



October 15, 2018

Tennessee Valley Authority
1101 Market Street
Chattanooga, Tennessee 37402

**Engineer’s Certification of Unstable Area Demonstration
Peabody Ash Pond
EPA Final CCR Rule
TVA Paradise Fossil Plant
Drakesboro, Kentucky**

1.0 PURPOSE

The purpose of this document is to certify that the Unstable Area Demonstration for the TVA Paradise Fossil Plant (PAF) Peabody Ash Pond is in compliance with the unstable area location requirements in the EPA Final CCR Rule at 40 CFR § 257.64.

2.0 BACKGROUND

As required by 40 CFR § 257.64 of the EPA Final CCR Rule, by October 17, 2018, an owner or operator of an existing surface impoundment or landfill must complete the unstable area demonstration. An existing CCR surface impoundment or landfill must not be located in an unstable area unless the owner or operator demonstrates that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit so that the integrity of the structural components of the CCR unit will not be disrupted.

In support of the above assessment, AECOM completed the evaluation described in the referenced “Engineer’s Certification of Unstable Area Demonstration (40 CFR § 257.64) for Coal Combustion Residuals (CCR), Existing Surface Impoundment – Peabody Ash Pond”, dated October 10, 2018. A complete listing of documents reviewed and utilized as part of this assessment is included in the References at the end of the report.

3.0 SUMMARY OF FINDINGS

Based upon the findings of the referenced Engineer’s Certification of Unstable Area Demonstration, AECOM has concluded that the Peabody Ash Pond meets the requirement of the EPA Final CCR Rule § 257.64(a).

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4.0 Qualified Professional Engineer Certification

I, Nicholas Golden, being a Professional Engineer in good standing in the State of Kentucky, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this certification has been prepared in accordance with generally accepted engineering practices; that the information contained herein is accurate as of the date of my signature below; and that Peabody Ash Pond meets the unstable area requirements of 40 CFR § 257.64(a).

SIGNATURE  _____

DATE 10/15/18

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ATTACHMENTS: Engineer's Certification of Unstable Area Demonstration (40 CFR § 257.64) for Coal Combustion Residuals (CCR) Existing Surface Impoundment – Peabody Ash Pond



COAL COMBUSTION PRODUCT DISPOSAL PROGRAM

**TENNESSEE VALLEY AUTHORITY – PARADISE FOSSIL PLANT
PEABODY ASH POND
DRAKESBORO, KENTUCKY**

**ENGINEER'S CERTIFICATE OF
UNSTABLE AREA DEMONSTRATION
(40 CFR §257.64)
FOR COAL COMBUSTION RESIDUALS (CCR)
EXISTING SURFACE IMPOUNDMENT**

Prepared for



Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

October 15, 2018 – Rev 0

Prepared by





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1.0 BACKGROUND

1.1 OBJECTIVE

The purpose of this Unstable Area Demonstration report is to evaluate compliance with 40 CFR § 257.64(a) of the Environmental Protection Agency Final Coal Combustion Residual Rule (EPA Final CCR Rule). This Report is based on existing documentation such as construction drawings, record drawings, and any other pertinent data and/or investigations to support historic conditions and operations at the Peabody Ash Pond at the Tennessee Valley Authority (TVA) Paradise Fossil Plant (PAF). All supporting pertinent documentation is located in the attached appendices.

1.2 RULE REQUIREMENTS

According to 40 CFR § 257.64(a) of the EPA Final CCR Rule, any new CCR landfills, existing, and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in an unstable area unless the owner or operator demonstrates that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.

In accordance with 40 CFR § 257.64(b), the owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable:

- 40 CFR § 257.64(b)(1) – On-site or local soil conditions that may result in significant differential settling;
- 40 CFR § 257.64(b)(2) – On-site or local geologic or geomorphologic features, and
- 40 CFR § 257.64(b)(3) – On-site or local human made features or events (both surface and subsurface).

40 CFR § 257.64(c) requires must obtain a certification from a qualified professional engineer stating that the demonstration meets the requirements of paragraph (a) of this section. In accordance with 40 CFR § 257.64(d)(1) the owner or operator must complete the required demonstration no later than October 17, 2018.

1.3 SITE DESCRIPTION

PAF is located in Drakesboro, Kentucky along the west bank of the Green River and State Route 176. The plant sits inside the eastern border of Muhlenberg County as depicted below in **Figure 1**. The plant features three units, constructed between 1963 and 1970, and three large natural-draft cooling towers. Units 1 and 2 were retired in 2017.



