GREAT RIVER ENERGY™

12300 Elm Creek Boulevard
Maple Grove, Minnesota 55369-4718
763-445-5000
greatriverenergy.com

September 1, 2021

VIA ELECTRONIC MAIL

Mr. Michael Regan
Administrator
USEPA Headquarters
1200 Pennsylvania Ave N.W.
Washington, DC 20460

RE: CCR Alternate Liner Demonstration Extension Request

Dear Mr. Regan:

Great River Energy is submitting the attached Alternate Liner Demonstration Extension Request for the Upstream Raise 91 CCR surface impoundment at Coal Creek Station. This extension request was prepared in response to the requirements at 40 CFR 257.71(d)(2)(ii)(A).

Should you have any questions regarding information in the attached request, please contact Shane Stockdill at 701-442-7010 or sstockdill@grenergy.com or Erik Heinen at 612.801.1269 or eheinen@grenergy.com.

Sincerely,

GREAT RIVER ENERGY

Greg Archer
Manager, Environmental Services

Attachments

c: Kirsten Hillyer (Hillyer.Kirsten@epa.gov)
Frank Behan (Behan.Frank@epa.gov)
Richard Huggins (Huggins.Richard@epa.gov)
Eric Olsen (eolsen@grenergy.com)
Jennifer Charles (jcharles@grenergy.com)
John Bauer (jbauer@grenergy.com)

TECHNICAL MEMORANDUM

DATE September 1, 2021 **Project No.** 21451024

TO Shane Stockdill
Great River Energy

CC Jennifer Charles, Craig Schuettpelz, Erin Hunter

FROM Todd Stong **EMAIL tstong@golder.com**

REQUEST FOR EXTENSION DUE TO ANALYTICAL LIMITATIONS FOR UPSTREAM RAISE 91 AT GREAT RIVER ENERGY'S COAL CREEK STATION

Golder Associates Inc. (Golder) has prepared this technical memorandum to request an "extension due to analytical limitations" for the alternate liner demonstration for the Upstream Raise 91 Coal Combustion Residual (CCR) surface impoundment at Great River Energy's (GRE's) Coal Creek Station (CCS). This request includes documentation to support an extension for submittal of the alternate liner demonstration per the requirements of Title 40 of the Code of Federal Regulations (40 CFR) Part 257 rule revision entitled "A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments," (hereafter referred to as "Part B") which was entered into the Federal Register on November 12, 2020 (EPA 2020).

Background

GRE submitted an alternate liner application to the Environmental Protection Agency (EPA) on November 30, 2020 associated with Upstream Raise 91 (Golder 2020). The liner system in Upstream Raise 91 was constructed with an upper component consisting of high-density polyethylene (HDPE) geomembrane having a thickness of 40 mils (0.040 inches) and a lower component consisting of a compacted low-permeability soil layer at least two feet thick with a hydraulic conductivity less than $1x10^{-7}$ centimeters per second (cm/sec). Construction Quality Assurance (CQA) monitoring was performed during installation of the Upstream Raise 91 composite liner system in 1992.

GRE anticipated that the EPA would make a decision on the alternate liner application for Upstream Raise 91 by April 11, 2021 as indicated in the preamble to Part B:

> *"…the initial application will be due no later than November 30, 2020, and EPA will make a decision on whether the facility qualifies to submit a demonstration no later than April 11, 2021."*

In response to delays in EPA decision making on the alternate liner applications, the EPA posted the following information on the Part B rule implementation website (website last updated May 13, 2021):

> *Under the Part B rule, facilities with an approved application to conduct an alternative liner demonstration have until November 30, 2021 to conduct the work and submit that demonstration. As EPA has not yet issued approvals and denials for submitted Part B applications, the time to conduct the demonstration work is narrowing, such that a facility may have difficulty completing the demonstration in the time*

between an approval and the November 30, 2021 deadline. Below is a frequent question about this deadline:

Question: Does the delay in EPA's issuing decisions make it such that facilities will need to perform the work for a demonstration without knowledge of whether their application is approved or denied?

