Development & Operations Report
West Carleton Environmental Centre
Volume 2 of 2

July 2014

Prepared for:
Waste Management of Canada Corporation
2301 Carp Road
Carp, Ontario K0A 1L0

Prepared by:
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Project No. 131-19416-00

Volume 2

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Appendix 1

Appendix 1-A

Letter from Jim Bradley, Minister of the Environment dated September 5, 2013 re: EA Approval

Order in Council dated August 28, 2013

Ministry of the Environment

Office of the Minister

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Ontario

ENV1283MC-2013-1796

SEP 05 2013

Mr. Tim Murphy
Director
Environmental Protection and Regulatory Affairs
Waste Management of Canada Corporation
117 Wentworth Street,
Brampton ON L6T 5L4

Dear Mr. Murphy:

Thank you for submitting your environmental assessment for the West Carleton Environmental Centre New Landfill Footprint on September 14, 2012, as amended on January 21, 2013. The ministry has completed its review and I wish to inform you that I have approved your environmental assessment with regard to the proposed undertaking.

Attached is a signed copy of the Notice of Approval to Proceed with the Undertaking as required by the Environmental Assessment Act.

Should you require further assistance please contact Jason Ryan, Supervisor, Project Coordination Unit of the Environmental Approvals Branch, at 416-314-7241 or by e-mail at Jason.Ryan@ontario.ca.

Yours sincerely,

Jim Bradley

Jim Bradley
Minister of the Environment

Attachment

c: Jack MacLaren, MPP, Carleton-Mississippi Mills

Order in Council
Décret

Ontario
Executive Council
Conseil des ministres

On the recommendation of the undersigned, the Lieutenant Governor, by and with the advice and concurrence of the Executive Council, orders that:

Sur la recommandation du soussigné, le lieutenant-gouverneur, sur l'avis et avec le consentement du Conseil des ministres, décrète ce qui suit :

WHEREAS section 9 of the Environmental Assessment Act provides that the Minister of the Environment, with the approval of the Lieutenant Governor in Council, may give approval to proceed with an undertaking, give approval to proceed with an undertaking subject to such conditions as the Minister considers necessary, or refuse to give approval to proceed with the undertaking; and

WHEREAS a Notice of Completion of the Review for the Environmental Assessment for a New Landfill Footprint at the West Carleton Environmental Centre (hereafter "the undertaking") was published on February 22, 2013, and one request for a referral to a hearing was received; and

WHEREAS, having considered the purpose of the Act, the Environmental Assessment of the undertaking, the Terms of Reference, and the submissions received, the undersigned Minister of the Environment considers that a hearing is unnecessary and is of the opinion that the undertaking should be given approval to proceed, subject to the conditions specified in the attached approval,

THEREFORE, pursuant to section 9 of the Environmental Assessment Act, approval to proceed with the undertaking is given in the form attached, subject to the conditions specified therein.

Recommended [signature] Minister of the Environment

Concurred [signature] Chair of Cabinet

Approved and Ordered AUG 2 8 2013
Date

[signature] Lieutenant Governor

O.C./Décret 1228/2013

ENVIRONMENTAL ASSESSMENT ACT

SECTION 9

NOTICE OF APPROVAL TO PROCEED WITH THE UNDERTAKING

RE: An Environmental Assessment for a New Landfill Footprint at the West Carleton Environmental Centre (Amended January 21, 2013)

Proponent: Waste Management of Canada Corporation

EA File No.: EA-02-08-02

TAKE NOTICE that the period for requesting a hearing, provided for in the Notice of Completion of the Review for the above-noted undertaking, expired on April 2, 2013.

I received one submission requesting a hearing by the Environmental Review Tribunal.

I consider a hearing to be unnecessary in this case. Having considered the purpose of the Environmental Assessment Act, the approved Terms of Reference, the Amended Environmental Assessment, the Ministry Review of the Environmental Assessment and submissions received, I hereby give approval to proceed with the Undertaking, subject to the conditions set out below.

REASONS

My reasons for giving approval are:

(1) The proponent has complied with the requirements of the Environmental Assessment Act.

(2) The Amended Environmental Assessment has been prepared in accordance with the approved Terms of Reference.

(3) On the basis of the proponent's Amended Environmental Assessment and the Ministry Review, the proponent's conclusion that, on balance, the advantages of this undertaking outweigh its disadvantages appears to be valid.

(4) No other beneficial alternative method of implementing the undertaking was identified.

(5) The proponent has demonstrated that the environmental effects of the undertaking can be appropriately prevented, changed, mitigated, or remedied.

(6) On the basis of the proponent's Amended Environmental Assessment, the Ministry Review and the conditions of approval, the construction, operation and maintenance of the undertaking will be consistent with the purpose of the Environmental Assessment Act (section 2).

(7) The government agency, public and Aboriginal review of the Amended Environmental Assessment has indicated no outstanding concerns that cannot be addressed through commitments made in the Amended Environmental Assessment, through the conditions set out below, or future additional approvals that will be required.

(8) The submissions received after the Notice of Completion of the Review was published are being dealt with through commitments made in the Amended Environmental Assessment, through the conditions set out below, or future additional approvals that will be required. I am not aware of any outstanding issues with respect to this undertaking which suggest that a hearing should be required.

CONDITIONS

The approval is subject to the following conditions:

1. Definitions

For the purposes of these conditions:

"CLC" means the Community Liaison Committee.

"construction" means physical construction activities, including, site preparation works, but does not include tendering of contracts.

"date of approval" means the date on which the Order in Council was approved by the Lieutenant Governor.

"Director" means the Director of the Environmental Approvals Branch.

"EAB" means the Environmental Approvals Branch of the Ministry of the Environment.

"environmental assessment" means the document titled West Carleton Environmental Centre New Landfill Footprint Environmental Assessment (as amended January 21, 2013).

"ministry" means the Ministry of the Environment.

"Notice" means this Notice of Approval to Proceed with the Undertaking.

"program" means compliance monitoring program.

"proponent" means Waste Management of Canada Corporation.

"Regional Director" means the Director of the ministry's Eastern Regional Office.

"site" means

- the entire waste disposal site, including the buffer lands, 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; and,
- the contaminant attenuation zone (CAZ), including portions of 2301, 2330, 2104, 2326 and 2300 Carp Road, located on Part of Lot 4, Concession 2, Part of Lot 3, Concession 2, and Part of Lot 2, Concession 2, in the former Township of Huntley, formerly in the Township of West Carleton, now in the City of Ottawa.

"undertaking" means the construction and operation of a new landfill footprint at the site, and as more specifically set out in the environmental assessment.

2. General Requirements

2.1 The proponent shall carry out the undertaking in accordance with the environmental assessment which is hereby incorporated in this approval by reference except as provided in these conditions and as provided in any other approval or permit that may be issued for the site.

2.2 The proponent shall fulfill all commitments made during the environmental assessment process.

2.3 The conditions set out in this Notice do not prevent more restrictive conditions being imposed under other statutes.

3. Public Record

3.1 Where a document is required for the public record, the proponent shall provide two copies of the document to the Director: a copy for the public record file maintained for the undertaking and a copy for staff use.

3.2 The EAB file number EA-02-08-02 shall be quoted on all documents submitted to the ministry pursuant to this Notice.

3.3 For every document submitted to the ministry, the proponent shall clearly identify which condition the document is meant to fulfill

3.4 Documents may be provided electronically where appropriate. The ministry may request that the document be provided in hardcopy.

4. Compliance Monitoring Program

4.1 The proponent shall prepare and submit to the Director for the public record, an environmental assessment compliance monitoring program.

4.2 The program shall be submitted to the Director within one year from the date of approval, or 60 days before the commencement of construction, whichever is earlier.

4.3 The program shall include monitoring of the proponent's implementation of the undertaking in accordance with the environmental assessment and the conditions in this Notice with respect to mitigation measures, public consultation, and additional studies and work to be carried out. The program shall also include monitoring of compliance with all commitments made in the environmental assessment and the subsequent review of the environmental assessment and the approval process for the environmental assessment with respect to mitigation measures, public consultation, and additional studies and work to be carried out.

4.4 The program must contain an implementation schedule.

4.5 The Director may require the proponent to amend the program. The program, as it may be amended by the Director, must be carried out by the proponent.

4.6 The proponent shall make the program documentation available to the ministry or its designate upon request in a timely manner when so requested by the ministry.

5. Compliance Reporting

5.1 The proponent shall prepare an annual compliance report which describes the proponent's compliance with the conditions in this Notice and the results of the program.

5.2 The annual compliance report shall be submitted for the public record on or before March 31 of each year, with the first report being due in 2014, and shall cover all activities of the previous calendar year.

5.3 The proponent shall submit annual compliance reports until all conditions are satisfied.

5.4 When all conditions have been satisfied, the proponent shall indicate in the annual compliance report that it is the final annual compliance report.

5.5 The proponent shall retain, either on site or in another location approved by the Director, copies of the annual compliance reports for each reporting year and any associated documentation of compliance monitoring activities.

5.6 The proponent shall make the compliance reports and supporting documentation available to the ministry or its designate upon request in a timely manner when requested to so by the ministry.

6. Community Liaison Committee

6.1 The proponent shall establish and maintain a CLC in respect of the undertaking to provide a forum for public concerns to be raised and for mitigation measures to be discussed where appropriate.

6.2 If there is no interest from the public in continuing the existing CLC or establishing and participating in a new CLC (once sufficient notice has been given) it may be discontinued. If discontinued the proponent shall publish a notice at least annually inviting expressions of interest in establishing or re-establishing the CLC.

6.3 If continued or re-established, the CLC shall serve as the focal point for dissemination, review and exchange of information and monitoring results relevant to the undertaking.

6.4 If there is interest in forming a CLC and members are willing to serve, the CLC shall be established.

6.5 The proponent shall provide administrative support for the CLC including, at minimum:

a) providing CLC meeting space;

b) preparing and publishing meeting notices;

c) recording minutes of each meeting; and,

d) preparing an annual report to be submitted as part of Compliance Reporting as required by Condition 5.

7. Complaint Protocol

7.1 The proponent shall prepare and implement a protocol on how it will deal with and respond to inquiries and complaints with respect to the undertaking.

7.2 The proponent shall submit the Complaint Protocol to the Director at least 6 months prior to the start of construction.

7.3 The Director may require the proponent to amend the Complaint Protocol at any time. Should an amendment be required, the Director shall notify the proponent in writing of the amendment required and when the amendment must be completed.

7.4 The proponent shall submit the amended Complaint Protocol to the Director within the time period specified by the Director.

7.5 The proponent shall implement the Complaint Protocol and any amendments to it.

8. Groundwater and Surface Water Monitoring Plan

8.1 The proponent shall prepare and submit to the Regional Director a draft Groundwater and Surface Water Monitoring Plan for review and comment prior to the commencement of construction of the undertaking. The Regional Director may require the proponent to amend the plan.

8.2 The proponent shall post the draft Groundwater and Surface Water Monitoring Plan on the proponent's website for the undertaking for a period of thirty days for review and public comment. The proponent shall take any comments received into consideration prior to finalizing the plan. Once finalized, the proponent shall implement the plan.

8.3 Any monitoring reports prepared by the proponent in accordance with the Groundwater and Surface Water Monitoring Plan shall be made publicly available on the proponent's website for the undertaking.

9. Species at Risk Mitigation, Compensation and Monitoring Plans

9.1 The proponent shall develop and implement a Bank Swallow Mitigation, Compensation and Monitoring Plan in consultation with Environment Canada and the Ontario Ministry of Natural Resources prior to the commencement of construction of the undertaking.

9.2 The Bank Swallow Mitigation, Compensation and Monitoring Plan shall include measures to mitigate impacts of the undertaking on the species, compensate for unavoidable adverse impacts and detail monitoring requirements.

9.3 The proponent shall conduct on-site surveys to determine the presence of Barn Swallow habitat on-site in consultation with the Ontario Ministry of Natural Resources.

9.4 Should Barn Swallow habitat be present, the proponent shall comply with the requirements of the Endangered Species Act, 2007.

9.5 The proponent shall conduct on-site surveys to determine the presence of Flooded Jellyskin habitat on-site in consultation with the Ontario Ministry of Natural Resources prior to the commencement of construction of the undertaking.

9.6 Should the presence of Flooded Jellyskin habitat be present, the proponent shall comply with the requirements of the Endangered Species Act, 2007.

10. Property Value Protection Plan

10.1 The proponent shall implement the Property Value Protection Plan as described in Appendix D – Community Commitments of the environmental assessment.

10.2 Should additional studies required for future approvals under the Environmental Protection Act indicate potential impacts to the value of a property; the proponent shall identify the potentially impacted properties by municipal address in the Property Value Protection Plan and shall notify the owners of the properties.

Dated the 16th day of August 2013 at TORONTO.

Minister of the Environment
77 Wellesley Street West
11th Floor, Ferguson Block
Toronto, Ontario
M7A 2T5

Approved by O.C. No. ________________

Date O.C. Approved ________________

Appendix 1-B

Sketch to Illustrate Lots 2, 3 and 4, Concession 2 and Lots 3, 4 and 5, Concession 3, Geographic Township of Huntley, City of Ottawa, prepared by Annis, O'Sullivan, Vollebekk Ltd. dated February 26, 2014

SKETCH TO ILLUSTRATE

PART OF LOTS 2, 3 And **4**
CONCESSION 2
And
PART OF LOTS 3, 4 And **5**
CONCESSION 3
Geographic Township of Huntley
CITY OF OTTAWA
Prepared by Annis, O'Sullivan, Vollebekk Ltd.
February 26, 2014

Scale 1 : 4000
160 120 80 40 0 80 160 Metres

Metric
DISTANCES AND COORDINATES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048.

SKETCH COMPILED FROM REGISTRY OFFICE RESEARCH AND OFFICE RECORDS.

PIN LIMITS HAVE NOT BEEN VERIFIED BY AN ACTUAL FIELD SURVEY.

SITE AREA A = 181.6 ± Hectares (449 ± Acres)

SITE AREA B = 49.3 ± Hectares (122 ± Acres)

SITE AREA C = 2.0 ± Hectares (5± Acres)

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Ontario Land Surveyors
Job No. 14792-14 WSP Pt Lts 2 3 4 C2 HU SK DI | N

Appendix 1-C

Legal Description of WCEC, Ottawa

Lands Identified as Parcel “A”

1. PIN 04536-0166 (LT), being Part of Lot 5, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 1 on Plan 5R-10801.

2. PIN 04536-0167 (LT), being Part of Lot 5, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Parts 2 and 3 on Plan 5R-10801.

3. PIN 04536-0168 (LT), being Part of Lot 5, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 1 on Plan 5R-3716.

4. PIN 04536-0169 (LT), being Part of Lot 5, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Parts 1 and 2 on Plan 5R-11322.

5. PIN 04536-0170 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument N731718.

6. PIN 04536-0171 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument NS253990.

7. PIN 04536-0172 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instruments CT157338 and CT157339, save and except lands set out in Instrument CT157340.

8. PIN 04536-0723 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 1 on Plan 5R-4345 and Part 1 on Plan 4R-14182.

9. PIN 04536-0399 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument NS138205, save and except Part 1 on Plan 4R-14182.

10. PIN 04536-0175 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument CT256061.

11. PIN 04536-0176 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument N299777.

12. PIN 04536-0177 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument N299973.

13. PIN 04536-0181 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Parts 1, 2, 3, 4, 5, 6, 7 and 8 on Plan 4R-9230.

14. PIN 04536-0392 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument N765624.

15. PIN 04536-1282 (LT), being Part of Lots 3 and 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 1 on Plan 5R-12533, save and except Parts 1 and 2 on Plan OC536758.

16. PIN 04536-0180 (LT), being Part of Lot 4, Concession 3, (Geographic Township of Huntley), now in the City of Ottawa, as set out in Instrument N765631.

Lands Identified As Parcel "B"

1. PIN 04508-0005 (LT), being Part of Lot 4, Concession 2, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 2 on Plan 5R-5121.

2. PIN 04508-0006 (LT), being Part of Lot 4, Concession 2, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 1 on Plan 5R-2401.

3. PIN 04508-0007 (LT), being Part of Lots 3 and 4, Concession 2, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 1 on Plan 5R-9728, together with a right-of-way as set out in Instrument N359845.

4. PIN 04508-0088 (LT), being Part of Lot 3, Concession 2, (Geographic Township of Huntley), now in the City of Ottawa, designated as Parts 1 and 2 on Plan 4R-19834, together with a right-of-way as set out in Instrument N359617 and subject to a right-of-way as set out in Instruments N359617, N359845 and N464480.

5. PIN 04508-0093 (LT), being Part of Lot 4, Concession 2, (Geographic Township of Huntley), now in the City of Ottawa, designated as Parts 2, 3, 6, 8, 9, 10,11 and 12 on Plan 4R-24158, subject to easements as set out in Instruments N359617, N359845, N464480 and OC1084547.

Lands Identified as Parcel "C"

1. Part of PIN 04487-1942 (LT), being Part of Lot 2, Concession 2, (Geographic Township of Huntley), now in the City of Ottawa, designated as Part 2 on Plan 4R-24837, subject to easements as set out in Instruments CR1194798 and CT1194800, and together with an easement as set out In Instrument CT1194799.

Appendix 3

Appendix 3-A

Table 6-10 entitled, “Intersection Analysis Results” from the Transportation Study[Ref. 7]

Table 6-10 Intersection Analysis Results

AM	Carp Road						WM Access
	Northbound			Southbound			Eastbound
	Left	*Through*	*Right*	*Left*	*Through*	*Right*	*Right*
Volume	75	1016	20	5	983	5	45
Delay (s)	22	15	10	10	2	0	16
LOS	C	B	A	A	A	A	B

PM	Carp Road						WM Access		East Side Dwy	
	Northbound			Southbound			Eastbound		Westbound	
	Left	*Through*	*Right*	*Left*	*Through*	*Right*	*Left*	*Right*	*Left*	*Right*
Volume	45	1026	0	0	1053	0	5	75	20	5
Delay (s)	12	8	0	0	2	0	136	25	85	57
LOS	B	A	A	A	A	A	F	C	F	F

The delays estimated for through vehicles during the simulation indicate that they are required to slow down for vehicles in front of them turning right into driveways. Similarly, delays for right turning vehicles indicate that they are slowing down to complete their turns. The longest delays are experienced by vehicles turning left to exit the WCEC and vehicles turning left to exit the east driveway due to the high volumes of through traffic on Carp Road with a single lane in each direction.

If the City of Ottawa widens Carp Road to two lanes in each direction, the level of service at the site access and east side driveway will improve and delays will be reduced.

The results of the analysis indicate that the traffic on Carp Road will continue to flow under good operating conditions. The trucks entering and exiting the WM site will experience delays, especially for vehicles electing to turn left.

Road Network (Site-Vicinity)

The transportation road network in the vicinity of the WCEC is characterized by:

- Carp Road, which provides site access and a route to the north and south of the site;
- Highway 417, which provides a major route and connections to the east, west and north of the site; and
- Richardson Side Road, which provides access to the residential areas north and west of the site as well as an alternative east-west route to Kanata.

Appendix 3-B

Geotechnical Investigations

a) Geotechnical Investigation, Waste Management, Carp Road, Carp, Ontario, Ref. No. 13-107, prepared by Alston Associates Inc., dated December 3, 2013

b) Addendum to Report, Geotechnical Investigation, Waste Management, Carp Road, Carp, Ontario, Ref. No. 13-107A, prepared by Alston Associates Inc., dated December 16, 2013

c) Supplemental Geotechnical Investigation, Proposed Landfill Expansion, West Carleton Environmental Centre, Carp, Ontario, prepared by Alston Associates Inc., dated March 12, 2014

alston associates inc.
consulting engineers

geotechnics
construction materials testing

GEOTECHNICAL INVESTIGATION
WASTE MANAGEMENT
CARP ROAD
CARP, ONTARIO

Ref. No. 13-107
3 December 2013

AECOM Canada
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Markham, Ontario
L3R 5Z6

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Ref. No. 13-107

CONTENTS

APPENDICES

ENCLOSURES

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/m^3. 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.

Vic Nersesian, P.Eng.

REGISTERED PROFESSIONAL ENGINEER
C. ALSTON
6 December 2013
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
V. NERSESIAN
33778705
Dec 6, 13
PROVINCE OF ONTARIO

/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.

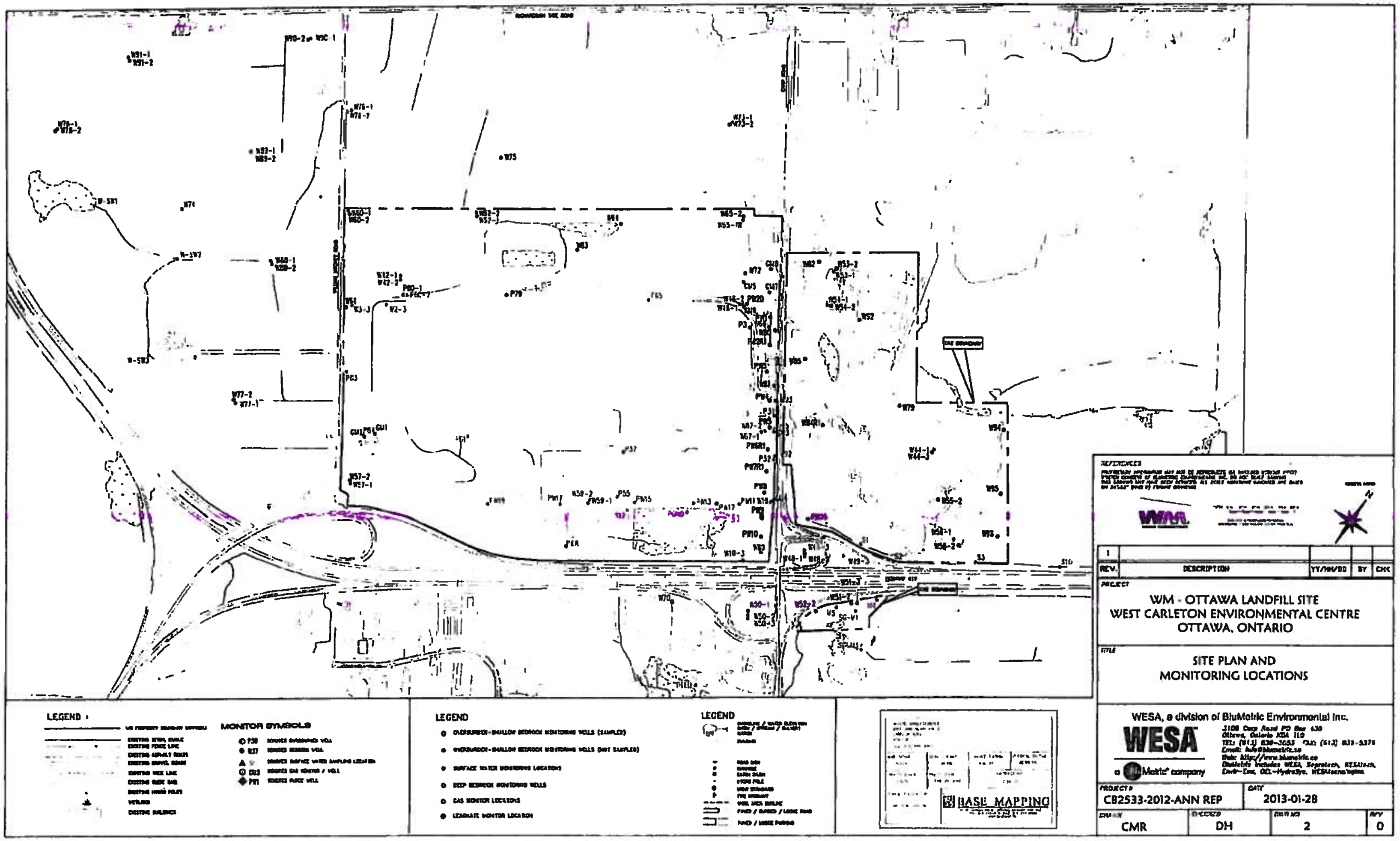
The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain 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
MONITOR SYMBOLS
BASE MAPPING
REFERENCES
REV.
DESCRIPTION
YY/MM/DD
BY
CHK
PROJECT
WM - OTTAWA LANDFILL SITE
WEST CARLETON ENVIRONMENTAL CENTRE
OTTAWA, ONTARIO
TITLE
SITE PLAN AND
MONITORING LOCATIONS
WESA, a division of BluMetric Environmental Inc.
WESA
a BluMetric company
PROJECT #
CB2533-2012-ANN REP
DATE
2013-01-28
CMR
DH
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Project No: C-B2853
Project: Hydrogeological Characterization
Client: Waste Management of Canada Corp.
Location: Ottawa, Ontario

Well ID: W60-1

Log File: B2853w60-1
Tem. File: B2853br
Field Personnel: B.A.

SUBSURFACE PROFILE

Depth	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation % (20, 60)	Fracture Frequency/ Run	Comments	K (m/sec)
ft m		Ground Surface	125.02					
		Sand Very loose, medium brown, medium grained Sand, with a trace of gravel.	123.65				s/u 0.63m TPVC 100mm² steel protective casing grouted to surface Elev. 125.56m TPVC	
		Sand Very dense, grey, wet, Sand, with some gravel.	123.19				w/l data recorded Jan. 6, 2004	
		Silty Sand Medium dense, grey, wet, fine grained silty Sand.	121.06					
		Silt Loose, grey, saturated, 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.	118.58					
		Silt Very dense, grey, Silt, with a trace of clay.	116.33				Cement grout with 4 lbs. of bentonite powder per bag of cement	
		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)				6		1 E-08
						4		
		- 9.4-9.7m weathered broken shale seams	112.22			3		4 E-10

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

WESA
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.

SUBSURFACE PROFILE

Columns: Depth | Stratigraphy | Description | Elevation (m) | Well Construction | Rock Quality Designation (% 20 60) | Fracture Frequency/ Run | Comments | K (m/sec)

Depth (ft): 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90

Depth (m): 14 15 16 17 18 19 20 21 22 23 24 25 26 27

Description	Elevation (m)	Fracture Frequency/ Run	Comments	K (m/sec)
- 13.7-14.2 totally healed, re-cemented with calcite vertical fracture.	111.28	4		
		2	Cement grout with 4 lbs. of bentonite powder per bag of cement	10 E-09
		2		
		4		9 E-10
	105.18		Bentonite gravel seal	
- fracture		2		2 E-07
	103.76			
- 21.26-21.7m vertical fracture		4	3.05m x 50mm slot 20 PVC screen within a 3M silica sand pack	
	102.11			1 E-07
- 22.9-23.5m horiz. fracture above a vertical fracture with calcite mineralization.		3		
	100.03	5	Bentonite gravel plug	
End of Cored Hole				

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.

WESA
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

Elevation	Description	Number	Type	N/ RGD %	% Recovery	Comments
125.12	Ground Surface					
124.82	***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
	Sand Very loose, medium brown, medium grained Sand, with a trace of gravel.	2	SS	3	57	
123.75		3	SS	>50	56	
123.29	***Sand*** Very dense, grey, wet, Sand, with some gravel.					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	
					100	
118.64	***Silt*** Very dense, grey, Silt, with a trace of clay.	12	RC		100	Bentonite gravel seal above silica sand pack
		13	RC		100	
116.43	***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					

Depth: ft / m (scale −1 to 36 ft; 0 to 11 m)

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

Depth (ft / m)	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
	125.83	Ground Surface							
0–7.9 ft (0–2.4 m)	123.39	(5) ***Sand*** Medium dense to dense, wet, brown, fine to medium grained Sand. Saturated sand at 6' (1.83m).		1	SS	15	75		s/u 0.89m 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		
				3	SS	40	83		w/l data recorded Jan. 7, 2004
				4	SS	58	83		
	122.17	(5) ***Sand*** Very dense, brown, saturated, medium to coarse grained Sand.		5	SS	>50	75		
				6	SS	>50	67		
	121.26	(5) ***Sand*** Very dense, greyish brown, saturated, coarse grained Sand.		7	SS	>50	100		Native soil collaspe
				8	SS	42	75		
	119.12	(5) ***Sandy Silt*** Dense, grey, wet, fine grained sandy Silt, to silty Sand.							Bentonite gravel seal
	118.51	(6) ***Silt and Sand*** Very dense, grey, Silt and Sand, with gravel and cobbles.		9	SS	>50	31		
	117.55	(6) ***Sand Till*** Till and boulders.		10	RC				
	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				
		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

Elevation	Description
124.91	Ground Surface
124.61	***Silty Sand*** Loose, brown, silty Sand.
	Sand Very dense, brown, wet to saturated, thinly bedded, medium grained Sand.
122.78	***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').
114.96	***Limestone*** Light to medium grey, very fine to medium coarse crystalline fossiliferous limestone (Bobcaygeon Formation, Lower Member).
113.00	End of Cored Hole

SAMPLE

Number	Type	N/ RGD %	% Recovery
1	SS	18	58
2	SS	55	88
3	SS	46	50
4	SS	79	50
5	SS	>50	67
6	SS	19	67
7	SS	17	58
8	RC		
9	SS	7	0
10	SS	>50	45
11	SS	41	17
12	SS	>50	0
13	SS	7	75
14	SS	46	42
15	RC		
16	RC		
17	RC		
18	RC		

Comments

s/u 0.48m TPVC
Elev. 125.39m TPVC

w/l data recorded Jan. 7, 2004

Bentonite slurry seal

Bentonite gravel seal above silica sand pack

3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack

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

Project: Hydrogeological Characterization

Client: Waste Management of Canada Corp.

Location: Ottawa, Ontario

Well ID: W64

Field Personnel: B.McC.

Log File: B2653w64

Template File: B2653soil

Depth (ft / m)	Elevation	Description	Symbol	Number	Type	N/ RGD %	% Recovery	Well Data	Comments
0	126.54	Ground Surface							
0–3 ft		**Sand** (5) Medium dense, brown, thinly bedded, medium grained Sand.		1	SS	19	58		e/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
	124.63			2	SS	>50	63		124.44 wl data recorded on Jan. 7, 2004 121.95
		Sand (5) Very dense, brown, dry, coarse grained Sand, with a trace of gravel.		3	SS	>50	56		
	123.41			4	SS	72	63		
		Sand (5) Very dense, brown, dry, thinly bedded, medium grained Sand. Moistsoil encountered at 3.35m (11').		5	SS	76	58		Bentonite slurry seal
				6	SS	40	58		
	121.88								Bentonite gravel seal
		Sand (5) Very dense, brown, saturated, thinly bedded, fine to medium grained Sand.		7	SS	75	58		
				8	SS	>50	63		110 87
	120.66								
		Sand (5) Very dense, brown, saturated fine grained Sand, with a trace of gravel.		9	SS	>50	47		
	119.65								
		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
	117.82	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

Depth (m)	Elevation	Description
0	126.75	Ground Surface
0 – ~1.8		*Silt* — Dense to very dense, dry, Silt with boulders and sand lenses. (4)
~1.8	124.92	*Sand* — Dense to very dense, brown, damp to dry, coarse grained Sand with a trace of fine to coarse gravel. (5)
~9.1	117.61	*Sand and Gravel* — Very dense, damp, brown, coarse grained sand and coarse gravel. Saturated soil 10.36m (34'). (4)
~11.8	114.91	*Limestone* — (Bobcaygeon Formation, Lower Member).
13	113.57	End of Cored Hole

SAMPLE

Number	Type	N/ RGD %	% Recovery
1	SS	38	17
2	SS	13	54
3	SS	73	54
4	SS	50	50
5	SS	28	54
6	SS	41	58
7	SS	45	54
8	SS	34	58
9	SS	45	63
10	SS	35	58
11	SS	>50	33
12	SS	55	75
13	SS	>50	47
14	SS	85	39
15	SS	>50	58
16	SS	>50	33
17	SS	>50	
			100
19	RC		
20	RC		

Comments (Well Data)

- s/u 0.43m TPVC, Elev. 127.18m TPVC
- Bentonite slurry seal
- Bentonite gravel seal above native soil collaspe
- w/l data recorded on Jan. 7, 2004
- 3.05m x 50mm slot 10 PVC screen with a 3M silica sand pack

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. 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

Depth (m)	Elevation	Description
0	130.57	Ground Surface
0 – 3	127.47	***Sand and Gravel*** Medium dense to very dense, light to dark brown, moist, bedded, stratified, sand and gravel with silt and trace clay. (4)
3 – 5	125.39	***Gravel*** Dense to very dense, medium brown, dry, fine to coarse gravel. (4)
5 –		***Sand*** Very dense, light brown to grey, dry to moist, fine to medium grained sand with trace of gravel. (5)

SAMPLE

Number	Type	N/ RGD %	% Recovery
1	SS	21	75
2	SS	19	29
3	SS	40	38
4	SS	55	67
5	SS	>50	25
6	SS	28	46
7	SS	65	50
8	SS	>50	42
9	SS	>50	78
			0
11	SS	72	75
			0
			0
14	SS	89	71

Comments

s/u 1.14m TOC, 1.07m TPVC
150mm steel well casing with locking cap grouted to surface
Elev. 131.71m TOCI.
Elev. 131.64m TPVC

Bentonite slurry seal

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

Depth	Elevation	SUBSURFACE PROFILE: Description	SAMPLE: Number	Type	N/ RGD %	% Recovery	Comments
29–36	119.60		15	SS	88	75	
			16	SS	>50	75	Bentonite slurry seal
			17	SS	95	83	
			18	SS	>50	43	
36–44	117.16 (12.85)	(4) ***Gravel*** Very dense, moist, greyish-brown, fine to medium grained Gravel, with some sand.	19	SS	>50	87	
			20	SS	>50	91	
			[illegible]			88	117.72 wl data recorded Jan. 7, 2004
			22	SS	>50	67	Bentonite gravel seal above silica sand pack
44–51	115.00 (114.20)	(4) ***Sand and Gravel*** Very dense, dark grey-brown, wet to saturated, coarse Sand and medium to coarse Gravel, with a trace of silt.	23	SS	90	78	
			24	SS	>50	87	116.37
			25	SS	>50	100	
51–58	112.89 (11.85)	(8) ***Limestone*** 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)	26	RC			
			27	RC			3.05m x 50mm slot 10 PVC screen within a 3M silica sand pack
			28	RC			
			29	RC			113.32
58–60		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: Dec. 1,2, 2003

Sheet: 2 of 2

WESA

A Better Environment For Business

Well ID: W73-2

Project No: C-B4853-08-02

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 (ft / m)	Description	Elevation (m)	Comments
0 / 0	Ground Surface	120.74	Elevation of TOC = 121.65 masl
0–2	*topsoil* moist, dark brown, loose with abundant organics		
2	*sand/gravel* moist, brown, loose mostly cobbles	120.13	
	clay moist, brown, soft with trace silt		
4	*gravel* moist, brown, loose with crushed rock fragments	118.82	bentonite gravel
8	*sand/gravel* moist, brown, loose sufficient cobbles and broken boulder fragments	118.30	WL - Apr.23/07 (117.25 masl)
14	*sand/gravel* wet, brown, loose	116.47	

Column headings: Depth; Stratigraphy; Description; Elevation (m); Well Construction; Rock Quality Designation % (20, 60); Fracture Frequency/Run; Comments; K (m/sec)

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

Well ID: W73-2

Project No: C-B4853-06-02
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 (ft)	Depth (m)	Description	Elevation (m)	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
16–19	5–6	***sand*** wet, brown, dense, well graded with some gravel near base	115.66			running sand	
20–23	6–7	***sand/gravel*** wet, brown, very dense with gravel and rock fragments	114.64				
24		***fractured bedrock*** angular limestone fragments and pebbles	113.42			3.05m x 50mm PVC screen within silica sand	
25–29	8–9	***Lindsay/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. ~8.25 to 8.43 mbgs - vertical		•	10		
30	9	joints at 9.1, 9.17, and 9.32 mbgs: horiz., 0.1 narrow, not healed, clean, smooth, dry.	111.78	•	3		
31		End of Borehole	111.40				
32–34	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-B4853-08-02
Project: WM Ottawa Landfill - Expansion Drilling
Client: Waste Management
Location: Paul's Farm (East of William Mooney)

Easting: 345843.62*
Northing: 5015892.95*
Field Personnel: S. Pfister/A. Wigston

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Description	Elevation (m)	Comments
-3 to -2				TOC Elevation = 124.62 masl
0	0	Ground Surface	123.72	
0 – 7	0 – 2.1	*sand* moist, brown, medium grained		fine sand
2 – 3				WL - Apr. 23/07 (122.91 masl)
5		wet		
6		gray, silty, fine grained	121.64	
7 – 8		*silty sand* wet, gray	121.39	
8 – 9		*sand* wet, grey, very dense, fine, with silt and gravel	120.87	bentonite gravel
10	3	spoon refusal, augered through cobbles	120.72	
11		*sand* wet, grey, very dense, fine, with silt and gravel	120.28	
12		spoon refusal, augered through cobbles	120.11	
13 – 15	4	*sand* wet, grey, dense, fine, with some medium brown, some iron stained nodules, some silt and gravel		

Columns also printed: Stratigraphy; Well Construction; Rock Quality Designator (%, 20, 60); Fracture Frequency/Run; K (m/sec)

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

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: 5015992.98"

Field Personnel: S. Pfister/A. Wigston

SUBSURFACE PROFILE

Description	Elevation (m)	Fracture Frequency/Run	Comments
	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	117.57		
spoon refusal, augered through cobbles	117.08		
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	116.28		3.05m x 50mm slot PVC screen within a silica sand pack
gravel large cobbles and gravel	115.92	4	
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.	114.28	7	
End of Borehole 9.5m below ground surface, hole terminated in bedrock			

Depth (ft): 16–34; Depth (m): 5–10

Rock Quality Designation % (20, 60); K (m/sec)

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-84853-06-02

Project: WM Ottawa Landfill - Expansion Drilling

Client: Waste Management

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

Easting: 346287.93*

Northing: 5016784.87*

Field Personnel: S. Pfister/A. Wigston

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Description	Elevation (m)	Comments
-4 to 0				*TOC Elevation = 124.47 masl*
0	0	Ground Surface	123.50	
0–0.8		*topsoil*	123.26	
0.8–6.9	1–2	*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. 29/07 (122.47 masl) bentonite gravel
6.9–8		spoon refusal, augered through cobbles	121.06	
8–9.5		*sand* moist, grey, dense, fine, with some silt and gravel, augered through cobbles	120.60	
9.5–10.5	3	spoon refusal, augered through cobbles	120.39	
10.5–14	4	*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

Other column headings: Stratigraphy; Well Construction; Rock Quality Designation (% 20 80); Fracture Frequency/Run; K (m/sec)

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: 1 of 2

WESA
A Better Environment For Business

Well ID: W76-2

Project No: C-B4853-08-02
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

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Description	Elevation (m)	Comments	Fracture Frequency/Run
15–16			[illegible]	3.05m x 50mm slot PVC screen within a silica sand pack	
16–22	5–6	***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.			15
21		-6.17 to 6.45 mbgs - vertical joint: ex. to very narrow, not healed, clean, rough and planar, dry.	[illegible]	45 cm of silica sand	
22.5	7	End of Borehole 6.88m below ground surface, hole terminated in bedrock			

Column headings: Depth; Stratigraphy; Description; Elevation (m); Well Construction; Rock Quality Designation (% 20 60); Fracture Frequency/Run; Comments; K (m/sec)

Depth scale: 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 (ft); 5, 6, 7, 8, 9 (m)

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
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FIGURE:

RECORD OF TEST HOLE

DESIGNATION: P79

COMPLETION DATE: AUGUST 12, 1993

PROJECT: LAIDLAW WASTE SYSTEMS, CARP

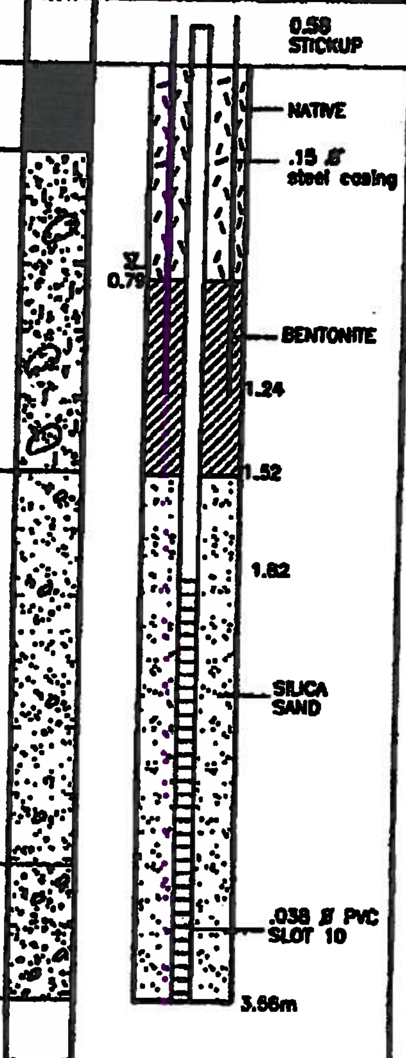
PROJECT NO.: 2849-R

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			

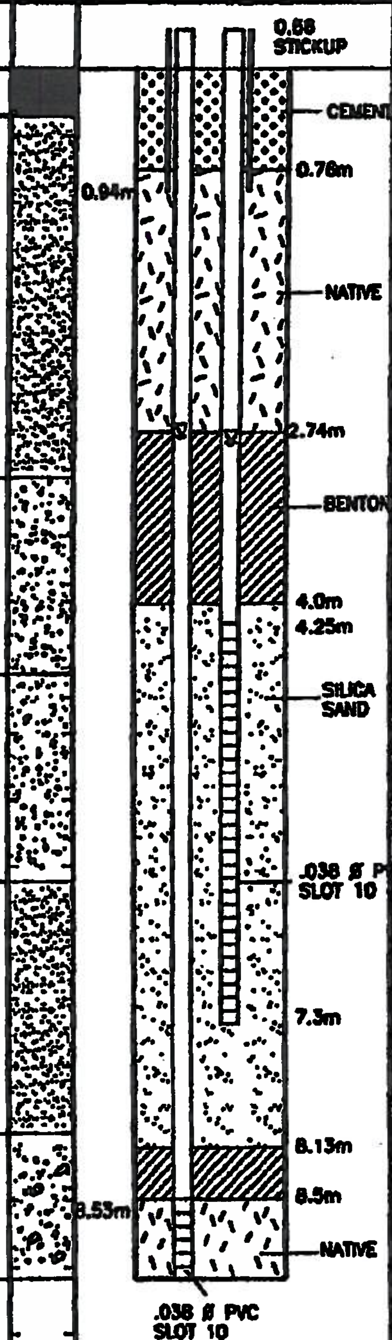


WATER AND EARTH SCIENCE ASSOCIATES LTD.
P.O.BOX 430
CARP, ONTARIO. K0A 1L0

FIGURE:	RECORD OF TEST HOLE	DESIGNATION P80	COMPLETION DATE AUGUST 12, 1993
PROJECT: LAIDLAW WASTE SYSTEMS, CARP		DRILLING METHODS:	HOLLOW STEM AUGER
		SUPERVISOR:	BRIAN ANDRESS
PROJECT NO.: 2849-R		DRILLING CONTRACTOR:	MARATHON DRILLING CO. LTD.

DEPTH METRES	ELEVATION METRES	STRATIGRAPHY
0	128.22	
	128.02	MEDIUM BROWN, MOIST, SANDY TOPSOIL
0.20		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	1.60 – 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

Depth scale (metres): 0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

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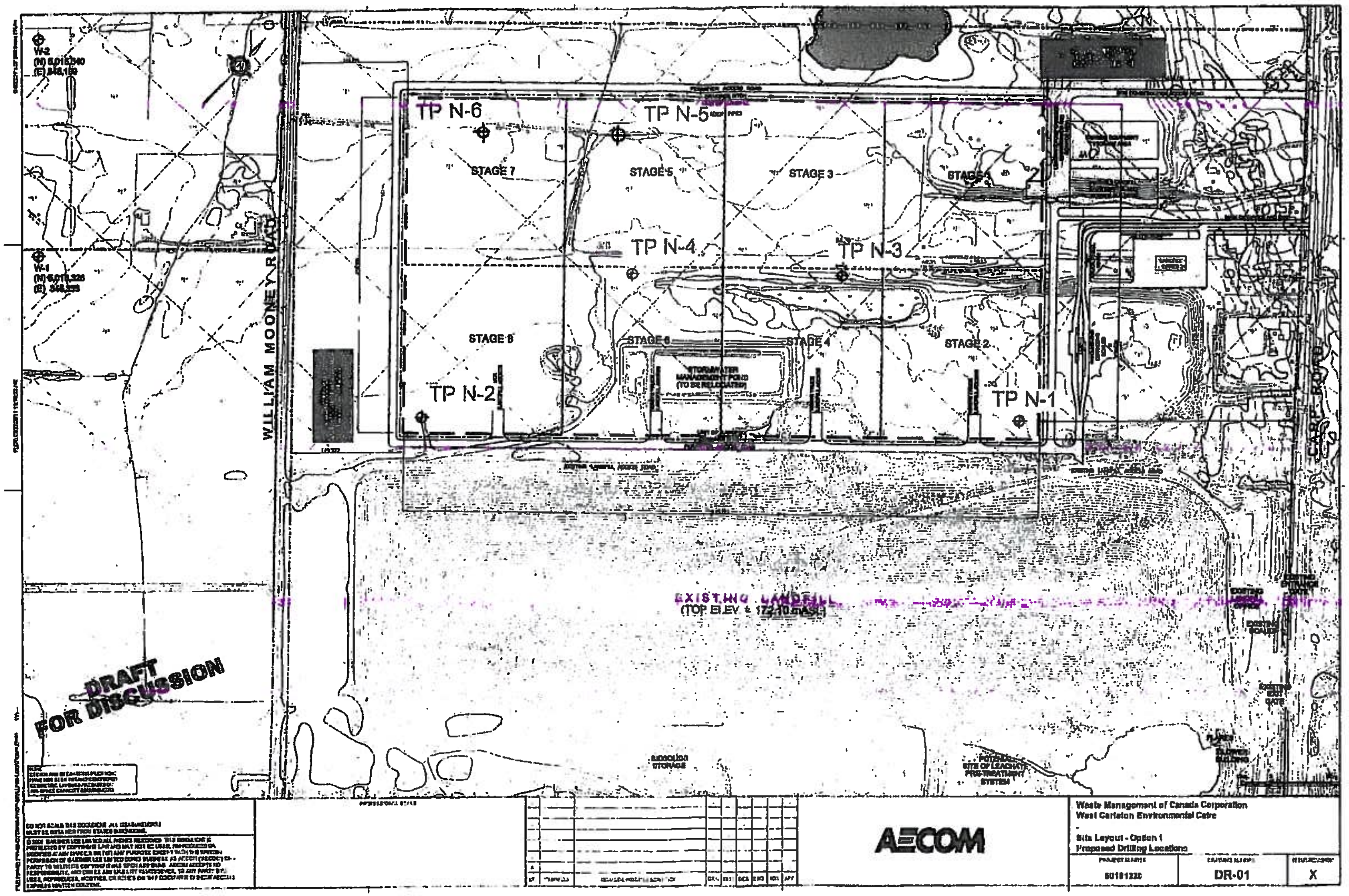
APPENDIX 'C'



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

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 5.0 below ground surface on completion.	23	14		moist, brown sand and gravel trace to some silt (PROBABLE FILL)		1		
0.4			30	13				2		
1.0			10	11				3		
1.3		Slow water infiltration in to test pit at 1.9 to 2.1 m depth.		8				4		
2.0				17		moist to wet grey SILT and fine SAND		5		
2.4				20				6		
3.0				11		GRAVELLY (approx. 2.8 to 3.2 m)		7		
3.8				17				8		
4.4				11				9		

Depth scale (m): 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75

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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.	8			see bottom of previous page		10		
						END OF BOREHOLE				

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	REVIEWED BY: DM	Page 2 of 2

CLIENT: AECOM	METHOD: Track Mounted Excavator		**TP No.: N2**
PROJECT: Carp Landfill	PROJECT ENGINEER: CA	ELEV. (m)	
LOCATION: Carp Road at Highway 417	NORTHING: 5014562	EASTING: 0423450	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) / Equiv. N-Value (Blows/300mm)	PL W.C. LL	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			15		moist, brown SAND and GRAVEL trace silt		2		
0.75			30		moist		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.	13		brown fine to medium SAND trace gravel trace silt		4		
1.75			17		wet / compact		5	17	
2			29					29	
2.25			36/175		dense			36/175	
		Refusal to advancement of dynamic cone test, probable boulder.			END OF BOREHOLE				

Scale: Static Cone Tip Resistance 40 80 120 160; Equiv. N-Value 20 40 60 80; PL W.C. LL 20 40 60 80

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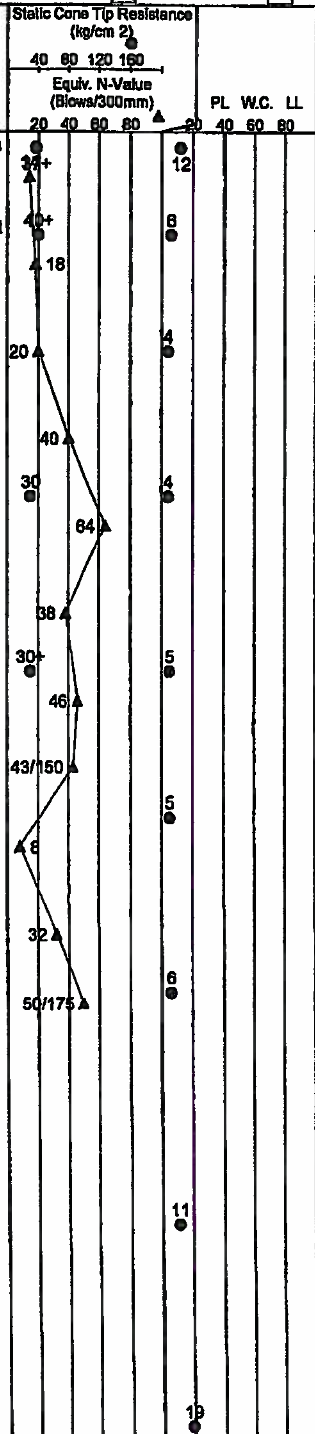
	REVIEWED BY: DM	Page 1 of 1

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 SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	DCPT(N)	ELEVATION (m)
0		Side walls of excavation sloughing from 4.0 m depth to base of excavation 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			32	
2.75						7	50/175	
3								
3.25								
3.5								
3.75						8		
4	▽	Water strike at 4.0 m depth.						
4.25				wet		9		
				END OF BOREHOLE				



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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) / Equiv. N-Value (Blows/300mm)	PL W.C. LL	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		
0.5			30			damp to moist brown SAND some gravel		2		
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		
2.5								6		
3						wet, brown fine to medium SAND		7		
						END OF BOREHOLE				

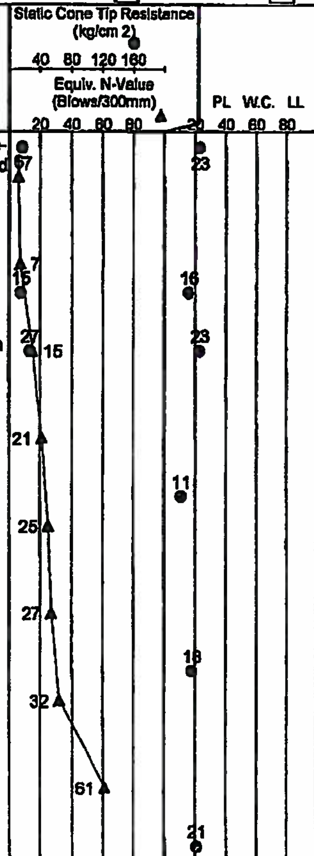
Depth scale (m): 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3

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 | SPLIT SPOON

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



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	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

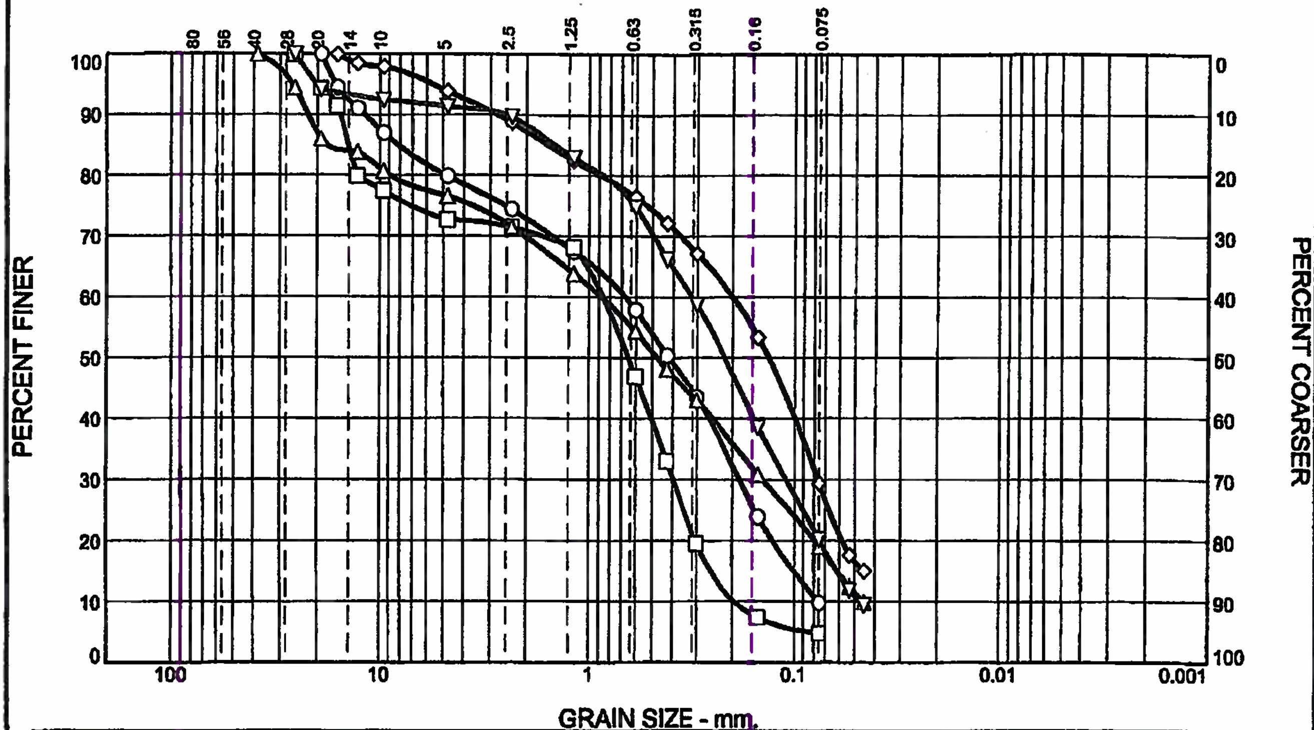
SAMPLE TYPE: AUGER | DRIVEN | CORING | DYNAMIC CONE | SHELBY | SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	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 – 0.2		Test pit dry and open on completion.	5			200 mm TOPSOIL	DRIVEN	1		
0.2 – 1.25			30 (at ~0.35 m); 30 (at ~1.0 m)			grey to brown damp to moist SAND some silt some gravel	DRIVEN	2, 3		
1.25 – 2.9						damp, grey SILTY fine to medium SAND trace gravel	DRIVEN	4, 5, 6		
						END OF BOREHOLE				

Depth scale (m): 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75

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

Grain Size Distribution Report



	% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines 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

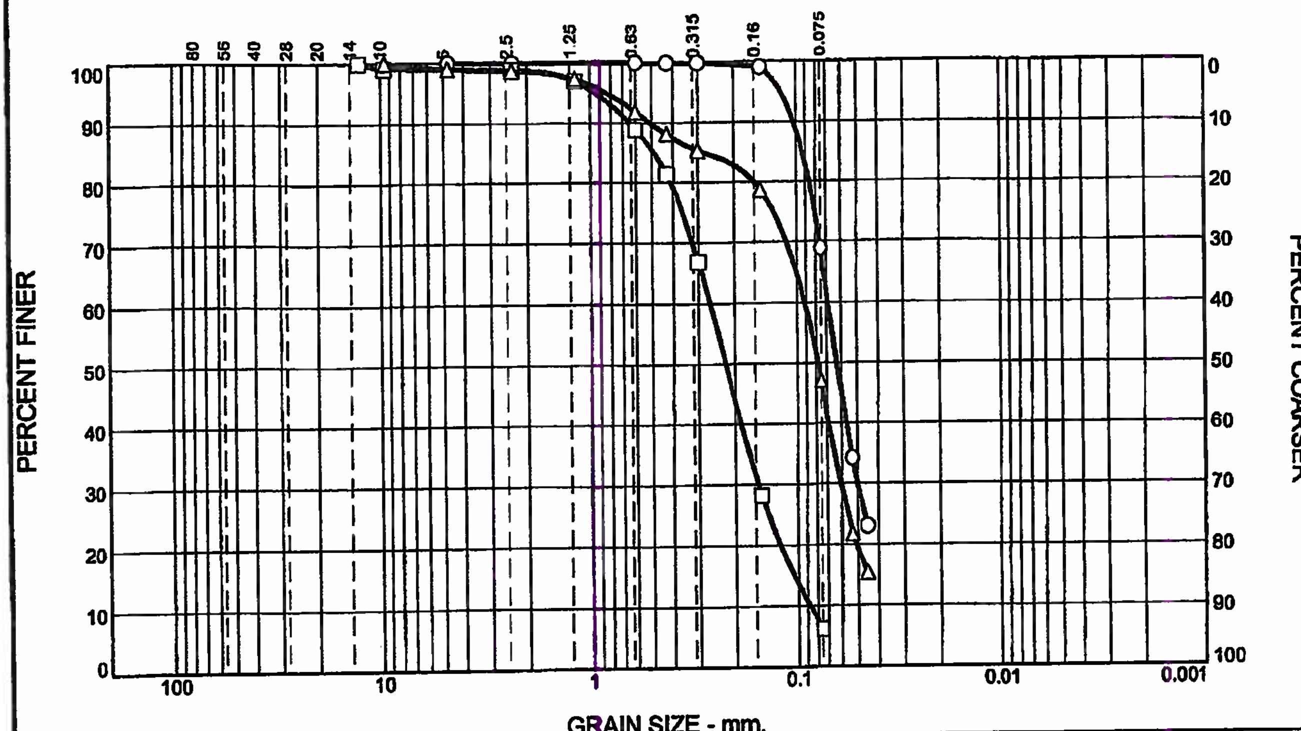
Remarks:

alston associates inc.
consulting engineers

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

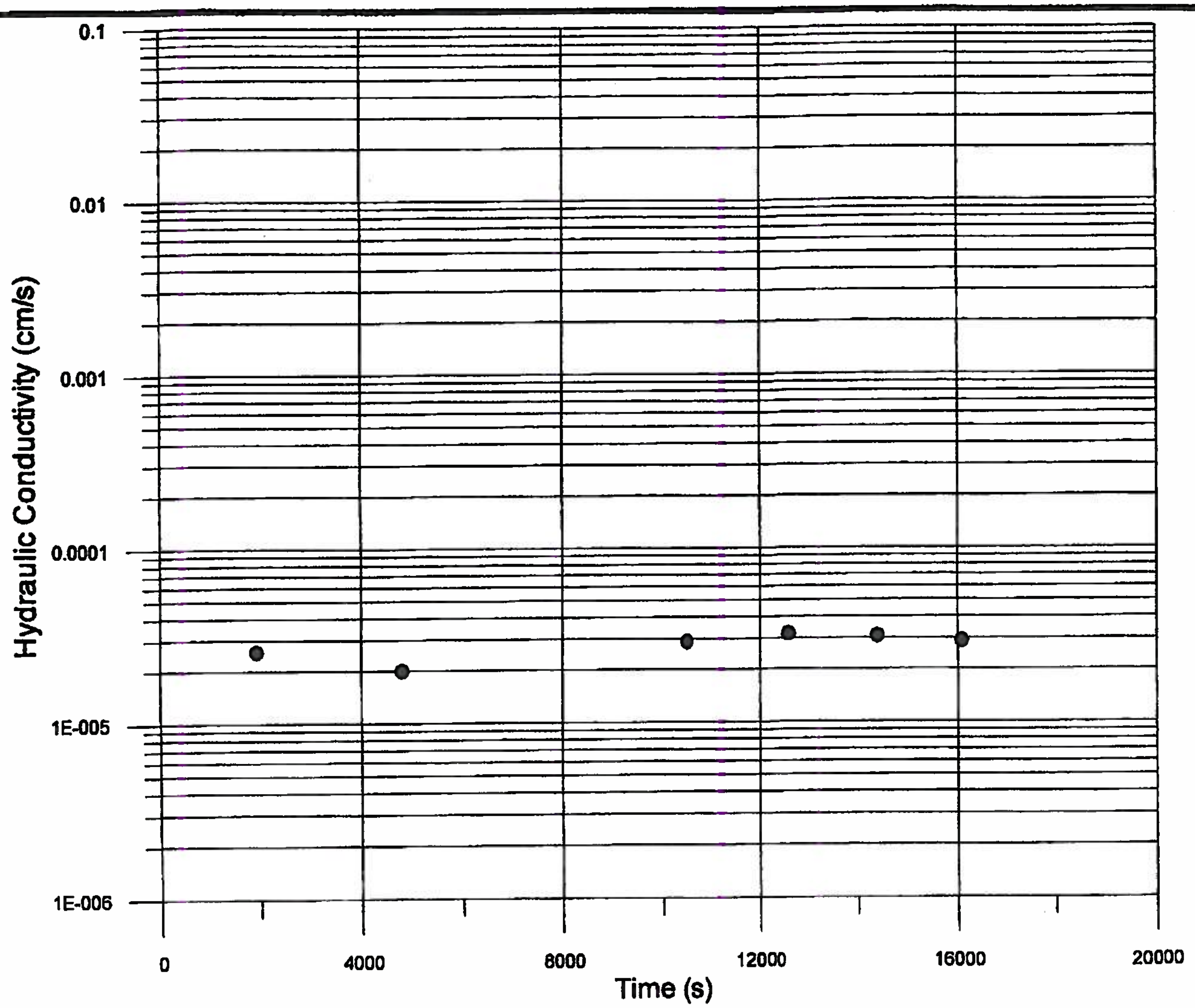
Remarks:

alston associates inc.
consulting engineers

Figure 2

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

HYDRAULIC CONDUCTIVITY TEST REPORT



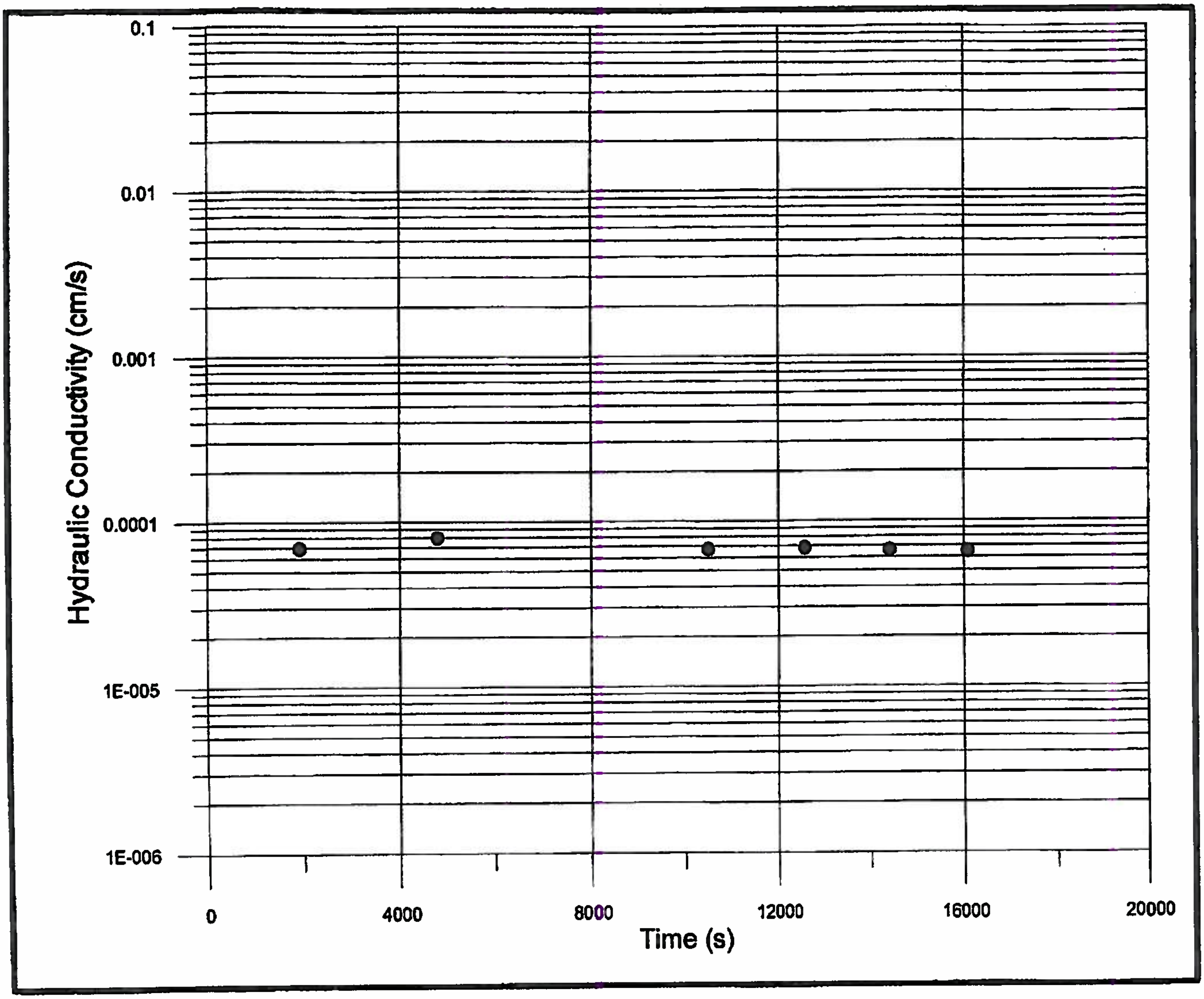
Client: AECOM
Project: Carp Landfill Extension
Alston Associates Inc. Ref. No.: 11-066
Material Description: Silty Sand to Sandy Silt
Sample Location: Test Pit N5, Sample 3
Final Hydraulic Conductivity Reading (cm/s): 2.9×10^{-5}

Remarks:

Figure No. 3

alston associates inc.

