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Revision 0

Evaluation of the Impact of Thin Pours on Saltstone Properties

A. D. Cozzi
C. A. Langton
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September 2012

Savannah River National Laboratory
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Prepared for the U.S. Department of Energy under contract number DE-AC09-08SR22470.

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EXECUTIVE SUMMARY

The proposed Saltstone Disposal Unit 6 (SDU6) is a larger structure than the SDU4 cells and larger than the disposal units (SDU2, SDU3, and SDU5) currently in use or under construction. The additional capacity provided by SDU6 is desired to reduce life cycle costs and support site accelerated closure goals.

The larger size of the planned SDU6 could result in saltstone being placed in thinner lifts as the unit is filled. This study was performed to determine whether thinner layers of saltstone negatively impact the performance of the waste form. A larger number of cold joints could potentially result in increased drying, salt deposition, and surface oxidation. A matrix of samples was prepared to simulate thin pours ranging from 0.5 to 6 inches thick. Each sample was cured for at least 28 days prior to further characterization.

Leachability results showed that there is no obvious impact of the number of grout layers on the Leachability Index values for Na and NO_3. The concentrations of Cr, NO_2, and C_2O_4 were below detection limits for all of the leachates. No attempt was made to evaluate the oxidation of these samples since no measureable Cr was leached, although this would appear to indicate that Cr in the samples remained reduced for cold joints with surfaces exposed for approximately four days.

The results of hydraulic conductivity measurements showed that the number of cold joints in the samples did not have a significant impact on the measured values for the vertical lift orientation (i.e., when the flow path is perpendicular to the cold joints). For the horizontal lift orientation (i.e., when the flow path is parallel to the cold joints), the number of cold joints in the samples also did not appear to have a significant impact on hydraulic conductivity. The measured hydraulic conductivity was faster when the flow path was parallel to the cold joints as compared to when the flow path was perpendicular to the cold joints. Percolation testing showed increased flow when the number of cold joints was increased.

Compressive strength testing showed that the maximum load at the onset of cracking was reduced by approximately 26% for those samples that contained cold joints as compared to the monolithic samples. The number of cold joints in the sample had no significant impact on the maximum load prior to cracking.

The porosity of the samples was not influenced by cold joints. This result was expected as the porosity is a material property affected by the properties of the components (premix and salt solution) and the water to premix ratio.

Overall, the only obvious impact of cold joints in the samples was to significantly increase hydraulic conductivity in the direction parallel to the cold joints. An increasing number of cold joints (thin layers) in the simulated saltstone samples did not exacerbate this effect, nor did it have a negative impact on the Leachability Indices or porosity for surfaces exposed for approximately four days. The presence of a cold joint reduced the compressive strength of the material, although this impact was seen regardless of the number of cold joints in the sample.

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LIST OF ABBREVIATIONS

IC	Ion Chromatography
ICP-AES	Inductively Coupled Plasma – Atomic Emission Spectroscopy
PA	Performance Assessment
PVC	Polyvinylchloride
RPM	Revolutions Per Minute
SDU6	Saltstone Disposal Unit 6
SRNL	Savannah River National Laboratory
TS	Total weight percent Solids
WAC	Waste Acceptance Criteria

1.0 Introduction

The proposed Saltstone Disposal Unit 6 (SDU6) is a larger structure than the SDU4 cells and larger than the disposal units (SDU2, SDU3, and SDU5) currently in use or under construction. The additional capacity provided by SDU6 is desired to reduce life cycle costs and support site accelerated closure goals.

Table 1-1 is a summary of the dimensions of the SDUs currently in use, under construction, and planned. A comparison of the parameters of the SDUs in this table shows the significant increase in scale for SDU6.

Table 1-1. Summary of Dimensions of Current and Proposed SDUs.

Parameter	Units	SDU4 Per Cell	SDU2/3/5 Per Cell	SDU6
Length	ft	100*	--	--
Width	ft	100*	--	--
Diameter	ft	--	150[†]	375[c]
Height	ft	25*	22[†]	43[b]
Slope from center	%	--	--	1.5[b]
Volume	Mgal	1.87	2.908[†]	~35.5
Volume/Height	gal/in	6,234	11,016	68,850
Fill rate @ 150 gpm grout[‡]	in/hr	1.44	0.82	0.13

‡Assumes self-leveling
*W828992
[†]WB00001K-4
[b]C-CC-Z-00042
[c]C-CC-Z-00039

The Task Requirements and Criteria document for conceptual design of SDU6 identified knowledge gaps associated with processing into a larger disposal unit.[1] The identified knowledge gaps were coupled with a high-level risk assessment[2] to document the technical assumptions, program needs, and the approach to address the needs used for the conceptual design of SDU6.[3]

Savannah River Remediation-Engineering Projects-SDU6 requested that the Savannah River National Laboratory (SRNL) evaluate and recommend strategies for technical issues associated with grout placement in SDU6.[4] Task 3 of that request asked that SRNL perform testing to determine whether the thin grout layers that may be associated with placement in the larger diameter SDU would negatively impact the leach response and hydraulic conductivity of the saltstone because of the additional number of cold joints. A larger number of cold joints could potentially result in increased drying, salt deposition, and surface oxidation. To address this request, SRNL developed a Task Technical and Quality Assurance Plan outlining a matrix of samples to be fabricated and defining the characterization work to be performed.[5]

Multilayer, simulated saltstone samples were fabricated in the laboratory. Standardized test methods were used to determine the hydraulic conductivity and leaching response of these samples. Hydraulic conductivity and relative Leachability Indices were used as measures of cured saltstone quality. Compressive strength testing was also used as an indication of the overall quality of select samples after a minimum of 28 days of curing. Further details of the sample design and fabrication, characterization, and results are presented in the sections that follow.

2.0 Experimental Procedure

2.1 Sample Fabrication

Saltstone premix is cement, granulated blast furnace slag, and fly ash blended in the ratios shown in Table 2-1. These same ratios were used for the simulated saltstone samples fabricated for this study. A large batch of premix was prepared by blending the appropriate masses of each component by shaking in a bag until visibly homogeneous. The material was then stored in a sealed bag prior to use.

Table 2-1. Nominal Saltstone Premix Blend Ratio.

Premix Component	Weight Percent
Cement	10
Slag	45
Fly Ash	45

A simplified salt solution was used based on the calendar year 2011 Waste Acceptance Criteria (WAC) analysis of Tank $50H^{9}$ with intentionally elevated quantities (1000 mg/L) of chromium and rhenium as a surrogate for technetium-99 (Table 2-2). The solution was prepared by adding the compounds in the order listed in the table with the exception of water. Approximately 10-20% of the water was reserved for rinsing throughout the preparation process. Chromium and rhenium were added in identical concentrations to evaluate whether a correlation exists between leaching of the two elements. Chromium was added to the salt solution as Cr^{+6} via sodium chromate and was reduced by the slag in the premix. This allowed for a potential evaluation of the oxidation of the samples for the various lifts. The simulated salt solution total weight percent solids (TS) is 25.13% and density is 1.207 g/ml.

Table 2-2. Simulant Salt Solution Based on CY11 WAC Analysis.

Compound	g/L	Component	M
Water	balance	Na	4.4E+00
KNO_3	0.55	Al	1.1E-01
$NaNO_3$	154.37	Cr	5.8E-03
NaOH (50%)	142.4	Re	1.6E-03
$Al(NO_3)_3{\cdot}9H_2O$	42.01	B	1.1E-02
$NaNO_2$	25.66	K	5.4E-03
Na_2CO_3	14.73	NO_3	2.2E+00
Na_2SO_4	6.59	NO_2	3.7E-01
Na_2CrO_4	0.94	OH	1.8E+00
$Na_3PO_4{\cdot}12H_2O$	1.9	CO_3	1.4E-01
$NaReO_4$	0.44	SO_4	4.6E-02
$Na_2C_2O_4$	1.24	C_2O_4	9.3E-03
H_3BO_3	0.71	Cl	4.6E-03
NaCl	0.27		

Simulated saltstone mixes using the premix in Table 2-1 and salt solution in Table 2-2 were prepared at a water to premix ratio of 0.60 by mass.

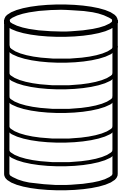
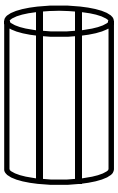
A matrix of samples was prepared in 3 inch by 6 inch cylindrical molds. These consisted of one lift (i.e., a full mold with no cold joints) up to twelve lifts (i.e., a full mold containing eleven cold joints) with the long axis of the cylindrical molds oriented both vertically and horizontally. The appropriate amount (dependent upon the size of the lift to be poured) of premix was weighed into a bag. The appropriate amount of salt solution was weighed into a 2000 ml beaker. A paddle mixer in a chemical fume hood was used with the blade set between 0.25 to 0.50 inches above the bottom of the 2000 ml beaker containing the simulated salt solution. The mixer was turned on and adjusted to an initial rotational speed of ~250 revolutions per minute (RPM). A corner was cut off of the bottom of the plastic bag containing the premix and the material was slowly poured into the beaker. The rotational speed of the mixer was increased as needed to ensure wetting of the premix as it was poured into the simulated salt solution. Once all the premix material was added, the speed of the mixer was adjusted until a vortex was formed around the shaft without significantly entraining air into the mix. Mixing continued for approximately three minutes after a vortex was formed. The speed of the mixer was continually adjusted during this time to avoid significant air entrainment. After three minutes of mixing, the mixer was turned off and the material was cast in triplicate in lifts of varying heights into cylindrical molds oriented either vertically or horizontally and cured at ambient temperature.

In addition to the solid vertical lifts, triplicate samples of the vertical cylinders were cast with a Polyvinylchloride (PVC), 1 inch diameter rod in the center of the cylinder to support later percolation tests. The samples were prepared by initially pouring a 0.5 inch lift into a cylindrical mold. After three days, PVC rods were centered in each of the cylinders on top of the first lift. The subsequent lifts were poured with the corresponding solid vertical lift samples but with the grout volume reduced appropriately to account for the PVC rod.

The curing conditions of the vertical samples were managed by sealing the samples in plastic bags containing water saturated wipes to maintain a humid environment. The horizontal samples were covered in Parafilm, capped, and taped prior to curing horizontally.

Table 2-3 is the pour schedule used for each lift. The lifts were placed twice per week. For each sample, the 28 day minimum curing period began after the final lift.

Table 2-3. Pour Schedule for Lift into Cylinders.

Lift Orientation		Pour Day‡												
		Pour Height (in.)	T	M	T	M	T	M	T	M	T	M	T	M
Vertical		0.5	X	X	X	X	X	X	X	X	X	X	X	X
		1	-	-	X	X	X	X	X	X	-	-	-	-
		3	-	-	X	X	-	-	-	-	-	-	-	-
		6	-	-	X	-	-	-	-	-	-	-	-	-
Horizontal		0.5	-	-	X	X	X	X	X	X	-	-	-	-
		1	-	-	X	X	X	-	-	-	-	-	-	-
		1.5	-	-	-	X	X	-	-	-	-	-	-	-

‡M-Monday; T-Thursday

To fill the vertical samples, the grout density and volume per lift of cylinder were used to calculate the amount of grout needed for each lift. A grout density of 1.72 g/cm^3 was used based on concurrent testing with a similar salt solution.[10] To fill the horizontal samples, the volume per lift was calculated from the area of the chord ACD in Figure 2-1, where line BD is the cylinder diameter (3 inches) and line ED is the lift height (either 0.5, 1, or 1.5 inches). Details of these calculations are provided in the task plan.[5]

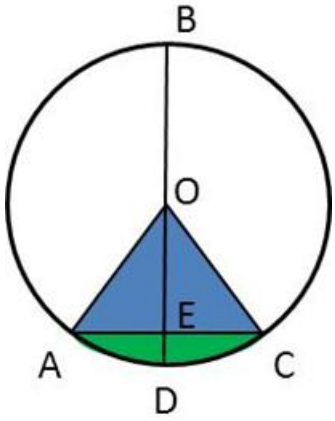


Figure 2-1. Measurements needed to calculate horizontal lift volumes.

Table 2-4 gives the volume of simulated saltstone targeted for each lift height in the horizontal cylinders. The lift intervals are 0.5, 1, and 1.5 inch, resulting in 6, 3, and 2 lifts, respectively. Table 2-5 gives the mass of grout targeted for each of the horizontal lifts. The appropriate mass of material was poured into the vertically oriented molds. The molds were then rotated to a horizontal condition to cure.

Table 2-4. Volume of Grout Needed for Each Lift for the Horizontal Samples.

Height (in)	Height (cm)	Volume (ml)	Addition 0.5 inch (ml)	Addition 1 inch (ml)	Addition 1.5 inch (ml)
0.5	1.27	76.1	76.1	--	--
1.0	2.54	202.8	126.7	202.8	--
1.5	3.81	347.5	144.7	--	347.5
2.0	5.08	--	144.7	289.4	--
2.5	6.35	--	126.7	--	--
3.0	7.62	--	76.1	202.8	347.5

Table 2-5. Mass of Grout Needed for Each Lift for the Horizontal Samples.