Figure 1: PAF Aerial View

Peabody Ash Pond first existed as a mining pond. TVA purchased the land on which Peabody sits between 1988 and 1996. Previous strip mining activities resulted in a mining pond made by dikes along the southern and eastern sides of what is today called Peabody Ash Pond. Surface mining in the area was conducted from 1960 to 1981. Subsequent surface mining operations were conducted within the area of Peabody Ash Pond between 1974 and 1991.

The impoundment has also been known as Jacob's Creek Ash Disposal Area Extension, and the original dikes were at an elevation of 400 feet. Construction documentation of the original dike could not be obtained. The dikes were raised to an elevation of 408 feet in 1997. In addition, a divider dike was built at this time, creating the Peabody Stilling Pond. Construction of the raised dike and Stilling Pond took place between February and September of 1997, with Peabody Ash Pond operations beginning immediately following construction. The original pond was known as the Ash Disposal Area and was later renamed to Peabody Ash Pond. Peabody Ash Pond is bordered by the closed former Jacob's Creek Ash Pond on the north side, Jacob's Creek on the east side, two lagoons on the south side, and hilly and grassy areas to the west (See **Figure 2**).



Figure 2. Site Overview

2.0 SITE ASSESSMENT

Per § 257.64(b) the unstable area demonstration must consider features or events when determining whether the area is unstable. An investigation of publicly available information and a desktop reconnaissance were examined in order to meet the requirements of § 257.64(b).

Historical mining was performed across the majority of the PAF property. In 2017, AECOM performed a desktop review of available information and site investigations pertaining to the Peabody Ash Pond. A review of available information obtained from the Kentucky Division of Mine Safety (DMS) and online maps from the Kentucky Mine Mapping Information System was previously performed by AECOM. Figure 3, Peabody Ash Pond Underground Map, displays the historic mines.

A review of available information obtained from the Kentucky Division of Mine Safety (DMS) and online maps from the Kentucky Mine Mapping Information System was previously performed by AECOM. Based on review of historical mine maps, two coal mines are located below the site, the Drake III Mine and Browder Mine (Attachment A). The Drake III Mine (KY Mine ID 06620-4) is located below the northern portion of the site, and was mined by the Pittsburg and Midway Coal Mining Company. This mine targeted the Coal Seam 9 via pillar and partial room extraction methods. Coal seam height generally varied from 5 to 6 feet thick, and mining pillars were on the order of 26 feet square, with an approximate 25 foot opening. The mining efforts took place from 1971 to 1979. After the abandonment of the Drake III mine in 1979, surface mining of the Coal Seam 9 was performed from 1982 to 1991. Historic documentation suggests the deep mines of Drake III were destroyed as part of these surface mining efforts to collect the remaining coal. The removal of the Drake III mine was not extensively documented.

Based on review of the mine map, the Browder Mine is located below the southwestern portion of the site, and was mined by the W.A. Wickliffe Coal Company until 1951. The mine map indicates rectangular pillars with dimension of about 55 by 18 feet, with 24 foot opening, were used in the Browder Mine.

AECOM performed a geotechnical exploration from January to May 2016 to support landfill design in accordance with KDEP requirements for a solid waste facility. A total of 55 borings were performed as part of the exploration, spaced on a regular pattern within the proposed landfill site. Eight of the borings were advanced through bedrock in an effort to verify the presence or absence of underground mining features related to No. 9 Coal Seam.

A coal layer was encountered near the elevation of the No. 9 Coal Seam. Unrecovered core losses, which were interpreted as voids and may indicate the presence of deep mines below the site, were generally recorded in the rock core borings at the approximate elevation of the No. 9 coal seam, with the exception of boring F-6, which encountered a relatively intact layer of coal.

AECOM performed a supplemental investigation in December 2016 and January 2017 in order to further characterize the bedrock and mine conditions below the proposed landfill. The exploration consisted of drilling two borings, UG-1 and UG-2, within the area of the first proposed landfill cell. Both of the borings were advanced through Coal Seam 9 mine interval and into the underlying rock. **Table 1** presents a summary of the depths and elevations where the No. 9 Coal Seam or mine workings were encountered during the AECOM explorations:

