



June 24, 2020

ECS Project No. ECS-2020-0003

MWM Environmental
Box 459
Souris, Manitoba
R0K 2C0

Attention: Mr. Tim Oliver
General Manager

**Re: Soil Hydraulic Conductivity Testing Program
Municipal Waste Management Ltd. SW35-8-21W Landfill
SW ¼ 35-8-21 WPM Municipality of Souris-Glenwood, Manitoba**

Environmental Consulting Solutions (ECS) was retained by MWM Environmental (MWM) to complete a soil investigation to determine the soil hydraulic conductivity of the clay material utilized in the construction of the new landfill cell in September/October 2020 at the above-referenced Site (*i.e.*, Municipal Waste Management Ltd. SW35-8-21 W Landfill).

In order to derive the appropriate scope of work for the Soil Hydraulic Conductivity Testing Program, ECS reviewed the following documents:

- *The Environmental Act License, License No. 3181* issued to Municipal Waste Management, in the Municipality of Souris-Glenwood, Province of Manitoba;
- *Proposed Regional Landfill SW 35-8-21 W1M Hydrogeological Assessment*, Roper Environmental Engineering Inc., dated January 22, 1992;
- *Municipal Waste Management Ltd Environmental Act Proposal for the Waste Disposal Ground Expansion, JR Cousins Consultants Ltd*, dated December 2015;
- *Hydraulic Conductivity Testing Report*, Stantec Consulting Ltd, dated June 16, 2014; and
- *Standards for Landfills in Manitoba*, Department of Sustainable Development, 2016.

The purpose of the proposed work program is to fulfill Section 38 to 40 of the Environmental Act License (Licence No.: 3181) issued to Municipal Waste Management Ltd.

A Site Map showing the location of the Site is presented as Figure 1 and a Site Plan showing the soil testing locations are presented on Figure 2 in Attachment A.

1.0 SCOPE OF WORK

The scope of work was outlined in ECS' proposal entitled *Proposal for Soil Hydraulic Conductivity Testing, Municipal Waste Management Ltd. SW35-8-21W Landfill, SW ¼ 35-8-21 WPM Municipality of Souris-Glenwood, Manitoba*, dated October 5, 2020. In general, the scope of work included obtaining a number of representative soil samples from the constructed clay landfill cell walls and floor to determine the soil hydraulic conductivity of the clay used to construct the base and walls for the new landfill cell at the subject Site. The scope of work for the project was as follows:

- A maximum of twenty (20) samples per cell or clay component will be obtained via a retained qualified drilling sub-contractor to a maximum depth of 1.37 m or 4.5 ft below existing surface grade (two split spoon advancements);
- Undisturbed soil samples will be obtained via a split-spoon sampling device equipped with Shelby Tubes. Recovered soil samples from each advancement will be visually observed and its physical characteristics documented; and,
- A maximum of twenty (20) soil samples will be submitted to an accredited laboratory (Stantec) for soil hydraulic conductivity testing.

2.0 SOIL QUALITY DESIGN CRITERIA

As outlined in *The Environmental Act Licence (Licence No. 3181) to Municipal Waste Management Ltd.* dated May 27, 2016, Sections 38 to 44 Liners and Clay Components outlines the following:

Cut off Components of the Development

38. The Licencee shall, where a cut-off perimeter around a component(s) of the Development is keyed into a suitable base of clay underneath the component(s), have the cut-off constructed in accordance with the following specifications:
 - a. The cut-off shall be made of clay which has been mechanically compacted;
 - b. The cut-off wall shall be at least one meter in width;
 - c. The cut-off wall shall have a hydraulic conductivity of 1×10^{-7} cm/second or less at all locations;
 - d. The cut-off shall be keyed into the underlying clay or clay liner a minimum of 0.3 metres;
 - e. The cut-off shall be constructed to an elevation of one (1) metre above the maximum leachate level in any waste cell or leachate pond; and
 - f. The cut-off shall be tested in accordance with Clauses 41-43 of the Environmental Act Licence.