Height (in)	Height (cm)	Volume (ml)	Additional 0.5 inch (g)	Additional 1 inch (g)	Additional 1.5 inch (g)
0.5	1.27	76.1	131.2	--	--
1.0	2.54	202.8	218.2	349.4	--
1.5	3.81	347.5	249.3	--	498.7
2.0	5.08	--	249.3	598.7	--
2.5	6.35	--	218.2	--	--
3.0	7.62	--	131.2	349.4	498.7

2.2 Sample Analysis

2.2.1 *Leach Testing*

Degradation and contaminant movement though saltstone is used in the Performance Assessment (PA) to model the release of contaminants to the environment.[11] Leachability measurements were performed following the ANSI/ANS 16-1 standard.[12] Leach testing specimens (the vertical pour samples only) were prepared in triplicate at room temperature and cured at room temperature for at least 28 days. The samples were right cylinders, with dimensions as given in Table 2-6. The volume of leachant used during each interval is also included in Table 2-6.

Table 2-6. Leach Testing Sample Dimensions and Leachant Volumes.

Vertical Pour Height (in.)	Sample ID	Diameter (mm)	Height (mm)	Mass (g)	Leachant Volume (ml)
0.5	0.5-5	76.33	119.51	943.8	3781.0
	0.5-6	76.78	122.12	968.1	3871.7
	0.5-13	77.27	120.31	960.8	3858.4
1.0	1.0-4	76.03	127.91	989.9	4018.1
	1.0-5	76.54	128.63	1012.9	4006.5
	1.0-6	77.87	129.79	1010.8	3981.0
3.0	3.0-4	77.26	129.53	1020.2	3953.2
	3.0-5	76.16	128.27	1009.0	4013.9
	3.0-6	76.19	127.69	995.7	4003.7
6.0	6.0-4	76.88	127.31	1002.5	4040.9
	6.0-5	76.44	129.55	1005.7	4000.8
	6.0-6	77.30	128.83	1013.8	4019.4

The leachates were at ambient temperature at the end of each interval. Aliquots of approximately 125 ml of each leachate were analyzed by Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES) for Cr, Na, and Re concentrations, and by Ion Chromatography (IC) for NO_2, NO_3, and C_2O_4 concentrations. Each aliquot was measured twice by ICP-AES with the mean of the two measurements used in calculating the Leachability Index. Single measurements were performed by IC. Blank samples consisting only of deionized water were also included for analysis with the leachate aliquots for each leaching interval.

2.2.2 *Hydraulic Conductivity*

The transport of water through saltstone is an input parameter to the numerical model that supports the PA.[13] Samples from each of the horizontal and vertical test conditions were

measured to determine the effect of the saltstone placement on the hydraulic conductivity following ASTM D-5084.[14] Due to the number of samples to be tested in triplicate, the procedure was carried out by AMEC Environment & Infrastructure (Atlanta, Georgia).

2.2.3 *Percolation Testing*

Vertical pour samples that were cast with a nonreactive, 1 inch diameter rod to displace a portion of the simulated saltstone were tested in triplicate using a percolation-type test where the void space of the demolded sample was filled with water and allowed to drain. A modified version of the field test was used to measure the unpressurized flow through each sample.[15] The PVC rods were removed and the samples were demolded and suspended in a covered vessel with water below the bottom of the sample (Figure 2-2). The hole left after removal of the rod was filled with water and the water level within the hole was then monitored over several days. The water was not replenished during the test.

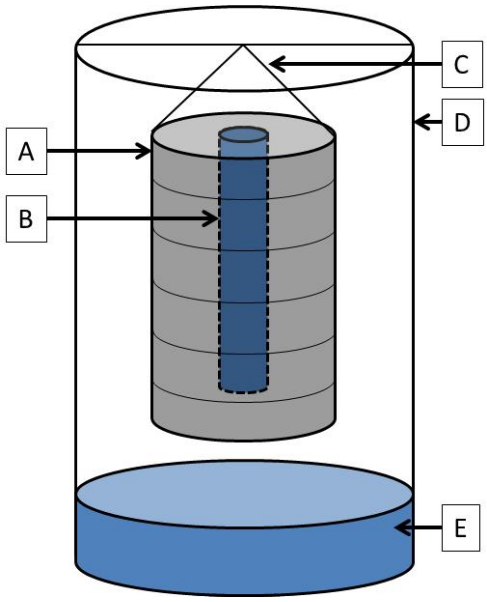


Figure 2-2. Percolation test with a vertical pour sample (A) containing a 1 inch diameter hole filled with water (B) suspended (C) inside a covered vessel (D) containing additional water below the sample (E).

2.2.4 *Compressive Strength*

Compressive strength is not a required property for saltstone permitting. However, compressive strength is commonly used as an indication of the overall quality (mix design and preparation) of the sample. After curing for a minimum of 28 days, vertical pour samples were removed from the molds and tested for compressive strength in triplicate following a procedure based on ASTM C39/39M.[16] The maximum load prior to cracking was recorded and used as a relative method of comparison among the samples with varying numbers of cold joints.

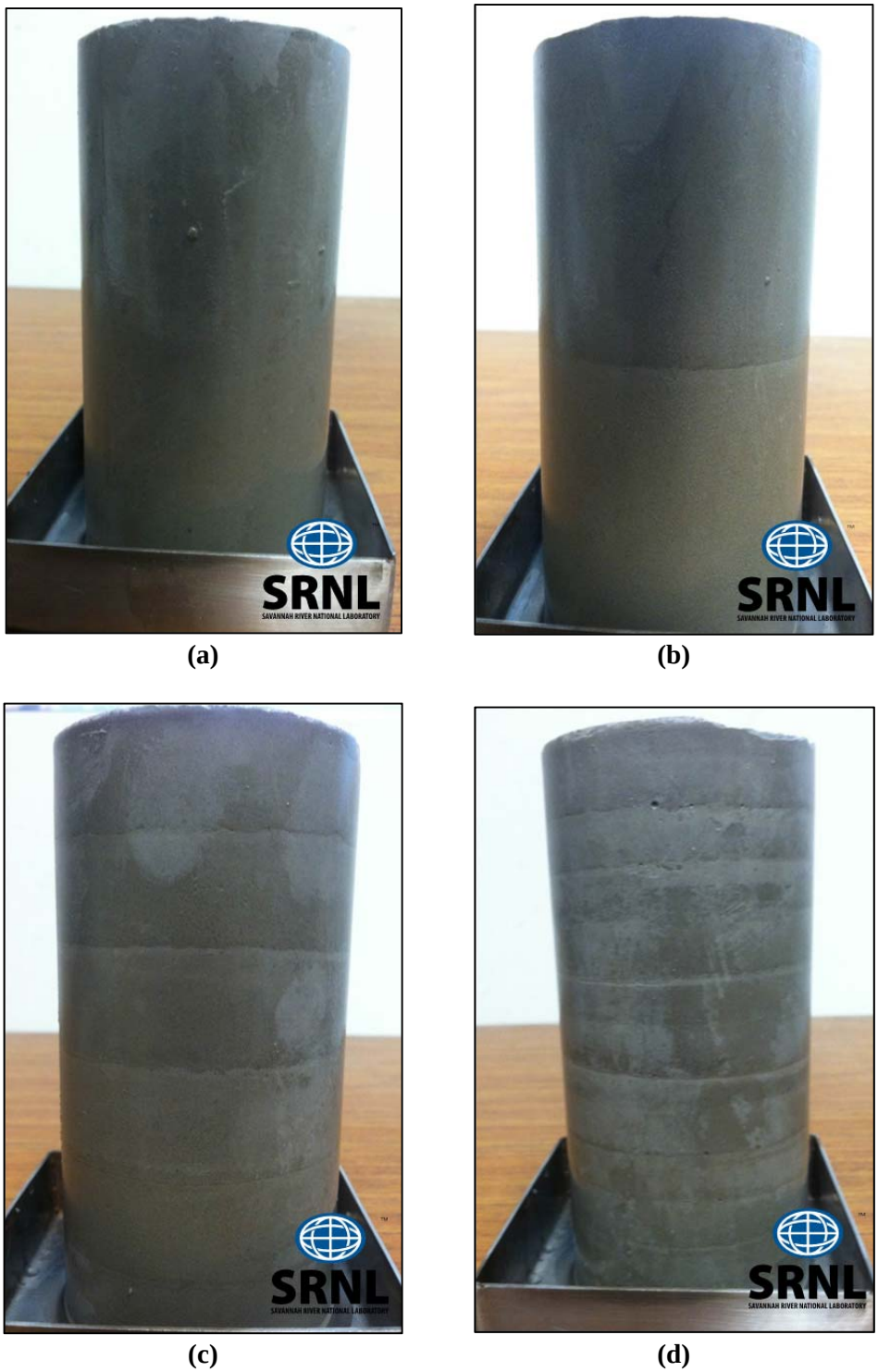
2.2.5 *Porosity*

Porosity is a material property that is used as an input parameter to the PA.[11] After curing for a minimum of 28 days, vertical pour samples were removed from their molds and the porosity was measured following the method developed in prior work.[17] The entire cylinder was measured

rather than a subsample in order to capture the effect of the thin layers. In addition, the density calculation was confirmed by determining the volume of the cylinder by geometrical methods.

3.0 Results and Discussion

Example photographs of the multilayer samples after demolding are shown in Figure 3-1. The cold joints between the layers were visible after demolding.



(a) **(b)**

(c) **(d)**

Figure 3-1. Single layer and multilayer vertical pour samples after demolding. Samples containing a single layer (a), 2 layers (b), 6 layers (c), and 12 layers (d) are shown.

3.1 Leach Testing

Per ANSI/ANS 16-1,[12] leaching intervals of 2, 7, 24, 48, 72, 96, and 120 hours were used. The last leaching interval for the 1 inch and 3 inch pours had to be extended from 120 hours to 168 hours. Although this deviates from the procedure, Leachability Indices were calculated for these samples by simply using the extended seventh interval. The beginning and end dates and times for each leaching interval were recorded in a controlled laboratory notebook.[a] The surfaces of the specimens appeared smooth both before and after leaching. No obvious changes in the shape or dimensions of the specimens were observed. No undissolved solids were visible in the leachates. The measured concentrations of each contaminant present in the leachate aliquots after each interval for each sample are given in Appendix A.

The concentrations of Cr, Na, Re, NO_2, and C_2O_4 were below detection limits for all of the blanks that were analyzed with the leachates. The concentrations of NO_3 were below detection limits for all of the blanks except for those submitted with the 6 inch pour samples leached for 30 seconds, 7 hours, and 120 hours. These values were relatively low (<13 mg/L) and were considered to have no impact on the results of the study.

The concentrations of Cr, NO_2, and C_2O_4 were below detection limits for all of the leachates. Therefore, Leachability Index values were not calculated for these contaminates. The Re concentration was below the detection limit for samples 0.5-6 and 0.5-13 after the initial 30 seconds of leaching, and was below the detection limit for sample 0.5-13 after the 120 hour leaching interval. A Leachability Index value is therefore not reported for sample 0.5-13.

Since the Cr concentrations were all below the detection limit, it is difficult to draw any correlation between leaching of Cr and Re. A concurrent study has shown that Re does not leach congruently with Cr and is not a good surrogate for Tc.[18] No attempt was made at evaluating the oxidation of these samples since no measureable Cr was leached, although this would appear to indicate that Cr in the samples remained reduced.

The Leachability Index for each specimen was calculated following ANSI/ANS 16-1.[12] The resulting values are given in Table 3-1. Note again that the final interval for samples of the 1 inch and 3 inch pours was 168 hours rather than 120 hours. The results show that there is no obvious impact of the number of grout layers on the Leachability Index values.

[a] SRNL-NB-2012-00059

Table 3-1. Leachability Index Values for Vertical Pour Samples.

Vertical Pour Height (in.)	Sample ID	Leachability Index		
		Na	Re	NO_3
0.5	0.5-5	9.0	10.0	9.1
	0.5-6	8.8	9.8	8.8
	0.5-13	9.0	10.0*	9.1
1.0	1.0-4	8.7	9.9	8.9
	1.0-5	8.9	10.1	9.0
	1.0-6	8.9	10.1	9.1
3.0	3.0-4	8.9	10.1	9.2
	3.0-5	8.8	10.0	9.1
	3.0-6	8.7	9.9	8.9
6.0	6.0-4	8.8	9.9	8.9
	6.0-5	8.6	9.7	8.6
	6.0-6	9.0	10.0	9.2

*Uses time intervals 1-6 since the Re concentration was below the detection limit for interval 7.

3.2 Hydraulic conductivity

Hydraulic conductivity measurements following ASTM D5084 were completed by AMEC. A copy of the test report from AMEC is included as Appendix B. A summary of the hydraulic conductivity data is presented in Table 3-2.

Table 3-2. Summary of Hydraulic Conductivity Data for the Vertical and Horizontal Samples with Single and Multiple Lifts.