HYDRAULIC CONDUCTIVITY TEST REPORT

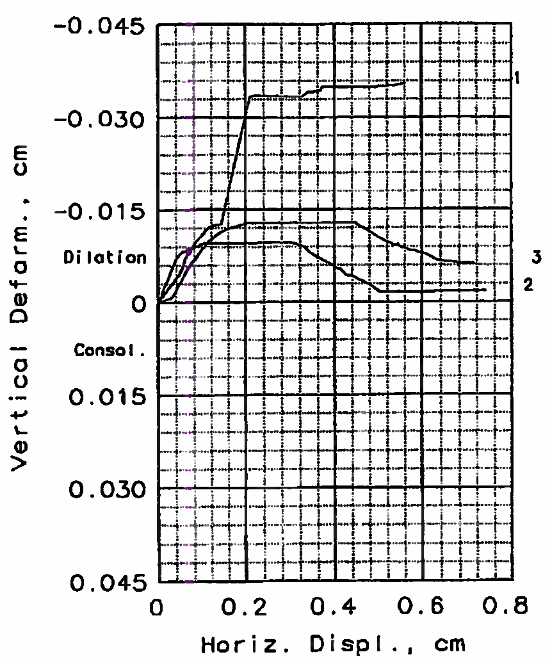


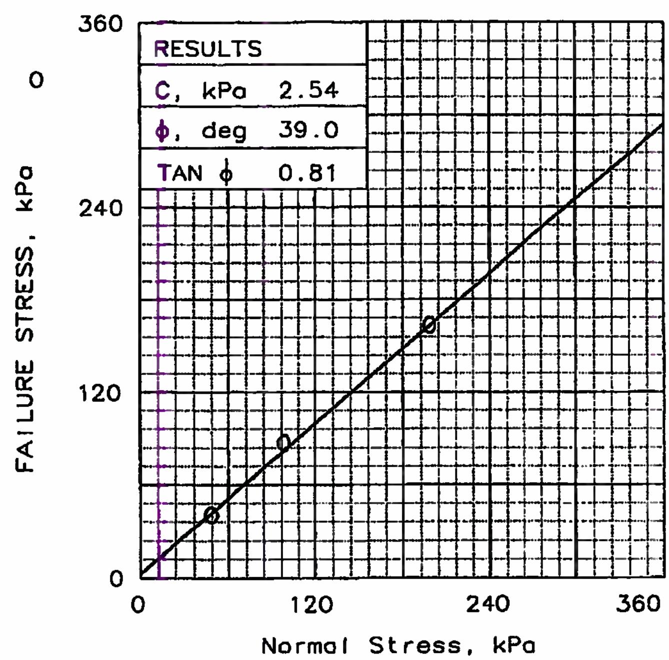
Client: AECOM
Project: Carp Landfill Extension
Alston Associates Inc. Ref. No.: 11-066
Material Description: Silty Sand to Sandy Silt
Sample Location: Test Pit N1, Sample 4
Final Hydraulic Conductivity Reading (cm/s): 6.5×10^{-5}

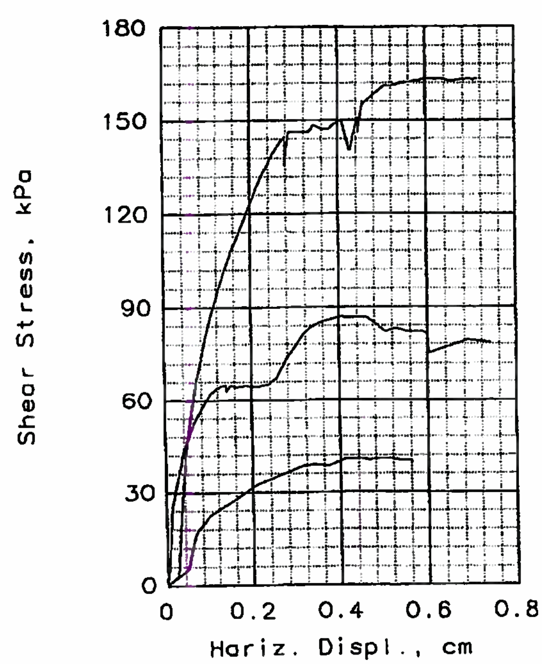
Remarks:

alston associates inc.

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

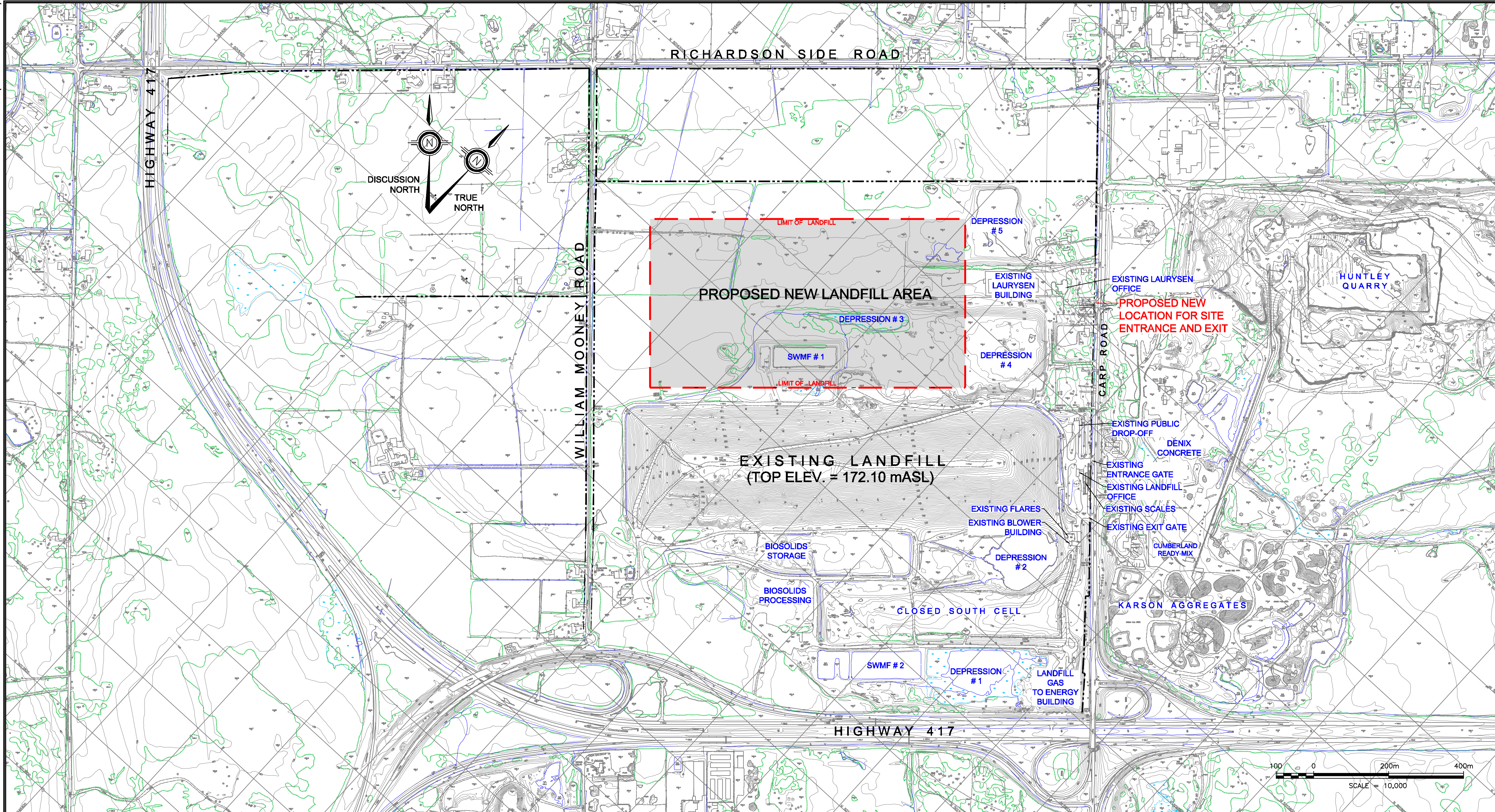
SAMPLE LOCATION: Test Pit N1, Sample 4
1.4 m depth

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

DIRECT SHEAR TEST REPORT

alston associates inc.

APPENDIX 'D'



LEGEND:

- PROPERTY BOUNDARY
- LIMIT OF PROPOSED NEW LANDFILL

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

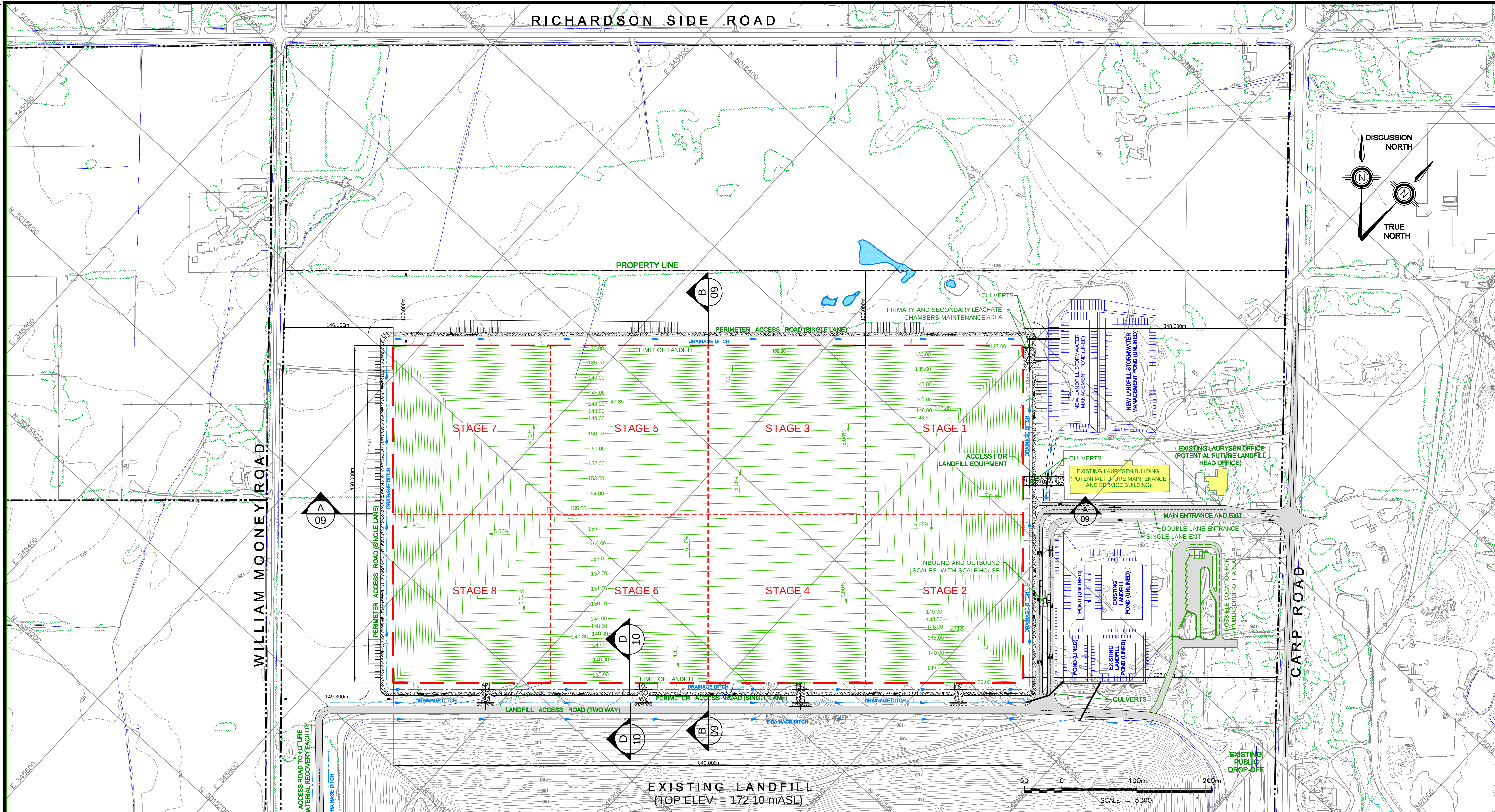
AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre
Preferred Concept

EXISTING CONDITIONS

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

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
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

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

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

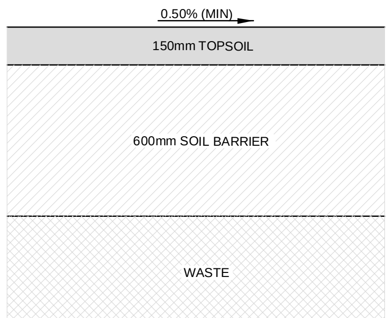
Waste Management of Canada Corporation
West Carleton Environmental Centre
Preferred Concept

FACILITY LAYOUT

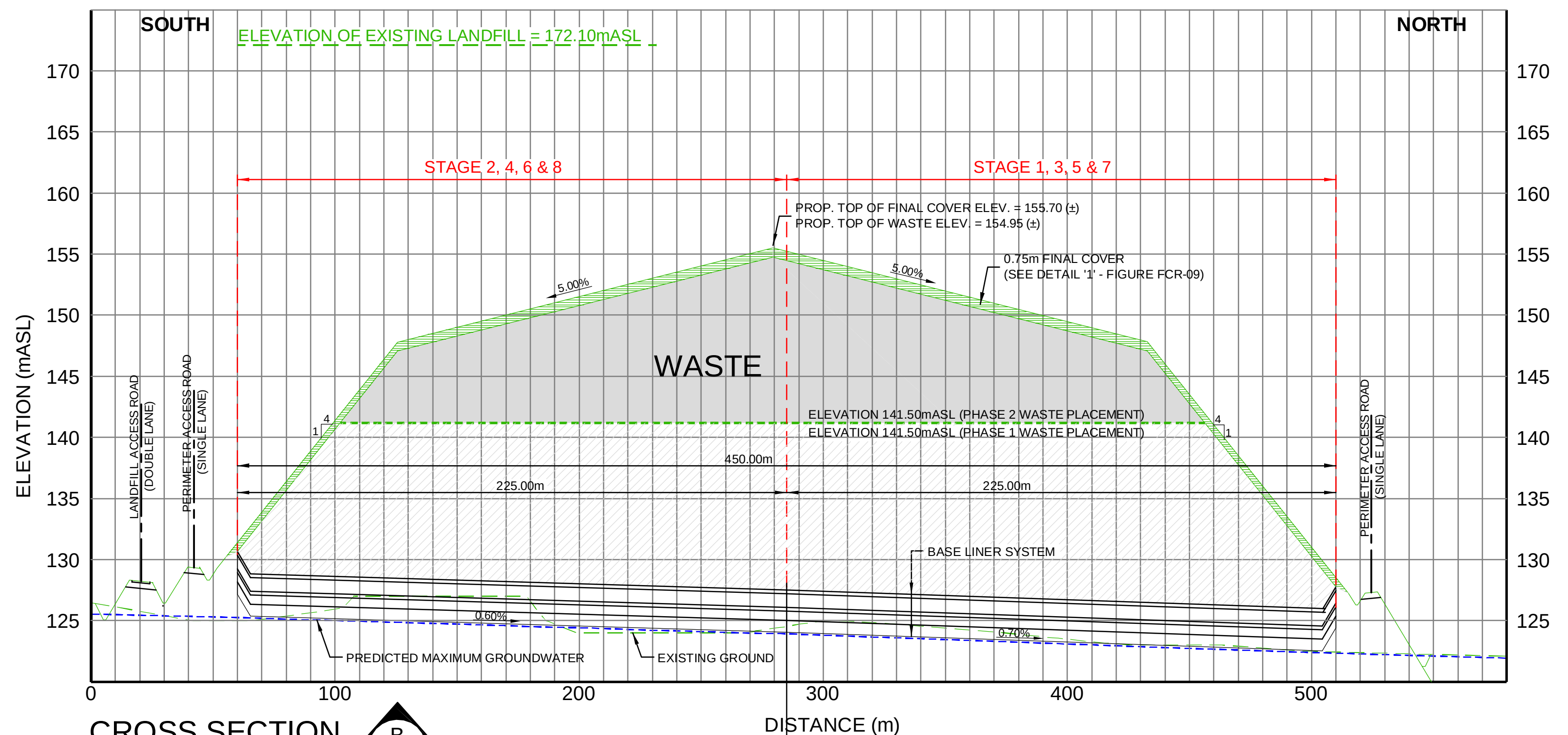
PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-03	.

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

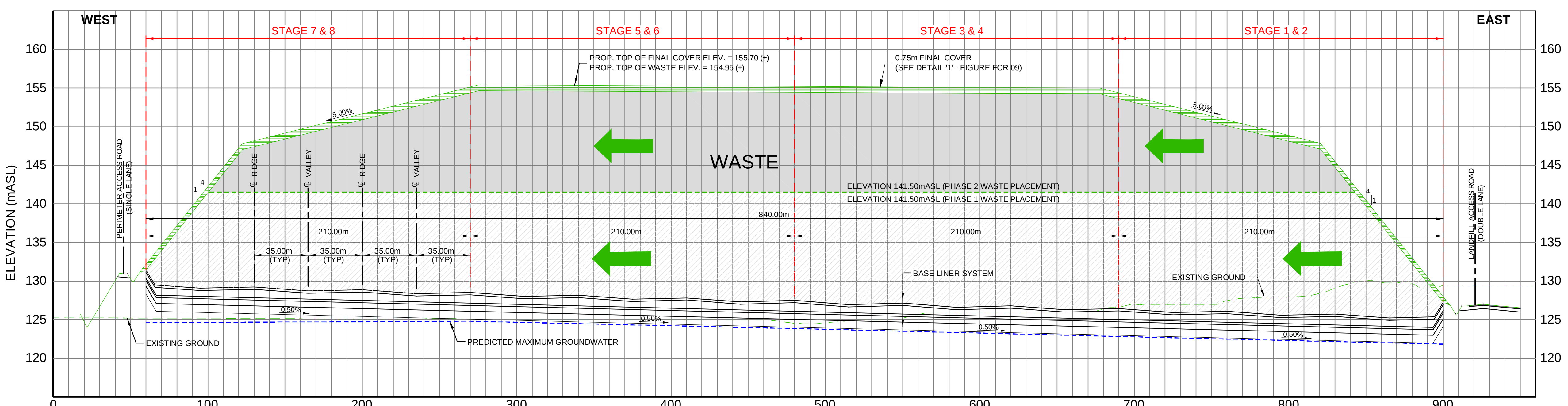


DETAIL 1/9
TYPICAL CONFIGURATION
THROUGH FINAL COVER SYSTEM
SCALE = 1:10



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

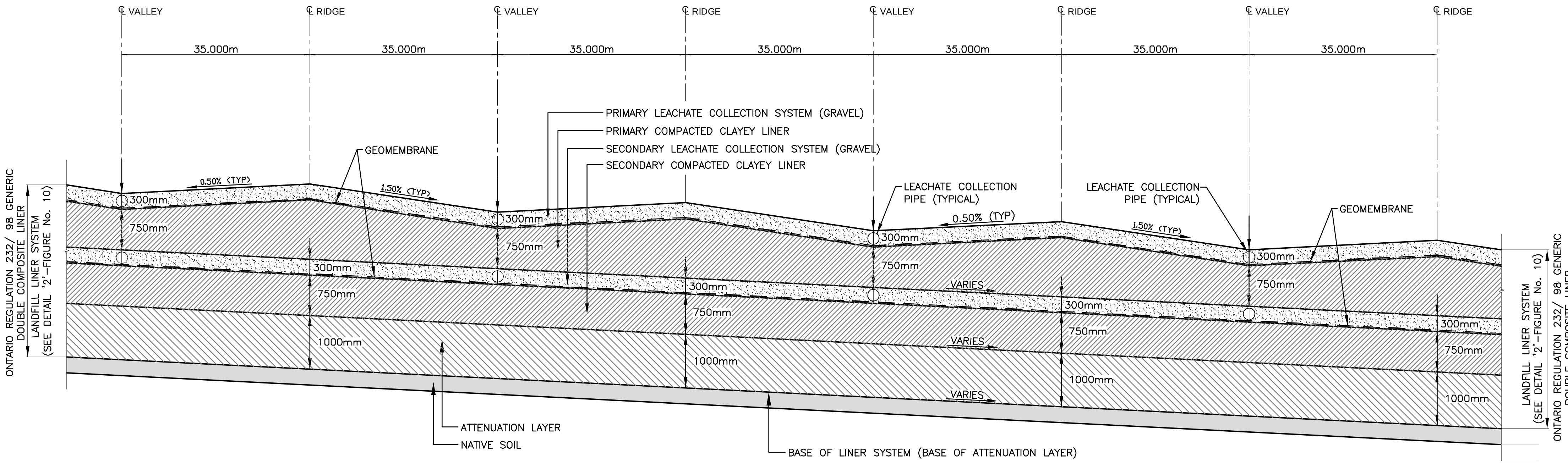
AECOM

Waste Management of Canada Corporation
West Carleton Environmental Centre

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

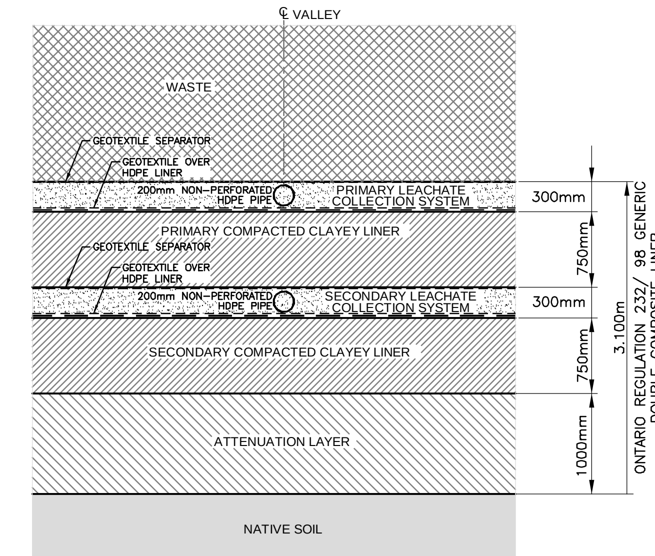
PROJECT NUMBER	FIGURE NUMBER	ISSUE/REVISION
60191228	FCR-10	.

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



CROSS SECTION C / 10

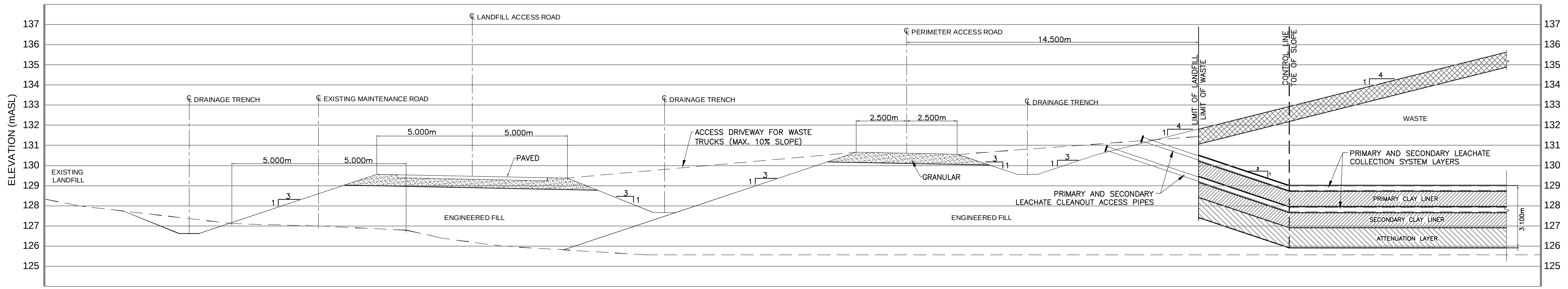
SCALE = 1:1000 (HORIZ)
= 1:100 (VERT)



DETAIL 2 / 10

TYPICAL CONFIGURATION THROUGH LINER SYSTEM

SCALE = 1:75



CROSS SECTION D / 10

SCALE = 1:200

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

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

LEGEND:

AECOM

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

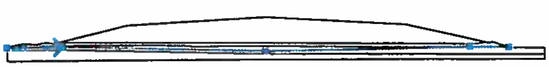
Standard - safety factors

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/m³]
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/m³]	γ_s [kN/m³]	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/m³
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/m³

Silty Sand Till

Unit weight :	γ = 22.50 kN/m³
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/m³

Clay Liner

Unit weight :	γ = 19.50 kN/m³
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/m³

Waste

Unit weight :	γ =	7.80 kN/m3
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/m3

Rigid bodies

No.	Name	Sample	γ [kN/m3]
1	Bedrock		24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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 x [m]	First point z [m]	Second point x [m]	Second point 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

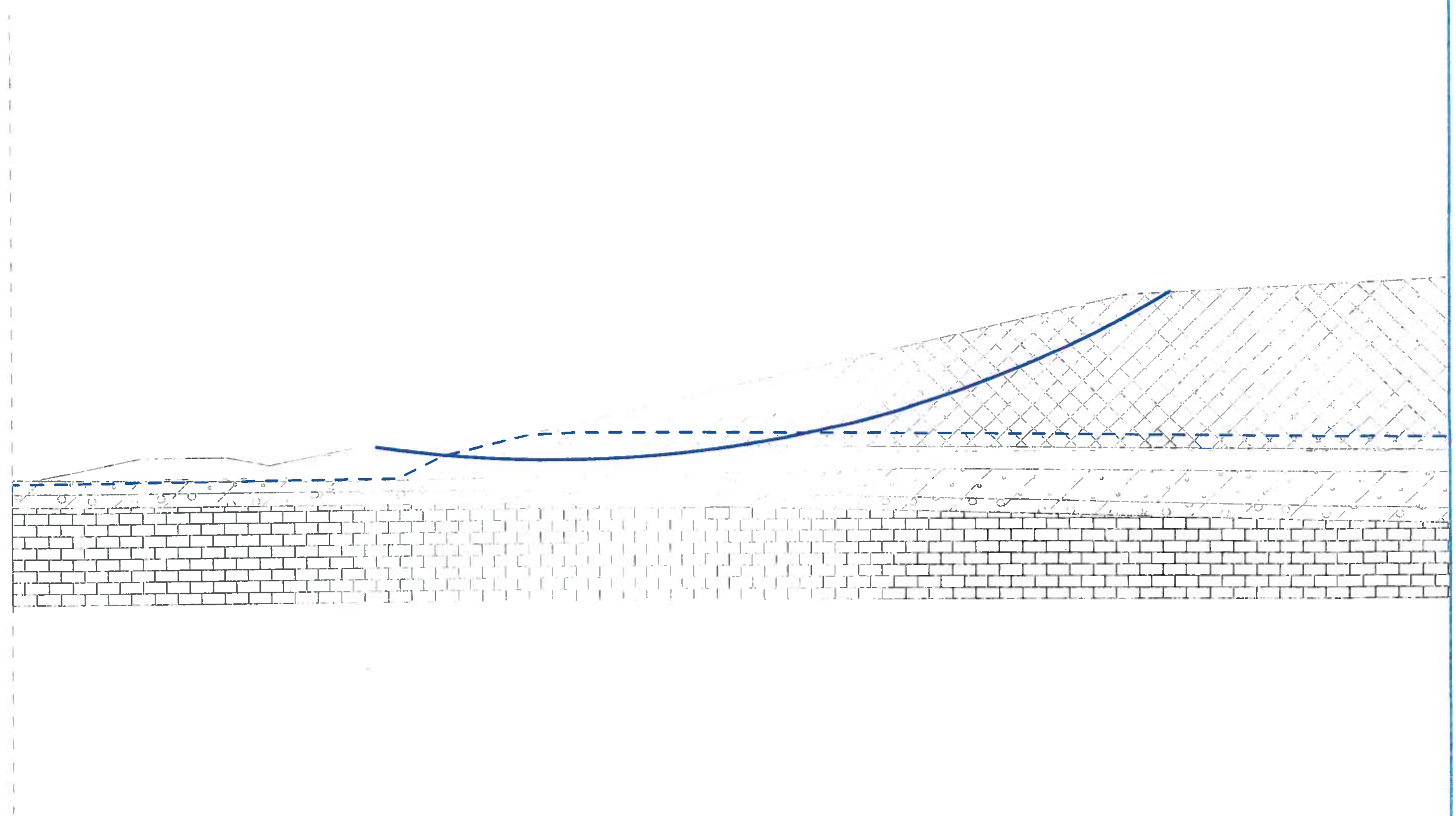
Slope stability ACCEPTABLE

CA/KC

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/m³
Oedometric modulus : E_{oed} = 110.00 MPa
Saturated unit weight : γ_{sat} = 22.00 kN/m³

Silty Sand Till
Unit weight : γ = 22.50 kN/m³
Oedometric modulus : E_{oed} = 350.00 MPa
Saturated unit weight : γ_{sat} = 22.50 kN/m³

Bedrock
Unit weight : γ = 24.00 kN/m³
Oedometric modulus : E_{oed} = 500.00 MPa
Saturated unit weight : γ_{sat} = 24.00 kN/m³

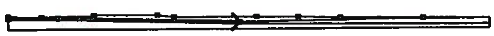
Clay Liner

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		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] x	z	x	z	Assigned soil
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

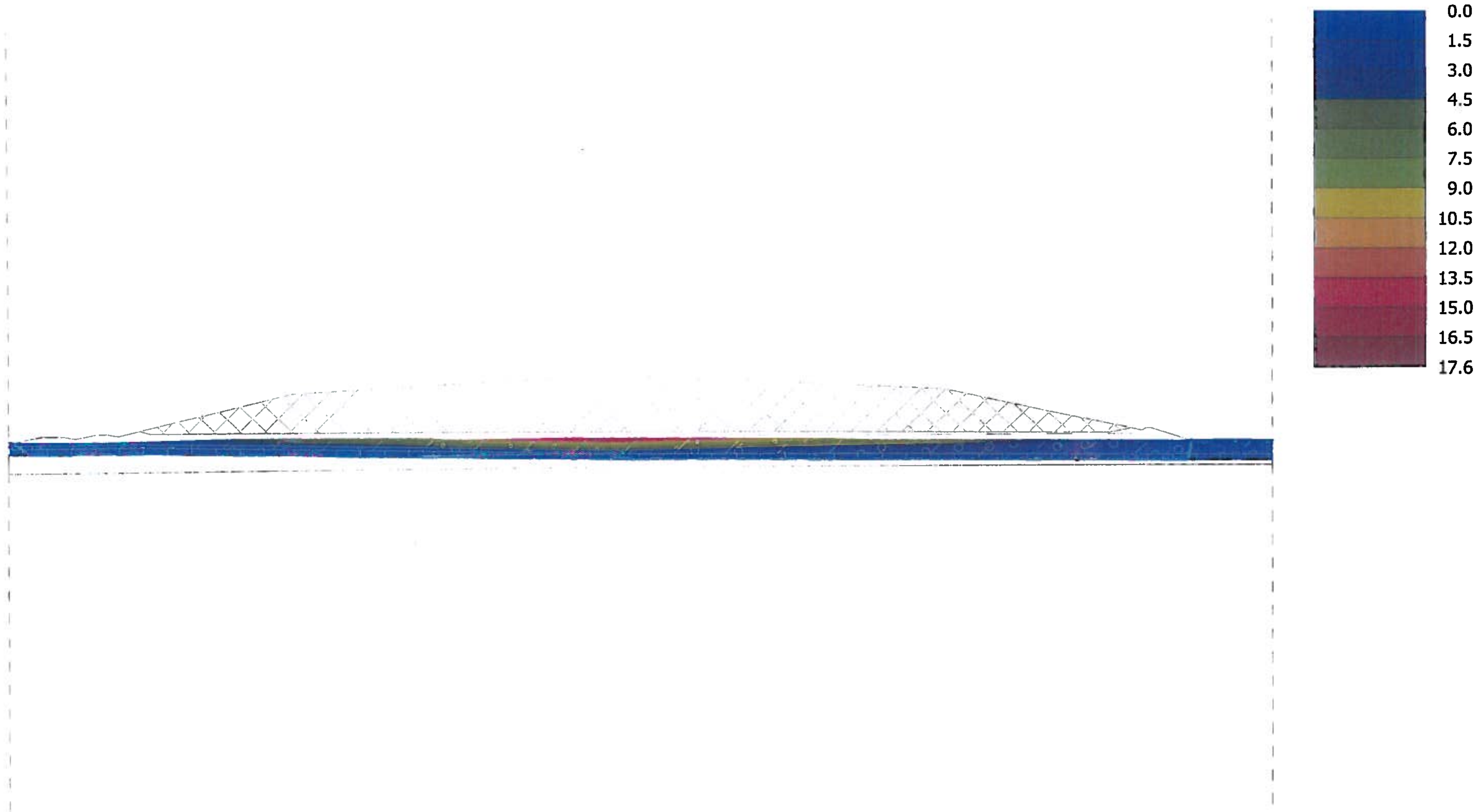
Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 17.6 mm
Maximum depth of influence zone = 10.00 m

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/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		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

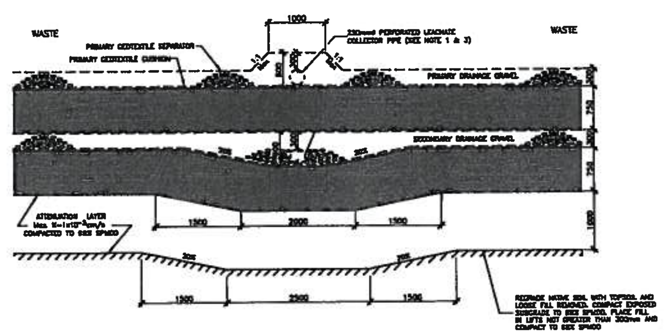
Name : 13-107 Carp Landfill Development

Stage : 3

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

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

APPENDIX 'G'

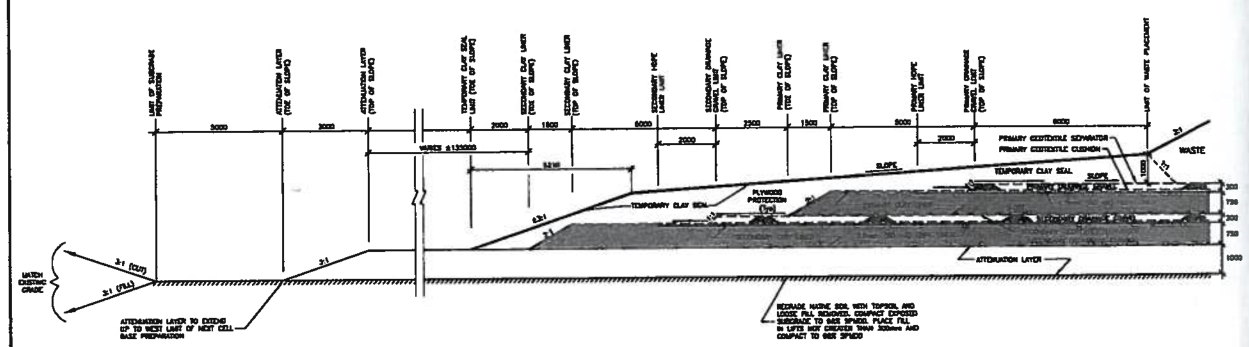


NOTES :

1. PERFORATED LEACHATE COLLECTION PIPE TO BE 250mm HDPE DR11 WITH 25mm 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 5mm (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.

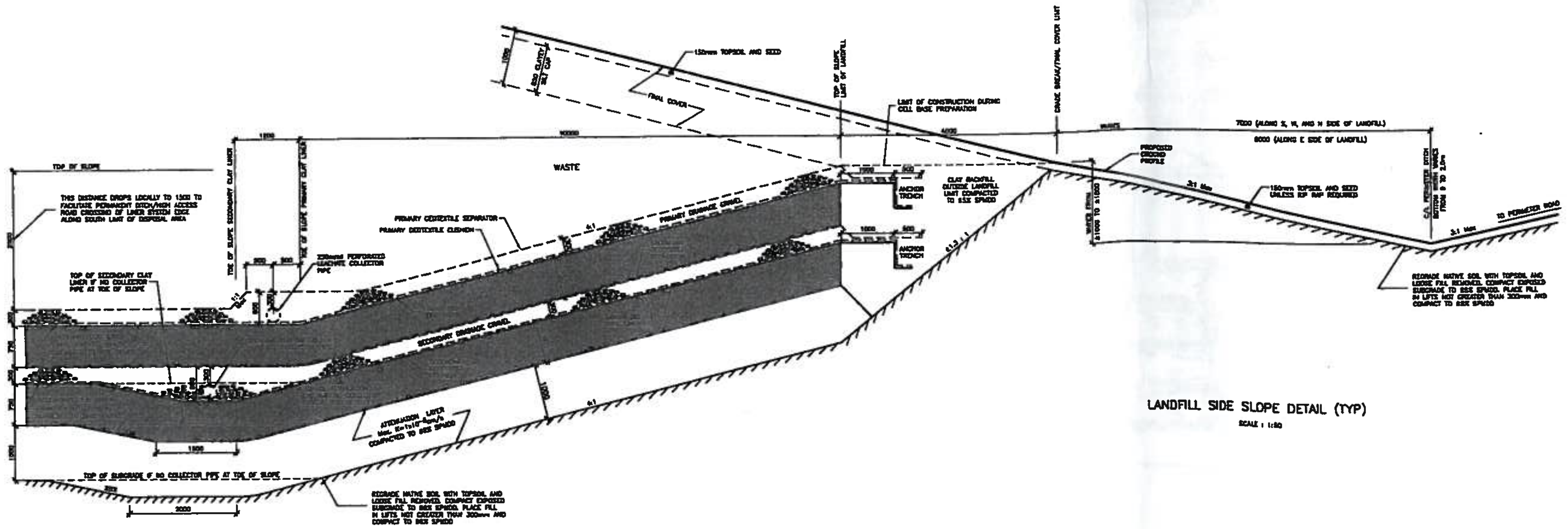
LANDFILL BASE DETAIL

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

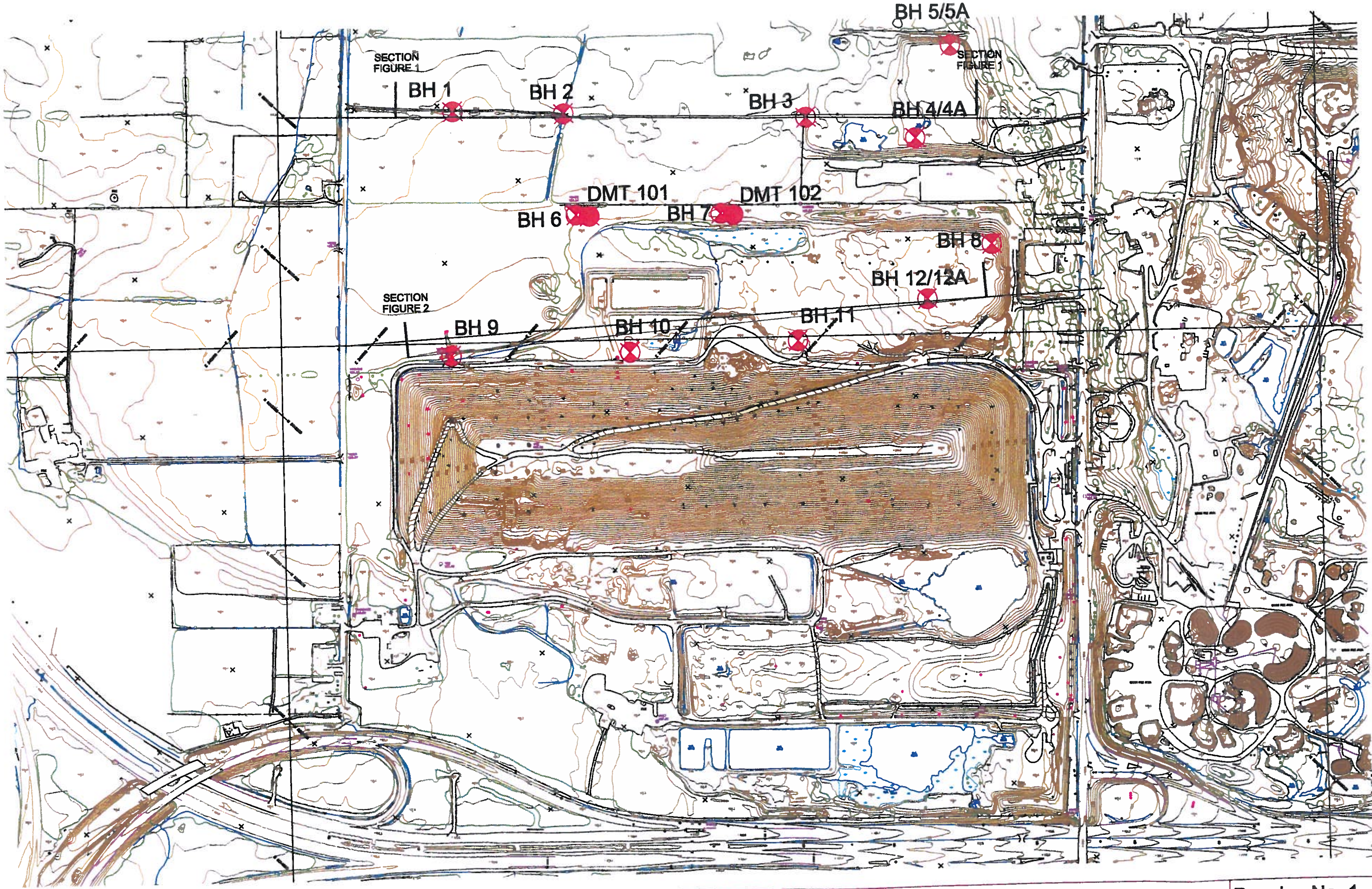
DWN BY: T C G
CHK BY: P S B
DATE: NOVEMBER 28, 2013
SCALE: SEE BAR SCALE

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	METHOD: Augering and Split Spoon Sampling		# BH No.: 1
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 124.94	
LOCATION: Carp, ON	NORTHING: 5015811.47	EASTING: 345627.665	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		Borehole dry and cave-in at 4.0 m below ground surface on completion.		32		70 mm black sandy TOPSOIL		1A		
			3	15		very loose moist, brown SILTY fine SAND (disturbed)		1B	3	124.5
0.5				17						124
1			20	9				2A / 2B	20	123.5
1.5			34	9		dense to very dense moist, grey SILTY SAND traces of gravel and clay occasional cobbles and boulders (TILL)		3	34	123
2 / 2.5			76	8				4	76	122.5
3			56	7				5	56	122 / 121.5
3.5 / 4			44	7				6	44	121 / 120.5
4.5		Hard augering at 4.9 m depth. Cobble/boulder encountered between 4.9 and 5.2 m depth.	80/275	7				7	80/275	120
5 / 5.5										119.5 / 119

END OF BOREHOLE
Refusal to advancement of augers at 5.94 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	METHOD: Augering and Split Spoon Sampling	**BH No.: 2**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN / ELEV. (m) 123.70	
LOCATION: Carp, ON	NORTHING: 5015944.509 / EASTING: 345780.621	PROJECT NO.: 13-107

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

Column headings: 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)

SOIL DESCRIPTION

Depth (m)	Soil Description
0 – ~0.8	very loose moist, brown fine sand with some gravel, FILL (Gravel Road)
~0.8 – 8.23	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.

REMARKS

Depth (m)	Remarks
0	Borehole cave-in at 4.0 m and water level at 2.4 m below ground surface on completion.
1.5	Hard augering at 1.5 m depth. Cobble/boulder encountered between 1.5 and 1.8 m depth.
2.4	Cobble/boulder encountered between 2.4 and 3.7 m m depth.
3.7	Hard augering at 3.7 m depth.
6.1	Water strike at 6.1 m depth. Split spoon bouncing.
7.6	Split spoon bouncing.

Water level symbol shown in instrumentation column at approx. 2.4 m depth.

SAMPLES

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

Depth scale (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

Elevation scale (m): 123.5, 123, 122.5, 122, 121.5, 121, 120.5, 120, 119.5, 119, 118.5, 118, 117.5, 117, 116.5, 116, 115.5

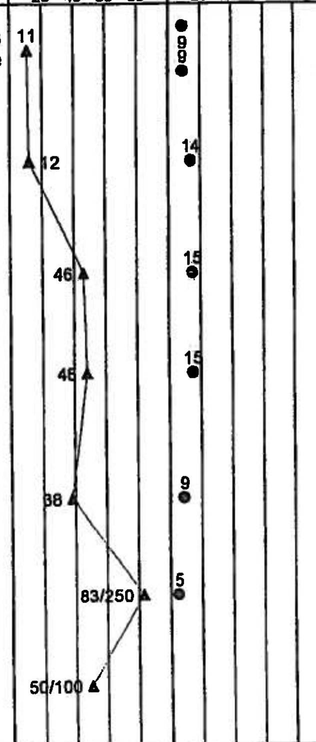
alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 8 August 2013
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		**BH No.: 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

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 – 0.3		Borehole cave-in at 3.4 m and water level at 2.6 m below ground surface on completion.				300 mm black TOPSOIL		1A		123
0.3 – 0.65			11	9, 9		reddish brown, damp fine SAND, trace roots		1B	11	
0.65 – 3.7			12	14		compact to very dense moist to wet SILTY fine SAND — brown		2	12	122.5, 122
			46	15		grey		3	46	121.5, 121
	▽ 2.6		46	15				4	48	120.5
		Hard augering at 3.0 m depth.	38	9		TILL		5	38	120
3.7 – 5.03		Split spoon bouncing	83/250	5		very dense wet, grey SAND and rock fragments		6	83/250	119.5, 119
		Cobble/boulder encountered between 4.3 and 5.0 m depth.	50/100					7	50/100	118.5

Depth scale (m): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 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	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	Casing Bentonite	Water level measured 0.3 m below ground surface on 9 August 2013.								118.5
0.5	Sand									118
1	Sand and screen (50 mm Diameter)					Straight auger to 1.8 m depth				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		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	Casing Bentonite	Water level measured 1.9 m below ground surface on completion, 1.0 m below ground surface on 9 August 2013.								117.5
0.5	Sand									117
1	Sand and screen (50 mm Diameter)	Cobbles/boulders encountered between 0.0 and 2.4 m depth.				Straight auger to 1.8 m depth				116.5
1.5										116
2										115.5
						END OF BOREHOLE Refusal to advancement of augers at 2.44 m depth belowground surface.				

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	REVIEWED BY: VN	Page 1 of 1

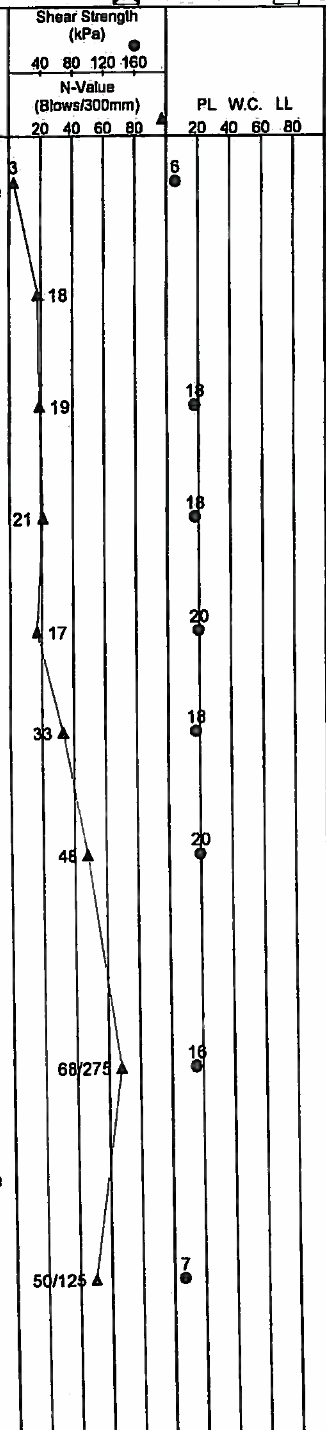
CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		**BH No.: 6**
PROJECT: Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 125.45	
LOCATION: Carp, ON	NORTHING: 5015824.984	EASTING: 345920.566	PROJECT NO.: 13-107

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

Columns: 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)

REMARKS

- 0 m: Grass Surface. Borehole cave-in at 3.0 m below ground surface on completion.
- 2.3 m: Water strike at 2.3 m depth.
- 7.0 m: Hard augering at 7.0 m depth.



SOIL DESCRIPTION

- 0.0–7.0 m: root invasion; compact moist to wet SAND trace to some silt trace clay; reddish brown to brown; grey (below approx. 5.5 m)
- 7.0–8.84 m: 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

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

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

alston associates inc. consulting engineers	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.: 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

Shear Strength (kPa): 40 80 120 160 — N-Value (Blows/300mm): 20 40 60 80 — PL W.C. LL: 20 40 60 80

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	N-Value	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 – 0.9		Grass Surface Borehole cave-in at 6.1 m and water level at 5.8 m below ground surface on completion.	3	root invasion loose, damp, brown medium to coarse SAND	1	3	125.5
0.9 – 3.0			23, 28, 27	damp, brown compact SILT some sand trace clay wet, grey	2 3 4	23 28 27	125, 124.5, 124, 123.5, 123
3.0 – 4.5			26, 28	compact wet, grey SILT and SAND trace clay	5 6	26 28	122.5, 122, 121.5
4.5 – 7.0	Water level at 5.8 m	Probable cobbles/ boulders encountered between 5.8 and 6.1 m depth. Hard augering at 6.1 to 7.0 m depth.	27, 55	dense to very dense wet, grey SILTY SAND traces of clay and gravel occasional cobbles and boulders (TILL)	7 8	27 55	121, 120.5, 120, 119.5, 119

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

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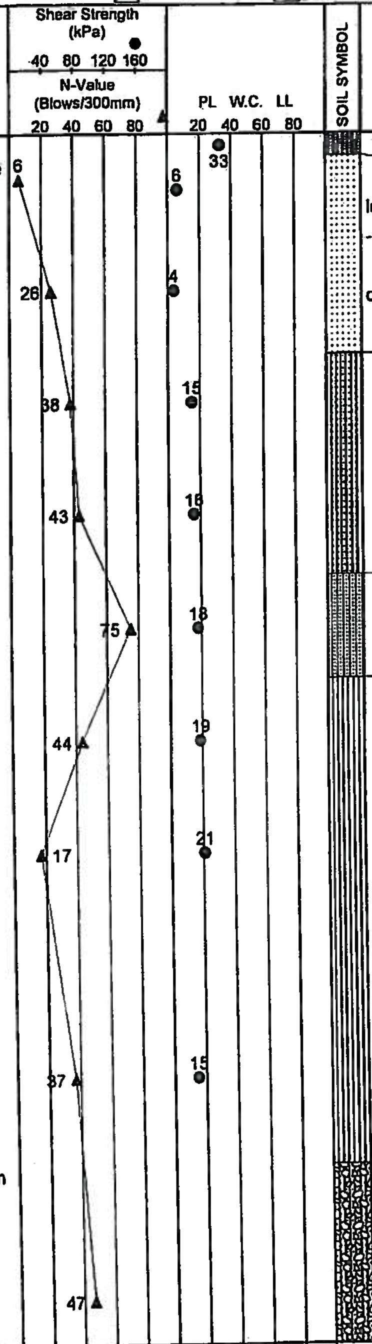
	REVIEWED BY: VN	Page 1 of 1

CLIENT: Waste Management	METHOD: Augering and Split Spoon Sampling		BH No.: 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)	INSTRUMENTATION DATA	REMARKS	N-Value	W.C.	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Borehole cave-in at 2.1 m below ground surface on completion.		33	150 mm TOPSOIL	1A		
			6	6	loose ------ compact moist, brown SAND trace silt	1B	6	127
1			26	4		2	26	126.5
1.5 – 2.5			38	15	dense to very dense moist to wet, grey SANDY SILT trace clay	3	38	125.5
			43	16		4	43	125
3 – 3.5			75	18	very dense wet, brown SILTY fine SAND	5	75	124
4			44	19	dense moist to wet grey SILT some sand trace clay occasional clay seams	6	44	123.5
			17	21		7	17	122.5
6 – 6.5			37	15		8	37	121
7 – 8		Hard augering at 7.0 m depth.	47		dense, moist, grey SILTY SAND traces of clay and gravel (TILL)	9	47	119.5
					END OF BOREHOLE Refusal to advancement of augers at 8.23 m below ground surface.			

Depth scale (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

Elevation scale (m): 127, 126.5, 126, 125.5, 125, 124.5, 124, 123.5, 123, 122.5, 122, 121.5, 121, 120.5, 120, 119.5

alston associates inc. consulting engineers	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.: 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 | SPLIT SPOON

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	N-Value (Blows/300mm)	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
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.		100 mm black sandy TOPSOIL	1A		
			6	loose to compact, moist, fine to medium SAND, traces of silt and gravel (brown ------ grey)	1B	6	125
0.5							124.5
1			20		2	20	124
1.5				compact, moist, grey SILTY SAND, traces of clay and gravel (TILL)			123.5
			17		3	17	
2		Hard augering at 2.1 m depth.					123
2.5			16		4	16	122.5
3			50/125		5	50/125	
				END OF BOREHOLE			

Shear Strength (kPa): 40 80 120 160
N-Value (Blows/300mm): 20 40 60 80
PL W.C. LL: 20 40 60 80

alston associates inc. consulting engineers	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

Columns: 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)

REMARKS

- Borehole dry and cave-in at 2.3 m below ground surface on completion. (0 m)
- Water strike at 1.5 m depth. (1.5 m)
- Hard augering at 4.6 m depth. (4.6 m)

SOIL DESCRIPTION

Depth (m)	Description
0 – 0.2	200 mm black TOPSOIL
0.2 – 3.3	loose to compact SILTY fine SAND; damp, brown (to ~1.4 m); moist to wet, grey
3.3 – 3.8	very stiff, grey SILTY CLAY
3.8 – 8.23	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.

