stability of temporary slopes which will be developed in the course of construction of the landfill facility is governed by the character, placement and compaction of the landfill materials. Typically, it is found that a gradient of 50% (1V:2H) is satisfactory, for excavation above the groundwater table, in native soil.

5.4 Slope Stability Analysis - Liner Construction

It is proposed to complete the construction of the liner, including the 2.5 m high slope at a 25% (IV:4H) gradient, at the liner perimeter. This slope must be stable in the period prior to placement of landfill as well as in service life. The relevant selected geotechnical parameters are given below:

- *Compacted clay landfill liner and attenuation layer unit weight 19.5 kN/m³, cohesion intercept nil, effective angle of internal friction 28°;*
- *Interface friction angle between non-woven geotextile and compacted day line 28°;*
- *Interface friction angle between non-woven geotextile and granular drainage layer, 36°;*
- *Interface friction angle between non-woven geotextile and textured geomembrane 36°;*
-

- *Interface friction angle between textured geomembrane and compacted clay landfill liner 28°.*

The listed parameters show that the critical layers for slope instability are the compacted clay liners; the clay material governs the interface properties. Thus, presuming that the critical failure mode will be sliding, the factor of safety with respect to slope instability is more than 2 for the static condition, which is satisfactory.

5.5 Settlement

An analysis of the expected settlement which will occur in the soils which underlie the landfill has been carried out using values of deformation (constrained) modulus measured by DMT. The results of analysis show that the maximum expected settlement in the native soils is less than 20 mm. Copies of settlement analyses in both east-west and north-south directions and which show estimated settlement along the length of the selected sections are attached in Appendix 'F'. On the basis that the soil profile consists of predominantly granular type soils, the rate of settlement is expected to be relatively rapid following the application.

5.6 Storm Water Infiltration Ponds

Storm water detention ponds are to be constructed at the eastern limit of the site. The results of the borehole data developed for the detention lagoons indicates that the side slope of the lagoons can be safely profiled to a gradient of 33% (IV:3H) provided that erosion resistant slope covers are introduced into the lagoon designs. Other considerations such as pond liner system may require adoption of flatter slope gradient.

5.7 Building Developments

Numerous building developments are anticipated at the site. However, those building locations have not been finalized. Based on the results of the boreholes advanced at the site, it is anticipated that conventional footing foundations applying a bearing pressure at Serviceability Limit States of 120 kPa at a depth below the ground surface of not less than 1.5 m (for heated buildings) may be adopted for preliminary design. It is anticipated that the site classification with respect to seismic site response will be Class 'D' with regard to building developments. Specific recommendations will be prepared when the site layout has been finalized.

6.0 LIMITATIONS OF REPORT

The Limitations of Report, as quoted in Appendix ‘A’, are an integral part of this report.

ALSTON ASSOCIATES INC.

Colin Alston, P.Eng.

C. ALSTON

6 December 2013

W. NERSESIAN

33778705

Dec 6,13

Vic Nersesian, P.Eng.

/ld

APPENDIX ‘A’

Appendix 'A'

LIMITATIONS OF REPORT

The conclusions and recommendations in this report are based on information determined at the test hole locations. Soil 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 soil investigation.

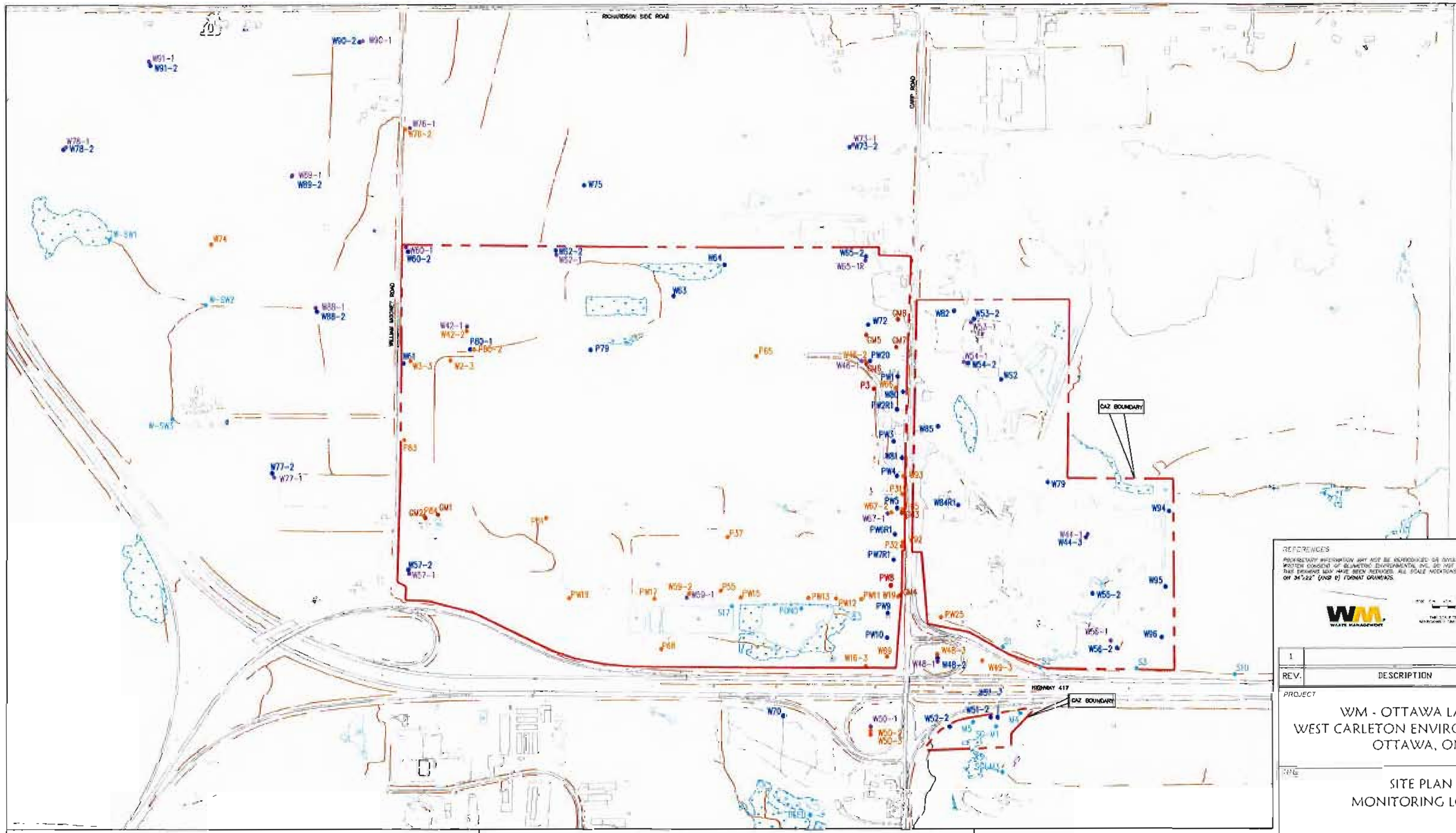
The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made as set out in this report. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

This report was prepared for AECOM Canada by Alston Associates Inc. The material in it reflects Alston Associates Inc. judgement in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions which the Third Party may make based on it, are the sole responsibility of such Third Parties.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the test holes. In cases where these recommendations are not followed, the company's responsibility is limited to accurately interpreting the conditions encountered at the test holes, only.

The comments given in this report on potential construction problems and possible methods are intended for the guidance of the design engineer, only. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. 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.

APPENDIX ‘B’



LEGEND

🟥	WM PROPERTY BOUNDARY (APPROX)
	EXISTING DITCH, SWALE
	EXISTING FENCE LINE
	EXISTING ASPHALT ROADS
	EXISTING GRAVEL ROADS
	EXISTING TREE LINE
	EXISTING GUIDE RAIL
	EXISTING HYDRO POLES
	WETLAND
	EXISTING BUILDINGS

MONITOR SYMBOLS

P59	DENOTES OVERBURDEN WELL
W37	DENOTES BEDROCK WELL
▲ S1	DENOTES SURFACE WATER SAMPLING LOCATION
GM3	DENOTES GAS MONITOR / WELL
PW1	DENOTES PURGE WELL

LEGEND

●	OVERBURDEN-SHALLOW BEDROCK MONITORING WELLS (SAMPLED)
●	OVERBURDEN-SHALLOW BEDROCK MONITORING WELLS (NOT SAMPLED)
●	SURFACE WATER MONITORING LOCATIONS
●	DEEP BEDROCK MONITORING WELLS
●	GAS MONITOR LOCATIONS
●	LEACHATE MONITOR LOCATION

LEGEND

	SHORELINE / WATER ELEVATION DITCH / STREAM / CULVERT MARSH
	BUILDING
	ROAD SIGN
	MANHOLE
	CATCH BASIN
	HYDRO POLE
	LIGHT STANDARD
	FIRE HYDRANT
	MISC. AREA OUTLINE
	PAVED / CURBED / LOOSE ROAD
	PAVED / LOOSE PARKING

BASE MAPPING

REFERENCES

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR COPIED WITHOUT PRIOR WRITTEN CONSENT OF BLUMETRIC ENVIRONMENTAL INC. DO NOT SCALE DRAWING. THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 34"x22" (ANSI D) FORMAT DRAWINGS.

GEODETIC NORTH

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

PROJECT

WM - OTTAWA LANDFILL SITE
WEST CARLETON ENVIRONMENTAL CENTRE
OTTAWA, ONTARIO

TITLE

SITE PLAN AND
MONITORING LOCATIONS

WESA, a division of BluMetric Environmental Inc.

a BluMetric company

3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053 FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca
BluMetric includes WESA, Seprotech, WESAtech, Envir-Eau, OEL-HydroSys, WESAtecnologías.

PROJECT #	DATE		
CB2533-2012-ANN REP	2013-01-28		
DRAWN	**CHECKED**	**DWG NO**	**REV**
CMR	DH	2	0

Project No: C-B2653

Project: Hydrogeological Characterization

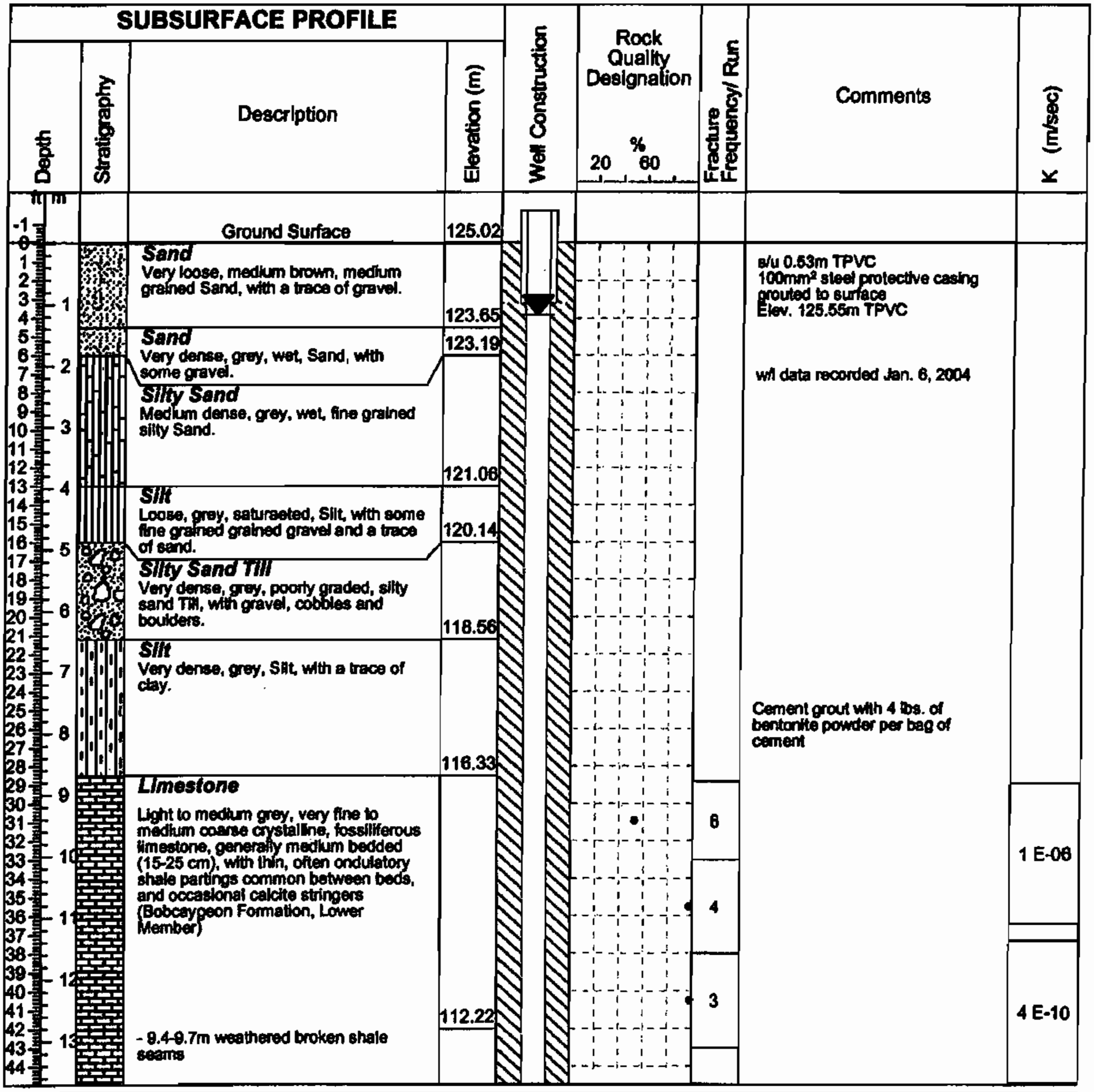
Client: Waste Management of Canada Corp.

Location: Ottawa, Ontario

Well ID: W60-1

Log File: B2653w60-1
Tem. File: B2653br
Field Personnel: B.A.

SUBSURFACE PROFILE



Description	Elevation (m)
Ground Surface	125.02
Sand Very loose, medium brown, medium grained Sand, with a trace of gravel.	123.65
Sand Very dense, grey, wet, Sand, with some gravel.	123.19
Silty Sand Medium dense, grey, wet, fine grained silty Sand.	121.06
Silt Loose, grey, saturaeted, Silt, with some fine grained grained gravel and a trace of sand.	120.14
Silty Sand Till Very dense, grey, poorly graded, silty sand Till, with gravel, cobbles and boulders.	118.56
Silt Very dense, grey, Silt, with a trace of clay.	116.33
Limestone Light to medium grey, very fine to medium coarse crystalline, fossiliferous limestone, generally medium bedded (15-25 cm), with thin, often ondulatory shale partings common between beds, and occasional calcite stringers (Bobcaygeon Formation, Lower Member) - 9.4-9.7m weathered broken shale seams	112.22

Comments:

s/u 0.53m TPVC
100mm² steel protective casing grouted to surface
Elev. 125.55m TPVC

w/l data recorded Jan. 6, 2004

Cement grout with 4 lbs. of bentonite powder per bag of cement

Drilled By: Downing Drilling
Drill Method: Diamond drilling
Hole Size: HW 4.5"(114mm)/HQ3 3.78(96mm)
Drill Date: Nov. 24, 2003

Datum: m.a.s.l.

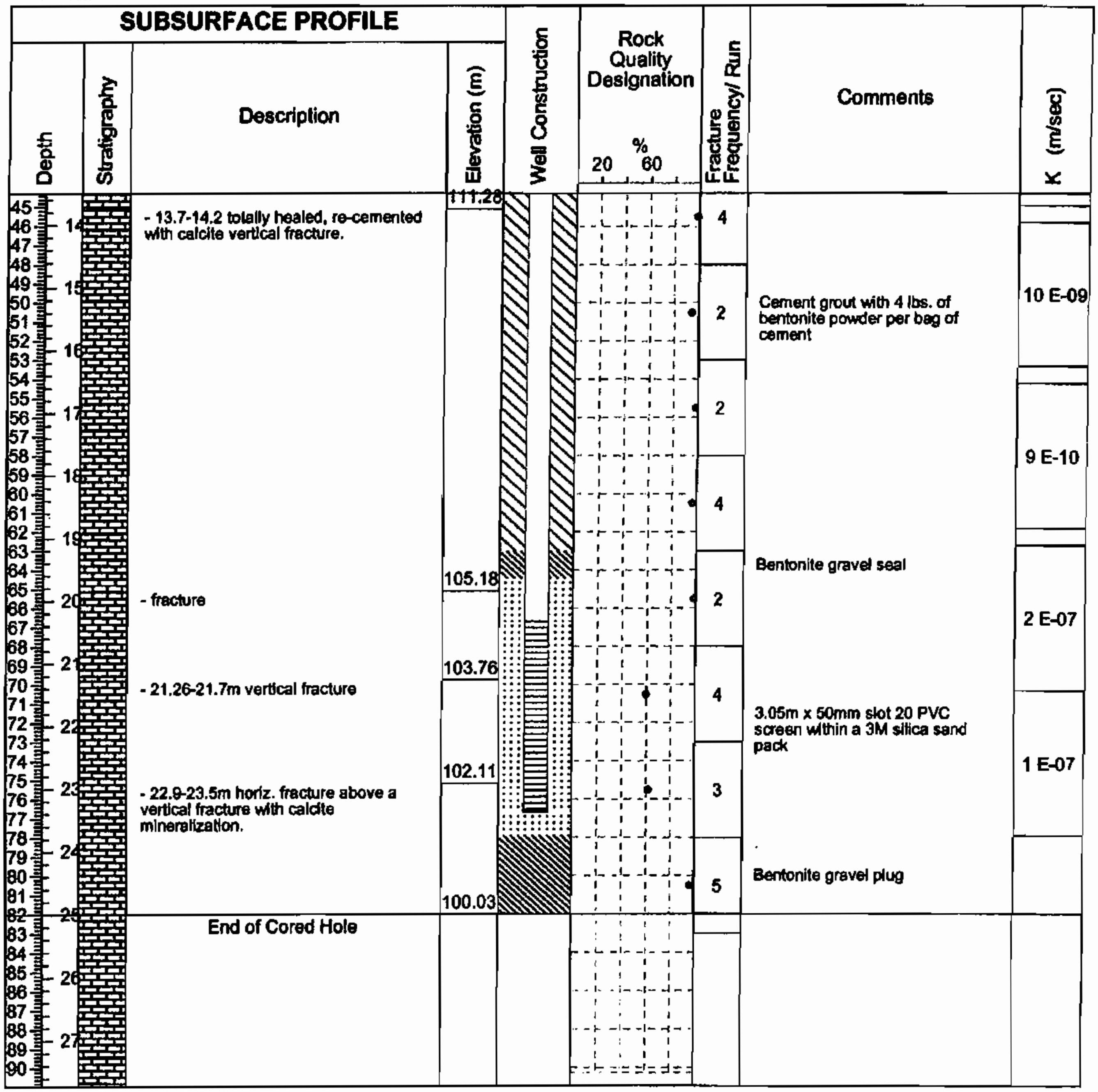
Sheet: 1 of 2

A Better Environment For Business

Project No: C-B2653
Project: Hydrogeological Characterization
Client: Waste Management of Canada Corp.
Location: Ottawa, Ontario

Well ID: W60-1

Log File: B2653w60-1
Tem. File: B2653br
Field Personnel: B.A.



- 13.7-14.2 totally healed, re-cemented with calcite vertical fracture.
- fracture
- 21.26-21.7m vertical fracture
- 22.9-23.5m horiz. fracture above a vertical fracture with calcite mineralization.

End of Cored Hole

Cement grout with 4 lbs. of bentonite powder per bag of cement

Bentonite gravel seal

3.05m x 50mm slot 20 PVC screen within a 3M silica sand pack

Bentonite gravel plug

Drilled By: Downing Drilling
Drill Method: Diamond drilling
Hole Size: HW 4.5"(114mm)/HQ3 3.78(96mm)
Drill Date: Nov. 24, 2003

Datum: m.a.s.l.

Sheet: 2 of 2

A Better Environment For Business

Project No: C-B2653

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

Location: Ottawa, Ontario

Well ID: W60-2

Field Personnel: B.McC.

Log File: B2653w60-2
Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE					
Depth ft m	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
	125.12	Ground Surface							
	124.92	***Topsoil*** Very loose, moist, organic soil (topsoil), with root fibers.		1	SS	4	63		s/u 0.53m TOC, 0.32m TPVC 150mm steel well casing with locking cap grouted to surface Elev. 125.65m TOC Elev. 125.44m TPVC
	123.75	***Sand*** Very loose, medium brown, medium grained Sand, with a trace of gravel.		2	SS	3	57		
	123.29	***Sand*** Very dense, grey, wet, Sand, with some gravel.		3	SS	>50	56		w/l data recorded Jan. 6, 2004
		Silty Sand Medium dense, grey, wet, fine grained silty Sand.		4	SS	21	50		
				5	SS	23	100		
				6	SS	19	100		
	121.16			7	SS	8	29		
		Silt Loose, grey, saturated, Silt, with some fime gravel and a trace of sand.		8	SS	11	0		Bentonite slurry seal
	120.24	***Silty Sand Till*** Very dense, grey, poorly graded, silty sand Till, with gravel, cobbles and boulders.		9	SS	>50	44		
							100		
	118.64						100		
		Silt Very dense, grey, Silt, with a trace of clay.		12	RC		100		Bentonite gravel seal above silica sand pack
	116.43			13	RC		100		
		Limestone Light to medium grey, very fine to medium coarse crystalline fossiliferous limestone (Bobcaygeon Formation, Lower Member).		14	RC		100		3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack
	114.33	End of Cored Hole							

Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond drilling
Hole Size: 8"(200)/3.78"(96mm)
Datum: m.a.s.l.
Drill Date: Nov. 19, 2003

Sheet: 1 of 1

WESA
A Better Environment For Business

Project No: C-B2653

Project: Hydrogeological Characterization

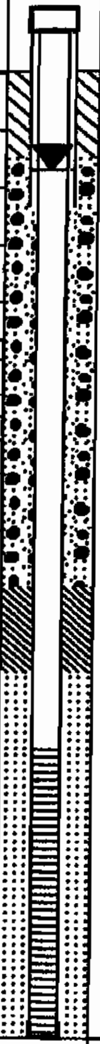
Client: Waste Management of Canada Corp.

Location: Ottawaw, Ontario

Well ID: W62-2

Field Personnel: B. McC.

Log File: B2653w62-2
Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE					
Depth ft m	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
-2 -1	125.83	Ground Surface							
0–7 ft 1, 2 m	123.39	⑤ ***Sand*** Medium dense to dense, wet, brown, fine to medium grained Sand. Saturated sand at 6' (1.83m).		1	SS	16	75		s/u 0.69m TOC, 0.61m TPVC 150mm steel well casing with locking cap grouted at surface. Elev. 126.49m TOC Elev. 126.41m TPVC
				2	SS	15	50		w/l data recorded Jan. 7, 2004
				3	SS	40	83		
				4	SS	58	83		
8–11 ft 3 m	122.17	⑤ ***Sand*** Very dense, brown, saturated, medium to coarse grained Sand.		5	SS	>50	76		
				6	SS	>50	67		
12–14 ft 4 m	121.26	⑤ ***Sand*** Very dense, greyish brown, saturated, coarse grained Sand.		7	SS	>50	100		Native soil collaspe
15–21 ft 5, 6 m	119.12	⑤ ***Sandy Silt*** Dense, grey, wet, fine grained sandy Silt, to silty Sand.		8	SS	42	75		Bentonite gravel seal
22–23 ft 7 m	118.51	⑤ ***Silt and Sand*** Very dense, grey, Silt and Sand, with gravel and cobbles.		9	SS	>50	31		
24–27 ft 8 m	117.55	⑥ ***Sand Till*** Till and boulders.		10	RC				
28–33 ft 9, 10 m	115.57	⑧ ***Limestone*** Light to medium grey, very fine to medium coarse crystalline fossiliferous limestone(Bobcaygeon Formation, Lower Member)		11	RC				3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack
				12	RC				
34 35		End of Cored Hole							

Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond drilling
Hole Size: 8"(200mm)/3.78"(96mm)
Datum: m.a.s.l.
Drill Date: Nov. 26, 2003

Sheet: 1 of 1

WESA
A Better Environment For Business

Project No: C-B2653

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

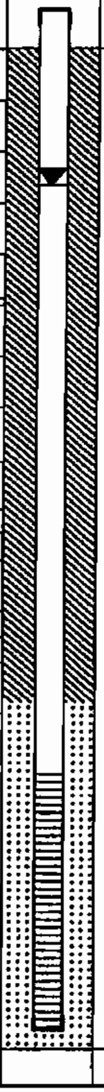
Location: Ottawa, Ontario

Well ID: W63

Field Personnel: B.McC.

Log File: B2653w63
Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE					
Depth ft m	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
-1	124.91	Ground Surface							
0–1	124.61	***Silty Sand*** ⑤ Loose, brown, silty Sand.		1	SS	18	58		s/u 0.48m TPVC Elev. 125.39m TPVC
2–6 (1)		***Sand*** ⑤ Very dense, brown, wet to saturated, thinly bedded, medium grained Sand.		2	SS	55	88		w/l data recorded Jan. 7, 2004
				3	SS	46	50		
7 (2)	122.78			4	SS	79	50		
8–32 (3–9)		⑥ ***Silty Sand Till*** Medium dense to very dense, moist to wet, grey, silty Sand Till, with trace gravel and boulders.Saturated soil at 7.3m (24').		5	SS	>50	67		
				6	SS	19	67		
				7	SS	17	58		Bentonite slurry seal
				8	RC				
				9	SS	7	0		
				10	SS	>50	45		
				11	SS	41	17		
				12	SS	>50	0		
									Bentonite gravel seal above silica sand pack
				13	SS	7	75		
				14	SS	46	42		
				15	RC				
33–38 (10–11)	114.96	***Limestone*** ⑧ Light to medium grey, very fine to medium coarse crystalline fossiliferous limestone (Bobcaygeon Formation, Lower Member).		16	RC				3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack
				17	RC				
				18	RC				
39–40 (12)	113.00	End of Cored Hole							



Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond drilling
Hole Size: 8"(200mm)/ 3.78"(96mm)
Datum: m.a.s.l.
Drill Date: Nov. 27,28, 2003

Sheet: 1 of 1

WESA
A Better Environment For Business

Project No: C-B2653

Well ID: W64

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

Location: Ottawa, Ontario

Field Personnel: B.McC.

Log File: B2653w64

Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE					
Depth ft m	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
	125.54	Ground Surface							
	124.63	**Sand** ⑤ Medium dense, brown, thinly bedded, medium grained Sand.		1 2	SS SS	19 >50	58 63		s/u 0.80m TOC, 0.73m TPVC 150mm steel well casing with locking cap grouted at surface Elev. 126.27m TOC Elev. 126.34m TPVC
	123.41	**Sand** ⑤ Very dense, brown, dry, coarse grained Sand, with a trace of gravel.		3	SS	>50	55		124.44 w/l data recorded on Jan. 7, 2004 121.95
	121.88	**Sand** ⑤ Very dense, brown, dry, thinly bedded, medium grained Sand. Moistsoil encountered at 3.35m (11').		4 5 6	SS SS SS	72 76 40	63 58 58		Bentonite slurry seal
	120.66	**Sand** ⑤ Very dense, brown, saturated, thinly bedded, fine to medium grained Sand.		7 8	SS SS	75 >50	58 63		Bentonite gravel seal 120 81
	119.65	**Sand** Very dense, brown, saturated fine grained Sand, with a trace of gravel.		9	SS	>50	47		
	117.82	**Limestone** ⑧ Light to medium grey, very fine to medium coarse crystalline fossiliferous limestone (Bobcaygeon Formation, Lower Member).		10	RC				3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack
		End of Cored Hole							

Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond drilling
Hole Size: 8"(200mm)/3.78"(96mm)
Datum: m.a.s.l.
Drill Date: Nov. 25, 2003

Sheet: 1 of 1

WESA
A Better Environment For Business

Project No: C-B2653

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

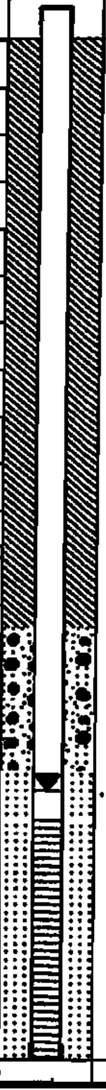
Location: Ottawa, Ontario

Well ID: W65-2

Field Personnel: B.McC.

Log File: B2653w65-2
Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE					
Depth ft m	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
-1	126.75	Ground Surface							
0 1 2		④ ***Silt*** Dense to very dense, dry, Silt with boulders and sand lenses.		1	SS	36	17		s/u 0.43m TPVC Elev. 127.18m TPVC
3 — 1 4				2	SS	13	54		
5 6	124.92			3	SS	73	54		
7 — 2 8		⑤ ***Sand*** Dense to very dense, brown, damp to dry, coarse grained Sand with a trace of fine to coarse gravel.		4	SS	50	50		Bentonite slurry seal
9 10 — 3				5	SS	29	54		
11 12				6	SS	41	58		
13 — 4 14				7	SS	45	54		
15 16				6	SS	34	58		
16 — 5 17 18				9	SS	45	63		
19 20 — 6				10	SS	35	58		
21 22				11	SS	>50	33		
23 — 7				12	SS	55	75		
24 25				13	SS	>50	47		Bentonite gravel seal above native soil collaspe
26 — 8 27				14	SS	95	39		
28 29 — 9	117.61								
30 31		4 ***Sand and Gravel*** Very dense, damp, brown, coarse grained sand and coarse gravel. Saturated soil 10.36m (34').		15	SS	>50	56		
32 33 — 10				16	SS	>50	33		w/l data recorded on Jan. 7, 2004
34 35				17	SS	>50			
36 — 11 37 38	114.91						100		3.05m x 50mm slot 10 PVC screen with a 3M silica sand pack
39 — 12		***Limestone***		19	RC				
40 41 42 43 — 13	113.57	(Bobcaygeon Formation, Lower Member).		20	RC				
		End of Cored Hole							



Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond Drilling
Hole Size: 8"(200mm)/3.76"(96mm)
Datum: m.a.s.l.
Drill Date: Nov. 24, 25, 2003

Sheet: 1 of 1

WESA
A Better Environment For Business

Project No: C-B2653

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

Location: Ottawa, Ontario

Well ID: W72

Field Personnel: D.R.

Log File: B2653w72
Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE					
Depth (ft / m)	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
-3 to 0 ft	130.57	Ground Surface							
0		④ ***Sand and Gravel*** Medium dense to very dense, light to dark brown, moist, bedded, stratified, sand and gravel with silt and trace clay.		1	SS	21	75		s/u 1.14m TOC, 1.07m TPVC 150mm steel well casing with locking cap grouted to surface Elev. 131.71m TOCl. Elev. 131.64m TPVC
				2	SS	19	29		
				3	SS	40	38		
				4	SS	55	67		
				5	SS	>50	25		
10 ft / 3 m	127.47	④ ***Gravel*** Dense to very dense, medium brown, dry, fine to coarse gravel.		6	SS	28	46		
				7	SS	65	50		
				8	SS	>50	42		
				9	SS	>50	78		
5 m	125.39	***Sand*** ⑤ Very dense, light brown to grey, dry to moist, fine to medium grained sand with trace of gravel.							
							0		
				11	SS	72	75		Bentonite slurry seal
							0		
							0		
				14	SS	89	71		

Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond drilling
Hole Size: 8"(200mm)/3.78"(96mm)
Datum: m.a.s.l.
Drill Date: Dec. 1,2, 2003

Sheet: 1 of 2

WESA
A Better Environment For Business

Project No: C-B2653

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

Location: Ottawa, Ontario

Well ID: W72

Field Personnel: D.R.

Log File: B2653w72
Template File: B2653soil

SUBSURFACE PROFILE				SAMPLE				Well Data	Comments
Depth	Elevation	Description	Symbol	Number	Type	N/RGD %	% Recovery		
29				15	SS	88	75		
30 9									
31				16	SS	>50	75		Bentonite slurry seal
32									
33 10				17	SS	95	63		
34									
35	119.60			18	SS	>50	43		
36 11									
37		④		19	SS	>50	87		
38				20	SS	>50	91		
39 12		***Gravel*** Very dense, moist, greyish-brown, fine to medium grained Gravel, with some sand.							
40							66		
41									117.72
42	12 65			22	SS	>50	67		w/l data recorded Jan. 7, 2004
43 13	117.16								
44									Bentonite gravel seal above silica sand pack
45		④		23	SS	90	76		
46 14	14,20	***Sand and Gravel***							116.37
47		Very dense, dark grey-brown, wet to saturated, coarse Sand and medium to coarse Gravel, with a trace of silt.		24	SS	>50	87		
48									
49 15									
50	115.00			25	SS	>50	100		
51		***Limestone***		26	RC				
52 16		⑧ Light to medium grey, very fine to medium coarse crystalline limestone, generally medium bedded (15-25 cm), with thin, often ondulatory shale partings common between beds, and occasional calcite stringers (Bobcaygeon Formation, Lower Member)		27	RC				3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack
53									
54									
55				28	RC				
56 17	11 85								113.32
57	112.89			29	RC				
58		End of Cored Hole							
59 18									
60									

Drilled By: Downing Drilling
Drill Method: H.S.A./Diamond drilling
Hole Size: 8"(200mm)/3.78"(96mm)
Datum: m.a.s.l.
Drill Date: Dec. 1,2, 2003

Sheet: 2 of 2

WESA
A Better Environment For Business

Project No: C-B4853-06-02

Well ID: W73-2

Project: WM Ottawa Landfill - Expansion Drilling

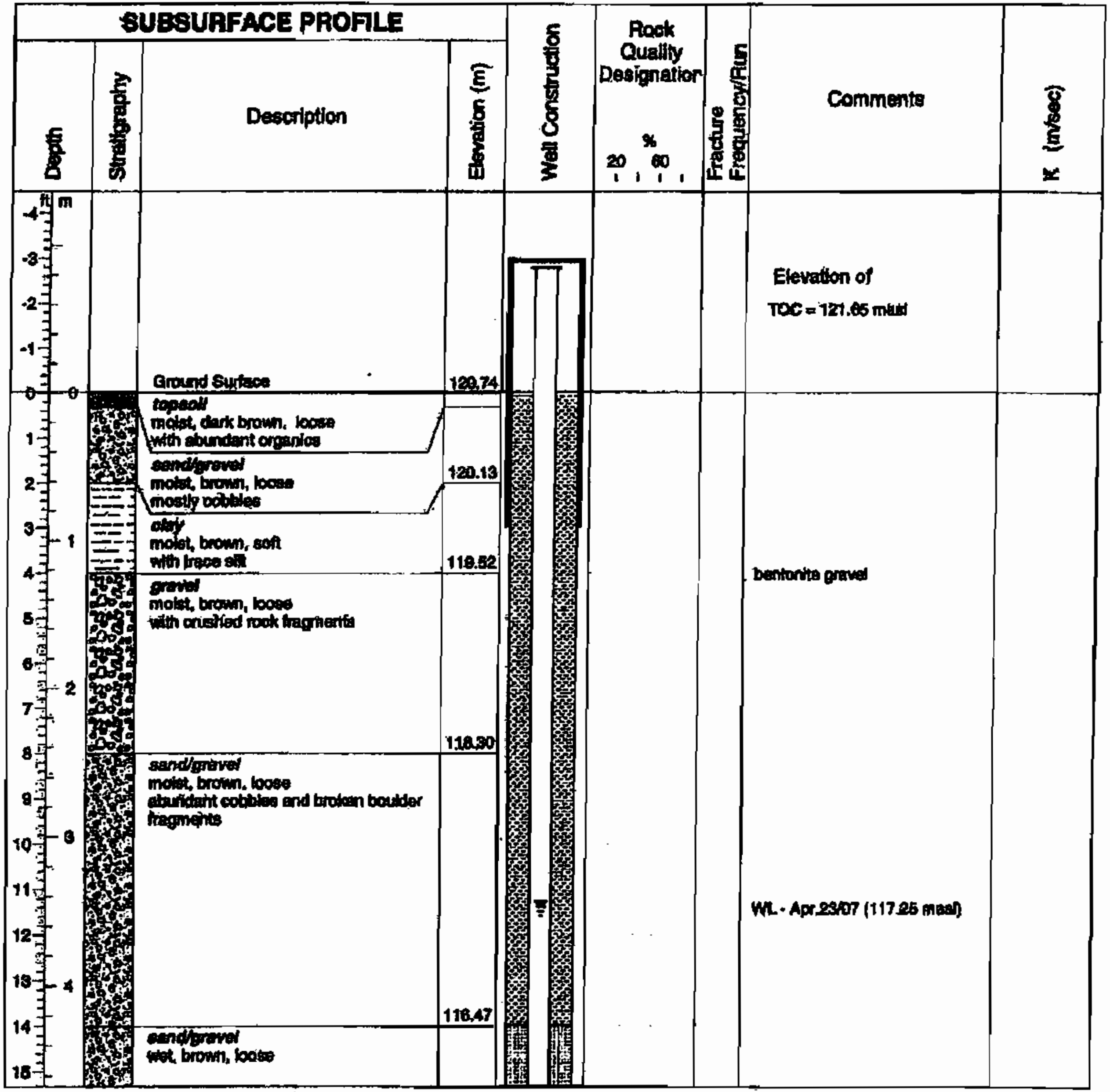
Client: Waste Management

Location: WM (former Mulligan property)

Easting: 346287.93

Northing: 5016542.84

Field Personnel: S. Pfister



Description	Elevation (m)	Comments
		Elevation of TOC = 121.65 masl
Ground Surface	120.74	
topsoil moist, dark brown, loose with abundant organics		
sand/gravel moist, brown, loose mostly cobbles	120.13	
clay moist, brown, soft with trace silt	119.52	
gravel moist, brown, loose with crushed rock fragments		bentonite gravel
sand/gravel moist, brown, loose abundant cobbles and broken boulder fragments	118.30	WL - Apr.23/07 (117.25 masl)
sand/gravel wet, brown, loose	116.47	

Drilled By: Downing Drilling

Drill Method: HS auger/diamond core

Drill Date: 15/Mar/2007

Hole Size: 8"/HQ

Datum: RTK GPS Survey (by OLS) UTM NAD27

Checked By: RLC

WinLOG Template: WMverticalhole

Sheet: 1 of 2

WESA
A Better Environment For Business

Project No: C-B4853-06-02

Well ID: W73-2

Project: WM Ottawa Landfill - Expansion Drilling

Client: Waste Management

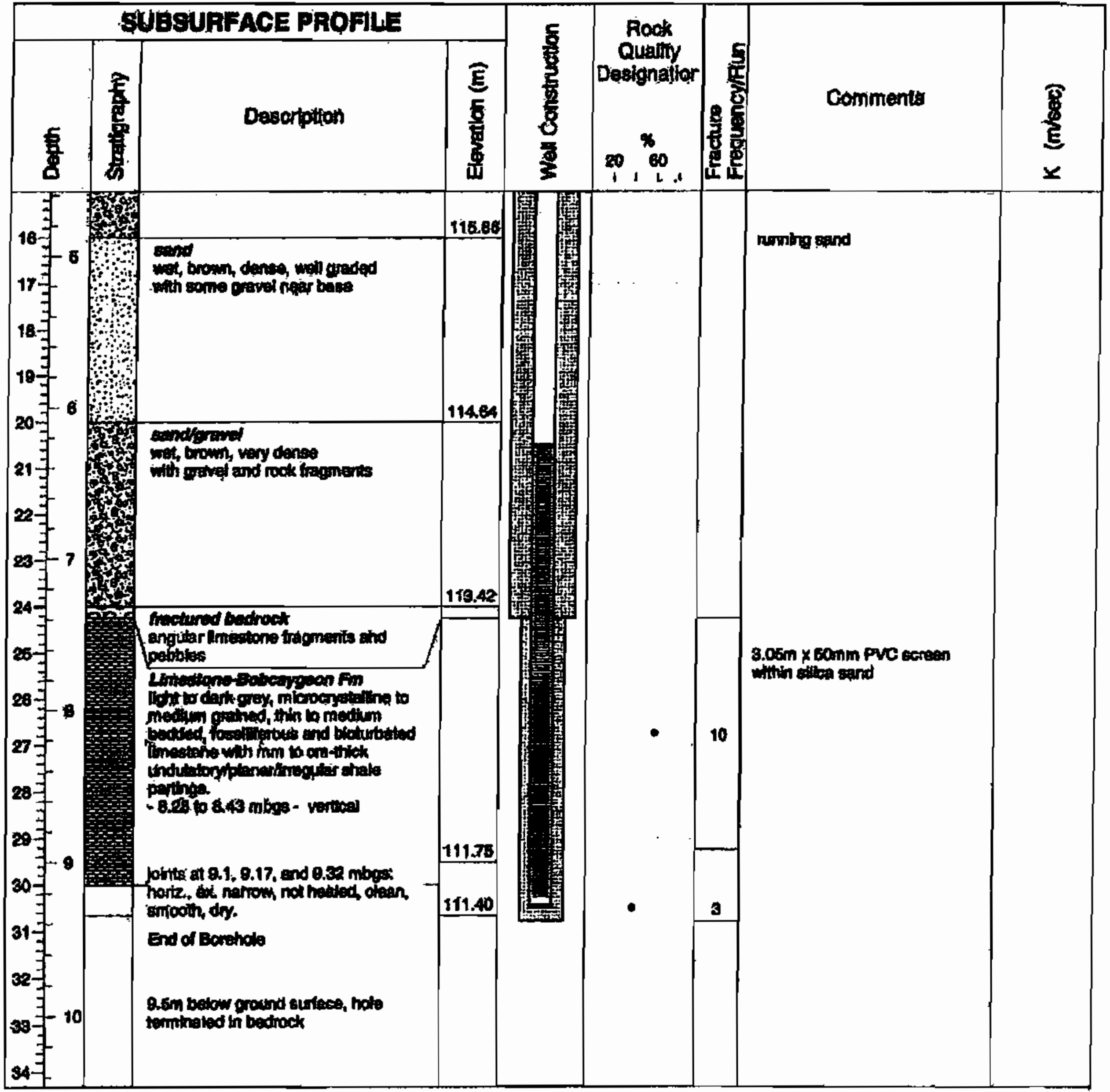
Location: WM (former Mulligan property)

Easting: 346287.93

Northing: 5016542.84

Field Personnel: S. Pfister

SUBSURFACE PROFILE



Depth	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation % 20 60	Fracture Frequency/Run	Comments	K (m/sec)
16 / 5			115.86					
16–20 / 5–6		***sand*** wet, brown, dense, well graded with some gravel near base	114.64				running sand	
20–24 / 6–7		***sand/gravel*** wet, brown, very dense with gravel and rock fragments	113.42					
24–25		***fractured bedrock*** angular limestone fragments and pebbles						
25–29 / 8–9		***Limestone-Bobcaygeon Fm*** light to dark grey, microcrystalline to medium grained, thin to medium bedded, fossiliferous and bioturbated limestone with mm to cm-thick undulatory/planar/irregular shale partings. - 8.28 to 8.43 mbgs - vertical	111.75		●	10	3.05m x 50mm PVC screen within silica sand	
29–30 / 9		joints at 9.1, 9.17, and 9.32 mbgs: horiz., ext. narrow, not healed, clean, smooth, dry.	111.40		●	3		
31		End of Borehole						
33 / 10		9.5m below ground surface, hole terminated in bedrock						

Drilled By: Downing Drilling

Drill Method: HS auger/diamond core

Drill Date: 15/Mar/2007

Hole Size: 8"/HQ

Datum: RTK GPS Survey (by OLS) UTM NAD27

Checked By: RLC

WinLOG Template: WMverticalhole

Sheet: 2 of 2

WESA
A Better Environment For Business

Well ID: W75

Project No: C-B4853-06-02

Project: WM Ottawa Landfill - Expansion Drilling

Client: Waste Management

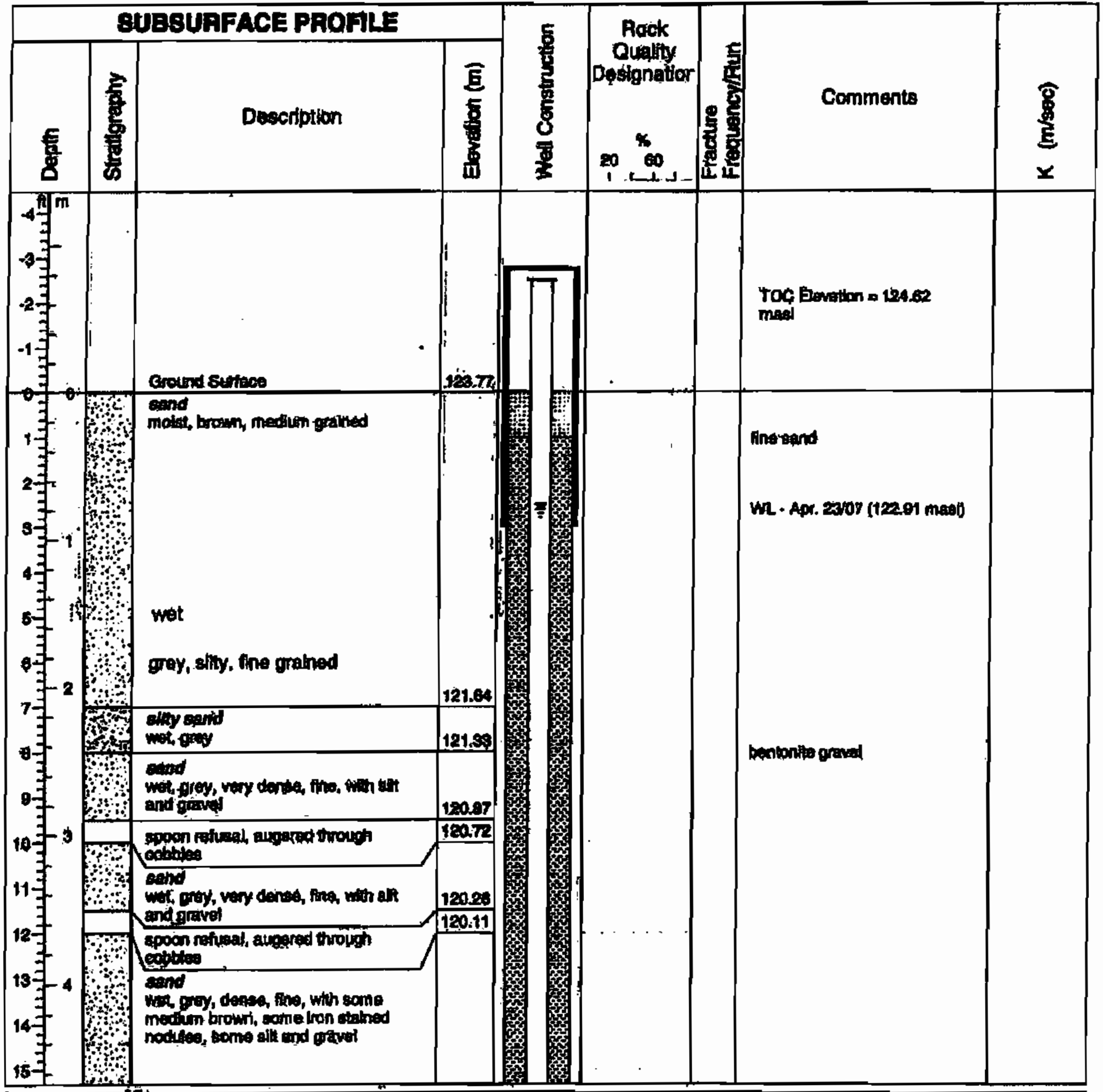
Location: Paul's Farm (East of William Mooney)

Easting: 345843.62*

Northing: 5015992.95*

Field Personnel: S. Pfister/A. Wigston

SUBSURFACE PROFILE



Description	Elevation (m)	Comments
		TOC Elevation = 124.62 masl
Ground Surface	123.77	
sand moist, brown, medium grained		fine sand
		WL - Apr. 23/07 (122.91 masl)
wet		
grey, silty, fine grained	121.64	
silty sand wet, grey	121.33	bentonite gravel
sand wet, grey, very dense, fine, with silt and gravel	120.97	
spoon refusal, augered through cobbles	120.72	
sand wet, grey, very dense, fine, with silt and gravel	120.26	
spoon refusal, augered through cobbles	120.11	
sand wet, grey, dense, fine, with some medium brown, some iron stained nodules, some silt and gravel		

Drilled By: Downing Drilling
Drill Method: HS auger/diamond core
Drill Date: 21/Mar/2007
Hole Size: 8"/HQ

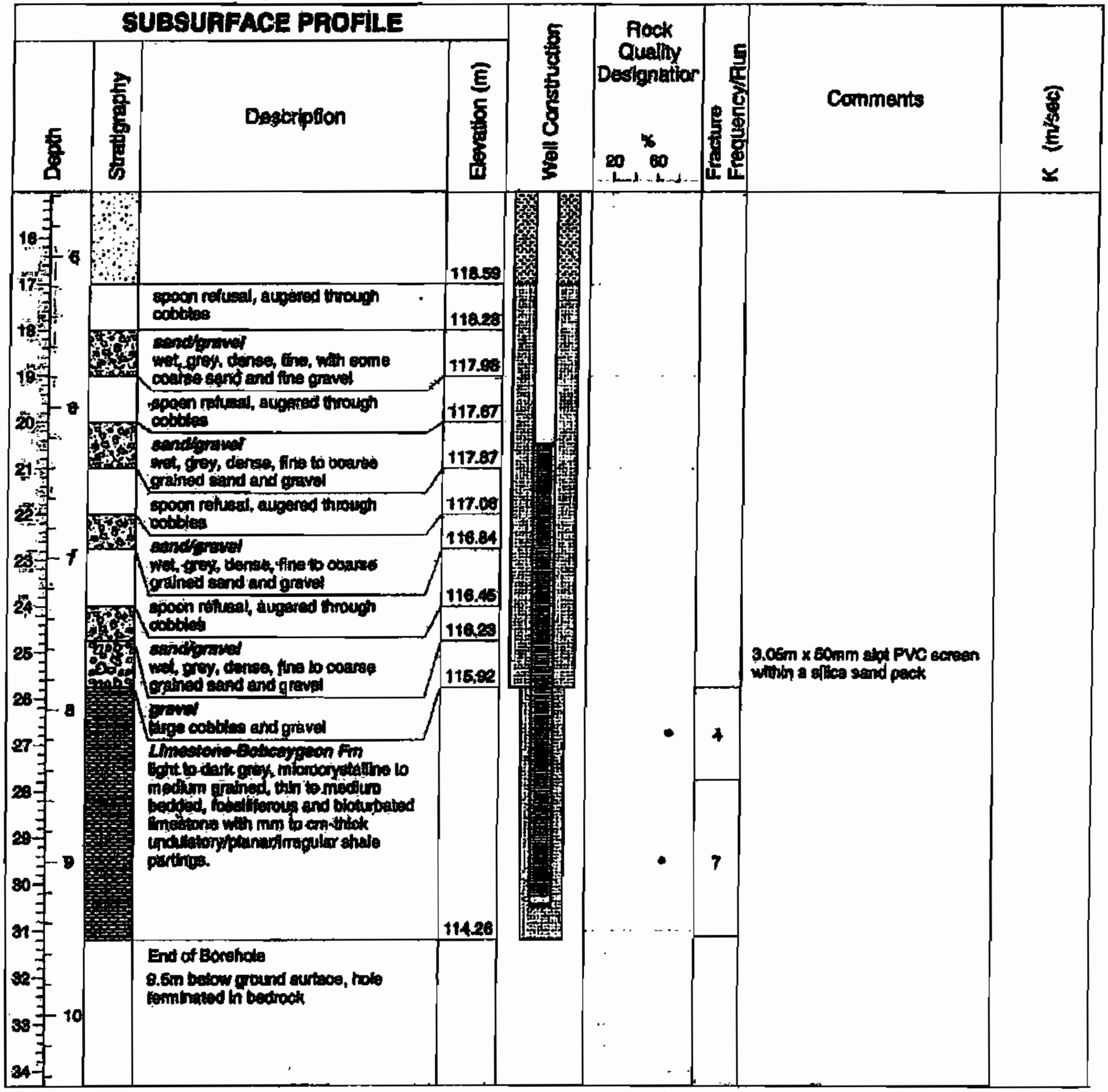
Datum: * RTK GPS Survey (by OLS) UTM NAD27
Checked By: RLC
WinLOG Template: WMverticalhole
Sheet: 1 of 2

WESA
A Better Environment For Business

Well ID: W75

Project No: C-B4853-06-02
Project: WM Ottawa Landfill - Expansion Drilling
Client: Waste Management
Location: Paul's Farm (East of William Mooney)

Easting: 345843.62*
Northing: 5015992.95*
Field Personnel: S. Pfister/A. Wigston



Description	Elevation (m)
	118.59
spoon refusal, augered through cobbles	118.28
sand/gravel wet, grey, dense, fine, with some coarse sand and fine gravel	117.98
spoon refusal, augered through cobbles	117.67
sand/gravel wet, grey, dense, fine to coarse grained sand and gravel	117.37
spoon refusal, augered through cobbles	117.06
sand/gravel wet, grey, dense, fine to coarse grained sand and gravel	116.84
spoon refusal, augered through cobbles	116.45
sand/gravel wet, grey, dense, fine to coarse grained sand and gravel	116.23
gravel large cobbles and gravel	115.92
Limestone-Bobcaygeon Fm light to dark grey, microcrystalline to medium grained, thin to medium bedded, fossiliferous and bioturbated limestone with mm to cm-thick undulatory/planar/irregular shale partings.	114.26
End of Borehole 9.5m below ground surface, hole terminated in bedrock	

Comments: 3.05m x 50mm slot PVC screen within a silica sand pack

Drilled By: Downing Drilling
Drill Method: HS auger/diamond core
Drill Date: 21/Mar/2007
Hole Size: 8"/HQ

Datum: * RTK GPS Survey (by OLS) UTM NAD27
Checked By: RLC
WinLOG Template: WMverticalhole
Sheet: 2 of 2

WESA
A Better Environment For Business

Well ID: W76-2

Project No: C-B4853-06-02

Project: WM Ottawa Landfill - Expansion Drilling

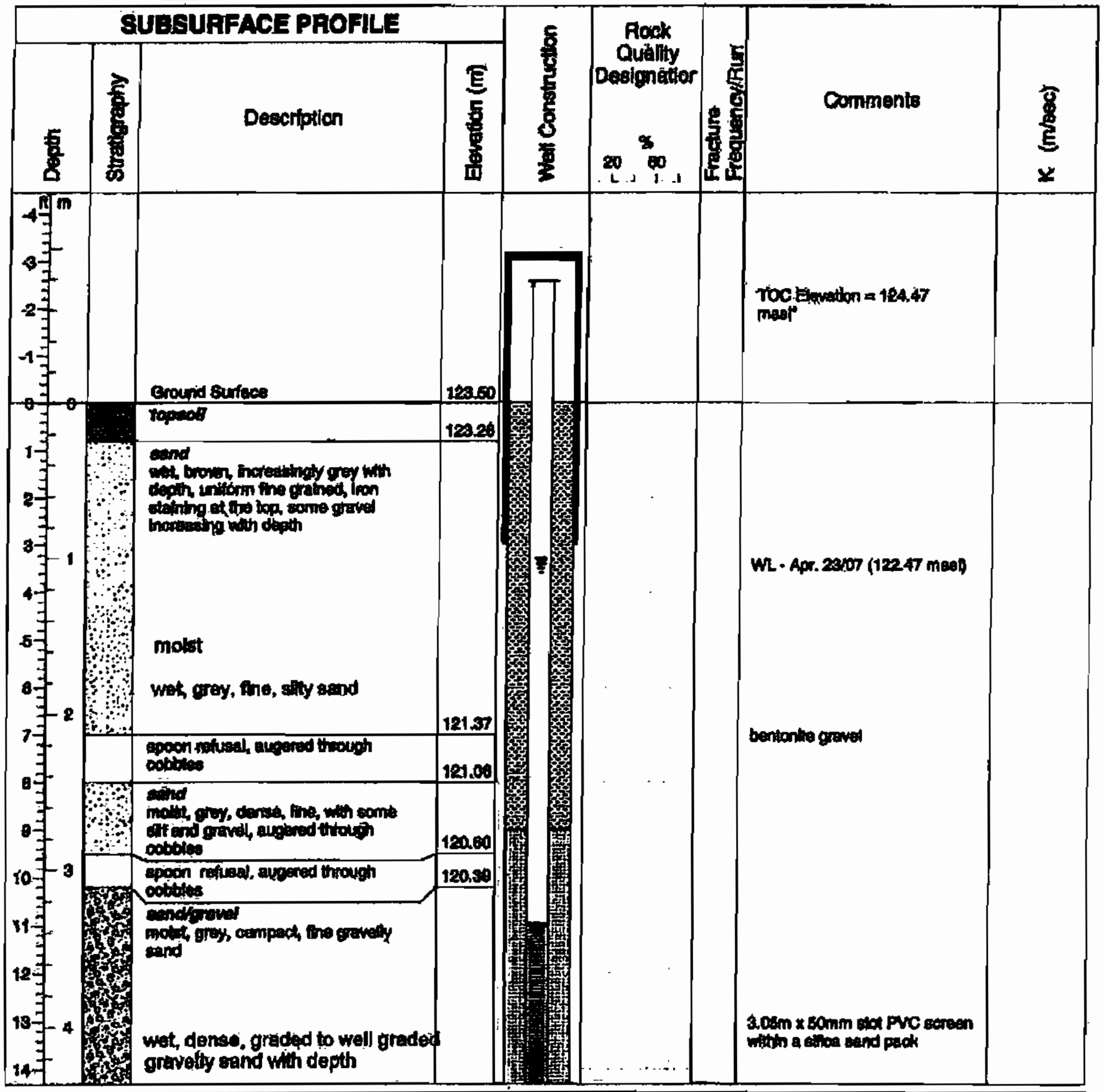
Client: Waste Management

Location: Paul's Farm (Next to William Mooney Dr)

Easting: 346287.93*

Northing: 5015784.87*

Field Personnel: S. Pfister/A. Wigston



Description	Elevation (m)	Comments
Ground Surface	123.50	TOC Elevation = 124.47 masl*
topsoil	123.26	
sand wet, brown, increasingly grey with depth, uniform fine grained, iron staining at the top, some gravel increasing with depth moist wet, grey, fine, silty sand	121.37	WL - Apr. 23/07 (122.47 masl) bentonite gravel
spoon refusal, augered through cobbles	121.06	
sand moist, grey, dense, fine, with some silt and gravel, augered through cobbles	120.60	
spoon refusal, augered through cobbles	120.39	
sand/gravel moist, grey, compact, fine gravelly sand wet, dense, graded to well graded gravelly sand with depth		3.05m x 50mm slot PVC screen within a silica sand pack

Drilled By: Downing Drilling

Drill Method: HB auger/diamond core

Drill Date: 22/Mar/2007

Hole Size: 8"/HQ

Datum: * RTK GPS Survey (by OLS) UTM NAD27

Checked By: RLC

WinLOG Template: WMverticalhole

Sheet: 1 of 2

WESA
A Better Environment For Business

Well ID: W76-2

Project No: C-B4853-06-02

Project: WM Ottawa Landfill - Expansion Drilling

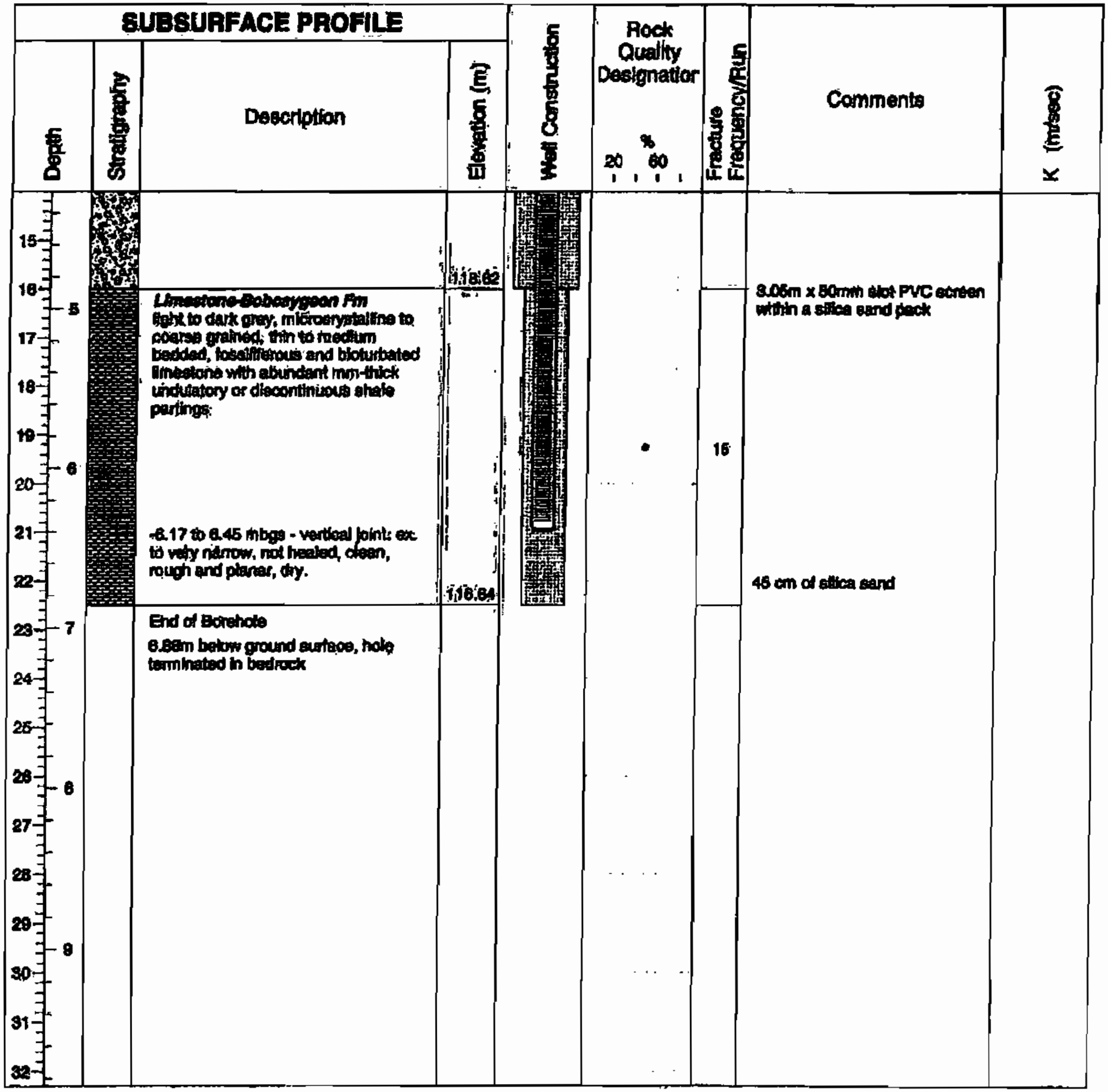
Client: Waste Management

Location: Paul's Farm (Next to William Mooney Dr)

Easting: 346287.93*

Northing: 5015784.87*

Field Personnel: S. Pfister/A. Wigston



Description	Elevation (m)	Fracture Frequency/Run	Comments
	118.62		3.05m x 50mm slot PVC screen within a silica sand pack
Limestone-Bobcaygeon Fm light to dark grey, microcrystalline to coarse grained, thin to medium bedded, fossiliferous and bioturbated limestone with abundant mm-thick undulatory or discontinuous shale partings. -6.17 to 6.45 mbgs - vertical joint: ex. to very narrow, not healed, clean, rough and planar, dry.	116.64	15	45 cm of silica sand
End of Borehole 6.86m below ground surface, hole terminated in bedrock			

Drilled By: Downing Drilling

Drill Method: HS auger/diamond core

Drill Date: 22/Mar/2007

Hole Size: 8"/HQ

Datum: * RTK GPS Survey (by OLS) UTM NAD27

Checked By: RLC

WinLOG Template: WMverticalhole

Sheet: 2 of 2

WESA
A Better Environment For Business

FIGURE:

RECORD OF TEST HOLE

DESIGNATION
P79

COMPLETION DATE
AUGUST 12, 1993

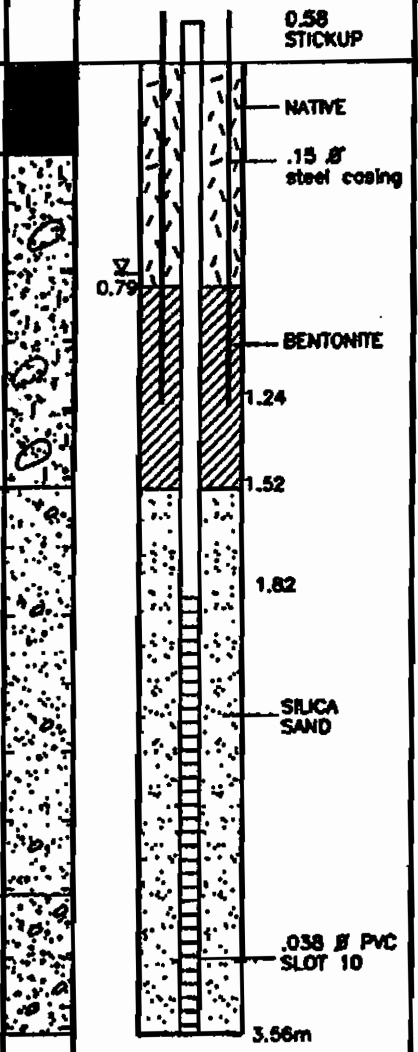
PROJECT: LAIDLAW WASTE SYSTEMS, CARP
PROJECT NO.: 2849-R

DRILLING METHODS: HOLLOW STEM AUGER
SUPERVISOR: BRIAN ANDRESS
DRILLING CONTRACTOR: MARATHON DRILLING CO. LTD.