Lift Orientation	Pour Height (in.)	Hydraulic Conductivity (cm/sec) at 20 °C			
		Replicate 1	Replicate 2	Replicate 3	Mean
Vertical	0.5	1.6E-9	4.2E-9	3.1E-9	3.0E-9
	1	2.5E-9	2.2E-9	4.0E-9	2.9E-9
	3	2.3E-9	2.0E-9	1.4E-9	1.9E-9
	6	5.9E-11	1.6E-9	2.6E-10	6.4E-10
Horizontal	0.5	3.6E-8	4.7E-8	3.7E-8	4.0E-8
	1	4.0E-8	2.4E-7	1.8E-7	1.5E-7
	1.5	4.0E-8	2.0E-7	1.4E-8	8.5E-8

The number of cold joints in the samples does not appear to have a significant impact on hydraulic conductivity for the vertical lift orientation (i.e., when the flow path is perpendicular to the cold joints). Note that there is more variability in the measurements for the 6 inch vertical pour samples (i.e., the monolithic pours). This is likely due to these values being so low that they are near the limit of what can be measured using this technique. For the horizontal lift orientation (i.e., when the flow path is parallel to the cold joints), the number of cold joints in the samples again does not appear to have a significant impact on hydraulic conductivity. Hydraulic conductivity appears to be somewhat faster when the flow path is parallel to the cold joints as compared to when the flow path is perpendicular to the cold joints.

3.3 Percolation Testing

The results of the percolation testing for the vertical pour samples are given in Table 3-3.

Table 3-3. Change in Water Level (mm) for Vertical Pour Percolation Test Samples.

Lift Orientation	Pour Height (in.)	Hours							
		1	8	24	32	48	56	72	80
Vertical	0.5	140	133	108	102	76	70	44	38
	1	140	137	127	121	119	116	113	110
	3	140	138	135	133	132	130	129	125
	6	140	138	135	133	130	129	125	124

The sample with 0.5 inch lifts lost more water than the other samples (~102 mm). The sample with 1 inch lifts lost ~30 mm, and the samples with 3 and 6 inch lifts lost ~15 mm. These results are presented graphically in Figure 3-2.

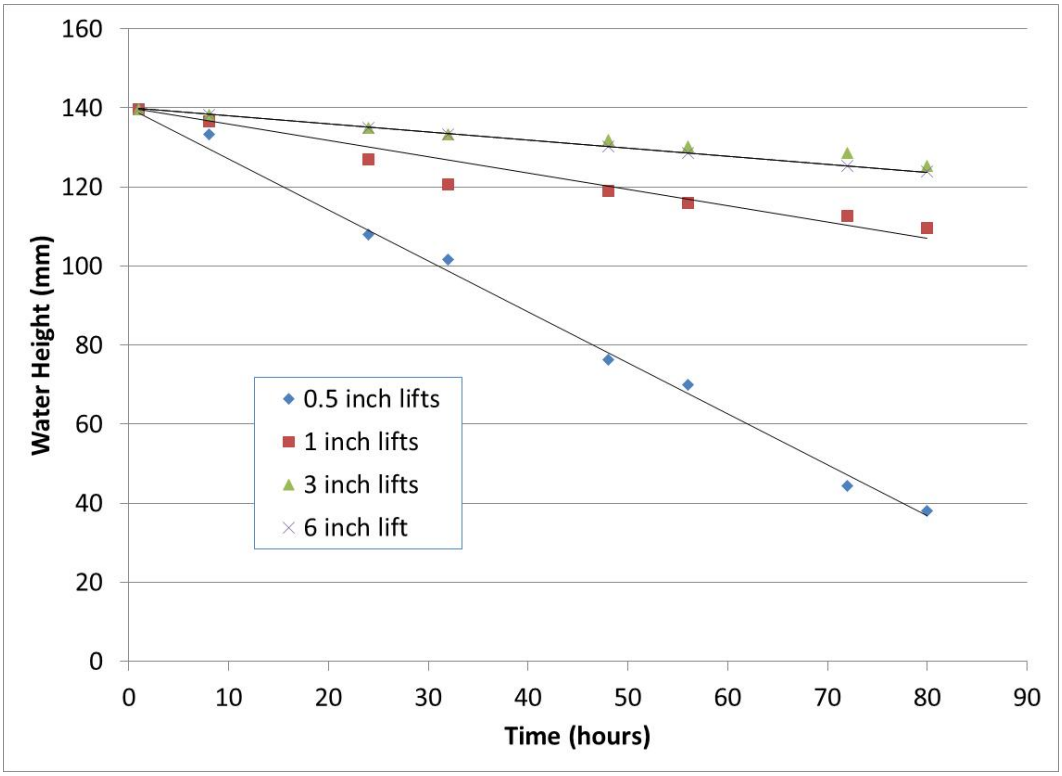


Figure 3-2. Change in Water Level (mm) for Vertical Pour Percolation Test Samples.

As opposed to the hydraulic conductivity tests on samples with vertical lifts where the sides of the samples are constrained to force flow perpendicular to the cold joints (see Section 3.2), the percolation method permitted flow parallel to or through the cold joints, more akin to the hydraulic conductivity testing of the samples with horizontally placed lifts. While the number of lifts had no obvious impact on the hydraulic conductivity results, the percolation results do show increased flow when the number of cold joints is increased.

3.4 Compressive Strength

Vertical pour samples were removed from the molds after curing for a minimum of 28 days and tested for compressive strength in triplicate following a procedure based on ASTM C39/39M.[16] The maximum load prior to cracking was recorded for use as a relative method of comparison among the samples with varying numbers of cold joints. The resulting data are given in Table 3-4.

Table 3-4. Maximum Load at the Onset of Cracking for Vertical Pour Samples.

Pour Height (in.)	Sample ID	Max. Load (lb)	Max. Load (kN)	Mean Max. Load (kN)
0.5	0.5-7	9820	43.7	43.9
	0.5-8	9869	43.9	
	0.5-9	9920	44.1	
1	1.0-7	9643	42.9	42.5
	1.0-8	9512	42.3	
	1.0-9	9497	42.2	
3	3.0-7	9618	42.8	42.1
	3.0-8	9449	42.0	
	3.0-9	9333	41.5	
6	6.0-7	11,697	52.0	54.0
	6.0-8	12,838	57.1	
	6.0-9	11,888	52.9	

A review of the data in Table 3-4 shows that the maximum load at the onset of cracking was reduced for those samples that contained cold joints (i.e., those with 0.5, 1, and 3 inch pour heights). The monolithic sample (i.e., the 6 inch pour height) had a mean maximum load prior to cracking that was about 26% greater than the samples with cold joints. The number of cold joints in the sample (from 1 in the samples with a 3 inch pour height to 11 in the samples with a 0.5 inch pour height) appears to have no significant impact on the maximum load prior to cracking.

3.5 Porosity

Vertical pour samples were removed from the molds after curing for a minimum of 28 days. The porosity was measured using the method developed in prior saltstone support.[17] The sample was demolded, weighed, and dried to a constant mass. The mass loss, assumed to be pore water, was used to calculate the mass of the pore solution, assumed to be the salt solution in Section 2.1. The density of the salt solution was used to calculate the volume of the pore solution. The volume of the sample was determined from the geometric measurements of the cylinders. The sample porosity given in Table 3-5 was calculated by dividing the volume of pore solution by the sample volume. A review of Table 3-5 shows that the porosity of the samples was not influenced by the number of cold joints. This result was expected as the porosity is a material property affected by the properties of the components (premix and salt solution) and the water to premix ratio, and because the cold joints account for a very small portion of the total sample volume.

Table 3-5. Porosity of Vertical Pour Samples.

Pour Height (in.)	Sample ID	Porosity (%)
0.5	0.5-10	55.1
1	1.0-10	54.3
3	3.0-10	55.3
6	6.0-10	54.2

4.0 Conclusions

The larger size of the planned SDU6 could result in saltstone being placed in thinner lifts as the unit is filled. This study was performed to determine whether thinner layers of saltstone negatively impact the performance of the waste form. A larger number of cold joints could potentially result in increased drying, salt deposition, and surface oxidation. A matrix of samples was prepared in 3 inch by 6 inch cylindrical molds to simulate thin pours ranging from 0.5 to 6 inches thick. These consisted of one lift (i.e., a full mold with no cold joints) up to twelve lifts (i.e., a full mold containing eleven cold joints) with the long axis of the cylindrical molds oriented both vertically and horizontally. Each sample was cured for at least 28 days prior to further characterization.

Leachability results showed that there is no obvious impact of the number of grout layers on the Leachability Index values for Na and NO_3. The concentrations of Cr, NO_2, and C_2O_4 were below detection limits for all of the leachates. Since the Cr concentrations were all below the detection limit, no correlation was identified between leaching of Cr and NO_3. Chromium is chemically stabilized in saltstone, while NO_3 is assumed to be completely soluble. No attempt was made to evaluate the oxidation of these samples since no measureable Cr was leached, although this would appear to indicate that Cr in the samples remained reduced for cold joints with surfaces exposed for approximately four days.

The results of hydraulic conductivity measurements showed that the number of cold joints in the samples did not have a significant impact on the measured values for the vertical lift orientation (i.e., when the flow path is perpendicular to the cold joints). For the horizontal lift orientation (i.e., when the flow path is parallel to the cold joints), the number of cold joints in the samples also did not appear to have a significant impact on hydraulic conductivity. The measured hydraulic conductivity was faster when the flow path was parallel to the cold joints as compared to when the flow path was perpendicular to the cold joints. Percolation testing showed increased flow when the number of cold joints was increased.

Compressive strength testing showed that the maximum load at the onset of cracking was reduced by approximately 26% for those samples that contained cold joints (i.e., those with 0.5, 1, and 3 inch pour heights) as compared to the monolithic samples (i.e., the 6 inch pour height). The number of cold joints in the sample had no significant impact on the maximum load prior to cracking.

The porosity of the samples was not influenced by cold joints. This result was expected as the porosity is a material property affected by the properties of the components (premix and salt solution) and the water to premix ratio.

Overall, the only obvious impact of cold joints in the samples was to significantly increase hydraulic conductivity in the direction parallel to the cold joints. An increasing number of cold

joints (thin layers) in the simulated saltstone samples did not exacerbate this effect, nor did it have a negative impact on the Leachability Indices or porosity for surfaces exposed for approximately four days. The presence of a cold joint reduced the compressive strength of the material, although this impact was seen regardless of the number of cold joints in the sample. An increasing number of thin layers did not further reduce the compressive strength, and this property is not considered in assessing the predicted performance of saltstone.

5.0 Future Work

The cold joints examined in this study cured for three to four days between pours. Longer times may have impacts on leachability due to surface oxidation and the deposition of salts resulting from drying. Future experiments could be tailored to determine whether the exposure time of the cold joints has a significant impact on saltstone properties.

6.0 References

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Appendix A. Measurements from the Leachability Experiments.

Table A-1. Measured Concentration of Each Contaminant, Conductivity, and pH for Each Leachate Aliquot after Each Interval for Each Sample.

Sample ID	Replicate	Cumulative Leaching Time (hrs)	Cr (mg/L)	Na (mg/L)	Re (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	C_2O_4 (mg/L)	Conductivity (uS/cm)	pH
0.5-13	1	30s	<0.100	9.45	<0.040	<10.0	12.3	<10.0	66.6	10.1
0.5-13	2	30s	<0.100	9.39	<0.040	-	-	-	-	-
0.5-5	1	30s	<0.100	15	0.047	<10.0	22.3	<10.0	111	10.3
0.5-5	2	30s	<0.100	15.2	0.051	-	-	-	-	-
0.5-6	1	30s	<0.100	10.7	<0.040	<10.0	14.1	<10.0	66.1	9.89
0.5-6	2	30s	<0.100	10.9	<0.040	-	-	-	-	-
1.0-4	1	30s	<0.100	12.93	0.0427	<10.0	13.3	<10.0	67	7.76
1.0-4	2	30s	<0.100	12.93	0.0466	-	-	-	-	-
1.0-5	1	30s	<0.100	11.94	0.0414	<10.0	11.6	<10.0	70	9.81
1.0-5	2	30s	<0.100	12.16	0.0427	-	-	-	-	-
1.0-6	1	30s	<0.100	11.65	0.0447	<10.0	11.7	<10.0	76.3	10.6
1.0-6	2	30s	<0.100	12.07	0.0479	-	-	-	-	-
3.0-4	1	30s	<0.100	11.59	0.0445	<10.0	13.2	<10.0	72.7	10
3.0-4	2	30s	<0.100	11.72	0.0467	-	-	-	-	-
3.0-5	1	30s	<0.100	11.34	0.0459	<10.0	12.1	<10.0	69.9	9.93
3.0-5	2	30s	<0.100	11.71	0.045	-	-	-	-	-
3.0-6	1	30s	<0.100	15.42	0.0548	<10.0	17.16	<10.0	96.3	10.103
3.0-6	2	30s	<0.100	15.68	0.0567	-	-	-	-	-
6.0-4	1	30s	<0.100	8.59	0.044	<10.0	14.7	<10.0	56.4	9.07
6.0-4	2	30s	<0.100	8.73	0.045	-	-	-	-	-
6.0-5	1	30s	<0.100	9.79	0.046	<10.0	16.4	<10.0	67.8	9.16
6.0-5	2	30s	<0.100	9.93	0.045	-	-	-	-	-
6.0-6	1	30s	<0.100	8.93	0.045	<10.0	13.8	<10.0	50.5	8.54
6.0-6	2	30s	<0.100	8.75	0.044	-	-	-	-	-
0.5-13	1	2	<0.100	17.8	0.044	<10.0	18.4	<10.0	152	11
0.5-13	2	2	<0.100	18.2	0.043	-	-	-	-	-
0.5-5	1	2	<0.100	16.3	0.044	<10.0	17.9	<10.0	138	10.8
0.5-5	2	2	<0.100	16.2	0.048	-	-	-	-	-
0.5-6	1	2	<0.100	19.5	0.055	<10.0	23.3	<10.0	159	10.8
0.5-6	2	2	<0.100	19.3	0.056	-	-	-	-	-
1.0-4	1	2	<0.100	37.81	0.0999	<10.0	44.4	<10.0	285.1	10.8
1.0-4	2	2	<0.100	38.55	0.0962	-	-	-	-	-
1.0-5	1	2	<0.100	19.5	0.05599	<10.0	44.7	<10.0	137.5	10.49
1.0-5	2	2	<0.100	19.23	0.0547	-	-	-	-	-
1.0-6	1	2	<0.100	23	0.0628	<10.0	24.2	<10.0	155.8	10.5
1.0-6	2	2	<0.100	23.45	0.0642	-	-	-	-	-
3.0-4	1	2	<0.100	20.06	0.0543	<10.0	19.3	<10.0	148.3	10.52
3.0-4	2	2	<0.100	20.15	0.0542	-	-	-	-	-
3.0-5	1	2	<0.100	31.42	0.0823	<10.0	33.9	<10.0	222.6	10.67
3.0-5	2	2	<0.100	31.59	0.0805	-	-	-	-	-
3.0-6	1	2	<0.100	42.42	0.0982	<10.0	47.7	<10.0	302	10.81