Clay Components of the Development

39. The Licencee shall, where a component of the Development is to be constructed with a clay liner, construct the liner underlying the component as described in Clauses 40 to 43 of the Environmental Act Licence.
40. The Licencee shall construct and maintain all clay lined component(s) of the Development in accordance with the following specifications:
 - a. The clay liner is recompacted to a minimum thickness of one (1) metre for the side slopes and for the base of waste cells or leachate ponds;
 - b. The hydraulic conductivity of the clay is 1×10^{-7} cm/s or less;
 - c. The liner extends a vertical distance of one (1) metre above normal operating level for any leachate storage component other than a landfill cell; and
 - d. The clay liner is installed under the entire base and side wall or berm of any waste containment cell(s) below grade

2.1 Previous Site Investigations

Roper Environmental Engineering (REE)

In 1992 a hydrogeological assessment was completed at the Site by Roper Environmental Engineering (REE). This investigation identified the following:

- On-Site soil profile identified as oxidized clay till (7m to 10 m) followed by grey, silty clay till to approximately 30 m below the surface. Observed layers of sand, clay till to the shale bedrock found at approximately 48 m below the surface;
- No significant water bearing zones were present in the first 31 m of the till material below surface;
- Hydraulic conductivity of the till material ranged between 8.8×10^{-7} cm/sec and 1×10^{-8} cm/sec, while the vertical flow velocities in the till ranged from 0.012 m/yr to 0.13 m/year;
- Based on vertical flow velocity, it would take approximately 150 years for leachate to reach the underlying water bearing zone.

Stantec Consultants Ltd.

In 2014, Stantec Consultants Ltd. (Stantec) completed analysis on two submitted soil samples (TH#2 and TH#3) for ASTM D5084, Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter. Results of the two soil sample analysis were observed to be:

TH#2	2.6×10^{-8} cm/s Brown, stiff, moist, high plasticity clay some medium to coarse sand, trace fine gravel
TH#3	1.4×10^{-8} cm/s Brown, firm, moist, high plasticity clay some medium to coarse sand, trace fine gravel



JR Cousin Consultants Ltd.

Between September 9 and 15, 2015 an on-Site investigation was completed by JR Cousin Consultants Ltd. (JRCC). This investigation identified the following:

- Purpose of the investigation was to determine whether the soils would be suitable for use as a clay cell liner in an undisturbed state (in-situ) or after re-working, and whether soils could be used for potential borrow material during construction;
- A total of nine (9) test holes were advanced across the Site to a maximum depth of 12 m bgs;
- General soil profile consisted of a layer of surficial black topsoil approximately 0.2 m thick, followed by layers of silt till and silty clay till, with thin layers of fine grain sand to depth of 0.7 – 3.4 m bgs. Below this was a consistent layer of high plastic clay till, observed at 4.5 m to 7.5 thick, followed by alternating layers of silty clay, silt till and high plastic clay till to the maximum depth investigated;
- Refusal or bedrock was not encountered within any of the test holes advanced during the investigation;
- Standing water recorded at depths ranging between 5.0 and 8.7 m bgs in five of the open test holes;
- Laboratory analysis of the submitted soil samples representative of the on-Site conditions indicated that soils with the following characteristics would provide a liner with a hydraulic conductivity of 1×10^{-7} cm/sec or less:
 - Liquid limit of 30% or greater;
 - Plastic index of 10% or greater;
 - 30% or more passing a number 200 mesh sieve;
 - 20% or more of clay particles.

The soil samples submitted had a liquid limit range from 52% - 64%; a plastic index ranging from 37% - 46%; and a clay content ranging from 41.3% - 51.1%. Therefore, based on the above results all of the soil samples submitted for analysis would be expected to achieve a hydraulic conductivity of 1×10^{-7} cm/sec or less.



3.0 METHODOLOGY

Prior to commencing the drilling activities, the locations of the underground utilities including telephone, electrical lines and natural gas were marked out by local locating companies.