DEPTH METRES	ELEVATION METRES	STRATIGRAPHY	TYPE	INTERVAL	N VALUE
0	126.11	MEDIUM BROWN, MOIST, TOPSOIL FILL			
0.36	125.75	GREY, MOIST, SILTY SAND WITH GRAVEL AND BOULDERS			
1.52	124.59	COMPACT TO DENSE, GREY, WET, SILT AND FINE SAND WITH A TRACE OF GRAVEL	SS1	1.52 2.1	31
3.05	123.06	LOOSE, GREY, SATURATED SAND AND GRAVEL TILL, TRACE OF CLAY	SS2	3.05 3.56	4
3.56	122.55	END OF HOLE 3.56m – BEDROCK REFUSAL			

LOG

INSTRUMENTATION



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P.O.BOX 430
CARP, ONTARIO K0A 1L0

FIGURE:	**RECORD OF TEST HOLE**	DESIGNATION P80	COMPLETION DATE AUGUST 12, 1993

PROJECT: LAIDLAW WASTE SYSTEMS, CARP

PROJECT NO.: 2849-R

DRILLING METHODS: HOLLOW STEM AUGER

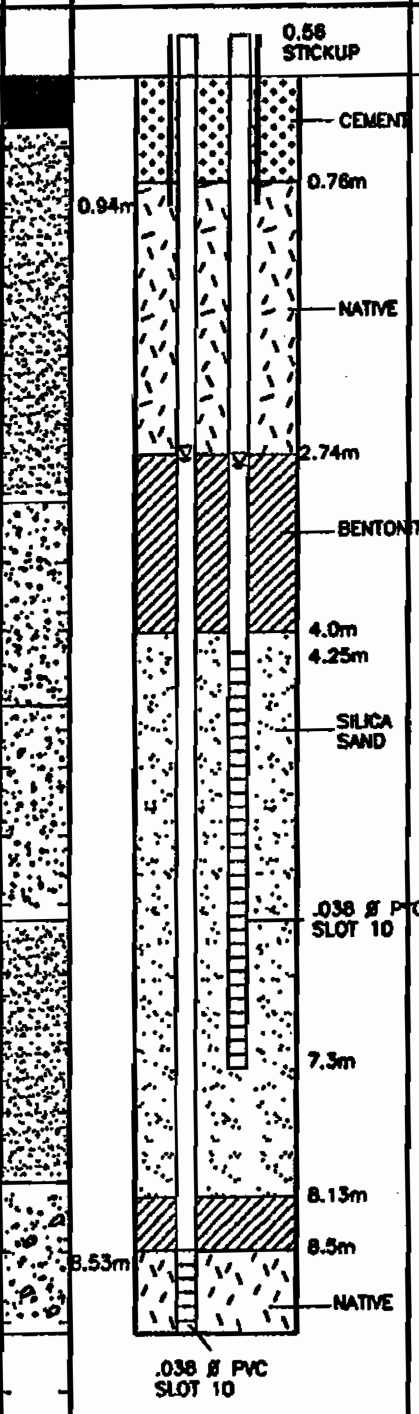
SUPERVISOR: BRIAN ANDRESS

DRILLING CONTRACTOR: MARATHON DRILLING CO. LTD.

DEPTH METRES	ELEVATION METRES	STRATIGRAPHY
0	128.22	MEDIUM BROWN, MOIST, SANDY TOPSOIL
0.20	128.02	COMPACT, LIGHT BROWN, MOIST, FINE TO COARSE SAND
3.05	125.17	DENSE, GREY, MOIST FINE SAND WITH A TRACE OF FINE GRAVEL
4.57	123.65	COMPACT, GREY-LIGHT BROWN, SATURATED, FINE SAND WITH A TRACE OF GRAVEL
6.1	122.12	DENSE, GREY-LIGHT BROWN, SATURATED FINE TO MEDIUM SAND.
8.0	120.22	LOOSE, GREY, SATURATED SAND AND GRAVEL TILL WITH A TRACE OF CLAY
9.14	119.08	END OF HOLE 9.14m - BEDROCK REFUSAL

LOG

INSTRUMENTATION



TYPE	INTERVAL	N VALUE
SS1	1.50 – 2.13	22
SS2	3.05 – 3.65	48
SS3	4.57 – 5.18	27
SS4	6.1 – 6.71	47
SS5	7.62 – 8.23	3

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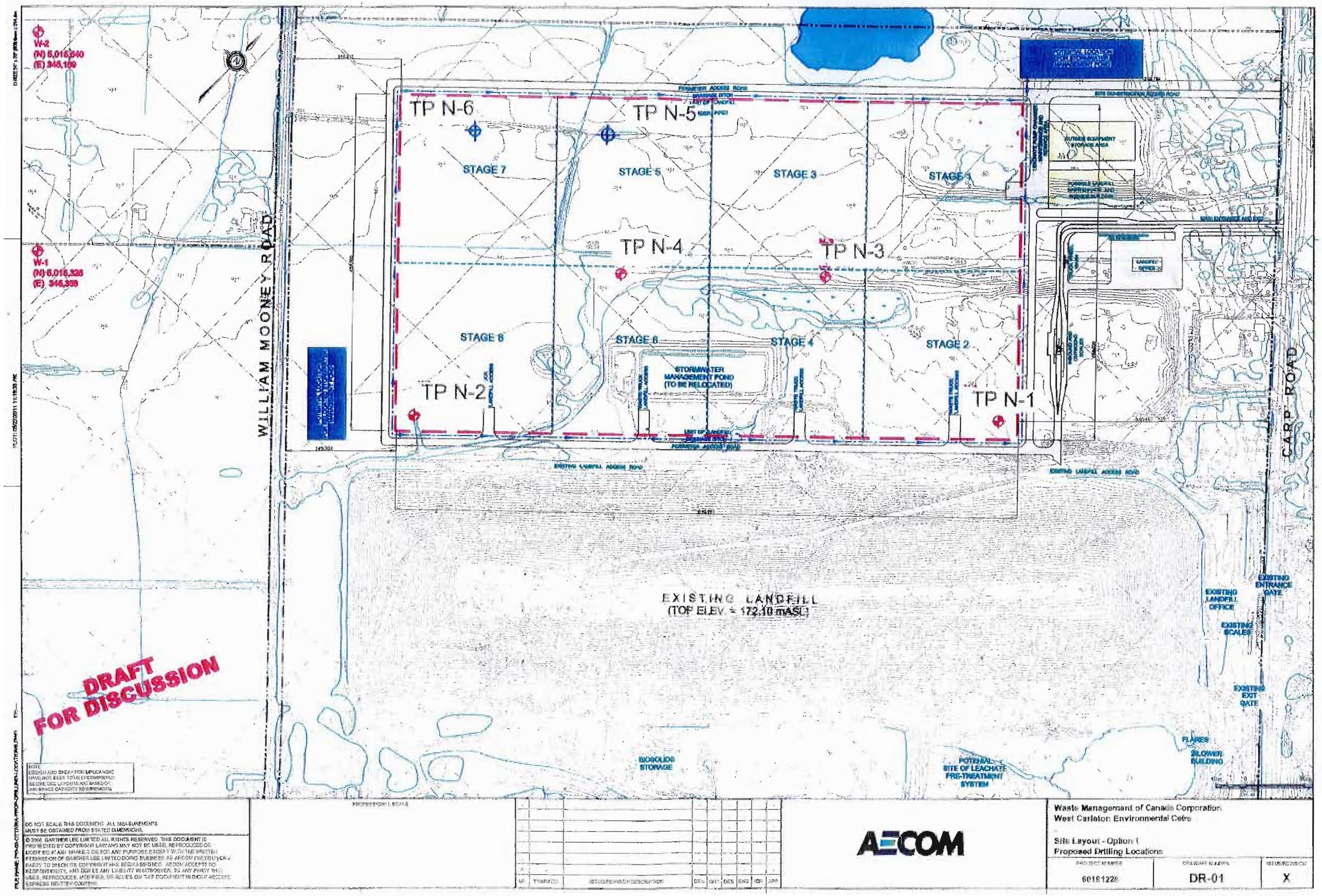
APPENDIX ‘C’



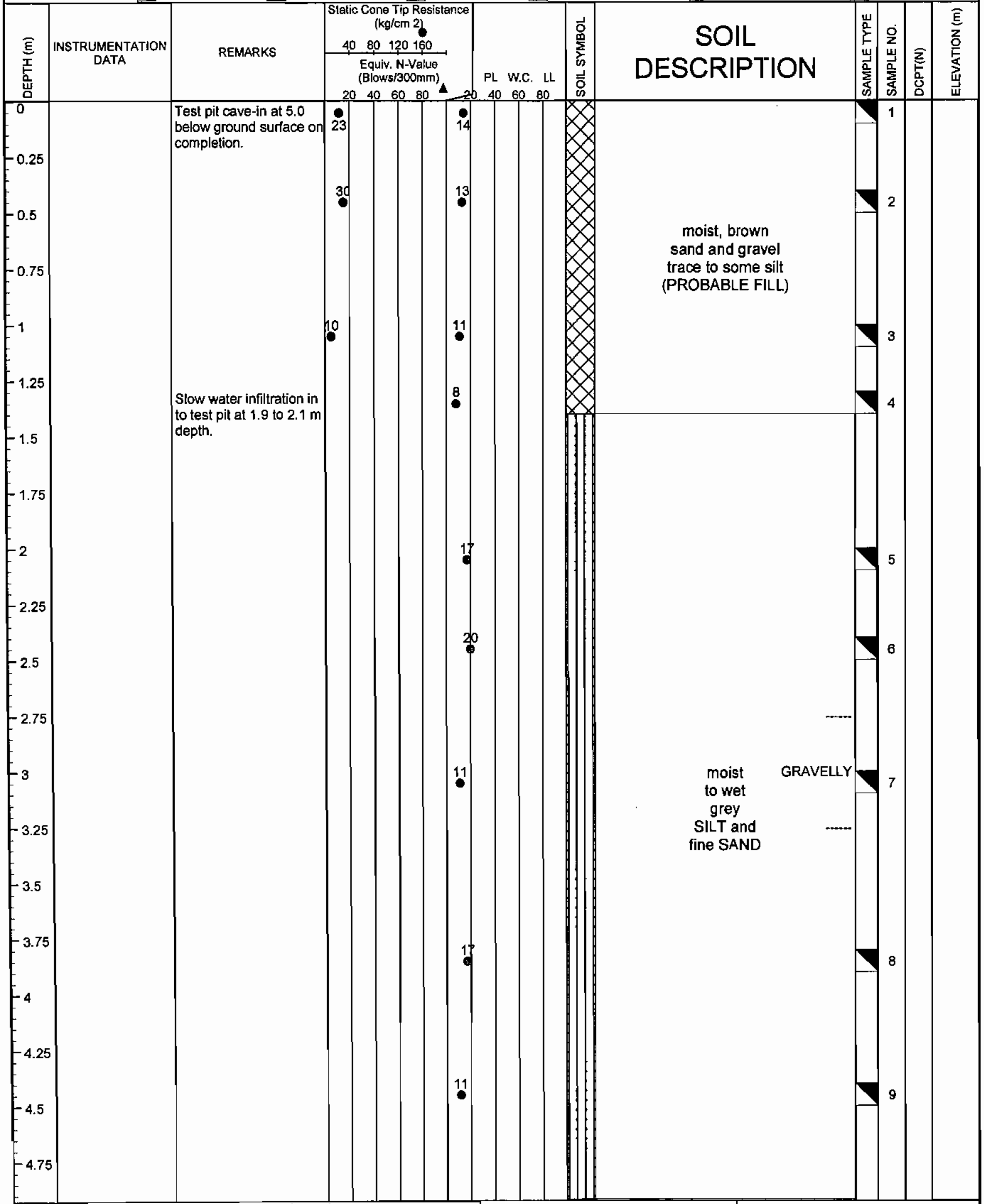
UTM Co-ordinates for each location shown on Test Pit Log Sheets

TEST PIT LOCATION PLAN
CARP LANDFILL
CARP, ONTARIO

Drawing No. 1
Ref. No. 11-066
June 2011
Scale: n.t.s.

CLIENT: AECOM	METHOD: Track Mounted Excavator	**TP No.: N1**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)
LOCATION: Carp Road at Highway 417	NORTHING: 5015067	EASTING: 0424059
		PROJECT NO.: 11-066

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



Test pit cave-in at 5.0 below ground surface on completion.

Slow water infiltration in to test pit at 1.9 to 2.1 m depth.

moist, brown
sand and gravel
trace to some silt
(PROBABLE FILL)

moist
to wet
grey
SILT and
fine SAND

GRAVELLY

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 31 May 2011
	REVIEWED BY: DM	Page 1 of 2

CLIENT: AECOM	METHOD: Track Mounted Excavator	**TP No.: N1**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5015067 EASTING: 0424059	PROJECT NO.: 11-066

SAMPLE TYPE AUGER DRIVEN CORING DYNAMIC CONE SHELBY SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Static Cone Tip Resistance (kg/cm 2) ● 40 80 120 160 Equiv. N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
5		Side walls caving at 5.0 m depth.	9 ●			see bottom of previous page	◣	10		
						END OF BOREHOLE				

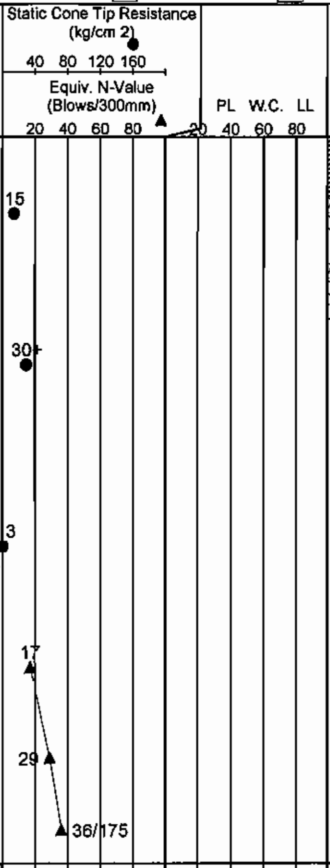
alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 31 May 2011
	REVIEWED BY: DM	Page 2 of 2

CLIENT: AECOM
PROJECT: Carp Landfill
LOCATION: Carp Road at Highway 417
METHOD: Track Mounted Excavator
PROJECT ENGINEER: CA
ELEV. (m)
NORTHING: 5014562
EASTING: 0423450

TP No.: N2

PROJECT NO.: 11-066

SAMPLE TYPE ▮ AUGER ◩ DRIVEN ⧗ CORING ▬ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Water level at 1.2 m and side walls of excavation sloughing from 1.2 m depth to base of exdcavation on completion.	200 mm TOPSOIL	◩	1		
0.25			moist, brown SAND and GRAVEL trace silt	◩	2		
0.5							
0.75			moist	◩	3		
1							
1.25	▼	Fast water infiltration in to test pit at 1.2 m depth. Dynamic Cone penetration test advanced from 1.4 to 2.4 m depth.	brown fine to medium SAND trace gravel trace silt	◩	4		
1.5							
1.75			wet compact	◩	5	17	
2						29	
2.25			dense			36/175	
		Refusal to advancement of dynamic cone test, probable boulder.	END OF BOREHOLE				

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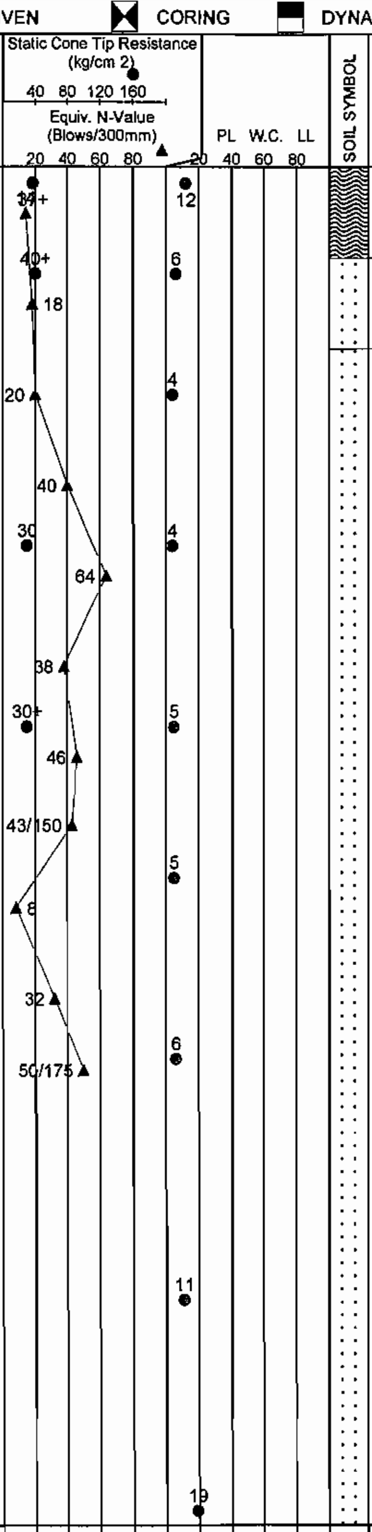
LOGGED BY: KC
REVIEWED BY: DM
DRILLING DATE: 31 May 2011
Page 1 of 1

CLIENT: AECOM	METHOD: Track Mounted Excavator		**TP No.: N3**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5015120	EASTING: 0423765	PROJECT NO.: 11-066

SAMPLE TYPE ▯ AUGER ◪ DRIVEN ⧓ CORING ▬ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Side walls of excavation sloughing from 4.0 m depth to base of exdcavation on completion, Wet layer at 4.0 m depth.	300 mm TOPSOIL	1	14	
0.25			moist, brown SAND some gravel	2	18	
0.5						
0.75			compact	3	20	
1			------		40	
1.25				4	64	
1.5			dense damp to moist		38	
1.75				5	46	
2					43/150	
2.25				6	8	
2.5			greyish brown fine to medium SAND trace silt			
2.75					32	
3				7	50/175	
3.25						
3.5						
3.75				8		
4	▽	Water strike at 4.0 m depth.	----			
4.25			wet	9		
			END OF BOREHOLE			

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 31 May 2011
	REVIEWED BY: DM	Page 1 of 1

CLIENT: AECOM
METHOD: Track Mounted Excavator

TP No.: N4

PROJECT: Carp Landfill
PROJECT ENGINEER: CA
ELEV. (m)
LOCATION: Carp Road at Highway 417
NORTHING: 5014894
EASTING: 0423507
PROJECT NO.: 11-066

SAMPLE TYPE: ▮ AUGER ◢ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Static Cone Tip Resistance (kg/cm 2) 40 80 120 160 ● / Equiv. N-Value (Blows/300mm) 20 40 60 80 ▲	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Test pit cave-in at 1.8 m and water level at 1.8 m below ground surface on completion.	● 17			400 mm TOPSOIL	◢	1		
0.25										
0.5			30 ●			damp to moist brown SAND some gravel	◢	2		
0.75										
1			30+ ●				◢	3		
1.25						moist greyish brown SILT and fine SAND	◢	4		
1.5		Boulder contacted at 1.5 m depth.								
1.75	▼	Water quickly infiltrating at 1.8 m depth.	30+ ●				◢	5		
2										
2.25										
2.5							◢	6		
2.75										
3						wet, brown fine to medium SAND	◢	7		
						END OF BOREHOLE				

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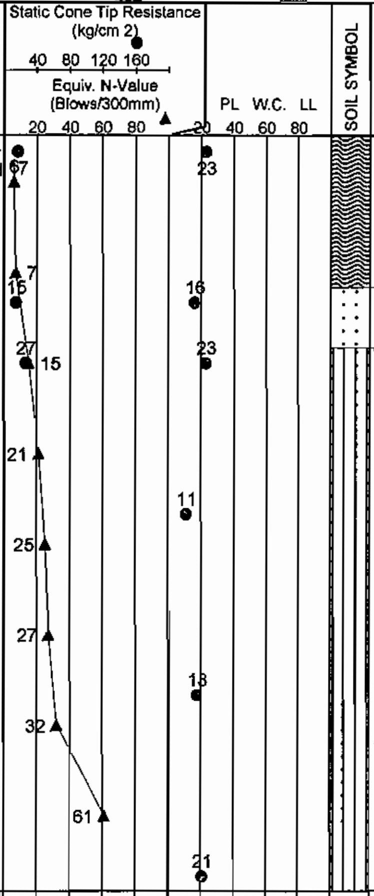
LOGGED BY: KC
DRILLING DATE: 31 May 2011
REVIEWED BY: DM

CLIENT: AECOM	METHOD: Rubber Tire Backhoe		**TP No.: N5**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5015006	EASTING: 0423376	PROJECT NO.: 11-066

SAMPLE TYPE ▮ AUGER ◢ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Test pit side wallls cave-in at 1.2 m below ground surface on completion.	500 mm TOPSOIL	◢	1	6	
0.25							
0.5						7	
			loose, moist, brown SAND, some gravel trace to some silt	◢	2		
0.75	▼	DCPT rods wet at 0.8 m depth.	moist to wet brown SILT and fine SAND	◢	3	15	
1						21	
1.25				◢	4	25	
1.5						27	
1.75			compact	◢	5		
2			----			32	
2.25			dense			61	
		Very slow water infiltration at 2.4 m depth.		◢	6		
			END OF BOREHOLE				



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	REVIEWED BY: DM	Page 1 of 1

CLIENT: AECOM
METHOD: Rubber Tire Backhoe
PROJECT: Carp Landfill
PROJECT ENGINEER: CA
ELEV. (m)

TP No.: N6

LOCATION: Carp Road at Highway 417
NORTHING: 5014917
EASTING: 0423264
PROJECT NO.: 11-066

SAMPLE TYPE: ▮ AUGER ◢ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Static Cone Tip Resistance (kg/cm 2) 40 80 120 160 / Equiv. N-Value (Blows/300mm) 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Test pit dry and open on completion.	5		▨	200 mm TOPSOIL	◥	1		
0.25			30+		⁘	grey to brown damp to moist SAND some silt some gravel	◥	2		
0.5					⁘					
0.75					⁘					
1			30+		⁘		◥	3		
1.25					⁘					
1.5					⁘	damp, grey SILTY fine to medium SAND trace gravel	◥	4		
1.75					⁘					
2					⁘		◥	5		
2.25					⁘					
2.5					⁘		◥	6		
2.75					⁘					
						END OF BOREHOLE				

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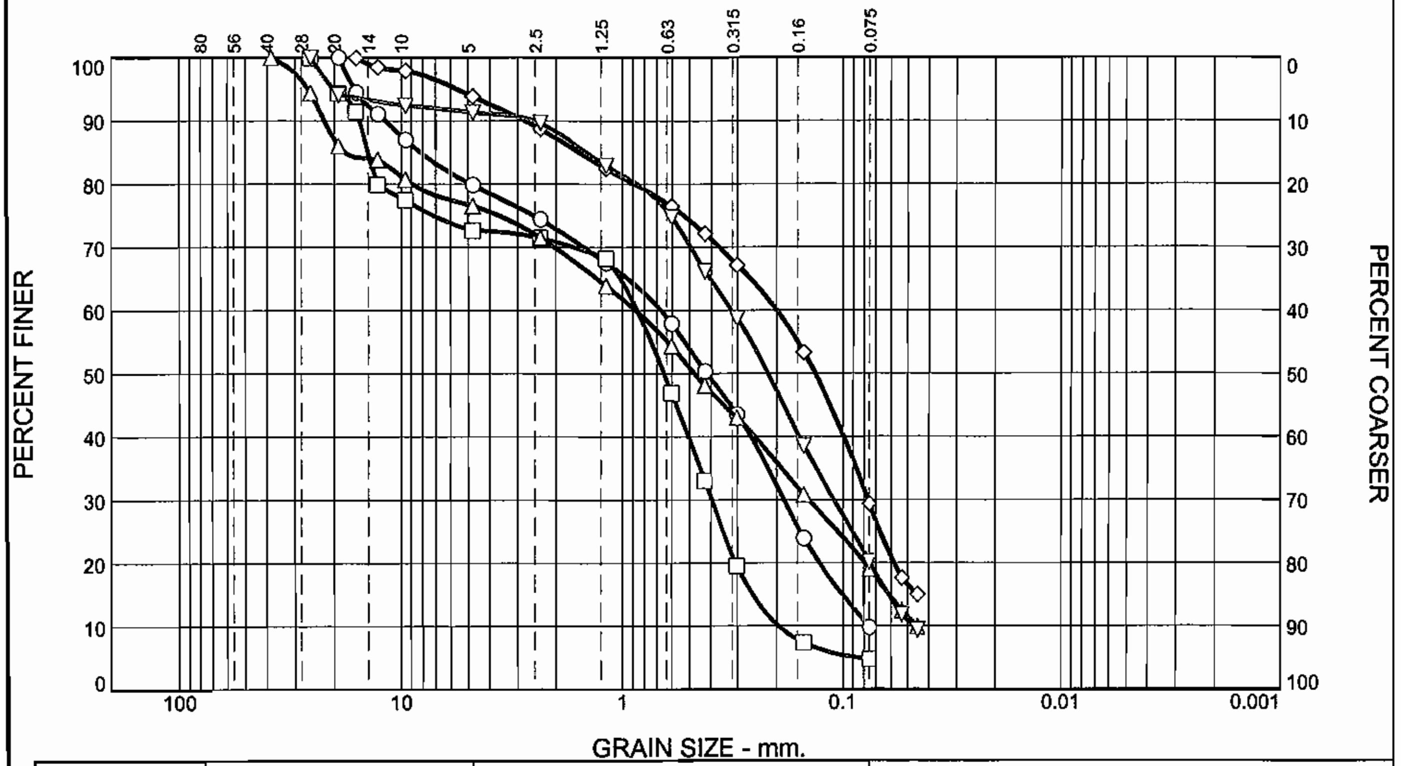
LOGGED BY: KC
REVIEWED BY: DM
DRILLING DATE: 1 June 2011
Page 1 of 1

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	20	7	23	40	10	
□	0	6	21	2	38	28	5	
△	0	14	9	7	22	29	19	
◇	0	0	6	7	15	43	29	
▽	0	6	3	3	22	46	20	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			8.1624	0.6693	0.4174	0.1856	0.1006	0.0761	0.68	8.80
□			14.0059	0.8551	0.6480	0.3943	0.2548	0.1939	0.94	4.41
△			17.8450	0.8651	0.4728	0.1427	0.0608	0.0452	0.52	19.16
◇			1.5512	0.1985	0.1334	0.0761				
▽			1.4459	0.3171	0.2181	0.1097	0.0613	0.0469	0.81	6.76

Material Description	USCS	AASHTO
○ SAND, some gravel to GRAVELLY, tracc to some silt		
□ GRAVELLY SAND, trace silt		
△ GRAVELLY SAND, somc silt		
◇ SILTY SAND, trace gravel		
▽ SAND, some silt to SILTY, trace gravel		

Project No. 11-066 **Client:** AECOM

Project: Carp Landfill

○ **Sample Number:** TP N1, Sample 2

□ **Sample Number:** TP N3, Sample 2

△ **Sample Number:** TP N6, Sample 2

◇ **Sample Number:** TP N5, Samplc 2

▽ **Sample Number:** TP N6, Sample 5

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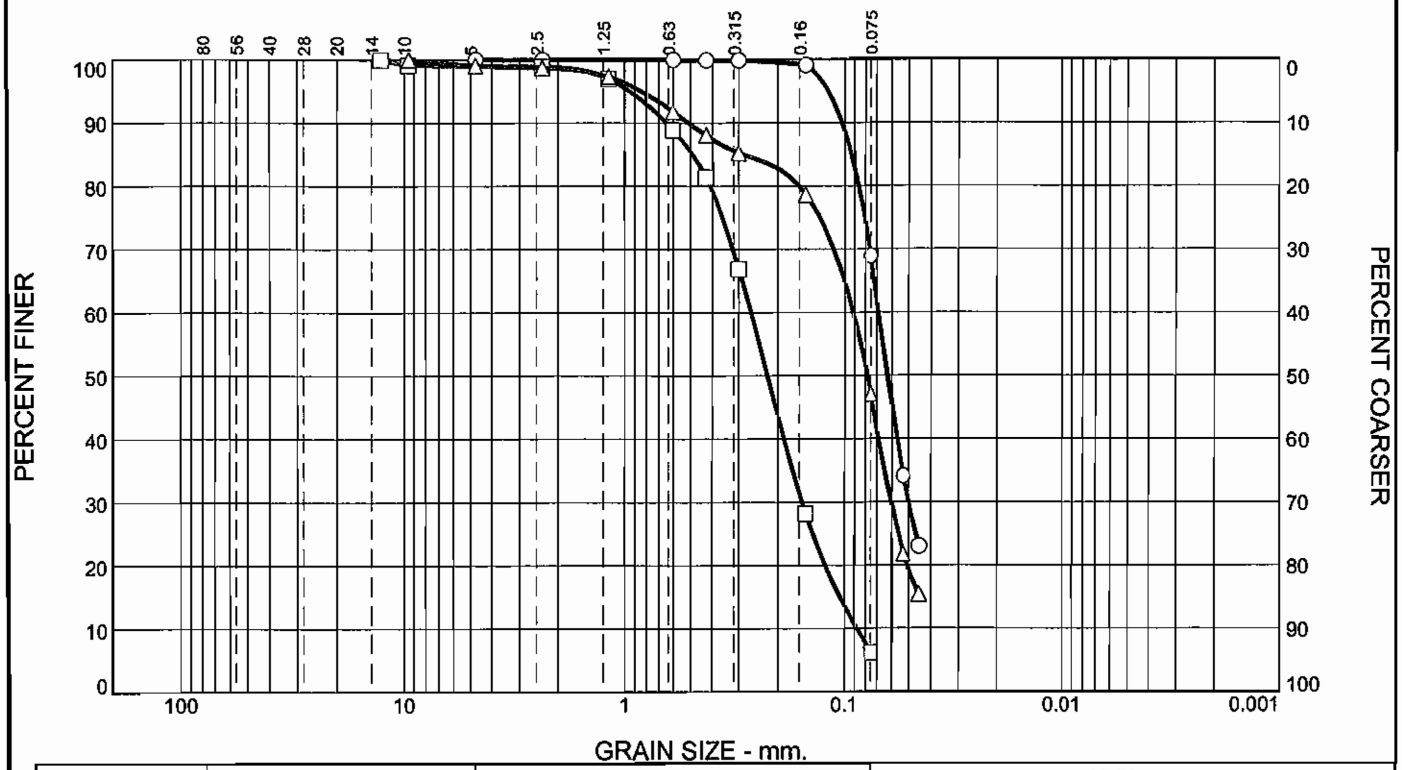
Remarks:

Figure 1

Tested By: ○ RP □ GP △ RP ◇ GP ▽ RP **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	0	31	69	
□	0	0	1	0	18	75	6	
△	0	0	1	0	11	41	47	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0932	0.0686	0.0625	0.0502				
□			0.4862	0.2642	0.2226	0.1555	0.1049	0.0873	1.05	3.03
△			0.2843	0.0912	0.0780	0.0602				

Material Description	USCS	AASHTO
○ SANDY SILT □ SAND, trace silt △ SILT and fine SAND		

Project No. 11-066 **Client:** AECOM

Project: Carp Landfill

○ **Sample Number:** TP N1, Sample 5

□ **Sample Number:** TP N3, Sample 4

△ **Sample Number:** TP N5, Sample 5

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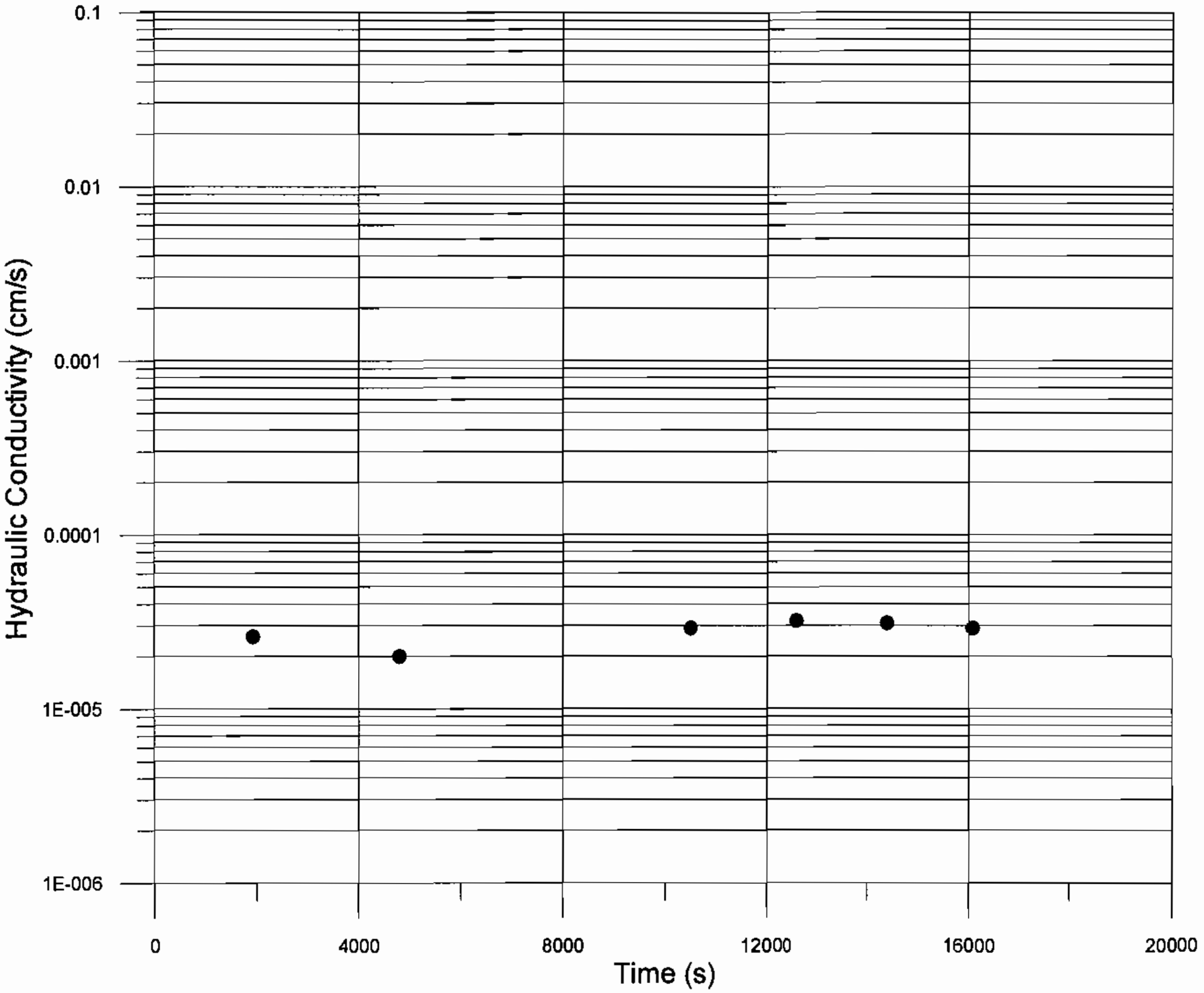
Remarks:

Figure 2

Tested By: ● GP ■ GP ▲ RP **Checked By:** JB

HYDRAULIC CONDUCTIVITY TEST REPORT



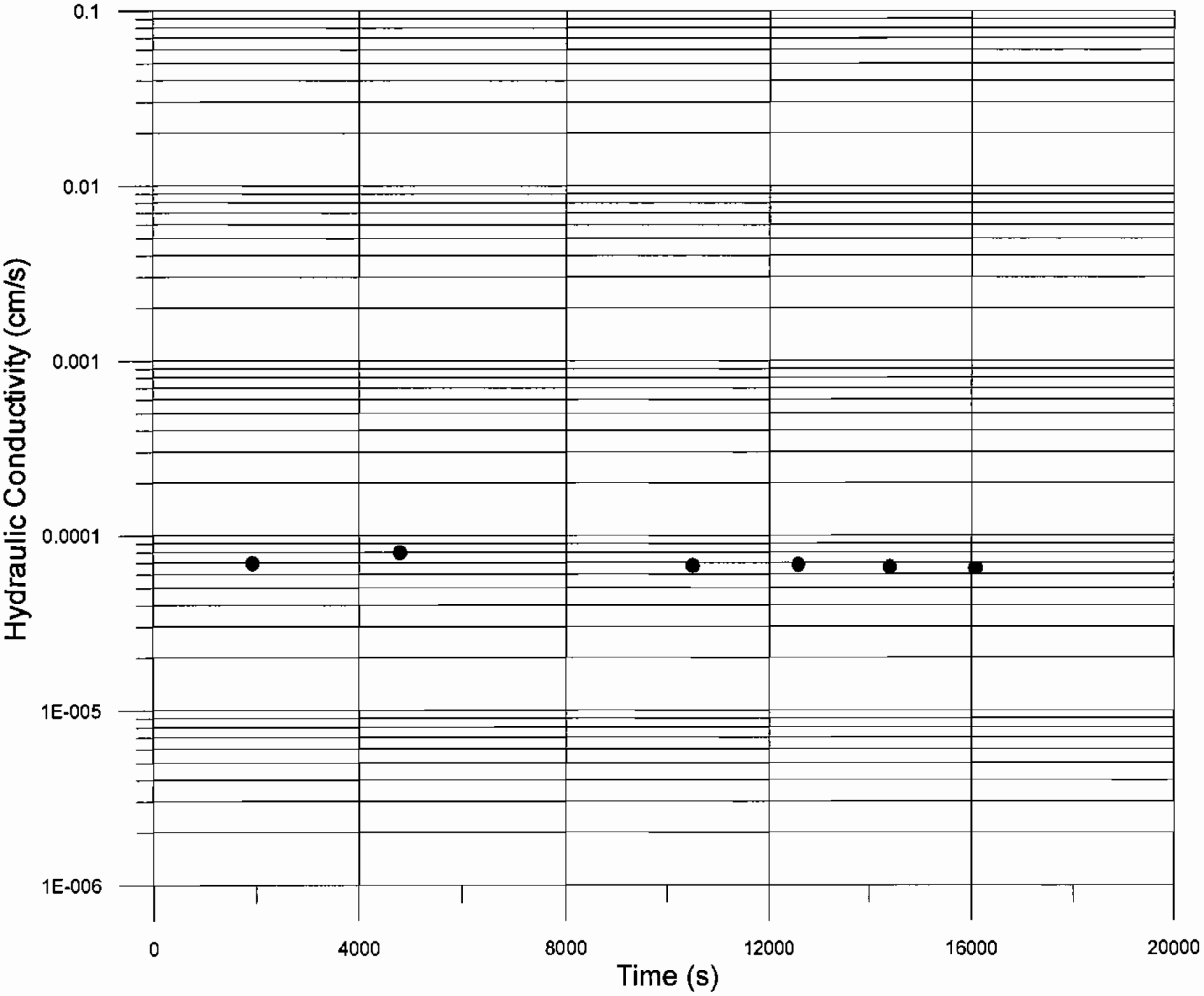
Client: AECOM
Project: Carp Landfill Extension
Alston Associates Inc. Ref. No.: 11-066
Material Description: Silty Sand to Sandy Silt
Sample Location: Test Pit N5, Sample 3
Final Hydraulic Conductivity Reading (cm/s): 2.9 x 10^{-5}

Remarks:

Figure No. 3

alston associates inc.

HYDRAULIC CONDUCTIVITY TEST REPORT



Client: AECOM
Project: Carp Landfill Extension
Alston Associates Inc. Ref. No.: 11-066
Material Description: Silty Sand to Sandy Silt
Sample Location: Test Pit N1, Sample 4
Final Hydraulic Conductivity Reading (cm/s): 6.5 x 10^{-5}

Remarks:

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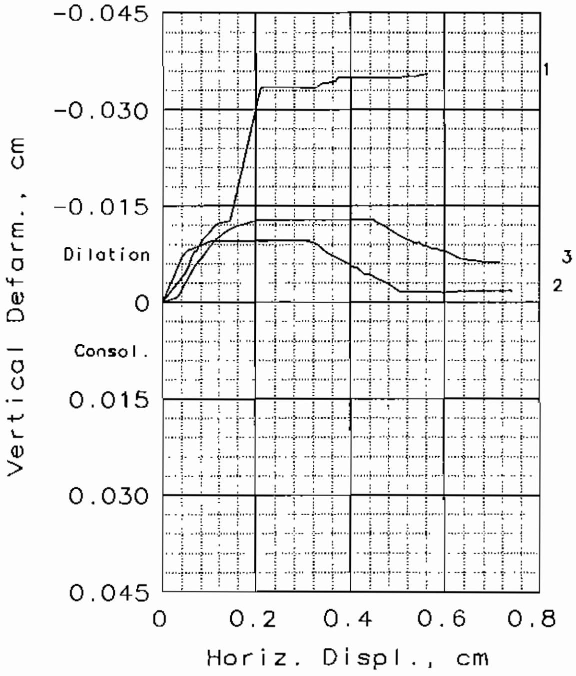
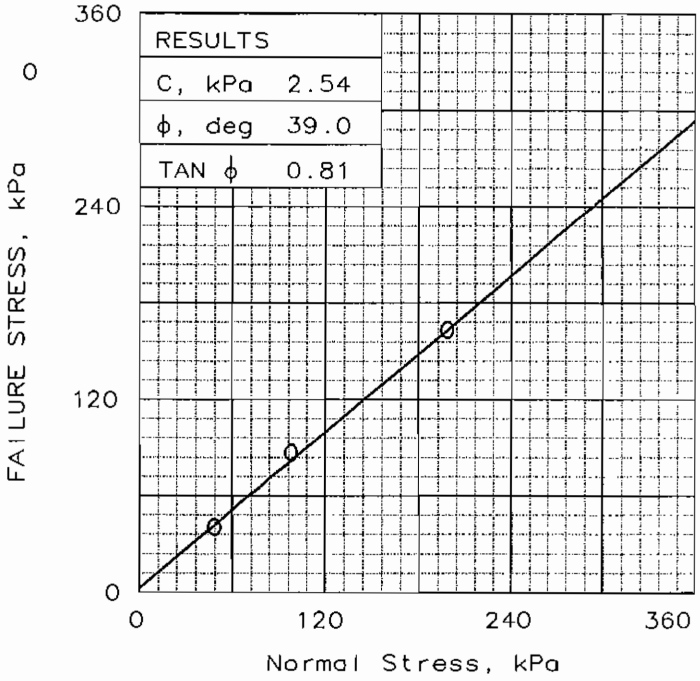
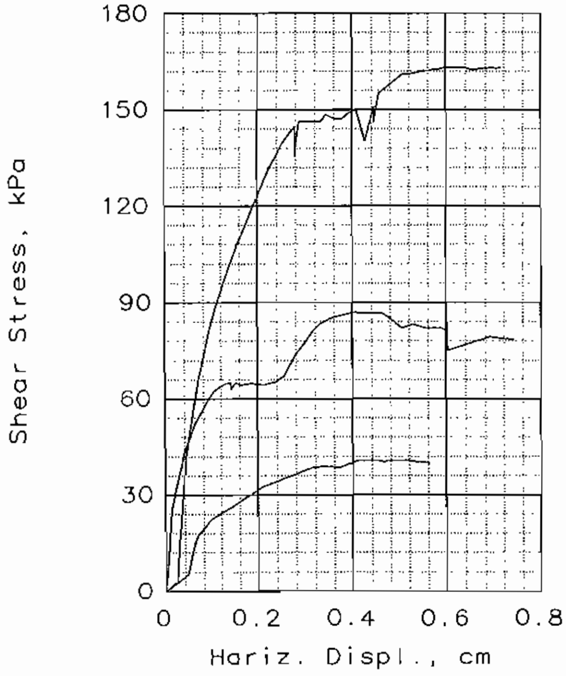
Figure No. 4







	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	19.7	19.7	19.7
	DRY DENSITY, kg/cu.m	1656.9	1704.8	1690.6
	SATURATION, %	84.7	91.3	89.3
	VOID RATIO	0.630	0.584	0.597
	DIAMETER, cm	5.00	5.00	5.00
	HEIGHT, cm	2.40	2.40	2.40
AT TEST	WATER CONTENT, %	18.3	19.5	19.2
	DRY DENSITY, kg/cu.m	1671.8	1735.3	1709.1
	SATURATION, %	80.4	94.7	89.6
	VOID RATIO	0.615	0.556	0.580
	DIAMETER, cm	5.00	5.00	5.00
	HEIGHT, cm	2.38	2.36	2.37
	NORMAL STRESS, kPa	50	100	200
	FAILURE STRESS, kPa	41	87	163
	DISPLACEMENT, cm	0.41	0.41	0.60
	ULTIMATE STRESS, kPa	41	87	163
	DISPLACEMENT, cm	0.41	0.41	0.60
	Strain rate, cm/min	0.0016	0.0016	0.0016

SAMPLE TYPE: Bulk Sample
DESCRIPTION: Silt and fine SAND

SPECIFIC GRAVITY= 2.7
REMARKS:

Fig. No.: 5

CLIENT: AECOM

PROJECT: Carp Landfill Expansion

SAMPLE LOCATION: Test Pit N1, Sample 4
1.4 m depth

PROJ. NO.: 11-066 DATE: 27 June 2011

DIRECT SHEAR TEST REPORT

alston associates inc.

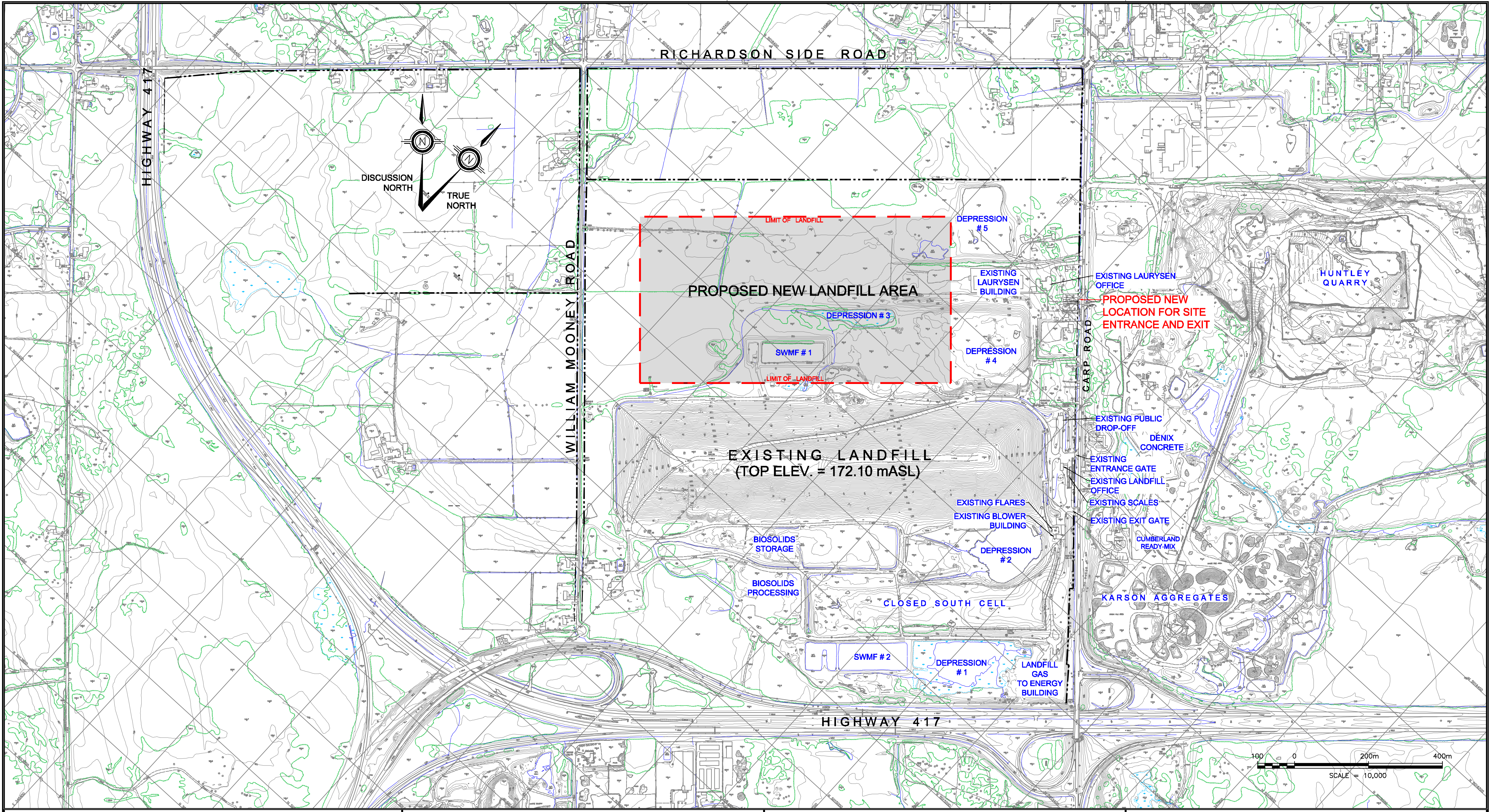
APPENDIX 'D'

B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 8/31/2012 9:54:33 AM

BY:----

FILE NAME: 60191228-FIG-02-EXISTING-CONDITIONS.DWG



LEGEND:

—··—··—	PROPERTY BOUNDARY
— — —	LIMIT OF PROPOSED NEW LANDFILL

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre
Preferred Concept

EXISTING CONDITIONS

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-02	.

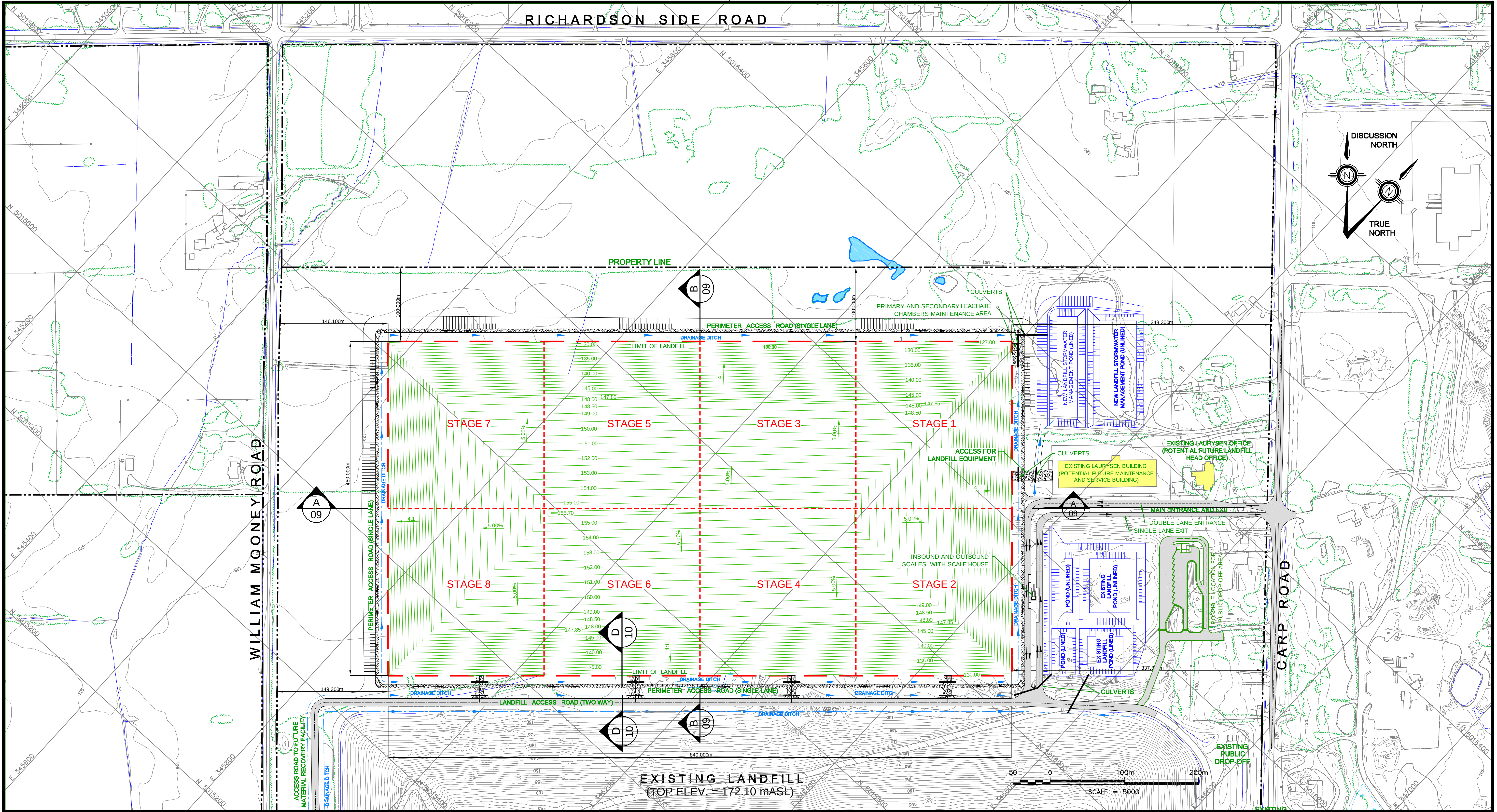
P:\60191228\000-CADD\040 CADD-BIM WIP\FCR_EA-FINAL-SUB-AUGUST-2012\60191228-FIG-02-Existing-Conditions.dwg Layout:Facility-layout Plotted: Aug 31, 2012 @ 9:54am by Lefebvrej

B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 8/31/2012 11:19:41 AM

BY:----

FILE NAME: 60191228-FIG-03-FACILITY-LAYOUT.DWG



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LEGEND:

—·—·—	PROPERTY BOUNDARY
— — —	LIMIT OF LANDFILL
- - - -	LIMIT OF LINER CONSTRUCTION (STAGES 1 TO 8)
5.00% →	DIRECTION OF SLOPE AND GRADE
145.00	TOP OF FINAL COVER CONTOUR AND ELEVATION
-·-→	SURFACE DRAINAGE DITCH AND FLOW DIRECTION
▒	PAVED ROAD
▨	GRAVEL ROAD

AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre
Preferred Concept

FACILITY LAYOUT

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-03	.

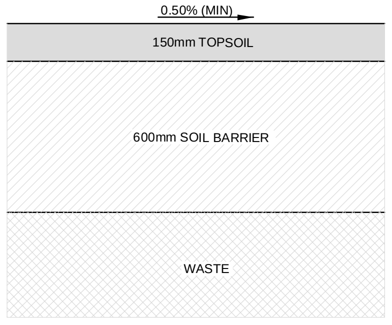
P:\60191228\000-CADD\040 CADD-BIM WIP\FCR_EA-FINAL-SUB-AUGUST-2012\60191228-FIG-03-Facility-Layout.dwg Layout:Facility-layout Plotted: Aug 31, 2012 @ 11:19am by Lefebvrej

B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 8/31/2012 9:39:43 AM

BY:----

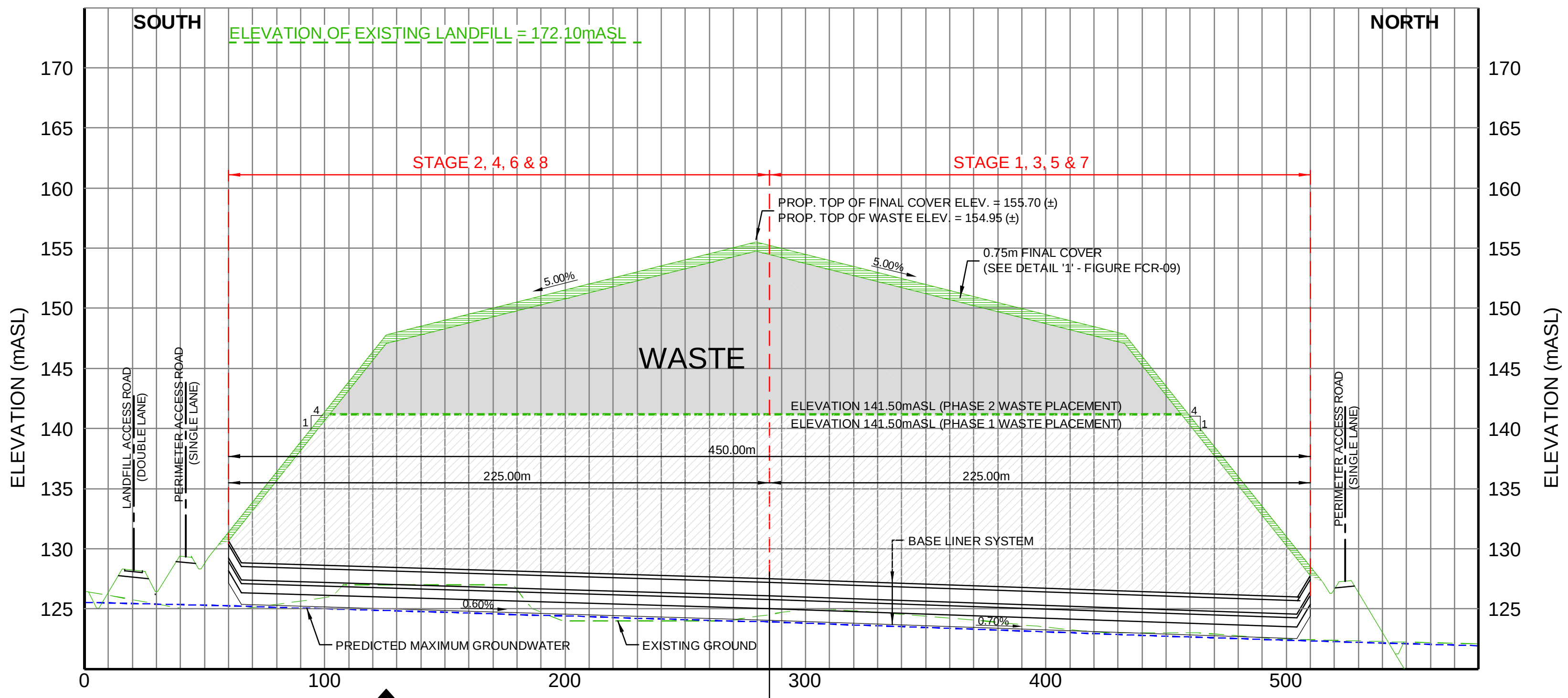
FILE NAME: 60191228-FIG-10-SECTIONS.DWG



DETAIL 1/9

TYPICAL CONFIGURATION THROUGH FINAL COVER SYSTEM

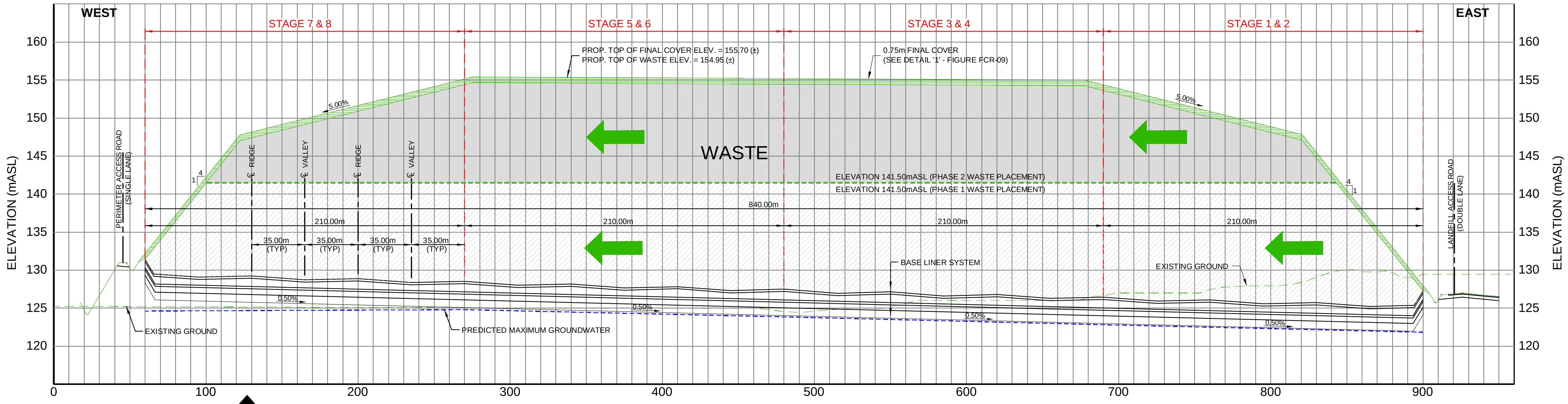
SCALE = 1:10



CROSS SECTION B/09

SCALE = 1:3000 (Horizontal)
SCALE = 1:600 (Vertical)

▒	PHASE 2 WASTE PLACEMENT ABOVE ELEVATION 141.50mASL
▨	PHASE 1 WASTE PLACEMENT BELOW ELEVATION 141.50mASL



CROSS SECTION A/09

SCALE = 1:3000 (Horizontal)
SCALE = 1:600 (Vertical)

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

LEGEND:

▒	PHASE 1 WASTE PLACEMENT
▨	PHASE 2 WASTE PLACEMENT
⬅	PROGRESSION OF WASTE PLACEMENT

AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre

Preferred Concept
CROSS SECTIONS 'A' AND 'B'
AND FINAL COVER DETAIL

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-10	.

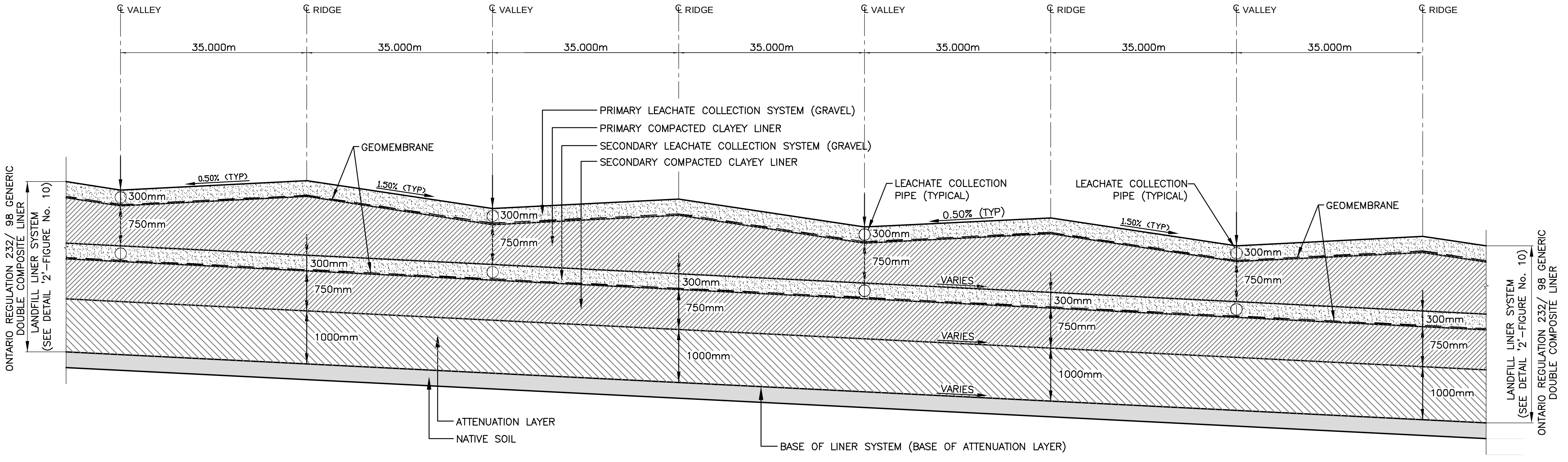
P:\60191228\000-CADD\040 CADD-BIM WIP\FCR_EA-FINAL-SUB-AUGUST-2012\60191228-FIG-10-Sections.dwg Layout:Facility-layout Plotted: Aug 31, 2012 @ 9:39am by Lefebvrej

B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 8/31/2012 9:18:01 AM

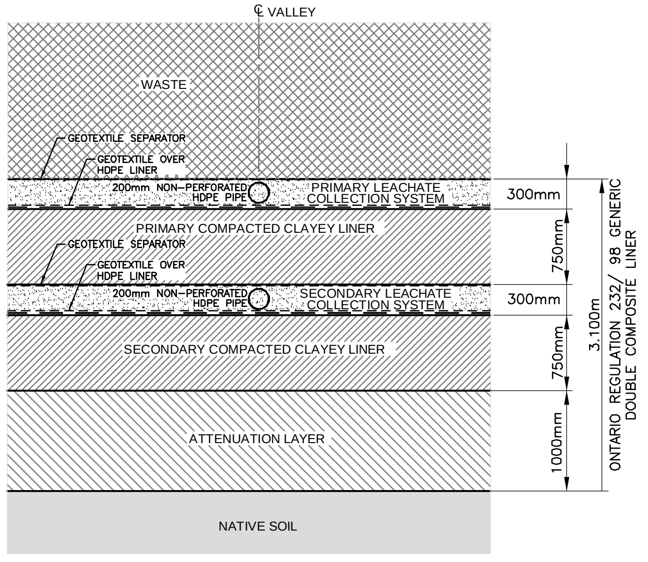
BY:----

FILE NAME: 60191228-FIG-11-SECTIONS.DWG



CROSS SECTION C/10

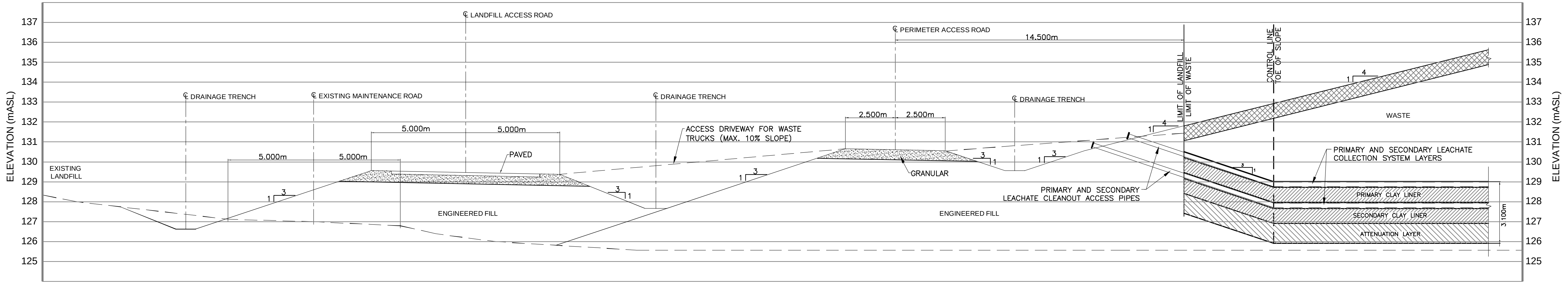
SCALE = 1:1000 (HORIZ)
= 1:100 (VERT)



DETAIL 2/10

TYPICAL CONFIGURATION THROUGH LINER SYSTEM

SCALE = 1:75



CROSS SECTION D/10

SCALE = 1:200

LEGEND:

DO NOT SCALE THIS DOCUMENT. ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

Waste Management of Canada Corporation
West Carleton Environmental Centre

Preferred Concept
CROSS SECTIONS 'C' AND 'D'
AND BASE LINER SYSTEM DETAIL

PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-11	.

