October
2017

COAL COMBUSTION RESIDUAL IMPOUNDMENT INSPECTION – CROSS GENERATING STATION

Pineville, South Carolina

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**Please note that the terms "embankment", "berm", "dike", and "dam" are used interchangeably within this report, as are the terms "pond", "basin", and "impoundment".*

Executive Summary

This assessment of the stability and functionality of the Cross Generating Station (CGS) coal combustion residual (CCR) management unit is based on a review of available documents and an on-site assessment conducted by Santee Cooper engineering staff on October 5, 2017. We found the supporting technical information to be generally adequate. As detailed in Section 5.4, the assessment team had several recommendations based on field observations that may help CGS to continue to maintain the management unit in safe condition.

In summary, the CGS CCR management unit, the Bottom Ash Pond, is in generally satisfactory condition for continued safe and reliable operation. No recognized existing or potential management unit safety deficiencies were identified within the parameters of design and operation, given the unit's low hazard potential classifications.

Summary of Recommendations

Bottom Ash Pond

1. Minor tractor rutting and occasional minor erosion was noted at various locations on the downstream slope of the Bottom Ash Pond. These areas should be monitored for further displacement of material during weekly inspections. Caution should be exercised when mowing the areas near the drainage ditch and toe of the slope.
2. Erosion of the downstream slope of the Bottom Ash Pond perimeter dike was noted directly below the western pipe bridge. Although no seepage or further movement was noted at the time of inspection, this area should be repaired to prevent further damage to the downstream toe of the perimeter dike within ninety (90) days of the date of this report.
3. Erosion on the inside slope of the perimeter dike was noted near the western pipe bridge. This area should be repaired and regraded within ninety (90) days of the date of this report.
4. The wet area near the abandoned underdrain outfall should continue to be monitored.
5. Some minor settlement was noted along the alignment of the coal pile runoff discharge pipe on the downstream slope of the dike, potentially due to poor

compaction of soils above the pipe after installation. This area should be monitored during weekly inspections for further settlement and/or erosion.

This assessment of dam safety reported herein is based on field observations and review of readily available information provided to the inspection team of the subject coal combustion residual (CCR) management unit at Cross Generating Station. Qualified Santee Cooper engineering staff performed the field observations and the review of pertinent information and made the assessment in conformance with the requirements of Section 257.83 of the Federal Register and in accordance with reasonable and generally accepted engineering practices.

Coal Combustion Residual Impoundment Inspection – Cross Generating Station

1.0 General Information and Introduction

1.1 Purpose and Scope

The purpose of this report is to fulfill the requirements of Section 257.83(b) of the Federal Register regarding the safety and inspection of CCR surface impoundments. Section 257.83(b) states that "If the existing or new CCR surface impoundment or any lateral expansion of the CCR surface impoundment is subject to the periodic structural stability assessment requirements under Section 257.73(d) or 257.74(d), the CCR unit must additionally be inspected on a periodic basis by a qualified professional engineer to ensure that the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering standards." The inspection must, at a minimum, include:

i. A review of available information regarding the status and condition of the CCR unit, including, but not limited to, files available in the operating record (e.g., CCR unit design and construction information required by Section 257.73(c)(1) and 257.74(c)(1), previous periodic structural stability assessments required under Section 257.73(d) and 257.74(d), the results of inspections by a qualified person, and results of previous annual inspections

ii. A visual inspection of the CCR unit to identify signs of distress or malfunction of the CCR unit and appurtenant structures

iii. A visual inspection of any hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit for structural integrity and continued safe and reliable operation

The inspection report must also be written by a qualified professional engineer and must address the following (required information on the CCR impoundments at CGS included in bold below the Federal Register excerpt):

i. Any changes in geometry of the impounding structure since the previous annual inspection

- **No change noted in the geometry of the Bottom Ash Pond**

ii. The location and type of existing instrumentation and the maximum recorded readings of each instrument since the previous annual inspection

