INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN
BIG BROWN STEAM ELECTRIC STATION
NORTH AND SOUTH BOTTOM ASH PONDS
FREESTONE COUNTY, TEXAS

October 2016

Prepared for:

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PBW Project No. 5196C

PROFESSIONAL CERTIFICATION

This document and all attachments were prepared by Pastor, Behling & Wheeler, LLC under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I hereby certify that the inflow design flood control plan has been prepared in accordance with the requirements of Section 257.82 of the CCR Rule.

Patrick J. Behling, P.E.
Principal Engineer
PASTOR, BEHLING & WHEELER, LLC

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1.0 INTRODUCTION

Luminant Generation Company, LLC (Luminant) operates the Big Brown Steam Electric Station (BBSES) located approximately 10 miles northeast of Fairfield, Freestone County, Texas (see Figure 1). The BBSES consists of two coal/lignite-fired units with a combined operating capacity of approximately 1,150 megawatts. Coal Combustion Residuals (CCR) including fly ash, bottom ash and boiler slag are generated as part of BBSES unit operation. The CCRs are transported off-site for beneficial use by third-parties or are managed/disposed of by Luminant at the BBSES.

The CCR Rule (40 CFR 257 Subpart D - *Standards for the Receipt of Coal Combustion Residuals in Landfills and Surface Impoundments*) has been promulgated by EPA to regulate the management and disposal of CCRs as solid waste under Resource Conservation and Recovery Act (RCRA) Subtitle D. The final CCR Rule was published in the Federal Register on April 17, 2015. The effective date of the CCR Rule was October 19, 2015.

The CCR Rule establishes national operating criteria for existing CCR surface impoundments and landfills, including development of initial and periodic inflow design flood control system plans (IDFCSPs) for all CCR impoundments. Pastor, Behling & Wheeler, LLC (PBW) was retained by Luminant to develop the initial IDFCSP for the CCR impoundments at the BBSES.

1.1 Inflow Design Flood Control System Plan Requirements

Section 257.82 of the CCR Rule specifies that an inflow design flood control system be designed, constructed, operated, and maintained for each existing CCR surface impoundment. The flood control system must adequately:

- Manage flow into the CCR impoundment during and following the peak discharge of the specified inflow design flood.
- Manage flow from the CCR impoundment to collect and control the peak discharge resulting from the specified inflow design flood.

The inflow design flood (IDF) for each CCR impoundment varies based on the hazard potential classification of the impoundment:

- High hazard potential impoundment: Probable Maximum Flood

- Significant hazard potential impoundment: 1,000-year flood
- Low hazard potential impoundment: 100-year flood

The inflow design flood control system plan must be certified by a qualified professional engineer and must document how the inflow design flood control system has been designed and constructed to comply with the requirements of section 257.82 of the CCR Rule.

In accordance with 257.82(c)(3) of the CCR Rule, the initial IDFCSP for an existing CCR surface impoundment must be completed and placed in the facility operating record no later than October 17, 2016. Periodic IDFCSPs must be completed every five years from the completion date of the initial plan. In addition, the IDFCSP must be amended whenever there is a change in conditions that would substantially affect the plan.

1.2 BBSES Impoundments Subject to Inflow Design Flood Control System Plan Requirements

The CCR Rule defines coal combustion residuals such as fly ash, bottom ash, boiler slag, flue gas desulfurization (FGD) materials (gypsum), and related solids generated from burning coal for the purpose of generating electricity by electric utilities and independent power producers. The IDFCSP requirements of the CCR Rule apply to surface impoundments that dispose or otherwise engage in solid waste management of CCRs.

This IDFCSP address the following CCR surface impoundments at the BBSES:

- North Bottom Ash Pond (NBAP); and
- South Bottom Ash Pond (SBAP).

The NBAP and SBAP (collectively "Bottom Ash Ponds" or "BAPs") are located approximately 1,500 feet northwest of the BBSES power plant (Figure 2). The BAPs are located approximately 1,000 feet from Fairfield Lake (normal pool elevation 310 feet above mean sea level (MSL)). The NBAP and SBAP are located immediately adjacent to each other and share an interior earthen embankment. Due to their proximity to each other, the NBAP and SBAP will be considered one CCR surface impoundment (identified as the "BAPs) for the purposes of this IDFCSP.

