Siting Board Post-Hearing 1-1:

Provide amount of property tax that is likely to be generated as result of Kentucky Municipal Energy transferring the substation to LG&E/KU.

Response: Please see response to Item 100 of the First Request for Information, which states: The LG&E substation will not be exempt from property taxation. Final substation configuration will not be known until after completion of the interconnection study in May 2025, but LG&E's share could amount to $5-15 million depending on the configuration. The substation is expected to be classified for tax purposes as manufacturer's machinery, which is exempt from local property taxes. The Commonwealth of Kentucky taxes manufacturer's machinery at a rate of 0.15%, so the state could receive between $7,500 and $22,500 annually in property taxes. LG&E will also own a few acres of land for the substation, but the taxable value will be only around $50,000, meaning that related local and state real estate property tax revenues will be less than $1,000 per year.

Witness: Doug Buresh

Siting Board Post-Hearing 1-2:

Provide any geotechnical reports that have not been provided to the Siting Board. Specifically, any reports regarding site development and previous mine use.

Response: RESPEC completed two reports (attached) looking at subsidence risk. Phase I report is dated November 2023 and the Phase II report is dated August 2024.

Witness: Doug Buresh

Siting Board Post-Hearing 1-3:

Provide a table with the distances from the nearest nonparticipating residence (dwelling, not property line) to the following:

a. Fencing.

b. Engine Hall.

c. Exhaust Stack.

d. Substation.

Response:

a. Fencing to Hendricks' residence approximately 700'

b. Engine Hall to Hendricks' residence approximately 850'

c. Exhaust Stack to Hendricks' residence approximately 1350'

d. Substation Fence to Hendricks' residence approximately 265'

Witness: Doug Buresh

PHASE I ANALYSIS OF POTENTIAL CONSTRUCTION SITE NEAR MADISONVILLE, KENTUCKY

PREPARED FOR
Bradley Kushner
nFront Consulting
2465 Southern Hills Ct.
Oveido, Florida 32765

NOVEMBER 2023

RESPEC.COM

PHASE I ANALYSIS OF POTENTIAL CONSTRUCTION SITE NEAR MADISONVILLE, KENTUCKY

PREPARED BY

RESPEC
146 East Third Street
Lexington, Kentucky 40508

PREPARED FOR

Bradley Kushner
nFront Consulting
2465 Southern Hills Ct.
Oveido, Florida 32765

NOVEMBER 2023

RESPEC

EXECUTIVE SUMMARY

nFront Consulting is evaluating the feasibility of the construction of a power supply on property in Madisonville, Kentucky. The site consists of 18 acres.

- The property in this area is underlain by 5 coal seams. Two seams, the West Kentucky #9 and West Kentucky #11 were mined directly underneath the project area. The West Kentucky #12, West Kentucky #13, and West Kentucky #14 have been economically mined near the area.
- There are no seams below the project area that may be developable by underground mining or surface mining.
- The surface ownership in the area is usually severed from the mineral ownership. In addition, mineral leases are seam-specific.
- Surface mining requires both mineral rights and surface rights.
- Underground mining only requires mineral rights, except for areas where there is surface activity, such as portals, shafts, preparation plants, rail loadout, and coal refuse disposal areas.
- No coal can be mined without a mining permit.
- An original underground mine permit application and amendments require public notice of the surface owner. Revisions do not require surface owner notification. The surface owner must be alerted at least 90 days before underground mining occurs under the property.
- 4 miles northeast of the project area is the Cardinal Mine with active permits that allow for mining of the WKY9 and WKY11 seams.
- 5 miles north of the project is the Warrior Mine with active permits that allow for mining of the WKY9 seam.
- 6-9 miles northwest of the project area is the Dotiki Mine with active permits that allow for mining of the WKY9 and WKY13 seam.
- 7 miles northeast of the project boundary is the Elk Creek Mine with active permits that allow for mining of the WKY9 and WKY11 seams.
- 15 miles north of the project area is the Sebree Mine with active permits that allow for the mining of the WKY9, WKY11, and WKY12 seams.
- There are no active permits overlapping the project area.
- Any surface impacts created by underground mining activity are the responsibility of the mine operator and any surface damage must be corrected.

Based on the site conditions and the current mine permit (or future mine permits) it is predicted that no underground mining will occur under the project area. The area under consideration may be susceptible to subsidence.

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LIST OF TABLES

1.0 INTRODUCTION

nFront Consulting is investigating the potential for the placement of a power supply in Hopkins County, Kentucky. RESPEC was retained to evaluate the potential effects of coal mining on the project. The project boundary was provided by nFront Consulting. The full project boundary consists of 18 acres. KYMEA has surface rights within the project boundary but does not control any mineral rights. The general location is shown in Figure 1-1, Location Map.

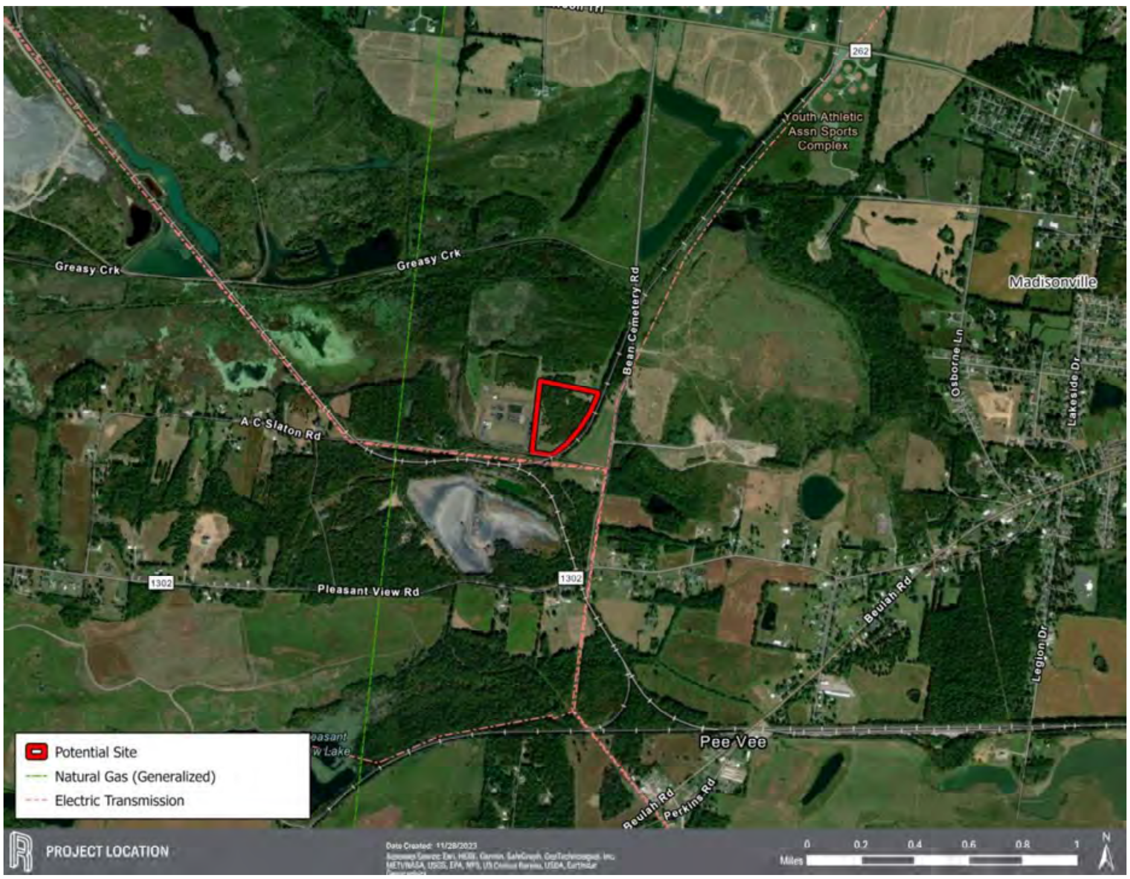

Figure 1-1: Location Map

This report is strictly a desktop evaluation. No site visit has been made to confirm any of the information gathered.

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2.0 SITE DESCRIPTION

2.1 LOCATION AND LAND USE

The site is located west of Madisonville, KY, and consists of 18 acres. The project area is generally bound by AC Slaton Rd in the south and railroads in the east and south.

Surface elevation ranges from 391 feet to 418 feet with an average elevation of 403 feet and an average slope of 4.77%. The predominant land use is farmland with small, wooded areas. Industrial facilities border the project area. Directly west of the site is the Madisonville Wastewater Treatment Plant. 800 feet south of the site is an inactive mine with permit # 8540218 which was released in 2018.

2.2 GENERAL GEOLOGY

The site is located within the Madisonville West 7½ minute geologic quadrangles (GQ). The GQs indicates that the material within the site is alluvium and Carthage. The ground surface area consists of alluvium, with a thickness varying from 0-25 feet. The alluvium is composed of silt, clay, sand, gravel: light brown to reddish-brown, unconsolidated, poorly sorted. The Carthage Material is described as sandstone, siltstone, shale, clay, limestone, and coal. The bedrock underlying the alluvium and Carthage materials are the Madisonville Limestone and Providence Limestone members.

The WKY7, 8, 9, 10, 11, 12, 13,14, and 15 coal seams are present in this quadrangle. The WKY14 and WKY12 seams are part of the Lisman Formation and the WKY11 and WKY9 are part of the Carbondale Formation. The GQ includes structure contours drawn on the base of the WKY9 coal seam. These contours indicate the WKY9 seam is approximately 0 feet to 600 feet below the ground surface. The GQs indicate that the Richland, Pleasant View, Beulah, South Reinecke, and North Reinecke Faults are present.

In the Madisonville CQ, "two large underground mines were active in 1963, one about three miles southwest of Madisonville in the WKY9 coal bed (previously in the WKY11 coal bed) and other about five miles west of Madisonville in the WKY11 coal bed. Other underground mines have been developed in the WKY9, 11, and 14 coal beds, but these were abandoned before 1962. Further detail can be found in the Past Mining section of the Mining History part. In recent years much of the coal has come from strip mines on the WKY 9, 11, and 14 coal bed." In addition to coal other resources are present in the CQ. "Limestone has been quarried in the city of Madisonville…Approximately 10 holes are reported to have been drilled for oil and gas in the area. Oil was discovered in 1963."

The outline of the site area is placed on a portion of the Madisonville West GQs in the figure labeled "KGS Geologic Quadrangle". The figure is included in Appendix A.

The Kentucky Geologic Survey (KGS) maintains a significant repository of coal data. This includes estimates of remaining resources and seam-specific reports. Excerpts from two KGS publications are presented in Appendix B, describing the mineability of the WKY9 and WKY11 seams.

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3.0 REGULATIONS/RULES REGARDING MINING

3.1 KENTUCKY MINING REGULATION

All coal mined in Kentucky must be included or addressed in a coal surface mining permit, even if the operation is an underground mine. Surface owner rights are required to create any disturbance to the surface. This includes direct mining areas such as mining pits, underground face-up areas, and mine shaft and mine slope areas. Surface rights are also required for all associated mining related facilities such as preparation plants, coal stockpiles, coal loading facilities, sediment control structures, railroad access, ventilation shafts, and access roads.

Mineral rights are required for any coal that is removed, whether by surface mining or underground mining methods. No surface rights are required for the removal of coal by underground mining methods. Areas of underground mining are not included within the state permit area. These areas are identified as "shadow areas.". Although not included in the permitted areas, the permit must address any potential adverse effects of the underground mining on surface facilities within the shadow area. This includes an evaluation of subsidence potential and effects on groundwater.

It is also noted that surface mining applications filed for underground mining operations must identify all the surface owners in the shadow area. Reclamation Advisory Memorandum (RAM)#165, issued January 17, 2018, states:

> *Surface owner names and addresses must be listed for proposed permit area and shadow area in Item 9.1. Public notice must still be provided to all owners and occupants of surface property and structures above the shadow area at least ninety (90) days prior to mining beneath the property or structure pursuant to 405 KAR 18:210 Section 2.*

3.2 SUBSIDENCE PROJECTION ZONES

The Kentucky Administrative Regulation, 405 KAR 18:210 Subsidence control, presents the rules regarding the protection of surface structures and the requirements for compensation if damage does occur. Section 1 of 405 KAR 18:210 presents the standard prohibiting subsidence which causes material damage to surface structure, which states.:

Section 1. General Requirements.

(1)(a) The permittee shall adopt:

1. Measures consistent with known technology that:

a. Prevent subsidence from causing material damage to the extent technologically and economically feasible.

b. Maximize mine stability; and

c. Maintain the value and reasonably foreseeable use of surface land.

Section 3 of 405 KAR 18:210 presents the requirements for repair of damage should subsidence damage occur. Section 3(1) addresses damage to the surface and Section 3(3) addresses structures other than noncommercial buildings and occupied residential dwellings and related structures.

Section 3. Repair of Damage.

(1) *Repair of damage to surface lands. The permittee shall correct any material damage resulting from subsidence caused to surface lands, to the extent technologically and economically feasible, by restoring the land to a condition capable of maintaining the value and reasonably foreseeable uses that it was capable of supporting before subsidence damage.*

(2) *Repair or compensation for damage to noncommercial buildings and occupied residential dwellings and related structures existing at the time of mining. The permittee shall promptly repair or compensate the owner for material damage resulting from subsidence caused to any noncommercial building or occupied residential dwelling or structure related thereto that existed at the time of mining. If repair is selected, the permittee shall fully rehabilitate, restore, or replace the damaged structure. If compensation is selected, the permittee shall compensate the owner of the damaged structure for the full amount of the decrease in value resulting from the subsidence related damage. The permittee may provide compensation by the purchase before mining of a noncancellable, premium prepaid insurance policy.*

(3) *Repair or compensation for damage to other structures. The permittee shall, to the extent required under applicable provisions of state law, either correct material damage resulting from subsidence caused to any structures or facilities not protected by subsection (2) of this section by repairing the damage or compensate the owner of the structures or facilities for the full amount of the decrease in value resulting from the subsidence. Repair of damage shall include rehabilitation, restoration, or replacement of damaged structures or facilities. Compensation may be accomplished by the purchase before mining of a noncancellable, premium prepaid insurance policy.*

RAM #107 presents the design standards used by the Kentucky Division of Mine Permits. subsidence rules. The protection method in RAM #107 requires setting the mining extraction such that the remaining pillars have the strength to support the weight of the overlying rock. A safety factor is required, based on the type of structure to be protected. RAM #107 assumes that adequate subsidence control is provided if the mine plan extracts less than 50% of the coal resource.

It is noted that protection zones do not project straight down. RAM #107 requires that a 15′ offset around each project structure be created. From the intersection of that 15′ buffer with the surface, the buffer is projected down and away from the structure at 15° until it intersects the coal seam. This 15° is referred to as the angle of draw. Figure 3.1 is obtained from "Coal Mine Ground Control", Syd S Peng, PhD, 1978, page 339. This figure shows the subsidence projection zone. This is the area labeled "Coal Pillar Left for Support." This is the area that must meet the requirements of RAM #107.

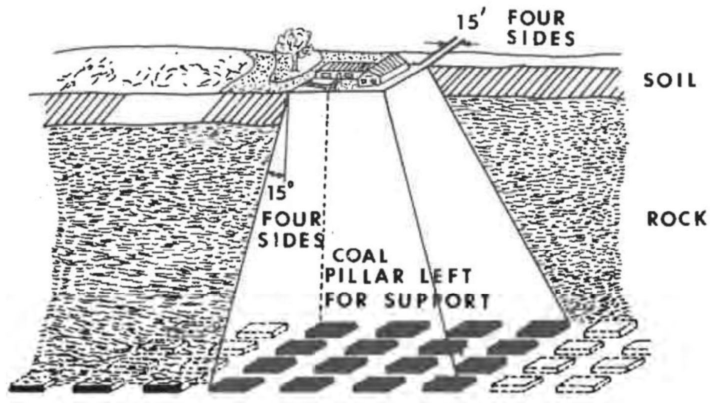

Figure 3.1. Subsidence Protection Zone

4.0 MINING HISTORY

4.1 SOURCES OF DATA

RESPEC gathered data from the following public data sources to evaluate the historic and present mining activity in the region:

- Mined-out polygons (minemaps.ky.gov/Maps/GISData) – This ESRI shapefile provides polygons for known areas of previous mining.
- Kentucky Division of Mine Permits (smis.ky.gov/smis.web) – DMP maintains a digital file of permit boundaries and most surface mining applications are available on-line through the Division's Surface Mining Information System (SMIS).
- Kentucky Mine Mapping Information System (minemaps.ky.gov) – Annual and/or final underground mine maps are available for download.

Inconsistencies in mine type and mine names were present in the ESRI shapefile of the mined-out area polygons and DMP permit boundaries. RESPEC attempted to correct the shapefile data within the vicinity of the potential site.

A summary of the data reviewed is presented in Table 4-1.

Table 4-1. Permit Details

PERMIT NO	TYPE	STATUS	COMPANY	Mine Name	Current Permitted Acres	Seam	Proximity From Site (miles)	Subsidence Violations
8540213	Surface	Reclamation Only	Hopkins County Coal LLC	Volunteer Mine	2080.85	9, 11, 12, 13, 14	5 E	
8540231	Surface	Active Operations	WEBSTER COUNTY COAL LLC	WEIRS CREEK	177.8	9, 11, 12, 13	9 NW	
8540234	Other	Active Operations	WEBSTER COUNTY COAL LLC	DOTIKI MINE	0.14	9, 11, 12, 13	7 NW	
8540241	UG	Active Operations	WARRIOR COAL LLC	WARRIOR MINE	30.7	9	5 N	
8540252	UG	Active Operations	HOPKINS COUNTY COAL LLC	Elk Creek Mine	65.12	9, 11	7 NE	
8540254	Surface	Active Operations	WARRIOR COAL LLC	Wolf Hollow Shaft	61.33		5 NW	
8545029	UG	Active Operations	WARRIOR COAL LLC	Cardinal Prep Plant	1550.6	9, 11, 14	0.5 N	
8545030	UG	Active Operations	WARRIOR COAL LLC	Hanson Shaft	226.8	9	2 NW	10/2/2007
8545032	UG	Active Operations	WARRIOR COAL LLC	Warrior Coal- Cardinal	23711.45	11	4 NE	4/20/2018 11/29/2011 12/30/2011
8545033	UG	Active Operations	WARRIOR COAL LLC	CARDINAL	21	9		
8545042	UG	Reclamation Only	REDMON COAL CO INC	STONEY POINT MINE	341.6	11	11 W	
8547006	Other	Active Operations	HOPKINS COUNTY COAL LLC		48.5	9	8 E	
8547007	Other	Active Operations	HOPKINS COUNTY COAL LLC	Volunteer Mine Road	38.1	9	8 E	
8549001	Surface	Active Operations	HOPKINS COUNTY COAL LLC	Volunteer Mine Hual Road	100.55		6 E	
8549004	Other	Active Operations	WARRIOR COAL LLC	Warrior Injection	4302		1 N	
8756001	Other	Reclamation Only	HARTSHORNE MINING, LLC	CYPRESS CRK MINE OVERLAND BELT	41.3		18 NE	
8898005	Other	Reclamation Only	COVOL FUELS NO 2 LLC	MINUTEMAN PLANT	457.37	9	18 SE	
9135023	UG	Active Temporary Cessation	ROUGH CREEK MINING LLC	Dodge Hill	316.45	6, 7		
9170032	Surface	Active Operations	HOPKINS COUNTY COAL LLC	Refuse Fill 1	813.3	13	13 NW	
9170034	Surface	Active Operations	HOPKINS COUNTY COAL LLC	Providence	1123.1	13	12 NW	

9170039	Other	Active Operations	SEBREE MINING LLC	ONTON #9 NANCE SHAFT	5.1			
9175013	UG	Active Temporary Cessation	WEBSTER COUNTY COAL LLC	Dotiki	20116.26	9, 13	9 NW	7/11/2023
9175015	UG	Reclamation Only	WEBSTER COUNTY COAL LLC	Dotiki	3869.79	9	6 NW	2/13/2015
9175016	UG	Actively Producing	WEBSTER COUNTY COAL LLC	Dotiki	41.2	9	3 N	6/8/2018
9175018	Other	Reclamation Only	HOPKINS COUNTY COAL LLC	Smith Mine #1	394.5	11, 12, 13		
9175023	UG	Reclamation Only	WEBSTER COUNTY COAL LLC	Dotiki 13 Mine	16.75	13	11 NW	
9175025	Surface	Active Operations	SEBREE MINING LLC	Sebree North #2	173	9, 11, 12	17 N	
9175026	UG	Active Operations	SEBREE MINING LLC	Sebree	13578	9	15 NE	
9175027	UG	Reclamation Only	SEBREE MINING LLC	Vision #9 Mine	129.4	9	18 N	
9176003	Other	Active Operations	STEAMPORT, LLC		18			
9179007	Other	Active Operations	SEBREE MINING LLC	SEBREE SOUTH IMPOUNDMENT	346.5		18 N	

4.2 PAST MINING

A review of the state's mined out polygons indicates the WKY9 seam along with the WKY11 seam are consistently mined throughout western Kentucky. The WKY14, WKY13, and WKY12 were mined via surface and underground mining near the site.

The Pleasant View Mine of West Kentucky Coal Company, later owned by Island Creek Coal Company, underground mined the WKY9 and WKY11 seams via Room and Pillar method underneath the project site. The mine was closed in 1965. The potential subsidence issues related to this mine are discussed in the section: Geotechnical Review.

The Oriole and the Ziegler No9 mine of Bell and Zoller Coal Company, located less than mile north of the project area, underground mined the WKY9 and WKY11 seams via the room and pillar method. Last reported activities of the Oriole and the Ziegler mines were in the 1960's and 1970's, respectively.

The North Diamond No2 mine of West Kentucky Coal Company, located less than a mile south of the project boundary, underground mined the WKY11 seam via the room and pillar method. The mine submitted its final mine map in 1950.

Surface mining of the WKY 12, WKY13, and WKY14 seams took place within 5 mi. proximity of the project boundary as seen in the Figure "Other Seams Surface" in Appendix A. These surface mines were all closed prior to 2000.

The figures listed below show the mined-out areas and active permits categorized by coal seam and the type of mining near the project area in Appendix A.

- WKY9 Surface
- WKY9 Underground
- WKY11 Surface
- WKY11 Underground
- Other Seams Surface
- Other Seams Underground

4.3 MINE PERMITTING

Permits are reviewed to determine areas previous operations have considered as potentially mineable. Data extracted from the permits include which seams are possibly mineable, the type of mining, and the extent of the resource. It is noted that permits issued by the Kentucky Division of Mine Permits (DMP) and with approved bonds in place, are identified by the DMP as "Active". This means that the permit meets all the DMP requirements and can be mined. A permit may be designated by DMP as an active permit, but there may be no past or active mining occurring. The permit data can be seen from Table 4-1. Active permit boundaries and the corresponding seam can be seen from the figures listed above in Appendix A.

4 miles northeast of the project area is the Cardinal Mine of Warrior Caol LLC with permit #s 8545030, 8545032, and 9175016. The permits allow for mining of the WKY9 and WKY11 seams. Since 2011, there have been multiple minor subsidence violations related to both permits, which is discussed further in the section, Subsidence History. The permit expires on 07/10/2025. All permits can be renewed for an additional five years if a renewal application is submitted prior to permit expiration.

Less than 5 miles north of the project area is the Warrior Mine with permit #s 8549004, 8540231, and 8545030. These permits allow for the mining of the WKY9 and include the Hanson shaft and the Warrior Injection site. The intended uses for these permits are underground mining, preparation plant, refuse disposal, use of surface area, and slurry injection.

6-9 miles northwest of the project boundary is the Dotiki mine of Webster County Coal LLC with permit #s 9175013 and 8540234. These permits allow for the underground mining of the WKY9 and WKY13 seams. Since 2015, there have been 2 instances of subsidence damage caused by this mine which is described further in section: Subsidence History. Due to the recent subsidence violation on 7/11/2023, the permit is currently under active temporary cessation.

7 miles northeast of the project boundary is the Elk Creek Mine of Hopkins County Coal LLC with permit # 8540252 which allows for the mining of the WKY9 and WKY11 seams. The Sebree Mine of Sebree Mining LLC is located over 15 miles north of the project area with permit #s 9175025 and 9175026. These permits allow for the mining of the WKY 9, WKY11, and WKY12 seams.

Other mines such as the Volunteer mine, Stoney Point Mine, Smith Mine #1, and Vision#9 Mine located within 20 miles radius proximity of the project area. However, the permits associated with these mines are under reclamation only, which indicates that there is no longer any active production on these mines.

4.4 SUBSIDENCE HISTORY

Located 6 miles northwest of the project area, the Dotiki Mine of Webster County Coal LLC, permit #9175013, had a subsidence violation as of 07/11/2023. The permit allows for mining of the WKY13 and WKY9 seams. The description of the violation states:

> *"The Permitee has failed to prevent subsidence causing material damage to State Highway 1340. Several large cracks have developed across HWY 1340 causing the road to be closed due to the damage."*

In 02/13/2015, located 9 miles northwest from the project area, the Dotiki Mine of Webster County Coal LLC, permit #9175015, had another subsidence violation. The permit allows for the mining of the WKY9 seam. The description of the violation states:

> *"The Clyde DeRossett subsidence investigation report received by this office on December 6, 2010, indicated that the Stanley property had been affected by mine subsidence. Based on 405 KAR 18:210, the Madisonville Regional Office directed Webster County Coal, LLC, to either compensate and/or repair the subsidence damage to the Stanley property. The Webster County*

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Coal letter dated April 29, 2011, regarding the Doug Stanley Property received by this office states that Webster County Coal does not believe that the damage to the Stanley Property was caused by subsidence. Therefore, Webster County Coal is in violation of 405 KAR 18:210 for not compensating and/or repairing the subsidence damage to the Stanley property."

Other subsidence violations took place near the project area. However, none of the violations resulted in physical subsidence issues. Warrior Coal LLC, located 2-4 miles northeast from the project area, was cited 4 times for exceeding extraction ratio and failing to submit subsidence maps. These violations were issues to permit #8545032 and 8545030 and it allows for the extraction of the WKY9 and WKY11 seams. Dotiki of Webster County Coal LLC was cited on 6/8/2018 for failing to submit underground maps prior to deadlines.

4.5 GEOTECHNICAL REVIEW

Mine subsidence is defined as ground movements that result from the collapse of overlying strata into mine voids. Surface subsidence manifests itself in three major ways:

- Cracks, fissures, and fractures
- Pits or sinkholes; and
- Troughs or sags

The type of features that occur on surface depend heavily on the type of mining that was practiced and other factors such as cover depth. Large mine voids that result from longwall mining or large-scale pillar collapses are typically associated with large-scale troughs and sags. Smaller scale collapses of shallow room and pillar mines are typically associated with pits and sinkholes. Cracks, fissures, and fractures are common indicators that subsidence has occurred and are seen with both small- and large-scale collapses.

Based on currently available information, mining activity at the Madisonville project site has occurred in two coal seams, WKY11 (upper seam) and WKY9 (lower seam). Based on a review of the available mine maps, mining in the vicinity of the Madisonville project site appears to have been conducted using room-and-pillar methods. While it is not known whether retreat mining (i.e., pillar extraction) was practiced, retreat mining is not indicated in the provided maps.

Mining-related subsidence occurs in two distinct phases: (1) active and (2) residual. Active subsidence occurs during mining operations, while residual subsidence occurs after mining has ceased. The period over which surface subsidence occurs depends heavily on the mining method used. In room-and-pillar mining, the magnitude of *active* subsidence is usually small and most of the subsidence, if it occurs, is residual. Residual subsidence from room and pillar mines may be delayed for decades until the support pillars have deteriorated or collapsed. The actual time involved depends on several factors including the strengths of coal, roof, and floor; extent of fracturing; presence of water; depth of workings; pillar size; and extraction ratio (i.e., the volume of coal mined divided by the total volume of coal within the reserve). The Madisonville site is currently subject to the potential for residual subsidence.
There are three basic mechanisms responsible for residual subsidence above room-and-pillar mines:

- Collapse of roof beds spanning adjacent pillars
- Squeezes or crushes
- Pillar failures

Roof collapses occur when the strata between pillars collapse. The height to which the collapse process can take place and whether appreciable subsidence will occur depend on the volume of original mine opening, the bulking factor of the strata (i.e., the amount that the strata increase in volume after collapse), and the location and thickness of the overlying competent strata. Considering the relatively high ratio of cover depth to extraction/seam height and assuming a room width on the order of 30 feet, RESPEC's opinion is that it is unlikely that roof collapses in either the WKY9 or WKY11 seams would result in appreciable surface subsidence.

Squeezes and crushes occur when a pillar or pillars punch into weaker immediate roof and/or floor strata. Pillar failures occur when a pillar or pillars are inadequate to support the loads of the overlying strata and undergo appreciable shortening. Considering the depth of cover and mining height of known workings beneath the Madisonville site, RESPEC considers it unlikely squeezes, crushes, or failures of individual, isolated pillars would result in appreciable surface subsidence.

RESPEC believes that appreciable residual subsidence is most likely to be associated with large-scale, multi-pillar squeezes, crushes, or failures. Whether such a scenario would result in appreciable surface subsidence would primarily depend on the lateral extent of the collapse, the depth of cover, and extraction/seam height. RESPEC is not aware of any evidence that suggests such large-scale collapses have occurred in the immediate vicinity of the Madisonville site.

RESPEC's opinion, based on our review of limited available information, is that the risk associated with surface subsidence at the Madisonville site is relatively low. However, to be fully confident in this assessment, additional information is required. If a decision is made to proceed with the Madisonville site, RESPEC recommends the following:

- Perform a visual surface investigation at the Madisonville site, and if possible, the adjoining properties to identify any signs of surface subsidence.
- Conduct a literature review to obtain any publicly available information regarding the stratigraphy and geotechnical properties of the strata.
- Conduct a pillar stability analysis to evaluate the factors-of-safety and anticipated long-term performance of the existing pillars. If collapses are considered likely, the analysis can be used to estimate the most-likely lateral extents of any potential collapses.
- If pillar stability analyses indicate potential for large-scale pillar collapse, subsidence analyses can be conducted based on the estimated lateral extents of potential collapses to determine if appreciable surface subsidence may occur.

If, after these engineering activities, there exists an unacceptable level of uncertainty with respect to subsidence risk, geotechnical core drilling could be conducted to quantify the site-specific roof and floor conditions and 3D void scanning could be conducted from boreholes to evaluate the conditions of existing workings and determine if appreciable seam closure has occurred.

If necessary, remedial activities could include backfilling existing mine workings, locating structures to avoid high-risk areas using predictive subsidence modeling, and employing construction techniques that will reduce transmission of deformations from the ground to the structures or that will strengthen the structures to tolerate expected deformations.

4.6 FUTURE MINING

Table 4-2. Coal Seam Data

Bed Name	Coal El. (Ft.)	Average Surface El.	Overburden (Ft.)	Pre-mining Tonnage	Coal Thick. (Ft)	Potential Mining Method
WKY14	342	403	61	260338	0	None
WKY13	329	403	74	41788	1.38	None
WKY12	277	403	126	129616	4.25	None
WKY11	265	403	138	194006	6.36	None
WKY9	179	403	224	154764	5.07	None

MINEABLE RESOURCES

RESPEC created a geologic model for all the coal seams in the project area. WKY9 and WKY11 seams have been historically mined and/or currently mined in the region. Other coal seams that have economic recovery potential are the WKY14 and WKY12. It is noted that the geologic model is a structure-only model. Topography, seam elevations, and seam thicknesses are represented in the model. There is no attempt to model coal quality. For this evaluation, it is assumed that any of the seams that are present in sufficient thickness, depth of cover, or mining ratio, will likely be of merchantable quality.

RESPEC constructed the geologic model using public data. The topographic surface was generated from Kentucky's GIS data. To generate the coal structure and thickness, drillholes from the University of Kentucky Geologic Survey in the Madisonville West quadrangle were used. RESPEC uses Carlson software's Geologic Module to maintain its coal geology databases. The data are managed as Carlson drillholes which are AutoCAD blocks with the strata and coal attached as extended entity data. The drillholes were obtained from the KGS's drillhole database. The geologic sections showing the surface elevation and relation of the coal seams and their locations are presented in Appendix A as "Geologic Model."

According to the Kentucky Geological Survey:

- Coal less than 28 in. (2.3 ft.) thick is generally not technologically mineable by underground methods.
- Coal less than 42 in. (3.5 ft.) thick is not considered economically mineable by underground method.
- 0-150 ft of overburden is generally surface-minable.
- 150-1500 ft of overburden is deep-mineable (Underground).
- Strip ratio (ratio of overburden to coal thickness) of less than 12 is mineable.

As seen Table 4-2, seams that are technologically and or economically mineable due to thickness analysis are the WKY14, WKY12, WKY11 and WKY9 seams. The mineability of the seams may increase if they are concurrently mined with another mineable seam as the acceptability of the overburden to coal thickness ratio will increase. Coal quality and other factors will further contribute to the mineability of the seam.

After reviewing the geologic model and applying the KGS limitations such as minimum mineable thickness, and minimum cover for underground mining, no potential mining resources were identified:

- WKY14 seam outcrops in the project area and is not consistent to be mined.
- WKY13 seam is too thin to be mined.
- WKY12 seam is closely tied to the WKY11 seam, thus deep mining is not possible due to subsidence risks.
- WKY12 seam has over 150ft of overburden, thus surface mining is not possible.
- WKY9 and WKY11 seams have already been mined out below the project area, thus further mining in these seams is unlikely.

Further analysis is required to determine the extent of the mineability of the different seams.

SURFACE MINING

To obtain a permit for a surface mining operation, the permittee must have surface mining rights. These rights are granted by the surface owner. There is no regulation that would override the surface owner's rights. If KYMEA will own or control the surface rights, no surface mining can occur without their approval.

UNDERGROUND MINING

Underground mining only requires mineral ownership rights. Surface owners are contacted prior to being undermined, but surface owner approval is not required for underground mining. Mineral ownership is commonly held by several different mineral owners, creating a patchwork of ownership similar to surface ownership. It is common practice for mining companies to purchase or lease mineral rights in advance of operations as needed. Mining companies must have contiguous mineral rights to access the underground resources.

If KYMEA owns mineral rights within the project area, they do not have to lease the coal to the proposed mine operation. The lack of access to these mineral rights could impact the mine plan of any proposed mining operation.

