LINER DESIGN CRITERIA DEMONSTRATION

NEW FGD POND
WILLIAMS STATION
GOOSE CREEK, SOUTH CAROLINA

Prepared For:

DOMINION ENERGY SOUTH CAROLINA, INC.
COLUMBIA, SOUTH CAROLINA

Prepared By:

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.
PITTSBURGH, PENNSYLVANIA

CEC Project 306-309

MAY 2021

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1.0 OBJECTIVE

This report has been prepared for South Carolina Generating Company (SCGENCO) and Dominion Energy South Carolina, Inc. (DESC) to demonstrate that the A.M. Williams Station (Williams Station) Coal Combustion Residuals (CCR) Unit described as the New flue gas desulfurization (FGD) Pond meets the requirements of the United States Environmental Protection Agency (USEPA) CCR Rule which was published in the Federal Register (FR) on April 17, 2015 as part of the Code of Federal Rules (CFR) Title 40, Part 257 (§257). Specifically, this report demonstrates the requirements for Liner Design Criteria as defined in §257.72 are met by the New FGD Pond. The New FGD Pond is classified as a new CCR Surface Impoundment by definition in §257.53 and is required to meet the composite liner system criteria that are established in §257.72.

2.0 BACKGROUND INFORMATION

2.1 INTRODUCTION

The Williams Station is a coal-fired power generation station located at 2242 Bushy Park Road in Goose Creek, South Carolina (refer to Figure 1) that is owned by SCGENCO and operated by DESC. The 650 MW coal-fired electric generating station is generally positioned within a small strip of lowlands between meanders of the Back River (west) and the Cooper River (east) as depicted in Figure 2. The station property is bound by Bushy Park Road to the west and tidal wetlands and/or lowlands border the remainder of the property. The Williams Station wastewater management impoundment complex, comprised of six interconnected separate ponds labeled Ponds A through E and the Coal Pile Runoff Pond, is located north of main station structures (refer to Figures 3 and 4).

Williams Station infrastructure includes a flue gas desulfurization (FGD) air quality control system that produces an FGD wastewater blowdown waste stream that is managed in an on-site FGD Pond that was originally constructed in 2009 in accordance with applicable South Carolina Department of Health and Environmental Control (SCDHEC) regulations and permits. This CCR Unit is also regulated as a CCR Surface Impoundment per Title 40 CFR, Part 257, Subpart D published in April 2015 (CCR Rule) by the USEPA and subsequent revisions. The CCR Rule Location Restrictions compliance demonstration for the original FGD Pond and dated October 2018, reported that the Williams Station FGD Pond did not satisfy the requirements of §257.63(a) – Seismic Impact Zones. As the FGD Pond is a critical operational component to Williams Station's ability to produce electricity and there were no other technically feasible on-site or off-site options to manage the FGD blowdown wastewater, DESC elected to continue operation of the FGD Pond in accordance with the alternative closure requirements identified in §257.103. Subsequently, DESC determined that the fastest technically feasible pathway to compliance was to open a new CCR impoundment within the footprint of the originally constructed FGD Pond that meets the CCR Rule's seismic impact zone location and liner design criteria. This action required a structural improvement to the FGD Pond perimeter dikes, closure of the currently operating FGD Pond in accordance with §257.102 and §257.103 for existing CCR surface impoundments, and then

opening a new pond (identified as the New FGD Pond) within the original pond footprint in accordance with the CCR Rule. This Liner Design Criteria Demonstration provides documentation and certification that the New FGD Pond composite liner is compliant with the Liner Design Criteria for New CCR Surface Impoundments as defined in §257.72 of the CCR Rule.

2.2 DESCRIPTION OF THE CCR UNIT

The FGD Pond is located within the boundaries of the wastewater management impoundment complex at the Williams Station facility and was originally constructed within the footprint of former Pond C in 2009. Figures 2 and 3 depict the location of the New FGD Pond in relation to Williams Station and the wastewater management impoundment complex, respectively. The New FGD Pond occupies essentially the same footprint as the former FGD Pond and is comprised of two approximate 700,000 gallon forebays (identified as Forebay 1 and Forebay 2) and occupies approximately two acres in total. Each forebay was constructed with a composite liner system comprised of the following, from bottom to top:

- 18-inch thick compacted clay soil liner (CCL);
- 60-mil textured HDPE geomembrane liner;
- 28-ounce per square yard geotextile cushion; and,
- 6-inch thick fabric formed concrete protection layer.

Note that the CCL liner described above varies within localized repair areas of the geomembrane liner that were necessary and completed as part of the original FGD Pond closure and opening of the New FGD Pond in 2021. In these localized areas, the CCL was partially removed for decontamination purposes. The CCL was then locally repaired with single or multiple layers of a geosynthetic clay liner (GCL) as needed to meet liner equivalency criteria.

The original FGD Pond was designed, constructed and operated in accordance with SCDHEC Bureau of Water Permit Number 19263-IW. The original construction was completed in 2009 and was certified to meet the design documents and Construction Quality Assurance (CQA) Plan by Garrett & Moore (CQA Report, Williams Station FGD Scrubber Blowdown Wastewater Pond,

dated September 14, 2009). In accordance with the FGD Pond Closure Plan – Amendment 1 dated February 2021, the original FGD Pond underwent construction to improve the structural integrity and increase the seismic stability of the perimeter dikes to meet the requirements of §257.63(a) – Seismic Impact Zones, and then closure by removal in accordance with the criteria defined in §257.102. The perimeter dikes were structurally improved by installing Deep Soil Mix (DSM) columns, comprised of two secant 8.5-feet diameter boreholes spaced at approximate 9.5 to 24.0 feet intervals and about 28.5 to 34.5 feet deep, through and below the perimeter dikes surrounding the FGD Pond. The DSM construction occurred in February and March of 2021 and the closure by removal was completed in March and April of 2021. The DSM design and construction was certified by Terracon and the FGD Pond closure by removal was certified by Civil & Environmental Consultants, Inc. [CEC]) Closure By Removal Certification, New FGD Pond, Williams Station, dated May 2021. The perimeter dike stabilization and closure activities, inspections, test results and certification reports are contained in the Construction Summary Report, FGD Pond, Williams Station, dated May 2021, and contained in the New FGD Pond Operating Record.