The field work for the Soil Hydraulic Conductivity Testing Program was carried out on May 13, 2021. A total of seven (7) boreholes (BH-01 to BH-07) were advanced at the Site by Paddock Drilling Ltd. (Paddock), a licensed drilling contractor under the full-time supervision of ECS staff and direction of Manitoba Conservation and Climate Officers. A truck mounted drilling machine equipped with augers and Shelby tubes was utilized for the soil sampling program.

As part of this program the soil auger was advanced to varying depths into the re-worked and/or the in-situ clay of the completed landfill berms and floor, as per the direction of the Manitoba Conservation and Climate Officer. Upon advancing the auger to the directed depth, the auger was extracted and the Shelby tube was advanced into the subsurface soil via a direct push methodology. Once the Shelby tube was advanced into the subsurface to obtain the soil sample, the Shelby tube was removed, the Shelby tube was then immediately taped at both ends of the tube to maintain the soil sample integrity and moisture content.

ECS staff continuously monitored the drilling activities to log the recovered soil cores and record the depth of the soil sample collection and total depth of boring.

A Site Plan showing the soil testing locations within the new landfill cell is presented on Figure 2 in Attachment A.



4.0 FINDINGS

4.1 Subsurface Conditions

The detailed soil profiles encountered during the May 13, 2021 field program are summarized in Table 1 below:

TABLE 1
Subsurface Soil Conditions

Boring Location	Soil Description	Borehole Depth (m bgs)	Shelby Tube Depth (m)	Shelby Tube % Recovery (m)
BH-01	Biege Clayey Silt Till, plastic some gravel, moist.	0.71	0.10 – 0.71	0.45
BH-02	Biege/Grey Clayey Silt Till, plastic, trace gravel, moist.	0.71	0.10 – 0.71	0.53
BH-03	Biege Clayey Silt Till, plastic trace gravel, moist.	1.21	1.21 – 1.82-	0.53
BH-04	Biege Clayey Silt Till, plastic some gravel, moist.	2.00	-	-
BH-05	Brown Clayey Silt Till, plastic trace gravel, moist.	3.00	-	-
BH-06	Brown Clayey Silt Till, plastic trace gravel, moist.	1.52	-	-
BH-07	Biege Clayey Silt Till, plastic trace gravel, moist.	1.52	0.91 – 1.52	0.43

Note:

- Shelby tube sample not recovered from this boring location at the direction of Manitoba Conservation and Climate Officer.

5.0 SOIL QUALITY

In accordance with the scope of work, laboratory analyses were performed on selected soil samples recovered from the advanced boreholes (BH-01, BH-03 and BH-07). The selection of drilling locations and selection of representative soil samples for analysis was based on the direction from the Manitoba Conservation and Climate Officer at the Site directing the field program on May 13, 2021.



5.1 Soil Hydraulic Conductivity Testing

Three (3) representative soil samples were collected from the drilling program and submitted to Stantec a certified materials testing laboratory located in Winnipeg, Manitoba to undergo analysis for hydraulic conductivity testing.

Laboratory analytical results indicate that the submitted soil samples have a hydraulic conductivity range between 1.00×10^{-8} cm/s to 4.00×10^{-8} cm/s. A summary of the laboratory analytical results for the three (3) submitted soil samples is outlined below in Table 2.

TABLE 2
Soil Analysis – Hydraulic Conductivity

Boring Location	Soil Description	Borehole Depth (m bgs)	Hydraulic Conductivity (cm/s)
BH-01	Brown Clayey Silt Till, plastic trace gravel, moist.	0.45	2.20×10^{-8}
BH-03	Biege Clayey Silt Till, plastic trace gravel, moist.	0.53	4.00×10^{-8}
BH-07	Biege Clayey Silt Till, plastic trace gravel, moist.	0.43	1.00×10^{-8}

Copies of the laboratory Certificates of Analysis for the tested soil samples are provided in Appendix B.