P:\60191228\000-CADD\040 CADD-BIM WIP\FCR_EA-FINAL-SUB-AUGUST-2012\60191228-FIG-11-Sections.dwg Layout:Facility-layout Plotted: Aug 31, 2012 @ 9:18am by Lefebvrej

APPENDIX ‘E’

Slope stability analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Slope Stability Analysis - south to north, center of pile
Author : CA/KC
Date : 2013-08-29

Settings

Standard - safety factors

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors		
Permanent design situation		
Safety factor :	SF_s =	1.50 [–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	15.00	2.35	14.97	15.00	17.50
		25.00	17.50	30.00	16.50	40.00	18.50
		45.00	18.50	50.00	17.50	60.00	19.87
		130.00	36.50	280.00	44.50	430.00	36.50
		515.26	17.55	520.00	16.50	522.00	17.50
		524.00	17.50	540.00	12.50	542.39	11.74
		542.41	11.73	580.00	11.50		
2		60.00	19.87	65.00	18.50	505.00	15.50
		515.26	17.55				
3		2.35	14.97	40.00	14.50	103.00	15.50
		103.11	15.61	193.33	14.83	200.00	14.00
		256.96	14.28	374.19	13.27	400.00	12.50
		500.00	12.00				
4		0.00	13.32	60.00	13.32	280.00	7.95
		500.00	12.00	542.41	11.73		
5		0.00	11.62	60.00	11.62	280.00	6.15
		500.00	5.00	580.00	5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Compact Silty Sand	▨	36.00	0.00	22.00
2	Silty Sand Till	▨	38.00	0.00	22.50

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
3	Clay Liner	⚋	28.00	0.00	19.50
4	Waste	▦	26.00	0.00	7.80

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact Silty Sand	▨	22.00		
2	Silty Sand Till	▨	22.50		
3	Clay Liner	⚋	19.50		
4	Waste	▦	7.80		

Soil parameters

Compact Silty Sand

Unit weight : γ = 22.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till

Unit weight : γ = 22.50 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 38.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Clay Liner

Unit weight : γ = 19.50 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 28.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Waste

Unit weight : γ = 7.80 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 26.00 °

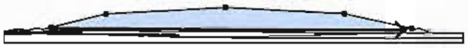
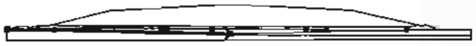
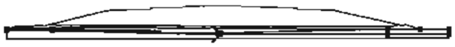
Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 7.80 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Bedrock	▦	24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	18.50	505.00	15.50	Waste ▩
		515.26	17.55	430.00	36.50	
		280.00	44.50	130.00	36.50	
		60.00	19.87			
2		542.41	11.73	542.39	11.74	Clay Liner ▤
		540.00	12.50	524.00	17.50	
		522.00	17.50	520.00	16.50	
		515.26	17.55	505.00	15.50	
		65.00	18.50	60.00	19.87	
		50.00	17.50	45.00	18.50	
		40.00	18.50	30.00	16.50	
		25.00	17.50	15.00	17.50	
		2.35	14.97	40.00	14.50	
		103.00	15.50	103.11	15.61	
		193.33	14.83	200.00	14.00	
		256.96	14.28	374.19	13.27	
		400.00	12.50	500.00	12.00	
3		60.00	13.32	280.00	7.95	Compact Silty Sand ▨
		500.00	12.00	400.00	12.50	
		374.19	13.27	256.96	14.28	
		200.00	14.00	193.33	14.83	
		103.11	15.61	103.00	15.50	
		40.00	14.50	2.35	14.97	
		0.00	15.00	0.00	13.32	
4		60.00	11.62	280.00	6.15	Silty Sand Till ▨
		500.00	5.00	580.00	5.00	
		580.00	11.50	542.41	11.73	
		500.00	12.00	280.00	7.95	
		60.00	13.32	0.00	13.32	
		0.00	11.62			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		500.00	5.00	280.00	6.15	Bedrock
		60.00	11.62	0.00	11.62	▦
		0.00	0.00	580.00	0.00	
		580.00	5.00			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	14.48	0.38	14.48	44.90	14.72
		50.10	17.29	60.15	19.75	65.91	20.01
		504.45	16.99	516.79	16.99	519.80	16.26
		542.25	11.29	579.35	10.80	580.00	10.79

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	64.09	[m]	Angles :	α_1 =	-9.12	[°]
	z =	152.89	[m]		α_2 =	31.45	[°]
Radius :	R =	136.11	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	133.31	36.84	132.71	36.53
2	132.80	36.54	130.07	36.41
3	132.53	36.90	50.65	17.45
4	51.04	17.46	49.94	17.54

Slope stability verification (Bishop)

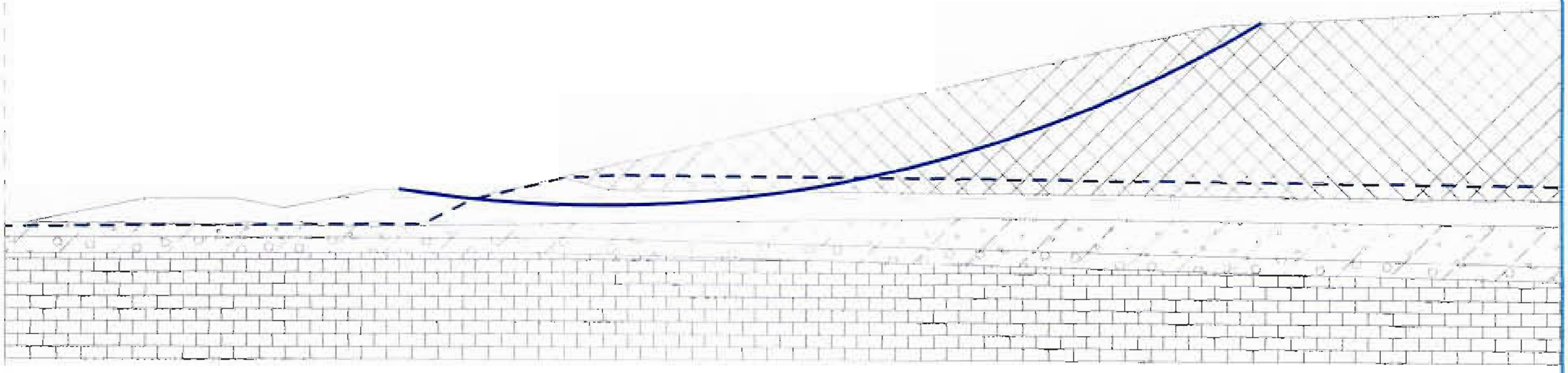
Sum of active forces : F_a = 785.35 kN/m
Sum of passive forces : F_p = 1626.18 kN/m

Sliding moment : M_a = 106893.90 kNm/m
Resisting moment : M_p = 221339.68 kNm/m
Factor of safety = 2.07 > 1.50

Slope stability ACCEPTABLE

Name : 13-107 Carp Landfill Development **Stage - analysis : 1 - 1**

Description : Slope Stability Analysis - south to north, center of pile



APPENDIX ‘F’

Settlement analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Settlement Analysis - south to north, center of pile
Author : CA/KC
Date : 2013-08-29

Settings

Standard - safety factors

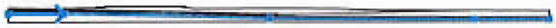
Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	125.50	40.00	125.00	103.00	126.00
		104.00	127.00	180.00	127.00	200.00	124.50
		300.00	125.00	350.00	124.50	400.00	123.00
		500.00	122.50	580.00	122.00		
2		0.00	123.82	60.00	123.82	280.00	118.45
		500.00	122.50				
3		0.00	122.12	60.00	122.12	280.00	116.65
		500.00	115.50	580.00	115.50		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	119.12	60.00	119.12	280.00	113.65
		500.00	112.50	580.00	112.50		

Soil parameters

Compact Silty Sand

Unit weight : γ = 22.00 kN/m^3
Oedometric modulus : E_{oed} = 110.00 MPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till

Unit weight : γ = 22.50 kN/m^3
Oedometric modulus : E_{oed} = 350.00 MPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Bedrock

Unit weight : γ = 24.00 kN/m^3
Oedometric modulus : E_{oed} = 500.00 MPa
Saturated unit weight : γ_{sat} = 24.00 kN/m^3

Clay Liner

Unit weight : γ = 19.50 kN/m³
Oedometric modulus : E_{oed} = 25.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m³

Waste
Unit weight : γ = 7.80 kN/m³
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 7.80 kN/m³

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		60.00	123.82	280.00	118.45	Compact Silty Sand ▨
		500.00	122.50	400.00	123.00	
		350.00	124.50	300.00	125.00	
		200.00	124.50	180.00	127.00	
		104.00	127.00	103.00	126.00	
		40.00	125.00	0.00	125.50	
		0.00	123.82			
2		60.00	122.12	280.00	116.65	Silty Sand Till ▨
		500.00	115.50	580.00	115.50	
		580.00	122.00	500.00	122.50	
		280.00	118.45	60.00	123.82	
		0.00	123.82	0.00	122.12	
3		500.00	115.50	280.00	116.65	Bedrock ▦
		60.00	122.12	0.00	122.12	
		0.00	110.50	580.00	110.50	
		580.00	115.50			

Water

Water type : No water

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

Results (Stage of construction 1)

Results

Analysis of geostatic stress was successfully completed

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		0.00	127.00	580.00	122.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		400.00	123.00	374.19	123.77	Compact Silty Sand ▨
		256.96	124.78	200.00	124.50	
		193.33	125.33	103.11	126.11	
		103.00	126.00	40.00	125.00	
		0.00	125.50	0.00	123.82	
		60.00	123.82	280.00	118.45	
		500.00	122.50			
2		60.00	122.12	280.00	116.65	Silty Sand Till ▨
		500.00	115.50	580.00	115.50	
		580.00	122.00	500.00	122.50	
		280.00	118.45	60.00	123.82	
		0.00	123.82	0.00	122.12	
3		500.00	115.50	280.00	116.65	Bedrock ▦
		60.00	122.12	0.00	122.12	
		0.00	110.50	580.00	110.50	
		580.00	115.50			

Water

Water type : No water

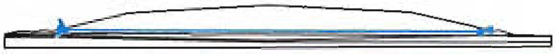
Results (Stage of construction 2)

Results

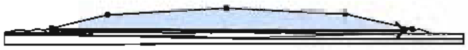
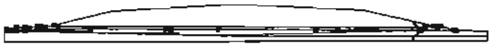
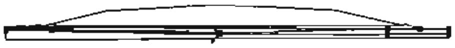
Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 0.0 mm
Maximum depth of influence zone = 0.00 m

Input data (Stage of construction 3)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		2.35	125.47	15.00	128.00	25.00	128.00
		30.00	127.00	40.00	129.00	45.00	129.00
		50.00	128.00	60.00	130.37	130.00	147.00
		280.00	155.00	430.00	147.00	515.26	128.05
		520.00	127.00	522.00	128.00	524.00	128.00
		540.00	123.00	542.39	122.24	542.41	122.23
2		60.00	130.37	65.00	129.00	505.00	126.00
		515.26	128.05				

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	129.00	505.00	126.00	Waste
		515.26	128.05	430.00	147.00	
		280.00	155.00	130.00	147.00	
		60.00	130.37			
2		400.00	123.00	500.00	122.50	Clay Liner
		542.41	122.23	542.39	122.24	
		540.00	123.00	524.00	128.00	
		522.00	128.00	520.00	127.00	
		515.26	128.05	505.00	126.00	
		65.00	129.00	60.00	130.37	
		50.00	128.00	45.00	129.00	
		40.00	129.00	30.00	127.00	
		25.00	128.00	15.00	128.00	
		2.35	125.47	40.00	125.00	
		103.00	126.00	103.11	126.11	
		193.33	125.33	200.00	124.50	
		256.96	124.78	374.19	123.77	
3		400.00	123.00	374.19	123.77	Compact Silty Sand
		256.96	124.78	200.00	124.50	
		193.33	125.33	103.11	126.11	
		103.00	126.00	40.00	125.00	
		2.35	125.47	0.00	125.50	
		0.00	123.82	60.00	123.82	
		280.00	118.45	500.00	122.50	
4		60.00	122.12	280.00	116.65	Silty Sand Till
		500.00	115.50	580.00	115.50	
		580.00	122.00	542.41	122.23	
		500.00	122.50	280.00	118.45	
		60.00	123.82	0.00	123.82	
		0.00	122.12			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		500.00	115.50	280.00	116.65	Bedrock ▦
		60.00	122.12	0.00	122.12	
		0.00	110.50	580.00	110.50	
		580.00	115.50			

Water

Water type : No water

Results (Stage of construction 3)

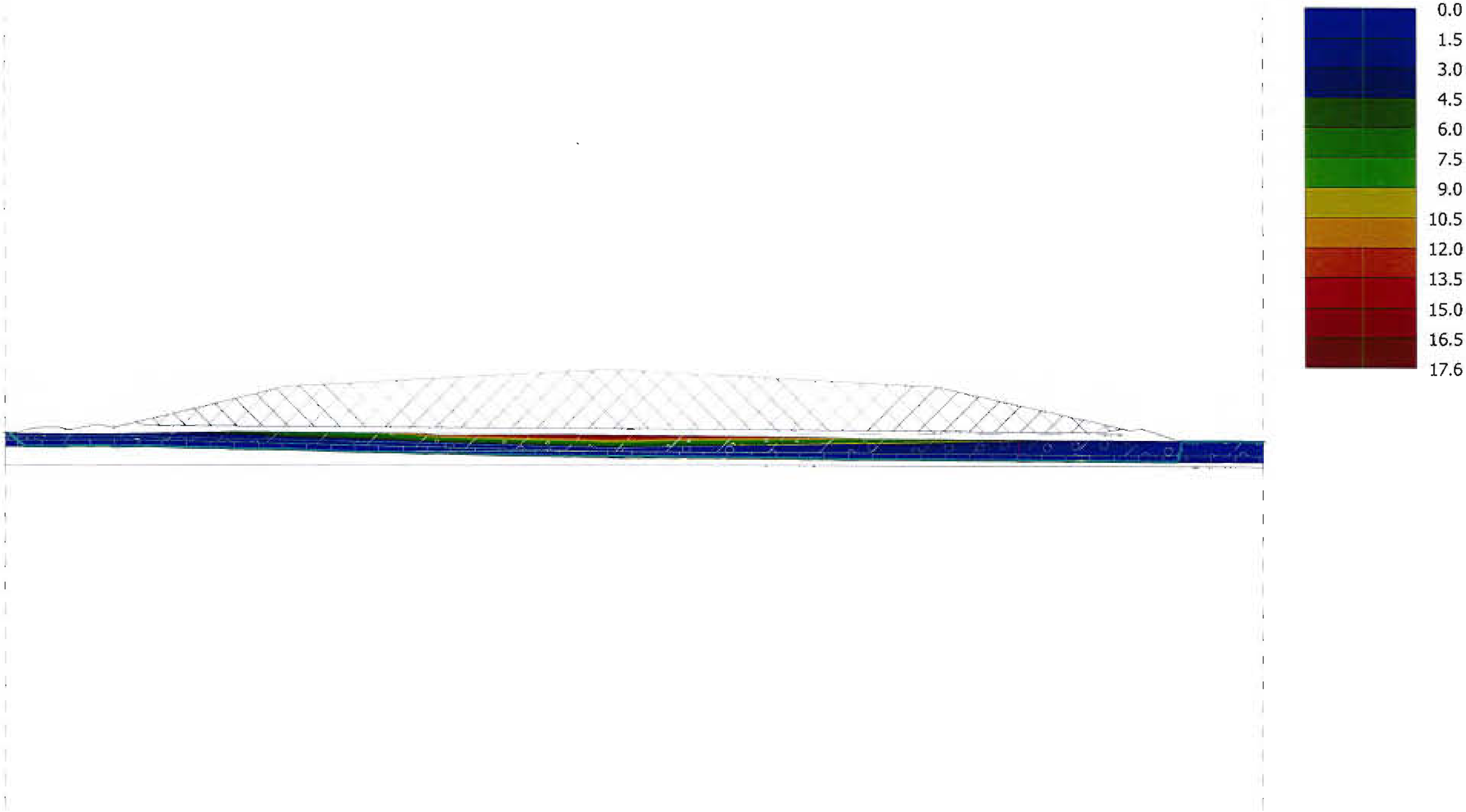
Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 17.6 mm
Maximum depth of influence zone = 10.00 m

Name : 13-107 Carp Landfill Development **Stage : 3**

Description : Settlement Analysis - south to north, center of pile

Results : overall; variable : Settlement; range : <0.0; 17.6> mm



Settlement analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Settlement Analysis - west to east, center of pile
Author : CA/KC
Date : 2013-08-29

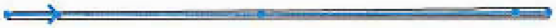
Settings

Standard - safety factors

Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	125.00	260.00	125.00	460.00	126.00
		480.00	125.50	510.00	126.00	700.00	127.00
		750.00	128.00	820.00	128.00	840.00	130.00
		900.00	130.00	960.00	130.00		
2		0.00	120.27	90.00	120.44	450.00	118.45
		900.80	121.93	960.00	121.93		
3		0.00	119.24	90.00	119.24	450.00	116.65
		900.00	117.42	960.00	117.42		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	116.24	90.00	116.24	450.00	113.65
		900.00	114.42	960.00	114.42		

Soil parameters

Compact Silty Sand
Unit weight : γ = 22.00 kN/m^3
Oedometric modulus : E_{oed} = 110.00 MPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till
Unit weight : γ = 22.50 kN/m^3
Oedometric modulus : E_{oed} = 350.00 MPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Bedrock
Unit weight : γ = 24.00 kN/m^3
Oedometric modulus : E_{oed} = 500.00 MPa
Saturated unit weight : γ_{sat} = 24.00 kN/m^3

Clay Liner

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 25.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Waste
Unit weight : γ = 7.80 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 7.80 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		90.00	120.44	450.00	118.45	Compact Silty Sand ▨
		900.80	121.93	960.00	121.93	
		960.00	130.00	900.00	130.00	
		840.00	130.00	820.00	128.00	
		750.00	128.00	700.00	127.00	
		510.00	126.00	480.00	125.50	
		460.00	126.00	260.00	125.00	
		0.00	125.00	0.00	120.27	
2		90.00	119.24	450.00	116.65	Silty Sand Till ▨
		900.00	117.42	960.00	117.42	
		960.00	121.93	900.80	121.93	
		450.00	118.45	90.00	120.44	
		0.00	120.27	0.00	119.24	
3		900.00	117.42	450.00	116.65	Bedrock ▦
		90.00	119.24	0.00	119.24	
		0.00	111.65	960.00	111.65	
		960.00	117.42			

Water

Water type : No water

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

Results (Stage of construction 1)

Results

Analysis of geostatic stress was successfully completed

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		0.00	126.00	960.00	122.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		90.00	120.44	450.00	118.45	Compact Silty Sand ▨
		900.80	121.93	960.00	121.93	
		960.00	122.00	240.00	125.00	
		0.00	125.00	0.00	120.27	
2		90.00	119.24	450.00	116.65	Silty Sand Till ▨
		900.00	117.42	960.00	117.42	
		960.00	121.93	900.80	121.93	
		450.00	118.45	90.00	120.44	
		0.00	120.27	0.00	119.24	
3		900.00	117.42	450.00	116.65	Bedrock ▦
		90.00	119.24	0.00	119.24	
		0.00	111.65	960.00	111.65	
		960.00	117.42			

Water

Water type : No water

Results (Stage of construction 2)

Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 0.0 mm
Maximum depth of influence zone = 0.00 m

Input data (Stage of construction 3)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		25.00	125.00	60.00	132.00	120.00	147.00
		270.00	155.00	700.00	155.00	820.00	147.00
		902.11	127.84	910.00	126.00	960.00	126.00

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
2		60.00	132.00	65.04	129.03	895.00	125.00
		900.00	127.00	902.11	127.84		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.04	129.03	895.00	125.00	Waste
		900.00	127.00	902.11	127.84	
		820.00	147.00	700.00	155.00	▨
		270.00	155.00	120.00	147.00	
		60.00	132.00			
2		960.00	122.00	960.00	126.00	Clay Liner
		910.00	126.00	902.11	127.84	
		900.00	127.00	895.00	125.00	▨
		65.04	129.03	60.00	132.00	
		25.00	125.00	240.00	125.00	
3		90.00	120.44	450.00	118.45	Compact Silty Sand
		900.80	121.93	960.00	121.93	
		960.00	122.00	240.00	125.00	▨
		25.00	125.00	0.00	125.00	
		0.00	120.27			
4		90.00	119.24	450.00	116.65	Silty Sand Till
		900.00	117.42	960.00	117.42	
		960.00	121.93	900.80	121.93	▨
		450.00	118.45	90.00	120.44	
		0.00	120.27	0.00	119.24	
5		900.00	117.42	450.00	116.65	Bedrock
		90.00	119.24	0.00	119.24	
		0.00	111.65	960.00	111.65	▨
		960.00	117.42			

Water

Water type : No water

Results (Stage of construction 3)

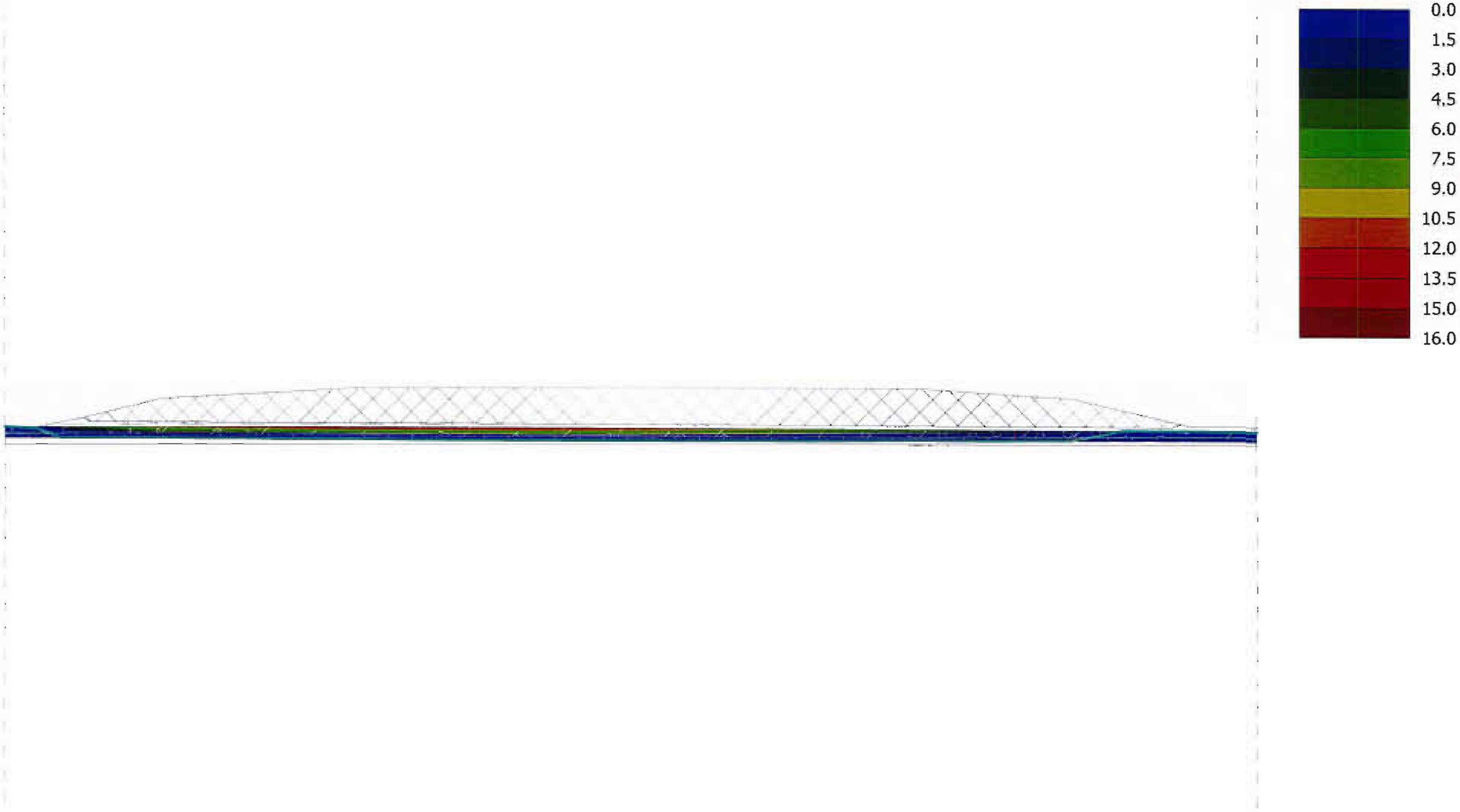
Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 16.0 mm
Maximum depth of influence zone = 10.00 m

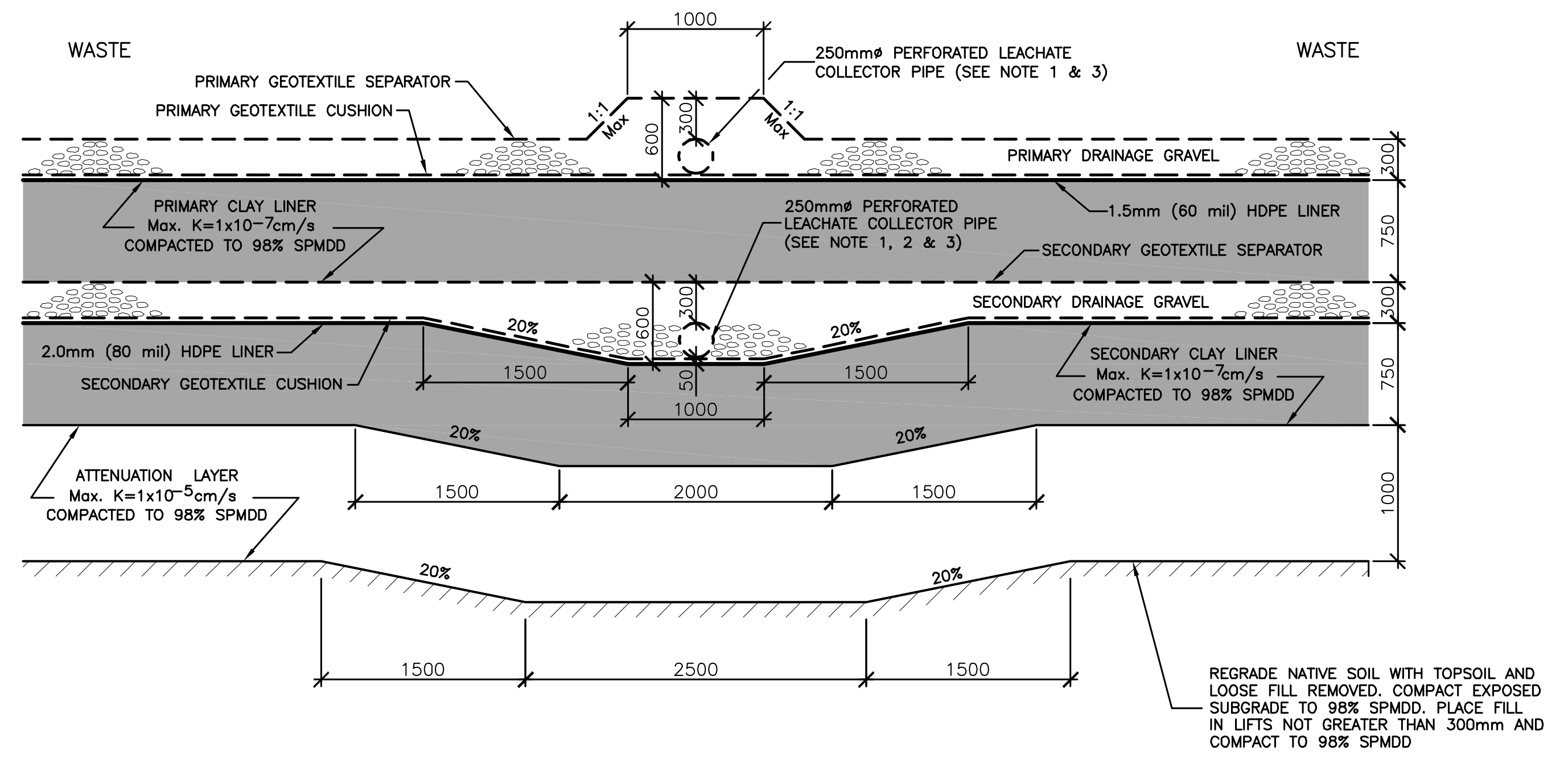
Name : 13-107 Carp Landfill Development **Stage : 3**

Description : Settlement Analysis - west to east, center of pile

Results : overall; variable : Settlement; range : <0.0; 16.0> mm



APPENDIX ‘G’

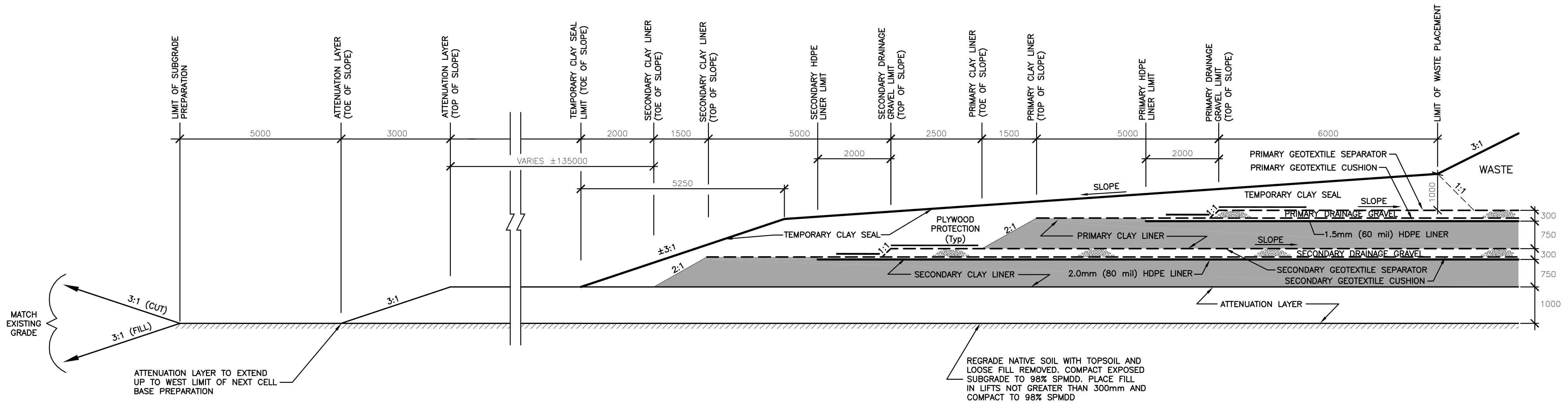


NOTES :

1. PERFORATED LEACHATE COLLECTION PIPE TO BE 250mmø HDPE DR11 WITH 25mmø PERFORATIONS AT 45, 135, 225 AND 315°, SPACED EVERY 300mm.
2. SECONDARY LEACHATE COLLECTOR TO BE INSTALLED UNDER EVERY SECOND PRIMARY LEACHATE COLLECTOR RUN
3. INSTALL 5mmø (3/16") CONTINUOUS (NO SPLICE) STAINLESS STEEL PULL CABLE (POLY COATED) INSIDE LEACHATE COLLECTOR PIPING RUNNING IN NORTH–SOUTH DIRECTION.
4. BOTTOM OF ATTENUATION LAYER TO BE AT OR ABOVE PREDICTED MAXIMUM SHALLOW GROUNDWATER LEVEL.

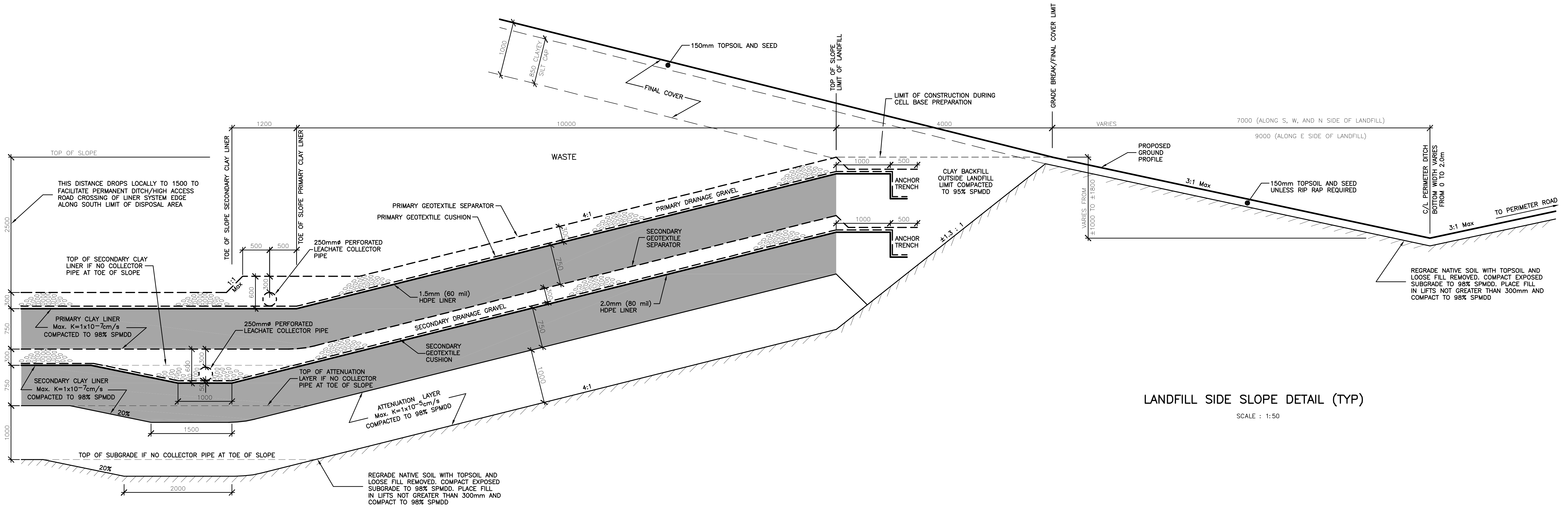
LANDFILL BASE DETAIL

SCALE : 1:50



TEMPORARY CLAY SEAL/CELL EXTENSION DETAIL (TYPICAL)

SCALE : 1:100



LANDFILL SIDE SLOPE DETAIL (TYP)

SCALE : 1:50

GENIVAR
1450 1st Ave. W, Suite 101, Owen Sound, ON, N4K 6W2
Telephone: (519) 376-7612 / Fax: (519) 376-8008
Toll Free: 1-888-376-7612

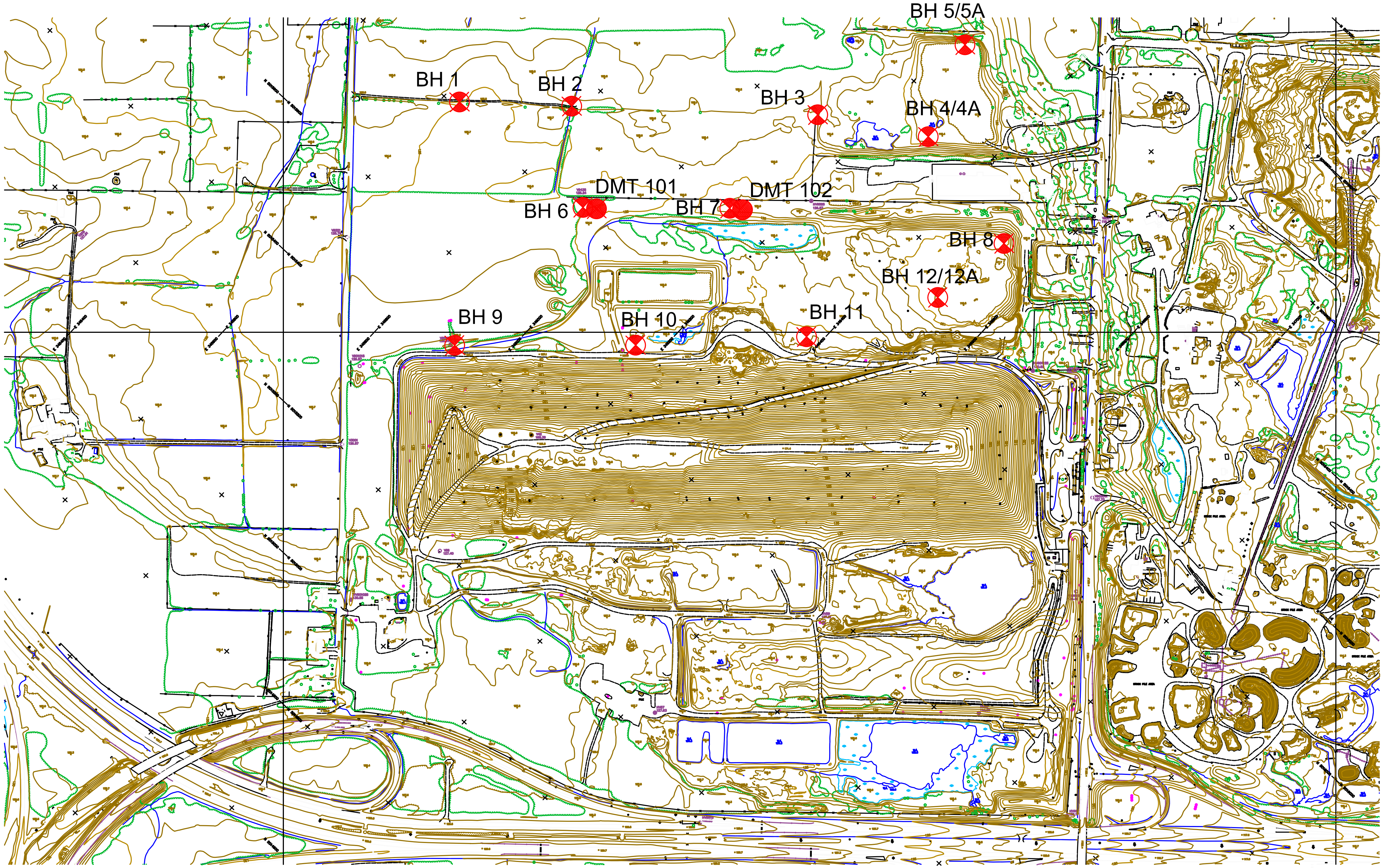
WASTE MANAGEMENT

LANDFILL BASE SECTIONS
WEST CARLETON ENVIRONMENTAL CENTRE

DWN BY: T C G DATE: NOVEMBER 28, 2013
CHK BY: P S B SCALE: SEE BAR SCALE
WASTE MANAGEMENT OF CANADA CORPORATION
DRAWING NO. 131-19416-00 - SK5

SHEET
SK5

ENCLOSURES



Borehole Location Plan
Landfill Expansion
Carp, ON

Drawing No. 1
Ref. No. 13-107
August 2013
Scale: 1:7500

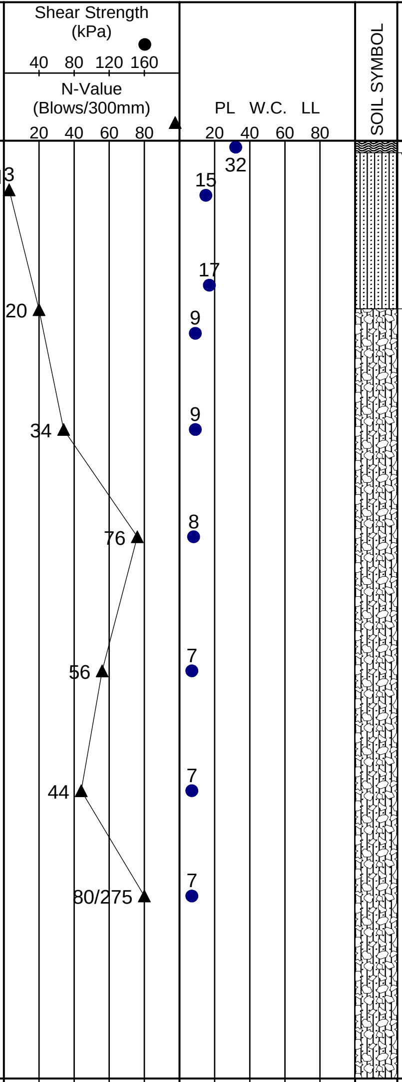
CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON
METHOD: Augering and Split Spoon Sampling
PROJECT ENGINEER: VN
ELEV. (m) 124.94
NORTHING: 5015811.47
EASTING: 345627.665

BH No.: 1

PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS
0		Borehole dry and cave-in at 4.0 m below ground surface on completion.
4.5		Hard augering at 4.9 m depth. Cobble/boulder encountered between 4.9 and 5.2 m depth.



SOIL DESCRIPTION

70 mm black sandy TOPSOIL

very loose
moist, brown
SILTY fine SAND
(disturbed)

dense to
very dense
moist, grey
SILTY SAND
traces of gravel
and clay
occasional cobbles
and boulders
(TILL)

END OF BOREHOLE
Refusal to advancement of augers at 5.94 m below ground surface.

SAMPLE NO.	SPT(N)
1A	
1B	3
2A	20
2B	
3	34
4	76
5	56
6	44
7	80/ 275

DEPTH (m): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5

ELEVATION (m): 124.5, 124, 123.5, 123, 122.5, 122, 121.5, 121, 120.5, 120, 119.5, 119

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REVIEWED BY: VN
DRILLING DATE: 8 August 2013

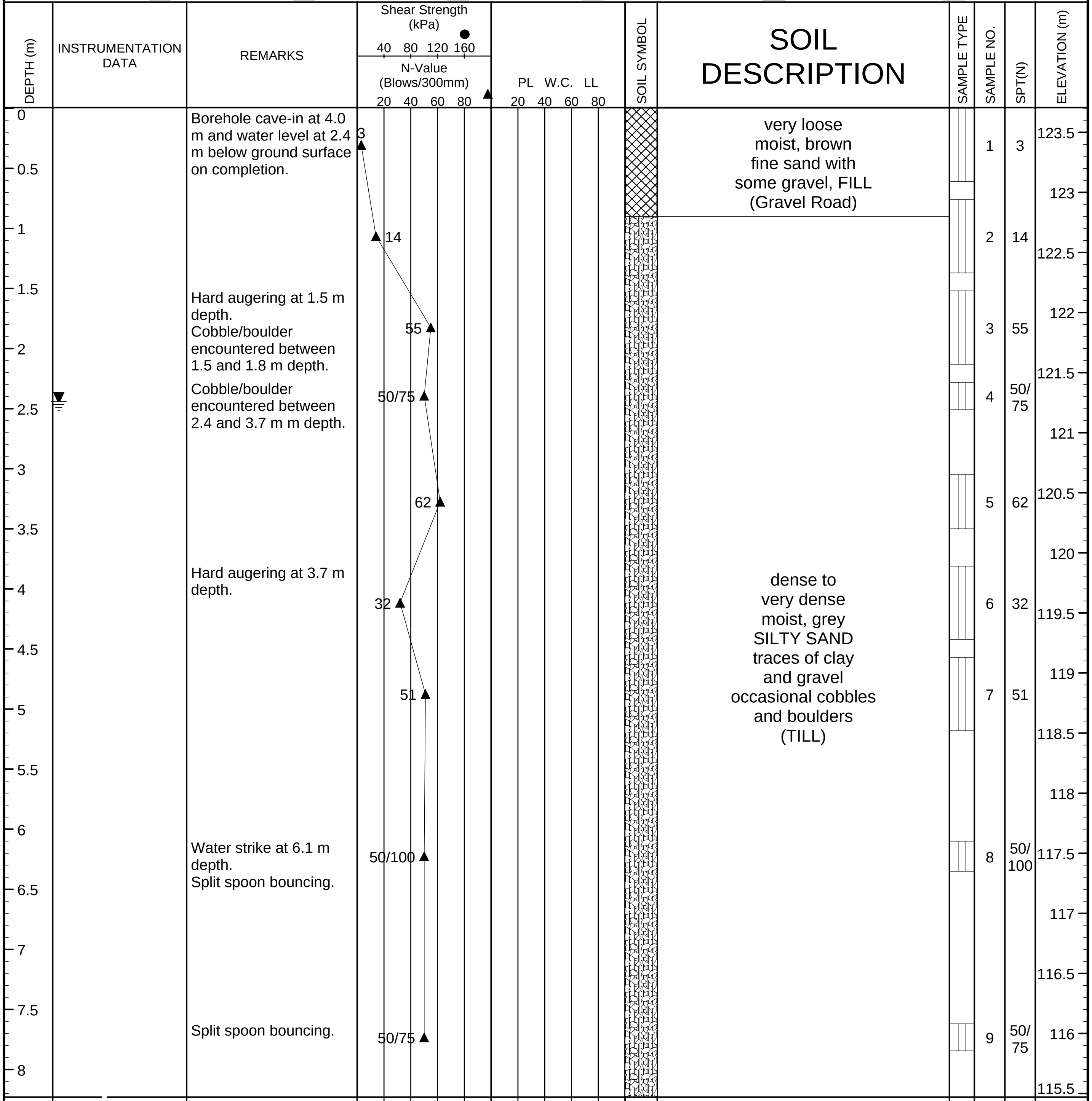
CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON

METHOD: Augering and Split Spoon Sampling
PROJECT ENGINEER: VN
ELEV. (m) 123.70
NORTHING: 5015944.509
EASTING: 345780.621

BH No.: 2

PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



REMARKS

Borehole cave-in at 4.0 m and water level at 2.4 m below ground surface on completion.

Hard augering at 1.5 m depth.
Cobble/boulder encountered between 1.5 and 1.8 m depth.

Cobble/boulder encountered between 2.4 and 3.7 m m depth.

Hard augering at 3.7 m depth.

Water strike at 6.1 m depth.
Split spoon bouncing.

Split spoon bouncing.

SOIL DESCRIPTION

very loose
moist, brown
fine sand with
some gravel, FILL
(Gravel Road)

dense to
very dense
moist, grey
SILTY SAND
traces of clay
and gravel
occasional cobbles
and boulders
(TILL)

END OF BOREHOLE
Refusal to advancement of augers at 8.23 m below ground surface.

SAMPLE NO.	SPT(N)
1	3
2	14
3	55
4	50/ 75
5	62
6	32
7	51
8	50/ 100
9	50/ 75

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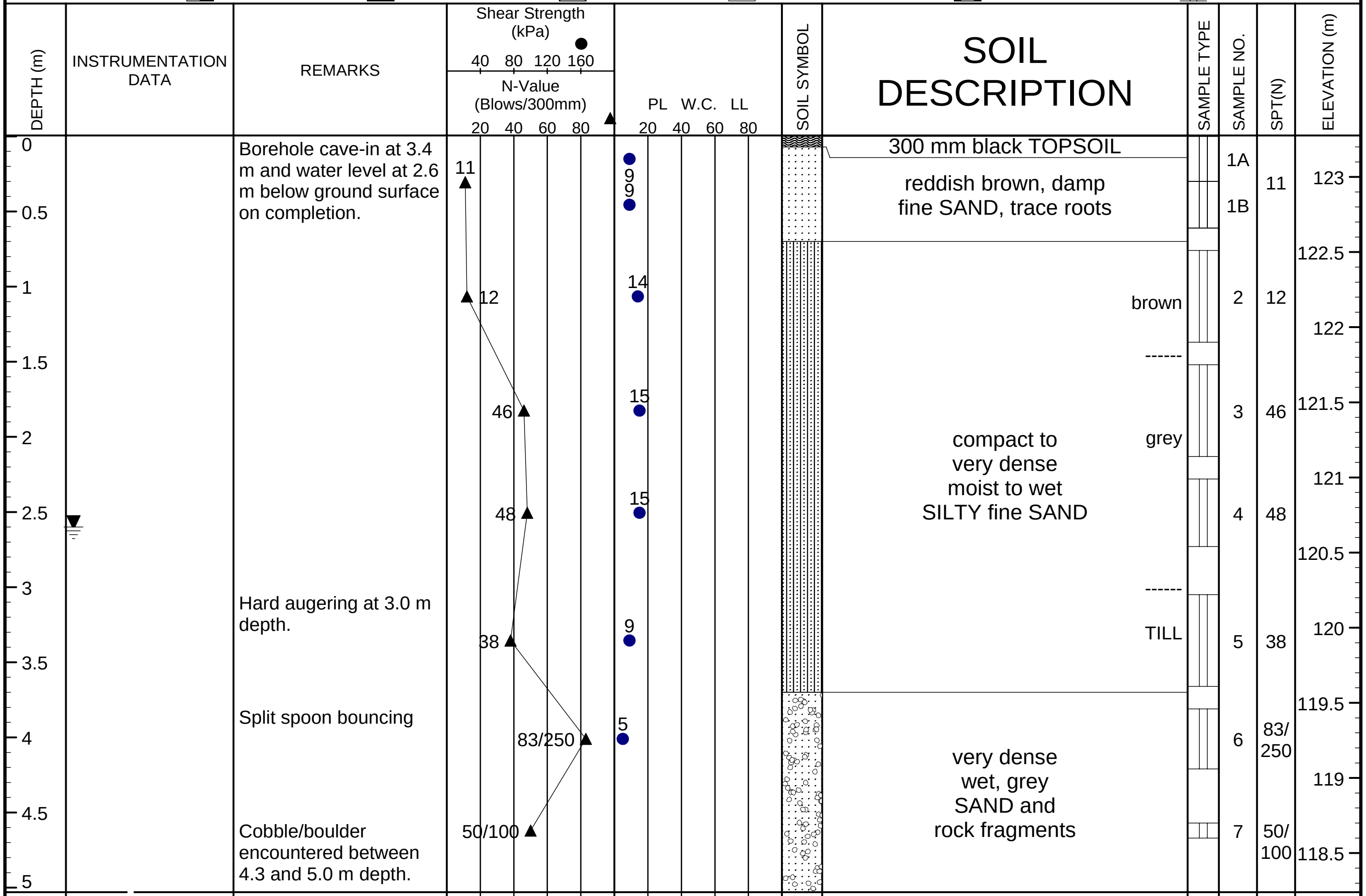
REVIEWED BY: VN
DRILLING DATE: 8 August 2013
Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling	**BH No.: 3**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN | ELEV. (m) 123.27	
LOCATION: Carp, ON	NORTHING: 5016236.919 | EASTING: 346115.227	PROJECT NO.: 13-107

SAMPLE TYPE ▮ AUGER ◢ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



REMARKS	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)
Borehole cave-in at 3.4 m and water level at 2.6 m below ground surface on completion.	300 mm black TOPSOIL	1A	11
	reddish brown, damp fine SAND, trace roots	1B	
	compact to very dense moist to wet SILTY fine SAND brown ------ grey	2	12
		3	46
		4	48
Hard augering at 3.0 m depth.	------ TILL	5	38
Split spoon bouncing	very dense wet, grey SAND and rock fragments	6	83/250
Cobble/boulder encountered between 4.3 and 5.0 m depth.		7	50/100

END OF BOREHOLE
Refusal to advancement of augers at 5.03 m below ground surface.

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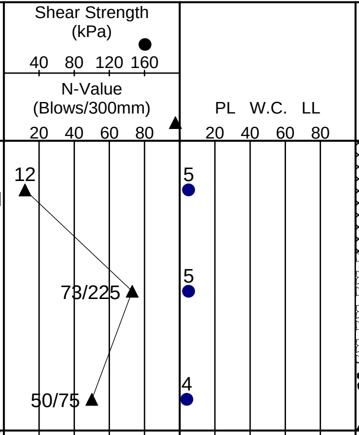
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling	**BH No.: 4**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN / ELEV. (m) 118.60	
LOCATION: Carp, ON	NORTHING: 5016344.465 / EASTING: 346287.868	PROJECT NO.: 13-107

SAMPLE TYPE: ▮ AUGER ◩ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Grass Surface. Borehole dry and cave-in at 1.2 m below ground surface on completion.	compact, brown to grey sand and gravel, FILL	⌶	1	12	118.5 118
1			very dense, very moist, grey SILTY SAND, traces of gravel and clay (TILL)	⌶	2	73/ 225	117.5
1.5		Cobble/boulder encountered between 1.2 and 1.8 m depth.	COBBLES and BOULDERS	⌶	3	50/ 75	117
			END OF BOREHOLE Refusal to advancement of augers at 1.83 m below ground surface.				

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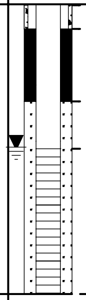
LOGGED BY: KC	DRILLING DATE: 8 August 2013
REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering		**BH No.: 4A**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 118.60	
LOCATION: Carp, ON	NORTHING: 5016344.465	EASTING: 346287.868	PROJECT NO.: 13-107

SAMPLE TYPE ◨ AUGER ◩ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Water level measured 0.3 m below ground surface on 9 August 2013.				Straight auger to 1.8 m depth				118.5
0.5										118
1										117.5
1.5		Cobbles/boulders encountered between 1.2 and 1.8 m depth.								117
						END OF BOREHOLE Refusal to advancement of augers at 1.83 m depth below ground surface.				

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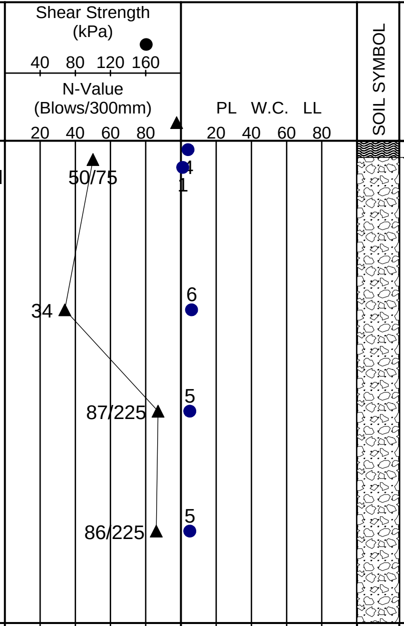
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		**BH No.: 5**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 117.58	
LOCATION: Carp, ON	NORTHING: 5016511.253	EASTING: 346222.746	PROJECT NO.: 13-107

SAMPLE TYPE ▯ AUGER ◩ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and cave-in at 1.5 m below ground surface on completion. Cobbles/boulders encountered between 0.3 and 3.0 m depth.	100 mm TOPSOIL		1A 1B	50/ 75	117.5
0.5							117
1			dense to very dense moist to wet brown medium to coarse SAND and GRAVEL occasional cobbles and boulders		2	34	116.5
1.5		Water strike at 1.5 m depth.			3	87/ 225	116
2							115.5
2.5					4	86/ 225	115
3			**END OF BOREHOLE** Refusal to advancement of augers at 3.05 m below ground surface.				

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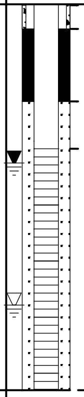
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering		**BH No.: 5A**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 117.58	
LOCATION: Carp, ON	NORTHING: 5016510.951	EASTING: 346222.746	PROJECT NO.: 13-107

SAMPLE TYPE ◨ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5 1 1.5 2		Water level measured 1.9 m below ground surface on completion, 1.0 m below ground surface on 9 August 2013. Cobbles/boulders encountered between 0.0 and 2.4 m depth.				Straight auger to 1.8 m depth				117.5 117 116.5 116 115.5
						END OF BOREHOLE Refusal to advancement of augers at 2.44 m depth belowground surface.				

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LOGGED BY: KC	DRILLING DATE: 8 August 2013
REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		**BH No.: 6**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 125.45	
LOCATION: Carp, ON	NORTHING: 5015824.984	EASTING: 345920.566	PROJECT NO.: 13-107

SAMPLE TYPE ▮ AUGER ◩ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m) | INSTRUMENTATION DATA | REMARKS | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NO. | SPT(N) | ELEVATION (m)

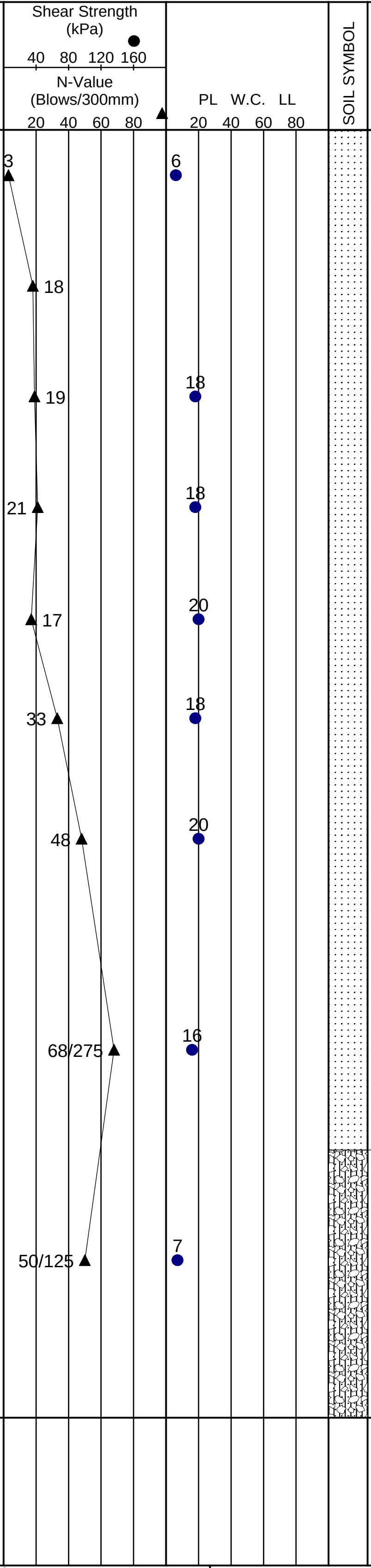
DEPTH (m): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5

REMARKS

Grass Surface
Borehole cave-in at 3.0 m below ground surface on completion.

Water strike at 2.3 m depth.

Hard augering at 7.0 m depth.



SOIL DESCRIPTION

root invasion
------

reddish brown
to brown

compact
moist to wet
SAND
trace to
some silt
trace clay

------

grey

very dense
moist to wet, grey
SILTY SAND
traces of
clay and gravel
occasional boulders
and cobbles
(TILL)

END OF BOREHOLE
Refusal to advancement of augers at 8.84 m below ground surface.

SAMPLE NO.	SPT(N)
1	3
2	18
3	19
4	21
5	17
6	33
7	48
8	68/ 275
9	50/ 125

ELEVATION (m): 125, 124.5, 124, 123.5, 123, 122.5, 122, 121.5, 121, 120.5, 120, 119.5, 119, 118.5, 118, 117.5, 117

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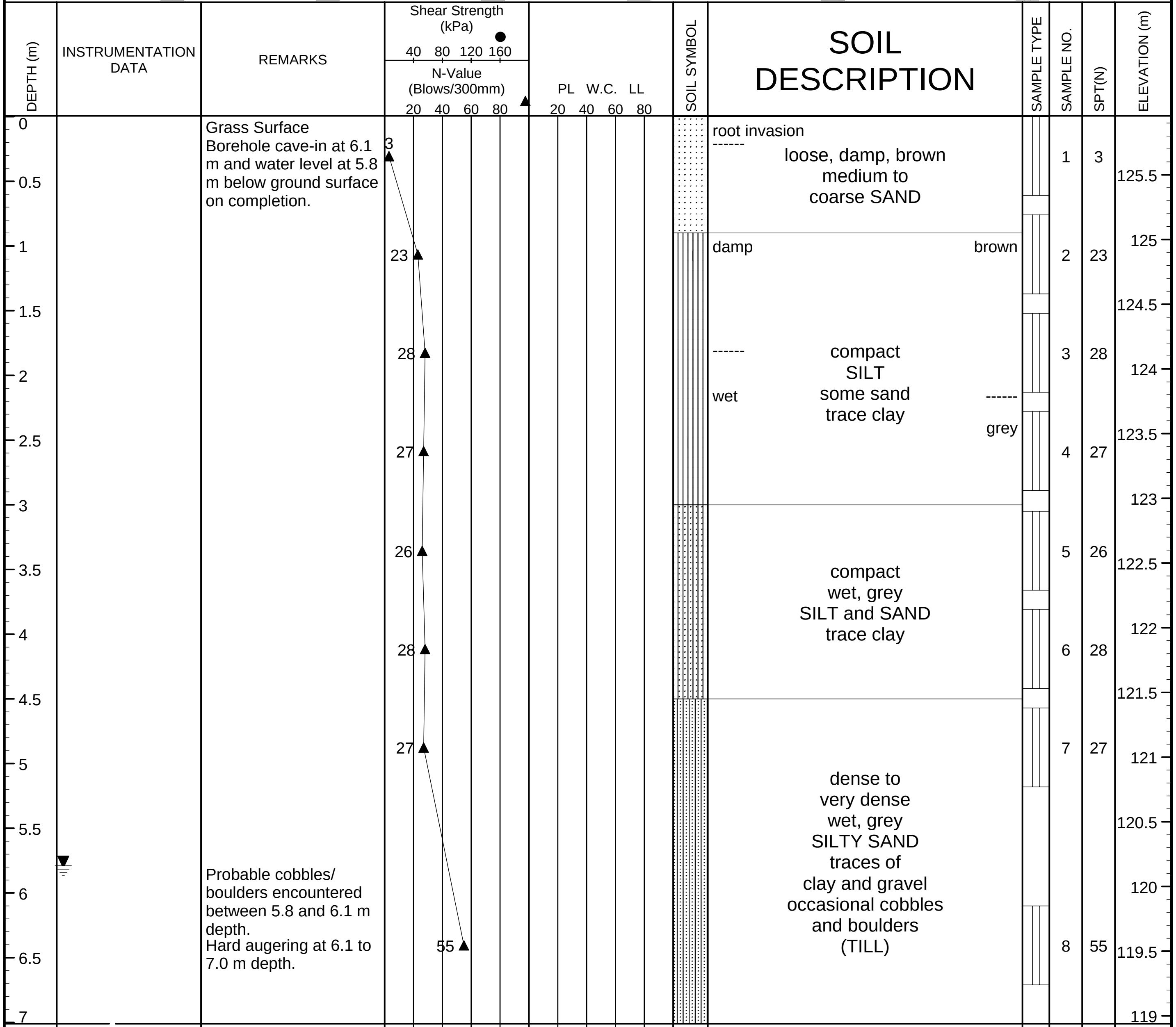
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		**BH No.: 7**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 125.95	
LOCATION: Carp, ON	NORTHING: 5016005.079	EASTING: 346114.995	PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



REMARKS:

Grass Surface
Borehole cave-in at 6.1 m and water level at 5.8 m below ground surface on completion.

Probable cobbles/ boulders encountered between 5.8 and 6.1 m depth.
Hard augering at 6.1 to 7.0 m depth.

SOIL DESCRIPTION

root invasion
------
loose, damp, brown medium to coarse SAND

damp brown
compact SILT some sand trace clay
------
wet
------
grey

compact wet, grey SILT and SAND trace clay

dense to very dense wet, grey SILTY SAND traces of clay and gravel occasional cobbles and boulders (TILL)

SAMPLE NO.	SPT(N)
1	3
2	23
3	28
4	27
5	26
6	28
7	27
8	55

END OF BOREHOLE
Refusal to advancement of augers at 7.0 m below ground surface.

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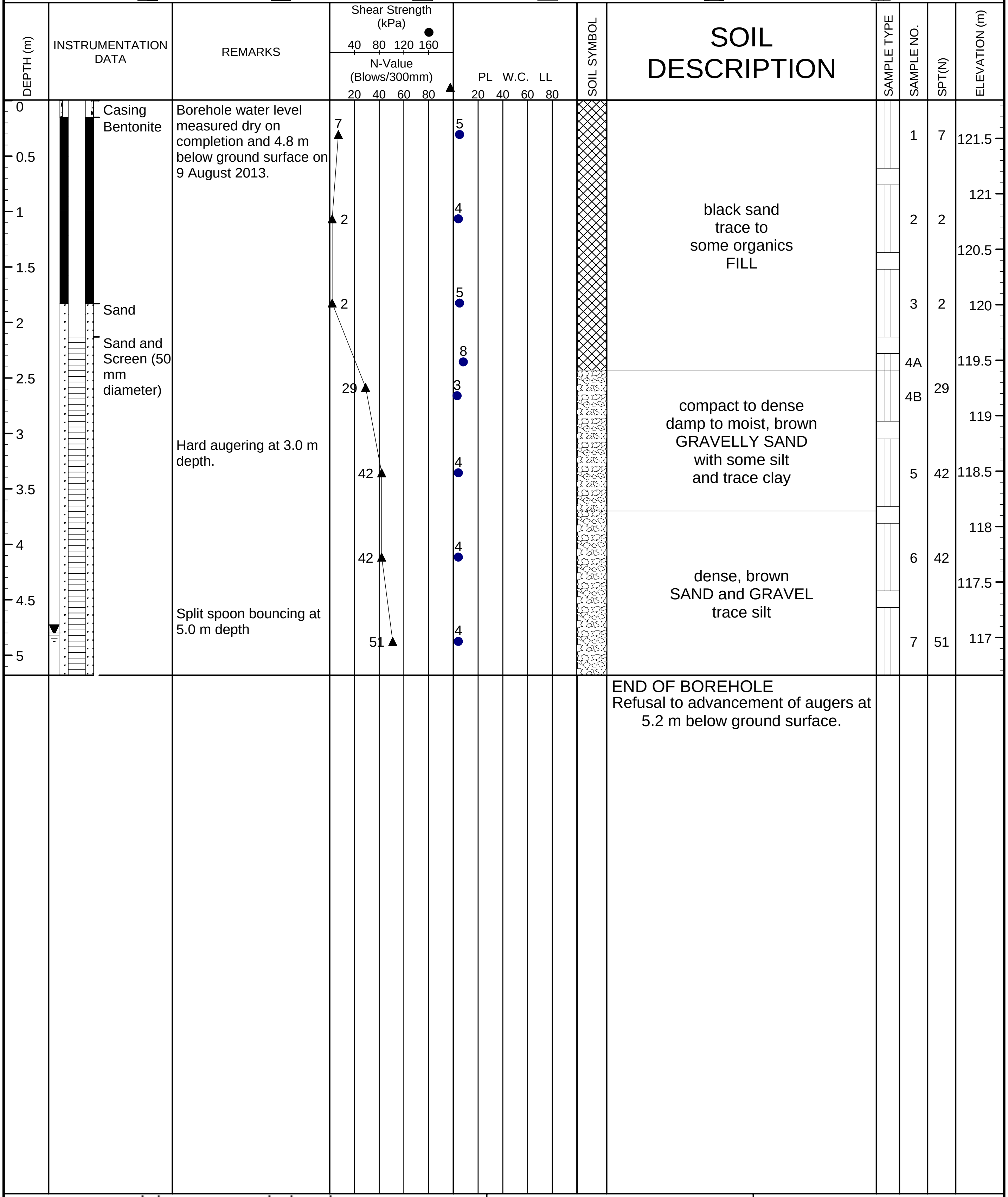
LOGGED BY: KC	DRILLING DATE: 6 August 2013
REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		**BH No.: 8**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 121.84	
LOCATION: Carp, ON	NORTHING: 5016297.222	EASTING: 346519.626	PROJECT NO.: 13-107

SAMPLE TYPE ▮ AUGER ◪ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



REMARKS

Borehole water level measured dry on completion and 4.8 m below ground surface on 9 August 2013.

Hard augering at 3.0 m depth.

Split spoon bouncing at 5.0 m depth

SOIL DESCRIPTION

black sand
trace to
some organics
FILL

compact to dense
damp to moist, brown
GRAVELLY SAND
with some silt
and trace clay

dense, brown
SAND and GRAVEL
trace silt

END OF BOREHOLE
Refusal to advancement of augers at 5.2 m below ground surface.