- **The Bottom Ash Pond has a staff gage but no formal dam safety instrumentation (see Section 4.3.3)**

iii. The approximate minimum, maximum, and present depth and elevation of the impounded water and CCR since the previous annual inspection

- **See Table 1.1 below for information on Bottom Ash Pond**

iv. The storage capacity of the impounding structure at the time of inspection

- **See Table 1.1 below for information on Bottom Ash Pond**

v. The approximate volume of the impounding water and CCR at the time of inspection

- **See Table 1.1 below for information on Bottom Ash Pond**

Ash Pond Name	*Bottom Ash Pond*
Surface Area (acre)	*79.0*
Approx. Current CCR Storage Volume (acre-feet)	*545*
Total Storage Capacity (acre-feet)	*1,158*
Total Water Storage (acre-feet)	*613*
Crest Elevation (feet)	*91.00*
Normal Pond Level/Depth (feet)	*88.0/12.0*
Maximum Pond Level/Depth (feet)	*89.5/13.5*
Minimum Pond Level/Depth (feet)	*86.6/10.6*

Table 1.1 – Impoundment Capacity Information

vi. Any appearances of an actual or potential structural weakness of the CCR unit, in addition to any existing conditions that are disrupting or have the potential to disrupt the operation and safety of the CCR unit and appurtenant structures

- **Some maintenance required on Bottom Ash Pond as discussed in the Executive**

Summary and Sections 4.2 and 5.4; however, pond is safe for continued operation

vii. Any other change(s) which may have affected the stability or operation of the impounding structure since the previous annual inspection.

- **No other changes noted on the Bottom Ash Pond that impact the stability or operation of the impounding structure**

2.0 Description of Coal Combustion Residual Management Units

2.1 Location and General Description

The Cross Generating Station (CGS) is located on the east bank of the Diversion Canal in Berkeley County, South Carolina, approximately 5.2 miles northeast of Cross, South Carolina. CGS is located on Cross Station Road, Pineville, South Carolina, 29468. Lake Marion is northwest of CGS, and Lake Moultrie is southeast of the station.

CGS has one CCR management impoundment, the Bottom Ash Pond. The Bottom Ash Pond is adjacent to the station Wastewater Decant Pond and is connected to the Wastewater Decant Pond via a trapezoidal weir. Table 2.1 below shows a summary of its size and general dimensions:

Table 2.1: Summary of Dam Dimensions and Size

	Bottom Ash Pond
Dam Height (ft)	14
Crest Width (ft)	15 to 24
Length (ft)	6899
Design Side Slopes (upstream) H:V	3:1
Design Side Slopes (downstream) H:V	3:1

2.2 Amount and Type of CCRs Currently Stored in Unit and Maximum Capacity

The amount of CCRs currently stored in the Bottom Ash Pond and its maximum capacity are summarized in Table 2.2 below. The Bottom Ash Pond is designed to contain bottom ash and boiler slag. The Bottom Ash Pond also receives economizer ash and discharges from the coal pile runoff retention basin and station drainage sumps. Water from the Bottom Ash Pond is recycled for use as ash seal and ash sluice water after being processed through the Wastewater Decant Pond.

Table 2.2: Amount of CCRs and Maximum Capacity of Bottom Ash Pond

Ash Pond Name	Bottom Ash Pond
Surface Area (acre)[1]	79.0
Approx. Current CCR Storage Volume (cubic yards)	879,000
Approx. Current CCR Storage Volume (acre-feet)	545
Total Storage Capacity (cubic yards)	1,868,240
Total Storage Capacity (acre-feet)	1,158
Total Water Storage (acre-feet)	613
Crest Elevation (feet)	91.00
Normal Pond Level/Depth[2] (feet)	88.0/12.0
Maximum Pond Level/Depth[2] (feet)	89.5/13.5
Minimum Pond Level/Depth[2] (feet)	86.6/10.6

1From Santee Cooper response to EPA's RFI dated March 17, 2009.
2Pond Levels for Bottom Ash Pond are taken from a shared staff gage in the Wastewater Decant Pond, from the 12 month period between October 2016 – October 2017.