6.0 SUMMARY OF FINDINGS

Based on the results of the Soil Hydraulic Conductivity Testing Program conducted at the Site, the following findings are presented:

- The general stratigraphy encountered during the drilling activities, as revealed in the boreholes, consists of a silty clay till with some sand and gravel. Observed soil conditions during the testing program were observed to be in line with that outlined in the REE, Stantec and JRCC reports as outlined in Section 2.1 above;
- Soil hydraulic conductivity results for the three (3) samples submitted for laboratory analysis indicate that the hydraulic conductivity of the soils sampled to be as follows:
 - BH-01 2.20 x 10⁻⁸ cm/s
 - BH-03 4.00 x 10⁻⁸ cm/s
 - BH-07 1.00 x 10⁻⁸ cm/s
- Based on the observed analytical results, all soil samples submitted for analysis of hydraulic conductivity are within the specifications as outlined in *The Environmental Act License, License No. 3181* issued to Municipal Waste Management, in the Municipality of Souris-Glenwood, Province of Manitoba and the *Standards for Landfills in Manitoba*, Department of Sustainable Development, 2016.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Soil Hydraulic Conductivity results were all observed to be within the specifications as outlined in *The Environmental Act License, License No. 3181* issued to Municipal Waste Management, in the Municipality of Souris-Glenwood, Province of Manitoba and the *Standards for Landfills in Manitoba*, Department of Sustainable Development, 2016.

Based on the results of this testing program, the soil utilized in the construction of the landfill cell walls and floor comply with the current Environmental Act License and Landfill Standards in Manitoba.



8.0 STANDARD LIMITATIONS

The findings and recommendations provided in this report were prepared by Environmental Consulting Solutions (ECS) in accordance with generally accepted professional engineering principles and practices. The recommendations are based on the results of field investigations and laboratory testing and are reflective only of the actual areas examined and/or investigated. It shall be recognized that samples taken represent one discrete portion of any site at any given time, and may or may not be representative of the entire site or the portion in question. Proper methodology can reduce but not eliminate the uncertainty that is inherent in the nature of this process. If conditions encountered during construction appear to be different than that previously shown through field investigations and laboratory testing at this Site, the Consultant should be notified immediately in order that the recommendations can be reviewed and modified as necessary to address the actual Site conditions.

This report is limited in scope to only those items that are specifically referenced in this report. There may be existing conditions that were not recorded in this report. Such conditions were not apparent to the Consultant due to the limitations of the scope of work for the project. The Consultant, therefore, accepts no liability for any costs incurred by the Client for subsequent discovery, manifestation or rectification of such conditions.

This report is intended solely for the Client named as a general indication of the visible or reported physical condition of the items addressed in the report at the time of the field investigations and laboratory testing. The material in this report reflects the Consultant's best judgement in light of the information available to it at the time of preparation.

This report and the information and data contained herein are to be treated as confidential and may be used only by the Client and its officers and employees in relation to the specific project that it was prepared for. Any use a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. The Consultant accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The report has been written to be read in its entirety, do not use any part of this report as a separate entity.



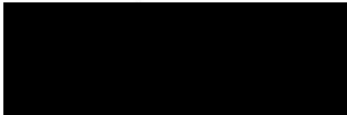
9.0

CLOSURE

We trust that this report meets with your current requirements. In the event that you may have any questions or require additional information with regards to this report, please do not hesitate to contact the undersigned.

Yours very truly,

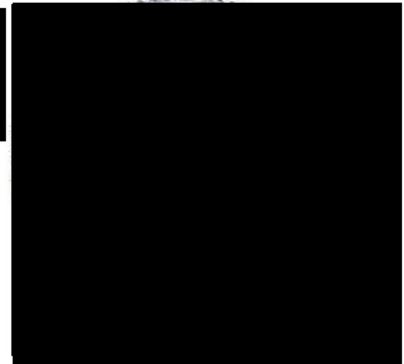
ENVIRONMENTAL CONSULTING SOLUTIONS



Doug Dolby, Dipl. T. Env.
Environmental Specialist



Senior Engineer



Attachments (2):

Attachment A – Figures
Attachment B – Certificates of Analysis



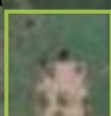
Appendices

Appendix A: Figures



ghway 349

Municipal Waste Management
SW35821W and
Souris Genwood, Manitoba



Road 47N


Provincial Road 250

Canadian Pacific Railway

2 Souris

2

LEGEND:

-  Approximate location of Property Boundaries



enviro-solutions.ca

Title

Site location Plan

Date

June 11, 2021

Project

Soil Hydrologic Conductivity Testing Program

Project No.