RESPEC

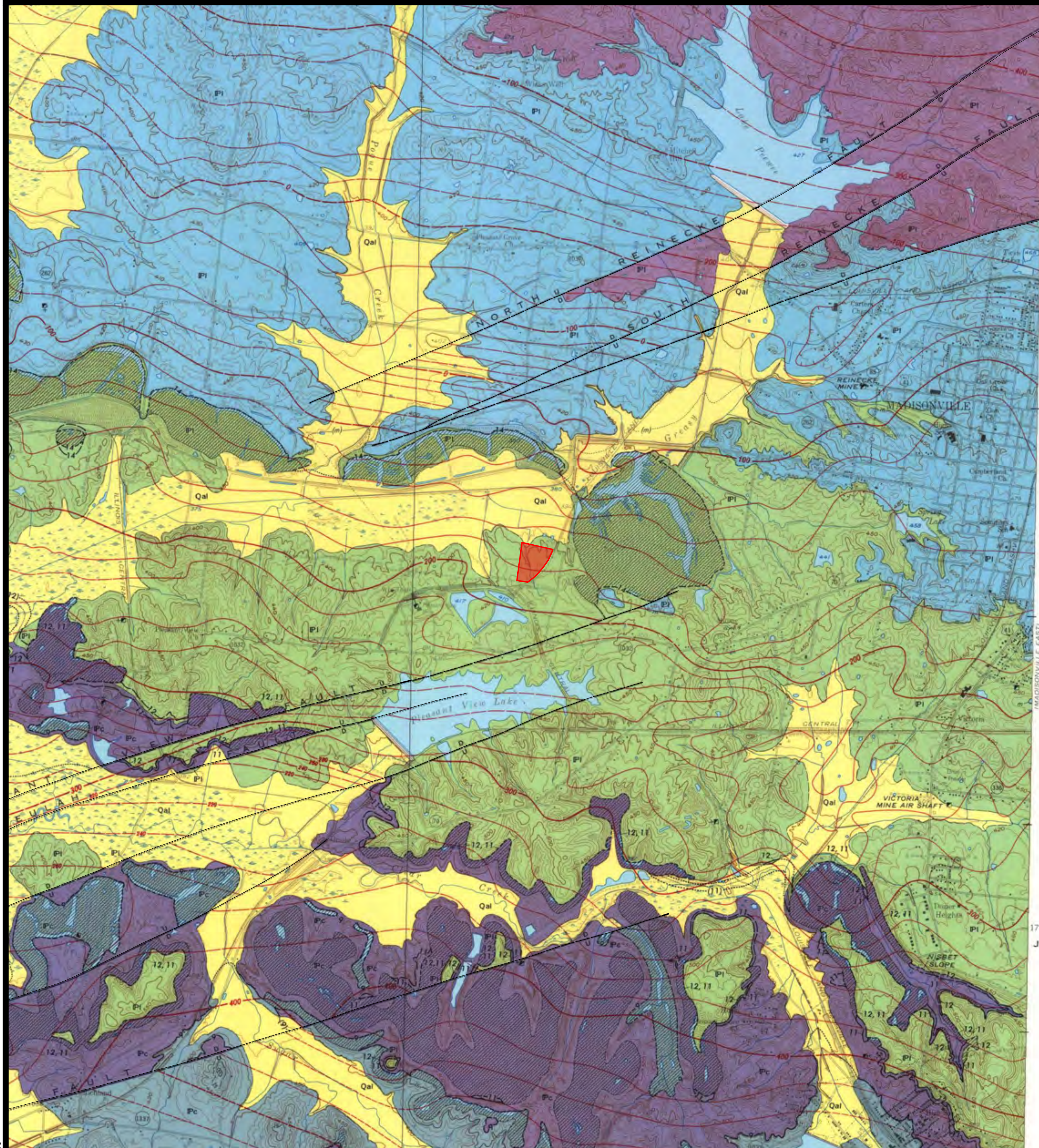
APPENDIX A

EXHIBITS

FAULTS

BASE OF WKY9 CONTOURS

PROJECT BOUNDARY



PREPARED BY:

RESPEC

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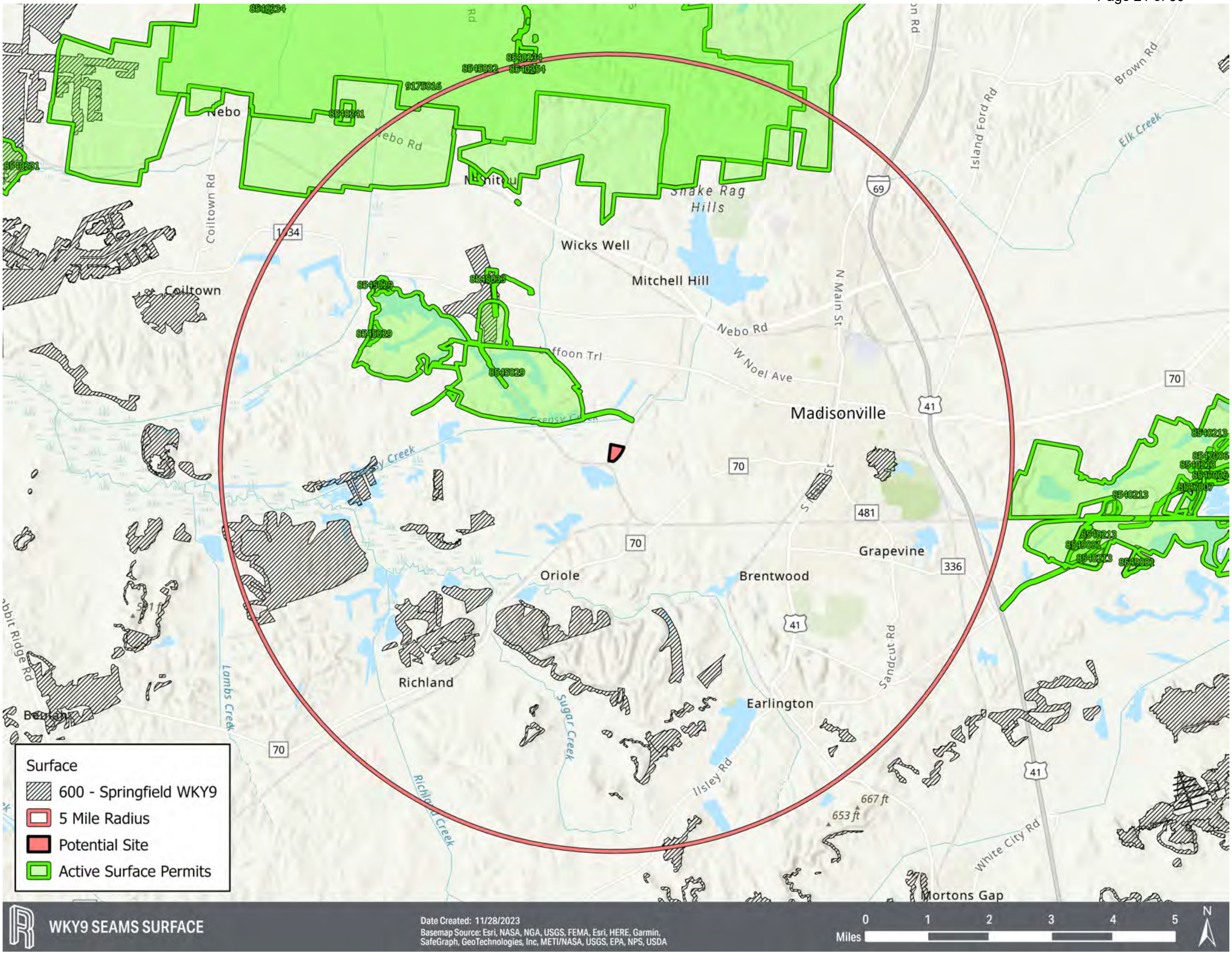
SCALE: 1"=4000'

KGS GEOLOGIC QUADRANGLE
MADISONVILLE WEST

drawing2.dwg Plot Date: 11/27/2023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5 Mile Radius
Potential Site
Active Surface Permits
WKY9 SEAMS SURFACE
Date Created: 11/28/2023
Basemap Source: Esri, NASA, NGA, USGS, FEMA, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA
Miles
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Madisonville
Nebo
Coiltown
Wicks Well
Mitchell Hill
Snake Rag Hills
Oriole
Brentwood
Grapevine
Richland
Earlington
Mortons Gap
Nebo Rd
W Noel Ave
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Island Ford Rd
Brown Rd
Elk Creek
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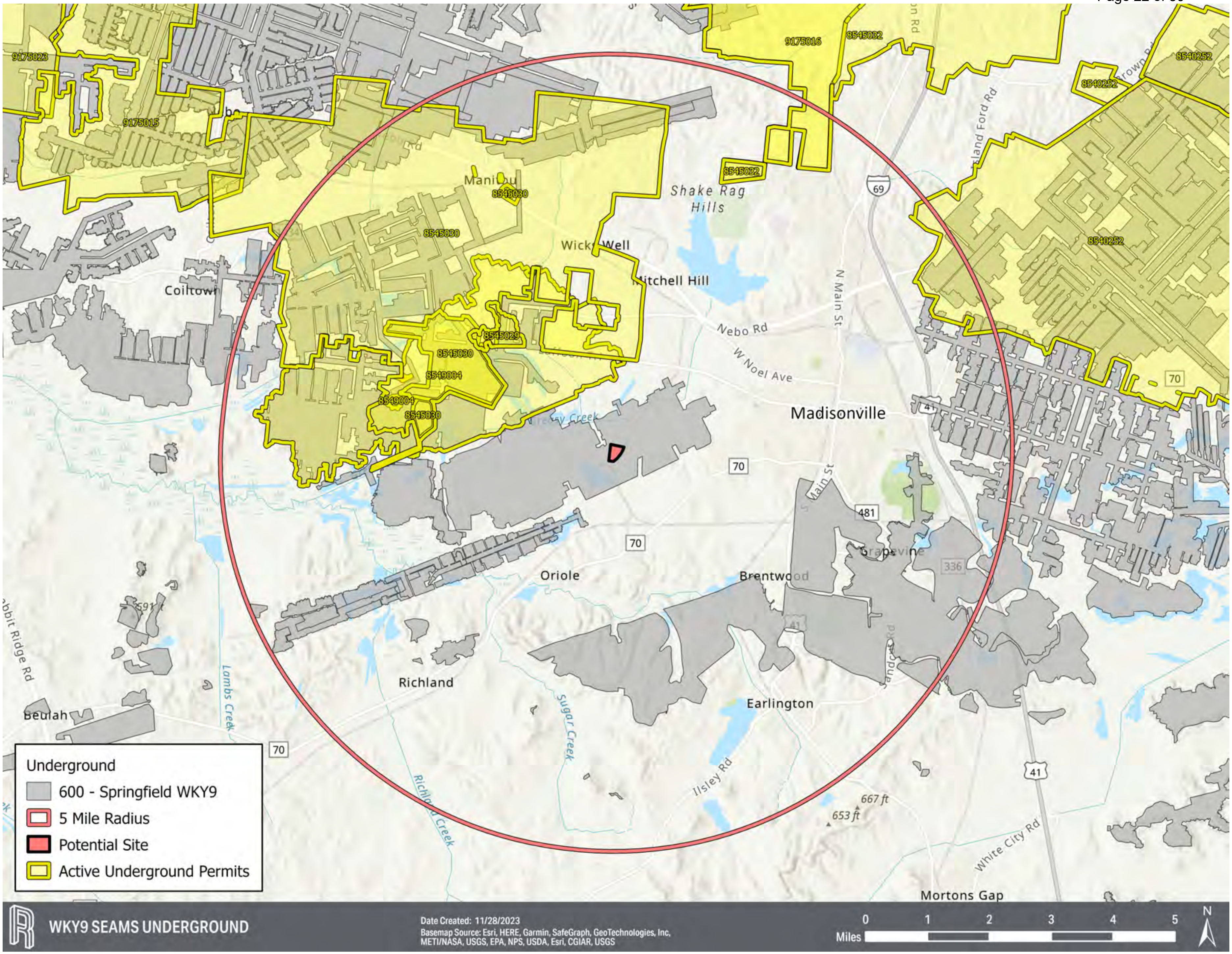
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Shake Rag Hills
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Wicks Well
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Grapevine
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Oriole
Brentwood
Richland
Earlington
Sugar Creek
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Beulah
Isley Rd
667 ft
653 ft
41
White City Rd
Richland Creek
Mortons Gap
Underground
600 - Springfield WKY9
5 Mile Radius
Potential Site
Active Underground Permits
WKY9 SEAMS UNDERGROUND
Date Created: 11/28/2023
Basemap Source: Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, Esri, CGIAR, USGS
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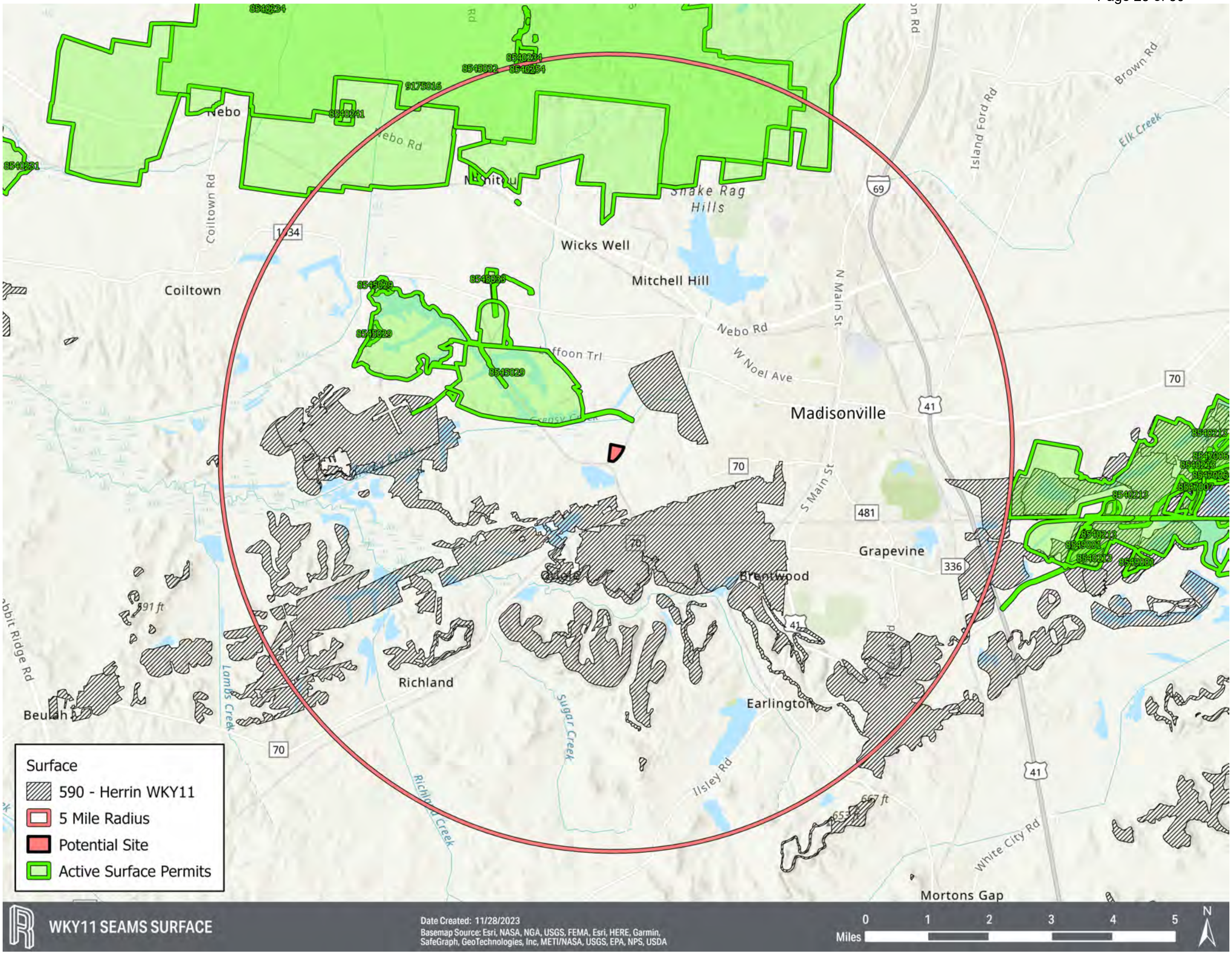
Surface
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5 Mile Radius
Potential Site
Active Surface Permits
WKY11 SEAMS SURFACE
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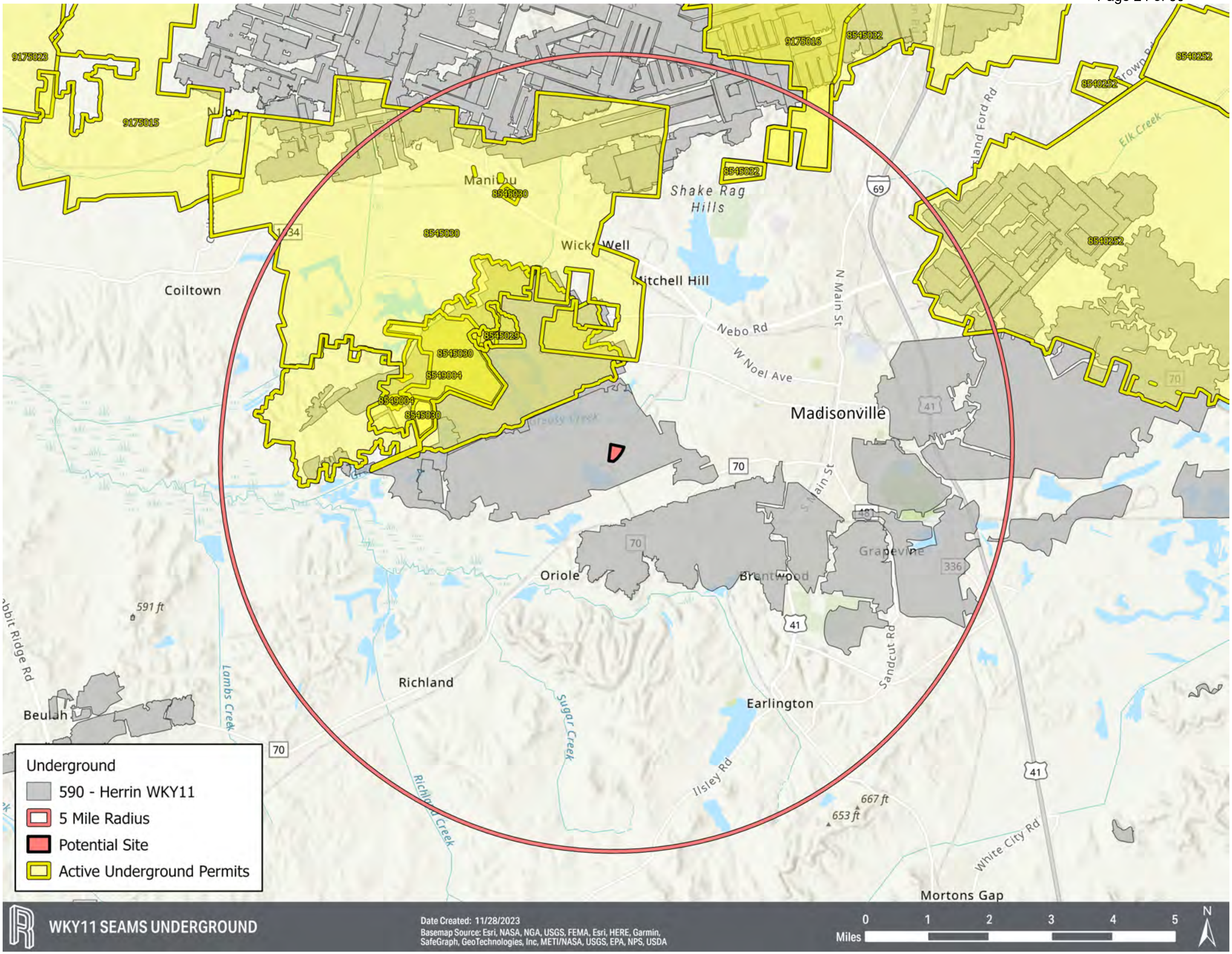
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Sugar Creek
Richland Creek
Sandcut Rd
Isley Rd
White City Rd
Mortons Gap
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Underground
590 - Herrin WKY11
5 Mile Radius
Potential Site
Active Underground Permits
WKY11 SEAMS UNDERGROUND
Date Created: 11/28/2023
Basemap Source: Esri, NASA, NGA, USGS, FEMA, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA
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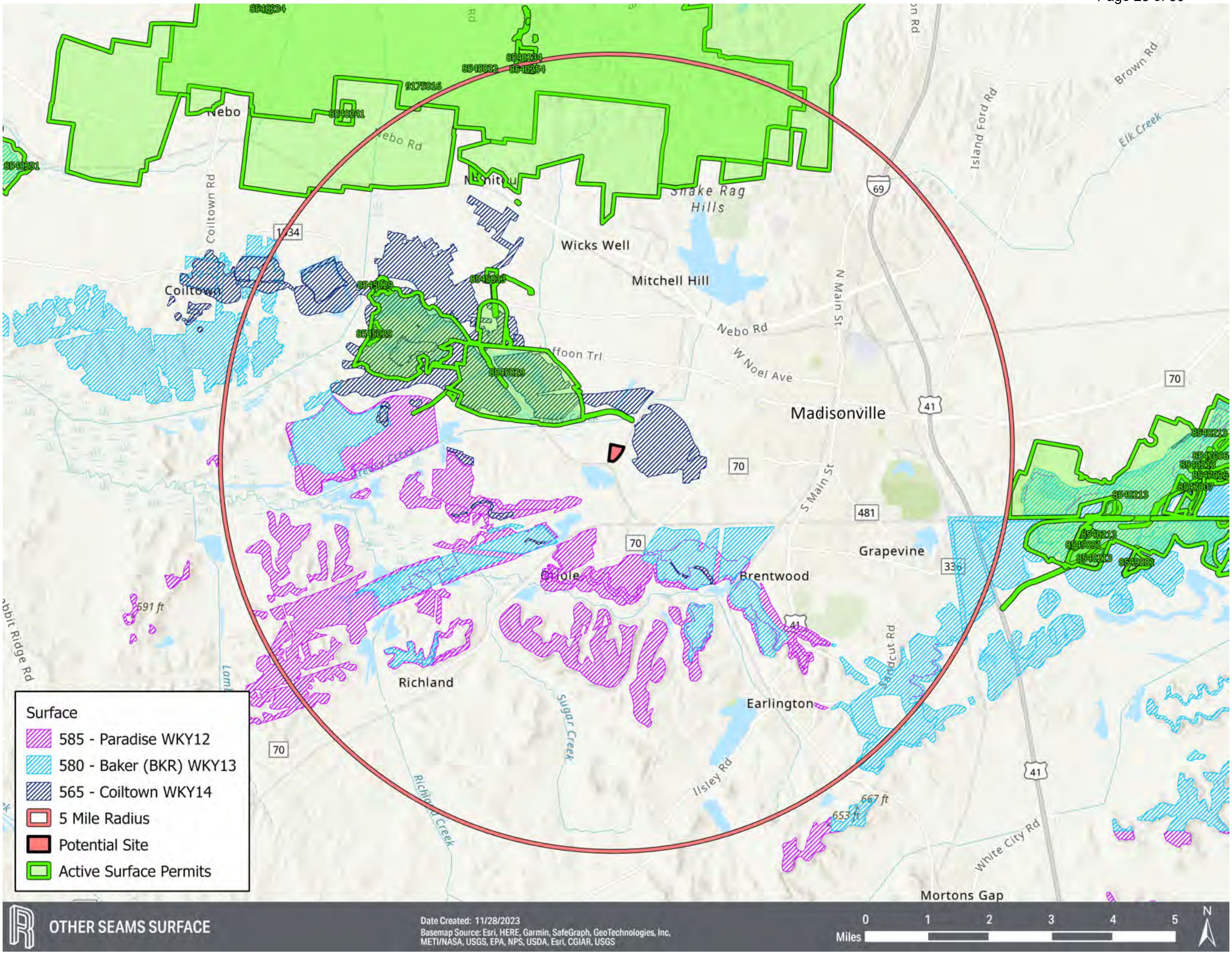
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Potential Site
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Wicks Well
Mitchell Hill
Snake Rag Hills
Madisonville
Grapevine
Brentwood
Richland
Earlington
Mortons Gap
Nebo Rd
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Island Ford Rd
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Sugar Creek
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Isley Rd
Sandcut Rd
White City Rd
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OTHER SEAMS SURFACE
Date Created: 11/28/2023
Basemap Source: Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, Esri, CGIAR, USGS
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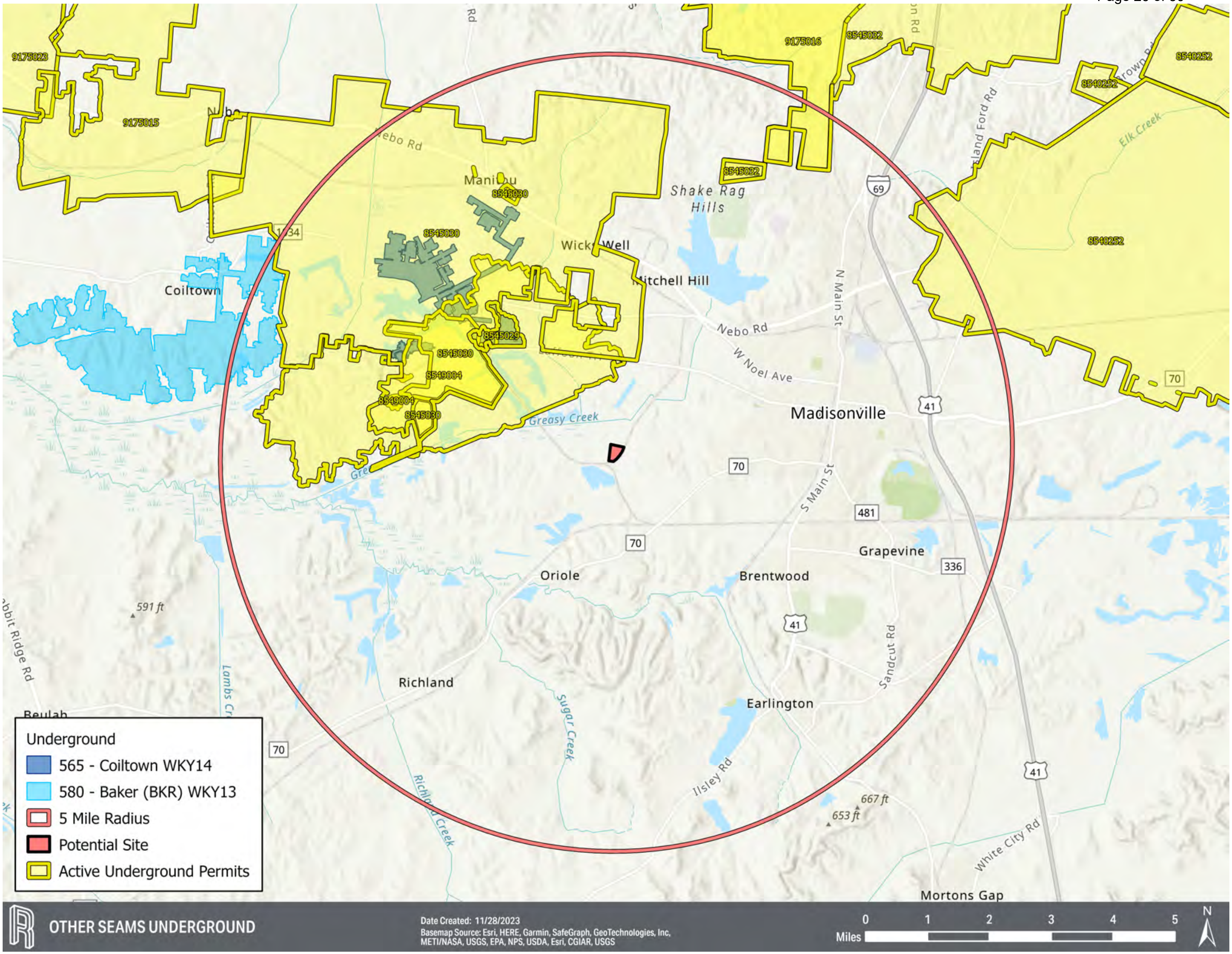
Underground
565 - Coiltown WKY14
580 - Baker (BKR) WKY13
5 Mile Radius
Potential Site
Active Underground Permits
OTHER SEAMS UNDERGROUND
Date Created: 11/28/2023
Basemap Source: Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, Esri, CGIAR, USGS
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Wicks Well
Mitchell Hill
Shake Rag Hills
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Mortons Gap
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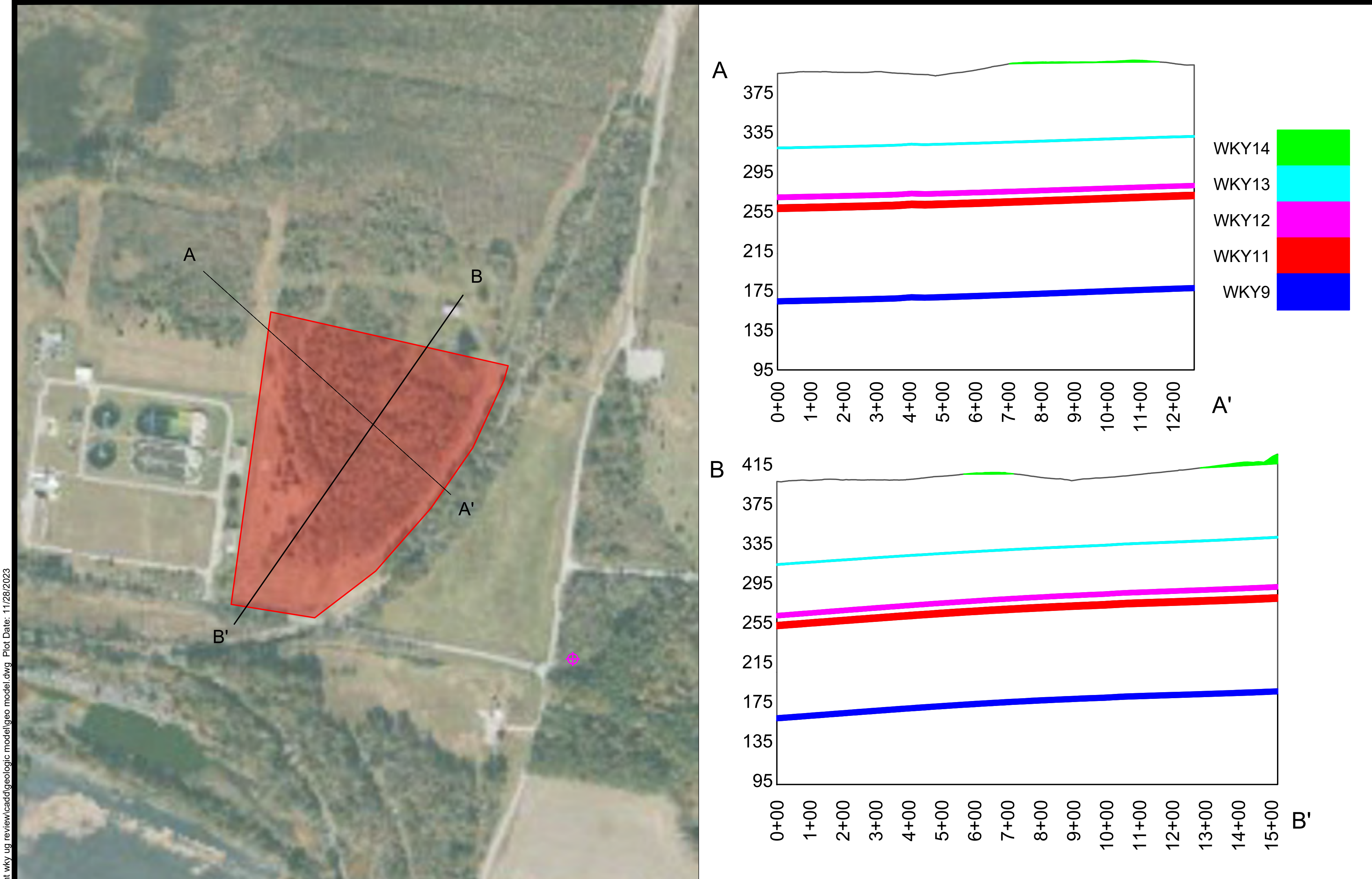

PREPARED BY:

RESPEC

0' 500'

SCALE: 1"=500'

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CROSS-SECTIONS

PROJECT BOUNDARY

GEOLOGIC MODEL

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APPENDIX B

KGS MINEABLE SEAM DESCRIPTIONS

The following are descriptions of the mineability of the WKY9 and WKY11 coals seams, the two most significant coal seams in the region.

WKY9 (SPRINGFIELD SEAM)

The following narrative regarding the WKY9 seam is extracted directly from the Kentucky Geological Survey "Remaining Resources of the Springfield Coal", Gerald A. Weisenfluh, 2010.

INTRODUCTION

Historically, the Springfield (W. Ky. No. 9) coal bed has been the leading source of coal production in the Western Kentucky Coal Field. With 2009 production more than 21 million tons and another 8 million tons of idle capacity, it is also the most important resource in the state of Kentucky. The Springfield coal is known for its lateral continuity in terms of both thickness and quality. It is a medium-sulfur product, desirable for power plants with sulfur-reduction capability, and has higher Btu values and lower chlorine contents compared to other Illinois Basin areas north of Kentucky. It is estimated to have the largest original and remaining resource in the Western Kentucky Coal Field (Greb and others, 1992). This map presents a revised interpretation of coal thickness since the last assessment (Andrews and others, 2000), uses newly acquired data, and presents updated mining information.

COAL THICKNESS

Across most of its extent in western Kentucky, the Springfield coal is greater than 42 in. thick, and in the southwestern half of the coal field is greater than 56 in. Most of the variation in thickness can be attributed to gradual tapering of the coal bed in a northeast direction or to abrupt erosional truncation by sandstone channels. No major splits in the Springfield coal have been documented in western Kentucky, although some splitting may occur in the vicinity of sandstone paleochannels. Some thin coal areas are also associated with faulting.

MINING

The Springfield coal bed has been mined since at least 1820, and it is still the source of most coal production from the Western Kentucky Coal Field. Early mines were near navigable waterways and relied on river transportation to distribute the coal. Most historical mines in Springfield were underground operations until the extensive development of surface mines in the 1950's and 1960's, when large areas along the southern margin of the coal field were surface mined. Most of the coal produced since the 1980's has been mined by underground methods, because most of the surface-mineable coal has been extracted. There are currently 14 active producing mines for the Springfield in western Kentucky (Table 1). Some of these underground mines also produce from the Herrin coal (W. Ky. No. 11) because faulting has brought the beds into juxtaposition along adjacent fault blocks. Currently, a depth of approximately 1,000 ft is the practical limit to mining because of roof- and floor-control issues related to overburden. The 1,000-ft depth limit is shown on the map.

WKY11 (HERRIN SEAM)

The following narrative regarding the WKY11 seam is extracted directly from the Kentucky Geological Survey "Remaining Resources of the Herrin Coal", Gerald A. Weisenfluh, 2011.

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INTRODUCTION

The Herrin coal bed (W. Ky. No. 11) is one of the most important coal resources in the Illinois Basin. In 2009, Herrin coal had an estimated 10 million tons of production in Kentucky and remained the second largest producer in the Western Kentucky Coal Field. The Herrin is known for its regionally extensive "blue band" rock parting, and, in Kentucky, its close association with the overlying Providence Limestone Member and Paradise coal (W. Ky. No. 11) (see, for example, Greb and others, 1992). In fact, the Herrin and Paradise coal beds were so closely spaced in some areas along the southern margin of the basin that they were mined together. Like most coals in western Kentucky, the Herrin is a medium-sulfur product. Because of relatively lower mining costs compared to Appalachian coals, the Herrin coal is increasingly in demand for electric power plants with sulfur-reduction capability. Scrubbed power plants can use higher-sulfur coals for fuel because the scrubbers remove almost all the sulfur dioxide produced by combustion of sulfur compounds in the coal from the emission stream. This recent demand has resulted in a significant increase in western Kentucky coal production since 2003, all of which is supplied by mining of the Herrin and Springfield coal beds.

COAL THICKNESS

Unlike the Springfield coal (see, for example, Weisenfluh, 2010), the Herrin coal does not extend throughout the Kentucky portion of the Illinois Basin. Two distinct areas of mineable coal occur-one along the southern margin of the field, and a second on the western side of the field (Union and western Henderson Counties). The Herrin coal is between 42 and 84 in. throughout most of the mineable area, although it ranges from 0 to 132 in. thick regionally. The extensive area of thin coal in the central and northeastern part of the coal field contains small islands of thicker coal, but none apparently extensive enough to support underground mining. Thickness reduction along the margins of the known coal bodies is typically abrupt and associated in places with a brecciated and oxidized coal and interbedded limestone sequence (Hower and others, 1987).

PHASE 2 ANALYSIS OF A SUBSIDENCE HAZARD FOR A POTENTIAL CONSTRUCTION SITE IN MADISONVILLE, KENTUCKY

REPORT RSI-3481

PREPARED BY
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Benjamin D. Haugen
John S. L. Morgan

RESPEC
3824 Jet Drive
Rapid City, South Dakota 57703

PREPARED FOR
nFront Consulting, Inc.
2465 Southern Hills Ct.
Oveido, Florida 32765

AUGUST 2024

Project Number M0330.24002

EXECUTIVE SUMMARY

RESPEC Company, LLC (RESPEC) conducted this subsidence hazard assessment of a candidate property for constructing power generation facilities in Madisonville, Kentucky, for nFront Consulting, Inc. (nFront) and the Kentucky Municipal Energy Agency (KYMEA)

The analyses began with a Task 1 evaluation to review historical coal mining information, regional geology, site visit, and mine stability results from the empirical tool Analysis of Coal Pillar Stability (ACPS), developed by the Mine Safety and Health Administration (MSHA). The subsequent Task 2 assessment included drilling, core logging, sampling, laboratory testing, and numerical modeling.

Mine maps and historical data for the coal seams underlying the Madisonville property were compiled and reviewed by RESPEC to determine which coal seams and mines underly the property, if future mining beneath the property was likely, and if subsidence is possible.

RESPEC concluded that future mining activity beneath the Madisonville property will not occur, but historical mines in the WKY 9 and WKY 11 coal seams could pose a subsidence threat. The location and geometry of the coal mines were determined by georeferencing historical mine maps. The depths, ages, and other information regarding the mines beneath the property were obtained from publicly available information.

A review of historical subsidence in the Madisonville area identified a few recent subsidence events that had caused structural damages. Poor shaft abandonment practices were deemed the likely cause for two of the three occurrences, while the third location was constructed over a swamp. These failures may have happened at approximately the same time because of earthquake shaking and/or heavy recent rainfall.

Our historical review, site inspection, and analysis in Task 1 indicated that the subsidence hazard on the property is low. No historical subsidence has been reported for the immediate area surrounding the property and no indications of subsidence were observed during the RESPEC site visit. Nearby sensitive infrastructure appears to have remained intact and undamaged by subsidence, and our analysis indicated that even the smallest pillars in the WKY 9 and WKY 11 mine workings beneath the property had acceptable stability factor values.

The core drilling and logging program revealed some rubblization in the coal seams and deterioration, which are consistent with the age and materials in the roof of the WKY 9 and WKY 11 mine levels. Our laboratory testing confirmed that the coal in both seams was stronger than initially assumed but also identified a weak shale unit above the WKY 11 mine level. The numerical models used for a 4-pillar collapse scenario on both levels at the same time predicted a maximum surface subsidence of slightly more than 3 inches. *Because a stacked-failure scenario is unlikely and the model included the conservative assumption that the rubble would provide no support to the overlying strata, we believe that the 2D section models indicate that subsidence risk is low.*

The maximum predicted surface subsidence was less than 1 inch using the 3D model—more than 2 inches less than the corresponding 2D section model predicted. *Because the same conservative* *conditions were used in the 3D model as for the 2D section model (i.e., total pillar removal, no support from the rubble, and stacked failures on both mine levels), the 3D numerical model results further reinforced that subsidence risk is low.*

In the extreme case of ultimate subsidence, where all the production and development pillars in the mines collapse and only the large barrier pillars remain, our 3D numerical models predicted a high variability of subsidence magnitudes across the property. The predicted surface subsidence varied from approximately 3 inches above the WKY 11 barrier pillars near the south end of the property to 24 inches above the WKY 9 and WKY 11 production pillars at the north end. Although an extreme case of subsidence is highly unlikely, modeling this scenario serves to guide a spatial analysis of where on the property subsidence hazards are highest. *By combining an interpolated pillar size map with the ultimate subsidence model results, we produced a relative subsidence hazard map confirming that while the subsidence hazard is low, the southern portion of the property has the lowest subsidence potential.*

RESPEC believes that the property is suitable for the construction of power generation facilities. Subsidence-sensitive facilities should be placed in the southern one-third of the property and, whenever possible, over the estimated locations of the WKY 9 and WKY 11 barrier pillars. An example placement of such facilities is shown in Figure ES-1.