SAMPLES

Sample No.	SPT(N)	N-Value plotted	W.C. (%) plotted
1A			9, 11
1B	6	6	7
2	17	17	21
3	15	15	19
4	17	17	16
5A	24	24	13
5B			26
6	23	23	10
7	94/225	94/225	9
8	94	94	5
9	50/125	50/125	

Elevation (m): 125.5, 125, 124.5, 124, 123.5, 123, 122.5, 122, 121.5, 121, 120.5, 120, 119.5, 119, 118.5, 118, 117.5

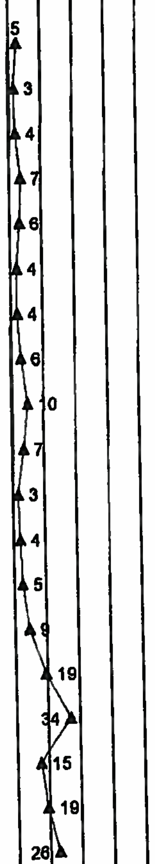
Depth (m): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 7 August 2013
	REVIEWED BY: VN	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	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				121.5, 121, 120.5
1.5 – 7.5						Dynamic Cone Penetration Test	Dynamic cone		--, 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
7.5						END OF DYNAMIC CONE PENETRATION TEST				



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

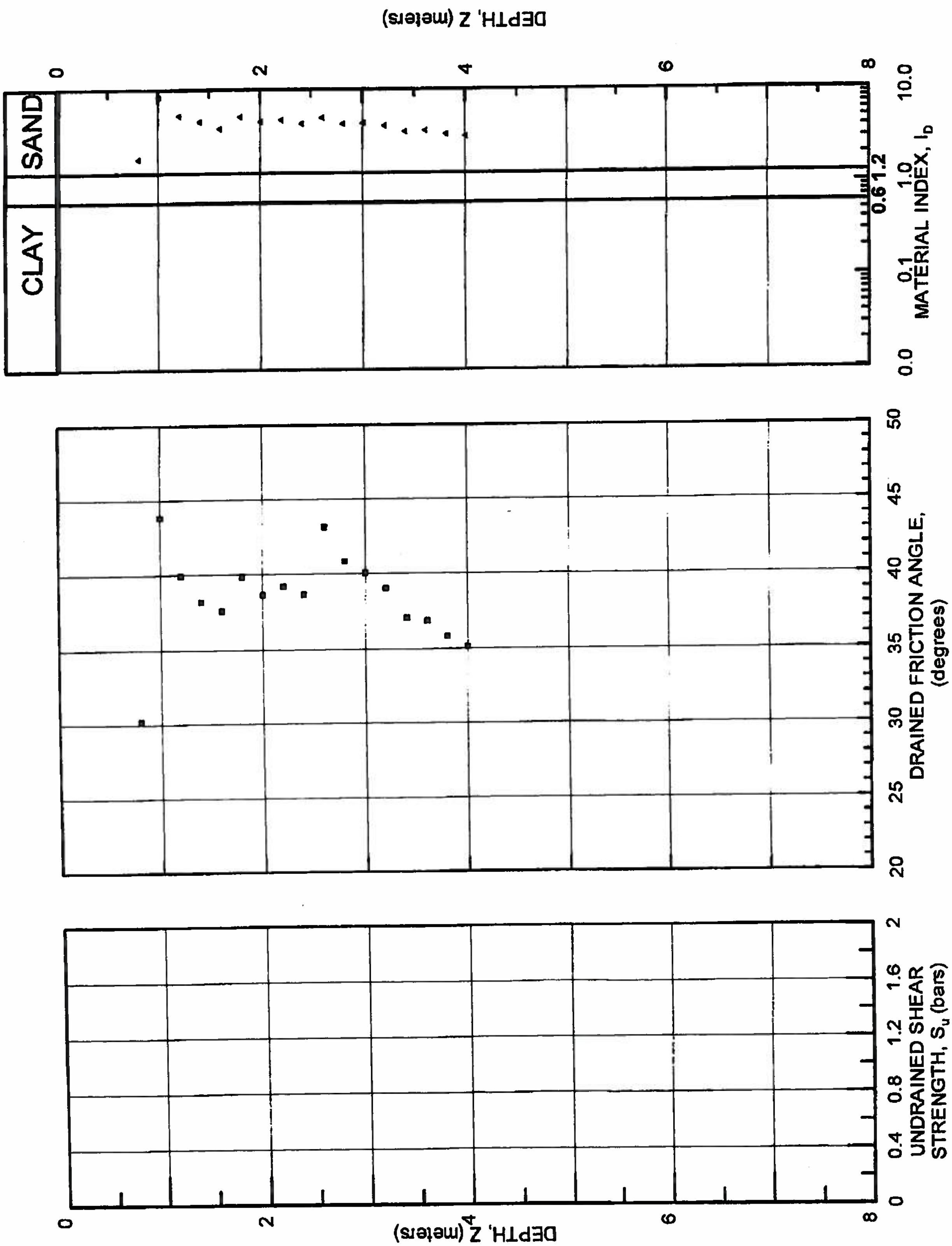
Z (M)	A (BAR)	B (BAR)	C (BAR)	P0 (BAR)	P1 (BAR)	P2 (BAR)	U0 (BAR)	ED (BAR)	ID	KD	GAMMA (T/M3)	SV' (BAR)	PC (BAR)	OCR	KO	PHI (PHI)	M (BAR)	Su (BAR) f(SV', Kd)	SOIL TYPE
0.8	1.20	4.00	0.00	1.34	3.70	0.00	0.000	82	1.77	7.87	1.7	0.17	3.0	17.56	1.32	30	186	—	SANDY SILT
1.0	1.50	12.00	0.00	1.25	11.70	0.00	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

PROJECT: Landfill Expansion LOCATION: Carp, ON	ALSTON ASSOCIATES INC. FIELD TECH.: KC SOUNDING DATE: 2013-08-06	SOUNDING **DMT 101**

DILATOMETER RESULTS

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

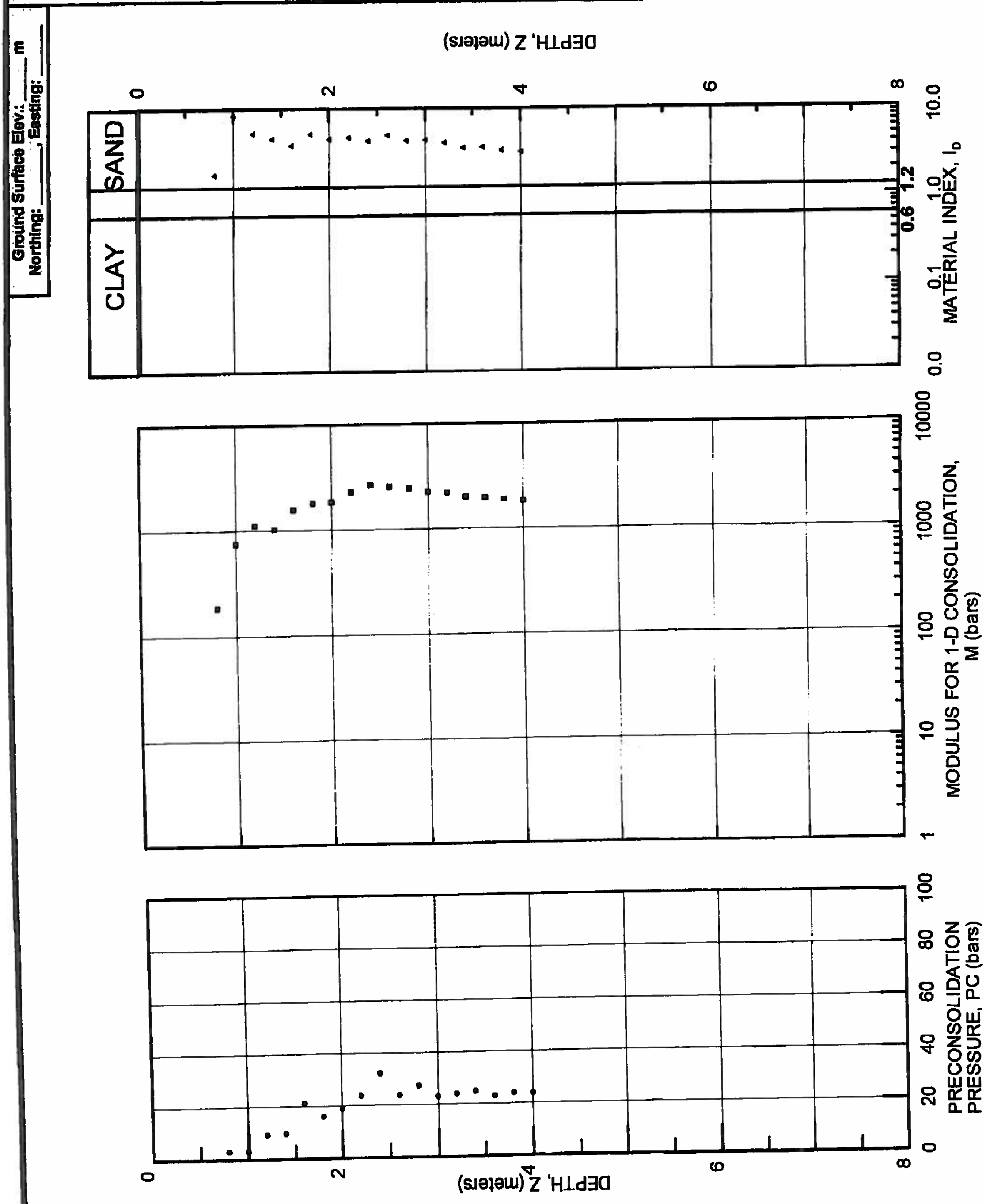


PROJECT: Landfill Expansion
LOCATION: Carp, ON

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

SOUNDING
DMT 101

DILATOMETER RESULTS



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

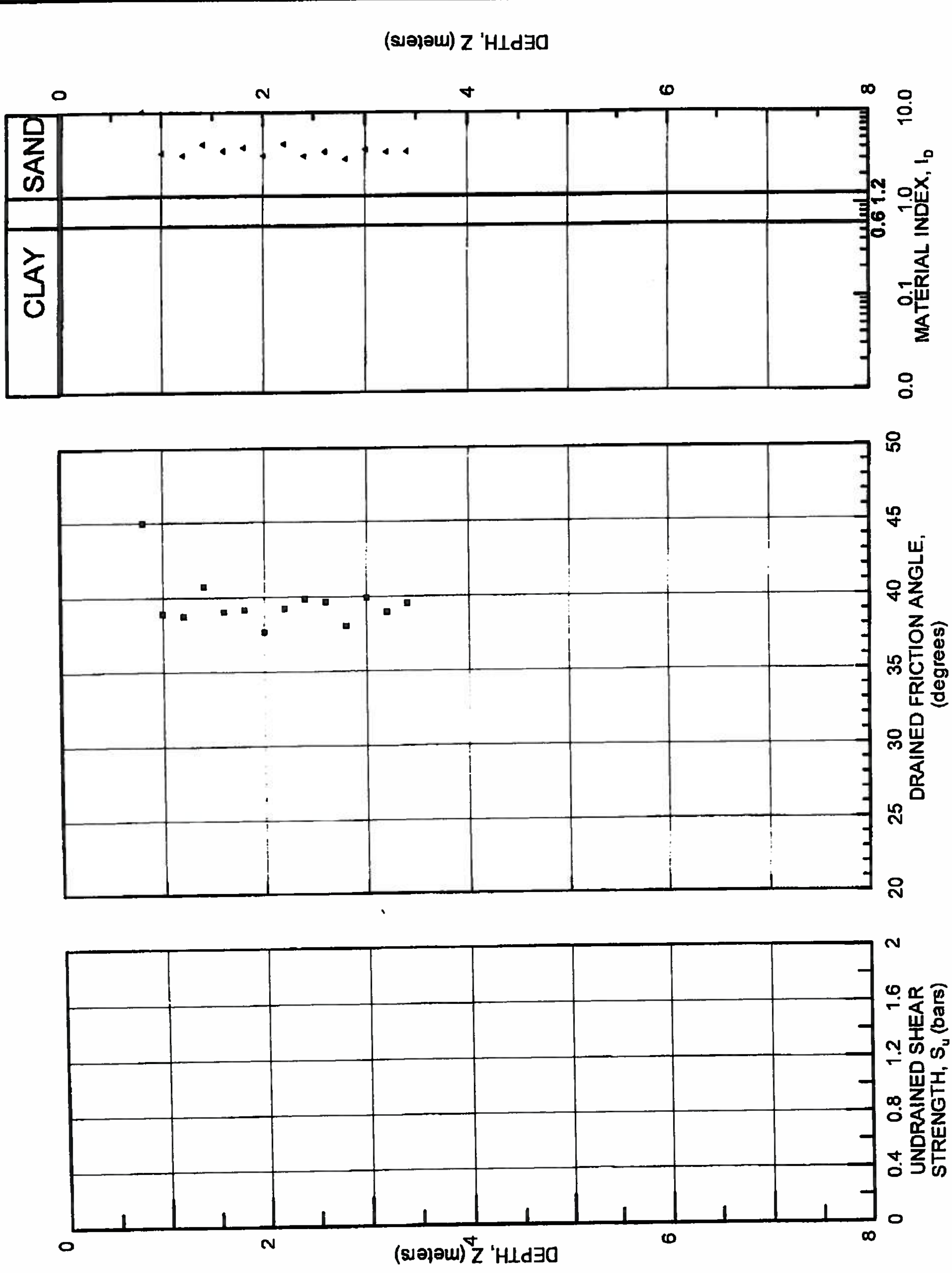
PROJECT: Landfill Expansion
LOCATION: Carp, ON

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

SOUNDING
DMT 102

DILATOMETER RESULTS

Ground Surface Elev.: ____ m
Northing: ____, Easting: ____

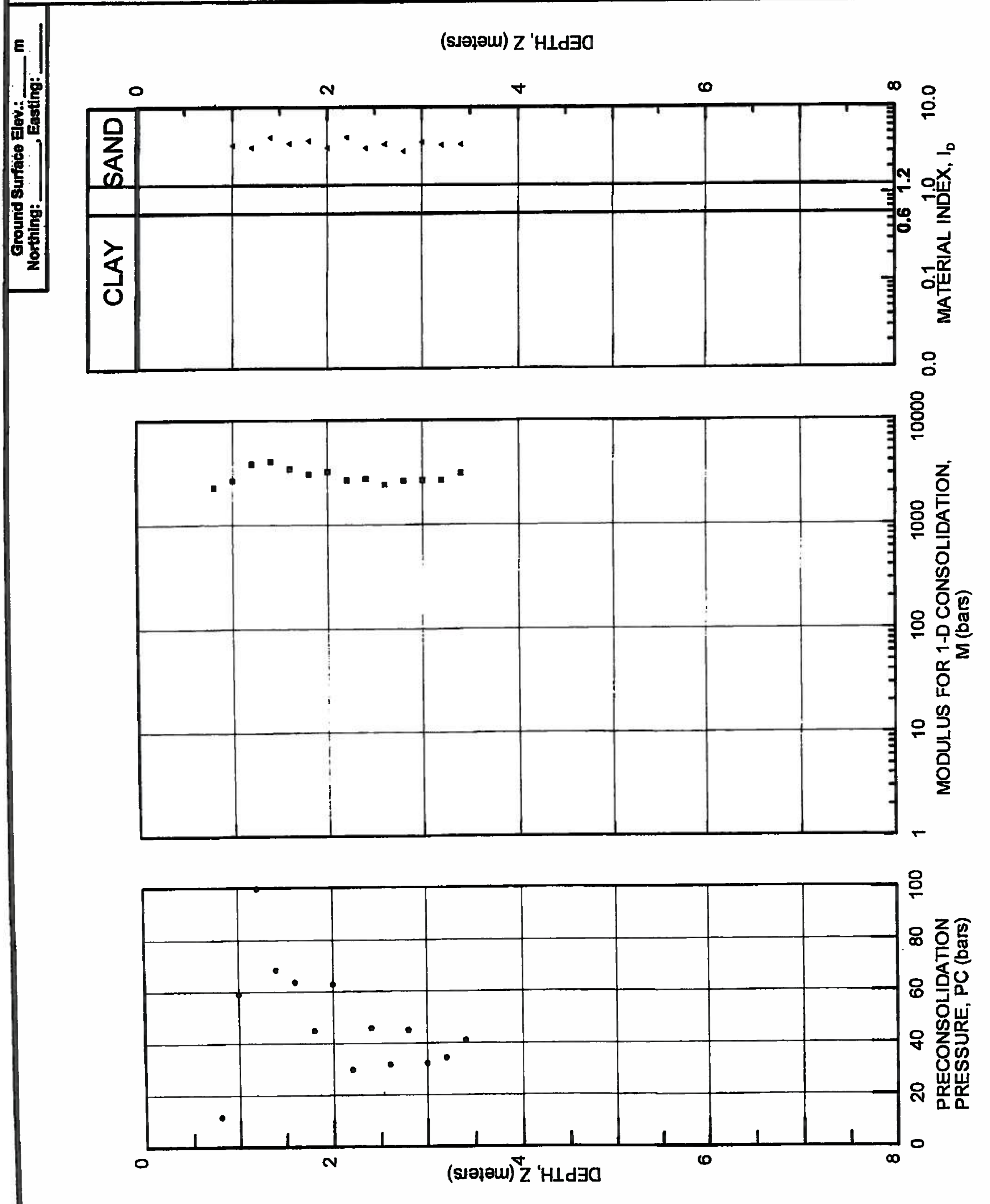


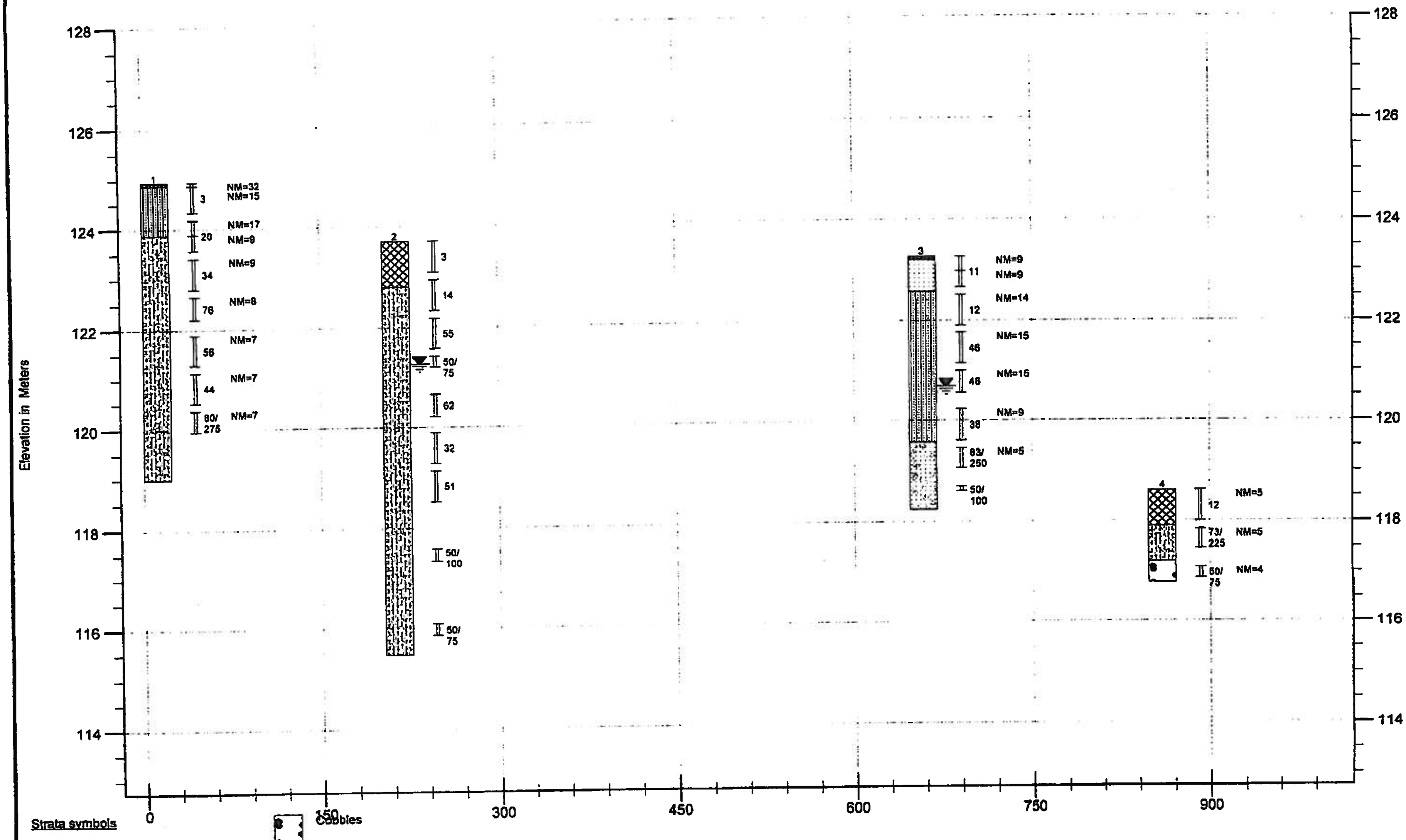
PROJECT: Landfill Expansion
LOCATION: Carp, ON

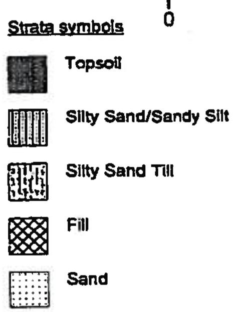
ALSTON ASSOCIATES INC.
FIELD TECH.: KC
SOUNDING DATE: 2013-08-06

SOUNDING
DMT 102

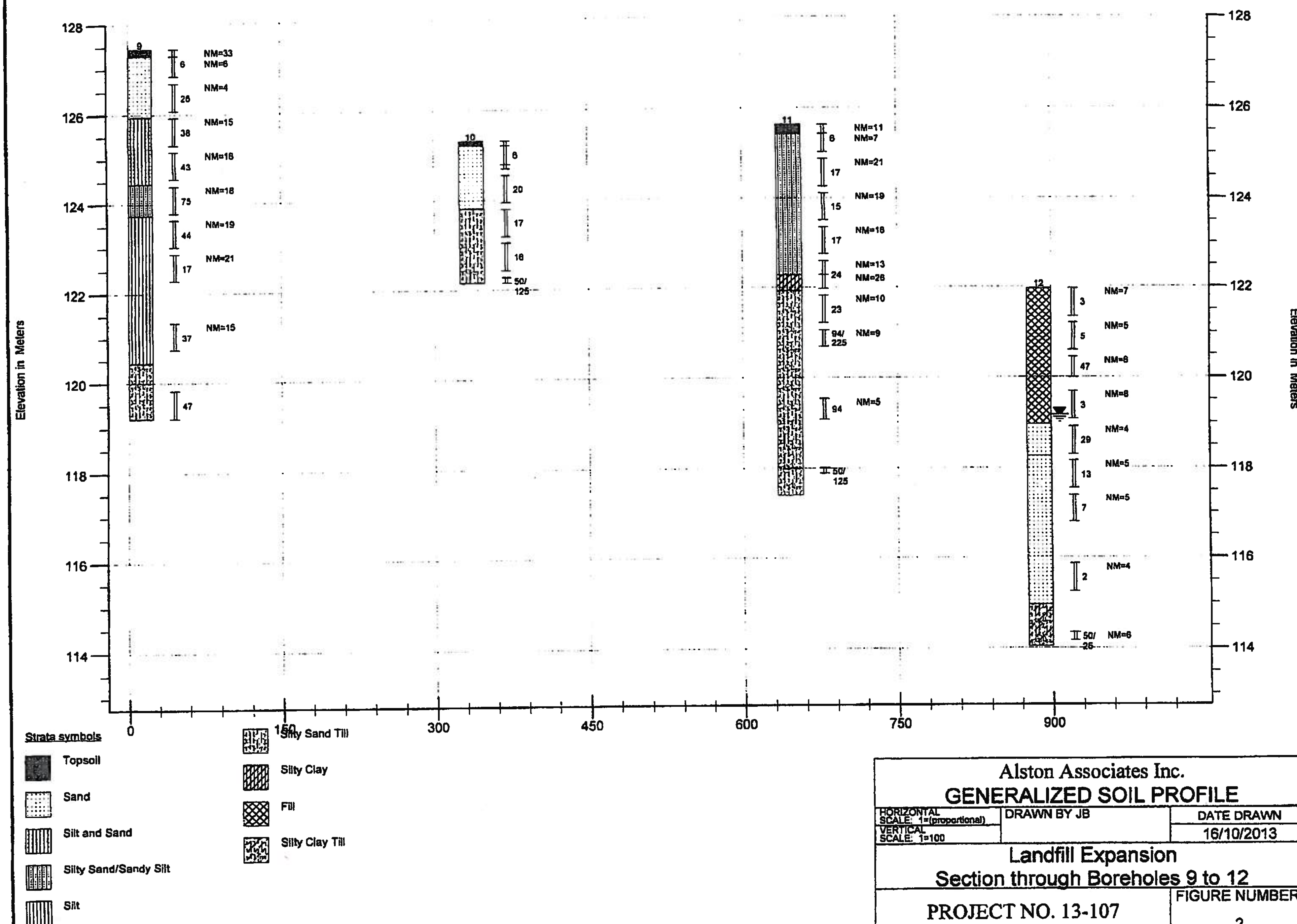
DILATOMETER RESULTS







Alston Associates Inc. 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



Alston Associates Inc.

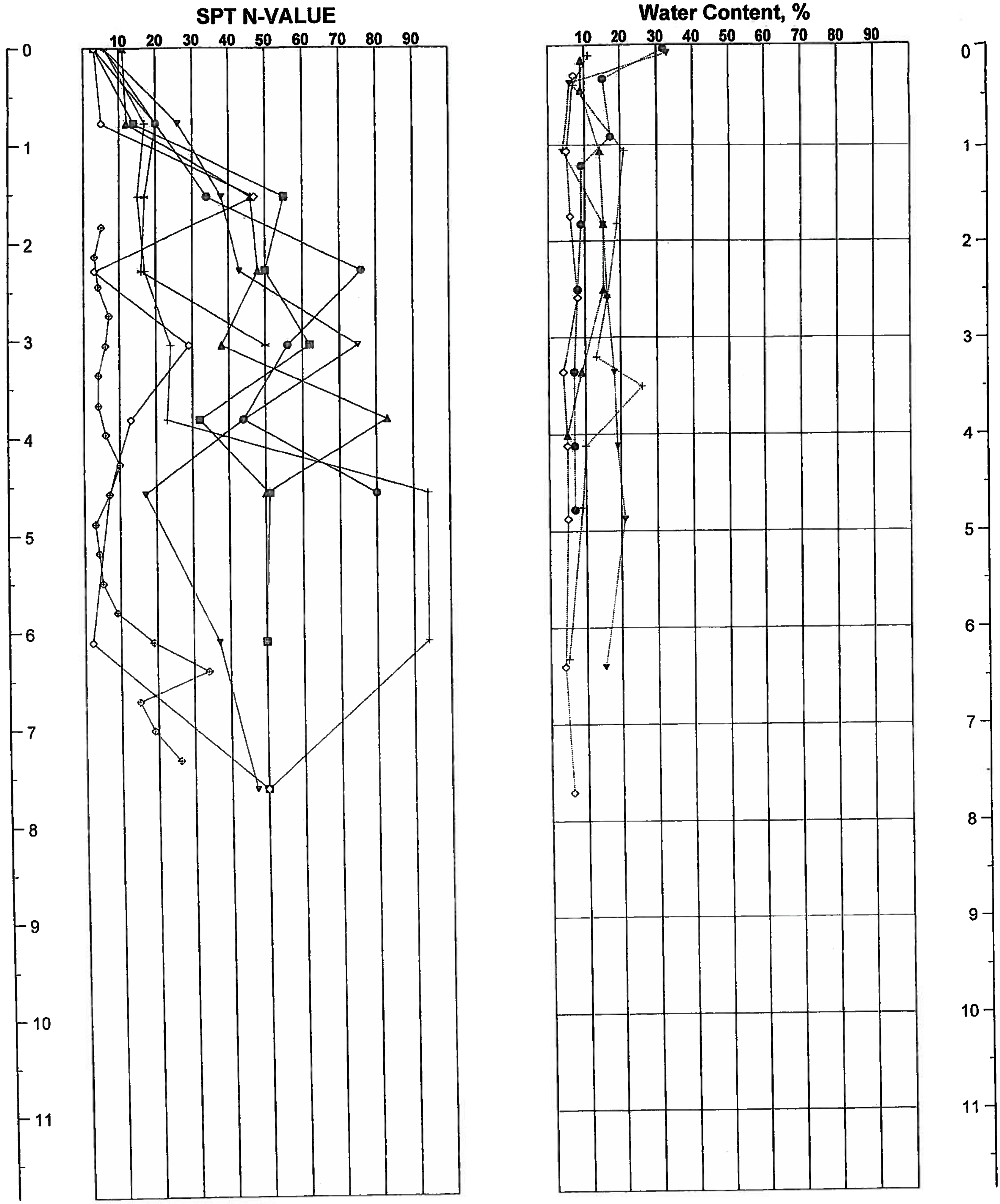
GENERALIZED SOIL PROFILE

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

Landfill Expansion
Section through Boreholes 9 to 12

PROJECT NO. 13-107	FIGURE NUMBER 2

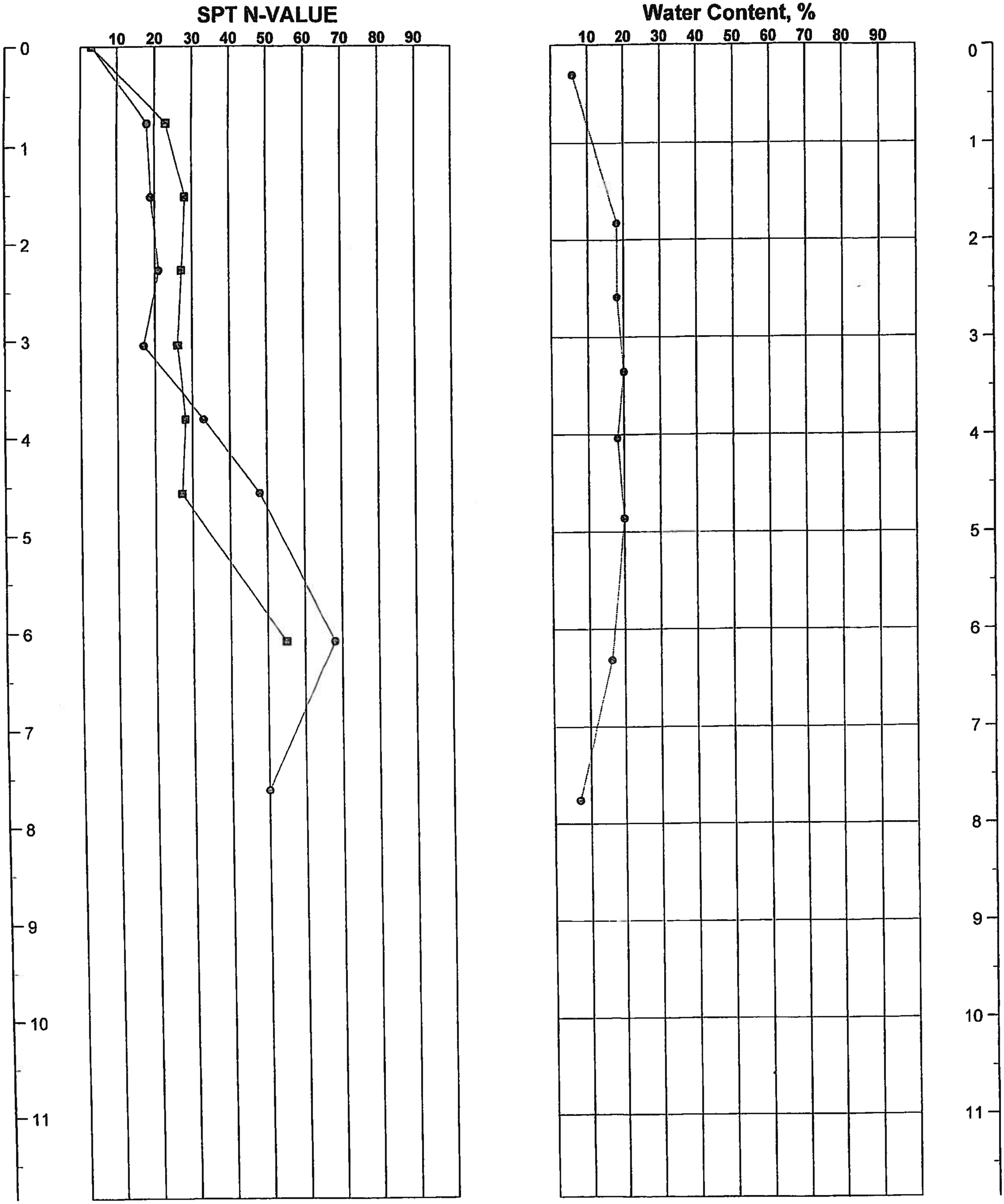
Alston Associates Inc.



Key to Borings

- ● 1
- ■ 2
- ▲ 3
- ▼ 9
- ∗ 10
- + 11
- ◇ 12
- ◈ 12A

Alston Associates Inc.	
Landfill Expansion	
Vertical Scale: 1 to 50	Figure: 3

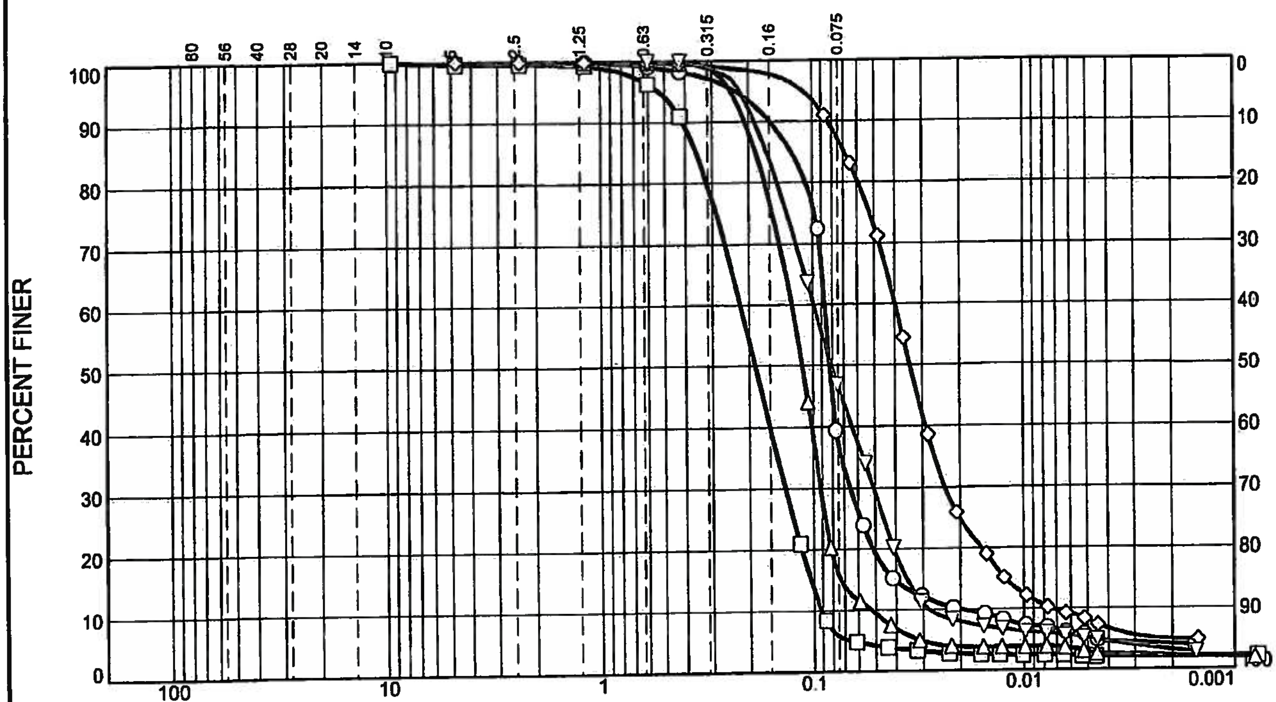


Key to Borings

- ● 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

Remarks:

alston associates inc.
consulting engineers

Figure 5

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

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
L3R 5Z6

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Ref. No. 13-107A

CONTENTS

Page No.

APPENDICES

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,

[Stamp: REGISTERED PROFESSIONAL ENGINEER, C. ALSTON, 20 March 2014, PROVINCE OF ONTARIO]

Colin Alston, P.Eng.

/ld

[Stamp: LICENSED PROFESSIONAL ENGINEER, V. NERSESIAN, 33778705, MARCH 2014, PROVINCE OF ONTARIO]

Vic Nersesian, P.Eng.

References

1. Alston Associates Inc. (2003), “Results of Direct Shear Tests carried out on Refuse Material, Richmond Landfill” Report to Canadian Waste Services Inc.

2. Alston Associates Inc. (2004) Addendum to 2003 report.

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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6. Hoechst Celanese Corporation
“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

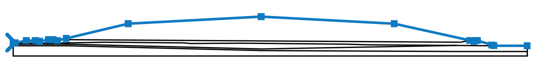
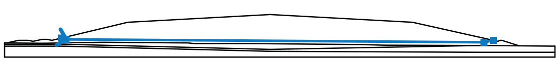
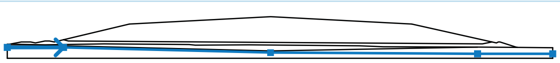
Standard - safety factors

Stability analysis

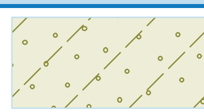
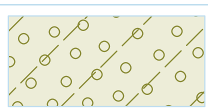
Verification methodology : Safety factors (ASD)

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/m³]
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/m³]	γ_s [kN/m³]	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/m³
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/m³

Silty Sand Till

Unit weight : γ = 22.50 kN/m³
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/m³

Clay Liner

Unit weight : γ = 19.50 kN/m³
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/m³

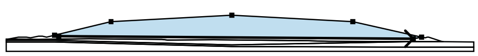
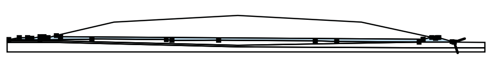
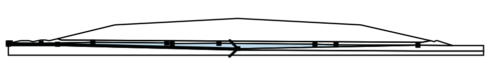
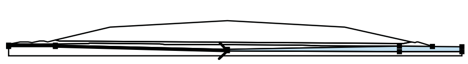
Waste

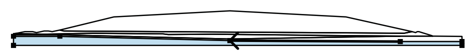
Unit weight :	γ =	14.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	28.00 °
Cohesion of soil :	c_{ef} =	30.00 kPa
Saturated unit weight :	γ_{sat} =	14.00 kN/m^3

Rigid bodies

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

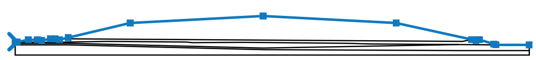
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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

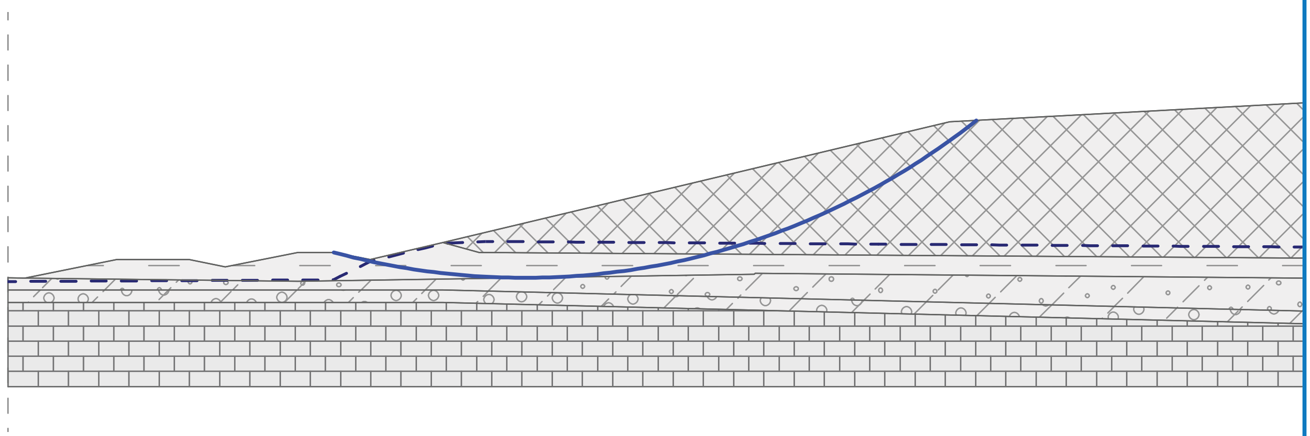
Slope stability verification (Bishop)

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

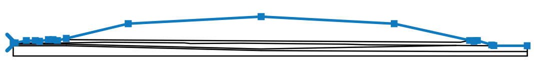
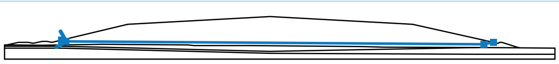
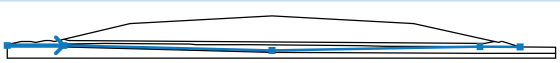
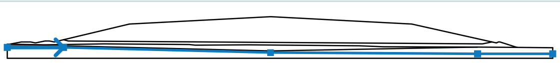
Standard - safety factors

Stability analysis

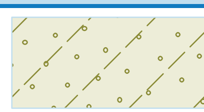
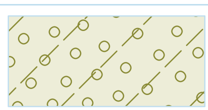
Verification methodology : Safety factors (ASD)

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

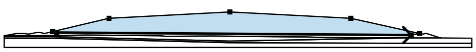
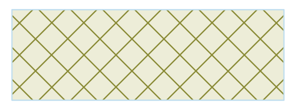
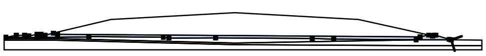
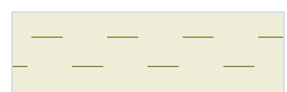
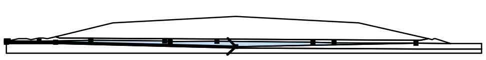
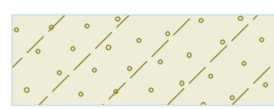
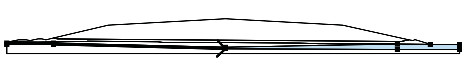
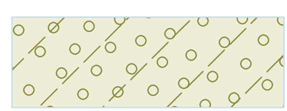
Waste

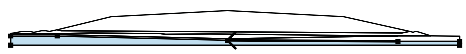
Unit weight :	γ = 14.00 kN/m^3
Stress-state :	effective
Angle of internal friction :	φ_{ef} = 37.00 °
Cohesion of soil :	c_{ef} = 9.00 kPa
Saturated unit weight :	γ_{sat} = 14.00 kN/m^3

Rigid bodies

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

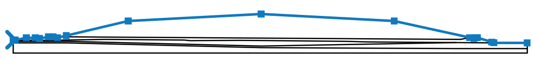
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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

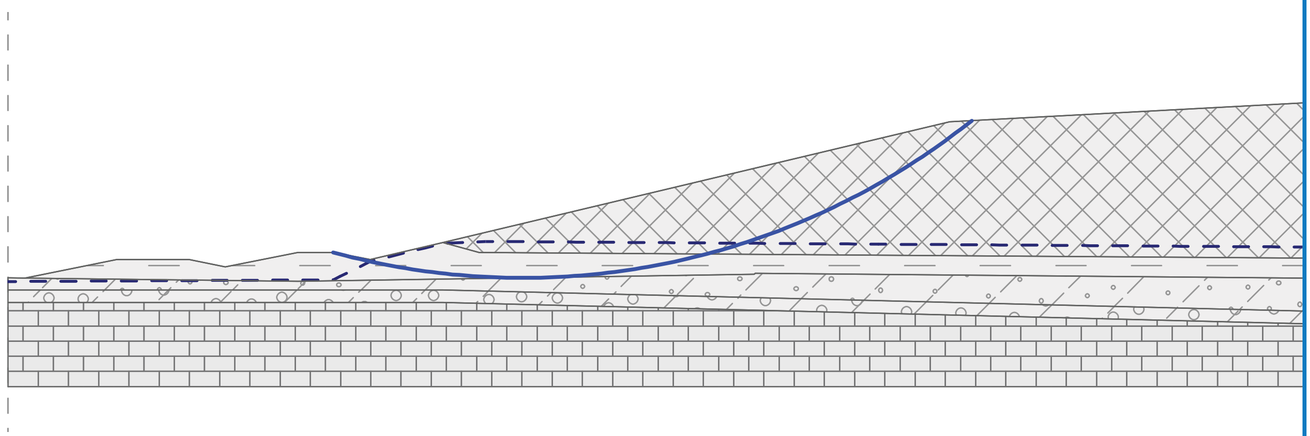
No.	First point		Second point	
	x [m]	z [m]	x [m]	z [m]
1	133.31	36.84	132.71	36.53
2	132.80	36.54	130.07	36.41
3	132.53	36.90	50.65	17.45
4	51.04	17.46	49.94	17.54

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

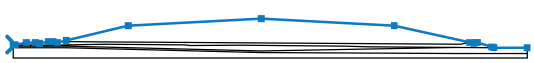
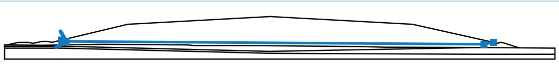
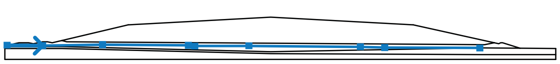
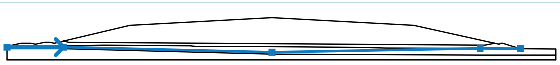
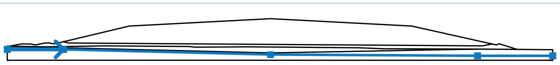
(input for current task)

Stability analysis

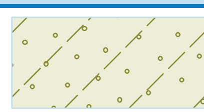
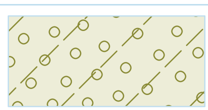
Verification methodology : Safety factors (ASD)

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

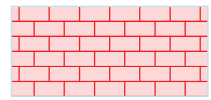
Clay Liner

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

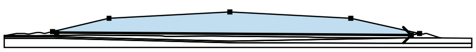
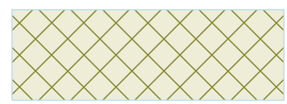
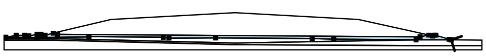
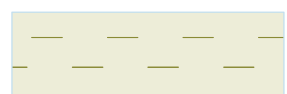
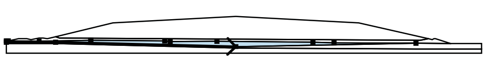
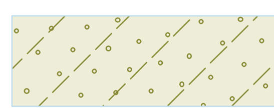
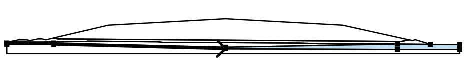
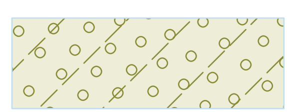
Waste

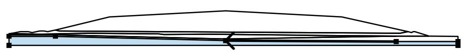
Unit weight :	γ = 14.00 kN/m^3
Stress-state :	effective
Angle of internal friction :	φ_{ef} = 28.00 °
Cohesion of soil :	c_{ef} = 30.00 kPa
Saturated unit weight :	γ_{sat} = 14.00 kN/m^3

Rigid bodies

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

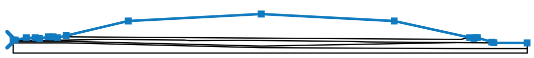
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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

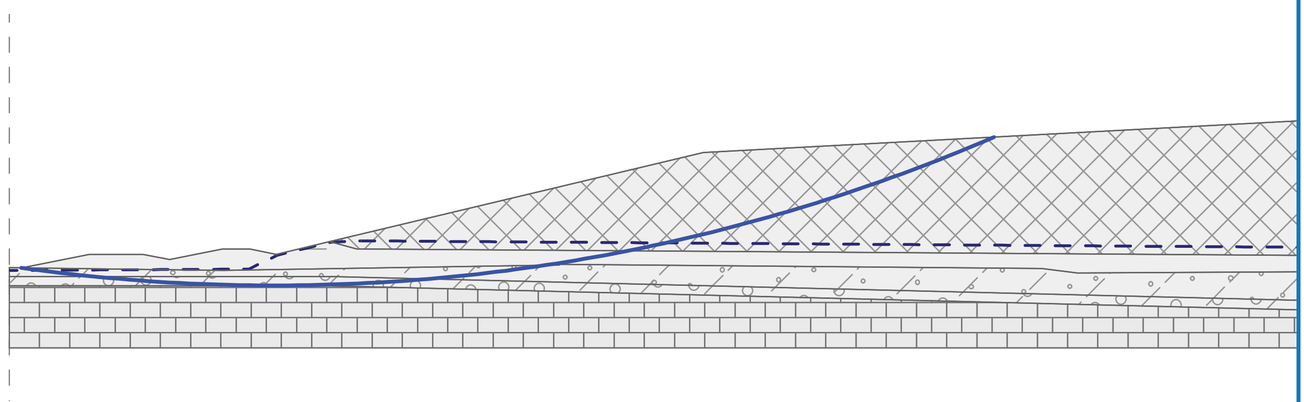
Slope stability verification (Bishop)

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

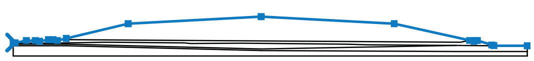
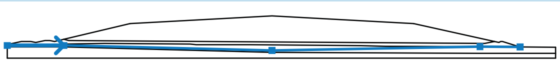
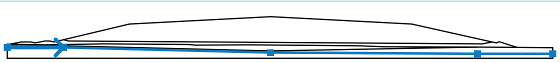
(input for current task)

Stability analysis

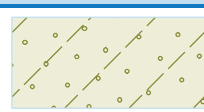
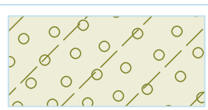
Verification methodology : Safety factors (ASD)

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

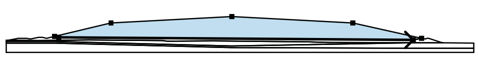
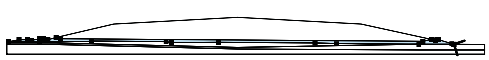
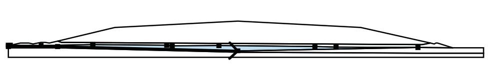
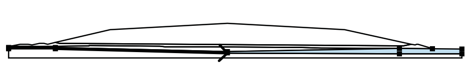
Waste

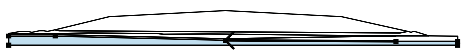
Unit weight :	γ =	14.00 kN/m³
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	37.00 °
Cohesion of soil :	c_{ef} =	9.00 kPa
Saturated unit weight :	γ_{sat} =	14.00 kN/m³

Rigid bodies

No.	Name	Sample	γ [kN/m³]
1	Bedrock		24.00

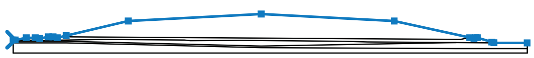
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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 =	75.91	[m]	Angles :	α_1 =	-13.41	[°]
	z =	206.67	[m]		α_2 =	30.86	[°]
Radius :	R =	195.37	[m]				
The slip surface after optimization.							