2.3 Principal Project Structures

2.3.1 Earth Embankments

The Bottom Ash Pond consists of a perimeter dike embankment that has geometric features and crest elevations as shown above in Tables 2.1 and 2.2. The dimensions and elevations are from construction drawings for the pond. The wider crests occur on the embankments along the southwest side of the Bottom Ash Pond (24 feet wide) to accommodate the layout of several pipelines from the power block. As discussed in Section 2.1, the Bottom Ash Pond is connected to the Wastewater Decant Pond via a trapezoidal weir, which is lined with silt curtain to further prevent material transport

between ponds. No CCRs are stored in the Wastewater Decant Pond. The Bottom Ash Pond is lined with Bentomat, which is a thin geocomposite of bentonite sandwiched between and contained by fabric layers. The inside slopes are also armored with Fabriform revetment (grout-filled cellular fabric form) to protect the liner and slope from wave erosion and exposure. No internal drainage blankets or toe drains for seepage control were included in the design of the dikes, but such seepage control features would not be warranted or expected for low perimeter dikes impounding a lined pond.

2.3.2 Outlet Structures

The Bottom Ash Pond discharges into the Wastewater Decant Pond through a 10-foot bottom width trapezoidal weir with 3:1 (horizontal to vertical) side slopes which is located between the ponds. The weir is armored with Fabriform revetment. The crest elevation of this structure is 95.0 feet (the elevation of the shared divider dike between the Wastewater Decant Pond and the Bottom Ash Pond) and its invert is at 85.0 feet. Water from the Bottom Ash Pond flows through the weir into the Wastewater Decant Pond, where it is pumped back to the CGS power block through the ash sluice system and the ash seal system. The Wastewater Decant Pond also contains the emergency outlet for both ponds. This outlet consists of a reinforced concrete box structure with a four (4) foot overflow section set at 89.5 feet. Emergency overflow discharges from the bottom of the overflow structure through an 18-inch diameter steel pipe. The invert of this pipe is at 78.0 feet.

3.0 Summary of Relevant Reports and Incidents

3.1 Summary of Reports on the Safety of CCR Unit

Furnished reports of weekly inspections, conducted by CGS personnel for the period October 2016 to October 2017 indicated no major structural or operational problems. No significant deterioration was indicated in the documentation reviewed. In addition, the annual inspection report completed by Civil Projects in January 2016 and the Bottom Ash Pond Inflow Design Flood Control System Plan and Initial Structural Stability Assessment, both produced by Worley-Parsons in October 2016 were reviewed.

As indicated in Section 5.4, careful inspection of the pipe bridge(s) and the slopes immediately downstream should be included in the weekly inspections particularly following significant rainfall events.

4.0 Field Observations

4.1 Project Overview and Significant Findings

Santee Cooper qualified engineers Michael Melchers, P.E. and Michelle Tudor, P.E. performed a site visit to CGS on October 5, 2017. The site visit began mid-morning. Weather conditions during the visit were approximately 70-75 degrees Fahrenheit, sunny and dry.

The overall condition of the CCR impoundment dikes was satisfactory with no significant findings noted.

4.2 Bottom Ash Pond

4.2.1 Crest

The crest of the Bottom Ash Pond perimeter dike was generally found to be in satisfactory condition. The limestone-surfaced crest road had a few isolated potholes from traffic. No major sags, depressions, or other signs of significant settlement were observed in the crest. No tension cracks or other signs of insipient mass soil movement were observed in the crest or along the edge of the crest.

4.2.2 Upstream/Inside Slope

The upstream/inside slope of the Bottom Ash Pond perimeter dike was generally found to be in satisfactory condition. The Fabriform revetment on the upstream inside slopes was in serviceable condition in most areas. One area on the southwest side, west of the pipe bridge, had an erosion gully down to the water surface. Small patches of vegetation were noted on the upstream slopes, generally along and just above the waterline or ash sediment line. No slumps, slides or other signs of shear failure were observed in the visible parts of the slopes above the water surface or ash surface.