Table A-1. Measured Concentration of Each Contaminant, Conductivity, and pH for Each Leachate Aliquot after Each Interval for Each Sample. **(cont'd)**

Sample ID	Replicate	Cumulative Leaching Time (hrs)	Cr (mg/L)	Na (mg/L)	Re (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	C_2O_4 (mg/L)	Conductivity (uS/cm)	pH
3.0-6	2	2	<0.100	43.2	0.0956	-	-	-	-	-
6.0-4	1	2	<0.100	22.3	0.069	<10.0	27.4	<10.0	176.2	10.09
6.0-4	2	2	<0.100	22.2	0.072	-	-	-	-	-
6.0-5	1	2	<0.100	25.8	0.077	<10.0	33.9	<10.0	197.5	10.13
6.0-5	2	2	<0.100	26.1	0.077	-	-	-	-	-
6.0-6	1	2	<0.100	21.4	0.07	<10.0	26.8	<10.0	168	9.99
6.0-6	2	2	<0.100	21.3	0.069	-	-	-	-	-
0.5-13	1	7	<0.100	23.3	0.071	<10.0	27.2	<10.0	200	11
0.5-13	2	7	<0.100	23.3	0.07	-	-	-	-	-
0.5-5	1	7	<0.100	17.7	0.059	<10.0	22.5	<10.0	157	10.8
0.5-5	2	7	<0.100	17.9	0.058	-	-	-	-	-
0.5-6	1	7	<0.100	20.7	0.065	<10.0	25.2	<10.0	182	10.8
0.5-6	2	7	<0.100	21.4	0.067	-	-	-	-	-
1.0-4	1	7	<0.100	19.34	0.0543	<10.0	19.1	<10.0	150.1	10.52
1.0-4	2	7	<0.100	19.51	0.0586	-	-	-	-	-
1.0-5	1	7	<0.100	22.88	0.062	<10.0	25.1	<10.0	115.3	8.32
1.0-5	2	7	<0.100	22.59	0.0576	-	-	-	-	-
1.0-6	1	7	<0.100	27.03	0.0718	<10.0	31	<10.0	209.2	10.62
1.0-6	2	7	<0.100	27.16	0.0736	-	-	-	-	-
3.0-4	1	7	<0.100	20.33	0.0541	<10.0	19.8	<10.0	103.2	8.43
3.0-4	2	7	<0.100	20.42	0.0546	-	-	-	-	-
3.0-5	1	7	<0.100	25.31	0.0685	<10.0	25.3	<10.0	127.9	8.3
3.0-5	2	7	<0.100	25.29	0.0666	-	-	-	-	-
3.0-6	1	7	<0.100	35.35	0.0887	<10.0	37.47	<10.0	231.6	10.39
3.0-6	2	7	<0.100	35.76	0.0872	-	-	-	-	-
6.0-4	1	7	<0.100	39.3	0.099	<10.0	48.8	<10.0	340	10.35
6.0-4	2	7	<0.100	39.2	0.1	-	-	-	-	-
6.0-5	1	7	<0.100	39.4	0.108	<10.0	50	<10.0	342	10.33
6.0-5	2	7	<0.100	39.2	0.108	-	-	-	-	-
6.0-6	1	7	<0.100	23.7	0.068	<10.0	30.7	<10.0	211.5	10.08
6.0-6	2	7	<0.100	23.4	0.068	-	-	-	-	-
0.5-13	1	24	<0.100	39.2	0.107	<10.0	47	<10.0	331	11.2
0.5-13	2	24	<0.100	39.4	0.109	-	-	-	-	-
0.5-5	1	24	<0.100	47	0.127	<10.0	60.6	<10.0	393	11.2
0.5-5	2	24	<0.100	46.9	0.129	-	-	-	-	-
0.5-6	1	24	<0.100	42.8	0.113	<10.0	53.9	<10.0	343	11.2
0.5-6	2	24	<0.100	43	0.115	-	-	-	-	-
1.0-4	1	24	<0.100	62.4	0.1479	<10.0	75.1	<10.0	492	11.01
1.0-4	2	24	<0.100	63.1	0.1468	-	-	-	-	-
1.0-5	1	24	<0.100	42.7	0.1042	<10.0	46.8	<10.0	340	10.89
1.0-5	2	24	<0.100	41.95	0.1065	-	-	-	-	-
1.0-6	1	24	<0.100	30.9	0.075	<10.0	34.1	<10.0	241.7	10.75

Table A-1. Measured Concentration of Each Contaminant, Conductivity, and pH for Each Leachate Aliquot after Each Interval for Each Sample. **(cont'd)**

Sample ID	Replicate	Cumulative Leaching Time (hrs)	Cr (mg/L)	Na (mg/L)	Re (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	C_2O_4 (mg/L)	Conductivity (uS/cm)	pH
1.0-6	2	24	<0.100	31.4	0.0747	-	-	-	-	-
3.0-4	1	24	<0.100	69.85	0.1419	<10.0	75.6	<10.0	526	11.11
3.0-4	2	24	<0.100	70.2	0.1397	-	-	-	-	-
3.0-5	1	24	<0.100	31.74	0.0738	<10.0	32.9	<10.0	256.1	10.71
3.0-5	2	24	<0.100	32.75	0.076	-	-	-	-	-
3.0-6	1	24	<0.100	33.49	0.0775	<10.0	34.4	<10.0	270.4	10.71
3.0-6	2	24	<0.100	33.43	0.075	-	-	-	-	-
6.0-4	1	24	<0.100	59.9	0.143	<10.0	71.6	<10.0	543	10.55
6.0-4	2	24	<0.100	60	0.139	-	-	-	-	-
6.0-5	1	24	<0.100	63.4	0.158	<10.0	76.2	<10.0	544	10.6
6.0-5	2	24	<0.100	62.9	0.155	-	-	-	-	-
6.0-6	1	24	<0.100	25.8	0.075	<10.0	29.3	<10.0	236	10.22
6.0-6	2	24	<0.100	26	0.074	-	-	-	-	-
0.5-13	1	48	<0.100	35.4	0.088	<10.0	41.1	<10.0	304	11
0.5-13	2	48	<0.100	35.1	0.088	-	-	-	-	-
0.5-5	1	48	<0.100	27.3	0.073	<10.0	31.2	<10.0	231	11
0.5-5	2	48	<0.100	26.5	0.079	-	-	-	-	-
0.5-6	1	48	<0.100	44.2	0.116	<10.0	54.7	<10.0	377	11.1
0.5-6	2	48	<0.100	44.5	0.115	-	-	-	-	-
1.0-4	1	48	<0.100	26.62	0.0693	<10.0	27.8	<10.0	233.7	10.66
1.0-4	2	48	<0.100	26.51	0.0713	-	-	-	-	-
1.0-5	1	48	<0.100	44.7	0.1029	<10.0	50.4	<10.0	397	10.9
1.0-5	2	48	<0.100	45	0.1019	-	-	-	-	-
1.0-6	1	48	<0.100	32.09	0.0822	<10.0	32.8	<10.0	237	10.55
1.0-6	2	48	<0.100	31.46	0.0808	-	-	-	-	-
3.0-4	1	48	<0.100	24.6	0.0634	<10.0	22.6	<10.0	218.8	10.54
3.0-4	2	48	<0.100	24.2	0.0607	-	-	-	-	-
3.0-5	1	48	<0.100	45.38	0.1079	<10.0	23.9	<10.0	390	10.83
3.0-5	2	48	<0.100	46	0.1052	-	-	-	-	-
3.0-6	1	48	<0.100	54.6	0.1283	<10.0	56.47	<10.0	453	10.92
3.0-6	2	48	<0.100	54.24	0.1269	-	-	-	-	-
6.0-4	1	48	<0.100	24.9	0.064	<10.0	28.3	<10.0	236.5	10.16
6.0-4	2	48	<0.100	24.8	0.065	-	-	-	-	-
6.0-5	1	48	<0.100	45	0.111	<10.0	53	<10.0	426	10.48
6.0-5	2	48	<0.100	45.4	0.11	-	-	-	-	-
6.0-6	1	48	<0.100	23.4	0.066	<10.0	24.6	<10.0	223.3	10.21
6.0-6	2	48	<0.100	23.5	0.065	-	-	-	-	-
0.5-13	1	72	<0.100	16.1	0.046	<10.0	17.1	<10.0	145	10.9
0.5-13	2	72	<0.100	15.1	0.046	-	-	-	-	-
0.5-5	1	72	<0.100	16.6	0.051	<10.0	17.7	<10.0	154	10.9
0.5-5	2	72	<0.100	16.3	0.053	-	-	-	-	-
0.5-6	1	72	<0.100	27.2	0.077	<10.0	30.3	<10.0	251	11.1

Table A-1. Measured Concentration of Each Contaminant, Conductivity, and pH for Each Leachate Aliquot after Each Interval for Each Sample. **(cont'd)**

Sample ID	Replicate	Cumulative Leaching Time (hrs)	Cr (mg/L)	Na (mg/L)	Re (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	C_2O_4 (mg/L)	Conductivity (uS/cm)	pH
0.5-6	2	72	<0.100	28	0.078	-	-	-	-	-
1.0-4	1	72	<0.100	34.9	0.0856	<10.0	34.4	<10.0	320	10.9
1.0-4	2	72	<0.100	34.1	0.0857	-	-	-	-	-
1.0-5	1	72	<0.100	20.84	0.055	<10.0	17.2	<10.0	185.7	10.72
1.0-5	2	72	<0.100	21.15	0.0505	-	-	-	-	-
1.0-6	1	72	<0.100	24.57	0.0609	<10.0	21.26	<10.0	212.1	10.8
1.0-6	2	72	<0.100	24.72	0.0597	-	-	-	-	-
3.0-4	1	72	<0.100	18.26	0.0439	<10.0	14.2	<10.0	167.6	10.66
3.0-4	2	72	<0.100	18.34	0.0444	-	-	-	-	-
3.0-5	1	72	<0.100	26.4	0.064	<10.0	24.9	<10.0	244.8	10.84
3.0-5	2	72	<0.100	26.51	0.0629	-	-	-	-	-
3.0-6	1	72	<0.100	20.59	0.0484	<10.0	16.27	<10.0	163.4	10.64
3.0-6	2	72	<0.100	20.7	0.0489	-	-	-	-	-
6.0-4	1	72	<0.100	19.2	0.054	<10.0	19.8	<10.0	200	10.16
6.0-4	2	72	<0.100	19	0.054	-	-	-	-	-
6.0-5	1	72	<0.100	31.2	0.082	<10.0	36.3	<10.0	317	10.34
6.0-5	2	72	<0.100	31.7	0.081	-	-	-	-	-
6.0-6	1	72	<0.100	17.8	0.055	<10.0	18.2	<10.0	182.3	10.14
6.0-6	2	72	<0.100	18	0.055	-	-	-	-	-
0.5-13	1	96	<0.100	16.8	0.052	<10.0	19.3	<10.0	168	10.9
0.5-13	2	96	<0.100	16.9	0.05	-	-	-	-	-
0.5-5	1	96	<0.100	21.3	0.062	<10.0	25.7	<10.0	213	11
0.5-5	2	96	<0.100	21.1	0.063	-	-	-	-	-
0.5-6	1	96	<0.100	24.4	0.07	<10.0	29.4	<10.0	229	11
0.5-6	2	96	<0.100	24.6	0.071	-	-	-	-	-
1.0-4	1	96	<0.100	19.67	0.051	<10.0	17.6	<10.0	172.9	10.55
1.0-4	2	96	<0.100	19.48	0.0566	-	-	-	-	-
1.0-5	1	96	<0.100	18.95	0.047	<10.0	15.4	<10.0	173.5	10.53
1.0-5	2	96	<0.100	19.3	0.0473	-	-	-	-	-
1.0-6	1	96	<0.100	25.2	0.0602	<10.0	21.26	<10.0	221.6	10.63
1.0-6	2	96	<0.100	24.77	0.0639	-	-	-	-	-
3.0-4	1	96	<0.100	20.06	0.0506	<10.0	17.4	<10.0	183.9	10.51
3.0-4	2	96	<0.100	19.91	0.0533	-	-	-	-	-
3.0-5	1	96	<0.100	26.2	0.064	<10.0	18	<10.0	247.7	10.68
3.0-5	2	96	<0.100	26.45	0.065	-	-	-	-	-
3.0-6	1	96	<0.100	24.26	0.0568	<10.0	20.7	<10.0	219.5	10.63
3.0-6	2	96	<0.100	24.19	0.0613	-	-	-	-	-
6.0-4	1	96	<0.100	19.5	0.054	<10.0	20.9	<10.0	199.3	10.44
6.0-4	2	96	<0.100	19.4	0.055	-	-	-	-	-
6.0-5	1	96	<0.100	23.3	0.07	<10.0	29.9	<10.0	280.8	10.6
6.0-5	2	96	<0.100	26.5	0.069	-	-	-	-	-
6.0-6	1	96	<0.100	11.7	0.041	<10.0	11.4	<10.0	129.7	10.27