SAMPLE NO.	SPT(N)
1	7
2	2
3	2
4A	
4B	29
5	42
6	42
7	51

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consulting engineers

LOGGED BY: KC	DRILLING DATE: 7 August 2013
REVIEWED BY: VN	Page 1 of 1

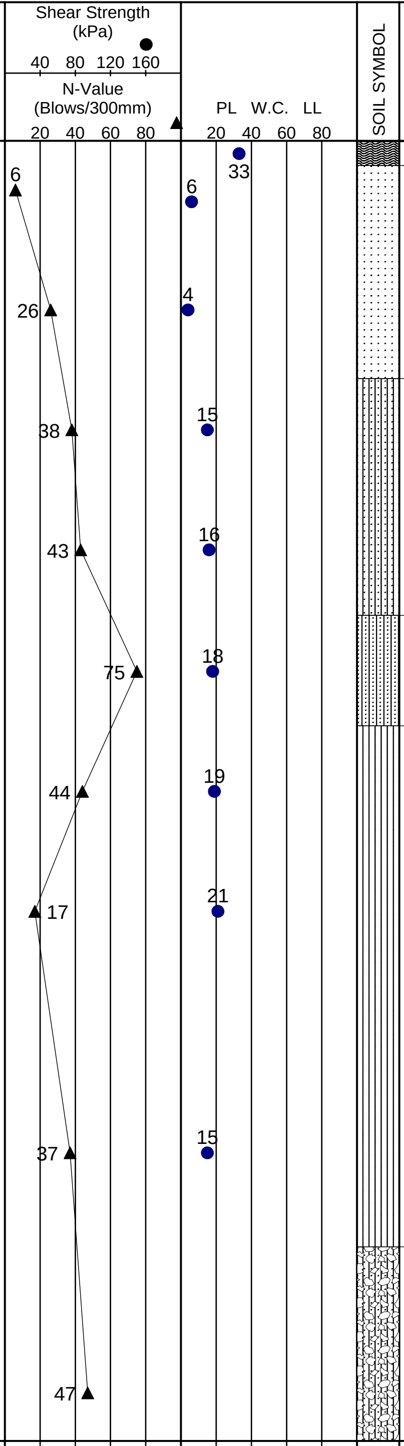
CLIENT: Waste Management
METHOD: Augering and Split Spoon Sampling

BH No.: 9

PROJECT: Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 127.44
LOCATION: Carp, ON
NORTHING: 5015484.789
EASTING: 345922.104
PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON

DEPTH (m)	REMARKS	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0	Borehole cave-in at 2.1 m below ground surface on completion.	150 mm TOPSOIL	1A		
0.5		loose ------ compact moist, brown SAND trace silt	1B	6	127
1			2	26	126.5
1.5					126
2		dense to very dense moist to wet, grey SANDY SILT trace clay	3	38	125.5
2.5			4	43	125
3		very dense wet, brown SILTY fine SAND	5	75	124.5
3.5					124
4		dense moist to wet grey SILT some sand trace clay occasional clay seams	6	44	123.5
4.5					123
5			7	17	122.5
5.5					122
6					121.5
6.5			8	37	121
7	Hard augering at 7.0 m depth.	dense, moist, grey SILTY SAND traces of clay and gravel (TILL)			120.5
7.5					120
8			9	47	119.5



END OF BOREHOLE
Refusal to advancement of augers at 8.23 m below ground surface.

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LOGGED BY: KC
REVIEWED BY: VN
DRILLING DATE: 8 August 2013

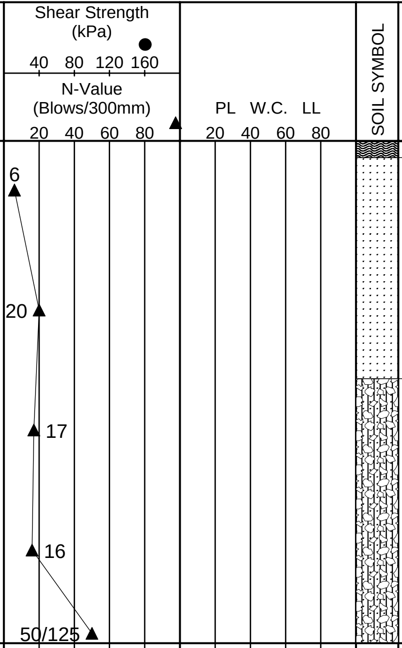
CLIENT: Waste Management
METHOD: Augering and Split Spoon Sampling

BH No.: 10

PROJECT: Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 125.32
LOCATION: Carp, ON
NORTHING: 5015708.354
EASTING: 346160.219
PROJECT NO.: 13-107

SAMPLE TYPE ▮ AUGER ◪ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▮ SHELBY Ⅰ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS
0		Borehole dry and open on completion. Contact made with a natural gas pocket at 3.05 m depth, drilling terminated, gas allowed to vent overnight. Augers pulled next day.
2		Hard augering at 2.1 m depth.



SOIL DESCRIPTION

SOIL DESCRIPTION
100 mm black sandy TOPSOIL
loose to compact moist fine to medium SAND traces of silt and gravel — brown ------ grey
compact, moist, grey SILTY SAND traces of clay and gravel (TILL)
END OF BOREHOLE

SAMPLE NO.	SPT(N)
1A	
1B	6
2	20
3	17
4	16
5	50/ 125

DEPTH (m): 0 0.5 1 1.5 2 2.5 3
ELEVATION (m): 125 124.5 124 123.5 123 122.5

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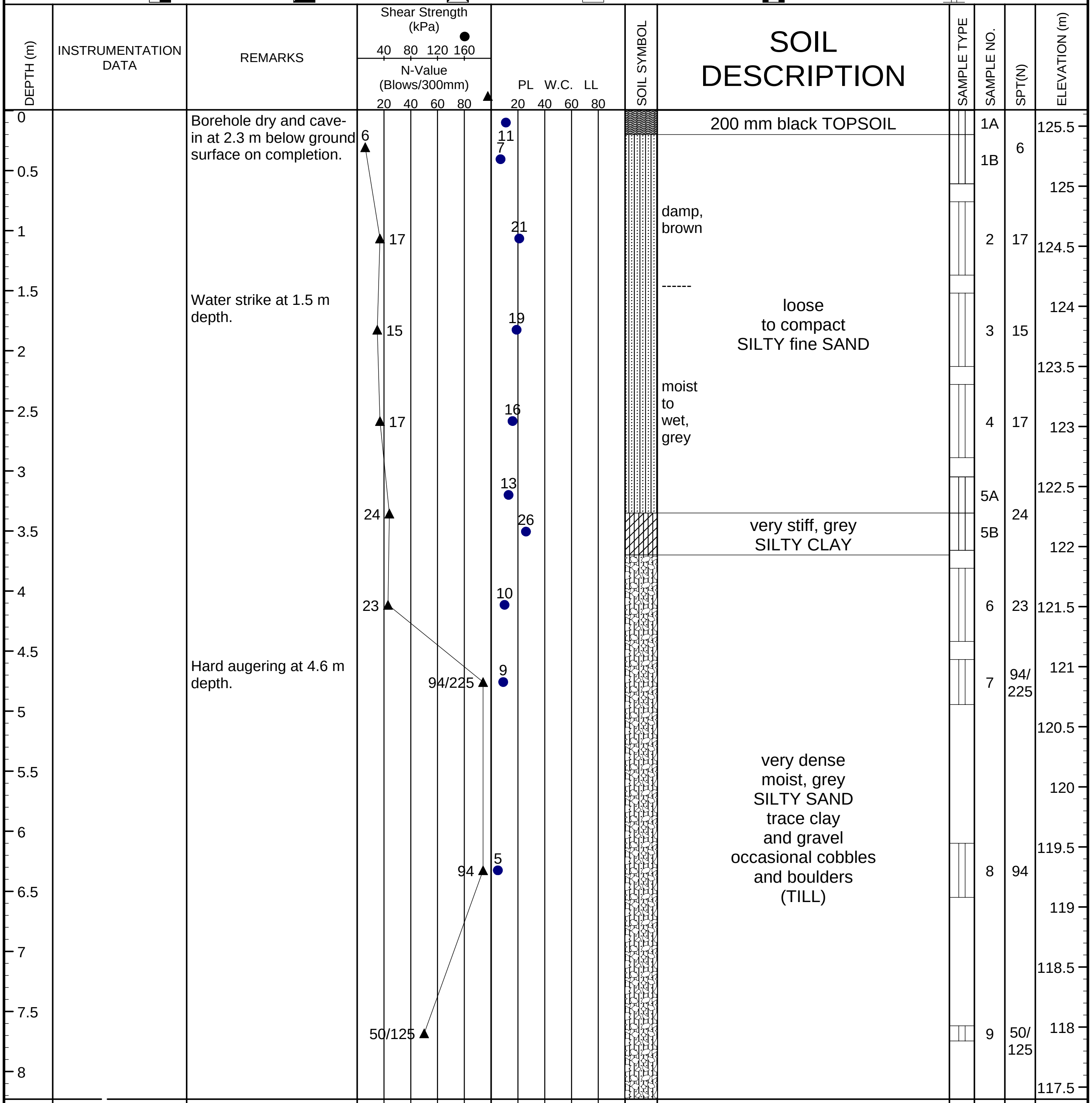
LOGGED BY: KC
DRILLING DATE: 7/8 August 2013
REVIEWED BY: VN
Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling	**BH No.: 11**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN · ELEV. (m) 125.63	
LOCATION: Carp, ON	NORTHING: 5015930.527 · EASTING: 346374.845	PROJECT NO.: 13-107

SAMPLE TYPE: ▮ AUGER ◢ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON



REMARKS

Borehole dry and cave-in at 2.3 m below ground surface on completion.

Water strike at 1.5 m depth.

Hard augering at 4.6 m depth.

SOIL DESCRIPTION

200 mm black TOPSOIL

loose
to compact
SILTY fine SAND

damp,
brown

------

moist
to
wet,
grey

very stiff, grey
SILTY CLAY

very dense
moist, grey
SILTY SAND
trace clay
and gravel
occasional cobbles
and boulders
(TILL)

END OF BOREHOLE
Refusal to advancement of augers at 8.23 m below ground surface.

SAMPLE NO.	SPT(N)	W.C.
1A	6	11
1B		7
2	17	21
3	15	19
4	17	16
5A	24	13
5B		26
6	23	10
7	94/225	9
8	94	5
9	50/125	

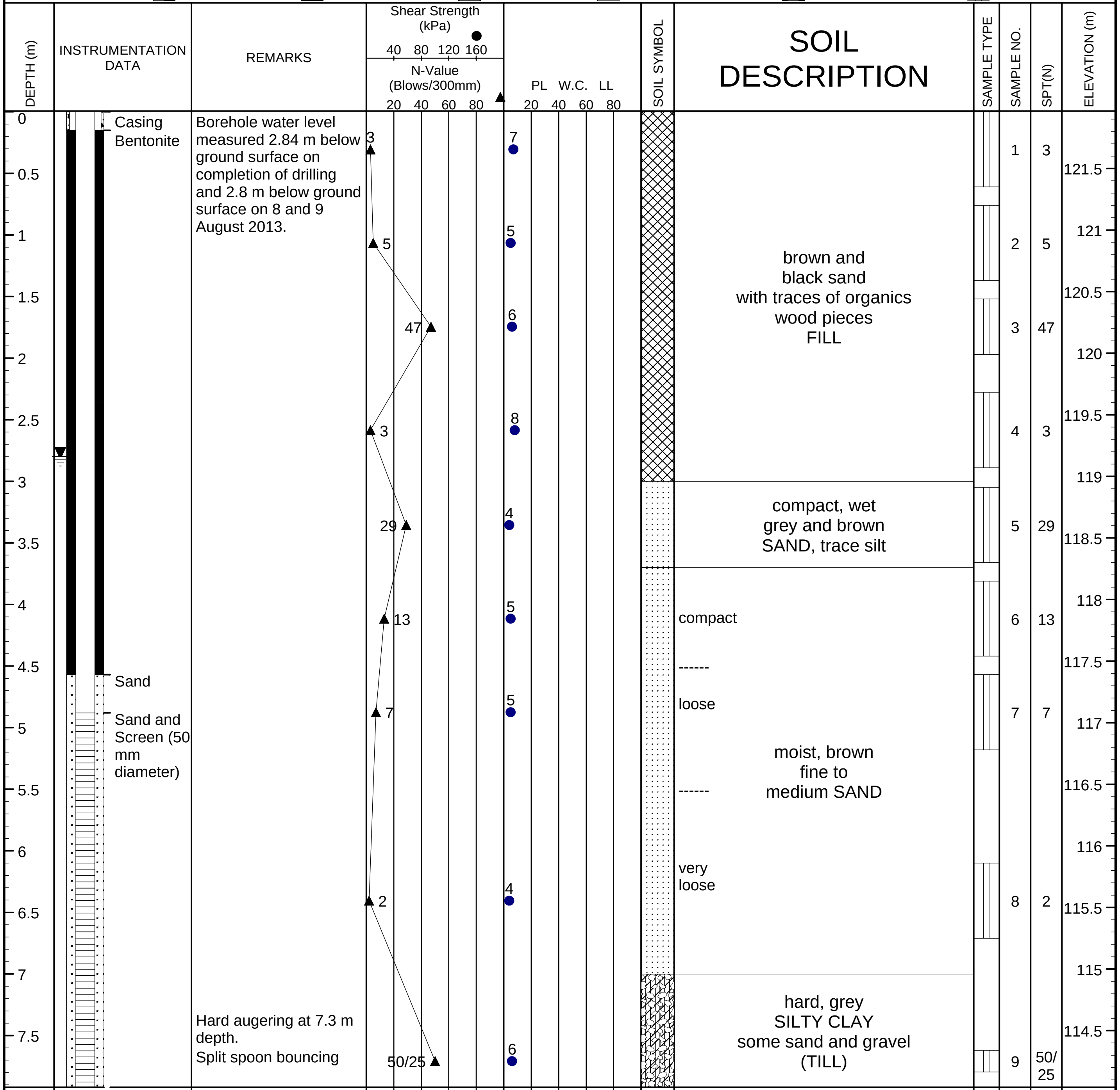
alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 7 August 2013
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON
METHOD: Augering and Split Spoon Sampling
PROJECT ENGINEER: VN
ELEV. (m) 121.96
NORTHING: 5016144.282
EASTING: 346499.092

BH No.: 12

PROJECT NO.: 13-107

SAMPLE TYPE ▮ AUGER ◩ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON



Borehole water level measured 2.84 m below ground surface on completion of drilling and 2.8 m below ground surface on 8 and 9 August 2013.

Hard augering at 7.3 m depth.
Split spoon bouncing

brown and
black sand
with traces of organics
wood pieces
FILL

compact, wet
grey and brown
SAND, trace silt

compact
------
loose
moist, brown
fine to
medium SAND
------
very
loose

hard, grey
SILTY CLAY
some sand and gravel
(TILL)

SAMPLE NO.	SPT(N)	W.C.
1	3	7
2	5	5
3	47	6
4	3	8
5	29	4
6	13	5
7	7	5
8	2	4
9	50/25	6

END OF BOREHOLE
Refusal to advancement of augers at 7.9 m below ground surface.

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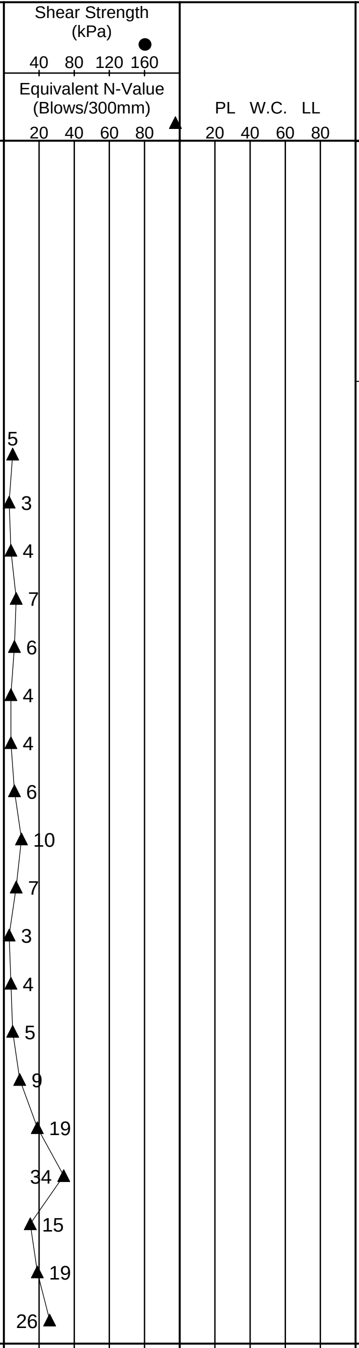
REVIEWED BY: VN
DRILLING DATE: 7 August 2013
Page 1 of 1

CLIENT: Waste Management	METHOD: Dynamic Cone Penetration Testing		**DCPT No.: 12A**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 121.96	
LOCATION: Carp, ON	NORTHING: 5016144.282	EASTING: 346499.092	PROJECT NO.: 13-107

SAMPLE TYPE: ▯ AUGER ◪ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0 0.5 1 1.5				Straight auger to 1.5 m depth				121.5 121 120.5
2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5				Dynamic Cone Penetration Test	▀		-- 5 3 4 7 6 4 4 6 10 7 3 4 5 9 19 34 15 19 26	120 119.5 119 118.5 118 117.5 117 116.5 116 115.5 115 114.5
				END OF DYNAMIC CONE PENETRATION TEST				



alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 7 August 2013
	REVIEWED BY: VN	Page 1 of 1

DMT 101

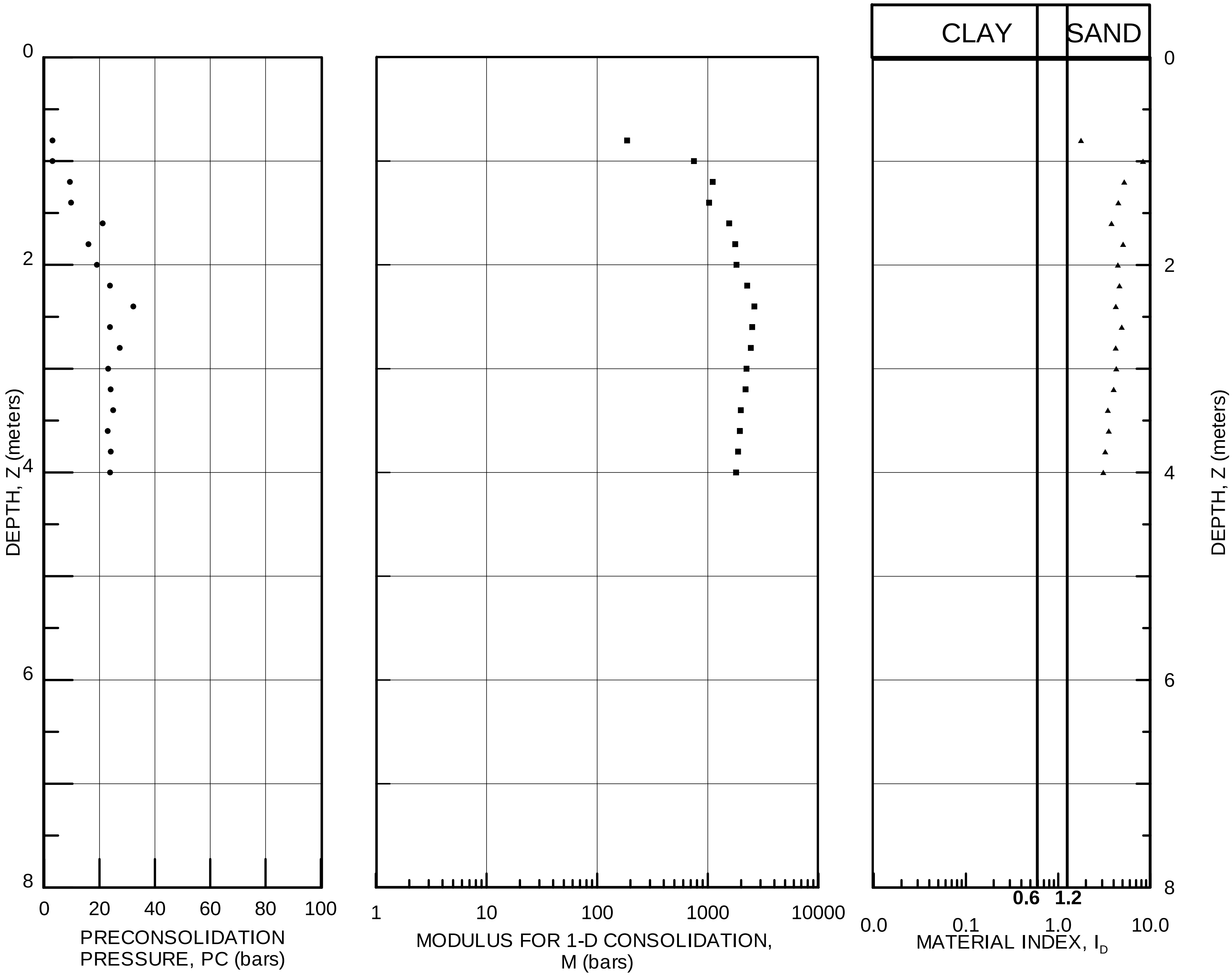
Z (M)	A (BAR)	B (BAR)	C (BAR)	P0 (BAR)	P1 (BAR)	P2 (BAR)	U0 (BAR)	ED (BAR)	ID	KD	GAMMA (T/M3)	SV' (BAR)	PC (BAR)	OCR	KO	PHI (PHI)	M (BAR)	Su (BAR) f(SV', Kd)	SOIL TYPE
0.8	1.20	4.00	0.00	1.34	3.70	0.00	0.000	82	1.77	7.87	1.7	0.17	3.0	17.56	1.32	30	186	---	SANDY SILT
1.0	1.50	12.00	0.00	1.25	11.70	0.00	0.000	363	8.34	6.10	1.8	0.21	3.0	14.72	0.08	44	751	---	SAND
1.2	2.80	15.50	0.00	2.44	15.20	0.00	0.000	443	5.22	10.07	1.9	0.24	9.3	38.31	1.17	40	1110	---	SAND
1.4	3.00	15.00	0.00	2.68	14.70	0.00	0.000	417	4.49	9.57	1.9	0.28	9.7	34.75	1.23	38	1027	---	SAND
1.6	4.80	20.80	0.00	4.28	20.50	0.00	0.000	563	3.79	13.40	2.0	0.32	21.1	66.18	1.72	38	1563	---	SAND
1.8	4.60	24.00	0.00	3.91	23.70	0.00	0.000	687	5.07	10.90	2.0	0.36	16.0	44.61	1.28	40	1773	---	SAND
2.0	5.20	24.80	0.00	4.50	24.50	0.00	0.000	694	4.45	11.31	2.0	0.40	19.0	47.85	1.41	39	1816	---	SAND
2.2	6.20	30.00	0.00	5.29	29.70	0.00	0.000	847	4.62	12.10	2.0	0.44	23.8	54.45	1.47	39	2271	---	SAND
2.4	7.50	34.00	0.00	6.45	33.70	0.00	0.000	945	4.22	13.55	2.0	0.48	32.2	67.58	1.68	39	2636	---	SAND
2.6	6.80	34.00	0.00	5.72	33.70	0.00	0.000	971	4.89	11.09	2.0	0.52	23.8	46.11	0.87	43	2523	---	SAND
2.8	7.40	33.5*	0.00	6.37	33.20	0.00	0.000	931	4.21	11.49	2.0	0.56	27.4	49.31	1.26	41	2450	---	SAND
3.0	7.00	32.0*	0.00	6.03	31.70	0.00	0.000	891	4.26	10.15	2.0	0.59	23.1	38.91	1.17	40	2239	---	SAND
3.2	7.30	32.0*	0.00	6.34	31.70	0.00	0.000	880	4.00	10.02	2.0	0.63	24.0	37.95	1.23	39	2201	---	SAND
3.4	7.50	30.0*	0.00	6.65	29.70	0.00	0.000	800	3.46	9.89	2.0	0.67	24.9	37.06	1.33	37	1992	---	SAND
3.6	7.40	30.0*	0.00	6.55	29.70	0.00	0.000	803	3.54	9.20	2.0	0.71	23.0	32.26	1.25	37	1950	---	SAND
3.8	7.70	29.5*	29.5*	6.89	29.20	0.00	0.000	774	3.24	9.17	2.0	0.75	24.1	32.07	1.30	36	1877	---	SILTY SAND
4.0	7.80	29.0*	0.00	7.02	28.70	0.00	0.000	752	3.09	8.88	2.0	0.79	23.8	30.15	1.29	35	1803	---	SILTY SAND

* B Reading limited by equipment control

Ground Surface Elev.: _____ m
Northing: _______, Easting: ______

PROJECT: Landfill Expansion
LOCATION: Carp, ON

DILATOMETER RESULTS



ALSTON ASSOCIATES INC.
FIELD TECH.: KC
SOUNDING DATE: 2013-08-06

SOUNDING
DMT 101

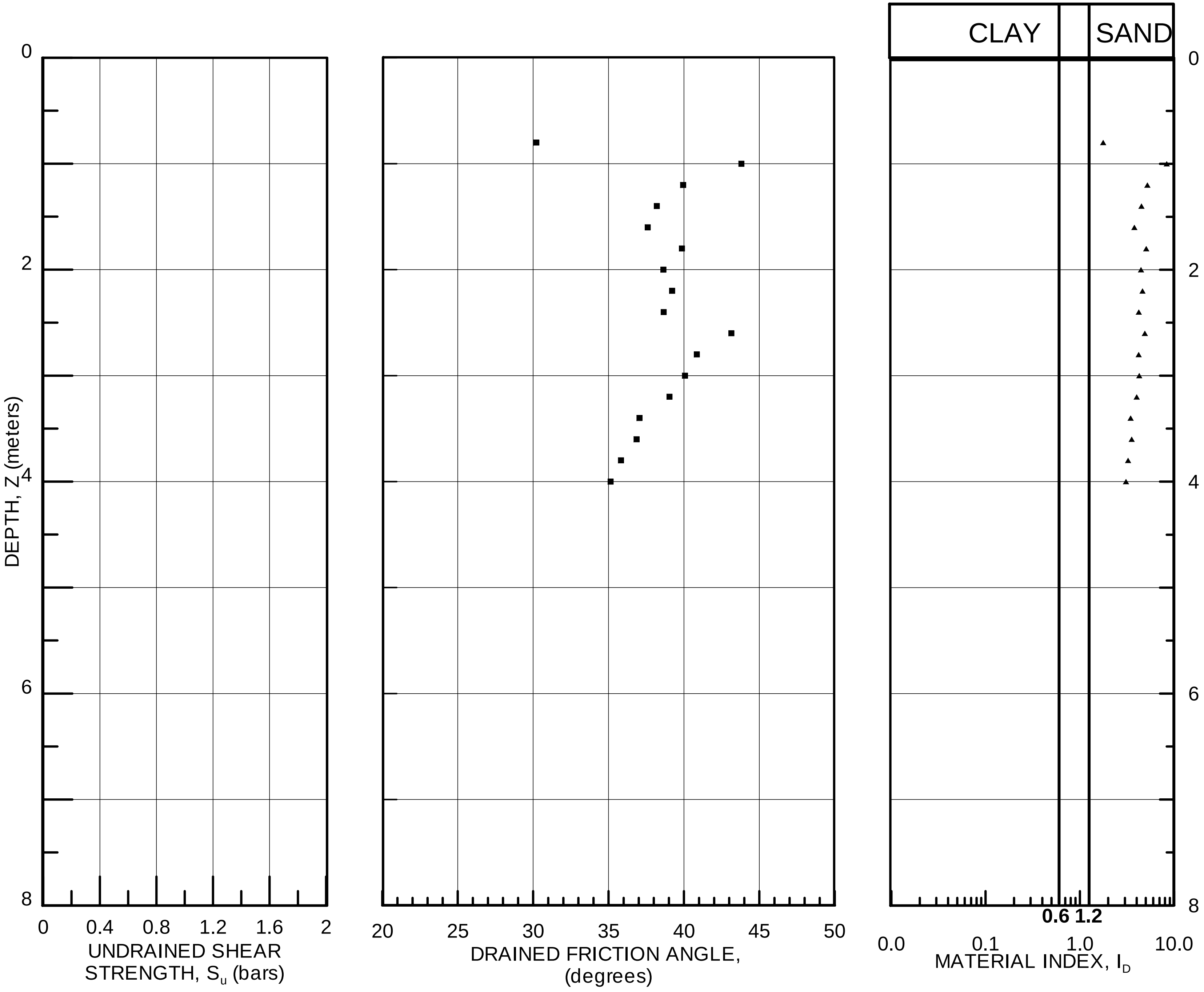
PROJECT: Landfill Expansion
LOCATION: Carp, ON

DILATOMETER RESULTS

ALSTON ASSOCIATES INC.
FIELD TECH.: KC
SOUNDING DATE: 2013-08-06

SOUNDING
DMT 101

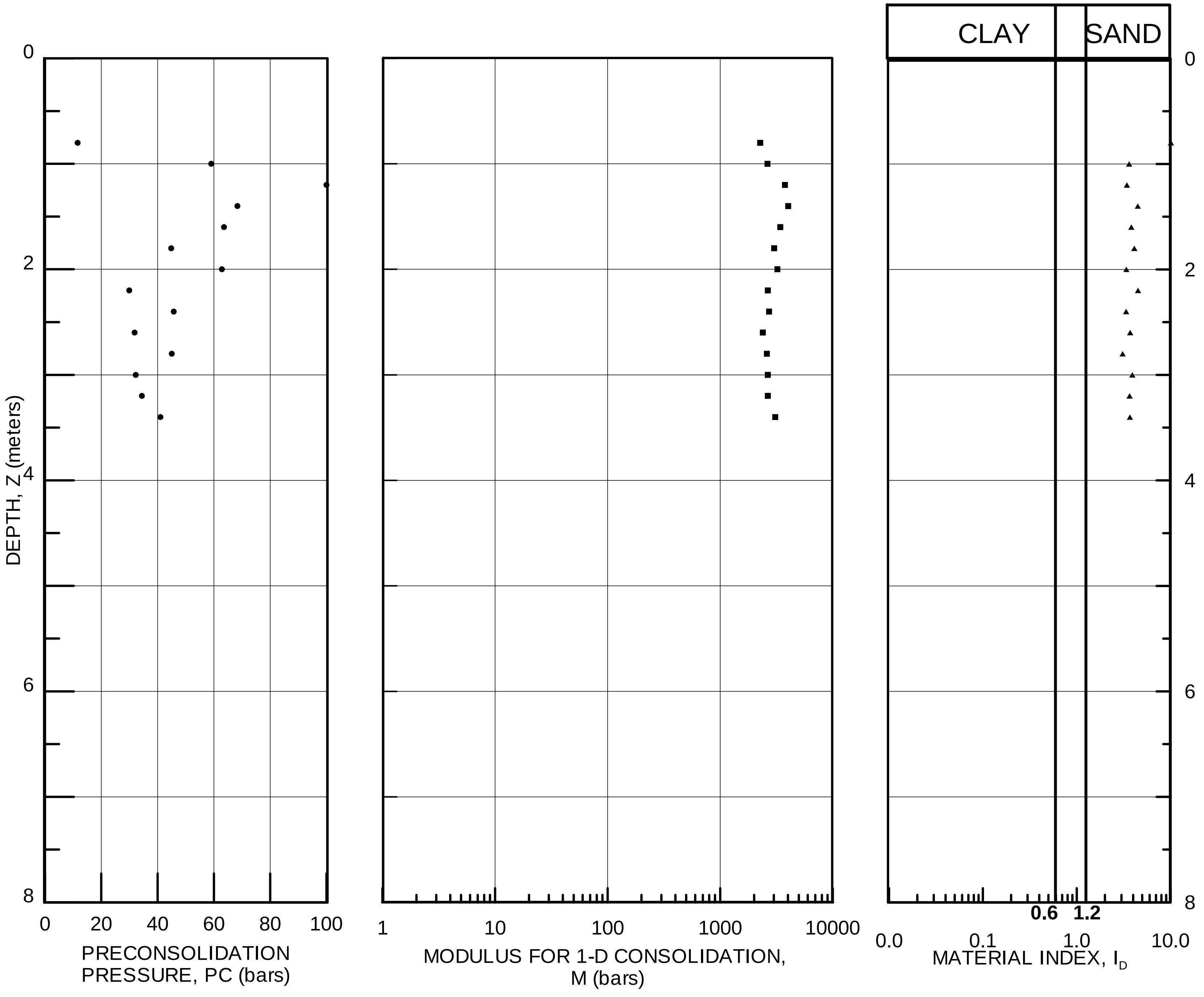
Ground Surface Elev.:_____ m
Northing: _______, Easting: _______



DMT 102

Z (M)	A (BAR)	B (BAR)	C (BAR)	P0 (BAR)	P1 (BAR)	P2 (BAR)	U0 (BAR)	ED (BAR)	ID	KD	GAMMA (T/M3)	SV' (BAR)	PC (BAR)	OCR	KO	PHI (PHI)	M (BAR)	Su (BAR) f(SV', Kd)	SOIL TYPE
0.8	3.20	26.00	0.00	2.31	25.68	0.00	0.000	811	10.10	13.60	1.9	0.17	11.6	68.08	0.38	45	2263	---	SAND
1.0	6.80	28.00	0.00	5.99	27.68	0.00	0.000	752	3.62	28.64	2.0	0.21	59.1	282.19	3.48	39	2630	---	SAND
1.2	9.80	38.50	0.00	8.62	38.18	0.00	0.000	1026	3.43	34.27	2.2	0.25	100.0	397.66	4.17	39	3760	---	SAND
1.4	9.00	42.00	0.00	7.60	41.68	0.00	0.000	1182	4.48	25.89	2.2	0.29	68.3	232.74	3.01	41	4021	---	SAND
1.6	9.00	38.00	0.00	7.80	37.68	0.00	0.000	1037	3.83	23.23	2.2	0.34	63.6	189.25	2.82	39	3419	---	SAND
1.8	8.00	35.50	0.00	6.88	35.18	0.00	0.000	982	4.11	18.19	2.2	0.38	44.9	118.63	2.21	39	3011	---	SAND
2.0	9.80	38.20	0.00	8.63	37.88	0.00	0.000	1015	3.39	20.54	2.2	0.42	62.9	149.60	2.58	38	3228	---	SAND
2.2	7.20	34.00	0.10	6.11	33.68	0.33	0.000	956	4.51	13.30	2.0	0.46	30.0	65.24	1.61	39	2649	---	SAND
2.4	9.00	35.00	0.30	7.95	34.68	0.53	0.000	927	3.36	15.85	2.2	0.50	45.8	91.18	1.88	40	2723	---	SAND
2.6	7.80	32.50	0.50	6.82	32.18	0.73	0.000	880	3.72	12.60	2.0	0.54	31.8	58.84	1.50	40	2392	---	SAND
2.8	9.50	35.00	0.60	8.48	34.68	0.83	0.000	909	3.09	14.54	2.2	0.58	45.1	77.30	1.84	38	2595	---	SILTY SAND
3.0	8.50	36.50	0.10	7.35	36.18	0.33	0.000	1000	3.92	11.76	2.2	0.63	32.2	51.54	1.38	40	2654	---	SAND
3.2	9.00	37.00	0.10	7.85	36.68	0.33	0.000	1000	3.67	11.76	2.2	0.67	34.4	51.58	1.45	39	2654	---	SAND
3.4	10.20	42.00	0.10	8.86	41.68	0.33	0.000	1139	3.70	12.49	2.2	0.71	41.0	57.81	1.50	40	3086	---	SAND

Ground Surface Elev.: _____ m
Northing: _______, Easting: ______



PROJECT: Landfill Expansion
LOCATION: Carp, ON

DILATOMETER RESULTS

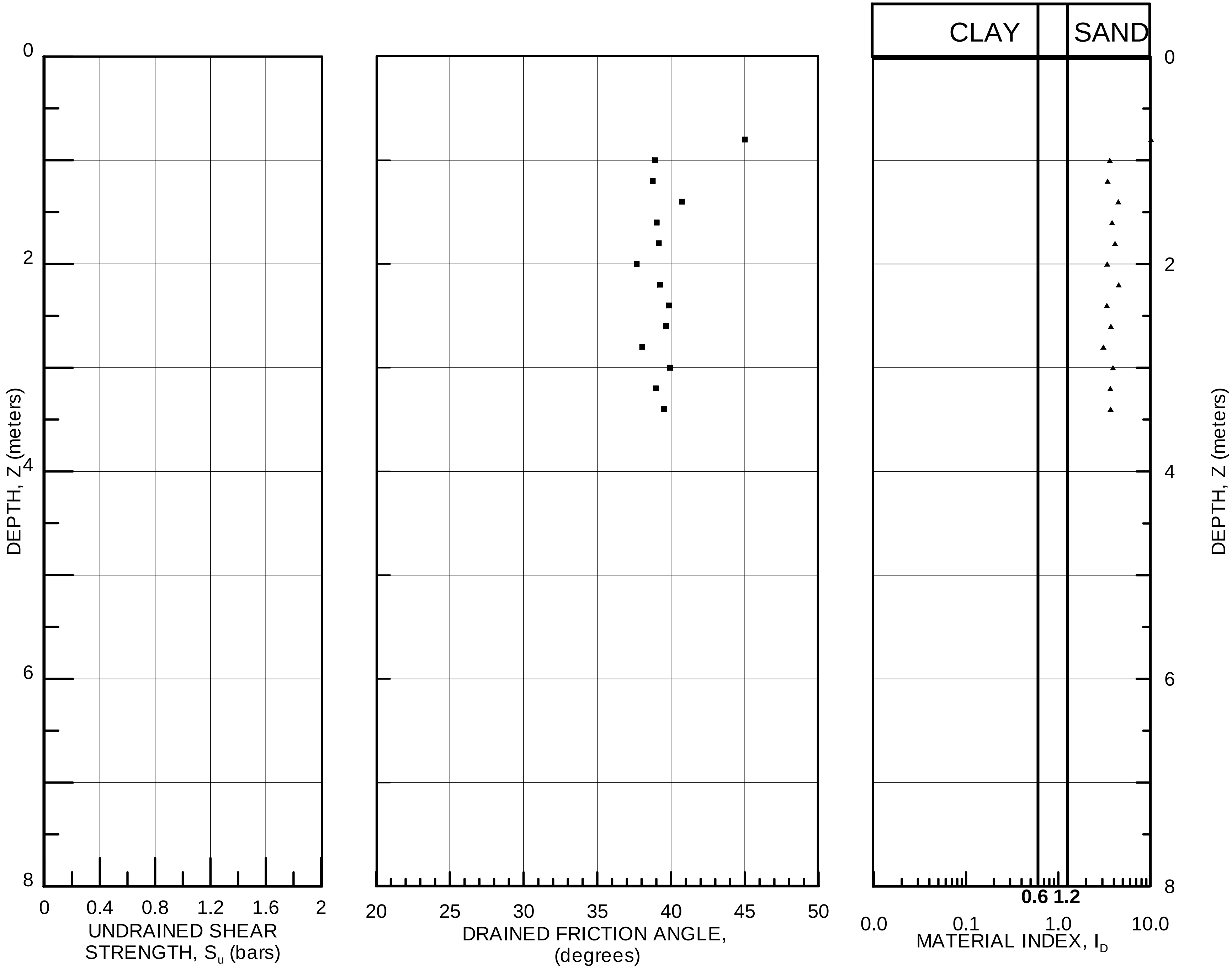
ALSTON ASSOCIATES INC.
FIELD TECH.: KC
SOUNDING DATE: 2013-08-06

SOUNDING
DMT 102

Ground Surface Elev.:_____ m
Northing: _______, Easting: _______

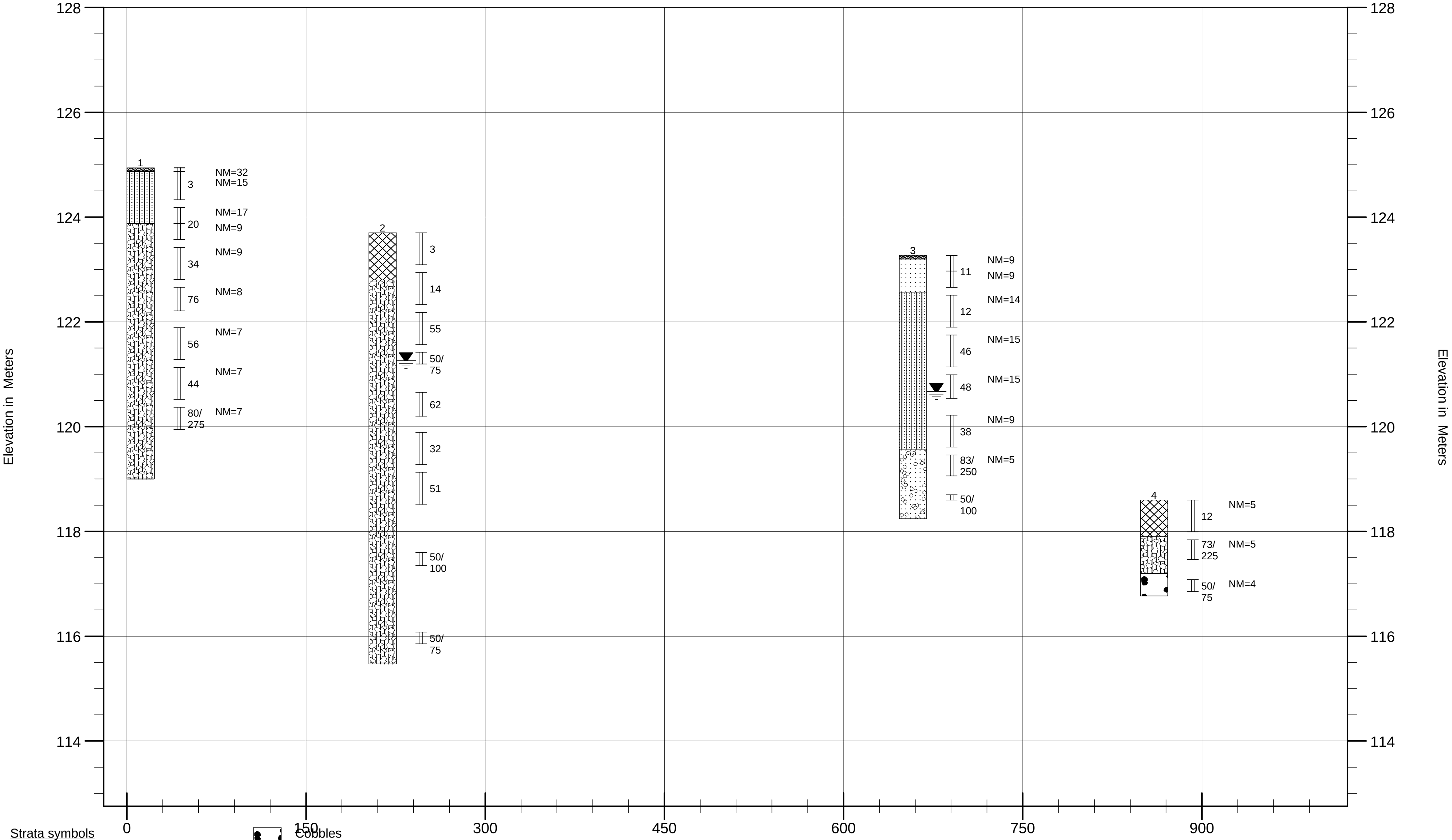
PROJECT: Landfill Expansion
LOCATION: Carp, ON

DILATOMETER RESULTS



ALSTON ASSOCIATES INC.
FIELD TECH.: KC
SOUNDING DATE: 2013-08-06

SOUNDING
DMT 102



Strata symbols

▦ Topsoil

▥ Silty Sand/Sandy Silt

▨ Silty Sand Till

▩ Fill

░ Sand

● Cobbles

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GENERALIZED SOIL PROFILE

HORIZONTAL
SCALE: 1=(proportional)
VERTICAL
SCALE: 1=100

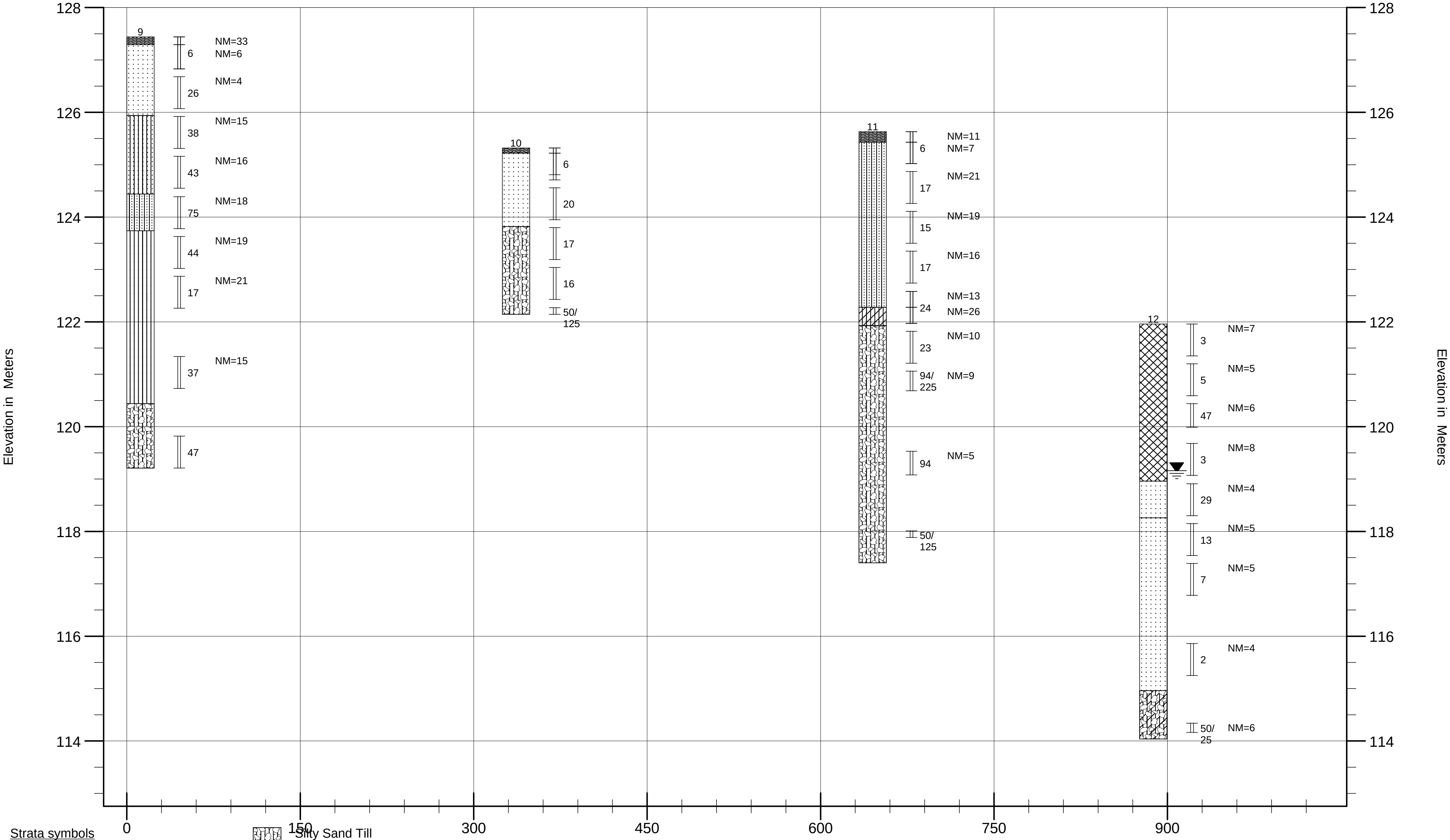
DRAWN BY JB

DATE DRAWN
16/10/2013

Landfill Expansion
Section through Boreholes 1 to4

PROJECT NO. 13-107

FIGURE NUMBER
1



Strata symbols

- ▩ Topsoil
- ⁙ Sand
- ▥ Silt and Sand
- ▥ Silty Sand/Sandy Silt
- ▥ Silt
- ▩ Silty Sand Till
- ▨ Silty Clay
- ▦ Fill
- ▩ Silty Clay Till

Alston Associates Inc.

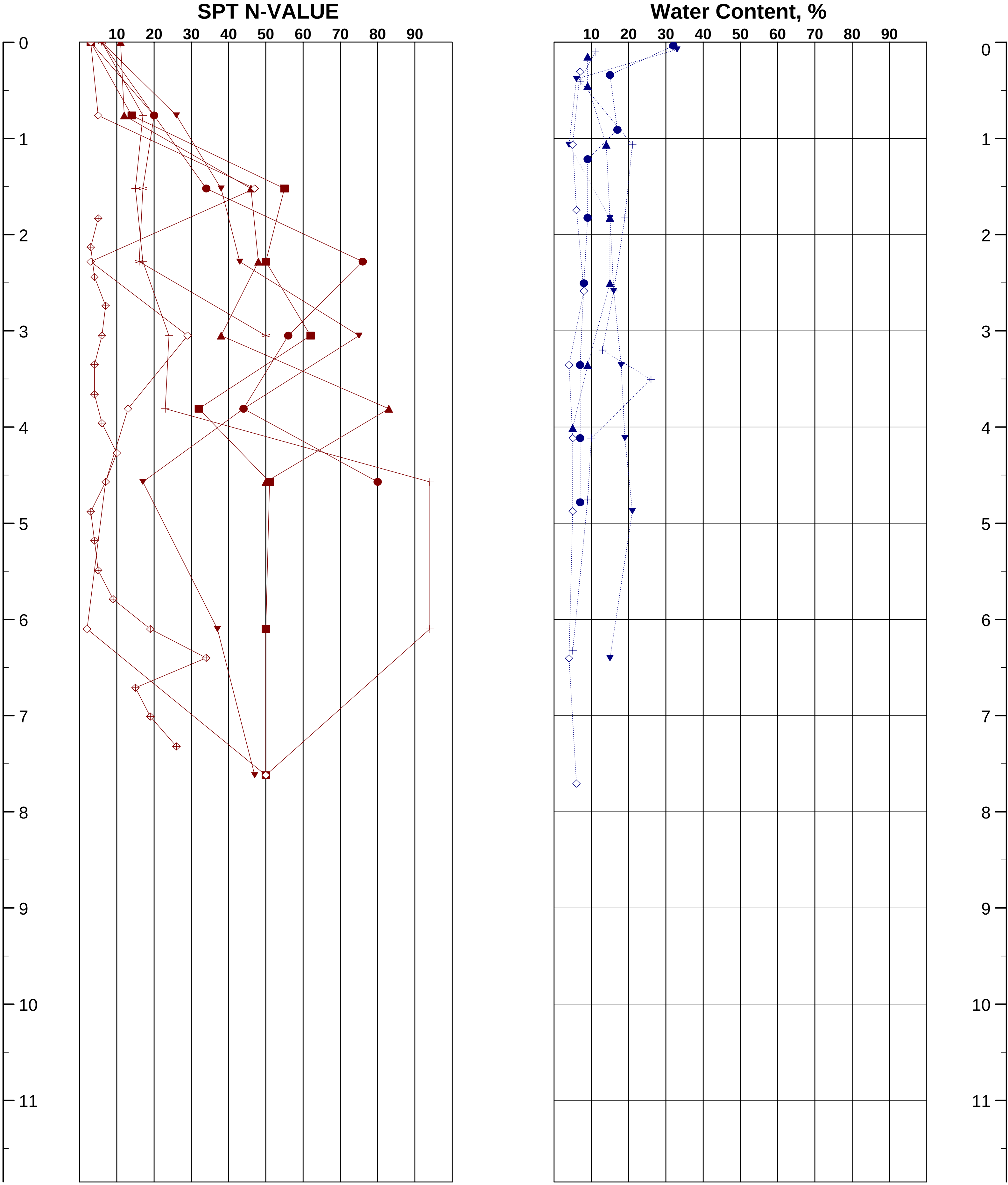
GENERALIZED SOIL PROFILE

HORIZONTAL SCALE: 1=(proportional)	DRAWN BY JB	DATE DRAWN
VERTICAL SCALE: 1=100		16/10/2013

Landfill Expansion
Section through Boreholes 9 to 12

PROJECT NO. 13-107

FIGURE NUMBER
2



Key to Borings

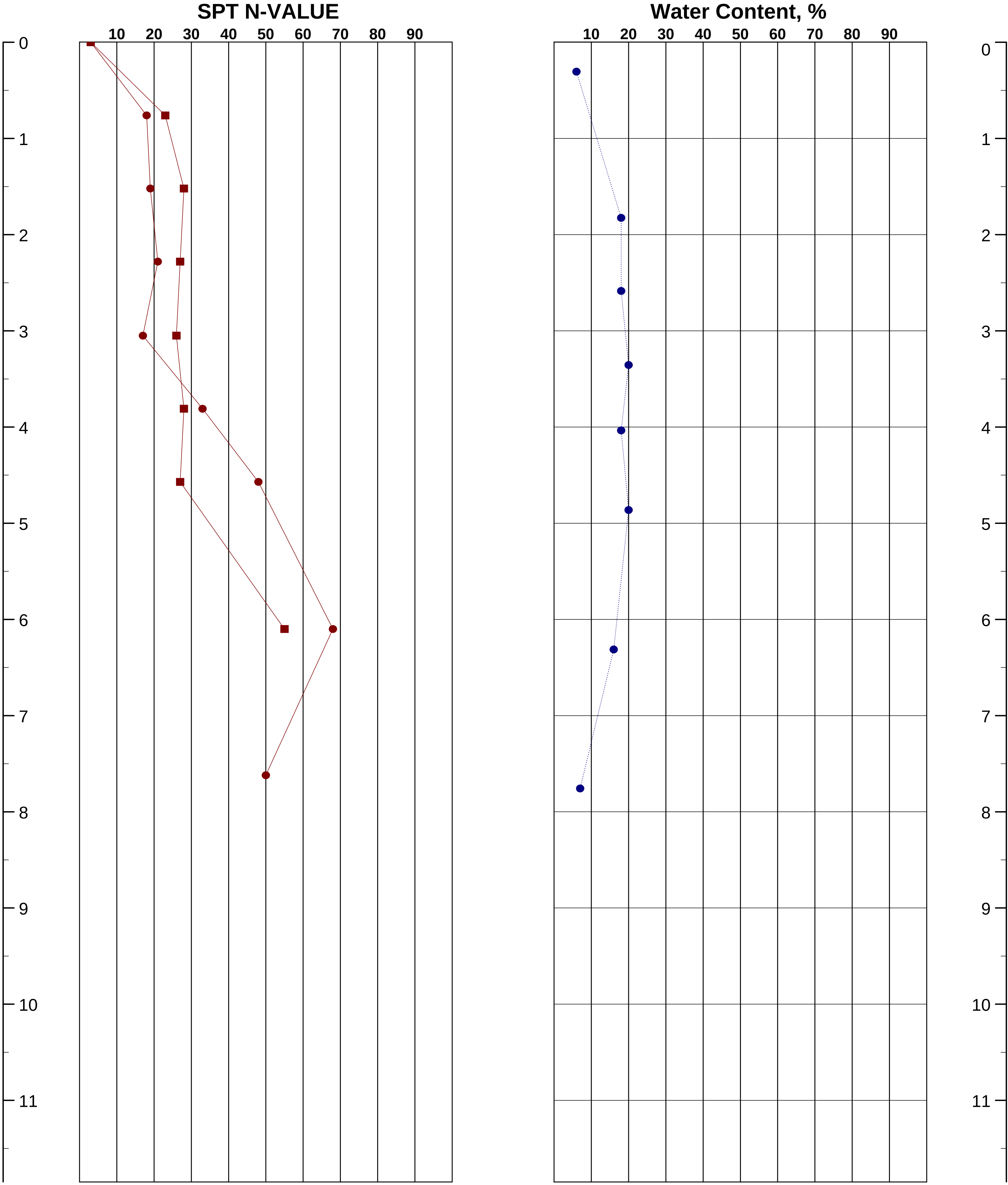
● 1 ▲ 3 ⚹ 10 ◇ 12

■ 2 ▼ 9 + 11 ⟡ 12A

Alston Associates Inc.

Landfill Expansion

Vertical Scale: 1 to 50	**Figure: 3**



Key to Borings

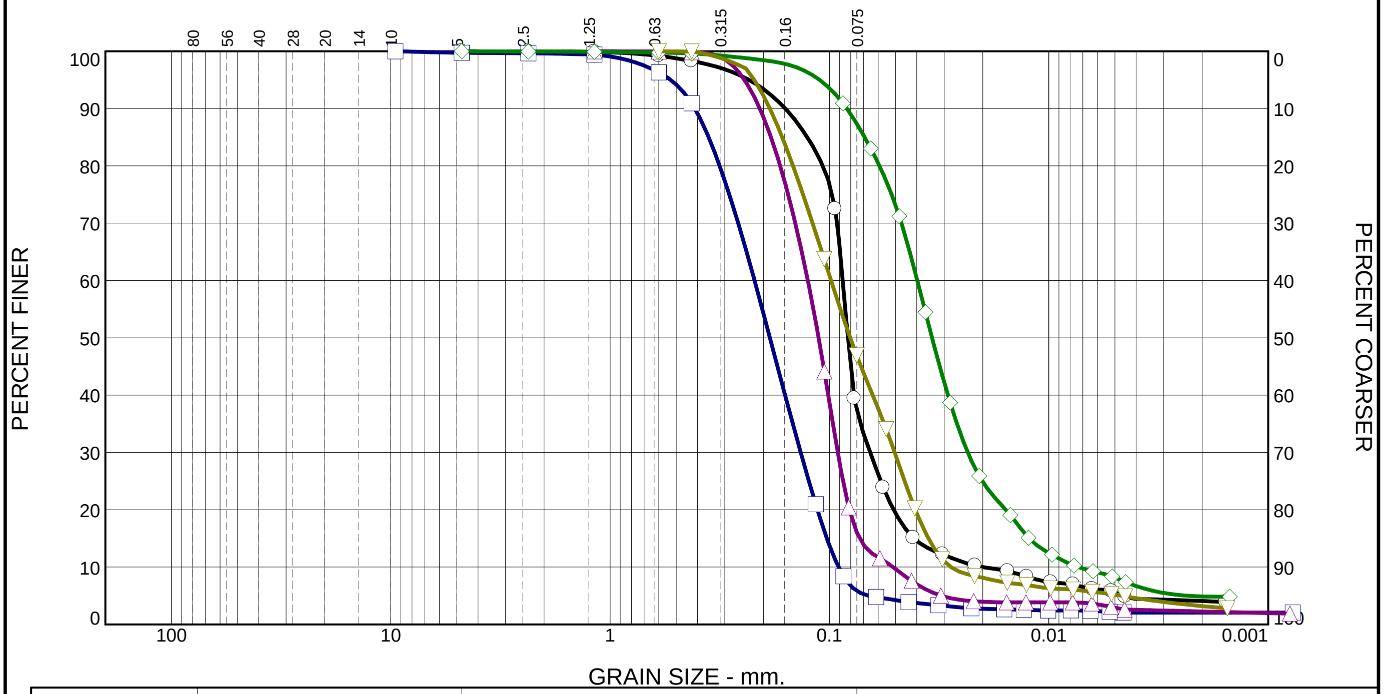
- ● **6**
- ■ **7**

Alston Associates Inc.

Landfill Expansion

Vertical Scale: 1 to 50	**Figure: 4**

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	2	61	33	4
□	0	0	0	0	9	85	4	2
△	0	0	0	0	0	84	14	2
◇	0	0	0	0	0	13	82	5
▽	0	0	0	0	0	53	44	3

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.1263	0.0869	0.0824	0.0652	0.0411	0.0200	2.44	4.34
□			0.3555	0.2197	0.1869	0.1353	0.1028	0.0910	0.92	2.41
△			0.1848	0.1255	0.1121	0.0917	0.0729	0.0514	1.30	2.44
◇			0.0692	0.0398	0.0341	0.0234	0.0123	0.0074	1.87	5.40
▽			0.1643	0.0983	0.0804	0.0505	0.0354	0.0279	0.93	3.52

Material Description	USCS	AASHTO
○ SILTY fine SAND, trace clay		
□ fine SAND, trace silt, trace clay		
△ fine SAND, some silt, trace clay		
◇ SILT, some fine sand, trace clay		
▽ SILT and fine SAND, trace clay		

Project No. 13-107 **Client:** Waste Management

Project: Landfill Expansion

○ **Sample Number:** BH 3, Sample 3

□ **Sample Number:** BH 6, Sample 5

△ **Sample Number:** BH 6, Sample 4

◇ **Sample Number:** BH 7, Sample 4

▽ **Sample Number:** BH 7, Sample 5

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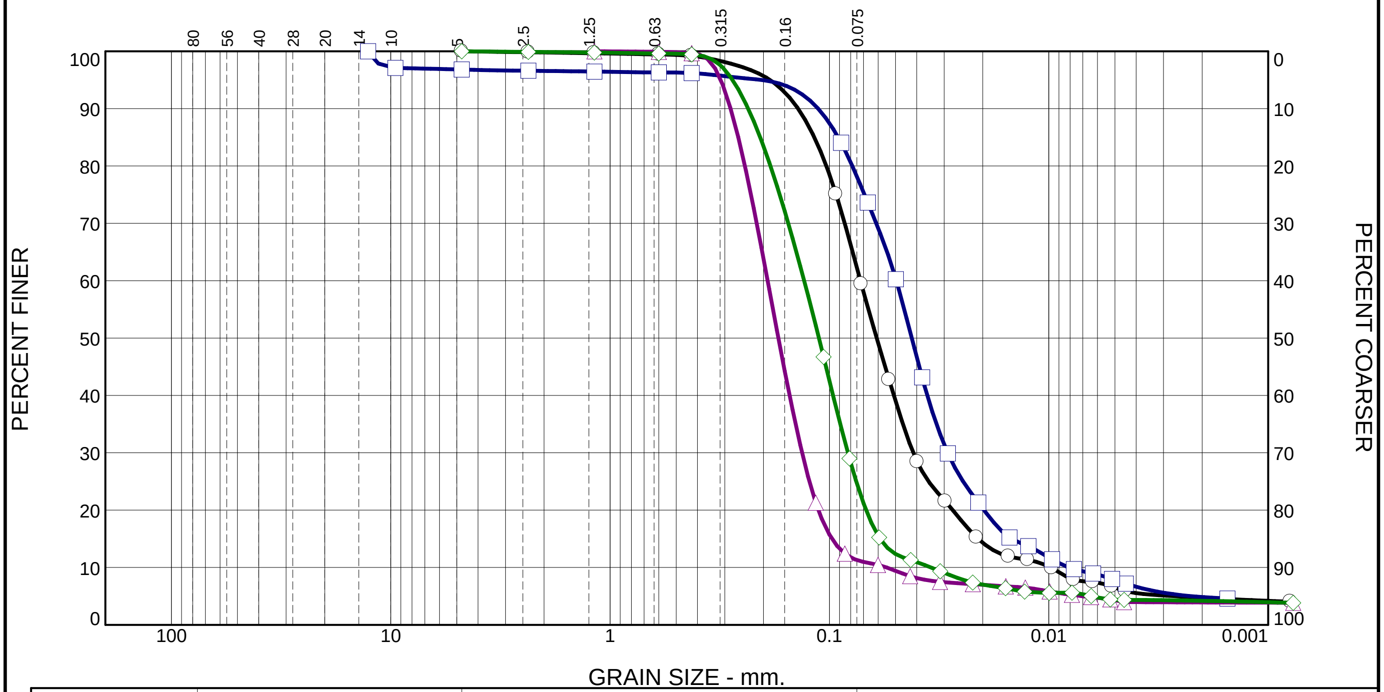
Remarks:

Figure 5

Tested By: ○ MA/AM □ MA/TA △ TA/AR ◇ AR/AM ▽ MP/AM **Checked By:** JB

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	1	37	57	5
□	0	0	3	0	1	18	73	5
△	0	0	0	0	0	89	7	4
◇	0	0	0	0	1	74	21	4

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.1173	0.0723	0.0609	0.0415	0.0210	0.0098	2.43	7.38
□			0.0913	0.0496	0.0422	0.0289	0.0148	0.0081	2.09	6.14
△			0.2606	0.1914	0.1709	0.1334	0.0975	0.0549	1.69	3.49
◇			0.2070	0.1304	0.1118	0.0825	0.0588	0.0345	1.51	3.78

Material Description	USCS	AASHTO
○ SANDY SILT, trace clay		
□ SILT, some fine sand, trace clay, trace gravel		
△ fine SAND, trace silt, trace clay		
◇ SILTY fine SAND, trace clay		

Project No. 13-107 **Client:** Waste Management

Project: Landfill Expansion

○ **Sample Number:** BH 9, Sample 3

□ **Sample Number:** BH 9, Sample 7

△ **Sample Number:** BH 12, Sample 5

◇ **Sample Number:** BH 12, Sample 8

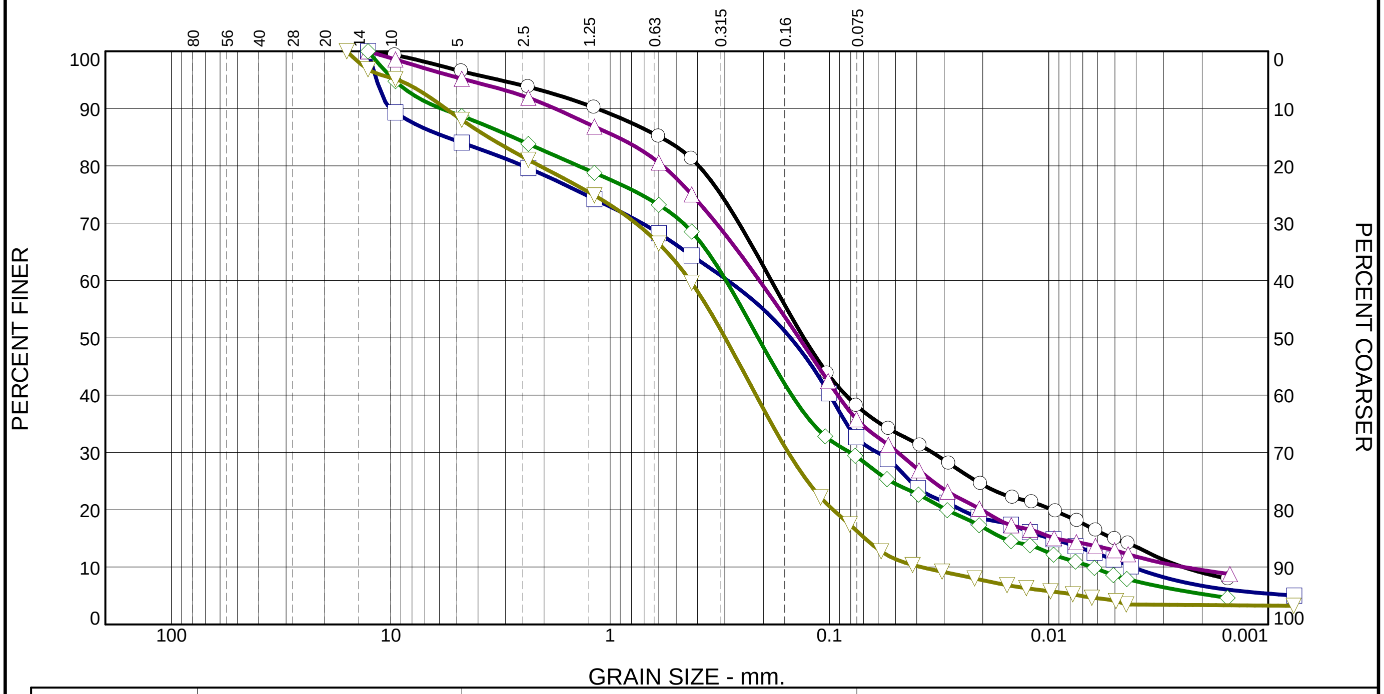
alston associates inc.
consulting engineers

Remarks:

Figure 6

Tested By: ○ TS/AR □ MA/AM △ TS/TA ◇ MA/TA **Checked By:** JB

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	3	4	12	43	29	9
□	0	0	16	6	14	31	26	7
△	0	0	5	4	16	39	27	9
◇	0	0	11	6	14	40	24	5
▽	0	0	12	8	20	44	13	3

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.5902	0.1844	0.1310	0.0340	0.0051	0.0024	2.57	75.48
□			5.5707	0.2909	0.1505	0.0605	0.0098	0.0041	3.03	70.12
△			0.9252	0.2086	0.1377	0.0488	0.0094	0.0024	4.72	86.26
◇			2.7697	0.2965	0.2113	0.0807	0.0161	0.0063	3.46	46.71
▽			3.5856	0.4322	0.2990	0.1541	0.0689	0.0382	1.44	11.30

Material Description	USCS	AASHTO
○ SILTY fine SAND, trace clay, trace gravel		
□ SILTY SAND, some gravel, trace clay		
△ SILTY fine SAND, trace clay, trace gravel		
◇ SILTY fine SAND, some gravel, trace clay		
▽ medium to fine SAND, some silt, some gravel, trace clay		

Project No. 13-107 **Client:** Waste Management

Project: Landfill Expansion

○ **Sample Number:** BH 1, Sample 3

□ **Sample Number:** BH 2, Sample 4

△ **Sample Number:** BH 2, Sample 6

◇ **Sample Number:** BH 4, Sample 2

▽ **Sample Number:** BH 5, Sample 2

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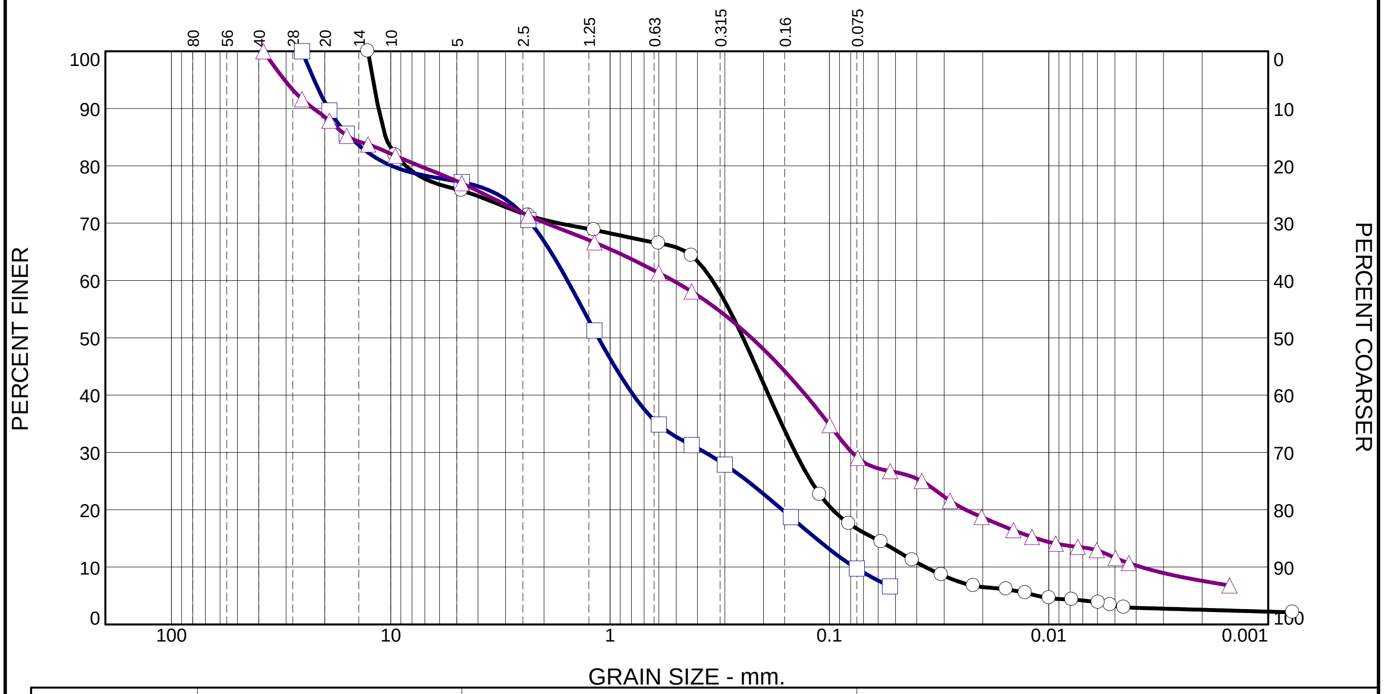
Remarks:

Figure 7

Tested By: ○ MA/AM □ MA/TA △ MP/AM ◇ MA/AM ▽ MA/TA **Checked By:** JB

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	24	5	7	47	14	3
□	0	10	13	10	36	21	10	
△	0	12	11	7	12	29	21	8

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			10.5465	0.3415	0.2479	0.1432	0.0622	0.0365	1.64	9.34
□			15.3170	1.5667	1.1313	0.3688	0.1152	0.0769	1.13	20.36
△			15.5394	0.5179	0.2267	0.0791	0.0114	0.0038	3.19	136.78

Material Description	USCS	AASHTO
○ GRAVELLY SAND, some silt, trace clay		
□ GRAVELLY SAND, trace to some silt		
△ SILTY SAND and GRAVEL, trace clay		

Project No. 13-107 **Client:** Waste Management

Project: Landfill Expansion

○ **Sample Number:** BH 8, Sample 4B

□ **Sample Number:** BH 8, Sample 6

△ **Sample Number:** BH 11, Sample 6

Remarks:

alston associates inc.
consulting engineers

Figure 8

Tested By: ○ MA/TA □ MA △ AR/AM **Checked By:** JB

APPENDIX 3

ADDENDUM TO REPORT, GEOTECHNICAL INVESTIGATION, WASTE MANAGEMENT, CARP ROAD, CARP, ONTARIO REF. NO. 13-107A, DATED DECEMBER 16, 2013

ADDENDUM TO REPORT
GEOTECHNICAL INVESTIGATION
WASTE MANAGEMENT
CARP ROAD
CARP, ONTARIO

Ref. No. 13-107A
16 December 2013

AECOM Canada
300 Town Centre Blvd.
Markham, Ontario
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Ref. No. 13-107A

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  2.2 Landfill Liner 3
  2.3 Native Soil Profile 4

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  3.1 Slope Stability 4
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APPENDICES

SLOPE STABILITY ANALYSIS, STATIC CONDITION, 1 YEAR OLD FILL . . . . Appendix ‘AA’

SLOPE STABILITY ANALYSIS, STATIC CONDITION, 16 YEARS OLD FILL . . . . Appendix ‘BB’

SLOPE STABILITY ANALYSIS, SEISMIC LOAD, 1 YEAR OLD FILL . . . . Appendix ‘CC’

SLOPE STABILITY ANALYSIS, SEISMIC LOAD, 16 YEARS OLD FILL . . . . Appendix ‘DD’

SETTLEMENT ANALYSIS, NORTH-SOUTH SECTION . . . . Appendix ‘EE’

SETTLEMENT ANALYSIS, EAST-WEST SECTION . . . . Appendix ‘FF’

ADDENDUM TO REPORT
GEOTECHNICAL INVESTIGATION
WASTE MANAGEMENT
CARP ROAD
CARP, ONTARIO

1.0 INTRODUCTION

A geotechnical investigation was carried out at the proposed landfill development site which is located immediately north of a closed landfilled site which was operated by Waste Management on the west side of Carp Road and north of Highway 417 in Carp, Ontario. The geotechnical investigation study presents the results of borehole explorations, test pit excavations and soundings put down at the site to determine in situ soil parameters for of the landfill facility; the results of the study have been presented in the companion report reference 13-107, date 3 December 2013. Analyses carried out in that report with regards to the stability of the side slopes of the completed landfill and the settlement characteristics of the supporting soil profile were made on the basis of conventional (conservative) parameters for shear strength and unit weight of the landfill materials and were intended to support the conceptual design of the landfill. Facility design has now progressed from conceptual to the detailed phase. This report addendum updates the geotechnical design of the landfill.