Response: EPA is aware of this issue, which has arisen as a result of unanticipated delays in making determinations on the Part B applications that have been submitted. EPA is weighing possible solutions to this issue and intends to take actions to ensure that any facility approved to conduct a demonstration has the same amount of time anticipated by the current regulation to initiate and complete the demonstration after an approval.

To date, GRE has not received a response from the EPA regarding it's alternate liner application. Nevertheless, GRE has proceeded with the alternate liner demonstration. Based on current lab testing progress, GRE does not anticipate that hydraulic conductivity testing of the low-permeability soil liner will be completed in time to meet the November 30, 2021 deadline for submission of the alternate liner demonstration.

Provision 257.71(d)(2)(ii)(A) of the rule states:

(A) Extension due to analytical limitations. If the owner or operator cannot meet the demonstration deadline due to analytical limitations related to the measurement of hydraulic conductivity, the owner or operator must submit a request for an extension no later than September 1, 2021 that includes a summary of the data that have been analyzed to date for the samples responsible for the delay and an alternate timeline for completion that has been certified by the laboratory. The extension request must include all of the following:

(1) A timeline of fieldwork to confirm that samples were collected expeditiously;

(2) A chain of custody documenting when samples were sent to the laboratory;

(3) Written certification from the lab identifying how long it is projected for the tests to reach the relevant termination criteria related to solution chemistry, and

(4) Documentation of the progression towards all test termination metrics to date.

GRE notes that this extension was created for analytical limitations as applied to EPA approved demonstration applications. The intent of this document is to address the bulleted items described above and attach necessary backup information.

(1) Timeline of Fieldwork

The alternate liner application for Upstream Raise 91 was completed at the end of November 2020 (Golder 2020).

In the early summer of 2021, as it appeared unlikely that EPA would decide on GRE's alternate liner application, GRE began field investigation efforts associated with the alternate liner demonstration. GRE evaluated existing site data and developed a detailed request for quote from drillers for additional information to characterize the area surrounding Upstream Raise 91. Once under contract, GRE planned to use this driller to assist in sampling the existing low-permeability soil liner at Upstream Raise 91. This request for quote was sent out in July of 2021.

GRE, Golder, and the driller pursued discussions related to scheduling a drill rig to start the site investigation work. Challenges occurred in procuring the drilling contractor's services and an agreement for drilling services was not completed until late August 2021. Drilling is scheduled to start in early September (to be completed by end of September). Because of these challenges, GRE pursued alternative options for low-permeability soil liner sampling to occur in August using resources from GRE, Golder, and the adjacent Falkirk Mining Company as described below.

In preparation, GRE temporarily lowered the water level in Upstream Raise 91 and removed existing CCR material and protective cover at three locations (North, West, and South sides) to expose areas of composite liner along the side slopes above normal impoundment operating levels. On August 19, Golder and GRE collected thin-walled tubes (Shelby tubes) from the 2-foot thick compacted low-permeability soil liner at these locations. Thin-walled sampling tubes were used to minimize the disturbance to the samples, which will be used for laboratory testing. A minimum of three samples were collected at each exposed composite liner location. Following collection of the samples, the composite liner was repaired. Low-permeability soil liner samples were shipped to Golder's geotechnical laboratory and were received on August 20. In addition, sampling of water from the Upstream Raise 91 sump reflective of liquid in direct contact with the composite liner was collected from the sump riser on August 18 by GRE personnel and shipped to Golder's geotechnical laboratory for use.

The collected low-permeability soil liner samples were extruded from sampling tubes on August 23. Three samples (one from each location) were set up for a long-term hydraulic conductivity test (per ASTM D5084) utilizing the liquid collected from the Upstream Raise 91 sump. The samples were set up on August 23. Additional index testing (moisture content, dry density, Atterberg Limits, grain size analysis) were also assigned from samples at the three locations to help relate the range in samples collected and being tested with the robust construction quality assurance (CQA) testing completed during liner construction.