CS - 2020 - 003

Location

SW ¼ 35821 WPM Souris Genwood, Manitoba

Scale

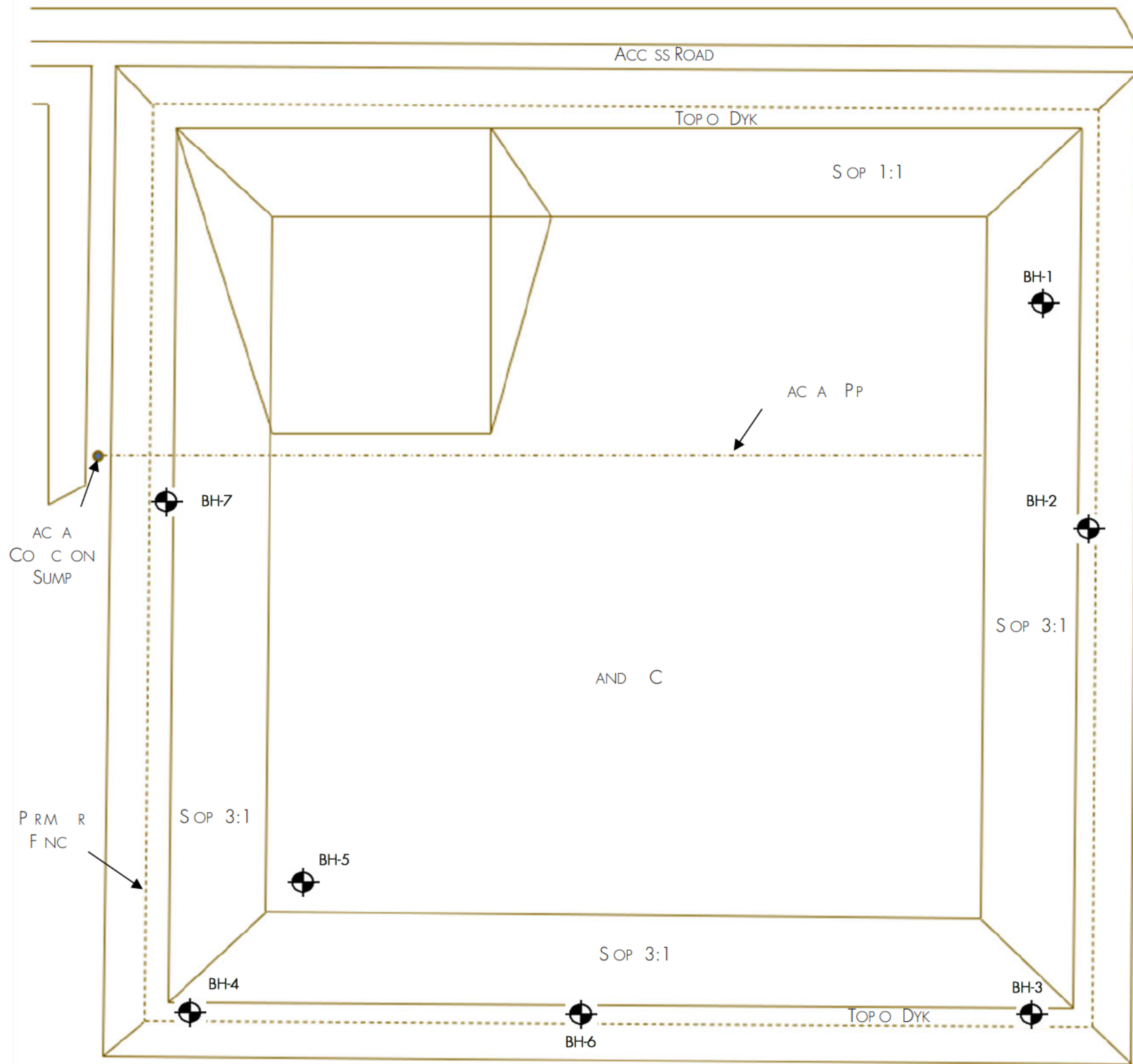
N/S

Drawn By

DD

Checked By

CN



LEGEND



Borehole Location
 Environmental Consulting Solutions (May 3, 2021)