It is the intention of Waste Management that the municipal waste materials be compacted to a dense condition, similar to that achieved on other current landfill sites in Ontario, which are operated by Waste Management. Selection of soil parameters for assessment of stability presented in this report is based on the results of the testing work carried out to determine the shear strength of samples of densely compacted municipal waste material on samples excavated from the Richmond Landfill site in Napanee, Ontario.

This study presents the results of detailed analysis of side slope stability for both static and seismic loading as well as anticipated settlement which will occur under the completed landfill site.

2.0 SELECTION OF SOIL PARAMETERS

2.1 Municipal Waste Material

Recent work carried out on active landfill sites shows that municipal waste can be compacted to a density which was not achievable prior to the development of the current generation of compaction equipment. Denser compaction of the waste material has resulted in a higher unit weight of the fill, and improved shear strength characteristics. Work carried out to determine the geotechnical parameters of landfilled municipal waste excavated from the Waste Management Richmond Landfill site shows the following representative soil parameters. (1) (2)

Age of Municipal Solid Waste	Cohesion Intercept C' (kPa)	Effective Angle of Internal ø'
6 months old	27	26°
1 year old	32	28°
16 years old	9	37°

Records for the Richmond Landfill indicate that the representative unit weight of the compacted waste, including daily cover, is 14 kN/m³.

Reference to the foregoing test results shows that in general, the shear strength characteristics of the landfilled municipal waste increase with time. This is attributed to a denser state of packing of the materials and increased interlock between rigid particles included in the waste fill.

Comparison was made of the recorded results with data reported by other researchers the test data for the Richmond site have been shown to be reasonably consistent with test results reported by others. (3) (4)

2.2 Landfill Liner

It is proposed that the landfill liner will consist of a double composite liner as required by the Ontario Ministry of the Environment. This consists of the following components:

- *Landfill leachate collection system embedded in 0.3 m thick layer of granular material;*
- *Needle punched nonwoven geotextile;*
- *1.5 mm thick HDPE liner;*
- *0.75 m thick engineered clay liner;*
- *Needle punched nonwoven geotextile;*
- *0.3 m thick granular secondary leachate collection layer;*
- *Needle punched nonwoven geotextile;*
- *2 mm thick HDPE liner;*
- *0.75 m thick engineered clayey secondary liner;*
- *1 m thick attenuation layer consisting or natural of constructed low permeability soil.*

In order to enhance the adhesion between the HDPE liner and both the overlying nonwoven geotextile, as well as the underlying engineered clayey liner, it is proposed that the HDPE be a textured material. Reference to published literature shows that the friction angle between non-woven geotextile and textured HDPE ranges from 32 to 38°. The friction angle between textured HDPE and compacted clay has been found to be more than 40° (5) (6) (7) (8). The friction angle of the granular material in the drainage layer is expected to exceed 35°for hard, durable stone.

On the basis of the given data, the controlling shear strength parameters of the composite double liner system are governed by the properties of the compacted clay layer.

On the basis of these data a conservative effective friction angle of 28° has been selected for static stability analysis; an undrained shear strength of the compacted clay layer of 120 kPa is of the liner is assumed, this value will be part of the specification for liner construction.

2.3 Native Soil Profile

The soil parameters for the native soil layers have been determined on the basis of laboratory and in situ test results. These are tabulated below.

Soil Unit	Unit Weight kN/m³	Cohesion Intercept C' (kPa)	Effective Angle of Internal Friction ø' °	Constrained Modulus MPa
Compact silty sand	22	Nil	38°	110
Silty sand till	22.5	Nil	40°	350

3.0 RESULTS OF ANALYSES

3.1 Slope Stability

An analysis has been carried out with regards to the stability of the side slopes of the completed landfill using the soil parameters given in Section 2 of this Addendum Report. Those results show a factor of safety with respect to global shear failure of more than 2 for both 1 year old and 16 year old municipal waste. The analysis results are attached in

Appendices 'AA' and 'BB', respectively. This exceeds the Ministry of the Environment requirement value of 1.5 and is satisfactory.

A seismic load of 0.42 g has been adopted for analysis of slope stability under seismic loads. For this analysis an undrained shear strength of the clay liner composite of 120 kPa has been adopted. The results of the stability analysis for the 1 year old and 16 year old waste are given in Appendices 'CC' and 'DD', respectively. The results of analysis show a factor of safety of more than 1.1 which is satisfactory.

3.2 Settlement

The settlement of the base of the liner under the full loads of the landfilled municipal waste have been calculated on the basis of deformation modulus values measured in the course of undertaking DMT soundings. The results of the analyses show estimated settlement in both north-south and east-west directions are attached in Appendices 'EE' and 'FF'. These analyses show that the maximum deformation of the landfill base under full load is expected to be in the range 25 to 30 mm. The calculated settlement profile beneath the landfill is given in Page 5 of each reported analysis.

ALSTON ASSOCIATES INC.

Yours very truly,

C. ALSTON
20 March 2014

Colin Alston, P.Eng.

/ld

V. NERSESIAN
33773705
MARCH 20/14

Vic Nersesian, P.Eng.

References

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3. Landva AO and Clark JI (1990) “Geotechnics of Waste Fill” Geotechnics of Waste Fill - Theory and Practice, ASTM STP 1070

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   “Soil/Geosynthetic Interface Friction by Direct Shear”, Tech Note 006-90

7. Bhatia SK Kasturi G
   Comparison of PVC and HDPE Geomembranes (interface friction performance)
   Department of Civil and Environmental Engineering, Syracuse University report for PVC Geomembrane Institute

8. Stark TD Williamson TA Eid HT (1996) “HDPE Geomembrane/Geotextile Interface Shear Strength” ASCE Journal of Geotech Engineering) Vol. 122, No. 3

APPENDIX ‘AA’

Slope stability analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Slope Stability Analysis - south to north, center of pile - (12 month old municipal waste)
Author : CA/KC
Date : 2013-08-29

Settings

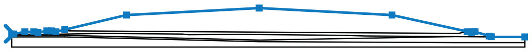
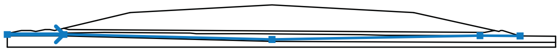
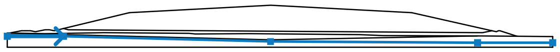
Standard - safety factors

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	SF_S =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	15.00	2.35	14.97	15.00	17.50
		25.00	17.50	30.00	16.50	40.00	18.50
		45.00	18.50	50.00	17.50	60.00	19.87
		130.00	36.50	280.00	44.50	430.00	36.50
		515.26	17.55	520.00	16.50	522.00	17.50
		524.00	17.50	540.00	12.50	542.39	11.74
		542.41	11.73	580.00	11.50		
2		60.00	19.87	65.00	18.50	505.00	15.50
		515.26	17.55				
3		2.35	14.97	40.00	14.50	103.00	15.50
		103.11	15.61	193.33	14.83	200.00	14.00
		256.96	14.28	374.19	13.27	400.00	12.50
		500.00	12.00				
4		0.00	13.32	60.00	13.32	280.00	7.95
		500.00	12.00	542.41	11.73		
5		0.00	11.62	60.00	11.62	280.00	6.15
		500.00	5.00	580.00	5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Compact Silty Sand	▨	38.00	0.00	22.00
2	Silty Sand Till	▨	40.00	0.00	22.50

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
3	Clay Liner	▨	28.00	0.00	19.50
4	Waste	▨	28.00	30.00	14.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact Silty Sand	▨	22.00		
2	Silty Sand Till	▨	22.50		
3	Clay Liner	▨	19.50		
4	Waste	▨	14.00		

Soil parameters

Compact Silty Sand

Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till

Unit weight : γ = 22.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 40.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Clay Liner

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

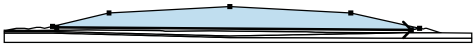
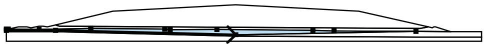
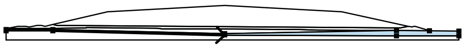
Waste

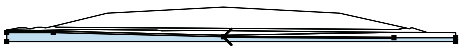
Unit weight : γ = 14.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 30.00 kPa
Saturated unit weight : γ_{sat} = 14.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Bedrock	▦	24.00

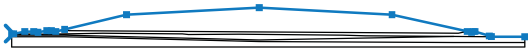
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	18.50	505.00	15.50	Waste
		515.26	17.55	430.00	36.50	
		280.00	44.50	130.00	36.50	▨
		60.00	19.87			
2		542.41	11.73	542.39	11.74	Clay Liner
		540.00	12.50	524.00	17.50	
		522.00	17.50	520.00	16.50	
		515.26	17.55	505.00	15.50	
		65.00	18.50	60.00	19.87	
		50.00	17.50	45.00	18.50	
		40.00	18.50	30.00	16.50	
		25.00	17.50	15.00	17.50	▤
		2.35	14.97	40.00	14.50	
		103.00	15.50	103.11	15.61	
		193.33	14.83	200.00	14.00	
		256.96	14.28	374.19	13.27	
		400.00	12.50	500.00	12.00	
3		60.00	13.32	280.00	7.95	Compact Silty Sand
		500.00	12.00	400.00	12.50	
		374.19	13.27	256.96	14.28	
		200.00	14.00	193.33	14.83	▨
		103.11	15.61	103.00	15.50	
		40.00	14.50	2.35	14.97	
		0.00	15.00	0.00	13.32	
4		60.00	11.62	280.00	6.15	Silty Sand Till
		500.00	5.00	580.00	5.00	
		580.00	11.50	542.41	11.73	
		500.00	12.00	280.00	7.95	▨
		60.00	13.32	0.00	13.32	
		0.00	11.62			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		500.00	5.00	280.00	6.15	Bedrock
		60.00	11.62	0.00	11.62	▨
		0.00	0.00	580.00	0.00	
		580.00	5.00			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	14.48	0.38	14.48	44.90	14.72
		50.10	17.29	60.15	19.75	65.91	20.01
		504.45	16.99	516.79	16.99	519.80	16.26
		542.25	11.29	579.35	10.80	580.00	10.79

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	71.27	[m]	Angles :	α_1 =	-15.16	[°]
	z =	115.57	[m]		α_2 =	38.35	[°]
Radius :	R =	100.57	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	133.31	36.84	132.71	36.53
2	132.80	36.54	130.07	36.41
3	132.53	36.90	50.65	17.45
4	51.04	17.46	49.94	17.54

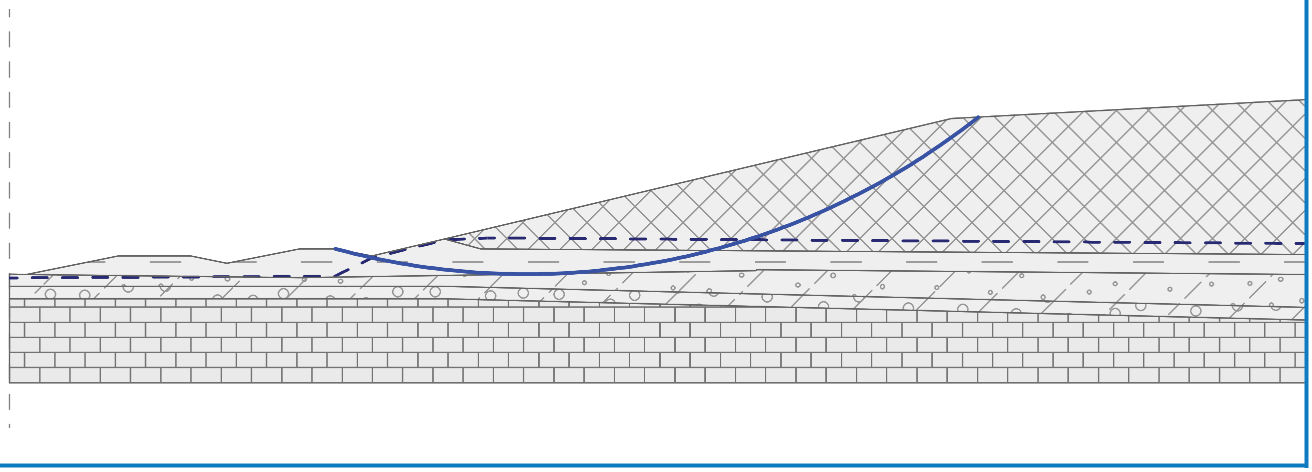
Slope stability verification (Bishop)

Sum of active forces : F_a = 1785.39 kN/m
Sum of passive forces : F_p = 4991.08 kN/m

Sliding moment : M_a = 179556.35 kNm/m
Resisting moment : M_p = 501952.96 kNm/m
Factor of safety = 2.80 > 1.50

Slope stability ACCEPTABLE

Name : 13-107 Carp Landfill Development	**Stage - analysis : 1 - 1**
Description : Slope Stability Analysis - south to north, center of pile	



APPENDIX ‘BB’

Slope stability analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Slope Stability Analysis - south to north, center of pile (sixteen year old municipal waste)
Author : CA/KC
Date : 2013-12-16

Settings

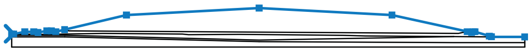
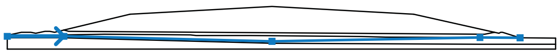
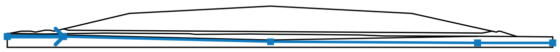
Standard - safety factors

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	SF_s =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	15.00	2.35	14.97	15.00	17.50
		25.00	17.50	30.00	16.50	40.00	18.50
		45.00	18.50	50.00	17.50	60.00	19.87
		130.00	36.50	280.00	44.50	430.00	36.50
		515.26	17.55	520.00	16.50	522.00	17.50
		524.00	17.50	540.00	12.50	542.39	11.74
		542.41	11.73	580.00	11.50		
2		60.00	19.87	65.00	18.50	505.00	15.50
		515.26	17.55				
3		2.35	14.97	40.00	14.50	103.00	15.50
		103.11	15.61	193.33	14.83	200.00	14.00
		256.96	14.28	374.19	13.27	400.00	12.50
		500.00	12.00				
4		0.00	13.32	60.00	13.32	280.00	7.95
		500.00	12.00	542.41	11.73		
5		0.00	11.62	60.00	11.62	280.00	6.15
		500.00	5.00	580.00	5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Compact Silty Sand	▨	38.00	0.00	22.00
2	Silty Sand Till	▨	40.00	0.00	22.50

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
3	Clay Liner	▨	28.00	0.00	19.50
4	Waste	▨	37.00	9.00	14.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact Silty Sand	▨	22.00		
2	Silty Sand Till	▨	22.50		
3	Clay Liner	▨	19.50		
4	Waste	▨	14.00		

Soil parameters

Compact Silty Sand
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till
Unit weight : γ = 22.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 40.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Clay Liner
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

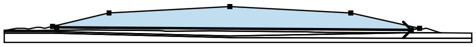
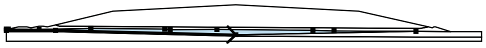
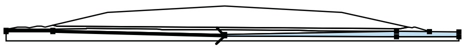
Waste

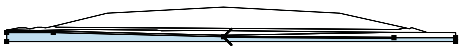
Unit weight : γ = 14.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 37.00 °
Cohesion of soil : c_{ef} = 9.00 kPa
Saturated unit weight : γ_{sat} = 14.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Bedrock	▦	24.00

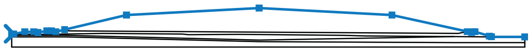
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	18.50	505.00	15.50	Waste
		515.26	17.55	430.00	36.50	
		280.00	44.50	130.00	36.50	▦
		60.00	19.87			
2		542.41	11.73	542.39	11.74	Clay Liner
		540.00	12.50	524.00	17.50	
		522.00	17.50	520.00	16.50	
		515.26	17.55	505.00	15.50	
		65.00	18.50	60.00	19.87	
		50.00	17.50	45.00	18.50	
		40.00	18.50	30.00	16.50	▤
		25.00	17.50	15.00	17.50	
		2.35	14.97	40.00	14.50	
		103.00	15.50	103.11	15.61	
		193.33	14.83	200.00	14.00	
		256.96	14.28	374.19	13.27	
		400.00	12.50	500.00	12.00	
3		60.00	13.32	280.00	7.95	Compact Silty Sand
		500.00	12.00	400.00	12.50	
		374.19	13.27	256.96	14.28	
		200.00	14.00	193.33	14.83	▨
		103.11	15.61	103.00	15.50	
		40.00	14.50	2.35	14.97	
		0.00	15.00	0.00	13.32	
4		60.00	11.62	280.00	6.15	Silty Sand Till
		500.00	5.00	580.00	5.00	
		580.00	11.50	542.41	11.73	
		500.00	12.00	280.00	7.95	▨
		60.00	13.32	0.00	13.32	
		0.00	11.62			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		500.00	5.00	280.00	6.15	Bedrock
		60.00	11.62	0.00	11.62	▨
		0.00	0.00	580.00	0.00	
		580.00	5.00			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	14.48	0.38	14.48	44.90	14.72
		50.10	17.29	60.15	19.75	65.91	20.01
		504.45	16.99	516.79	16.99	519.80	16.26
		542.25	11.29	579.35	10.80	580.00	10.79

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	71.04	[m]	Angles :	α_1 =	-15.27	[°]
	z =	114.44	[m]		α_2 =	38.55	[°]
Radius :	R =	99.45	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	133.31	36.84	132.71	36.53
2	132.80	36.54	130.07	36.41
3	132.53	36.90	50.65	17.45
4	51.04	17.46	49.94	17.54

Slope stability verification (Bishop)

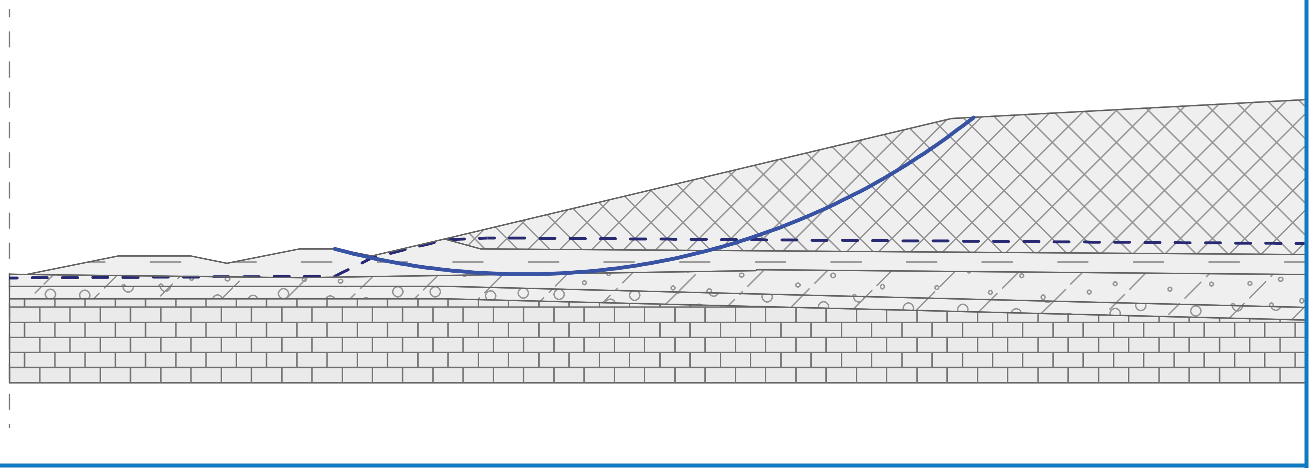
Sum of active forces : F_a = 1759.03 kN/m
Sum of passive forces : F_p = 4817.30 kN/m

Sliding moment : M_a = 174935.66 kNm/m
Resisting moment : M_p = 479080.29 kNm/m
Factor of safety = 2.74 > 1.50

Slope stability ACCEPTABLE

Name : 13-107 Carp Landfill Development | **Stage - analysis : 1 - 1**

Description : Slope Stability Analysis - south to north, center of pile



APPENDIX ‘CC’

Slope stability analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Slope Stability Analysis - south to north, center of pile (12 month old municipal waste)
Author : CA/KC
Date : 2013-12-09

Settings

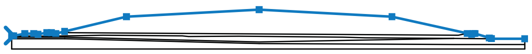
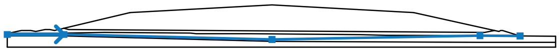
(input for current task)

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor :	SF_S =	1.10	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	15.00	2.35	14.97	15.00	17.50
		25.00	17.50	30.00	16.50	40.00	18.50
		45.00	18.50	50.00	17.50	60.00	19.87
		130.00	36.50	280.00	44.50	430.00	36.50
		515.26	17.55	520.00	16.50	522.00	17.50
		524.00	17.50	540.00	12.50	542.39	11.74
		542.41	11.73	580.00	11.50		
2		60.00	19.87	65.00	18.50	505.00	15.50
		515.26	17.55				
3		2.35	14.97	40.00	14.50	103.00	15.50
		103.11	15.61	193.33	14.83	200.00	14.00
		256.96	14.28	374.19	13.27	400.00	12.50
		500.00	12.00				
4		0.00	13.32	60.00	13.32	280.00	7.95
		500.00	12.00	542.41	11.73		
5		0.00	11.62	60.00	11.62	280.00	6.15
		500.00	5.00	580.00	5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Compact Silty Sand	▨	38.00	0.00	22.00
2	Silty Sand Till	▨	40.00	0.00	22.50

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
3	Clay Liner	▨	0.00	120.00	19.50
4	Waste	▨	28.00	30.00	14.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact Silty Sand	▨	22.00		
2	Silty Sand Till	▨	22.50		
3	Clay Liner	▨	19.50		
4	Waste	▨	14.00		

Soil parameters

Compact Silty Sand
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till
Unit weight : γ = 22.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 40.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Clay Liner
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 0.00 °
Cohesion of soil : c_{ef} = 120.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

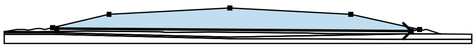
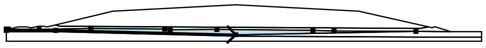
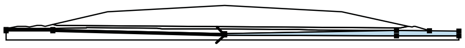
Waste

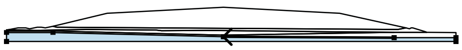
Unit weight :	γ = 14.00 kN/m^3
Stress-state :	effective
Angle of internal friction :	φ_{ef} = 28.00 °
Cohesion of soil :	c_{ef} = 30.00 kPa
Saturated unit weight :	γ_{sat} = 14.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Bedrock	▨	24.00

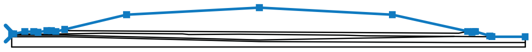
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	18.50	505.00	15.50	Waste ▨
		515.26	17.55	430.00	36.50	
		280.00	44.50	130.00	36.50	
		60.00	19.87			
2		542.41	11.73	542.39	11.74	Clay Liner ▨
		540.00	12.50	524.00	17.50	
		522.00	17.50	520.00	16.50	
		515.26	17.55	505.00	15.50	
		65.00	18.50	60.00	19.87	
		50.00	17.50	45.00	18.50	
		40.00	18.50	30.00	16.50	
		25.00	17.50	15.00	17.50	
		2.35	14.97	40.00	14.50	
		103.00	15.50	103.11	15.61	
		193.33	14.83	200.00	14.00	
		256.96	14.28	374.19	13.27	
		400.00	12.50	500.00	12.00	
3		60.00	13.32	280.00	7.95	Compact Silty Sand ▨
		500.00	12.00	400.00	12.50	
		374.19	13.27	256.96	14.28	
		200.00	14.00	193.33	14.83	
		103.11	15.61	103.00	15.50	
		40.00	14.50	2.35	14.97	
		0.00	15.00	0.00	13.32	
4		60.00	11.62	280.00	6.15	Silty Sand Till ▨
		500.00	5.00	580.00	5.00	
		580.00	11.50	542.41	11.73	
		500.00	12.00	280.00	7.95	
		60.00	13.32	0.00	13.32	
		0.00	11.62			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		500.00	5.00	280.00	6.15	Bedrock
		60.00	11.62	0.00	11.62	
		0.00	0.00	580.00	0.00	▨
		580.00	5.00			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	14.48	0.38	14.48	44.90	14.72
		50.10	17.29	60.15	19.75	65.91	20.01
		504.45	16.99	516.79	16.99	519.80	16.26
		542.25	11.29	579.35	10.80	580.00	10.79

Tensile crack

Tensile crack not inputted.

Earthquake

Horizontal seismic coefficient : K_h = 0.42
Vertical seismic coefficient : K_v = 0.00

Settings of the stage of construction

Design situation : seismic

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	49.63	[m]	Angles :	α_1 =	-7.99	[°]
	z =	352.95	[m]		α_2 =	23.26	[°]
Radius :	R =	341.29	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	133.31	36.84	132.71	36.53
2	132.80	36.54	130.07	36.41
3	132.53	36.90	50.65	17.45
4	51.04	17.46	49.94	17.54

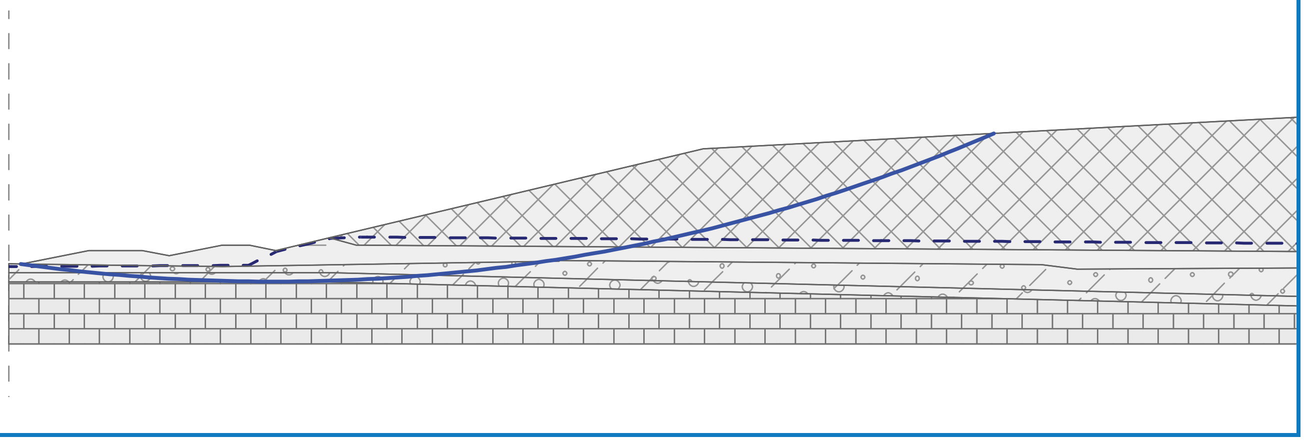
Slope stability verification (Bishop)

Sum of active forces : F_a = 14306.23 kN/m
Sum of passive forces : F_p = 15840.69 kN/m

Sliding moment : M_a = 4882572.52 kNm/m
Resisting moment : M_p = 5406270.52 kNm/m
Factor of safety = 1.11 > 1.10

Slope stability ACCEPTABLE

Name : 13-107 Carp Landfill Development	Stage - analysis : 1 - 1
Description : Slope Stability Analysis - south to north, center of pile	



APPENDIX ‘DD’

Slope stability analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Slope Stability Analysis (seismic)- south to north, center of pile (sixteen year old municipal waste)
Author : CA/KC
Date : 2013-12-16

Settings

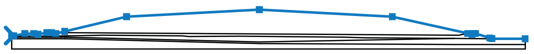
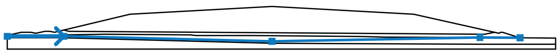
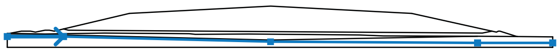
(input for current task)

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor :	SF_S =	1.10	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	15.00	2.35	14.97	15.00	17.50
		25.00	17.50	30.00	16.50	40.00	18.50
		45.00	18.50	50.00	17.50	60.00	19.87
		130.00	36.50	280.00	44.50	430.00	36.50
		515.26	17.55	520.00	16.50	522.00	17.50
		524.00	17.50	540.00	12.50	542.39	11.74
		542.41	11.73	580.00	11.50		
2		60.00	19.87	65.00	18.50	505.00	15.50
		515.26	17.55				
3		2.35	14.97	40.00	14.50	103.00	15.50
		103.11	15.61	193.33	14.83	200.00	14.00
		256.96	14.28	374.19	13.27	400.00	12.50
		500.00	12.00				
4		0.00	13.32	60.00	13.32	280.00	7.95
		500.00	12.00	542.41	11.73		
5		0.00	11.62	60.00	11.62	280.00	6.15
		500.00	5.00	580.00	5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Compact Silty Sand	▨	38.00	0.00	22.00
2	Silty Sand Till	▨	40.00	0.00	22.50

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
3	Clay Liner	▤	0.00	120.00	19.50
4	Waste	▩	37.00	9.00	14.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact Silty Sand	▨	22.00		
2	Silty Sand Till	▨	22.50		
3	Clay Liner	▤	19.50		
4	Waste	▩	14.00		

Soil parameters

Compact Silty Sand
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till
Unit weight : γ = 22.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 40.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Clay Liner
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 0.00 °
Cohesion of soil : c_{ef} = 120.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

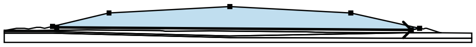
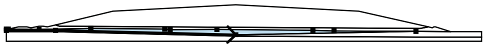
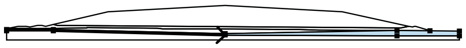
Waste

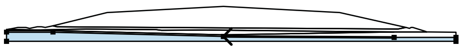
Unit weight : γ = 14.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 37.00 °
Cohesion of soil : c_{ef} = 9.00 kPa
Saturated unit weight : γ_{sat} = 14.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Bedrock	▨	24.00

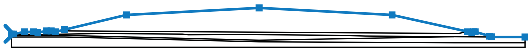
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	18.50	505.00	15.50	Waste
		515.26	17.55	430.00	36.50	▨
		280.00	44.50	130.00	36.50	
		60.00	19.87			
2		542.41	11.73	542.39	11.74	Clay Liner
		540.00	12.50	524.00	17.50	▨
		522.00	17.50	520.00	16.50	
		515.26	17.55	505.00	15.50	
		65.00	18.50	60.00	19.87	
		50.00	17.50	45.00	18.50	
		40.00	18.50	30.00	16.50	
		25.00	17.50	15.00	17.50	
		2.35	14.97	40.00	14.50	
		103.00	15.50	103.11	15.61	
		193.33	14.83	200.00	14.00	
		256.96	14.28	374.19	13.27	
		400.00	12.50	500.00	12.00	
3		60.00	13.32	280.00	7.95	Compact Silty Sand
		500.00	12.00	400.00	12.50	▨
		374.19	13.27	256.96	14.28	
		200.00	14.00	193.33	14.83	
		103.11	15.61	103.00	15.50	
		40.00	14.50	2.35	14.97	
		0.00	15.00	0.00	13.32	
4		60.00	11.62	280.00	6.15	Silty Sand Till
		500.00	5.00	580.00	5.00	▨
		580.00	11.50	542.41	11.73	
		500.00	12.00	280.00	7.95	
		60.00	13.32	0.00	13.32	
		0.00	11.62			

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Surface position</th><th colspan="4">Coordinates of surface points [m]</th><th rowspan="2">Assigned
soil</th></tr>
<tr><th>x</th><th>z</th><th>x</th><th>z</th></tr>
<tr><td rowspan="4">5</td><td rowspan="4"></td><td>500.00</td><td>5.00</td><td>280.00</td><td>6.15</td><td rowspan="2">Bedrock</td></tr>
<tr><td>60.00</td><td>11.62</td><td>0.00</td><td>11.62</td></tr>
<tr><td>0.00</td><td>0.00</td><td>580.00</td><td>0.00</td><td rowspan="2">▨</td></tr>
<tr><td>580.00</td><td>5.00</td><td></td><td></td></tr>
</table>

Water

Water type : GWT

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">GWT location</th><th colspan="6">Coordinates of GWT points [m]</th></tr>
<tr><th>x</th><th>z</th><th>x</th><th>z</th><th>x</th><th>z</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4"></td><td>0.00</td><td>14.48</td><td>0.38</td><td>14.48</td><td>44.90</td><td>14.72</td></tr>
<tr><td>50.10</td><td>17.29</td><td>60.15</td><td>19.75</td><td>65.91</td><td>20.01</td></tr>
<tr><td>504.45</td><td>16.99</td><td>516.79</td><td>16.99</td><td>519.80</td><td>16.26</td></tr>
<tr><td>542.25</td><td>11.29</td><td>579.35</td><td>10.80</td><td>580.00</td><td>10.79</td></tr>
</table>

Tensile crack

Tensile crack not inputted.

Earthquake

Horizontal seismic coefficient : K_h = 0.42

Vertical seismic coefficient : K_v = 0.00

Settings of the stage of construction

Design situation : seismic

Results (Stage of construction 1)

Analysis 1

Circular slip surface

<table>
<tr><th colspan="8">Slip surface parameters</th></tr>
<tr><td rowspan="2">Center :</td><td>x =</td><td>75.91</td><td>[m]</td><td rowspan="2">Angles :</td><td>α_1 =</td><td>-13.41</td><td>[°]</td></tr>
<tr><td>z =</td><td>206.67</td><td>[m]</td><td>α_2 =</td><td>30.86</td><td>[°]</td></tr>
<tr><td>Radius :</td><td>R =</td><td>195.37</td><td>[m]</td><td colspan="4"></td></tr>
<tr><td colspan="8">The slip surface after optimization.</td></tr>
</table>

Segments restricting slip surface

<table>
<tr><th rowspan="2">No.</th><th colspan="2">First point</th><th colspan="2">Second point</th></tr>
<tr><th>x [m]</th><th>z [m]</th><th>x [m]</th><th>z [m]</th></tr>
<tr><td>1</td><td>133.31</td><td>36.84</td><td>132.71</td><td>36.53</td></tr>
<tr><td>2</td><td>132.80</td><td>36.54</td><td>130.07</td><td>36.41</td></tr>
<tr><td>3</td><td>132.53</td><td>36.90</td><td>50.65</td><td>17.45</td></tr>
<tr><td>4</td><td>51.04</td><td>17.46</td><td>49.94</td><td>17.54</td></tr>
</table>

Slope stability verification (Bishop)

Sum of active forces : F_a = 14020.36 kN/m

Sum of passive forces : F_p = 15847.67 kN/m

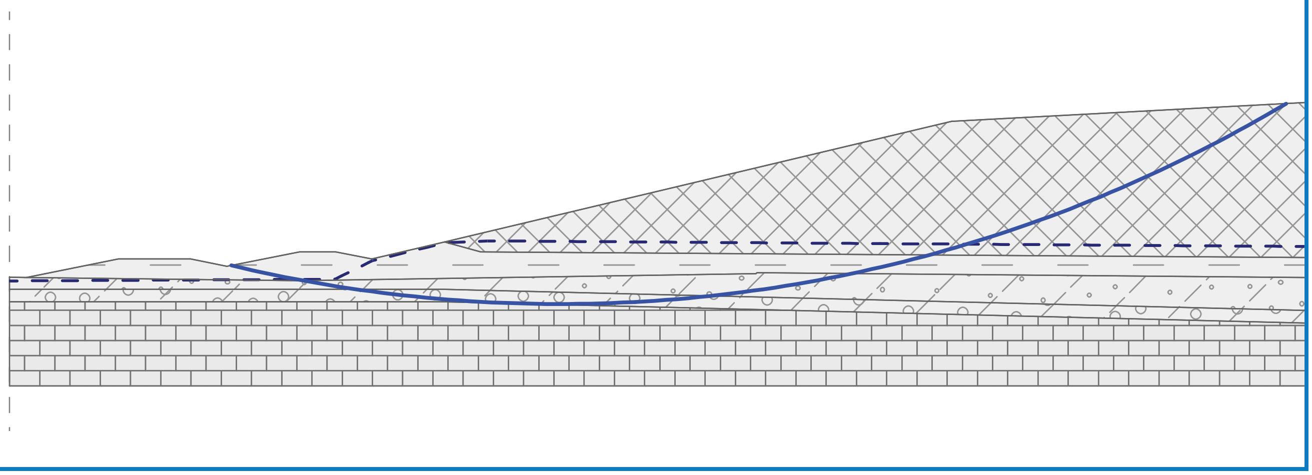
Sliding moment : M_a = 2739157.55 kNm/m

Resisting moment : M_p = 3096159.81 kNm/m

Factor of safety = 1.13 > 1.10

Slope stability ACCEPTABLE

Name : 13-107 Carp Landfill Development	**Stage - analysis : 1 - 1**
Description : Slope Stability Analysis - south to north, center of pile	



APPENDIX ‘EE’

Settlement analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Settlement Analysis - south to north, center of pile
Author : CA/KC
Date : 2013-08-29

Settings

Standard - safety factors

Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	125.50	40.00	125.00	103.00	126.00
		104.00	127.00	180.00	127.00	200.00	124.50
		300.00	125.00	350.00	124.50	400.00	123.00
		500.00	122.50	580.00	122.00		
2		0.00	123.82	60.00	123.82	280.00	118.45
		500.00	122.50				
3		0.00	122.12	60.00	122.12	280.00	116.65
		500.00	115.50	580.00	115.50		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	119.12	60.00	119.12	280.00	113.65
		500.00	112.50	580.00	112.50		

Soil parameters

Compact Silty Sand
Unit weight : γ = 22.00 kN/m^3
Oedometric modulus : E_{oed} = 110.00 MPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till
Unit weight : γ = 22.50 kN/m^3
Oedometric modulus : E_{oed} = 350.00 MPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Bedrock
Unit weight : γ = 24.00 kN/m^3
Oedometric modulus : E_{oed} = 500.00 MPa
Saturated unit weight : γ_{sat} = 24.00 kN/m^3

Clay Liner

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 25.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Waste
Unit weight : γ = 14.00 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 14.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		60.00	123.82	280.00	118.45	Compact Silty Sand ▨
		500.00	122.50	400.00	123.00	
		350.00	124.50	300.00	125.00	
		200.00	124.50	180.00	127.00	
		104.00	127.00	103.00	126.00	
		40.00	125.00	0.00	125.50	
		0.00	123.82			
2		60.00	122.12	280.00	116.65	Silty Sand Till ▨
		500.00	115.50	580.00	115.50	
		580.00	122.00	500.00	122.50	
		280.00	118.45	60.00	123.82	
		0.00	123.82	0.00	122.12	
3		500.00	115.50	280.00	116.65	Bedrock ▦
		60.00	122.12	0.00	122.12	
		0.00	110.50	580.00	110.50	
		580.00	115.50			

Water

Water type : No water

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

Results (Stage of construction 1)

Results

Analysis of geostatic stress was successfully completed

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		0.00	127.00	580.00	122.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		400.00	123.00	374.19	123.77	Compact Silty Sand
		256.96	124.78	200.00	124.50	▨
		193.33	125.33	103.11	126.11	
		103.00	126.00	40.00	125.00	
		0.00	125.50	0.00	123.82	
		60.00	123.82	280.00	118.45	
		500.00	122.50			
2		60.00	122.12	280.00	116.65	Silty Sand Till
		500.00	115.50	580.00	115.50	▨
		580.00	122.00	500.00	122.50	
		280.00	118.45	60.00	123.82	
		0.00	123.82	0.00	122.12	
3		500.00	115.50	280.00	116.65	Bedrock
		60.00	122.12	0.00	122.12	▨
		0.00	110.50	580.00	110.50	
		580.00	115.50			

Water

Water type : No water

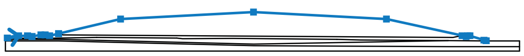
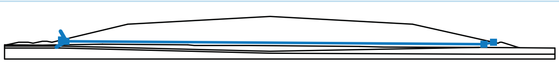
Results (Stage of construction 2)

Results

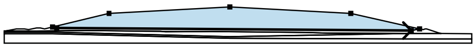
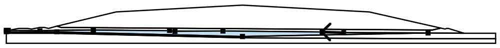
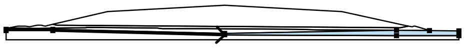
Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 0.0 mm
Maximum depth of influence zone = 0.00 m

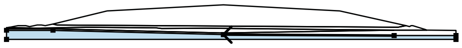
Input data (Stage of construction 3)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		2.35	125.47	15.00	128.00	25.00	128.00
		30.00	127.00	40.00	129.00	45.00	129.00
		50.00	128.00	60.00	130.37	130.00	147.00
		280.00	155.00	430.00	147.00	515.26	128.05
		520.00	127.00	522.00	128.00	524.00	128.00
		540.00	123.00	542.39	122.24	542.41	122.23
2		60.00	130.37	65.00	129.00	505.00	126.00
		515.26	128.05				

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.00	129.00	505.00	126.00	Waste ▨
		515.26	128.05	430.00	147.00	
		280.00	155.00	130.00	147.00	
		60.00	130.37			
2		400.00	123.00	500.00	122.50	Clay Liner ▨
		542.41	122.23	542.39	122.24	
		540.00	123.00	524.00	128.00	
		522.00	128.00	520.00	127.00	
		515.26	128.05	505.00	126.00	
		65.00	129.00	60.00	130.37	
		50.00	128.00	45.00	129.00	
		40.00	129.00	30.00	127.00	
		25.00	128.00	15.00	128.00	
		2.35	125.47	40.00	125.00	
		103.00	126.00	103.11	126.11	
		193.33	125.33	200.00	124.50	
		256.96	124.78	374.19	123.77	
3		400.00	123.00	374.19	123.77	Compact Silty Sand ▨
		256.96	124.78	200.00	124.50	
		193.33	125.33	103.11	126.11	
		103.00	126.00	40.00	125.00	
		2.35	125.47	0.00	125.50	
		0.00	123.82	60.00	123.82	
		280.00	118.45	500.00	122.50	
4		60.00	122.12	280.00	116.65	Silty Sand Till ▨
		500.00	115.50	580.00	115.50	
		580.00	122.00	542.41	122.23	
		500.00	122.50	280.00	118.45	
		60.00	123.82	0.00	123.82	
		0.00	122.12			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		500.00	115.50	280.00	116.65	Bedrock
		60.00	122.12	0.00	122.12	
		0.00	110.50	580.00	110.50	▨
		580.00	115.50			

Water

Water type : No water

Results (Stage of construction 3)

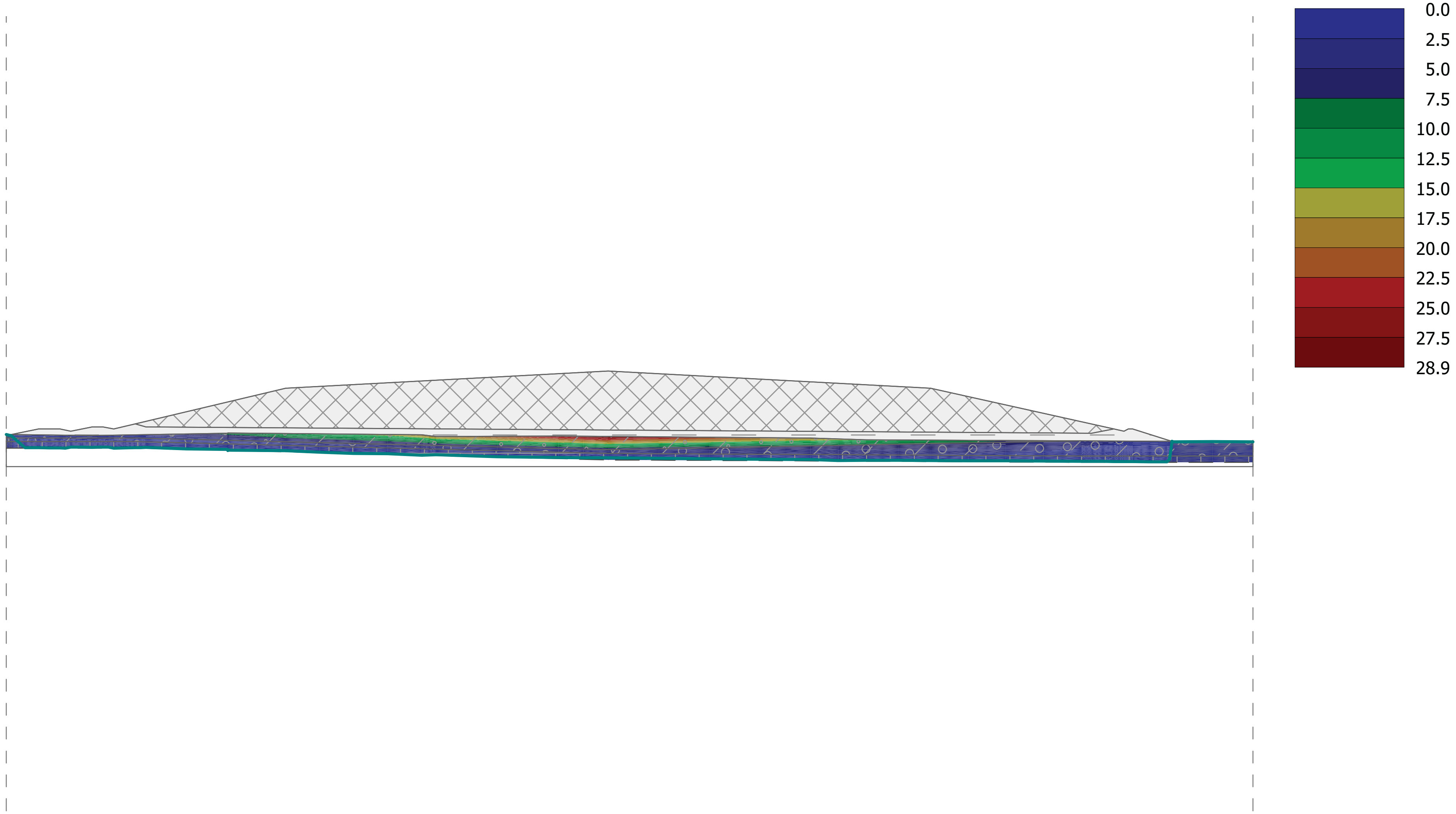
Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 28.9 mm
Maximum depth of influence zone = 10.00 m

Name : 13-107 Carp Landfill Development | **Stage : 3**

Description : Settlement Analysis - south to north, center of pile

Results : overall; variable : Settlement; range : <0.0; 28.9> mm



APPENDIX ‘FF’

Settlement analysis

Input data

Project

Task : 13-107 Carp Landfill Development
Description : Settlement Analysis - west to east, center of pile
Author : CA/KC
Date : 2013-08-29

Settings

Standard - safety factors

Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	125.00	260.00	125.00	460.00	126.00
		480.00	125.50	510.00	126.00	700.00	127.00
		750.00	128.00	820.00	128.00	840.00	130.00
		900.00	130.00	960.00	130.00		
2		0.00	120.27	90.00	120.44	450.00	118.45
		900.80	121.93	960.00	121.93		
3		0.00	119.24	90.00	119.24	450.00	116.65
		900.00	117.42	960.00	117.42		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	116.24	90.00	116.24	450.00	113.65
		900.00	114.42	960.00	114.42		

Soil parameters

Compact Silty Sand
Unit weight : γ = 22.00 kN/m^3
Oedometric modulus : E_{oed} = 110.00 MPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Sand Till
Unit weight : γ = 22.50 kN/m^3
Oedometric modulus : E_{oed} = 350.00 MPa
Saturated unit weight : γ_{sat} = 22.50 kN/m^3

Bedrock
Unit weight : γ = 24.00 kN/m^3
Oedometric modulus : E_{oed} = 500.00 MPa
Saturated unit weight : γ_{sat} = 24.00 kN/m^3

Clay Liner

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 25.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Waste
Unit weight : γ = 14.00 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 14.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		90.00	120.44	450.00	118.45	Compact Silty Sand
		900.80	121.93	960.00	121.93	
		960.00	130.00	900.00	130.00	
		840.00	130.00	820.00	128.00	▨
		750.00	128.00	700.00	127.00	
		510.00	126.00	480.00	125.50	
		460.00	126.00	260.00	125.00	
		0.00	125.00	0.00	120.27	
2		90.00	119.24	450.00	116.65	Silty Sand Till
		900.00	117.42	960.00	117.42	
		960.00	121.93	900.80	121.93	▨
		450.00	118.45	90.00	120.44	
		0.00	120.27	0.00	119.24	
3		900.00	117.42	450.00	116.65	Bedrock
		90.00	119.24	0.00	119.24	
		0.00	111.65	960.00	111.65	▨
		960.00	117.42			

Water

Water type : No water

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

Results (Stage of construction 1)

Results

Analysis of geostatic stress was successfully completed

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		0.00	126.00	960.00	122.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		90.00	120.44	450.00	118.45	Compact Silty Sand
		900.80	121.93	960.00	121.93	▨
		960.00	122.00	240.00	125.00	
		0.00	125.00	0.00	120.27	
2		90.00	119.24	450.00	116.65	Silty Sand Till
		900.00	117.42	960.00	117.42	▨
		960.00	121.93	900.80	121.93	
		450.00	118.45	90.00	120.44	
		0.00	120.27	0.00	119.24	
3		900.00	117.42	450.00	116.65	Bedrock
		90.00	119.24	0.00	119.24	▦
		0.00	111.65	960.00	111.65	
		960.00	117.42			

Water

Water type : No water

Results (Stage of construction 2)

Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 0.0 mm
Maximum depth of influence zone = 0.00 m

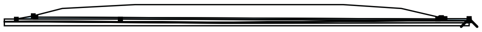
Input data (Stage of construction 3)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		25.00	125.00	60.00	132.00	120.00	147.00
		270.00	155.00	700.00	155.00	820.00	147.00
		902.11	127.84	910.00	126.00	960.00	126.00

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
2		60.00	132.00	65.04	129.03	895.00	125.00
		900.00	127.00	902.11	127.84		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		65.04	129.03	895.00	125.00	Waste
		900.00	127.00	902.11	127.84	
		820.00	147.00	700.00	155.00	▨
		270.00	155.00	120.00	147.00	
		60.00	132.00			
2		960.00	122.00	960.00	126.00	Clay Liner
		910.00	126.00	902.11	127.84	
		900.00	127.00	895.00	125.00	▨
		65.04	129.03	60.00	132.00	
		25.00	125.00	240.00	125.00	
3		90.00	120.44	450.00	118.45	Compact Silty Sand
		900.80	121.93	960.00	121.93	
		960.00	122.00	240.00	125.00	▨
		25.00	125.00	0.00	125.00	
		0.00	120.27			
4		90.00	119.24	450.00	116.65	Silty Sand Till
		900.00	117.42	960.00	117.42	
		960.00	121.93	900.80	121.93	▨
		450.00	118.45	90.00	120.44	
		0.00	120.27	0.00	119.24	
5		900.00	117.42	450.00	116.65	Bedrock
		90.00	119.24	0.00	119.24	
		0.00	111.65	960.00	111.65	▨
		960.00	117.42			

Water

Water type : No water

Results (Stage of construction 3)

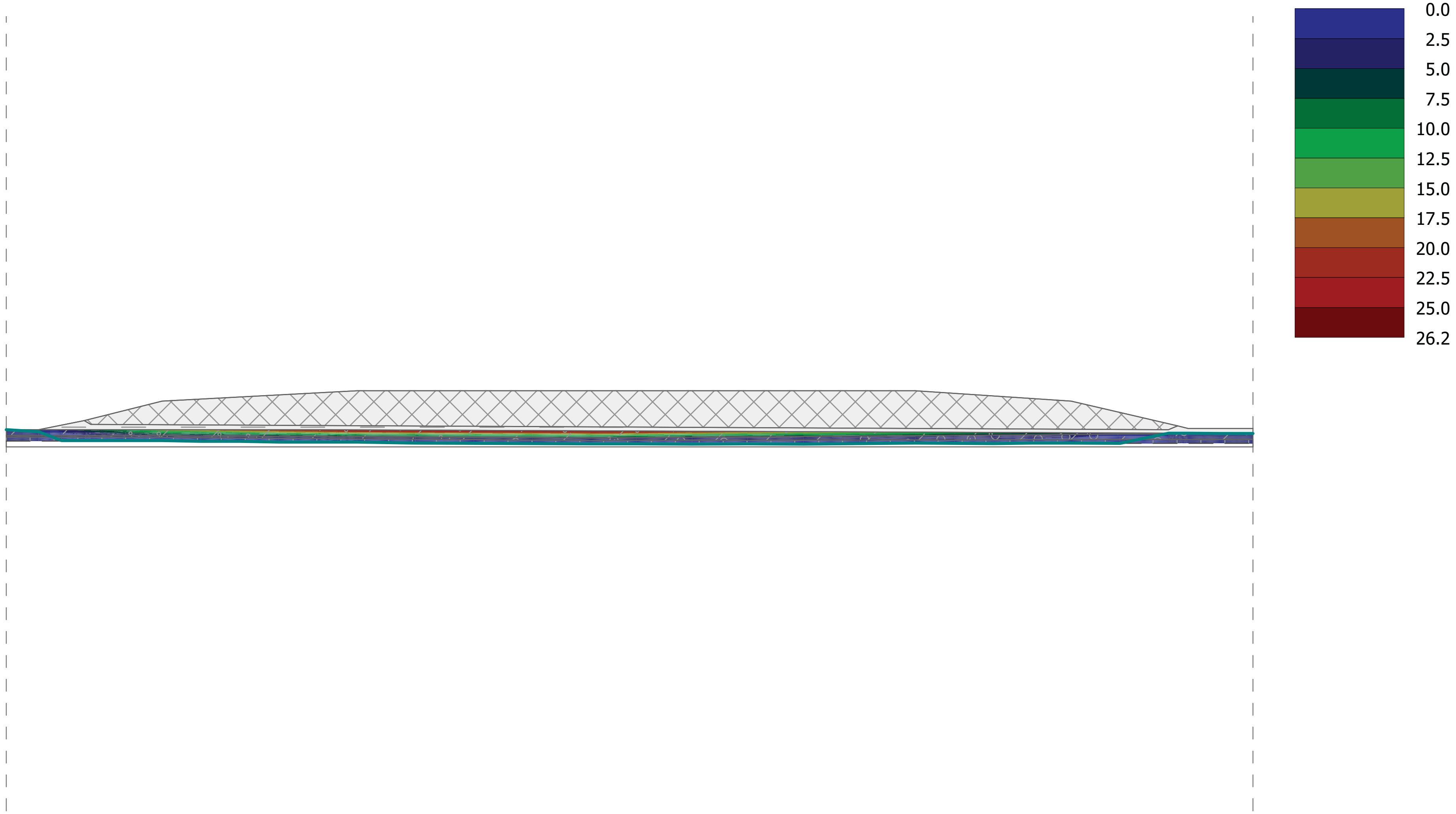
Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 26.2 mm
Maximum depth of influence zone = 10.00 m

Name : 13-107 Carp Landfill Development **Stage : 3**

Description : Settlement Analysis - west to east, center of pile

Results : overall; variable : Settlement; range : <0.0; 26.2> mm



APPENDIX 4

SUPPLEMENTAL GEOTECHNICAL INVESTIGATION, PROPOSED LANDFILL EXPANSION, WEST CARLETON ENVIRONMENTAL CENTRE, CARP, ONTARIO, REF. NO. 13-182, DATED MARCH 12, 2014

alston associates inc.
consulting engineers

geotechnics
construction materials testing

SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
PROPOSED LANDFILL EXPANSION
WEST CARLETON ENVIRONMENTAL CENTRE
CARP, ONTARIO

REPORT REF. NO. 13-182
12 March 2014

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1 INTRODUCTION

Alston Associates Inc. (**AAI**) has been retained by WSP Canada Inc. to carry out a supplemental geotechnical investigation for the proposed landfill expansion located at West Carleton Environmental Centre (WCEC) in Carp, Ontario. Authorization to proceed with this study was given by Peter Brodzikowski, P.Eng. of WSP Canada Inc.

We understand that two stormwater management (SWM) ponds and two infiltration basins are proposed for construction at the east end of the proposed landfill expansion site. We also understand that it is proposed to construct a paved access road extending from the southwest corner of the proposed landfill site to the proposed Carp Road widening, construct a granular-surfaced maintenance/service road surrounding the perimeter of the proposed landfill, and pave the existing gravel road at the southwest corner of the proposed landfill site. We also understand that several underground utilities will be installed within the proposed landfill expansion site.

The purpose of this investigation was to characterize the subsurface soil and groundwater conditions, to determine the relevant geotechnical properties of encountered soils, and to provide geotechnical recommendations for:

- Structural design of proposed paved and granular-surfaced roads, including recommendations for placement of subgrade and components of the various pavement structures;
- Geotechnical support and guidance in design of infiltration basins, including recommendations relating to percolation rate of the in-situ soils and design of above grade containment berms;
- Recommendations relating to the design and construction of two proposed lined SWM ponds;
- Design recommendations required for paving the existing gravel road to the transfer station at the southwest corner of the Waste Management (WM) property; and
- Recommendations regarding installation of various utilities, including suitability of native soils and requirements for imported soils as bedding and backfill material.

This report presents the results of the investigation performed in accordance with the general terms of reference outlined above and is intended for the guidance of the client and the design engineers only. It is assumed that the design will be in accordance with the applicable codes and standards.

2 BACKGROUND

In August 2013, a geotechnical investigation study was undertaken by **AAI** to determine the subsurface conditions for the captioned landfill expansion. Fieldwork for the investigation included advancing twelve (12) boreholes at the site, amongst which, four Boreholes numbered 4, 5, 8 and 12 were located within the area of the proposed infiltration basins then proposed. The findings of that study were presented in **AAI** geotechnical report Ref. 13-107 dated 3 December, 2013. Copies of the logs for Boreholes 4, 5, 8 and 12 are attached in Appendix C of this report.

3 FEATURES FOR SUPPLEMENTAL GEOTECHNICAL INVESTIGATION

The proposed WCEC landfill expansion is located immediately north of the existing closed Carp landfill site.

The proposed infiltration basins and SWM ponds are to be located to the east side of the proposed landfill expansion site. According to Drawing No. 131-19416-00-4-7 prepared by Waste Management of Canada Corporation / WSP Canada Inc., Infiltration Basin No. 1 and SWM Pond No. 1 will be located at the existing rehabilitated pit / old borrow area, designated as “Depression #4”. Infiltration Basin No. 2 and SWM Pond No. 2 are to be located at the existing “Depression #5”. An existing maintenance building separates the proposed basins.

A gravel road is located along the west perimeter of the existing closed Carp landfill site. This access road which currently extends from the existing waste transfer building to approximately 400 m north, will be extended to the new access road at Carp Road. It is also proposed to pave this access way with asphaltic concrete. The access road extending between Carp Road and the east limit of the proposed landfill site will also be paved with either asphaltic concrete and/or portland cement concrete pavement.

4 FIELDWORK AND LABORATORY TESTING

The fieldwork for this investigation was carried out during the period between December 16 and 20, 2013, and consisted of twenty (20) exploratory boreholes, numbered 201 to 220 inclusive.

Borehole 201 was positioned within the footprint of the proposed SWM Pond No. 2. This borehole was advanced to 2 m below grade.

Boreholes 202, 203, 204 and 205 were positioned within the footprint of the proposed Infiltration Basin No. 2, and extended to depths ranging from 1.6 m to 7.6 m below grade.

Boreholes 206, 207, 208 and 209 were positioned within the footprint of the proposed Infiltration Basin No. 1, and extended to depths ranging from 4 m to 8.2 m below grade.

Boreholes 210 and 211 were drilled within the footprint of the proposed SWM Pond No. 2, and extended to depths of 4.3 m and 7.6 m (respectively) below grade. These boreholes were advanced to the depth of refusal of further advancement.

Boreholes 201 through 211 were advanced to the depth of refusal to further advancement of the auger.

Boreholes 212 to 220 (inclusive) were positioned within the existing gravel access road located along the west frontage of the closed Carp landfill site. These boreholes were advanced to depths ranging from 1.65 m to 1.8 m below grade.