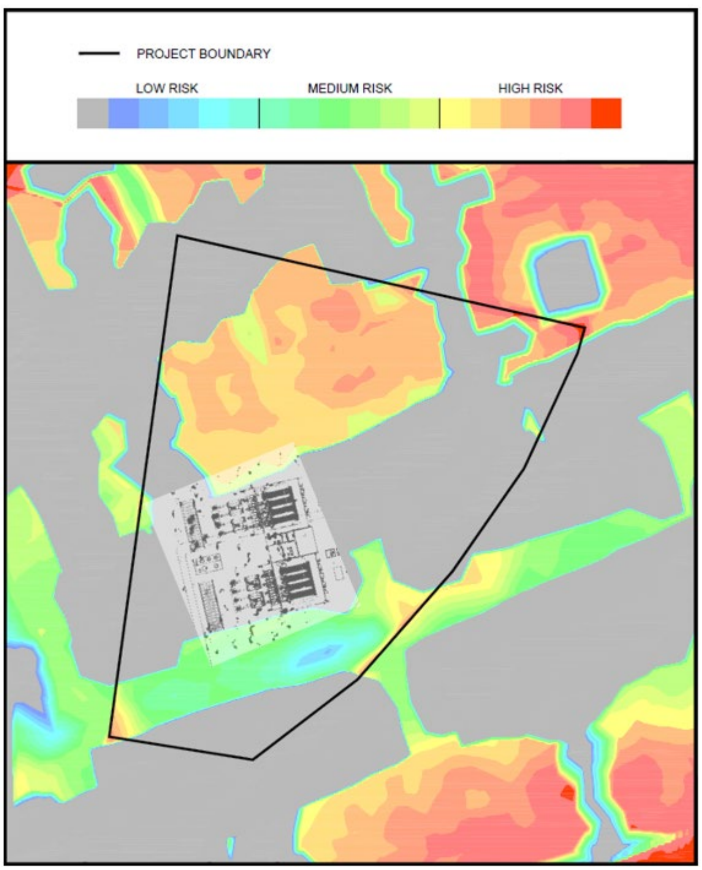

Figure ES-1. Subsidence Risk Isopach With an Example of Facilities Located Over the Lowest Risk Area.

Although RESPEC believes the risk of subsidence on the property is low, especially near its southern margins and above the WKY 9 and WKY 11 barrier pillars, subsidence remains a risk. Additional verification of the barrier pillar locations is recommended to resolve any mine plan georeferencing errors and ensure that any WKY 11 voids encountered are grouted.

Because the property overlies historical coal mines, RESPEC makes no claims that subsidence cannot or will not occur on the Madisonville property. Furthermore, the predicted subsidence magnitudes presented in this report were developed using numerical model simulations that rely on several assumptions and are not guaranteed or warranted in any way to correlate directly with ground behavior. The predictions, claims, recommendations, and judgments presented herein are made under our best professional assessment given the data and information available to us at the time this study was performed.

RESPEC

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RESPEC

LIST OF FIGURES

RESPEC

LIST OF FIGURES (CONTINUED)

1.0 INTRODUCTION

RESPEC Company, LLC (RESPEC) conducted a preliminary subsidence hazard assessment of a candidate property for constructing power generation facilities in Madisonville, Kentucky [RESPEC, 2023]. After this assessment, nFront Consulting, Inc. (nFront) and the Kentucky Municipal Energy Agency (KYMEA) requested RESPEC to perform additional subsidence hazard analyses.

1.1 OBJECTIVES AND GENERAL APPROACH

The analyses began with a Task 1 evaluation based on historical coal mining information, site visit, and results from the empirical tool developed by the Mine Safety and Health Administration (MSHA) known as the Analysis of Coal Pillar Stability (ACPS) program. After completing the ACPS analysis, nFront and KYMEA requested that RESPEC move to a Task 2 assessment that included drilling, core logging, sampling, laboratory testing, and numerical modeling. Additional background information is provided in the following sections. The primary objective of the study was to provide nFront and KYMEA decision-making information to determine whether the Madisonville property is suitable for power generation facilities that are highly sensitive to differential settlement and subsidence.

1.2 TECHNICAL APPROACH

RESPEC structured the subsidence hazard assessment in a manner that provided nFront and KYMEA with multiple decision points at certain stages. Based on the historical information reviewed by RESPEC [2023], our first step was to use the ACPS program to evaluate stability factor (SF) values for pillars in historical coal mines underlying the Madisonville property (please note that SF values in ACPS are distinct from factor-of-safety [FS] values because they are not a ratio of resisting to driving forces, but are a metric for evaluating stability). This task also included a site inspection to determine if indications of subsidence were present on the property. Our second step was to gather drillhole data, perform laboratory strength testing on rock samples, and use the results to model subsidence magnitudes under varying conditions. RESPEC also reviewed historical subsidence events in the Madisonville area to evaluate the subsidence hazard for the property of interest relative to nearby properties.

1.2.1 TASK 1 ANALYSIS

1.2.1.1 HISTORICAL REVIEW

1.2.1.1.1 Historical Mine Maps. Mine maps and historical data for the coal seams underlying the Madisonville property were compiled and reviewed by RESPEC [2023] to provide nFront and KYMEA with a preliminary assessment of the subsidence hazard for the Madisonville property. This review used publicly available data to determine the following:

- Whether and which coal seams and mines underly the Madisonville property
- If future mining beneath the Madisonville property poses a substantial threat of subsidence
- Where is mining currently taking place in relationship to the Madisonville property
- If subsidence is possible on the Madisonville property

RESPEC [2023] predicted that future mining activity beneath the Madisonville property will not occur, but historical mines in the WKY 9 and WKY 11 coal seams could pose a subsidence threat. The location and geometry of the coal mines were determined by georeferencing historical mine maps using marked control points. The depths, ages, and other information regarding the mines beneath the Madisonville property were gathered from publicly available information, which was largely sourced from the Kentucky Geological Survey (KGS).

During the current study, RESPEC performed a cursory review of available georeferenced mine maps and found a discrepancy between the locally georeferenced maps used by RESPEC [2023] and a georeferenced scanned map available from the KGS. RESPEC's [2023] WKY 9 map workings were offset by 182 feet (ft) to the northwest of the KGS maps, and the WKY 11 map was offset by 126 ft to the northeast of the KGS maps. The RESPEC [2023] maps were also rotated slightly relative to the KGS maps, as depicted in Figures B-1 and B-2. Our experience with KGS-georeferenced maps, however, is that these maps are often georeferenced at a large scale (e.g., georeferencing control points can be several to tens of miles apart), resulting in distortions and misrepresentations of local-scale features.

Furthermore, when we evaluated the mined-area polygons provided by the KGS, several locations were inconsistent with the georeferenced mine maps, which led us to believe that the KGS georeferencing process may have some errors. For these reasons and because determining the cause of differences between the sources and verifying the relative accuracy of RESPEC's [2023] maps are difficult, the maps provided by RESPEC [2023] were used for the current study.

1.2.1.1.2 Historical Subsidence Events. In addition to incorporating the Phase 1 review of historical subsidence in the Madisonville area [RESPEC, 2023], Phase 2 also consisted of reviewing a few recent subsidence events in the Madisonville area that had caused structural damage. The following two significant events were identified, which differed from those reviewed during Phase 1:

- A series of three sinkholes that formed within a few days of each other in 2000.
- Subsidence at a Walmart Super Center that led to the store's closure in 2016.

The 2000 subsidence event included a large, 150- by 40-ft sinkhole within a lawn and garden center; a sinkhole beneath Bryan Lake in nearby Graham, Kentucky; and a sinkhole underneath a café in Providence, Kentucky. Poor shaft abandonment practices were deemed the likely cause for all three occurrences, and these failures may have happened at approximately the same time because of earthquake shaking and/or heavy recent rainfall. The subsidence event that led to the closure of the Walmart Super Center in 2016 was caused by ongoing collapses of abandoned mine shafts. Both subsidence events were caused by the collapse of historical mine workings, rather than subsidence violations of the active mines reviewed during Phase 1.

1.2.1.2 SITE INSPECTION

On January 9, 2024, two RESPEC personnel visited the Madisonville property to note potential drillhole locations and any indications of surface subsidence. The potential drillhole locations and access were evaluated to ensure safe drilling would be possible. RESPEC's site team observed that drillhole MAD-DH-2 would likely need a tracked drill rig because of the soft ground and its proximity to powerlines. This drillhole was relocated and renamed MAD-DH-02-ALT. Access to drillholes MAD-DH-01 and MAD-DH-03 was convenient and safe.

RESPEC

1.2.1.3 ANALYSIS OF COAL PILLAR STABILITY EVALUATION

For the Task 1 preliminary engineering analysis, the ACPS software tool provided by MSHA was used. In ACPS, the SF for a pillar system is obtained by dividing the total load-bearing capacity of the pillar system by the total load applied to it. ACPS has been verified through back analyses of more than 600 development and retreat mining case histories [Mark, 2010], and based on the statistical distribution of the room-and-pillar case history database, an ACPS SF of 1.5 for production pillars was determined [Mark and Agioutantis, 2019]. A pillar system SF value over 1.5 is considered to be safe.

RESPEC's ACPS analysis was based on existing mine maps, publicly available information for the coal seams and overburden units beneath the Madisonville property, and reasonable engineering assumptions. The central concept for the preliminary analysis was that if the smallest pillars within the Upper Mine Level (WKY 11) and the Lower Mine Level (WKY 9) beneath the Madisonville property have SF values greater than 1.5, then a minimal probability exists for pillar failure.

The ACPS analysis was performed by dividing the mapped mine areas into regions of reasonably consistent pillar geometries, and each region was evaluated independently. The Upper Mine Level (WKY 11) was divided into three regions: (1) North Panel, (2) Chain Pillars, and (3) South Panel, as shown in Figure B-3. Each of the WKY 11 regions was further divided into smaller sections for a more detailed analysis, as depicted in Figure B-4. The Lower Mine Level (WKY 9) was similarly divided into three regions: (1) North Panel, (2) Chain Pillars, and (3) South Panel, as shown in Figure B-5, and each WKY 9 region was further divided into smaller sections for detailed analysis, as illustrated in Figure B-6.

The depths of cover (i.e., distance from the mine level to the ground surface) for the WKY 9 and WKY 11 mine levels varied across the Madisonville property as detailed in Figure B-7. The thicknesses of the coal seams under the Madisonville property also differed, as shown in Figure B-8. The data provided in Figures B-7 and B-8 were from publicly available drillhole data held by the KGS and were not site-specific; instead, the drillhole data were interpolated across the site to create maps of seam thickness and depth of cover. The exact coal seam depths and mine excavation heights were not available for the ACPS analysis but were reasonably estimated using our interpolation methods.

The SF values for a pillar system are dependent on the depth of cover and the entry heights (i.e., mining height). Generally, as the depth of cover and entry height increase, ACPS-predicted SF values decrease. Because of the uncertainties in the KGS data, the ACPS models were run with varying depths of cover and entry heights using the pillar dimensions equal to the smallest pillar in the section being modeled. The results of the ACPS analysis are provided in Figures B-9 through B-25 and discussed further in Chapter 2.0.

1.2.2 TASK 2 ANALYSIS

After presenting the results of the Task 1 analyses, nFront, KYMEA, and RESPEC agreed that drilling drillholes would be prudent to reduce uncertainties in the depth of cover and mine entry heights of the WKY 9 and WKY 11 coal seams. After completing the drilling and core logging, nFront and KYMEA requested that RESPEC perform numerical modeling to evaluate the stability of the WKY 9 and WKY 11 mine levels and more deeply assess the subsidence and differential settlement hazards at the site.

RESPEC

1.2.2.1 CORE DRILLING AND LOGGING

To verify the depths of cover and entry heights, two drillholes, MAD-DH-03 and MAD-DH-02-ALT, were drilled at the Madisonville property, as depicted in Figure B-26. The core obtained from the drilling program was logged and photographed in the field by RESPEC personnel; the core logs included geology and geotechnical properties. Tabular versions of the MAD-DH-03 and MAD-DH-02-ALT drillholes are provided in Tables A-1 and A-2, respectively. The core logs are included in Appendix B.

1.2.2.2 CORE SAMPLING AND LABORATORY TESTING

The cores recovered during the drilling program were shipped to RESPEC's Materials Testing Laboratory in Rapid City, South Dakota, for sampling and strength testing. Thirty-two samples were selected from the cores. Among the samples, 20 were selected for strength testing: 8 triaxial (TRX), 8 unconfined compression (UCC), and 4 Brazilian tensile (BRZ). The testing was performed on coal, sandstone, limestone, and shale geologic units. The results of the laboratory testing are discussed in Chapter 2.0 and detailed in Tables A-3, A-4, and A-5 for TRX, UCC, and BRZ, respectively.

1.2.2.3 NUMERICAL MODELING

Evidence found during the drilling and core logging indicated that portions of the WKY 9 and WKY 11 mine levels may have begun to deteriorate (refer to Chapter 2.0). Because of this finding, nFront, KYMEA, and RESPEC agreed that a numerical model was prudent to evaluate the stability of the mine beneath the Madisonville property and the magnitude and area of subsidence that may occur. The numerical modeling was performed using *FLAC3D* [Itasca Consulting Group, Inc., 2023]. The stratigraphy of the rock mass was defined based on the core logs, as depicted in Figure B-27, and additional details regarding the geologic stratigraphy used for numerical modeling are provided in Table A-6. A series of 2D section models and 3D models were simulated.

1.2.2.3.1 Two-Dimensional Section Models. Two-dimensional section models are quicker to run and, because of their simplicity, are commonly used to evaluate the potential failure mechanisms in a mine and the relationships between pillar collapses to subsidence of the ground surface above. The average dimensions of the smallest pillars used for the Task1 ACPS analysis were applied to determine the size of rooms and pillars for the 2D section models. These pillars were 26 ft by 30 ft with 22-ft entry widths. The 2D section models were simulated for a simplified mine geometry in which the pillars and rooms were vertically stacked.

Figure B-28 illustrates the overview of the 2D section model, which extended 3,328 ft in the *x*-direction (to accommodate the full extent of the property boundary), 24 ft in the *y*-direction, and 500 ft vertically. The kinematic boundary conditions specified along the vertical and bottom boundaries of the model prevented normal displacement to the surfaces (lateral displacement was allowed). The top surface was allowed to move freely.

The mine rooms were modeled as 22 ft wide, with heights of 6.7 ft in the Upper Mine Level and 6.9 ft in the Lower Mine Level. For simplicity, the voids on both levels were modeled as the same size, assuming an equilateral triangle (side = 22 ft), and the in situ stresses were modeled to be lithostatic.

Because few physical observations for calibrating or validating the numerical models were available, the models were calibrated to the development of voids, as seen in the drillholes. Reverse calibration was used to determine the correct material properties indicative of the field scale material properties (in conjunction with the laboratory test data). Upon calibration, the model predicted some failure in the roof of the Upper Mine Level, which was similar to the presence of voids (approximately 2 ft) in the roof of the WKY 11 coal seam, as depicted in Figure B-29. Also upon calibration, the model predicted a triangular/arch-shaped failure in the roof of the Lower Mine Level similar to the presence of voids (approximately 8 ft) in the WKY 9 coal seam, as illustrated in Figure B-29. The calibrated material properties used for the numerical models were based on the laboratory test data and reverse calibration and are listed in Tables A-7 and A-8.

Once calibrated, the triangular failure zones in the mine roofs were included in the excavation geometry, forming rooms with additional voids above them in the model. This final 2D section model is referred to as the Current Condition model. The Current Condition model is conservative because it assumes that the collapsed areas of the WKY 9 and WKY 11 roofs do not provide any support for the overlying strata.

After running the Current Condition model simulations, RESPEC investigated what the effects of localized pillar collapses would be by incrementally removing pillars in the model. In the 2D section models, pillars were removed to represent four scenarios in which one, two, three, and four pillars, respectively, had completely collapsed and their remnant materials did not provide any support to the overlying strata or neighboring pillars. These conditions were conservative (i.e., the pillar remnants would provide some support) but provided insight into the sensitivity of ground-surface movements to pillar collapses. Note that, initially, the pillar collapses were modeled to occur simultaneously within the WKY 9 and WKY 11 mine levels in a stacked configuration. This type of scenario is highly unlikely and pillar collapses are not expected to occur within both mine levels in the same area at the same time.

Because simultaneous failure of stacked pillars in both mining levels is highly unlikely, two additional 4-pillar collapse condition simulations were run in which four pillars were removed separately in each mine level. The purpose of the additional 4-pillar collapse simulations was to provide a more realistic but conservative evaluation of the influence on surface subsidence from each mine level.

1.2.2.3.2 Three-Dimensional Models. The 2D section models included a simplistic version of the mine geometry and, most importantly, did not include the effects of varying pillar and entry dimensions (as is the case with the mines in the WKY 9 and WKY 11 coal seams). To account for the actual mine geometries, RESPEC elected to create a 3D model that incorporated the pillar and entry geometries included in publicly available mine maps. The calibrated material properties and the stratigraphy used for the 2D section models were used for the 3D model. Figure B-36 illustrates the overview of the 3D model, which extended 1,400 ft in the x-direction, 1,500 ft in the y-direction, and 500 ft vertically to encapsulate the ariel extents of the Madisonville property. The kinematic boundary conditions specified along the vertical and bottom boundaries of the model prevented normal displacement to the surfaces (lateral displacement was allowed). The top surface was allowed to move freely.

The collapse conditions simulated in the 3D model included two collapse conditions: (1) 170-ft by 170-ft area of pillar collapse and (2) 240-ft by 240-ft area of pillar collapse, which were similar to the 3-pillar and 4-pillar collapse conditions, respectively, simulated by the 2D section model. The pillar collapses simulated in the 3D model were selected to be far from the barrier pillars because barrier pillars substantially reduce stress concentrations and, thereby, reduce the likelihood of pillar collapse.

Regarding the 2D section modeling scenarios, note that full pillar collapses in the WKY 9 and WKY 11 mine levels are unlikely, based on the results of the Task 1 analysis. In addition, if pillars do collapse, they will leave behind remnant materials that will provide some ground support, which would reduce the magnitude of surface subsidence. However, the collapsed pillars were completely removed from the mine to simulate a worst-case scenario that provided bounding conditions for evaluating the subsidence hazard at the Madisonville property. The collapsed pillars were also simultaneously removed from both mine levels in a vertically stacked condition. This type of scenario is highly unlikely and adds to the conservatism of the 3D modeling results.

The publicly available mine maps used for the Task 1 ACPS analysis were used to define the pillar dimensions in the 3D model. The position and orientations of the WKY 9 and WKY 11 mine geometries were also based on the publicly available mine maps (Figure B-36). The topography of the Madisonville property is nearly flat and was modeled as such, and the in situ stress conditions were modeled to be lithostatic and isotropic.

Although the calibrated material properties used for the 2D section models were replicated in the 3D model, RESPEC elected to calibrate the 3D model by comparing predicted ground behavior with observations from the drillholes. Similar to the 2D section models, the 3D model predicted some failure in the roof of the WKY 11 mine level that was consistent with the presence of voids (approximately 2 ft) in the WKY 11 coal seam, as shown in Figure B-37. The 3D model also predicted triangular/arch-shaped failures in the roof of the WKY 9 mine level, which were consistent with the observed voids (approximately 8 ft) in the WKY 9 coal seam [Figure B-37]).

After calibration, the 3D model simulations were studied to evaluate the influence of subsidence hazards of the large barrier pillars of both mine levels. In theory, these large barrier pillars will remain stable long into the future, including an ultimate subsidence scenario in which all the smaller production pillars have collapsed. The ultimate subsidence scenario is the least likely collapse scenario to happen during the useful life of the facilities proposed to be constructed on the Madisonville property.

For the ultimate subsidence scenario, a gob of damaged rock material was assumed to have formed with an initial bulking factor of approximately 1.5, corresponding to a maximum strain of around 33 percent. The gob was modeled as a strain-hardening material, using methods created by Pappas and Mark [1993] and modified by Esterhuizen, Mark, and Murphy [2010a]. Figure B-41 shows the surface subsidence plot for the ultimate subsidence scenario. The least amount of subsidence occurs in the areas over the barrier pillars in the WKY 11 seam.

1.2.2.4 ULTIMATE SUBSIDENCE HAZARD MAPPING

To provide nFront and KYMEA with guidance concerning where on the Madisonville property subsidence or differential settlement is least likely to occur, RESPEC combined the results of the 3D model with the pillar geometries in the mine maps to create a hazard isopach map. The hazard isopach map does not provide probabilities or magnitudes of predicted surface subsidence. Rather, the map was created to illustrate the relative likelihood and severity of subsidence or differential settlement.

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2.0 RESULTS AND DISCUSSION

2.1 TASK 1 ANALYSIS

2.1.1 HISTORICAL REVIEW

2.1.1.1 HISTORICAL MINE MAPS

Uncertainties exist in the exact locations of the mine workings in WKY 9 and WKY 11, which is common with historical underground mines and can rarely be avoided when investigating subsidence risk. RESPEC believes we have located the WKY 9 and WKY 11 mine workings as accurately as possible because our drilling and core logging were consistent with the expected intersection of pillars and rooms in both mine levels and the mine maps were georeferenced using local control points. However, the mine workings may not be located in the exact locations used for the current study. Based on the differences in georeferencing between KGS and RESPEC [2023], we expect that the mine workings are not misplaced more than approximately 100 to 200 ft in our models.

2.1.1.2 HISTORICAL SUBSIDENCE EVENTS

RESPEC reviewed three surface subsidence events reported in the Madisonville area. Of the three, two subsidence events reviewed for the current study were caused by collapses of abandoned mine shafts. No evidence was found that mine shafts are present beneath the Madisonville property, and we believe the risk of shaft collapse-related subsidence on the property is very low. The other subsidence-related issue was probably caused by the previous presence of a swamp in the construction area; however, no evidence exists of a swamp at the Madisonville property. The historical events reviewed by RESPEC [2023] were for active mines and there is little to no chance of future mining beneath the Madisonville property.

The following local newspaper article links were used for this study:

1. **Kentucky New Era., 2000.** "Gigantic Hole Was Abandoned Coal Mine Shaft," *Kentucky New Era.*, Hopkinsville, KY, June 20. Available online at *https://www.kentuckynewera.com/article_3ac9aa9e-6db1-5711-9aed-5cd2ee428885.html*
2. **Hughes, M., 2023.** "Future of Former Madisonville Walmart Up in the Air," *The Times Leader*, February 4. Available online at *https://www.timesleader.net/news/future-of-former-madisonville-walmart-up-in-the-air/article_a79e61a6-9f31-5769-a080-26c64be83c55.html*
3. **WFIE, 2016.** "Madisonville Walmart to Close, Deemed Unsafe," 14 News, WFIE, Evansville, IN, June 17. Available online at *https://www.14news.com/story/32250640/madisonville-walmart-to-close-deemed-unsafe/*

2.1.2 SITE INSPECTION

RESPEC personnel did not observe any indications of subsidence on the Madisonville property, but a portion of the property adjacent to the neighboring water treatment facility did appear to have been regraded and revegetated. In this area, these indications may have been obscured. There were no visual signs that subsidence or differential settlement had occurred at the Madisonville property. A letter summarizing RESPEC's site-visit findings is provided in Appendix A.

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In addition to our findings from the Madisonville property, the presence of a water treatment plant next to the area of interest and a well-traveled railroad track surrounding the property indicate that subsidence has not been a concern in the immediate area. We estimate that the railroad track and water treatment plant have been in service since at least the 1980s, and have found no indication, on site or otherwise, that damaging subsidence has occurred beneath them.

2.1.3 ANALYSIS OF COAL PILLAR STABILITY EVALUATION

The ACPS-predicted SF value was over 1.5 for all likely depths of cover and entry heights (Figures B-9 through B-25). Considering the relatively low depth of cover and short entry heights in the WKY 9 and WKY 11 mine levels, this result was consistent with RESPEC's expectations and provided additional confidence that subsidence risk at the site was relatively low. Our observations during the initial site visit and inspection indicated that subsidence had probably not or had minimally occurred on the Madisonville property. Those observations were also consistent with the results of the ACPS analysis.

2.2 TASK 2 ANALYSIS

2.2.1 CORE DRILLING, LOGGING, SAMPLING, AND LABORATORY TESTING

During the drilling program, voids at depths of 131.7 and 239.7 ft were encountered in the MAD-DH-03 drillhole. In the other drillhole, MAD-DH-02-ALT, a void was encountered at a depth of 236 ft. After further analysis of the core logs and the core photographs, we believe that the MAD-DH-03 drillhole intersected mine openings on both the WKY 9 and WKY 11 mine levels. The MAD-DH-02-ALT drillhole most likely intersected a pillar in the WKY 11 mine level and a void on the WKY 9 mine level. The coal seam thickness for the WKY 11 mine level is 6.7 ft and at an average depth of 137.3 ft. The seam thickness for the WKY 9 mine level is 6.9 ft and at an average depth of 236.8 ft. The total void height on the WKY 11 mine level was determined to be 8.9 ft, including the seam thickness of 6.7 ft and voids that may have opened as the roof of the mine deteriorated. The total void height on the WKY 9 mine level was 14 ft, including the seam thickness of 6.9 ft and mine roof deterioration voids.

The seam heights and depths were very similar to the publicly available information and the observed void conditions are consistent with general mine behavior in aging and abandoned coal mines. However, some small differences in the depth of cover and seam thickness estimates were valuable to understand.

The laboratory test data show that the coal in the WKY 9 and WKY 11 seams was of higher strength than originally assumed for the ACPS analysis. We also discovered a beam of relatively high-strength sandstone above the WKY 9 (lower) seam and a relatively weaker beam of shale above the WKY 11 (upper) seam. The laboratory test results were generally consistent with our experience in similar geologic environments. The core drilling, logging, and laboratory tests did not reveal particularly weak or degraded materials in the subsurface below the Madisonville property. The laboratory test data were used to develop the material properties used in the numerical models. Table A-3, A-4, and A-5 summarizes the laboratory test results.

2.2.2 NUMERICAL MODELING

The results of RESPEC's numerical modeling are included in the following sections.

2.2.2.1 TWO-DIMENSIONAL MODELS

The surface subsidence profile for the Current Condition model showed that the subsidence profile is nearly flat, and the ground surface has likely moved no more than 0.33 inch since the WKY 9 and WKY 11 mine levels were excavated, as shown in Figure B-30. The zone state plot (i.e., showing areas of failure and nonfailure) depicted in Figure B-30 indicated that ground damage is probably localized around the WKY 9 and WKY 11 excavations, which is consistent with rubblized zones and voids found during drilling.

The 2D section model simulation in which one pillar was removed showed that the subsidence profile is nearly horizontal, and the predicted surface subsidence would be an additional 0.10 inch to the Current Condition subsidence prediction (0.43 inch total), as illustrated in Figure B-31. The zone failure state plot showed limited damage to the roofs over the pillar collapse area (Figure B-31).

The surface subsidence profile for the 2-pillar collapse condition showed that the maximum predicted subsidence would be an additional 0.27 inch to the Current Condition subsidence prediction (0.60 inch total), as shown in Figure B-32. The zone failure state plot showed limited damage to the roofs over the pillar collapse areas (Figure B-32).

The surface subsidence profile for the 3-pillar collapse condition showed that the maximum predicted subsidence would be an additional 0.83 inch to the Current Condition subsidence prediction (1.16 inches total), as depicted in Figure B-33. The zone failure state plot showed arch-shaped damage to the roof of the WKY 11 mine level that propagated into the weak shale above it. Comparatively smaller damage areas above the WKY 9 seam were likely the result of the strong sandstone overlying it (Figure B-33).

The maximum predicted surface subsidence for the 4-pillar collapse condition was much greater than the other pillar collapse scenarios at 2.83 inches in addition to the Current Condition subsidence prediction (3.16 inches total), as shown in Figure B-34. The zone failure state plot showed significant damage to the strata above both coal seams; however, like the 3-pillar collapse condition, most of the damage was predicted to occur in the weak shale overlying WKY 11 (Figure B-34).

The maximum predicted surface subsidence when only one of the mine levels had a 4-pillar collapse was 1.21 inches in addition to the Current Condition subsidence prediction (1.54 inches total) and occurred when the WKY 9 mine level pillars were removed, as illustrated in Figure B-35. In this scenario, damage to the strata overlying the WKY 9 seam propagates upward and affects the Current Condition excavations in WKY 11, causing significant arch-shaped damage to the weak shale above WKY 11 and induce surface subsidence (Figure B-35).

When four pillars were removed from only the WKY 11 (upper) mine level, the maximum predicted surface subsidence was 0.81 inches in addition to the Current Condition subsidence prediction (1.14 inches total), as depicted in Figure B-35. Like the simulation where four pillars were removed in WKY 9, there were arch-shaped damage areas in the weak shale above WKY 11; however, the magnitude of subsidence was less because the WKY 9 excavations were unaffected by the simulated collapse in the WKY 11 mine (Figure B-35). This result is consistent with expected ground behavior in a multi-level mining scenario; failures in the upper level often do not affect the lower level.

The results of the 2D section modeling exercise were consistent with expected ground behavior and showed that damage to the weak shale overlying the WKY 11 mine level was the primary driver of the predicted subsidence. Substantial damage to the shale did not occur until three or four pillars were removed from both mine levels, which are unlikely scenarios. Furthermore, when 4-pillar collapses were simulated on the individual levels, the maximum predicted subsidence was small (1.54 inches).

2.2.2.2 THREE-DIMENSIONAL MODELS

The 170-ft by 170-ft pillar collapse simulation predicted maximum vertical subsidence of 0.55 inch, as shown in Figure B-38. The predicted maximum subsidence was substantially less than the 1.16 inches predicted using a similar collapse scenario in the 2D section model. The difference between the 2D and 3D model results is attributed to the pillar geometries used in the 2D section models being selected by estimating the size of the smallest pillars in the production panels of the WKY 9 and WKY 11 mine levels. Larger pillars surrounding the simulated collapse area provided additional support over what was simulated in the 2D section models, thereby reducing the predicted surface subsidence in the 3D models.

Similar to the 170-ft by 170-ft pillar collapse simulation, the 240-ft by 240-ft 3D collapse simulation predicted substantially less surface subsidence than during the 2D simulations because the surrounding pillars provided additional support. The maximum predicted surface subsidence was 0.96 inch, as shown in Figure B-39, compared to the 3.16 inches predicted by the 2D section models.

The 3D and 2D section models both predicted that the weak shale layer above the WKY 11 (upper) mine level would take substantial damage in a pillar collapse scenario. Despite the differences between the 2D and 3D models (e.g., actual mine geometries versus assumed pillar and entry dimensions), the results were consistent with RESPEC's hypothesized ground conditions and the drilling, sampling, and laboratory testing program. Furthermore, as was true in the 2D section models, the 3D model results showed that pillar collapses in the WKY 11 mine level caused more surface subsidence than collapses in the WKY 9 mine level because of the presence of the weak shale above WKY 11.

The 3D model of ultimate subsidence (i.e., the scenario in which all but the barrier pillars collapse on both mine levels) predicted a maximum surface subsidence of 24.1 inches above the production mine areas near the north of the Madisonville property and 3.2 inches above the WKY 11 barrier pillars, as depicted in Figures B-40 and 41. Although the maximum predicted ultimate surface subsidence was greater than 2 ft, the modeled ultimate subsidence scenario is considered extremely unlikely to occur, and the model indicated that constructing facilities above the barrier pillars will substantially reduce subsidence hazards on the Madisonville property.

2.2.3 ULTIMATE SUBSIDENCE HAZARD MAPPING

The ultimate subsidence hazard mapping effort showed that the southern margin of the Madisonville property above the WKY 11 barrier pillars has the lowest subsidence and differential settlement hazard, as provided in Figure B-41. This result was expected and is consistent with RESPEC's experience of historical underground mines. Because of the weak shale above the WKY 11 mine level, the location of the barrier pillars in WKY 11 is most influential on the subsidence hazard isopach map shown in Figure B-42. The other major driver of subsidence hazards is the production pillar size, which caused the model results for the ultimate subsidence scenario (Figure B-41) to differ from the hazard map (Figure B-42).

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3.0 CONCLUSIONS

3.1 SUBSIDENCE HAZARD

Our historical review, site inspection, and ACPS analysis in Task 1 indicated that the subsidence hazard on the Madisonville property is low. No historical subsidence has been reported for the immediate area surrounding the property and no indications of subsidence were observed when we visited the property. Nearby sensitive infrastructure appears to have remained intact and undamaged by subsidence, and our ACPS analysis indicated that even the smallest pillars in the WKY9 and WKY11 mine workings beneath the property had acceptable SF values.

The core drilling and logging program revealed some rubblization in the coal seams and deterioration that is consistent with the age and materials in the roof of the WKY 9 and WKY 11 mine levels. Our laboratory testing confirmed that the coal in both seams was stronger than assumed during the Task 1 ACPS analysis but also identified a weak shale unit above WKY 11 that, if a collapse occurred in WKY 11, could fail and lead to surface subsidence under extraordinary circumstances (i.e., multiple fully collapsed pillars with zero supporting loads from pillar and roof rubble). The numerical models used for a 4-pillar collapse scenario on both levels at the same time predicted a maximum surface subsidence of slightly more than 3 inches. Because a stacked-failure scenario is unlikely and the model included the conservative assumption that the rubble would provide no support to the overlying strata, we believe that the 2D section models indicate that subsidence risk is low.

The 3D models predicted even less subsidence for the 4-pillar collapse scenario, despite the total collapse area being larger because the model included a 4x4 pillar area, rather than the 2D section model's 4x1 pillar area. The maximum predicted surface subsidence was less than 1 inch using the 3D model—more than 2 inches less than the corresponding 2D section model predicted. The difference in the results is attributed to support being provided by pillars outside the collapse area and the influence of large production pillars and barrier pillars affecting the stress regime of the entire modeled area. Because the same conservative conditions were used in the 3D model (i.e., total pillar removal, no support from the rubble, and stacked failures on both mine levels), the 3D numerical model results further reinforced that subsidence risk is low on the Madisonville property.

In the extreme case of ultimate subsidence, where all of the production and development pillars in the mines collapse and only the large barrier pillars remain, our 3D numerical models predicted a high variability of subsidence magnitudes across the Madisonville property. The predicted surface subsidence varied from approximately 3 inches above the WKY11 barrier pillars near the south end of the property to 24 inches above the WKY9 and WKY11 production pillars at the north end. Such an extreme case of subsidence is highly unlikely; however, modeling this scenario serves to guide a spatial analysis of where on the property subsidence hazards are highest. By combining an interpolated pillar size map with the ultimate subsidence model results, we produced a relative subsidence hazard map (Figure B-42) and confirmed that while the subsidence hazard on the Madisonville property is low, the southern portion of the property has by far the lowest subsidence hazard.

3.2 SUITABILITY OF THE MADISONVILLE PROPERTY

RESPEC believes that the Madisonville property is suitable for the construction of power generation facilities. Subsidence-sensitive facilities should be placed in the southern one-third of the property and, whenever possible, over the estimated locations of the WKY9 and WKY11 barrier pillars (with preference for above the WKY11 barrier pillars). An example placement of such facilities is shown in Figure B-42.

Because some outstanding concerns exist regarding the exact georeferencing of the historic mine mapping and, therefore, the location of the barrier pillars as they relate to the property boundary, we recommend performing additional drilling to verify the location of the barrier pillars. If any of these new exploratory holes intersect a mine void, the void should be grouted with a low-slump grout. More generally, low-slump grout can be used in mine voids encountered during drilling to increase the stability of mine openings and reduce the risk of pillar or roof collapse and, thus, the risk of subsidence.

Although we believe the risk of subsidence on the Madisonville property is low, especially near its southern margins and above the WKY9 and WKY11 barrier pillars, subsidence remains a risk. The property overlies historical coal mines and RESPEC makes no claims that subsidence cannot or will not occur on the Madisonville property. Furthermore, the predicted subsidence magnitudes presented in this report were developed using numerical model simulations that rely on several assumptions and are not guaranteed or warranted in any way to correlate directly with ground behavior. The predictions, claims, recommendations, and judgments presented herein are made under our best professional assessment given the data and information available to us at the time this study was performed.