(2) Chain of Custody

As described above, samples of the low-permeability soil liner (ten thin-walled tube samples) from Upstream Raise 91 were collected by Todd Stong (Golder) on August 19, 2021 and shipped to Golder's geotechnical lab in Lakewood, Colorado. The samples were received by Patrick Harrell (Golder) on August 20, 2021. Two boxes were used for shipping and the completed chain of custody information is included as Attachment 1.

GRE staff collected 37 1-liter bottles from the Upstream Raise 91 sump on August 18, 2021. These bottles were placed in two coolers and shipped by David Christianson (GRE) to Golder's geotechnical lab in Lakewood Colorado. The water samples were received by Patrick Harrell (Golder) on August 20, 2021. The completed chain of custody information is included as Attachment 1.

(3) Projected Test Termination

As described above and in Part B, the laboratory testing for hydraulic conductivity uses liquid from the Upstream Raise 91 sump and is being run until "equilibrium between the inflow and outflow, within acceptable tolerance limits, for both electrical conductivity and pH" is achieved. The duration of these tests is dependent upon several factors such as sample size, soil hydraulic conductivity, gradient at which the test is being run, and the amount of liquid required to pass through the sample to obtain the desired chemical equilibrium. Based on results from previous hydraulic conductivity testing, and general information from published papers and the attached laboratory certification, the projected test duration varies between samples and is estimated between 130 and 190

days or terminating between January and March of 2022. As stated in 257.71(d)(2)(ii)(B), GRE will have 45 days beyond the timeframe certified by the laboratory to submit the completed demonstration.

A calculation and certification from the lab supporting the projected test termination timing is included as Attachment 2.

(4) Progress Towards Test Termination

As discussed above, the hydraulic conductivity testing of the Upstream Raise 91 low-permeability soil liner using liquid from the Upstream Raise 91 sump was setup on August 23. A copy of the bench sheets for the laboratory testing through the morning of September 1 are included as Attachment 3.

Closing

GRE is requesting an extension to submit the completed demonstration 45 days beyond the timeframe certified by the laboratory. The need for this extension is due to delays related to the timeline for review and approval of GRE's alternate liner demonstration application (submitted November 30, 2020), and challenges in procuring a drilling contractor, collecting low-permeability soil samples, and starting hydraulic conductivity testing. The timeframe certified by the laboratory has been estimated based on the best available information at this time and may change as additional information is obtained during testing.

References

ASTM International. 2016. ASTM D5084 – Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. Last Modified in 2016.

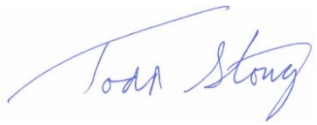
Benson, C.H., Chen, J.N., Edil, T.B., and Likos, W.J. 2018. Hydraulic Conductivity of Compacted Soil Liners Permeated with Coal Combustion Product Leachates. Journal of Geotechnical and Geoenvironmental Engineering. Volume 144, Issue 4. April 2018.

EPA. 2020. Code of Federal Regulations Title 40 Part 257: Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments. November 12, 2020.

Golder Associates Inc. (Golder). 2020. Application to Submit an Alternative Liner Demonstration for the Upstream Raise 91 CCR Surface Impoundment, Great River Energy - Coal Creek Station. November 25, 2020.

Golder Associates Inc.