Segments restricting slip surface

No.	First point x [m]	First point z [m]	Second point x [m]	Second point 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

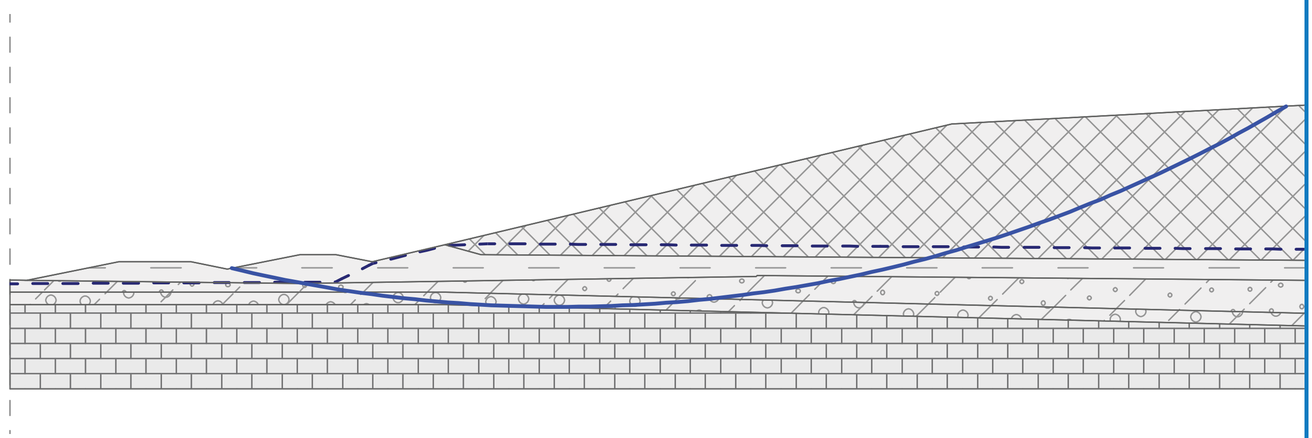
Slope stability verification (Bishop)

Sum of active forces : F_a = 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

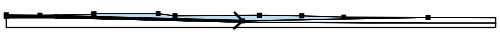
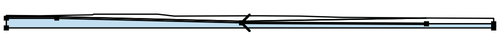
Clay Liner

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] x	z	x	z	Assigned soil
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

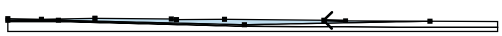
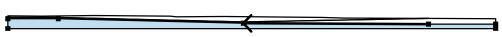
Analysis of geostatic stress was successfully completed

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

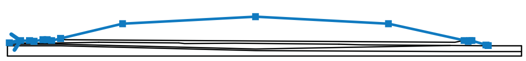
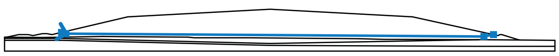
Results (Stage of construction 2)

Results

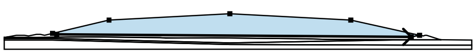
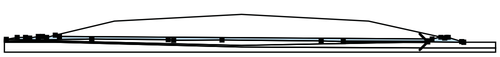
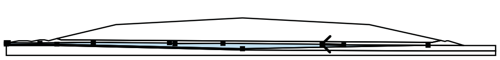
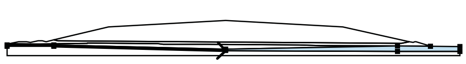
Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 0.0 mm
Maximum depth of influence zone = 0.00 m

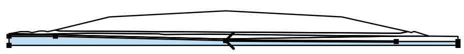
Input data (Stage of construction 3)

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] x	z	x	z	Assigned soil
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

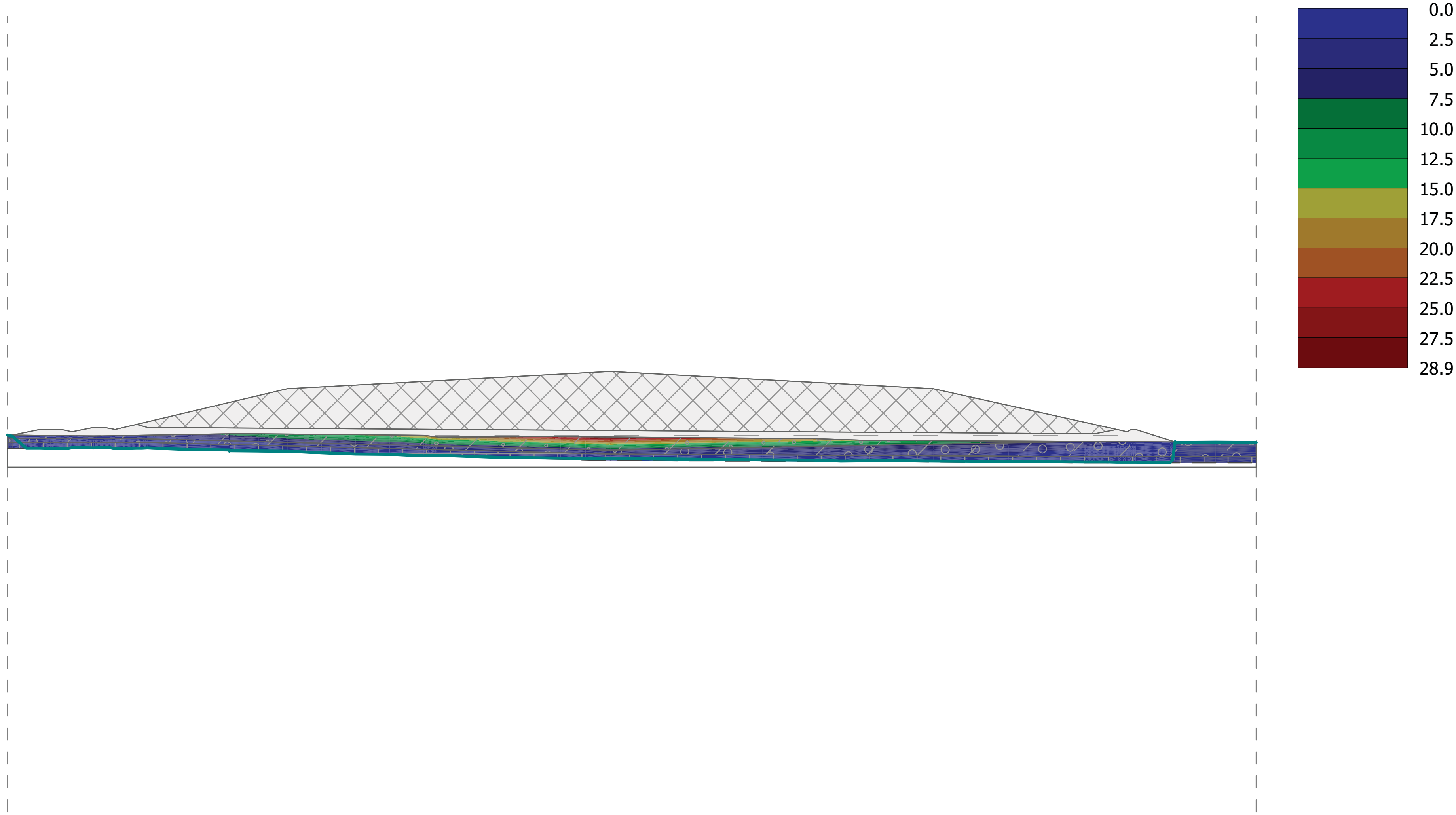
Results (Stage of construction 3)

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

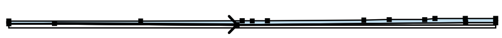
Clay Liner

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

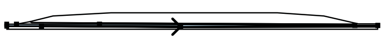
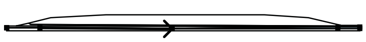
Input data (Stage of construction 3)

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

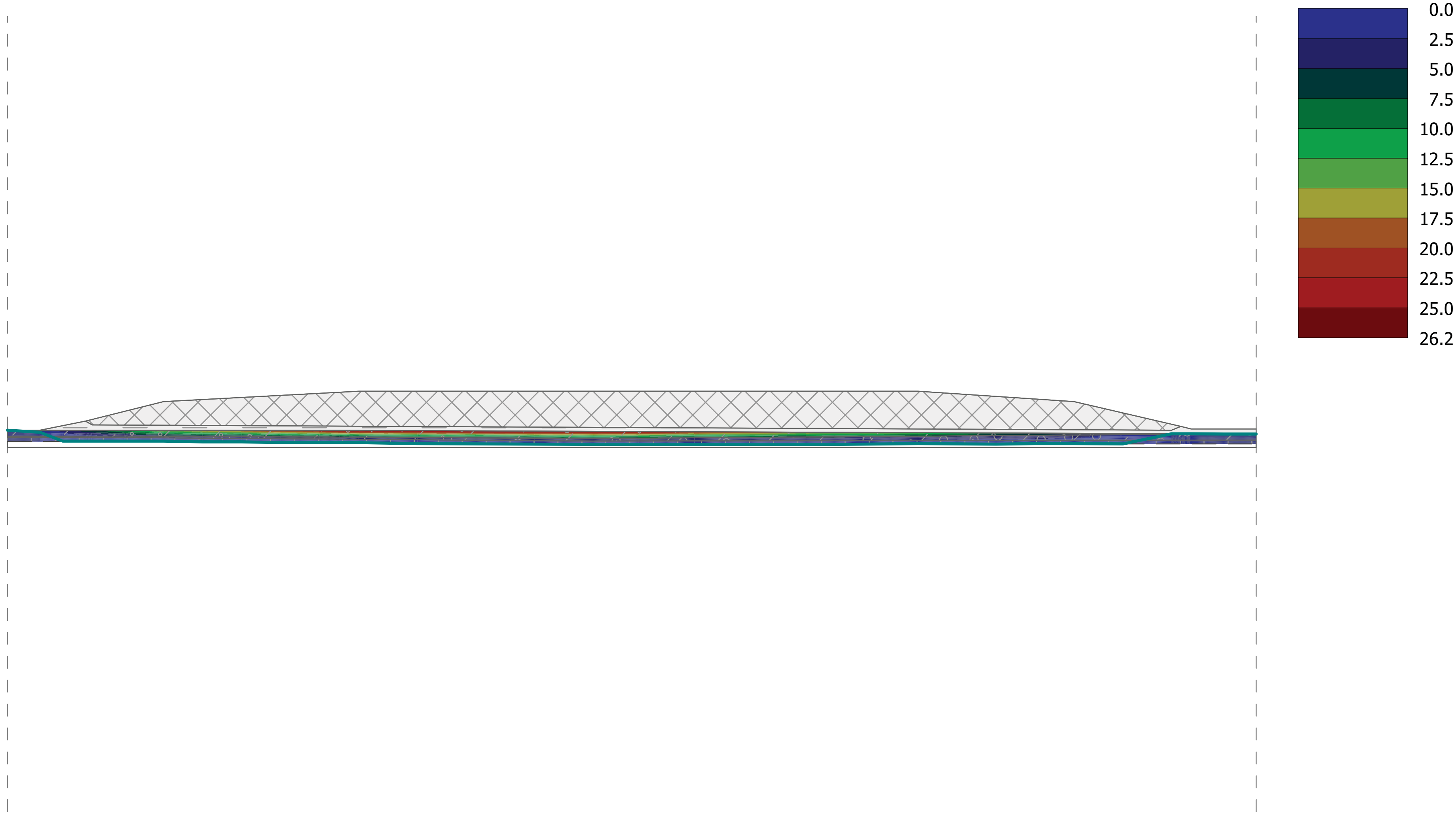
Results (Stage of construction 3)

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



SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
PROPOSED LANDFILL EXPANSION
WEST CARLETON ENVIRONMENTAL CENTRE
CARP, ONTARIO

REPORT REF. NO. 13-182
12 March 2014

Prepared For:
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CONTENTS

APPENDICES

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

<table>
<tr><th>Borehole No.</th><th>Ground elevation</th><th>Approximate Sample Depth & Sample No.</th><th>Sample Description</th><th>Gravel %</th><th>Sand %</th><th>Silt %</th><th>Clay %</th><th>Liquid Limit</th><th>Plastic Limit</th></tr>
<tr><td>212</td><td>98.33 m</td><td>Near Surface, sample 1</td><td>Sand and gravel, trace silt</td><td>40</td><td>51</td><td colspan="2">9</td><td>-</td><td>-</td></tr>
<tr><td>213</td><td>98.30 m</td><td>Near Surface, sample 1</td><td>Gravelly sand, trace silt</td><td>32</td><td>59</td><td colspan="2">9</td><td>-</td><td>-</td></tr>
<tr><td>215</td><td>98.29 m</td><td>Near Surface, sample 1</td><td>Gravelly sand, trace silt</td><td>32</td><td>58</td><td colspan="2">10</td><td>-</td><td>-</td></tr>
<tr><td>215</td><td>98.29 m</td><td>0.5 m depth, sample 2</td><td>Silty sand, trace gravel, some clay</td><td>9</td><td>39</td><td>33</td><td>19</td><td>27.8</td><td>11.9</td></tr>
<tr><td>217</td><td>98.49 m</td><td>Near Surface, sample 1</td><td>Gravelly sand, trace silt</td><td>32</td><td>59</td><td colspan="2">9</td><td>-</td><td>-</td></tr>
<tr><td>219</td><td>98.91 m</td><td>0.5 m depth, sample 2</td><td>Gravelly silty sand, trace clay</td><td>25</td><td>46</td><td>22</td><td>7</td><td>19.5</td><td>6.6</td></tr>
<tr><td>220</td><td>99.04 m</td><td>Near Surface, sample 1</td><td>Sand, some gravel, trace silt and clay</td><td>17</td><td>71</td><td>9</td><td>3</td><td>-</td><td>-</td></tr>
</table>

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:

- o Plasticity Index greater than 7 percent.
- o 100 percent of the particles passing 75 mm sieve.
- o Not less than 70 percent of the particles, by weight, passing the 0.075 mm sieve.
- o Not less than 20 percent of the particles, by weight, passing the 0.002 mm sieve.
- o Placed in maximum 300 mm lifts and compacted to a minimum of 98% SPMDD.
- o 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
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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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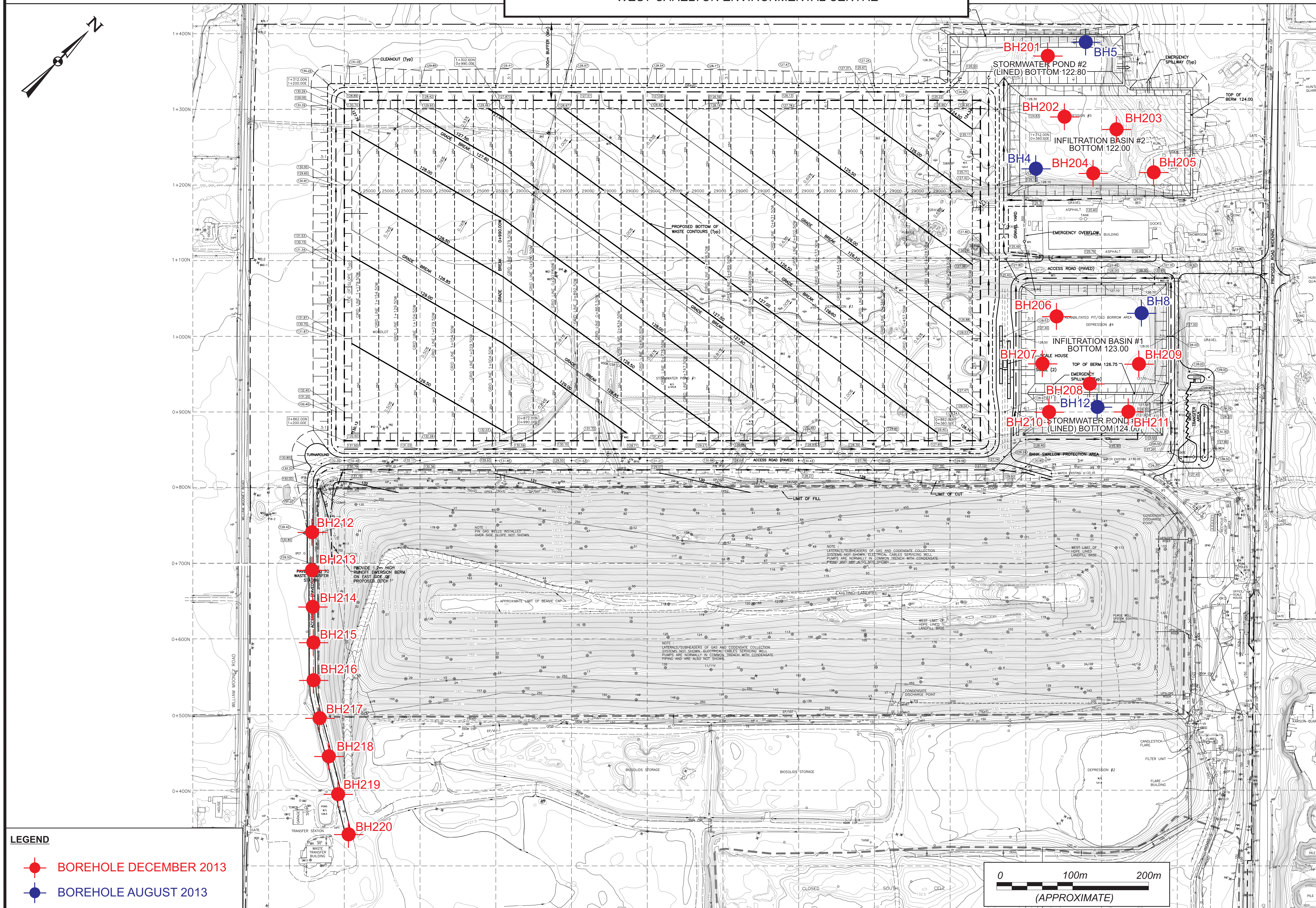
consulting engineers

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	**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

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	N-Value (Blows/300mm)	W.C. (%)	SOIL DESCRIPTION	SAMPLE TYPE	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.	11	9	300 mm black TOPSOIL	Split spoon	1A	11	123
0.5				9	reddish brown, damp fine SAND, trace roots	Split spoon	1B		
1			12	14	compact to very dense moist to wet SILTY fine SAND — brown	Split spoon	2	12	122.5 / 122
1.5–2			46	15	------ grey	Split spoon	3	46	121.5
2.5	Water level (▼)		48	15		Split spoon	4	48	121 / 120.5
3		Hard augering at 3.0 m depth.	38	9	------ TILL	Split spoon	5	38	120
4		Split spoon bouncing	83/250	5	very dense wet, grey SAND and rock fragments	Split spoon	6	83/250	119.5 / 119
4.5		Cobble/boulder encountered between 4.3 and 5.0 m depth.	50/100			Split spoon	7	50/100	118.5
5									

Chart scales: Shear Strength (kPa) 40 80 120 160; N-Value (Blows/300mm) 20 40 60 80; PL W.C. LL 20 40 60 80

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	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	N-Value (Blows/300mm)	W.C. (%)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0		Grass Surface. Borehole dry and cave-in at 1.2 m below ground surface on completion.	12	5	compact, brown to grey sand and gravel, FILL	Split spoon	1	12	118.5
0.5									118
1			73/225	5	very dense, very moist, grey SILTY SAND, traces of gravel and clay (TILL)	Split spoon	2	73/225	117.5
1.5		Cobble/boulder encountered between 1.2 and 1.8 m depth.	50/75	4	COBBLES and BOULDERS	Split spoon	3	50/75	117
					END OF BOREHOLE Refusal to advancement of augers at 1.83 m below ground surface.				

Shear Strength (kPa): 40 80 120 160
N-Value (Blows/300mm): 20 40 60 80
PL W.C. LL: 20 40 60 80

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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 – 1.83 (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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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

Column headings: 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)

Depth (m)	N-Value	W.C.	Sample No.	SPT(N)
0–0.3	50/75	4 / 1	1A / 1B	50/75
1.0	34	6	2	34
1.7	87/225	5	3	87/225
2.5	86/225	5	4	86/225

Elevation scale (m): 117.5, 117, 116.5, 116, 115.5, 115

REMARKS:

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.

Water strike at 1.5 m depth.

SOIL DESCRIPTION:

100 mm TOPSOIL

dense to very dense moist to wet brown medium to coarse SAND and GRAVEL occasional cobbles and boulders

END OF BOREHOLE
Refusal to advancement of augers at 3.05 m below ground surface.

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	Casing Bentonite	Water level measured 1.9 m below ground surface on completion, 1.0 m below ground surface on 9 August 2013.								117.5
0.5	Sand									117
1	Sand and screen (50 mm Diameter)	Cobbles/boulders encountered between 0.0 and 2.4 m depth.				Straight auger to 1.8 m depth				116.5
1.5										116
2										115.5
						END OF BOREHOLE Refusal to advancement of augers at 2.44 m depth belowground surface.				

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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

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 DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 – 2.45	Casing; Bentonite (0 – 1.85); Sand (1.85 – 2.15); Sand and Screen (50 mm diameter) (2.15 – 5.2)	Borehole water level measured dry on completion and 4.8 m below ground surface on 9 August 2013.	N: 7, 2, 2; W.C.: 5, 4, 5, 8	black sand trace to some organics FILL	1, 2, 3	7, 2, 2	121.5, 121, 120.5, 120, 119.5
2.45 – 3.72		Hard augering at 3.0 m depth.	N: 29, 42; W.C.: 3, 4	compact to dense damp to moist, brown GRAVELLY SAND with some silt and trace clay	4A, 4B, 5	29, 42	119, 118.5
3.72 – 5.2		Split spoon bouncing at 5.0 m depth	N: 42, 51; W.C.: 4, 4	dense, brown SAND and GRAVEL trace silt	6, 7	42, 51	118, 117.5, 117

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

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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

DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	W.C. (%)
0.0 – 3.0	brown and black sand with traces of organics wood pieces FILL	Split spoon	1	3	7
		Split spoon	2	5	5
		Split spoon	3	47	6
		Split spoon	4	3	8
3.0 – 3.7	compact, wet grey and brown SAND, trace silt	Split spoon	5	29	4
3.7 – 7.0	moist, brown fine to medium SAND: compact	Split spoon	6	13	5
	------ loose	Split spoon	7	7	5
	------ very loose	Split spoon	8	2	4
7.0 – 7.9	hard, grey SILTY CLAY some sand and gravel (TILL)	Split spoon	9	50/25	6

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

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

Elevation (m) scale: 121.5, 121, 120.5, 120, 119.5, 119, 118.5, 118, 117.5, 117, 116.5, 116, 115.5, 115, 114.5

Shear Strength (kPa): 40 80 120 160
N-Value (Blows/300mm): 20 40 60 80
PL W.C. LL: 20 40 60 80

INSTRUMENTATION DATA:
- Casing
- Bentonite
- Sand
- Sand and Screen (50 mm diameter)

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

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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	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				121.5, 121
1.5 – 7.5						Dynamic Cone Penetration Test	Dynamic cone		--	120.5
			5						5	120
			3						3	
			4						4	119.5
			7						7	119
			6						6	
			4						4	118.5
			4						4	118
			6						6	
			10						10	117.5
			7						7	117
			3						3	
			4						4	116.5
			5						5	
			9						9	116
			19						19	
			34						34	115.5
			15						15	115
			19						19	
			26						26	114.5
						END OF DYNAMIC CONE PENETRATION TEST				

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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	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 open and groundwater level at 1.8 m below ground surface on completion.				200 mm TOPSOIL	Driven	1		
0.5						damp, brown gravelly sand with organics trace silt and clay, FILL				117
1			71/250	5		very dense brown SAND and GRAVEL some rock fragments	Split spoon	2	71/250	116.5
1.5		Water strike at 1.5 m depth	50/125				Split spoon	3	50/125	116
	▽									115.5
						END OF BOREHOLE Refusal to advancement of augers at 2.0 m depth.				

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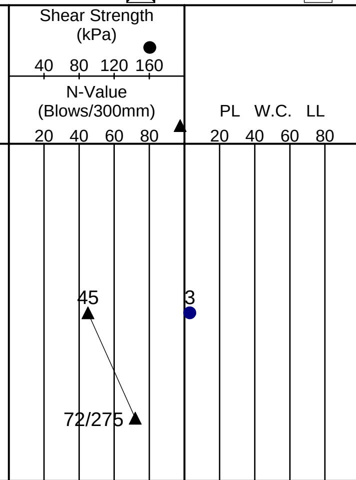
CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 202**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 117.68	
LOCATION: Carp, ON	NORTHING: 5015467	EASTING: 423857	PROJECT NO.: 13-182

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 – 0.76		Borehole dry and open on completion.	brown sand and gravel with rock fragments some silt, some organics, FILL	Driven	1		117.5 / 117
0.76 – 1.5			dense, brown SAND, trace silt trace gravel	Split Spoon	2	45	116.5
1.5 – 2.1			very dense, brown SAND and GRAVEL trace rock fragments	Split Spoon	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 | 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 – 0.75		Borehole open and groundwater level at 1.8 m depth on completion.		5		brown SAND and GRAVEL trace silt trace to some clay	Driven	1		117
0.75 – 1.4			50/125			very dense, moist brown SAND trace rock fragments	Split spoon	2	50/125	116.5 / 116
1.4 – 2.7	▽ (1.8 m)	Water strike at 1.5 m depth.	23; 59/225			compact ------ very dense; wet, coarse SAND with inclusions of rock fragments	Split spoon	3, 4	23, 59/225	115.5 / 115
2.7						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						brown SAND and GRAVEL trace rock fragments				117.5
1		Cobbles/boulders encountered between 0.63 and 1.5 m depth.		3			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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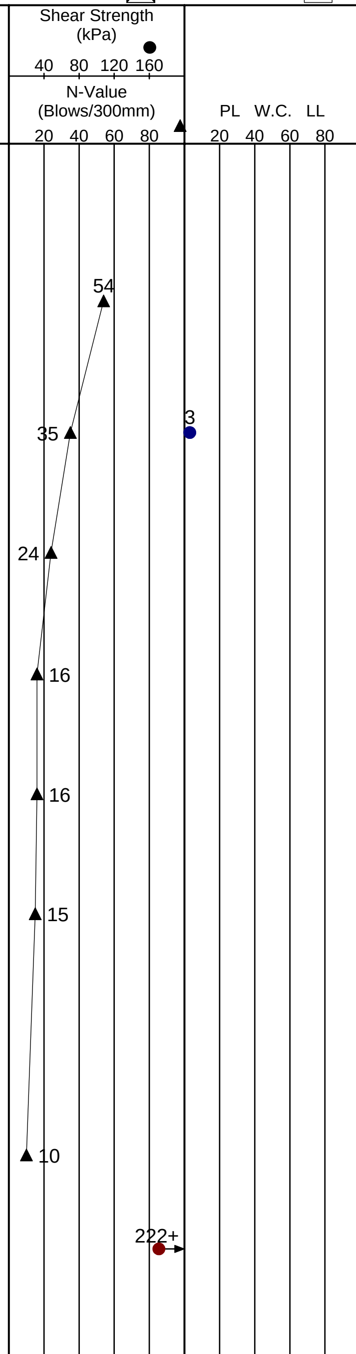
CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 205**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 122.59	
LOCATION: Carp, ON	NORTHING: 5015490	EASTING: 423996	PROJECT NO.: 13-182

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

REMARKS: Borehole dry and open on completion.



DEPTH (m)	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)
0 – 0.2	200 mm TOPSOIL	1	
0.2 – 1.5	very dense ------ brown to dark brown sand and gravel with inclusions of rock fragments (probable FILL)	2	54
1.5 – 3.0	hard ------ very stiff moist, brownish grey SILTY CLAY some sand trace gravel	3	35
		4	24
3.0 – 3.7	very stiff, moist, grey SILTY CLAY, some sand (TILL)	5	16
3.7 – 4.5	compact, moist, grey SANDY SILT (TILL)	6	16
4.5 – 7.6	stiff moist, grey SILTY CLAY trace sand and gravel (TILL)	7	15
		8	10
		9	

Depth scale (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

Elevation scale (m): 122.5, 122, 121.5, 121, 120.5, 120, 119.5, 119, 118.5, 118, 117.5, 117, 116.5, 116, 115.5, 115

END OF BOREHOLE
Refusal to advancement of augers at 7.6 m depth.

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BH No.: 206

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: 5015262	EASTING: 424026

PROJECT NO.: 13-182

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

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	N-Value (Blows/300mm)	PL W.C. LL	SOIL DESCRIPTION	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 – 1.4		Borehole dry and open on completion. 25 mm ice and 200 mm frost penetration at borehole location.	5		1.4 m TOPSOIL	1, 2	5	121.96 – 120.56
1.4 – 2.7			14, 28	13	compact, moist SILTY fine SAND trace clay trace gravel; brown ------ brown and grey	3, 4	14, 28	
2.7 – 4.0			52, 50+		very dense moist, brown SILTY SAND (TILL)	5, 6	52, 50+	

Shear Strength (kPa) scale: 40 80 120 160. N-Value scale: 20 40 60 80. PL W.C. LL scale: 20 40 60 80.

Depth scale (m): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5. Elevation scale (m): 121.5, 121, 120.5, 120, 119.5, 119, 118.5.

END OF BOREHOLE
Refusal to advancement of augers at 4.0 m depth.

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 207**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 121.96	
LOCATION: Carp, ON	NORTHING: 5015200	EASTING: 424053	PROJECT NO.: 13-182

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

Columns: 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)

Remarks:

- 0 m: 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.
- approx. 3.9 m: 300 mm of "blowback" in augers after obtaining Sample 6

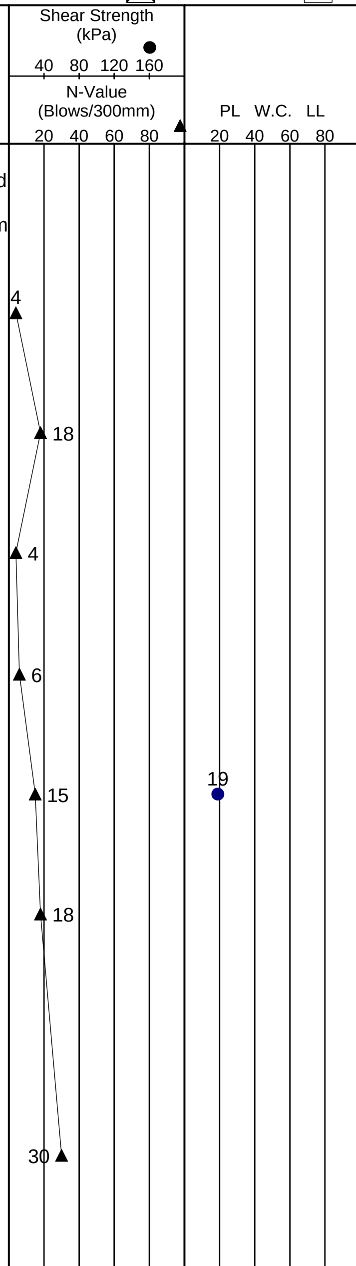
Depth (m)	Soil Description	Sample No.	SPT(N)
0 – 0.6	600 mm TOPSOIL	1	
0.6 – 1.5	dense, moist, grey silty sand with some gravel FILL	2	32
1.5 – 2.8	very dense damp, dark brown silty sand with inclusions of rock fragments FILL	3	55
		4	57/275
2.8 – 3.7	compact, wet SAND some silt trace clay trace gravel	5	21 (W.C. 22)
3.7 – 5.6	compact wet, brown SILTY SAND	6	18
		7	18
5.6 – 6.7	compact wet, brown SILT to SANDY SILT	8	14
6.7 – 8.2	Dynamic Cone Penetration Test		13
			15
			11
			26
			28

END OF BOREHOLE
Refusal to advancement of dynamic cone at 8.2 m depth.

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

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



DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 – 0.7		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.	dark brown to black sand, some gravel FILL	Auger	1		121.5
0.7 – 2.1			buried TOPSOIL (approximately 1.4 m thick)	Split spoon	2	4	121
				Split spoon	3	18	120.5 / 120
2.1 – 3.7			loose wet, grey silt, sand and gravel FILL	Split spoon	4	4	119.5 / 119
				Split spoon	5	6	118.5
3.7 – 4.5		Water strike at 3.8 m	compact wet, brown SAND trace silt	Split spoon	6	15	118
4.5 – 7.2		300 mm "blowback" in augers at Sample 7.	compact wet, brown SANDY SILT trace gravel	Split spoon	7	18	117.5 / 117 / 116.5 / 116
		Augers grinding	------ trace rock fragments	Split spoon	8	30	115.5 / 115

END OF BOREHOLE
Refusal to advancement of augers at 7.2 m depth.

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CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		BH No.: 209
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 121.95	
LOCATION: Carp, ON	NORTHING: 5015287	EASTING: 424150	PROJECT NO.: 13-182

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

Shear Strength (kPa): 40 80 120 160 — N-Value (Blows/300mm): 20 40 60 80 — PL W.C. LL: 20 40 60 80

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	N-Value	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 – 0.7		25 mm ice and 200 mm frost penetration at borehole location.		brown sand silt and gravel FILL	Driven	1		121.5
0.7 – 1.5			9	buried TOPSOIL (approximately 700 mm thick)	Split spoon	2	9	121
1.5 – 3.0			9	loose ------ dense; moist, dark brown sand, trace gravel some organics FILL	Split spoon	3	9	120
			34		Split spoon	4	34	119.5
3.0 – 5.2			48	dense ------ very dense; SAND with inclusions of rock fragments	Split spoon	5	48	118.5
		Hard augering at 3.8 m depth	50/75		Split spoon	6	50/75	118
			50/75		Split spoon	7	50/75	117

END OF BOREHOLE
Refusal to advancement of augers at 5.2 m depth.

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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	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 – 0.7		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	Driven	1		121.5
0.7 – 1.5			28			very stiff, moist, brown clayey silt, trace sand some gravel, FILL	Split spoon	2	28	121 / 120.5
1.5 – 3.0			14 / 4			compact – moist ------ grey sandy silt FILL ------ loose – wet	Split spoon	3 / 4	14 / 4	120 / 119.5 / 119
3.0 – 4.3		Split spoon bouncing	50/125 / 75/225			very dense wet, grey SAND and GRAVEL with inclusions of rock fragments	Split spoon	5 / 6	50/125 / 75/225	118.5 / 118

END OF BOREHOLE
Refusal to advancement of augers at 4.3 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.: 211**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN / ELEV. (m) 122.52	
LOCATION: Carp, ON	NORTHING: 5015230 / EASTING: 424181	PROJECT NO.: 13-182

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

Shear Strength (kPa) ● 40 80 120 160; N-Value (Blows/300mm) ▲ 20 40 60 80; PL W.C. LL 20 40 60 80

DEPTH (m)	INSTRUMENTATION DATA	REMARKS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO.	SPT(N)	ELEVATION (m)
0 – 0.7		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	Auger	1		122.5
0.7 – 1.5			very dense, damp SILTY SAND trace gravel	Split spoon	2	51	
1.5 – 4.5			dense ------ compact; brown SILTY SAND; damp to moist ------ wet	Split spoon	3	39	
				Split spoon	4	24	
				Split spoon	5	23	
				Split spoon	6	25	
4.5 – 5.7			compact wet, brown medium SAND trace gravel	Split spoon	7	28	
5.7 – 7.6		Augers grinding	dense; wet, grey SILTY SAND trace gravel some rock fragments (TILL) ------ very dense	Split spoon	8	32	
7.6				Split spoon	9	50/25	115

END OF BOREHOLE
Refusal to advancement of augers at 7.6 m depth.

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 18 Dec. 2013
	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 212**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 98.33	
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	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		4			Driven	1		98
0.5			50/125			------ sand and gravel FILL, very dense	Split spoon	2	50/125	97.5
1										
1.5			16			very stiff, dark brown clayey silt, trace sand and gravel, FILL	Split spoon	3	16	97

END OF BOREHOLE
Refusal to advancement of augers at 1.8 m depth.

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	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		**BH No.: 213**
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 98.30	
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	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 – 0.6		Borehole dry and open on completion. 200 mm frost penetration		6	FILL	gravelly sand trace silt FILL	Driven	1		98
0.6 – 1.2			67		FILL	hard, moist, dark brown clayey silt, trace sand and gravel, FILL	Split Spoon	2	67	97.5
1.2 – 1.8			15		FILL	stiff, moist, brown clayey silt, trace sand trace organics, FILL	Split Spoon	3	15	97 / 96.5
						END OF BOREHOLE				

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	DRIVEN	1		98
0.5						silty sand some gravel FILL	DRIVEN	2		97.5
1										97
1.5			42 ▲			hard, dark brown clayey silt, trace sand and gravel, FILL	SPLIT SPOON	3	42	96.5
						END OF BOREHOLE				

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 19 Dec. 2013
	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	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	3		FILL	gravelly sand trace to some silt FILL	DRIVEN	1		98
0.5 – 1			7	●├┤	FILL	silty sand, trace gravel some clay, FILL	DRIVEN	2		97.5
1 – 1.5			18		FILL	very stiff, moist, brown clayey silt, trace sand and gravel, FILL	SPLIT SPOON	3	18	97
						END OF BOREHOLE				

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 19 Dec. 2013
	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	DRIVEN	1		98
0.5 – 1						brown/dark brown silty sand, trace gravel FILL	DRIVEN	2		97.5
1 – 1.5			16			very stiff, moist, dark brown clayey silt, trace gravel trace organics, FILL	SPLIT SPOON	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 | 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		5		gravelly sand trace silt FILL	DRIVEN	1		98
0.5 – 1			50/100			very dense gravel and rock fragments with some clayey silt, FILL	SPLIT SPOON	2	50/ 100	97.5
1.5			8			loose, dark brown sand, trace gravel FILL	SPLIT SPOON	3	8	97
						END OF BOREHOLE				

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 19 Dec. 2013
	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	Driven	1		99
0.5			50/75			very dense, damp, brown fine sand to sandy silt trace to some gravel, FILL	Split spoon	2	50/75	98.5
1										98
1.5			14			stiff, moist, grey clayey silt, trace gravel FILL	Split spoon	3	14	97.5
						END OF BOREHOLE				

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 19 Dec. 2013
	REVIEWED BY: VN	Page 1 of 1

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	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	Driven	1		
0.5			50/75	3 H		very dense, damp, brown gravelly silty sand trace clay, FILL	Split spoon	2	50/75	98.5
1										98
1.5			24			very stiff, moist, grey SILTY CLAY trace sand and gravel	Split spoon	3	24	97.5
						END OF BOREHOLE				

alston associates inc. consulting engineers	LOGGED BY: KC	DRILLING DATE: 19 Dec. 2013
	REVIEWED BY: VN	Page 1 of 1

CLIENT: WSP Canada Inc.	METHOD: Augering and Split Spoon Sampling		BH No.: 220
PROJECT: WCEC Landfill Expansion	PROJECT ENGINEER: VN	ELEV. (m) 99.04	
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 – 0.5		Borehole dry and open on completion. 200 mm frost penetration		9		sand, some gravel trace silt and clay FILL	Driven	1		99
0.5 – 1			50/125			very dense, moist, brown fine sand to sandy silt trace to some gravel, FILL	Split Spoon	2	50/ 125	98.5 / 98
1 – 1.5			15			stiff, moist, grey clayey silt, trace gravel FILL	Split Spoon	3	15	97.5
						END OF BOREHOLE				

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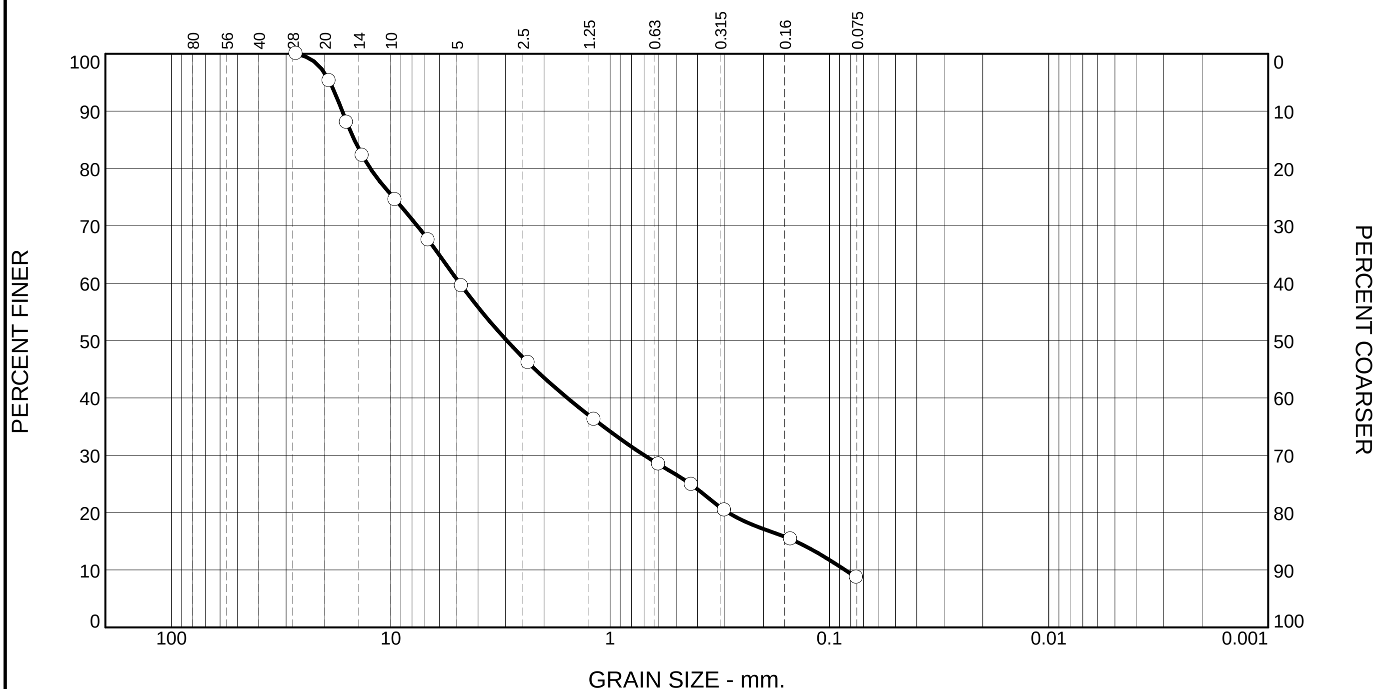
	REVIEWED BY: VN	Page 1 of 1

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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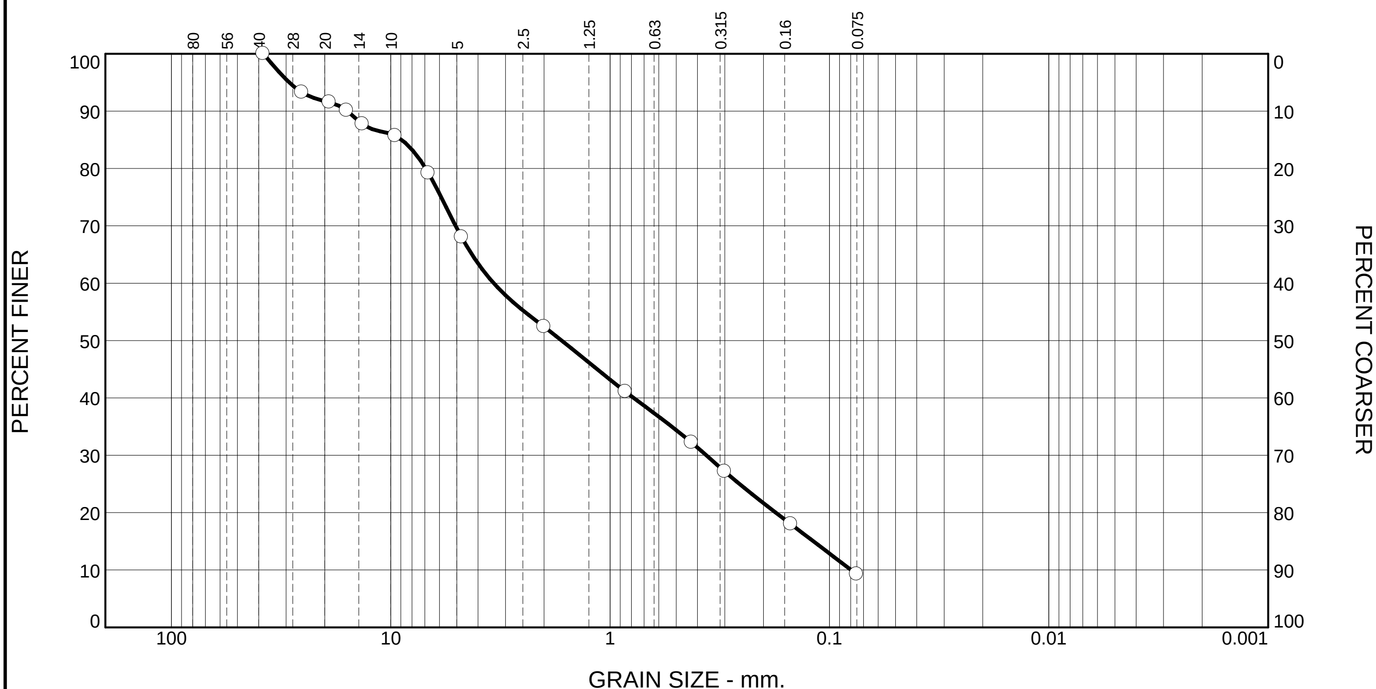
Figure E-1

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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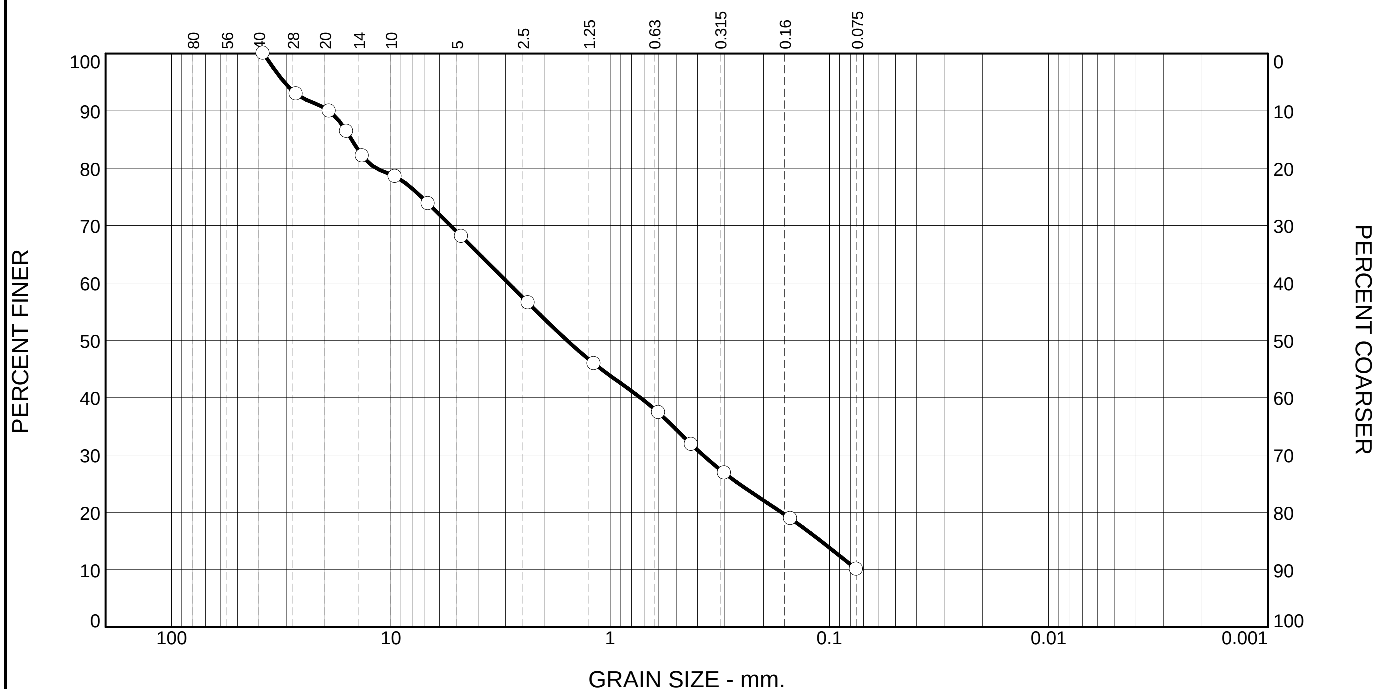
Figure E-2

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

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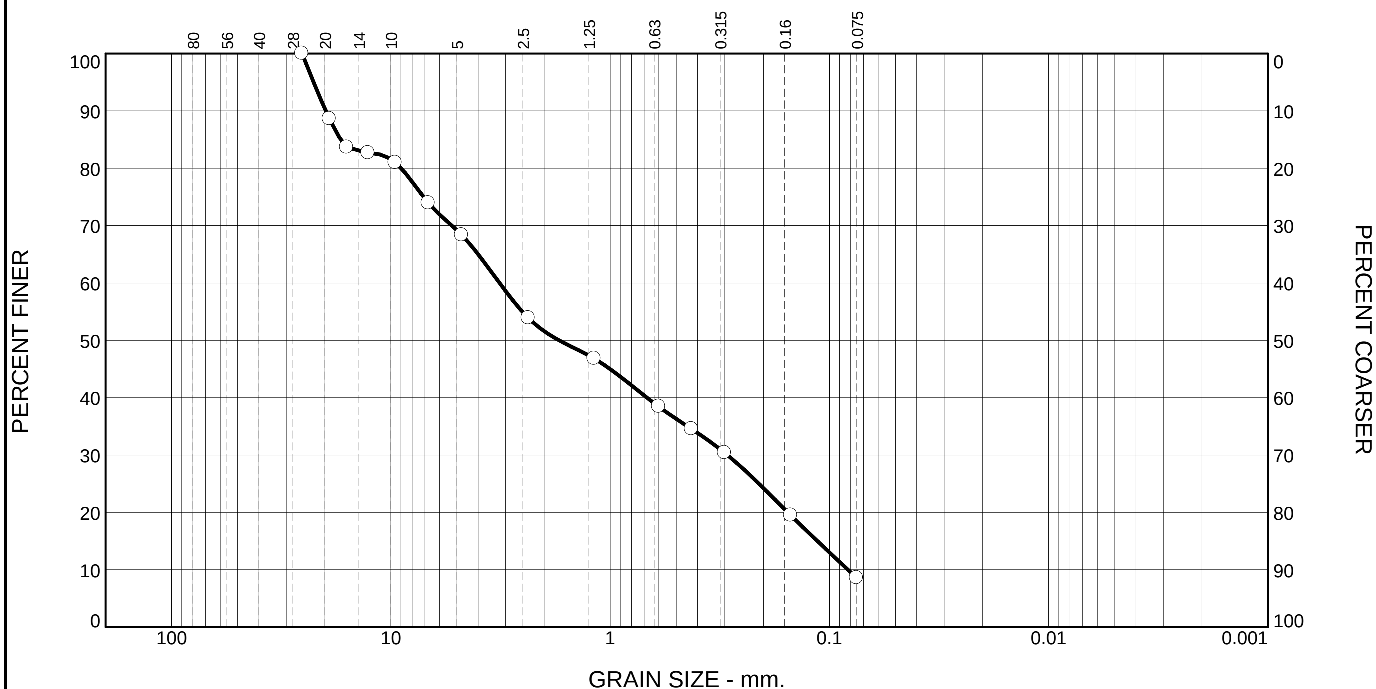
Remarks:

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:

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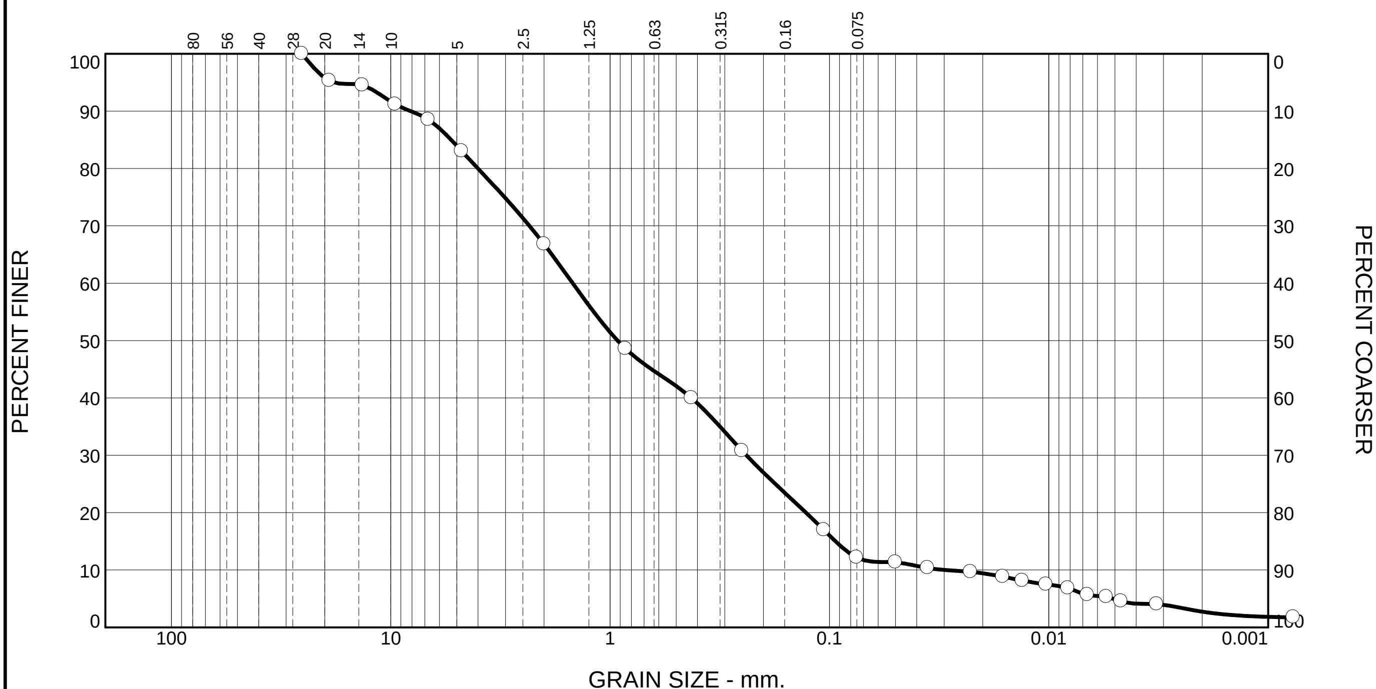
Figure E-4

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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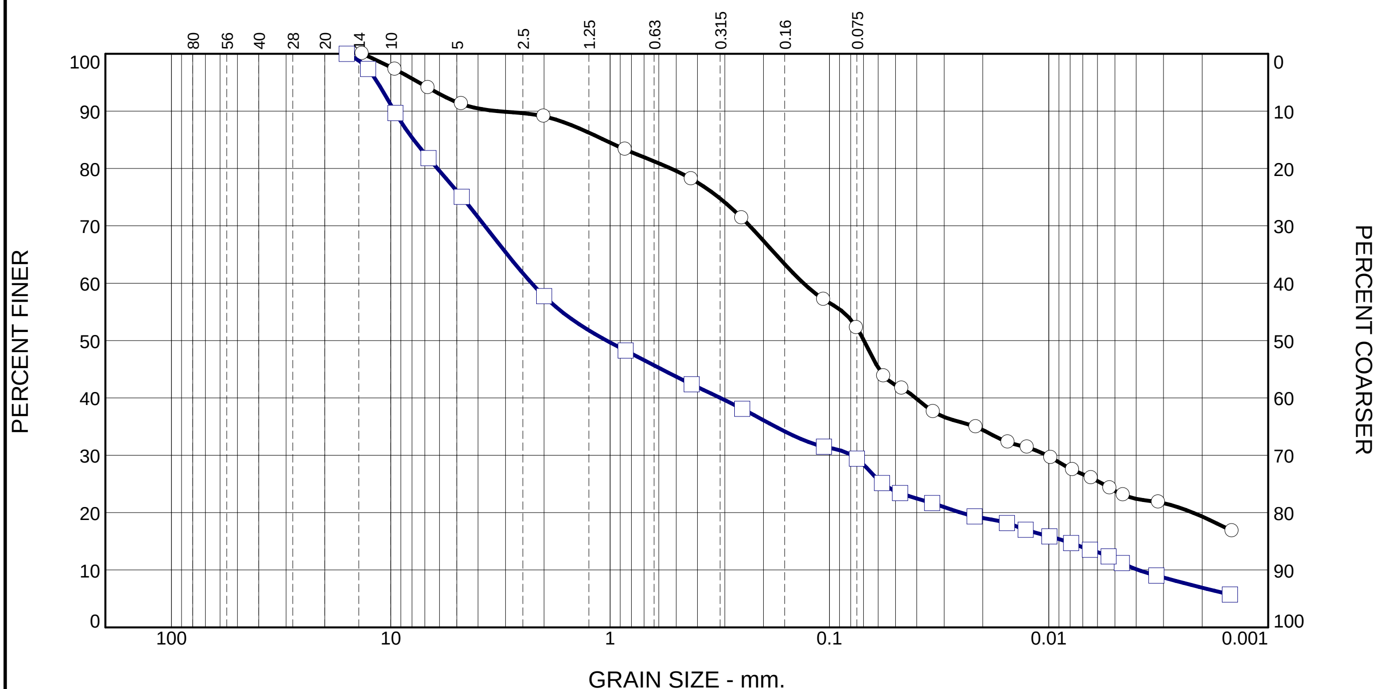
Figure E-5

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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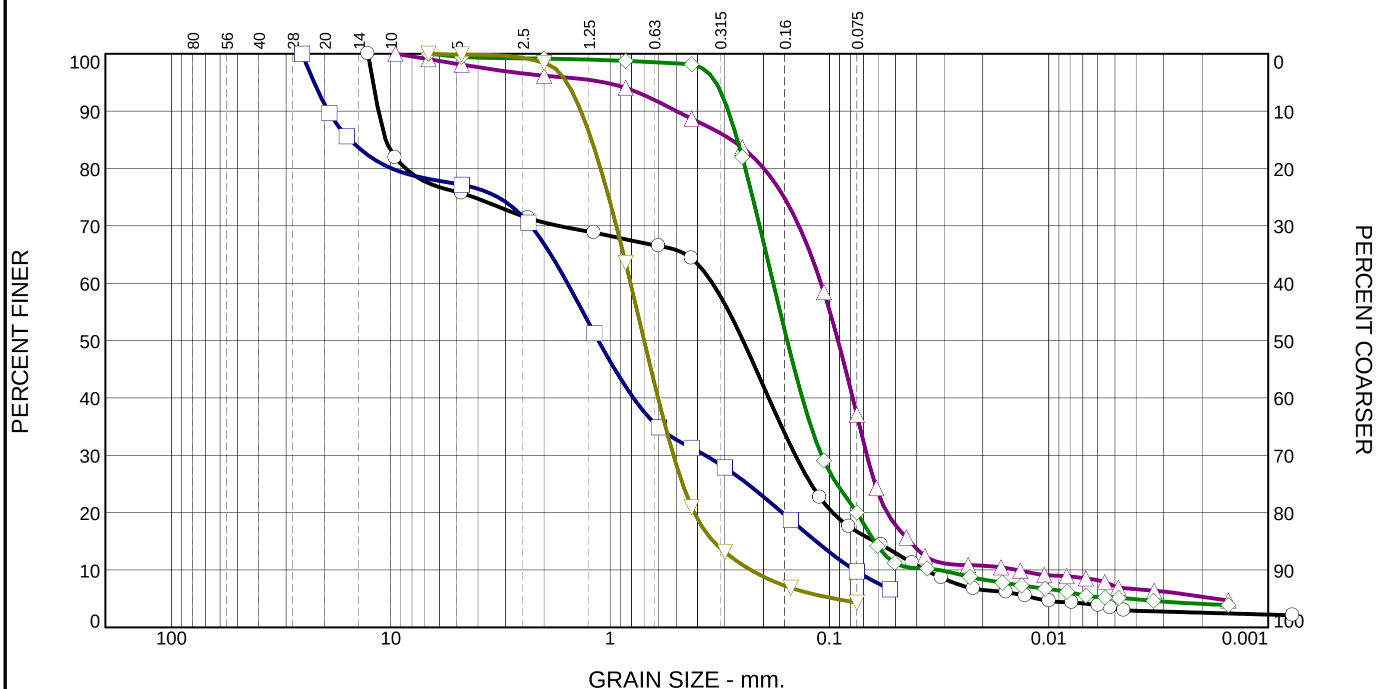
Figure E-6

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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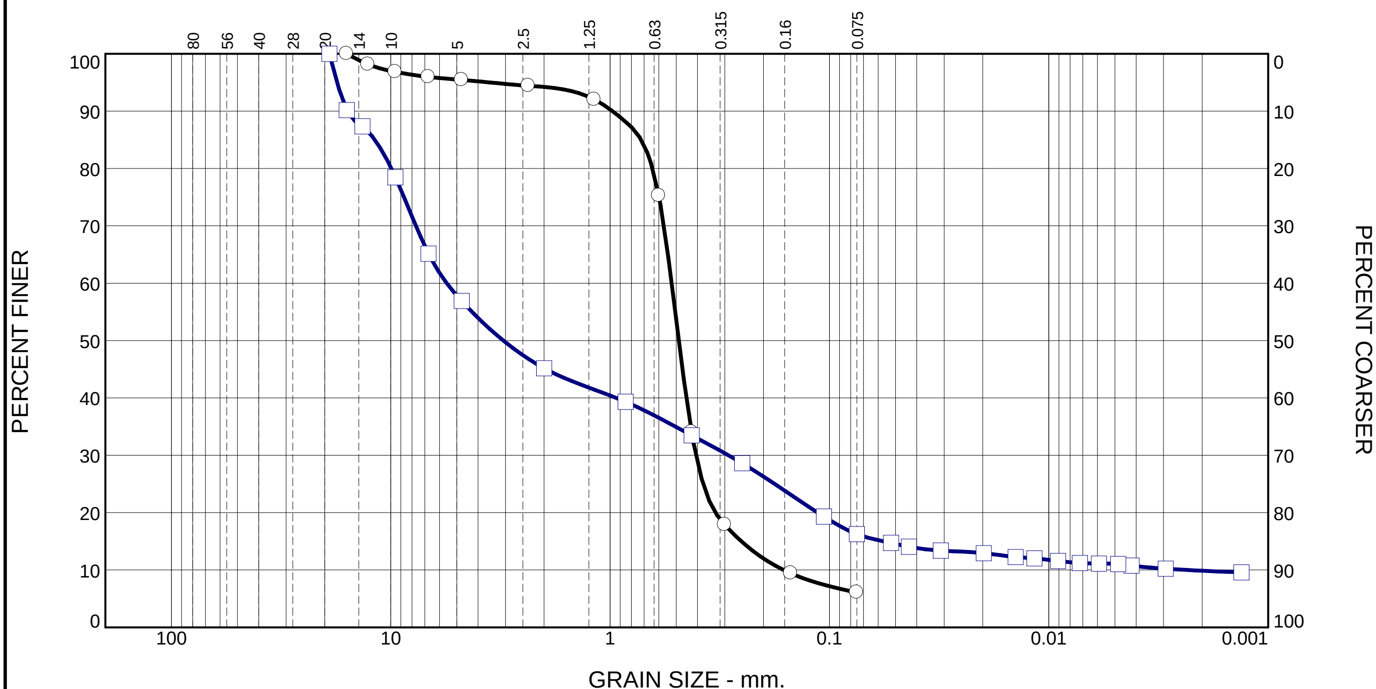
Remarks:

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

Remarks:

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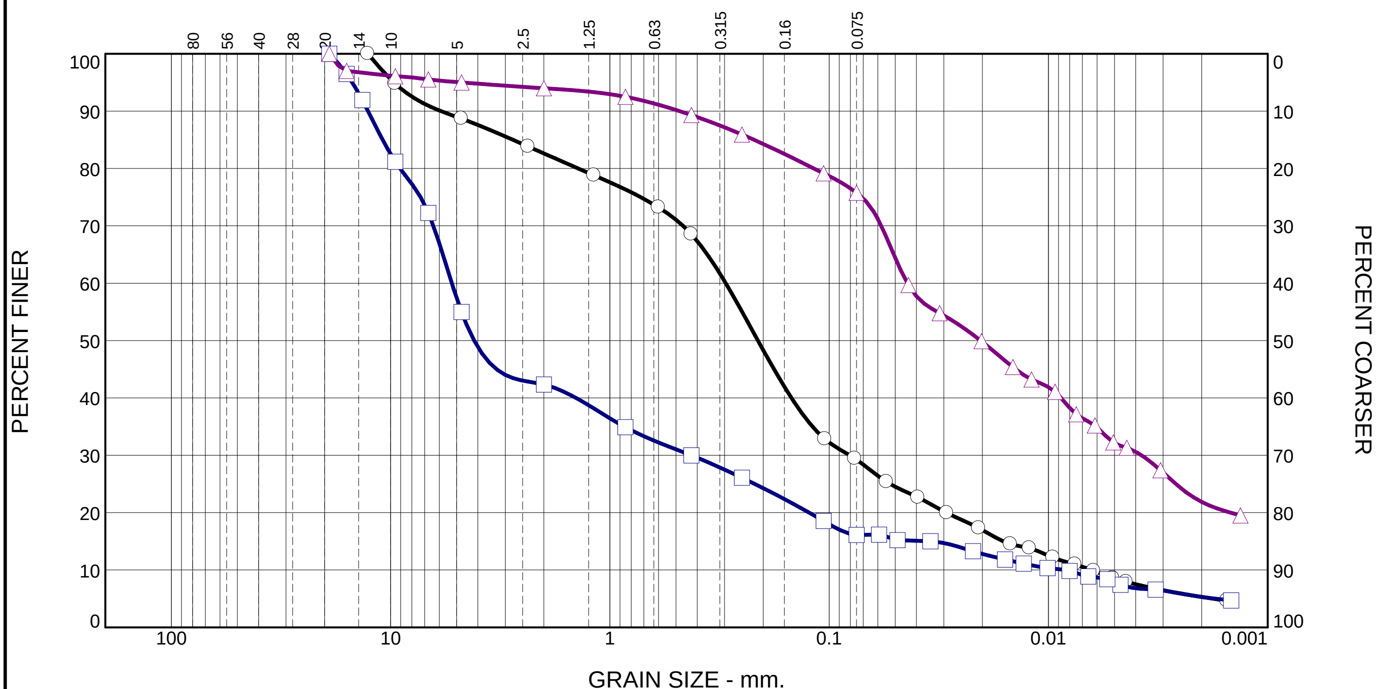
Figure E-8

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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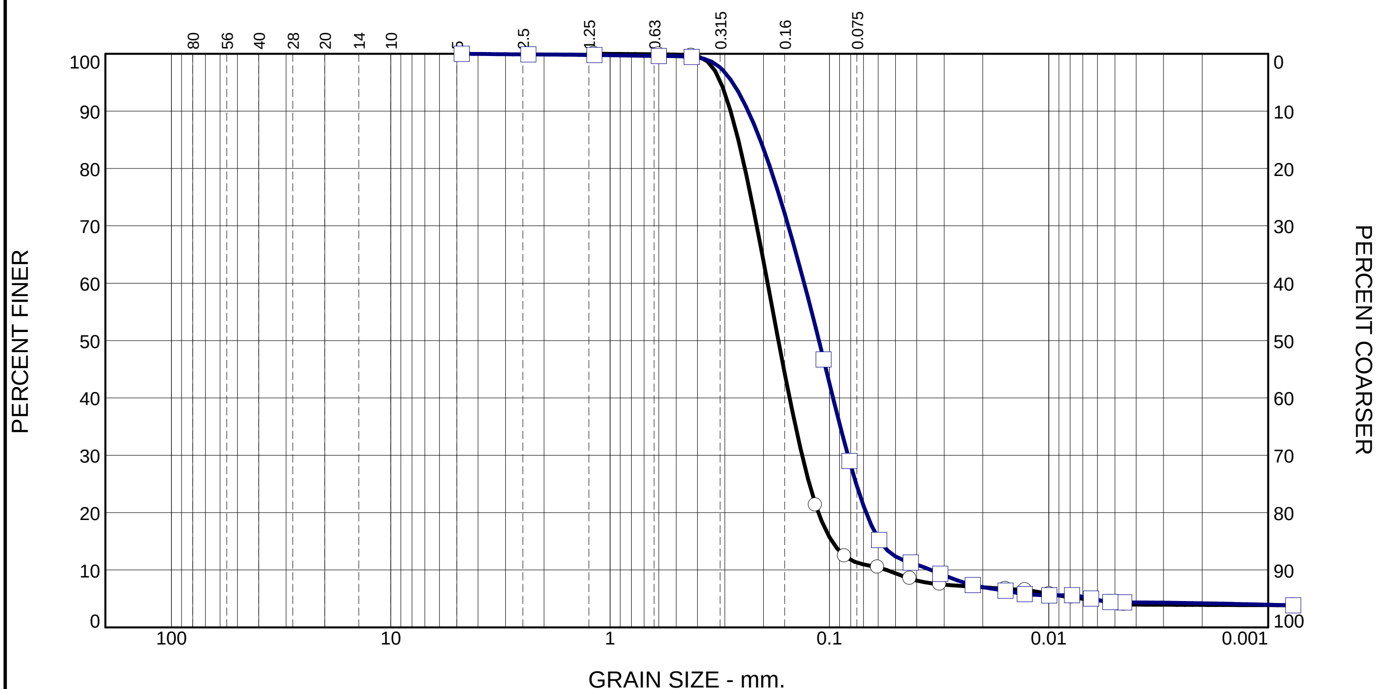
consulting engineers