Table A-1. Measured Concentration of Each Contaminant, Conductivity, and pH for Each Leachate Aliquot after Each Interval for Each Sample. **(cont'd)**

Sample ID	Replicate	Cumulative Leaching Time (hrs)	Cr (mg/L)	Na (mg/L)	Re (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	C_2O_4 (mg/L)	Conductivity (uS/cm)	pH
6.0-6	2	96	<0.100	11.6	0.04	-	-	-	-	-
0.5-13	1	120	<0.100	9.63	<0.040	<10.0	10.7	<10.0	94	10.5
0.5-13	2	120	<0.100	10.7	<0.040	-	-	-	-	-
0.5-5	1	120	<0.100	15.8	0.048	<10.0	16.8	<10.0	162	10.8
0.5-5	2	120	<0.100	15.7	0.047	-	-	-	-	-
0.5-6	1	120	<0.100	23.9	0.067	<10.0	27.3	<10.0	230	11
0.5-6	2	120	<0.100	24	0.069	-	-	-	-	-
6.0-4	1	120	<0.100	28	0.073	<10.0	28.9	<10.0	269.9	10.48
6.0-4	2	120	<0.100	28.3	0.072	-	-	-	-	-
6.0-5	1	120	<0.100	25.5	0.067	<10.0	25.5	<10.0	223	10.38
6.0-5	2	120	<0.100	25.4	0.066	-	-	-	-	-
6.0-6	1	120	<0.100	25.5	0.066	<10.0	24.6	<10.0	229.7	10.35
6.0-6	2	120	<0.100	26.5	0.068	-	-	-	-	-
1.0-4	1	168	<0.100	59.96	0.1398	<10.0	66.4	<10.0	517	11.02
1.0-4	2	168	<0.100	60.5	0.1374	-	-	-	-	-
1.0-5	1	168	<0.100	35.69	0.0773	<10.0	34	<10.0	283.5	10.68
1.0-5	2	168	<0.100	35.34	0.0807	-	-	-	-	-
1.0-6	1	168	<0.100	33.77	0.0745	<10.0	29.3	<10.0	254.4	10.64
1.0-6	2	168	<0.100	33.7	0.0714	-	-	-	-	-
3.0-4	1	168	<0.100	41.46	0.0927	<10.0	46.2	<10.0	354	10.79
3.0-4	2	168	<0.100	42.85	0.0907	-	-	-	-	-
3.0-5	1	168	<0.100	44.68	0.0957	<10.0	44.87	<10.0	373	10.87
3.0-5	2	168	<0.100	44.82	0.0982	-	-	-	-	-
3.0-6	1	168	<0.100	51.79	0.1131	<10.0	55.7	<10.0	398	10.84
3.0-6	2	168	<0.100	53.06	0.1065	-	-	-	-	-

Appendix B. AMEC Hydraulic Conductivity Test Report.

August 1, 2012

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

Attention: Mr. Bill Joyce, STR

Subject: **Test Report – SDU-6 Task 3 Grout Samples**
Subcontract No. AC54317N, Delivery Order No. 34
Specification K-SPC-G-00013, Rev. 13
AMEC Project No. 6155-08-0031

Dear Mr. Joyce:

AMEC Environment & Infrastructure (AMEC) has completed the assigned testing services for Delivery Order No. 34, Subcontract No. AC54317N. 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:

Permeability	ASTM D5084

These tests were performed in accordance with the above referenced contract order and AMEC's Quality Assurance Manual (QAM) Revision 1.

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

Sincerely,

AMEC

Jianren Wang
Principal

John Lynch
Principal

Cc: SRNS
Vendor Documents
Building 704-IN/Room 137
Aiken, SC 29808

AMEC Environment & Infrastructure
396 Plasters Avenue, NE • Atlanta, GA 30324 • Phone: 404-873-4761 • Fax: 404-817-0221
AMEC.com

ATTACHMENT 1

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JW & JL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/15/2012*
Boring No.	*V6.0-1*	Reviewed By	*JW*
Sample No.	*V6.0-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11605*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.1*
Wet Unit Weight, pcf:	*105.8*
Dry Unit Weight, pcf:	*73.4*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***5.9E-11***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JW & JL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/15/12
Boring No.	V6.0-1	Reviewed By	JW
Sample No.	V6.0-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11605
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.137	Location 1	3.040	Wet Soil+Pan, grams	825.75
Location 2	4.159	Location 2	3.023	Dry Soil + Pan, grams	572.66
Location3	4.087	Location 3	3.021	Pan Weight, grams	0
Average	4.128	Average	3.028	Moisture Content, %	44.2
Volume, in^3	29.72	Wet Soil + Tare, grams	825.13	Dry Unit Weight, pcf	73.4
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	101.9
Soil Sample Wt., g	825.13	Dry Soil +Tare, grams	572.66	Diameter, in.	N/A
Dry UW, pcf	73.4	Moisture Content, %	44.1	Length, in.	N/A
Saturation, %	101.7			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
67440	1.70	27.10	26.90	0.20	23.6	30.5	30.2	6.61E-11	6.07E-11
95520	1.70	27.10	26.85	0.25	22.3	30.5	30.1	5.84E-11	5.53E-11
330660	1.70	25.70	24.90	0.80	22.6	28.8	27.8	5.79E-11	5.44E-11
347580	1.70	25.70	24.80	0.90	22.6	28.8	27.7	6.21E-11	5.83E-11
360000	1.70	25.70	24.75	0.95	22.6	28.8	27.6	6.33E-11	5.95E-11
414021	1.70	25.70	24.50	1.20	22.3	28.8	27.3	6.99E-11	6.62E-11

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

Avg. k at 20 °C **5.9E-11** **cm/sec**

a_a =	0.76712 cm²	a_p=	0.031416 cm²	Remarks:	
A =	46.46 cm²	M_1=	0.03018		
L =	10.48 cm	M_2=	1.04095		
S=L/A=	0.22567 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0005418 for 15° to 25°		

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JW & JL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/15/2012*
Boring No.	*V6.0-2*	Reviewed By	*JW JEY*
Sample No.	*V6.0-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11606*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.4*
Wet Unit Weight, pcf:	*107.2*
Dry Unit Weight, pcf:	*74.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.6E-09***

Remarks: _____

Equipment List
SRNS Delivery Order No. 34
Subcontract No. AC54317N

Equipment Name	Laboratory ID
Oven	109
Balance	416
Thermometer	2866
Caliper	2373
Pressure Transducers	3638

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JW & JL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/15/12
Boring No.	V6.0-2	Reviewed By	JW
Sample No.	V6.0-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11606
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.508	Location 1	3.009	Wet Soil+Pan, grams	902.40
Location 2	4.531	Location 2	3.005	Dry Soil + Pan, grams	629.27
Location3	4.519	Location 3	3.001	Pan Weight, grams	0
Average	4.519	Average	3.005	Moisture Content, %	43.4
Volume, in^3	32.05	Wet Soil + Tare, grams	902.16	Dry Unit Weight, pcf	74.8
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	103.9
Soil Sample Wt., g	902.16	Dry Soil +Tare, grams	629.27	Diameter, in.	N/A
Dry UW, pcf	74.8	Moisture Content, %	43.4	Length, in.	N/A
Saturation, %	103.8			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
3120	1.70	24.40	24.20	0.20	22.1	24.9	24.6	1.78E-09	1.69E-09
6600	1.70	24.40	24.10	0.30	22.1	24.9	24.5	1.26E-09	1.20E-09
10980	1.50	26.40	25.30	1.10	22.3	27.3	26.0	2.58E-09	2.44E-09
13748	1.50	26.40	25.10	1.30	22.4	27.3	25.8	2.45E-09	2.31E-09
68880	1.50	26.40	23.00	3.40	22.3	27.3	23.4	1.34E-09	1.27E-09
78360	1.50	26.40	22.80	3.60	22.3	27.3	23.2	1.25E-09	1.19E-09
90120	1.50	26.40	22.00	4.40	22.6	27.3	22.3	1.36E-09	1.28E-09

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

Avg. k at 20 °C **1.6E-09** **cm/sec**

a_a =	0.76712 cm²	a_p=	0.031416 cm²	Remarks:	
A =	45.76 cm²	M_1=	0.03018		
L =	11.48 cm	M_2=	1.04095		
S=L/A=	0.25088 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0006023 for 15° to 25°		

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JW & JL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/15/2012*
Boring No.	*V6.0-3*	Reviewed By	*JW*
Sample No.	*V6.0-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11607*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.0*
Wet Unit Weight, pcf:	*107.0*
Dry Unit Weight, pcf:	*74.3*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.6E-10***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JW & JL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/15/12
Boring No.	V6.0-3	Reviewed By	JW
Sample No.	V6.0-3	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11607
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.274	Location 1	3.012	Wet Soil+Pan, grams	856.37
Location 2	4.291	Location 2	2.999	Dry Soil + Pan, grams	594.60
Location3	4.349	Location 3	2.998	Pan Weight, grams	0
Average	4.305	Average	3.003	Moisture Content, %	44.0
Volume, in^3	30.49	Wet Soil + Tare, grams	855.96	Dry Unit Weight, pcf	74.3
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	104.0
Soil Sample Wt., g	855.96	Dry Soil +Tare, grams	594.60	Diameter, in.	N/A
Dry UW, pcf	74.3	Moisture Content, %	44.0	Length, in.	N/A
Saturation, %	103.9			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
78480	1.70	25.40	24.20	1.20	22.1	27.2	25.8	3.96E-10	3.77E-10
7380	1.70	24.50	24.40	0.10	22.1	26.2	26.1	3.56E-10	3.39E-10
14990	1.70	24.50	24.30	0.20	23.6	26.2	26.0	3.52E-10	3.23E-10
68280	1.70	24.50	23.90	0.60	23.6	26.2	25.5	2.34E-10	2.15E-10
80100	1.70	24.50	23.80	0.70	22.3	26.2	25.4	2.33E-10	2.21E-10
96120	1.70	24.50	23.70	0.80	22.4	26.2	25.3	2.22E-10	2.10E-10
154500	1.70	24.50	23.50	1.00	22.4	26.2	25.0	1.74E-10	1.64E-10

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

Avg. k at 20 °C **2.6E-10** **cm/sec**

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

A = 45.69 cm^2 M_1 = 0.03018

L = 10.93 cm M_2 = 1.04095

S=L/A= 0.23928 1/cm $C = M_1S/(G_{Hg}-1)$ = 0.0005745 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JW & JL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/15/2012*
Boring No.	*V3.0-1*	Reviewed By	*JW*
Sample No.	*V3.0-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11608*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.8*
Wet Unit Weight, pcf:	*107.1*
Dry Unit Weight, pcf:	*74.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.3E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JW & JL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/15/12
Boring No.	V3.0-1	Reviewed By	JW
Sample No.	V3.0-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11608
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.522	Location 1	3.015	Wet Soil+Pan, grams	903.84
Location 2	4.581	Location 2	3.006	Dry Soil + Pan, grams	624.35
Location3	4.482	Location 3	2.999	Pan Weight, grams	0
Average	4.528	Average	3.007	Moisture Content, %	44.8
Volume, in^3	32.15	Wet Soil + Tare, grams	903.76	Dry Unit Weight, pcf	74.0
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	104.9
Soil Sample Wt., g	903.76	Dry Soil +Tare, grams	624.35	Diameter, in.	N/A
Dry UW, pcf	74.0	Moisture Content, %	44.8	Length, in.	N/A
Saturation, %	104.8			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
4860	1.50	22.80	22.30	0.50	22.1	23.3	22.7	3.07E-09	2.92E-09
8100	1.50	22.80	22.00	0.80	22.1	23.3	22.4	2.97E-09	2.82E-09
12000	1.50	22.80	21.80	1.00	22.1	23.3	22.1	2.52E-09	2.39E-09
22430	1.50	22.80	21.00	1.80	22.1	23.3	21.2	2.47E-09	2.35E-09
79080	1.50	22.80	18.20	4.60	22.1	23.3	18.0	1.94E-09	1.85E-09
85080	1.50	22.80	18.00	4.80	22.1	23.3	17.8	1.89E-09	1.80E-09
92880	1.50	22.80	17.80	5.00	22.1	23.3	17.6	1.82E-09	1.73E-09