Appendix B: Certificates of Analysis



Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg MB R3Y 1G4

June 8, 2021
File: 123315489

Attention: Mr. Doug Dolby
Environmental Consulting Solutions
216 – 740 Rosser Avenue
Brandon, Manitoba, R7A 0K9

Good day Doug,

Reference: Municipal Waste Management – Souris (ECS-2021-MWM)

On May 18, 2021, three (3) soil samples were submitted to our laboratory for analysis. The following test was conducted on select soil samples:

- ASTM D5084 - *Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

The resulting test data is attached.

We appreciate the opportunity to assist you on this project. Please contact the undersigned if you have any questions regarding this report.

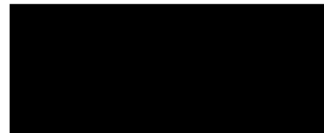
Regards,

Stantec Consulting Ltd.



Larry Presado, C.Tech.
Senior Geotechnical Technologist

Phone: (204) 488-6999
larry.presado@stantec.com



Guillaume Beauce, P.Eng.
Associate – Materials Testing Services

Phone: (204) 928-7618
guillaume.beauce@stantec.com

Attachment: 3 x Hydraulic Conductivity Reports



Stantec Consulting Ltd.
 199 Henlow Bay, Winnipeg, MB R3Y 1G4
 Tel: (204) 488-6999

ASTM D5084 - MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER

TO Environmental Consulting Solutions
 216 - 740 Rosser Avenue
 Brandon, Manitoba
 R7A 0K9

PROJECT MWM Souris

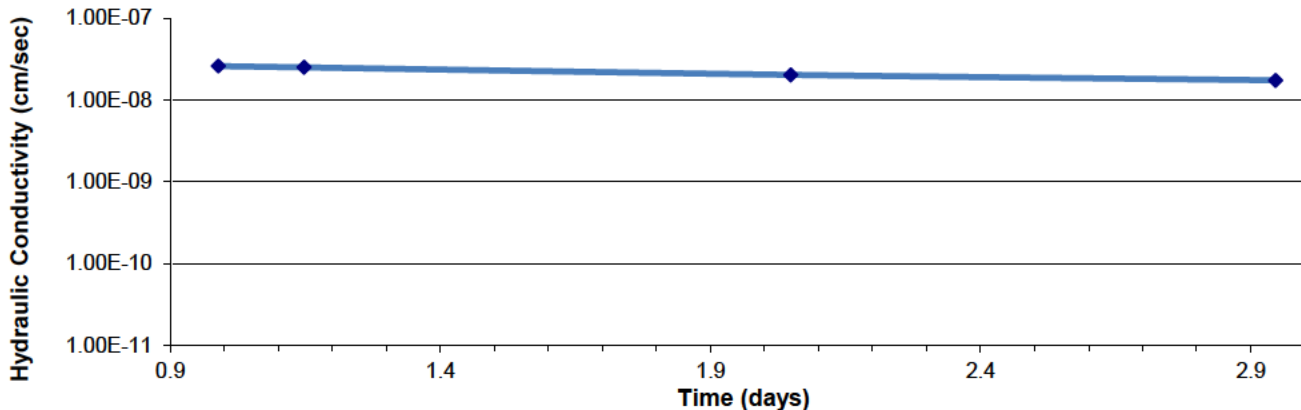
PROJECT NO. 123315489

ATTN: Doug Dolby

REPORT NO. 1


SAMPLE ID: BH01 @ 18"
 SOIL DESCRIPTION: Silty clay, brown, firm, moist, medium plasticity, trace fine to coarse-grained sand, trace fine gravel
 DATE TESTED: May 28 to June 3, 2021
 CONFINING PRESSURE (kPa): 137.9
 EFFECTIVE SATURATION STRESS (kPa): 34.5
 ASSUMED SPECIFIC GRAVITY: 2.75
 HYDRAULIC GRADIENT: 19.0
 TYPE OF PERMEANT LIQUID: De-aired Water
 HYDRAULIC CONDUCTIVITY, "k" (cm/s): 2.4E-08
 HYDRAULIC CONDUCTIVITY, "k₂₀" (cm/s): 2.2E-08

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm ³)	Water Content by Mass (%)	Water Content by Volume (%)	Saturation (%)
Initial Reading	77.4	71.8	618.3	1.594	23.6	37.6	89.4
Final Reading	78.1	72.0	650.0	1.651	23.9	39.5	98.7



COMMENTS:

REPORT DATE: 2021.Jun.04

REVIEWED BY  Guillaume Beauce, P.Eng.
 Associate - Materials Testing Services

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided only on written request. The data presented above is for the sole use of the client stipulated above. Stantec is not responsible, nor can be held liable, for the use of this report by any other party, with or without the knowledge of Stantec.



Stantec Consulting Ltd.
 199 Henlow Bay, Winnipeg, MB R3Y 1G4
 Tel: (204) 488-6999

ASTM D5084 - MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER

TO Environmental Consulting Solutions
 216 - 740 Rosser Avenue
 Brandon, Manitoba
 R7A 0K9

PROJECT MWM Souris

PROJECT NO. 123315489

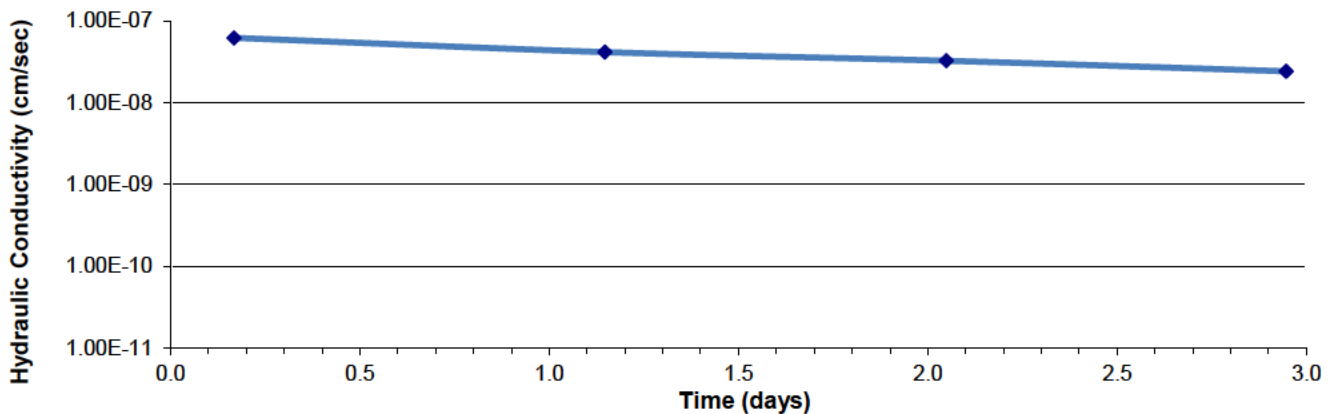
ATTN: Doug Dolby

REPORT NO. 2

SAMPLE ID: BH03 @ 21"
 SOIL DESCRIPTION: Silt and clay, brown/grey, stiff, moist, medium plasticity, trace fine to coarse-grained sand


DATE TESTED: May 28 to June 3, 2021
 CONFINING PRESSURE (kPa): 137.9
 EFFECTIVE SATURATION STRESS (kPa): 34.5
 ASSUMED SPECIFIC GRAVITY: 2.75
 HYDRAULIC GRADIENT: 18.8
 TYPE OF PERMEANT LIQUID: De-aired Water
 HYDRAULIC CONDUCTIVITY, "k" (cm/s): 4.0E-08
 HYDRAULIC CONDUCTIVITY, "k₂₀" (cm/s): 3.7E-08