Figure E-9

Tested By: ○ MA/AM □ GL/RH △ TS **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines 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

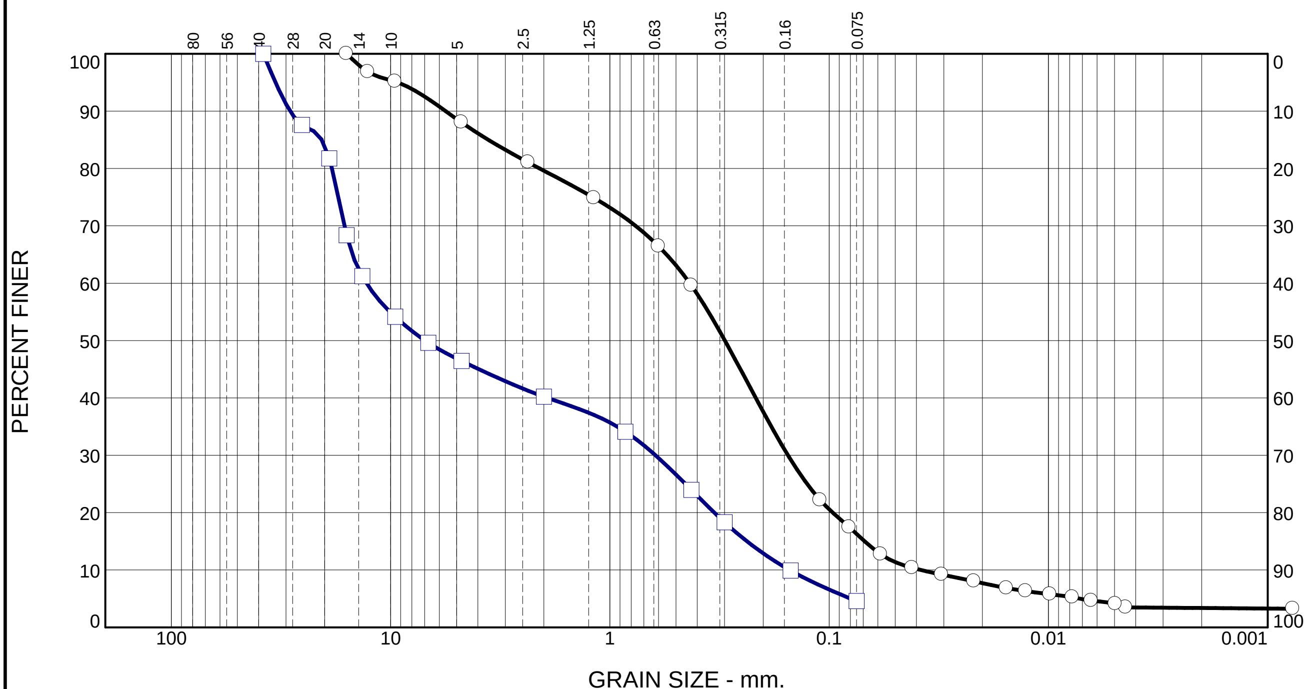
Remarks:

alston associates inc.
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

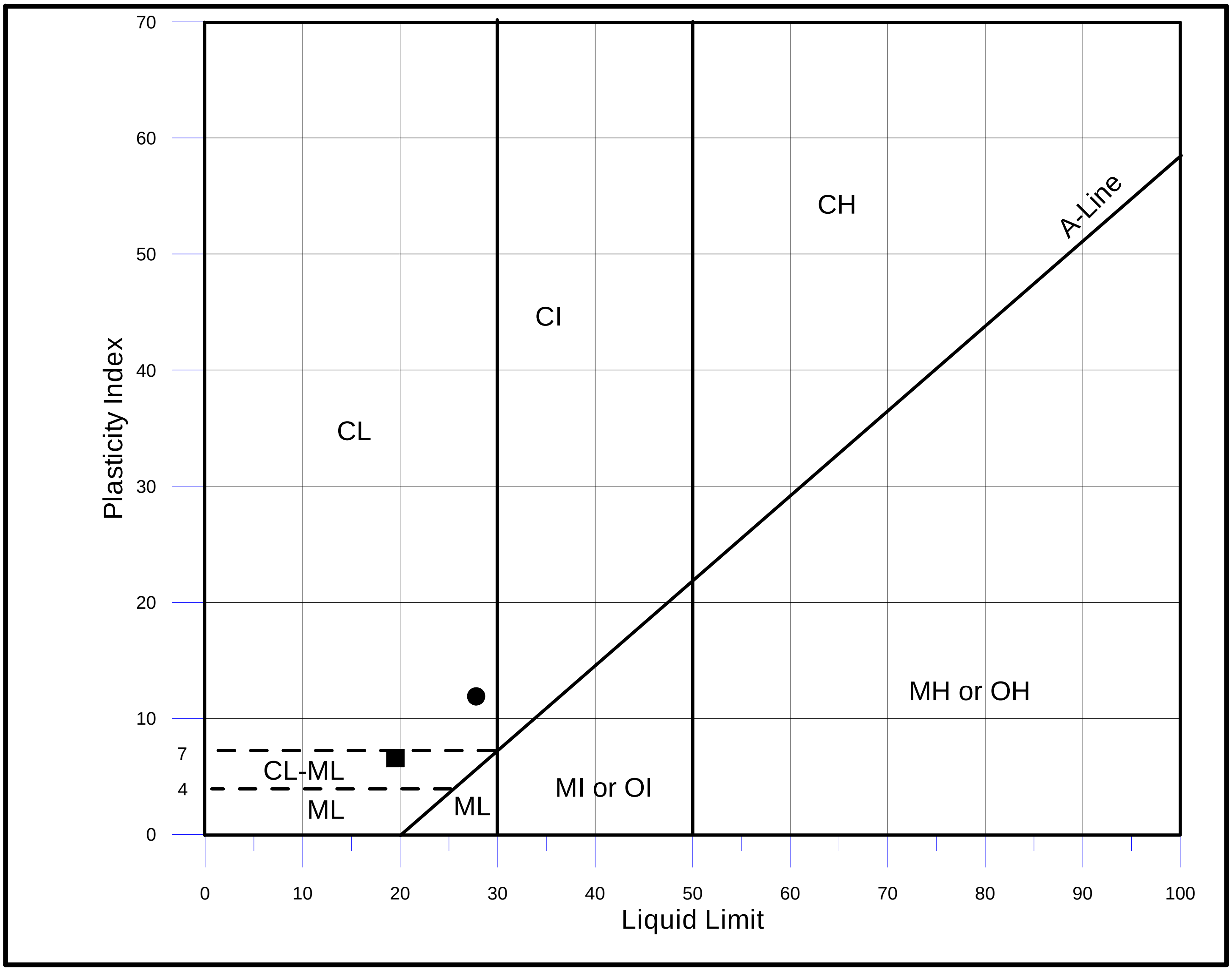
Remarks:

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

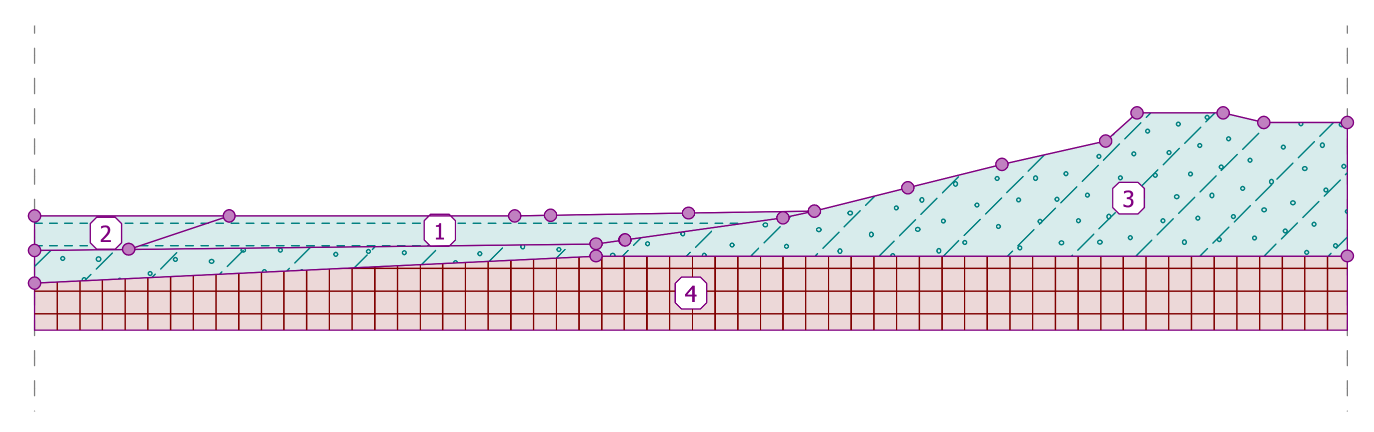
Slope stability analysis

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

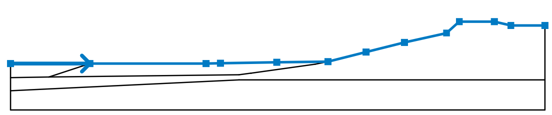
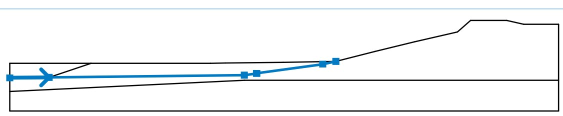
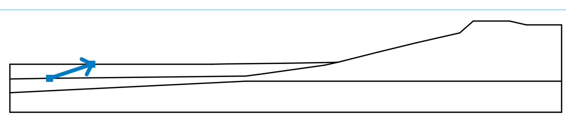
Standard - safety factors

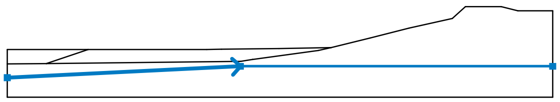
Stability analysis

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/m3
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/m3

Proposed Fill for Ponds

Unit weight :	γ =	19.00 kN/m3
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/m3

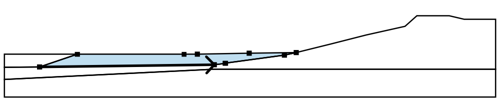
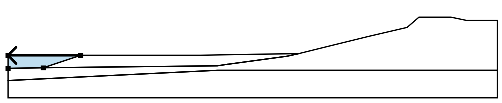
Proposed Uncompacted Fill for Ponds

Unit weight :	γ =	18.00 kN/m3
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/m3

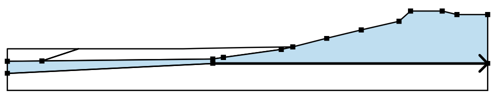
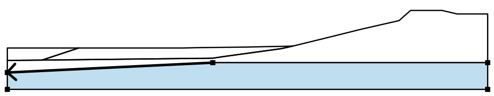
Rigid bodies

No.	Name	Sample	γ [kN/m3]
1	Probable Bedrock		24.00

Assigning and surfaces

No.	Surface position	x	z	x	z	Assigned soil
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	

(Coordinates of surface points [m])

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

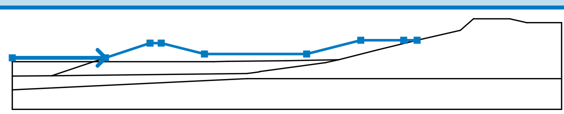
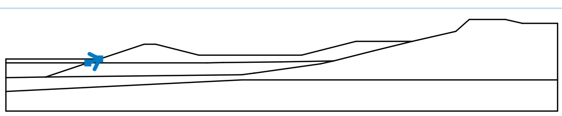
Earthquake not included.

Settings of the stage of construction

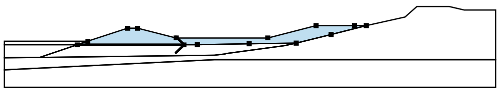
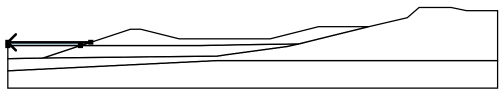
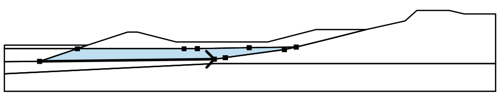
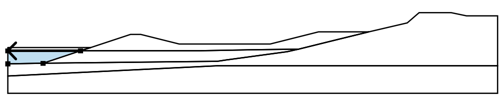
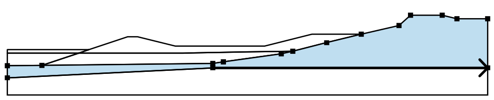
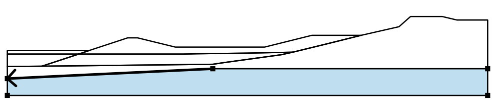
Design situation : permanent

Input data (Stage of construction 2)

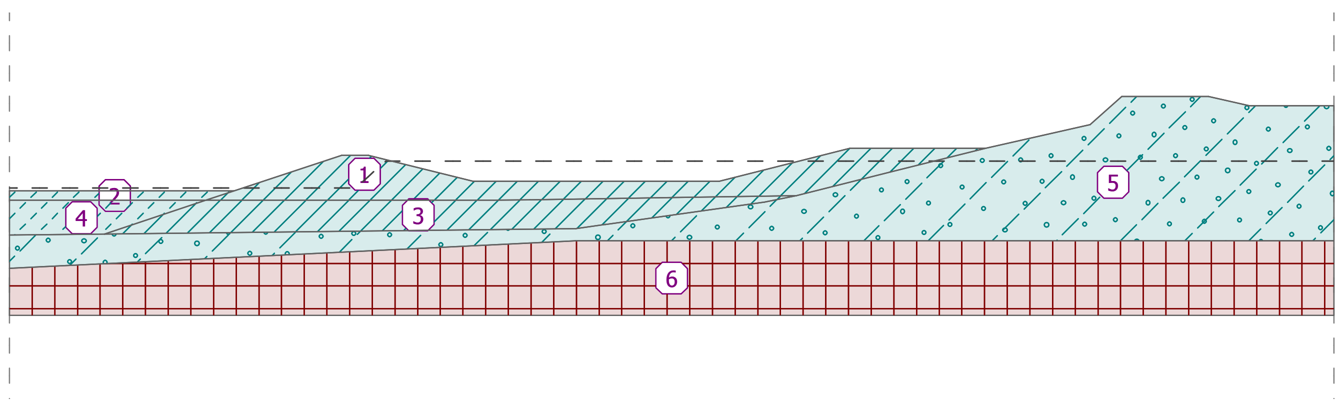
Embankment interface

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

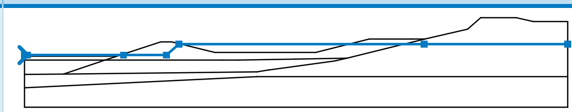
No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		20.82	122.00	51.33	122.00	Proposed Fill for Ponds
		55.14	122.06	69.89	122.29	
		83.35	122.50	93.33	125.00	
		103.40	127.50	100.00	127.50	
		89.03	127.50	75.20	124.00	
		49.11	124.00	38.05	126.75	
		35.18	126.75	23.81	123.00	
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 x [m]	First point z [m]	Second point x [m]	Second point 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

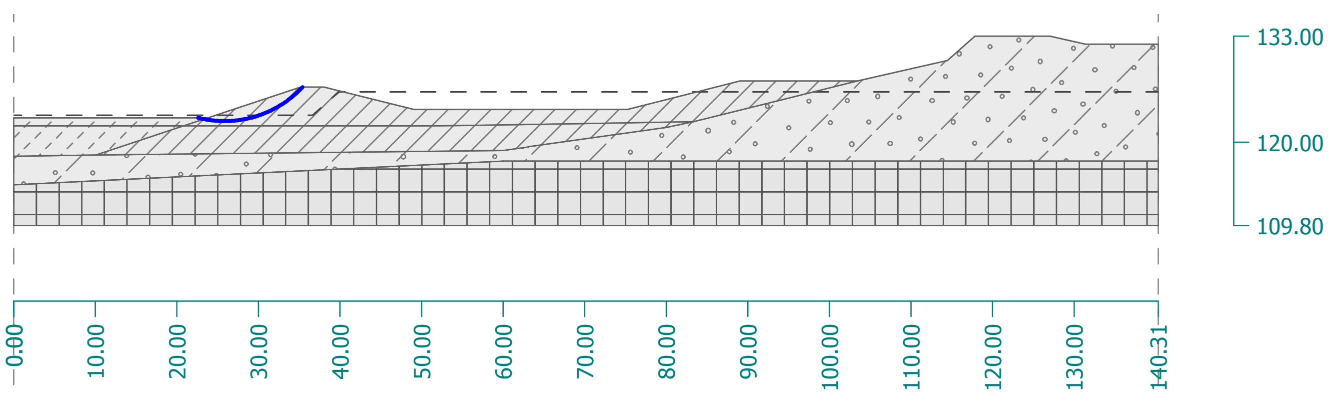
Slope stability verification (Bishop)

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



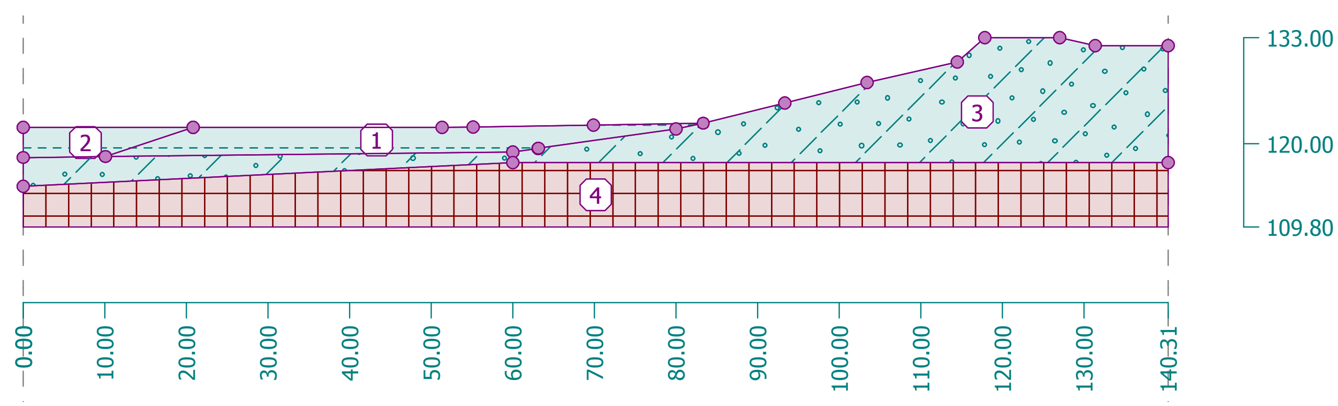
Slope stability analysis

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

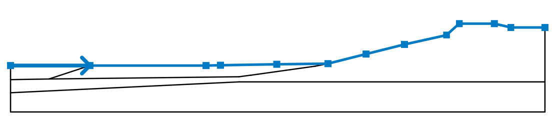
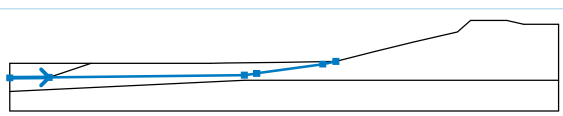
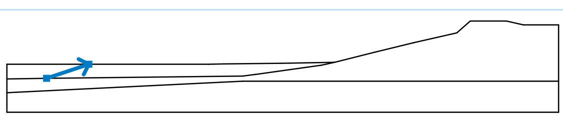
Standard - safety factors

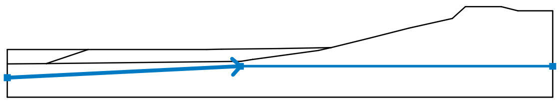
Stability analysis

Verification methodology : Safety factors (ASD)

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

Interface

No.	Interface location	x	z	x	z	x	z
		Coordinates of interface points [m]					
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/m3
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/m3

Proposed Fill for Ponds

Unit weight :	γ =	19.00 kN/m3
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/m3

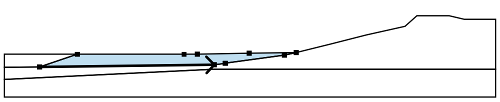
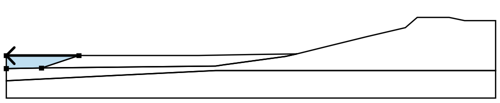
Proposed Uncompacted Fill for Ponds

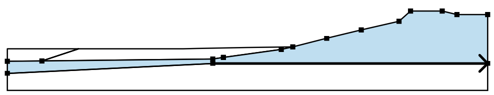
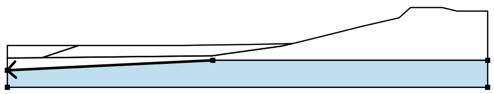
Unit weight :	γ =	18.00 kN/m3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	27.00 °
Cohesion of soil :	c_{ef} =	0.00 kPa
Saturated unit weight :	γ_{sat} =	18.00 kN/m3

Rigid bodies

No.	Name	Sample	γ [kN/m3]
1	Probable Bedrock		24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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

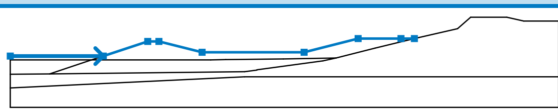
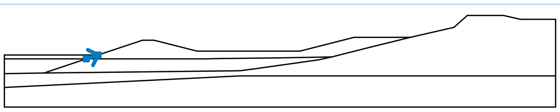
Earthquake not included.

Settings of the stage of construction

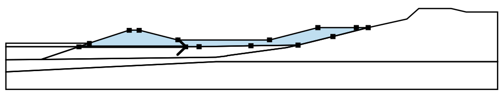
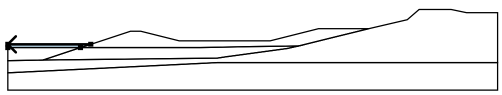
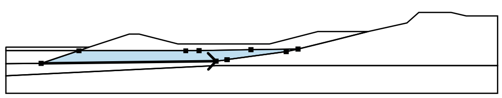
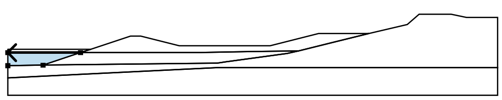
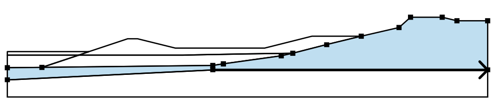
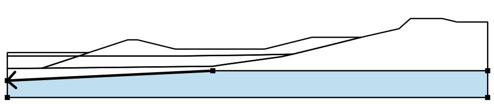
Design situation : permanent

Input data (Stage of construction 2)

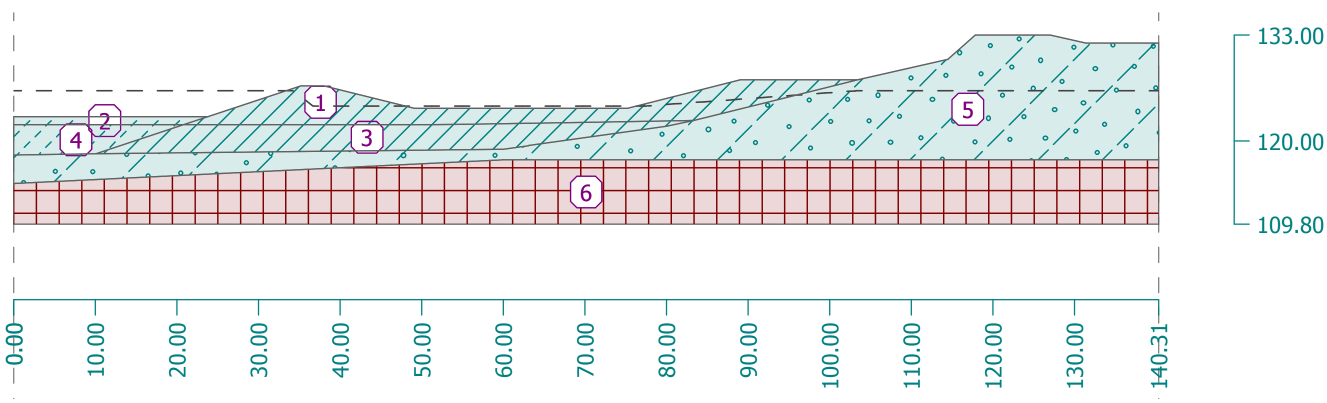
Embankment interface

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

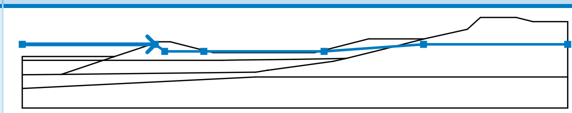
No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		20.82	122.00	51.33	122.00	Proposed Fill for Ponds
		55.14	122.06	69.89	122.29	
		83.35	122.50	93.33	125.00	
		103.40	127.50	100.00	127.50	
		89.03	127.50	75.20	124.00	
		49.11	124.00	38.05	126.75	
		35.18	126.75	23.81	123.00	
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 x [m]	First point z [m]	Second point x [m]	Second point 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

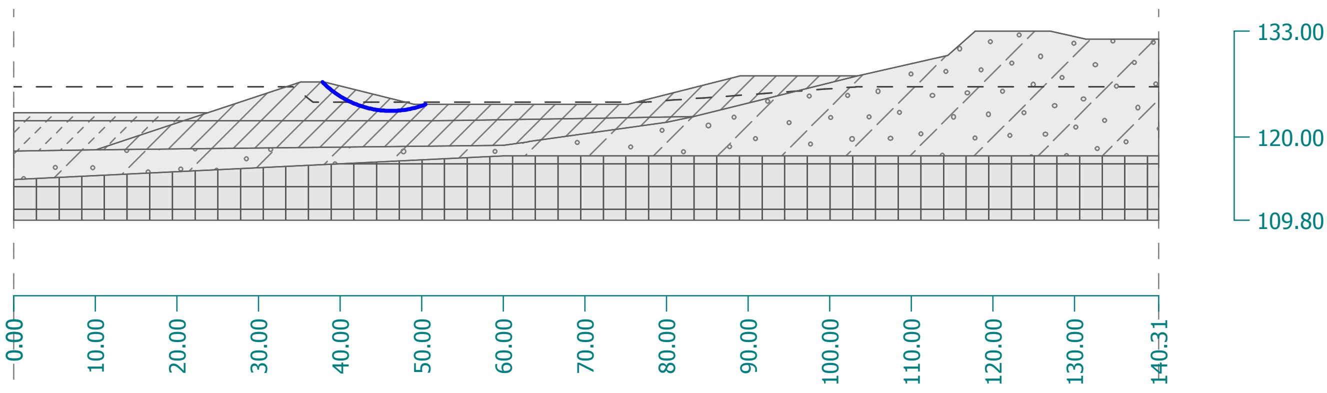
Slope stability verification (Bishop)

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**



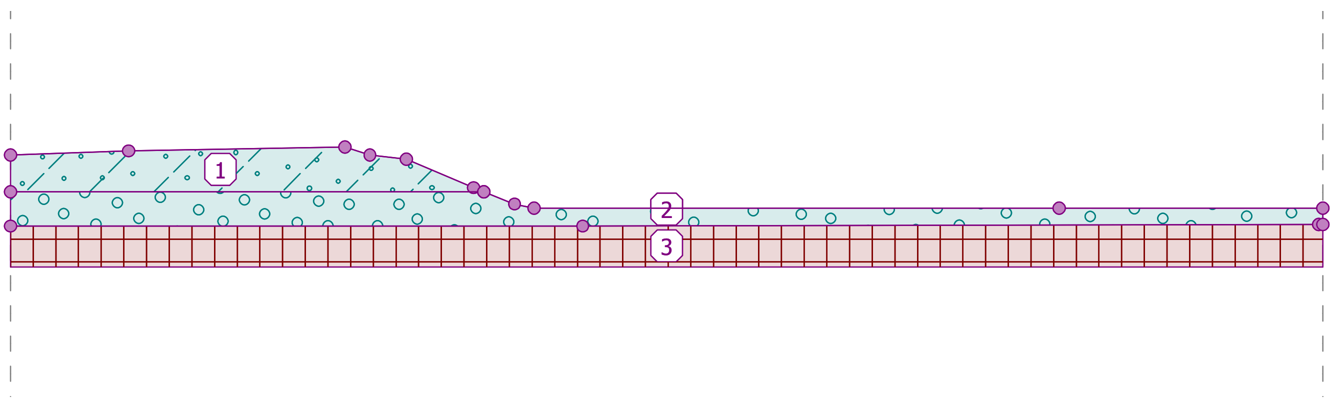
Slope stability analysis

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

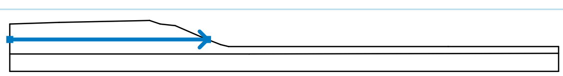
Standard - safety factors

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

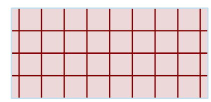
Proposed Fill for Ponds

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

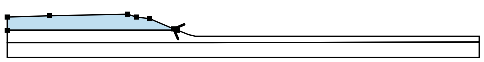
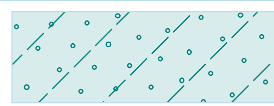
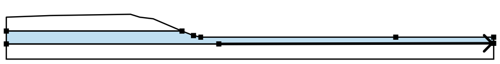
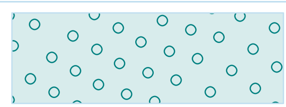
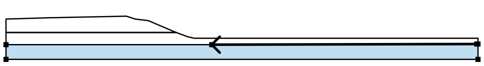
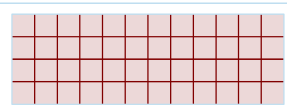
Proposed Uncompacted Fill for Ponds

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] x	z	x	z	Assigned soil
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

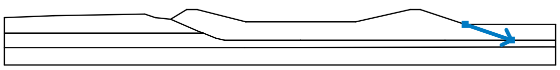
Earthquake not included.

Settings of the stage of construction

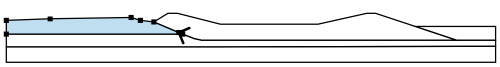
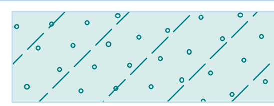
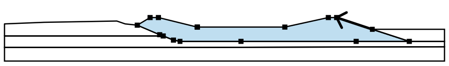
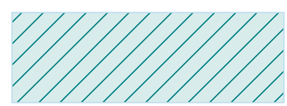
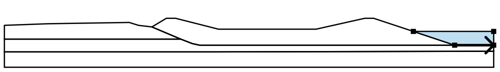
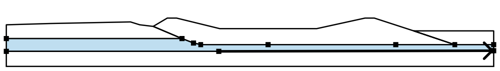
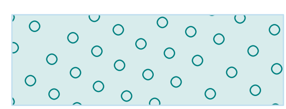
Design situation : permanent

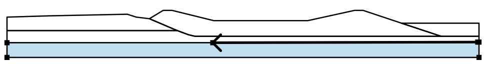
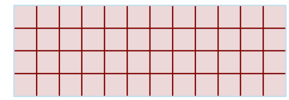
Input data (Stage of construction 2)

Embankment interface

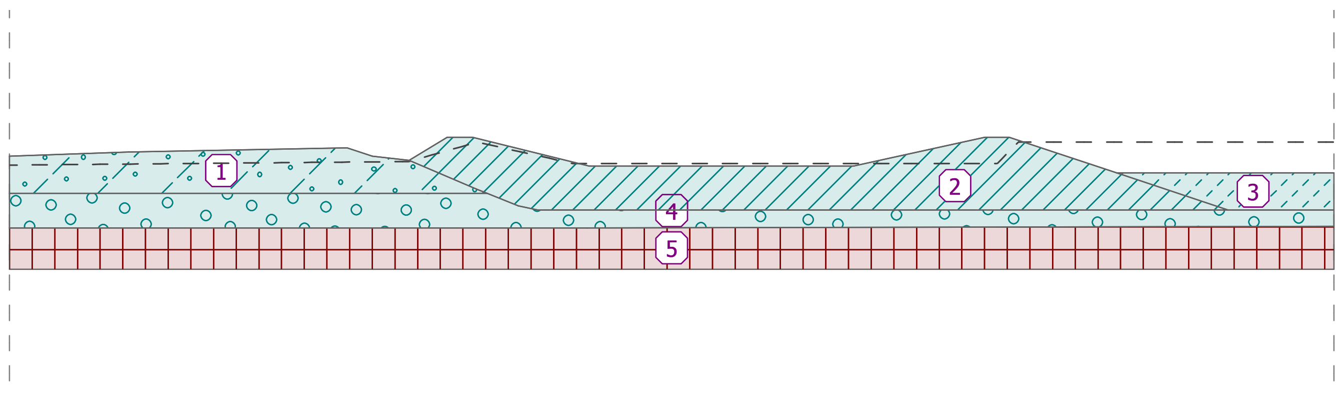
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		48.42	123.50	53.06	126.30	56.12	126.30
		70.25	122.80	70.38	122.80	102.27	122.80
		118.18	126.30	121.14	126.30	134.18	122.00
		160.50	122.00				
2		134.18	122.00	147.68	117.50		

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

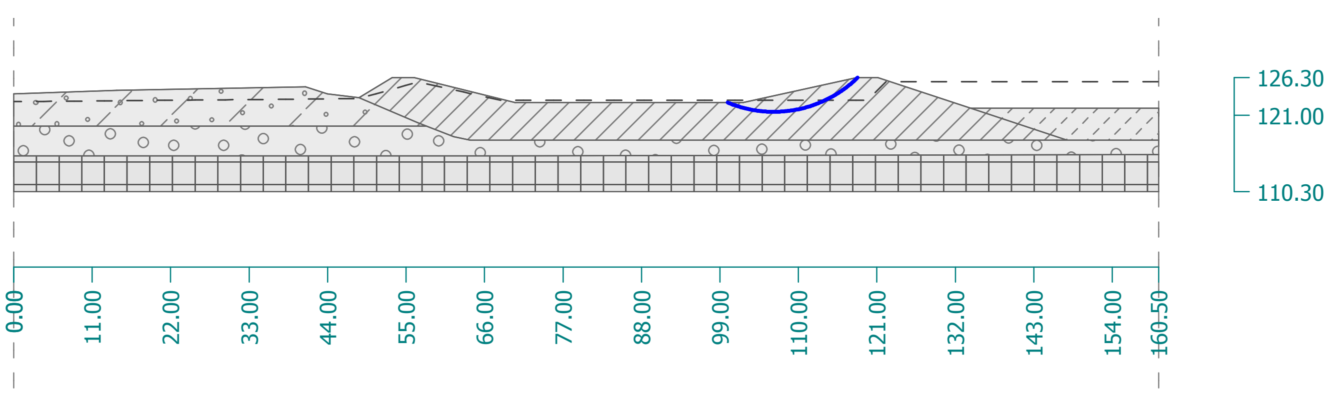
Sliding moment : $M_a =$ 1856.79 kNm/m

Resisting moment : $M_p =$ 4793.13 kNm/m

Factor of safety = 2.58 > 1.50

Slope stability ACCEPTABLE

Name : Analysis | **Stage - analysis : 2 - 1**



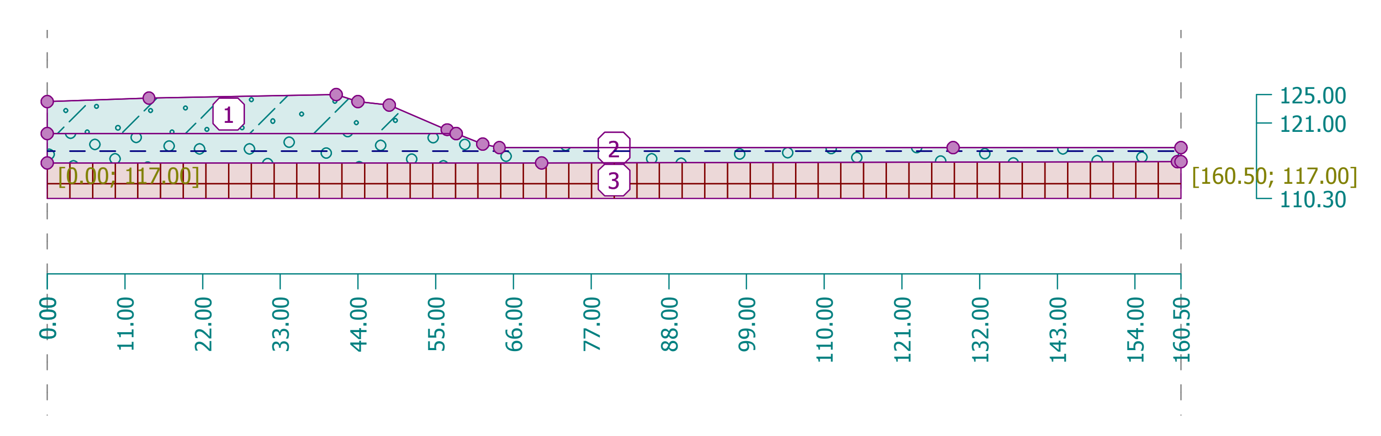
Slope stability analysis

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

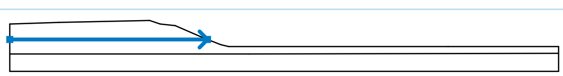
Standard - safety factors

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

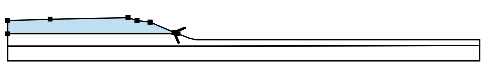
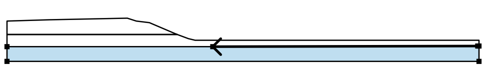
Proposed Uncompacted Fill for Ponds

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

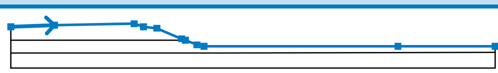
No.	Name	Sample	γ [kN/m^3]
1	Probable Bedrock		24.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
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

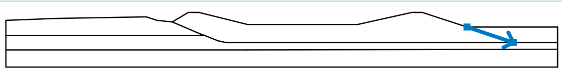
Earthquake not included.

Settings of the stage of construction

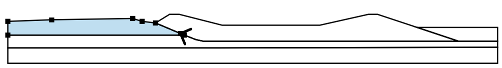
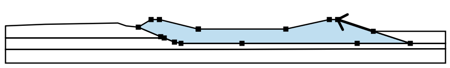
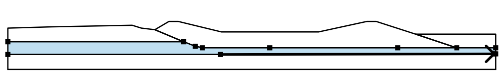
Design situation : permanent

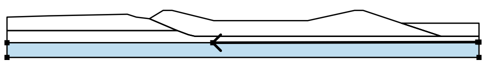
Input data (Stage of construction 2)

Embankment interface

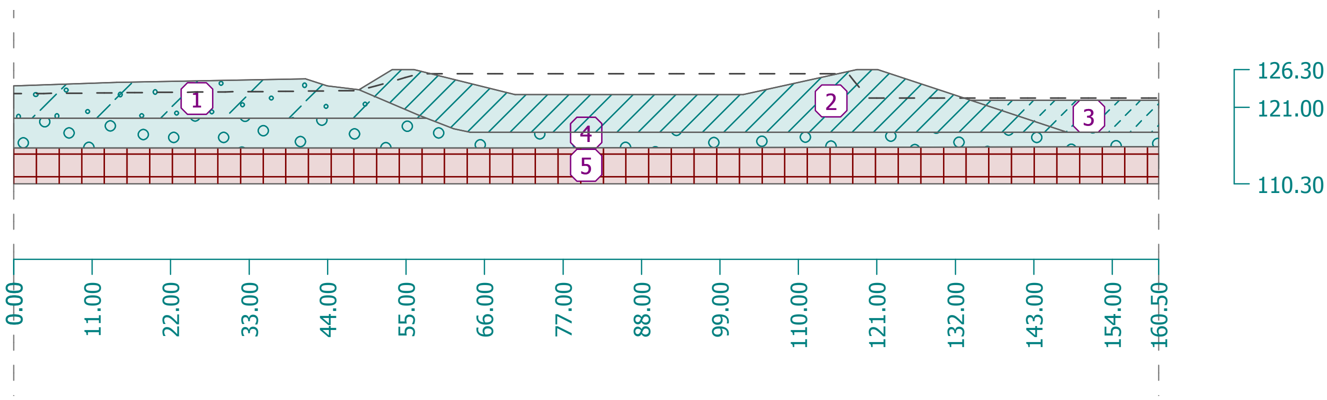
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		48.42	123.50	53.06	126.30	56.12	126.30
		70.25	122.80	70.38	122.80	102.27	122.80
		118.18	126.30	121.14	126.30	134.18	122.00
		160.50	122.00				
2		134.18	122.00	147.68	117.50		

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

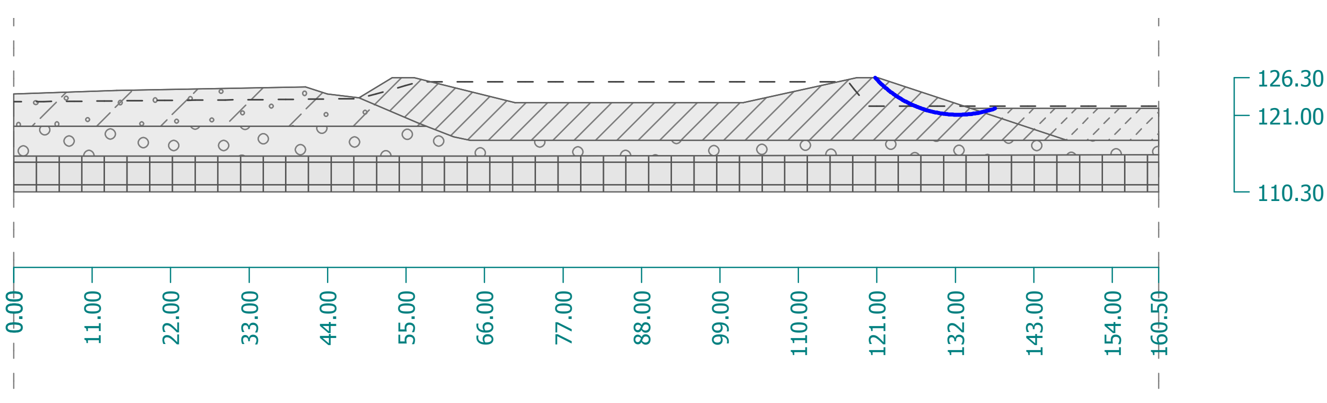
Sliding moment : M_a = 1895.11 kNm/m

Resisting moment : M_p = 3629.32 kNm/m

Factor of safety = 1.92 > 1.50

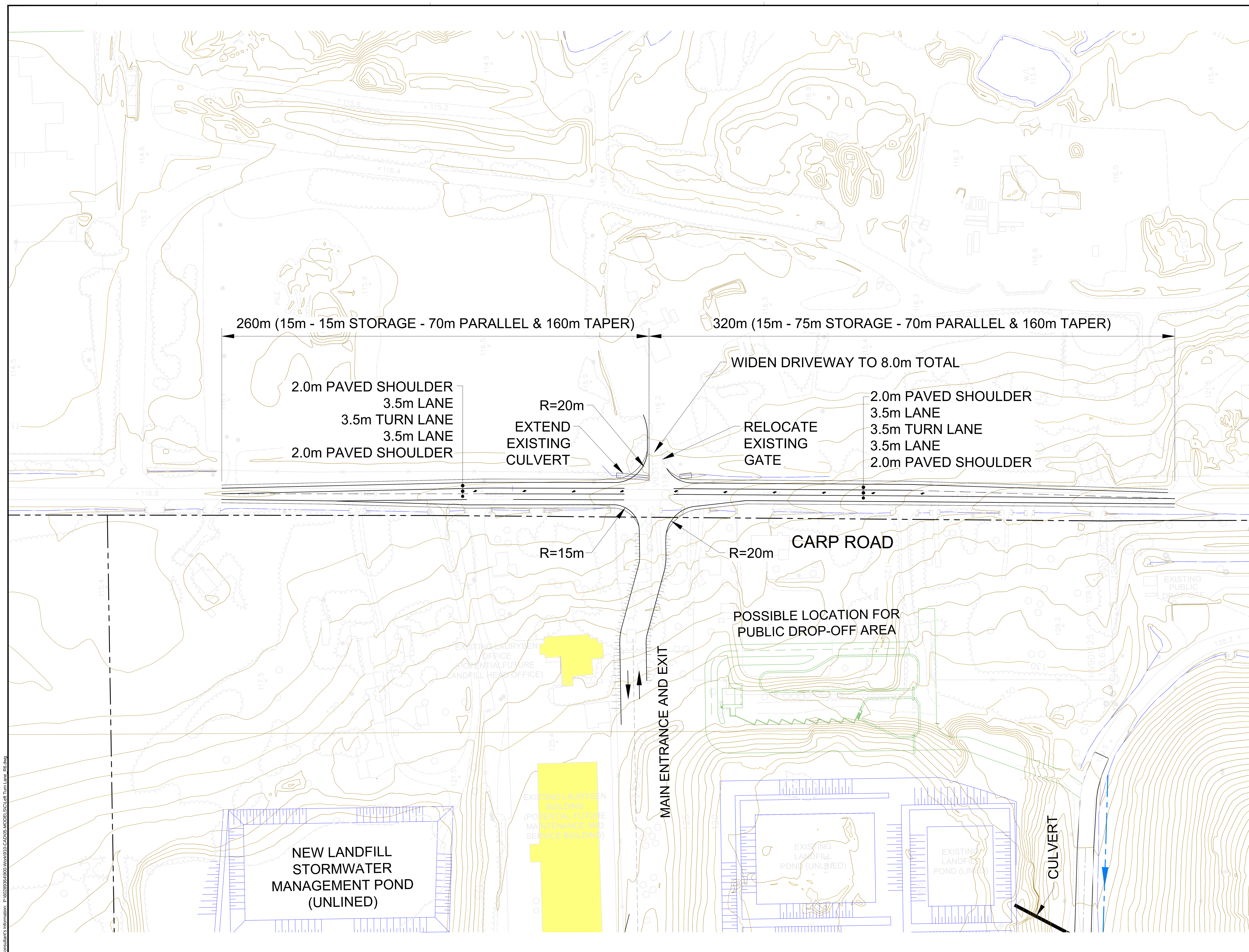
Slope stability ACCEPTABLE

Name : Analysis | **Stage - analysis : 2 - 1**



Appendix 3-C

Figure 3 (Modified) entitled, Carp Road - Proposed Northbound Left Turn Lane Concept Plan from Complete Zoning Bylaw Amendment Submission to the City of Ottawa (Transportation Impact Study)



NOTE :

IT IS THE RESPONSIBILITY OF THE CONTRACTORS TO INFORM THEMSELVES OF THE EXACT LOCATION OF, AND ASSUME ALL LIABILITY FOR DAMAGE TO ALL UTILITIES, SERVICES AND STRUCTURES WHETHER ABOVE GROUND OR BELOW GRADE BEFORE COMMENCING THE WORK. SUCH INFORMATION IS NOT NECESSARILY SHOWN ON THE DRAWING, AND WHERE SHOWN, THE ACCURACY CANNOT BE GUARANTEED.

WITH THE SOLE EXCEPTION OF THE BENCHMARK(S) SPECIFICALLY DESCRIBED FOR THIS PROJECT, NO ELEVATION INDICATED OR ASSUMED HEREON IS TO BE USED AS A REFERENCE ELEVATION FOR ANY PURPOSE.

Scale 1 : 1000

0 10 25 50 75

No.	DATE	BY	ISSUES / REVISIONS
1	Jan. 2014	VM	Revised Entrance

AECOM

AECOM Canada Ltd.
1150 Morrison Drive, (302), Ottawa, Ontario, Canada K2H 8S9
T613.820.8282 F613.820.8338

CLIENT:

WASTE MANAGEMENT

PROJECT:

WEST CARLETON ENVIRONMENTAL CENTRE

DRAWING:

CARP ROAD PROPOSED NORTHBOUND LEFT TURN LANE CONCEPT PLAN

DRAWN BY:	CHECKED BY:	PROJECT No.:
L. Huijer	V. Skelton	60191228
DESIGNED BY: L.Huijer	APPROVED BY: .	DRAWING No. .
SCALE: N/A	DATE: December 2011	

Consultant's Information: P:\60289364\900-Work\910-CAD\05-MODELS\C\Left Turn Lane_R6.dwg

Appendix 4

Appendix 4-A

Landscape Development Plan Concept, prepared by AECOM[Ref. 8]

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Do not scale this document. All measurements must be obtained from stated dimensions.

LEGEND:
- EXISTING VEGETATION TO BE PROTECTED AND PRESERVED
- PROPOSED CONIFEROUS TREE PLANTING
- PROPOSED DECIDUOUS TREE PLANTING

AECOM

AECOM Canada Ltd.
1150 Morrison Drive, (302), Ottawa, Ontario, Canada K2H 8S9
T613.820.8282 F613.820.8338

No.	DATE	BY	ISSUES / REVISIONS
1			

CLIENT: WASTE MANAGEMENT

DRAWN BY: A. BECKING
CHECKED BY:
DESIGNED BY: A. BECKING
APPROVED BY:
SCALE: 1:2000
DATE:

PROJECT: Waste Management of Canada Corporation
West Carleton Environmental Centre

DRAWING: LANDSCAPE DEVELOPMENT PLAN CONCEPT

PROJECT No.: 690289364

DRAWING No.:

Appendix 4-B

Specifications and CQA/CQC Program for Liner Systems, WCEC Landfill Expansion Area

Appendix 4-B

Specifications and CQA/CQC Program for Liner Systems WCEC Landfill Expansion Area

1. Introduction

The engineered landfill base is to comply with the MOE Landfill Standards Generic Option II Double Liner, including a 1 m attenuation layer. This includes the attenuation layer, a secondary clay liner, secondary drainage layer system, primary clay liner, and primary drainage layer, including all associated geotextiles, high density polyethylene (HDPE) liners, and leachate collector systems.

The CQA/CQC requirements were developed considering the following technical guidance documents:

- Landfill Standards (MOE 1998 and updated January 2012);
- Geosynthetic Institute Specifications (online);
- Quality Assurance and Quality Control for Waste Containment Facilities, US EPA 600/R-93/182; and
- Design, Construction and Evaluation of Clay Liners for Waste Management Facilities, US EPA 530/SW-86/007F.

2. Objectives

It is the objective to outline a system of inspections and testing activities, prepared in advance of construction, to provide acceptable workmanship and compliance with the design specifications, and provide documentation of the "as constructed" liner system. Specific objectives are as follows:

- to use suitable borrow materials to construct the engineered landfill base;
- properly place and compact clay liner materials;
- properly place drainage and HDPE liner systems; and
- protect liners and drainage systems.

Inspection procedures of the landfill base (subgrade), various liner system materials, conformance with specifications, processing to achieve geotechnical design criteria, proper placement and compaction of liner materials, proper placement and joining of liner systems, placement and joining of drainage layers, and protection of liner and drainage systems from potential damage during construction activities and localized environmental factors are envisaged.

3. Ontario Provincial Standard Specifications

Certain Ontario Provincial Standard Specifications (OPSS) apply to the work, and in particular the following sections:

- OPSS 206 Grading
- OPSS 212 Borrow
- OPSS 501 Compacting
- OPSS 802 Topsoil
- OPSS 804 Seed and Cover
- OPSS 1004 Aggregates – Miscellaneous

4. Landfill Subbase

The landfill expansion will be set on native sands and silts.

The landfill subbase will be inspected and constructed as follows:

- Any organic lenses, topsoil, loose fill and contaminated fill should be removed and properly filled where required with on-site or imported material, placed in lifts no thicker than 200 mm and compacted to 98% SPMDD.
- Compact the exposed subgrade to 98% SPMDD before any fill placement.

Appropriate survey methods (laser, total station, GPS, etc.) should be used for grade control within the design tolerances.

Landfill subgrade soil should be prepared with appropriate compactors, with a smooth drum used on the top lift to create a uniform landfill base. The final subgrade should be smooth graded in accordance with the elevations of the contract drawing.

5. Attenuation Layer

The material for the attenuation layer can be on-site material or imported material, provided it has appropriate permeability characteristics with a maximum permeability of 1 x 10^{-7} m/s, and is of appropriate uniform composition to provide reasonable construction handling and installation, requiring neither excessive drying, or wetting and reworking.

Generally, materials from on-site are not anticipated to be satisfactory for the attenuation layer, containing materials with excessively high permeability. Acceptable material will be tested considering the below frequency and will have the characteristics as outlined below.

CQA/CQC tests should be carried out as follows:

Parameter (ASTM reference	**Test Frequency**	**Criteria**
Water Content (ASTM D2216, D4643)	1 test per 4,000 m^3	-2 to +1% of optimum
Atterberg Limits (ASTM D4318)	1 test per 10,000 m^3	Plasticity Index (I_P) >10%
Particle Size Distribution (ASTM D422)	1 test per 10,000 m^3	Per below particle size dist.
Compaction Curve (ASTM D698, D1557)	1 test per 10,000 m^3	Material specific
Hydraulic Conductivity (ASTM D5084)	1 test per 25,000 m^3	$\leq 1 \times 10^{-7}$ m/s

Particle size distribution for the attenuation layer is to comply with the following:

Sieve Size (mm)	**% Passing**
106	100
4.75	85 – 100
1.18	70 – 95
0.3	58 – 85
0.075	45 – 70
0.002	5 – 25

CQA/CQC test data and observation of borrow excavation, based on ASTM D2488 procedures, are required to confirm that acceptable materials are used in the attenuation layer.

Temporary stockpiles shall employ protective measures and monitoring to protect the material such that it is usable when required. Measures could include grading, drainage, silt fence placement, or moisture addition.

6. Clay Liner Material

The material for the primary and secondary clay liners shall be imported. Index properties of the material, including grain size distribution, Atterberg limits, unit weight, porosity, and optimum moisture content, shall be obtained from the borrow source prior to soil delivery to the site.

Silty clay liner material shall have a hydraulic conductivity of less than 1 x 10^{-9} m/s.

Based on testing, the moisture content of the soil shall be above the plastic limit, favourable for remolding and recompaction of the low hydraulic conductivity liner. The material shall be free as possible from gravel or cobbles, which could require picking or rock removal from liners, particularly near the upper 150 mm.

The following test for material for liners shall be followed:

Parameter (ASTM reference	Test Frequency	Criteria
Water Content (ASTM D2216, D4643)	1 test per 2,000 m^3	+1 to +3% of optimum
Atterberg Limits (ASTM D4318)	1 test per 2,000 m^3	Plasticity Index (I_P) >10%
Particle Size Distribution (ASTM D422)	1 test per 2,000 m^3	Per below particle size dist.
Compaction Curve (ASTM D698, D1557)	1 test per 5,000 m^3	Material Specific
Hydraulic Conductivity (ASTM D5084)	1 test per 10,000 m^3	≤1 x 10^{-9} m/s

Particle size distribution for the liner material is to comply with the following:

Sieve Size (mm)	% Passing
100	100
4.75	96 – 100
0.075	70 – 100
0.002	25 - 60

Test data and observations for the liner material, based on ASTM D2488 procedures, are required to confirm that acceptable plastic soils are used for the liner. Reference standards and guidelines recognize that borrow material is variable with some test results falling outside of prescribed ranges. The proposed CQA/CQC plan should consider failing material tests in accordance with US EPA recommendations for maximum allowable percentages of outliers, which typically range from 5 to 10 percent depending on the quality parameter.

Depending on construction phasing, it is anticipated that clay liner material may have to be segregated and temporarily stockpiled on the site prior to liner installation. Protective measures for material stockpiles should be monitored during the CQA/CQC program, to document soil conditions and to reduce processing requirements during liner construction. Protection measures should consider: grading, drainage, silt fence replacement, or moisture addition.

7. Primary and Secondary Clay Liners

7.1 Primary and Secondary Clay Liners CQA/CQC

The CQA/CQC plan for the clay liner systems will address the following:

- processing;
- placement of loose lifts;
- compaction;
- final lift thickness;
- protection; and
- hydraulic conductivity testing

7.1.1 Processing

Processing of the liner material involves adjustment of water content, removal of oversize material, and reduction of clod size.

Provided that water content of the liner soil does not have to be reduced by more than about 3% for optimum compaction, it should be acceptable to spread the material in loose lifts to construct the liner. Otherwise a temporary drying area may be required, however, this can be done as part of the liner construction (i.e. leave a loose lift to dry for several hours prior to compaction). Alternately, if the material is too dry, or dries in hot weather conditions, moisture may have to be added. Moisture addition typically requires use of spray bars and thorough soil mixing, and proper hydration may take in excess of 24 hours. A function of the CQA/CQC testing program will be to ensure that liner material is not compacted until the soil moisture content is within the acceptability range. The water source and quality should be determined in advance of construction as part of the final CQA/CQC plan.

It is preferable that particle size distribution data indicate that removal of oversized material from the liner material is minimal, if any. Cobbles larger than 100 mm in diameter shall be removed from the liner. This criterion will be evaluated and a cobble removal and CQA/CQC program be developed as part of the borrow material source selection.

The maximum permitted clod size in processed silty clay for liner lift construction is 100 mm. Larger clods potentially affect the integrity of the liner and increase bulk hydraulic conductivity. Processing of liner material to reduce clod size potentially involves pulverization, discing, rototilling and/or other mechanical methods. It is noted that clods of soil greater than 100 mm that are drier than design moisture may not be present in the loose lifts, at the time of compaction of the liner. Confirmation and documentation of acceptable clod size involves continual supervision by the CQA/CQC inspector.

7.1.2 Placement of Loose Lifts

CQA/CQC for loose lift placement involves continuous supervision by the inspector, to confirm acceptable lift thickness and material properties, as well as confirmation of no dry soil clods greater than 100 mm prior to compaction. The CQA/CQC inspector should document weather conditions at the time of placement and confirm no liner contamination, such as sand and gravel. Recommended loose lift thickness not greater than 150% of the target compacted lift thickness. Note that the loose lifts should not be placed thicker than 150% of the length of the compactors ‘sheepsfoot’. It is noted that the first lift of the primary liner is considered a sacrificial lift to protect the underlying geosynthetic materials from damage by the sheepsfoot compactor. Therefore, the first lift needs to be compacted approximately 200% (or more if required) of the length of the compactors ‘sheepsfoot’ (i.e. a double- thick lift or more). The upper portion of this initial lift is checked for compliance with CQA/CQC criteria, as detailed in these specifications.

Lifts that are exposed for greater than 48 hrs, or are subject to precipitation, excessive drying, or freeze/thaw, should be reworked prior to placement of the subsequent lift. This reworking should include scarifying and recompacting the lift in accordance with design specifications prior to placing the next lift. It is noted that after a lift is placed and verified to be constructed to proper compaction and moisture, the soil can dry out to approximately 4% below optimum (material dependent) without cracking or negatively affecting the hydraulic conductivity. This effect is not observed for soil exposed (i.e. uncovered) to the atmosphere. Where this effect occurs, the soil will not require repair, as determined by CQC personnel or the design engineer. However, if adding an additional clayey soil lift overtop, the upper 50 mm of the drier than optimum moisture will need to be rehydrated to +1 to +3% of optimum moisture to facilitate proper lift kneading.