TABLE 1: AECOM SUMMARY OF NO. 9 COAL SEAM DEPTHS				
BORING	SURFACE ELEVATION	NO. 9 COAL SEAM (PARADISE MINE)		REMARKS
		COAL SEAM DEPTH RANGE (FT.)	COAL SEAM THICKNESS (FT.)	
A-3	461.6	178.3 – 184.3	6.0	Void encountered at No. 9 Coal Seam elevation
B-1	447.1	161.0 - 171.5	10.5	Low recovery encountered at No. 9 Coal Seam elevation
C-5	443.2	NA	NA	Boring terminated above No. 9 Coal Seam elevation
D-5	425.6	162.5 – 170.4	7.9	Void encountered at No. 9 Coal Seam elevation
E-5	413.6	140.0 – 145.2	5.2	Void encountered at No. 9 Coal Seam elevation
F-6	461.9	168.0 – 174.0	6.0	Relatively intact coal at No. 9 Coal Seam elevation
H-2	448.3	155.0 – 161.6	6.6	Void encountered at No. 9 Coal Seam elevation



TABLE 1: AECOM SUMMARY OF NO. 9 COAL SEAM DEPTHS

BORING	SURFACE ELEVATION	NO. 9 COAL SEAM (PARADISE MINE)		REMARKS
		COAL SEAM DEPTH RANGE (FT.)	COAL SEAM THICKNESS (FT.)	
I-2	439.2	153.9 – 160.9	7.0	Void encountered at No. 9 Coal Seam elevation
UG-1	473	181.6 – 191.0	-9.4	5 ft. void with 4.4 ft. muck pile encountered at No. 9 Coal Seam elevation
UG-2	455	149.8 – 166.0	-16.2	8.1 ft. total void with 9.2 ft. of rubble encountered at No. 9 Coal Seam elevation

3.0 FOUNDATION CONDITIONS

3.1 SITE GEOLOGY

PAF is located within the Shawnee Hills Section of the Interior Low Plateaus Physiographic Province in Northwestern Kentucky. Major geologic units in the area from the ground surface downward include Quaternary Age Alluvium and Residuum, the Upper Pennsylvanian Age Sturgis Formation and the Middle Pennsylvanian Age Carbondale Formation. The Sturgis Formation is made up of the former Lisman and Henshaw formations. Unmined areas, particularly in the flood plain of the Green River, consist of Quaternary Alluvial Sands, silts, and clays. Upland areas may consist of up to 25 feet of residual material derived from the weathering of shale and sandstone bedrock materials.

The site is located in the Western Kentucky Coal Field, an extension of the Illinois Basin, a depositional and structural feature centered in Illinois and extending into parts of Kentucky and Indiana. The Illinois Basin is Paleozoic in age and bounded to the north by the Wisconsin arch, to the East by the Cincinnati arch, to the Southeast by the Nashville dome, to the southwest by the Ozark dome, and to the northwest by the Mississippi River arch.

The Site is located within the Moorman Syncline, a surface expression of the Rough Creek Graben. Late Middle-Pennsylvanian Age rock exposures have been mapped in close proximity to the Site and comprise the Carbondale Formation. This formation extends from the Davis coal (W. Ky. No. 6) at the base of the formation to the Herrin coal (W. Ky. No. 11) at the top. The Cochester coal (W. Ky., No. 8) and overlying Springfield coal (W. Ky. No. 9) are also found within the Carbondale formation. The Springfield and Herrin coals are the most extensively mined coals of the Carbondale Formation. In Western Kentucky, from one coal to the next, a general stratigraphic series associated with a single sedimentary cycle, also called a cyclothem, may be found that consists of the following vertical sequence: coal-thin dark shale-silty gray shale, sandstone-seat earth-next coal. Limestone, part of a classic cyclothem, is uncommon in

Western Kentucky and localized differences in depositional history lead to variations in the occurrence in thickness of sandstones across individual cyclothem.

The previous strip mining operations left earth fill dikes along the southern and eastern sides of Peabody Ash Pond, with dike crests at elevation 400 feet. These dikes were later raised to 408 feet.

The original embankment fill materials generally consist of moist, stiff, silty, lean clay (CL) with irregular quantities of silt, sand, coal and rock fragments indicating that the original embankment was constructed using the local mine spoil materials.

The raised embankment of the Peabody Ash Pond dike consists of moist, stiff, lean clay (CL) with some rock fragments. The embankment materials consist of mine spoils, and the embankment was constructed in a controlled manner with compactive effort. The embankment fill extends from the crest elevation (approximately 408 feet) to elevations of approximately 400 feet to 395 feet, resulting in an embankment varying from 8 to 13 feet in thickness.