Craig Schuettpelz, PE
Senior Engineer
CCS/TJS/



Todd Stong, PE
Associate and Senior Consultant

Attachments: Attachment 1 – Chain of Custody Information – Soil and Water Samples
Attachment 2 – Lab Certification – Projected Test Duration
Attachment 3 – Laboratory Testing Information

https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024/techmemos/ur91 ald extension letter/rev1_01sep21/21451024-tm-1-extensionrequest_01sep.docx

ATTACHMENT 1

Chain of Custody Information
Soil and Water Samples

GEOTECHNICAL LABORATORY SAMPLE TEST SCHEDULE AND TRANSMITTAL AND CHAIN OF CUSTODY RECORD

GOLDER
MEMBER OF WSP

DATE: Aug 19, 2021 SAMPLED BY: Todd Stong [X] = Requested Test COC Number: 1

PROJECT NUMBER: 21451024 Phase 007 PROJECT NAME: UR91 Alternate Liner Demonstration PROJECT MANAGER: Craig Schuettpelz

Sample Type: (J) - Jar, (T) - Tube, (ST) - Shelby Tube, (CR) - Core, (B) - Bag, (P) - Pail, (O) - Other

SAMPLE IDENTIFICATION	SAMPLE DEPTH (ft)	SAMPLE TYPE	WATER CONTENT	ATTERBERG LIMITS	- #200 SIEVE (Passing)	SIEVE (3" THRU #200)	HYDROMETER & SIEVE	SIEVE (3" THRU #200)	SIEVE (3" THRU #200)	UNIT WEIGHT	SPECIFIC GRAVITY	PROCTOR (Standard)	PROCTOR (Modified)	UNCONFINED COMPRESSION *	TRIAXIAL U/U *	TRIAXIAL C/U *	TRIAXIAL C/D *	DIRECT SHEAR *	PERMEABILITY (Flex Wall) *	PERMEABILITY (Rigid Wall) *	SLURRY CONSOLIDATION *	CONSOLIDATION *	SWELL or SETTLEMENT *	DIRECT SIMPLE SHEAR *	LARGE SCALE DIRECT SHEAR *	INTERFACE SHEAR *	pH LEVEL	ORGANIC CONTENT	10" COMPRESSION/PERM *	LINER LOAD *	12" COMPRESSION/PERC *	UNIAXIAL COMP. STRENGTH	SWCC *	REMARKS
	TEST Method		D2216	D4318	D1140	D422	D422	C136	D6913	D7263	D854	D698	D1557	D2166	D2850	D4767	D7181	D3080	D5084			D2435	D4546	D6528	D3080	D5321/D6243	D4972	D2974					D7012	D6836	SPECIAL INSTRUCTIONS TO LAB (* Include Test Parameters)
S-ST-1	0-2																																	
S-ST-2	0-2																																	
N-ST-4	0-2																																	
N-ST-1	0-2																																	
N-ST-3	0-2																																	

Test Comments:

Permeability tests will be long-term permeability tests that will need to reach physical (permeability) and chemical stability (pH and EC).

Testing to be assigned after Sample extrusion at the lab.

Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:
Todd Stong	Golder	8/19/2021 1:00pm	Patrick Harrell	Golder	20 AUG 2021 @ 16:15

SAMPLE STORAGE POLICY:

All samples will be disposed of thirty (30) days after submission of the test results unless otherwise stated in a written request to the Geotechnical Laboratory. GAI will charge a storage fee of $35.00 per month per sample after the 30 days or return the samples to client at the clients expense.

Golder Geotechnical Lab
9197 West 6th Ave
Building C Suite 100
Lakewood, Colorado 80215
Telephone: (303) 980-0540

SEND REPORT TO:

NAME: Craig Schuettpelz
COMPANY: Golder
ADDRESS:
CITY: STATE: ZIP:
PHONE: FAX:

GEOTECHNICAL LABORATORY SAMPLE TEST SCHEDULE AND TRANSMITTAL AND CHAIN OF CUSTODY RECORD

GOLDER
MEMBER OF WSP

DATE: Aug 19, 2021 SAMPLED BY: Todd Stong [X] = Requested Test COC Number: 2

PROJECT NUMBER: 21451024 Phase 007 PROJECT NAME: UR91 Alternate Liner Demonstration PROJECT MANAGER: Craig Schuettpelz