The locations of the boreholes are shown on the attached Borehole Location Plan as Drawing No. 1 in Appendix B. For ease of reference, Boreholes 4, 5, 8 and 12 that were put down by **AAI** in August 2013 are also shown on the Borehole Location Plan.

The ground surface elevations at the locations of Boreholes 201 to 205 (inclusive) were referenced to the existing ground surface at the monitoring well installed in Borehole 4, which has a geodetic elevation of 118.60 m. This borehole was advanced by **AAI** in August 2013.

The ground surface elevations of Boreholes 206 to 211 (inclusive) were referenced to the top of the monitoring well installed in Borehole BH12, which has a geodetic elevation of 122.85 m. This borehole was also advanced by **AAI** in August 2013.

The ground surface elevations at the locations of Boreholes 212 to 220 (inclusive) were referenced to the floor slab of the existing waste transfer building located on the southwest side of the existing Carp landfill site. The floor slab of the building was assigned an elevation of 100.00 m.

The fieldwork was supervised by an experienced representative from this office who directed the advancement of the drilling, sampling and in situ testing, observed groundwater conditions, and prepared field Borehole Log Sheets.

4.1 Soil Sampling and Testing

The boreholes were advanced to the sampling depths by means of continuous flight solid stem augers. Standard Penetration Tests (SPT) were carried out in accordance with ASTM Method D1586, at frequent intervals of depth and representative samples were recovered using split spoon samplers. The results of the Standard Penetration Tests in terms of ‘N’ values have been used to infer the consistency of cohesive soils or the compactness condition of non-cohesive soils encountered in the boreholes.

Field vane shear test was carried out at Borehole 205; in the clayey soil at the depth zone where the standard penetration resistance “N” value was 10. The test provides an in situ measurement of the undrained shear strength of the clay soil unit.

Dynamic Cone Penetration Test (DCPT) was carried out below the sampling depth at Borehole 207, from 6.6

m to 8.2 m depth. The DCPT involves driving a 50 mm outside diameter cone into the ground using standard penetration test (DPSH) energy. The number of blows of the striking hammer required to drive the cone through successive 300 mm depth increments was recorded and these are presented on the borehole log as penetration index results.

Groundwater level observations were made in all boreholes during and upon completion of drilling of each borehole.

Soil samples retained from the split spoon sampler were identified in the field and detailed examinations were made in the laboratory for final geotechnical classification of soil types.

4.2 Laboratory Testing

The soil samples recovered from the boreholes were transported to our laboratory for detailed examination, soil classification and laboratory testing. The laboratory tests included determination of natural water contents, Atterberg Limits tests and soil particle size including sieve and hydrometer analyses on selected soil samples.

Water content tests were carried out on selected soil samples retained from the boreholes. The water contents of the tested soil samples are shown on the borehole logs enclosed in Appendix D.

Seven (7) soil samples, obtained from Boreholes 203 (sample 1), 204 (sample 2), 205 (sample 3), 206 (sample 3), 207 (sample 5), 215 (sample 2) and 219 (sample 2) were subjected to sieve and hydrometer analysis.

Nine (9) soil samples obtained from Boreholes 201 (sample 2), 202 (sample 2) and 208 (sample 6), as well as sample 1 from Boreholes 212, 213, 215, 217 and 220 were subjected to sieve analyses.

Atterberg Limits tests were performed on two (2) soil samples obtained from sample 2 from Boreholes 215 and 219.

The laboratory test results are presented in Appendix E.

5 SUBSURFACE AND GROUNDWATER CONDITIONS

Details of the subsurface conditions encountered are given on the individual borehole logs in Appendix D. A brief description of the soil units and groundwater conditions at each proposed feature locations are given in the following subsections.

It should be noted that the boundaries of soil types indicated on the borehole logs are inferred from non-continuous soil sampling and observations made during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design, and therefore, should not be construed as exact planes of geological change.

5.1 Existing Gravel Road at the Southwest Corner of the Proposed Landfill Expansion Site

Nine (9) boreholes, numbered 212 to 220 inclusive, were advanced along the existing gravel road located at the southwest corner of the proposed landfill expansion site.

The boreholes revealed that the existing gravel road pavement consists of predominantly gravelly sand, with trace to some silt. At Boreholes 214, 215, 216, 217, 218, 219 and 220, the gravelly sand fill is underlain by variable fill materials including sand, sandy silt to silty sand, with trace to some gravel, and trace to some clay.

Standard penetration tests performed in the granular fill layer recorded N values ranging from 50/125 mm to 50/75 mm penetration, corresponding to a very dense compactness condition. The high measured N values may be affected by the sampling spoon striking large size gravel and/or rock fragments embedded in the granular fill.

The thickness of the granular fill ranges to a maximum of 1.2 m, but is generally 600 mm.

Sieve analyses were carried out on four (4) representative gravelly sand samples, and hydrometer analyses were on three (3) sandy fill samples. The grain size analysis results are enclosed in Appendix E as Figures E-1 to E-6, and summarized in Table No. 1 below. In addition, Atterberg Limits tests were performed on two (2) silty sand samples; the results are enclosed in Appendix E as Figure E-12.

Table No. 1. Summary of Grain size Analyses of Granular Fill Samples

Borehole No.	Ground elevation	Approximate Sample Depth & Sample No.	Sample Description	Gravel %	Sand %	Silt %	Clay %	Liquid Limit	Plastic Limit
212	98.33 m	Near Surface, sample 1	Sand and gravel, trace silt	40	51	9		-	-
213	98.30 m	Near Surface, sample 1	Gravelly sand, trace silt	32	59	9		-	-
215	98.29 m	Near Surface, sample 1	Gravelly sand, trace silt	32	58	10		-	-
215	98.29 m	0.5 m depth, sample 2	Silty sand, trace gravel, some clay	9	39	33	19	27.8	11.9
217	98.49 m	Near Surface, sample 1	Gravelly sand, trace silt	32	59	9		-	-
219	98.91 m	0.5 m depth, sample 2	Gravelly silty sand, trace clay	25	46	22	7	19.5	6.6
220	99.04 m	Near Surface, sample 1	Sand, some gravel, trace silt and clay	17	71	9	3	-	-

With the exception of Boreholes 217 and 219, a layer of clayey silt fill with trace sand and gravel was contacted below the granular fill; extending to the explored depths of the boreholes. Standard penetration resistance in the clayey fill had N values ranging from 14 to 67, indicating a stiff to hard consistency.

At Borehole 217, the gravelly sand fill is underlain by a layer of gravel and rock fragments, followed by loose sand fill with trace gravel. At Borehole 219, native silty clay was contacted below the granular fill. Standard penetration resistance in the clay unit recorded N value of 24, indicating a very stiff consistency.

Groundwater was not encountered in the boreholes upon completion of drilling.

5.2 Proposed Infiltration Basin No. 1

Four (4) boreholes, numbered 206, 207, 208 and 209 were advanced within the footprint of the proposed Infiltration Basin No. 1. One borehole, BH8, instrumented with a monitoring well was previously put down by **AAI** during the August 2013 geotechnical investigation.

A layer of topsoil comprises the uppermost stratum of the soil profile at Boreholes 206 and 207. The thickness of the topsoil is 1.4 m and 0.6 m respectively.

At Boreholes 208 and 209, the topsoil is overlain by an approximately 700 mm thick layer of fill. The fill consists of mainly sand and gravel, with some silt. The thickness of the buried topsoil approximates 1.4 m in Borehole 208, and 700 mm in Borehole 209.

Fill layer is present at the surface at Borehole 8, below the topsoil in Borehole 207, and underneath the buried topsoil in Boreholes 208 and 209. The fill consists of sand with trace organics in BH8, silty sand with some gravel and inclusions of rock fragments in Borehole 207, a mixture of silt, sand and gravel in Borehole 208, and sand with trace gravel and some organics in Borehole 209. Standard penetration tests carried out in the fill layer recorded N-values ranging from 2 (at Borehole 8, from 0.8 m to 2. 1 m depth) to 57 blows per 275 mm penetration (at Borehole 207, 2.3 m depth), indicating a very loose to very dense compactness condition. It should however be noted that the high N-values are likely attributed to the sampling spoon striking large particle(s) embedded within the fill, and are not considered to be representative of the compactness condition of the fill soils.

Underlying the fill in Boreholes 8, 207, 208 and 209, and below the topsoil in Borehole 206 is the native soil, which consists of sand and gravel in Borehole 8, and silty to sandy soils in the remaining boreholes with the soil fractions present in varying portions ranging from silt, sandy silt, silty sand to sand. At Boreholes 206 and 209, the sand stratum has inclusions of rock fragments at lower horizons.

Standard penetration tests carried out in the native silt to sand deposits measured N-values ranging from 14 to 50 blows per 75 mm penetration, indicating a compact to very dense compactness condition. In general, the lower N-values were measured at shallow depths of the native soils. The sand and gravel soils that were encountered in Borehole 8 had N-values of 29 to 51, corresponding to a compact to very dense compactness condition.

Dynamic Cone Penetration Test (DCPT) was carried out below the sampling depth at Borehole 207. The DCPT was performed from 6.7 m down to 8.2 m depth. The penetration resistance values measured from the DCPT ranged from 11 to 28, followed by refusal of cone penetration below 8.2 m depth.

All the boreholes were advanced to the depth of refusal of further advancement of the boreholes, which is assumed to be an inferred bedrock surface.

Grain size distribution tests were carried out on three samples of the native soils from Boreholes 206, 207 and 208 and on two samples from Borehole 8 (previous investigation). The grain size analysis results are enclosed in Appendix E as Figure E-7, and summarized in Table No. 2 below. Permeability of the various soil samples which are estimated based on Hazen's formula are also included in Table 2.

Table No. 2. Summary of Grain size Analyses of Native Soil Samples

Borehole No.	Ground elevation	Approximate Sample Depth & Sample No.	Sample Description	Gravel %	Sand %	Silt %	Clay %	Estimated Permeability cm/sec
206	121.96 m	1.5 m, sample 3	Silty fine sand, trace clay, trace gravel	2	61	32	5	$2.3x10^{-4}$
207	121.96 m	3.1 m, sample 5	Sand, some silt, trace gravel, trace clay	1	79	16	4	$9x10^{-4}$
208	121.95 m	3.8 m, sample 6	Sand, trace silt	0	96	4		$5x10^{-2}$
8	121.84 m	2.5 m, sample 4B	Gravelly sand, some silt trace clay	24	59	14	3	$1.4x10^{-3}$
8	121.84 m	3.8 m, sample 6	Gravelly sand, trace to some silt	23	67	10		$6.4x10^{-3}$

Groundwater was not encountered in Boreholes 206 and 209 upon completion of drilling. Wet silty and sandy soils were encountered in Boreholes 207 and 208; groundwater observations were not made due to caving of the boreholes at approximate elevation 118.25 m.

The monitoring well installed in Borehole 8 (August 2013) measured groundwater level at a depth of 4.8 m below grade; Elevation 117.04 m.

5.3 Proposed Infiltration Basin No. 2

Four boreholes, numbered 202, 203, 204 and 205, were advanced within the footprint of the proposed Infiltration Basin No. 2. One borehole, BH4, was put down by **AAI** in the August 2013 geotechnical investigation.

A surficial layer of topsoil 200 mm thick is present in in Borehole 205.

Fill soil is present at the ground surface in Boreholes 4 and 202 and below the topsoil layer in Borehole 205. The fill consists of a mixture of sand and gravel, trace to some silt, with inclusions of rock fragments. Standard penetration tests carried out in the fill layer provided N-values of 12 in Borehole 4, and 54 in Borehole 205, indicating a compact to very dense compactness condition. The high N-value is believed to be attributed to the sampling spoon striking large gravel and/or rock fragments embedded within the fill, and are not considered to be representative of the compactness condition of the fill soils.

The surface soil stratum in Boreholes 203 and 204, and below the fill in Boreholes 4, 202 and 205 is native soil.

At Boreholes 202, 203 and 204, the native soil consists of predominantly sand, with trace to some gravel and trace silt, and inclusions of rock fragments. Standard penetration tests carried out in the sand-gravel soils provided N-values ranging from 23 to 50 blows per 125 mm penetration, corresponding to a compact to very dense compactness condition.

At Borehole 205, the native soil consists of silty clay, with trace to some sand and trace gravel. Below an approximate depth of 3 m, the silty clay is a glacial till deposit, with trace sand and embedded gravel. Standard penetration resistance in the clay soil unit provided N-values ranging from 10 to 35 blows, indicating a stiff to hard consistency. A sandy silt (till) stratum was positioned within the clay soils; from approximately 3.7 m to 4.5 m depth. The sandy silt till has N-value of 16, corresponding to a compact condition.

At Borehole 4, the native soil is a glacial deposit (till) consisting of silty sand with trace gravel and clay, followed by cobbles and boulders extending to the explored depth of the borehole. Both the till soil and the cobbles/boulders have a very dense compactness condition, as indicated by very high N-values of 73/225 mm to 50/75 mm penetration.

A field vane shear test was carried out in the lower silty clay in Borehole 205, at the depth zone where the measured penetration resistance "N" values was 10. The undrained shear strength of the tested soil was in excess of 222 kPa, corresponding to very stiff consistency.

All the boreholes were advanced to refusal of further advancement of the boreholes, which is assumed to be an inferred bedrock surface.

Grain size distribution tests were carried out on four (4) native soil samples from Boreholes 202, 203, 204 and 205, and one sample from Borehole 4. The grain size analysis results are enclosed in Appendix E as Figures E-8 and E-9, and summarized in Table No. 3 below. Permeability of the various sandy soil samples which are estimated based on Hazen's formula are also included in Table 3.

Table No. 3. Summary of Grain size Analyses of Native Soil Samples

Borehole No.	Ground elevation	Approximate Sample Depth & Sample No.	Sample Description	Gravel %	Sand %	Silt %	Clay %	Estimated Permeability cm/sec
202	117.68 m	0.8 m, sample 2	Sand, trace silt, trace gravel	5	89	6		$4x10^{-2}$
203	117.35 m	Near surface, sample 1	Sand and gravel, trace silt, trace to some clay	43	41	6	10	$1.6x10^{-5}$
204	117.79 m	0.8 m, sample 2	Sand and gravel, some silt, trace clay	45	39	11	5	$8.1x10^{-5}$
205	122.59 m	1.5 m, sample 3	Silty clay, some sand, trace gravel	5	19	54	22	$< 1x10^{-7}$
4	118.60 m	0.8 m, sample 2	Silty fine sand, some gravel, trace clay	11	60	24	5	$8.1x10^{-5}$

Groundwater was encountered in Borehole 203 upon completion of drilling at 1.8 m depth below grade; Elevation 115.55 m. The remaining boreholes were dry upon completion of drilling.

5.4 Proposed Stormwater Management Pond No. 1

Two boreholes, numbered 210 and 211, were advanced within the footprint of the proposed Stormwater Management (SWM) Pond No. 1. One borehole, BH12, instrumented with a monitoring well was previously put down by **AAI** in the August 2013 geotechnical investigation.

Fill is present at all three boreholes. The fill consists of sandy silt at Borehole 210, silty sand with some gravel at Borehole 211, and sand with trace organics at Borehole 12. The fill extends to an approximate depth of 3 m at Boreholes 210 and 12, and 0.7 m at Borehole 211. Standard penetration tests carried out in the fill layer recorded N-values ranging from 3 to 28. The in situ test results indicate that the compactness condition of the fill is very loose to compact.

Underlying the fill, a sand and gravel unit with inclusions of rock fragments was contacted in Borehole 210 extending to the explored depth of the borehole. Sand to silty sand soils are present below the fill in Boreholes 211 and 12.

At Borehole 211, the upper section of the silty sand deposit is brown, changing to grey below an approximate depth of 5.6 m. The grey sand unit is a glacial deposit; with inclusions of trace gravel and rock fragments.

Standard penetration tests carried out in the sand-gravel soils provided N-values ranging from 23 blows per 300 mm penetration to 50 blows per 25 mm penetration, corresponding to a compact to very dense compactness condition.

At Borehole 12, low penetration resistance N-values of 2 to 7 were recorded in the sand soil unit, between approximately 4.5 m to 7 m depth. The Dynamic Cone Penetration Test that was performed adjacent to this borehole revealed that the penetration index values for the sand soils between 6 m to 7 m depths were higher than those obtained using the Standard Penetration Test method. In this regard, we are of the opinion that the lower penetration resistance values was attributed to the hydrostatic uplift pressure during the Standard Penetration Test, causing loosening of the sand soils close to the base of the open borehole during the test.

All the boreholes were advanced to the depth of refusal of further advancement of the boreholes, which is assumed to be an inferred bedrock surface.

The monitoring well installed in Borehole 12 (August 2013) measured groundwater level at a depth of 2.8 m below grade; Elevation 119.16 m. Groundwater observations were not made in Boreholes 210 and 211 due to caving of the sandy soils at elevations 119.7 m and 118.8 m respectively.

Grain size distribution tests were carried out on two (2) native soil samples from Borehole 12. The grain size analysis results are enclosed in Appendix E as Figure E-10, and summarized in Table No. 4 below. Permeability of the sand soil samples which are estimated based on Hazen's formula are also included in Table 4.

Table No. 4. Summary of Grain size Analysis of Native Soil Samples

Borehole No.	Ground elevation	Approximate Sample Depth & Sample No.	Sample Description	Gravel %	Sand %	Silt %	Clay %	Estimated Permeability cm/sec
12	121.96 m	3.1 m, sample 5	Fine sand, trace silt, trace clay	0	89	7	4	$3x10^{-3}$
12	121.96 m	6.1 m, sample 8	Silty fine sand, trace clay	0	75	21	4	$1.2x10^{-3}$

5.5 Proposed Stormwater Management Pond No. 2

One borehole, numbered 201 was advanced at the location of the proposed SWM Pond No. 2. One boreholes, BH5, was previously put down by **AAI** in the August 2013 geotechnical investigation.

The boreholes revealed that 100 and 200 mm thick layer of topsoil is present at Boreholes 5 and 201 respectively. At Borehole 201, the topsoil is underlain by an approximately 400 mm thick layer of fill consisting of gravelly sand, with some organics and traces of silt and clay.

The fill at Borehole 201, and the topsoil at Borehole 5 are underlain by native soil. The native soil present at Borehole 201 consists of sand with inclusions of rock fragments. In Borehole 5 the native soil consists of medium to coarse sand and gravel. Standard penetration tests carried out in the native sand-gravel soils provided N-values ranging from 12 to 50/125 mm penetration, indicating a compact to very dense compactness condition.

Both boreholes were advanced to the depth of refusal of further advancement of the boreholes, which is assumed to be an inferred bedrock surface.

Grain size distribution test was carried out on one native sand sample obtained from Borehole 201 at 0.8 m depth, and one soil sample retained from Borehole 5 at 1 m depth. Results of the grain size analyses are enclosed in Appendix E as Figure E-11, and summarized in Table No. 5 below. Permeability of the soil samples which are estimated based on Hazen's formula are also included in Table 5.

Table No. 5. Summary of Grain size Analysis of Native Soil Samples

Borehole No.	Ground elevation	Approximate Sample Depth & Sample No.	Sample Description	Gravel %	Sand %	Silt %	Clay %	Estimated Permeability cm/sec
5	117.58 m	1.0 m, sample 2	Medium to fine sand, some silt, some gravel, trace clay	12	72	13	3	1.4x10^{-3}
201	117.30 m	0.8 m, sample 2	Sand and gravel, trace silt	54	41	5		2.3x10^{-2}

Groundwater was encountered in the open Borehole 201 upon completion of drilling, at a depth of 1.8 m below grade; elevation 115.50 m, and in the open Borehole 5 at a depth of 1.5 m below grade; at elevation 116.08 m.

6 DISCUSSION AND RECOMMENDATIONS

The following discussions and recommendations are based on the factual data obtained from this investigation and are intended for use by this project's design engineers.

6.1 Roadway Pavement

It is understood that new roads are proposed for construction to provide access for the new landfill expansion. The proposed roads will include:

- a new paved access road extending from the southwest corner of the proposed landfill site to the proposed Carp Road widening
- new granular-surfaced maintenance/service road (ring road) surrounding the perimeter of the proposed landfill
- pave the existing gravel road at the southwest corner of the proposed landfill site

According to Section 7.3 of Supporting Document 4, Facility Characteristics Report prepared by AECOM, truck traffic associated with the landfill operation will include hauling waste to the site as well as haulage of construction materials.

Based on Drawing No. 131-19416-00 – SK10 prepared by WM / WSP Canada Inc., the indications are that with the exception of the existing gravel road extending north from the existing waste transfer building, the grades along all remaining proposed roads will be raised by as much as 8 m.

The following recommendations regarding placement of fill under proposed roads should be adhered to during the construction stage:

- All exposed topsoil and organic soils must be removed, and the underlying subgrade soils compacted prior to any new fill placement.

- Fill operations should be monitored and compaction tests should be performed to ensure that the materials are being adequately compacted.
- Material used as fill should be free of organics and/or other unsuitable material, and must be placed in lifts suitable for the material and size of compactor being used, and compacted to at least 96% Standard Proctor Maximum Dry Density (SPMDD).
- If fill is required adjacent to sloped banks (> 3:1, horizontal to vertical), it is imperative that the fill is placed in stepped planes in order to avoid a plane weakness.
- The fill operation should take place in favorable climatic conditions. If the work is carried out in months where freezing temperatures may occur, all frost affected material must be removed prior to the placement of frost-free fill.

Based on information provided by WSP Canadawe understand that the roadways throughout the site should be designed for a service life of 25 years and the following anticipated traffic:

Section of the main road from the landfill entrance to the turnaround near SW corner of the expansion area:

- Average annual daily traffic (AADT) – 700
- 55% packer and roll-off trucks (3-4 axles)
- 26% tractor trailers (7-9 axles)
- 19% small passenger cars and pickups

Section of road from the turnaround to Waste Transfer Processing Facility

- AADT - 138
- 80% roll off trucks (3-4 axles)
- 20% tractor trailers (7-9 axles)

Ring road surrounding waste disposal area

The ring road surrounding the proposed waste disposal area will be used by internal site traffic which may include rock trucks.

We also understand that as loaded tractor trailers may keep down liftable axles and apply additional stress on pavement on all 90 degree turns.

Based on a design life of 25 years, the anticipated usage provided above, and a CBR of 4 for the compacted fill subgrade, the following pavement designs are recommended for the gravel and paved roads.

Section of the main road from the landfill entrance to the turnaround near SW corner of the expansion area:

- Asphaltic concrete surface course – 50 mm HL3 High Stability or Superpave 12.5 Level D with PG 64-28 asphalt cement
- Asphaltic concrete base course – 100mm (2 layers) HL8 Heavy Duty Binder Course or Superpave 19 Level D with PG 64-28 asphalt cement
- Granular base course – 150 mm of Granular 'A'
- Granular sub-base course – 550 mm of Granular 'B' Type II

As an alternate to the asphaltic concrete pavement recommended above, in areas where trucks are to repeatedly stop and go, such as at gates, as well as make sharp turns, a Portland cement concrete pavement may be considered. The concrete pavement should consist of:

- Concrete – 250 mm
- Granular base course – 150 mm of Granular 'A'
- Granular sub-base course – 300 mm of Granular 'B' Type II

The concrete must be air entrained, and possess minimum compressive and flexural strengths of 35 MPa and 4.8 MPa respectively.

Section of road from the turnaround to Waste Transfer Processing Facility

- Asphaltic concrete surface course – 40 mm HL3 High Stability or Superpave 12.5 Level D with PG 64-28 asphalt cement
- Asphaltic concrete base course – 80mm (2 layers) HL8 Heavy Duty Binder Course or Superpave 19 Level D with PG 64-28 asphalt cement
- Granular base course – 150 mm of Granular 'A'
- Granular sub-base course – 400 mm of Granular 'B' Type II

The in situ granular soil along the existing gravel road north of the transfer station may be left in place, and overlain with a minimum of 150 mm thick Granular 'A' base prior to placement of the asphaltic concrete layers recommended above.

Ring road surrounding waste disposal area

- Granular surface course – 300 mm of Granular 'A'

- Granular base course – 450 mm of Granular 'B' Type II

It should be noted that all proposed roadways will be suitable for use by fire trucks.

The subgrade must be compacted to at least 98% SPMDD for at least the upper 600 mm and 96% below this level. Where fine-grained clay soils are used for subgrade upfill, the degree of compaction specification alone cannot ensure distress free subgrade. Proof-rolling of the roadway subgrade must be carried out and witnessed by AAI personnel for final recommendations of sub-base.

The granular pavement structure materials should be placed in lifts not exceeding 150 mm thick and be compacted to a minimum of 100% SPMDD. Asphaltic concrete materials should be rolled and compacted as per OPSS 310. The granular and asphaltic concrete pavement materials and their placement should conform to OPSS 310, 501, 1010 and 1150.

The long-term performance of the proposed pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over-emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be crowned and sloped (at a minimum crossfall of 2% for both the pavement surface and the subgrade) to provide effective drainage. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Sub-drains or roadside drainage ditches must be provided to facilitate effective and assured drainage of the pavement structures as required to intercept excess subsurface moisture and minimize subgrade softening. The invert of sub-drains and drainage ditches should be maintained at least 0.3 m below subgrade level.

In the event that the near surface subgrade soil cannot be maintained dry by providing good ditches and sub drains, than the fill within the uppermost 900 mm should consist of Select Subgrade Material (sandy soil).

6.2 Proposed Infiltration Basins

Details of the proposed Infiltration Basins No. 1 and No. 2 are provided in Drawing No. 131-19416-00 – SK10 prepared by WM / WSP Canada Inc. dated November 21, 2013.

According to this drawing, the proposed base elevation of Infiltration Basin No. 1 is 123.00 m, and of Infiltration Basin No. 2 is 122.00 m. The proposed grades at the top of the basins (containment berms) would range between 126.7 and 128 m at Infiltration Basin 1 and between 124.5 and 126.3 m at Infiltration Basin No. 2. The side slopes of both infiltration basin embankments would be 3H to 1V.

The existing site grades within the bases of the proposed infiltration basins range between 122 and 122.5 m, and between 117.5 to 124.5 m, at Basins 1 and 2 respectively. On this basis, the existing site grades will be raised to achieve the design base elevations of both infiltration basins.

Our recommendations regarding the construction of the proposed infiltration basins are:

- The existing topsoil, organic soil and any fill materials present within the footprints of the infiltration basins must be removed down to the native soil stratum.
- Soil possessing the design infiltration rate should be placed loosely within the base of both basins to the proposed grades of 122 m and 123 m.
- Fill placed within the containment berms of the basins should consist of clayey soils and compacted to a minimum 98% SPMDD. The uppermost at least 600 mm depth of the clayey soil placed within the berms should have the following properties:
    - Plasticity Index greater than 7 percent.
    - 100 percent of the particles passing 75 mm sieve.
    - Not less than 70 percent of the particles, by weight, passing the 0.075 mm sieve.
    - Not less than 20 percent of the particles, by weight, passing the 0.002 mm sieve.
    - Placed in maximum 300 mm lifts and compacted to a minimum of 98% SPMDD.
    - Placed at or slightly above optimum moisture content.

The permeability of the 5 soil samples retained from the footprint of Infiltration Basin 1 are estimated to be in the range of $5x10^{-2}$ to $2.3x10^{-4}$ cm/sec, corresponding to approximate percolation times of 3 to 10 min/cm respectively.

The permeability of the 4 soil samples retained from the footprint of Infiltration Basin 2 (Boreholes 202, 203, 204 and 4) are estimated to be in the range of $4x10^{-2}$ to $1.6x10^{-5}$ cm/sec, corresponding to approximate percolation times of 3 to 20 min/cm respectively. The silty clay present in Borehole 205, situated in the southeast quadrant of the footprint of Infiltration Basin 2 is considered to be impervious, with an estimated permeability of less than 10^{-7} cm/sec and corresponding percolation time in excess of 50 min/cm.

6.3 Proposed Stormwater Management Ponds

Details of the proposed SWM ponds which are provided in Drawing No. 131-19416-00 – SK10 prepared by WM / WSP Canada Inc. dated November 21, 2013 are summarized as follows:

	Proposed Base Elevation (m)	Existing Base Elevation (m)	Proposed top of Berm Elevation (m)	Existing top of Berm Elevation (m)
SWM Pond 1	124.0	122.5 to 124.0	126.75 to 129.0	122.0 to 125.0
SWM Pond 2	122.8	117.5 to 122.5	126.3 to 126.8	117.5 to 125.0

The waterside slopes of the containment berms of the ponds would be 4H:1V and the landside or downstream slopes of the embankments would be 3H:1V. The top width of the berms will be approximately 3 m.

Three boreholes, numbered 12, 210 and 211, were advanced within the footprint of the proposed SWM Pond No. 1. Fill is present at all three boreholes. The fill consists of sandy silt at Borehole 210, silty sand with some gravel at Borehole 211, and sand with trace organics at Borehole 12. The fill extends to an approximate depth of 3 m at Borehole 210 and 12, and 0.7 m at Borehole 211. The in situ test results indicate that the compactness condition of the fill is very loose to compact. Underlying the fill, a sand and gravel unit with inclusions of rock fragments was contacted in Borehole 210 extending to the explored depth of the borehole. Sand to silty sand soils are present below the fill in Boreholes 211 and BH12. At Borehole 211, the upper section of the silty sand deposit is brown, changing to grey below an approximate depth of 5.6 m. The grey sand unit is a glacial deposit; with inclusions of trace gravel and rock fragments.

Two boreholes, numbered 5 and 201 were advanced at the location of the proposed SWM Pond No. 2. The boreholes revealed that 100 to 200 mm thick layer of topsoil is present at all three boreholes. At Borehole 201, the topsoil is underlain by an approximately 400 mm thick layer of fill consisting of gravelly sand, with some organics and traces of silt and clay. The fill at Borehole 201, and the topsoil at Boreholes 5 are underlain by native soil. The native soil present at Borehole 201 consists of sand with inclusions of rock fragments. In Borehole 5 the native soil consists of medium to coarse sand and gravel.

The groundwater table across the area of the ponds is situated below elevation 120 m and is not anticipated to impact construction and continued performance of the ponds, as the bases of the ponds would be set above elevation 122.8 m.

Based on the available information, the bases of the ponds would be raised by as much as 5 m, and the containment berms would be raised by as much as 7 m. The soil present within the bases and side slopes of SWM Pond 1 consist of up to 3 m of loose fill underlain by sandy and gravelly soils. The soil that is present within the bases and side slopes of SWM Pond 2 consist of a thin (less than 400 mm thick) layer of topsoil or fill underlain by sand and gravelly sand soil.

Based on the above considerations the following recommendations are provided for construction of the proposed ponds:

- The existing topsoil, organic soil and any fill materials present within the footprints of the stormwater ponds must be removed down to the native soil stratum.
- Fill placed within the bases and containment berms of the pond should consist of clayey soils and

compacted to a minimum 98% SPMDD. The uppermost at least 600 mm depth of the clayey soil placed within the pond base and sidewalls should have the following properties:

- Plasticity Index greater than 7 percent.
- 100 percent of the particles passing 75 mm sieve.
- Not less than 70 percent of the particles, by weight, passing the 0.075 mm sieve.
- Not less than 20 percent of the particles, by weight, passing the 0.002 mm sieve.
- Placed in maximum 300 mm lifts and compacted to a minimum of 98% SPMDD.
- Placed at or slightly above optimum moisture content.

Alternatively a geosynthetic liner may be used. However since the bases and containment berms are to be raised using earth fill, installation of a compacted clay liner is considered to be more economical. Installation of a compacted clay liner is also more standard construction practice as compared to the more specialized procedures/specifications for geosynthetic liners. From a geotechnical perspective, a compacted clay liner is considered to be the preferred option.

6.4 Slope Stability Analyses

Analyses have been carried out to assess the stability of the side slopes of the completed infiltration basins and stormwater management ponds. Those analyses show a minimum factor of safety under a static loading condition with respect to global stability of 1.90; more than the required value of 1.5, which is satisfactory. Copies of the stability analyses for various sections and loading conditions are attached in Appendix ‘F’. The soil parameters adopted for design evaluations are based on interpreted in situ and laboratory test data, as well as conservative values for the proposed fills, and are given in the analysis sheets.

The proposed containment berm gradients within the ponds and basins will remain stable against any sliding failure. The minimum Safety Factor of the global stability of the embankments; 1.90, is well over the minimum specified factor of 1.5, for any of the loading conditions.

6.5 Excavation, Backfill and Dewatering

Based on the field results, excavation of the soils at this site above the bedrock can be carried out with heavy hydraulic excavators.

All excavations must be carried out in accordance with Occupational Health and Safety Act (OHSA). The soil profile at the site generally consists of an upper layer of fill which is of variable quality and variable condition. On the basis of our inspection of the soil samples, it should be assumed that the fill materials will conform to Type 3 or Type 4 classification, as given in the Occupational Health and Safety Regulations. The compact to dense sand soils stiff silty clay which lie above the water table are expected to conform to Type 2 or Type 3 classification; below the water table the sand can be expected to behave as a flowing soil unless the soil is dewatered. Temporary excavation side-slopes should not exceed 1.0 horizontal to 1.0 vertical. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation. Locally, where very loose or soft soil is encountered at shallow depths or within zones of persistent seepage, it will be necessary to flatten the side slopes as necessary to achieve stable conditions. Excavation side-slopes should not be left exposed to inclement weather. Excavation slopes consisting of sandy soils will be prone to gullying in periods of wet weather, unless the slopes are properly sheeted with tarpaulins.

Where workers must enter excavations extending deeper than 1.2 m below grade, the excavation side-walls must be suitably sloped and/or braced in accordance with the Occupational Health and Safety Act and Regulation for Construction Projects. The design of temporary shoring should be in accordance with the earth pressure diagram (Figure 26.8) from the Canadian Foundation Engineering Manual.

It is anticipated that proposed sewer pipe inverts and proposed manhole chambers will be situated above the groundwater level and as such dewatering should not be necessary. Surface water should be directed away from open excavations.

Based on the existing topography at the subject site and proposed grades, it is anticipated that significant cut and fill operations will be required for development of the property.

On-site excavated inorganic native soils are considered suitable for reuse as backfill material or engineered fill, provided their water content is within 2% of their optimum moisture content (OMC) as determined by Standard Proctor test, and the materials are effectively compacted with heavy vibratory pad-type rollers (cohesive soils) and smooth drum rollers (cohesionless soils). The compactors must be of sufficient size and energy to break down the lumps and to knead the soil into a homogeneous mass as water and compaction effort is applied. If the equipment does not have sufficient energy to break down the lumps, there is a tendency to bridging and post construction settlements. In areas of narrow trenches or confined spaces such as around foundations, foundation walls, etc., the use of aggregate fill such as Granular 'B' (OPSS 1010) is required if there is to be post-construction grade integrity.

New fill placed to raise the existing grade must be compacted to the specified compaction requirements recommended in the preceding paragraphs. It is best to schedule deep fill placement as far in advance of finish surfacing as possible for best grade integrity.

If construction is carried out in inclement weather, there is a likelihood that some amount of road sub-base supplement may be required (i.e. some sub-excavation followed by granular replacement).

Should construction proceed during the winter season, it is imperative to ensure that frozen material is not utilized as trench backfill, beneath pavements or ponds.

6.6 Bedding for Sewers and Water Mains

The undisturbed natural soils at the site are suitable for supporting water mains, sewer pipes, manholes, catch basins and other related structures. Based on the present site grades, sewer pipes and water mains will probably be supported on the engineered fill, or undisturbed native soil deposits.

The type of bedding depends mainly on the strength of the subgrade immediately below the invert levels.

Normal Class ‘B’ bedding is recommended for underground utilities. Granular ‘A’ or 19 mm crusher-run limestone can be used as bedding material. The bedding material should be compacted to a minimum of 96% SPMDD.

Pipe bedding and backfill for flexible pipes should be undertaken in accordance with OPSD 802.010, 802.013, and 802.014. Pipe embedment and cover for rigid pipes should be undertaken in accordance with OPSD 802.030, 802.031, 802.032, 802.033 and 802.034.

Fine sand may be used as bedding material for HDPE pipes.

If unsuitable bedding conditions occur, careful preparation and strengthening of the trench bases prior to sewer installation will be required. The subgrade may be strengthened by placing a thick mat consisting of 50 mm crusher-run limestone. Field conditions will determine the depth of stone required. Geotextiles and/or geogrids may be helpful and these options should be reviewed by **AAI** on a case by case basis.

Sand cover material should be placed as backfill to at least 300 mm above the top of pipes. Placement of additional granular material (thickness dictated by the type of compaction equipment) as required or use of smaller compaction equipment for the first few lifts of native material above the pipe will probably be necessary to prevent damage to the pipe during the trench backfill compaction.

Where necessary, especially within and in close proximity of ponds and pond embankments, plugs should be provided within the bedding materials to prevent water seepage through bedding material,.

It is recommended that service trenches be backfilled with on-site native materials such that at least 96% of Standard Proctor Maximum Dry Density (SPMDD) is obtained in the lower zone of the trench and 98% of SPMDD for the upper 600 mm. However, prior to building the roads, the subgrade should be thoroughly proof-rolled and re-compacted to 98% of SPMDD to ensure uniformity in subgrade strength and support.

7 LIMITATIONS OF REPORT

The Limitations of Report, as quoted in Appendix 'A', are an integral part of this report.

alston associates inc.

LICENSED PROFESSIONAL ENGINEER
V. NERSESIAN
33778705
12/03/14
PROVINCE OF ONTARIO

Vic Nersesian, P. Eng.
Vice President, Geotechnical Services

APPENDIX A

LIMITATIONS OF REPORT

limitations of report

The conclusions and recommendations in this report are based on information determined at the inspection locations. Soil 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 soil investigation.

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 details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made as set out in this report. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

This report was prepared for WSP Canada Inc. by Alston Associates Inc. The material in it reflects Alston Associates Inc. judgement in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions which the Third Party may make based on it, are the sole responsibility of such Third Parties.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the test holes. In cases where these recommendations are not followed, the company’s responsibility is limited to accurately interpreting the conditions encountered at the test holes, only.

The comments given in this report on potential construction problems and possible methods are intended for the guidance of the design engineer, only. The number of inspection locations may not be sufficient to determine all the factors that may affect construction methods and costs. 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.

APPENDIX B

DRAWING NO. 1: BOREHOLE LOCATION PLAN

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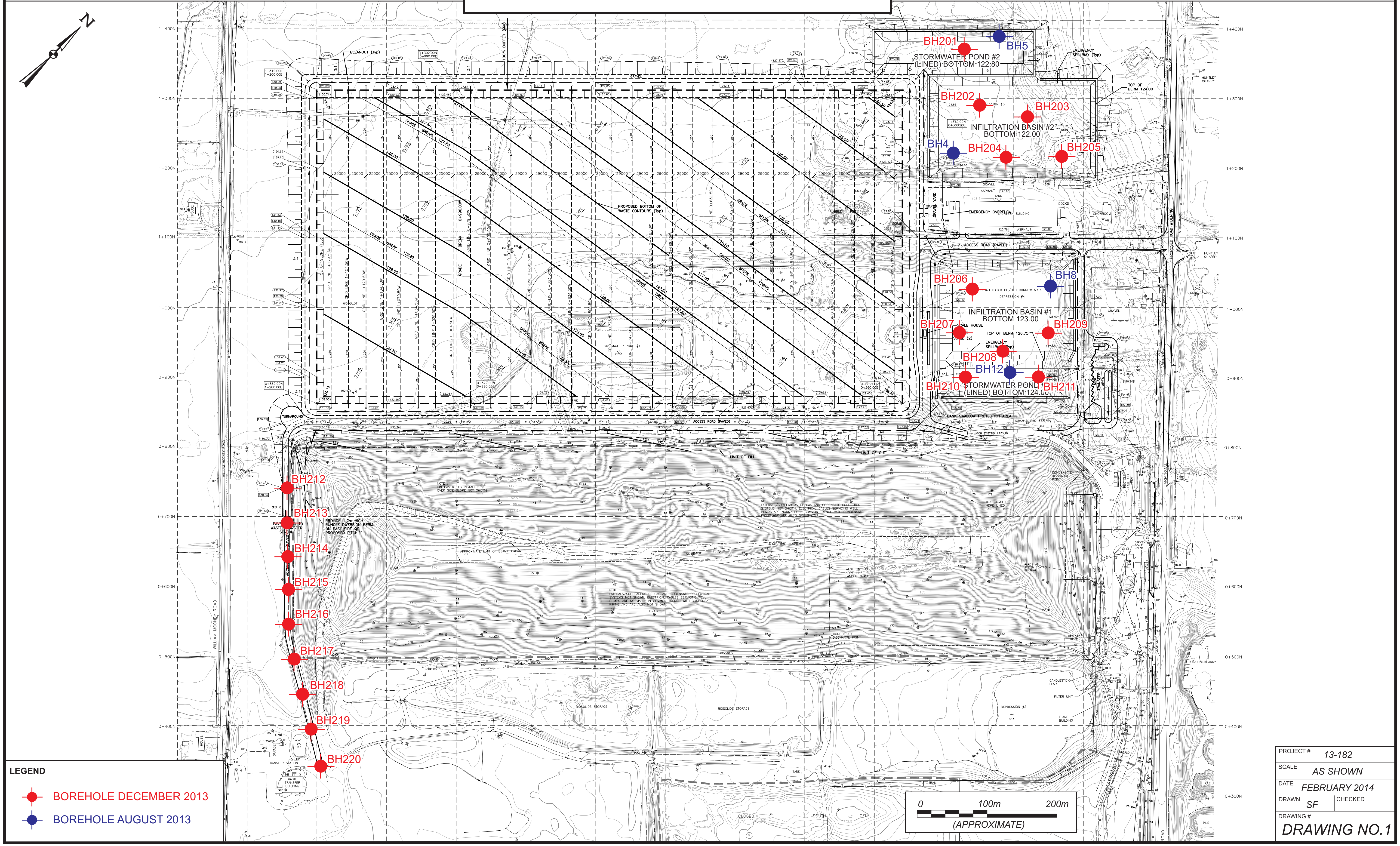
BOREHOLE LOCATION PLAN
WEST CARELTON ENVIRONMENTAL CENTRE

CLIENT
WSP CANADA INC.



LEGEND

🟥	BOREHOLE DECEMBER 2013
🟦	BOREHOLE AUGUST 2013

PROJECT # 13-182
SCALE AS SHOWN
DATE FEBRUARY 2014
DRAWN SF
CHECKED
DRAWING #
DRAWING NO.1

APPENDIX C

AAI 2013 GEOTECHNICAL INVESTIGATION: LOGS OF BOREHOLES 3, 4, 5, 8 & 12

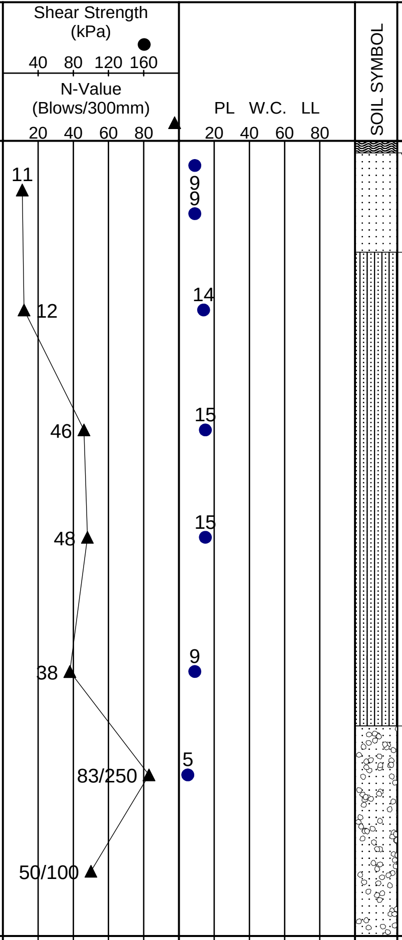
CLIENT: Waste Management
METHOD: Augering and Split Spoon Sampling
PROJECT: Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 123.27
LOCATION: Carp, ON
NORTHING: 5016236.919
EASTING: 346115.227

BH No.: 3

PROJECT NO.: 13-107

SAMPLE TYPE: ▮ AUGER ◩ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole cave-in at 3.4 m and water level at 2.6 m below ground surface on completion.	300 mm black TOPSOIL	1A	11	123
0.5			reddish brown, damp fine SAND, trace roots	1B		
1			compact to very dense moist to wet SILTY fine SAND brown ------ grey ------ TILL	2	12	122.5 122
1.5				3	46	121.5
2						121
2.5	▼			4	48	120.5
3		Hard augering at 3.0 m depth.		5	38	120
3.5						119.5
4		Split spoon bouncing	very dense wet, grey SAND and rock fragments	6	83/250	119
4.5		Cobble/boulder encountered between 4.3 and 5.0 m depth.		7	50/100	118.5
5						



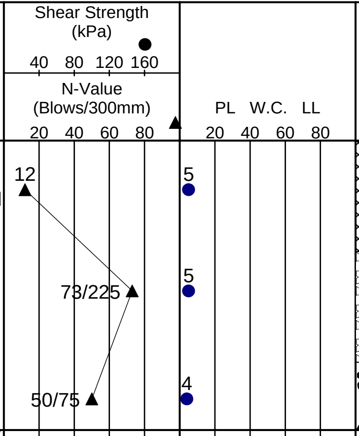
END OF BOREHOLE
Refusal to advancement of augers at 5.03 m below ground surface.

alston associates inc.
consulting engineers

LOGGED BY: KC
DRILLING DATE: 9 August 2013
REVIEWED BY: VN

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling	**BH No.: 4**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN ELEV. (m) 118.60	
LOCATION: Carp, ON	NORTHING: 5016344.465 EASTING: 346287.868	PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Grass Surface. Borehole dry and cave-in at 1.2 m below ground surface on completion.	compact, brown to grey sand and gravel, FILL		1	12	118.5 118
1			very dense, very moist, grey SILTY SAND, traces of gravel and clay (TILL)		2	73/ 225	117.5
1.5		Cobble/boulder encountered between 1.2 and 1.8 m depth.	COBBLES and BOULDERS		3	50/ 75	117
			END OF BOREHOLE Refusal to advancement of augers at 1.83 m below ground surface.				

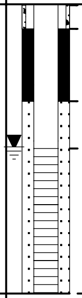
alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 8 August 2013
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON
METHOD: Augering
PROJECT ENGINEER: VN
ELEV. (m) 118.60
NORTHING: 5016344.465
EASTING: 346287.868

BH No.: 4A

PROJECT NO.: 13-107

SAMPLE TYPE ◨ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5 1 1.5	 Casing Bentonite Sand Sand and screen (50 mm Diameter)	Water level measured 0.3 m below ground surface on 9 August 2013. Cobbles/boulders encountered between 1.2 and 1.8 m depth.				Straight auger to 1.8 m depth				118.5 118 117.5 117
						END OF BOREHOLE Refusal to advancement of augers at 1.83 m depth below ground surface.				

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LOGGED BY: KC
REVIEWED BY: VN
DRILLING DATE: 8 August 2013

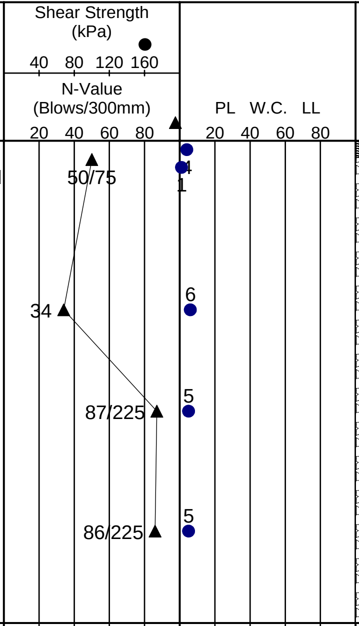
CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON
METHOD: Augering and Split Spoon Sampling
PROJECT ENGINEER: VN
ELEV. (m) 117.58
NORTHING: 5016511.253
EASTING: 346222.746

BH No.: 5

PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and cave-in at 1.5 m below ground surface on completion. Cobbles/boulders encountered between 0.3 and 3.0 m depth.	100 mm TOPSOIL		1A 1B	50/ 75	117.5
0.5			dense to very dense moist to wet brown medium to coarse SAND and GRAVEL occasional cobbles and boulders				117
1					2	34	116.5
1.5		Water strike at 1.5 m depth.			3	87/ 225	116
2							115.5
2.5					4	86/ 225	115
3			END OF BOREHOLE Refusal to advancement of augers at 3.05 m below ground surface.				



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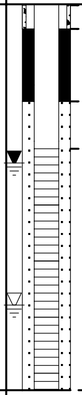
LOGGED BY: KC
REVIEWED BY: VN
DRILLING DATE: 8 August 2013
Page 1 of 1

CLIENT: Waste Management	METHOD: Augering		**BH No.: 5A**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 117.58	
LOCATION: Carp, ON	NORTHING: 5016510.951	EASTING: 346222.746	PROJECT NO.: 13-107

SAMPLE TYPE ◧ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5 1 1.5 2	 Casing Bentonite Sand Sand and screen (50 mm Diameter)	Water level measured 1.9 m below ground surface on completion, 1.0 m below ground surface on 9 August 2013. Cobbles/boulders encountered between 0.0 and 2.4 m depth.				Straight auger to 1.8 m depth				117.5 117 116.5 116 115.5
						END OF BOREHOLE Refusal to advancement of augers at 2.44 m depth belowground surface.				

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 8 August 2013
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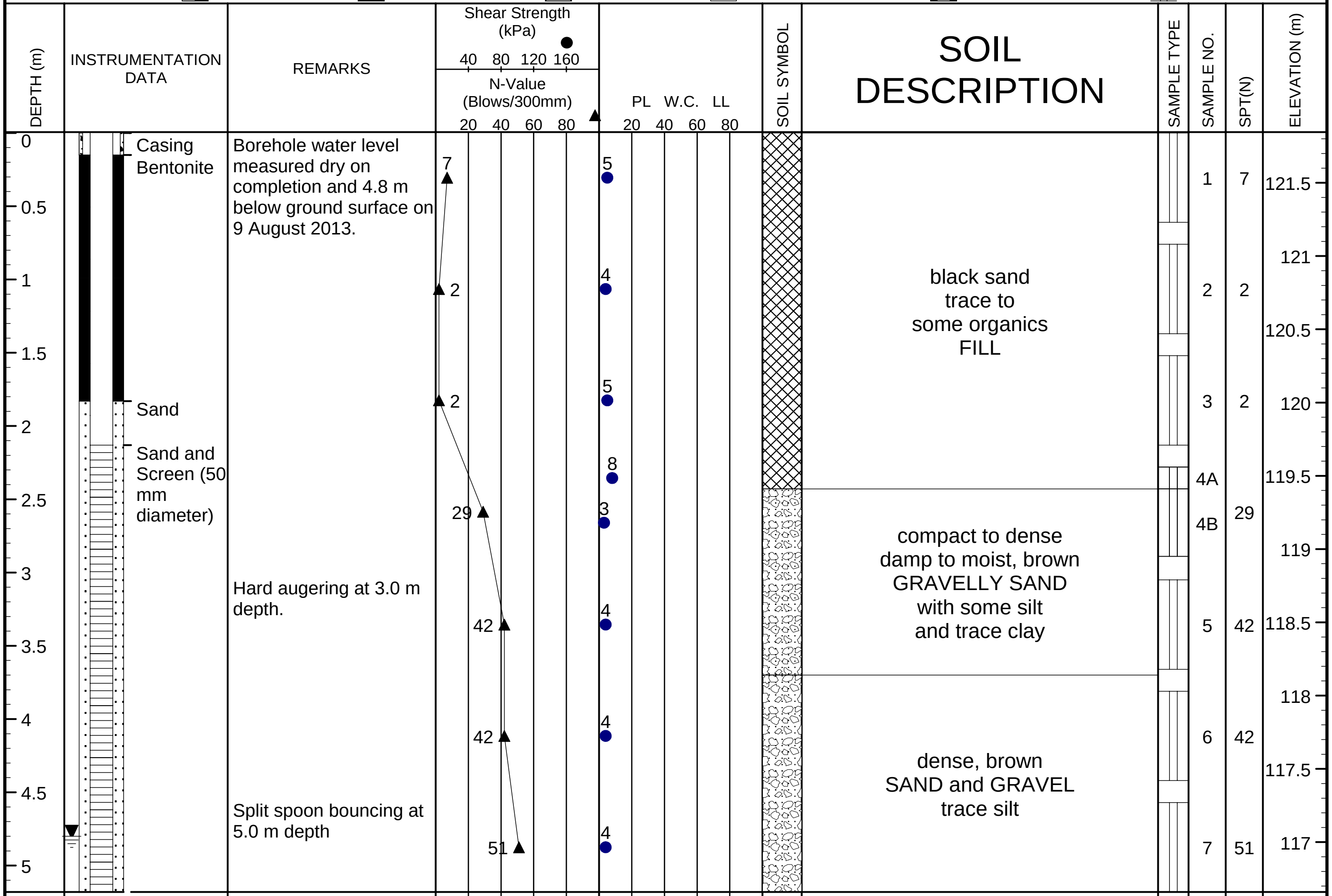
CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON
METHOD: Augering and Split Spoon Sampling
PROJECT ENGINEER: VN
ELEV. (m) 121.84
NORTHING: 5016297.222
EASTING: 346519.626

BH No.: 8

PROJECT NO.: 13-107

SAMPLE TYPE ▮ AUGER ◩ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



REMARKS

Borehole water level measured dry on completion and 4.8 m below ground surface on 9 August 2013.

Hard augering at 3.0 m depth.

Split spoon bouncing at 5.0 m depth

SOIL DESCRIPTION

black sand
trace to
some organics
FILL

compact to dense
damp to moist, brown
GRAVELLY SAND
with some silt
and trace clay

dense, brown
SAND and GRAVEL
trace silt

END OF BOREHOLE
Refusal to advancement of augers at 5.2 m below ground surface.

SAMPLE NO.	SPT(N)
1	7
2	2
3	2
4A	29
4B	
5	42
6	42
7	51

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DRILLING DATE: 7 August 2013
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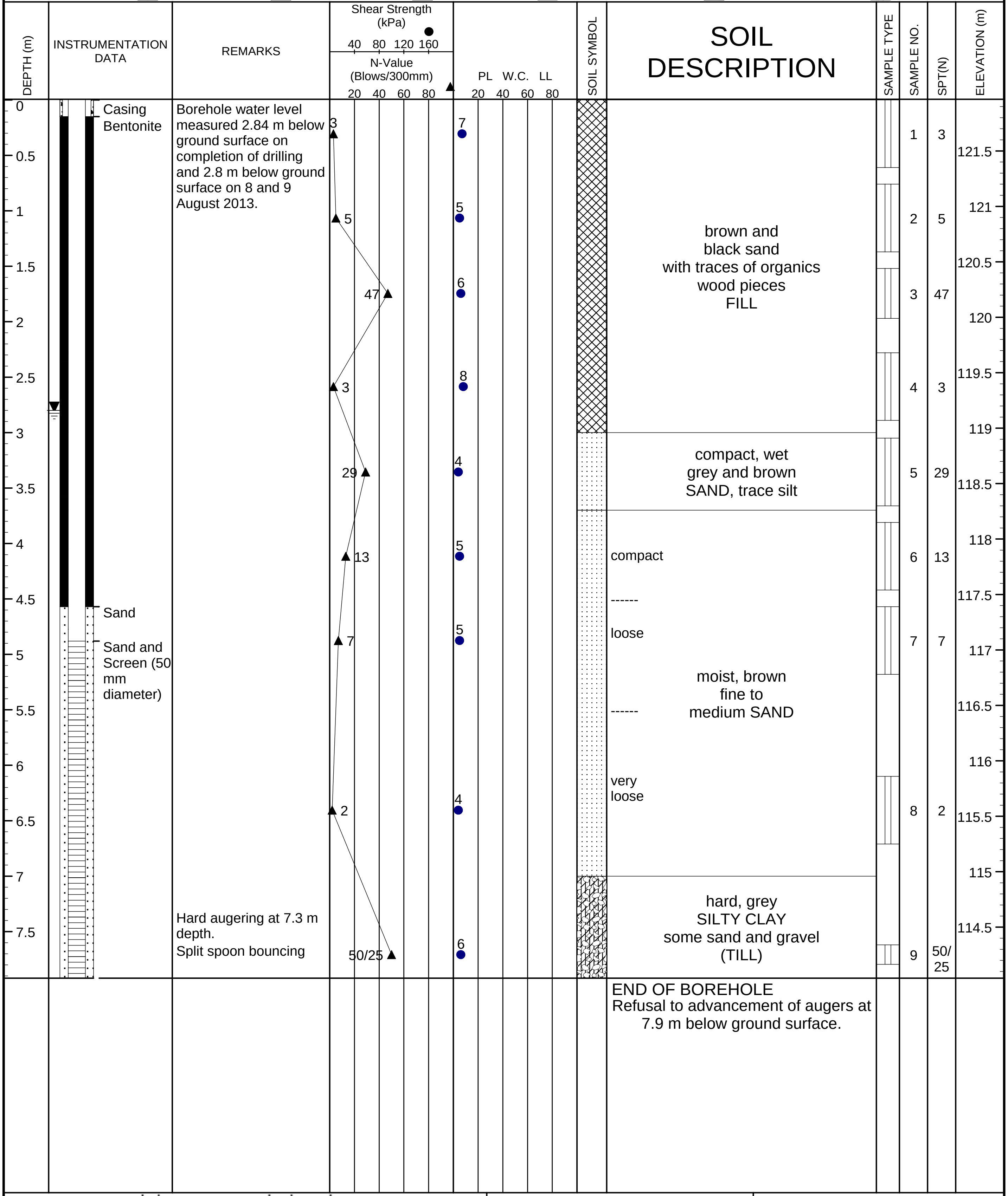
CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling	**BH No.: 12**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN ELEV. (m) 121.96	
LOCATION: Carp, ON	NORTHING: 5016144.282 EASTING: 346499.092	PROJECT NO.: 13-107

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



SOIL DESCRIPTION

REMARKS:

Borehole water level measured 2.84 m below ground surface on completion of drilling and 2.8 m below ground surface on 8 and 9 August 2013.

Hard augering at 7.3 m depth.
Split spoon bouncing

SAMPLE NO.	SPT(N)	W.C.
1	3	7
2	5	5
3	47	6
4	3	8
5	29	4
6	13	5
7	7	5
8	2	4
9	50/ 25	6

brown and
black sand
with traces of organics
wood pieces
FILL

compact, wet
grey and brown
SAND, trace silt

compact
------
loose
------
very
loose

moist, brown
fine to
medium SAND

hard, grey
SILTY CLAY
some sand and gravel
(TILL)

END OF BOREHOLE
Refusal to advancement of augers at 7.9 m below ground surface.

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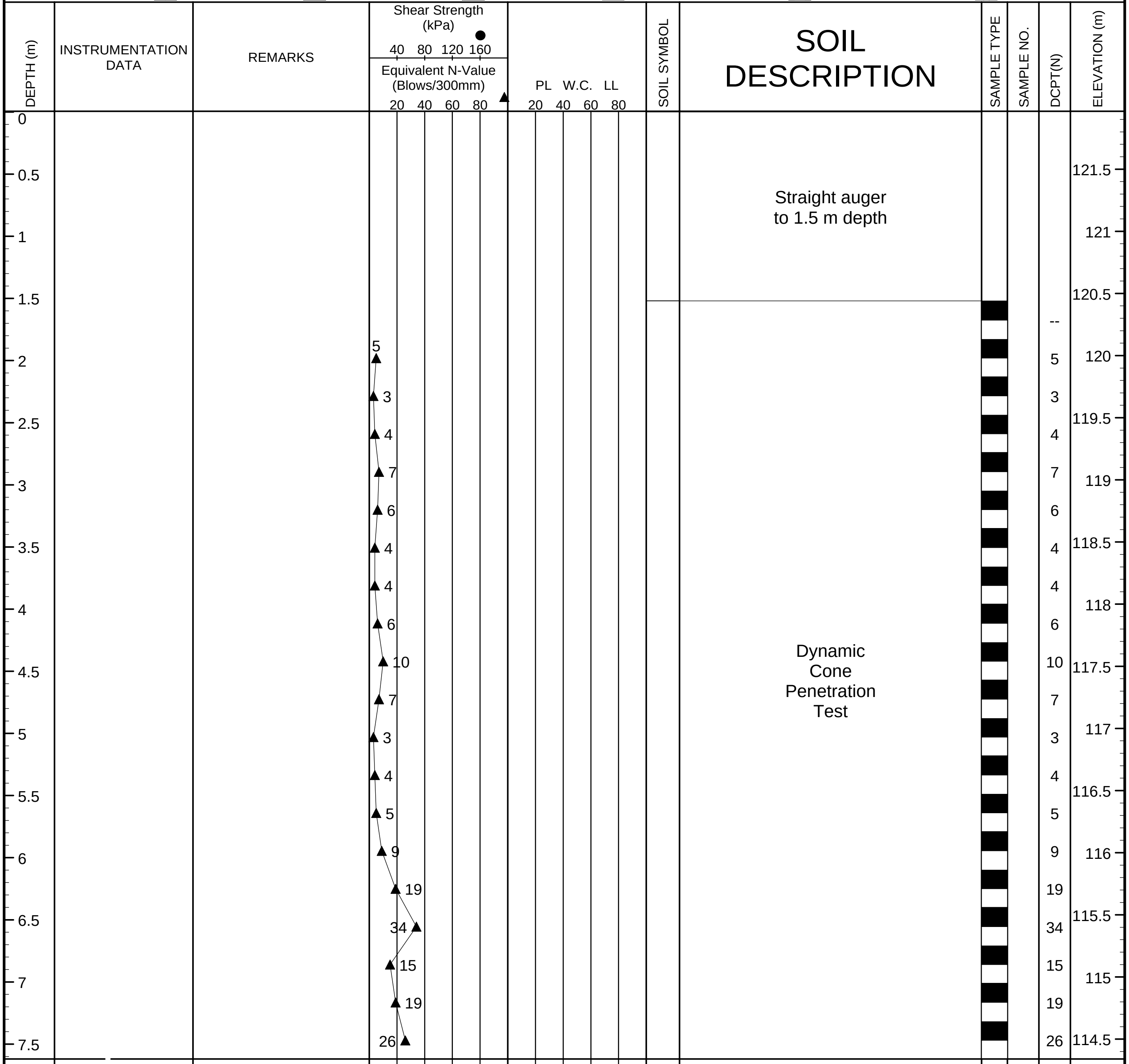
CLIENT: Waste Management
PROJECT: Landfill Expansion
LOCATION: Carp, ON
METHOD: Dynamic Cone Penetration Testing
PROJECT ENGINEER: VN
ELEV. (m) 121.96
NORTHING: 5016144.282
EASTING: 346499.092

DCPT No.: 12A

PROJECT NO.: 13-107

SAMPLE TYPE ▯ AUGER ◪ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 / Equivalent N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0 – 1.5						Straight auger to 1.5 m depth				121.96 – 120.5
1.5 – 7.5						Dynamic Cone Penetration Test	▀		-- 5 3 4 7 6 4 4 6 10 7 3 4 5 9 19 34 15 19 26	120.5 – 114.5
						END OF DYNAMIC CONE PENETRATION TEST				



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REVIEWED BY: VN
DRILLING DATE: 7 August 2013
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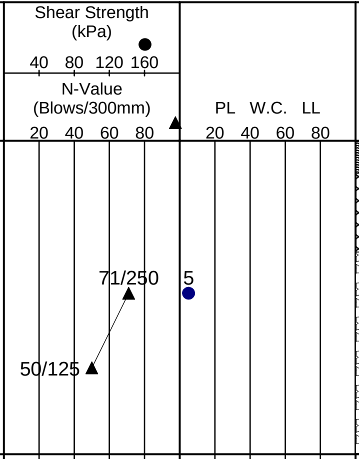
APPENDIX D

BOREHOLE LOGS

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 201**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 117.3	
LOCATION: Carp, ON	NORTHING: 5015513	EASTING: 423788	PROJECT NO.: 13-182

SAMPLE TYPE ◨ AUGER ◪ DRIVEN ⧗ CORING ⬒ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole open and groundwater level at 1.8 m below ground surface on completion.	200 mm TOPSOIL	◪	1		
0.5			damp, brown gravelly sand with organics trace silt and clay, FILL				117
1			very dense brown SAND and GRAVEL some rock fragments	⌶	2	71/ 250	116.5
1.5		Water strike at 1.5 m depth		⌶	3	50/ 125	116
	∇						115.5
			END OF BOREHOLE Refusal to advancement of augers at 2.0 m depth.				

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	REVIEWED BY: VN	Page 1 of 1

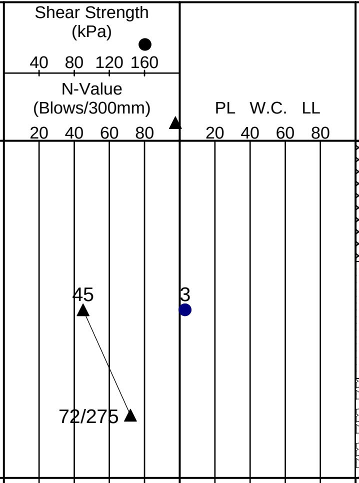
CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling
PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 117.68
LOCATION: Carp, ON
NORTHING: 5015467
EASTING: 423857

BH No.: 202

PROJECT NO.: 13-182

SAMPLE TYPE ▐ AUGER ◢ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▌▐ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole dry and open on completion.	▩	brown sand and gravel with rock fragments some silt, some organics, FILL	◢	1		117.5 117
1 1.5			⠿	dense, brown SAND, trace silt trace gravel	⌶	2	45	116.5
2			⠿	very dense, brown SAND and GRAVEL trace rock fragments	⌶	3	72/ 275	116
				END OF BOREHOLE Refusal to advancement of augers at 2.1 m depth.				



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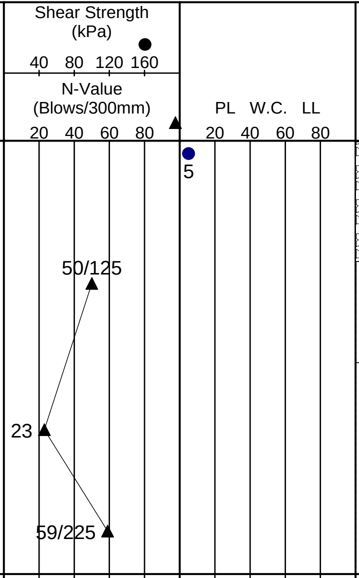
CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling	**BH No.: 203**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN ELEV. (m) 117.35	
LOCATION: Carp, ON	NORTHING: 5015500 EASTING: 423922	PROJECT NO.: 13-182

SAMPLE TYPE ▮ AUGER ◢ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▯ SHELBY Ⅱ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole open and groundwater level at 1.8 m depth on completion.	brown SAND and GRAVEL trace silt trace to some clay	◢	1		117
1			very dense, moist brown SAND trace rock fragments	Ⅱ	2	50/ 125	116.5 116
1.5 2	▽	Water strike at 1.5 m depth.	compact wet, coarse SAND with inclusions of rock fragments	Ⅱ	3	23	115.5
2.5			------ very dense	Ⅱ	4	59/ 225	115
			END OF BOREHOLE Refusal to advancement of augers at 2.7 m depth.				