3.2 SUBSURFACE CONDITIONS

(b) The owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable.

3.2.1 SOIL CONDITIONS

(b)(1) the owner or operator must consider the on-site or local soil conditions that may result in significant differential settling in determining whether an area is unstable.

Stantec (2010) performed drilling and sampling including twenty-two hollow stem auger borings along the crest and exterior toe of the dike. In addition, nine of the borings were completed as piezometers. AECOM (2015) performed an additional geotechnical exploration to supplement the existing data. The exploration included advancing four Cone Penetration Test (CPT) soundings with pore pressure dissipation testing along the crest of the dike.

The original embankments and the raised dike were constructed of stiff mine soil materials consisting generally of moist lean clay with irregular quantities of silt, sand, and coal and rock fragments. Underlying soils included mine spoil materials, bottom ash, and weathered shale materials. The Safety Factor Assessment completed in 2016 determined that there were no areas within the soil materials that were deemed to be unstable.

3.2.1 §257.64(B)(2) SITE GEOLOGIC/GEOMORPHIC FEATURES

(b)(2) the owner or operator must consider on-site or local geologic or geomorphologic features

PAF is located in the central portion of western Kentucky along the west shore of the Green River just north (downstream) of the confluence of the Green River and Jacob's Creek. The region is underlain by coal rich Pennsylvanian age bedrock formations. Strip mining operations have significantly altered the topography and geology within the vicinity of the plant and, as such, portions of the site are likely underlain by mine spoils. Geologic mapping indicates the plant and surrounding areas are underlain by the Sturgis and Carbondale Formations in general order of descending geology. The Sturgis Formation is described as consisting of interlayered medium- to coarse-grained micaceous sandstone, silty and clayey shale, coal, and underclay. The Carbondale Formation generally consists of cyclic sequences of fine-grained sandstone, sandy shale, coal, and silty underclay. Although not depicted on the geologic mapping, alluvial deposits are likely present along the banks of the Green River. The geologic mapping indicates this alluvium generally consists of gravel, sand, silt, and clay and may be as much as 90 feet thick.

The Green River occupies a relatively flat-bottomed, alluvium-filled valley formed by the erosion of weak Pennsylvanian shales (Ryder, 1974). During Pleistocene time, the Green River was filled with coarse-grained deposits (fine sand to gravel) derived from the glaciers to the north and transported to the area by the Ohio River. Eventually, the Green River drainage basin became choked with sediment, causing impoundment of the north-flowing streams and deposition of finer-grained sediments (clay and silt) overlying the coarse deposits.

Beneath the residuum and the alluvial deposits, bedrock was encountered. Results from recovered cores consisted of two distinct bedrock units. One consists of moderately hard, fine to coarse grained, thinly bedded sandstone with occasional shale and clay seams, which appear to be part of the Carbondale Formation. The other consists of durable, dark gray, thinly bedded, laminated shale with occasional clay seams. The shale appears to be part of the Shelburn Formation.

3.3 §257.64(b)(3) NATURAL AND MAN MADE UNSTABLE AREAS

(b)(3) the owner or operator must consider on-site or local man-made features or events (both surface and subsurface)

AECOM analyzed publicly available information, historical drawing and recent geotechnical, structural and safety reports in order to determine the presence of unstable areas. The following sections examine potential natural and man-made unstable areas that may be present within the site.

3.3.1 NATURAL UNSTABLE AREAS

The Sturgis Formation (containing the former Lisman Formation) consists of interbedded sandstone, siltstone, shale, limestone, and coal. The contact between the Sturgis and Carbondale formation is the top of the Number 11 coal seam. The Carbondale Formation underlies the Sturgis and consists of alternating sandstone, siltstone, coal, silty shale, and limestone in some areas. It is the major coal producing formation in the Western Kentucky Coal Field and includes Coal Seam Numbers 6 through 11.

No karst or other natural unstable areas have been noted within the site.

3.3.2 MAN-MADE UNSTABLE AREAS

The desktop review completed by AECOM in 2017 reviewed available geotechnical and mining data previously discussed. Review of historical geotechnical explorations and mine maps indicate the site and surrounding area are underlain by mine spoil deposits from previous mining operations. Based on review of historical mine maps, one inactive coal mine is located below the site, the Sinclair 286 Mine. Collapse of abandoned mine works generally could result in surface subsidence and potentially compromise the structural integrity of the unit’s embankments. In support of the desktop review completed by AECOM, a Deep Mine Stability Assessment was performed in 2018 to assess the potential structural impacts the mine found within the site will have on the integrity of the impoundment.