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APPENDIX A

TABLES

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Table A-1. Core Log for MAD-DH-03

Top (ft)	Bottom (ft)	Thickness (ft)	Formation	Comments
0	9.6	9.6	Overburden	
9.6	11.2	1.6	Sandstone	
11.2	16.2	5	Sandstone	
16.2	19.6	3.4	Sandstone	
19.6	26.2	6.6	Shale+Clay+Coal	
26.2	31.2	5	Shale+Clay+Coal	
31.2	36.2	5	Shale+Sandstone	
36.2	41.2	5	Sandstone+Shale	
41.2	64.2	23	Sandstone	
64.2	64.5	0.3	Coal	
64.5	67.7	3.2	Sandstone	
67.7	76	8.3	Shale	
76	77.2	1.2	Coal	
77.2	91.2	14	Mudstone	
91.2	121.2	30	Shale	
121.2	121.9	0.7	Limestone	
121.9	126.3	4.4	Coal	
126.3	127	0.7	Shale	
127	131.7	4.7	Limestone	
131.7	137.1	5.4	VOID	WKY 11
137.1	137.4	0.3	Limestone-VOID	Void Rock
137.4	140.6	3.2	VOID+Clay	
140.6	140.7	0.1	Coal	
140.7	140.9	0.2	Clay	
140.9	142.1	1.2	Shale	
142.1	152.8	10.7	Mudstone	
152.8	204.2	51.4	Sandstone	
204.2	205.6	1.4	Mudstone	
205.6	227.3	21.7	Sandstone	
227.3	239.7	12.4	Shale	
239.7	246.6	6.9	VOID	Hard Rock at 246.6 ft
246.6	249.5	2.9	Clay	
249.5	253.2	3.7	Mudstone	Heavy Damage

ft = feet

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Table A-2. Core Log for MAD-DH-02-ALT

Top (ft)	Bottom (ft)	Thickness (ft)	Formation	Comments
0	10.5	10.5	Overburden	
10.5	11	0.5	Mudstone	
11	16	5	Sandstone	
16	21	5	Sandstone	
21	26	5	Sandstone	
26	30	4	Sandstone	
30	31.1	1.1	Coal	
31.1	36	4.9	Mudstone	
36	51.5	15.5	Shale	
51.5	56	4.5	Sandstone	
56	61	5	Sandstone	
61	71	10	Sandstone	
71	75.1	4.1	Coal	
75.1	79.6	4.5	Sandstone	
79.6	88.8	9.2	Shale	
88.8	90.5	1.7	Coal	
90.5	114	23.5	Shale	
114	129.5	15.5	Shale	
129.5	132.3	2.8	Limestone	
132.3	132.5	0.2	Shale	
132.5	137.4	4.9	Coal	Paradise Coal
137.4	137.7	0.3	Mudstone	Lost Drilling Water (300 gallons) to the Formation
137.7	138.1	0.4	Clay	
138.1	142.8	4.7	Limestone	
142.8	149.5	6.7	Coal	WKY 11
149.5	166.5	17	Mudstone	
166.5	219.9	53.4	Sandstone	
219.9	236	16.1	Shale	
236	245	9	VOID	Tool Drop Started at 236 ft
245	250	5	VOID Shale	Drilling Solid at 250 ft
250	254	4	Shale	

Table A-3. Summary of the Eight Triaxial Strength Tests

Formation I.D.	Geologic Unit	Young's Modulus (psi)	Poisson's Ratio (—)	σ Confined (psi)	σ Axial (psi)	σ Difference (psi)	p σ Mean (psi)	q σ Shear (psi)	Density (g/cc)
nFront/MAD-04/211.7-212.3	Sandstone	1,795,000	0.11	1,000	11,350	10,350	6,175	5,175	2.4
nFront/MAD-08/117.6-118.9	Shale	1,457,000	0.13	500	5,930	5,430	3,215	2,715	2.6
nFront/MAD-14/230.3-230.7	Shale	2,029,000	0.14	750	9,710	8,960	5,230	4,480	2.6
nFront/MAD-18/100.3-100.8	Shale	1,247,000	0.25	1,000	7,000	6,000	4,000	3,000	2.6
nFront/MAD-22/128.8-129.5	Limestone	7,334,000	0.23	500	17,910	17,410	9,205	8,705	2.7
nFront/MAD-23-1/130.3	Sandstone	10,791,000	0.25	750	19,990	19,240	10,370	9,620	2.7
nFront/MAD-23-2/130.8	Sandstone	9,911,000	0.24	1,000	20,740	19,740	10,870	9,870	2.7
nFront/MAD-30/229.3-229.85	Sandstone	2,079,000	0.23	1,250	11,110	9,860	6,180	4,930	2.7

psi = pounds per square inch

g/cc = grams per cubic centimeter

Table A-4. Summary of the Eight Unconfined Compression Tests

Formation I.D.	Geologic Unit	Young's Modulus (psi)	Poisson's Ratio (—)	σ Confined (psi)	σ Axial (psi)	σ Difference (psi)	p σ Mean (psi)	q σ Shear (psi)	Density (g/cc)
NFRONT/MAD-05/99.6-100.2	Shale	326,000	0.07	—	3,550	3,550	1,775	1,775	2.6
NFRONT/MAD-09/134.8-135.3	Coal	291,000	0.04	—	2,020	2,020	1,010	1,010	1.4
NFRONT/MAD-10/137.1-137.5	Coal	358,000	0.11	—	2,010	2,010	1,005	1,005	1.4
NFRONT/MAD-10/143.0-143.4	Coal	412,000	0.16	—	2,090	2,090	1,045	1,045	1.3
NFRONT/MAD-16/122.4-122.8	Coal	143,000	0.02	—	4,180	4,180	2,090	2,090	1.4
NFRONT/MAD-21/127.4-128.0	Limestone	4,182,000	0.09	—	8,550	8,550	4,275	4,275	2.7
NFRONT/MAD-24/206.2-207.0	Sandstone	460,000	0.03	—	5,470	5,470	2,735	2,735	2.3
NFRONT/MAD-28/228.5-229.2	Shale	1,471,000	0.11	—	5,190	5,190	2,595	2,595	2.6

RESPEC

Table A-5. Summary of the Four Brazilian Tensile Strength Tests

Formation I.D.	Geologic Unit	Tensile Strength (psi)
nFront/MAD-07/113.2-113.8	Shale	526.68
nFront/MAD-02/188.5-189.0	Sandstone	266.17
nFront/MAD-11/140.7-142.1	Limestone	1,018.13
nFront/MAD-15/232.4-232.9	Shale	936.94

Table A-6. Geologic Stratification Used for the Numerical Models

Strata	Strata Top Depth (ft)	Strata Bottom Depth (ft)	Strata Thickness (ft)
Overburden	0	−10.05	10.05
Sandstone	−10.05	−24.8	14.75
Coal	−24.8	−31.1	6.3
Shale	−31.1	−43.85	12.75
Sandstone	−43.85	−67.6	23.75
Coal	−67.6	−69.8	2.2
Sandstone	−69.8	−73.65	3.85
Shale	−73.65	−82.4	8.75
Coal	−82.4	−83.85	1.45
Shale	−83.85	−125.35	41.5
Limestone	−125.35	−127.2	1.85
Coal_Paradise	−127.2	−131.85	4.65
Shale	−131.85	−132.55	0.7
Limestone	−132.55	−137.25	4.7
Coal_Wky11	−137.25	−143.95	6.7
Mudstone	−143.95	−158.55	14.6
Sandstone	−158.55	−222.5	63.95
Shale	−222.5	−236.75	14.25
Coal_Wky9	−236.75	−243.65	6.9
Shale	−243.65	−400	156.35

Table A-7. Material Properties of Geologic Units Used in the Numerical Models

Geologic Unit	Young's Modulus (psi)	Friction (degree)	Cohesion (psi)	Tensile Strength (psi)	Density (g/cc)	Poisson's Ratio (—)
Overburden	997,859	20	147.9	42	2.6	0.25
Sandstone	1,723,000	30	971.7	336.4	2.4	0.25
Shale	1,515,600	20	883.2	252.3	2.6	0.25
Limestone	3,222,700	38	1,266.1	504.7	2.4	0.25
Mudstone	1,100,800	20	294.4	84.1	2.6	0.25

Table A-8. Hoek-Brown Parameters for Modeling Coal Material in *FLAC3D* as Used by Esterhuizen et al. [2010][1]

Property	Value
UCS (laboratory scale)	2,900 psi
Young's modulus	435,113 psi
Poisson's ratio	0.25
m-value	1.47
s-value	0.07
m-residual	1
s-residual	0.001
Interface friction angle	25
Interface Cohesion	14.5 psi
Interface tensile strength	0
Interface normal stiffness	44,207,502 psi/ft
Interface shear stiffness	22,103,751 psi/ft
a-parameter	0.65

psi/ft = pounds per square inch per foot

1 **Esterhuizen, G., C. Mark and M.M. Murphy, 2010.** "Numerical Model Calibration for Simulating Coal Pillars, Gob and Overburden Response," *Proceedings of the 29th International Conference on Ground Control in Mining*, Morgantown, WV, pp. 46-57.

APPENDIX B

FIGURES

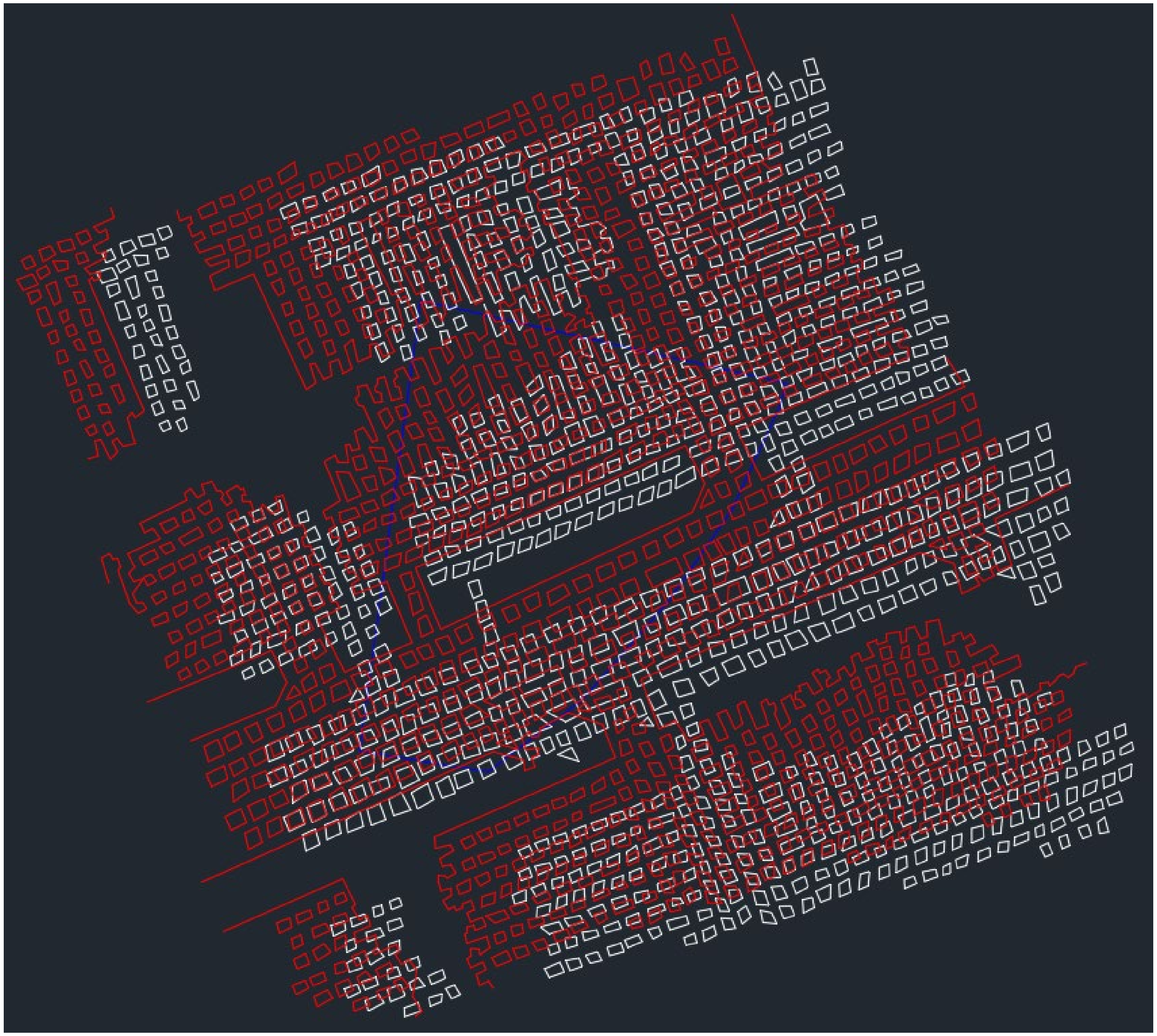


Figure B-1. Comparison of the Kentucky Geological Survey (White) and RESPEC Georeferenced (Red) Mine Maps for WKY 9.

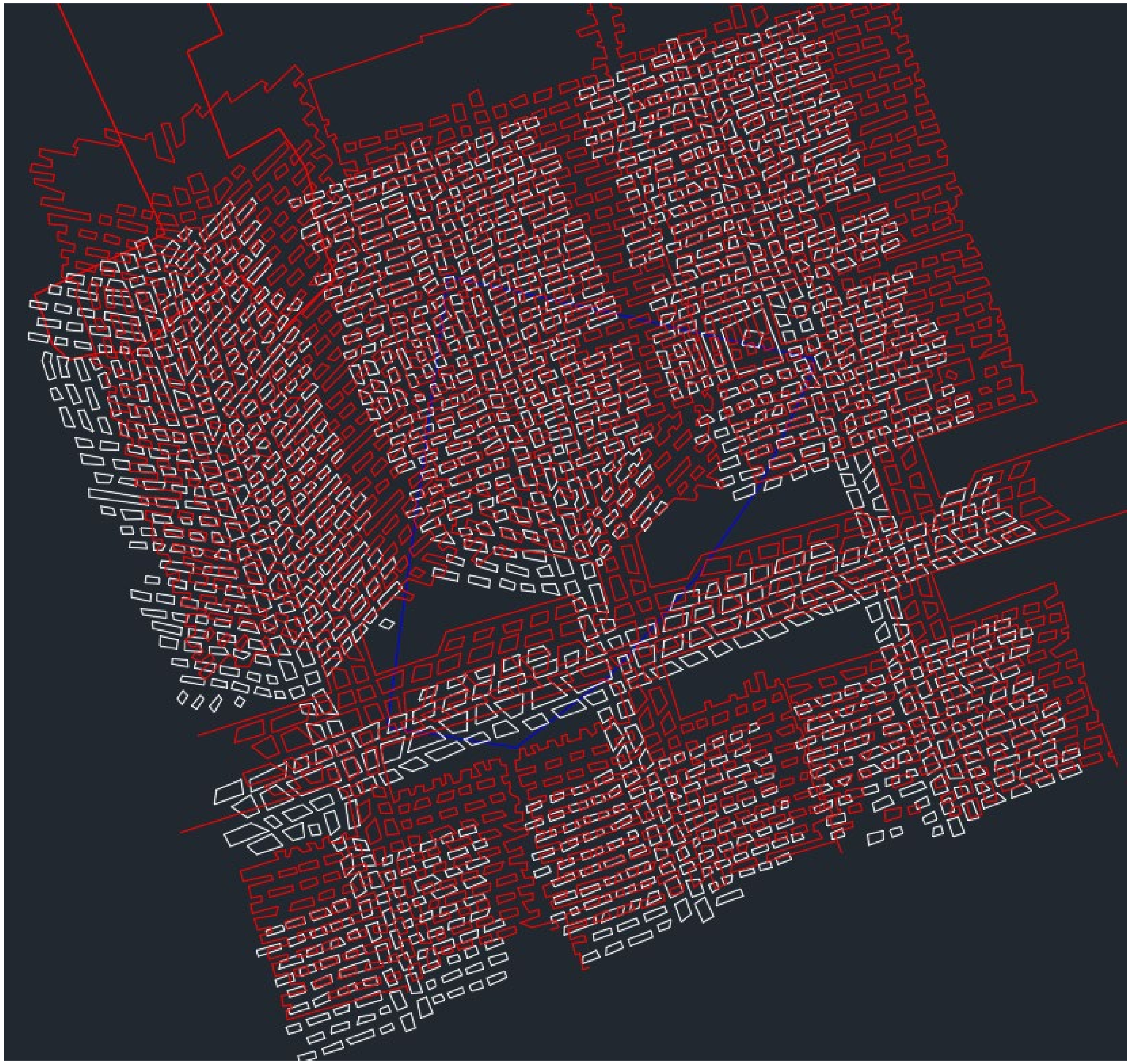


Figure B-2. Comparison of the Kentucky Geological Survey (White) and RESPEC Georeferenced (Red) Mine Maps for WKY 11.

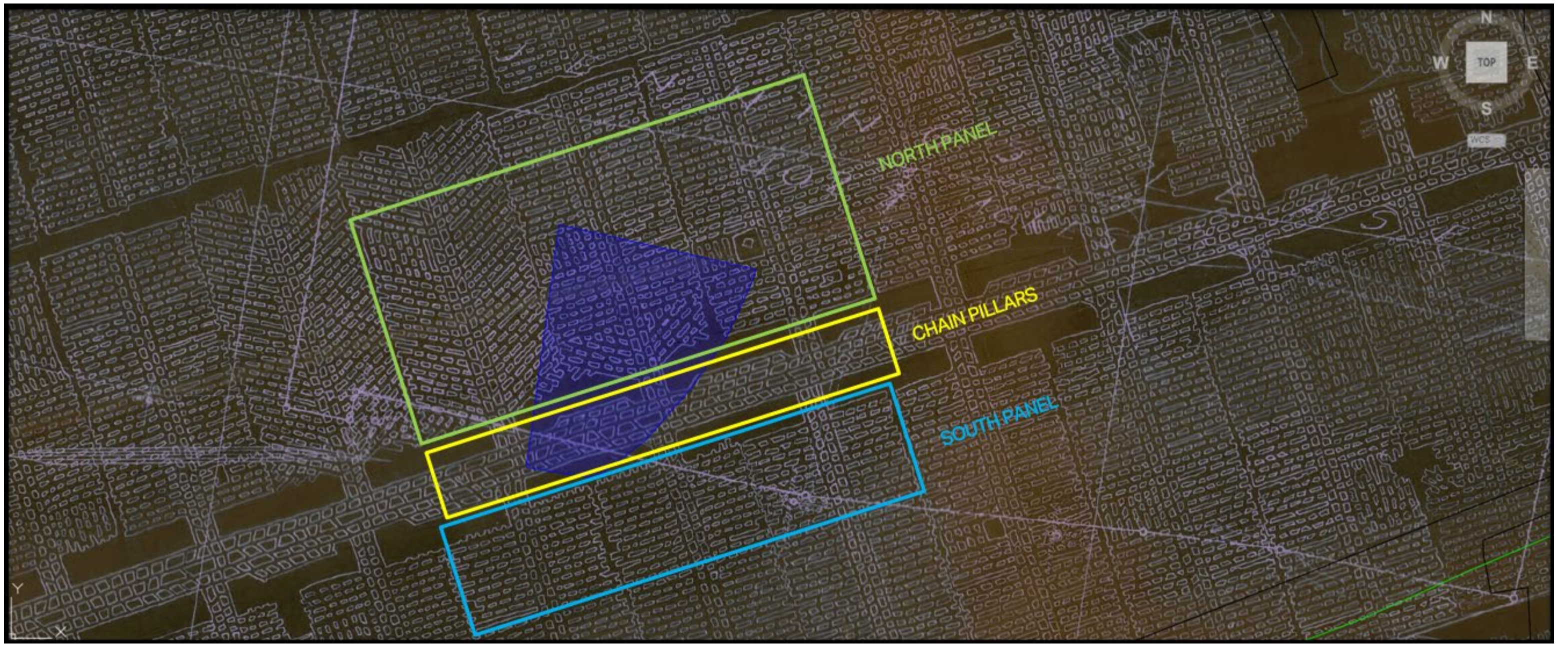


Figure B-3. Upper Mine Level (WKY 11) Divided Into Three Regions.

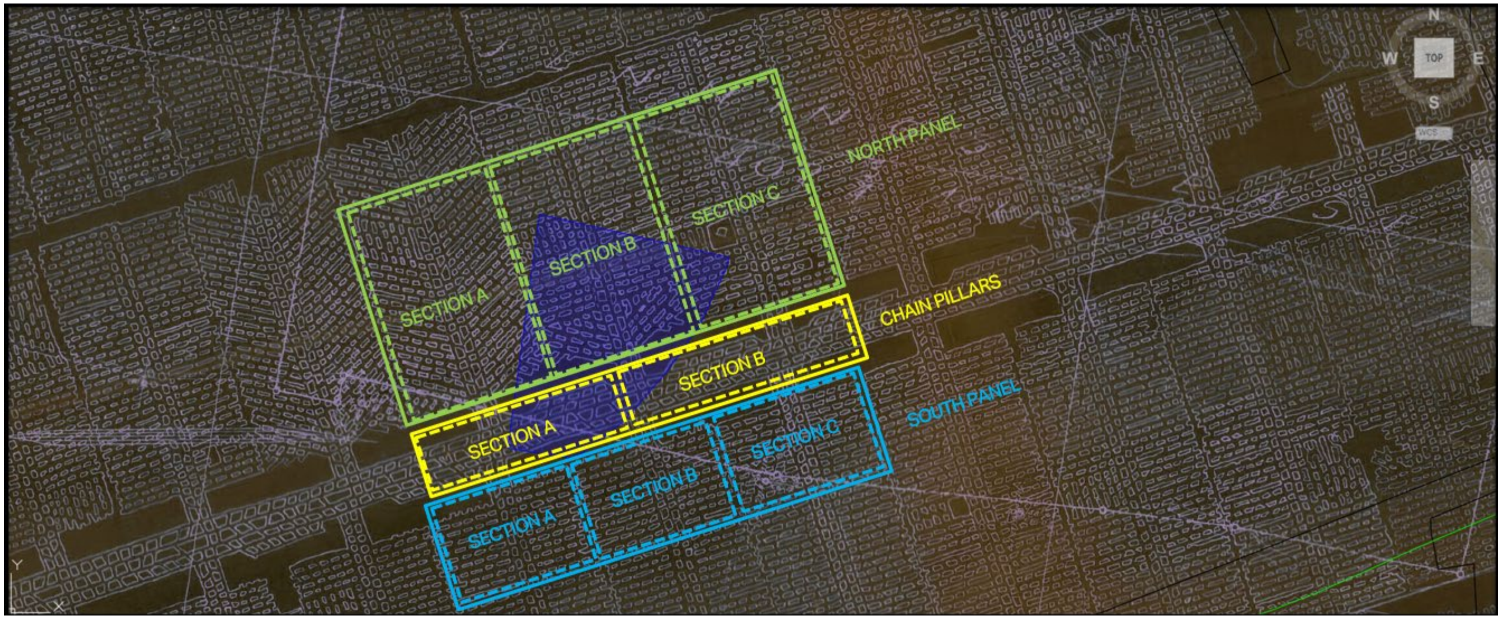


Figure B-4. The Three Regions of Upper Mine Level (WKY 11) Further Divided Into Smaller Sections.

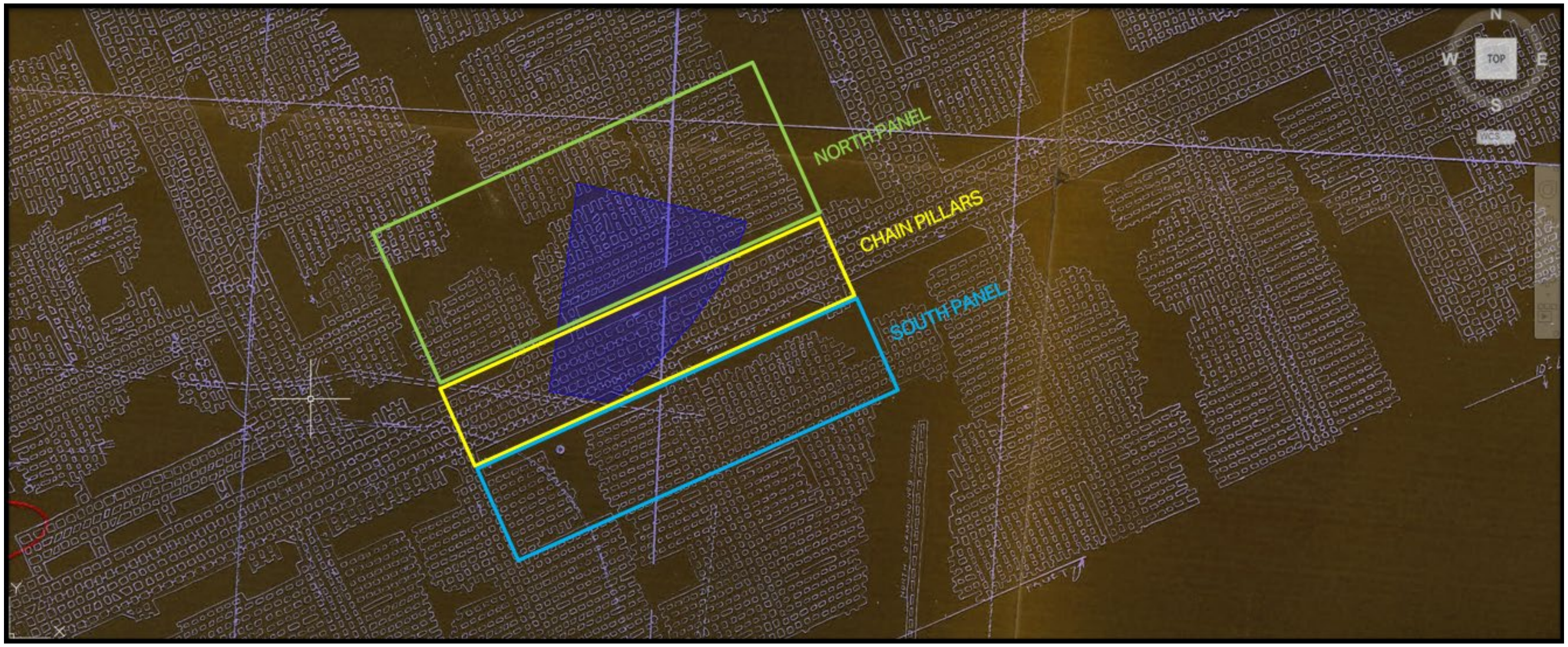


Figure B-5. Lower Mine Level (WKY 9) Divided Into Three Regions.

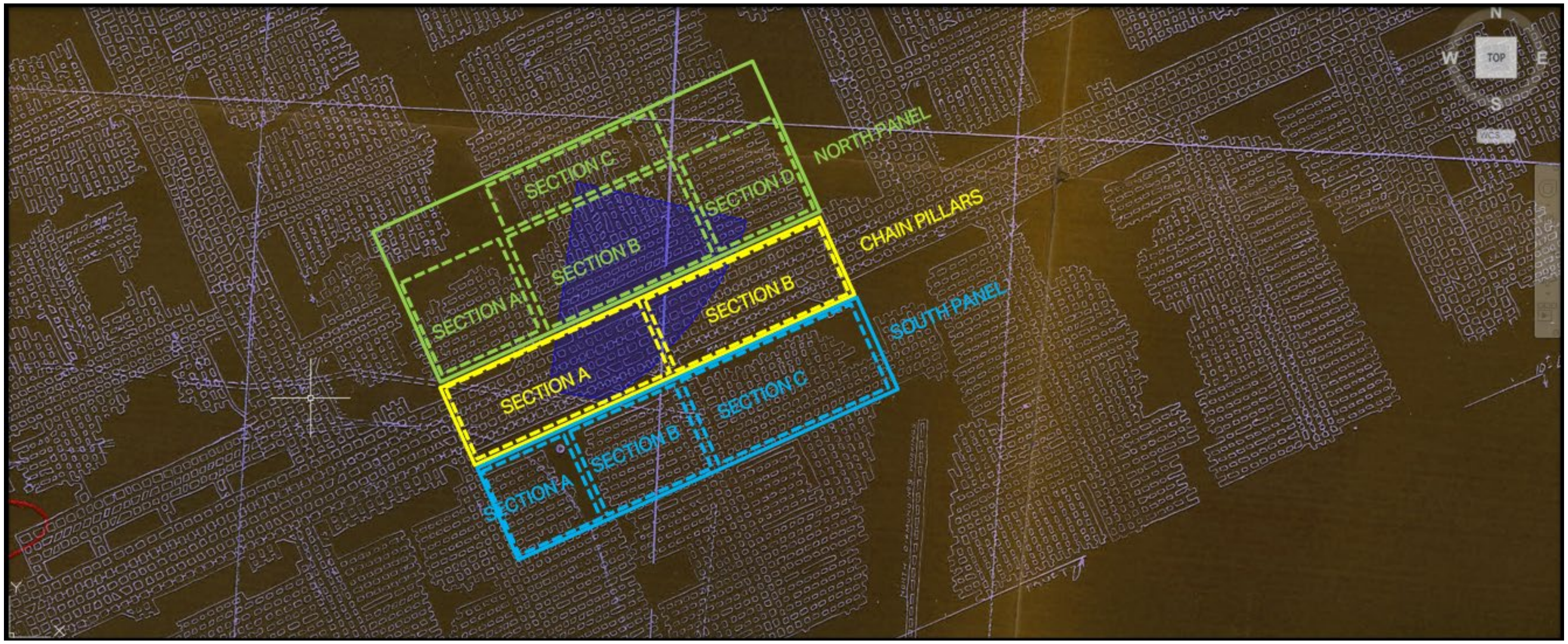


Figure B-6. The Three Regions of Lower Mine Level (WKY 11) Further Divided Into Smaller Sections.

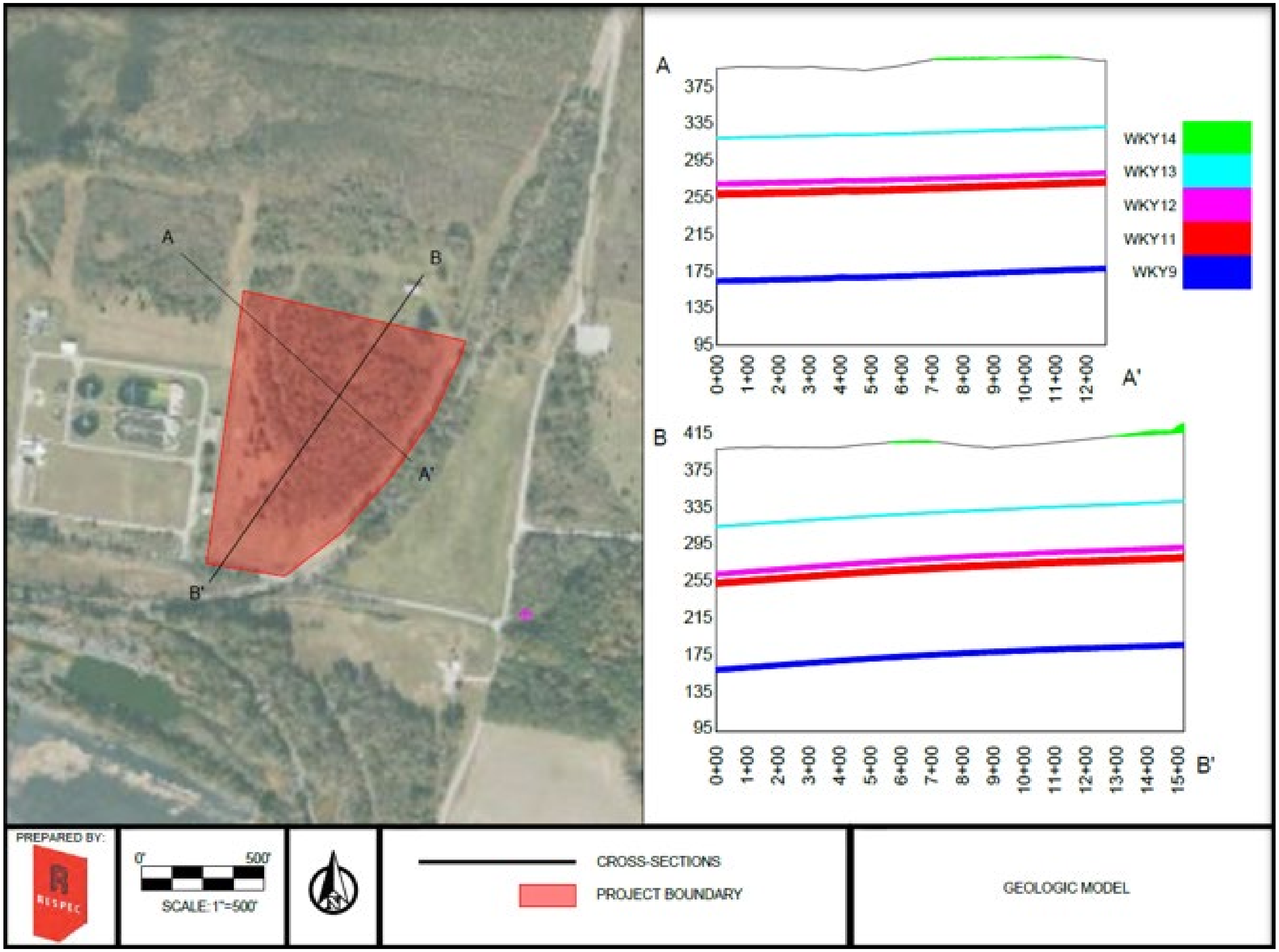


Figure B-7. Cross Sections of the Geologic Model Obtained From Publicly Available Data.

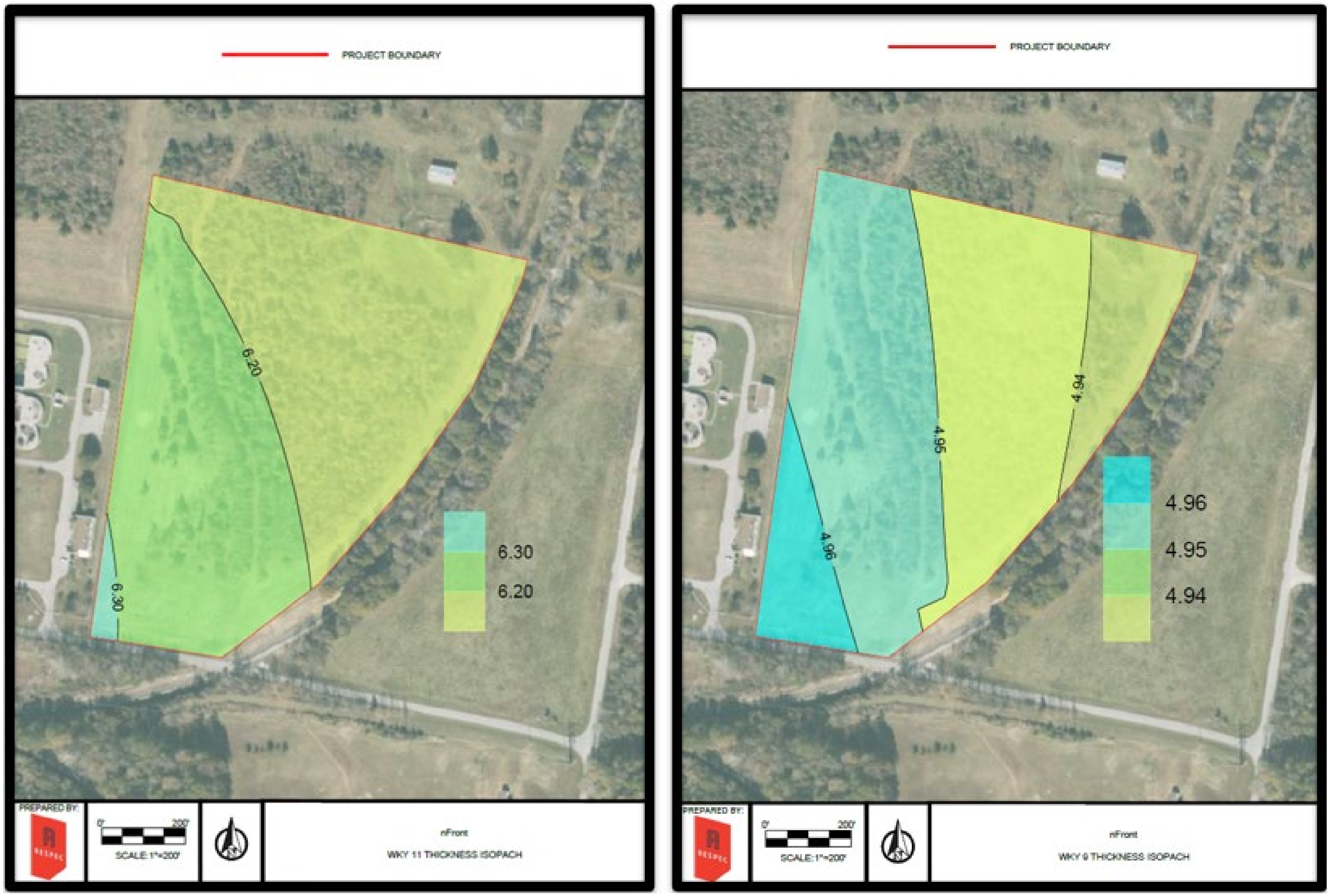


Figure B-8. Isopach for Coal Seam Thickness for Upper Mine Level (Left) and Lower Mine Level (Right) Obtained From Publicly Available Data.

