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May 7, 2020

Savannah River Nuclear Solutions
Bldg. 730-2B Room 2158
Aiken, SC 29808

Attention: Mr. William Joyce, STR

Subject: **Test Report – CLSM Proposed TCG Hydraulic Conductivity Test**
Subcontract No. 0000441257, Delivery Order No. 4
Specification K-SPC-G-00013, Rev. 15
Wood E&IS Project No. 6162-19-1253.04

Dear Mr. Joyce:

Wood Environment & Infrastructure Solutions, Inc. (Wood) has completed the assigned testing services for Delivery Order No. 4, Subcontract No. 0000441257. The test results are included in Attachment 1. An equipment list used in this Delivery Order is included in Attachment 2. The tests performed in this Delivery Order are listed below along with applicable ASTM or other procedures:

Hydraulic Conductivity	ASTM D 5084-16a

These tests were performed in accordance with the above referenced contract order and Wood's QAPD Revision 1 for Subcontract No. 0000441257.

We appreciate the opportunity of serving your geotechnical laboratory testing needs. If you have questions, please contact us.

Sincerely,

Wood Environment & Infrastructure Solutions, Inc.

Jianren Wang
Technical Lead

Pieter DePree
Project Manager

Cc: SRNS
Vendor Documents
Building 704-IN/Room 137
Aiken, SC 29808
(VendorDocument@srs.gov)

SRNS
Procurement Administrator
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Aiken, SC 29808

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woodplc.com

ATTACHMENT 1

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HYDRAULIC CONDUCTIVITY

Project No.	*6162-19-1253.04*	Tested By	*JW*
Project Name	***CLSM Proposed TCS Hydraulic***	Test Date	*5/4/2020*
Boring No.	*20014-1A*	Reviewed By	*POP*
Sample No.	*20014-1A*	Review Date	*5/7/20*
Sample Depth	*N/A*	Lab No.	*18574*
Sample Description	***CLSM Mix ZB-FF-8-D***		

ASTM D50840-16 Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*10.0*
Wet Unit Weight, pcf:	*135.2*
Dry Unit Weight, pcf:	*122.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.0E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 16) (Method F, Constant Volume Falling Head)

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Project Number	6162-19-1253.04	Tested By	JW
Project Name	CLSM Proposed TCS Hydraulic Conductivity Test	Test Date	05/04/20
Boring No.	20014-1A	Reviewed By	PDP
Sample No.	20014-1A	Review Date	5/7/20
Sample Depth	N/A	Lab No.	18574
Sample Description	CLSM Mix ZB-FF-8-D		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	AB-19
Location 1	5.910	Location 1	3.030	Wet Soil+Pan, grams	1606.77
Location 2	5.934	Location 2	3.032	Dry Soil + Pan, grams	1460.26
Location3	5.831	Location 3	3.033	Pan Weight, grams	88.83
Average	5.892	Average	3.032	Moisture Content, %	10.7
Volume, in^3	42.53	Wet Soil + Tare, grams	1509.10	Dry Unit Weight, pcf	124.0
SG Assumed	2.55	Tare Weight, grams	0.00	Saturation, %	96.1
Soil Sample Wt., g	1509.10	Dry Soil +Tare, grams	1371.43	Diameter, in.	N/A
Dry UW, pcf	122.8	Moisture Content, %	10.0	Length, in.	N/A
Saturation, %	86.7			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	49.2
Back Pressure, psi	39.2
Confining Pressure, psi	10.0
Initial Burett Reading	17.3
Final Burett Reading	11.0
Volume Change, cc	6.3

Permeant used: water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
780	1.70	15.50	15.10	0.40	22.8	11.6	11.2	3.03E-08	2.83E-08
1740	1.70	15.50	14.80	0.70	22.8	11.6	11.0	2.41E-08	2.25E-08
2820	1.70	15.50	14.60	0.90	22.8	11.6	10.8	1.92E-08	1.80E-08
4140	1.70	15.50	14.20	1.30	22.8	11.6	10.5	1.92E-08	1.80E-08
4920	1.70	15.50	13.95	1.55	22.8	11.6	10.2	1.95E-08	1.82E-08
6540	1.70	15.50	13.70	1.80	22.8	11.6	10.0	1.72E-08	1.61E-08
8040	1.70	15.50	13.20	2.30	22.7	11.6	9.6	1.83E-08	1.71E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
7	Core	N/A	N/A	Vertical