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CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling

BH No.: 204

PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 117.79
LOCATION: Carp, ON
NORTHING: 5015436
EASTING: 423936
PROJECT NO.: 13-182

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 / N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and open on completion.					DRIVEN	1		
0.5										117.5
1		Cobbles/boulders encountered between 0.63 and 1.5 m depth.	3			brown SAND and GRAVEL trace rock fragments	DRIVEN	2		117
1.5			50/125 ▲			very dense, brown SAND and GRAVEL	SPLIT SPOON	3	50/ 125	116.5

END OF BOREHOLE
Refusal to advancement of augers at 1.6 m depth.

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DRILLING DATE: 19 Dec. 2013
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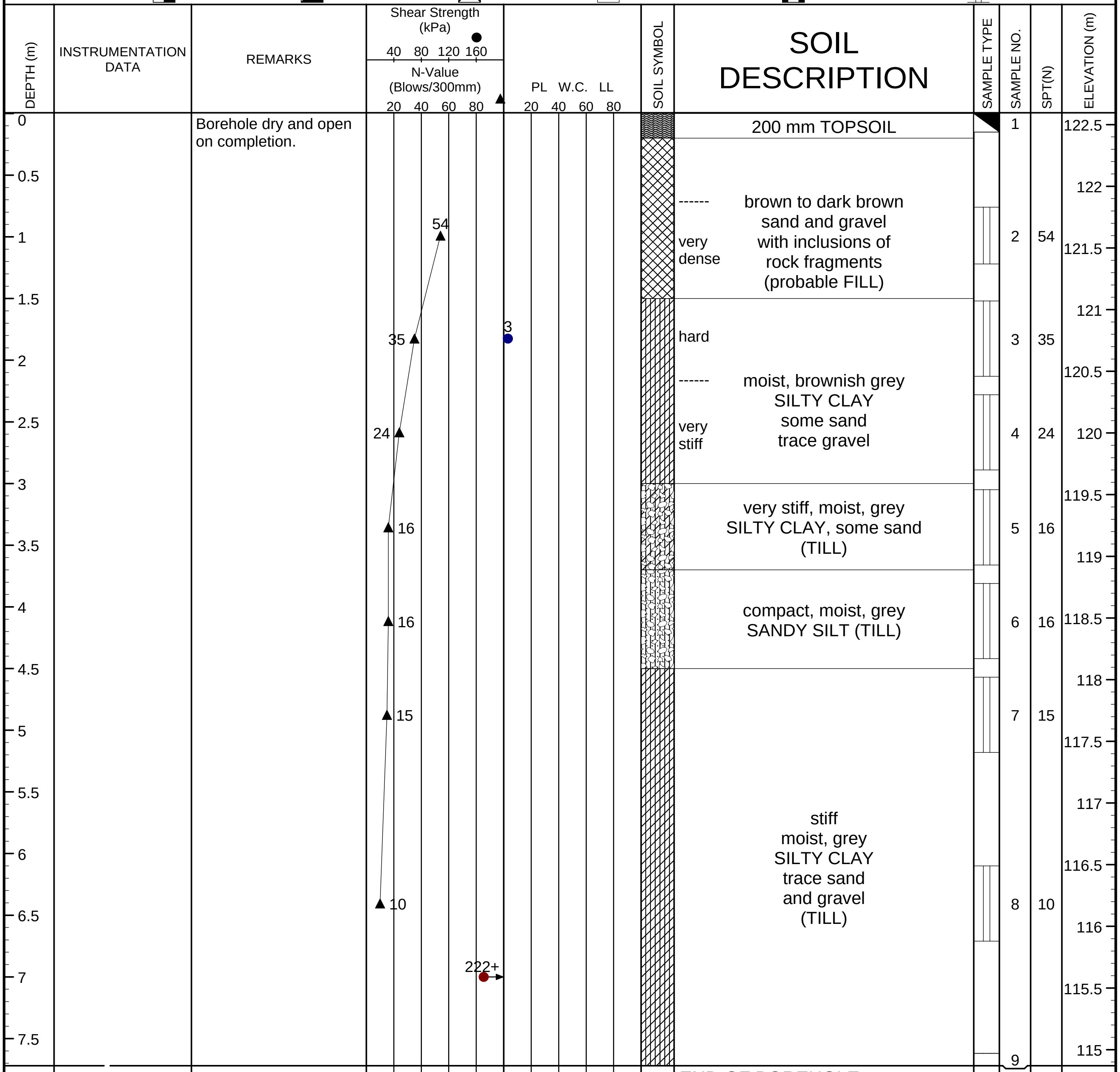
CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling	**BH No.: 205**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN ELEV. (m) 122.59	
LOCATION: Carp, ON	NORTHING: 5015490 EASTING: 423996	PROJECT NO.: 13-182

SAMPLE TYPE ▐ AUGER ◢ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▌▐ SHELBY ⌶ SPLIT SPOON



SOIL DESCRIPTION

REMARKS: Borehole dry and open on completion.

200 mm TOPSOIL

------ very dense — brown to dark brown sand and gravel with inclusions of rock fragments (probable FILL)

hard ------ very stiff — moist, brownish grey SILTY CLAY some sand trace gravel

very stiff, moist, grey SILTY CLAY, some sand (TILL)

compact, moist, grey SANDY SILT (TILL)

stiff moist, grey SILTY CLAY trace sand and gravel (TILL)

END OF BOREHOLE
Refusal to advancement of augers at 7.6 m depth.

SAMPLE NO.	SPT(N)
1	
2	54
3	35
4	24
5	16
6	16
7	15
8	10
9	

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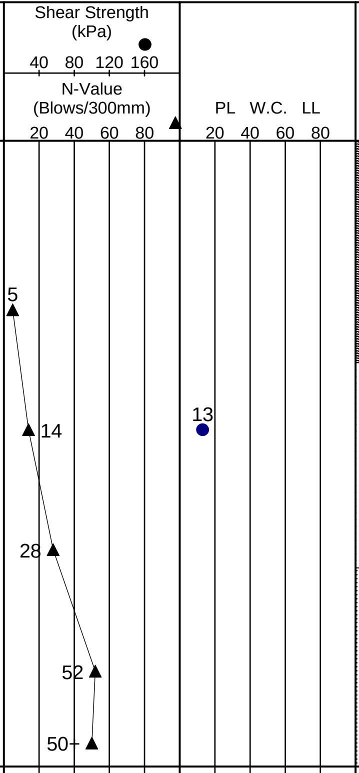
	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling	BH No.: 206
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN ELEV. (m) 121.96	
LOCATION: Carp, ON	NORTHING: 5015262 EASTING: 424026	PROJECT NO.: 13-182

SAMPLE TYPE ◨ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

REMARKS

Borehole dry and open on completion.
25 mm ice and 200 mm frost penetration at borehole location.



DEPTH (m)	SOIL DESCRIPTION		SAMPLE NO.	SPT(N)	ELEVATION (m)
0	1.4 m TOPSOIL		1		
0.5					121.5
1			2	5	121
1.5	compact, moist SILTY fine SAND trace clay trace gravel	brown			120.5
2			3	14	120
2.5		------ brown and grey	4	28	119.5
3	very dense moist, brown SILTY SAND (TILL)				119
3.5			5	52	118.5
			6	50+	

END OF BOREHOLE
Refusal to advancement of augers at 4.0 m depth.

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	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling	
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 121.96
LOCATION: Carp, ON	NORTHING: 5015200	EASTING: 424053

BH No.: 207

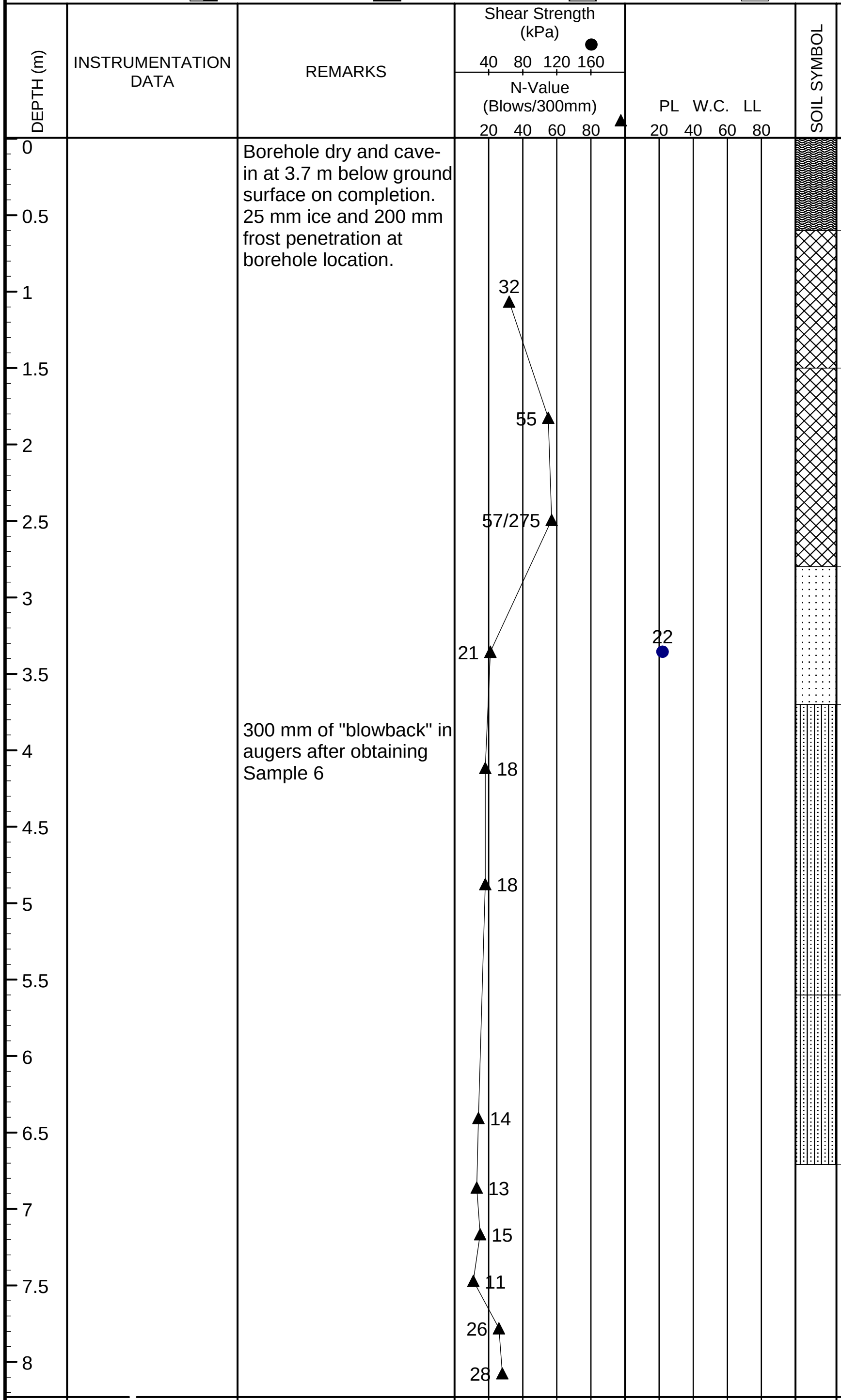
PROJECT NO.: 13-182

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON

REMARKS:

Borehole dry and cave-in at 3.7 m below ground surface on completion. 25 mm ice and 200 mm frost penetration at borehole location.

300 mm of "blowback" in augers after obtaining Sample 6



SOIL DESCRIPTION	SAMPLE NO.	SPT(N)
600 mm TOPSOIL	1	
dense, moist, grey silty sand with some gravel FILL	2	32
very dense damp, dark brown silty sand with inclusions of rock fragments FILL	3 4	55 57/275
compact, wet SAND some silt trace clay trace gravel	5	21
compact wet, brown SILTY SAND	6 7	18 18
compact wet, brown SILT to SANDY SILT	8	14
Dynamic Cone Penetration Test		13 15 11 26 28

ELEVATION (m): 121.5, 121, 120.5, 120, 119.5, 119, 118.5, 118, 117.5, 117, 116.5, 116, 115.5, 115, 114.5, 114

END OF BOREHOLE
Refusal to advancement of dynamic cone at 8.2 m depth.

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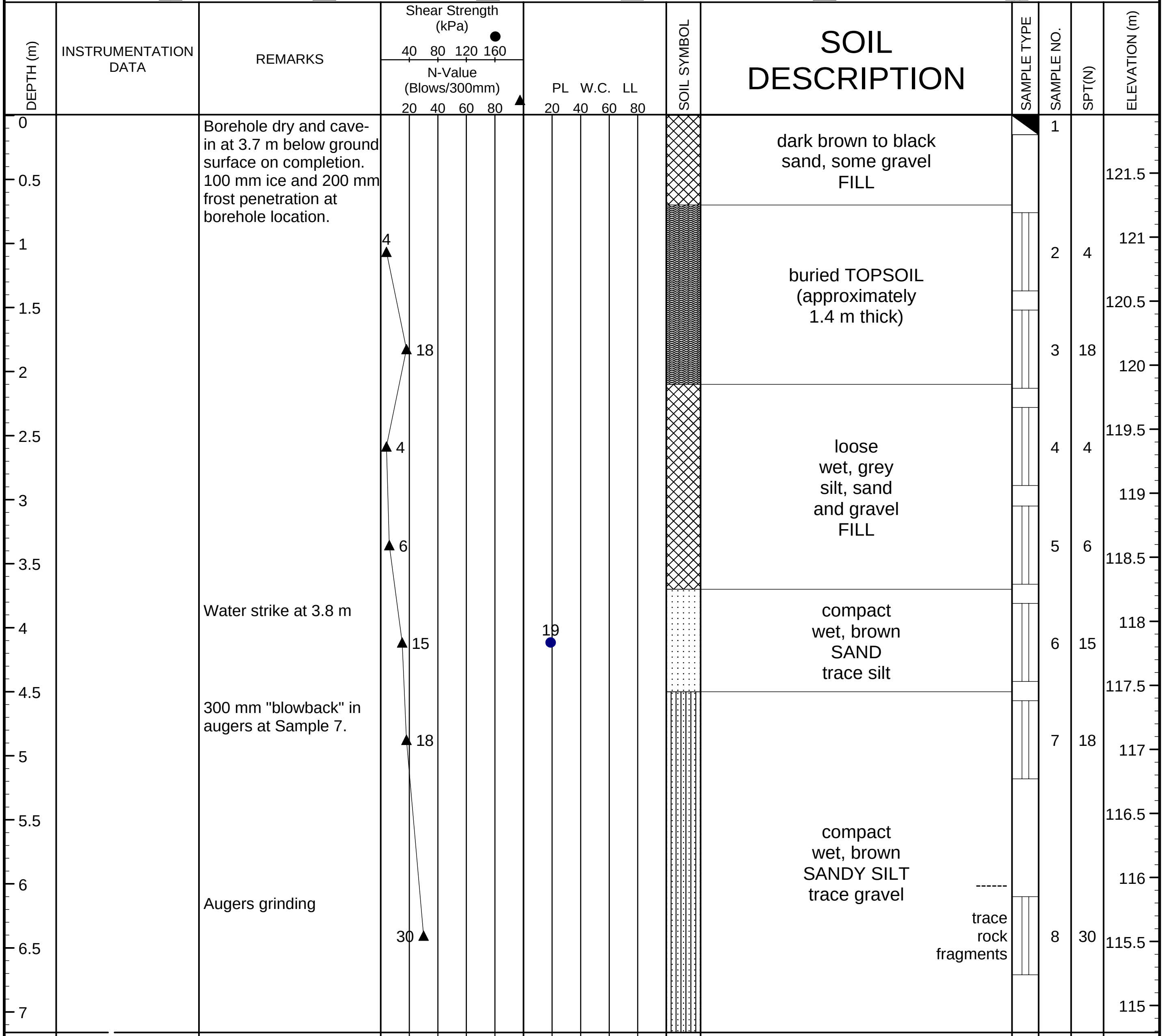
CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling

BH No.: 208

PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 121.95
LOCATION: Carp, ON
NORTHING: 5015224
EASTING: 424119
PROJECT NO.: 13-182

SAMPLE TYPE ▮ AUGER ◪ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



SOIL DESCRIPTION

REMARKS:

Borehole dry and cave-in at 3.7 m below ground surface on completion. 100 mm ice and 200 mm frost penetration at borehole location.

Water strike at 3.8 m

300 mm "blowback" in augers at Sample 7.

Augers grinding

dark brown to black sand, some gravel FILL

buried TOPSOIL (approximately 1.4 m thick)

loose wet, grey silt, sand and gravel FILL

compact wet, brown SAND trace silt

compact wet, brown SANDY SILT trace gravel

------

trace rock fragments

SAMPLE NO.	SPT(N)
1	
2	4
3	18
4	4
5	6
6	15
7	18
8	30

END OF BOREHOLE
Refusal to advancement of augers at 7.2 m depth.

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DRILLING DATE: 18 Dec. 2013
REVIEWED BY: VN
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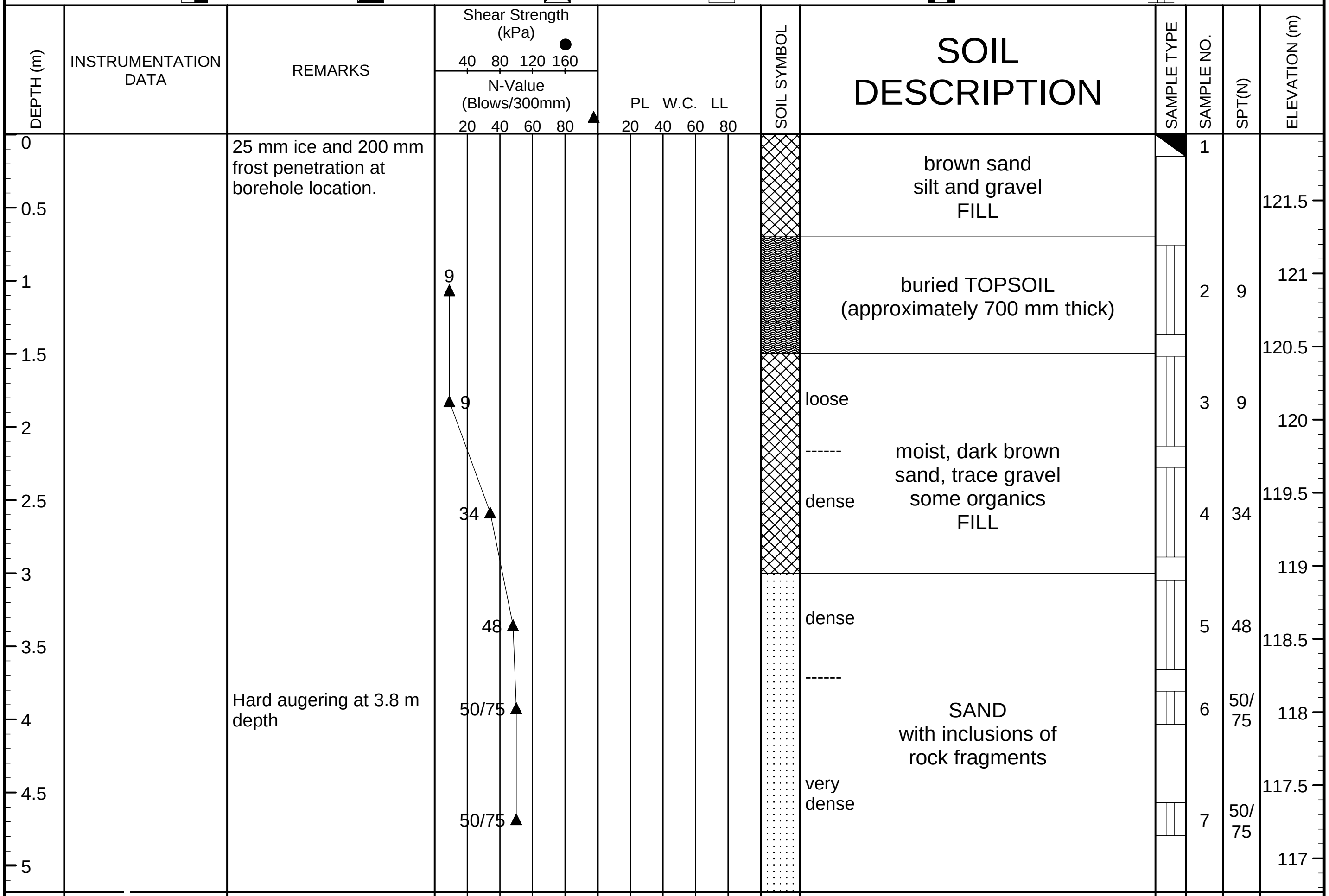
CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling
PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 121.95
LOCATION: Carp, ON
NORTHING: 5015287
EASTING: 424150

BH No.: 209

PROJECT NO.: 13-182

SAMPLE TYPE ◨ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON



REMARKS	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)
25 mm ice and 200 mm frost penetration at borehole location.	brown sand silt and gravel FILL	1	
	buried TOPSOIL (approximately 700 mm thick)	2	9
	loose ------ dense; moist, dark brown sand, trace gravel some organics FILL	3 4	9 34
Hard augering at 3.8 m depth	dense ------ very dense; SAND with inclusions of rock fragments	5 6 7	48 50/75 50/75

END OF BOREHOLE
Refusal to advancement of augers at 5.2 m depth.

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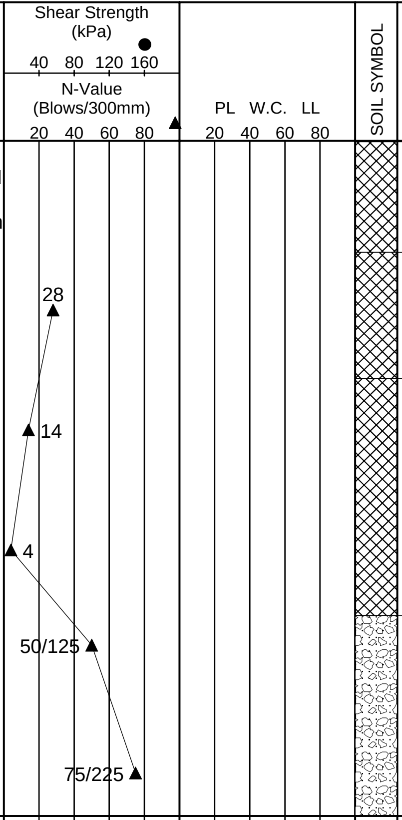
LOGGED BY: KC
DRILLING DATE: 18 Dec. 2013
REVIEWED BY: VN

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 210**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 121.97	
LOCATION: Carp, ON	NORTHING: 5015161	EASTING: 424102	PROJECT NO.: 13-182

SAMPLE TYPE ▯ AUGER ◪ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole dry and cave-in at 2.3 m below ground surface on completion. 100 mm ice and 200 mm frost penetration at borehole location.	wet, brown sandy silt FILL	◪	1		121.5
1			very stiff, moist, brown clayey silt, trace sand some gravel, FILL	⌶	2	28	121
1.5 2 2.5			compact moist ------ grey ------ sandy silt FILL loose wet	⌶ ⌶	3 4	14 4	120.5 120 119.5
3 3.5 4		Split spoon bouncing	very dense wet, grey SAND and GRAVEL with inclusions of rock fragments	⌶ ⌶	5 6	50/ 125 75/ 225	119 118.5 118
			END OF BOREHOLE Refusal to advancement of augers at 4.3 m depth.				

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	REVIEWED BY: VN	Page 1 of 1

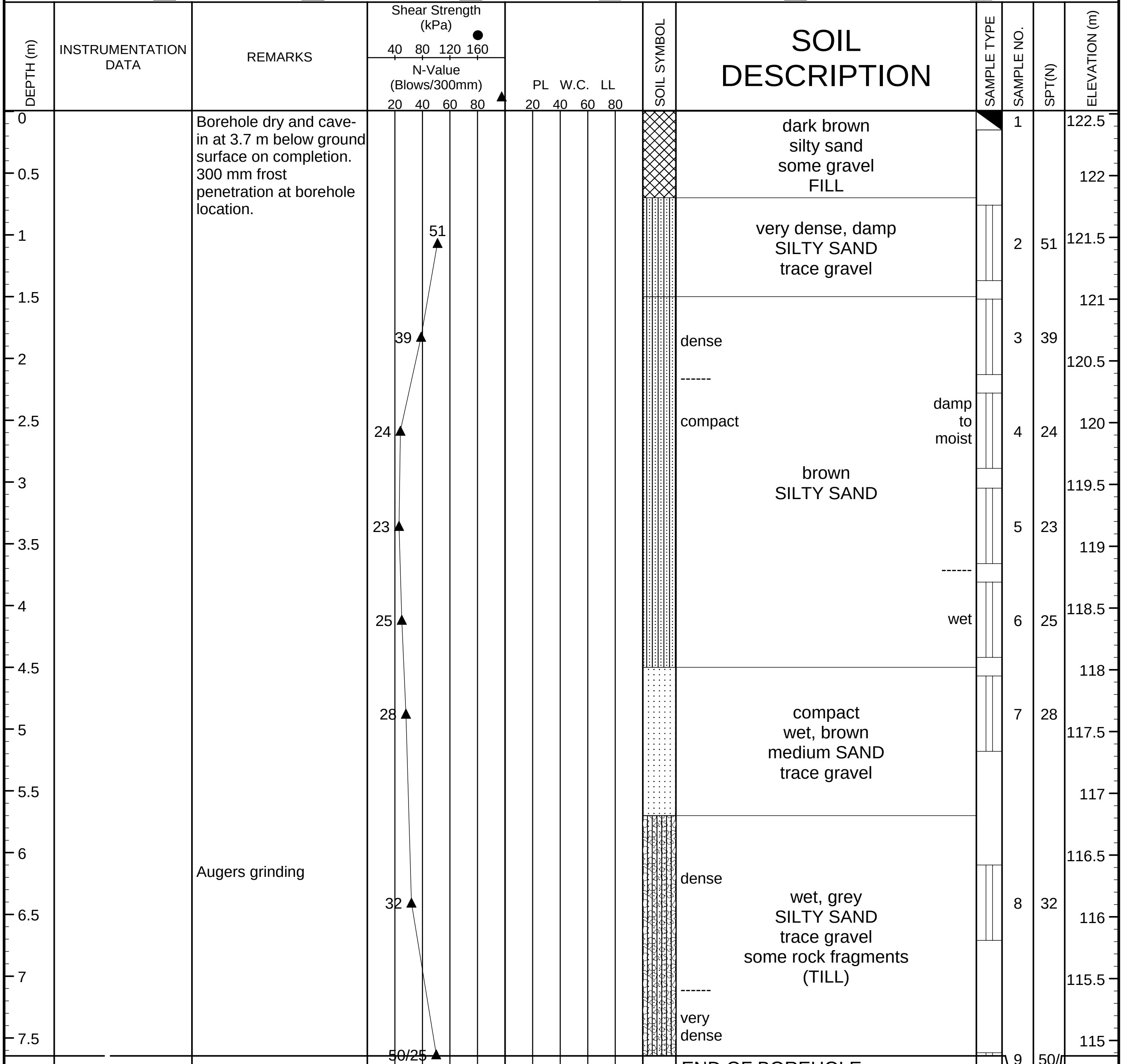
CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling
PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 122.52

BH No.: 211

LOCATION: Carp, ON
NORTHING: 5015230
EASTING: 424181
PROJECT NO.: 13-182

SAMPLE TYPE ◧ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)
0		Borehole dry and cave-in at 3.7 m below ground surface on completion. 300 mm frost penetration at borehole location.	dark brown silty sand some gravel FILL	1	
			very dense, damp SILTY SAND trace gravel	2	51
			dense ------ compact damp to moist brown SILTY SAND ------ wet	3 4 5 6	39 24 23 25
			compact wet, brown medium SAND trace gravel	7	28
		Augers grinding	dense wet, grey SILTY SAND trace gravel some rock fragments (TILL) ------ very dense	8 9	32 50/25
			END OF BOREHOLE Refusal to advancement of augers at 7.6 m depth.		



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DRILLING DATE: 18 Dec. 2013
REVIEWED BY: VN
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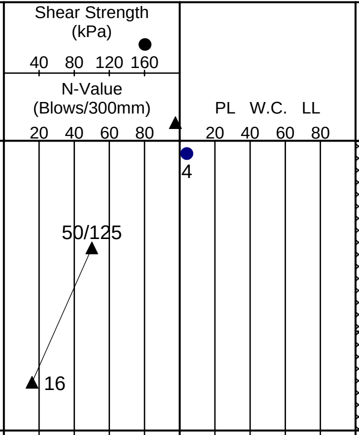
CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling
PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 98.33

BH No.: 212

LOCATION: Carp, ON
NORTHING: 5014389
EASTING: 423467
PROJECT NO.: 13-182

SAMPLE TYPE: AUGER, DRIVEN, CORING, DYNAMIC CONE, SHELBY, SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and open on completion. 200 mm frost penetration	------ sand and gravel FILL very dense	1		98
0.5				2	50/ 125	97.5
1						
1.5			very stiff, dark brown clayey silt, trace sand and gravel, FILL	3	16	97

END OF BOREHOLE
Refusal to advancement of augers at 1.8 m depth.

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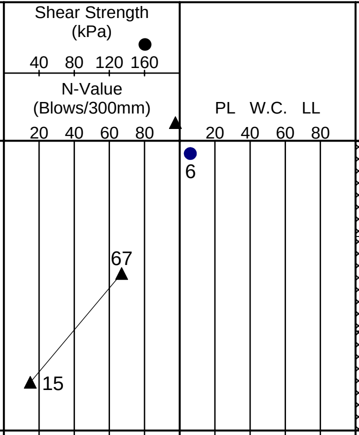
LOGGED BY: KC
DRILLING DATE: 19 Dec. 2013
REVIEWED BY: VN

CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling
PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 98.30

BH No.: 213

LOCATION: Carp, ON
NORTHING: 5014352
EASTING: 423500
PROJECT NO.: 13-182

SAMPLE TYPE ◧ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ◫ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole dry and open on completion. 200 mm frost penetration	▨	gravelly sand trace silt FILL	◪	1		98
1			▨	hard, moist, dark brown clayey silt, trace sand and gravel, FILL	⌶	2	67	97.5
1.5			▨	stiff, moist, brown clayey silt, trace sand trace organics, FILL	⌶	3	15	97 96.5
				END OF BOREHOLE				

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CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling

BH No.: 214

PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 98.11
LOCATION: Carp, ON
NORTHING: 5014315
EASTING: 423534
PROJECT NO.: 13-182

SAMPLE TYPE: ◨ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▯ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 / N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and open on completion. 200 mm frost penetration			▨	sand and gravel FILL	◪	1		98
0.5					▨	silty sand some gravel FILL	◪	2		97.5
1										97
1.5			▲ 42		▨	hard, dark brown clayey silt, trace sand and gravel, FILL	⌶	3	42	96.5

END OF BOREHOLE

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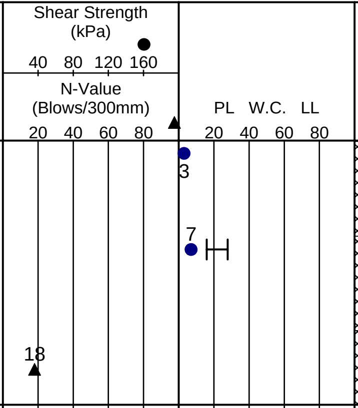
REVIEWED BY: VN
Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		# BH No.: 215
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 98.29	
LOCATION: Carp, ON	NORTHING: 5014281	EASTING: 423566	PROJECT NO.: 13-182

SAMPLE TYPE ▯ AUGER ◢ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole dry and open on completion. 200 mm frost penetration	▩	gravelly sand trace to some silt FILL	◢	1		98
1			▩	silty sand, trace gravel some clay, FILL	◢	2		97.5
1.5			▩	very stiff, moist, brown clayey silt, trace sand and gravel, FILL	⌶	3	18	97

END OF BOREHOLE

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REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling	**BH No.: 216**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN / ELEV. (m) 98.35	
LOCATION: Carp, ON	NORTHING: 5014244 / EASTING: 423599	PROJECT NO.: 13-182

SAMPLE TYPE ▯ AUGER ◪ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole dry and open on completion. 200 mm frost penetration			▨	sand and gravel, FILL	◪	1		98
1					▨	brown/dark brown silty sand, trace gravel FILL	◪	2		97.5
1.5			16 ▲		▨	very stiff, moist, dark brown clayey silt, trace gravel trace organics, FILL	⌶	3	16	97
						END OF BOREHOLE				

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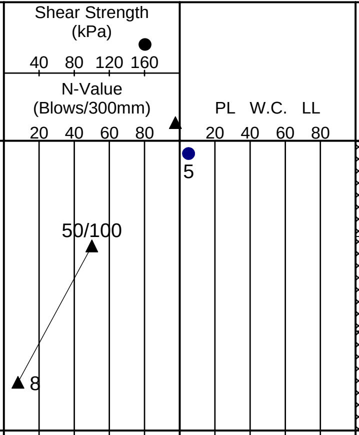
	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 217**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 98.49	
LOCATION: Carp, ON	NORTHING: 5014211	EASTING: 423638	PROJECT NO.: 13-182

SAMPLE TYPE ◧ AUGER ◪ DRIVEN ⧓ CORING ⬒ DYNAMIC CONE ▯ SHELBY Ⅱ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 0.5		Borehole dry and open on completion. 200 mm frost penetration	▩	gravelly sand trace silt FILL	◪	1		98
1			▩	very dense gravel and rock fragments with some clayey silt, FILL	Ⅱ	2	50/ 100	97.5
1.5			▩	loose, dark brown sand, trace gravel FILL	Ⅱ	3	8	97
				END OF BOREHOLE				

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	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.

METHOD: Augering and Split Spoon Sampling

BH No.: 218

PROJECT: WCEC Landfill Expansion

PROJECT ENGINEER: VN

ELEV. (m) 99.03

LOCATION: Carp, ON

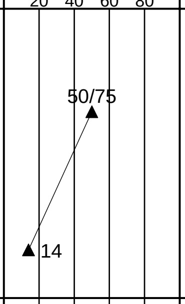
NORTHING: 5014283

EASTING: 423681

PROJECT NO.: 13-182

SAMPLE TYPE						
	AUGER	DRIVEN	CORING	DYNAMIC CONE	SHELBY	SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 / N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and open on completion. 200 mm frost penetration			▨	sand and gravel, FILL	AUGER	1		99
0.5 1			50/75		▨	very dense, damp, brown fine sand to sandy silt trace to some gravel, FILL	SPLIT SPOON	2	50/ 75	98.5 98
1.5			14		▨	stiff, moist, grey clayey silt, trace gravel FILL	SPLIT SPOON	3	14	97.5
						END OF BOREHOLE				



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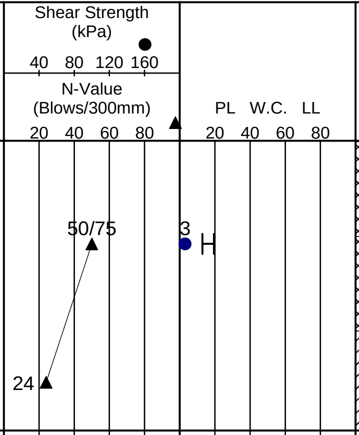
CLIENT: WSP Canada Inc.
METHOD: Augering and Split Spoon Sampling

BH No.: 219

PROJECT: WCEC Landfill Expansion
PROJECT ENGINEER: VN
ELEV. (m) 98.91
LOCATION: Carp, ON
NORTHING: 5014152
EASTING: 423724
PROJECT NO.: 13-182

SAMPLE TYPE ▯ AUGER ◪ DRIVEN ⧗ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and open on completion. 200 mm frost penetration	sand and gravel, FILL	◪	1		
0.5							98.5
			very dense, damp, brown gravelly silty sand trace clay, FILL	⌶	2	50/ 75	
1							98
1.5			very stiff, moist, grey SILTY CLAY trace sand and gravel	▮	3	24	97.5
			END OF BOREHOLE				

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REVIEWED BY: VN
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CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling	
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN ELEV. (m) 99.04	**BH No.: 220**
LOCATION: Carp, ON	NORTHING: 5014122 EASTING: 423770	PROJECT NO.: 13-182

SAMPLE TYPE ▯ AUGER ◪ DRIVEN ⧓ CORING ▀ DYNAMIC CONE ▮ SHELBY ⌶ SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	Shear Strength (kPa) ● 40 80 120 160 N-Value (Blows/300mm) ▲ 20 40 60 80	PL W.C. LL 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole dry and open on completion. 200 mm frost penetration		● 9	▨	sand, some gravel trace silt and clay FILL	◪	1		99
0.5			▲ 50/125		▨	very dense, moist, brown fine sand to sandy silt trace to some gravel, FILL	⌶	2	50/ 125	98.5
1					▨					98
1.5			▲ 15		▨	stiff, moist, grey clayey silt, trace gravel FILL	⌶	3	15	97.5
						END OF BOREHOLE				

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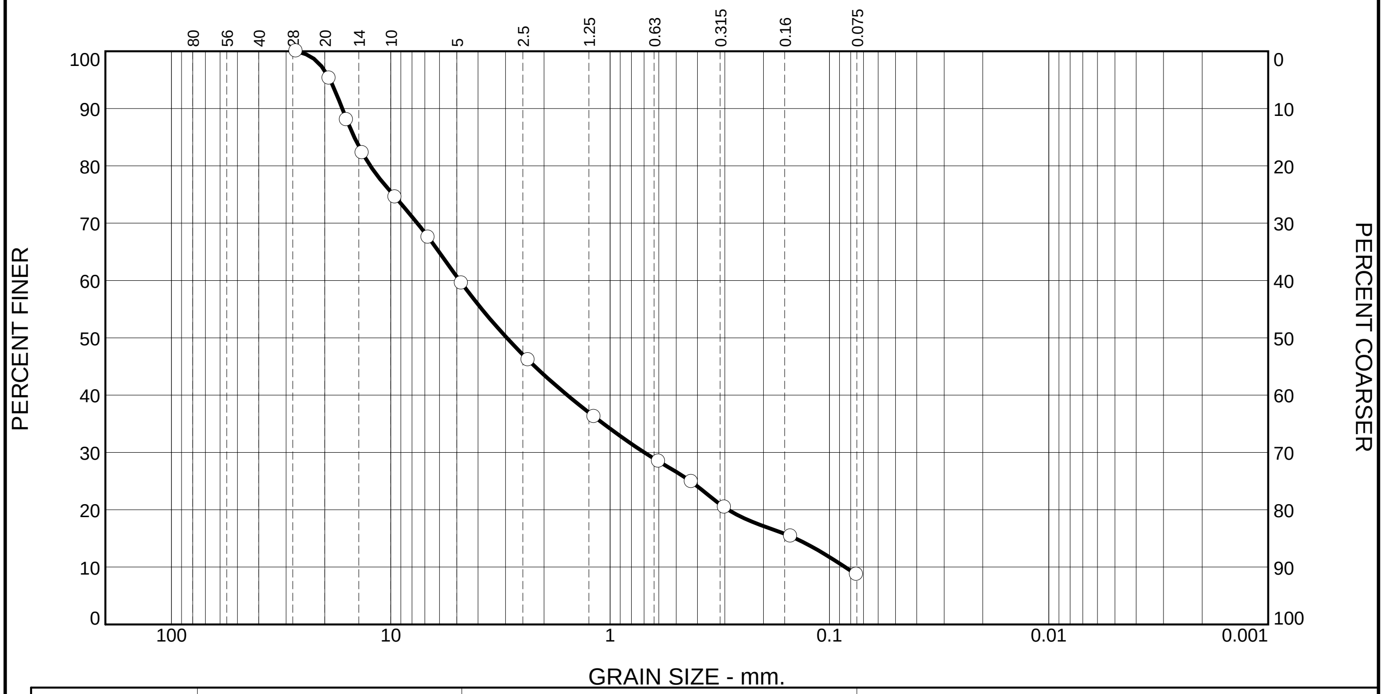
	REVIEWED BY: VN	Page 1 of 1

APPENDIX E

LABORATORY TEST RESULTS

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	5	35	16	19	16	9	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			14.6581	4.8520	2.9595	0.6987	0.1429	0.0848	1.19	57.23

Material Description	USCS	AASHTO
○ SAND and GRAVEL, trace silt		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 212, Sample 1

Remarks:

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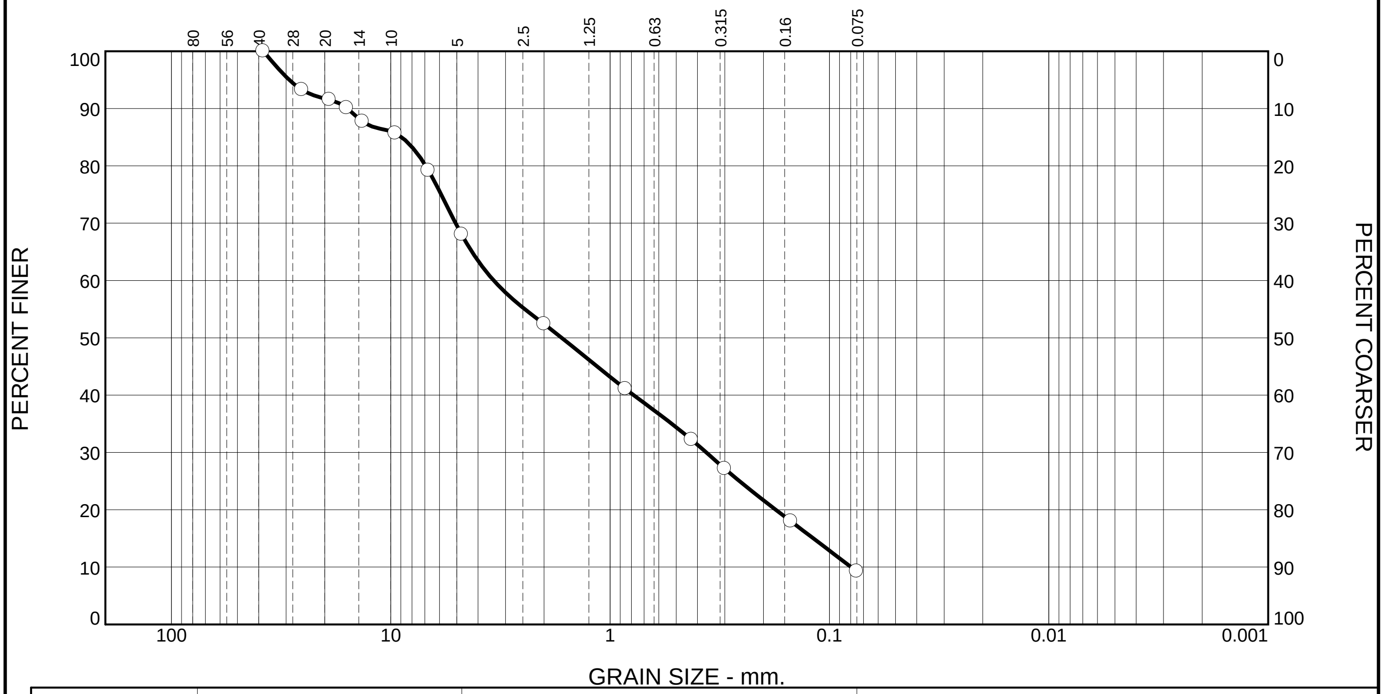
Figure E-1

Tested By: GL **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	8	24	16	20	23	9	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			8.9168	3.3944	1.6630	0.3646	0.1184	0.0797	0.49	42.60

Material Description	USCS	AASHTO
○ GRAVELLY SAND, trace silt		

Project No. 13-182 **Client:** WSP Canada Inc.
Project: WCEC Landfill Expansion
○ **Sample Number:** BH 213, Sample 1

Remarks:

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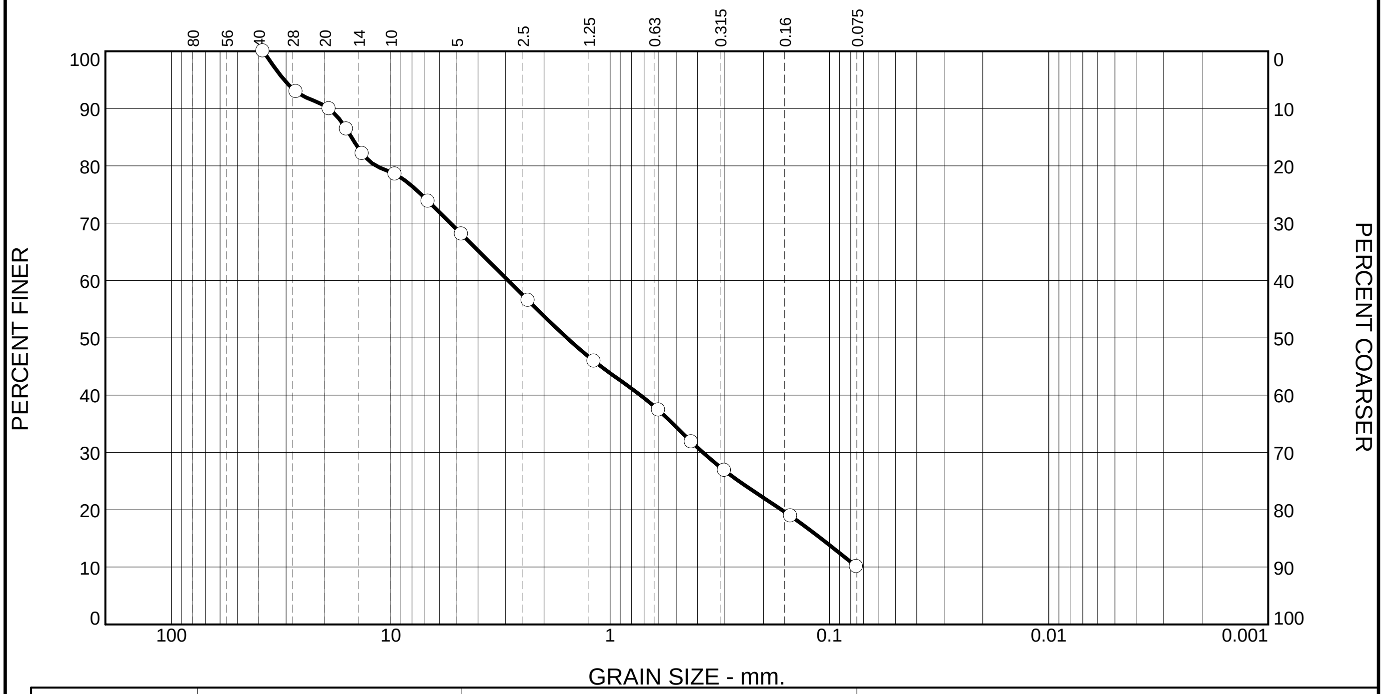
Figure E-2

Tested By: GL **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	10	22	14	22	22	10	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			15.0908	2.9203	1.5748	0.3777	0.1093			

Material Description	USCS	AASHTO
○ GRAVELLY SAND, trace to some silt		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 215, Sample 1

Remarks:

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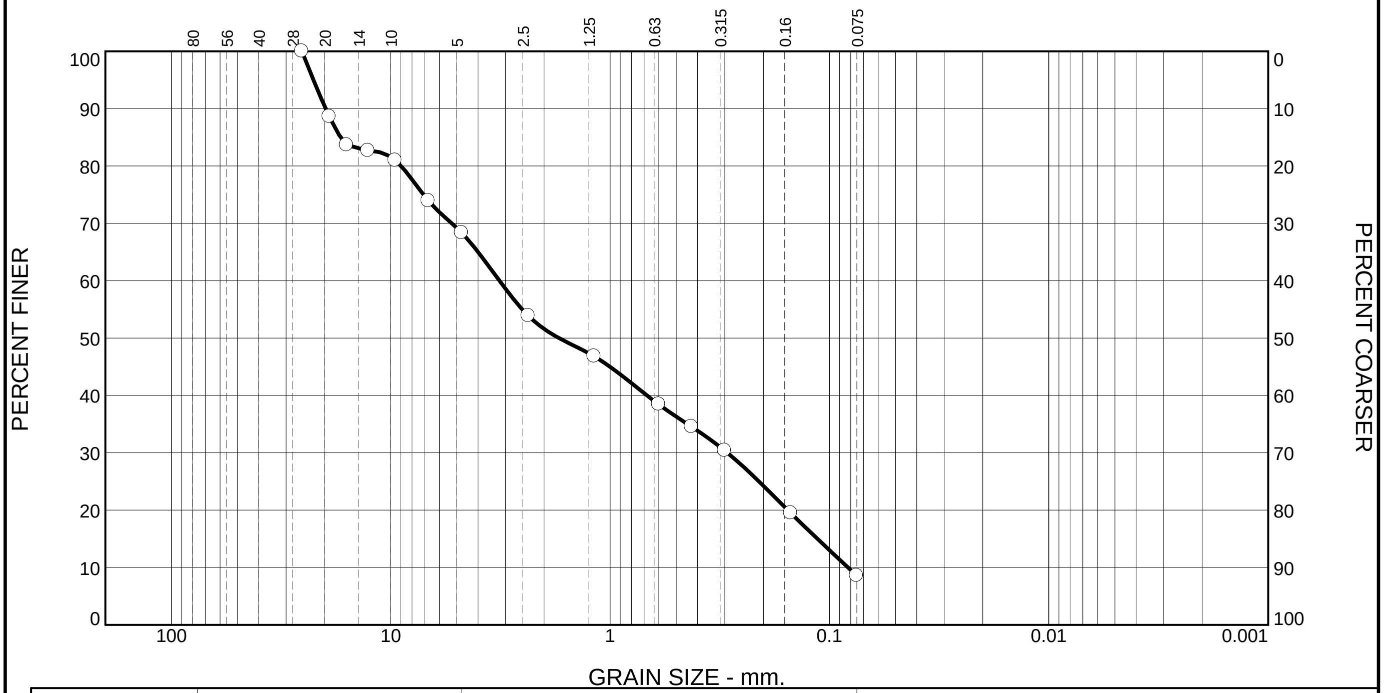
Figure E-3

Tested By: GL **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	11	21	16	17	26	9	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			16.9520	3.1958	1.7119	0.2919	0.1135	0.0823	0.32	38.83

Material Description	USCS	AASHTO
○ GRAVELLY SAND, trace silt		

Project No. 13-182 **Client:** WSP Canada Inc.
Project: WCEC Landfill Expansion
○ **Sample Number:** BH 217, Sample 1

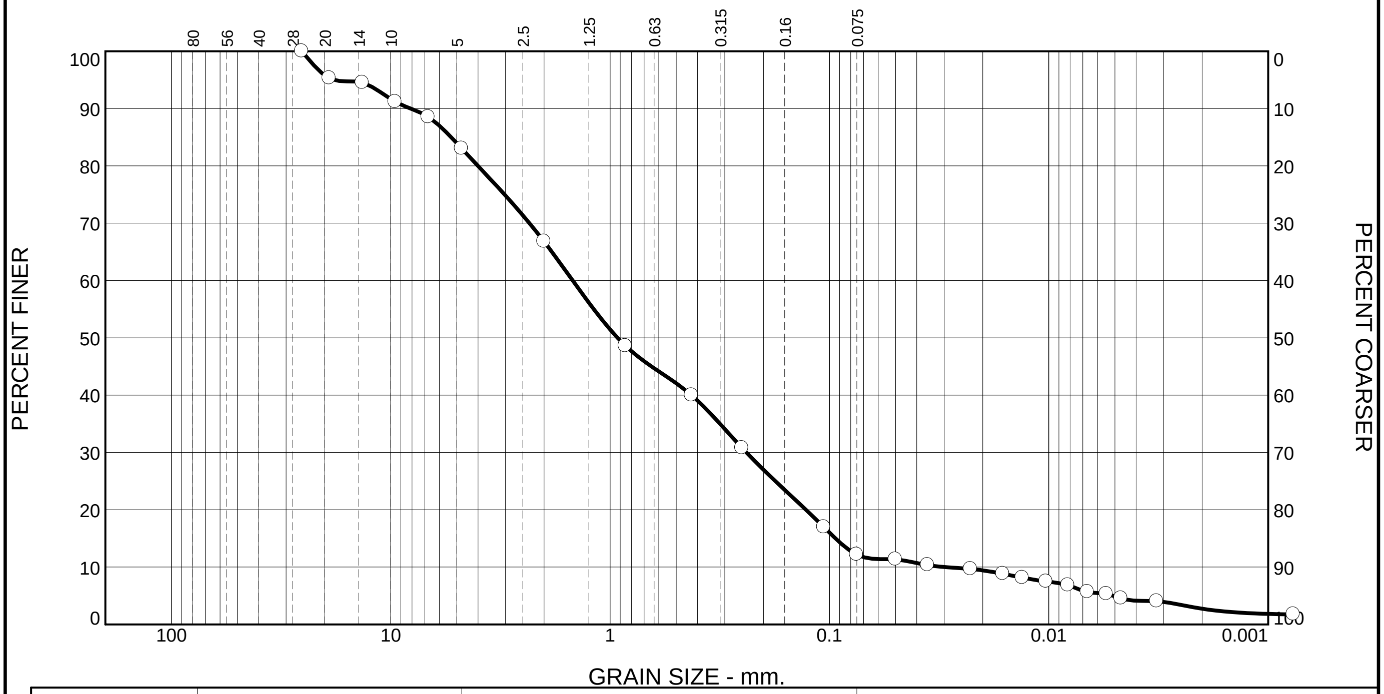
Remarks:

alston associates inc.
consulting engineers

Figure E-4

Tested By: MA **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	5	12	16	27	28	9	3

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			5.3062	1.4820	0.9243	0.2392	0.0939	0.0299	1.29	49.63

Material Description	USCS	AASHTO
○ SAND, some gravel, trace silt, trace clay		

Project No. 13-182 **Client:** WSP Canada Inc.
Project: WCEC Landfill Expansion
○ **Sample Number:** BH 220, Sample 1

Remarks:

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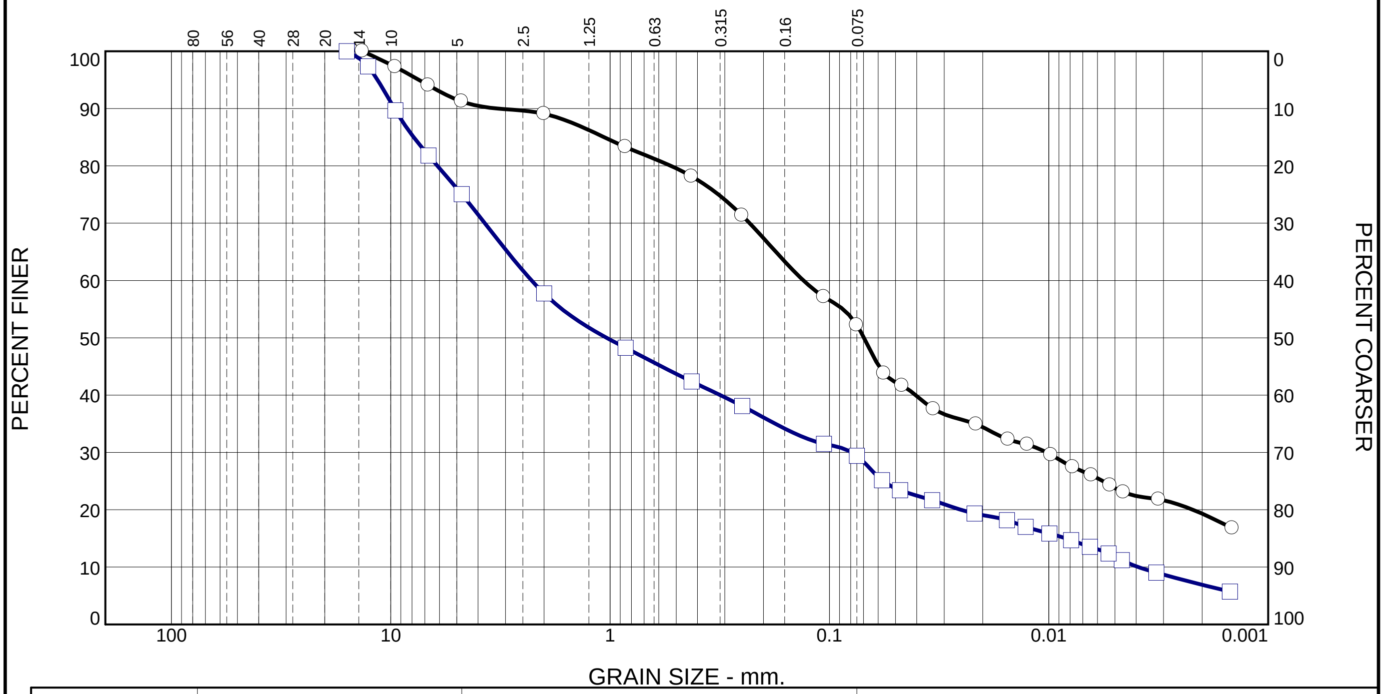
consulting engineers

Figure E-5

Tested By: TS/RH **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	9	2	11	26	33	19
□	0	0	25	17	16	13	22	7

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			1.0643	0.1314	0.0696	0.0102				
□			7.8634	2.2801	1.0370	0.0790	0.0084	0.0039	0.70	583.78

Material Description	USCS	AASHTO
○ SILTY SAND, some clay to CLAYEY, trace gravel		
□ GRAVELLY SILTY SAND, trace clay		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 215, Sample 2

□ **Sample Number:** BH 219, Sample 2

Remarks:

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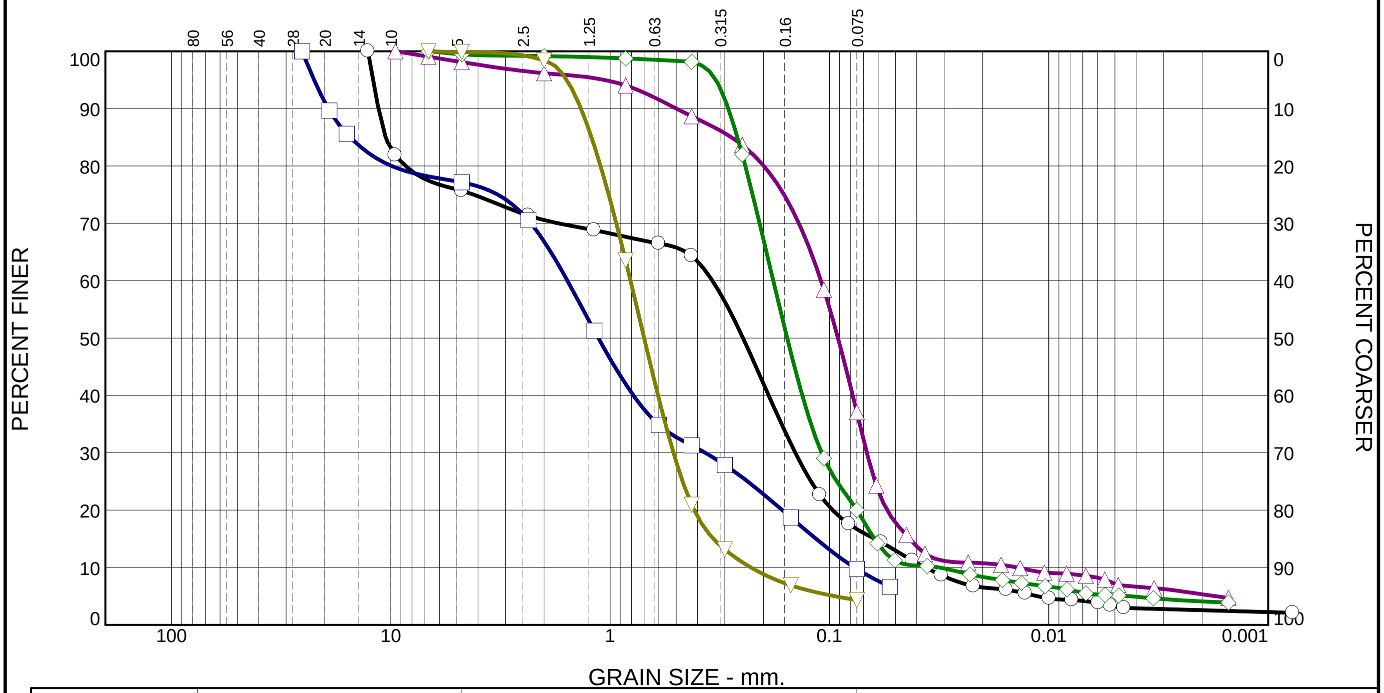
Figure E-6

Tested By: ○ GL/RH □ TS/NW **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	24	5	7	47	14	3
□	0	10	13	10	36	21	10	
△	0	0	2	2	7	52	32	5
◇	0	0	1	0	1	78	16	4
▽	0	0	0	2	77	17	4	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			10.5465	0.3415	0.2479	0.1432	0.0622	0.0365	1.64	9.34
□			15.3170	1.5667	1.1313	0.3688	0.1152	0.0769	1.13	20.36
△			0.2799	0.1093	0.0914	0.0675	0.0431	0.0140	2.98	7.82
◇			0.2629	0.1804	0.1560	0.1087	0.0625	0.0316	2.07	5.71
▽			1.2160	0.8074	0.7000	0.5143	0.3386	0.2283	1.43	3.54

Material Description	USCS	AASHTO
○ GRAVELLY SAND, some silt, trace clay		
□ GRAVELLY SAND, trace to some silt		
△ SILTY fine SAND, trace clay, trace gravel		
◇ fine SAND, some silt, trace clay, trace gravel		
▽ SAND, trace silt	SP	

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 8, Sample 4B

□ **Sample Number:** BH 8, Sample 6

△ **Sample Number:** BH 206, Sample 3

◇ **Sample Number:** BH 207, Sample 5

▽ **Sample Number:** BH 208, Sample 6

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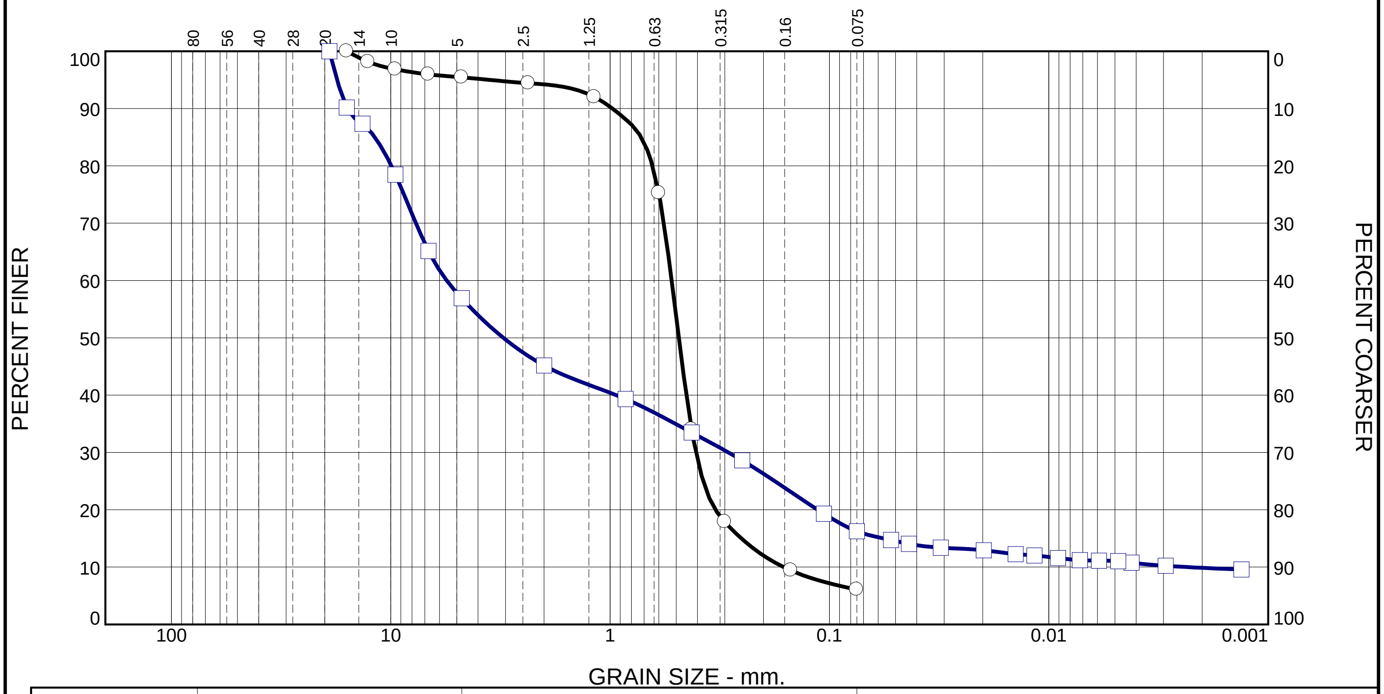
Remarks:

Figure E-7

Tested By: ○ MA/TA □ MA △ GL/RH ◇ GL/NW ▽ GL **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	5	1	60	28	6	
☐	0	0	43	12	12	17	6	10

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.7217	0.5240	0.4859	0.4062	0.2523	0.1618	1.95	3.24
☐			11.8154	5.5569	3.0714	0.2887	0.0567	0.0023	6.40	2371.56

Material Description	USCS	AASHTO
○ SAND, trace silt, trace gravel		
☐ SANDY GRAVEL, trace to some clay, trace silt		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○

☐ **Sample Number:** BH 203, Sample 1

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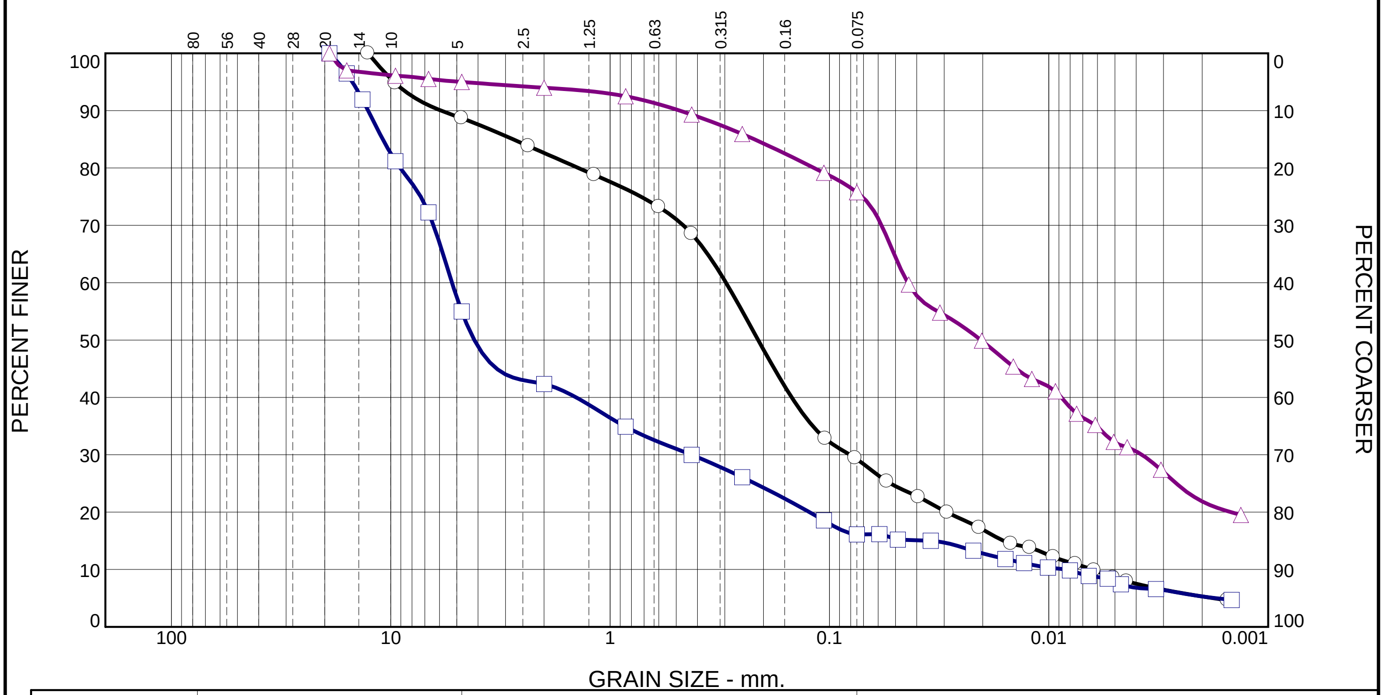
Remarks:

Figure E-8

Tested By: GL/NW **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	11	6	14	40	24	5
□	0	0	45	13	12	14	11	5
△	0	0	5	1	5	13	54	22

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			2.7697	0.2965	0.2113	0.0807	0.0161	0.0063	3.46	46.71
□			10.8767	5.2580	4.1604	0.4263	0.0342	0.0084	4.11	625.30
△			0.2200	0.0440	0.0204	0.0038				

Material Description	USCS	AASHTO
○ SILTY fine SAND, some gravel, trace clay		
□ SAND and GRAVEL, trace to some silt, trace clay		
△ SILTY CLAY, some sand, trace gravel		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 4, Sample 2

□ **Sample Number:** BH 204, Sample 2

△ **Sample Number:** BH 205, Sample 3

Remarks:

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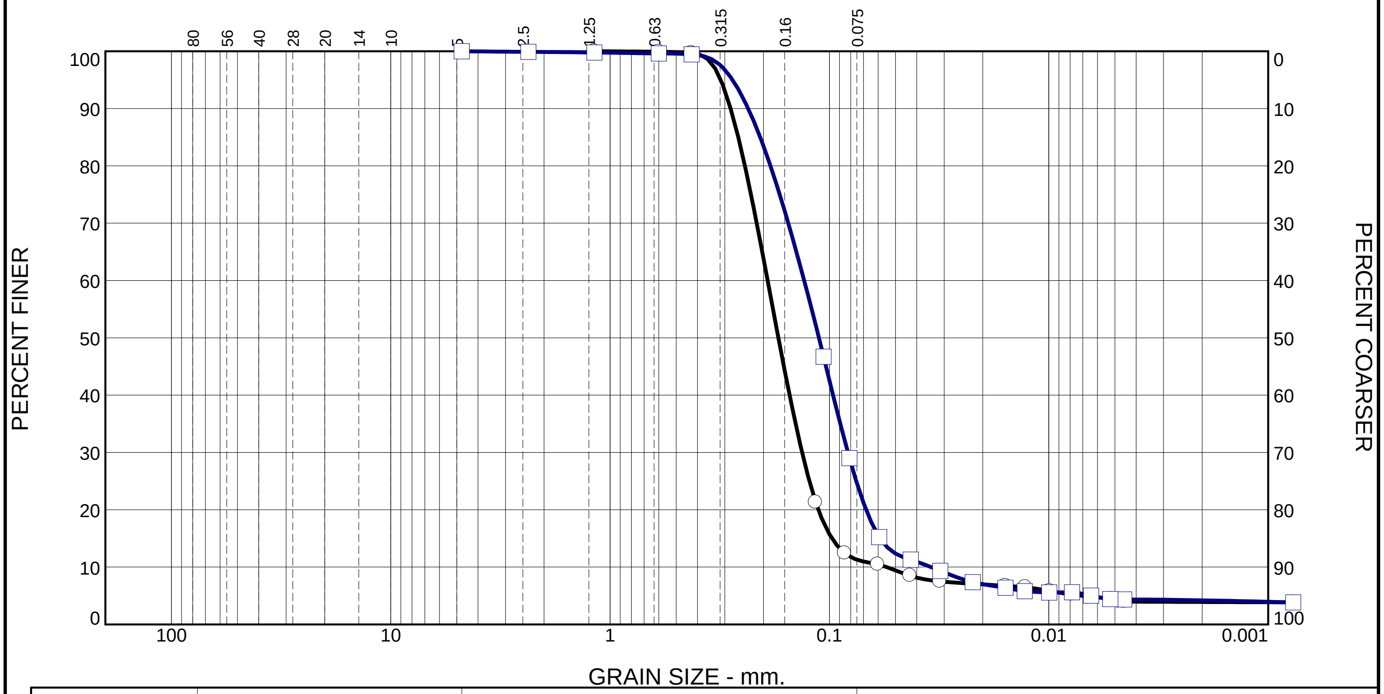
Figure E-9

Tested By: ○ MA/AM □ GL/RH △ TS **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	0	89	7	4
□	0	0	0	0	1	74	21	4

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.2606	0.1914	0.1709	0.1334	0.0975	0.0549	1.69	3.49
□			0.2070	0.1304	0.1118	0.0825	0.0588	0.0345	1.51	3.78

Material Description	USCS	AASHTO
○ fine SAND, trace silt, trace clay		
□ SILTY fine SAND, trace clay		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 12, Sample 5

□ **Sample Number:** BH 12, Sample 8

Remarks:

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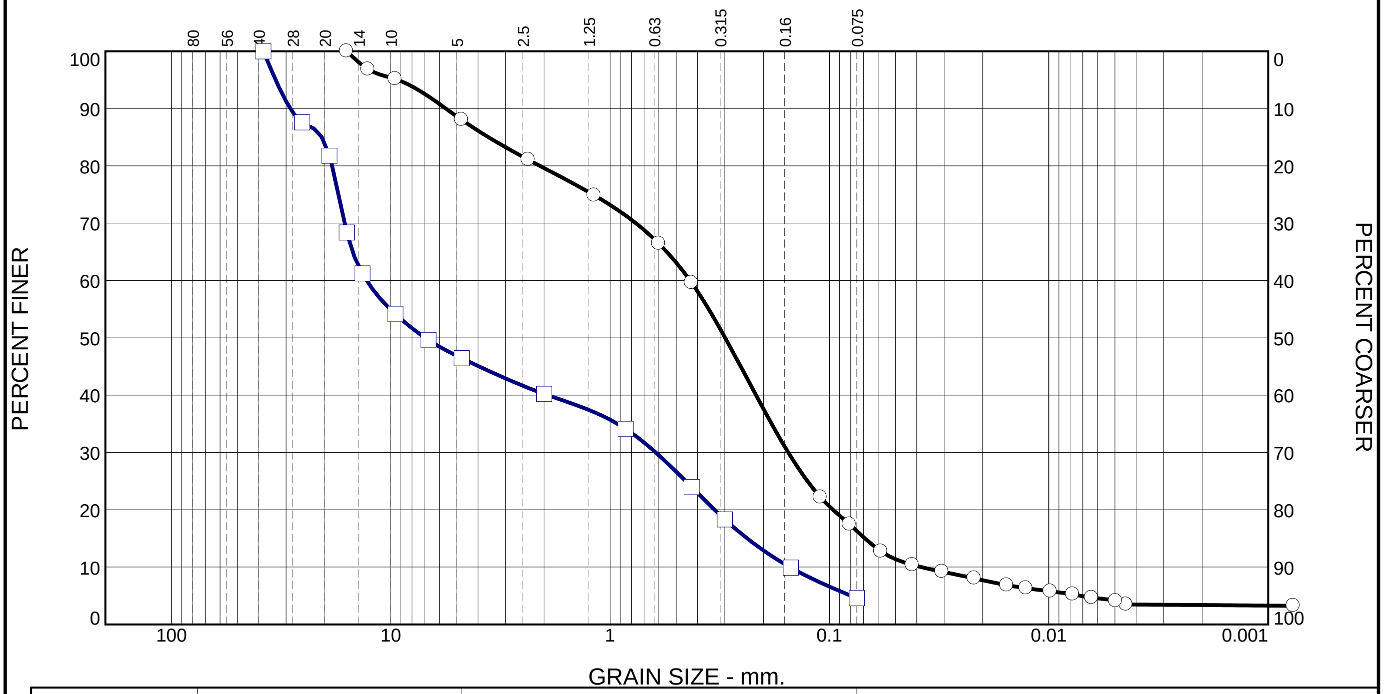
consulting engineers

Figure E-10

Tested By: ○ TS/TA □ MA/TA **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	12	8	20	44	13	3
☐	0	18	36	6	16	19	5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			3.5856	0.4322	0.2990	0.1541	0.0689	0.0382	1.44	11.30
☐			20.6029	12.8735	6.9728	0.6199	0.2372	0.1516	0.20	84.93

Material Description	USCS	AASHTO
○ medium to fine SAND, some silt, some gravel, trace clay		
☐ SAND and GRAVEL, trace silt		

Project No. 13-182 **Client:** WSP Canada Inc.