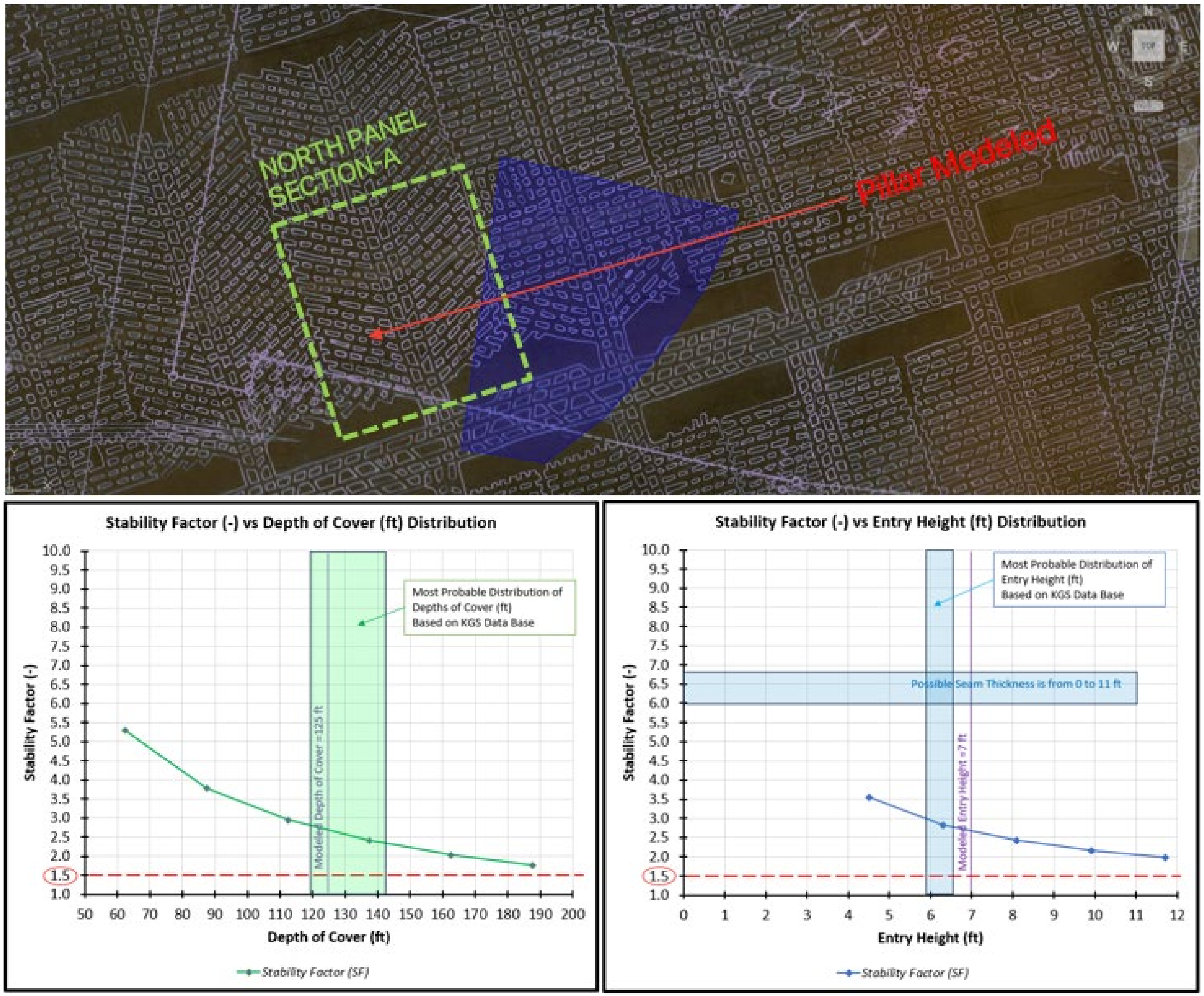


Figure B-9. Upper Mine Level – North Panel – Section A, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

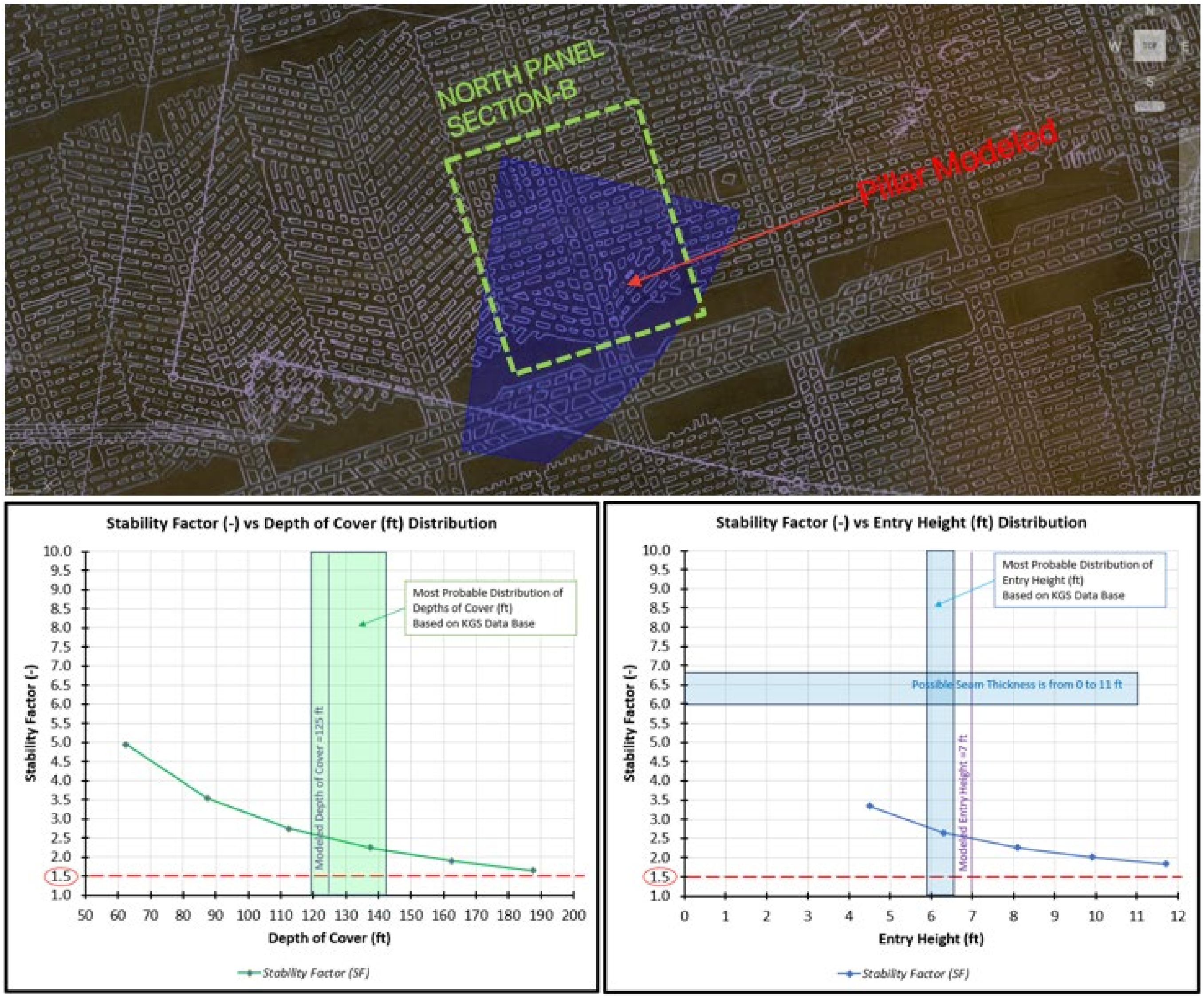


Figure B-10. Upper Mine Level – North Panel – Section B, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

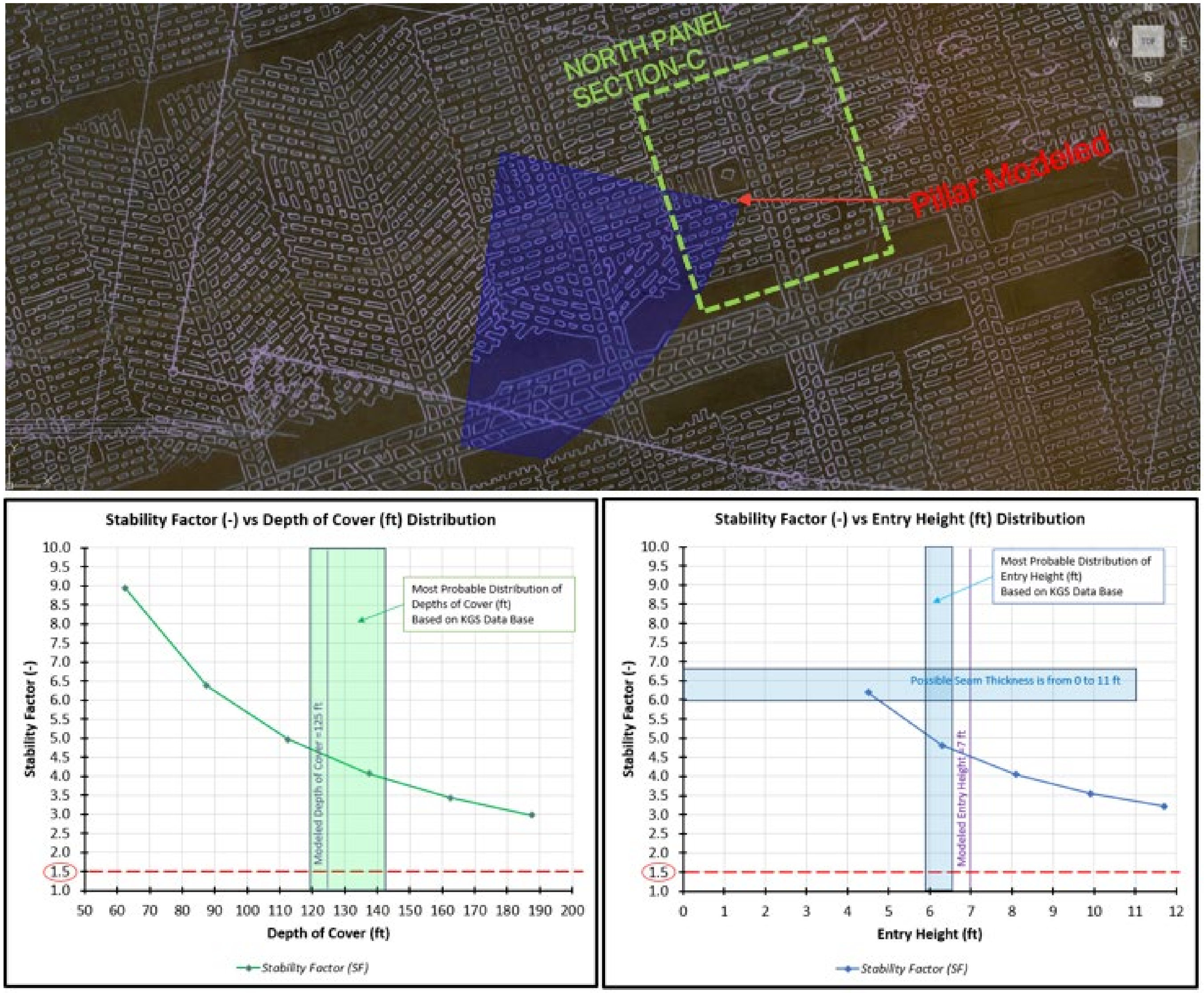


Figure B-11. Upper Mine Level – North Panel – Section C, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

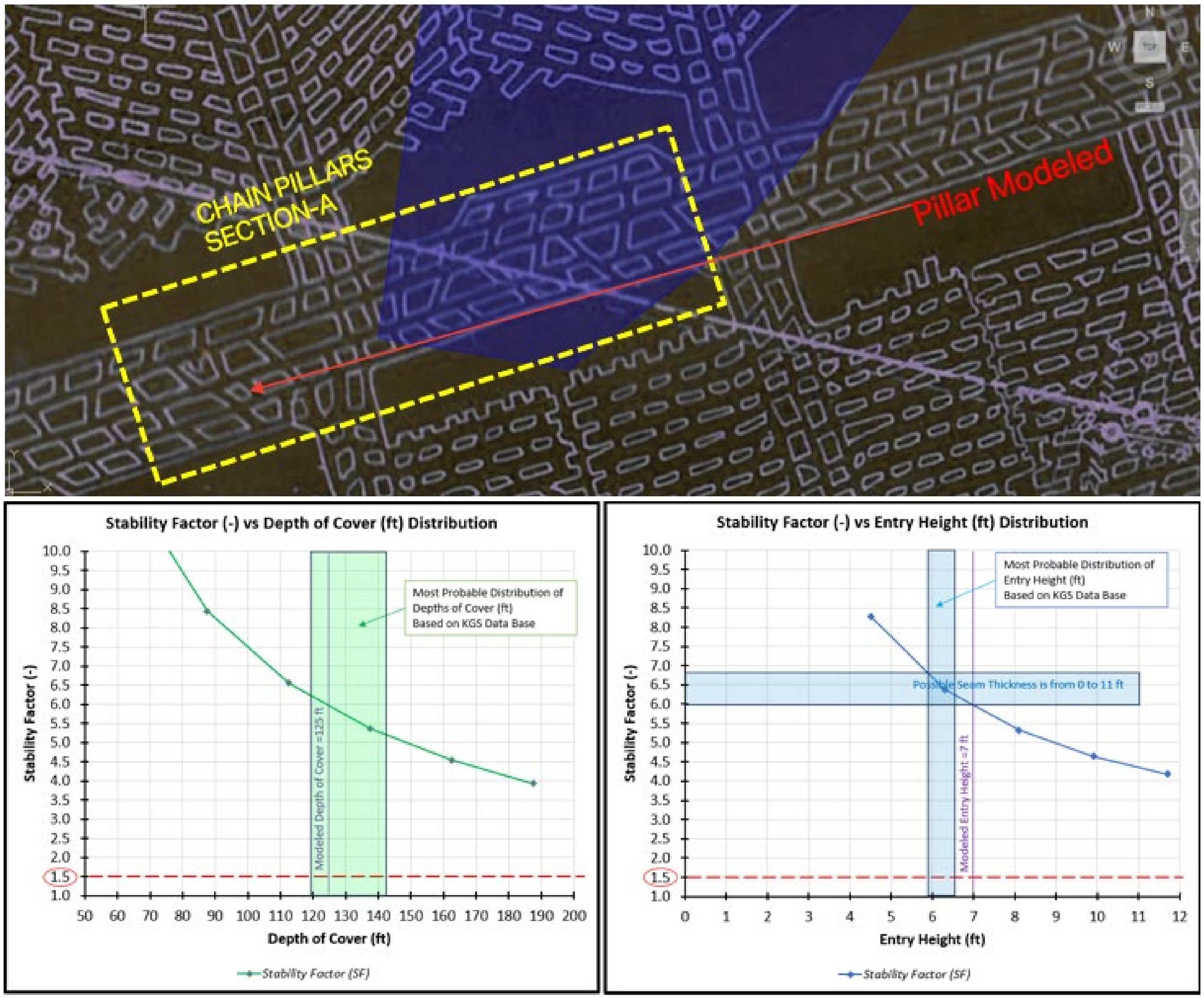


Figure B-12. Upper Mine Level – Chain Pillars – Section A, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

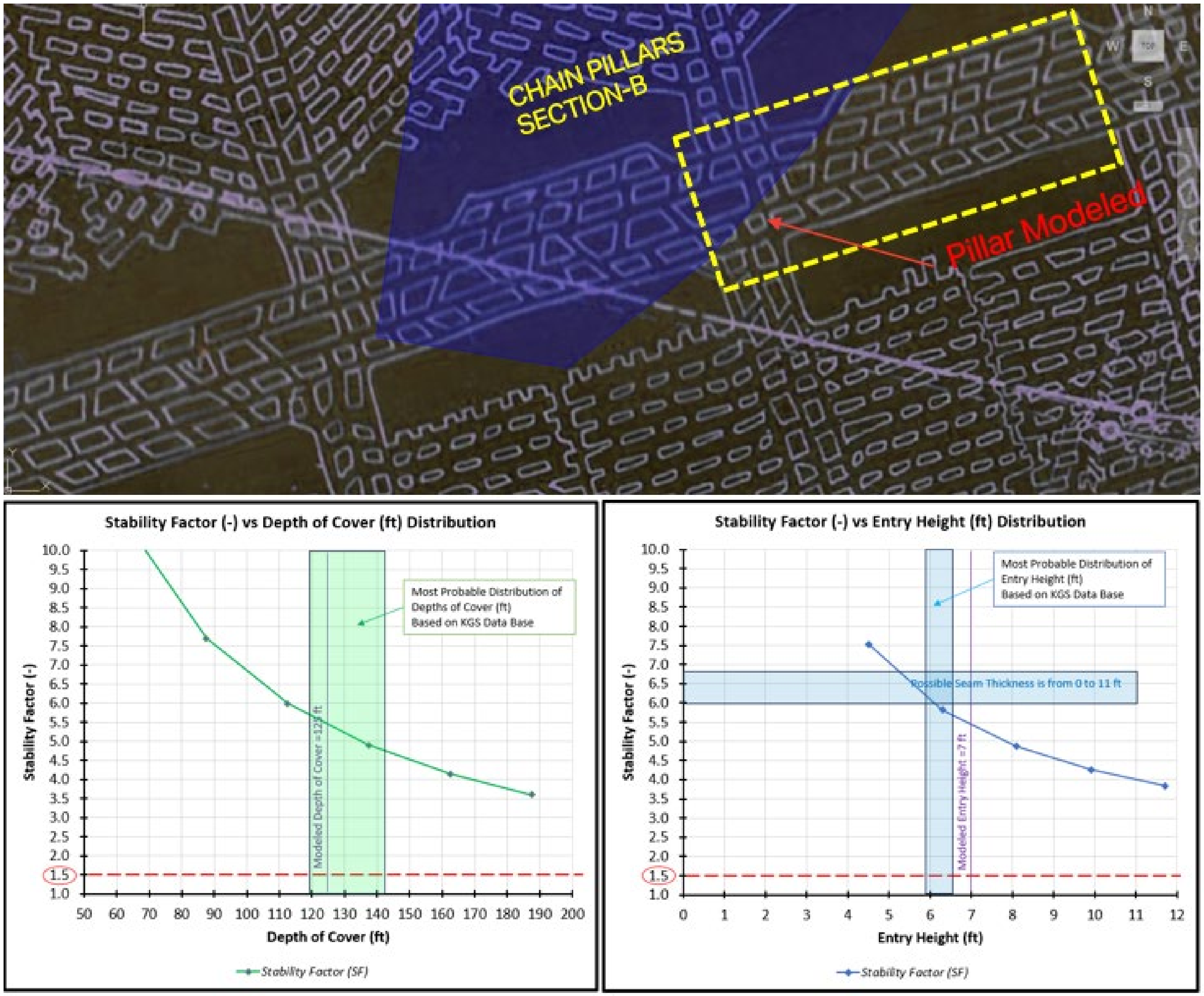


Figure B-13. Upper Mine Level – Chain Pillars – Section B, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

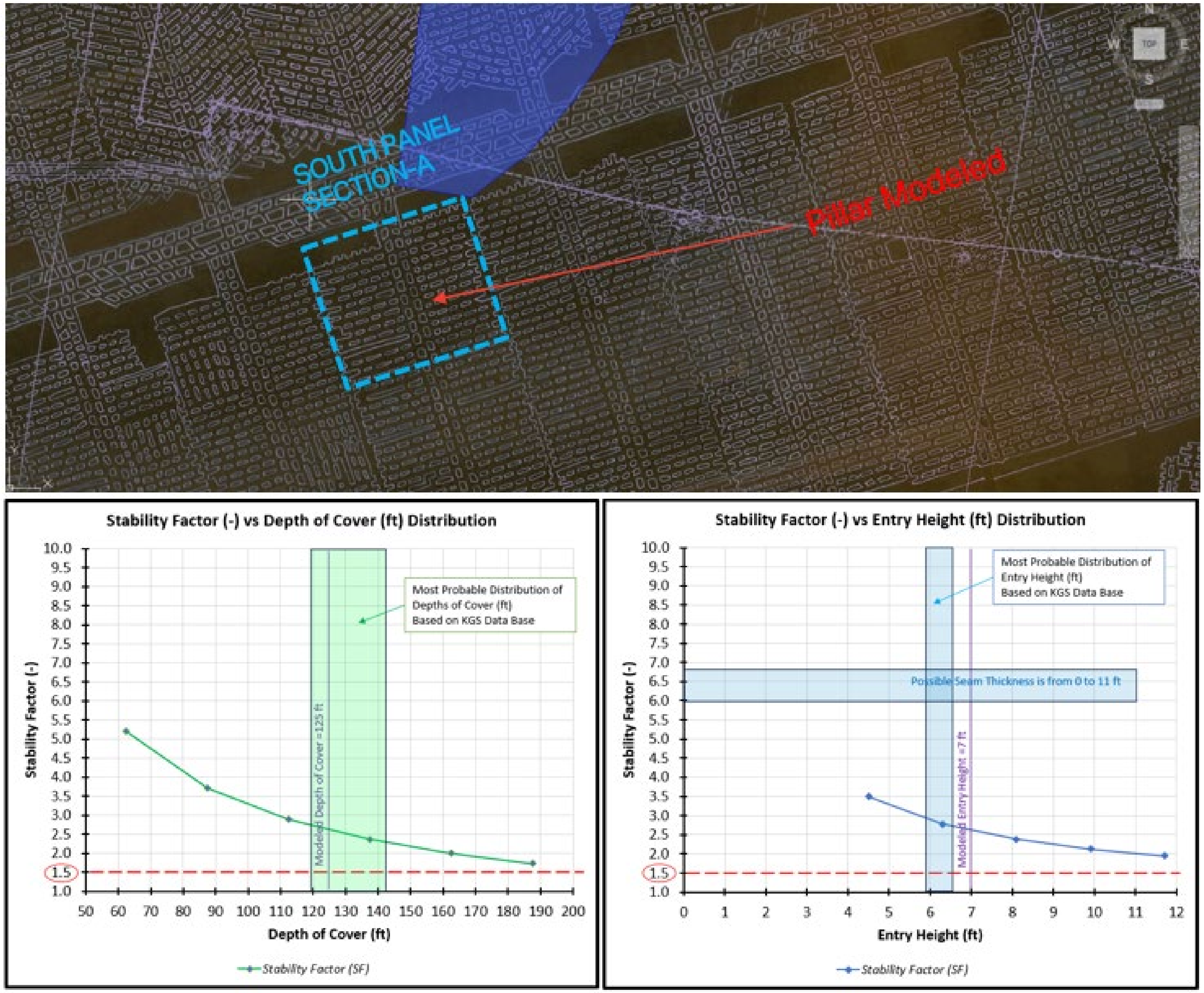


Figure B-14. Upper Mine Level – South Panel – Section A, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

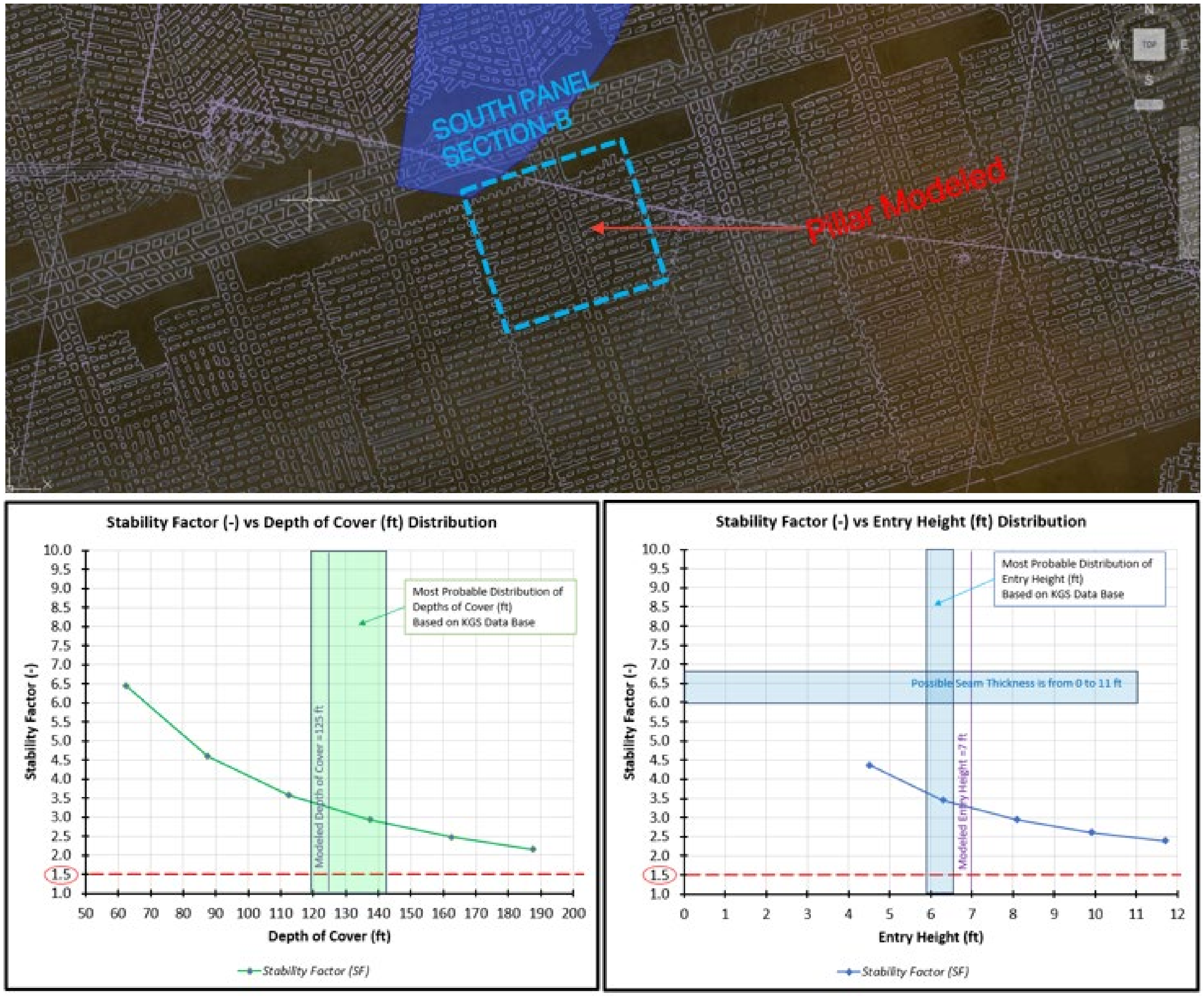


Figure B-15. Upper Mine Level – South Panel – Section B, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

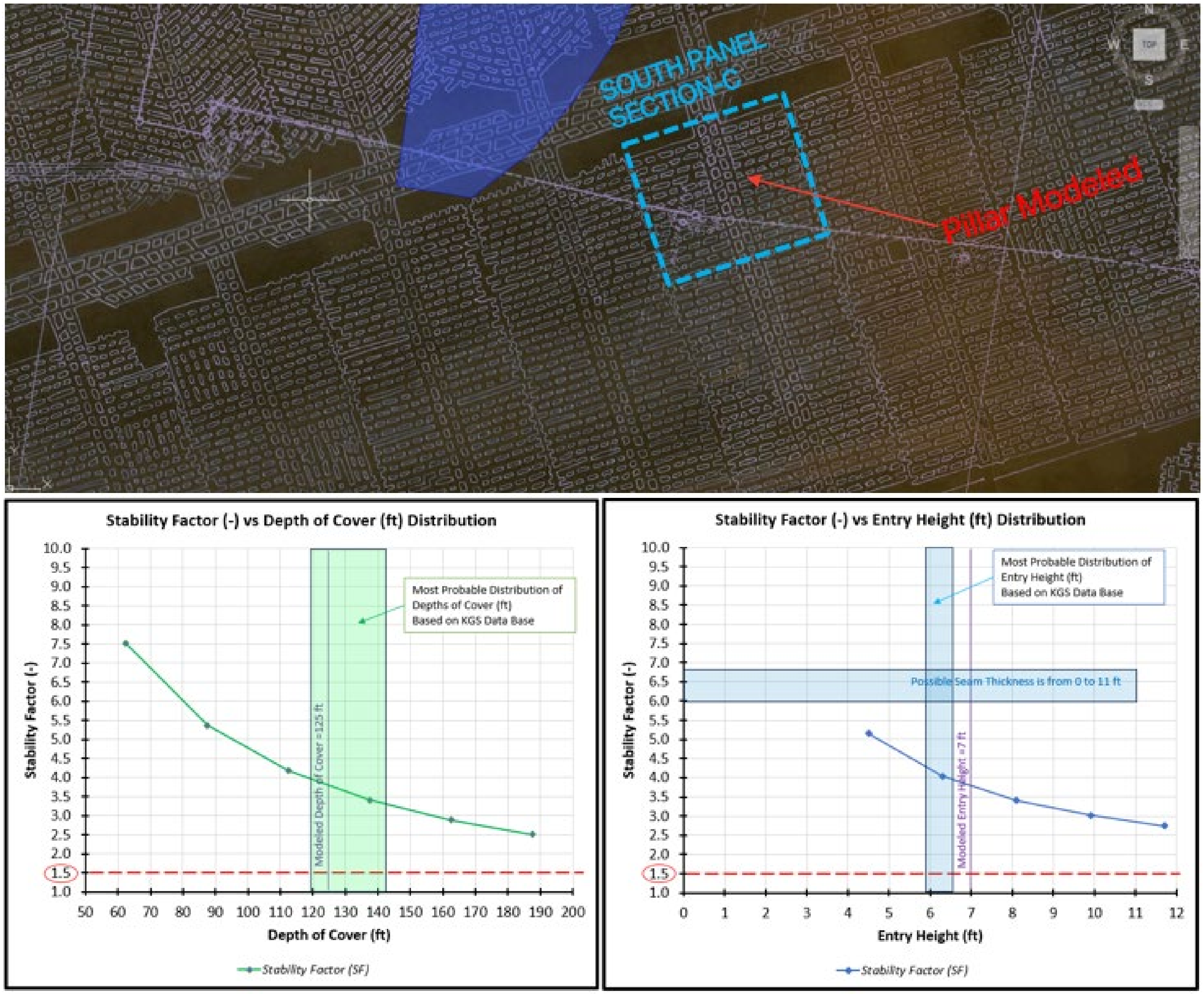


Figure B-16. Upper Mine Level – South Panel – Section C, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

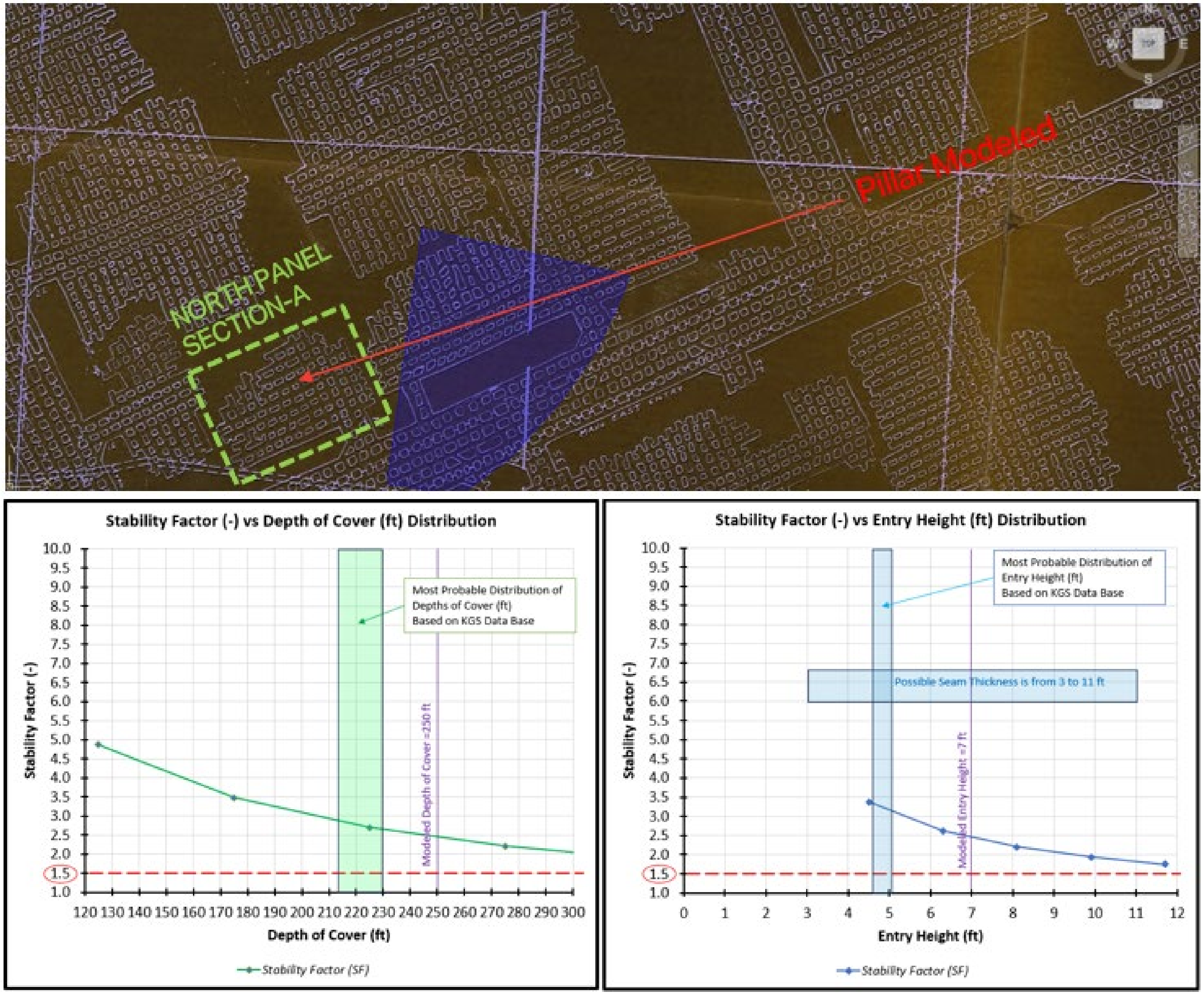


Figure B-17. Lower Mine Level – North Panel – Section A, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

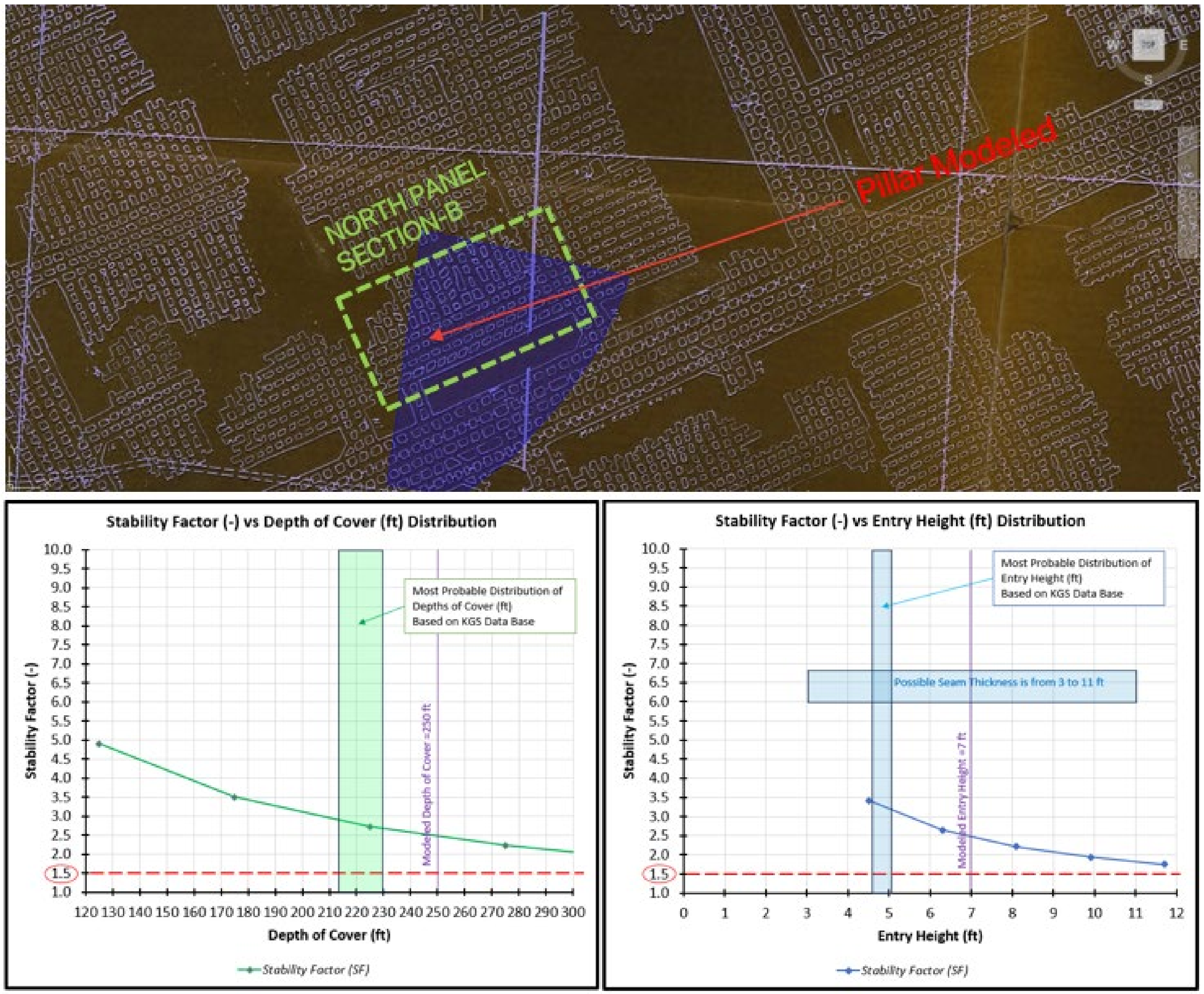


Figure B-18. Lower Mine Level – North Panel – Section B, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

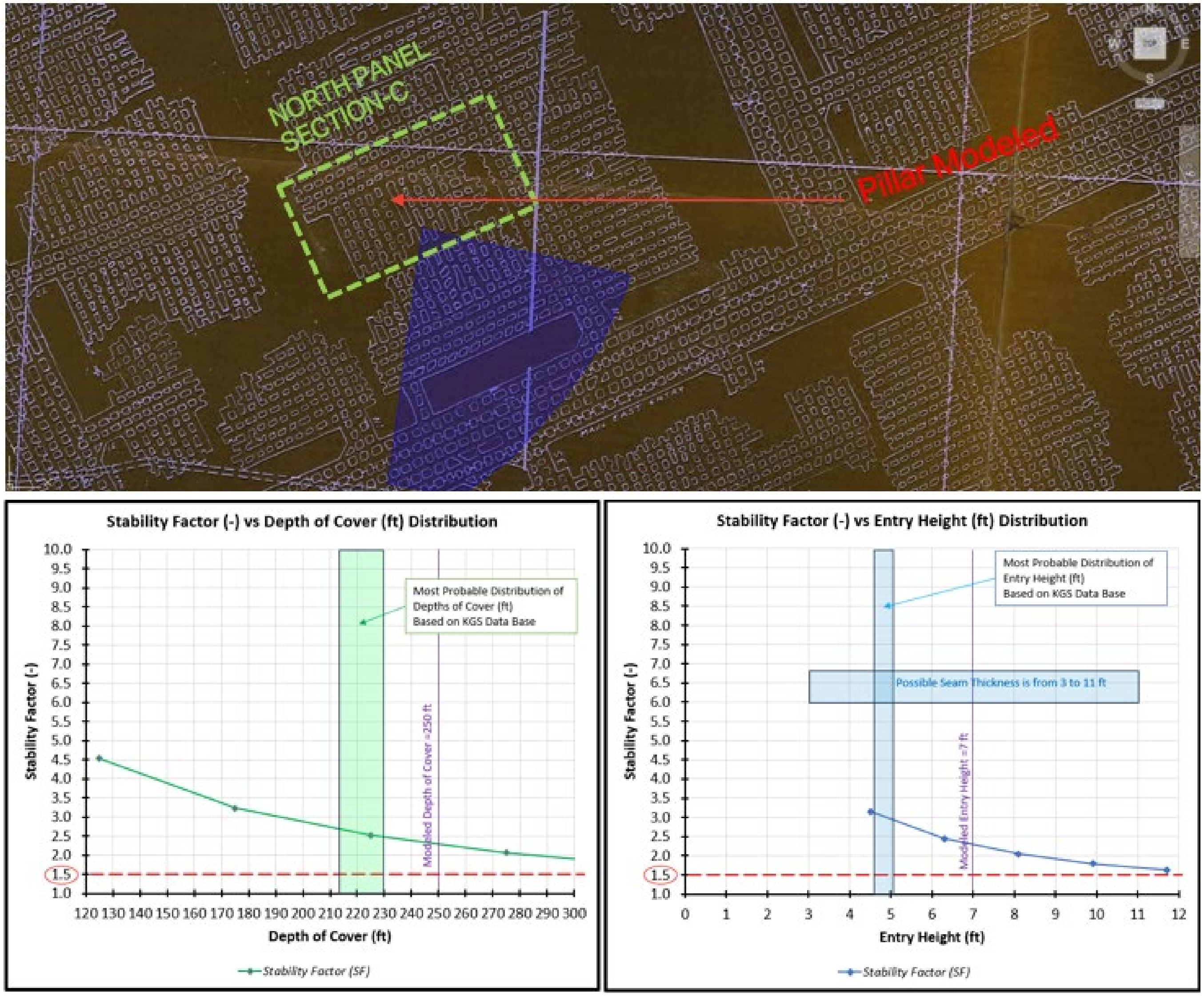


Figure B-19. Lower Mine Level – North Panel – Section C, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