Sample Type: (J) - Jar, (T) - Tube, (ST) - Shelby Tube, (CR) - Core, (B) - Bag, (P) - Pail, (O) - Other

SAMPLE IDENTIFICATION	SAMPLE DEPTH (ft)	SAMPLE TYPE	WATER CONTENT	ATTERBERG LIMITS	- #200 SIEVE (Passing)	SIEVE (3" THRU #200)	HYDROMETER & SIEVE	SIEVE (3" THRU #200)	SIEVE (3" THRU #200)	UNIT WEIGHT	SPECIFIC GRAVITY	PROCTOR (Standard)	PROCTOR (Modified)	UNCONFINED COMPRESSION *	TRIAXIAL U/U *	TRIAXIAL C/U *	TRIAXIAL C/D *	DIRECT SHEAR *	PERMEABILITY (Flex Wall) *	PERMEABILITY (Rigid Wall) *	SLURRY CONSOLIDATION *	CONSOLIDATION *	SWELL or SETTLEMENT *	DIRECT SIMPLE SHEAR *	LARGE SCALE DIRECT SHEAR *	INTERFACE SHEAR *	pH LEVEL	ORGANIC CONTENT	10" COMPRESSION/PERM *	LINER LOAD *	12" COMPRESSION/PERC *	UNIAXIAL COMP. STRENGTH	SWCC *		REMARKS
	TEST Method		D2216	D4318	D1140	D422	D422	C136	D6913	D7263	D854	D698	D1557	D2166	D2850	D4767	D7181	D3080	D5084			D2435	D4546	D6528	D3080	D5321/D6243	D4972	D2974				D7012	D6836			SPECIAL INSTRUCTIONS TO LAB (* Include Test Parameters)
W-ST-1	0-2																																		
W-ST-3	0-2																																		
N-ST-2	0-2																																		
S-ST-3	0-2																																		
W-ST-2	0-2																																		

Test Comments:

Permeability tests will be long-term permeability tests that will need to reach physical (permeability) and chemical stability (pH and EC).

Testing to be assigned after sample extrusion at the lab.

Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:
Todd Stong Todd Stong	Golder	8/19/2021 1:00pm	Patrick Harrell	Golder	20Aug2021 @ 16:00

SAMPLE STORAGE POLICY:

All samples will be disposed of thirty (30) days after submission of the test results unless otherwise stated in a written request to the Geotechnical Laboratory. GAI will charge a storage fee of $35.00 per month per sample after the 30 days or return the samples to client at the clients expense.

Golder Geotechnical Lab
9197 West 6th Ave
Building C Suite 100
Lakewood, Colorado 80215
Telephone: (303) 980-0540

SEND REPORT TO:

NAME: Craig Schuettpelz
COMPANY: Golder
ADDRESS:
CITY: STATE: ZIP:
PHONE: FAX:

ATTN: Craig Schuettpelz
Golder Associates Inc.
Denver Laboratory
9197 West 6th Avenue, Suite 100
Lakewood, Colorado 80215

Please find enclosed (12)-1L unpreserved bottles for Sump-UR91 collected on 8/18/2021 07:59 by CRN / REJ.
Note: (25)-1L bottles were collected in total. The remaining bottles are in another cooler associated with this shipment.

Contact Shane Stockdill for any questions regarding project specifics related to these samples.

David Christianson | Generation Chemist
GREAT RIVER ENERGY
2875 Third Street SW
Underwood, ND 58576
T: 701-442-7757 | C: 701-460-7073
dchristianson@grenergy.com | www.greatriverenergy.com

6/18/2021 10:05 David Christianson GRE
20 AUG 2021 13:10 Patrick Harrell Golder

L One COC for all 37 - 1L bottles

ATTACHMENT 2

Lab Certification
Projected Test Duration

GOLDER
MEMBER OF WSP

TECHNICAL MEMORANDUM

DATE September 1, 2021 **Project No.** 21451024

TO Shane Stockdill
Great River Energy

CC Jennifer Charles, Todd Stong, Matt Barrett

FROM Craig Schuettpelz **EMAIL cschuettpelz@golder.com**

LAB CERTIFICATION – PROJECTED TEST DURATION

Three samples of low-permeability soil liner collected from the Upstream Raise 91 liner system were provided to the laboratory along with liquid from the Upstream Raise 91 sump. On August 23, 2021 these samples were set up for long-term hydraulic conductivity testing (per ASTM D5084) utilizing the liquid collected from the Upstream Raise 91 sump.