1.3 Description of Bottom Ash Ponds

A simplified process flow diagram for the BAPs is shown on Figure 3. The BAPs receive recovered overflow from bottom ash dewatering bins and other BBSES process wastewater sources. The ponds also act as a surge basin for stormwater runoff from the BBSES ash-water system and infrequently receive non-hazardous liquid metal cleaning wastes delivered by truck from other Luminant facilities under a Texas Commission on Environmental Quality (TCEQ) industrial waste permit. Bottom ash process water, other process waters and stormwater runoff from the BBSES ash-water system are pumped to each pond through a series of above grade pipes on the east end. The BAPs are located partially above and partially below grade and all material that enters the ponds is pumped into the impoundment – there are no gravity discharges to the BAPs.

A 30-inch diameter subsurface water pipe exits the NBAP on the west end and a 42-inch subsurface water pipe exits the SBAP on the west end. These subsurface lines are connected to a below grade valve box immediately west of the SBAP. Piping from the valve box is connected to a low pressure ash water pump station located east of the SBAP. The BAPs do not have an emergency spillway. Decanted water is returned to the power plant for use in the bottom ash system. When sufficient bottom ash has accumulated in the first pond, the bottom ash slurry is diverted to the second pond. Bottom ash in the first pond is then removed and taken to the nearby Luminant mine for placement in in Area C or other beneficial use.

The NBAP and the SBAP are each approximately 1,400 feet long by 250 feet wide. The BAPs are constructed partially above and partially below grade and are surrounded by engineered earthen embankments that extend approximately 14 to 21 feet above grade. The exterior slopes of the embankments are vegetated with grasses and similar vegetation.

The BAPs were originally constructed in the late 1960s and were relined with a 3-foot thick clay liner in 1989-1990. As-built engineering drawings indicate that the clay liner has a permeability of $<1 \times 10^{-7}$ cm/sec (TXU, 1991; TUEC, 1998). The bottom of the BAPs is located at approximately 328 feet MSL and the crest elevation of the earthen embankments is approximately 350 feet MSL. The design operating fluid/CCR level in the BAPs is approximately 347 feet MSL (approximately 3 feet below the crest of the perimeter embankments). A digital topographic site plan of the BAPs was created from the as-built engineering drawings for the ponds (PBW, 2016). Based on this site plan and using a design operating elevation of 347 feet MSL, the design operating capacity of the NBAP is approximately 40,000,000 gallons (123 acre-ft) and the design operating capacity of the SBAP is approximately 39,700,000 gallons (122 acre-ft). The total design operating capacity of the BAPs is approximately 79,700,000 gallons or approximately 245 acre-ft.

The US Army Corps of Engineers (USACE) classifies the relative size of dams based on the height of the dam and the storage capacity of the impounded area behind the dam (USACE, 1979). As shown in the table below, based on the embankment height (14 to 21 feet above grade) and total operating capacity (245 acre-ft) of the BAPs, the BAPs would be categorized as a small impoundment using the USACE dam size classification criteria:

USACE Dam Size Classification		
Size Category	**Impoundment Capacity (acre-ft)**	**Impoundment Height (ft)**
Small	50 and < 1,000	25 and < 40
Intermediate	1,000 and < 50,000	40 and < 100
Large	> 50,000	> 100

The BAPs are classified as a low hazard potential impoundment in accordance with the requirements of Section 257.73(a)(2) of the CCR Rule (PBW, 2016).

1.4 2014 EPA Evaluation of BAP Hydraulic Capacity

In 2009, the EPA initiated a program to assess the stability and functionality of coal ash impoundments at coal-fired electric generating plants across the United States. The assessment of the stability and functionality of the BBSES BAPs was performed in 2012 by Dewberry Consultants, LLC (Dewberry) on behalf of EPA. The results of the Dewberry assessment were presented in *Coal Combustion Residue Impoundment Round 12 - Dam Assessment Report, Big Brown Steam Electric Station Bottom Ash Pond*, Fairfield, Texas, Dewberry Consultants LLC, March 2014 (Dewberry, 2014).