Engineering analysis of the mine geometry, pillar stability and bearing capacity of the existing mines were conducted in the Deep Mine Stability Assessment to evaluate the potential for future mine instability.

3.3.2.1 Pillar Stability

A Pillar Stability Analysis was performed in order to evaluate the factor of safety against pillar collapse for existing conditions of Sinclair 286 Mine. The stability analysis was performed using the tributary method within the SDPS program which consists of dividing the pillar strength, calculated using five pillar strength formulas, by the overburden load carried by the pillar. The target factors of safety are based on general accepted standard of engineering practices. The target factor of safety and calculated factor of safety are presented below in Table 3.

TABLE 3: PILLAR STABILITY RESULTS				
METHOD	PILLAR STRENGTH (PSI)	PILLAR STRESS (PSI)	TARGET FACTOR OF SAFETY	CALCULATED FACTOR OF SAFETY
Bieniawski	1980	537	1.75	3.7
Holland-Gaddy	1325	537	2.0	2.5

3.3.2.2 Bearing Capacity

In addition to the Pillar Stability Analysis, the Bearing Capacity was assessed as the stresses within the pillars due to supporting the overburden is transferred from the pillars to the mine floor. These stresses can exceed the capacity of the mine floor rock which can lead to excessive pillar settlement or bearing capacity failure of the floor. The calculated pillar stresses, strengths, and factor of safety for each mine condition is presented in Table 4 below. The calculated factors of safety for the mines are well above the target factors of safety for the conditions examined.



TABLE 4: BEARING CAPACITY FACTOR OF SAFETY				
MINE CONDITION	PILLAR STRESS (PSI)	ALLOWABLE BEARING CAPACITY (PSI)	TARGET FACTOR OF SAFETY	CALCULATED FACTOR OF SAFETY
Dry	618	7,000	3.0	11.3
Wet	618	6300	3.0	10.1

3.3.2.3 **Man-Made Unstable Areas Conclusion**

A review of the available information and an analysis of the existing pillars determined that the existing mine is stable and has a low risk of impact to Peabody Ash pond due to pillar crushing, bearing capacity failure, or roof beam failure. Therefore the integrity of the CCR unit has been demonstrated through analysis with adequate factors of safety to meet the requirements of § 257.64 with respect to the presence of underground mines.

4.0 HISTORICAL REMEDIAL ACTION

No record or knowledge of historical structural instabilities have been identified for Peabody Ash Pond. This CCR unit is subject to TVA’s CCP Storage Facilities Inspection Program. The inspection program includes scheduled formal, intermediate, and informal inspections as well as unscheduled special (emergency) inspections. Additionally, TVA plant personnel make daily observations and perform weekly reviews of the disposal areas. Maintenance is performed on an as-needed basis, and TVA documents all repair and maintenance activities.

No large scale (i.e. global) instability conditions have been identified at the site. Furthermore, no historic evidence of deep mine collapse such as sinkholes are known to have occurred on the PAF property.

5.0 CONCLUSIONS

AECOM has concluded that TVA PAF Peabody Ash Pond meets the unstable area requirements specified within 40 CFR § 257.64 of the EPA Final CCR Rule and poses no imminent threat.

6.0 REFERENCES

- AECOM, Peabody Ash Pond, History of Construction (40 CFR §257.73(c)) for CCR Certification, 2016.
- AECOM, Peabody Ash Pond, Geotechnical Exploration and Analysis CCR Rule Compliance (Rev. 0), 2016.
- AECOM, Peabody Ash Pond, Initial Structural Stability Assessment (40 CFR §257.73 (d)(1))