7.1.3 Compaction

Subject to the design specifications, it is recommended, based on acceptable results for other similar compacted clay liners constructed in 100 mm thick lifts that a sheepsfoot compactor of suitable size should be utilized with roller feet of 100 mm to 150 mm long to penetrate the entire lift thickness in order to apply kneading of the upper lift to the lower lift. It is noted that alternate machinery (heavier and longer feet) may be used, upon demonstrated adequate liner construction.

Machine speed should be controlled to ensure adequate penetration, kneading, and compaction. The number of machine passes should be approximately six and adjusted (up or down) as required during construction, depending on CQA/CQC test results, but should be at least four per lift. The passes should not be in the exact same path for each pass in order to increase the area covered by the kneading process by the 'sheepsfoot'. Three observations of machine passes per hectare per lift will be completed to verify the consistency of the kneading/compaction process.

It is recommended that CQA/CQC testing of compacted soil be performed using a grid or random sampling method. Grid stakes should be avoided as they penetrate and create holes in the liner. Holes from grid stakes or other source (i.e. CQA/CQC testing equipment) shall be backfilled with bentonite chips. The testing is as summarized below.

Parameter (ASTM ref. method)	Test Frequency	Criteria
Rapid Density Tests (ASTM D2922)	13 test per hectare per lift	98% SPMDD
Rapid Moisture Tests (ASTM D2922)	13 test per hectare per lift	+1 to +3% of optimum
Water Content Test (ASTM D2216)	2 tests per hectare per lift	+1 to +3% of optimum
Density Test (ASTM D1556 or D2167)	1 test per hectare per lift	98% SPMDD

Adjustment of testing frequencies may be required in the field, subject to test results, at the discretion of the CQA/CQC inspector. Additional testing may also be required to define non-conforming areas and to facilitate necessary repairs.

7.1.4 Compacted Lift Thickness

The minimum thickness of the clay liner is 750 mm and shall be constructed in a minimum of five lifts. As discussed, to prevent damage to the underlying materials, the first lift needs to be compacted approximately 200% (or more if required) of the length of the compactors 'sheepsfoot' (i.e. a double- thick lift or more). It is suggested that the following US EPA recommended tolerance be used: up to 5 percent of lift thickness determinations are permitted to be out of specification, but by no more than 25 mm at any location. Loose and compacted lift thickness should be evaluated by the CQA/CQC inspector by direct measurements and appropriate elevation survey techniques during construction.

7.1.5 Protection

Following placement and compaction, it is important that the constructed liner be protected from environmental factors, such as desiccation and freezing. The liner lifts should be rolled to create a thin dense skin during the protection period (note a sheepsfoot compactor makes a thin dense skin to a lift). The final lift shall be graded and proof rolled to remove the undulations from the compactor's feet to facilitate water drainage. Water may be added to keep the liner moist. Alternately, the liner can be covered with a plastic sheet to reduce evaporation. Accumulated surface water should be controlled by pumping off the water to prevent softening.

Regular inspections of liner protection are part of a CQA program, and the inspector should be aware of environmental factors that will potentially damage the liner. These conditions should be addressed, and corrective procedures, such as soil recompaction or replacement, should be undertaken if it is determined that unacceptable damage effects have occurred.

7.1.6 Hydraulic Conductivity

US EPA reference documents indicate that liner hydraulic conductivity testing on small laboratory specimens is a useful guide, but does not necessarily ensure that the full scale field hydraulic conductivity of the liner is sufficiently low. Thus, the focus of the CQA/CQC program should be on the quality of the liner material and construction procedures. Laboratory hydraulic conductivity testing should be completed in accordance with the following program to evaluate the acceptability of the low permeability liner.

Parameter (ASTM reference method)	Test Frequency	Criteria
Shelby Tube Samples and Laboratory Testing (ASTM D1587 and D5084)	2 tests per hectare	$\leq 1 \times 10^{-9}$ m/s

8. HDPE Liners

8.1 Supply of Primary and Secondary HDPE Liners

Primary HDPE liner shall be 60 mil (1.5 mm) thickness. Secondary HDPE liner shall be 80 mil (2 mm) thickness. All material supplied for slopes shall be of the same thickness for each relevant liner, textured (both sides) and extend to the base as indicated on the contract drawings. Textured material to be of same product as the parent HDPE liner material.

8.1.1 Material Classification and Formulation

This specification covers high density polyethylene geomembrane with a formulated sheet density of 0.940 g/cm^3 or higher (ASTM D1505 or ASTM D792 method B). Resin shall be tested by the manufacturer and certified copies of such tests for lot(s) supplied shall be submitted.

The polyethylene resin from which the geomembrane is made shall generally be in the density range of 0.932 g/cm^3 or higher, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min.

The resin shall be virgin material with no more than 10 percent rework. If rework is used, it must be a similar HDPE as the parent material. No post-consumer resin of any type shall be added to the formulation.

8.1.2 Physical, Mechanical and Chemical Property Requirements

- thickness (ASTM D5199): 1.5 mm or 2 mm as required (-10%) minimum average, testing frequency every roll
- density (ASTM D1505): 0.94 g/cm^3 minimum, testing frequency - 90,000 kg
- carbon black content (ASTM D4218): 2 to 3%, testing frequency - 9,000 kg
- carbon black dispersion (ASTM D5596): Nine (9) of ten (10) views shall be in Category 1 or 2. No more than one (1) view in Category 3. Applies to near spherical agglomerates. Testing frequency: 20,000 kg
- tensile properties (ASTM D6693, Type IV) Testing frequency: 9,000 kg
  - yield strength: 22 kN/m (1.5 mm); 29 kN/m (2.0 mm) minimum average
  - break strength: 40 kN/m (1.5 mm); 53 kN/m (2.0 mm) minimum average
  - yield elongation: 13% minimum average
  - break elongation: 700% minimum average
- tear resistance (ASTM D1004): 187 N (1.5 mm); 249 N (2.0 mm) minimum average, testing frequency - 20,000 kg
- puncture resistance (ASTM D4833): 480 N (1.5 mm); 640 N (2.0 mm) minimum average, testing frequency - 20,000 kg
- Material shall comply with the latest version of the Geosynthetic Research Institute (GRI) specification GM 13 for oven aging at 85ºC for oxidative induction time (OIT).

Specifications for textured HDPE liner are the same as above except thickness, which is tested according to ASTM D5994 and shall be as follows:

- nominal thickness 1.5 mm (-5%); 2.0 mm (-5%) minimum average; and
- the lowest individual reading for any of the 10 values shall not be less than 15% of nominal thickness.

A manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment. HDPE shall be rolled on cores with a minimum outside diameter of 150 mm.

8.1.3 Seam Characteristics (ASTM D6392)

- Hot Wedge Seams
  - shear strength per 25 mm width: 525 N (1.5 mm); 701 N (2.0 mm)
  - shear elongation at break: 50%
  - peel strength per 25 mm width: 398 N (1.5 mm); 530 N (2.0 mm)
  - peel separation: 25%
- Extrusion Fillet Seams
  - shear strength per 25 mm width: 525 N (1.5 mm); 701 N (2.0 mm)
  - shear elongation at break: 50%
  - peel strength per 25 mm width: 340 N (1.5 mm); 455 N (2.0 mm)
  - peel separation: 25%

Note 1: Value listed for shear and peel strengths are for 4 out of 5 test specimens; the fifth specimen can be as low as 80% of the listed values.

Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D6392 (in this regard, separation in place (SIP) is an acceptable break code):

Hot wedge: AD and AD-Brk >25%
Extrusion Fillet: AD1, AD2 Exception: AD-WLD (unless strength is achieved)

SIP is a locus-of-break where the failure surface propagates within one of the seamed sheets during destructive testing (usually in the peel mode). SIP is acceptable if the required strength, shear elongation and peel separation criteria are met.

8.1.4 Extrudate Rod or Bead

Extrudate material shall be made of the same type of resin as the geomembrane. Additives shall be thoroughly dispersed. Material shall be free of contamination by moisture or foreign material.

The Contractor shall submit the HDPE liner specifications for approval. The supplied HDPE liner shall conform to the approved HDPE liner manufacturer's specifications, which may be more stringent than some of those above.

8.1.5 Transportation, Handling and Storage

HDPE liner shall be supplied in rolls. Labels on each roll shall identify the thickness of the material, roll dimensions, lot and roll number, product and manufacturer's name and mass of roll.

The Contractor shall unload and handle the bulk material on site in accordance with the manufacturer's instructions. During storage, geosynthetic rolls shall be elevated off the ground and adequately covered to protect them from the following:

- site construction damage;
- ponded water;
- extended ultraviolet radiation, including sunlight;
- chemicals that are strong acids or strong bases;
- flames, including welding sparks; and
- any other environmental condition that may damage the property values of the geosynthetic.

The Contractor shall conduct a visual inspection of the surface of all rolls for defects and damage. Report all damage to the supplier, and to the carrier, if believed due to the transportation of the material.

Ensure that equipment used to unload or handle the material is adequate and safe. Carefully supervise the unloading and handling to ensure that the material is handled with care and not damaged. The Contractor will assist the Engineer in processing samples for conformance testing.

The Contractor will arrange with the Owner sufficient storage space in a location(s) near the job site and protect it from vandalism and other hazards, which might pose a threat to the material.

8.2 Placement of HDPE Liner

The HDPE liner shall be installed by a qualified contractor, approved by the HDPE liner manufacturer.

8.2.1 Acceptance of Laying Surface

The Contractor shall be responsible for preparing and maintaining the subgrade in a condition suitable for the installation of the HDPE liner.

The soil surface to be lined shall be firm and unyielding, sufficient to permit the movement of vehicles and welding equipment over the subgrade without causing rutting or other deleterious effects. The subgrade shall have no sharp or abrupt changes in the grade and be proof-rolled smooth

8.2.2. Preparation for Geomembrane Deployment

Prior to commencement of liner placement, the Contractor shall produce layout drawings to indicate the panel configuration and the locations of seams for the project. Such panel layout drawings shall be considered shop drawings and shall be submitted to the Engineer for review.

Each panel used for the installation shall be given a number or alphanumeric identifier consistent with the layout drawing. This identification number shall be related to the manufacturing roll number that identifies the resin type, lot number and date of manufacture. The Contractor shall be responsible for writing the roll number on each installed panel and unused roll.

The Contractor shall install the field panels in the location indicated on the layout drawings. Any revision to the location other than indicated on the layout drawings shall be noted and revised in the field on a layout drawing, which will be modified at the completion of the project to reflect actual panel locations.

8.2.3 Placement of Liner

Do not place geomembrane during precipitation, in the presence of excessive moisture such as fog or dew, in an area of stranding water or during high winds.

Provide and place adequate temporary loading and/or anchoring (sand bags, tires, etc.), which will prevent damage to the geomembrane and prevent uplift of the geomembrane by wind.

Place geomembrane in a manner to minimize wrinkles, but when placed must provide sufficient allowance for expansion and contraction of the material. Place the material such that it is not wrinkled/creased, but with sufficient slackness to prevent bridging and excessive tension.

Place panels adjacent so the overlaps created by fusion welding shall not obstruct downgradient water flow.

Protect the geomembrane in areas of heavy traffic by placing a protective cover (i.e. extra geotextile cushion) over the membrane.

Any area of panel seriously damaged by tearing, twisting, crimping, etc., shall be marked, cut out and removed from the work area, replaced with new material, with the resulting seams and repairs prepared in accordance with the following specifications.

8.2.4 Field Seaming

Place panels and orient seams parallel to the slope, i.e., oriented along and not across the slope. Where possible, horizontal seams should be placed not less than 1.5 m from the toe of slope. Number each seam consistent with the panel layout drawing for documentation of seam testing results. In addition, the following information shall be written beside the beginning of each seam:

- welder technician's name;
- machinery type and number;
- date and hour of installation; and,
- temperature settings on the welding machine and direction of travel.

All personnel performing seaming operations shall be skilled and trained in the operation of the specific seaming equipment being used and will demonstrate such skill by successfully welding a test seam. The Installer crew supervisor shall provide direct supervision at all times of all seaming personnel to verify proper welding procedures are being followed.

8.2.5 Equipment

Fusion Welding

Fusion welding consists of placing a heated wedge mounted on a self-propelled vehicular unit between two overlapped sheets such that the surface of both sheets is heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels that compress the two panels together so that a continuous homogenous fusion weld is performed. The fusion welder shall be equipped with an electronic controller, which continuously monitors the temperature of the wedge.

Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two sheets to be welded. The molten polymer causes some material of each sheet to be liquefied resulting in a homogenous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

Generally, seams shall be fusion welded with a double fusion weld with an air test channel between the two welds, which can be non-destructive tested. Extrusion fillet welding shall be employed where double wedge fusion welding cannot be employed, such as to repair test sections.

8.2.6 Seam Preparation

For each method, weather conditions shall be such that seaming produces quality seams.

Fusion Welding

Overlap the panels of the geomembrane approximately 100 mm or as recommended by the manufacturer. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. Grinding is not required for fusion welding.

Adjust the panels so that the seams are aligned with the fewest number of wrinkles and "fish mouths".

A movable protective layer may be required directly below the overlap geomembrane that is to be seamed, to prevent the build-up of moisture between the panels and to protect the underlying liner system.

Extrusion Welding

Overlap the panels of the geomembrane a minimum of 75 mm or as recommended by the manufacturer.

Temporarily bond "tack" the panels of the geomembrane to be welded taking care not to damage the geomembrane.

Grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Grinding shall not materially diminish the liner thickness.

Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt and debris of any kind.

Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel.

Keep the welding rod clean, dry and off the ground.

8.2.7 Test Seams

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day, or if significant weather conditions, equipment, or welding personnel have changed since the last calibration/verification.

Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

The test seams shall be at least 3 m long and shall be made by joining two (2) pieces of the geomembrane approximately 225 mm to 300 mm in width each (or as necessary for testing in the field).

Visually inspect the seam for squeeze-out, footprint, pressure and general appearance.

Five (5) random samples 25 mm wide shall be cut from the test seam. The specimens shall be tested in a peel using a field tensiometer. Trial weld specimens shall pass when all seam strength specifications are met. All test results shall be recorded. If a specimen fails any tests, the entire calibration/verification procedure shall be repeated.

If any of the second test specimens fail, the seaming apparatus shall not be acceptable and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved

After successful completion of the test, the remaining portion of the test seam can be discarded. The Contractor will maintain documentation of the test seams, listing the seamer's identification number, date and time, welders name, temperature control setting and test results.

Records of passing test results shall be maintained on the Engineer's or the manufacturer's suggested forms. These and other test results shall be permanently documented and submitted to the Owner at the completion of the project.

8.2.8 General Seaming Procedure

Seams must extend 300 mm minimum into the anchor trenches. The liner at the bottom of an anchor trench shall not be seamed to allow water trapped in the trench to infiltrate into the soil below the liner. Alternatively, extend seams as far as feasible into the anchor trenches and later puncture liner at the trench bottom to avoid accumulation of rainwater.

While welding a seam, monitor and maintain the proper overlap.

Inspect seam area to assure area is clean and free of moisture, dust, dirt and debris of any kind.

While welding a seam, monitor temperature gauges and speed to assure proper settings are maintained and that the seaming apparatus is operating properly.

Align wrinkles at the seam overlap to allow welding through the wrinkle.

"Fish mouths" or wrinkles at seam overlaps that cannot be welded through shall be cut along the ridge to achieve a flat overlap. The cut "fish mouth" or wrinkle shall be seamed. Any portion where the overlap is inadequate for extrusion welding shall be patched with an oval or a round patch of the same geomembrane extending a minimum of 150 mm beyond the cut in all directions.

All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld and grind off 50 mm minimum from either side of the wedge-welded seam. Extrusion weld all the areas prepared by the grinding.

8.2.9 In-Place Seam Testing

The Contractor shall non-destructively test all field seams over their full length using air pressure, vacuum testing or other approved methods to verify the continuity and integrity of all seams.

8.2.10 Air Pressure Testing

All fusion seams with an air channel shall be air tested in accordance to ASTM D5820. The central unwelded channel shall be tested by inflating the sealed channel with air and observing the stability of the pressurized channel over time.

Equipment for Air Testing

- air pump, manual or motor driven, capable of generating and sustaining a pressure of 350 kPa (50 psi);
- sealing equipment appropriate to seal the two (2) ends of the air channel;
- sharp hollow needle to insert air into the open channel and to allow monitoring its pressure; and
- pressure gauge capable of indicating the air pressure in 7 kPa (1 psi) within the test range.

Procedure for Air Testing

Seal both ends of the seam to be tested.

Connect the pressure gauge directly to the air channel.

Connect an air pump to the pressure gauge with a flexible hose via a quick connect and pressurize the air channel to the pressure appropriate for the geomembrane type (210 kPa (30 psi)).

Remove the flexible hose that connects the air channel to the pressure gauge. Following pressure stabilization, observe the air pressure gauge for the desired test time. The test time should be a minimum of two (2) minutes. Mark the time and pressure of the beginning and end of the test. The maximum allowable pressure drop (14 kPa (2 psi)) may be compared to the maximum allowable value.

If the pressure does not drop below the maximum allowable value after the specified test period, open the air channel at the end, away from the pressure gauge. Air should rush out and the pressure gauge should register an immediate drop in pressure, indicating that the entire length of the seam has been tested. If this does not happen, either the air channel is blocked or the equipment is faulty, and the test is not valid. Attempt to locate the problem and retest the seam in accordance with the project specifications.

If the pressure drop is greater than the maximum allowable value after the test period, check the seals of the air channel. Reseal these areas if a leak is noticed, and then repeat the entire test.

If significant changes in the geomembrane temperature occur during pressure testing (for example, cloud cover or other shading), a variation in channel pressure may be recorded due to expansion or contraction of the air channel. If an increase or decrease in temperature is suspected of having caused a pressure variation, repeat the test after the geomembrane temperature has stabilized.

Any dual seam that cannot be successfully tested using this practice should be marked and tested using another non-destructive testing practice, when possible.

If the test fails, follow one or more of these procedures:

1. While the channel is under pressure, walk the length of the seam listening for a leak.

2. While the channel is under pressure, apply a soapy solution to the seam edge and look for bubbles formed by air escaping.

3. Retest the seam in smaller increments until the leak is found.

Once the leak is found using one of the procedures above, cut out the leak area and retest the portions of the seams between the leak areas. Continue this procedure until all sections of the seam pass the pressure test.

Repair the leak and test repaired area.

If it is impossible to achieve successful air test results over any reasonable length of seams such that repair by extrusion weld shall be longer than 15 m, the entire defective seam shall be removed and a strip of geomembrane shall be installed with two (2) new fusion welds. The new welds will then be air pressure tested as per above.

8.2.11 Vacuum Testing

This test shall be used when the geometry of the weld makes air pressure testing impossible or impractical. The test shall be carried out in accordance to ASTM D5641.

Equipment for Vacuum Testing

- a vacuum box assembly consisting of a rigid housing, transparent viewing window, a soft pliable gasket attached to the bottom, porthole or valve assembly and a vacuum gauge;
- a vacuum pump assembly equipped with a pressure controller;
- a rubber pressure/vacuum hose with fittings and connection;
- a bucket and means to apply a soapy solution; and,
- a soapy solution.

Procedure for Vacuum Testing

The area of the seam to be evaluated should be clean and free of soil or foreign objects that might prohibit a good seal from being formed between the vacuum chamber and the geomembrane.

Wet an area immediately adjacent to and including the geomembrane seam or test area measuring approximately twice the width and length of the vacuum chamber with a foaming solution.

Place the vacuum chamber over the wet area of the geomembrane such that the gasket is in complete contact with the surface, and the test area is centred under the viewing port.

Turn on vacuum pump and apply a normal force to the top of the vacuum chamber to affect a seal and open the vacuum valve.

Ensure that a leak tight seal is created between the vacuum chamber gasket and the geomembrane material. For most cases, a minimum vacuum of 28 to 55 kPa (4 to 8 psi) as registered on the vacuum gauge should be appropriate.

With the vacuum applied, maintain the normal force and observe the geomembrane seam or test area through the viewing port for bubbles resulting from the flow of air through defects in the seam. The vacuum should be held over the test site for a duration of not less than ten (10) seconds. If the vacuum cannot be held for the minimum ten (10) seconds, the test area should be marked as untested. It is essential that the viewing port remains clean at all times to facilitate unobstructed viewing.

If the bubbles appear on the geomembrane seam, turn the three-way vacuum valve to vent the chamber and remove the vacuum chamber from the seam. The defective area should then be marked for repair.

If the bubbles do not appear through the geomembrane seam or test area within the specified dwell time, turn the vacuum valve to vent the chamber from the seam.

Move the vacuum chamber to the adjoining portion of the seam or test area overlapping the previously tested area by a distance no less than 10 percent of the minimum chamber length or at least 50 mm, whichever is the greater and repeat the procedure until the entire seam has been tested and passed as acceptable.

8.2.12 Destructive Testing

Destructive testing shall be carried out in accordance with ASTM D6392 to determine and evaluate seam strength. Samples that are cut out shall receive subsequent patching and testing.

Procedure for Destructive Testing

Destructive test samples shall be marked and cut out randomly as determined by the CQC personnel. The frequency of destructive test samples will be calculated of one test location every 200 m of seam length or utilize the batch sample method of attributes described by Geosynthetic Institute's GRI GM14 document to potentially minimize the number of test samples taken, as determined by contractor performance.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystalline or other potential causes of faulty seams, as determined by the CQC personnel.

All destructive test locations shall be documented and recorded on the 'As Built' drawings.

The sample shall be 300 mm wide (minimum) with a seam 710 to 900 mm long centred lengthwise in the sample and cut in half. Otherwise the sample shall be as required for the independent test apparatus. One half of the cut sample shall be used for independent testing and the second half shall be left intact and archived by Owner/Contractor.

A 25 mm wide coupon shall be cut from each end of the test seam for field testing. The two samples shall be tested in the field in a tensiometer for peel. If any field sample fails, it will be assumed that the sample failed destructive testing. The failure procedure outlined in these specifications shall be followed to locate passing samples suitable for independent testing.

If the sample passes the field test, the sample shall be used for independent testing to evaluate seam strength, and to confirm field testing.

Ten (10) 25 mm wide samples shall be obtained from the independent destructive test sample. Five (5) samples shall be tested in tensiometer for shear and five (5) for peel. Passing results of destructive seam test must be obtained for 4 out of 5 samples when tested for peel and shear strength. The fifth result must meet or exceed 80% of the value specified in Section 8.1.3. Independent destructive seam testing shall be carried out in accordance with ASTM D6392.

8.2.13 Procedure in the Event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the sample must lay a minimum of 3 m in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then samples can be cut for independent testing.

If the samples passed independent testing, then repair the seam between the two passing sample locations.

If the length of seam to be repaired is longer than 15 m, the entire defective seam shall be removed and a strip of geomembrane shall be installed with two new fusion welds. The replacement fusion welds shall be tested for integrity according to these specifications.

If either of the samples fails, then additional samples will be taken in accordance with the above procedure, until two passing samples are found to establish the zone in which the seam should be reconstructed.

All failing seams must be bounded from each side by samples passing destructive tests even if that requires locating a passing sample on another seam joined on another day.

All destructive seam samples shall be numbered and recorded on the appropriate CQA/CQC forms.

8.2.14 Defects and Repair

Walkthrough and visually check all seams and non-seamed areas of the geomembrane for defects, holes, blisters and signs of damage during installation. All damaged areas shall be marked, repaired and tested.

Repair Procedure

Any portion of the geomembrane showing a flaw, or failing a destructive or non-destructive test, shall be repaired and tested. CQC personnel may decide and recommend the following:

- Patching is used to repair large holes, tears and destructive locations. All patches shall extend at least 150 mm beyond the edges of the defect and all corners of the patches shall be rounded.
- Grinding and welding is done to repair sections of extruded seams.
- Spot welding or seaming is used to repair small tears, pinholes or other minor localized flaws.
- Capping is used to repair lengths of failed extruded seams.
- Removal of a bad seam and replacement with a strip of new material seamed into place. This type of repair shall be required if the length of seam repair exceeds 15 m.

Every repair shall be non-destructively tested using the methods according to these specifications. Repairs that pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. The CQC personnel may call for destructive tests. Repair test results shall be logged on the CQC personnel's recommended form(s). All repair locations shall be recorded on the "As Built" drawings.

9. Geotextile Cushions

Geotextile cushion means geotextile filter cloth placed over the HDPE liners to protect the liner from the overlying drainage gravel material. Supply geotextile cushion in the weight specified on the drawings and specifications. Material may be installed in more than one (1) layer if more economical.

9.1 Material Specifications

Geotextile shall be nonwoven, needle-punched polypropylene with the characteristics specified in the contract with respect to the following:

- mass per unit area (ASTM D5261) - 1,288 g/m^2 (38 oz/sy) (secondary cushion), assuming angular stone shape. Provide as required in multiple textile layers. The cushion could be reduced to 610 g/m^2 (18 oz/sy) for round stone shape.
- mass per unit area (ASTM D5261) - 1,694 g/m^2 (50 oz/sy) (primary cushion). The above selection assumes angular stone shape. The cushion can be reduced to 610 g/m^2 (18 oz/sy) if round stone is used.

All geotextile cushion shall have sewn joints.

The following provisions apply to geotextile cushion and geotextile separator.

Geotextile Manufacturing Quality Assurance testing shall be performed at a frequency in accordance with ASTM D4354.

The geotextile manufacturer will issue a certificate stating the name of the manufacturer, product name and style number, chemical composition of the filaments and other pertinent information to describe the geotextile fully.

The manufacturer's certificate shall state that the finished geotextile meets MARV requirements of the specification as evaluated under the manufacturer's quality control program.

Geotextile labelling, shipment and storage shall follow ASTM D4873. Onsite storage will need to consider the protection of the geotextile from damage. Product labels shall clearly show the manufacturer or supplier name, style and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.

Each geotextile roll shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage due to shipment, water, sunlight and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.

During storage, geotextile rolls shall be stored and adequately covered to protect them from the following:

- site construction damage;
- ponded water;
- extended ultraviolet radiation, including sunlight;
- chemicals that are strong acids or strong bases;
- flames, including welding sparks; and

- any other environmental condition that may damage the property values of the geotextile.

10. Geotextile Separators

Provide geotextile separators over gravel drainage layers as shown on the drawings and specified in the contract documents.

10.1 Material Specifications

The geotextile separator shall be nonwoven, needle-punched. Material shall comply with the following requirements:

- AOS (ASTM D4751) – 0.21 mm maximum average roll value (Max ARV);
- permittivity (ASTM D4491) – 0.2 sec^{-1} Minimum Average Roll Value (MARV);
- mass per unit area (ASTM D5261) – 339 g/m^2 (MARV);
- grab tensile strength (ASTM D4632) – 900 N (MARV);
- tear strength (ASTM D4533) – 350 N MARV;
- puncture resistance (ASTM D4833) – 500 N (MARV);
- UV stability (ASTM D7238) – 50% at 500 hrs;
- elongation (ASTM D4632) – at least 50%; and
- CBR puncture strength (ASTM D6241) – 2,000 N (MARV).

Geotextile Manufacturing Quality Assurance testing shall be performed at a frequency in accordance with ASTM D4354.

11. Place Geotextile

For each of the secondary liner and the primary liner, place geotextile as indicated on the drawings. The following provisions apply to geotextile cushion and separator.

Handle geotextile in a manner to ensure it is not damaged.

All geotextile shall only be placed on subgrades approved by the CQA/CQC inspector. The subgrade is to be free from excess rutting and defects that could affect the geotextile function and that the geotextile is not damaged during installation. All of this will be documented in the CQA/CQC report. Also, document any potential for deleterious material trapped before the geotextile, geotextile anchoring details (temporary and permanent), trimming and cutting methods, seaming methods or overlap distances recorded, in accordance with design specifications, wind uplift protection during installation, and any repair areas for whatever means.

Place geotextile in such a manner to minimize folds and wrinkles.

Weigh geotextile with sand bags or equivalent to prevent wind displacement.

Use approved cutters (hook blade) for cutting geotextile. Use care to protect other underlying materials from damage. Do not entrap stones, dirt or other foreign material.

Geotextile shall be seamed by sewing. No horizontal seams shall be allowed on side slopes. Sew the seam along the entire length. Seam strength shall be equal to at least 90% of the parent material (ASTM D4632). Testing frequency will be one test per layer of geotextile cushion per construction year.

Overlap geotextile a minimum of 150 mm before seaming. Sewn seem to be a minimum of 75 mm from edge of geotextile. Any area that cannot be sewn, shall have a patch placed over it as detailed below.

Repair holes or tears by patching from the same geotextile, seam into place where any tear exceeds 10% of the width of the roll, and the roll shall be removed and replaced. A patch of the same geotextile material shall be spot seamed and placed with a minimum overlap of 600 mm in all directions.

Protect geotextile against damage after installation.

Ensure that all geotextile has sufficient slack to prevent bridging that could tear the material.

Geotextile must be installed in such a manner so they do not shift, or become overstressed or punctured during placement of overlying materials. Continuous CQA/CQC inspections are required during the geotextile backfilling/covering operations to document acceptable procedures and results.

The first lift of the primary clay liner is of concern, because compactor feet may potentially puncture and damage the geotextile or HDPE liner. The CQA/CQC inspector shall confirm the required double lift thickness is being implemented for the first lift such that the geotextile or HDPE liner will not be punctured or damaged during compaction.

12. Quality Assurance, Quality Control for Supply and Placement of Geosynthetics

CQC and independent testing personnel will act as a Quality Assurance Monitor. The CQC personnel will observe and inspect the placement of the various geosynthetic materials to verify the construction is carried out as specified. The independent testing personnel, where relevant, will carry out and document the findings of the tests outlined in these specifications for HDPE liners and geotextile layers, as well as other tests as specified.

Other installation/testing methods may be developed over time and may be approved for use at the site by the design engineer.

13. Drainage Layers

The landfill engineered base will include primary and secondary drainage layers that consist of clear stone. It is recommended that the drainage gravel as tested at the source have no more than 1 percent fines (particles finer than 0.075 mm. The gradation requirement for the drainage gravel is noted in the summary below:

Percent Passing (%)	Sieve Size (mm)
100	50
0 – 85	37
0 – 10	19
0 – 1	0.0075

The drainage gravel will also have a uniformity coefficient D_{60}/D_{10} of less than 2.0. Frequency of testing the drainage gravel will be once every 5,000 m^3 and be tested per ASTM D422.

The stone drainage layer should be protected from contamination by fines and loose waste, and significant crushing during delivery and placement. The US EPA recognizes that some material degradation will occur during material handling and therefore, every effort should be implemented to reduce material handling after delivery and stockpiling at the site to final resting position in the liner system.

Drainage gravel shall be installed without causing undue stress and displacement of the underlying materials, particularly HDPE liner. The Contractor shall utilize low ground pressure (LGP) earthmoving equipment for placement and spreading of gravel on the slope and base. Such equipment shall never operate on less than 300 mm of gravel. There is no compaction specification for placement of drainage gravel. The Contractor will be allowed to use wheeled equipment (trucks) for the supply of gravel material into the cell area, but because such equipment exerts much higher ground pressure, the use of trucks would be allowed only along the specially built, thick gravel ramps/roads. The required gravel thickness along such ramps shall be determined by a test strip and as approved by CQC personnel.

14. Certification

The CQA/CQC program for the landfill expansion liner shall include continuous construction oversight by a qualified technician.

On completion of each phase of the liner system and prior to installing the select waste layer, the CQA/CQC personnel shall certify the liner system. The certification report should summarize test data, and include 'As Built' drawings. A preparation report will be submitted to the MOE in accordance with Section 19 of Ontario Regulation 232/98. The preparation report will document the: 1) construction activities; 2) quality assurance and quality control (QA/QC) activities; and 3) provide a summary that confirms that the site conditions and details of the construction of each segment was in accordance with the design plans and specifications of the site.

Appendix 4-C

Geotextile Cushion Sizing

Appendix 4-C
Geotextile Cushion Sizing

Operational Conditions

Primary HDPE Liner 1.5 mm (60 mil) thick

Assume that subgrade (clay liner) is carefully prepared without any significant isolated protrusions underneath geomembrane.

The Narejo empirical formula defines the required unit mass of geotextile cushion, as follows:

$$m = \frac{FS \cdot P \cdot MF_S \cdot MF_{PD} \cdot MF_A \cdot FS_{CR} \cdot FS_{CBD} \cdot H^2}{450} = \frac{3 \cdot 434 \cdot 1 \cdot 0.5 \cdot 0.75 \cdot 1.1 \cdot 1.5 \cdot 25^2}{450} = \frac{503{,}507}{450}$$

$$= 1{,}119\ g/m^2$$

$say\ 1{,}152\ g/m^2$ (34 oz/sy) minimum

m - required mass of geotextile cushion per unit area [g/m^2].

FS - global factor of safety against geomembrane puncture – 3 minimum recommended value

P - pressure over geomembrane - 434 kPa

MF_S - modification factor for protrusion shape - 1 for angular stone

MF_{PD}- modification factor for packing density - 0.5 for uniformly packed stone

MF_A - modification factor for overburden arching effect - 0.75 moderate arching

FS_{CR} - reduction factor for long-term creep - 1.1 conservative value for geotextile having unit mass > 1,100 g/m^2

FS_{CBD}- reduction factor for long-term chemical/biological degradation - 1.5 for harsh leachate

H - effective protrusion height - 25 mm for maximum stone of 50 mm diameter

Secondary HDPE Liner 2.0 mm (80 mil) thick

Unit mass of geotextile cushion could be reduced due to increased thickness of the geomembrane by factor F equal to 0.75 (1.5/2.0).

$$m = \frac{FS \cdot P \cdot MF_S \cdot MF_{PD} \cdot MF_A \cdot FS_{CR} \cdot FS_{CBD} \cdot H^2 \cdot F}{450} = \frac{3 \cdot 434 \cdot 1 \cdot 0.5 \cdot 0.75 \cdot 1.3 \cdot 1.3 \cdot 25^2 \cdot 0.75}{450} = \frac{386{,}786}{450}$$

$$= 860\ g/m^2$$

$say\ 881\ g/m^2$ (26 oz/sy) minimum

m - required mass of cushion geotextile per unit area [g/m^2].

FS - global factor of safety against geomembrane puncture – 3 minimum recommended value

P - pressure over geomembrane - 434 kPa

MF_S - modification factor for protrusion shape - 1 for angular stone

MF_{PD}- modification factor for packing density - 0.5 for uniformly packed stone

MF_A - modification factor for overburden arching effect - 0.75 moderate arching

FS_{CR} - reduction factor for long-term creep - 1.3 conservative value for geotextile having unit mass <1,100 g/m^2

FS_{CBD}- reduction factor for long-term chemical/biological degradation - 1.3 for moderate leachate

H - effective protrusion height - 25 mm for maximum stone of 50 mm diameter

Construction Conditions

Primary HDPE liner 1.5 mm (60 mil) thick

Geomembrane puncture resistance P_t for selected geotextile cushion having unit mass of 1,119 g/m^2:

$$P_t = \frac{450 \cdot m}{H^2 \cdot MF_S \cdot MF_{PD} \cdot FS_{CR} \cdot F_{CBD} \cdot FS} = \frac{450 \cdot 1{,}119}{25^2 \cdot 1 \cdot 0.5 \cdot 1.1 \cdot 1.5 \cdot 6} = \frac{503{,}550}{3{,}094} = 163\ kPa$$

m – 1,119 g/m^2

H – 25 mm

MF_S – 1

MF_{PD} – 0.5

FS_{CR} – 1.1

FS_{CBD} – 1.5

FS – 6.0 increased factor of safety due to construction inaccuracies

- Dozer

Check dozer spreading stone operating over 0.3 m thick stone layer. Dozer contact ground pressure should be no more than 62 kPa (9 psi) which is valid for Caterpillar D6 dozer or lighter. In addition allow for dynamic stress factor to account for sudden braking and turning. Assuming conservative value of 1.5 we get modified contact stress of 93 kPa (1.5 · 62) which is significantly less than calculated puncture contact stress/geomembrane puncture resistance of 163 kPa. Selected geotextile cushion is adequate for stone placement with dozer having ground pressure of no more than 62 kPa (9 psi).

- Triaxial Truck

Check for triaxial truck delivering stone into cell. A triaxial truck has a maximum weight limit for a single axle of 9,000 kg in accordance with the Highway Traffic Act. Front axle will be critical as it has the smallest contact area with the ground surface. It is assumed that ground contact stress is equal to tire pressure 689 kPa (100 psi or 70,307 kg/m^2). In addition, allow for dynamic stress factor equal to 1.5 to account for sudden braking. Calculate puncture stress for stone ramp having thickness of 0.75 m. See table below.

Front Axle Load	**Contact Stress (Tire Pressure)**	**Single Tire Contact Area**	**Radius of Contact Area – r**	**Influence Factor (see attached Figure I for x = 0**				**Dynamic Stress Factor**	**Puncture Contact Stress**
				z	**z/r**	**x/r**	**I**		
[kg]	**[kg/m^2]**	**[m^2]**	**[m]**	**[m]**	**[1]**	**[1]**	**[1]**	**[1]**	**[kg/m^2]**
A	B	C=A/2B	D=(C/π)$^{0.5}$	E	F=E/D	G=0/D	H (Figure I)	I	J=B·H·I
9,000	70,307 (689 kPa or 100 psi)	0.064	0.14	0.75	5.36	0	0.055	1.5	5,800 (57 kPa or 8 psi)

Calculated puncture contact stress is approximately three times less than geomembrane puncture resistance (163 kPa). To be on the safe side use 0.9 m thick (minimum) ramps for stone delivery into cell with triaxial trucks.

<u>Secondary HDPE Liner 2.0 m (80 mil) thick</u>

Geomembrane puncture resistance for selected geotextile cushion:

$$P_t = \frac{450 \cdot m}{H^2 \cdot MF_S \cdot MF_{PD} \cdot FS_{CR} \cdot F_{CBD} \cdot FS \cdot F} = \frac{450 \cdot 860}{25^2 \cdot 1 \cdot 0.5 \cdot 1.3 \cdot 1.3 \cdot 6 \cdot 0.75} = \frac{387{,}000}{2{,}377} = 163\ kPa$$

m – 860 g/m^2

H – 25 mm

MF_S – 1

MF_{PD} – 0.5

FS_{CR} – 1.3

FS_{CBD} – 1.3

F – 0.75

FS – 6.0 increased factor of safety due to construction inaccuracies

- Dozer

Modified contact stress for Caterpillar D6 dozer or lighter is the same as for primary HDPE liner at 93 kPa and is significantly smaller than puncture contact stress/geomembrane puncture resistance of 163 kPa.

- Triaxial Truck

Puncture contact stress resulting from operation of triaxial truck over 0.75 m thick ramp is the same as that calculated for primary HDPE liner and significantly smaller than geomembrane puncture resistance of 163 kPa. Use 0.9 m thick (minimum) ramp to deliver stone into cell.

Summary

As an additional precaution, apply overall arbitrary factor of safety of 1.5 to account for various difficult to predict factors including construction inaccuracies. This way, the selected geotextile cushion shall be as follows:

- primary geotextile cushion: 1,119 x 1.5 = 1,679 g/m^2, say 1,694 g/m^2 (50 oz/sy)
- secondary geotextile cushion: 860 x 1.5 = 1,290 g/m^2, say 1,288 g/m^2 (38 oz/sy)

Appendix 4-D

Leachate Collector Strength Calculations

Appendix 4-D

Leachate Collector Strength Calculations

Based on R. Kerry Rowe, Robert M. Quigley, Richard W. I. Brachman and John R. Booker book "Barrier Systems for Waste Disposal Facilities, page 469.

Height of load above collection pipe - 156 - 125 = 31 m = H

Assume unit weight of overlying material - γ = 14 kN/m^3 (1,428 kg/m^3)

Vertical overburden stress - σ_v

$$\sigma_v = \gamma H = 14 \cdot 31 = 434\ kN/m^2 = 434\ kPa$$

Horizontal stress (for gravel drainage blanket) - σ_h

$$\sigma_h = K\sigma_v = 0.15 \cdot 434 = 65\ kPa$$

K - coefficient of lateral earth pressure, K = 0.15 for gravel. See pages 473 and 477 of above noted reference.

Mean stress - σ_m

$$\sigma_m = \frac{\sigma_v + o_h}{2} = \frac{434 + 65}{2} = 250\ kPa$$

Deviator stress - σ_d

$$\sigma_d = \frac{\sigma_v - o_h}{2} = \frac{434 - 65}{2} = 185\ kPa$$

σ_o - normal stress on pipe from mean boundary stress
σ_2 - normal stress on pipe from deviator boundary stress
τ_2 - shear stress on pipe from deviator boundary stress

<u>Smooth interface</u>

$\sigma_o = A_m\sigma_m$ $\quad\quad$ $\sigma_2 = A_{d\sigma}\sigma_d$ $\quad\quad$ $\tau_2 = A_{d\tau}\sigma_d$

A - pipe stress factors based on elastic arching solution

$$A_m = \frac{2\,(1 - v_s)}{1 + C(1 - 2v_s)} = \frac{2 \cdot 0.7}{1 + 1.53 \cdot 0.4} = \frac{1.4}{1.61} = 0.87$$

ν_s - Poisson ratio of gravel - 0.3, page 477 of above noted reference

$$C = \frac{E_S \cdot \ D_P}{2\ (1+v_s)(1-2v_s)E_p A_p} = \frac{25 \cdot 0.245}{2 \cdot 1.3 \cdot 0.4 \cdot 155 \cdot 0.0248} = \frac{6.13}{4.00} = 1.53$$

E_S - soil Young modulus - for gravel - 25 MPa, page 473 of above noted reference

E_P - Young modulus HDPE pipe, 207 MPa @ 50 yr and 23ºC, KWH catalogue

D_P - mid-surface pipe diameter for Ø250 DR11 ⇒ 0.245 m

A_P - cross-sectional per unit length of pipe ⇒ equal to pipe thickness, thus 0.0248 m = t

For E_P, apply reduction coefficient of 0.75 to account for landfill temperature of 35ºC,
then E_P = 0.75 · 207 = 155 MPa

Refer to graph showing creep rupture characteristics at various temperatures for justification of reduction coefficient.

$$A_{d\sigma} = \frac{12(1-v_S)}{2F+5-6v_s} = \frac{12 \cdot 0.7}{61.94+5-1.8} = \frac{8.4}{65.14} = 0.129$$

$$F = \frac{E_S D_P^3}{48(1+v_s)E_P I_P} = \frac{25 \cdot 0.248^3}{48 \cdot 1.3 \cdot 155 \cdot 0.00000127} = \frac{0.381}{0.0123} = 30.97$$

I_P - second moment of area per unit length of pipe $I_P = t^3/12$

$$I_P = \frac{0.0248^3}{12} = 0.00000127$$

$$\sigma_o = A_m \sigma_m = 0.87 \cdot 250 = 218\ kPa$$

$$\sigma_2 = A_{d\sigma} \sigma_d = 0.129 \cdot 185 = 24\ kPa$$

$$\tau_2 = A_{dr} \sigma_d = 0$$

Pipe Deflection

$$\Delta D_V = -2\ (w_0 + w_2)(vertical)$$

$$w_0 = \frac{\sigma_0 D_P^2}{4 E_P A_P} = \frac{218 \cdot 0.245^2}{4 \cdot 155{,}000 \cdot 0.0248} = \frac{13.08}{15{,}376} = 0.00085\ m$$

$$w_2 = \frac{(2\sigma_2 + \tau_2) D_P^4}{288\ E_P I_P} = \frac{2 \cdot 24 \cdot 0.245^4}{288 \cdot 155{,}000 \cdot 0.00000127} = \frac{0.173}{56.69} = 0.0031\ m$$

$$\Delta D_V = -2\ (0.00085 + 0.0031) = -0.0079\ m$$

$$\%\Delta D_V = \frac{\Delta D_V}{D_P} = \frac{0.0079}{0.245} = 0.0322 = 3.22\%$$

$$\Delta D_h = -2\,(w_0 - w_2) = -2\,(0.00085 - 0.0031) = 0.0045\;m\;(horizontal)$$

$$\%\Delta D_h = \frac{\Delta D_V}{D_P} = \frac{0.0045}{0.245} = 0.0184 = 1.84\%$$

To account for variations induced by the coarse gravel, calculated deflection should be increased by 30% based on a large-scale laboratory test. This test was completed for a thicker pipe DR9, slightly coarser gravel than the MOE standard, and for pipe of a smaller diameter. These factors should reduce the required increase, which was arbitrarily chosen at 30%.

In this case, the revised pipe deflection will be as follows:

$$\%\Delta D_V = 1.3\;\cdot 3.22 = 4.19\%$$

Deflection is less than 5% recommended by the Plastic Pipe Institute.

Determine Pipe Stresses

Maximum compressive stress at interior spring line for smooth interface.

$$\tau_2 = 0$$

$$\sigma_{\theta_{SP}} = \frac{\sigma_0 D_P}{2t} + \sigma_2\left(\frac{D_P}{2t} + \frac{D_P^2}{2t^2}\right) + \tau_2\left(\frac{D_P}{3t} + \frac{D_P^2}{4t^2}\right)$$

$$\sigma_{\theta_{SP}} = \frac{218 \cdot 0.245}{2 \cdot 0.0248} + 24\left(\frac{0.245}{6 \cdot 0.0248} + \frac{0.245^2}{2 \cdot 0.0248^2}\right) =$$

$$= 1{,}077 + 24(1.65 + 48.48) = 1{,}077 + 1{,}210 = 2{,}287\;kPa, say\;2.3\;MPa$$

This is less than compressive stress of 4.5 MPa with a factor of safety FS = 2 for HDPE pipe. This is OK.

Stress at pipe crown and invert (maximum tensile stress).

$$\sigma_{\theta_{in}} = \frac{\sigma_0 D_P}{2t} - \sigma_2\left(\frac{D_P}{6t} + \frac{D_P^2}{2t^2}\right) - \tau_2\left(\frac{D_P}{3t} + \frac{D_P^2}{4t^2}\right)$$

$$\sigma_{\theta_{in}} = 1{,}077 - 1{,}210 = -133\;kPa, say - 0.15\;MPa$$

tensile stress (negative) will occur at pipe invert and pipe crown.

Pipe Perforations

Pipe will have four (4) perforations at quarter points along the perimeter, i.e., 1:30, 4:30, 7:30 and 10:30 o'clock. Stresses are the smallest at these locations and are as follows:

$$\sigma_{\theta_{45}} = \frac{\sigma_0 D_P}{2t} = \frac{218 \cdot 0.245}{2 \cdot 0.0248} = 1{,}077\;kPa = 1.1\;MPa$$

The above stress must be increased by $\chi_{\sigma 0}$ stress concentration factor due to perforations, which is estimated at 2.5 (page 476, Figure 15.11 of above noted reference).

$\sigma_P = 2.5 \cdot 1.1 = 2.75\ MPa, < 4.5\ MPa, therefore\ OK$

For this to be applicable, pipe perforations shall be:

$$hole\ diameter\ \leq \frac{D_{85}}{1.2} \leq \frac{37}{1.2} \leq 31\ mm$$

Use perforations of 25 mm diameter spaced every 300 mm of pipe length to avoid penetration of small stones into pipe interior.

D_{85} of gravel - 37 mm minimum.

Summary

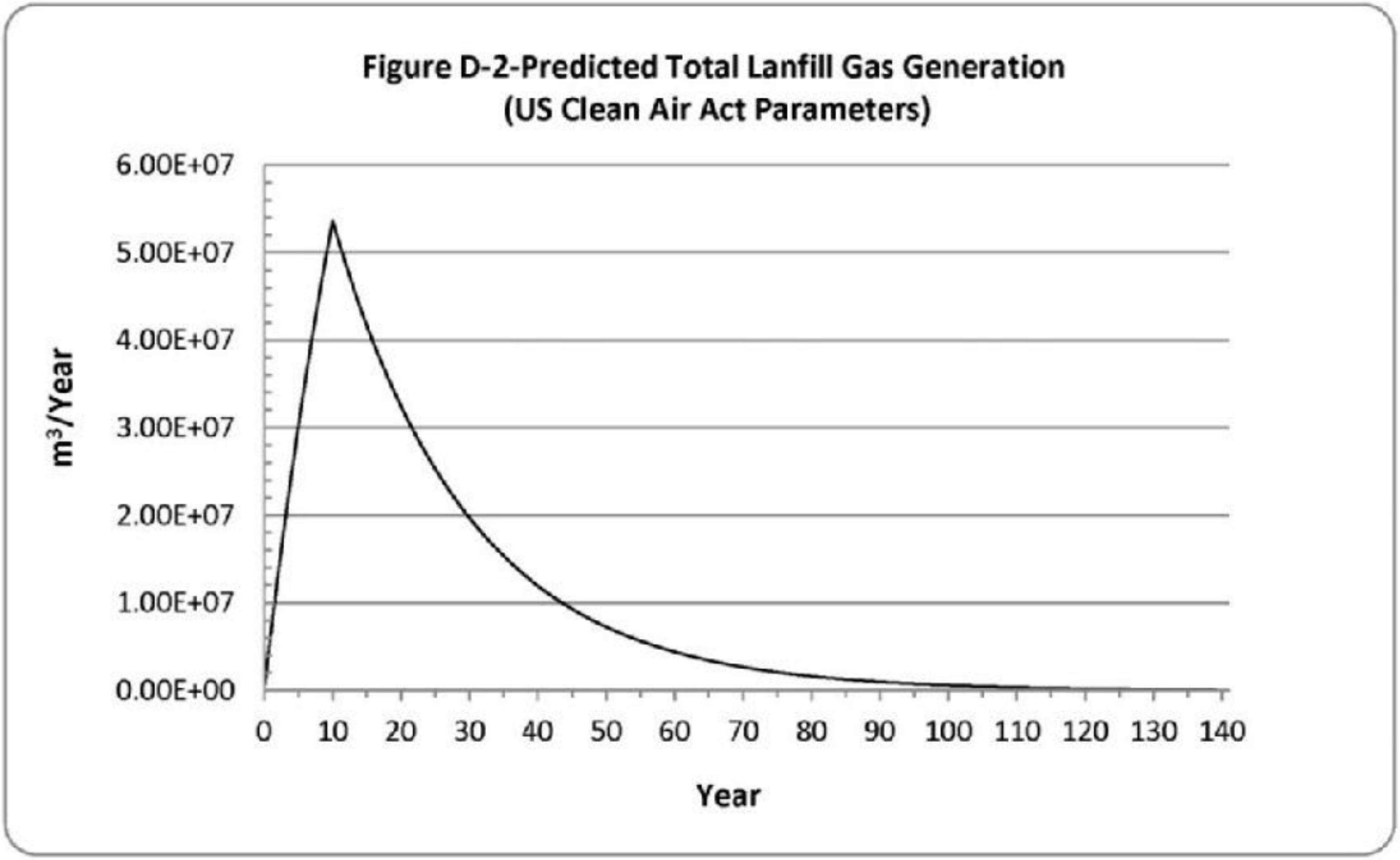
HDPE DR11 pipe is suitable based on the above calculations, but in order to be on the safe side with an increased factor of safety and to account for various difficult to predict factors, a heavier pipe, DR9, has been selected for installation.

Appendix 5

Appendix 5-A

Figure D-2 – Predicted Total Landfill Gas Generation, Appendix D[Ref. 4]

Appendix 5-A: Figure D-2, Appendix D[Ref. 4]



Appendix 5-B

Gas Well Spacing Calculation

Appendix 5-B
Gas Well Spacing Calculation

Gas well spacing is calculated by the formula as follows:

$$r_1 = \left[\frac{2\, g\, kT_s\, (h_s \,/\, h_T)}{P_s\, (dG\, / dt)\, \rho \mu T}\, (P_1^2 - P_0^2)^{\frac{1}{2}} \right]$$

Where

r_1 = the radius of influence of the gas well, feet

g = acceleration due to gravity, feet per second squared

k = absolute permeability of the waste, square feet

T_s = standard temperature, 520° degrees Rankine

h_S = the length of the slotted gas pipe, feet

h_T = the total length of the gas pipe, feet

P_s = standard pressure, 2,116.8 pounds per square foot

dG / dt = the gas generation rate, cubic feet per pound/second

ρ = waste density, pounds per cubic foot

μ = the absolute landfill gas viscosity, pounds per foot/second

T = the temperature of the flowing gas, degrees Rankine

P_1 = the absolute pressure at extreme radius of influence, pounds per square foot

P_0 = the vacuum on the well, pounds per square foot

Depth of waste = 27.5 m max

Moisture content = 35 – 38% (wet basis)

dG/dt = 40 mL/kg/day = 7.42×10^{-9} ft^3/lb s

P_0 = Vacuum = 5" WC = 2090.8 psf

h_S/ h_T = 0.66

k = 1.75×10^{-4} cm/sec = 1.6×10^{-11} ft^2

ρ = 65.4 lb/ft^3

T = 38.5°C = 561° Rankine

μ = gas viscosity 8.31×10^{-6} lbs/ft s

r_1 = 90'

Spacing = 180' (2 x r_1) = 54.9 m

Use 55 m x 48 m grid for well spacing. Offset wells for good gas coverage.

Appendix 6

Appendix 6-A

Purge Well Flow and Quality Data[Ref. 15]

Appendix 6-A

Table 2.1. Summary of Flows

Month	Average Daily Leachate Flow (m^3/d)	Average Daily Purge Well Flow (m^3/d)	Average Daily Blend Flow (m^3/d)	Peak Blend Flow (m^3/d)
January	53	481	535	1,080
February	63	568	631	1,097
March	72	650	722	1,037
April	74	665	739	1,080
May	74	662	736	1,123
June	75	673	748	1,120
July	67	605	672	1,261
August	60	544	604	1,261
September	56	502	558	1,227
October	60	539	599	1,210
November	71	636	707	1,210
December	62	555	617	994
Average	66	590	659	1,261*

* Peak blend flow.

Table 2.2. Summary of Leachate Quality

Parameter	Number of Samples	Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)
Ammonia	7	1,371	1,600	1,200
BOD_5	9	1,566	2,300	930
COD	7	5,514	7,400	3,400
TKN	5	1,620	1,800	1,400
Total Phosphorus	8	14	26	8
pH	8	7.6	7.8	7.5
TSS	7	146	350	66
Alkalinity ($CaCO_3$)	7	7,666	8,450	6,910

Table 2.3. Summary of Purge Well Water Quality

Parameter	Number of Samples	Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)
BOD_5	45	184	630	11
TKN	47	152	370	360
pH	47	1	2.4	0.13
TSS	47	65	290	26

Note: Data from 2009 (Ref. 15, Sec. 2)

Appendix 6-B

Process Flow Diagram[Ref. 16], Drawing P01

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No.	DATE	BY	ISSUES / REVISIONS
4	NOV.16/12	MA	ISSUED FOR TENDER
3	OCT.30/12	MA	ISSUED FOR CLIENT REVIEW
2	JUL.10/12	MA	ISSUED FOR CLIENT REVIEW
1	MAR.15/11	MG	ISSUED FOR CLIENT REVIEW

CLIENT:
WASTE MANAGEMENT

DRAWN BY: M. ANDERSON	CHECKED BY: M. ANIYE
DESIGNED BY: M. ANIYE	APPROVED BY: M. ANIYE
SCALE: N.T.S.	DATE: MAR./11

PROJECT:
OTTAWA LANDFILL
LEACHATE TREATMENT SYSTEM

DRAWING:
PROCESS
FLOW DIAGRAM

PROJECT No.: 60156478

DRAWING No.: P01

Appendix 6-C

HELP Model Results

WCEC Expansion
Final Cover

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\ottawa\weather\OTTAWA.D4
TEMPERATURE DATA FILE:       C:\ottawa\weather\OTTAWA.D7
SOLAR RADIATION DATA FILE:   C:\ottawa\weather\OTTAWA.D13
EVAPOTRANSPIRATION DATA:     C:\ottawa\weather\FAIRGRAS.D11
SOIL AND DESIGN DATA FILE:   C:\ottawa\soil\CAP5V1.D10
OUTPUT DATA FILE:            C:\ottawa\output\2CAP5.OUT


TIME:  14:13     DATE:   9/24/2013


******************************************************************************

     TITLE:  WCEC Expansion Final Cover Slope 5%

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1 (topsoil)
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   7
          THICKNESS                    =     15.00   CM
          POROSITY                     =      0.4730 VOL/VOL
          FIELD CAPACITY               =      0.2220 VOL/VOL
          WILTING POINT                =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3527 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2 (cap)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	85.00 CM
POROSITY	=	0.4790 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4062 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

LAYER 3 (waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1000.00 CM
POROSITY	=	0.5000 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2978 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-04 CM/SEC

LAYER 4 (waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1700.00 CM
POROSITY	=	0.5000 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2947 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	30.00 CM
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL

WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0352 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC
SLOPE	=	0.50 PERCENT
DRAINAGE LENGTH	=	50.0 METERS

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.15 CM
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS	=	5.00 HOLES/HECTARE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 7 (clay liner)

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	75.00 CM
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	30.00 CM
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC
SLOPE	=	0.50 PERCENT
DRAINAGE LENGTH	=	100.0 METERS

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.20 CM
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	2.00 HOLES/HECTARE
FML INSTALLATION DEFECTS	=	5.00 HOLES/HECTARE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 10 (clay liner)

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	75.00 CM
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 11 (attenuation layer)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	100.00 CM
POROSITY	=	0.4610 VOL/VOL
FIELD CAPACITY	=	0.3600 VOL/VOL
WILTING POINT	=	0.2030 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3599 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.%

AND A SLOPE LENGTH OF 150. METERS.