4.2.3 Downstream/Outside Slope and Toe

The downstream slope and toe of the Bottom Ash Pond was found to be in generally

satisfactory condition. Grass on the outside slope was typically observed to be maintained in good condition with isolated rutting, particularly near to toe of the dam by the perimeter drainage ditch. No obvious signs of slumps, slides, bulges, tension cracks, seepage or animal holes were observed on the outside slope. A small wet area in the location of the abandoned underdrain system outfall was noted.

Additionally, in the vicinity of the coal pile runoff discharge pipe (installed in 2015), it appeared that compaction had not been fully realized, and a low spot on the slope was visible.

The area beyond the outside toe of the dike on the southeast side was observed to be covered in woody vegetation. There were no indications of seepage.

4.2.4 Abutments and Groin Areas

There are no abutments or groins in the dike embankment. No erosion or displacements were observed where the Bottom Ash Pond meets the Wastewater Decant Pond dike.

4.2.5 Overflow Structure/Outlet

Water flows from the Bottom Ash Pond to the Wastewater Decant Pond through a trapezoidal weir. The Fabriform-armored notch appeared to be in satisfactory condition with no major depressions, displacements, or deterioration. A silt curtain system keeps the structure clear of any deposited materials, allowing free flow of clarified water between the Bottom Ash Pond and the Wastewater Decant Pond.

4.2.6 Outlet Conduit

There is no outlet conduit from or through the Bottom Ash Pond perimeter dike.

4.2.7 Emergency Spillway

There is no emergency spillway within the Bottom Ash Pond; however, the capacity of the trapezoidal weir between the Bottom Ash Pond and the Wastewater Decant Pond allows water to be transferred from the Bottom Ash Pond to the Wastewater Decant Pond and then out through the Wastewater Decant Pond's emergency overflow structure during large storm events (if necessary).

4.2.8 Other Conduits

The Bentomat liner in the Bottom Ash Pond was installed during initial construction of the pond. Due to high groundwater in the vicinity of CGS, an underdrain system consisting of slotted 12" HDPE pipe installed in sand-lined trenches was used to dewater the area, allowing the liner to be safely installed without uplift concerns during construction. Upon filling of the pond, the underdrain system was abandoned in-place and the outfall (consisting of a sump area and pump) was closed using grout. Because the underdrain system utilized small pipes installed in controlled backfill, and because the invert of the outfall is over ten (10) feet below grade, this system presents minimal risk to the integrity of the Bottom Ash Pond. Closure of the sump area further minimizes the risk of any sediment transport. This structure is completely below grade, preventing visual inspection of the structure itself; however, the vicinity of the outfall is in satisfactory condition.

Process water pipes, including bottom ash feed lines and pumped storm water discharge lines, enter the Bottom Ash Pond in four (4) locations. The majority of the lines enter the pond through two (2) concrete bridge structures at the top of the perimeter dike. These structures were found to be in satisfactory condition; however, the more western pipe bridge, located in the southwest corner of the pond near the coal pile, showed signs of erosion directly below the concrete structure. The erosion is not currently a threat to safe operation of the pond bur repair is recommended, as outlined in section 5.4.

Two (2) other small HDPE lines penetrate the top of the perimeter dike near the southwestern corner of the pond. The two (2) individual pipe crossings are fairly recent installations and were placed at the top of the perimeter dike and backfilled using flowable fill to ensure proper material compaction around the conduit. These crossings were found to be in satisfactory condition, although a low lying area above the coal pile runoff discharge pipe should be monitored to ensure no further settlement.

4.3 Adequacy of Maintenance, Operating and Surveillance Procedures

4.3.1 Adequacy of Maintenance Procedures

Overall, maintenance of the impounding embankments and emergency outlet works of the Bottom Ash Pond appears to be adequate. No major maintenance issues were noted during the field inspection or in the weekly inspection reports completed by CGS personnel and reviewed by the inspection team.

Some minor maintenance of small erosion areas is warranted. These repairs should be completed within the timeframes discussed in the Executive Summary and Section 5.4 of this report.