The anticipated termination criteria for these tests includes:

- Steady measured hydraulic conductivity as defined in ASTM D5084
- Steady flow ratio (incremental outflow ÷ incremental inflow) of 1 ± 0.25
- Steady pH ratio (effluent pH ÷ influent pH) and electrical conductivity ratio (effluent EC ÷ influent EC) of 1 ± 0.1; pH and electrical conductivity are used as indicators of chemical equilibrium

It is projected that these hydraulic conductivity tests will require a significant amount of time to complete based on the termination criteria. This certification has been prepared to document our estimate for the duration of these three hydraulic conductivity tests based on a review of laboratory testing information completed to-date, construction quality assurance (CQA) documentation from the Upstream Raise 91 liner construction, and research information related to the hydraulic conductivity of compacted soil liners permeated with coal combustion residual (CCR) leachates. The calculations used to estimate test duration are attached and the main assumptions are discussed below:

- Hydraulic Conductivity 3.4×10^{-8} cm/sec
  - Initial testing results from the three samples of low-permeability soil liner from Upstream Raise 91 are not yet stable enough to estimate hydraulic conductivity accurately.
  - Construction quality assurance (CQA) data obtained during installation of the composite liner system at Upstream Raise 91 included testing of hydraulic conductivity of the low-permeability soil layer. 170 falling-head permeability tests were conducted on Shelby tube samples taken from the low-permeability soil layer during construction of Upstream Raise 91. The hydraulic conductivity from these tests ranged from approximately 5×10^{-9} centimeters per second (cm/sec) to 1×10^{-7} cm/sec with a geometric mean hydraulic conductivity of 1.7×10^{-8} cm/sec.

Golder Associates Inc.
7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226 T: +1 303 980-0540 F: +1 (303) 985 2080

  - Research on the hydraulic conductivity of compacted soil liners permeated with CCR leachates (Benson et al. 2018) suggest that the CCR leachates may increase the hydraulic conductivity of compacted soil liners when compared with hydraulic conductivity tests run with deionized (DI) water. The ratio of hydraulic conductivity of clayey (classified as CL and CH materials per USCS methods) samples permeated with CCR leachate versus those permeated with DI water ranged from less than 1.0 to more than 15, with a rounded average of approximately 2.0.
  - Based on the geometric mean hydraulic conductivity from CQA testing of $1.7x10^{-8}$ cm/sec and a multiplier of 2.0 to account for use of CCR leachate instead of DI water, an estimated hydraulic conductivity over the testing time period of $3.4x10^{-8}$ cm/sec is being used for all three samples for this estimate of test duration.

- Estimated pore volumes of flow required 3.5
  - Research by Craig Benson (Benson et al. 2018) evaluated the hydraulic conductivity of compacted soil liners permeated with various synthetic CCR leachates. Four of the materials tested were classified as CL and CH type materials (per USCS methods), which is the classification for the low-permeability soil layer constructed at Upstream Raise 91. For the CL and CH samples evaluated by Benson et al., the average number of pore volumes required to reach chemical equilibrium was approximately 3.6 (ranged between 1.1 and 9.8).
  - An estimated 3.5 pore volumes to reach chemical equilibrium (based on termination criteria discussed above) for all three samples is assumed for this estimate of test duration.
- Gradient (based on recommendations in ASTM D5084) 20 cm/cm
  - In accordance with ASTM D5084 and based on experience with long-term hydraulic conductivity testing, an average hydraulic gradient of approximately 20 cm/cm over the duration of the tests is assumed for this estimate of test duration.