Avg. k at 20 °C **2.0E-08** **cm/sec**

a_a = 0.76712 cm^2
A = 46.57 cm^2
L = 14.96 cm
S=L/A= 0.32133 1/cm

a_p= 0.031416 cm^2
M_1= 0.03018
M_2= 1.04095
$C = M_1S/(G_{Hg}-1)$= 0.0007715 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6162-19-1253.04*	Tested By	*JW*
Project Name	***CLSM Proposed TCS Hydraulic***	Test Date	*5/4/2020*
Boring No.	*20014-1B*	Reviewed By	*POP*
Sample No.	*20014-1B*	Review Date	*5/7/20*
Sample Depth	*N/A*	Lab No.	*18575*
Sample Description	***CLSM Mix ZB-FF-8-D***		

ASTM D50840-16 Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*10.8*
Wet Unit Weight, pcf:	*135.3*
Dry Unit Weight, pcf:	*122.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.1E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 16) (Method F, Constant Volume Falling Head)

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Project Number	6162-19-1253.04	Tested By	JW
Project Name	CLSM Proposed TCS Hydraulic Conductivity Test	Test Date	05/04/20
Boring No.	20014-1B	Reviewed By	PDP
Sample No.	20014-1B	Review Date	5/7/20
Sample Depth	N/A	Lab No.	18575
Sample Description	CLSM Mix ZB-FF-8-D		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	AB-14
Location 1	5.913	Location 1	3.031	Wet Soil+Pan, grams	1595.84
Location 2	5.889	Location 2	3.032	Dry Soil + Pan, grams	1443.81
Location3	5.847	Location 3	3.036	Pan Weight, grams	82.11
Average	5.883	Average	3.033	Moisture Content, %	11.2
Volume, in^3	42.50	Wet Soil + Tare, grams	1509.31	Dry Unit Weight, pcf	122.6
SG Assumed	2.55	Tare Weight, grams	0.00	Saturation, %	95.5
Soil Sample Wt., g	1509.31	Dry Soil +Tare, grams	1361.70	Diameter, in.	N/A
Dry UW, pcf	122.0	Moisture Content, %	10.8	Length, in.	N/A
Saturation, %	91.0			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	49
Back Pressure, psi	39
Confining Pressure, psi	10
Initial Burett Reading	24
Final Burett Reading	21
Volume Change, cc	3

Permeant used: water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
1920	1.30	18.20	17.70	0.50	22.5	14.2	13.8	1.25E-08	1.18E-08
2880	1.30	18.20	17.50	0.70	22.5	14.2	13.6	1.18E-08	1.11E-08
4080	1.30	18.20	17.30	0.90	22.5	14.2	13.4	1.08E-08	1.01E-08
6300	1.30	18.20	16.80	1.40	22.5	14.2	13.0	1.10E-08	1.04E-08
9360	1.30	18.20	16.00	2.20	22.5	14.2	12.3	1.20E-08	1.13E-08
11580	1.30	18.20	15.80	2.40	22.6	14.2	12.1	1.06E-08	9.99E-09
13920	1.30	18.20	15.50	2.70	22.6	14.2	11.9	1.01E-08	9.45E-09

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
7	Core	N/A	N/A	Vertical

Avg. k at 20 °C **1.1E-08** **cm/sec**

a_a = 0.76712 cm^2 a_p = 0.031416 cm^2

A = 46.61 cm^2 M_1 = 0.03018

L = 14.94 cm M_2 = 1.04095

S=L/A= 0.32058 1/cm $C = M_1S/(G_{Hg}-1)$ = 0.0007697 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6162-19-1253.04*	Tested By	*JW*
Project Name	***CLSM Proposed TCS Hydraulic***	Test Date	*5/4/2020*
Boring No.	*20014-1C*	Reviewed By	*POP*
Sample No.	*20014-1C*	Review Date	*5/7/20*
Sample Depth	*N/A*	Lab No.	*18576*
Sample Description	***CLSM Mix ZB-FF-8-D***		

ASTM D50840-16 Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*11.3*
Wet Unit Weight, pcf:	*135.3*
Dry Unit Weight, pcf:	*121.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.1E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 16) (Method F, Constant Volume Falling Head)