SCS RUNOFF CURVE NUMBER	=	81.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	50.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	19.789	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	23.860	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	10.345	CM
INITIAL SNOW WATER	=	4.541	CM
INITIAL WATER IN LAYER MATERIALS	=	940.640	CM
TOTAL INITIAL WATER	=	945.181	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM OTTAWA

STATION LATITUDE	=	45.29	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	134	
END OF GROWING SEASON (JULIAN DATE)	=	270	
EVAPORATIVE ZONE DEPTH	=	50.0	CM
AVERAGE ANNUAL WIND SPEED	=	12.90	KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.40	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	64.90	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.60	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	75.60	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OTTAWA

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
62.9	49.7	57.5	71.1	86.6	92.7
84.4	83.8	92.7	85.9	82.7	69.5

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OTTAWA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.2	-7.9	-2.2	6.5	13.5	18.7
21.2	19.9	15.3	8.4	2.0	-5.6

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR OTTAWA
AND STATION LATITUDE = 45.29 DEGREES

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	53.96	56.00	65.16	74.04	83.77	85.37
	77.52	72.00	105.69	78.07	86.70	61.92
STD. DEVIATIONS	21.80	24.10	24.70	28.10	35.66	33.68
	29.31	24.46	57.45	37.78	38.19	28.48
RUNOFF						
TOTALS	0.875	2.614	98.813	81.245	1.583	1.465
	0.128	0.192	6.003	2.837	2.659	1.037
STD. DEVIATIONS	3.955	5.138	58.113	54.807	4.904	2.744
	0.321	0.670	10.548	6.736	6.233	2.289
EVAPOTRANSPIRATION						
TOTALS	10.970	10.523	12.854	40.810	89.168	90.574
	102.057	71.589	53.825	35.440	20.544	10.131
STD. DEVIATIONS	1.726	2.108	2.168	15.950	24.369	19.995
	29.898	23.985	17.056	7.009	3.342	1.573
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	10.8090	4.3373	6.0012	9.8521	17.5396	13.5470
	6.0054	5.9809	8.7938	13.9541	15.7152	14.5083
STD. DEVIATIONS	5.9384	5.0783	5.6127	5.1932	5.3864	4.5586
	3.2862	4.4697	4.8192	5.8020	4.3896	5.1002
PERCOLATION/LEAKAGE THROUGH LAYER 7						
TOTALS	0.0004	0.0002	0.0002	0.0003	0.0006	0.0004
	0.0002	0.0002	0.0003	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001

	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.0004	0.0002	0.0002	0.0003	0.0005	0.0005
	0.0003	0.0002	0.0003	0.0004	0.0005	0.0005
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001

PERCOLATION/LEAKAGE THROUGH LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.6727	0.2977	0.3735	0.6335	1.0915	0.8712
	0.3737	0.3722	0.5655	0.8684	1.0106	0.9029
STD. DEVIATIONS	0.3696	0.3503	0.3493	0.3340	0.3352	0.2931
	0.2045	0.2782	0.3099	0.3611	0.2823	0.3174

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0001	0.0000	0.0000	0.0000	0.0001	0.0001
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	MM	CU. METERS	PERCENT

PRECIPITATION	900.20	(142.707)	9002.0	100.00
RUNOFF	199.451	(40.0980)	1994.51	22.156
EVAPOTRANSPIRATION	548.485	(59.9014)	5484.85	60.929
LATERAL DRAINAGE COLLECTED FROM LAYER 5	127.04381	(38.47871)	1270.438	14.11284
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00423	(0.00120)	0.042	0.00047
AVERAGE HEAD ON TOP OF LAYER 6	6.694	(2.030)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00416	(0.00120)	0.042	0.00046
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00006	(0.00000)	0.001	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	25.216	(4.1759)	252.16	2.801

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(MM)	(CU. METERS)
PRECIPITATION	91.90	919.000
RUNOFF	118.695	1186.9534
DRAINAGE COLLECTED FROM LAYER 5	1.01077	10.10772
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000031	0.00031
AVERAGE HEAD ON TOP OF LAYER 6	19.500	
MAXIMUM HEAD ON TOP OF LAYER 6	30.817	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	10.5 METERS	
DRAINAGE COLLECTED FROM LAYER 8	0.00003	0.00026
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.001	
MAXIMUM HEAD ON TOP OF LAYER 9	0.044	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.0 METERS	
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00000
SNOW WATER	234.17	2341.7305
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4668	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2069	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(CM)	(VOL/VOL)
1	3.7259	0.2484
2	32.6628	0.3843
3	292.0000	0.2920
4	568.6496	0.3345
5	1.4841	0.0495
6	0.0000	0.0000
7	32.0250	0.4270
8	0.9600	0.0320
9	0.0000	0.0000
10	32.0250	0.4270
11	35.9908	0.3599
SNOW WATER	8.697	

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WCEC Expansion
Daily Covered Area (Fine Sand Loam)

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07   (1 NOVEMBER 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\ottawa\weather\OTTAWA.D4
TEMPERATURE DATA FILE:        C:\ottawa\weather\OTTAWA.D7
SOLAR RADIATION DATA FILE:    C:\ottawa\weather\OTTAWA.D13
EVAPOTRANSPIRATION DATA:      C:\ottawa\weather\OTTBARE.D11
SOIL AND DESIGN DATA FILE:    C:\ottawa\soil\DLYCOVER.D10
OUTPUT DATA FILE:             C:\ottawa\output\DCover.OUT


TIME:  14:32     DATE:   9/24/2013


******************************************************************************

     TITLE:  WCEC Expansion Daily Covered Area  (Fine Sand Loam)

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1 (daily cover)
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   7
          THICKNESS                    =     15.00    CM
          POROSITY                     =      0.4730 VOL/VOL
          FIELD CAPACITY               =      0.2220 VOL/VOL
          WILTING POINT                =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3565 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.520000001000E-03 CM/SEC
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LAYER 2 (waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1000.00	CM
POROSITY	=	0.5000	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2958	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-04	CM/SEC

LAYER 3 (waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1700.00	CM
POROSITY	=	0.5000	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3007	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	30.00	CM
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0327	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	0.50	PERCENT
DRAINAGE LENGTH	=	50.0	METERS

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.15	CM
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL

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WILTING POINT                  =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =       2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS       =       5.00   HOLES/HECTARE
FML PLACEMENT QUALITY          =  3 - GOOD


                    LAYER  6 (clay liner)
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               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                      =     75.00    CM
POROSITY                       =       0.4270 VOL/VOL
FIELD CAPACITY                 =       0.4180 VOL/VOL
WILTING POINT                  =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.100000001000E-06 CM/SEC


                    LAYER  7
                    --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER  21
THICKNESS                      =     30.00    CM
POROSITY                       =       0.3970 VOL/VOL
FIELD CAPACITY                 =       0.0320 VOL/VOL
WILTING POINT                  =       0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.300000012000      CM/SEC
SLOPE                          =       0.50   PERCENT
DRAINAGE LENGTH                =    100.0     METERS


                    LAYER  8
                    --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                      =       0.20   CM
POROSITY                       =       0.0000 VOL/VOL
FIELD CAPACITY                 =       0.0000 VOL/VOL
WILTING POINT                  =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT     =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.      =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY            =       2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS       =       5.00   HOLES/HECTARE
FML PLACEMENT QUALITY          =  3 - GOOD
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LAYER 9 (clay liner)

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	75.00 CM
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 10 (attenuation layer)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	100.00 CM
POROSITY	=	0.4610 VOL/VOL
FIELD CAPACITY	=	0.3600 VOL/VOL
WILTING POINT	=	0.2030 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3599 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 150. METERS.

SCS RUNOFF CURVE NUMBER	=	87.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	20.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	6.632	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.595	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.945	CM
INITIAL SNOW WATER	=	4.541	CM
INITIAL WATER IN LAYER MATERIALS	=	914.286	CM
TOTAL INITIAL WATER	=	918.827	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM OTTAWA

STATION LATITUDE	=	45.29 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	134
END OF GROWING SEASON (JULIAN DATE)	=	270
EVAPORATIVE ZONE DEPTH	=	20.0 CM
AVERAGE ANNUAL WIND SPEED	=	12.90 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.40 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	64.90 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.60 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	75.60 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OTTAWA

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
62.9	49.7	57.5	71.1	86.6	92.7
84.4	83.8	92.7	85.9	82.7	69.5

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OTTAWA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.2	-7.9	-2.2	6.5	13.5	18.7
21.2	19.9	15.3	8.4	2.0	-5.6

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OTTAWA AND STATION LATITUDE = 45.29 DEGREES

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	53.96	56.00	65.16	74.04	83.77	85.37
	77.52	72.00	105.69	78.07	86.70	61.92
STD. DEVIATIONS	21.80	24.10	24.70	28.10	35.66	33.68
	29.31	24.46	57.45	37.78	38.19	28.48
RUNOFF						
TOTALS	0.948	2.798	106.620	85.234	2.922	4.244
	1.622	1.341	10.798	4.883	4.449	1.128
STD. DEVIATIONS	4.357	5.524	60.532	56.509	6.490	5.599
	2.116	2.441	13.753	7.403	7.003	2.498
EVAPOTRANSPIRATION						
TOTALS	10.889	10.459	12.233	39.129	77.019	71.943
	68.563	65.246	59.936	38.139	22.159	10.345
STD. DEVIATIONS	1.705	2.096	2.117	15.021	27.210	20.428
	28.630	20.635	20.343	10.795	3.564	1.607
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	5.5352	5.8565	16.5840	21.0123	22.1480	10.4378
	8.8157	13.3625	14.1938	17.6136	13.4790	11.5973
STD. DEVIATIONS	5.3992	6.2982	7.6390	6.1988	5.0445	3.3885
	4.4977	7.2845	7.1949	4.7178	5.5230	6.4206
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0002	0.0002	0.0005	0.0007	0.0007	0.0004
	0.0003	0.0004	0.0005	0.0006	0.0004	0.0004
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001
	0.0001	0.0002	0.0002	0.0001	0.0002	0.0002
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0003	0.0002	0.0004	0.0006	0.0007	0.0005
	0.0003	0.0004	0.0004	0.0005	0.0005	0.0004
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
	0.0001	0.0002	0.0002	0.0002	0.0001	0.0002
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.3445	0.4005	1.0321	1.3512	1.3783	0.6712
	0.5486	0.8316	0.9128	1.0961	0.8668	0.7217
STD. DEVIATIONS	0.3360	0.4317	0.4754	0.3986	0.3139	0.2179
	0.2799	0.4533	0.4627	0.2936	0.3552	0.3996

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	MM		CU. METERS	PERCENT
PRECIPITATION	900.20	(142.707)	9002.0	100.00
RUNOFF	226.989	(44.4694)	2269.89	25.215
EVAPOTRANSPIRATION	486.058	(59.6841)	4860.58	53.994
LATERAL DRAINAGE COLLECTED FROM LAYER 4	160.63591	(42.48689)	1606.359	17.84447
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00524	(0.00130)	0.052	0.00058
AVERAGE HEAD ON TOP OF LAYER 5	8.463	(2.237)		
LATERAL DRAINAGE COLLECTED	0.00517	(0.00130)	0.052	0.00057

FROM LAYER 7				
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00006	(0.00000)	0.001	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.001	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	26.512	(4.2707)	265.12	2.945

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(MM)	(CU. METERS)
PRECIPITATION	91.90	919.000
RUNOFF	121.107	1211.0674
DRAINAGE COLLECTED FROM LAYER 4	1.18018	11.80184
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000036	0.00036
AVERAGE HEAD ON TOP OF LAYER 5	22.768	
MAXIMUM HEAD ON TOP OF LAYER 5	35.204	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	11.3 METERS	
DRAINAGE COLLECTED FROM LAYER 7	0.00003	0.00031
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.001	
MAXIMUM HEAD ON TOP OF LAYER 8	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 METERS	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00000
SNOW WATER	234.66	2346.6045

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4333
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0972

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(CM)	(VOL/VOL)
1	3.8313	0.2554
2	291.7204	0.2917
3	578.4694	0.3403
4	1.3870	0.0462
5	0.0000	0.0000
6	32.0250	0.4270
7	0.9600	0.0320
8	0.0000	0.0000
9	32.0250	0.4270
10	35.9908	0.3599
SNOW WATER	8.697	

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WCEC Expansion
Daily Covered Area (Sand)

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\ottawa\weather\OTTAWA.D4
TEMPERATURE DATA FILE:        C:\ottawa\weather\OTTAWA.D7
SOLAR RADIATION DATA FILE:    C:\ottawa\weather\OTTAWA.D13
EVAPOTRANSPIRATION DATA:      C:\ottawa\weather\OTTBARE.D11
SOIL AND DESIGN DATA FILE:    C:\ottawa\soil\DCOVERV1.D10
OUTPUT DATA FILE:             C:\ottawa\output\DcoverV1.OUT


TIME:  15:22      DATE:   9/24/2013


******************************************************************************

    TITLE:  WCEC Expansion Daily Covered Area (Sand)

******************************************************************************


    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1 (daily cover)
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   2
          THICKNESS                    =     15.00   CM
          POROSITY                     =      0.4370 VOL/VOL
          FIELD CAPACITY               =      0.0620 VOL/VOL
          WILTING POINT                =      0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2901 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.579999993000E-02 CM/SEC
```

LAYER 2 (waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1000.00 CM
POROSITY	=	0.5000 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2959 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-04 CM/SEC

LAYER 3 (Waste)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1700.00 CM
POROSITY	=	0.5000 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3046 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	30.00 CM
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0323 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC
SLOPE	=	0.50 PERCENT
DRAINAGE LENGTH	=	50.0 METERS

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.15 CM
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL

```
WILTING POINT                   =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT      =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY             =       2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS        =       5.00   HOLES/HECTARE
FML PLACEMENT QUALITY           =  3 - GOOD


                       LAYER  6 (clay liner)
                       --------

             TYPE 3 - BARRIER SOIL LINER
             MATERIAL TEXTURE NUMBER  16
THICKNESS                       =     75.00    CM
POROSITY                        =       0.4270 VOL/VOL
FIELD CAPACITY                  =       0.4180 VOL/VOL
WILTING POINT                   =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT      =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.100000001000E-06 CM/SEC


                       LAYER  7
                       --------

          TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER  21
THICKNESS                       =     30.00    CM
POROSITY                        =       0.3970 VOL/VOL
FIELD CAPACITY                  =       0.0320 VOL/VOL
WILTING POINT                   =       0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT      =       0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.300000012000     CM/SEC
SLOPE                           =       0.50   PERCENT
DRAINAGE LENGTH                 =     100.0    METERS


                       LAYER  8
                       --------

          TYPE 4 - FLEXIBLE MEMBRANE LINER
             MATERIAL TEXTURE NUMBER  35
THICKNESS                       =       0.20   CM
POROSITY                        =       0.0000 VOL/VOL
FIELD CAPACITY                  =       0.0000 VOL/VOL
WILTING POINT                   =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT      =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.       =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY             =       2.00   HOLES/HECTARE
FML INSTALLATION DEFECTS        =       5.00   HOLES/HECTARE
FML PLACEMENT QUALITY           =  3 - GOOD
```

LAYER 9 (clay liner)

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	75.00 CM
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 10 (attenuation layer)

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	100.00 CM
POROSITY	=	0.4610 VOL/VOL
FIELD CAPACITY	=	0.3600 VOL/VOL
WILTING POINT	=	0.2030 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3599 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 2 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 150. METERS.

SCS RUNOFF CURVE NUMBER	=	78.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.0000	HECTARES
EVAPORATIVE ZONE DEPTH	=	20.0	CM
INITIAL WATER IN EVAPORATIVE ZONE	=	5.494	CM
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.055	CM
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.745	CM
INITIAL SNOW WATER	=	4.541	CM
INITIAL WATER IN LAYER MATERIALS	=	919.972	CM
TOTAL INITIAL WATER	=	924.513	CM
TOTAL SUBSURFACE INFLOW	=	0.00	MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM OTTAWA

STATION LATITUDE	=	45.29 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	134
END OF GROWING SEASON (JULIAN DATE)	=	270
EVAPORATIVE ZONE DEPTH	=	20.0 CM
AVERAGE ANNUAL WIND SPEED	=	12.90 KPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.40 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	64.90 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	71.60 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	75.60 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
62.9	49.7	57.5	71.1	86.6	92.7
84.4	83.8	92.7	85.9	82.7	69.5

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ALBANY NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-10.2	-7.9	-2.2	6.5	13.5	18.7
21.2	19.9	15.3	8.4	2.0	-5.6

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR OTTAWA AND STATION LATITUDE = 45.29 DEGREES

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	53.96	56.00	65.16	74.04	83.77	85.37
	77.52	72.00	105.69	78.07	86.70	61.92
STD. DEVIATIONS	21.80	24.10	24.70	28.10	35.66	33.68
	29.31	24.46	57.45	37.78	38.19	28.48
RUNOFF						
TOTALS	0.694	1.355	91.878	83.043	1.083	0.704
	0.069	0.098	2.251	0.933	1.086	0.265
STD. DEVIATIONS	3.469	3.153	59.293	54.535	4.051	1.446
	0.271	0.345	4.825	2.663	3.679	0.719
EVAPOTRANSPIRATION						
TOTALS	10.889	10.459	12.233	32.692	68.377	66.442
	65.422	61.935	56.337	36.515	22.148	10.342
STD. DEVIATIONS	1.705	2.096	2.117	14.657	20.767	20.069
	24.387	17.932	18.376	10.423	3.615	1.606
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	8.2826	13.1276	27.8972	30.9562	30.1101	12.3715
	11.8372	17.8167	19.6347	22.6282	17.6405	15.9731
STD. DEVIATIONS	7.2665	10.9126	11.9673	9.7191	7.7080	4.5802
	6.6320	10.6235	10.1910	7.6398	7.6890	9.6194
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0003	0.0004	0.0009	0.0009	0.0009	0.0004
	0.0004	0.0006	0.0006	0.0007	0.0006	0.0005
STD. DEVIATIONS	0.0002	0.0003	0.0004	0.0003	0.0002	0.0001
	0.0002	0.0003	0.0003	0.0002	0.0002	0.0003
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0004	0.0003	0.0007	0.0009	0.0010	0.0006
	0.0004	0.0005	0.0006	0.0007	0.0006	0.0005
STD. DEVIATIONS	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002
	0.0001	0.0003	0.0003	0.0003	0.0002	0.0002
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.5154	0.8955	1.7361	1.9907	1.8738	0.7956
	0.7366	1.1088	1.2626	1.4082	1.1344	0.9940
STD. DEVIATIONS	0.4522	0.7442	0.7447	0.6250	0.4797	0.2945
	0.4127	0.6611	0.6553	0.4754	0.4945	0.5986

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	MM		CU. METERS	PERCENT
PRECIPITATION	900.20	(142.707)	9002.0	100.00
RUNOFF	183.460	(39.8354)	1834.60	20.380
EVAPOTRANSPIRATION	453.792	(52.7999)	4537.92	50.410
LATERAL DRAINAGE COLLECTED FROM LAYER 4	228.27562	(67.90868)	2282.756	25.35832
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00721	(0.00202)	0.072	0.00080
AVERAGE HEAD ON TOP OF LAYER 5	12.043	(3.583)		
LATERAL DRAINAGE COLLECTED	0.00713	(0.00201)	0.071	0.00079

FROM LAYER 7				
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00006 (	0.00000)	0.001	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.001 (	0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (	0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	34.666 (	5.1551)	346.66	3.851

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(MM)	(CU. METERS)
PRECIPITATION	91.90	919.000
RUNOFF	120.261	1202.6121
DRAINAGE COLLECTED FROM LAYER 4	1.70386	17.03865
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000050	0.00050
AVERAGE HEAD ON TOP OF LAYER 5	32.871	
MAXIMUM HEAD ON TOP OF LAYER 5	47.960	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	13.5 METERS	
DRAINAGE COLLECTED FROM LAYER 7	0.00004	0.00045
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.002	
MAXIMUM HEAD ON TOP OF LAYER 8	0.021	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 METERS	
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00000
SNOW WATER	234.66	2346.6045

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4391

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0373

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(CM)	(VOL/VOL)
1	2.1097	0.1406
2	291.5585	0.2916
3	606.2183	0.3566
4	1.5931	0.0531
5	0.0000	0.0000
6	32.0250	0.4270
7	0.9600	0.0320
8	0.0000	0.0000
9	32.0250	0.4270
10	35.9908	0.3599
SNOW WATER	8.697	

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Appendix 6-D

Testing & Monitoring – Poplar/Willow Plantations

Appendix 6-D

Testing & Monitoring – Poplar/Willow Plantations

This appendix outlines the testing and monitoring for the contingency poplar/willow plantations proposed to be implemented at the WCEC.

1.1 Soil Testing Before Planting Plantation

Soil tests will determine if fertilizer is required or if soil amendments are required to correct pH, etc. Since the leachate will not have significant amounts of phosphorus or potassium, the fertilizer requirements will be determined.

Soil analyses include pH, conductivity, cation exchange capacity, sodium absorption ratio, total organic carbon, organic matter, moisture content, soil phosphorus, sulphur, fluoride, TKN, ammonia, nitrate plus nitrite, a full metal scan, calcium, potassium, sodium, chloride and sulphates. The test results will also provide background information before irrigation commences.

Conduct tests for each hectare before planting and annually after irrigation.

1.2 Proposed Operational Monitoring

Poplar and irrigation system monitoring will consist of the following:

- soil sampling before irrigation, outlined above;
- monthly recording of soil moisture meter locations – one set per irrigation zone or 2 per hectare;
- annual soil samples for the first five (5) years, and once biennially thereafter;
- leaf tissue analyses twice per year; and
- crop inspection twice per year.

1.2.1 Surface Water

Monitoring downstream of the poplar/willow plantations would occur at various stations depending upon the plantation planted/operated.

Samples would be taken as follows:

- existing trees, south side, Area 1 (Refer to **Figure 4-14**), inlet to Stormwater Pond #2 and Depression #1;
- existing trees, north side, Area 1, inlet to Depression #2 (**Figure 4-14**);
- expansion trees, north side, Area 2, inlet to Stormwater Pond #2;
- expansion trees, south side, Area 2, inlet to Depression #1;
- expansion trees, Area 3, drainage area (northwest of Closed South Cell);
- expansion trees, Area 4, outlet of ditch at southeast corner area of Area 4; and
- expansion trees, Area 5, inlet to Depression #2.

Normal monitoring of surface water is described in the EMP(Ref. 30) and will confirm any detrimental effects to surface water if as a result of irrigation or landfill impacts.

The reader is referred to Section 8 of this report regarding site surface water.

1.2.2 Soil Moisture

In each irrigation zone, or every 2.2 ha, whichever is less, the soil moisture will be monitored with soil moisture meters equipped with data loggers to provide daily moisture readings to assist with irrigation scheduling and to monitor seasonal changes and moisture content at various depths. The purpose of the meters is to determine the soil moisture at 0.3, 0.9 and 1.5 m depth.

1.2.3 Soil Sampling

A soil sample will be taken at 0.6 and 0.9 m maximum depth to analyze the following:

- nitrate;
- ammonium and ammonia;
- TKN;
- phosphorus;
- calcium;
- magnesium;
- sodium;
- potassium;
- TOC;
- sulphate and chloride;
- boron; and

- total metals

The analytical results will provide information about any possible toxicity build-ups in the soil from irrigation. It is recommended that the above parameters be tested annually for five (5) years at each zone and biennially thereafter.

1.2.4 Leaf Tissue Analyses

Leaf tissue analyses would consist of the following:

- total nitrogen;
- phosphorus;
- potassium;
- boron;
- sulphate; and
- micronutrients, including copper, iron, manganese and zinc.

The analytical results will provide guidance regarding sufficiency of nutrients in the plant, as well as possible effects from toxicity.

1.2.5 Plantation Inspections

Inspections are proposed in June and September for insect infestation, plant vigour, leaf necrosis and general crop condition and height and diameter of trees.

1.2.6 Storm Event Surface Water Monitoring

Once per season, during times or irrigation and storm events (>25 mm precipitation), surface runoff in ditches at all relevant locations (in Section 1.2.1) would be sampled and tested in accordance with guidance with **Appendix 8-C**.

Such storm event monitoring will ensure that leachate from irrigation is not escaping to surface runoff before adsorption into the soil or on the plant tissue. The locations and frequency of this monitoring will be reviewed periodically.

1.3 Reporting

At the end of each irrigation season the results of monitoring and operation will be prepared by a competent professional to summarize the following:

- flows applied/disposed on plantation plots;
- effluent quality applied to the plantation;
- all monitoring lab or measurement results; and
- interpretation with recommendations for change as required.

The summary results, conclusion and recommendations will be appended to the Annual Report which is required as part of the EMP[Ref. 30].

Appendix 7

Appendix 7-A

Table 3. Summary of the IGMP prepared by Beacon Environmental[Ref. 46]

Table 3. Summary of the IGMP

Component	Location/Feature	Activity	Objective
Design	• Active tipping face	• Minimize area, one face • Diligent daily cover, especially at end of day • No access to containers with food waste • Use inflammable cover	• Minimize feeding opportunities
	• SWM Ponds	• Monitor bird use of ponds • Implement measures to reduce attractiveness should ponds attract gulls • Allow wet low grade areas to regenerate with vegetation	• Reduce bathing and drinking areas • Respond if behaviour changes
	• Other Landscaped Areas and Litter Management	• Minimize tracking of garbage • Wildlife-proof litter containers • Explanatory signage and instruction forbidding feeding of wildlife • Increased shrub landscaping around buildings • Long grass policy where feasible • Signage explaining long grass policy • Regular litter management procedures and techniques	• Reduce feeding and loafing opportunities
	• Buildings	• Apply bird spikes to any ridges where loafing is noted to regularly occur	• Reduce roof top loafing
Deterrents	• Whistlers	• Use of whistlers or equivalent devices within the identified noise limits • Vary approach • Mix with lethal reinforcement • Apply safety and other regulations, rules, guidelines	• Scare birds away from site
	• Propane cannons	• Move regularly • Mix with lethal control • Vary firing sequence and timing	• Scare birds away
	• Lethal Reinforcement	• Selective occasional killing of gulls • Leaving dead gulls in view when possible • Use of birds of prey • Follow all safety and other rules and regulations • Secure, fence and gate site • Staff and airport communication	• Critical reinforcement of other primary deterrent methods
Staffing and Communication		• Staff on duty during operating hours trained to deal with gulls • Back-up staff trained to provide coverage during breaks, vacation, illness • Develop communication strategy with airport	• Ensure effective, dedicated and motivated personnel • Reduce conflict with airport
Training	• On site	• Develop and deliver a Tier One program for management and all staff • Develop and deliver a Tier Two program for key staff (and/or contractors) • Integrate wildlife management procedures into facility operations manual • Ensure that safety training is undertaken	• Ensure that dedicated trained staff have the resources, knowledge, motivation and skills necessary • Ensure safety is a priority
Monitoring and Review	• On site	• Daily counts of key species • Maintain log • Annual summary of activities • Annual two day external review	• Tools to determine efficacy and improve plan • Independent verification
Permit Requirements	• On site	• Migratory Bird Convention Act – harass and kill • Firearms Act – PAL, CFSC, FRC • Provincial regulations – Hunter Education/OIC • City By-Laws – discharge of firearm and noise exemptions	• Ensure compliance with law, regulations and policies
Performance Criteria	• On-site and airport	• Immediate active response to feeding and loafing gulls	• Meet objectives of the plan
Contingency	• On-site	• Three step process: review; identify whether improvements or a contingency method is required; full time staff	• Improve, correct or instigate new methods to meet plan objectives

Appendix 8

Appendix 8-A

Stormwater Modelling Procedure Summary

Appendix 8-A

Stormwater Modelling Procedure Summary

Hydrologic modelling of the stormwater management system is limited to the post development conditions because there will be no off-site discharge from lands encompassing waste disposal area. All runoff originating from landfilling areas will be diverted to infiltration basins and recharged into subsurface groundwater regime.

Post Development Conditions

1. Establish drainage network schematic for each infiltration basin watershed.

2. Define input parameters for SCS Unit Hydrograph Method used by Bentley PondPack model. These include the following parameters:

    a) Subwatershed area.
    b) Time of concentration for each subwatershed which is established within PondPack model using Kirpich equation. This method is conservative and provides relatively short times.
    c) CN curve number for each watershed. Cumulative CN value was established for each subwatershed from conservatively selected CN values corresponding to various applicable land cover features.

3. Enter geometric information for drainage channels as required for hydrograph routing by Modified Puls Method.

4. Establish stormwater pond and infiltration basin dimensions. Use constant infiltration rate of 12 mm/hour recommended by a hydrogeologist for sizing of both infiltration basins.

5. Size outlet structures including emergency overflows for all water storage facilities.

6. Run PondPack model for 24 hour SCS storm (2 to 100 year return period). Verify peak flows and check water levels at each water storage location to ensure compliance with design criteria.

7. Optimize size of water storage facilities and fit them into the overall site design.

In addition to PondPack Modelling, the Rational Method was used to calculate peak flows for all subwatersheds using the following input parameters:

a) subwatershed area;

b) runoff coefficient C;

c) time of concentration (Kirpich Method)

d) rainfall intensity i calculated from Ottawa Intensity Duration Frequency (IDF) data.

The peak flow increase factor was applied to all storms having a return period of more than 10 years. Rational Method peak flows were used for sizing of all proposed culverts.

Settling Velocities for Lined Ponds

Formula to calculate settling velocity is:

$$V_s = \frac{1.2\ Q}{A}$$

Q - is 1:100 year peak pond outflow

A - is water surface area in pond at top of settlement zone i.e. invert of culvert outlet

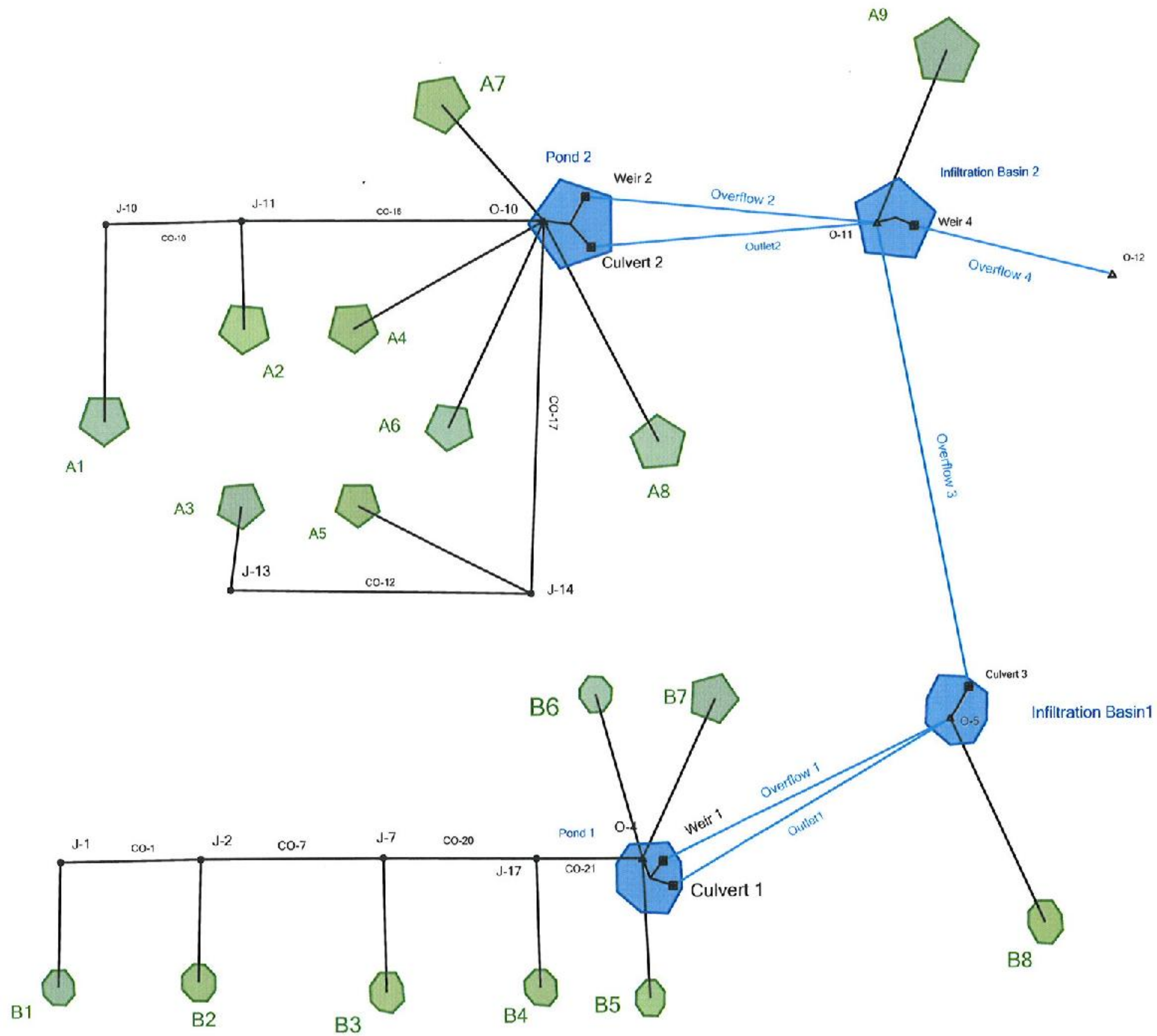
The table below shows calculation results including size of settled particles corresponding to settling velocity V_s

Pond #	Settled Particle Size [Microns]	Q [m^3/s]	A [m^2]	Top of Settlement Zone Elevation [masL]	Calculated V_S [m/s]
1	7	0.15	4,768	124.6	$3.78 \times \cdot 10^{-5}$
2	7	0.26	7,537	123.4	$4.14 \times \cdot 10^{-5}$

Appendix 8-B

Pondpack Printouts - Drainage Areas A & B Post Development

Scenario: Post-Development 1



DrainageAreaABUpdateJan13-2014 V2.ppc
24/02/2014

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Bentley PondPack V8i
[08.11.01.56]

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m^3)	Time to Peak (hours)	Peak Flow (m^3/s)
B1	Post-Development 1	1	39.304	4.000	0.01
B1	Post-Development 2	2	260.430	12.050	0.09
B1	Post-Development 5	5	469.578	12.000	0.17
B1	Post-Development 10	10	625.463	12.000	0.23
B1	Post-Development 25	25	835.319	12.000	0.30
B1	Post-Development 50	50	998.254	12.000	0.36
B1	Post-Development 100	100	1,164.530	12.000	0.42
B2	Post-Development 1	1	81.099	4.000	0.02
B2	Post-Development 2	2	532.187	12.050	0.18
B2	Post-Development 5	5	957.761	12.050	0.33
B2	Post-Development 10	10	1,274.768	12.000	0.44
B2	Post-Development 25	25	1,701.333	12.000	0.60
B2	Post-Development 50	50	2,032.357	12.000	0.72
B2	Post-Development 100	100	2,370.120	12.000	0.84
B3	Post-Development 1	1	91.633	4.000	0.02
B3	Post-Development 2	2	589.981	12.050	0.19
B3	Post-Development 5	5	1,057.917	12.050	0.35
B3	Post-Development 10	10	1,405.903	12.050	0.48
B3	Post-Development 25	25	1,873.697	12.050	0.64
B3	Post-Development 50	50	2,236.521	12.050	0.76
B3	Post-Development 100	100	2,606.481	12.050	0.89
B4	Post-Development 1	1	132.466	4.000	0.03
B4	Post-Development 2	2	806.832	12.050	0.25
B4	Post-Development 5	5	1,431.332	12.050	0.47
B4	Post-Development 10	10	1,893.604	12.050	0.63
B4	Post-Development 25	25	2,513.233	12.050	0.84
B4	Post-Development 50	50	2,992.779	12.050	1.00
B4	Post-Development 100	100	3,481.132	12.050	1.16
B6	Post-Development 1	1	43.523	4.000	0.01
B6	Post-Development 2	2	188.590	11.950	0.08
B6	Post-Development 5	5	310.749	11.950	0.13
B6	Post-Development 10	10	398.220	11.950	0.16
B6	Post-Development 25	25	513.158	11.950	0.21
B6	Post-Development 50	50	600.799	11.950	0.25
B6	Post-Development 100	100	689.175	11.950	0.28
B5	Post-Development 1	1	1.699	4.000	0.00
B5	Post-Development 2	2	40.691	12.000	0.01
B5	Post-Development 5	5	86.904	12.000	0.03
B5	Post-Development 10	10	123.801	11.950	0.05
B5	Post-Development 25	25	175.536	11.950	0.07
B5	Post-Development 50	50	216.907	11.950	0.09
B5	Post-Development 100	100	260.005	11.950	0.11
B8	Post-Development 1	1	2.605	4.000	0.00
B8	Post-Development 2	2	145.039	12.000	0.04
B8	Post-Development 5	5	328.872	12.000	0.12

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m³)	Time to Peak (hours)	Peak Flow (m³/s)
B8	Post-Development 10	10	478.810	12.000	0.18
B8	Post-Development 25	25	691.781	11.950	0.27
B8	Post-Development 50	50	863.720	11.950	0.35
B8	Post-Development 100	100	1,043.816	11.950	0.42
A3	Post-Development 1	1	176.301	4.000	0.04
A3	Post-Development 2	2	939.128	12.100	0.26
A3	Post-Development 5	5	1,620.856	12.100	0.47
A3	Post-Development 10	10	2,119.459	12.100	0.63
A3	Post-Development 25	25	2,782.781	12.100	0.82
A3	Post-Development 50	50	3,293.334	12.100	0.98
A3	Post-Development 100	100	3,811.363	12.100	1.13
A5	Post-Development 1	1	266.065	4.000	0.06
A5	Post-Development 2	2	1,474.826	12.100	0.43
A5	Post-Development 5	5	2,566.979	12.050	0.78
A5	Post-Development 10	10	3,368.714	12.050	1.04
A5	Post-Development 25	25	4,437.816	12.050	1.39
A5	Post-Development 50	50	5,262.091	12.050	1.65
A5	Post-Development 100	100	6,099.392	12.050	1.91
A6	Post-Development 1	1	156.932	4.000	0.03
A6	Post-Development 2	2	884.477	12.050	0.28
A6	Post-Development 5	5	1,544.741	12.050	0.50
A6	Post-Development 10	10	2,030.176	12.050	0.67
A6	Post-Development 25	25	2,678.094	12.050	0.89
A6	Post-Development 50	50	3,177.971	12.050	1.05
A6	Post-Development 100	100	3,686.004	12.050	1.22
A1	Post-Development 1	1	133.316	4.000	0.03
A1	Post-Development 2	2	783.839	12.050	0.25
A1	Post-Development 5	5	1,380.814	12.050	0.45
A1	Post-Development 10	10	1,821.396	12.050	0.61
A1	Post-Development 25	25	2,410.811	12.050	0.81
A1	Post-Development 50	50	2,866.316	12.050	0.96
A1	Post-Development 100	100	3,329.778	12.050	1.11
A2	Post-Development 1	1	184.626	4.000	0.04
A2	Post-Development 2	2	1,058.116	12.050	0.33
A2	Post-Development 5	5	1,854.329	12.050	0.61
A2	Post-Development 10	10	2,440.572	12.050	0.81
A2	Post-Development 25	25	3,223.760	12.050	1.07
A2	Post-Development 50	50	3,828.438	12.050	1.27
A2	Post-Development 100	100	4,443.225	12.050	1.48
A4	Post-Development 1	1	185.334	4.000	0.04
A4	Post-Development 2	2	1,070.547	12.100	0.30
A4	Post-Development 5	5	1,879.389	12.100	0.55
A4	Post-Development 10	10	2,475.374	12.100	0.73
A4	Post-Development 25	25	3,271.983	12.100	0.97
A4	Post-Development 50	50	3,887.223	12.100	1.15

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m^3)	Time to Peak (hours)	Peak Flow (m^3/s)
A4	Post-Development 100	100	4,512.912	12.100	1.33
A7	Post-Development 1	1	63.373	4.000	0.01
A7	Post-Development 2	2	274.673	11.950	0.11
A7	Post-Development 5	5	452.532	11.950	0.19
A7	Post-Development 10	10	579.957	11.950	0.24
A7	Post-Development 25	25	747.310	11.950	0.31
A7	Post-Development 50	50	874.962	11.950	0.36
A7	Post-Development 100	100	1,003.662	11.950	0.41
A9	Post-Development 1	1	3.228	4.000	0.00
A9	Post-Development 2	2	178.594	12.000	0.05
A9	Post-Development 5	5	404.959	12.000	0.15
A9	Post-Development 10	10	589.557	12.000	0.22
A9	Post-Development 25	25	851.827	11.950	0.33
A9	Post-Development 50	50	1,063.524	11.950	0.43
A9	Post-Development 100	100	1,285.273	11.950	0.52
B7	Post-Development 1	1	46.468	4.000	0.01
B7	Post-Development 2	2	186.891	11.950	0.08
B7	Post-Development 5	5	302.339	11.950	0.13
B7	Post-Development 10	10	384.373	11.950	0.16
B7	Post-Development 25	25	491.580	11.950	0.20
B7	Post-Development 50	50	573.048	11.950	0.23
B7	Post-Development 100	100	655.025	11.950	0.27
A8	Post-Development 1	1	129.776	4.000	0.02
A8	Post-Development 2	2	538.133	12.100	0.16
A8	Post-Development 5	5	877.114	12.050	0.27
A8	Post-Development 10	10	1,118.799	12.050	0.34
A8	Post-Development 25	25	1,435.324	12.050	0.44
A8	Post-Development 50	50	1,676.159	12.050	0.51
A8	Post-Development 100	100	1,918.721	12.050	0.58

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m^3)	Time to Peak (hours)	Peak Flow (m^3/s)
J-1	Post-Development 1	1	39.304	4.000	0.01
J-1	Post-Development 2	2	260.430	12.050	0.09
J-1	Post-Development 5	5	469.578	12.000	0.17
J-1	Post-Development 10	10	625.463	12.000	0.23
J-1	Post-Development 25	25	835.319	12.000	0.30
J-1	Post-Development 50	50	998.254	12.000	0.36
J-1	Post-Development 100	100	1,164.530	12.000	0.42
J-2	Post-Development 1	1	120.403	4.000	0.03
J-2	Post-Development 2	2	792.617	12.050	0.23
J-2	Post-Development 5	5	1,427.339	12.050	0.46

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m³)	Time to Peak (hours)	Peak Flow (m³/s)
J-2	Post-Development 10	10	1,900.230	12.050	0.62
J-2	Post-Development 25	25	2,536.651	12.050	0.84
J-2	Post-Development 50	50	3,030.610	12.050	1.01
J-2	Post-Development 100	100	3,534.650	12.050	1.18
J-7	Post-Development 1	1	212.037	4.050	0.05
J-7	Post-Development 2	2	1,382.598	12.100	0.36
J-7	Post-Development 5	5	2,485.256	12.100	0.72
J-7	Post-Development 10	10	3,306.162	12.050	0.99
J-7	Post-Development 25	25	4,410.349	12.050	1.36
J-7	Post-Development 50	50	5,267.132	12.050	1.65
J-7	Post-Development 100	100	6,141.131	12.050	1.95
J-10	Post-Development 1	1	133.316	4.000	0.03
J-10	Post-Development 2	2	783.839	12.050	0.25
J-10	Post-Development 5	5	1,380.814	12.050	0.45
J-10	Post-Development 10	10	1,821.396	12.050	0.61
J-10	Post-Development 25	25	2,410.811	12.050	0.81
J-10	Post-Development 50	50	2,866.316	12.050	0.96
J-10	Post-Development 100	100	3,329.778	12.050	1.11
J-11	Post-Development 1	1	317.942	4.000	0.07
J-11	Post-Development 2	2	1,841.954	12.100	0.53
J-11	Post-Development 5	5	3,235.143	12.050	0.98
J-11	Post-Development 10	10	4,261.969	12.050	1.33
J-11	Post-Development 25	25	5,634.571	12.050	1.78
J-11	Post-Development 50	50	6,694.754	12.050	2.13
J-11	Post-Development 100	100	7,773.003	12.050	2.49
J-13	Post-Development 1	1	176.301	4.000	0.04
J-13	Post-Development 2	2	939.128	12.100	0.26
J-13	Post-Development 5	5	1,620.856	12.100	0.47
J-13	Post-Development 10	10	2,119.459	12.100	0.63
J-13	Post-Development 25	25	2,782.781	12.100	0.82
J-13	Post-Development 50	50	3,293.334	12.100	0.98
J-13	Post-Development 100	100	3,811.363	12.100	1.13
J-14	Post-Development 1	1	442.337	4.000	0.09
J-14	Post-Development 2	2	2,413.955	12.100	0.64
J-14	Post-Development 5	5	4,187.835	12.100	1.18
J-14	Post-Development 10	10	5,488.173	12.100	1.58
J-14	Post-Development 25	25	7,220.569	12.100	2.11
J-14	Post-Development 50	50	8,555.425	12.100	2.50
J-14	Post-Development 100	100	9,910.783	12.100	2.91
O-12	Post-Development 1	1	0.000	0.000	0.00
O-12	Post-Development 2	2	0.000	0.000	0.00
O-12	Post-Development 5	5	0.000	0.000	0.00
O-12	Post-Development 10	10	0.000	0.000	0.00
O-12	Post-Development 25	25	0.000	0.000	0.00
O-12	Post-Development 50	50	0.000	0.000	0.00

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m³)	Time to Peak (hours)	Peak Flow (m³/s)
O-12	Post-Development 100	100	0.000	0.000	0.00
J-17	Post-Development 1	1	344.474	4.050	0.08
J-17	Post-Development 2	2	2,189.430	12.100	0.49
J-17	Post-Development 5	5	3,916.588	12.100	1.04
J-17	Post-Development 10	10	5,199.766	12.100	1.45
J-17	Post-Development 25	25	6,923.582	12.100	2.00
J-17	Post-Development 50	50	8,259.911	12.100	2.42
J-17	Post-Development 100	100	9,622.263	12.100	2.85

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m³)	Time to Peak (hours)	Peak Flow (m³/s)	Maximum Water Surface Elevation (m)	Maximum Pond Storage (m³)
Pond 1 (IN)	Post-Development 1	1	436.164	4.000	0.09	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 1	1	426.876	5.350	0.00	124.68	2,992.977
Pond 1 (IN)	Post-Development 2	2	2,605.631	12.150	0.51	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 2	2	2,582.949	15.400	0.04	124.88	3,967.417
Pond 1 (IN)	Post-Development 5	5	4,616.580	12.150	1.07	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 5	5	4,591.860	14.450	0.08	125.08	5,042.154
Pond 1 (IN)	Post-Development 10	10	6,106.160	12.100	1.49	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 10	10	6,079.712	14.600	0.10	125.25	5,989.070
Pond 1 (IN)	Post-Development 25	25	8,103.885	12.100	2.08	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 25	25	8,074.945	14.800	0.12	125.47	7,317.894
Pond 1 (IN)	Post-Development 50	50	9,650.664	12.100	2.54	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 50	50	9,619.856	15.000	0.13	125.64	8,382.155

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m³)	Time to Peak (hours)	Peak Flow (m³/s)	Maximum Water Surface Elevation (m)	Maximum Pond Storage (m³)
Pond 1 (IN)	Post-Development 100	100	11,226.469	12.100	3.00	(N/A)	(N/A)
Pond 1 (OUT)	Post-Development 100	100	11,193.734	15.150	0.15	125.81	9,488.267
Infiltration Basin1 (IN)	Post-Development 1	1	429.482	5.350	0.00	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 1	1	0.000	0.000	0.00	123.00	50.829
Infiltration Basin1 (IN)	Post-Development 2	2	2,727.988	15.100	0.05	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 2	2	0.000	0.000	0.00	123.03	524.711
Infiltration Basin1 (IN)	Post-Development 5	5	4,920.732	12.000	0.13	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 5	5	0.000	0.000	0.00	123.06	1,164.700
Infiltration Basin1 (IN)	Post-Development 10	10	6,558.493	12.000	0.20	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 10	10	0.000	0.000	0.00	123.11	2,040.455
Infiltration Basin1 (IN)	Post-Development 25	25	8,766.726	12.000	0.30	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 25	25	0.000	0.000	0.00	123.18	3,370.441
Infiltration Basin1 (IN)	Post-Development 50	50	10,483.576	12.000	0.39	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 50	50	0.000	0.000	0.00	123.24	4,483.774
Infiltration Basin1 (IN)	Post-Development 100	100	12,237.550	11.950	0.48	(N/A)	(N/A)
Infiltration Basin1 (OUT)	Post-Development 100	100	0.000	0.000	0.00	123.31	5,669.231
Pond 2 (IN)	Post-Development 1	1	1,295.666	4.000	0.25	(N/A)	(N/A)

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m^3)	Time to Peak (hours)	Peak Flow (m^3/s)	Maximum Water Surface Elevation (m)	Maximum Pond Storage (m^3)
Pond 2 (OUT)	Post-Development 1	1	1,228.215	5.200	0.02	123.55	5,377.426
Pond 2 (IN)	Post-Development 2	2	7,023.711	12.150	1.50	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 2	2	6,905.374	15.700	0.10	123.87	8,045.212
Pond 2 (IN)	Post-Development 5	5	12,176.754	12.150	2.94	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 5	5	12,042.702	15.950	0.15	124.25	11,447.227
Pond 2 (IN)	Post-Development 10	10	15,954.419	12.100	4.01	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 10	10	15,809.295	16.100	0.18	124.53	14,117.647
Pond 2 (IN)	Post-Development 25	25	20,987.852	12.100	5.46	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 25	25	20,828.485	16.400	0.22	124.88	17,809.569
Pond 2 (IN)	Post-Development 50	50	24,866.495	12.100	6.58	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 50	50	24,696.226	16.700	0.24	125.15	20,734.756
Pond 2 (IN)	Post-Development 100	100	28,805.057	12.100	7.71	(N/A)	(N/A)
Pond 2 (OUT)	Post-Development 100	100	28,623.886	16.800	0.26	125.40	23,742.911
Infiltration Basin 2 (IN)	Post-Development 1	1	1,231.415	5.200	0.02	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 1	1	0.000	0.000	0.00	122.01	156.337
Infiltration Basin 2 (IN)	Post-Development 2	2	7,083.969	15.300	0.11	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 2	2	0.000	0.000	0.00	122.05	1,347.599

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (m^3)	Time to Peak (hours)	Peak Flow (m^3/s)	Maximum Water Surface Elevation (m)	Maximum Pond Storage (m^3)
Infiltration Basin 2 (IN)	Post-Development 5	5	12,447.661	12.000	0.16	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 5	5	0.000	0.000	0.00	122.16	3,996.583
Infiltration Basin 2 (IN)	Post-Development 10	10	16,398.852	12.000	0.26	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 10	10	0.000	0.000	0.00	122.25	6,381.230
Infiltration Basin 2 (IN)	Post-Development 25	25	21,680.284	12.000	0.41	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 25	25	0.000	0.000	0.00	122.38	9,827.333
Infiltration Basin 2 (IN)	Post-Development 50	50	25,759.750	12.000	0.52	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 50	50	0.000	0.000	0.00	122.48	12,611.927
Infiltration Basin 2 (IN)	Post-Development 100	100	29,909.159	11.950	0.63	(N/A)	(N/A)
Infiltration Basin 2 (OUT)	Post-Development 100	100	0.000	0.000	0.00	122.59	15,530.431

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.248 hours
Area (User Defined)	5.750 ha

Computational Time Increment	0.033 hours
Time to Peak (Computed)	12.032 hours
Flow (Peak, Computed)	1.12 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	1.11 m³/s

Drainage Area	
SCS CN (Composite)	80.900
Area (User Defined)	5.750 ha
Maximum Retention (Pervious)	60.0 mm
Maximum Retention (Pervious, 20 percent)	12.0 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	57.9 mm
Runoff Volume (Pervious)	3,329.496 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	3,329.778 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.248 hours
Computational Time Increment	0.033 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.84 m³/s
Unit peak time, Tp	0.165 hours
Unit receding limb, Tr	0.661 hours
Total unit time, Tb	0.826 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	110.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.40 m/s
Segment Time of Concentration	0.077 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	70.00 m
Slope	0.250 m/m
Tc Multiplier	2.000
Average Velocity	0.67 m/s
Segment Time of Concentration	0.029 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	290.00 m
Slope	0.006 m/m
Tc Multiplier	0.750
Average Velocity	0.57 m/s
Segment Time of Concentration	0.142 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.248 hours

Modified Puls Results Summary	
Length (Channel)	430.00 m
Travel Time (Channel)	0.091 hours
Number of Sections	1
Length (Section)	430.00 m
Flow (Weighted)	0.39 m³/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	130.11 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	128.91 m
Volume (Starting, per section)	0.000 m³
Flow (Out Starting)	0.00 m³/s
Infiltration (Starting, per section)	0.00 m³/s
Flow (Total Out Starting)	0.00 m³/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	1.11 m³/s	Time to Peak (In)	12.050 hours
Flow (Peak Out)	1.05 m³/s	Time to Peak (Out)	12.100 hours

Mass Balance (m³)	
Volume (Initial)	0.000 m³
Volume (Total Inflow)	3,329.776 m³
Volume (Total Infiltration)	0.000 m³
Volume (Total Outlet Outflow)	3,329.776 m³
Volume (Retained)	0.000 m³
Volume (Unrouted)	0.000 m³
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.250 hours
Area (User Defined)	7.590 ha

Computational Time Increment	0.033 hours
Time to Peak (Computed)	12.058 hours
Flow (Peak, Computed)	1.48 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	1.48 m³/s

Drainage Area	
SCS CN (Composite)	81.200
Area (User Defined)	7.590 ha
Maximum Retention (Pervious)	58.8 mm
Maximum Retention (Pervious, 20 percent)	11.8 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	58.5 mm
Runoff Volume (Pervious)	4,443.191 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	4,443.225 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.250 hours
Computational Time Increment	0.033 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	2.41 m³/s
Unit peak time, Tp	0.167 hours
Unit receding limb, Tr	0.666 hours
Total unit time, Tb	0.833 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	140.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.42 m/s
Segment Time of Concentration	0.092 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	80.00 m
Slope	0.250 m/m
Tc Multiplier	2.000
Average Velocity	0.69 m/s
Segment Time of Concentration	0.032 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	220.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.49 m/s
Segment Time of Concentration	0.125 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.250 hours

Modified Puls Results Summary	
Length (Channel)	400.00 m
Travel Time (Channel)	0.142 hours
Number of Sections	1
Length (Section)	400.00 m
Flow (Weighted)	0.87 m³/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	128.16 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	126.96 m
Volume (Starting, per section)	0.000 m³
Flow (Out Starting)	0.00 m³/s
Infiltration (Starting, per section)	0.00 m³/s
Flow (Total Out Starting)	0.00 m³/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	2.49 m³/s	Time to Peak (In)	12.050 hours
Flow (Peak Out)	2.19 m³/s	Time to Peak (Out)	12.150 hours

Mass Balance (m³)	
Volume (Initial)	0.000 m³
Volume (Total Inflow)	7,773.002 m³
Volume (Total Infiltration)	0.000 m³
Volume (Total Outlet Outflow)	7,773.002 m³
Volume (Retained)	0.000 m³
Volume (Unrouted)	0.000 m³
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.324 hours
Area (User Defined)	6.300 ha

Computational Time Increment	0.043 hours
Time to Peak (Computed)	12.094 hours
Flow (Peak, Computed)	1.14 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.100 hours
Flow (Peak Interpolated Output)	1.13 m³/s

Drainage Area	
SCS CN (Composite)	82.100
Area (User Defined)	6.300 ha
Maximum Retention (Pervious)	55.4 mm
Maximum Retention (Pervious, 20 percent)	11.1 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	60.5 mm
Runoff Volume (Pervious)	3,809.572 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	3,811.363 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.324 hours
Computational Time Increment	0.043 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.54 m³/s
Unit peak time, Tp	0.216 hours
Unit receding limb, Tr	0.864 hours
Total unit time, Tb	1.080 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	105.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.39 m/s
Segment Time of Concentration	0.074 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	70.00 m
Slope	0.250 m/m
Tc Multiplier	2.000
Average Velocity	0.67 m/s
Segment Time of Concentration	0.029 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	460.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.58 m/s
Segment Time of Concentration	0.221 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.324 hours

Modified Puls Results Summary	
Length (Channel)	215.00 m
Travel Time (Channel)	0.099 hours
Number of Sections	1
Length (Section)	215.00 m
Flow (Weighted)	0.41 m^3/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	129.88 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	128.68 m
Volume (Starting, per section)	0.000 m^3
Flow (Out Starting)	0.00 m^3/s
Infiltration (Starting, per section)	0.00 m^3/s
Flow (Total Out Starting)	0.00 m^3/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	1.13 m^3/s	Time to Peak (In)	12.100 hours
Flow (Peak Out)	1.07 m^3/s	Time to Peak (Out)	12.150 hours

Mass Balance (m^3)	
Volume (Initial)	0.000 m^3
Volume (Total Inflow)	3,811.376 m^3
Volume (Total Infiltration)	0.000 m^3
Volume (Total Outlet Outflow)	3,811.376 m^3
Volume (Retained)	0.000 m^3
Volume (Unrouted)	0.000 m^3
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.320 hours
Area (User Defined)	7.740 ha

Computational Time Increment	0.043 hours
Time to Peak (Computed)	12.073 hours
Flow (Peak, Computed)	1.35 m^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.100 hours
Flow (Peak Interpolated Output)	1.33 m^3/s

Drainage Area	
SCS CN (Composite)	81.100
Area (User Defined)	7.740 ha
Maximum Retention (Pervious)	59.2 mm
Maximum Retention (Pervious, 20 percent)	11.8 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	58.3 mm
Runoff Volume (Pervious)	4,514.567 m^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	4,512.912 m^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.320 hours
Computational Time Increment	0.043 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.92 m^3/s
Unit peak time, Tp	0.213 hours
Unit receding limb, Tr	0.853 hours
Total unit time, Tb	1.066 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	150.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.43 m/s
Segment Time of Concentration	0.097 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	80.00 m
Slope	0.250 m/m
Tc Multiplier	2.000
Average Velocity	0.69 m/s
Segment Time of Concentration	0.032 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	400.00 m
Slope	0.005 m/m
Tc Multiplier	0.750
Average Velocity	0.58 m/s
Segment Time of Concentration	0.190 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.320 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.286 hours
Area (User Defined)	10.270 ha

Computational Time Increment	0.038 hours
Time to Peak (Computed)	12.071 hours
Flow (Peak, Computed)	1.93 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	1.91 m³/s

Drainage Area	
SCS CN (Composite)	81.600
Area (User Defined)	10.270 ha
Maximum Retention (Pervious)	57.3 mm
Maximum Retention (Pervious, 20 percent)	11.5 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	59.4 mm
Runoff Volume (Pervious)	6,099.708 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	6,099.392 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.286 hours
Computational Time Increment	0.038 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	2.85 m³/s
Unit peak time, Tp	0.190 hours
Unit receding limb, Tr	0.762 hours
Total unit time, Tb	0.952 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	100.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.39 m/s
Segment Time of Concentration	0.071 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	160.00 m
Slope	0.015 m/m
Tc Multiplier	0.750
Average Velocity	0.73 m/s
Segment Time of Concentration	0.061 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	290.00 m
Slope	0.080 m/m
Tc Multiplier	0.750
Average Velocity	1.59 m/s
Segment Time of Concentration	0.051 hours

Segment #4: Kirpich (TN)	
Hydraulic Length	170.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.46 m/s
Segment Time of Concentration	0.103 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.286 hours

Modified Puls Results Summary	
Length (Channel)	490.00 m
Travel Time (Channel)	0.154 hours
Number of Sections	1
Length (Section)	490.00 m
Flow (Weighted)	1.04 m³/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	128.94 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	127.74 m
Volume (Starting, per section)	0.000 m³
Flow (Out Starting)	0.00 m³/s
Infiltration (Starting, per section)	0.00 m³/s
Flow (Total Out Starting)	0.00 m³/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	2.91 m³/s	Time to Peak (In)	12.100 hours
Flow (Peak Out)	2.57 m³/s	Time to Peak (Out)	12.150 hours

Mass Balance (m³)	
Volume (Initial)	0.000 m³
Volume (Total Inflow)	9,910.780 m³
Volume (Total Infiltration)	0.000 m³
Volume (Total Outlet Outflow)	9,910.780 m³
Volume (Retained)	0.000 m³
Volume (Unrouted)	0.000 m³
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.255 hours
Area (User Defined)	6.250 ha

Computational Time Increment	0.034 hours
Time to Peak (Computed)	12.051 hours
Flow (Peak, Computed)	1.22 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	1.22 m³/s

Drainage Area	
SCS CN (Composite)	81.400
Area (User Defined)	6.250 ha
Maximum Retention (Pervious)	58.0 mm
Maximum Retention (Pervious, 20 percent)	11.6 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	59.0 mm
Runoff Volume (Pervious)	3,685.372 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	3,686.004 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.255 hours
Computational Time Increment	0.034 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.95 m³/s
Unit peak time, Tp	0.170 hours
Unit receding limb, Tr	0.679 hours
Total unit time, Tb	0.849 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	150.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.43 m/s
Segment Time of Concentration	0.097 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	85.00 m
Slope	0.250 m/m
Tc Multiplier	2.000
Average Velocity	0.70 m/s
Segment Time of Concentration	0.034 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	250.00 m
Slope	0.006 m/m
Tc Multiplier	0.750
Average Velocity	0.56 m/s
Segment Time of Concentration	0.123 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.255 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.100 hours
Area (User Defined)	1.500 ha

Computational Time Increment	0.013 hours
Time to Peak (Computed)	11.933 hours
Flow (Peak, Computed)	0.42 m^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.41 m^3/s

Drainage Area	
SCS CN (Composite)	85.000
Area (User Defined)	1.500 ha
Maximum Retention (Pervious)	44.8 mm
Maximum Retention (Pervious, 20 percent)	9.0 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	66.9 mm
Runoff Volume (Pervious)	1,003.741 m^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	1,003.662 m^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.100 hours
Computational Time Increment	0.013 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.19 m^3/s
Unit peak time, Tp	0.067 hours
Unit receding limb, Tr	0.267 hours
Total unit time, Tb	0.333 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.302 hours
Area (User Defined)	2.800 ha

Computational Time Increment	0.040 hours
Time to Peak (Computed)	12.084 hours
Flow (Peak, Computed)	0.59 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	0.58 m³/s

Drainage Area	
SCS CN (Composite)	85.700
Area (User Defined)	2.800 ha
Maximum Retention (Pervious)	42.4 mm
Maximum Retention (Pervious, 20 percent)	8.5 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	68.5 mm
Runoff Volume (Pervious)	1,918.732 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	1,918.721 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.302 hours
Computational Time Increment	0.040 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	0.73 m³/s
Unit peak time, Tp	0.201 hours
Unit receding limb, Tr	0.806 hours
Total unit time, Tb	1.007 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	240.00 m
Slope	0.003 m/m
Tc Multiplier	0.750
Average Velocity	0.43 m/s
Segment Time of Concentration	0.155 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	250.00 m
Slope	0.005 m/m
Tc Multiplier	0.750
Average Velocity	0.53 m/s
Segment Time of Concentration	0.131 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	50.00 m
Slope	0.050 m/m
Tc Multiplier	0.750
Average Velocity	0.89 m/s
Segment Time of Concentration	0.016 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.302 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.100 hours
Area (User Defined)	3.460 ha

Computational Time Increment	0.013 hours
Time to Peak (Computed)	11.947 hours
Flow (Peak, Computed)	0.52 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.52 m³/s

Drainage Area	
SCS CN (Composite)	70.000
Area (User Defined)	3.460 ha
Maximum Retention (Pervious)	108.9 mm
Maximum Retention (Pervious, 20 percent)	21.8 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	37.2 mm
Runoff Volume (Pervious)	1,285.498 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	1,285.273 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.100 hours
Computational Time Increment	0.013 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	2.74 m³/s
Unit peak time, Tp	0.067 hours
Unit receding limb, Tr	0.267 hours
Total unit time, Tb	0.333 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.188 hours
Area (User Defined)	2.110 ha

Computational Time Increment	0.025 hours
Time to Peak (Computed)	12.009 hours
Flow (Peak, Computed)	0.43 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.000 hours
Flow (Peak Interpolated Output)	0.42 m³/s

Drainage Area

SCS CN (Composite)	79.600
Area (User Defined)	2.110 ha
Maximum Retention (Pervious)	65.1 mm
Maximum Retention (Pervious, 20 percent)	13.0 mm

Cumulative Runoff

Cumulative Runoff Depth (Pervious)	55.2 mm
Runoff Volume (Pervious)	1,164.532 m³

Hydrograph Volume (Area under Hydrograph curve)

Volume	1,164.530 m³

SCS Unit Hydrograph Parameters

Time of Concentration (Composite)	0.188 hours
Computational Time Increment	0.025 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	0.89 m³/s
Unit peak time, Tp	0.125 hours
Unit receding limb, Tr	0.500 hours
Total unit time, Tb	0.625 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	340.00 m
Slope	0.012 m/m
Tc Multiplier	0.750
Average Velocity	0.79 m/s
Segment Time of Concentration	0.119 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	100.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.40 m/s
Segment Time of Concentration	0.069 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.188 hours

Modified Puls Results Summary	
Length (Channel)	250.00 m
Travel Time (Channel)	0.134 hours
Number of Sections	1
Length (Section)	250.00 m
Flow (Weighted)	0.14 m^3/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	131.36 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	130.36 m
Volume (Starting, per section)	0.000 m^3
Flow (Out Starting)	0.00 m^3/s
Infiltration (Starting, per section)	0.00 m^3/s
Flow (Total Out Starting)	0.00 m^3/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	0.42 m^3/s	Time to Peak (In)	12.000 hours
Flow (Peak Out)	0.36 m^3/s	Time to Peak (Out)	12.100 hours

Mass Balance (m^3)	
Volume (Initial)	0.000 m^3
Volume (Total Inflow)	1,164.534 m^3
Volume (Total Infiltration)	0.000 m^3
Volume (Total Outlet Outflow)	1,164.534 m^3
Volume (Retained)	0.000 m^3
Volume (Unrouted)	0.000 m^3
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.203 hours
Area (User Defined)	4.280 ha

Computational Time Increment	0.027 hours
Time to Peak (Computed)	12.012 hours
Flow (Peak, Computed)	0.85 m^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.000 hours
Flow (Peak Interpolated Output)	0.84 m^3/s

Drainage Area	
SCS CN (Composite)	79.700
Area (User Defined)	4.280 ha
Maximum Retention (Pervious)	64.7 mm
Maximum Retention (Pervious, 20 percent)	12.9 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	55.4 mm
Runoff Volume (Pervious)	2,371.010 m^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	2,370.120 m^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.203 hours
Computational Time Increment	0.027 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.67 m^3/s
Unit peak time, Tp	0.136 hours
Unit receding limb, Tr	0.542 hours
Total unit time, Tb	0.678 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	75.00 m
Slope	0.286 m/m
Tc Multiplier	2.000
Average Velocity	0.71 m/s
Segment Time of Concentration	0.029 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	25.00 m
Slope	0.020 m/m
Tc Multiplier	2.000
Average Velocity	0.20 m/s
Segment Time of Concentration	0.035 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	250.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.50 m/s
Segment Time of Concentration	0.139 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.203 hours

Modified Puls Results Summary	
Length (Channel)	250.00 m
Travel Time (Channel)	0.103 hours
Number of Sections	1
Length (Section)	250.00 m
Flow (Weighted)	0.41 m^3/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	130.28 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	129.28 m
Volume (Starting, per section)	0.000 m^3
Flow (Out Starting)	0.00 m^3/s
Infiltration (Starting, per section)	0.00 m^3/s
Flow (Total Out Starting)	0.00 m^3/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	1.18 m^3/s	Time to Peak (In)	12.050 hours
Flow (Peak Out)	1.09 m^3/s	Time to Peak (Out)	12.100 hours

Mass Balance (m^3)	
Volume (Initial)	0.000 m^3
Volume (Total Inflow)	3,534.656 m^3
Volume (Total Infiltration)	0.000 m^3
Volume (Total Outlet Outflow)	3,534.656 m^3
Volume (Retained)	0.000 m^3
Volume (Unrouted)	0.000 m^3
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.234 hours
Area (User Defined)	4.670 ha

Computational Time Increment	0.031 hours
Time to Peak (Computed)	12.020 hours
Flow (Peak, Computed)	0.89 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	0.89 m³/s

Drainage Area	
SCS CN (Composite)	79.900
Area (User Defined)	4.670 ha
Maximum Retention (Pervious)	63.9 mm
Maximum Retention (Pervious, 20 percent)	12.8 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	55.8 mm
Runoff Volume (Pervious)	2,606.385 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	2,606.481 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.234 hours
Computational Time Increment	0.031 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.59 m³/s
Unit peak time, Tp	0.156 hours
Unit receding limb, Tr	0.623 hours
Total unit time, Tb	0.779 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	10.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.23 m/s
Segment Time of Concentration	0.012 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	140.00 m
Slope	0.285 m/m
Tc Multiplier	2.000
Average Velocity	0.82 m/s
Segment Time of Concentration	0.047 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	25.00 m
Slope	0.020 m/m
Tc Multiplier	2.000
Average Velocity	0.20 m/s
Segment Time of Concentration	0.035 hours

Segment #4: Kirpich (TN)	
Hydraulic Length	250.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.50 m/s
Segment Time of Concentration	0.139 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.234 hours

Modified Puls Results Summary	
Length (Channel)	310.00 m
Travel Time (Channel)	0.103 hours
Number of Sections	1
Length (Section)	310.00 m
Flow (Weighted)	0.68 m³/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	129.21 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	128.21 m
Volume (Starting, per section)	0.000 m³
Flow (Out Starting)	0.00 m³/s
Infiltration (Starting, per section)	0.00 m³/s
Flow (Total Out Starting)	0.00 m³/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	1.95 m³/s	Time to Peak (In)	12.050 hours
Flow (Peak Out)	1.79 m³/s	Time to Peak (Out)	12.100 hours

Mass Balance (m³)	
Volume (Initial)	0.000 m³
Volume (Total Inflow)	6,141.144 m³
Volume (Total Infiltration)	0.000 m³
Volume (Total Outlet Outflow)	6,141.144 m³
Volume (Retained)	0.000 m³
Volume (Unrouted)	0.000 m³
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.246 hours
Area (User Defined)	6.100 ha

Computational Time Increment	0.033 hours
Time to Peak (Computed)	12.036 hours
Flow (Peak, Computed)	1.17 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	12.050 hours
Flow (Peak Interpolated Output)	1.16 m³/s

Drainage Area	
SCS CN (Composite)	80.500
Area (User Defined)	6.100 ha
Maximum Retention (Pervious)	61.5 mm
Maximum Retention (Pervious, 20 percent)	12.3 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	57.1 mm
Runoff Volume (Pervious)	3,480.797 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	3,481.132 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.246 hours
Computational Time Increment	0.033 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	1.97 m³/s
Unit peak time, Tp	0.164 hours
Unit receding limb, Tr	0.656 hours
Total unit time, Tb	0.820 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	13.00 m
Slope	0.050 m/m
Tc Multiplier	2.000
Average Velocity	0.24 m/s
Segment Time of Concentration	0.015 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	140.00 m
Slope	0.285 m/m
Tc Multiplier	2.000
Average Velocity	0.82 m/s
Segment Time of Concentration	0.047 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	25.00 m
Slope	0.020 m/m
Tc Multiplier	2.000
Average Velocity	0.20 m/s
Segment Time of Concentration	0.035 hours

Segment #4: Kirpich (TN)	
Hydraulic Length	255.00 m
Slope	0.004 m/m
Tc Multiplier	0.750
Average Velocity	0.50 m/s
Segment Time of Concentration	0.141 hours

Segment #5: Kirpich (TN)	
Hydraulic Length	55.00 m
Slope	0.013 m/m
Tc Multiplier	0.200
Average Velocity	2.02 m/s
Segment Time of Concentration	0.008 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.246 hours

Modified Puls Results Summary	
Length (Channel)	165.00 m
Travel Time (Channel)	0.056 hours
Number of Sections	1
Length (Section)	165.00 m
Flow (Weighted)	1.01 m^3/s
Overflow Channel	No Overflow Data
Elevation (Overflow)	127.40 m

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Starting Water Surface)	126.40 m
Volume (Starting, per section)	0.000 m^3
Flow (Out Starting)	0.00 m^3/s
Infiltration (Starting, per section)	0.00 m^3/s
Flow (Total Out Starting)	0.00 m^3/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	2.85 m^3/s	Time to Peak (In)	12.100 hours
Flow (Peak Out)	2.78 m^3/s	Time to Peak (Out)	12.100 hours

Mass Balance (m^3)	
Volume (Initial)	0.000 m^3
Volume (Total Inflow)	9,622.263 m^3
Volume (Total Infiltration)	0.000 m^3
Volume (Total Outlet Outflow)	9,622.263 m^3
Volume (Retained)	0.000 m^3
Volume (Unrouted)	0.000 m^3
Error (Mass Balance)	0.0 %

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.106 hours
Area (User Defined)	0.640 ha

Computational Time Increment	0.014 hours
Time to Peak (Computed)	11.942 hours
Flow (Peak, Computed)	0.11 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.11 m³/s

Drainage Area

SCS CN (Composite)	72.000
Area (User Defined)	0.640 ha
Maximum Retention (Pervious)	98.8 mm
Maximum Retention (Pervious, 20 percent)	19.8 mm

Cumulative Runoff

Cumulative Runoff Depth (Pervious)	40.6 mm
Runoff Volume (Pervious)	260.041 m³

Hydrograph Volume (Area under Hydrograph curve)

Volume	260.005 m³

SCS Unit Hydrograph Parameters

Time of Concentration (Composite)	0.106 hours
Computational Time Increment	0.014 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	0.48 m³/s
Unit peak time, Tp	0.071 hours
Unit receding limb, Tr	0.283 hours
Total unit time, Tb	0.353 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	20.00 m
Slope	0.285 m/m
Tc Multiplier	2.000
Average Velocity	0.53 m/s
Segment Time of Concentration	0.011 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	165.00 m
Slope	0.005 m/m
Tc Multiplier	0.750
Average Velocity	0.48 m/s
Segment Time of Concentration	0.095 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.106 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.100 hours
Area (User Defined)	1.030 ha

Computational Time Increment	0.013 hours
Time to Peak (Computed)	11.933 hours
Flow (Peak, Computed)	0.29 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.28 m³/s

Drainage Area	
SCS CN (Composite)	85.000
Area (User Defined)	1.030 ha
Maximum Retention (Pervious)	44.8 mm
Maximum Retention (Pervious, 20 percent)	9.0 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	66.9 mm
Runoff Volume (Pervious)	689.236 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	689.175 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.100 hours
Computational Time Increment	0.013 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	0.82 m³/s
Unit peak time, Tp	0.067 hours
Unit receding limb, Tr	0.267 hours
Total unit time, Tb	0.333 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.091 hours
Area (User Defined)	0.940 ha

Computational Time Increment	0.012 hours
Time to Peak (Computed)	11.929 hours
Flow (Peak, Computed)	0.28 m^3/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.27 m^3/s

Drainage Area	
SCS CN (Composite)	86.200
Area (User Defined)	0.940 ha
Maximum Retention (Pervious)	40.7 mm
Maximum Retention (Pervious, 20 percent)	8.1 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	69.7 mm
Runoff Volume (Pervious)	655.080 m^3

Hydrograph Volume (Area under Hydrograph curve)	
Volume	655.025 m^3

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.091 hours
Computational Time Increment	0.012 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	0.82 m^3/s
Unit peak time, Tp	0.060 hours
Unit receding limb, Tr	0.242 hours
Total unit time, Tb	0.302 hours

Time of Concentration Results

Segment #1: Kirpich (TN)	
Hydraulic Length	25.00 m
Slope	0.010 m/m
Tc Multiplier	0.400
Average Velocity	0.76 m/s
Segment Time of Concentration	0.009 hours

Segment #2: Kirpich (TN)	
Hydraulic Length	170.00 m
Slope	0.010 m/m
Tc Multiplier	0.750
Average Velocity	0.63 m/s
Segment Time of Concentration	0.075 hours

Segment #3: Kirpich (TN)	
Hydraulic Length	30.00 m
Slope	0.005 m/m
Tc Multiplier	0.200
Average Velocity	1.22 m/s
Segment Time of Concentration	0.007 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.091 hours

Storm Event	100YR 24hr SCS II
Return Event	100 years
Duration	144.000 hours
Depth	106.6 mm
Time of Concentration (Composite)	0.100 hours
Area (User Defined)	2.810 ha

Computational Time Increment	0.013 hours
Time to Peak (Computed)	11.947 hours
Flow (Peak, Computed)	0.43 m³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	0.42 m³/s

Drainage Area	
SCS CN (Composite)	70.000
Area (User Defined)	2.810 ha
Maximum Retention (Pervious)	108.9 mm
Maximum Retention (Pervious, 20 percent)	21.8 mm

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	37.2 mm
Runoff Volume (Pervious)	1,044.003 m³

Hydrograph Volume (Area under Hydrograph curve)	
Volume	1,043.816 m³

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.100 hours
Computational Time Increment	0.013 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	2.23 m³/s
Unit peak time, Tp	0.067 hours
Unit receding limb, Tr	0.267 hours
Total unit time, Tb	0.333 hours