The only waste stream to be placed in the New FGD Pond is wet FGD blowdown from the FGD system. The FGD blowdown contains residual gypsum solids that are discharged from the secondary hydrocyclone overflows and pumped to the operating forebay of the New FGD Pond. Each FGD forebay allows the gypsum solids to settle and provide temporary storage until removed, dewatered, and disposed in the Williams Station Highway 52 Landfill. A solids removal treatment system (i.e., Lamella clarifier with one filter press) is used to remove solids prior to discharge to the New FGD Pond. The New FGD Pond is permitted to receive approximately 0.319 million gallons a day (MGD) of wastewater which is the same as the original FGD Pond. There are no non-CCR waste streams discharged to or placed in the New FGD Pond. The New FGD Pond discharges to Pond D which flows into Pond E and then to the National Pollutant Discharge Elimination System (NPDES) permitted outfall in accordance with SCDHEC NPDES Permit SC0003883 (effective January 1, 2017).

3.0 COMPLIANCE DEMONSTRATION

The applicable sections of §257.72 (Liner design criteria for new CCR surface impoundments and any lateral expansion of a CCR surface impoundment) are presented below in bold, italic font. The responses follow each section of the rule and are provided in normal font.

3.1 §257.72 LINER DESIGN CRITERIA FOR NEW CCR SURFACE IMPOUNDMENTS

3.1.1 §257.72(a) Rule Description

40 CFR 257.72(a) states:

> ***(a) New CCR surface impoundments and lateral expansions of existing and new CCR surface impoundments must be designed, constructed, operated, and maintained with either a composite liner or an alternative composite liner that meets the requirements of §257.70(b) or (c).***

3.1.2 Compliance With 40 CFR §257.72(a)

The enclosed report within Appendix A entitled "Documentation of Liner Type" for the Williams Station FGD Pond, prepared by Garrett & Moore, dated October 2016 was prepared to confirm that the composite liner system for the originally constructed FGD Pond met the requirement in 40 CFR 257.71 for existing CCR surface impoundments. As noted in the referenced report (Section 4 FGD Pond), the minimum 18-inch thick CCL does not comply with the 24-inch thick CCL required by 40 CFR 257.71(a)(1); therefore, an alternative composite liner system was demonstrated in the referenced report in conformance with 40 CFR 257.70(c). Specifically, the referenced report (Section 5 Alternate Composite Liner Demonstration, page 4, states "Based on the above results, the liquid flow rate through the lower component of the existing pond's alternate composite liner system is less than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. Therefore, the lower component of the pond's alternative composite liner system meets the requirements."

CEC has reviewed the "Documentation of Liner Type" and compared the relevant information to the New FGD Pond conditions to confirm that there have been no changes in conditions that would affect the referenced report. Because there are no changed conditions and the New FGD Pond is located within the footprint of the original FGD Pond without modification to the pond configuration or liner system the previously demonstrated compliance with the requirements in 40 CFR 257.70(c) and 257.71 remains applicable to the composite liner system for the New FGD Pond and the requirements of 40 CFR 257.72. Therefore, CEC is providing professional engineer certification that the New FGD Pond existing liner system meets the requirements in 40 CFR 257.70(c) and 257.72(a).

The exception to the above composite liner certification is for localized repairs that were made to the composite liner system as part of the FGD Pond closure and opening of the New FGD Pond in 2021, which are described below. CEC performed equivalency calculations using Darcy's Law equation for water flow through sections of the liner to be repaired to provide an alternative composite liner demonstration in compliance with 257.70(c), and confirm that the GCL is a suitable equivalent impermeable barrier as that of the thickness of CCL to be removed as part of closure by removal decontamination.

As part of the original FGD Pond closure, two localized leaks were detected in the HDPE geomembrane liner in Forebay Nos. 1 and 2 (i.e., one confirmed leak within Forebay No. 1 and one confirmed leak within Forebay No. 2). As a result, approximately 12 inches of the existing 18-inch thick CCL was removed from beneath the geomembrane within the localized leak area in Forebay No. 1 and approximately 3 inches of the existing 18-inch thick CCL was removed within the localized leak area in Forebay No. 2 for closure by removal decontamination purposes. The plan dimensions of the CCL removal was approximately 21 feet by 14 feet by about 1 foot deep and 5 feet by 2 feet by about 3 inches deep within Forebay Nos. 1 and 2, respectively. In addition, there was an area in Forebay 2 that though a leak was not detected, a soft subgrade was observed. The area of CCL removal was approximately 10 feet by 10 feet by about 11 inches deep.

For each repair area, the CCL was locally replaced with structural fill soil in conjunction with CETCO Resistex 200 DN GCL (geosynthetic clay liner). Specifically, the repair area within Forebay No. 1 consisted of 3 layers of GCL and 12 inches of structural fill soil (i.e., each layer of GCL is separated by 4 inches of structural fill). The repair areas within Forebay No. 2 consisted of 1 layer of GCL and 3 inches of structural fill and 3 layers of GCL and 11 inches of structural fill.

The Dominion Williams Station FGD Pond Liner Repair Liner Equivalency Calculation prepared by CEC is included as Appendix B. Additional detail regarding the activities performed as part of the liner repairs, in accordance with the referenced equivalency calculation, are described in the Construction Summary Report dated May 2021. CEC is providing professional engineer certification that the New FGD Pond liner system repairs meet the requirements in 40 CFR 257.70(c) and 257.72(a).

3.1.3 §257.72(b) Rule Description

40 CFR 257.72(b) states:

> ***(b) Any liner specified in this section must be installed to cover all surrounding earth likely to be in contact with CCR. Dikes shall not be constructed on top of the composite liner.***

3.1.4 Compliance With 40 CFR §257.72(b)

The New FGD Pond composite liner has been constructed within and between Forebay 1 and Forebay 2 to an elevation that exceeds the maximum probable CCR level within the two forebays. The perimeter dikes and the interior berm separating the two forebays are not constructed over the liner system. The Garrett & Moore CQA Report, Williams Station FGD Scrubber Blowdown Wastewater Pond, dated September 14, 2009 provides documentation that the dikes were not constructed above the liner. CEC has reviewed the "CQA Report" and compared the relevant information to the New FGD Pond conditions. Because the New FGD Pond is located within the footprint of the original FGD Pond without modification to the pond configuration or liner system,

the previously demonstrated compliance with the requirements in 40 CFR 257.72(b) remains applicable to the composite liner system for the New FGD Pond. Therefore, CEC is providing professional engineer certification that the New FGD Pond liner system meets the requirements in 40 CFR 257.72(b).