As part of the assessment, Dewberry evaluated the “Hydrologic/Hydraulic Safety” of the BAPs and concluded the following:

- The BAPs only receive water pumped into the units at a controlled rate and direct rainfall.
- The normal pool elevation of the BAPs is managed to a relatively constant elevation of 347 feet, providing a 3-foot freeboard.
- Dewberry examined the 100-year rainfall event and compared the data with the available freeboard. The freeboard should be adequate to contain the one-percent probability, 24- hour precipitation event (10.6 inches) without overtopping the impoundment embankments.
- Based on the information reviewed, the BAPs were given the highest rating of “Satisfactory” for hydrologic and hydraulic safety.

2.0 HYDRAULIC CAPACITY EVALUATION OF BAPS

The CCR Rule defines the inflow design flood (IDF) as "the flood hydrograph that is used in the design or modification of the CCR surface impoundment and its appurtenant works." From an engineering design standpoint, the IDF is the rate of water coming into a surface impoundment over time that the impoundment must be able to safely pass or contain using a combination of outlet works and surcharge storage (freeboard).

The IDFCSP for the BAPS must demonstrate that the impoundment is designed to manage flow into and out of the units during and following the peak discharge of the specified inflow design flood. This demonstration will be accomplished through calculation of a water balance for the BAPs. The basic equation for the water balance is as follows:

Inflows = Outflows + Change in Impoundment Storage

For the water balance to demonstrate compliance with CCR requirements, the rate of inflows into the BAPs (the inflow design flood) must not be greater than the rate of outflows from the BAPs plus the maximum allowable storage in the impoundment.

2.1 Inflows to BAPs

The BAPs are located partially above and partially below grade and inflows that enter the impoundment are pumped into the units under controlled conditions – there are no gravity or uncontrolled discharges to the BAPs. As shown on Figure 3, water coming into the BAPs consists of the following:

- bottom ash process water
- condensate storage & polishing system water
- boiler feed water treatment water
- make-up water from operating pond (to maintain the operating level in the BAP during periods of low inflows/evaporation); and
- liquid wastes from other Luminant facilities that are delivered to the BAPs by truck in accordance with the TCEQ permit.

Most of the sources of inflow to the BAPs are process units that generate water at controlled rates. The rates at which these inflows are pumped into the BAPs are not significantly affected by variations in precipitation intensity and associated flood conditions.

Stormwater runoff generated from lignite storage areas is also pumped into the BAPs. The quantity of stormwater runoff generated from the lignite storage areas does vary depending on precipitation; however, runoff from the lignite storage areas is allowed to accumulate in these areas and is pumped into the BAPs at a controlled rate managed by trained operators. As a result, the rate at which this inflow is pumped into the BAPs is not significantly affected by variations in precipitation intensity and associated flood conditions.

In addition, the BAPs receive water from direct precipitation on the impoundment itself. This inflow is affected by variations in precipitation intensity and associated flood conditions.

2.2 Outflows from BAPs

Decant water is pumped out of the BAPs and returned to the BBSES bottom ash handling system or transferred to the Operating Pond as a source of process water at the BBSES. The rate of outflow from the BAPs is controlled to maintain the maximum operating level in the impoundment of approximately elevation 347 feet. Based on a crest elevation of approximately 350 feet for the earthen embankments around the BAPs, a minimum 3-foot freeboard is maintained in the BAPs under normal operating conditions.

It should be noted that water is also removed from the BAPs through natural evaporation; however, evaporation from the BAPs was not considered as part of this evaluation.

2.3 Inflow Design Flood for BAPs

As described in Section 1.2, the BAPs are classified as a low hazard potential CCR Impoundment. In accordance with Section 257.82(a)(3) of the CCR Rule, the inflow design flood for a low hazard potential CCR impoundment is the 100-year flood event. Direct precipitation on the BAPs is the only inflow source that is affected by the inflow design flood.

The 100-year, 24-hour storm for the BAPs was estimated to be 8.2 inches based on the 100-Year, 24-Hour Rainfall Graph from US Department of Commerce Technical Paper No. 40 (Hershfield, 1961). A copy of the 100-Year, 24-Hour Rainfall Graph from Technical Paper No. 40 is reproduced in Appendix A.