Based on the above major assumptions and attached calculation sheet, the projected test duration varies between samples and is estimated between 130 and 190 days or terminating between January and March of 2022.

These test duration and termination dates are estimated based on the best available information at the time of this certification and the assumptions presented above and may change as additional information is obtained during testing.

The undersigned attest to the assumptions and methods used to estimate the projected test completion date for an alternate liner demonstration per the requirements of the 40 CFR Part 257 rule revision entitled “A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments.”

Golder Associates Inc.

Craig Schuettpelz, PE
Senior Engineer
CCS/TJS/

Matt Barrett
Associate and Geotechnical Laboratory Manager

Attachment: Supporting Calculation – Projected Test Duration

References

ASTM International. 2016. ASTM D5084 – Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. Last Modified in 2016.

Benson, C.H., Chen, J.N., Edil, T.B., and Likos, W.J. 2018. Hydraulic Conductivity of Compacted Soil Liners Permeated with Coal Combustion Product Leachates. Journal of Geotechnical and Geoenvironmental Engineering. Volume 144, Issue 4. April 2018.

EPA. 2020. Code of Federal Regulations Title 40 Part 257: Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments. November 12, 2020.

ATTACHMENT

Supporting Calculation
Projected Test Duration

Projected Test Duration

Chemical Equilibrium Hydraulic Conductivity Testing (ASTM D5084)

Great River Energy - Coal Creek Station

Upstream Raise 91 Clay Liner

By:	TJS
Chkd:	CCS
Date:	8/31/2021
Project:	21451024

Sample ID	-	-	N-ST-4	W-ST-1	S-ST-3
Diameter	d	cm	7.255	7.263	7.251
Diameter	d	in	2.856	2.859	2.855
Length	l	cm	7.479	7.738	7.682
Length	l	in	2.944	3.046	3.024
Cross Sectional Area	a	ft^2	0.044	0.045	0.044
Total Volume	V_t	ft^3	0.011	0.011	0.011
Initial Weight	W_t	g	691.02	665.79	633.69
Initial Weight	W_t	lb	1.52	1.47	1.40
Initial Moisture Content	ω	-	*15.4%*	18.0%	25.1%
Moist Unit Weight	γ	pcf	139.5	129.6	124.7
Dry Unit Weight	γd	pcf	120.9	109.9	99.7
Specific Gravity (assumed)	Gs	assumed	2.7	2.7	2.7
Void Ratio	e		0.39	0.53	0.69
Porosity	n		0.28	0.35	0.41
Volume Voids	V_v	ft^3	0.003	0.004	0.005
Volume Voids (pore volume)	V_v	ml	87	112	130
Average gradient across sample	i	ft/ft	20	20	20
Pore volumes to chemical equilibrium	x	-	3.5	3.5	3.5
Hydraulic Conductivity	Ksat	cm/sec	3.40E-08	3.40E-08	3.40E-08
Hydraulic Conductivity	Ksat	ft/day	9.64E-05	9.64E-05	9.64E-05
Flowrate across sample	Q	ft^3/day	8.58E-05	8.60E-05	8.57E-05
Duration for x pore volumes	t	days	126	160	187
Test Start (after saturation and consolidation)			8/27/2021	8/27/2021	8/27/2021
Test Duration			130	170	190
Projected Test Termination			1/4/2022	2/13/2022	3/5/2022

ATTACHMENT 3

Laboratory Testing Information

FLEXIBLE WALL TRIAXIAL PERMEABILITY
ASTM D 5084
METHOD C, FALLING HEAD W/INCREASING TAIL WATER PRESSURE

PROJECT TITLE	GRE		**Using Pipettes Only**	Yes	**COMMENTS**	Long-term perm test	
PROJECT NUMBER	21451024.007		**Using Pipettes & Burettes**	No			
SAMPLE ID	S-ST-3	**BOARD#**	3-Right	**TECH**	PRH		
SAMPLE TYPE	Intact	**CELL #**	7	**DATE**			