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Project Number	6162-19-1253.04	Tested By	JW
Project Name	CLSM Proposed TCS Hydraulic Conductivity Test	Test Date	05/04/20
Boring No.	20014-1C	Reviewed By	PDP
Sample No.	20014-1C	Review Date	5/7/20
Sample Depth	N/A	Lab No.	18576
Sample Description	CLSM Mix ZB-FF-8-D		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	T-3
Location 1	5.975	Location 1	3.024	Wet Soil+Pan, grams	1558.75
Location 2	5.918	Location 2	3.024	Dry Soil + Pan, grams	1402.80
Location3	5.805	Location 3	3.023	Pan Weight, grams	51.29
Average	5.899	Average	3.024	Moisture Content, %	11.5
Volume, in^3	42.36	Wet Soil + Tare, grams	1504.26	Dry Unit Weight, pcf	122.2
SG Assumed	2.55	Tare Weight, grams	0.00	Saturation, %	97.4
Soil Sample Wt., g	1504.26	Dry Soil +Tare, grams	1351.51	Diameter, in.	N/A
Dry UW, pcf	121.5	Moisture Content, %	11.3	Length, in.	N/A
Saturation, %	93.2			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	48.9
Back Pressure, psi	38.9
Confining Pressure, psi	10.0
Initial Burett Reading	24.0
Final Burett Reading	20.2
Volume Change, cc	3.8

Permeant used: water

Elapsed Time (sec)	z_o (cm)	za (cm)	zb (cm)	Δz_p (cm)	Temp (°C)	Intial Hydraulic Gradient	Final Hydraulic Gradient	k cm/sec	k cm/sec at 20 °C
810	1.70	26.00	24.90	1.10	22.7	20.4	19.4	4.63E-08	4.34E-08
1740	1.70	26.00	24.30	1.70	22.7	20.4	18.9	3.37E-08	3.16E-08
2100	1.70	25.50	22.60	2.90	22.5	20.0	17.4	5.02E-08	4.73E-08
5010	1.70	25.50	21.00	4.50	22.5	20.0	16.0	3.40E-08	3.20E-08
7500	1.70	25.50	20.70	4.80	22.5	20.0	15.8	2.44E-08	2.30E-08
9660	1.70	25.50	20.00	5.50	22.6	20.0	15.2	2.21E-08	2.08E-08
12000	1.70	25.50	19.20	6.30	22.6	20.0	14.5	2.09E-08	1.96E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
7	Core	N/A	N/A	Vertical

Avg. k at 20 °C **3.1E-08** **cm/sec**

a_a = 0.76712 cm^2 | a_p = 0.031416 cm^2

A = 46.33 cm^2 | M_1 = 0.03018

L = 14.98 cm | M_2 = 1.04095

S=L/A= 0.32345 1/cm | $C = M_1S/(G_{Hg}-1)$ = 0.0007766 for 15° to 25°

Remarks:

ATTACHMENT 2

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Wood M&TE Acceptance for Project Use

Project Name: CLSM Proposed TCG Hydraulic Cond

Project Number: 6162-19-1253.04

M&TE	LID	Applicable Test Method	Test Method Equipment Tolerance *choose strictest*	Calibration Date	Calibration Due	Calibration Frequency
Caliper - 8"	4217		See Calibration Record	2/20/20	2/20/21	12 months
Pressure Transducer	3638		See Calibration Record	4/30/20	4/30/21	12 months
Pressure Transducer	5072		See Calibration Record	4/30/20	4/30/21	12 months
Scale	4989		See Calibration Record	4/17/20	4/17/21	12 months
Thermometer	4551/4982		See Calibration Record	5/17/19	5/17/20	12 months
Timer	2605		See Calibration Record4/23/20	4/23/20	10/23/20	6 months
Timer	2607		See Calibration Record	4/23/20	10/23/20	6 months
Timer	2608		See Calibration Record	4/23/20	10/23/20	6 months
Oven	4635		See Calibration Record	4/30/20	8/20/20	4 months

The attached listed M&TE and associated "calibration" documentation have been reviewed and are accepted for use on this project. The M&TE has been "calibrated" and/or has had critical dimensions verified within the defined "calibration" interval and the M&TE is not out of tolerance and meets the test method or procedure requirements. The calibrations are traceable to NIST or known physical constants. Only the listed M&TE shall be used for assigned testing purposes.

Accepted by

4/30/20
Date

ATLNUC-02 Rev. 0
Form Approved for use by: 9/5/19