2.4 Hydraulic Capacity Evaluation

A hydraulic capacity evaluation was performed on the BAPs for the inflow design flood as part of the development of the IDFCSP. The evaluation was based on the water balance equation described above and the following assumptions:

- The BAPs are located above grade and all material that enters the ponds from the BBSES is pumped into the impoundment – there are no uncontrolled gravity discharges to the BAPs.
- The design operating level in the BAPs is approximately elevation 347 feet and the crest elevation of the earthen embankments around the BAPs is approximately 350 feet. As a result, a minimum 3-foot freeboard is maintained in the BAPs under normal operating conditions.
- Inflows to and outflows from the BAPs considered as part of the evaluation are as described in Sections 2.1 and 2.2 of this report.
- The rate of water decanted from the BAPs (process outflow) is assumed to be equivalent to the inflow of process water to the impoundment (except for direct precipitation on the BAPs) during the design flood event so that the design operating level of 347 feet is maintained in the BAPs.
- Stormwater runoff from the lignite storage areas is not pumped to the BAPs during the design flood event. As a result, the lignite storage areas will accumulate stormwater.
- Truck deliveries of process waters from other Luminant facilities is assumed to be negligible based on historical usage and would not be allowed during a storm event.
- Evaporation from the BAPs is assumed to be negligible during the design flood event.

Based on these assumptions, the general water balance equation for the BAPs can be modified as follows:

Process Inflows + Direct Precipitation = Process Outflows + Change in BAP Storage

Since the rate of water decanted from the BAPs (process outflow) is assumed to be equivalent to the process water inflows to the impoundment, the BAP water balance equation becomes:

Direct Precipitation = Change in BAP Storage

For the 100-year, 24-hour design flood event, direct precipitation on the BAPs is estimated to be 10.60 inches. Based on the above equation, the water surface in the BAPs would rise 10.60 inches (approximately 0.9 feet) to accommodate this precipitation. Since the design operating level for the BAPs is Elevation 347 and the crest elevation of the earthen embankments around the BAPs is approximately 350 feet, the resulting water surface elevation of 347.9 feet would still allow for approximately 2.1 feet of freeboard to remain in the BAPs. As a result, the BAPs are adequately designed to manage the inflow design flood in accordance with Section 257.82 of the CCR Rule.

3.0 INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN FOR BAPS

As currently configured, the BAPs are adequately designed to manage the 100-year, 24-hour inflow design flood in accordance with Section 257.82 of the CCR Rule. The BAPs should be operated in accordance with the following Inflow Design Flood Control System Plan to maintain adequate freeboard in the impoundment to manage the design flood conditions:

- The operating level in the BAPs should be maintained at approximately elevation 347 feet MSL or lower to provide a minimum 3 feet of freeboard in the impoundment under normal operating conditions.
- The rate of water decanted from the BAPs (process outflow) should be equivalent to the inflows of process water pumped to the impoundment during the design flood event so that the operating level of 347 feet is maintained in the BAPs.
- Stormwater runoff from the lignite storage areas should not be pumped to the BAPs during heavy precipitation events until Luminant personnel document through visual inspection that adequate freeboard is available in the BAPs. As a result, the lignite storage areas will accumulate stormwater during periods of heavy precipitation until such time as the water can be pumped to the BAPs or otherwise managed.
- Truck deliveries of process waters from other Luminant facilities should be suspended during periods of heavy precipitation.

In accordance with 257.82(c)(3) of the CCR Rule, this initial IDFCSP must be placed in the BBSES facility operating record no later than October 17, 2016. Subsequent periodic IDFCSPs must be completed every five years from the completion date of this initial plan. In addition, the IDFCSP must be amended whenever there is a change in conditions that would substantially affect the plan.

4.0 REFERENCES

Dewberry Consultants, LLC (Dewberrry), 2014. *Final Coal Combustion Residue Impoundment Round 12 - Dam Assessment Report, Big Brown Steam Electric Station Bottom Ash Pond, Fairfield, Texas*, EP-09W001727, March.

Hershfield, OM. 1961. Rainfall Frequency Atlas of the United States for Durations from 30 minutes to 24 hours and Return Periods from 1 to 100 Years, U.S. Dept. Commerce, Weather Bureau. Technical Paper No. 40. Washington, DC.

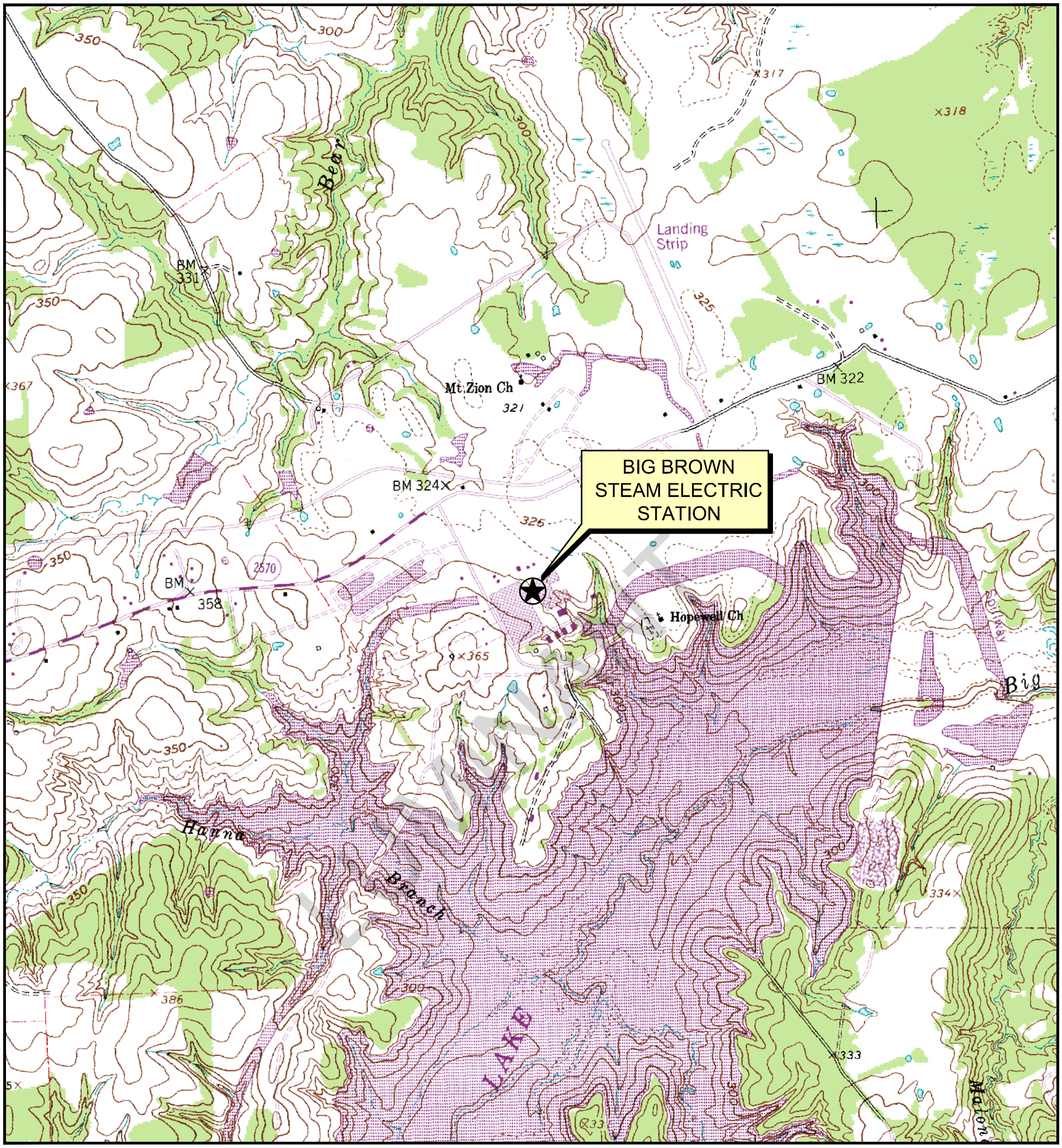
Pastor, Behling & Wheeler, LLC (PBW), 2016. Hazard Classification Assessment – Big Brown Steam Electric Station North and South Bottom Ash Ponds, Freestone County, Texas. October.

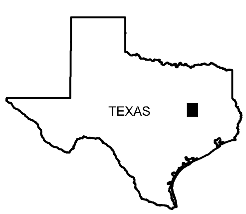
Texas Utilities Electric Company (TUEC), 1998. *Application for Permit to Receive and Process Non-Hazardous Solid Waste, Big Brown Steam Electric Station, Freestone County, Texas*. February.