4.3.2 Adequacy of Operating Procedures

Based on field observations and discussions with CGS personnel, the operating procedures for the Bottom Ash Pond appear to be adequate.

4.3.3 Adequacy of Surveillance Procedures

CGS personnel complete daily informal inspections and weekly formal inspections on the Bottom Ash Pond dikes in accordance with good engineering practice and Section 257.83 of the Federal Register. These inspections are being properly documented and should continue as they are currently being conducted. The pipe bridge crossings on the southwest edge of the Bottom Ash Pond should be closely inspected following heavy rainfall as outlined in Section 5.4 below.

The Bottom Ash Pond has no formal dam performance monitoring instrumentation. A staff gage in the Wastewater Decant Pond is used to monitor water levels in the Bottom Ash Pond due to their hydraulic connectivity.

5.0 Conclusions and Recommendations

Conclusions are based on visual observations from a one-day site visit on October 5, 2017, and review of technical documentation provided to the inspection team.

5.1 Conclusions Regarding the Structural Soundness of the Management Unit

Based on a review of the engineering data provided and the observations of the inspection team during the site visit, the embankments and emergency outlet of the Bottom Ash Pond appear to be structurally sound under static loading conditions. The dike embankments are also indicated to be stable under moderate seismic loading conditions, provided no excessive loss of shear strength occurs in the Pleistocene foundation soils. Isolated layers of very loose to loose sands and some layers of very soft to soft silty clays occur at depth in the foundation soil profile beneath the dikes. However, localized liquefaction or deformations probably would not be reflected through the firmer and stiffer overlying soils in sufficient magnitude to create unacceptable displacements in the dike embankments under moderate earthquake shaking.

5.2 Conclusions Regarding the Hydrologic/Hydraulic Safety of the Management Unit

An Inflow Design Flood Control System Plan was written by Worley Parsons in October 2016 for the Bottom Ash Pond. Stormwater analysis was performed using Bentley PondPack and it was concluded that the Bottom Ash Pond, with a normal operating elevation of 88.0 feet and emergency overflow structure weir at elevation 89.5' would maintain a water level below the emergency overflow structure weir during the 10-year, 24-hour storm event and would safely pass the 100-year storm even while maintaining a minimum one-foot freeboard, as required.

5.3 Conclusions Regarding Field Observations

The inspection team was provided access to all areas in the vicinity of the Bottom Ash Pond as required to conduct a thorough field inspection. The visible portions of the embankment dikes and emergency outlet structures were observed to have no signs of

overstress, significant settlement, shear failure or other signs of instability. No changes to the geometry of the impounding structures at the Bottom Ash Pond were noted.

5.4 Recommendations for the Bottom Ash Pond

The following maintenance and monitoring items were noted during the field inspection. Recommendations for repair and/or monitoring follow:

1. Minor tractor rutting and occasional minor erosion was noted at various locations on the downstream slope of the Bottom Ash Pond. These areas should be monitored for further displacement of material during weekly inspections. Caution should be exercised when mowing the areas near the drainage ditch and toe of the slope, since this area often retains more moisture. If condition changes are noted in weekly inspections that warrant repair, an engineered solution should be implemented.
2. Erosion of the downstream slope of the Bottom Ash Pond perimeter dike was noted directly below the western pipe bridge. Although no seepage or further movement was noted at the time of inspection, this area should be repaired to prevent further damage to the downstream toe of the perimeter dike within ninety (90) days of the date of this report. Competent, properly compacted soil or rock should be used to complete this repair. These areas should be closely inspected during the station's weekly impoundment inspections, especially after heavy rains.
3. Erosion on the inside slope of the perimeter dike was noted near the western pipe bridge. This area should be repaired and regraded within ninety (90) days of the date of this report.
4. The wet area near the abandoned underdrain outfall should continue to be monitored. If condition changes are noted in weekly inspections that warrant repair, an engineered solution should be implemented.
5. In the vicinity of the coal pile runoff discharge pipe, the low spot should be monitored. If condition changes are noted in weekly inspections that warrant repair, an engineered solution should be implemented.