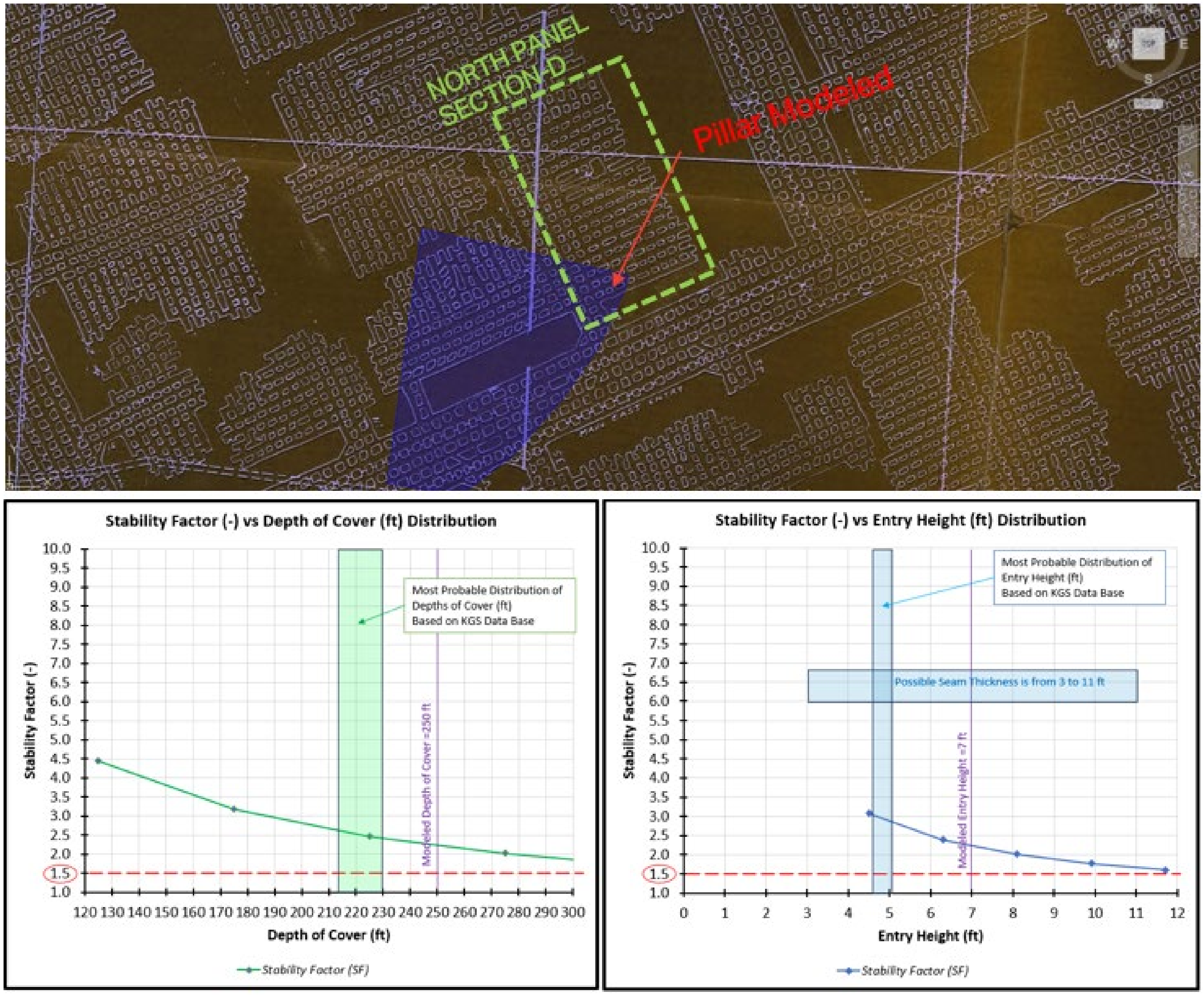


Figure B-20. Lower Mine Level – North Panel – Section D, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

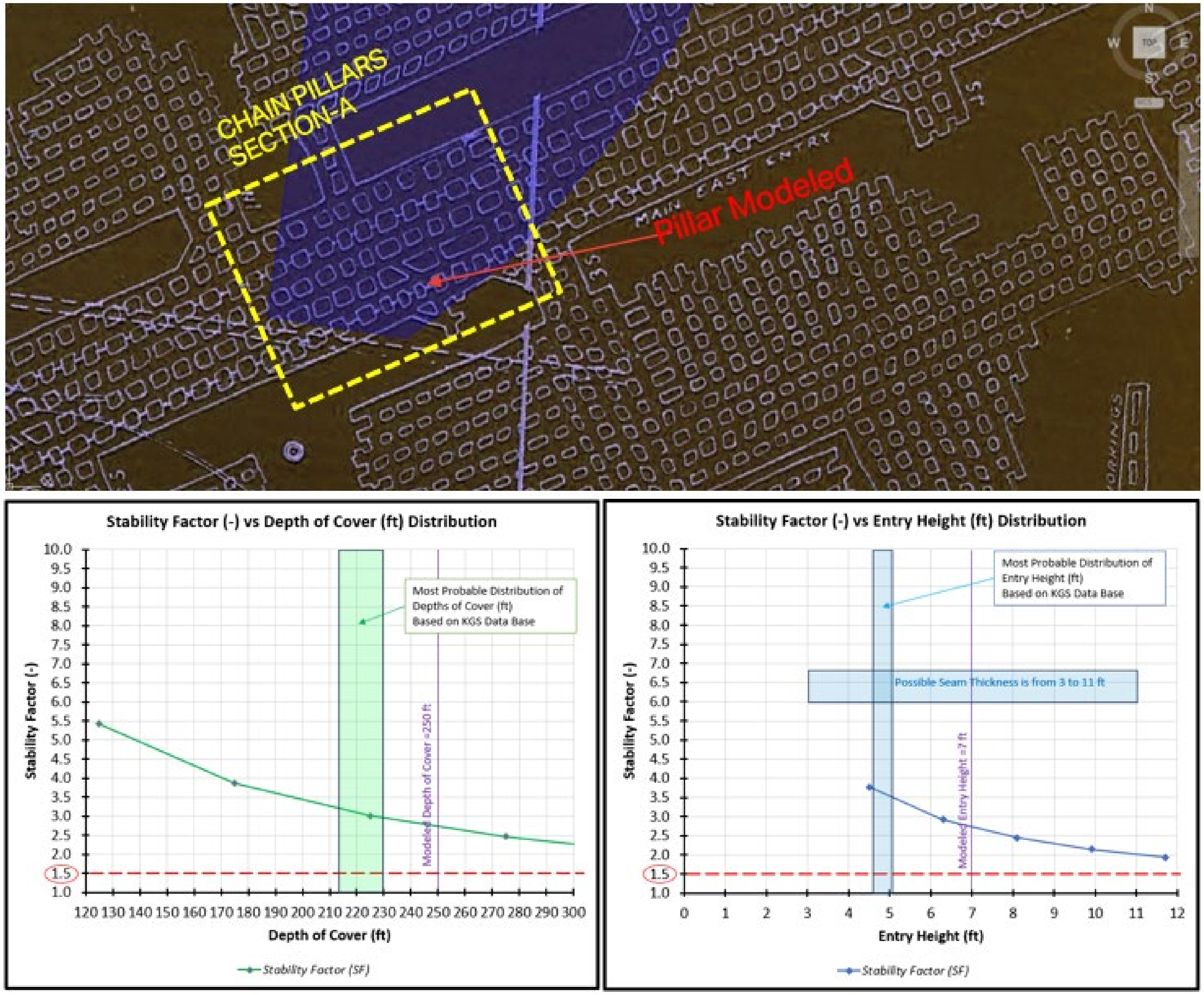


Figure B-21. Lower Mine Level – Chain Pillars – Section A, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

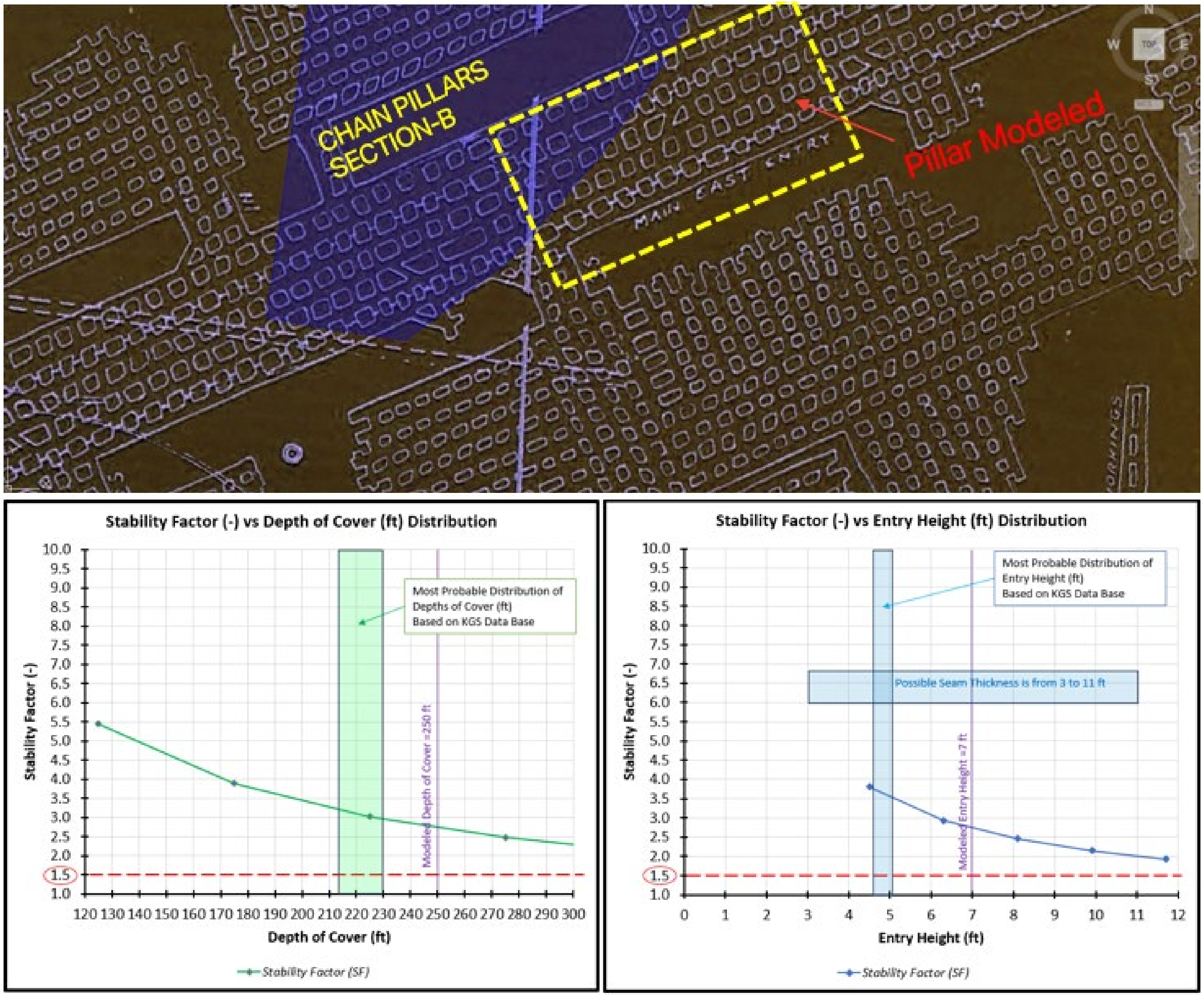


Figure B-22. Lower Mine Level – Chain Pillars – Section B, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

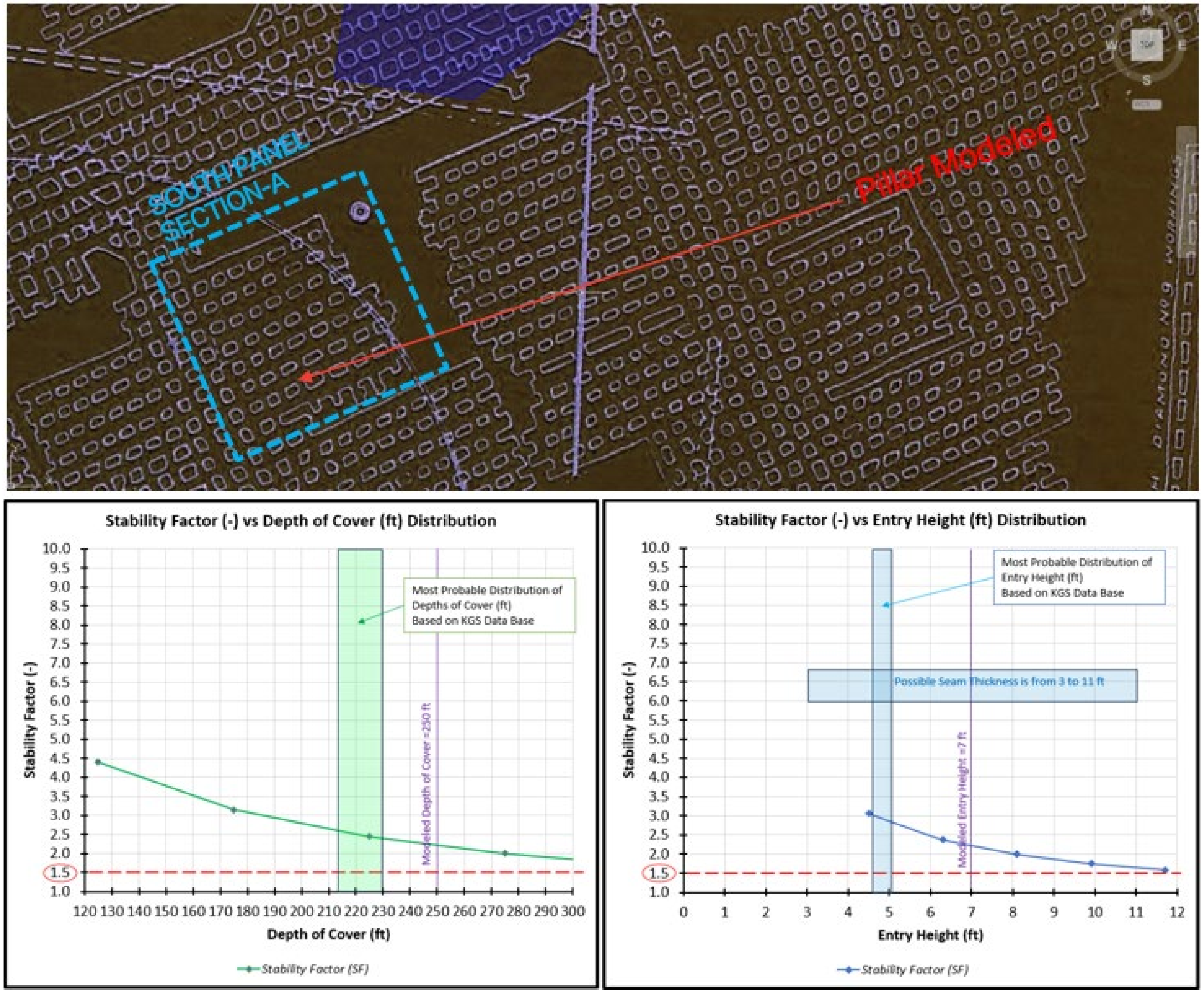


Figure B-23. Lower Mine Level – South Panel – Section A, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

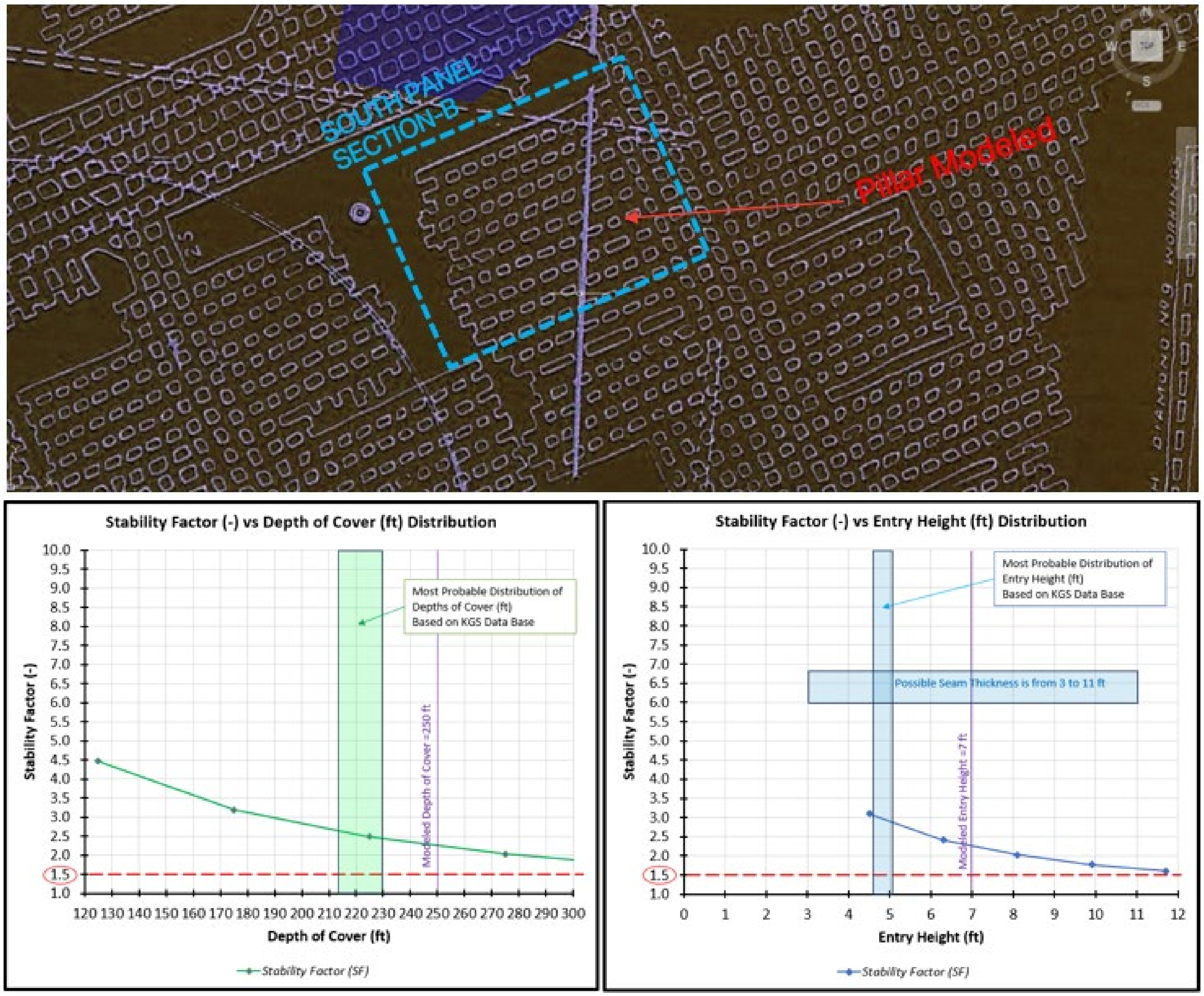


Figure B-24. Lower Mine Level – South Panel – Section B, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

RESPEC

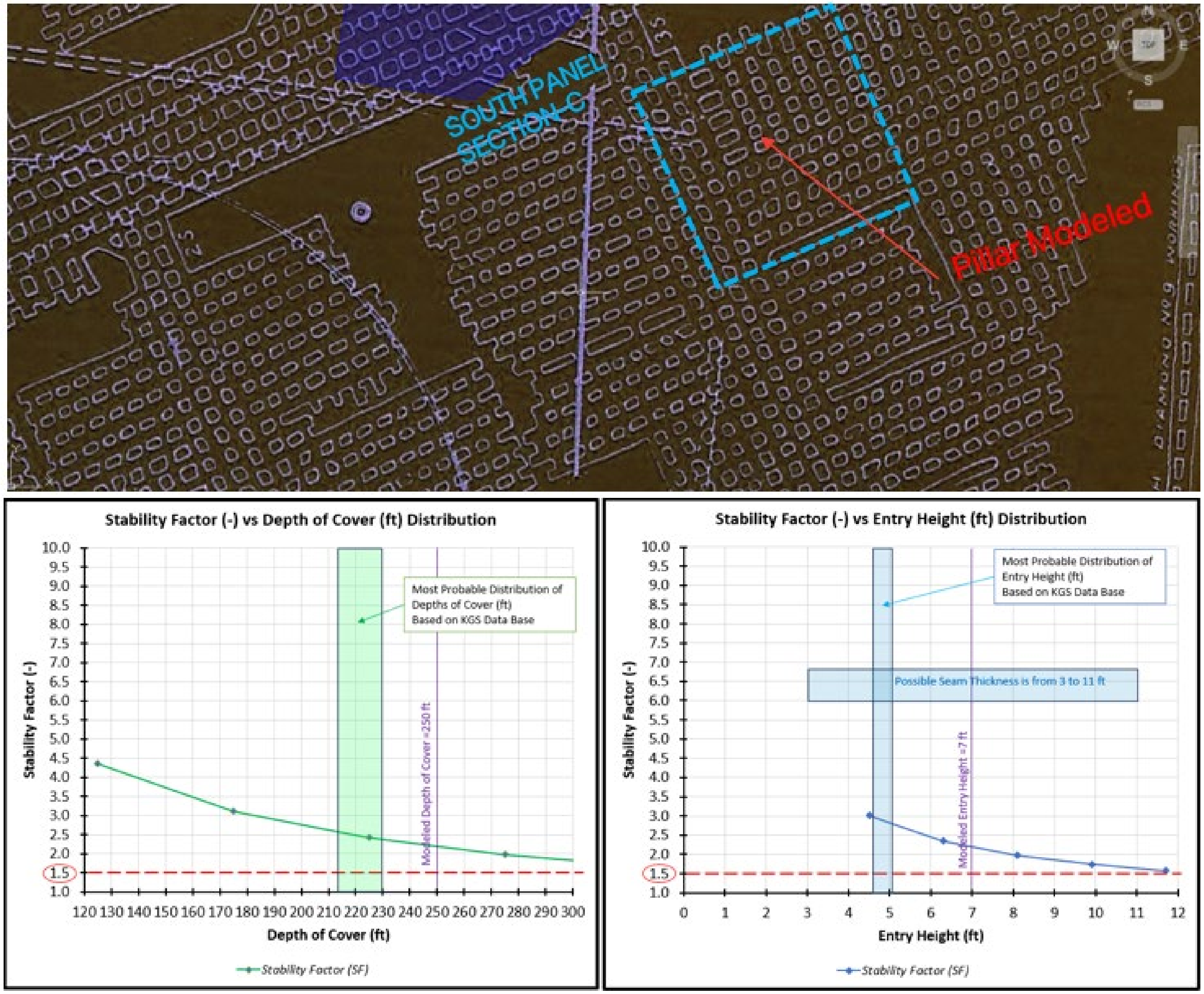


Figure B-25. Lower Mine Level – South Panel – Section C, Analysis of Coal Pillar Stability Analysis Results. The top figure shows the smallest pillar in the section that was modeled. The bottom left figure shows the stability factor distribution for varying depths of cover. The bottom right figure shows the stability factor distribution for varying entry heights.

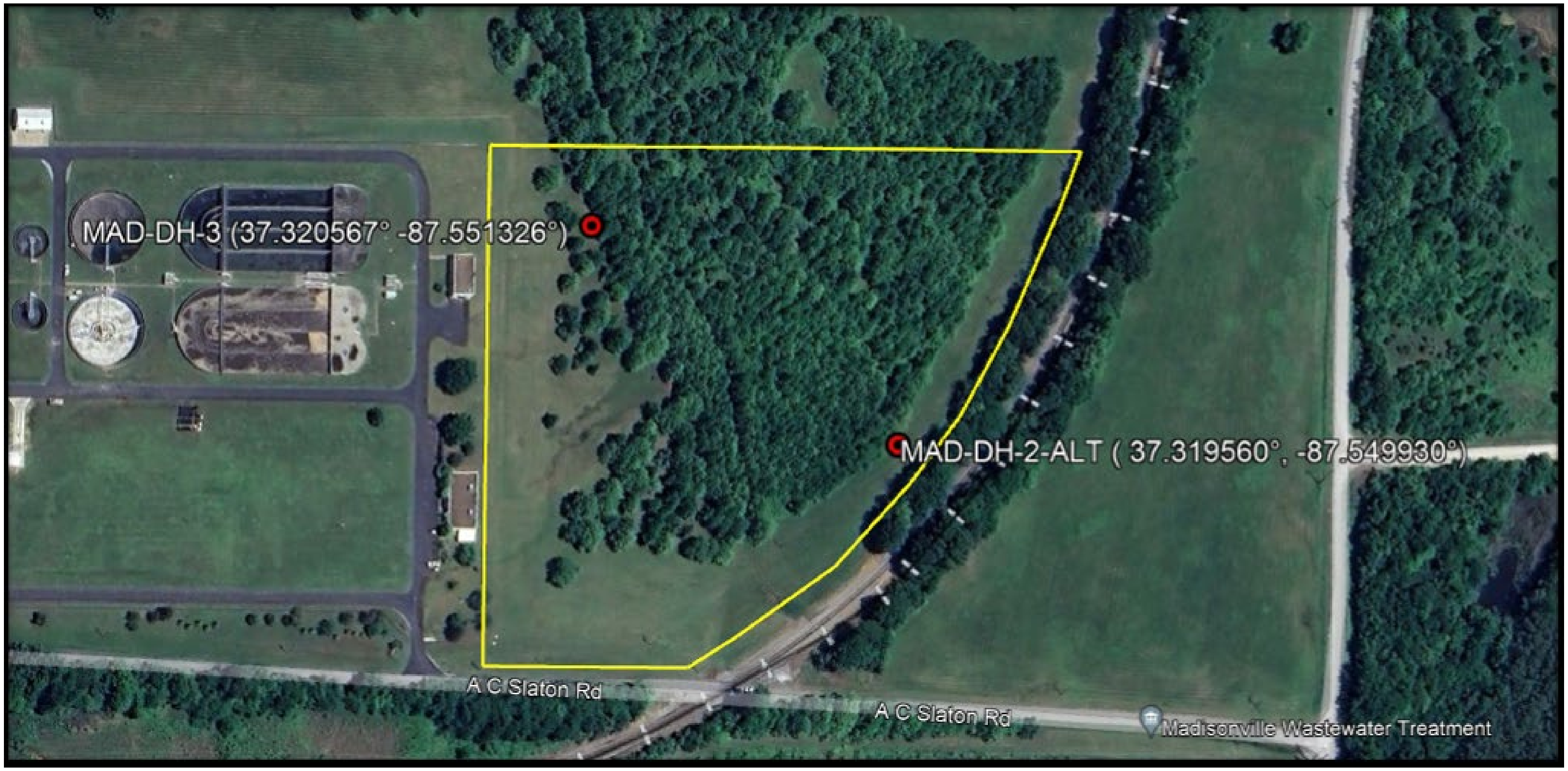


Figure B-26. Approximate Locations of the Two Drillholes Drilled on the Madisonville Property.

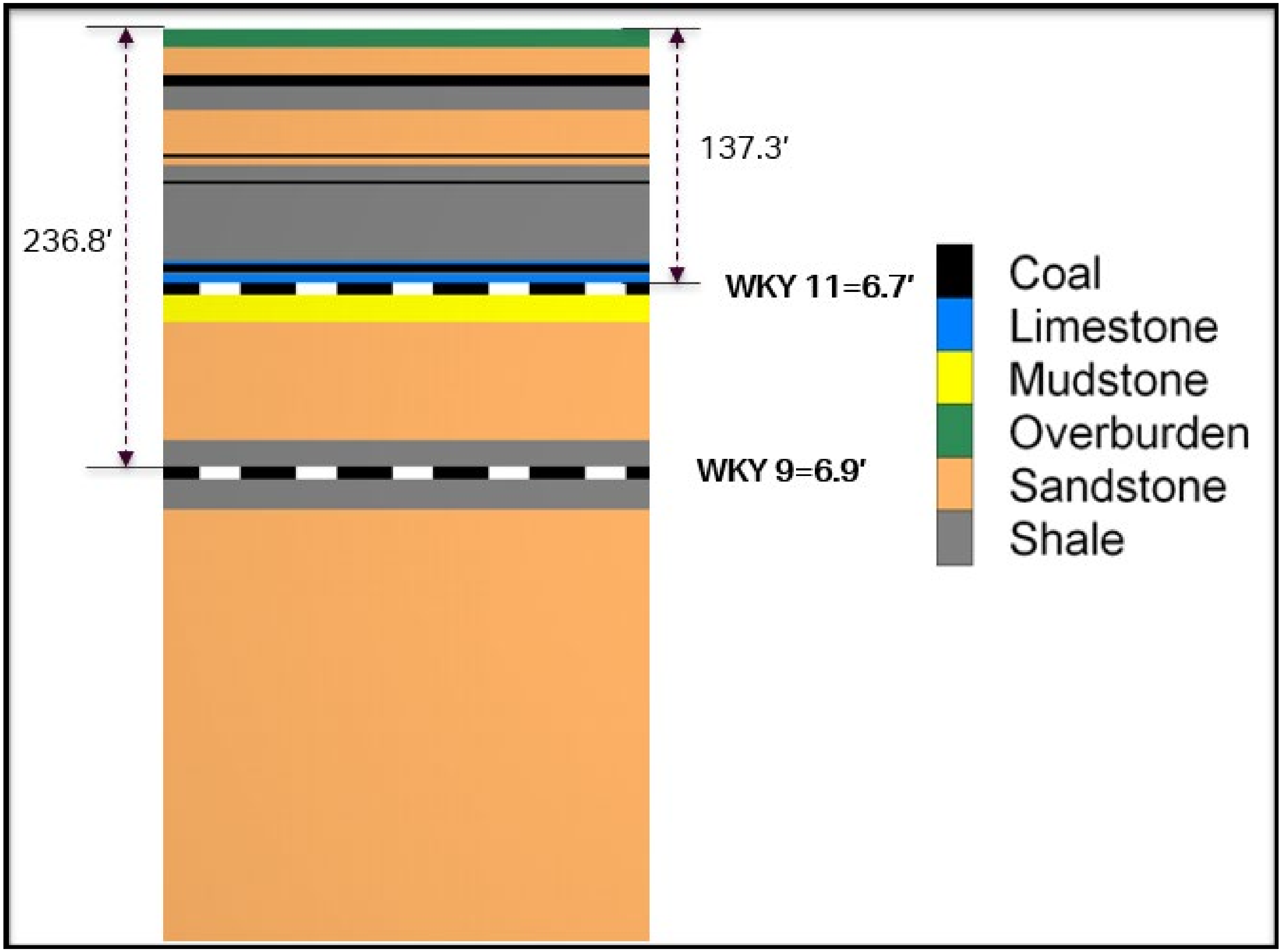


Figure B-27. Geologic Cross Section Determined From the Drilling Campaign.

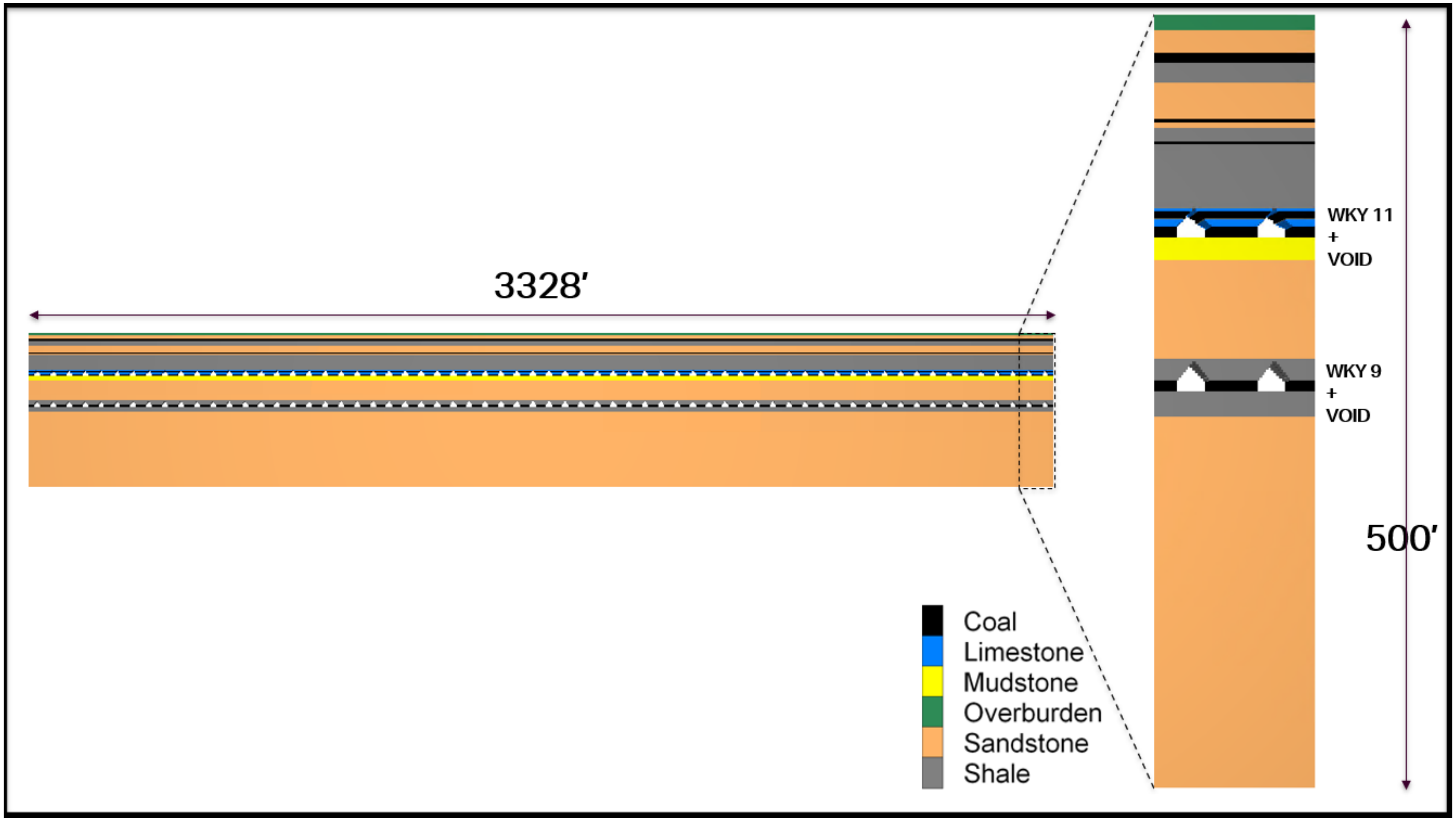


Figure B-28. Extents of the Two-Dimensional Section Model.

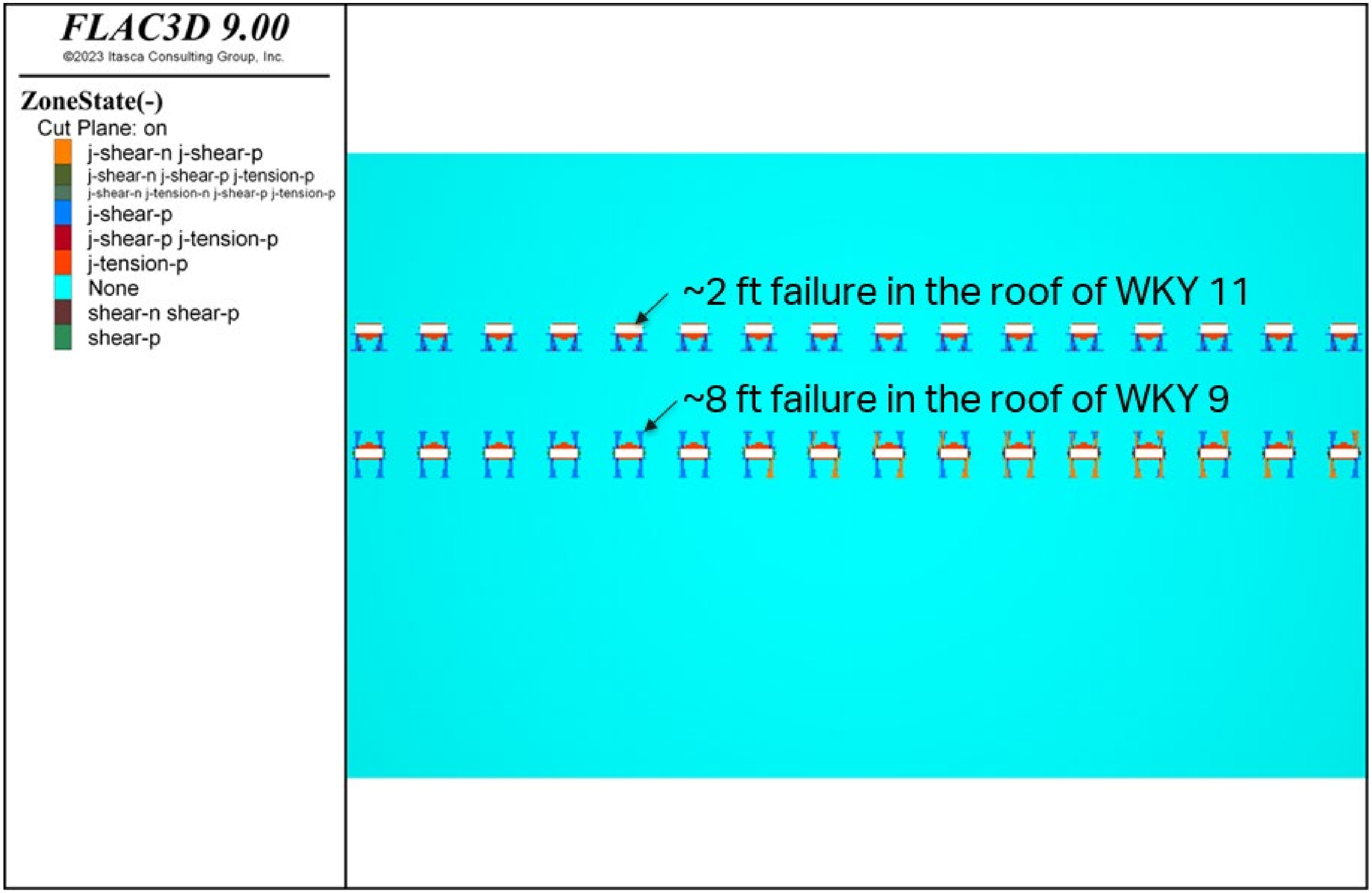


Figure B-29. Two-Dimensional Section Model Calibration to Observed Void Sizes in the Drillholes.

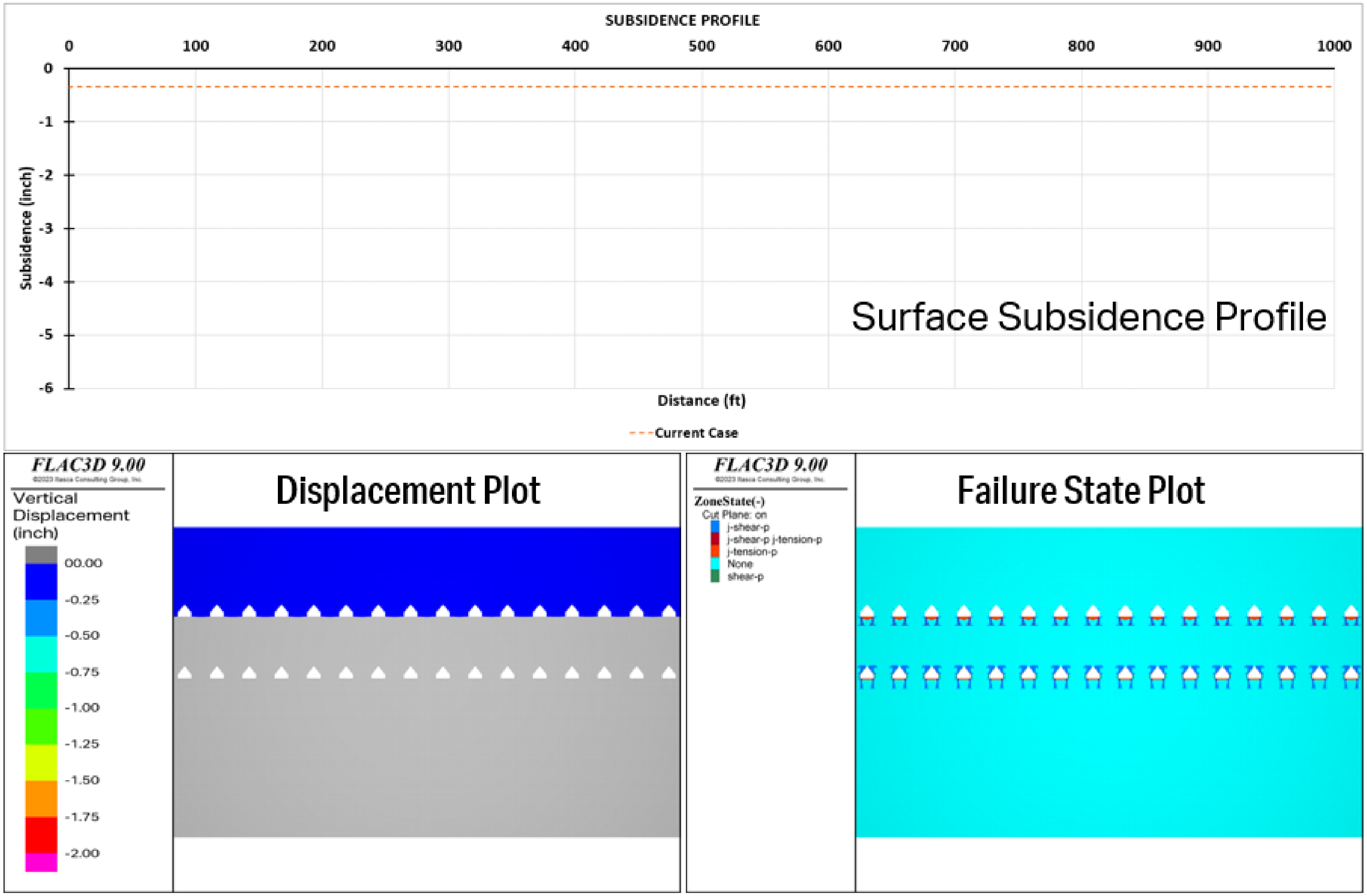


Figure B-30. Numerical Model Results for the Two-Dimensional Section Model Analysis of the Uncollapsed Current Condition. The top figure shows the surface subsidence profile. The bottom left figure shows the vertical displacement plot. The bottom right figure shows the failure states of the zones.

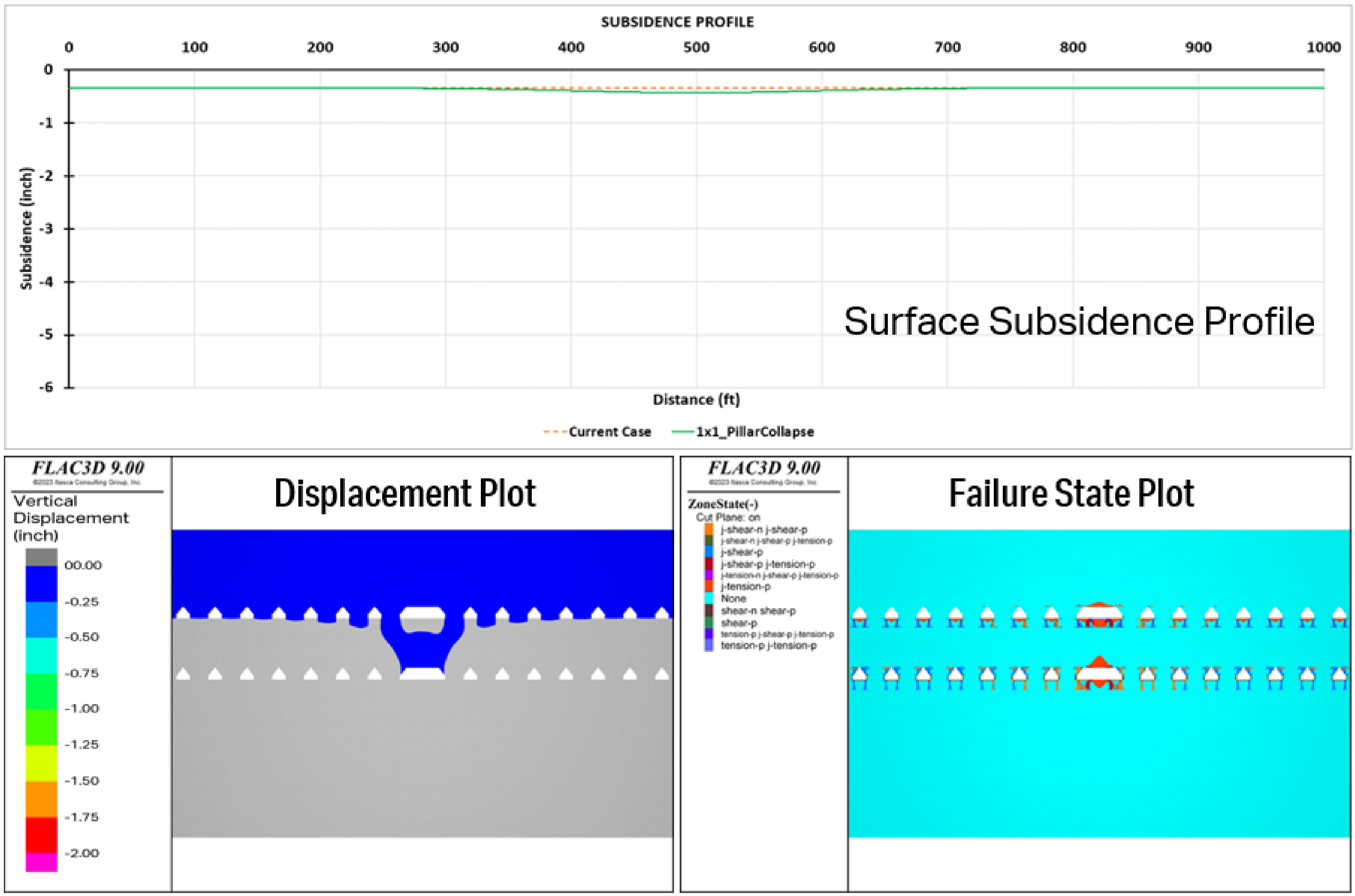


Figure B-31. Numerical Model Results for the Two-Dimensional Section Model Analysis of the 1×1 Pillar Collapsed Condition. The top figure shows the surface subsidence profile comparisons. The bottom left figure shows the vertical displacement plot. The bottom right figure shows the failure states of the zones.

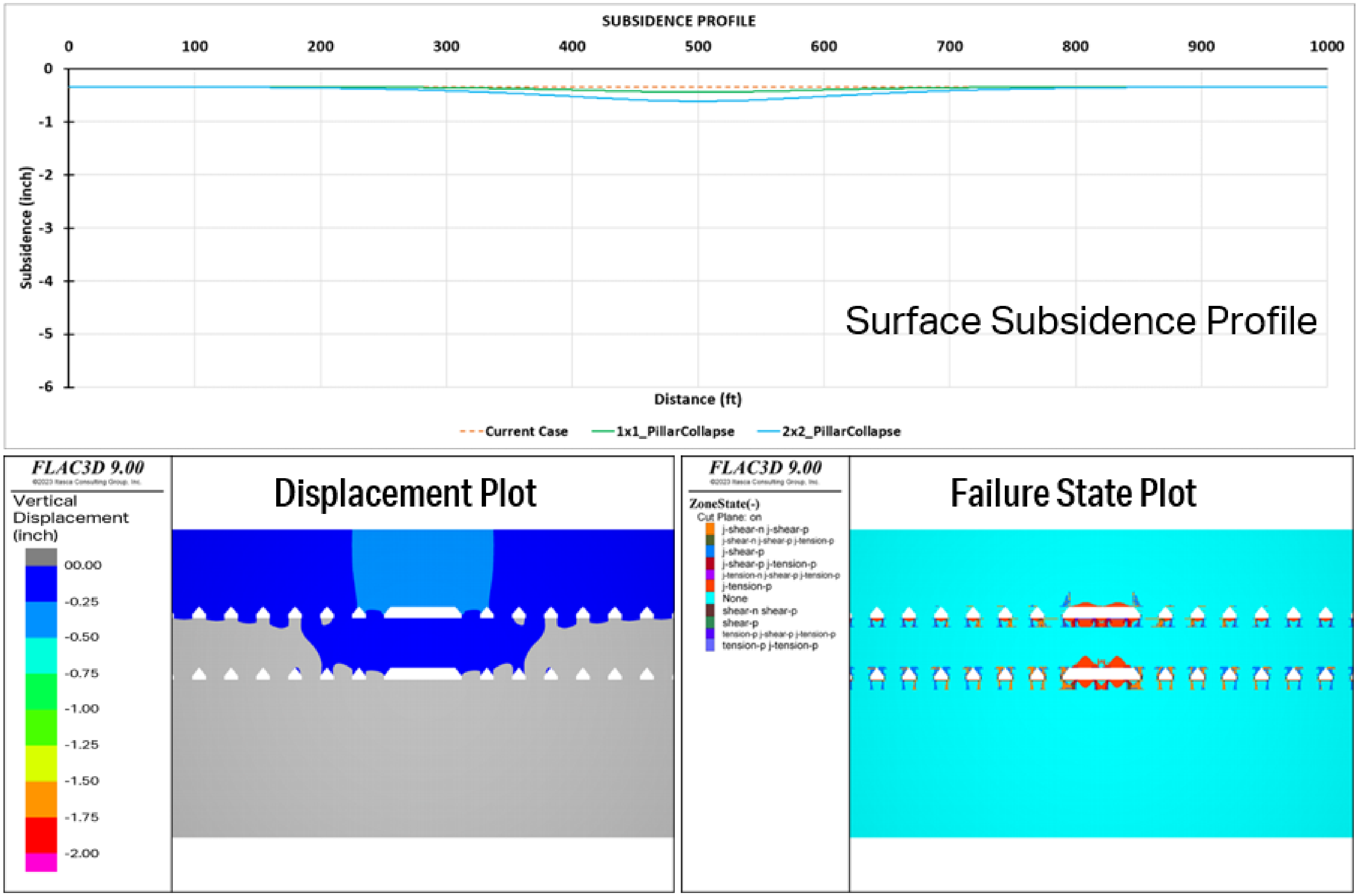


Figure B-32. Numerical Model Results for the Two-Dimensional Section Model Analysis of the 2×1 Pillar Collapsed Condition. The top figure shows the surface subsidence profile comparisons. The bottom left figure shows the vertical displacement plot. The bottom right figure shows the failure states of the zones.

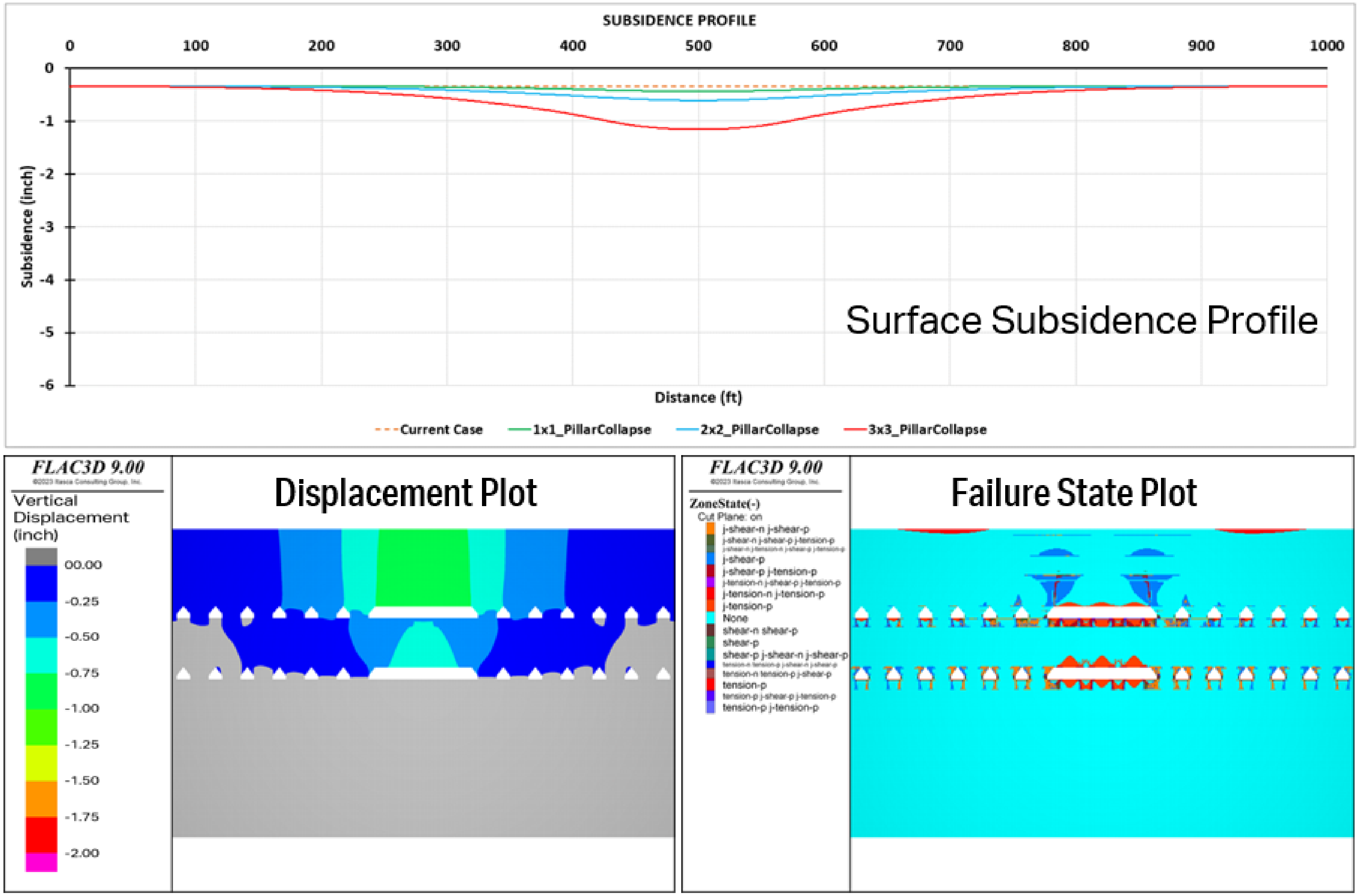


Figure B-33. Numerical Model Results for the Two-Dimensional Section Model Analysis of the 3×1 Pillar Collapsed Condition. The top figure shows the surface subsidence profile comparisons. The bottom left figure shows the vertical displacement plot. The bottom right figure shows the failure states of the zones.

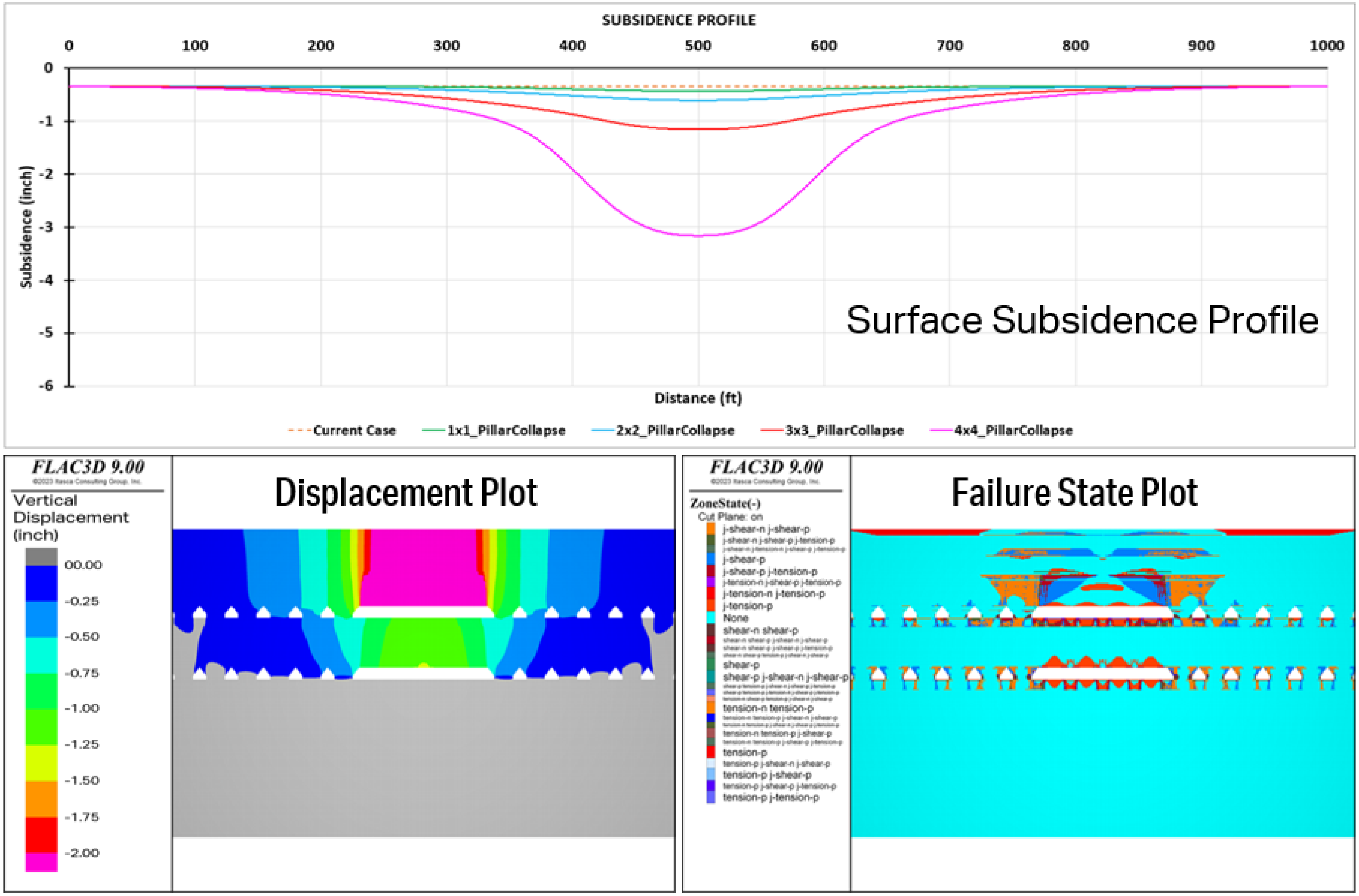


Figure B-34. Numerical Model Results for the Two-Dimensional Section Model Analysis of the 4×1 Pillar Collapsed Condition. The top figure shows the surface subsidence profile comparisons. The bottom left figure shows the vertical displacement plot. The bottom right figure shows the failure states of the zones.

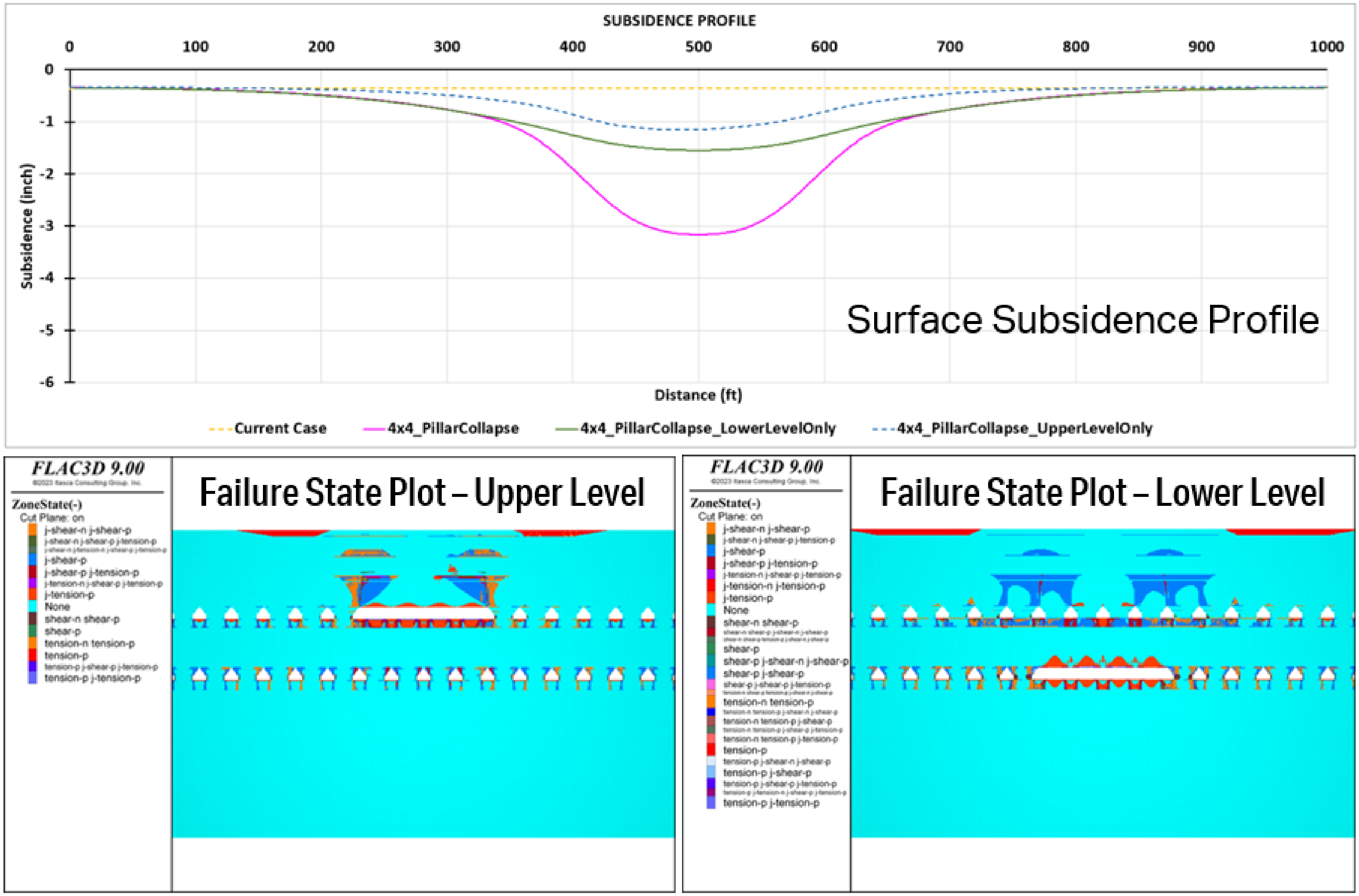


Figure B-35. Numerical Model Results for the Two-Dimensional Section Model Analysis of the 4×1 Pillar Collapsed Condition on the Upper and Lower Mine Levels, Separately. The top figure shows the surface subsidence profile comparisons. The bottom left figure shows the failure states of the zones when the pillar collapsed on the Upper Mine Level. The bottom right figure shows the failure states of the zones when the pillar collapsed on the Lower Mine Level.

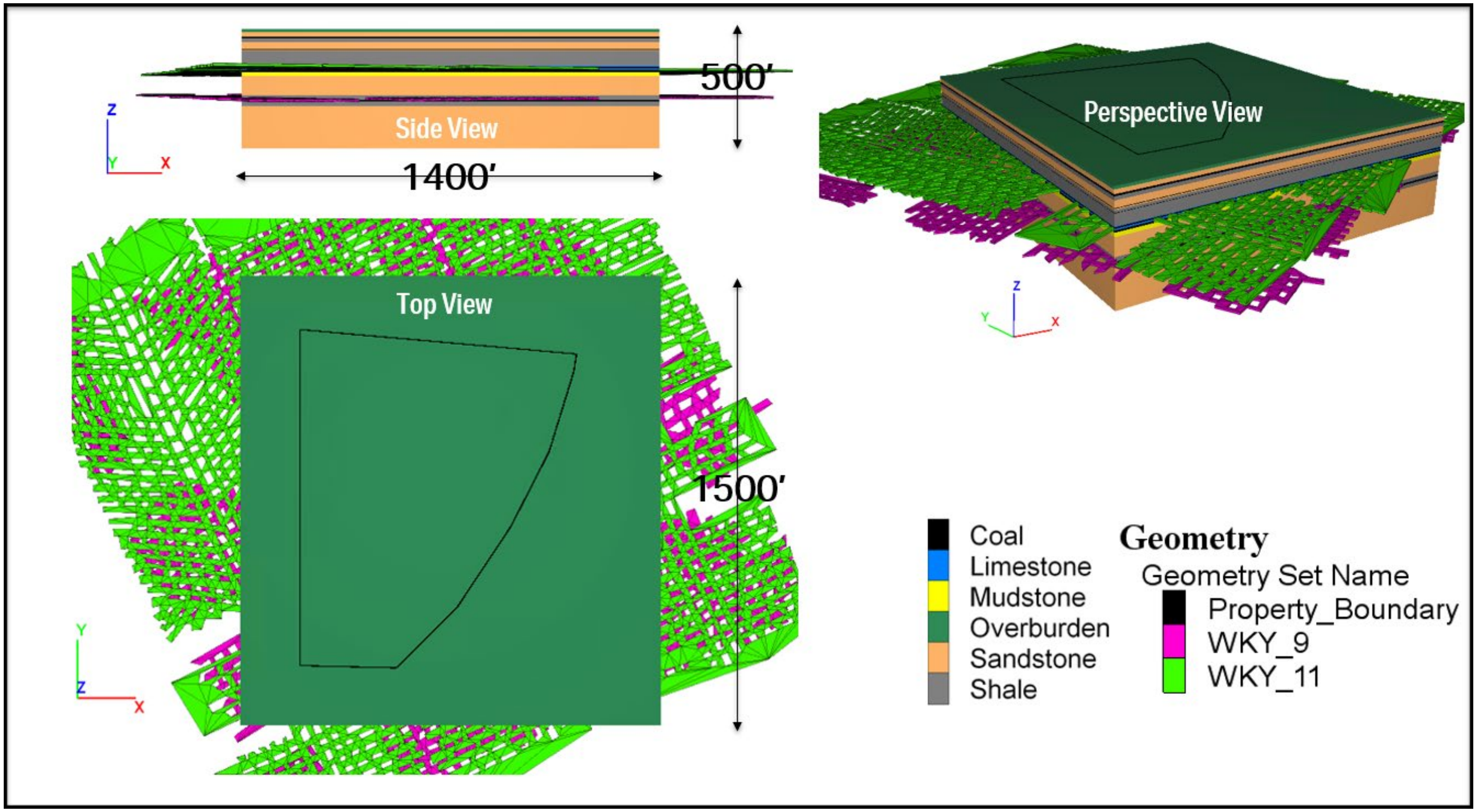


Figure B-36. Top View, Side View, and Perspective View of the Three-Dimensional Model.

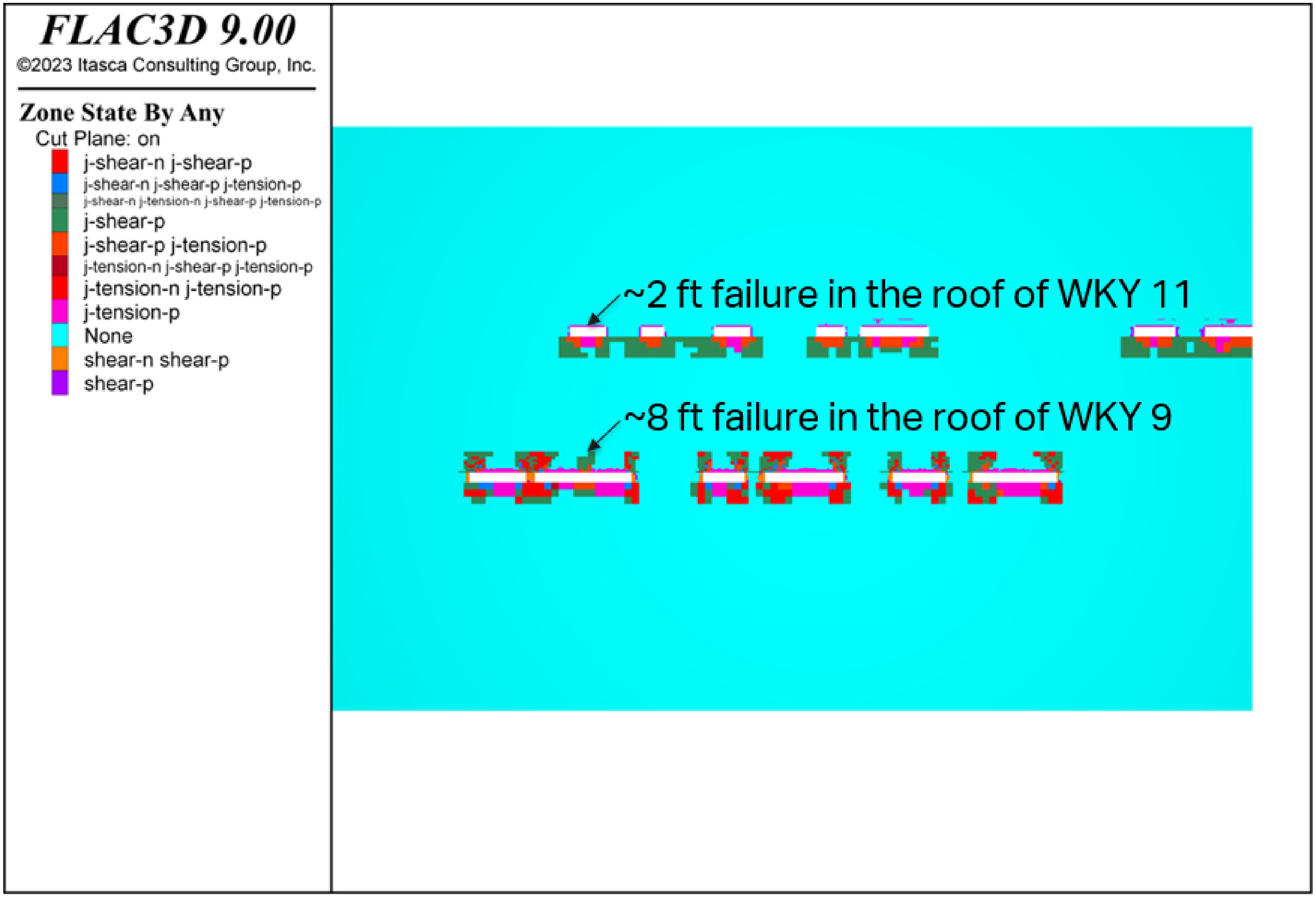


Figure B-37. Three-Dimensional Model Calibration to Observed Void Sizes in the Drillholes.

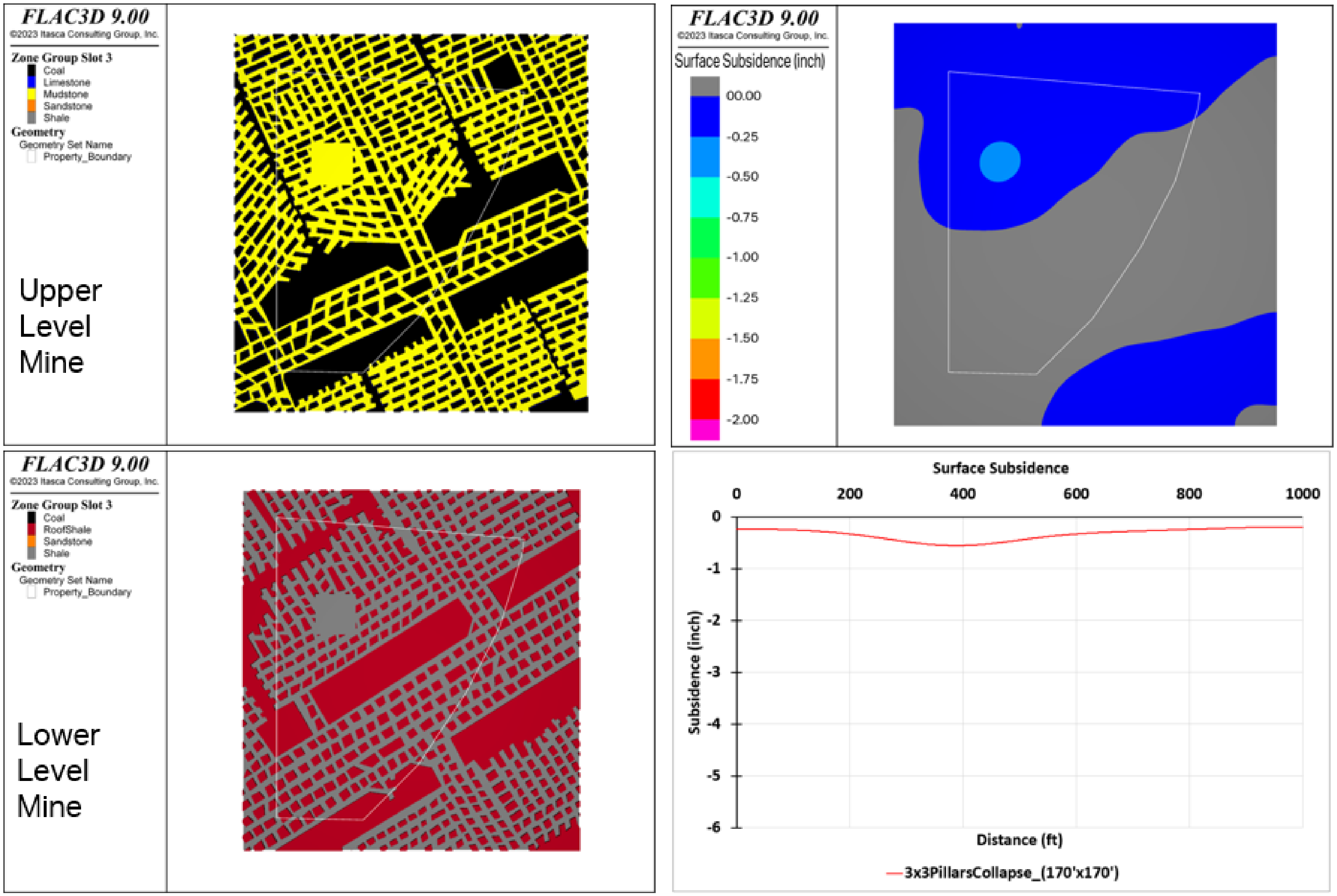


Figure B-38. Numerical Model Results for the Three-Dimensional Model Analysis of the 3×3 Pillar Collapsed (170-Foot by 170-Foot Area) Condition. The top left figure shows the 170-foot by 170-foot pillar collapsed area on the Upper Mine Level. The bottom left figure shows the 170-foot by 170-foot pillar collapsed area on the Lower Mine Level. The top right figure shows the resulting surface subsidence distribution plot. The bottom right figure shows the resulting surface subsidence profile.