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

Avg. k at 20 °C **2.3E-09** **cm/sec**

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

A = 45.81 cm^2 M_1= 0.03018

L = 11.50 cm M_2= 1.04095

S=L/A= 0.25110 1/cm $C = M_1S/(G_{Hg}-1)$= 0.0006029 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/27/2012*
Boring No.	*V3.0-2*	Reviewed By	*JWG*
Sample No.	*V3.0-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11609*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.5*
Wet Unit Weight, pcf:	*107.5*
Dry Unit Weight, pcf:	*74.4*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.0E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

amec

Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/27/12
Boring No.	V3.0-2	Reviewed By	JW
Sample No.	V3.0-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11609
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.416	Location 1	2.994	Wet Soil+Pan, grams	882.14
Location 2	4.408	Location 2	3.009	Dry Soil + Pan, grams	610.50
Location3	4.452	Location 3	2.992	Pan Weight, grams	0
Average	4.425	Average	2.998	Moisture Content, %	44.5
Volume, in^3	31.25	Wet Soil + Tare, grams	882.05	Dry Unit Weight, pcf	74.4
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	105.5
Soil Sample Wt., g	882.05	Dry Soil +Tare, grams	610.50	Diameter, in.	N/A
Dry UW, pcf	74.4	Moisture Content, %	44.5	Length, in.	N/A
Saturation, %	105.5			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
5220	1.50	22.80	22.40	0.40	22.9	23.8	23.4	2.24E-09	2.09E-09
7890	1.50	22.80	22.10	0.70	22.9	23.8	23.0	2.61E-09	2.44E-09
15840	1.50	22.80	22.05	0.75	22.9	23.8	22.9	1.40E-09	1.30E-09
3600	1.50	24.80	24.20	0.60	23.0	26.1	25.4	4.47E-09	4.16E-09
14100	1.50	24.80	24.10	0.70	23.1	26.1	25.2	1.34E-09	1.24E-09
3600	1.50	26.40	26.20	0.20	23.1	27.8	27.6	1.38E-09	1.28E-09
6120	1.50	26.40	26.10	0.30	23.1	27.8	27.5	1.22E-09	1.14E-09

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-09 cm/sec**

a_s =	0.76712 cm^2	a_p=	0.031416 cm^2	Remarks:
A =	45.55 cm^2	M_1=	0.03018	
L =	11.24 cm	M_2=	1.04095	
S=L/A=	0.24675 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0005924 for 15° to 25°	

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/27/2012*
Boring No.	*V3.0-3*	Reviewed By	*JW*
Sample No.	*V3.0-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11610*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.4*
Wet Unit Weight, pcf:	*108.7*
Dry Unit Weight, pcf:	*75.3*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.4E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/27/12
Boring No.	V3.0-3	Reviewed By	JW
Sample No.	V3.0-3	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11610
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.397	Location 1	2.911	Wet Soil+Pan, grams	870.30
Location 2	4.401	Location 2	3.005	Dry Soil + Pan, grams	602.76
Location3	4.397	Location 3	2.998	Pan Weight, grams	0
Average	4.398	Average	2.971	Moisture Content, %	44.4
Volume, in^3	30.50	Wet Soil + Tare, grams	870.47	Dry Unit Weight, pcf	75.3
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	107.7
Soil Sample Wt., g	870.47	Dry Soil +Tare, grams	602.76	Diameter, in.	N/A
Dry UW, pcf	75.3	Moisture Content, %	44.4	Length, in.	N/A
Saturation, %	107.8			Volume, in^3	N/A

Consolidation

Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
4680	1.70	23.50	23.20	0.30	23.1	24.5	24.2	1.85E-09	1.72E-09
10200	1.70	23.50	22.90	0.60	22.9	24.5	23.8	1.71E-09	1.59E-09
14880	1.70	23.50	22.80	0.70	22.9	24.5	23.7	1.37E-09	1.28E-09
19260	1.70	23.50	22.60	0.90	22.9	24.5	23.5	1.37E-09	1.28E-09
21300	1.70	23.50	22.50	1.00	22.9	24.5	23.4	1.38E-09	1.29E-09
23340	1.70	23.50	22.40	1.10	22.9	24.5	23.2	1.39E-09	1.29E-09
25200	1.70	23.50	22.30	1.20	22.9	24.5	23.1	1.40E-09	1.31E-09

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

Avg. k at 20 °C **1.4E-09** **cm/sec**

a_a =	0.76712 cm²	a_p=	0.031416 cm²	Remarks:	
A =	44.74 cm²	M_1=	0.03018		
L =	11.17 cm	M_2=	1.04095		
S=L/A=	0.24972 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0005996 for 15° to 25°		

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/28/2012*
Boring No.	*H1.5-1*	Reviewed By	*JW 9/28*
Sample No.	*H1.5-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11611*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.3*
Wet Unit Weight, pcf:	*105.8*
Dry Unit Weight, pcf:	*73.3*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***4.0E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/28/12
Boring No.	H1.5-1	Reviewed By	JW
Sample No.	H1.5-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11611
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.657	Location 1	3.014	Wet Soil+Pan, grams	922.99
Location 2	4.646	Location 2	3.001	Dry Soil + Pan, grams	639.43
Location3	4.640	Location 3	3.035	Pan Weight, grams	0
Average	4.648	Average	3.017	Moisture Content, %	44.3
Volume, in^3	33.22	Wet Soil + Tare, grams	922.89	Dry Unit Weight, pcf	73.3
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	102.1
Soil Sample Wt., g	922.89	Dry Soil +Tare, grams	639.43	Diameter, in.	N/A
Dry UW, pcf	73.3	Moisture Content, %	44.3	Length, in.	N/A
Saturation, %	102.1			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
2340	1.70	25.00	20.50	4.50	22.9	24.8	19.8	5.90E-08	5.50E-08
4200	1.70	25.00	18.50	6.50	23.0	24.8	17.6	5.02E-08	4.67E-08
9600	1.70	25.00	13.70	11.30	23.1	24.8	12.3	4.50E-08	4.18E-08
4380	1.70	25.50	20.30	5.20	23.1	25.3	19.6	3.62E-08	3.36E-08
4140	1.70	26.40	21.40	5.00	23.1	26.3	20.8	3.51E-08	3.26E-08
6900	1.70	26.40	18.90	7.50	23.1	26.3	18.0	3.38E-08	3.14E-08
1740	1.70	24.70	22.30	2.40	23.1	24.5	21.8	4.06E-08	3.77E-08

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

Avg. k at 20 °C **4.0E-08** **cm/sec**

a_n = 0.76712 cm^2 a_p= 0.031416 cm^2
A = 46.11 cm^2 M_1= 0.03018
L = 11.81 cm M_2= 1.04095
S=L/A= 0.25601 1/cm $C = M_1S/(G_{Hg}-1)$= 0.0006147 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*6/27/2012*
Boring No.	*H1.5-2*	Reviewed By	*JW JCB*
Sample No.	*H1.5-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11612*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.3*
Wet Unit Weight, pcf:	*105.6*
Dry Unit Weight, pcf:	*73.2*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.0E-07***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	06/27/12
Boring No.	H1.5-2	Reviewed By	JW
Sample No.	H1.5-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11612
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.849	Location 1	3.029	Wet Soil+Pan, grams	963.17
Location 2	4.846	Location 2	3.024	Dry Soil + Pan, grams	667.65
Location3	4.847	Location 3	3.011	Pan Weight, grams	0
Average	4.847	Average	3.021	Moisture Content, %	44.3
Volume, in^3	34.75	Wet Soil + Tare, grams	963.21	Dry Unit Weight, pcf	73.2
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	101.5
Soil Sample Wt., g	963.21	Dry Soil +Tare, grams	667.65	Diameter, in.	N/A
Dry UW, pcf	73.2	Moisture Content, %	44.3	Length, in.	N/A
Saturation, %	101.5			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
640	1.70	24.10	19.40	4.70	22.9	22.9	17.9	2.46E-07	2.30E-07
1080	1.70	24.40	18.10	6.30	22.9	23.2	16.5	2.02E-07	1.88E-07
960	1.70	23.50	17.70	5.80	22.9	22.3	16.1	2.16E-07	2.01E-07
1500	1.70	24.50	16.00	8.50	22.9	23.3	14.2	2.09E-07	1.95E-07
855	1.70	25.50	20.00	5.50	22.9	24.3	18.5	2.06E-07	1.92E-07
900	1.70	26.30	20.50	5.80	22.9	25.1	19.0	2.00E-07	1.87E-07
720	1.70	25.00	20.70	4.30	22.9	23.8	19.2	1.89E-07	1.77E-07

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-07** **cm/sec**

a_a =	0.76712	cm^2	a_p=	0.031416	cm^2
A =	46.25	cm^2	M_1=	0.03018	
L =	12.31	cm	M_2=	1.04095	
S=L/A=	0.26618	1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0006391	for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/2/2012*
Boring No.	*H1.5-3*	Reviewed By	*JW*
Sample No.	*H1.5-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11613*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.8*
Wet Unit Weight, pcf:	*107.1*
Dry Unit Weight, pcf:	*74.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.4E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number 6155-08-0031.34 Tested By JEL
Project Name SDU-6 Task 3 Grout Samples Test Date 07/02/12
Boring No. H1.5-3 Reviewed By JW
Sample No. H1.5-3 Review Date 08/01/12
Sample Depth N/A Lab No. 11613
Sample Description Grout Core

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.397	Location 1	3.010	Wet Soil+Pan, grams	880.52
Location 2	4.396	Location 2	3.010	Dry Soil + Pan, grams	612.11
Location3	4.396	Location 3	3.015	Pan Weight, grams	0
Average	4.396	Average	3.012	Moisture Content, %	43.8
Volume, in^3	31.32	Wet Soil + Tare, grams	880.26	Dry Unit Weight, pcf	74.5
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	104.1
Soil Sample Wt., g	880.26	Dry Soil +Tare, grams	612.11	Diameter, in.	N/A
Dry UW, pcf	74.5	Moisture Content, %	43.8	Length, in.	N/A
Saturation, %	104.0			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
4200	1.70	24.00	21.10	2.90	23.0	25.1	21.7	2.02E-08	1.88E-08
720	1.70	25.00	24.50	0.50	23.0	26.2	25.6	1.83E-08	1.70E-08
1620	1.70	25.00	24.10	0.90	23.0	26.2	25.2	1.48E-08	1.38E-08
2700	1.70	25.00	23.70	1.30	23.0	26.2	24.7	1.29E-08	1.20E-08
3660	1.70	25.00	23.20	1.80	23.0	26.2	24.1	1.34E-08	1.24E-08
4920	1.70	25.00	22.60	2.40	23.0	26.2	23.4	1.34E-08	1.25E-08

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

Avg. k at 20 °C 1.4E-08 cm/sec

a_a = 0.76712 cm^2 a_p= 0.031416 cm^2
A = 45.96 cm^2 M_1= 0.03018
L = 11.17 cm M_2= 1.04095
S=L/A= 0.24297 1/cm $C = M_1S/(G_{Hg}-1)$= 0.0005834 for 15° to 25°

Remarks:

RCN: SRS256
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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/2/2012*
Boring No.	*H1.0-1*	Reviewed By	*JW 8/8*
Sample No.	*H1.0-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11614*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.3*
Wet Unit Weight, pcf:	*106.0*
Dry Unit Weight, pcf:	*73.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***4.0E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/02/12
Boring No.	H1.0-1	Reviewed By	JW
Sample No.	H1.0-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11614
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.654	Location 1	3.033	Wet Soil+Pan, grams	924.12
Location 2	4.646	Location 2	2.993	Dry Soil + Pan, grams	640.32
Location3	4.650	Location 3	3.020	Pan Weight, grams	0
Average	4.650	Average	3.015	Moisture Content, %	44.3
Volume, in^3	33.21	Wet Soil + Tare, grams	924.11	Dry Unit Weight, pcf	73.5
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	102.4
Soil Sample Wt., g	924.11	Dry Soil +Tare, grams	640.32	Diameter, in.	N/A
Dry UW, pcf	73.5	Moisture Content, %	44.3	Length, in.	N/A
Saturation, %	102.4			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
2040	1.70	25.00	21.50	3.50	23.0	24.8	20.9	5.13E-08	4.78E-08
4620	1.70	25.00	18.50	6.50	23.0	24.8	17.6	4.57E-08	4.26E-08
720	1.70	25.00	23.90	1.10	23.0	24.8	23.6	4.31E-08	4.01E-08
1620	1.70	25.00	22.70	2.30	23.0	24.8	22.2	4.12E-08	3.84E-08
2760	1.70	25.00	21.40	3.60	23.0	24.8	20.8	3.91E-08	3.64E-08
3660	1.70	25.00	20.30	4.70	23.0	24.8	19.6	3.96E-08	3.69E-08
5040	1.70	25.00	19.00	6.00	23.0	24.8	18.2	3.81E-08	3.55E-08