Sample Data, Initial				**Sample Data, Final**		**Water Contents**	**Initial**	**Final**
Height, inches	3.025	B-Value,f	0.97	Height, inches		Tare:		
Diameter, inches	2.955	Cell Pres	110.0	Diameter, inches		Wt soil&tare, i		
Mass, g	633.69	Bot. Pres.	72.0	Mass, g		Wt soil&tare, f		
Permeant:	Site Water	Top Pres.	70.0			Wt Tare		

TIME FUNCTION			READINGS		TIME FUNCTION			READINGS		TIME FUNCTION			READINGS	
DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)	DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)	DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)
8-30	8	35	1.25	22.5										
	16	29	1.3	22.4										
8-31	6	11	1.55	22.4										
	15	52	1.65	22.3										
9-1	9	22	1.95	22.25										

Checked	
Reviewed	
Date	

FLEXIBLE WALL TRIAXIAL PERMEABILITY
ASTM D 5084
METHOD C, FALLING HEAD W/INCREASING TAIL WATER PRESSURE

PROJECT TITLE	GRE	**Using Pipettes Only**	Yes	**COMMENTS**	Long-term perm test
PROJECT NUMBER	21451024.007	**Using Pipettes & Burettes**	No		
SAMPLE ID	W-ST-1	**BOARD#** 2-M10	**TECH** PRH		
SAMPLE TYPE	Intact	**CELL #** 3	**DATE**		

Sample Data, Initial				**Sample Data, Final**		**Water Contents**	**Initial**	**Final**
Height, inches	3.046	B-Value,f	0.96	Height, inches		Tare:		
Diameter, inches	2.859	Cell Pres	110.0	Diameter, inches		Wt soil&tare, i		
Mass, g	665.79	Bot. Pres.	72.0	Mass, g		Wt soil&tare, f		
Permeant:	Site Water	Top Pres.	70.0			Wt Tare		

TIME FUNCTION			READINGS		TIME FUNCTION			READINGS		TIME FUNCTION			READINGS	
DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)	DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)	DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)
8-30	9	35	6.8	23.95										
	16	29	6.9	23.95										
8-31	6	10	7.05	24.0										
	15	51	7.05	23.95										
9-1	9	21	7.35	24.0										

Checked	
Reviewed	
Date	

FLEXIBLE WALL TRIAXIAL PERMEABILITY
ASTM D 5084
METHOD C, FALLING HEAD W/INCREASING TAIL WATER PRESSURE

PROJECT TITLE	GRE	**Using Pipettes Only**	Yes	**COMMENTS**	Long-term perm test		
PROJECT NUMBER	21451024.007	**Using Pipettes & Burettes**	No				
SAMPLE ID	N-ST-4	**BOARD#**	1-Left	**TECH**	PRM		
SAMPLE TYPE	Intact	**CELL #**	AA	**DATE**			

Sample Data, Initial				**Sample Data, Final**		**Water Contents**	**Initial**	**Final**
Height, inches	2.944	B-Value,f	0.95	Height, inches		Tare:		
Diameter, inches	2.856	Cell Pres	110.0	Diameter, inches		Wt soil&tare, i		
Mass, g	691.02	Bot. Pres.	72.0	Mass, g		Wt soil&tare, f		
Permeant:	Site Water	Top Pres.	70.0			Wt Tare		

TIME FUNCTION			READINGS	
DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)
8-30	9	42	1.95	19.9
	16	30	1.8	19.95
8-31	6	10	2.1	20.1
	15	50	2.0	21.5
9-1	9	20	2.35	20.4

TIME FUNCTION			READINGS	
DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)

TIME FUNCTION			READINGS	
DATE	HOUR	MIN	Inflow (cc)	Outflow (cc)

Checked	
Reviewed	
Date	