TXU Electric Company (TXU), 1991. As-Built Engineering Drawings 119-1134-301-01, 119-1134-301-02, and 119-1134-301-03, Big Brown Steam Electric Station – Bottom Ash Ponds, February 8.

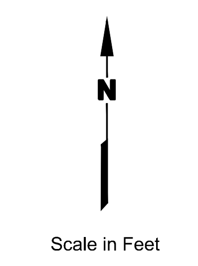
United States Army Corps of Engineers (USACE), 1979. *Recommended Guidelines for Safety Inspections of Dams*, ER 1110-2-106, September 26.

Figures





QUADRANGLE LOCATION



Scale in Feet

SOURCE:
Base map from www.tnris.gov, Young, TX 7.5 min. USGS quadrangle dated 1961, revised 1982.

LUMINANT GENERATION COMPANY, LLC
BIG BROWN STEAM ELECTRIC STATION

Figure 1

SITE LOCATION MAP

PROJECT: 5196C	BY: ADJ	REVISIONS
DATE: AUG., 2016	CHECKED: RBL/PJB	

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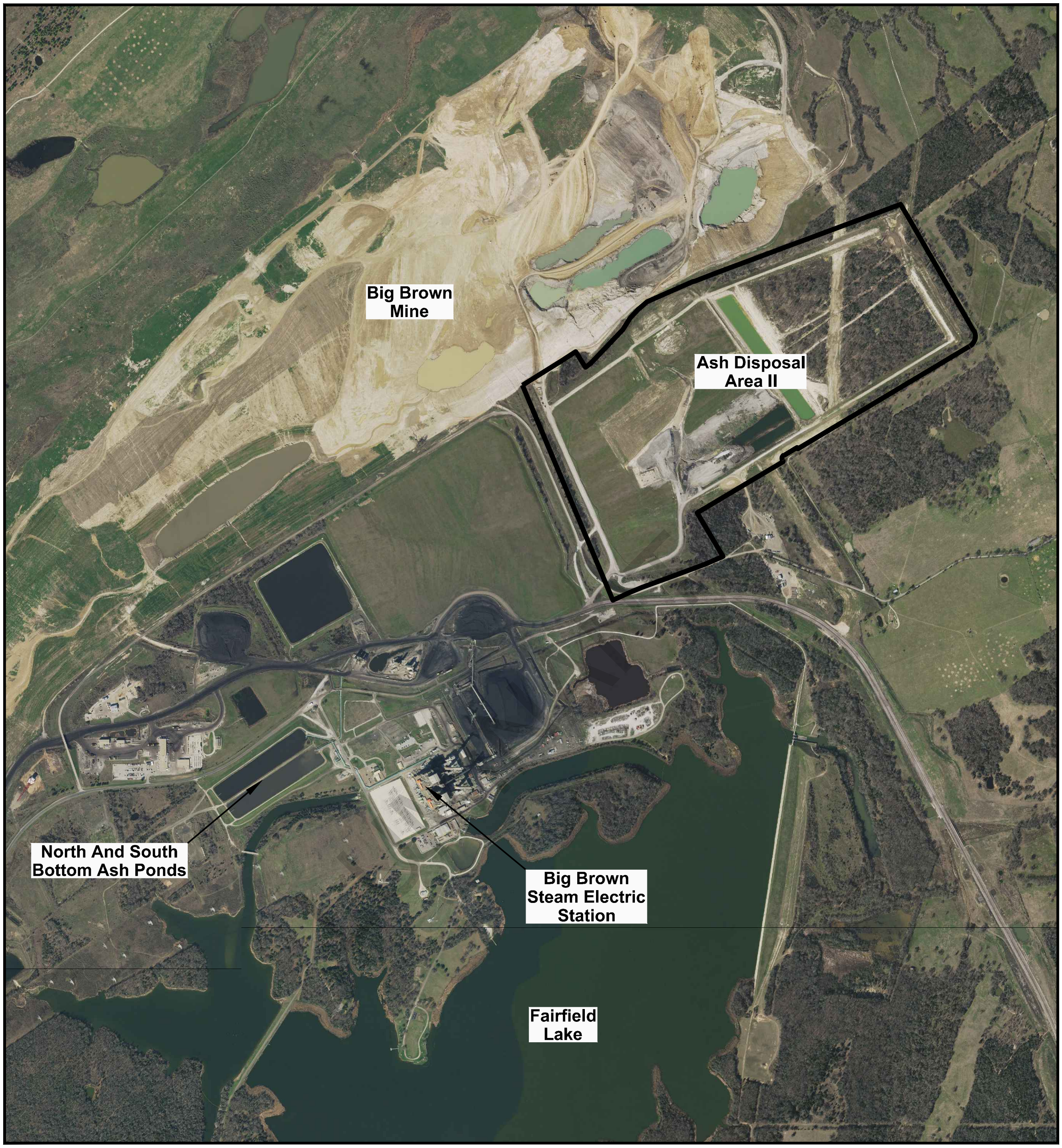

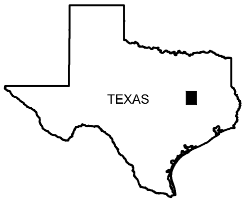

PHOTOGRAPH LOCATION

N

Scale in Feet

0 1000 2000

SOURCE:
Imagery from www.tnris.gov, Young, aerial photographs, 2015.

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BIG BROWN STEAM ELECTRIC STATION

Figure 2

SITE VICINITY MAP

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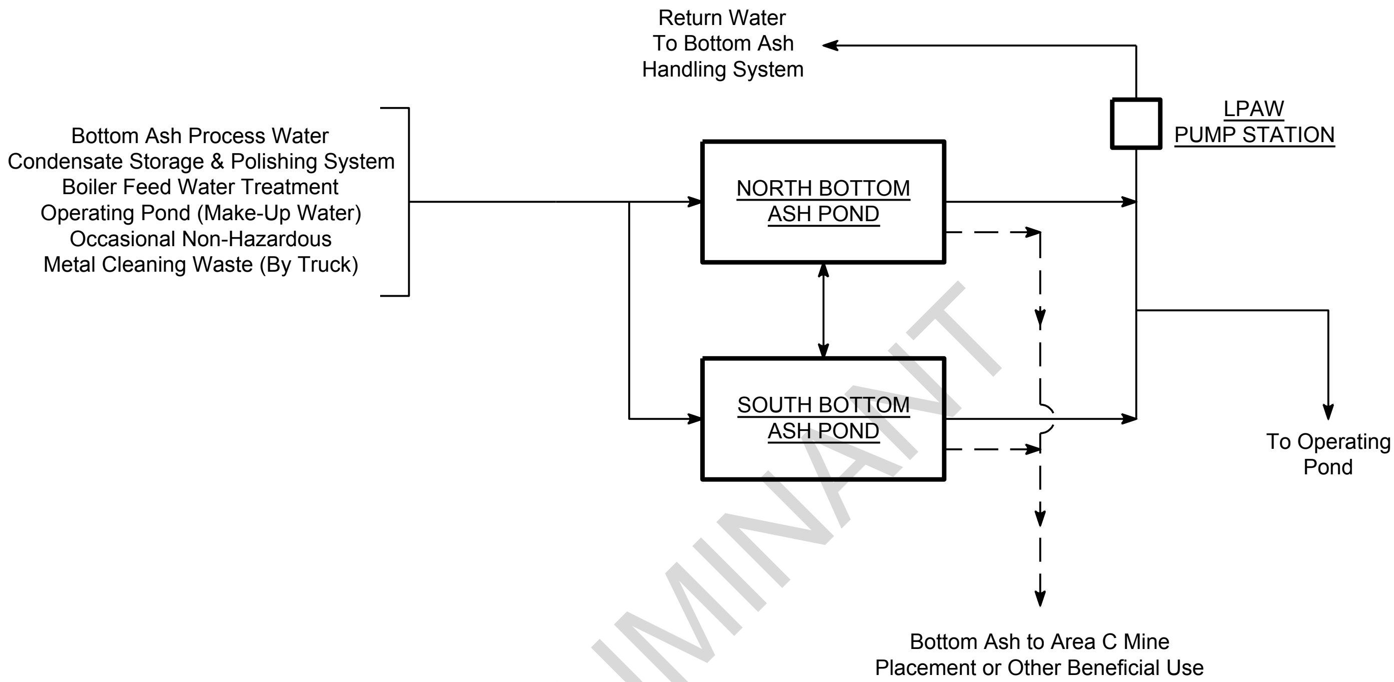

EXPLANATION

Water

Solids

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BIG BROWN STEAM ELECTRIC STATION