```
               Length
       .--Top---- B ----------.
  W    |                      |
  i    |    .------b2------.  |
  d    A    b1             |  C
  t    |    `----Bottom----'  |
  h    |                      |
       `----------D----------'
      Diagram Not to Scale
```

Pond Volume Calculation for Trapezoidal Basin

Trapezoid Top Elevation	126.75 m
Trapezoid Top Length (A to C)	172.00 m
Trapezoid Top Width (B to D)	48.00 m
Trapezoid Bottom Elevation	124.00 m
Trapezoid Bottom Length	150.00 m
Trapezoid Bottom Width	26.00 m

Pond Volume Calculation for Trapezoidal Basin	
Trapezoid Width Offset (B to b2)	11.00 m
Trapezoid Length Offset (A to b1)	11.00 m
Trapezoid Vertical Increment	0.10 m

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
124.00	0.0	0.390	0.000	0.000	0.000
124.10	0.0	0.404	1.191	397.059	397.059
124.20	0.0	0.418	1.234	411.246	808.304
124.30	0.0	0.433	1.277	425.602	1,233.907
124.40	0.0	0.447	1.320	440.072	1,673.979
124.50	0.0	0.462	1.364	454.655	2,128.606
124.60	0.0	0.477	1.408	469.380	2,597.986
124.70	0.0	0.492	1.453	484.218	3,082.204
124.80	0.0	0.507	1.498	499.198	3,581.401
124.90	0.0	0.522	1.543	514.291	4,095.720
125.00	0.0	0.537	1.589	529.525	4,625.245
125.10	0.0	0.553	1.635	544.901	5,170.146
125.20	0.0	0.568	1.681	560.390	5,730.509

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
125.30	0.0	0.584	1.728	575.993	6,306.530
125.40	0.0	0.600	1.775	591.737	6,898.267
125.50	0.0	0.616	1.823	607.623	7,505.862
125.60	0.0	0.632	1.871	623.622	8,129.483
125.70	0.0	0.648	1.919	639.734	8,769.246
125.80	0.0	0.664	1.968	655.988	9,425.234
125.90	0.0	0.681	2.017	672.384	10,097.618
126.00	0.0	0.697	2.067	688.892	10,786.510
126.10	0.0	0.714	2.117	705.543	11,492.052
126.20	0.0	0.731	2.167	722.306	12,214.358
126.30	0.0	0.748	2.218	739.211	12,953.541
126.40	0.0	0.765	2.269	756.230	13,709.771
126.50	0.0	0.782	2.320	773.390	14,483.161
126.60	0.0	0.799	2.372	790.663	15,273.795
126.75	0.0	0.826	2.437	1,218.644	16,492.468

Structure ID: Culvert 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	291.0 mm
Length	20.00 m
Length (Computed Barrel)	20.00 m
Slope (Computed)	0.005 m/m

Outlet Control Data	
Manning's n	0.013
Ke	0.900
Kb	0.033
Kr	0.900
Convergence Tolerance	0.00 m

Inlet Control Data	
Equation Form	Form 1
K	0.0098
M	2.0000
C	0.0398
Y	0.6700
T1 ratio (HW/D)	1.158
T2 ratio (HW/D)	1.304
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	124.94 m	T1 Flow	0.07 m^3/s
T2 Elevation	124.98 m	T2 Flow	0.08 m^3/s

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	124.60 m
Volume (Initial)	2,597.986 m³
Flow (Initial Outlet)	0.00 m³/s
Flow (Initial Infiltration)	0.00 m³/s
Flow (Initial, Total)	0.00 m³/s
Time Increment	0.050 hours

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
124.00	0.00	0.000	0.390	0.00	0.00	0.00
124.05	0.00	196.757	0.397	0.00	0.00	2.19
124.10	0.00	397.051	0.404	0.00	0.00	4.41
124.15	0.00	600.897	0.411	0.00	0.00	6.68
124.20	0.00	808.310	0.418	0.00	0.00	8.98
124.25	0.00	1,019.308	0.426	0.00	0.00	11.33
124.30	0.00	1,233.906	0.433	0.00	0.00	13.71
124.35	0.00	1,452.120	0.440	0.00	0.00	16.13
124.40	0.00	1,673.966	0.447	0.00	0.00	18.60
124.45	0.00	1,899.460	0.455	0.00	0.00	21.11
124.50	0.00	2,128.618	0.462	0.00	0.00	23.65
124.55	0.00	2,361.457	0.469	0.00	0.00	26.24
124.60	0.00	2,597.991	0.477	0.00	0.00	28.87
124.65	0.00	2,838.237	0.484	0.00	0.00	31.54
124.70	0.01	3,082.212	0.492	0.00	0.01	34.25
124.75	0.01	3,329.930	0.499	0.00	0.01	37.01
124.80	0.02	3,581.409	0.507	0.00	0.02	39.82
124.85	0.04	3,836.663	0.514	0.00	0.04	42.67
124.90	0.05	4,095.710	0.522	0.00	0.05	45.56
124.95	0.06	4,358.565	0.530	0.00	0.06	48.49
125.00	0.07	4,625.244	0.537	0.00	0.07	51.47
125.05	0.08	4,895.763	0.545	0.00	0.08	54.48
125.10	0.09	5,170.138	0.553	0.00	0.09	57.53
125.15	0.09	5,448.384	0.560	0.00	0.09	60.63
125.20	0.10	5,730.520	0.568	0.00	0.10	63.77
125.25	0.10	6,016.559	0.576	0.00	0.10	66.95
125.30	0.11	6,306.518	0.584	0.00	0.11	70.18
125.35	0.11	6,600.413	0.592	0.00	0.11	73.45
125.40	0.12	6,898.260	0.600	0.00	0.12	76.76
125.45	0.12	7,200.075	0.608	0.00	0.12	80.12
125.50	0.12	7,505.875	0.616	0.00	0.12	83.52
125.55	0.13	7,815.674	0.624	0.00	0.13	86.97
125.60	0.13	8,129.490	0.632	0.00	0.13	90.46
125.65	0.14	8,447.337	0.640	0.00	0.14	93.99
125.70	0.14	8,769.233	0.648	0.00	0.14	97.58
125.75	0.14	9,095.192	0.656	0.00	0.14	101.20

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
125.80	0.15	9,425.232	0.664	0.00	0.15	104.87
125.85	0.15	9,759.367	0.672	0.00	0.15	108.59
125.90	0.21	10,097.615	0.681	0.00	0.21	112.41
125.95	0.33	10,439.990	0.689	0.00	0.33	116.33
126.00	0.49	10,786.510	0.697	0.00	0.49	120.34
126.05	0.69	11,137.190	0.706	0.00	0.69	124.44
126.10	0.93	11,492.046	0.714	0.00	0.93	128.62
126.15	1.22	11,851.093	0.722	0.00	1.22	132.90
126.20	1.54	12,214.349	0.731	0.00	1.54	137.26
126.25	1.91	12,581.829	0.739	0.00	1.91	141.71
126.30	2.32	12,953.549	0.748	0.00	2.32	146.24
126.35	2.77	13,329.525	0.756	0.00	2.77	150.87
126.40	3.26	13,709.773	0.765	0.00	3.26	155.59
126.45	3.80	14,094.308	0.773	0.00	3.80	160.41
126.50	4.39	14,483.149	0.782	0.00	4.39	165.31
126.55	5.02	14,876.309	0.791	0.00	5.02	170.32
126.60	5.71	15,273.805	0.799	0.00	5.71	175.41
126.65	6.44	15,675.651	0.808	0.00	6.44	180.61
126.70	7.22	16,081.861	0.817	0.00	7.22	185.90
126.75	8.05	16,492.460	0.826	0.00	8.05	191.30

```
          Length
    .--Top---- B ----------.
W   |                      |
i   |    .------b2------.  |
d   A    b1             |  C
t   |    `----Bottom----'  |
h   |                      |
    `----------D-----------'
     Diagram Not to Scale
```

Pond Volume Calculation for Trapezoidal Basin	
Trapezoid Top Elevation	126.30 m
Trapezoid Top Length (A to C)	228.00 m
Trapezoid Top Width (B to D)	62.00 m
Trapezoid Bottom Elevation	122.80 m
Trapezoid Bottom Length	200.00 m
Trapezoid Bottom Width	32.00 m

Pond Volume Calculation for Trapezoidal Basin	
Trapezoid Width Offset (B to b2)	15.00 m
Trapezoid Length Offset (A to b1)	14.00 m
Trapezoid Vertical Increment	0.10 m

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
122.80	0.0	0.640	0.000	0.000	0.000
122.90	0.0	0.660	1.950	649.872	649.872
123.00	0.0	0.680	2.009	669.693	1,319.565
123.10	0.0	0.700	2.069	689.685	2,009.250
123.20	0.0	0.720	2.129	709.790	2,719.040
123.30	0.0	0.740	2.190	730.037	3,449.077
123.40	0.0	0.761	2.251	750.425	4,199.502
123.50	0.0	0.781	2.313	770.954	4,970.484
123.60	0.0	0.802	2.375	791.626	5,762.082
123.70	0.0	0.823	2.437	812.410	6,574.520
123.80	0.0	0.844	2.500	833.365	7,407.885
123.90	0.0	0.865	2.563	854.433	8,262.318
124.00	0.0	0.886	2.627	875.642	9,137.960

Elevation (m)	Planimeter (m²)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m³)	Volume (Total) (m³)
124.10	0.0	0.908	2.691	896.993	10,034.952
124.20	0.0	0.929	2.755	918.485	10,953.438
124.30	0.0	0.951	2.820	940.091	11,893.557
124.40	0.0	0.973	2.886	961.867	12,855.423
124.50	0.0	0.995	2.951	983.756	13,839.179
124.60	0.0	1.017	3.017	1,005.786	14,844.965
124.70	0.0	1.039	3.084	1,027.958	15,872.923
124.80	0.0	1.061	3.151	1,050.272	16,923.223
124.90	0.0	1.084	3.218	1,072.727	17,995.951
125.00	0.0	1.107	3.286	1,095.296	19,091.246
125.10	0.0	1.129	3.354	1,118.034	20,209.280
125.20	0.0	1.152	3.423	1,140.886	21,350.166
125.30	0.0	1.175	3.492	1,163.879	22,514.045
125.40	0.0	1.199	3.561	1,187.014	23,701.031
125.50	0.0	1.222	3.631	1,210.290	24,911.321
125.60	0.0	1.245	3.701	1,233.680	26,145.001
125.70	0.0	1.269	3.772	1,257.240	27,402.241
125.80	0.0	1.293	3.843	1,280.913	28,683.125
125.90	0.0	1.317	3.914	1,304.727	29,987.852
126.00	0.0	1.341	3.986	1,328.683	31,316.535
126.10	0.0	1.365	4.058	1,352.781	32,669.316
126.20	0.0	1.389	4.131	1,376.992	34,046.307
126.30	0.0	1.414	4.204	1,401.372	35,447.680

Structure ID: Culvert 2
Structure Type: Culvert-Circular

Number of Barrels	1
Diameter	327.0 mm
Length	20.00 m
Length (Computed Barrel)	20.00 m
Slope (Computed)	0.005 m/m

Outlet Control Data

Manning's n	0.013
Ke	0.900
Kb	0.028
Kr	0.900
Convergence Tolerance	0.00 m

Inlet Control Data

Equation Form	Form 1
K	0.0098
M	2.0000
C	0.0398
Y	0.6700
T1 ratio (HW/D)	1.158
T2 ratio (HW/D)	1.304
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	123.78 m	T1 Flow	0.09 m^3/s
T2 Elevation	123.83 m	T2 Flow	0.11 m^3/s

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	123.40 m
Volume (Initial)	4,199.502 m³
Flow (Initial Outlet)	0.00 m³/s
Flow (Initial Infiltration)	0.00 m³/s
Flow (Initial, Total)	0.00 m³/s
Time Increment	0.050 hours

Elevation (m)	Outflow (m³/s)	Storage (m³)	Area (ha)	Infiltration (m³/s)	Flow (Total) (m³/s)	2S/t + O (m³/s)
122.80	0.00	0.000	0.640	0.00	0.00	0.00
122.85	0.00	322.459	0.650	0.00	0.00	3.58
122.90	0.00	649.861	0.660	0.00	0.00	7.22
122.95	0.00	982.223	0.670	0.00	0.00	10.91
123.00	0.00	1,319.562	0.680	0.00	0.00	14.66
123.05	0.00	1,661.895	0.690	0.00	0.00	18.47
123.10	0.00	2,009.240	0.700	0.00	0.00	22.32
123.15	0.00	2,361.614	0.710	0.00	0.00	26.24
123.20	0.00	2,719.033	0.720	0.00	0.00	30.21
123.25	0.00	3,081.516	0.730	0.00	0.00	34.24
123.30	0.00	3,449.078	0.740	0.00	0.00	38.32
123.35	0.00	3,821.738	0.750	0.00	0.00	42.46
123.40	0.00	4,199.512	0.761	0.00	0.00	46.66
123.45	0.00	4,582.418	0.771	0.00	0.00	50.92
123.50	0.01	4,970.472	0.781	0.00	0.01	55.23
123.55	0.02	5,363.693	0.792	0.00	0.02	59.61
123.60	0.03	5,762.095	0.802	0.00	0.03	64.05
123.65	0.04	6,165.699	0.812	0.00	0.04	68.55
123.70	0.05	6,574.519	0.823	0.00	0.05	73.10
123.75	0.07	6,988.573	0.833	0.00	0.07	77.72
123.80	0.09	7,407.880	0.844	0.00	0.09	82.40
123.85	0.10	7,832.454	0.854	0.00	0.10	87.13
123.90	0.11	8,262.315	0.865	0.00	0.11	91.91
123.95	0.12	8,697.478	0.876	0.00	0.12	96.75
124.00	0.12	9,137.962	0.886	0.00	0.12	101.65
124.05	0.13	9,583.783	0.897	0.00	0.13	106.62
124.10	0.13	10,034.958	0.908	0.00	0.13	111.63
124.15	0.14	10,491.504	0.918	0.00	0.14	116.71
124.20	0.15	10,953.440	0.929	0.00	0.15	121.85
124.25	0.15	11,420.780	0.940	0.00	0.15	127.05
124.30	0.16	11,893.544	0.951	0.00	0.16	132.31
124.35	0.16	12,371.748	0.962	0.00	0.16	137.63
124.40	0.17	12,855.409	0.973	0.00	0.17	143.01
124.45	0.17	13,344.545	0.984	0.00	0.17	148.45
124.50	0.18	13,839.172	0.995	0.00	0.18	153.95
124.55	0.18	14,339.307	1.006	0.00	0.18	159.51

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
124.60	0.19	14,844.969	1.017	0.00	0.19	165.13
124.65	0.19	15,356.173	1.028	0.00	0.19	170.82
124.70	0.20	15,872.937	1.039	0.00	0.20	176.56
124.75	0.20	16,395.278	1.050	0.00	0.20	182.37
124.80	0.21	16,923.215	1.061	0.00	0.21	188.24
124.85	0.21	17,456.761	1.073	0.00	0.21	194.18
124.90	0.22	17,995.938	1.084	0.00	0.22	200.17
124.95	0.22	18,540.759	1.095	0.00	0.22	206.23
125.00	0.22	19,091.244	1.107	0.00	0.22	212.35
125.05	0.23	19,647.408	1.118	0.00	0.23	218.53
125.10	0.23	20,209.270	1.129	0.00	0.23	224.78
125.15	0.24	20,776.846	1.141	0.00	0.24	231.09
125.20	0.24	21,350.154	1.152	0.00	0.24	237.46
125.25	0.24	21,929.210	1.164	0.00	0.24	243.90
125.30	0.25	22,514.032	1.175	0.00	0.25	250.40
125.35	0.25	23,104.636	1.187	0.00	0.25	256.97
125.40	0.26	23,701.042	1.199	0.00	0.26	263.60
125.45	0.37	24,303.263	1.210	0.00	0.37	270.41
125.50	0.59	24,911.320	1.222	0.00	0.59	277.38
125.55	0.88	25,525.227	1.234	0.00	0.88	284.50
125.60	1.24	26,145.004	1.245	0.00	1.24	291.74
125.65	1.66	26,770.666	1.257	0.00	1.66	299.11
125.70	2.14	27,402.231	1.269	0.00	2.14	306.61
125.75	2.68	28,039.716	1.281	0.00	2.68	314.23
125.80	3.27	28,683.139	1.293	0.00	3.27	321.97
125.85	3.92	29,332.515	1.305	0.00	3.92	329.84
125.90	4.63	29,987.863	1.317	0.00	4.63	337.83
125.95	5.40	30,649.199	1.329	0.00	5.40	345.94
126.00	6.22	31,316.543	1.341	0.00	6.22	354.18
126.05	7.10	31,989.907	1.353	0.00	7.10	362.55
126.10	8.04	32,669.313	1.365	0.00	8.04	371.03
126.15	9.04	33,354.775	1.377	0.00	9.04	379.65
126.20	10.10	34,046.312	1.389	0.00	10.10	388.39
126.25	11.22	34,743.940	1.401	0.00	11.22	397.26
126.30	12.40	35,447.677	1.414	0.00	12.40	406.26

```
             Length
     .--Top---- B ----------.
W    |                      |
i    |    .------b2------.  |
d    A    b1             |  C
t    |    `----Bottom----'  |
h    |                      |
     `----------D-----------'
      Diagram Not to Scale
```

Pond Volume Calculation for Trapezoidal Basin

Trapezoid Top Elevation	126.75 m
Trapezoid Top Length (A to C)	180.50 m
Trapezoid Top Width (B to D)	138.50 m
Trapezoid Bottom Elevation	123.00 m
Trapezoid Bottom Length	158.00 m
Trapezoid Bottom Width	116.00 m

Pond Volume Calculation for Trapezoidal Basin	
Trapezoid Width Offset (B to b2)	11.25 m
Trapezoid Length Offset (A to b1)	11.25 m
Trapezoid Vertical Increment	0.10 m

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
123.00	0.0	1.833	0.000	0.000	0.000
123.10	0.0	1.849	5.523	1,841.020	1,841.020
123.20	0.0	1.866	5.573	1,857.557	3,698.577
123.30	0.0	1.882	5.622	1,874.122	5,572.699
123.40	0.0	1.899	5.672	1,890.772	7,463.500
123.50	0.0	1.916	5.723	1,907.508	9,371.007
123.60	0.0	1.933	5.773	1,924.300	11,295.307
123.70	0.0	1.950	5.824	1,941.176	13,236.483
123.80	0.0	1.967	5.874	1,958.138	15,194.622
123.90	0.0	1.984	5.925	1,975.157	17,169.778
124.00	0.0	2.001	5.977	1,992.232	19,162.010
124.10	0.0	2.018	6.028	2,009.392	21,171.402
124.20	0.0	2.035	6.080	2,026.637	23,198.010

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
124.30	0.0	2.053	6.132	2,043.938	25,241.948
124.40	0.0	2.070	6.184	2,061.297	27,303.245
124.50	0.0	2.088	6.236	2,078.740	29,381.985
124.60	0.0	2.105	6.289	2,096.268	31,478.281
124.70	0.0	2.123	6.342	2,113.853	33,592.133
124.80	0.0	2.140	6.395	2,131.522	35,723.656
124.90	0.0	2.158	6.448	2,149.277	37,872.933
125.00	0.0	2.176	6.501	2,167.060	40,039.992
125.10	0.0	2.194	6.555	2,184.956	42,224.949
125.20	0.0	2.212	6.609	2,202.909	44,427.858
125.30	0.0	2.230	6.663	2,220.919	46,648.776
125.40	0.0	2.248	6.717	2,239.013	48,887.818
125.50	0.0	2.266	6.772	2,257.192	51,145.010
125.60	0.0	2.285	6.826	2,275.429	53,420.439
125.70	0.0	2.303	6.881	2,293.750	55,714.160
125.80	0.0	2.321	6.936	2,312.127	58,026.287
125.90	0.0	2.340	6.992	2,330.590	60,356.877
126.00	0.0	2.358	7.047	2,349.109	62,705.986
126.10	0.0	2.377	7.103	2,367.713	65,073.699
126.20	0.0	2.396	7.159	2,386.374	67,460.101
126.30	0.0	2.415	7.215	2,405.120	69,865.221
126.40	0.0	2.433	7.272	2,423.950	72,289.171
126.50	0.0	2.452	7.328	2,442.838	74,732.009
126.60	0.0	2.471	7.385	2,461.782	77,193.790
126.75	0.0	2.500	7.457	3,728.394	80,922.185

Infiltration	
Infiltration Method (Computed)	Average Infiltration Rate
Infiltration Rate (Average)	12.0000 mm/h

Initial Conditions	
Elevation (Water Surface, Initial)	123.00 m
Volume (Initial)	0.000 m^3
Flow (Initial Outlet)	0.00 m^3/s
Flow (Initial Infiltration)	0.00 m^3/s
Flow (Initial, Total)	0.00 m^3/s
Time Increment	0.050 hours

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
123.00	0.00	0.000	1.833	0.00	0.00	0.00
123.05	0.00	918.456	1.841	0.06	0.06	10.27
123.10	0.00	1,841.032	1.849	0.06	0.06	20.52
123.15	0.00	2,767.735	1.858	0.06	0.06	30.81
123.20	0.00	3,698.576	1.866	0.06	0.06	41.16
123.25	0.00	4,633.562	1.874	0.06	0.06	51.55
123.30	0.00	5,572.704	1.882	0.06	0.06	61.98
123.35	0.00	6,516.009	1.891	0.06	0.06	72.46
123.40	0.00	7,463.487	1.899	0.06	0.06	82.99
123.45	0.00	8,415.148	1.908	0.06	0.06	93.57
123.50	0.00	9,370.999	1.916	0.06	0.06	104.19
123.55	0.00	10,331.051	1.924	0.06	0.06	114.85
123.60	0.00	11,295.311	1.933	0.06	0.06	125.57
123.65	0.00	12,263.790	1.941	0.06	0.06	136.33
123.70	0.00	13,236.495	1.950	0.06	0.06	147.14
123.75	0.00	14,213.436	1.958	0.07	0.07	157.99
123.80	0.00	15,194.623	1.967	0.07	0.07	168.89
123.85	0.00	16,180.063	1.975	0.07	0.07	179.84
123.90	0.00	17,169.767	1.984	0.07	0.07	190.84
123.95	0.00	18,163.742	1.992	0.07	0.07	201.89
124.00	0.00	19,161.998	2.001	0.07	0.07	212.98
124.05	0.00	20,164.545	2.009	0.07	0.07	224.12
124.10	0.00	21,171.390	2.018	0.07	0.07	235.30
124.15	0.00	22,182.544	2.027	0.07	0.07	246.54
124.20	0.00	23,198.014	2.035	0.07	0.07	257.82
124.25	0.00	24,217.811	2.044	0.07	0.07	269.15
124.30	0.00	25,241.942	2.053	0.07	0.07	280.53
124.35	0.00	26,270.417	2.061	0.07	0.07	291.96
124.40	0.01	27,303.246	2.070	0.07	0.08	303.45
124.45	0.02	28,340.436	2.079	0.07	0.09	314.98
124.50	0.03	29,381.998	2.088	0.07	0.10	326.56
124.55	0.04	30,427.939	2.096	0.07	0.11	338.20
124.60	0.06	31,478.270	2.105	0.07	0.13	349.89
124.65	0.07	32,532.998	2.114	0.07	0.14	361.62
124.70	0.09	33,592.133	2.123	0.07	0.16	373.41

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
124.75	0.11	34,655.685	2.132	0.07	0.18	385.25
124.80	0.13	35,723.661	2.140	0.07	0.20	397.13
124.85	0.15	36,796.072	2.149	0.07	0.22	409.07
124.90	0.17	37,872.925	2.158	0.07	0.24	421.05
124.95	0.17	38,954.231	2.167	0.07	0.24	433.07
125.00	0.17	40,039.997	2.176	0.07	0.24	445.13
125.05	0.17	41,130.233	2.185	0.07	0.24	457.25
125.10	0.17	42,224.949	2.194	0.07	0.25	469.41
125.15	0.18	43,324.152	2.203	0.07	0.25	481.63
125.20	0.18	44,427.853	2.212	0.07	0.25	493.89
125.25	0.18	45,536.059	2.221	0.07	0.25	506.21
125.30	0.18	46,648.781	2.230	0.07	0.26	518.58
125.35	0.18	47,766.026	2.239	0.07	0.26	530.99
125.40	0.19	48,887.804	2.248	0.07	0.26	543.46
125.45	0.19	50,014.125	2.257	0.08	0.26	555.98
125.50	0.19	51,144.996	2.266	0.08	0.27	568.54
125.55	0.19	52,280.428	2.275	0.08	0.27	581.16
125.60	0.19	53,420.428	2.285	0.08	0.27	593.83
125.65	0.20	54,565.007	2.294	0.08	0.27	606.55
125.70	0.20	55,714.172	2.303	0.08	0.28	619.32
125.75	0.20	56,867.934	2.312	0.08	0.28	632.14
125.80	0.20	58,026.300	2.321	0.08	0.28	645.02
125.85	0.21	59,189.280	2.331	0.08	0.28	657.94
125.90	0.21	60,356.884	2.340	0.08	0.29	670.92
125.95	0.21	61,529.119	2.349	0.08	0.29	683.94
126.00	0.21	62,705.996	2.358	0.08	0.29	697.02
126.05	0.21	63,887.522	2.368	0.08	0.29	710.15
126.10	0.22	65,073.708	2.377	0.08	0.30	723.34
126.15	0.22	66,264.561	2.386	0.08	0.30	736.57
126.20	0.22	67,460.091	2.396	0.08	0.30	749.86
126.25	0.22	68,660.308	2.405	0.08	0.30	763.19
126.30	0.22	69,865.219	2.415	0.08	0.30	776.58
126.35	0.23	71,074.835	2.424	0.08	0.31	790.03
126.40	0.23	72,289.163	2.433	0.08	0.31	803.52
126.45	0.23	73,508.214	2.443	0.08	0.31	817.07
126.50	0.23	74,731.995	2.452	0.08	0.31	830.67
126.55	0.23	75,960.517	2.462	0.08	0.32	844.32
126.60	0.24	77,193.787	2.471	0.08	0.32	858.03
126.65	0.24	78,431.815	2.481	0.08	0.32	871.78
126.70	0.24	79,674.611	2.490	0.08	0.32	885.60
126.75	0.24	80,922.182	2.500	0.08	0.32	899.46

```
          Length
    .--Top---- B ----------.
W   |                      |
i   |   .------b2------.   |
d   A   b1             |   C
t   |   `----Bottom----'   |
h   |                      |
    `----------D-----------'
      Diagram Not to Scale
```

Pond Volume Calculation for Trapezoidal Basin

Trapezoid Top Elevation	124.50 m
Trapezoid Top Length (A to C)	232.00 m
Trapezoid Top Width (B to D)	133.00 m
Trapezoid Bottom Elevation	122.00 m
Trapezoid Bottom Length	217.00 m
Trapezoid Bottom Width	118.00 m

Pond Volume Calculation for Trapezoidal Basin	
Trapezoid Width Offset (B to b2)	7.50 m
Trapezoid Length Offset (A to b1)	7.50 m
Trapezoid Vertical Increment	0.10 m

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
122.00	0.0	2.561	0.000	0.000	0.000
122.10	0.0	2.581	7.712	2,570.660	2,570.660
122.20	0.0	2.601	7.773	2,590.822	5,161.481
122.30	0.0	2.621	7.833	2,611.068	7,772.578
122.40	0.0	2.642	7.894	2,631.400	10,403.977
122.50	0.0	2.662	7.955	2,651.788	13,055.737
122.60	0.0	2.682	8.017	2,672.232	15,727.998
122.70	0.0	2.703	8.078	2,692.762	18,420.760
122.80	0.0	2.724	8.140	2,713.377	21,134.137
122.90	0.0	2.744	8.202	2,734.048	23,868.185
123.00	0.0	2.765	8.264	2,754.804	26,622.989
123.10	0.0	2.786	8.327	2,775.617	29,398.607
123.20	0.0	2.807	8.390	2,796.515	32,195.122

Elevation (m)	Planimeter (m^2)	Area (ha)	A1+A2+sqr (A1*A2) (ha)	Volume (m^3)	Volume (Total) (m^3)
123.30	0.0	2.828	8.452	2,817.470	35,012.620
123.40	0.0	2.849	8.516	2,838.509	37,851.129
123.50	0.0	2.870	8.579	2,859.633	40,710.734
123.60	0.0	2.891	8.642	2,880.814	43,591.548
123.70	0.0	2.913	8.706	2,902.052	46,493.600
123.80	0.0	2.934	8.770	2,923.375	49,416.975
123.90	0.0	2.955	8.834	2,944.782	52,361.757
124.00	0.0	2.977	8.899	2,966.246	55,328.003
124.10	0.0	2.999	8.963	2,987.795	58,315.770
124.20	0.0	3.020	9.028	3,009.401	61,325.171
124.30	0.0	3.042	9.093	3,031.064	64,356.235
124.40	0.0	3.064	9.159	3,052.839	67,409.074
124.50	0.0	3.086	9.224	3,074.671	70,483.745

Infiltration	
Infiltration Method (Computed)	Average Infiltration Rate
Infiltration Rate (Average)	12.0000 mm/h

Initial Conditions	
Elevation (Water Surface, Initial)	122.00 m
Volume (Initial)	0.000 m^3
Flow (Initial Outlet)	0.00 m^3/s
Flow (Initial Infiltration)	0.00 m^3/s
Flow (Initial, Total)	0.00 m^3/s
Time Increment	0.050 hours

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
122.00	0.00	0.000	2.561	0.00	0.00	0.00
122.05	0.00	1,282.814	2.571	0.09	0.09	14.34
122.10	0.00	2,570.661	2.581	0.09	0.09	28.65
122.15	0.00	3,863.552	2.591	0.09	0.09	43.01
122.20	0.00	5,161.495	2.601	0.09	0.09	57.44
122.25	0.00	6,464.499	2.611	0.09	0.09	71.91
122.30	0.00	7,772.572	2.621	0.09	0.09	86.45
122.35	0.00	9,085.725	2.631	0.09	0.09	101.04
122.40	0.00	10,403.966	2.642	0.09	0.09	115.69
122.45	0.00	11,727.303	2.652	0.09	0.09	130.39
122.50	0.00	13,055.747	2.662	0.09	0.09	145.15
122.55	0.00	14,389.306	2.672	0.09	0.09	159.97
122.60	0.00	15,727.989	2.682	0.09	0.09	174.84
122.65	0.00	17,071.804	2.693	0.09	0.09	189.78
122.70	0.00	18,420.762	2.703	0.09	0.09	204.77
122.75	0.00	19,774.871	2.713	0.09	0.09	219.81
122.80	0.00	21,134.139	2.724	0.09	0.09	234.91
122.85	0.00	22,498.577	2.734	0.09	0.09	250.08
122.90	0.00	23,868.193	2.744	0.09	0.09	265.29
122.95	0.00	25,242.996	2.755	0.09	0.09	280.57
123.00	0.00	26,622.994	2.765	0.09	0.09	295.90
123.05	0.00	28,008.198	2.776	0.09	0.09	311.29
123.10	0.00	29,398.616	2.786	0.09	0.09	326.74
123.15	0.00	30,794.256	2.797	0.09	0.09	342.25
123.20	0.00	32,195.129	2.807	0.09	0.09	357.82
123.25	0.00	33,601.243	2.817	0.09	0.09	373.44
123.30	0.00	35,012.607	2.828	0.09	0.09	389.12
123.35	0.00	36,429.229	2.839	0.09	0.09	404.86
123.40	0.00	37,851.120	2.849	0.09	0.09	420.66
123.45	0.00	39,278.288	2.860	0.10	0.10	436.52
123.50	0.00	40,710.742	2.870	0.10	0.10	452.44
123.55	0.00	42,148.490	2.881	0.10	0.10	468.41
123.60	0.00	43,591.543	2.891	0.10	0.10	484.45
123.65	0.08	45,039.909	2.902	0.10	0.17	500.62
123.70	0.22	46,493.596	2.913	0.10	0.32	516.92

Elevation (m)	Outflow (m^3/s)	Storage (m^3)	Area (ha)	Infiltration (m^3/s)	Flow (Total) (m^3/s)	2S/t + O (m^3/s)
123.75	0.43	47,952.615	2.923	0.10	0.52	533.33
123.80	0.68	49,416.974	2.934	0.10	0.77	549.85
123.85	0.97	50,886.682	2.945	0.10	1.07	566.48
123.90	1.32	52,361.747	2.955	0.10	1.42	583.22
123.95	1.71	53,842.180	2.966	0.10	1.81	600.06
124.00	2.15	55,327.989	2.977	0.10	2.25	617.00
124.05	2.64	56,819.183	2.988	0.10	2.74	634.06
124.10	3.17	58,315.770	2.999	0.10	3.27	651.22
124.15	3.75	59,817.761	3.009	0.10	3.85	668.50
124.20	4.39	61,325.164	3.020	0.10	4.49	685.88
124.25	5.07	62,837.988	3.031	0.10	5.17	703.37
124.30	5.80	64,356.241	3.042	0.10	5.90	720.97
124.35	6.59	65,879.934	3.053	0.10	6.69	738.69
124.40	7.42	67,409.075	3.064	0.10	7.52	756.51
124.45	8.31	68,943.673	3.075	0.10	8.41	774.46
124.50	9.26	70,483.736	3.086	0.10	9.36	792.51

Appendix 8-C

Stormwater Management Performance Assessment

Appendix 8-C

Stormwater Management Performance Assessment

This appendix outlines decision making criteria related to operation of the stormwater management (SWM) system. It includes performance assessment of the SWM ponds, disposal of secondary drainage layer (SDL) water and construction water into the SWM conveyance/holding system. Decision making criteria are presented in the following flow charts. The following field and laboratory sampling information shall be read in conjunction with the flow charts.

1. Sampling Locations

- Stormwater Pond Inlet
- Stormwater Pond Content
- Stormwater Pond Outlet (only if outlet valve open).
- SDL sampling port near Pumping Station PS6.
- Construction water-variable locations.

2. Water Quality Based on Field Sampling

Level 1

- conductivity < 1,000 µS/cm

Level 2

- 1,000 µS/cm < conductivity < 2,000 µS/cm

Level 3

- conductivity > 2,000 µS/cm
- 6.5 < pH < 9.0
- dissolved oxygen (DO) < 3 mg/L May through October
  <5 mg/L November to April

3. Water Quality Based on Laboratory Sample

Elevated:

- conductivity between 1,000 and 2,000 µS/cm
- TDS between 600 and 1,200 mg/L
- chloride between 150 and 250 mg/L
- sodium between 110 and 200 mg/L

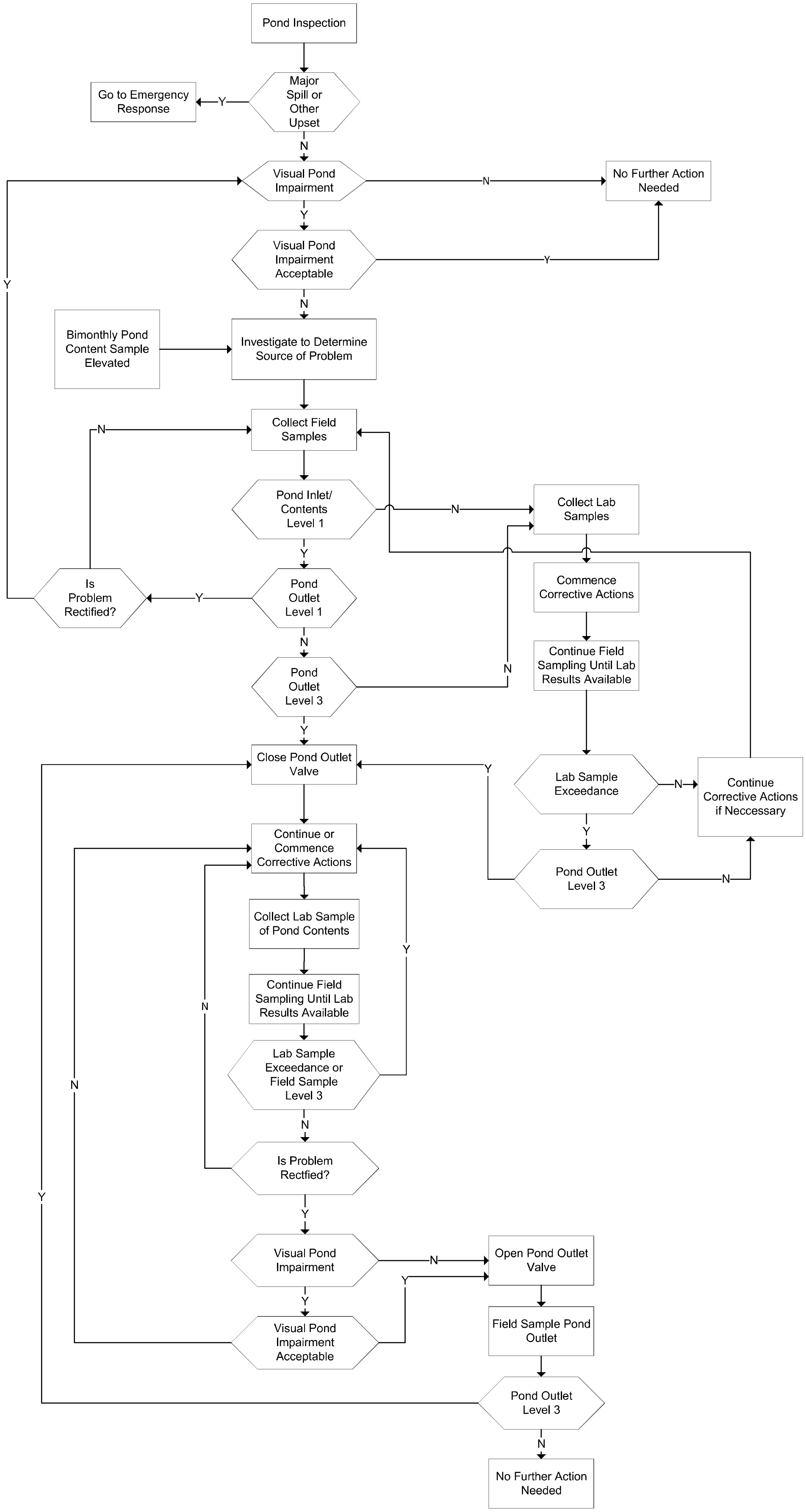
Exceedance:

- conductivity > 2,000 µS/cm
- TDS > 1,200 mg/L
- chloride > 250 mg/L
- sodium > 200 mg/L

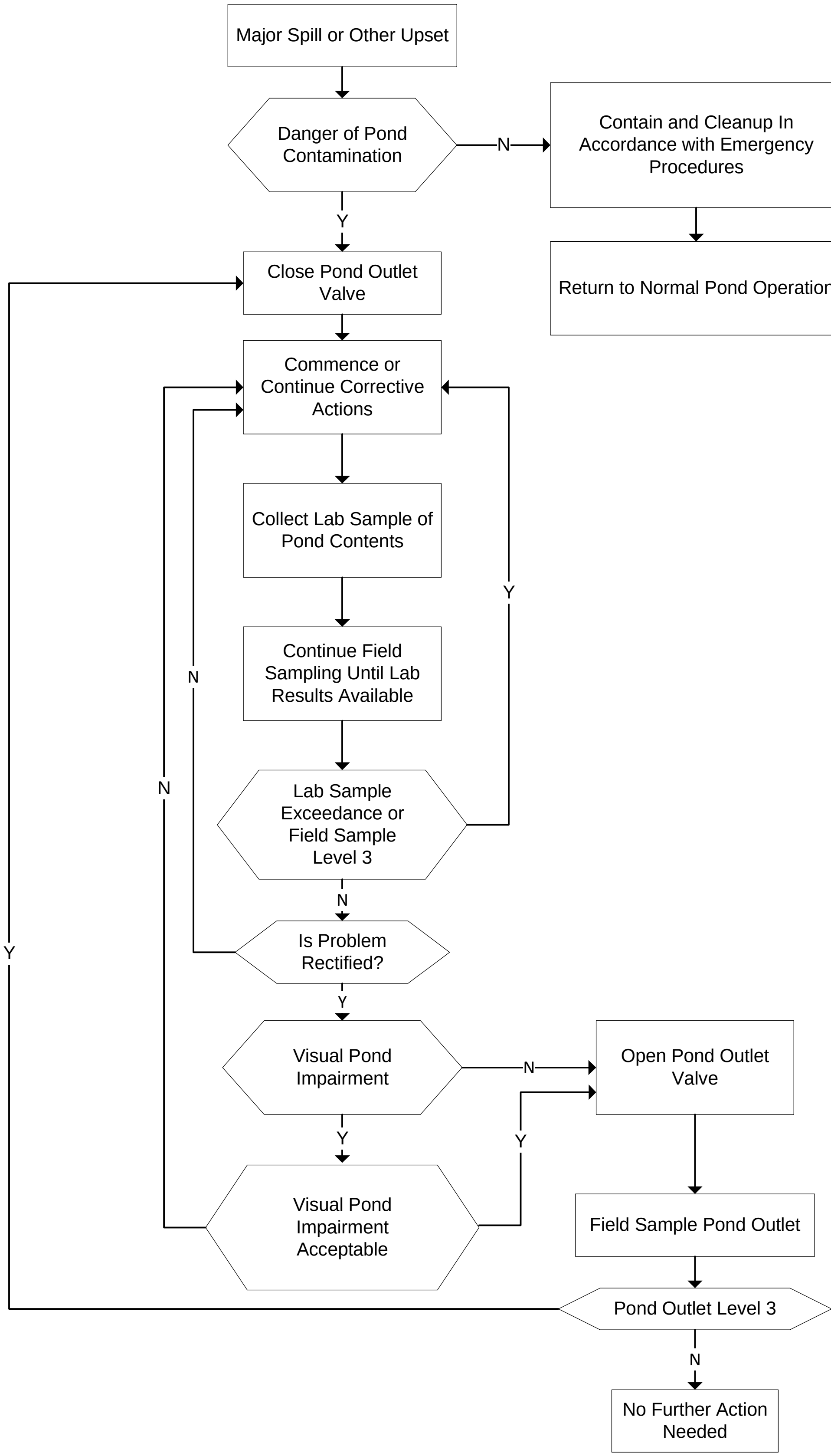
Increased turbidity shall not be considered as visual impairment of surface water. In case of a spill, indicator parameters should be revised/added based on the nature of spilled liquid.

Corrective actions will always depend on the nature of the problem. Usually it will require fixing the source of the problem such as leachate seep, exposed waste, spill, etc. If the pond contents are contaminated, corrective measures may include in-situ treatment, dilution (mixing to agitate contents, floating aerator and/or other measures to prevent stagnation), containment with booms, removal of floating material and removal of pond contents for treatment on-site or off-site.

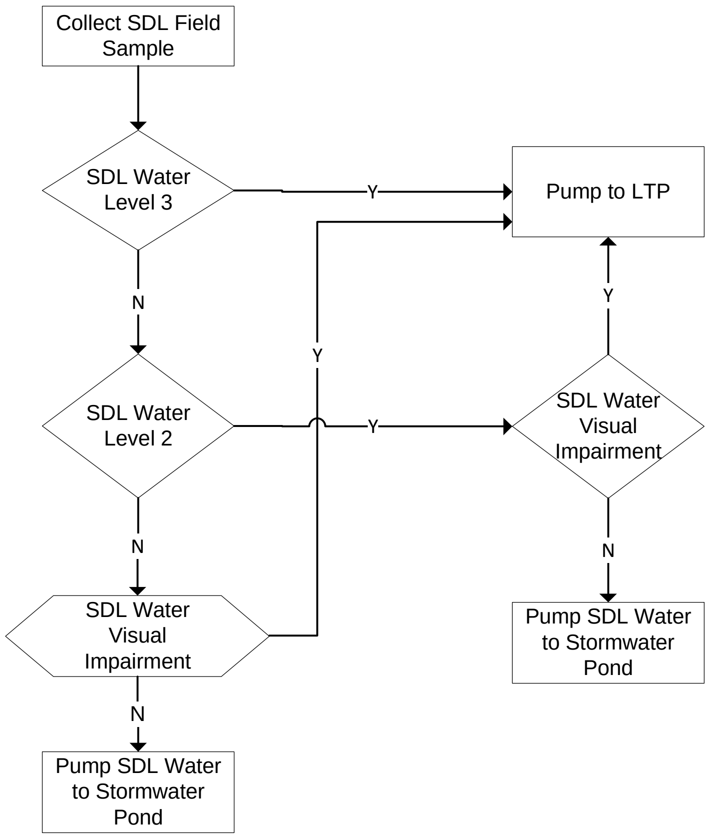
A - Regular Pond Operation



B - Stormwater Pond Emergency Response



C - Handling of Secondary Drainage Layer (SDL) Water



D - Construction DewaterIng
(Handling of Construction Water (CW))