3.1.5 §257.72(c) Rule Description

40 CFR 257(c) states:

> ***(c) Prior to construction of the CCR surface impoundment or any lateral expansion of a CCR surface impoundment, the owner or operator must obtain certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority that the design of the composite liner or, if applicable, the design of an alternative composite liner complies with the requirements of this section.***

3.1.6 Compliance With 40 CFR §257.72(c)

The New FGD Pond is located within the same footprint as the original FGD Pond; therefore, the "Documentation of Liner Type" prepared by Garrett & Moore and contained within Appendix A provides the professional engineer certification for the New FGD Pond composite liner system design. CEC has reviewed the "Documentation of Liner Type" and compared the relevant information to the New FGD Pond conditions. Based on our review, CEC is providing professional engineer certification that the New FGD Pond liner system meets the requirements in 40 CFR 257.72(c).

In addition, CEC is providing professional engineer certification for the localized repairs to the CCL component of the composite liner system that were completed as part of the FGD Pond closure and opening of the New FGD Pond in 2021.

CEC performed an alternative composite liner demonstration, Dominion Williams Station FGD Pond Liner Repair Liner Equivalency Calculation included in Appendix B, that demonstrates the liquid flow rate of the CETCO Resistex 200 DN GCL is less than or equal to 4 inches of the

originally constructed CCL having a permeability of 3.4 x 10^{-8} cm/sec (i.e., one layer of the referenced GCL is required for each 4 inches of CCL (removal based on the results of the Liner Equivalency Calculation in Appendix B). Also, based on the referenced calculation Conclusion multiple layers of GCL are equivalent for increase CCL thickness. Based on the above results, the liquid flow rate through the replacement GCL layer is less than the liquid flow rate through a 4-inch thick CCL. The liquid flow rate through the three replacement GCL layers is also less than the liquid flow rate through a 12-inch thick CCL. Therefore, the replacement GCL meets the regulatory equivalency requirement for 4 inches of CCL. If more than 4 inches of CCL must be removed, additional layers of GCL will be installed to meet the equivalency of one layer per 4 inches of CCL."

Based on the composite liner design certifications referenced above, CEC is providing professional engineer certification that the design of the composite liner system for the New FGD Pond meets the requirements of 257.72(c).

3.1.7 §257.72(d) Rule Description

40 CFR 257(d) states:

> ***(d) Upon completion, the owner or operator must obtain certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority that the composite liner or if applicable, the alternative composite liner has been constructed in accordance with the requirements of this section.***

3.1.8 Compliance With 40 CFR §257.72(d)

The original FGD Pond composite liner system construction was completed in 2009 and was certified to meet the design documents and CQA Plan by Garrett & Moore (CQA Report, Williams Station FGD Scrubber Blowdown Wastewater Pond, dated September 14, 2009). CEC has performed an evaluation of the original liner design and the certification documents developed by Garrett & Moore. Based on our review of the previous liner demonstration and as the New FGD Pond is located within the footprint of the original FGD Pond, without modification to the

composite liner system, the information in the above construction certification is still valid. Therefore, CEC is providing professional engineer certification that the New FGD Pond liner system construction meets the requirements in 40 CFR 257.72(d).

In addition, the localized repairs that were made to the composite liner system as part of the FGD Pond closure and opening of the New FGD Pond in 2021 are certified below. The construction of the New FGD Pond composite liner system within the localized repair areas was observed and documented by a CEC representative. In general, the CEC representative observed and documented: 1) thickness of the CCL removed to achieve closure by removal decontamination; 2) placement, compaction and thickness of the structural fill soil and GCL layers; 3) replacement of the 60 Mil textured HDPE geomembrane liner and 28 ounce geotextile cushion layer; and, 4) replacement of the concrete protective cover. Based on our observations during construction, CEC confirms that the construction of the New FGD Pond composite liner within the repair areas was performed in general accordance with the design and material requirements contained in the Liner Equivalency Calculation (Appendix B), and material and installation requirements contained in the Liner Repair Specifications prepared by CEC. A detailed description of the construction activities associated with the New FGD Pond composite liner system are summarized in the Construction Summary Report, FGD Pond, Williams Station prepared by CEC dated May 2021.

Based on the information referenced above, CEC is providing professional engineer certification that that the construction of the composite liner system for the New FGD Pond meets the requirements of 257.72(d).

3.1.9 §257.72(E) Rule Description

40 CFR 257(e) states:

> ***(e) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in §257.105(f), the notification requirements specified in §257.106(f), and the Internet requirements specified in §257.107(f).***

3.1.10 Compliance With 40 CFR §257.72(e)

This demonstration will be placed in the Operating Record and the CCR Unit website, as well as a notification to SCDHEC, to meet the record keeping [§257.105(f)], notification [§257.106(f)], and the internet posting [§257.107(f)] requirements.

4.0 CERTIFICATION

This Liner Design Criteria Demonstration confirms that the New FGD Pond complies with the composite liner system requirements of the CCR Rule. In summary, Williams Station New FGD Pond has been designed and constructed to meet the CCR Rule liner system requirements as defined in §257.72. Section 3.0 of this report provides supporting information and conclusions demonstrating that the New FGD Pond composite liner meets the design criteria defined in §257.72.

The following certification statement provides confirmation that this report was prepared by a qualified professional engineer and that there is sufficient information to demonstrate that the New FGD Pond meets the composite liner meets the design criteria defined in §257.72.

Professional Engineer's Certification

By means of this certification, I certify that I have reviewed this Liner Design Criteria Demonstration, New FGD Pond, Williams Station, and the design and construction of New FGD Pond meets the requirements of Section 40 CFR 257.72.

SOUTH CAROLINA CERTIFICATE OF AUTHORIZATION CIVIL & ENVIRONMENTAL CONSULTANTS, INC. No. 4888

Scott L. Brown, P.E.

Printed Name of Professional Engineer

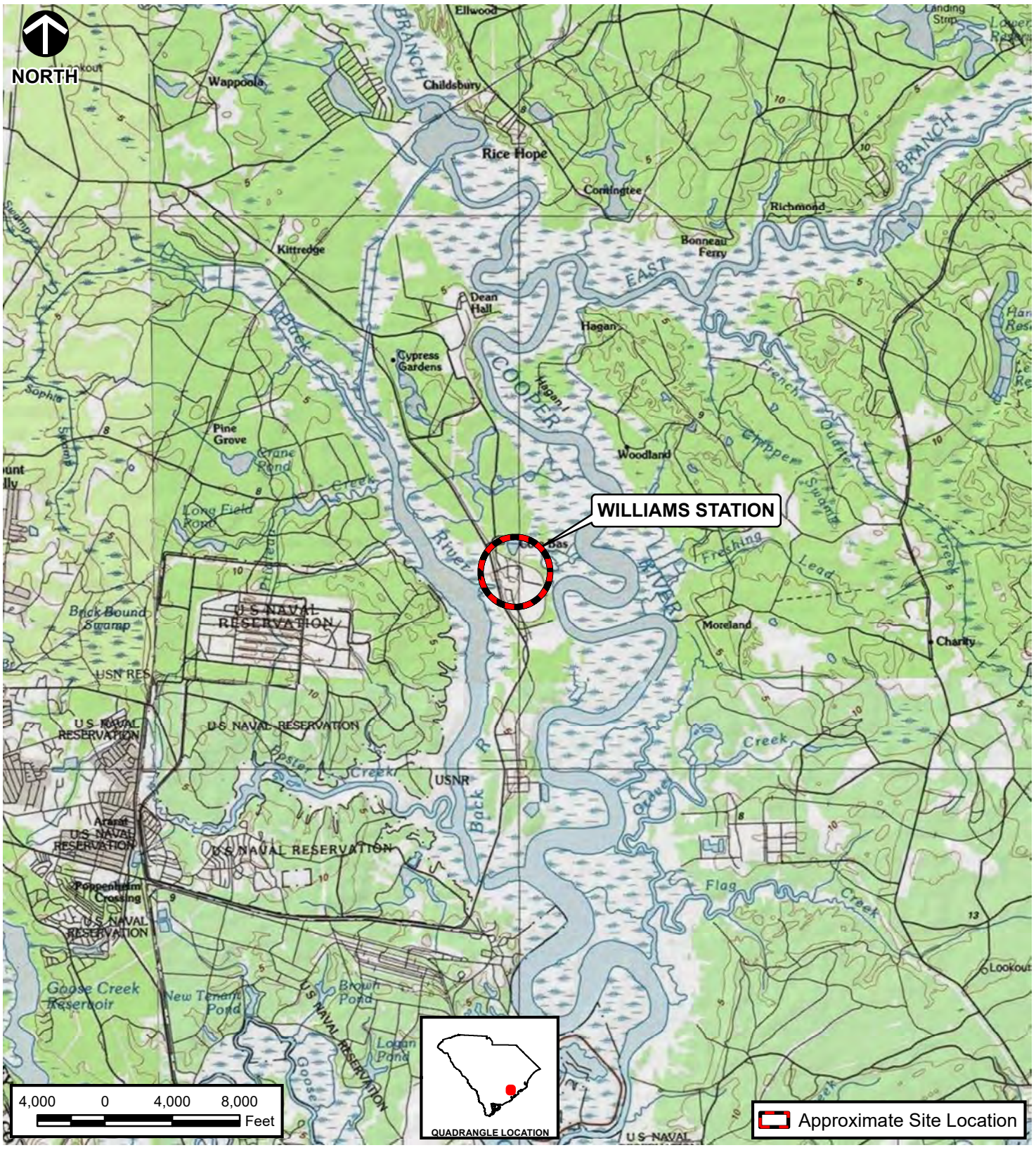
Scott L Brown

Signature

SOUTH CAROLINA REGISTERED PROFESSIONAL ENGINEER No. 25687 SCOTT L. BROWN

25687	South Carolina	5-7-21
Registration No.	Registration State	Date

FIGURES



SOURCE: PORTION OF THE USGS 7.5-MINUTE SERIES TOPOGRAPHIC QUADRANGLE MAP(S): KITTREDGE, SOUTH CAROLINA, 1979.

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NEW FGD POND
WILLIAMS POWER STATION
GOOSE CREEK, SOUTH CAROLINA

SITE LOCATION MAP

DRAWN BY:	CEJ	CHECKED BY:	APA	APPROVED BY:	APA*	FIGURE NO:	1
DATE:	APRIL 27, 2021	DWG SCALE:	1 " = 8,000 '	PROJECT NO:	306-309-AW01		

Signature on File *

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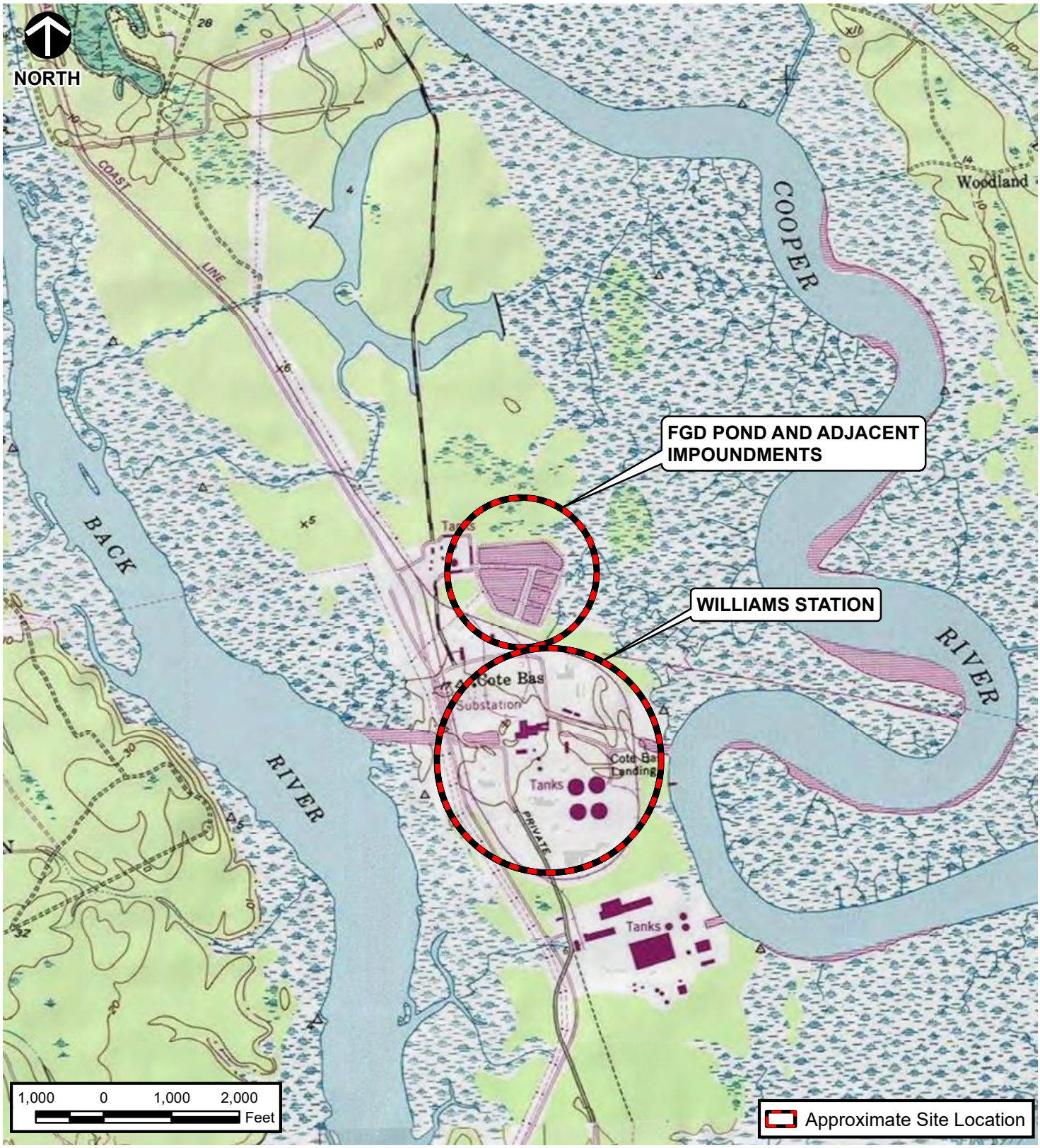

SOURCE: PORTION OF THE USGS 7.5-MINUTE SERIES TOPOGRAPHIC QUADRANGLE MAP(S): KITTREDGE, SOUTH CAROLINA, 1979.

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SITE AND VICINITY AERIAL MAP

DRAWN BY:	CEJ	CHECKED BY:	APA	APPROVED BY:	APA*	FIGURE NO:	2
DATE:	APRIL 27, 2021	DWG SCALE:	1 " = 2,000 '	PROJECT NO:	306-309-AW01		

Signature on File *

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SOURCE: ESRI WORLD IMAGERY (CLARITY) / ARCGIS MAP SERVICE ACCESSED 4/26/21, IMAGERY DATE: 2020.

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WILLIAMS STATION OVERVIEW MAP

DRAWN BY:	CEJ	CHECKED BY:	APA	APPROVED BY:	APA*	FIGURE NO:	3
DATE:	APRIL 27, 2021	DWG SCALE:	1 " = 600 '	PROJECT NO:	306-309-AW01		

Signature on File *

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WILLIAMS STATION FGD POND &
ADJACENT IMPOUNDMENTS MAP

DRAWN BY:	CEJ	CHECKED BY:	APA	APPROVED BY:	APA*	FIGURE NO:	4
DATE:	APRIL 27, 2021	DWG SCALE:	1 " = 250 '	PROJECT NO:	306-309-AW01		

Signature on File *

APPENDIX A

DOCUMENTATION OF LINER TYPE

SOUTH CAROLINA ELECTRIC & GAS

SCANA®
POWER FOR LIVING

DOCUMENTATION OF LINER TYPE

FOR THE

WILLIAMS STATION FGD POND

BERKELEY COUNTY, SOUTH CAROLINA

OCTOBER 2016

SOUTH CAROLINA
GARRETT AND MOORE, INC.
No. C3371
CERTIFICATE OF AUTHORIZATION

GARRETT & MOORE
Engineering for the Power and Waste Industries

SOUTH CAROLINA
REGISTERED PROFESSIONAL ENGINEER
22411
10/14/16
J. STEFAN BRAY

1 OVERVIEW

The EPA Administrator, Gina McCarthy, signed the Disposal of Coal Combustion Residuals from Electric Utilities final rule on December 19, 2014, and it was published in the Federal Register (FR) on April 17, 2015. The regulations provide a comprehensive set of requirements for the safe disposal of coal combustion residuals (CCRs), commonly known as coal ash, from coal-fired power plants. The rule will be administered as part of the Resource Conservation and Recovery Act [RCRA, 42 United States Code (U.S.C.) §6901 et seq.], using the Subtitle D approach.

South Carolina Electric & Gas (SCE&G) is subject to the CCR Rule. Based on SCE&G's review of the rule, the **Flue Gas Desulfurization (FGD) Pond at SCE&G Williams Station** has been determined to be an existing CCR surface impoundment subject to the CCR rule requirements.

2 PURPOSE

The purpose of this document is to document that the Williams Station FGD Pond was constructed with a liner system that meets CCR rule §257.71 - *Liner design criteria for existing CCR surface impoundments.*

3 APPLICABLE REGULATIONS

CCR rule §257.71 - *Liner design criteria for existing CCR surface impoundments* states the following:

> (a)(1) No later than October 17, 2016, the owner or operator of an existing CCR surface impoundment must document whether or not such unit was constructed with any one of the following:
>
> > (i) A liner consisting of a minimum of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec;
> >
> > (ii) A composite liner that meets the requirements of **§ 257.70(b)**; or
> >
> > (iii) An alternative composite liner that meets the requirements of **§ 257.70(c)**.
>
> (2) The hydraulic conductivity of the compacted soil must be determined using recognized and generally accepted methods.
>
> (3) An existing CCR surface impoundment is considered to be an existing unlined CCR surface impoundment if either:
>
> > (i) The owner or operator of the CCR unit determines that the CCR unit is not constructed with a liner that meets the requirements of paragraphs (a)(1)(i), (ii), or (iii) of this section; or
> >
> > (ii) The owner or operator of the CCR unit fails to document whether the CCR unit was constructed with a liner that meets the requirements of paragraphs (a)(1)(i), (ii), or (iii)

of this section. (4) All existing unlined CCR surface impoundments are subject to the requirements of § 257.101(a).

CCR rule **§ 257.70 (b)** states:

A composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil geomembrane liner (GM), and the lower component consisting of at least a two foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} centimeters per second (cm/ sec). GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. The GM or upper liner component must be installed in direct and uniform contact with the compacted soil or lower liner component. The composite liner must be:

(1) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the CCR or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(2) Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on slopes;

(3) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(4) Installed to cover all surrounding earth likely to be in contact with the CCR or leachate.

CCR Rule **§ 257.70 (c)** states:

If the owner or operator elects to install an alternative composite liner, all of the following requirements must be met:

(1) An alternative composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil GM, and a lower component, that is not a geomembrane, with a liquid flow rate no greater than the liquid flow rate of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. If the lower component of the alternative liner is compacted soil, the GM must be installed in direct and uniform contact with the compacted soil.

(2) The owner or operator must obtain certification from a qualified professional engineer that the liquid flow rate through the lower component of the alternative composite liner is no greater than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. The hydraulic conductivity for the two feet of compacted soil used in the comparison shall be no greater than 1×10^{-7} cm/sec. The hydraulic conductivity of

any alternative to the two feet of compacted soil must be determined using recognized and generally accepted methods. The liquid flow rate comparison must be made using Equation 1 of this section, which is derived from Darcy's Law for gravity flow through porous media.

(Eq. 1) $QA=q=k\ (h/t+1)$

Where, Q = flow rate (cm^3/s); A = surface area of the liner (cm^2);

q = flow rate per unit area ($cm^3/s/\ cm^2$);

k = liner's hydraulic conductivity (cm/s);

h = hydraulic head above the liner (cm);

t = thickness of the liner (cm).

4 FGD POND

Williams Station is coal-fired electric generation plant located in Goose Creek, Berkeley County, South Carolina. The FGD Pond is used to manage wastewater generated from the flue gas desulfurization scrubber system. The FGD pond was constructed in accordance with construction permit (permit 19263-IW) issued from the South Carolina Department of Health and Environmental Control (DHEC) on March 9, 2009, and placed into operation in accordance with an operation approval issued by DHEC on October 6, 2009. Effluent discharge for the FGD Pond is regulated under NPDES Permit #SC0003883.

The FGD Pond includes two settling bays, each approximately 1.0 acre. The liner system for the FGD Pond is comprised of the following materials, from top to bottom:

- 60-mil HDPE Geomembrane Liner (GM)
- Min. 18"-thick Compacted Soil Liner (CSL)

Review of the liner system indicates that the existing liner system does not conform with the requirements of regulation §257.71 (a)(1), (i) and (ii) as the compacted soil liner component of the composite liner system is not a minimum 24" thick, as required by the regulation. Therefore, an alternate composite liner demonstration is necessary to demonstrate existing liner system meets the requirements of **§ 257.70(c)** and therefore complies with **§257.71**.

5 ALTERNATE COMPOSITE LINER DEMONSTRATION

§ 257.70 (c)(1) requires that an alternative composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil GM, and a lower component, that is not a geomembrane, with a liquid flow rate no greater than the liquid flow rate of two feet of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick.

§ 257.70 (c)(2) requires the owner or operator must obtain certification from a qualified professional engineer that the liquid flow rate through the lower component of the alternative composite liner is no greater than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. The hydraulic conductivity for the two feet of compacted soil used in the comparison shall be no greater than 1×10^{-7} cm/sec. The hydraulic conductivity of any alternative to the two feet of compacted soil must be determined using recognized and generally accepted methods. The liquid flow rate comparison must be made using Equation 1 of this section, which is derived from Darcy's Law for gravity flow through porous media.

With regards to § 257.70 (c)(1), the FGD Pond's existing composite liner system includes a 60-mil HDPE geomembrane liner (GM). Therefore, the GM upper component of the existing pond's liner system meets upper GM component required by the CCR rule.

With regards to § 257.70 (c)(1) and (2), the FGD Pond's existing composite liner system include a lower component comprised of a minimum 18" thick low permeable compacted soil liner (CSL).

As required by§ 257.70 (c)(2), Darcy's Law is used demonstrate that the liquid flow rate of the lower component of the pond's composite liner system meet or exceeds the liquid flow rate of a 24" thick compacted soil liner with a hydraulic conductivity 1×10^{-7} cm/sec. A spreadsheet comparing the two lower unit components is attached.

The results of the Darcy's Law calculation indicates that the following liquid flow rates:

- 24" thick compacted soil liner w/ hydraulic conductivity 1×10^{-7} cm/sec = 3.0×10^{-7} $cm^3/s/cm^2$
- FGD Pond's existing system (minimum 18" thick low permeable CSL) = 1.25×10^{-7} $cm^3/s/cm^2$

Based on the above results, the liquid flow rate through the lower component of the existing pond's alternate composite liner system is less than the liquid flow rate through two feet of compacted soil with a hydraulic conductivity of 1×10^{-7} cm/sec. Therefore, the lower component of the pond's alternative composite liner system meets the requirements.

It is also noteworthy to add that a geomembrane leak location survey was performed on the installed 60-mil HDPE geomembrane liner to verify the geomembrane liner was free of holes, which is above and beyond the requirements of the CCR rules and provides another level of protection to ensure the integrity of the pond's liner system.

GARRETT & MOORE
Engineering for the Power and Waste Industries

JOB NAME **SCE&G Williams Station FGD Pond**
SUBJECT **Composite Liner Lower Component Flow Rate**

Purpose Estimate the rate of flow through the lower component of the composite liner using Darcy's Law

$$\frac{Q}{A} = q = k\left(\frac{h}{t} + 1\right)$$

Where, Q = flow rate (cm^3/s); k = liner's hydraulic conductivity (cm/s);
A = surface area of the liner (cm^2); h = hydraulic head above the liner (cm);
q = flow rate per unit area ($cm^3/s/cm^2$); t = thickness of the liner (cm).

Base scenario - 24" thick Compacted Soil Liner with hydraulic conductivity of $1x10^{-7}$ cm/sec

Where:

1.00E-07	k	liner's hydraulic conductivity (cm/sec)
121.92	h	hydraulic head above the liner (cm) (*normal pool water depth*)
60.96	t	thickness of the liner (cm)
3.00E-07	q	flow rate per unit area ($cm^3/s/cm^2$)

Alternate Liner - 18" thick low permeable CSL (k ranging from 4.1×10^{-8} to 7.7×10^{-9})

The CSL was installed in 3 approximate 6-inch-thick lifts. To calculate a composite permeability for the 18-inch liner, the maximum (fastest) permeability for each of the three lifts were determined, with the mean of these three values yielding a composite value for the entire liner. Permeability test results performed on undisturbed tube samples of the soil liner performed as part of the QA/QC program during construction of the CSL were used in the analysis. Based on the analysis, a composite mean value of 3.4 x 10-8 cm/s was calculated for the CSL component of the lower liner.

3.40E-08	k	liner's composite hydraulic conductivity (cm/sec)
121.92	h	hydraulic head above the liner (cm) (*normal pool water depth*)
45.72	t	effective thickness of the liner (cm)
1.25E-07	q	flow rate per unit area ($cm^3/s/cm^2$)

APPENDIX B

DOMINION WILLIAMS STATION FGD POND LINER REPAIR LINER EQUIVALENCY CALCULATION

CALCULATION BRIEF

DOMINION WILLIAMS STATION
FGD POND LINER REPAIR
LINER EQUIVALENCY CALCULATIONS

OBJECTIVE: Determine the minimum thickness of the existing compacted clay liner (CCL) that must remain below a localized geomembrane repair that will include partial removal of the CCL that is replaced with a geocomposite clay liner (GCL).

METHODOLOGY: Use Darcy's Law equation for flow through a porous media to demonstrate the equivalency of differing material in a base liner system.

REFERENCES:

1. CCR Rule Documentation: Williams Station FGD Pond, Documentation of Liner Type, prepared by Garrett & Moore, dated October 2016.

2. GCL Material (Resistex 200DN) Certified Properties: Technical Reference provided by CETCO.

BACKGROUND:

The current liner system for the FGD Pond, as constructed in 2009, is comprised of a 60-mil HDPE geomembrane liner underlain by a minimum 18-inch thick compacted clay liner (CCL). Due to isolated and localized leaks being detected within the HDPE geomembrane liner of the Williams Station FGD Pond, repairs will be implemented. In the process of repairing the FGD pond geomembrane liner, a portion of the existing 18-inch thick CCL will be removed and replaced with structural fill soil and a GCL. Where necessary, the thickness of removed or excavated CCL will be replaced with structural fill material and overlain with a GCL. Therefore, the purposes of this calculation brief is to confirm that the inclusion of the GCL layer will be a suitable equivalent impermeable barrier as that of the CCL removed and the structural fill soil replacing the excavated CCL does not need to meet a specified permeability to achieve the composite liner permeability equivalency. The thickness of CCL to be removed is unknown, so this calculation is based on an assumed 4 inch thickness. If greater than four inches of existing CCL is excavated, additional GCL layers will be added to maintain the required equivalency. A second scenario will be analyzed to demonstrate that if twelve inches of CCL is removed that three GCL layers will be equivalent.

On April 17, 2015 the United States Environmental Protection Agency (USEPA) published new rules (CCR Rules or §257) for landfills and surface impoundments that contain CCR materials produced from electric utilities. The rules specified that CCR impoundments must have a composite bottom liner. The default liner per §257.71 consists of a 24-inch thick CCL with a maximum hydraulic conductivity of 1E-07cm/s in combination with a geomembrane meeting minimum thickness requirements. Because the existing CCL is thinner than the required 24-inch thickness, an alternate composite liner demonstration was necessary to demonstrate existing liner system meets the requirements of §257.70, and therefore complies with §257.71. This demonstration was presented in the Williams Station FGD Pond, Documentation of Liner Type, prepared by Garrett & Moore, dated October 2016.

Since the geomembrane portion of the liner system being replaced matches that of the existing system, no analysis or equivalency determination is required. In the CCR Rules, GCL's are allowed as an acceptable alternative to the CCL provided that their equivalency could be demonstrated using Darcy's Law equation for flow per §257.70(c). The parameters in the equation include the thickness of the layer (CCL or GCL), hydraulic conductivity of the layer, and the hydraulic head above the liner.

$q = k(h/t+1)$

q = flow rate per unit area ($cm^3/s/cm^2$)
k = hydraulic conductivity of the liner (cm/s)
h = hydraulic head above the liner (cm)
t = thickness of the liner (cm)

ANALYSIS:

The analysis presented below provides calculations to demonstrate that the liquid flow rate of the specified GCL is less than or equal to the excavated CCL, evaluating two scenarios:

Scenario 1: Assuming a thickness of excavated CCL of 4 inches, demonstrate that the liquid flow rate of 1 layer of the specified GCL is less than or equal to the excavated CCL.

Scenario 2: Assuming a thickness of excavated CCL of 12 inches, demonstrate that the liquid flow rate of 3 layers of the specified GCL is less than or equal to the excavated CCL.

CCL Flow Rate

The expected flow rate through a 4-inch thick layer of CCL based on the following assumptions from Ref. No. 1:

- The hydraulic conductivity of the CCL to be excavated has a composite mean value of $3.40E^{-08}$ cm/s
- The hydraulic head above the liner is 121.92 cm (48 inches - normal pool water depth)
- The thickness of the CCL to be removed is 10.16 cm (4 inches)

$q = k(h/t+1)$

q = flow rate per unit area ($cm^3/s/cm^2$)
k = hydraulic conductivity of the liner (cm/s)
h = hydraulic head above the liner (cm)
t = thickness of the liner (cm)

$q = k(h/t+1) = 3.40E^{-08}$ cm/s (121.92 cm/10.16 cm + 1) = $4.42E^{-07}$ $cm^3/s/cm^2$

GCL Flow Rate

The expected flow rate through the specified GCL based on the following assumptions from Ref. No. 1:

- The specified GCL is CETCO Resistex 200 DN.
- The hydraulic conductivity of the GCL is $3.0E^{-09}$ cm/s
- The hydraulic head above the liner is 121.92 cm (48 inches - normal pool water depth)
- The effective thickness of the GCL to be used is 0.9 cm

$q = k(h/t+1)$

q = flow rate per unit area ($cm^3/s/cm^2$)

k = hydraulic conductivity of the liner (cm/s)
h = hydraulic head above the liner (cm)
t = thickness of the liner (cm)

$q = k(h/t+1) = 3.00E^{-9}$ cm/s (121.92 cm/0.9 cm + 1) = $4.09E^{-07}$ $cm^3/s/cm^2$

The results of the Darcy's Law calculation result in the following liquid flow rates:

- FGD Pond existing 4" thick CCL w/ hydraulic conductivity of $3.40E^{-08}$ cm/s = $4.42E^{-07}$ $cm^3/s/cm^2$
- Replacement GCL w/ hydraulic conductivity of $3.00E^{-09}$ cm/s = $4.09E^{-07}$ $cm^3/s/cm^2$

Scenario 2:

CCL Flow Rate
The expected flow rate through a 12-inch thick layer of CCL based on the following assumptions from Ref. No. 1:

- The hydraulic conductivity of the CCL to be excavated has a composite mean value of $3.40E^{-08}$ cm/s
- The hydraulic head above the liner is 121.92 cm (48 inches - normal pool water depth)
- The thickness of the CCL to be removed is 30.48 cm (12 inches)

$q = k(h/t+1)$

q = flow rate per unit area ($cm^3/s/cm^2$)
k = hydraulic conductivity of the liner (cm/s)
h = hydraulic head above the liner (cm)
t = thickness of the liner (cm)

$q = k(h/t+1) = 3.40E^{-08}$ cm/s (121.92 cm/30.48 cm + 1) = $1.70E^{-07}$ $cm^3/s/cm^2$

GCL Flow Rate
The expected flow rate through the specified GCL based on the following assumptions from Ref. No. 1:

- The specified GCL is CETCO Resistex 200 DN.
- The hydraulic conductivity of the GCL is $3.0E^{-09}$ cm/s
- The hydraulic head above the liner is 121.92 cm (48 inches - normal pool water depth)
- The effective thickness of the three GCL layers to be used is 2.7 cm

$q = k(h/t+1)$

q = flow rate per unit area ($cm^3/s/cm^2$)
k = hydraulic conductivity of the liner (cm/s)
h = hydraulic head above the liner (cm)
t = thickness of the liner (cm)

$q = k(h/t+1) = 3.00E^{-9}$ cm/s (121.92 cm/2.7 cm + 1) = $1.39E^{-07}$ $cm^3/s/cm^2$

The results of the Darcy's Law calculation result in the following liquid flow rates:

- FGD Pond existing 12" thick CCL w/ hydraulic conductivity of $3.40E^{-08}$ cm/s = $1.70E^{-07}$ $cm^3/s/cm^2$
- Replacement 3 layers of GCL w/ hydraulic conductivity of $3.00E^{-09}$ cm/s = $1.39E^{-07}$ $cm^3/s/cm^2$

CONCLUSION: **Based on the above results, the liquid flow rate through the replacement GCL layer is less than the liquid flow rate through a 4-inch thick CCL. The liquid flow rate through the three replacement GCL layers is also less than the liquid flow rate through a 12-inch thick CCL. Therefore, the replacement GCL meets the regulatory equivalency requirement for 4 inches of CCL. If more than 4 inches of CCL must be removed, additional layers of GCL will be installed to meet the equivalency of one layer per 4 inches of CCL.**

ATTACHMENT 1

REFERENCE 2 – CETCO TECHNICAL REFERENCE

RESISTEX® 200 DN CERTIFIED PROPERTIES

CETCO® Resistex® geosynthetic clay liners are engineered to provide the highest level of chemical compatibility in extremely aggressive leachate environments such as some coal combustion product storage facilities, mining operations, and industrial waste storage facilities. Site-specific compatibility testing is strongly recommended.[7]

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY	CERTIFIED VALUES
Nonwoven Base Geotextile Mass/Area[1]	ASTM D5261	200,000 ft^2 (20,000 m^2)	6.0 oz/yd^2 (203 g/m^2) min.
Nonwoven Cap Geotextile Mass/Area[1]	ASTM D5261	200,000 ft^2 (20,000 m^2)	6.0 oz/yd^2 (203 g/m^2) min.
Bentonite Moisture Content[2]	ASTM D2216	1 per 50 tonnes	12% max.
Bentonite Swell Index[2]	ASTM D5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[2]	ASTM D5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[3]	ASTM D5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2) min.
Total Mass/Area[3]	ASTM D5993	40,000 ft^2 (4,000 m^2)	0.83 lb/ft^2 (4.1 kg/m^2) min.
GCL Moisture Content	ASTM D5993	40,000 ft^2 (4,000 m^2)	35% max.
GCL Grab Strength[4]	ASTM D6768	200,000 ft^2 (20,000 m^2)	50 lbs/in (8.8 kN/m) min.
GCL Peel Strength	ASTM D6496	40,000 ft^2 (4,000 m^2)	3.5 lbs/in (610 N/m) min.
GCL Hydraulic Conductivity[5]	ASTM D5887	250,000 ft^2 (25,000 m^2)	3 x 10^{-11} m/s max.
GCL Hydrated Internal Shear Strength[6]	ASTM D6243	1,000,000 ft^2 (100,000 m^2)	500 psf (24 kPa) typ.@ 200 psf (9.6 kPa)

Notes:

[1] Geotextile property tests performed on the geotextile components before they are incorporated into the finished GCL product.

[2] Bentonite property tests performed before the bentonite is incorporated into the finished GCL product.

[3] Reported at 0 percent moisture content.

[4] All tensile strength testing is performed in the machine direction using ASTM D6768.

[5] Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (550 kPa) cell pressure, 77 psi (530 kPa) headwater pressure and 75 psi (515 kPa) tailwater pressure.

[6] Peak values measured at 200 psf (9.6 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

[7] Compatibility testing via ASTM D6766 recommended using site-specific leachate as the permeate fluid. Pre-hydration requirements for the GCL sample and other testing parameters such as confining stress to be prescribed by the design professional.