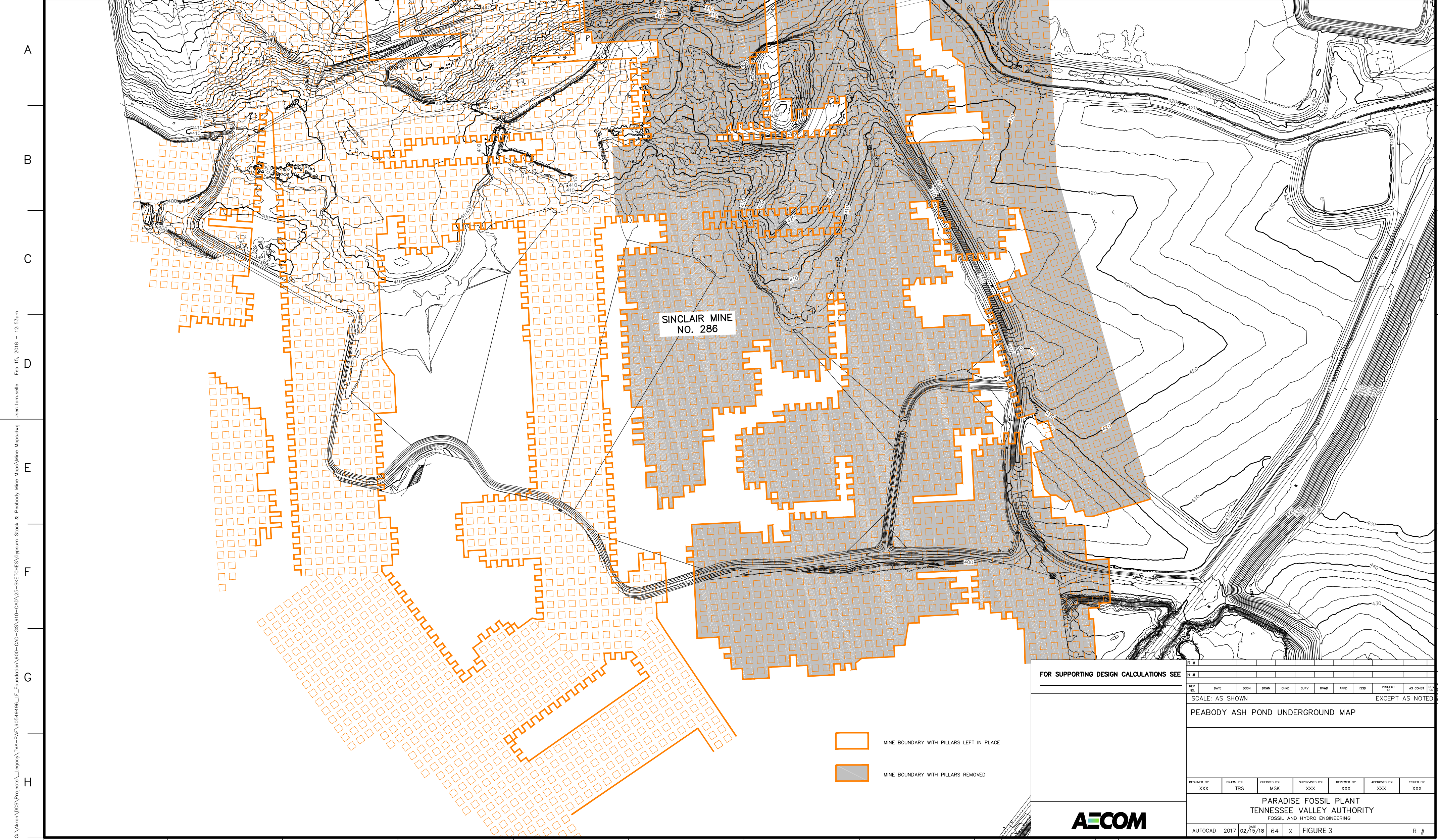


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- AECOM, 2018. Deep Mine Stability Assessment Peabody Ash Pond, TVA Paradise Fossil Plant. September 10, 2018.
- Kentucky Mine Mapping Service, 2015. Online Interactive Mine Mapping Accessed at: <http://epcgis.ky.gov/flexviewers/minemapping/> on January 21, 2015.
- University of Kentucky Geological Survey, 2015. Online Geologic Interactive Map. Accessed at: <http://kgs.uky.edu/kgsmmap/kgsgeserver/viewer.asp> on January 21, 2015.

FIGURES

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SINCLAIR MINE
NO. 286

-  MINE BOUNDARY WITH PILLARS LEFT IN PLACE
-  MINE BOUNDARY WITH PILLARS REMOVED

FOR SUPPORTING DESIGN CALCULATIONS SEE

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT	AS CONST.	REV. BY

SCALE: AS SHOWN EXCEPT AS NOTED

PEABODY ASH POND UNDERGROUND MAP

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:
XXX	TBS	MSK	XXX	XXX	XXX	XXX

PARADISE FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD	2017	02/15/18	64	X	FIGURE 3	R #
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AECOM
TASK COMPLETED BY: REV NO.

PLOT FACTOR:XX
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY