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CROSS GENERATING STATION

Bottom Ash Pond Initial Structural Stability Assessment

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BOTTOM ASH POND INITIAL STRUCTURAL STABILITY ASSESSMENT

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REV	DESCRIPTION	ORIGINATOR	REVIEWER	APPROVER	DATE
0	Issued for Use	B Gordon	F Wood	F Wood	17 Oct 2016
1	Issued for Use	ben.gordon@worleyparsons.com B Gordon	Digitally signed by: Fletcher Wood Date: 2016.11.03 13:47:32 -06'00' F Wood	Digitally signed by: Fletcher Wood Date: 2016.11.03 13:49:24 -06'00' F Wood	3 Nov 2016

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APPENDIX A - Bottom Ash Pond Plan View

SOUTH CAROLINA
WORLEY PARSONS GROUP INC.
No. 1505
CERTIFICATE OF AUTHORIZATION

SOUTH CAROLINA
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No. 24767
FLETCHER M. WOOD

3-NOV-2016

1. INTRODUCTION

The United States Environmental Protection Agency (EPA) promulgated new regulations regarding Coal Combustion Residuals (CCRs). These regulations (40 CFR Part 257) were published in the Federal Register on April 17, 2015. One of the requirements of the new regulations (§257.73(d)) is to conduct periodic structural stability assessments. The intent of the assessment is to document that the construction, operation, and maintenance of the CCR unit are consistent with recognized and generally accepted good engineering practices. This document presents the initial structural stability assessment of the Bottom Ash Pond at the Cross Generating Station in Pineville, South Carolina. Subsequent assessments are to be completed every five years. The format of this document is based on the order of the requirements listed in the regulations.

The Bottom Ash Pond at Cross Generating Station continues to perform satisfactorily and has been maintained in good condition. There are no significant findings that would indicate that the impoundment does not meet the standard of care with respect to the design, construction, operation, and maintenance of an impoundment containing coal combustion residuals.

2. STRUCTURAL STABILITY ASSESSMENT

An extensive desktop review of site history and engineering reports, a subsurface investigation, and a laboratory testing program was performed to document the construction history, characterize the dike and subsurface soils, and evaluate the existing condition of the Bottom Ash Pond. Based on the information available at the time of this report, the Bottom Ash Pond appears to have been designed, constructed, operated, and maintained with foundations to remain stable under static and seismic conditions, adequate slope protection, mechanically compacted dikes, and slopes with vegetation not exceeding six inches in height, in accordance with §257.73(d)(1)(i) through (iv) of the CCR Rule. The spillway was designed to manage flow during and following the peak discharge from the 100-year design storm to meet the requirements of §257.73(d)(1)(v). The influence of hydraulic structures underlying and penetrating the perimeter dike was evaluated and found to meet the requirements of §257.73(d)(1)(vi).

2.1 Site Visit

WorleyParsons visited Cross Generating Station on April 27, 2016 to inspect the condition of the Bottom Ash Pond. Prior to the inspection, the team met in a site conference room to discuss current pond operating procedures with plant personnel, and to review the maintenance history with respect to features identified in existing documents [Ref. 1, 2], including the initial annual inspection report and subsequent weekly inspections. The inspection team then performed a detailed inspection of the pond, including upstream embankment slopes (above the water line), downstream embankment slopes, embankment penetrations, and hydraulic structures. The impoundment dikes were observed to be in satisfactory condition, with the impoundment generally operated and maintained in accordance with commonly accepted engineering practice. The inspection did not observe evidence of a deficiency to the structural integrity of the surface impoundment.

2.2 Stable Foundations and Abutments

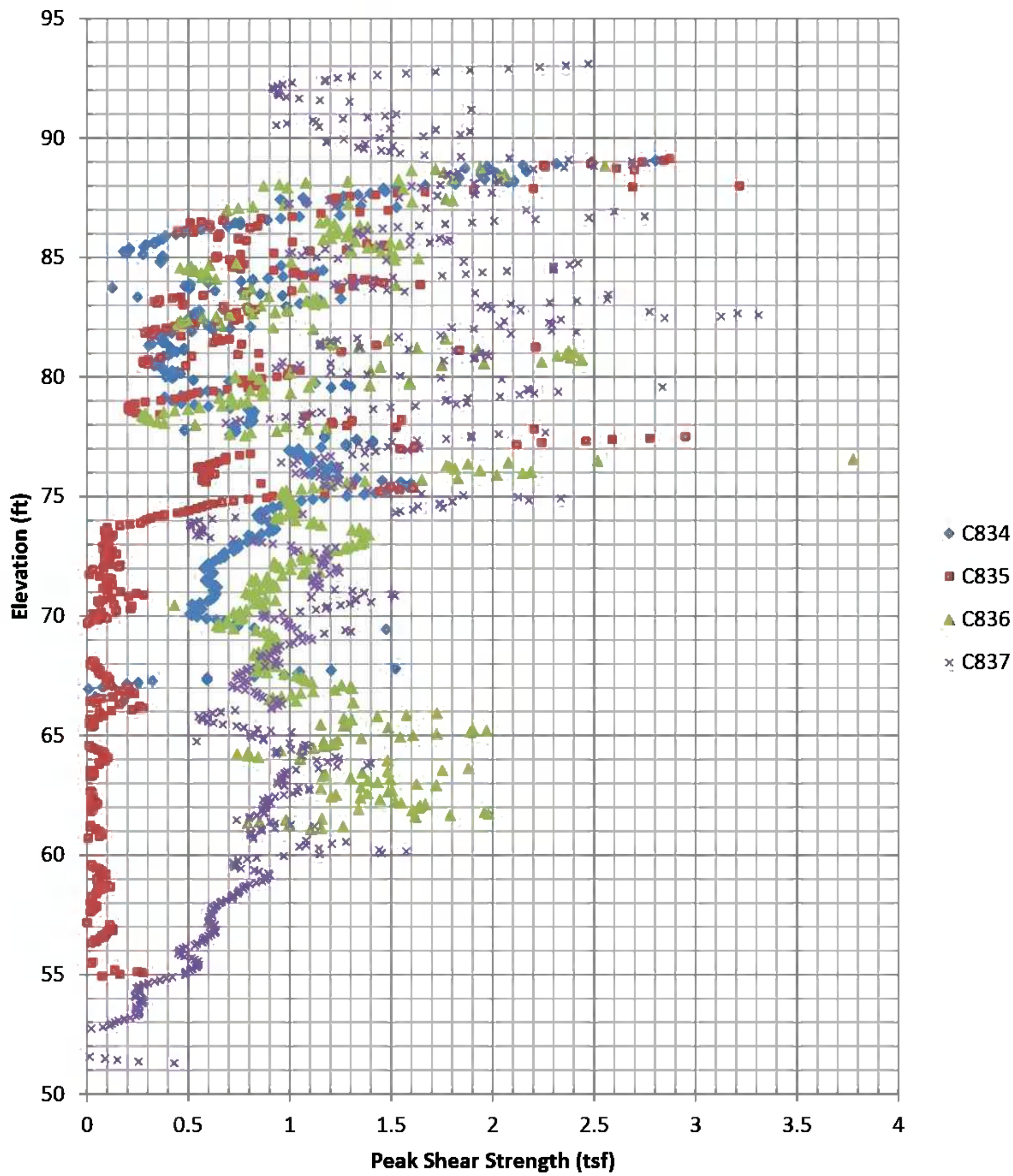
The Bottom Ash Pond was constructed over Pleistocene sediments of the Atlantic Coastal Plain. These sediments typically consist of soft to stiff sandy lean clay and fat clay with a few layers of silty sand. The thickness of the soil layer varies from approximately 17 to 36 feet. The underlying Santee Limestone is variably weathered and in many locations can be sampled with a split-spoon sampler. The limestone surface elevation varies. Groundwater levels fluctuate seasonally, and are typically between 2 and 10 feet below the existing ground surfaces.

As shown in Figure 1, one of the four CPT soundings performed by Terracon in 2015 shows much lower peak shear strengths compared to the other three soundings. These soundings were advanced through the embankment of the Bottom Ash Pond. While the plot shows more scatter in the data between the elevations of 80 and 75 feet, peak undrained shear strengths are generally less than 2.0 tsf, and average around 1.0 tsf. However, at the location of sounding C-835, the soils encountered had peak shear strengths generally less than 0.1 tsf below an elevation of 74 feet.

The above worst-oase soil conditions were modelled in the Initial Safety Faotor Assessment [Ref. 4]. The assessment demonstrated that both static and seismic faotors of safety exoeeded the minimum requirements set forth in §257.73(e). Although some localized soil zones have the potential to exhibit a reduoed strength during a seismio event, they are not considered liquefiable in the classic sense. Also, these zones are not laterally continuous, so widespread loss of strength is unlikely.

In the thirty years since Cross Generating Station was constructed, there has been no documented instability within the ash impoundment area. Modelling of the Bottom Ash Pond, using conservative soil properties, resulted in acceptable safety factors. Therefore, there is no evidence to suggest that the foundations of the Bottom Ash Pond are not stable.

Figure 1


95
90
85
80
75
70
65
60
55
50
Elevation (ft)
0
0.5
1
1.5
2
2.5
3
3.5
4
Peak Shear Strength (tsf)
C834
C835
C836
C837

2.3 Slope Protection

The interior slopes of the Bottom Ash Pond are covered with a three-inch thick layer of concrete revetment mat. The revetment extends from the crest of the embankment to four feet beyond the toe of the embankment. This concrete revetment mat provides protection to the embankment from surface erosion, wave action, and adverse effects associated with rapid drawdown.

2.4 Dike Compaction

Compaction test reports from the construction of the Bottom Ash Pond are not available. Earthwork specifications (included in Ref. 5) indicate the embankments were constructed of on-site excavated soil with the maximum particle size not exceeding 1/2 of the lift thickness (12 inches). The specifications required the subgrade to be compacted to a minimum density of 90 percent of modified Proctor (or 95 percent of standard Proctor) in areas receiving fill. Fill was to be placed in maximum 12-inch loose lifts and compacted to either 90 percent of maximum density as determined by the Modified Proctor test, or 95 percent of the maximum density as determined by the Standard Proctor test. According to personnel involved with the design and construction of the Bottom Ash Pond, all work was verified by third party monitoring, testing, and inspection services.

Proctor data from the Woodward-Clyde and Law geotechnical reports [Ref. 6 and 7] are presented in Table 1. The TP-200 series test pits were excavated under Law's direction, and modified Proctors were performed. These test pits were located across the generating station area. The other test pits were excavated under Woodward-Clyde's direction and standard Proctors were performed. These test pit locations were primarily in the area of the proposed bottom ash pond. The Proctor tests were performed on remolded soils obtained from shallow depths.

Table 2 presents the unit weights and moisture contents of undisturbed samples that were obtained of the Bottom Ash Pond embankment during Terracon's 2015 subsurface exploration. Although the densities shown in Table 2 cannot be directly correlated to the Proctor values provided in Table 1 due to differences in grain size distributions and Atterberg Limits, the general range of dry density and moisture content is similar, particularly when compared with standard Proctor data. The average dry density of the undisturbed samples is higher than the average density of the Standard Proctor samples, and the average moisture contents differ by less than a percent. While this observation does not confirm the embankments meet the required Proctor percentages, it, along with the specifications, does provide assurance that compaction was performed during construction.

Table 1: Proctor Data

Test Pit	Depth (ft)	USCS Soil Classification	Proctor Type	Maximum Dry Density (pcf)	Optimum Moisture (%)
TP-12 & TP-24	0 - 1.4	CL	Standard	120.3	12.5
TP-16, TP-24, & TP-29	2.0 - 4.0	CH	Standard	99.1	21.4
TP-6, TP-24, & TP-29	6.0 - 7.0	SC	Standard	101.7	21.0
TP-7	4.0 - 5.0	CH	Standard	97.7	24.3
TP-12	2.0 - 4.0	CH	Standard	103.8	19.6
			Average:	104.5	19.8
TP-223	2.5 - 5.0	SC	Modified	125.9	10.7
TP-228	0.9 - 2.0	SC	Modified	127.4	8.9
TP-229	1.0 - 3.0	SM	Modified	131.3	7.5
TP-242	2.5 - 5.0	SC	Modified	122.0	11.8
TP-243	2.0 - 4.5	SM-SC	Modified	121.3	12.6
TP-246	0.8 - 2.5	SM-SC	Modified	133.0	8.2
TP-248	2.5 - 5.0	SM-SC	Modified	123.4	11.6
			Average:	126.3	10.2

Table 2: Undisturbed Sample Density

Boring	Depth (ft)	USCS Soil Classification	Average Dry Density (pcf)	Average Moisture (%)
B-734	2 - 4	CL	110.0	16.4
	6 - 8	SC	111.3	15.7
B-735	4 - 6	SC	97.8	25.1
	8 - 10	SC	107.7	20.8
		Average:	106.7	19.5

Regardless of the data, visual observations indicate that the embankments were sufficiently compacted to withstand the loading conditions applied. There is no evidence of subsidence or settlement of the embankments. There have been no reported instances of any instability or other conditions since the Bottom Ash Pond was ocnstructed that would indicate insufficient compaction.

2.5 Slope Vegetation

At the time of the inspection, vegetation on the exterior slopes of the Bottom Ash Pond was typically not more than six inches in height. With the exception of one shrub that has subsequently been removed, woody vegetation was not observed. The vegetation appeared to be well-maintained. No areas of distressed vegetation were observed.

2.6 Spillway Configuration

Water from the Bottom Ash Pond is discharged into the Wastewater Decant Pond via a trapezoidal weir. The water flows over the weir into the Wastewater Decant Pond where it is pumped back to the power block for use as ash sluice and ash seal water, or undergoes pH treatment prior to discharge into the Diversion Canal. This weir is the only discharge structure for the Bottom Ash Pond.

2.6.1 Spillway Construction

The trapezodial weir is surfaced with a three-inch thick layer of concrete erosion control revetment. The revetment extends from the crest of the embankment along the three horizontal to one vertical sideslopes and across the invert of the weir. Beneath the revetment is a foot of structural fill or sand, followed by a bentonite geocomposite liner. The weir elevation is 85.0 feet and the normal pool elevation is 88.0 feet, so water can freely flow between the Bottom Ash Pond and the Wastewater Decant Pond.

2.6.2 Spillway Capacity

The Bottom Ash Pond is classified as having a low hazard potential [Ref. 8]. Therefore, the spillway must adequately manage the flow of the 100-year flood event. The precipitation associated with the 100-year, 24-hour event is 9.59 inches [Ref. 9]. Since the pond is completely contained within a perimeter embankment, it does not receive uncontrolled off-site drainage. The water surface elevation for the 100 year storm is 89.31 feet [Ref. 3] As such, there is sufficient flood storage volume between the normal operating pool water level elevation of 88.0 feet and the top of the embankment at approximate elevation 91.0 feet (lowest surveyed elevation 90.46 feet) to store the approximately 1.1 feet of water from the 100 year storm. Even with the 100 year storm, there is still more than a foot of freeboard remaining.

2.7 Hydraulic Structures

The only known hydraulic structure underlying the base of the Bottom Ash Pond was the underdrain system, installed at the time of construction. This system, described in the History of Construction Report [Ref. 5], was abandoned in place, and the outfall manhole grouted.

Several process water pipes are routed into the Bottom Ash Pond. These pipes include stormwater discharge lines and bottom ash feed pipes. Most of these pipes are routed through concrete pipe trenches. Construction drawings indicate the trenches have 18-inch thick bottom slabs and one foot thick walls. The invert elevations of the trenches are approximately 88 feet, which corresponds to the normal operating pool elevation. A concrete wall extends across the pond end of the trenches from the invert to approximately Elevation 91 feet, thus precluding the flow of pond water back through the trenches during periods when the water level in the pond is above the normal pool level. The bentonite geocomposite liner extends to the top of the pipe trench foundation slabs.

An abandoned six-inch diameter steel outfall pipe from the coal pile runoff pond extends through the embankment at Elevation 89.0 feet. This pipe also penetrates the liner and erosion control revetment. Based on recommendations subsequent to the site visit, this pipe has been grouted shut prior to the publication of this report. Operationally, this pipe was replaced by a six-inch diameter HDPE pipe, located near monitoring well CAP 3. Lean concrete was placed around the new pipe where it penetrated the concrete revetment.

The only other hydraulic structure is a 16-inch diameter HDPE pipe conveying leachate from the Class 3 landfill leachate collection pond. This pipe was installed in July 2015, and is located above the liner. Lean concrete was also placed around the end of the pipe where it penetrates the revetment.

None of these structures showed any indication of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or debris that would negatively affect their operation. The integrity of these hydraulic structures appeared to be adequate with respect to continued safe operation of the impoundment.

2.8 Downstream Slopes

The crest of the Bottom Ash Pond is approximately 11 feet higher than adjacent site grades, and is not located near any bodies of water. The embankment at the southeast corner of the impoundment is common to the Wastewater Decant Pond. As indicated in Section 2.6, they are hydraulically connected, as water from the Bottom Ash Pond flows through a trapezoidal opening in the embankment to the Wastewater Decant Pond. Since both the Wastewater Decant Pond and the Bottom Ash Pond have bentonite liners, rapid drawdown of the Wastewater Decant Pond would have minimal effect on the embankment.

3. STRUCTURAL DEFICIENCIES

There are no known structural deficiencies of the Bottom Ash Pond at this time.

The inspection did note some areas that should be monitored to minimize the potential for future deterioration, as well as some areas to be repaired or remediated to ensure continued safe operation of the impoundment. Recommended repair procedures are presented in Section 4 of this report.

1. Weekly monitoring of the several areas of bare soil between monitoring wells CAP 6 and CAP 7, as well as east of CAP 8, should be continued. These bare soil areas appear to be due to tractor tires, likely as a result of mowing operations.

2. Weekly monitoring of several small wet areas near the former dewatering outfall manhole should also be continued. These wet areas are located in the perimeter drainage channel and just above the waterline at the toe of the embankment between monitoring wells CAP 7 and CAP 8. The wet areas are attributed to water draining through the sand bedding used for the dewatering pipes. The primary objective is to ensure piping does not develop.

3. A section of the perimeter drainage channel near monitoring well CAP 2 contains a buildup of sediment. This sediment could potentially block the flow of water in the channel, resulting in the channel overflowing its banks and creating wet areas along the toe of the embankment.

4. A depression along the perimeter drainage channel near monitoring well CAP 9 should be repaired to facilitate mowing of the embankment in this area.

5. A portion of the concrete revetment at the northeast corner of the trapezoidal weir is damaged and should be repaired so that the underlying soils protecting the bentonite liner are not affected by erosive forces due to flow and wave action.

6. The abandoned coal pile runoff outfall pipe could allow water to flow back through the pipe during periods when the pond level is high, creating the potential for backflow towards the downslope end of the pipe.

7. Regrading should be performed to mitigate the conditions responsible for causing the erosion observed at the downslope ends of the three pipe trenches along the southern embankment of the ash pond. While the erosion does not currently pose a threat to the stability of the embankment, further erosion could theoretically undermine the foundations of the pipe trenches.

4. CORRECTIVE MEASURES

Several areas of the Bottom Ash Pond were observed to have conditions that could potentially lead to some form of future damage to the impoundment structure if not repaired. At the time of the inspection, none of these areas represented a significant or imminent hazard to the structural integrity of the impoundment that warranted immediate repairs. The corrective measures were recommended for completion by September 30, 2016. Based on follow-up correspondence from Santee Cooper on October 13, 2016, all corrective measures were completed in accordance with the recommended timeframe as noted below, prior to the publication of this assessment.

1. A small shrub was observed at the toe of the impoundment, just west of monitoring well CAP 2. This shrub should be removed and the ground surface compacted and reseeded. In the same area, there was a buildup of sediment in the perimeter drainage channel. The drainage channel should be cleaned out to restore the intended water flow. *(Note: this work was completed by June 14, 2016)*

2. A depression approximately 30 feet long and 8 inches deep was observed along the toe of the impoundment just east of monitoring well CAP 9. This depression was adjacent to the perimeter drainage channel. This depression should be filled in or re-graded and re-seeded. *(Note: this work was completed by June 14, 2016)*

3. The concrete revetment in the northeast corner of the trapezoidal spillway appears to have been damaged by an excavator. The revetment in this area was broken and displaced from its original position. The area around the damaged revetment should be sawcut and the loose, broken revetment pieces removed. The underlying soils should be graded to the approximate original contours and covered with new revetment or a product like concrete cloth. The new protective covering should overlap the existing revetment by a minimum of six inches on all sides. *(Note: this work was completed by June 16, 2016)*

4. An abandoned coal pile runoff outfall pipe is still present within the embankment. The pipe was cut off where it crosses the perimeter drainage channel, but the downslope end of the pipe appears to be buried. The downslope end of the pipe should be located, and the entire pipe either removed or filled with grout or flowable fill. *(Note: this work was completed by September 30, 2016)*

5. Erosion at the downstream end of the three pipe trench grade crossings along the southern embankment of the ash pond continues. These eroded areas should be filled with larger stone, such as AASHTO No. 1. This area should be regraded and carefully maintained to minimize

runoff, thus reducing the probability of erosion below the pipe trenches. *(Note: this work was completed by July 22, 2016)*

5. SUMMARY

Based on available data, discussions with Santee Cooper personnel, and inspection of the ash impoundment, the Bottom Ash Pond at Cross Generating Station was designed and constructed using recognized and generally accepted good engineering practices. Likewise, the operation and maintenance of the facility also follow recognized and generally accepted good engineering practices. At the time of the inspection, there were no observations that would indicate instability of the structure or preclude the continued safe operation of the impoundment.

The following areas are recommended for continued periodic observations or maintenance:

1. Weekly monitoring of the several areas of bare soil between monitoring wells CAP 6 and CAP 7, as well as to the east of CAP 8.

2. Weekly monitoring of several small wet areas near the dewatering outfall manhole.

3. Continued maintenance of the slopes to prevent the growth of woody vegetation, and removal of any such vegetation observed.

4. Continued maintenance of the perimeter drainage channel to maintain adequate grades and capacity.

5. Continued monitoring of repair areas discussed in Section 4 during periodic inspections to ensure the repairs continue to function as intended.

Based on the evaluations presented in this report, the Bottom Ash Pond at Cross Generating Station satisfies the structural stability requirements for existing surface impoundments in accordance with §257.73(d)(1).

6. CERTIFICATION

I, the undersigned Professional Engineer registered in good standing in the State of South Carolina, do hereby certify under penalty of law that I have personally examined and am familiar with the information submitted in this demonstration, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I certify, for the above-referenced CCR impoundment, that the initial structural stability assessment as specified in Section 40 CFR §257.73(d)(1) was conducted in accordance with the requirements of the section.

SOUTH CAROLINA CERTIFICATE OF AUTHORIZATION
WORLEY PARSONS GROUP INC.
No. 1505

SOUTH CAROLINA LICENSED PROFESSIONAL ENGINEER
No. 24767
FLETCHER M. WOOD

3-NOV-2016

Fletcher Wood
Printed Name of Professional Engineer

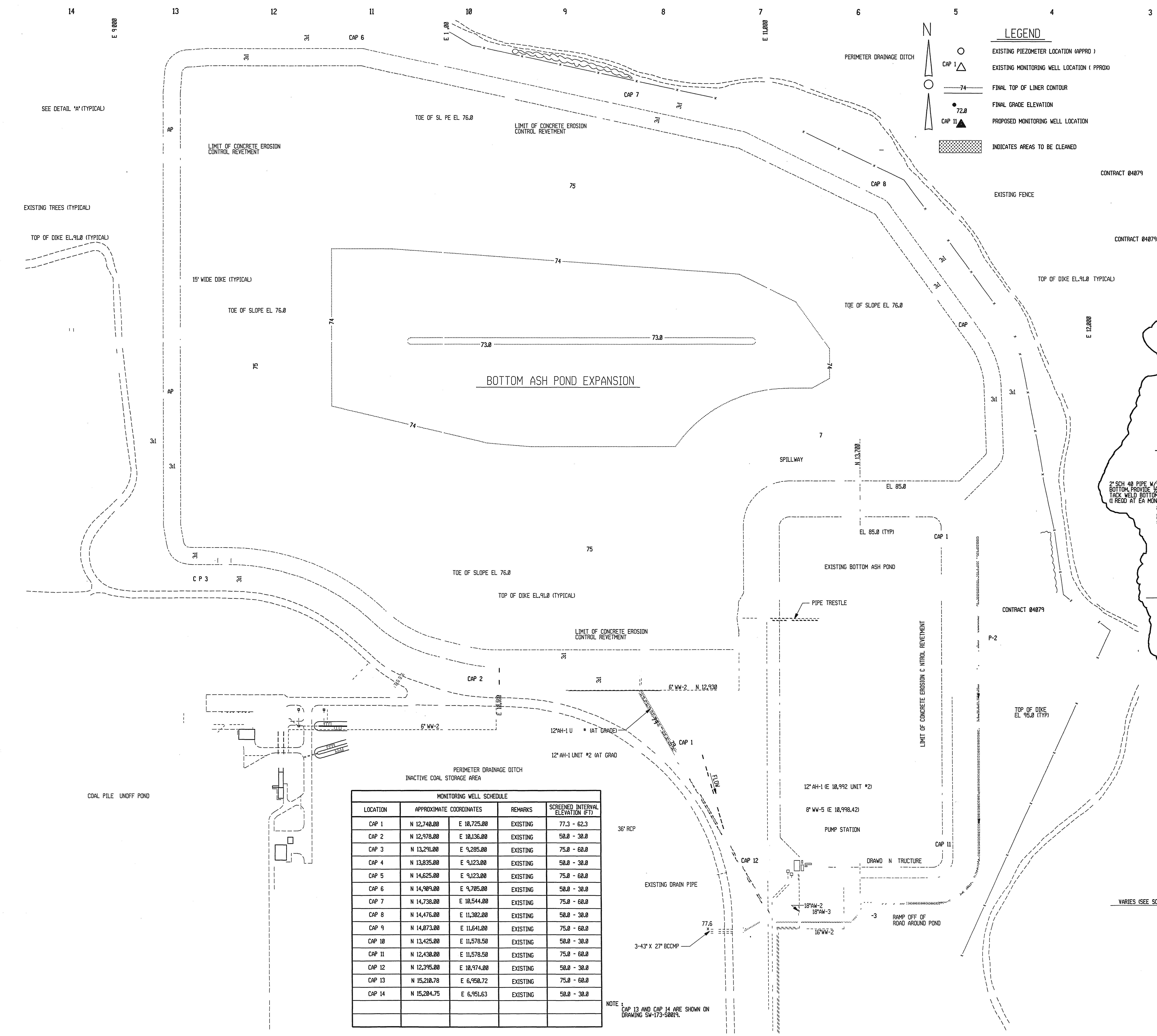
Signature of Professional Engineer

24767
South Carolina License #

7. REFERENCES

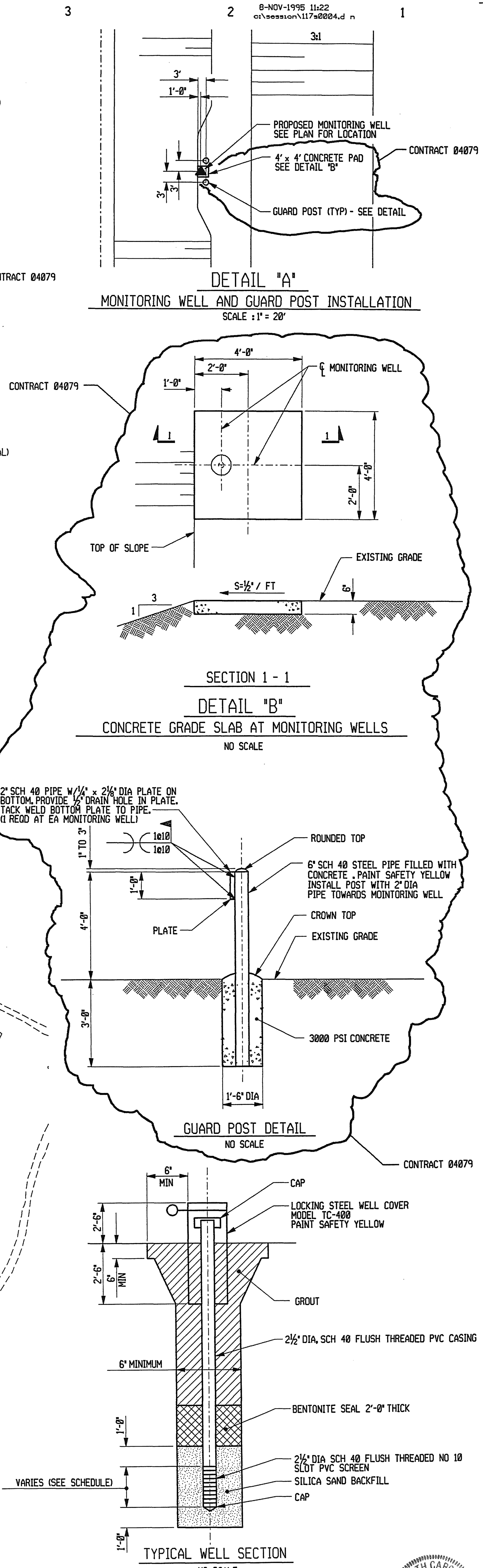
1. Dewberry & Davis, LLC, Coal Combustion Residue Impoundment Round 9 - Dam Assessment Report Cross Generating Station, December 2011.
2. Santee Cooper, Coal Combustion Residual Impoundment Inspection - Cross Generating Station, January 2016.
3. WorleyParsons Document CROSS-0-LI-044-0008, Bottom Ash Pond Inflow Design Flood Control System Plan, October, 2016.
4. WorleyParsons Document CROSS-0-LI-044-0010, Bottom Ash Pond Initial Safety Factor Assessment, October, 2016.
5. WorleyParsons Document CROSS-0-LI-044-0007, Bottom Ash Pond History of Construction, October, 2016.
6. Woodward-Clyde Consultants, Unit 1 Subsurface Investigation Cross Generating Station, January 26, 1981.
7. Law Engineering Testing Company, Final Report Cross Generating Station, February 9, 1979.
8. WorleyParsons Document CROSS-0-LI-044-0006, Bottom Ash Pond Initial Hazard Potential Classification Assessment, October, 2016.
9. NOAA Atlas 14, Volume 2, Version 3, PDS-based point precipitation frequency estimates with 90% confidence intervals for Pineville, South Carolina, accessed March 23, 2016.

Appendix A - Bottom Ash Pond Plan View



MONITORING WELL SCHEDULE				
LOCATION	APPROXIMATE COORDINATES		REMARKS	SCREENED INTERVAL ELEVATION (FT)
CAP 1	N 12,740.00	E 10,725.00	EXISTING	77.3 - 62.3
CAP 2	N 12,978.00	E 10,136.00	EXISTING	50.0 - 30.0
CAP 3	N 13,291.00	E 9,285.00	EXISTING	75.0 - 60.0
CAP 4	N 13,835.00	E 9,123.00	EXISTING	50.0 - 30.0
CAP 5	N 14,625.00	E 9,123.00	EXISTING	75.0 - 60.0
CAP 6	N 14,909.00	E 9,705.00	EXISTING	50.0 - 30.0
CAP 7	N 14,738.00	E 10,544.00	EXISTING	75.0 - 60.0
CAP 8	N 14,476.00	E 11,302.00	EXISTING	50.0 - 30.0
CAP 9	N 14,073.00	E 11,641.00	EXISTING	75.0 - 60.0
CAP 10	N 13,425.00	E 11,578.50	EXISTING	50.0 - 30.0
CAP 11	N 12,430.00	E 11,578.50	EXISTING	75.0 - 60.0
CAP 12	N 12,395.00	E 10,974.00	EXISTING	50.0 - 30.0
CAP 13	N 15,210.78	E 6,950.72	EXISTING	75.0 - 60.0
CAP 14	N 15,204.75	E 6,951.63	EXISTING	50.0 - 30.0

NOTE : CAP 13 AND CAP 14 ARE SHOWN ON DRAWING SW-173-S0019.



REFERENCES :
BA-117-S0001 BOTTOM ASH POND EXPANSION - PLAN

SCALE IN FEET

REV	REVISION	DATE	MADE	CHKD	LD	PE
0	ISSUE FOR CONSTRUCTION (CONTRACT 04079)	-	KPF	ALM	ALM	EFK
1	ISSUED FOR RECORD - INCORPORATED AS-BUILT MARK-UPS SUBMITTED BY CONTRACTOR	11-21-95	KPF	ALM	ALM	EFK

DRAWN BY GHC CHECKED BY A.L.M. DATE 11-21-95

Scale: 1"=100' E
W.O. 046151

Santee Cooper
CROSS GENERATING STATION
UNIT 1

BOTTOM ASH POND EXPANSION
MONITORING WELL LOCATION PLAN

GILBERT/COMMONWEALTH, INC.
ENGINEERS AND CONSULTANTS READING, PA

BA-117-S0004 1
DRAWING NUMBER REV

MONITORING WELL LOCATION PLAN