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

Avg. k at 20 °C **4.0E-08** **cm/sec**

a_s =	0.76712	cm^2	a_p=	0.031416 cm^2	Remarks:
A =	46.07	cm^2	M_1=	0.03018	
L =	11.81	cm	M_2=	1.04095	
S=L/A=	0.25636	1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0006155 for 15° to 25°	

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/2/2012*
Boring No.	*H1.0-2*	Reviewed By	*JW*
Sample No.	*H1.0-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11615*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.1*
Wet Unit Weight, pcf:	*106.1*
Dry Unit Weight, pcf:	*73.7*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.4E-07***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

amec

Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/02/12
Boring No.	H1.0-2	Reviewed By	JW
Sample No.	H1.0-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11615
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.505	Location 1	3.011	Wet Soil+Pan, grams	894.44
Location 2	4.482	Location 2	3.017	Dry Soil + Pan, grams	619.38
Location3	4.484	Location 3	3.013	Pan Weight, grams	0
Average	4.490	Average	3.014	Moisture Content, %	44.4
Volume, in^3	32.03	Wet Soil + Tare, grams	892.30	Dry Unit Weight, pcf	73.7
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	103.2
Soil Sample Wt., g	892.30	Dry Soil +Tare, grams	619.38	Diameter, in.	N/A
Dry UW, pcf	73.7	Moisture Content, %	44.1	Length, in.	N/A
Saturation, %	102.4			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
540	1.70	25.00	19.50	5.50	23.0	25.7	19.4	3.11E-07	2.89E-07
720	1.70	25.00	19.10	5.90	23.0	25.7	18.9	2.53E-07	2.35E-07
1080	1.70	25.00	17.00	8.00	23.0	25.7	16.5	2.44E-07	2.27E-07
600	1.70	25.00	20.30	4.70	23.0	25.7	20.3	2.34E-07	2.18E-07
540	1.70	25.00	20.20	4.80	23.0	25.7	20.2	2.66E-07	2.48E-07
1080	1.70	25.00	16.70	8.30	23.0	25.7	16.2	2.55E-07	2.38E-07
480	1.70	25.00	20.70	4.30	23.0	25.7	20.7	2.64E-07	2.46E-07

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

Avg. k at 20 °C **2.4E-07 cm/sec**

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

A = 46.02 cm^2 M_1 = 0.03018

L = 11.41 cm M_2 = 1.04095

S=L/A= 0.24784 1/cm $C = M_1S/(G_{Hg}-1)$ = 0.0005950 for 15° to 25°

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/2/2012*
Boring No.	*H1.0-3*	Reviewed By	*JWJeN*
Sample No.	*H1.0-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11616*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.8*
Wet Unit Weight, pcf:	*105.9*
Dry Unit Weight, pcf:	*73.6*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.8E-07***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/02/12
Boring No.	H1.0-3	Reviewed By	JW
Sample No.	H1.0-3	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11616
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.507	Location 1	3.011	Wet Soil+Pan, grams	900.01
Location 2	4.504	Location 2	3.038	Dry Soil + Pan, grams	626.07
Location3	4.495	Location 3	3.032	Pan Weight, grams	0
Average	4.502	Average	3.027	Moisture Content, %	43.8
Volume, in^3	32.40	Wet Soil + Tare, grams	900.41	Dry Unit Weight, pcf	73.6
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	101.5
Soil Sample Wt., g	900.41	Dry Soil +Tare, grams	626.07	Diameter, in.	N/A
Dry UW, pcf	73.6	Moisture Content, %	43.8	Length, in.	N/A
Saturation, %	101.7			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
540	1.70	25.00	20.70	4.30	23.0	25.6	20.7	2.34E-07	2.18E-07
720	1.70	25.50	20.60	4.90	23.0	26.2	20.6	1.98E-07	1.84E-07
900	1.70	25.00	19.00	6.00	23.0	25.6	18.7	2.05E-07	1.91E-07
660	1.70	25.80	20.70	5.10	23.0	26.5	20.7	2.23E-07	2.08E-07
540	1.70	25.00	22.00	3.00	23.0	25.6	22.2	1.58E-07	1.47E-07
1080	1.70	25.00	20.20	4.80	23.0	25.6	20.1	1.32E-07	1.23E-07
540	1.70	25.00	21.50	3.50	23.0	25.6	21.6	1.86E-07	1.73E-07

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

Avg. k at 20 °C **1.8E-07 cm/sec**

a_a =	0.76712	cm^2	a_p=	0.031416 cm^2	Remarks:
A =	46.43	cm^2	M_1=	0.03018	
L =	11.44	cm	M_2=	1.04095	
S=L/A=	0.24630	1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0005913 for 15° to 25°	

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/10/2012*
Boring No.	*V0.5-1*	Reviewed By	*JWJ*
Sample No.	*V0.5-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11617*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.7*
Wet Unit Weight, pcf:	*106.4*
Dry Unit Weight, pcf:	*74.0*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.6E-09***

Remarks: Top layey separated during the test.

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/10/12
Boring No.	V0.5-1	Reviewed By	JWJ
Sample No.	V0.5-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11617
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/a
Location 1	5.513	Location 1	3.041	Wet Soil+Pan, grams	1116.33
Location 2	5.511	Location 2	3.048	Dry Soil + Pan, grams	776.43
Location3	5.521	Location 3	3.024	Pan Weight, grams	0
Average	5.515	Average	3.038	Moisture Content, %	43.8
Volume, in^3	39.97	Wet Soil + Tare, grams	1115.87	Dry Unit Weight, pcf	74.0
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	102.6
Soil Sample Wt., g	1115.87	Dry Soil +Tare, grams	776.43	Diameter, in.	N/A
Dry UW, pcf	74.0	Moisture Content, %	43.7	Length, in.	N/A
Saturation, %	102.5			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
4980	2.20	26.40	25.95	0.45	22.8	21.7	21.3	2.82E-09	2.64E-09
9600	2.20	26.40	25.85	0.55	22.9	21.7	21.2	1.79E-09	1.67E-09
19680	2.20	26.40	25.70	0.70	22.9	21.7	21.1	1.12E-09	1.04E-09
7440	2.20	26.70	26.20	0.50	22.3	22.0	21.5	2.08E-09	1.97E-09
14580	2.20	26.70	26.10	0.60	22.9	22.0	21.4	1.27E-09	1.19E-09
21900	2.20	26.70	25.90	0.80	22.6	22.0	21.2	1.14E-09	1.07E-09

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

Avg. k at 20 °C **1.6E-09 cm/sec**

a_a =	0.76712 cm^2	a_p=	0.031416 cm^2	Remarks:	Top layey separated during the test.
A =	46.76 cm^2	M_1=	0.03018		
L =	14.01 cm	M_2=	1.04095		
S=L/A=	0.29960 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0007193 for 15° to 25°		

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/10/2012*
Boring No.	*V0.5-2*	Reviewed By	*JW*
Sample No.	*V0.5-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11618*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.9*
Wet Unit Weight, pcf:	*105.9*
Dry Unit Weight, pcf:	*73.1*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***4.2E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/10/12
Boring No.	V0.5-2	Reviewed By	JW
Sample No.	V0.5-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11618
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	5.418	Location 1	3.047	Wet Soil+Pan, grams	1094.29
Location 2	5.412	Location 2	3.031	Dry Soil + Pan, grams	754.76
Location3	5.409	Location 3	3.049	Pan Weight, grams	0
Average	5.413	Average	3.042	Moisture Content, %	45.0
Volume, in^3	39.35	Wet Soil + Tare, grams	1093.90	Dry Unit Weight, pcf	73.1
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	102.9
Soil Sample Wt., g	1093.90	Dry Soil +Tare, grams	754.76	Diameter, in.	N/A
Dry UW, pcf	73.1	Moisture Content, %	44.9	Length, in.	N/A
Saturation, %	102.8			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
5820	1.50	26.00	25.10	0.90	22.8	22.4	21.5	4.72E-09	4.41E-09
12810	1.50	26.00	24.80	1.20	22.9	22.4	21.3	2.88E-09	2.68E-09
19920	1.50	26.00	24.50	1.50	22.9	22.4	21.0	2.33E-09	2.17E-09
5040	1.50	25.80	25.30	0.50	22.8	22.2	21.7	3.02E-09	2.83E-09
7380	1.50	27.60	25.90	1.70	22.3	23.9	22.2	6.70E-09	6.34E-09
14700	1.50	27.60	24.60	3.00	22.9	23.9	21.0	6.10E-09	5.70E-09
21840	1.50	27.60	23.40	4.20	22.6	23.9	19.9	5.91E-09	5.55E-09

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

Avg. k at 20 °C **4.2E-09** **cm/sec**

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

A = 46.90 cm^2 M_1= 0.03018

L = 13.75 cm M_2= 1.04095

S=L/A= 0.29316 1/cm $C = M_1S/(G_{Hg}-1)$= 0.0007039 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/10/2012*
Boring No.	*V0.5-3*	Reviewed By	*JW*
Sample No.	*V0.5-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11619*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*44.1*
Wet Unit Weight, pcf:	*107.6*
Dry Unit Weight, pcf:	*74.7*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.1E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/10/12
Boring No.	V0.5-3	Reviewed By	JW
Sample No.	V0.5-3	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11619
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	5.501	Location 1	3.006	Wet Soil+Pan, grams	1108.23
Location 2	5.496	Location 2	3.003	Dry Soil + Pan, grams	769.05
Location3	5.491	Location 3	3.034	Pan Weight, grams	0
Average	5.496	Average	3.014	Moisture Content, %	44.1
Volume, in^3	39.22	Wet Soil + Tare, grams	1107.89	Dry Unit Weight, pcf	74.7
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	105.3
Soil Sample Wt., g	1107.89	Dry Soil +Tare, grams	769.05	Diameter, in.	N/A
Dry UW, pcf	74.7	Moisture Content, %	44.1	Length, in.	N/A
Saturation, %	105.2			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
60570	1.60	27.30	22.15	5.15	22.6	23.1	18.3	2.81E-09	2.64E-09
5400	1.60	27.10	26.10	1.00	22.8	23.0	22.0	5.62E-09	5.26E-09
12240	1.60	27.10	25.50	1.60	22.9	23.0	21.5	4.02E-09	3.75E-09
19380	1.60	27.10	24.90	2.20	22.9	23.0	20.9	3.53E-09	3.30E-09
25080	1.60	27.10	24.60	2.50	23.0	23.0	20.6	3.12E-09	2.91E-09
82560	1.60	27.10	22.00	5.10	22.5	23.0	18.2	2.06E-09	1.94E-09
4980	1.60	25.70	25.40	0.30	22.8	21.7	21.4	1.91E-09	1.78E-09

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-09** **cm/sec**

a_a =	0.76712 cm²	a_p=	0.031416 cm²	Remarks:	
A =	46.04 cm²	M_1=	0.03018		
L =	13.96 cm	M_2=	1.04095		
S=L/A=	0.30321 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0007280 for 15° to 25°		

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/10/2012*
Boring No.	*V1.0-1*	Reviewed By	*JW*
Sample No.	*V1.0-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11620*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.8*
Wet Unit Weight, pcf:	*107.6*
Dry Unit Weight, pcf:	*74.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.5E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/10/12
Boring No.	V1.0-1	Reviewed By	JW
Sample No.	V1.0-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11620
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.966	Location 1	3.000	Wet Soil+Pan, grams	993.57
Location 2	4.975	Location 2	3.008	Dry Soil + Pan, grams	690.68
Location3	4.960	Location 3	3.001	Pan Weight, grams	0
Average	4.967	Average	3.003	Moisture Content, %	43.9
Volume, in^3	35.18	Wet Soil + Tare, grams	993.31	Dry Unit Weight, pcf	74.8
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	105.0
Soil Sample Wt., g	993.31	Dry Soil +Tare, grams	690.68	Diameter, in.	N/A
Dry UW, pcf	74.8	Moisture Content, %	43.8	Length, in.	N/A
Saturation, %	104.9			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
60780	1.70	27.70	20.65	7.05	22.6	25.9	18.6	3.62E-09	3.40E-09
6600	1.70	26.60	25.90	0.70	22.8	24.8	24.1	2.98E-09	2.79E-09
13560	1.70	26.60	25.20	1.40	22.9	24.8	23.4	2.95E-09	2.75E-09
20640	1.70	26.60	24.70	1.90	22.9	24.8	22.8	2.66E-09	2.48E-09
26400	1.70	26.60	24.30	2.30	23.0	24.8	22.4	2.54E-09	2.36E-09
83940	1.70	26.50	21.90	4.60	22.5	24.7	19.9	1.69E-09	1.60E-09
5040	1.70	25.20	24.80	0.40	22.8	23.4	23.0	2.35E-09	2.20E-09

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

Avg. k at 20 °C **2.5E-09** **cm/sec**

a_a =	0.76712 cm²	a_p=	0.031416 cm²	Remarks:	
A =	45.69 cm²	M_1=	0.03018		
L =	12.62 cm	M_2=	1.04095		
S=L/A=	0.27610 1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0006629 for 15° to 25°		

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/17/2012*
Boring No.	*V1.0-2*	Reviewed By	*JW*
Sample No.	*V1.0-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11621*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.7*
Wet Unit Weight, pcf:	*106.1*
Dry Unit Weight, pcf:	*74.4*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***2.2E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

amec

Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/17/12
Boring No.	V1.0-2	Reviewed By	JW
Sample No.	V1.0-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11621
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	5.078	Location 1	3.028	Wet Soil+Pan, grams	1014.02
Location 2	5.072	Location 2	3.039	Dry Soil + Pan, grams	710.53
Location3	5.030	Location 3	3.013	Pan Weight, grams	0
Average	5.060	Average	3.027	Moisture Content, %	42.7
Volume, in^3	36.41	Wet Soil + Tare, grams	1013.74	Dry Unit Weight, pcf	74.4
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	101.1
Soil Sample Wt., g	1013.74	Dry Soil +Tare, grams	710.53	Diameter, in.	N/A
Dry UW, pcf	74.4	Moisture Content, %	42.7	Length, in.	N/A
Saturation, %	101.0			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
1050	2.20	24.80	24.60	0.20	21.9	22.1	21.9	5.86E-09	5.60E-09
4080	2.20	24.80	24.50	0.30	22.0	22.1	21.8	2.27E-09	2.16E-09
9240	2.20	24.80	24.40	0.40	22.4	22.1	21.7	1.34E-09	1.26E-09
5340	2.20	27.00	26.70	0.30	22.8	24.3	23.9	1.58E-09	1.48E-09
10800	2.20	27.00	26.55	0.45	22.6	24.3	23.8	1.17E-09	1.10E-09
3540	2.20	27.10	26.80	0.30	22.6	24.4	24.0	2.37E-09	2.23E-09
61200	2.20	27.10	24.30	2.80	21.9	24.4	21.5	1.35E-09	1.29E-09

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

Avg. k at 20 °C **2.2E-09** **cm/sec**

a_a = 0.76712 cm^2 a_p= 0.031416 cm^2
A = 46.42 cm^2 M_1= 0.03018
L = 12.85 cm M_2= 1.04095
S=L/A= 0.27688 1/cm $C = M_1S/(G_{Hg}-1)$= 0.0006648 for 15° to 25°

Remarks:

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/17/2012*
Boring No.	*V1.0-3*	Reviewed By	*JWJ*
Sample No.	*V1.0-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11622*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.5*
Wet Unit Weight, pcf:	*107.5*
Dry Unit Weight, pcf:	*74.9*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***4.0E-09***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/17/12
Boring No.	V1.0-3	Reviewed By	JW
Sample No.	V1.0-3	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11622
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	5.263	Location 1	3.029	Wet Soil+Pan, grams	1063.47
Location 2	5.318	Location 2	3.009	Dry Soil + Pan, grams	740.65
Location3	5.301	Location 3	2.994	Pan Weight, grams	0
Average	5.294	Average	3.011	Moisture Content, %	43.6
Volume, in^3	37.69	Wet Soil + Tare, grams	1063.08	Dry Unit Weight, pcf	74.9
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	104.6
Soil Sample Wt., g	1063.08	Dry Soil +Tare, grams	740.65	Diameter, in.	N/A
Dry UW, pcf	74.9	Moisture Content, %	43.5	Length, in.	N/A
Saturation, %	104.4			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
900	1.70	24.40	24.25	0.15	21.9	21.2	21.1	5.39E-09	5.15E-09
2850	1.70	24.40	23.90	0.50	22.0	21.2	20.7	5.72E-09	5.45E-09
5100	1.70	24.40	23.60	0.80	22.0	21.2	20.4	5.15E-09	4.91E-09
10320	1.70	24.40	23.20	1.20	22.4	21.2	20.1	3.86E-09	3.64E-09
16020	1.70	24.40	22.80	1.60	22.8	21.2	19.7	3.34E-09	3.13E-09
21480	1.70	24.40	22.50	1.90	22.6	21.2	19.4	2.98E-09	2.80E-09
24420	1.70	24.40	22.30	2.10	22.8	21.2	19.2	2.91E-09	2.73E-09

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

Avg. k at 20 °C **4.0E-09 cm/sec**

a_a =	0.76712 cm^2	a_p =	0.031416 cm^2	Remarks:
A =	45.93 cm^2	M_1 =	0.03018	
L =	13.45 cm	M_2 =	1.04095	
S=L/A=	0.29278 1/cm	$C = M_1S/(G_{Hg}-1)$ =	0.0007029 for 15° to 25°	

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/17/2012*
Boring No.	*H0.5-1*	Reviewed By	*JWG*
Sample No.	*H0.5-1*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11623*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*43.6*
Wet Unit Weight, pcf:	*107.4*
Dry Unit Weight, pcf:	*74.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.6E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/17/12
Boring No.	H0.5-1	Reviewed By	JW
Sample No.	H0.5-1	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11623
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.398	Location 1	2.976	Wet Soil+Pan, grams	882.07
Location 2	4.463	Location 2	2.996	Dry Soil + Pan, grams	614.31
Location3	4.510	Location 3	2.996	Pan Weight, grams	0
Average	4.457	Average	2.989	Moisture Content, %	43.6
Volume, in^3	31.28	Wet Soil + Tare, grams	882.05	Dry Unit Weight, pcf	74.8
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	104.4
Soil Sample Wt., g	882.05	Dry Soil +Tare, grams	614.31	Diameter, in.	N/A
Dry UW, pcf	74.8	Moisture Content, %	43.6	Length, in.	N/A
Saturation, %	104.4			Volume, in^3	N/A

Consolidation

Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
1725	1.70	26.00	23.20	2.80	21.9	27.0	23.7	4.45E-08	4.25E-08
2220	1.70	26.00	22.70	3.30	21.9	27.0	23.2	4.12E-08	3.94E-08
2850	1.70	26.00	22.20	3.80	21.9	27.0	22.6	3.74E-08	3.58E-08
3510	1.70	26.00	21.60	4.40	22.0	27.0	21.9	3.57E-08	3.40E-08
930	1.70	23.80	22.75	1.05	22.0	24.5	23.3	3.27E-08	3.12E-08
1620	1.70	23.80	21.70	2.10	22.0	24.5	22.1	3.86E-08	3.68E-08
2280	1.70	23.80	21.30	2.50	22.0	24.5	21.6	3.30E-08	3.14E-08

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

Avg. k at 20 °C **3.6E-08** **cm/sec**

a_a =	0.76712	cm^2	a_p=	0.031416 cm^2	Remarks:
A =	45.28	cm^2	M_1=	0.03018	
L =	11.32	cm	M_2=	1.04095	
S=L/A=	0.25002	1/cm	$C = M_1S/(G_{Hg}-1)$=	0.0006003 for 15° to 25°	

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/17/2012*
Boring No.	*H0.5-2*	Reviewed By	*JW JEY*
Sample No.	*H0.5-2*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11624*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.9*
Wet Unit Weight, pcf:	*108.2*
Dry Unit Weight, pcf:	*75.7*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***4.7E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/17/12
Boring No.	H0.5-2	Reviewed By	JW
Sample No.	H0.5-2	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11624
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N/A
Location 1	4.643	Location 1	2.962	Wet Soil+Pan, grams	909.53
Location 2	4.657	Location 2	2.956	Dry Soil + Pan, grams	636.35
Location3	4.648	Location 3	2.965	Pan Weight, grams	0
Average	4.649	Average	2.961	Moisture Content, %	42.9
Volume, in^3	32.02	Wet Soil + Tare, grams	909.35	Dry Unit Weight, pcf	75.7
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	105.4
Soil Sample Wt., g	909.35	Dry Soil +Tare, grams	636.35	Diameter, in.	N/A
Dry UW, pcf	75.7	Moisture Content, %	42.9	Length, in.	N/A
Saturation, %	105.3			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
2100	1.60	24.20	20.40	3.80	21.9	24.1	19.8	5.85E-08	5.59E-08
2610	1.60	24.20	19.80	4.40	21.9	24.1	19.2	5.54E-08	5.29E-08
3240	1.60	24.20	19.10	5.10	21.9	24.1	18.4	5.27E-08	5.04E-08
3900	1.60	24.20	18.40	5.80	22.0	24.1	17.6	5.09E-08	4.85E-08
990	1.60	24.50	23.00	1.50	22.0	24.4	22.7	4.55E-08	4.34E-08
1700	1.60	24.50	22.10	2.40	22.0	24.4	21.7	4.34E-08	4.13E-08
2310	1.60	24.50	21.45	3.05	22.0	24.4	21.0	4.12E-08	3.93E-08

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

Avg. k at 20 °C **4.7E-08** **cm/sec**

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

A = 44.43 cm^2 M_1 = 0.03018

L = 11.81 cm M_2 = 1.04095

S=L/A= 0.26582 1/cm $C = M_1S/(G_{Hg}-1)$ = 0.0006382 for 15° to 25°

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HYDRAULIC CONDUCTIVITY

Project No.	*6155-08-0031.34*	Tested By	*JEL*
Project Name	*SDU-6 Task 3 Grout Samples*	Test Date	*7/19/2012*
Boring No.	*H0.5-3*	Reviewed By	*JW*
Sample No.	*H0.5-3*	Review Date	*8/1/2012*
Sample Depth	*N/A*	Lab No.	*11625*
Sample Description	*Grout Core*		

ASTM D5084 - Method F (CVFH)

Sample Type:	*Core*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*42.3*
Wet Unit Weight, pcf:	*107.5*
Dry Unit Weight, pcf:	*75.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.7E-08***

Remarks: _____

PERMEABILITY TEST
(ASTM D5084 - 03) (Method F, Constant Volume Falling Head)

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Project Number	6155-08-0031.34	Tested By	JEL
Project Name	SDU-6 Task 3 Grout Samples	Test Date	07/19/12
Boring No.	H0.5-3	Reviewed By	JW
Sample No.	H0.5-3	Review Date	08/01/12
Sample Depth	N/A	Lab No.	11625
Sample Description	Grout Core		

Initial Sample Data				Final Sample Data	
Length, in		Diameter, in		Pan No.	N?A
Location 1	4.575	Location 1	3.030	Wet Soil+Pan, grams	903.06
Location 2	4.540	Location 2	2.960	Dry Soil + Pan, grams	634.31
Location3	4.560	Location 3	2.978	Pan Weight, grams	0
Average	4.558	Average	2.989	Moisture Content, %	42.4
Volume, in^3	31.99	Wet Soil + Tare, grams	902.84	Dry Unit Weight, pcf	75.5
SG Assumed	2.40	Tare Weight, grams	0.00	Saturation, %	103.5
Soil Sample Wt., g	902.84	Dry Soil +Tare, grams	634.31	Diameter, in.	N/A
Dry UW, pcf	75.5	Moisture Content, %	42.3	Length, in.	N/A
Saturation, %	103.4			Volume, in^3	N/A

Consolidation	
Chamber Pressure, psi	70
Back Pressure, psi	60
Confining Pressure, psi	10
Initial Burett Reading	0
Final Burett Reading	0
Volume Change, cc	0

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
1860	1.50	22.40	19.85	2.55	22.4	22.7	19.8	4.48E-08	4.23E-08
2880	1.50	22.40	18.80	3.60	22.4	22.7	18.6	4.21E-08	3.98E-08
1120	1.50	23.00	21.50	1.50	22.3	23.3	21.6	4.13E-08	3.91E-08
2490	1.50	23.00	20.20	2.80	22.4	23.3	20.2	3.59E-08	3.39E-08
3360	1.50	23.00	19.30	3.70	22.4	23.3	19.2	3.61E-08	3.41E-08
1000	1.50	23.40	22.10	1.30	22.5	23.8	22.3	3.92E-08	3.69E-08
2100	1.50	23.40	21.00	2.40	22.4	23.8	21.1	3.54E-08	3.34E-08

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

Avg. k at 20 °C **3.7E-08 cm/sec**

a_s = 0.76712 cm^2 a_p= 0.031416 cm^2 Remarks:

A = 45.28 cm^2 M_1= 0.03018

L = 11.58 cm M_2= 1.04095

S=L/A= 0.25570 1/cm $C = M_1S/(G_{Hg}-1)$= 0.0006139 for 15° to 25°

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ATTACHMENT 2

Equipment List
SRNS Delivery Order No. 34
Subcontract No. AC54317N

Equipment Name	Laboratory ID
Oven	109
Balance	416
Thermometer	2866
Caliper	2373
Pressure Transducers	3638

Distribution:

P. M. Almond, 773-43A
J. M. Bricker, 704-27S
T. E. Brooks, 707-14E
A. D. Cozzi, 999-W
W. E. Daniel, 999-W
R. E. Eibling, 999-W
T. L. Fellinger, 704-26S
S. D. Fink, 773-A
K. M. Fox, 999-W
B. J. Giddings, 786-5A
E. K. Hansen, 999-W
C. C. Herman, 999-W
T. H. Huff, 707-13E
P. R. Jackson, DOE-SR, 703-46A
C. A. Langton, 773-43A
J. N. Leita, 704-Z
S. L. Marra, 773-A
D. H. Miller, 999-W
J. E. Occhipinti, 704-S
F. M. Pennebaker, 773-42A
B. R. Pickenheim, 999-W
M. M. Reigel, 999-W
K. H. Rosenberger, 705-1C
M. G. Serrato, 773-42A
F. M. Smith, 705-1C
A. V. Staub, 704-27S
D. B. Stefanko, 773-43A
K. H. Subramanian, 766-H
J. R. Tihey, 704-Z

Records Administration (EDWS)