Figure 3

SIMPLIFIED CCR SURFACE IMPOUNDMENT FLOW DIAGRAM

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DATE: SEP, 2016	CHECKED: PJB	

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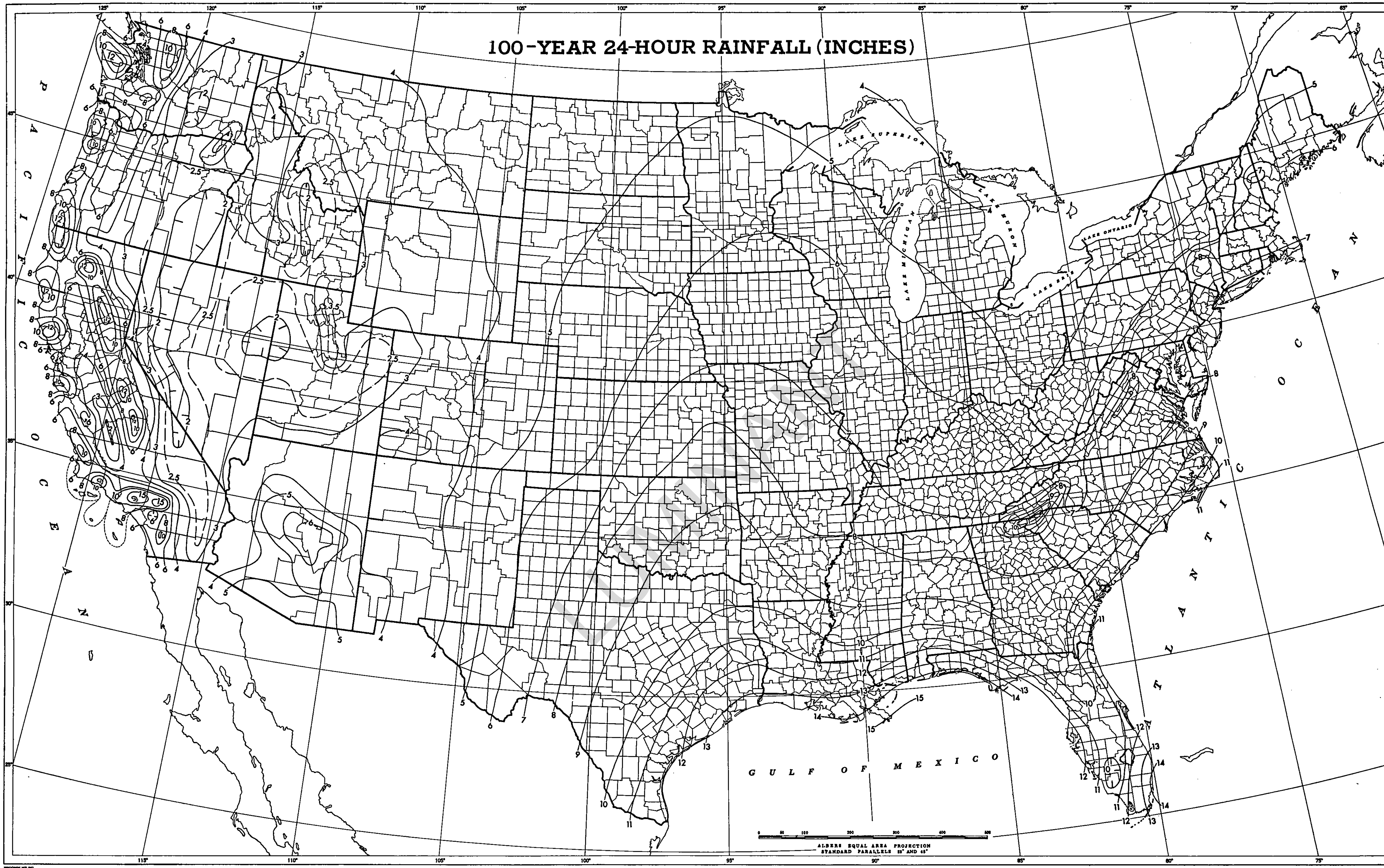
Appendix A

US Department of Commerce Technical Paper No. 40
100-Year, 24-Hour Rainfall Graph


100-YEAR 24-HOUR RAINFALL (INCHES)
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°