Project: WCEC Landfill Expansion

○ **Sample Number:** BH 5, Sample 2

☐ **Sample Number:** BH 201, Sample 2

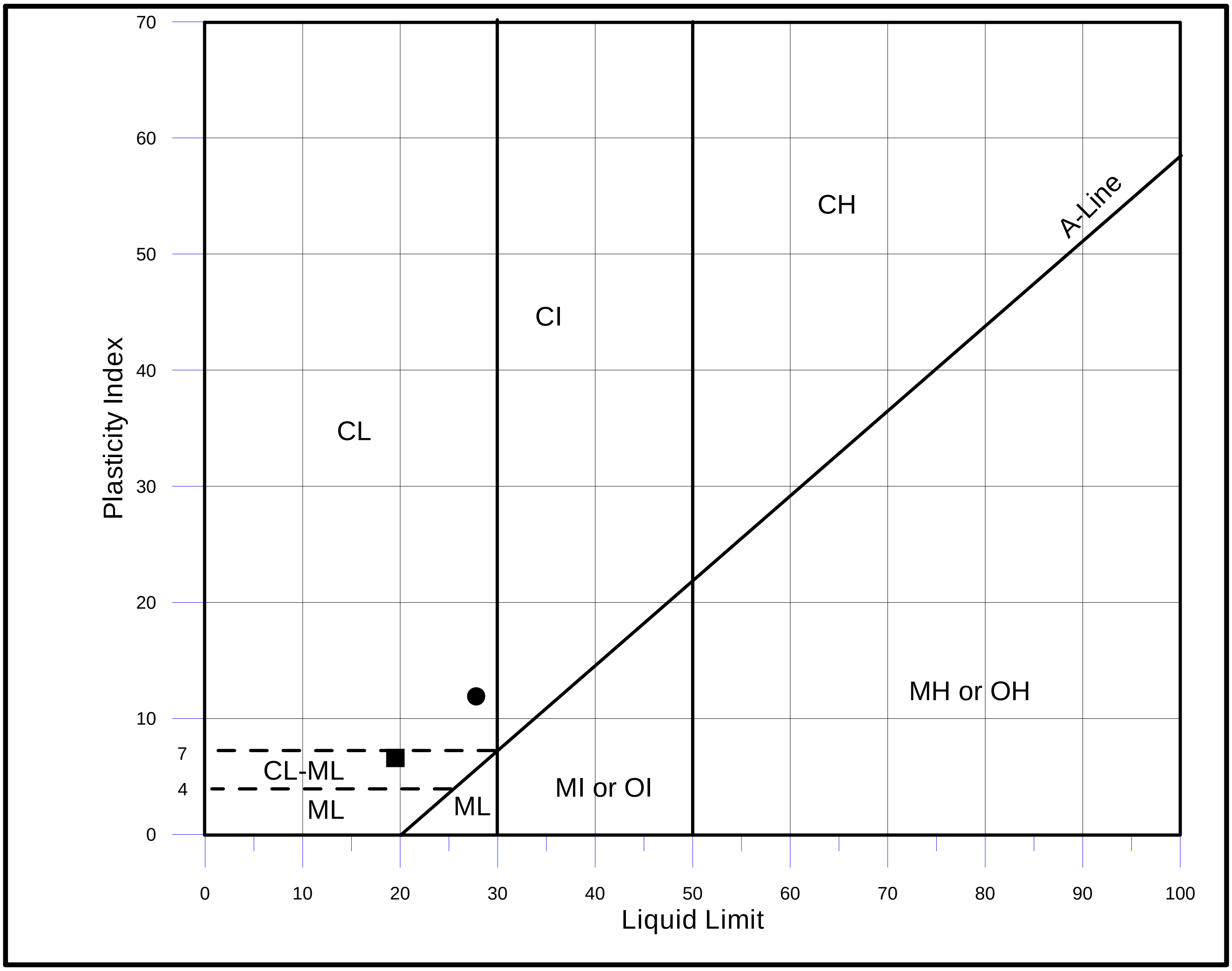
Remarks:

alston associates inc.
consulting engineers

Figure E-11

Tested By: ○ MA/TA ☐ GL **Checked By:** JB

PLASTICITY CHART



Client: WSP Canada Inc.
Project: WCEC Landfill Expansion, Carp, Ontario
Ref. No.: 13-182

Sample	Symbol
Borehole 215, Sample 2	●
Borehole 219, Sample 2	■

Remarks:

alston associates inc.

Figure No. E-12

APPENDIX F

SLOPE STABILITY ANALYSES

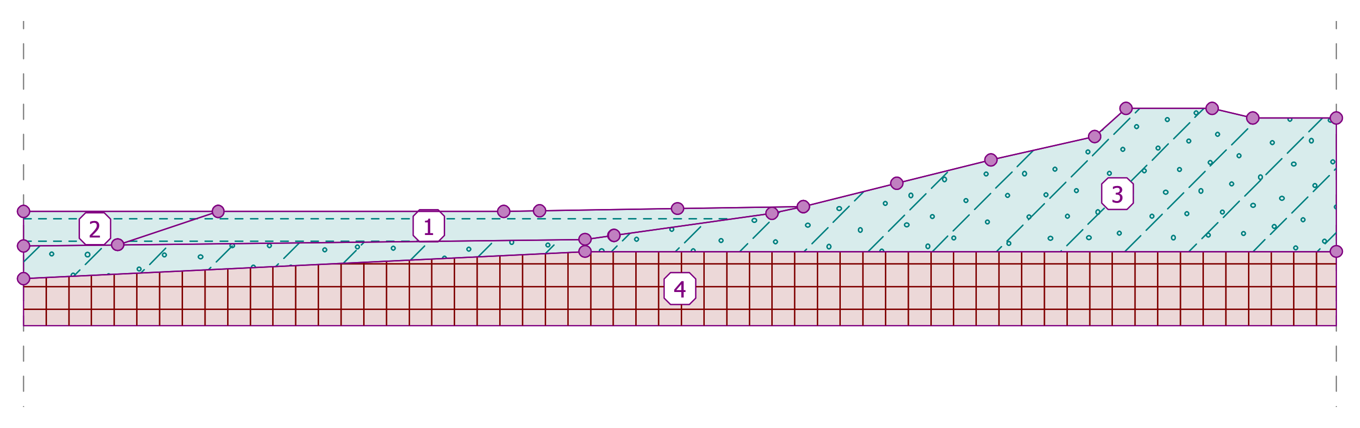
Slope stability analysis

Input data

Project

Task : 13-182 Carp Landfill
Description : Cross Section - Infiltration Basin 1 (empty) and Stormwater Pond 1 (full)
Author : KC
Date : 2014-01-27

Name : Project	**Stage : 1**



Settings

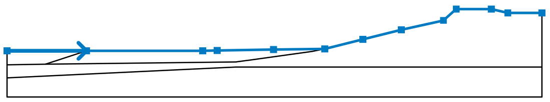
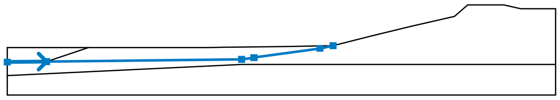
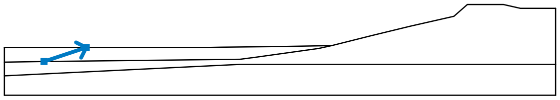
Standard - safety factors

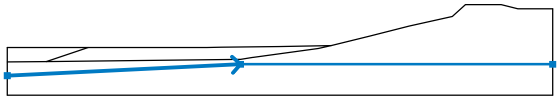
Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	SF_s =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	122.00	20.82	122.00	51.33	122.00
		55.14	122.06	69.89	122.29	83.35	122.50
		93.33	125.00	103.40	127.50	114.47	130.00
		117.83	133.00	127.02	133.00	131.37	132.00
		140.31	132.00				
2		0.00	118.30	10.07	118.42	60.00	119.00
		63.09	119.43	63.14	119.44	80.00	121.80
		83.35	122.50				
3		10.07	118.42	20.82	122.00		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		0.00	114.80	60.00	117.70	140.31	117.70

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Fill	▨	26.00	0.00	20.00
2	Compact to Very Dense Sand to Silty Sand	▨	36.00	0.00	22.00
3	Proposed Fill for Ponds	▨	32.00	0.00	19.00
4	Proposed Uncompacted Fill for Ponds	▨	27.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Fill	▨	20.00		
2	Compact to Very Dense Sand to Silty Sand	▨	22.00		
3	Proposed Fill for Ponds	▨	19.00		
4	Proposed Uncompacted Fill for Ponds	▨	18.00		

Soil parameters

Fill

Unit weight : γ = 20.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 26.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Compact to Very Dense Sand to Silty Sand

Unit weight : γ = 22.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Proposed Fill for Ponds

Unit weight : γ = 19.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 32.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Proposed Uncompacted Fill for Ponds

Unit weight : γ = 18.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 27.00 °

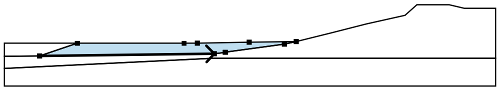
Cohesion of soil : c_{ef} = 0.00 kPa

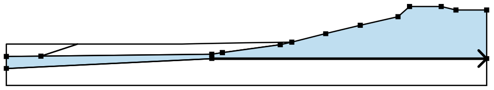
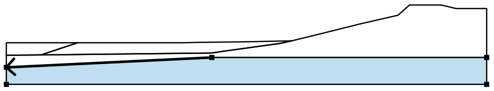
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Probable Bedrock	▦	24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		10.07	118.42	60.00	119.00	Fill
		63.09	119.43	63.14	119.44	
		80.00	121.80	83.35	122.50	▤
		69.89	122.29	55.14	122.06	
		51.33	122.00	20.82	122.00	
2		20.82	122.00	0.00	122.00	Fill
		0.00	118.30	10.07	118.42	▤

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
3		60.00	117.70	140.31	117.70	Compact to Very Dense Sand to Silty Sand
		140.31	132.00	131.37	132.00	
		127.02	133.00	117.83	133.00	
		114.47	130.00	103.40	127.50	
		93.33	125.00	83.35	122.50	▨
		80.00	121.80	63.14	119.44	
		63.09	119.43	60.00	119.00	
		10.07	118.42	0.00	118.30	
		0.00	114.80			
4		60.00	117.70	0.00	114.80	Probable Bedrock
		0.00	109.80	140.31	109.80	
		140.31	117.70			▦

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
Ground water table not specified.							

Tensile crack

Tensile crack not inputted.

Earthquake

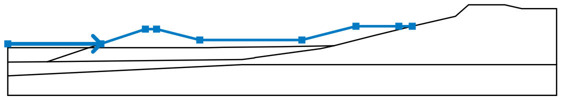
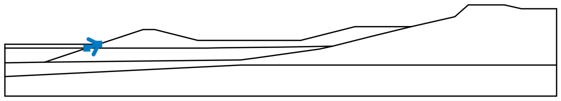
Earthquake not included.

Settings of the stage of construction

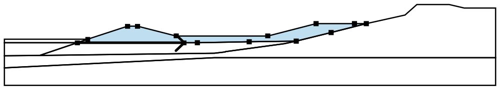
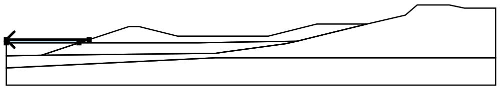
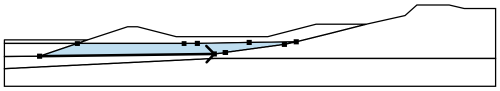
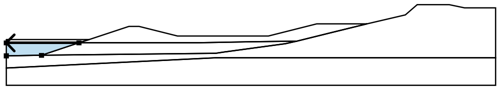
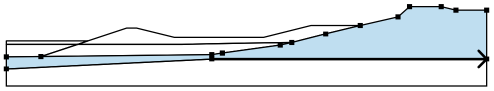
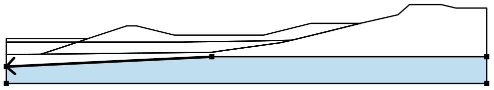
Design situation : permanent

Input data (Stage of construction 2)

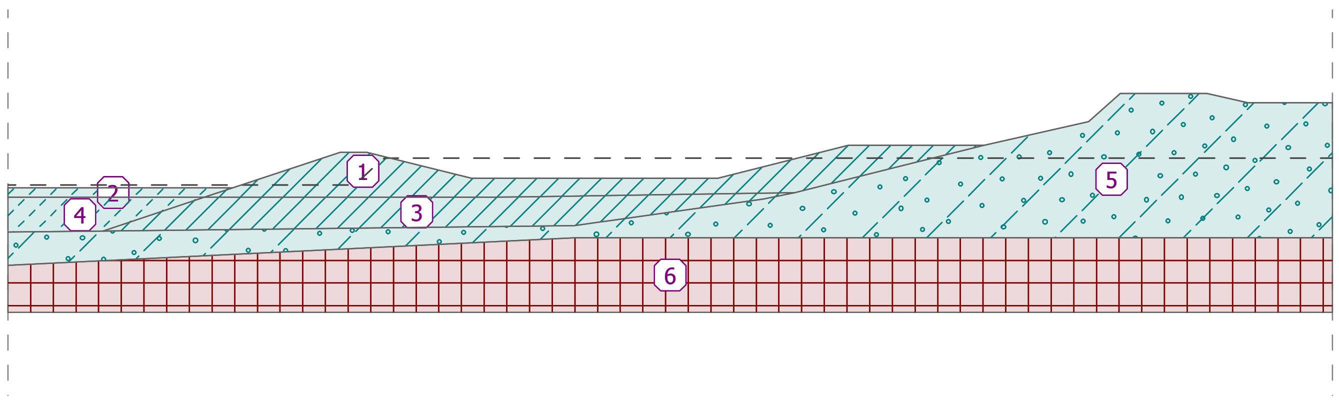
Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	123.00	23.81	123.00	35.18	126.75
		38.05	126.75	49.11	124.00	75.20	124.00
		89.03	127.50	100.00	127.50	103.40	127.50
2		20.82	122.00	23.81	123.00		

Assigning and surfaces

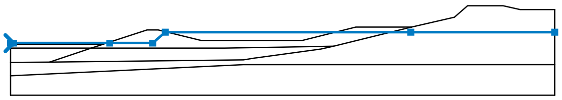
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		20.82	122.00	51.33	122.00	Proposed Fill for Ponds
		55.14	122.06	69.89	122.29	▨
		83.35	122.50	93.33	125.00	
		103.40	127.50	100.00	127.50	
		89.03	127.50	75.20	124.00	
		49.11	124.00	38.05	126.75	
		35.18	126.75	23.81	123.00	
2		23.81	123.00	0.00	123.00	Proposed Uncompacted Fill for Ponds
		0.00	122.00	20.82	122.00	▨
3		10.07	118.42	60.00	119.00	Proposed Fill for Ponds
		63.09	119.43	63.14	119.44	▨
		80.00	121.80	83.35	122.50	
		69.89	122.29	55.14	122.06	
		51.33	122.00	20.82	122.00	
4		20.82	122.00	0.00	122.00	Proposed Uncompacted Fill for Ponds
		0.00	118.30	10.07	118.42	▨
5		60.00	117.70	140.31	117.70	Compact to Very Dense Sand to Silty Sand
		140.31	132.00	131.37	132.00	▨
		127.02	133.00	117.83	133.00	
		114.47	130.00	103.40	127.50	
		93.33	125.00	83.35	122.50	
		80.00	121.80	63.14	119.44	
		63.09	119.43	60.00	119.00	
		10.07	118.42	0.00	118.30	
		0.00	114.80			
6		60.00	117.70	0.00	114.80	Probable Bedrock
		0.00	109.80	140.31	109.80	▦
		140.31	117.70			

Name : Soils and assignment | Stage : 2



Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	123.30	0.72	123.30	25.54	123.30
		36.64	123.30	39.88	126.15	103.20	126.15
		140.31	126.15				

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	25.84	[m]	Angles :	α_1 =	-14.38	[°]
	z =	135.67	[m]		α_2 =	47.00	[°]
Radius :	R =	13.08	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	23.49	123.09	23.96	122.93
2	23.72	122.89	35.35	126.70
3	35.20	126.54	35.23	126.87

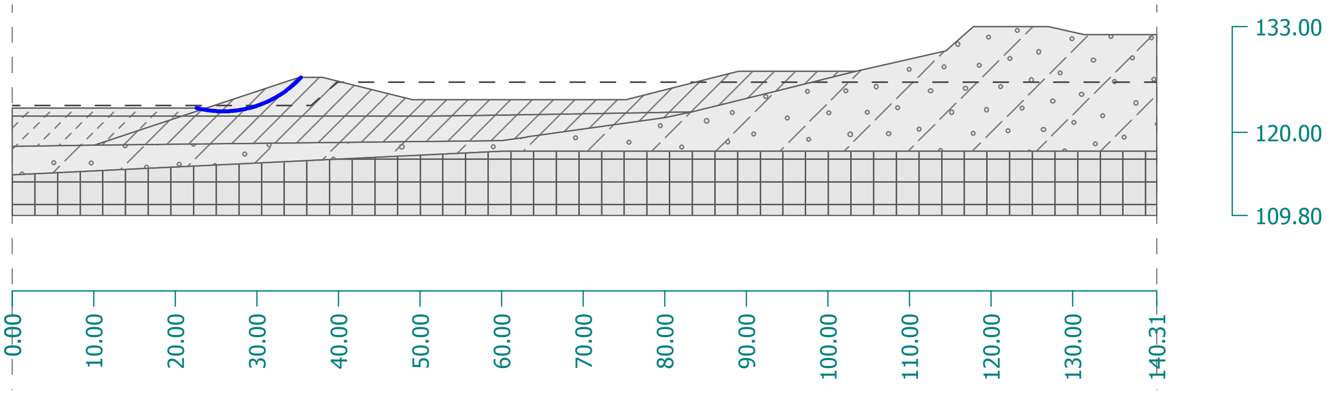
Slope stability verification (Bishop)

Sum of active forces : F_a = 77.98 kN/m

Sum of passive forces : F_p = 148.52 kN/m

Sliding moment : M_a = 1020.03 kNm/m
Resisting moment : M_p = 1942.59 kNm/m
Factor of safety = 1.90 > 1.50
Slope stability ACCEPTABLE

Name : Analysis	**Stage - analysis : 2 - 1**



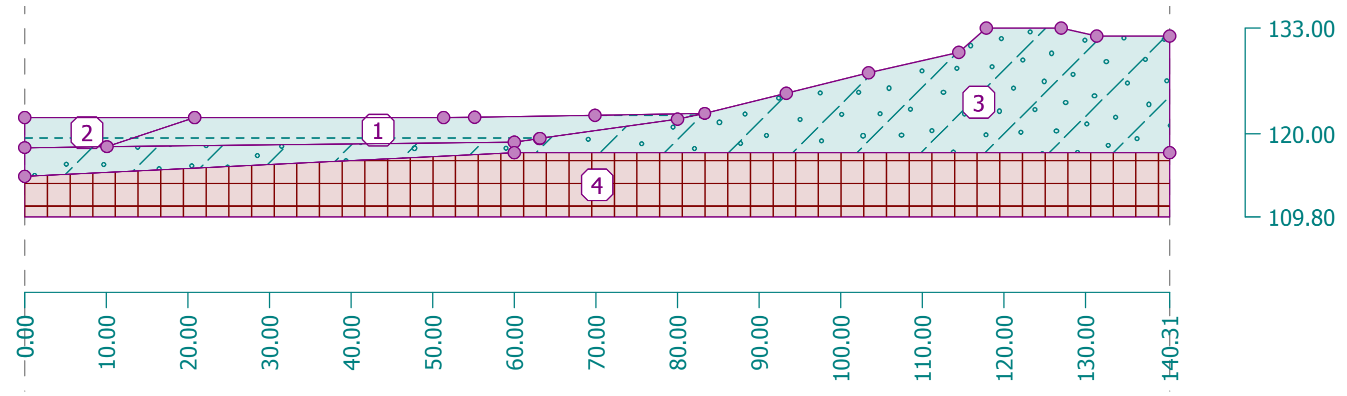
Slope stability analysis

Input data

Project

Task : 13-182 Carp Landfill
Description : Cross Section - Infiltration Basin 1 (full) and Stormwater Pond 1 (empty)
Author : KC
Date : 2014-01-27

Name : Project **Stage : 1**



Settings

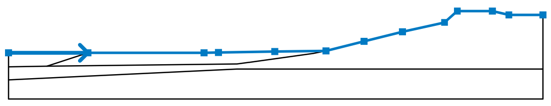
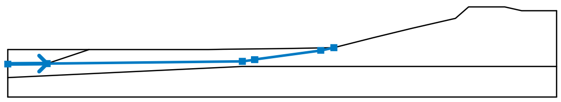
Standard - safety factors

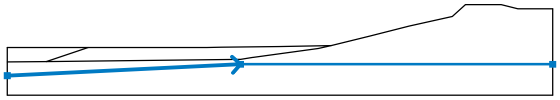
Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	SF_S =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	122.00	20.82	122.00	51.33	122.00
		55.14	122.06	69.89	122.29	83.35	122.50
		93.33	125.00	103.40	127.50	114.47	130.00
		117.83	133.00	127.02	133.00	131.37	132.00
		140.31	132.00				
2		0.00	118.30	10.07	118.42	60.00	119.00
		63.09	119.43	63.14	119.44	80.00	121.80
		83.35	122.50				
3		10.07	118.42	20.82	122.00		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		0.00	114.80	60.00	117.70	140.31	117.70

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Fill	▤	26.00	0.00	20.00
2	Compact to Very Dense Sand to Silty Sand	▨	36.00	0.00	22.00
3	Proposed Fill for Ponds	▨	32.00	0.00	19.00
4	Proposed Uncompacted Fill for Ponds	▨	27.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Fill	▤	20.00		
2	Compact to Very Dense Sand to Silty Sand	▨	22.00		
3	Proposed Fill for Ponds	▨	19.00		
4	Proposed Uncompacted Fill for Ponds	▨	18.00		

Soil parameters

Fill

Unit weight : γ = 20.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 26.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Compact to Very Dense Sand to Silty Sand

Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Proposed Fill for Ponds

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 32.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

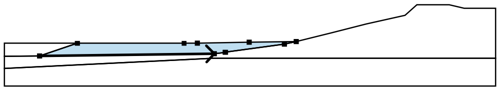
Proposed Uncompacted Fill for Ponds

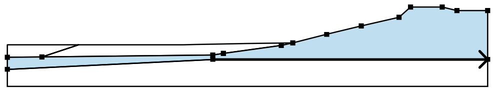
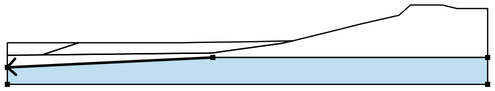
Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Probable Bedrock	▦	24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		10.07	118.42	60.00	119.00	Fill ▤
		63.09	119.43	63.14	119.44	
		80.00	121.80	83.35	122.50	
		69.89	122.29	55.14	122.06	
		51.33	122.00	20.82	122.00	
2		20.82	122.00	0.00	122.00	Fill ▤
		0.00	118.30	10.07	118.42	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
3		60.00	117.70	140.31	117.70	Compact to Very Dense Sand to Silty Sand ▨
		140.31	132.00	131.37	132.00	
		127.02	133.00	117.83	133.00	
		114.47	130.00	103.40	127.50	
		93.33	125.00	83.35	122.50	
		80.00	121.80	63.14	119.44	
		63.09	119.43	60.00	119.00	
		10.07	118.42	0.00	118.30	
		0.00	114.80			
4		60.00	117.70	0.00	114.80	Probable Bedrock ▦
		0.00	109.80	140.31	109.80	
		140.31	117.70			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
Ground water table not specified.							

Tensile crack

Tensile crack not inputted.

Earthquake

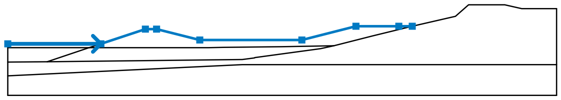
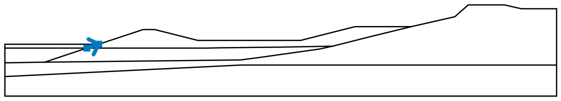
Earthquake not included.

Settings of the stage of construction

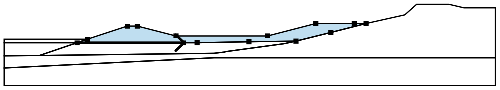
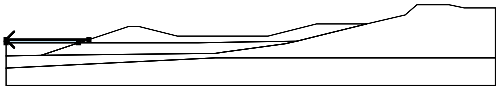
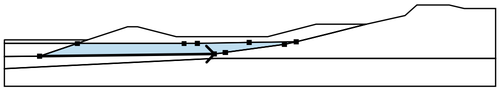
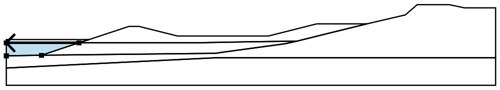
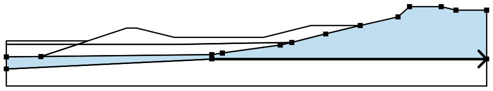
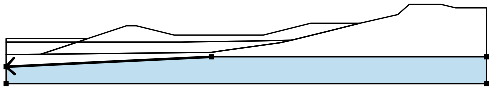
Design situation : permanent

Input data (Stage of construction 2)

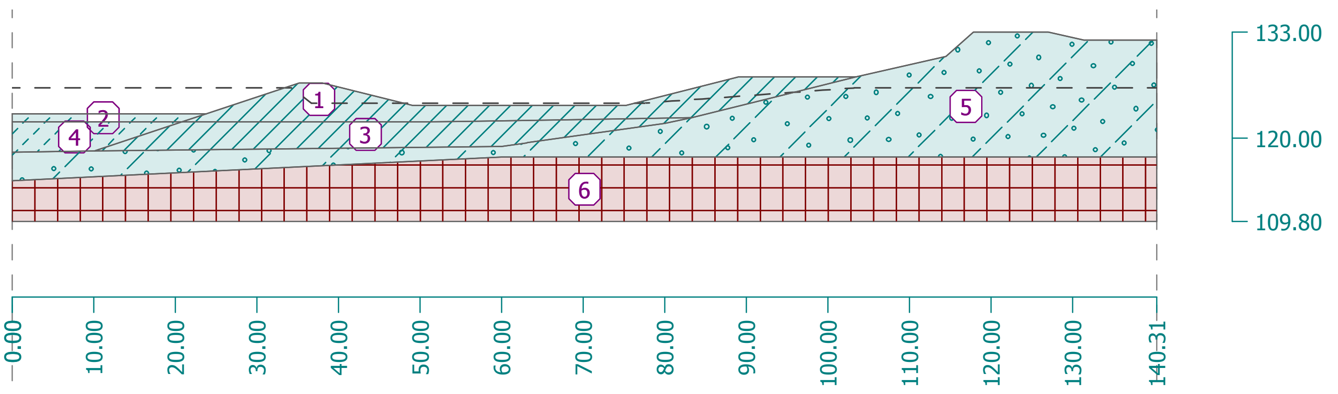
Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	123.00	23.81	123.00	35.18	126.75
		38.05	126.75	49.11	124.00	75.20	124.00
		89.03	127.50	100.00	127.50	103.40	127.50
2		20.82	122.00	23.81	123.00		

Assigning and surfaces

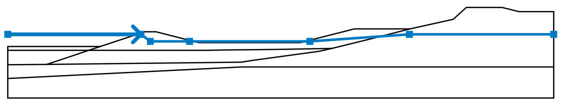
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		20.82	122.00	51.33	122.00	Proposed Fill for Ponds
		55.14	122.06	69.89	122.29	▨
		83.35	122.50	93.33	125.00	
		103.40	127.50	100.00	127.50	
		89.03	127.50	75.20	124.00	
		49.11	124.00	38.05	126.75	
		35.18	126.75	23.81	123.00	
2		23.81	123.00	0.00	123.00	Proposed Uncompacted Fill for Ponds
		0.00	122.00	20.82	122.00	▨
3		10.07	118.42	60.00	119.00	Proposed Fill for Ponds
		63.09	119.43	63.14	119.44	▨
		80.00	121.80	83.35	122.50	
		69.89	122.29	55.14	122.06	
		51.33	122.00	20.82	122.00	
4		20.82	122.00	0.00	122.00	Proposed Uncompacted Fill for Ponds
		0.00	118.30	10.07	118.42	▨
5		60.00	117.70	140.31	117.70	Compact to Very Dense Sand to Silty Sand
		140.31	132.00	131.37	132.00	▨
		127.02	133.00	117.83	133.00	
		114.47	130.00	103.40	127.50	
		93.33	125.00	83.35	122.50	
		80.00	121.80	63.14	119.44	
		63.09	119.43	60.00	119.00	
		10.07	118.42	0.00	118.30	
		0.00	114.80			
6		60.00	117.70	0.00	114.80	Probable Bedrock
		0.00	109.80	140.31	109.80	▦
		140.31	117.70			

Name : Soils and assignment | Stage : 2



Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	126.15	34.26	126.15	36.65	124.30
		46.74	124.30	77.61	124.30	103.20	126.15
		140.31	126.15				

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	46.23	[m]	Angles :	α_1 =	-45.72	[°]
	z =	134.94	[m]		α_2 =	21.15	[°]
Radius :	R =	11.73	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	37.79	126.88	38.29	126.53
2	37.97	126.63	49.26	123.88
3	49.03	123.84	49.35	124.15

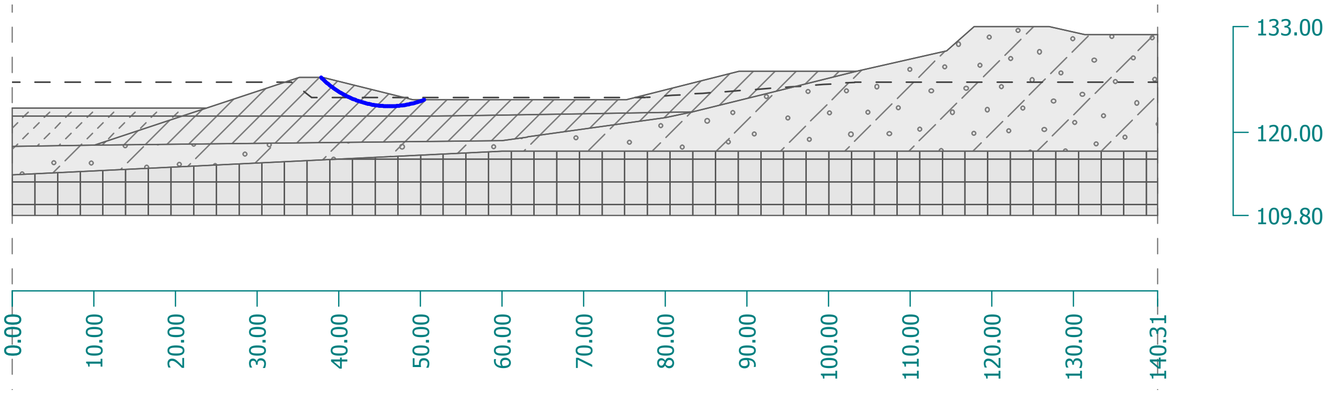
Slope stability verification (Bishop)

Sum of active forces : F_a = 60.63 kN/m

Sum of passive forces : F_p = 141.52 kN/m

Sliding moment : M_a = 711.19 kNm/m
Resisting moment : M_p = 1660.00 kNm/m
Factor of safety = 2.33 > 1.50
Slope stability ACCEPTABLE

Name : Analysis	**Stage - analysis : 2 - 1**



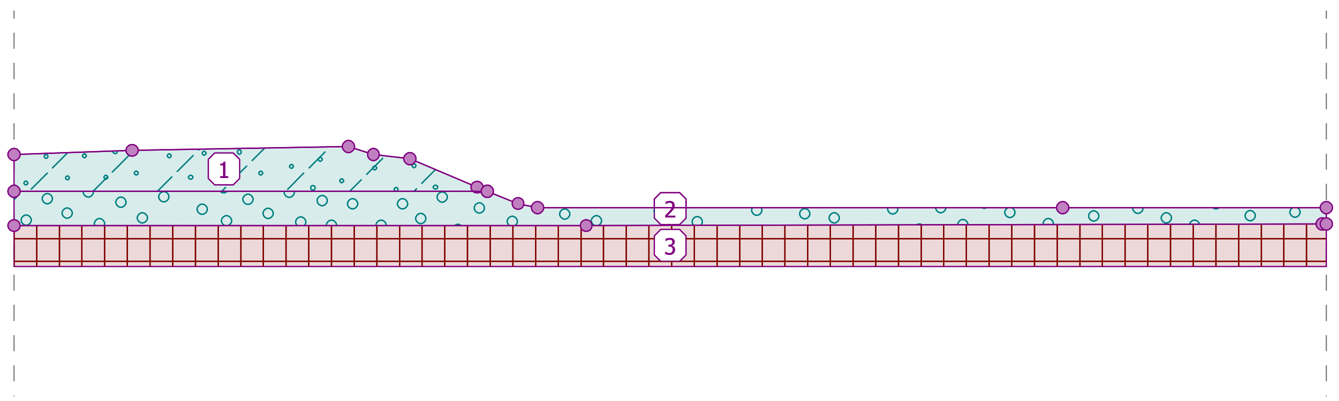
Slope stability analysis

Input data

Project

Task : 13-182 Carp Landfill
Description : Cross Section - Infiltration Basin 2 (empty) and Stormwater Pond 3 (full)
Author : KC
Date : 2014-01-27

Name : Project **Stage : 1**



Settings

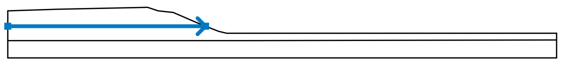
Standard - safety factors

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	SF_s =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	124.00	14.43	124.50	40.91	125.00
		43.97	124.00	48.42	123.50	56.62	120.00
		57.88	119.50	61.66	118.00	64.03	117.50
		128.26	117.50	160.50	117.50		
2		0.00	119.50	57.88	119.50		
3		0.00	115.30	70.00	115.30	160.00	115.50
		160.50	115.50				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Compact to Very Dense Silty Fine Sand	▨	36.00	0.00	22.00
2	Very Dense Sand and Rock Fragments	▨	38.00	0.00	23.00
3	Proposed Fill for Ponds	▨	32.00	0.00	19.00
4	Proposed Uncompacted Fill for Ponds	▨	27.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact to Very Dense Silty Fine Sand	▨	22.00		
2	Very Dense Sand and Rock Fragments	▨	23.00		
3	Proposed Fill for Ponds	▨	19.00		
4	Proposed Uncompacted Fill for Ponds	▨	18.00		

Soil parameters

Compact to Very Dense Silty Fine Sand

Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Very Dense Sand and Rock Fragments

Unit weight : γ = 23.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 23.00 kN/m^3

Proposed Fill for Ponds

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 32.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

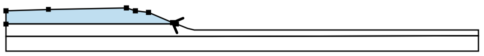
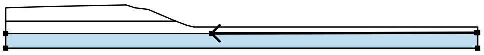
Proposed Uncompacted Fill for Ponds

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Probable Bedrock	▨	24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		57.88	119.50	56.62	120.00	Compact to Very Dense Silty Fine Sand ▨
		48.42	123.50	43.97	124.00	
		40.91	125.00	14.43	124.50	
		0.00	124.00	0.00	119.50	
2		70.00	115.30	160.00	115.50	Very Dense Sand and Rock Fragments ▨
		160.50	115.50	160.50	117.50	
		128.26	117.50	64.03	117.50	
		61.66	118.00	57.88	119.50	
		0.00	119.50	0.00	115.30	
3		160.00	115.50	70.00	115.30	Probable Bedrock ▨
		0.00	115.30	0.00	110.30	
		160.50	110.30	160.50	115.50	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
Ground water table not specified.							

Tensile crack

Tensile crack not inputted.

Earthquake

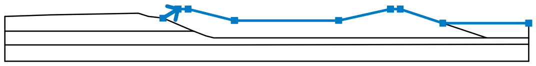
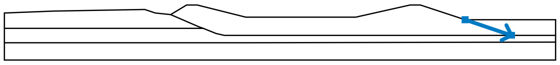
Earthquake not included.

Settings of the stage of construction

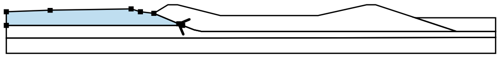
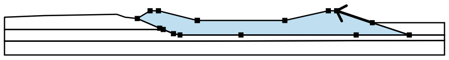
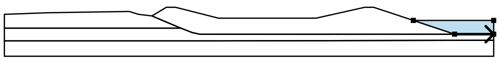
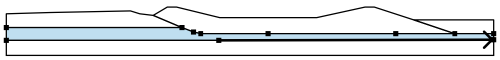
Design situation : permanent

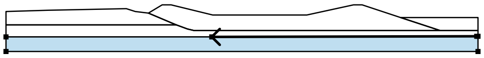
Input data (Stage of construction 2)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		48.42	123.50	53.06	126.30	56.12	126.30
		70.25	122.80	70.38	122.80	102.27	122.80
		118.18	126.30	121.14	126.30	134.18	122.00
		160.50	122.00				
2		134.18	122.00	147.68	117.50		

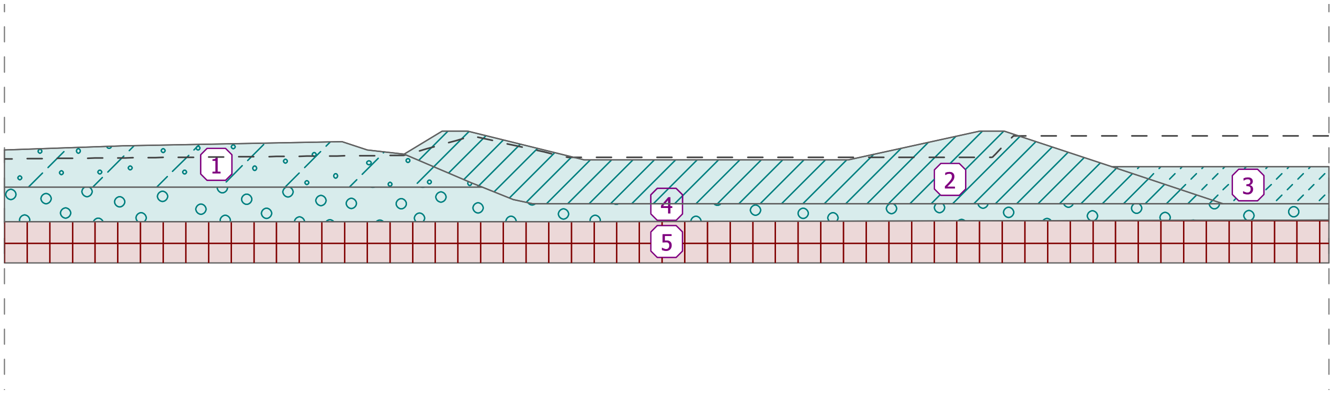
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		57.88	119.50	56.62	120.00	Compact to Very Dense Silty Fine Sand
		48.42	123.50	43.97	124.00	
		40.91	125.00	14.43	124.50	▨
		0.00	124.00	0.00	119.50	
2		134.18	122.00	121.14	126.30	Proposed Fill for Ponds
		118.18	126.30	102.27	122.80	
		70.38	122.80	70.25	122.80	▨
		56.12	126.30	53.06	126.30	
		48.42	123.50	56.62	120.00	
		57.88	119.50	61.66	118.00	
		64.03	117.50	86.22	117.50	
		128.26	117.50	147.68	117.50	
3		147.68	117.50	160.50	117.50	Proposed Uncompacted Fill for Ponds
		160.50	122.00	134.18	122.00	▨
4		70.00	115.30	160.00	115.50	Very Dense Sand and Rock Fragments
		160.50	115.50	160.50	117.50	
		147.68	117.50	128.26	117.50	▨
		86.22	117.50	64.03	117.50	
		61.66	118.00	57.88	119.50	
		0.00	119.50	0.00	115.30	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		160.00	115.50	70.00	115.30	Probable Bedrock ▦
		0.00	115.30	0.00	110.30	
		160.50	110.30	160.50	115.50	

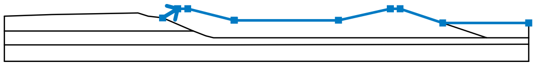
Name : Soils and assignment

Stage : 2



Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	122.92	48.42	123.35	56.67	125.70
		68.31	123.10	104.37	123.10	119.68	123.10
		122.26	125.70	160.50	125.70		

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	106.56	[m]	Angles :	α_1 =	-22.69	[°]
	z =	138.29	[m]		α_2 =	44.43	[°]
Radius :	R =	16.79	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	101.50	122.88	102.39	122.65
2	101.98	122.67	118.15	126.21
3	117.87	126.08	118.35	126.38

Slope stability verification (Bishop)

Sum of active forces : F_a = 110.59 kN/m

Sum of passive forces : F_p = 285.48 kN/m

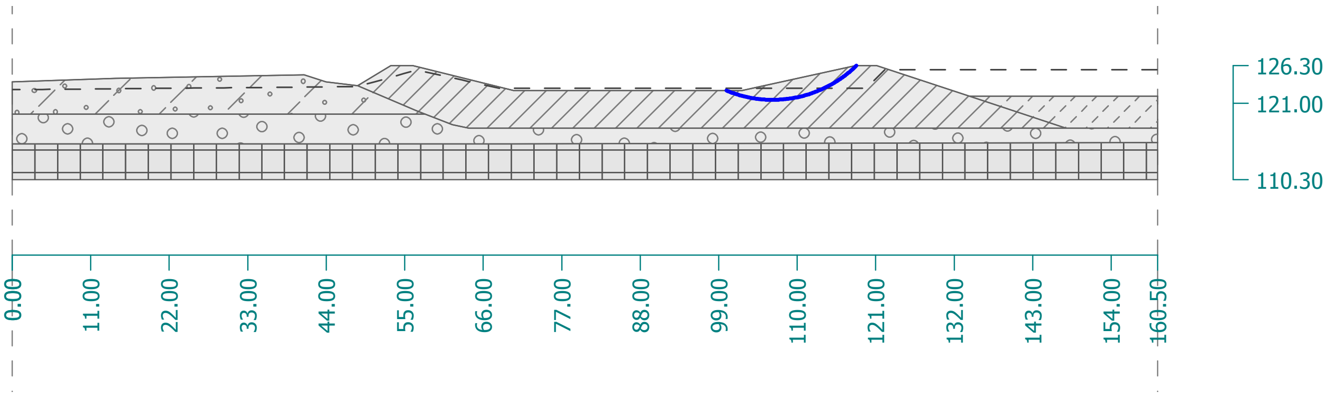
Sliding moment : M_a = 1856.79 kNm/m

Resisting moment : M_p = 4793.13 kNm/m

Factor of safety = 2.58 > 1.50

Slope stability ACCEPTABLE

Name : Analysis | **Stage - analysis : 2 - 1**



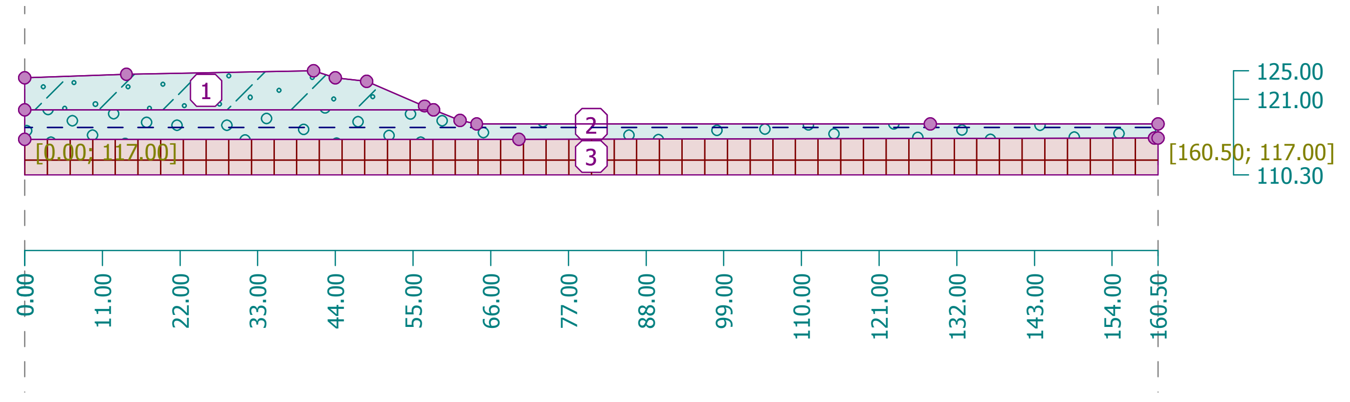
Slope stability analysis

Input data

Project

Task : 13-182 Carp Landfill
Description : Cross Section - Infiltration Basin 2 (full) and Stormwater Pond 3 (empty)
Author : KC
Date : 2014-01-27

Name : Project **Stage : 1**



Settings

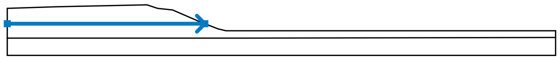
Standard - safety factors

Stability analysis

Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor :	SF_s =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	124.00	14.43	124.50	40.91	125.00
		43.97	124.00	48.42	123.50	56.62	120.00
		57.88	119.50	61.66	118.00	64.03	117.50
		128.26	117.50	160.50	117.50		
2		0.00	119.50	57.88	119.50		
3		0.00	115.30	70.00	115.30	160.00	115.50
		160.50	115.50				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Compact to Very Dense Silty Fine Sand	▨	36.00	0.00	22.00
2	Very Dense Sand and Rock Fragments	▨	38.00	0.00	23.00
3	Proposed Fill for Ponds	▨	32.00	0.00	19.00
4	Proposed Uncompacted Fill for Ponds	▨	27.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Compact to Very Dense Silty Fine Sand	▨	22.00		
2	Very Dense Sand and Rock Fragments	▨	23.00		
3	Proposed Fill for Ponds	▨	19.00		
4	Proposed Uncompacted Fill for Ponds	▨	18.00		

Soil parameters

Compact to Very Dense Silty Fine Sand

Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Very Dense Sand and Rock Fragments

Unit weight : γ = 23.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 23.00 kN/m^3

Proposed Fill for Ponds

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 32.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

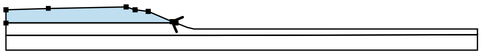
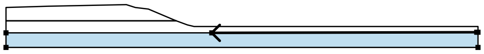
Proposed Uncompacted Fill for Ponds

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Probable Bedrock	▦	24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		57.88	119.50	56.62	120.00	Compact to Very Dense Silty Fine Sand
		48.42	123.50	43.97	124.00	
		40.91	125.00	14.43	124.50	▨
		0.00	124.00	0.00	119.50	
2		70.00	115.30	160.00	115.50	Very Dense Sand and Rock Fragments
		160.50	115.50	160.50	117.50	
		128.26	117.50	64.03	117.50	▨
		61.66	118.00	57.88	119.50	
		0.00	119.50	0.00	115.30	
3		160.00	115.50	70.00	115.30	Probable Bedrock
		0.00	115.30	0.00	110.30	
		160.50	110.30	160.50	115.50	▦

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	117.00	160.50	117.00		

Tensile crack

Tensile crack not inputted.

Earthquake

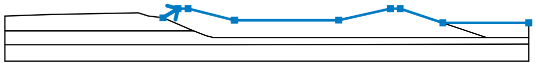
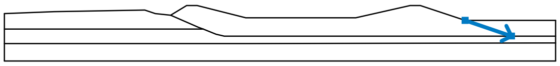
Earthquake not included.

Settings of the stage of construction

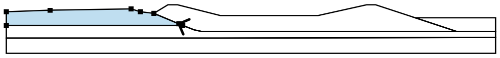
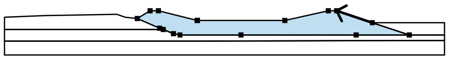
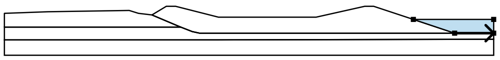
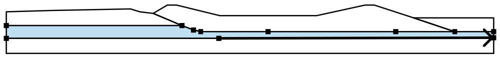
Design situation : permanent

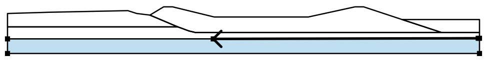
Input data (Stage of construction 2)

Embankment interface

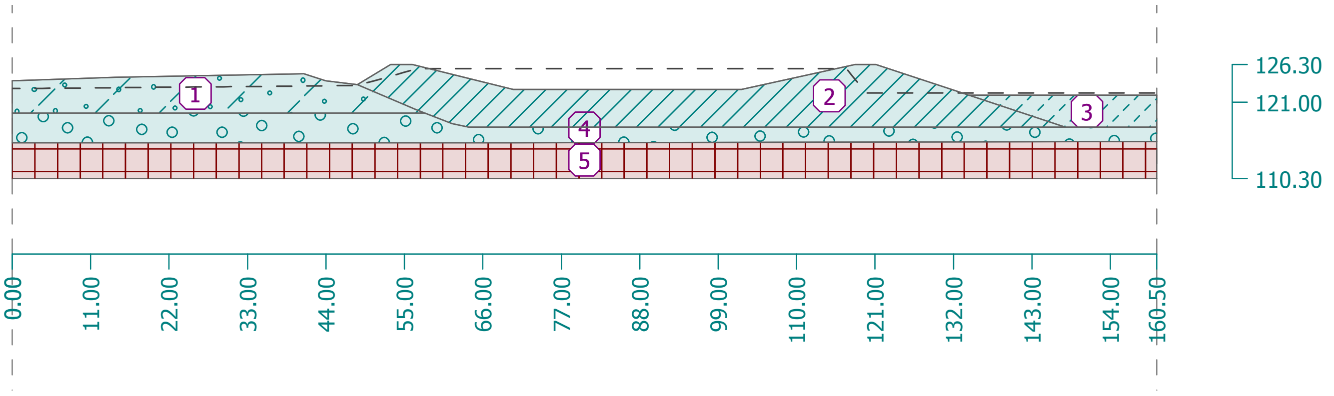
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		48.42	123.50	53.06	126.30	56.12	126.30
		70.25	122.80	70.38	122.80	102.27	122.80
		118.18	126.30	121.14	126.30	134.18	122.00
		160.50	122.00				
2		134.18	122.00	147.68	117.50		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		57.88	119.50	56.62	120.00	Compact to Very Dense Silty Fine Sand
		48.42	123.50	43.97	124.00	
		40.91	125.00	14.43	124.50	▨
		0.00	124.00	0.00	119.50	
2		134.18	122.00	121.14	126.30	Proposed Fill for Ponds
		118.18	126.30	102.27	122.80	
		70.38	122.80	70.25	122.80	
		56.12	126.30	53.06	126.30	
		48.42	123.50	56.62	120.00	▨
		57.88	119.50	61.66	118.00	
		64.03	117.50	86.22	117.50	
		128.26	117.50	147.68	117.50	
3		147.68	117.50	160.50	117.50	Proposed Uncompacted Fill for Ponds
		160.50	122.00	134.18	122.00	▨
4		70.00	115.30	160.00	115.50	Very Dense Sand and Rock Fragments
		160.50	115.50	160.50	117.50	
		147.68	117.50	128.26	117.50	
		86.22	117.50	64.03	117.50	▨
		61.66	118.00	57.88	119.50	
		0.00	119.50	0.00	115.30	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		160.00	115.50	70.00	115.30	Probable Bedrock ▦
		0.00	115.30	0.00	110.30	
		160.50	110.30	160.50	115.50	

Name : Soils and assignment	Stage : 2



Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	122.92	48.42	123.35	56.67	125.70
		117.01	125.70	119.78	122.30	132.52	122.30
		160.50	122.30				

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	132.40	[m]	Angles :	α_1 =	-48.09	[°]
	z =	136.74	[m]		α_2 =	19.43	[°]
Radius :	R =	15.63	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	120.86	126.24	134.36	121.80
2	134.02	121.75	134.64	122.14
3	121.08	126.38	121.07	126.12

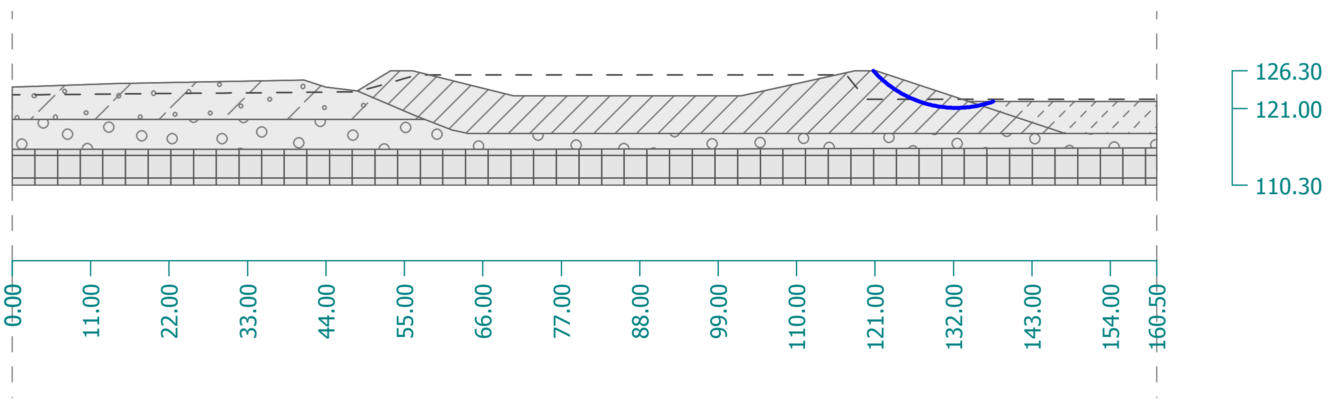
Slope stability verification (Bishop)

Sum of active forces : F_a = 121.25 kN/m
Sum of passive forces : F_p = 232.20 kN/m

Sliding moment : M_a = 1895.11 kNm/m
Resisting moment : M_p = 3629.32 kNm/m
Factor of safety = 1.92 > 1.50

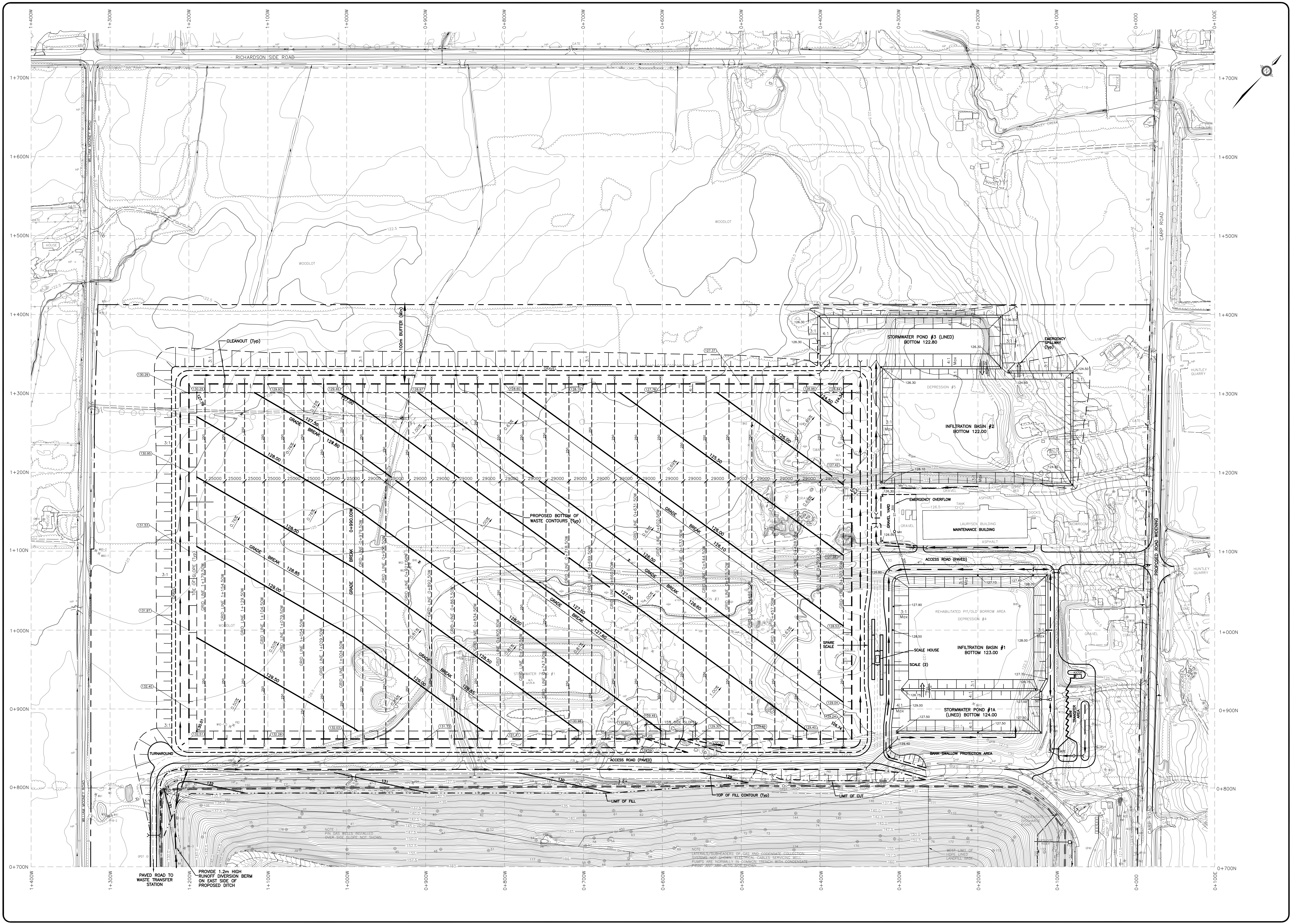
Slope stability ACCEPTABLE

Name : Analysis **Stage - analysis : 2 - 1**



APPENDIX 5

DRAWING 131-19416-00 – SK10



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WASTE MANAGEMENT®

PROPOSED BOTTOM OF WASTE CONTOURS

WEST CARLETON ENVIRONMENTAL CENTRE

DWN BY: T C G
CHK BY: P S B
DATE: NOVEMBER 28, 2013
SCALE: SEE BAR SCALE

WASTE MANAGEMENT OF CANADA CORPORATION

DRAWING NO. 131-19416-00 - SK10

SHEET SK10