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm ³)	Water Content by Mass (%)	Water Content by Volume (%)	Saturation (%)
Initial Reading	78.2	71.9	643.2	1.662	22.0	36.5	92.3
Final Reading	78.9	72.4	654.4	1.562	29.1	45.4	105.2



COMMENTS:

REPORT DATE: 2021.Jun.04

REVIEWED BY  Guillaume Beauce, P.Eng.
 Associate - Materials Testing Services

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ASTM D5084 - MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER

TO Environmental Consulting Solutions
 216 - 740 Rosser Avenue
 Brandon, Manitoba
 R7A 0K9

PROJECT MWM Souris

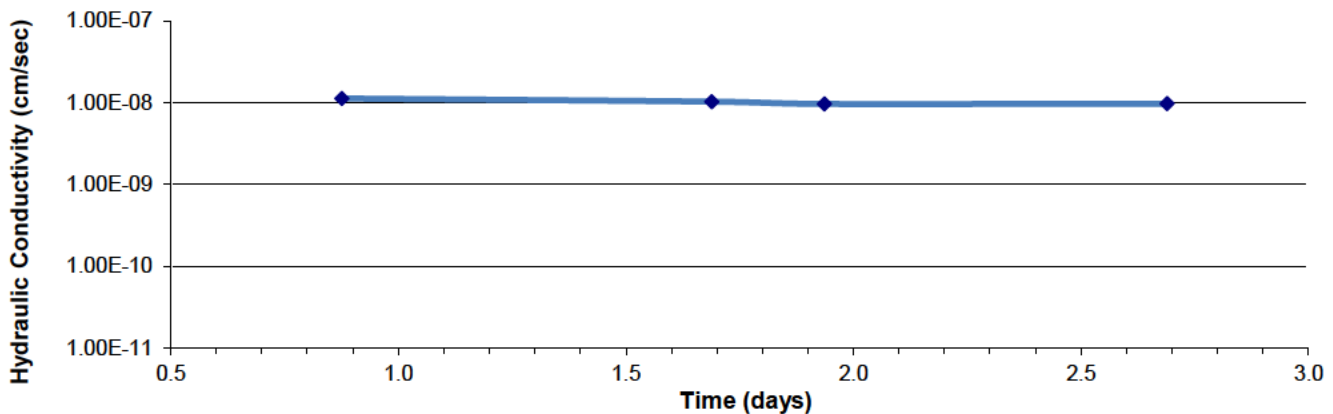
PROJECT NO. 123315489

ATTN: Doug Dolby

REPORT NO. 3

SAMPLE ID: BH07 @ 17"
 SOIL DESCRIPTION: Silty clay, brown/grey, firm, moist, medium plasticity, trace fine to coarse-grained sand, trace fine gravel, trace organic materials
 DATE TESTED: May 28 to June 3, 2021
 CONFINING PRESSURE (kPa): 137.9
 EFFECTIVE SATURATION STRESS (kPa): 34.5
 ASSUMED SPECIFIC GRAVITY: 2.75
 HYDRAULIC GRADIENT: 19.0
 TYPE OF PERMEANT LIQUID: De-aired Water
 HYDRAULIC CONDUCTIVITY, "k" (cm/s): 1.1E-08
 HYDRAULIC CONDUCTIVITY, "k₂₀" (cm/s): 1.0E-08

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm ³)	Water Content by Mass (%)	Water Content by Volume (%)	Saturation (%)
Initial Reading	77.8	71.5	589.7	1.471	28.3	41.7	89.6
Final Reading	78.3	71.8	598.1	1.389	35.9	49.8	100.6



COMMENTS:



REPORT DATE: 2021.Jun.04

REVIEWED BY Guillaume Beauce, P.Eng.
 Associate - Materials Testing Services

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