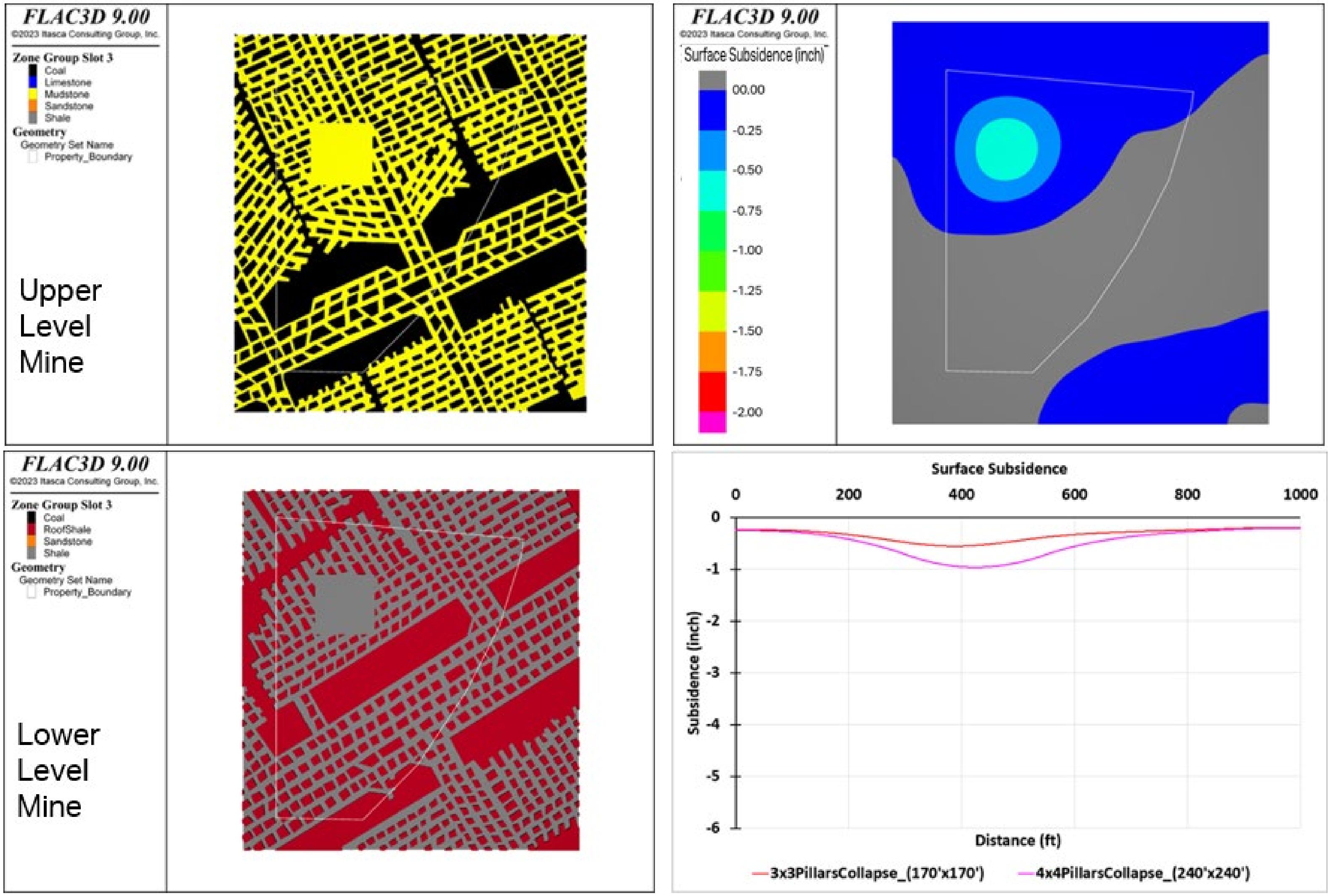


Figure B-39. Numerical Model Results for the Three-Dimensional Model Analysis of the 4×4 Pillar Collapsed (240-Foot by 240-Foot Area) Condition. The top left figure shows the 240-foot by 240-foot pillar collapsed area on the Upper Mine Level. The bottom left figure shows the 240-foot by 240-foot pillar collapsed area on the Lower Mine Level. The top right figure shows the resulting surface subsidence distribution plot. The bottom right figure shows the resulting surface subsidence profile comparison.

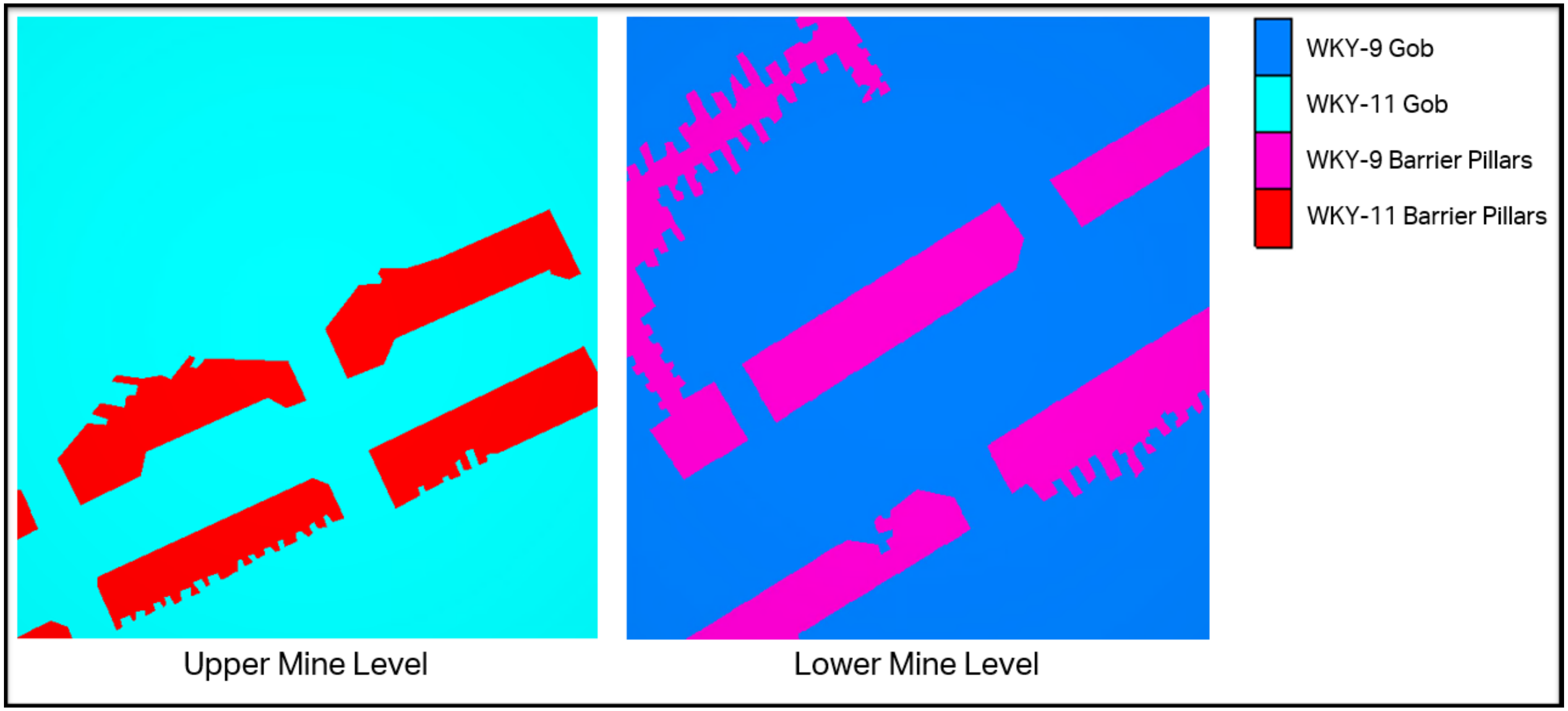


Figure B-40. The Uncollapsed Barrier Pillars and Gobs on the Upper Mine Level (Left) and Lower Mine Level (Right).

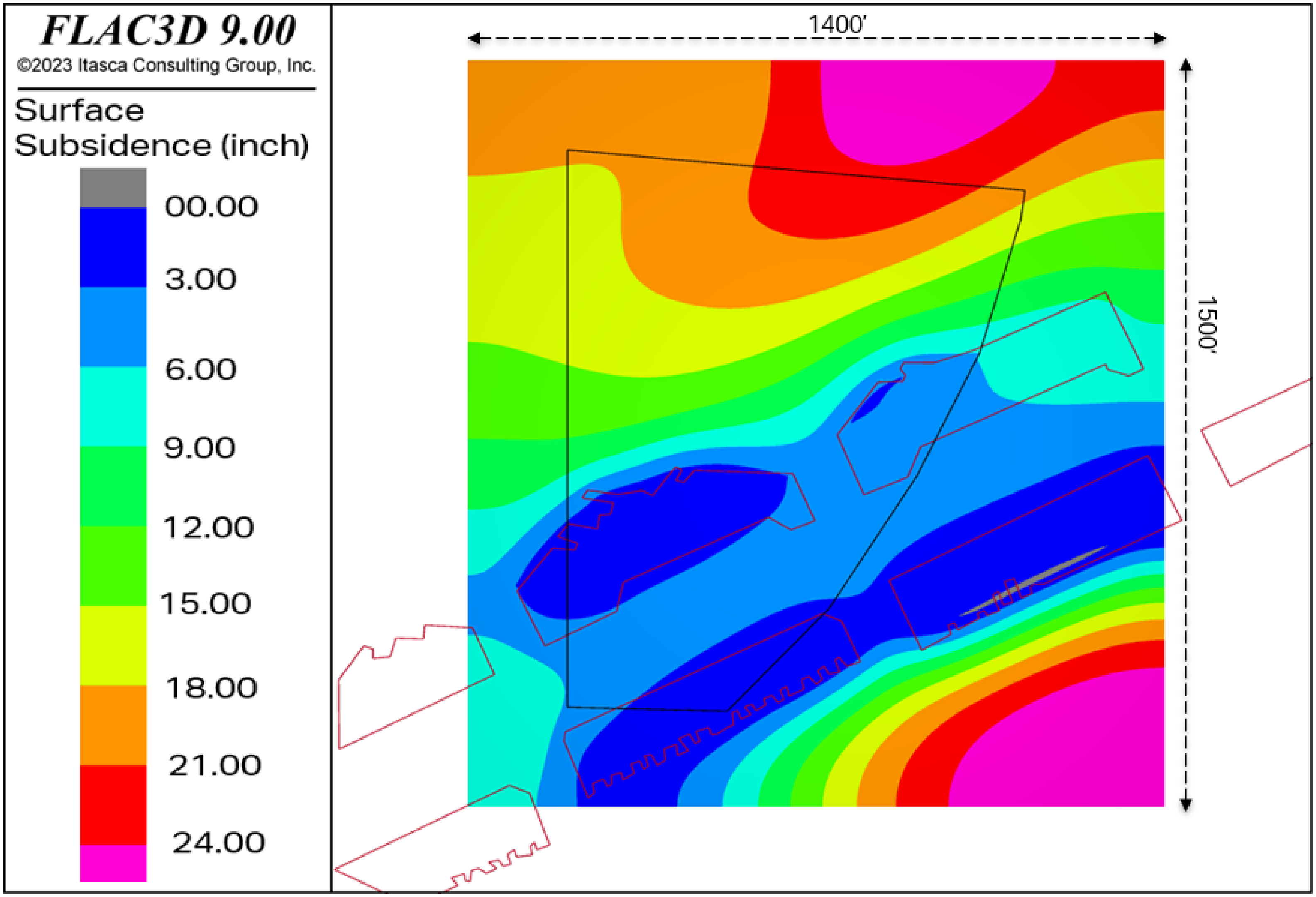


Figure B-41. Surface Subsidence Plot for the Ultimate Subsidence Scenario.

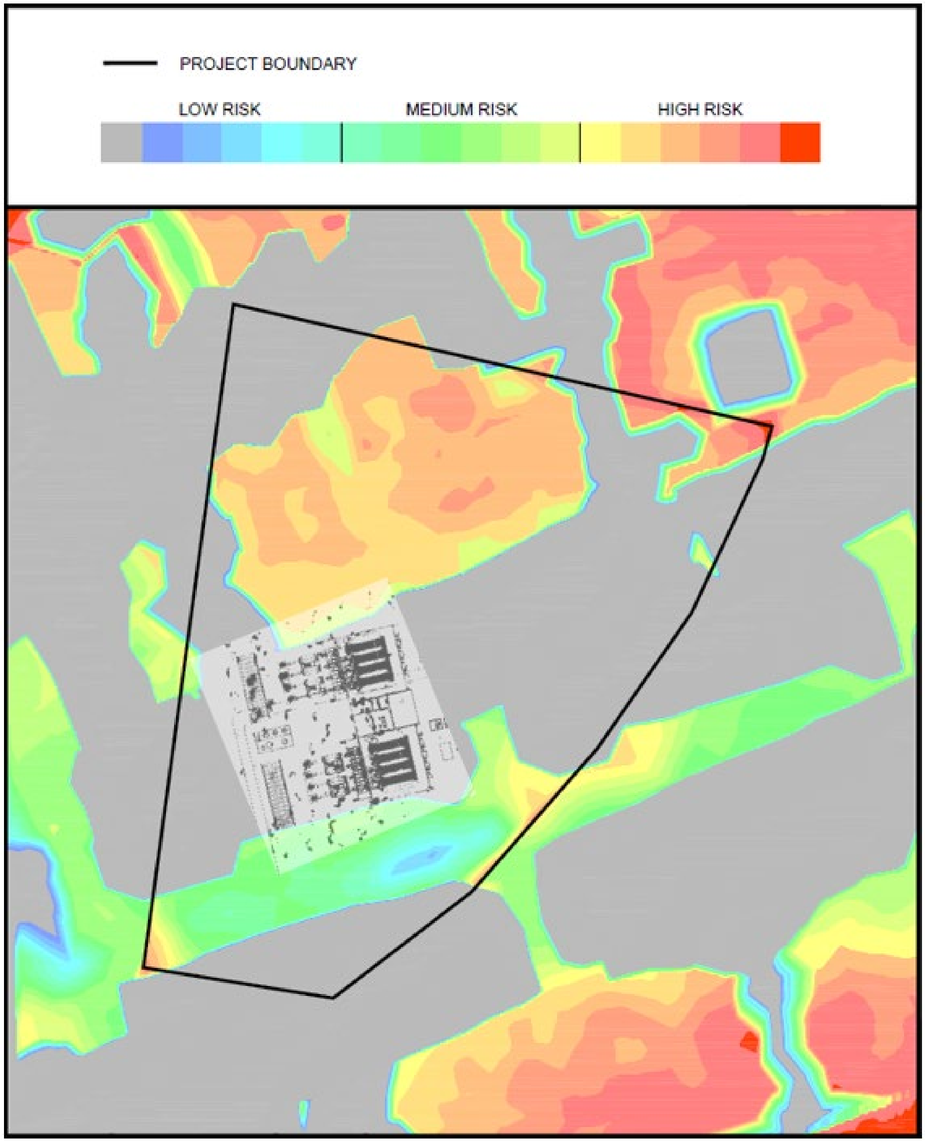


Figure B-42. Subsidence Risk Isopach With an Example of Facilities Located Over the Lowest Risk Area.

APPENDIX C

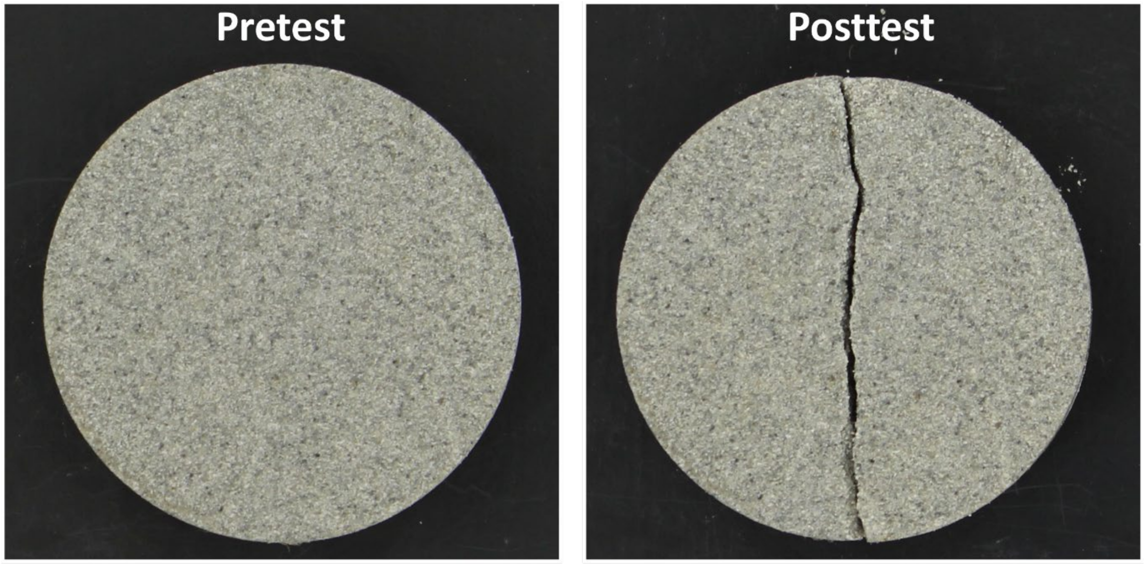
TEST RESULTS AND PRE- AND POSTTEST PHOTOGRAPHS OF BRAZILIAN TEST SPECIMENS

RESPEC

Table C-1. Summary of Brazilian Indirect Tensile Strength Test Results

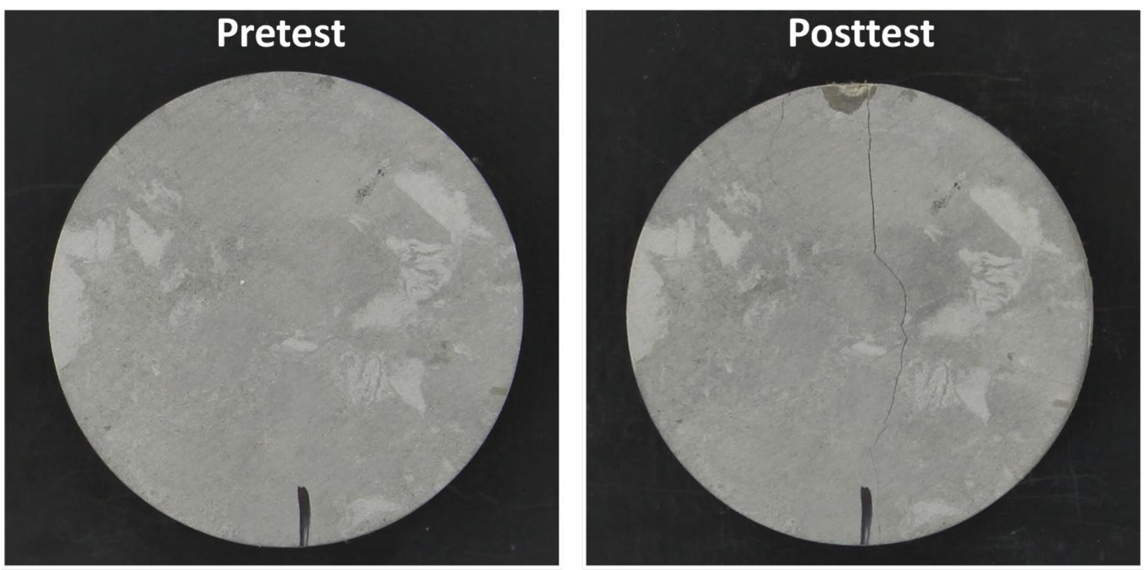
Specimen I.D.	Strength (psi)
NFRONT/MAD-07/113.2	527
NFRONT/MAD-02/188.5	266
NFRONT/MAD-11/140.7	1,018
NFRONT/MAD-15/232.4	937
Average Tensile Strength	687
Standard Deviation	± 306

psi = pounds per square inch



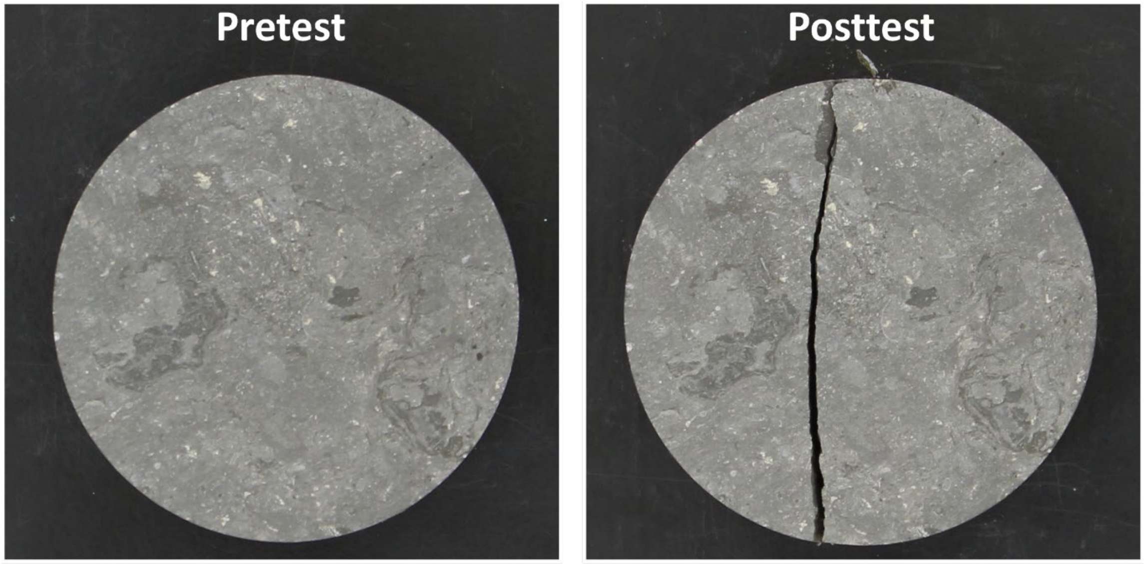
NFRONT/MAD-02/188.5

Figure C-1. Pre- and Posttest Photographs of Brazilian Test Specimen NFRONT/MAD-02/188.5.



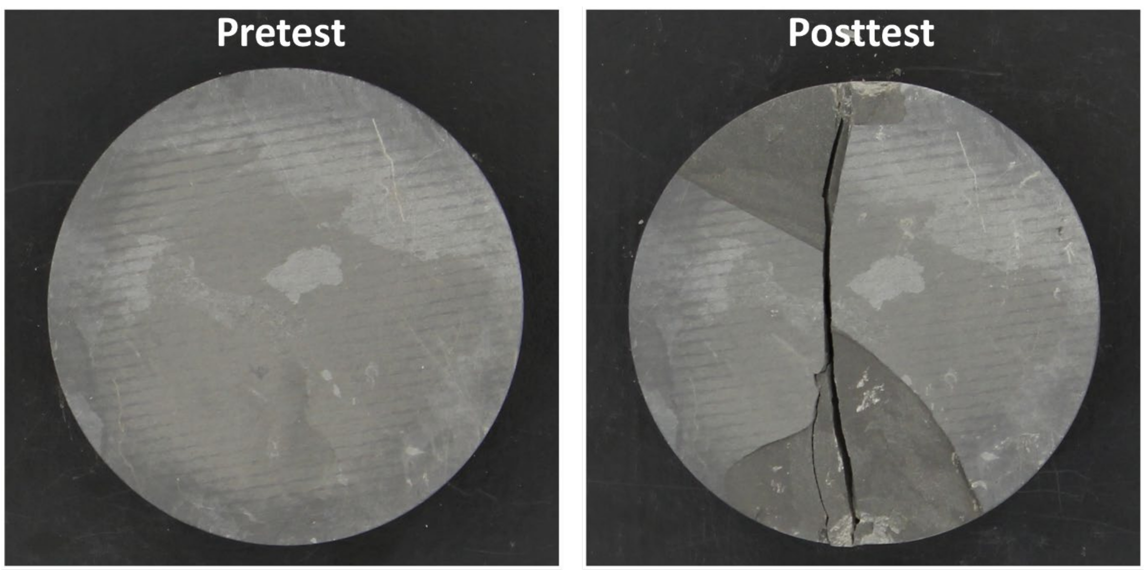
NFRONT/MAD-07/113.2

Figure C-2. Pre- and Posttest Photographs of Brazilian Test Specimen NFRONT/MAD-07/113.2.



NFRONT/MAD-11/140.7

Figure C-3. Pre- and Posttest Photographs of Brazilian Test Specimen NFRONT/MAD-11/140.7



NFRONT/MAD-15/232.4

Figure C-4. Pre- and Posttest Photographs of Brazilian Test Specimen NFRONT/MAD-15/232.4.

APPENDIX D

TEST RESULTS; CONSTANT STRAIN RATE, STANDARD TRIAXIAL COMPRESSION, AND UNCONFINED COMPRESSION TEST PLOTS; AND PRE- AND POSTTEST PHOTOGRAPHS OF THE TEST SPECIMENS

RESPEC

Table D-1. Standard Triaxial Compression and Unconfined Compression Test Results

Specimen I.D.	Young's Modulus (psi)	Poisson's Ratio (—)	Confining Pressure (psi)	Maximum Stress Difference (psi)	Density (g/cc)
NFRONT/MAD-05/99.6	326,000	0.07	0	3,550	2.57
NFRONT/MAD-04/211.7	1,795,000	0.11	1,000	10,350	2.40
NFRONT/MAD-08/117.6	1,457,000	0.13	500	5,430	2.56
NFRONT/MAD-09/134.8	291,000	0.04	0	2,020	1.36
NFRONT/MAD-10/137.1	358,000	0.11	0	2,010	1.35
NFRONT/MAD-10/143.0	412,000	0.16	0	2,090	1.25
NFRONT/MAD-14/230.3	2,029,000	0.14	750	8,960	2.59
NFRONT/MAD-16/122.4	143,000	0.02	0	4,180	1.43
NFRONT/MAD-18/100.3	1,247,000	0.25	1,000	6,000	2.56
NFRONT/MAD-21/127.4	4,182,000	0.09	0	8,550	2.67
NFRONT/MAD-22/128.8	7,334,000	0.23	500	17,410	2.72
NFRONT/MAD-23-1/130.3	10,791,000	0.25	750	19,240	2.70
NFRONT/MAD-23-2/130.8	9,911,000	0.24	1,000	19,740	2.69
NFRONT/MAD-24/206.2	460,000	0.03	0	5,470	2.33
NFRONT/MAD-28/228.5	1,471,000	0.11	0	5,190	2.64
NFRONT/MAD-30/229.3	2,079,000	0.23	1,250	9,860	2.65

psi = pounds per square inch
g/cc = grams per cubic centimeter

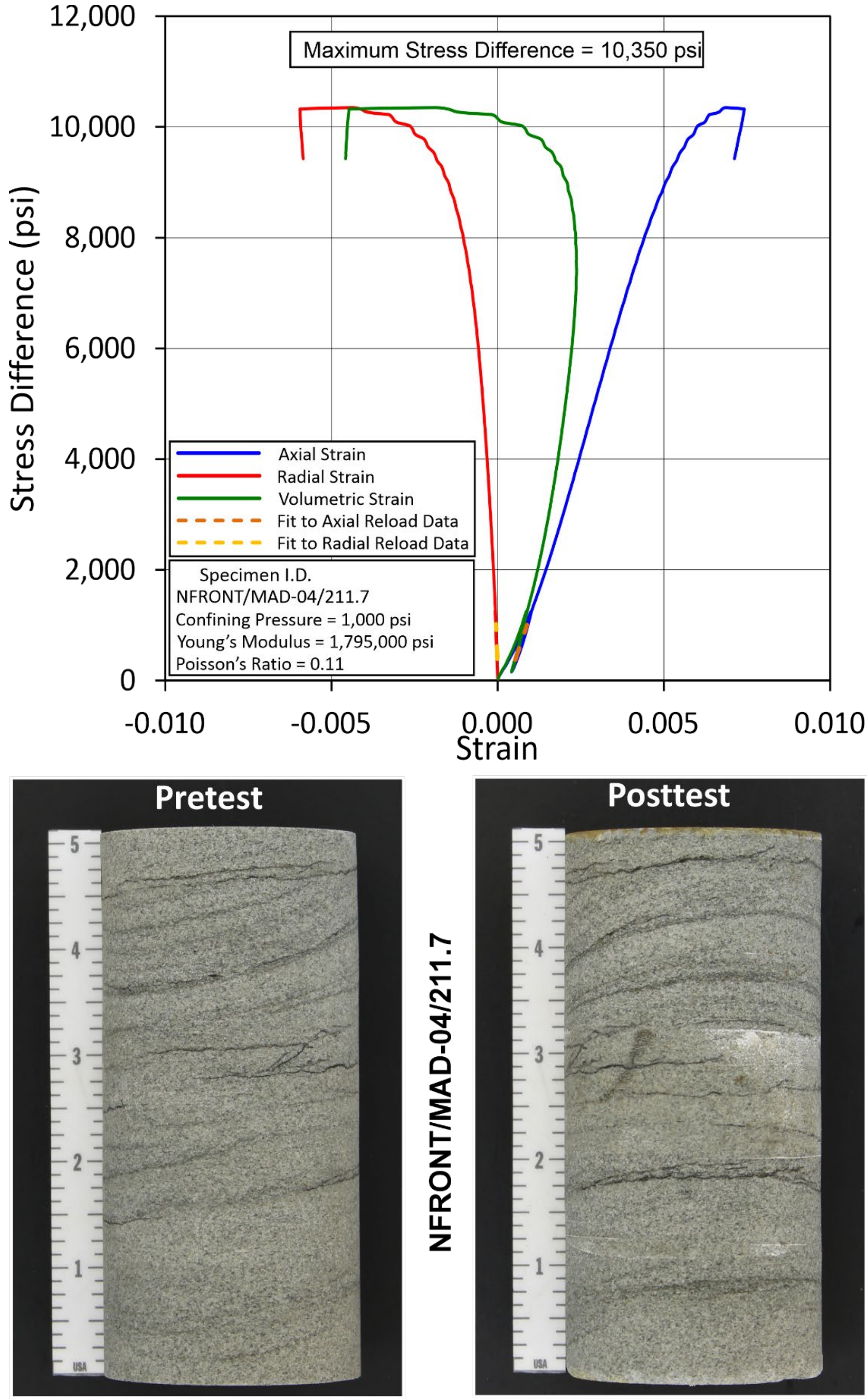


Figure D-1. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-04/211.7.

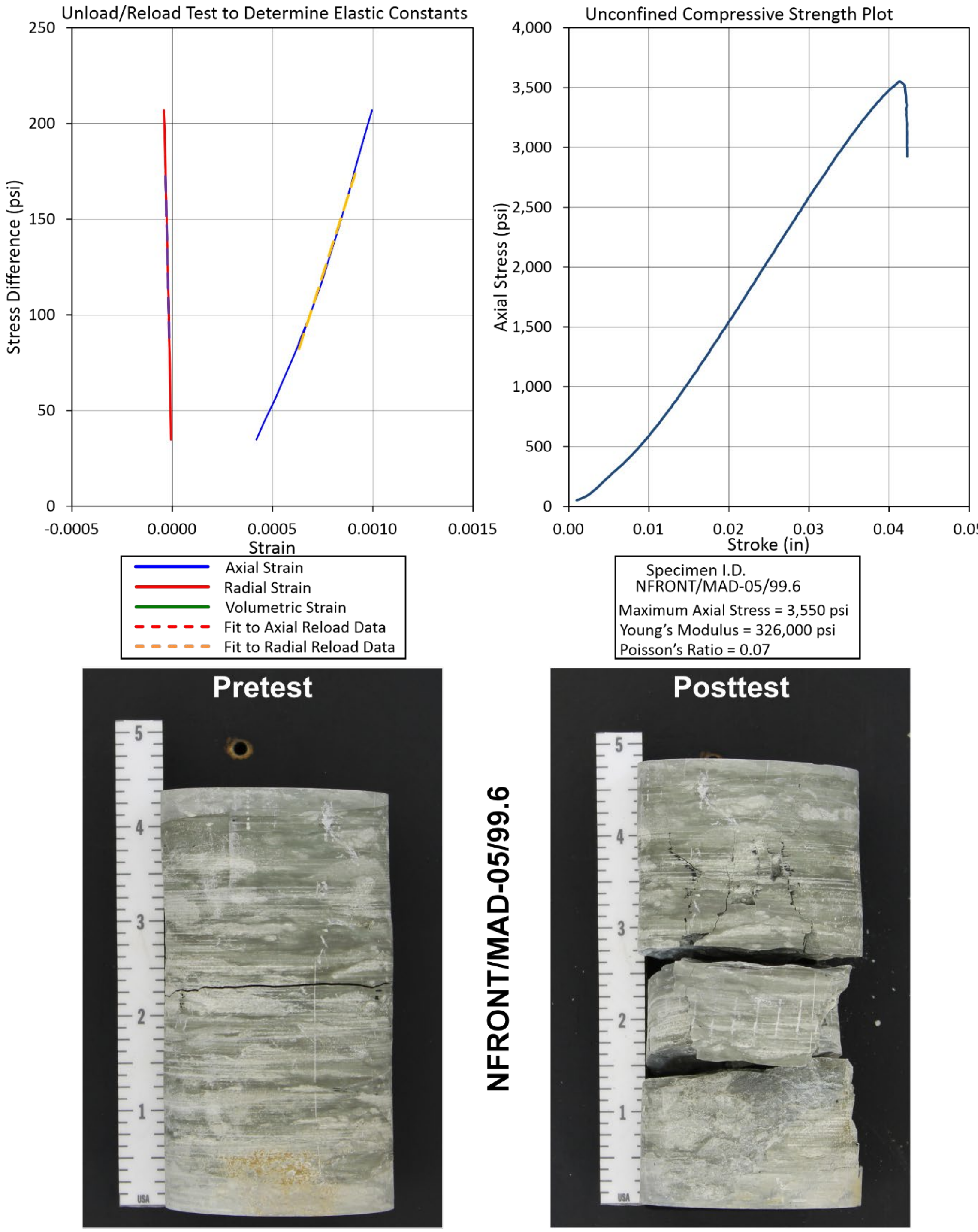
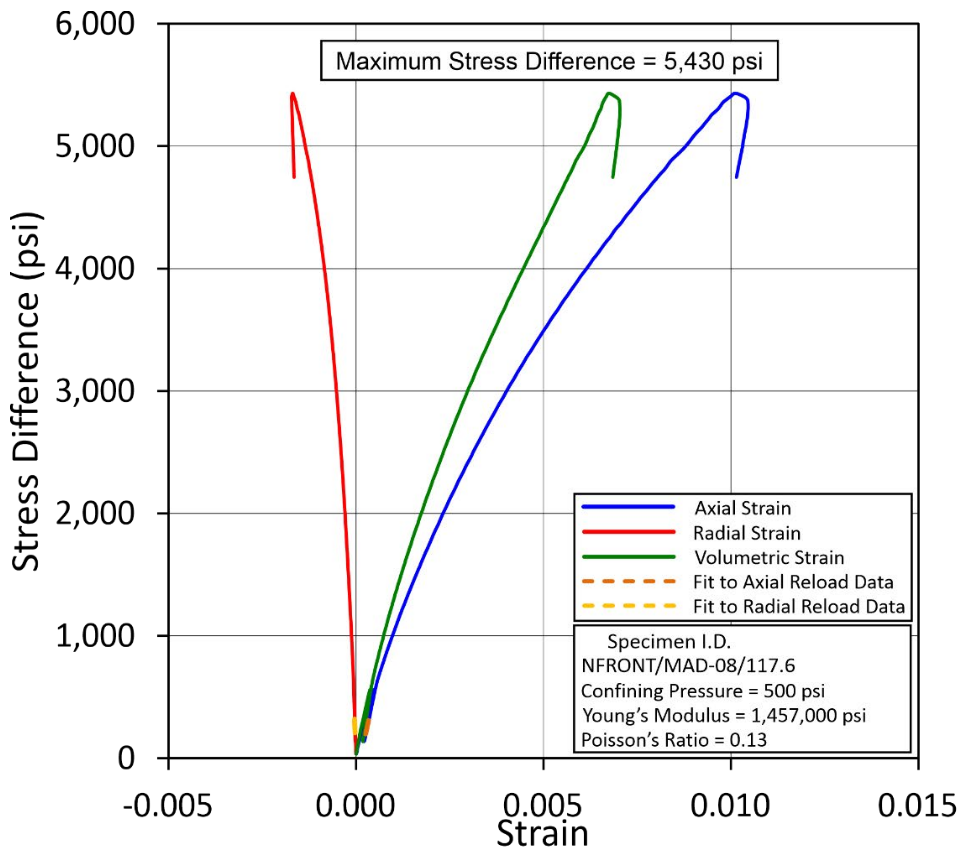


Figure D-2. Unconfined Compression and Constant Strain Rate Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-05/99.6.



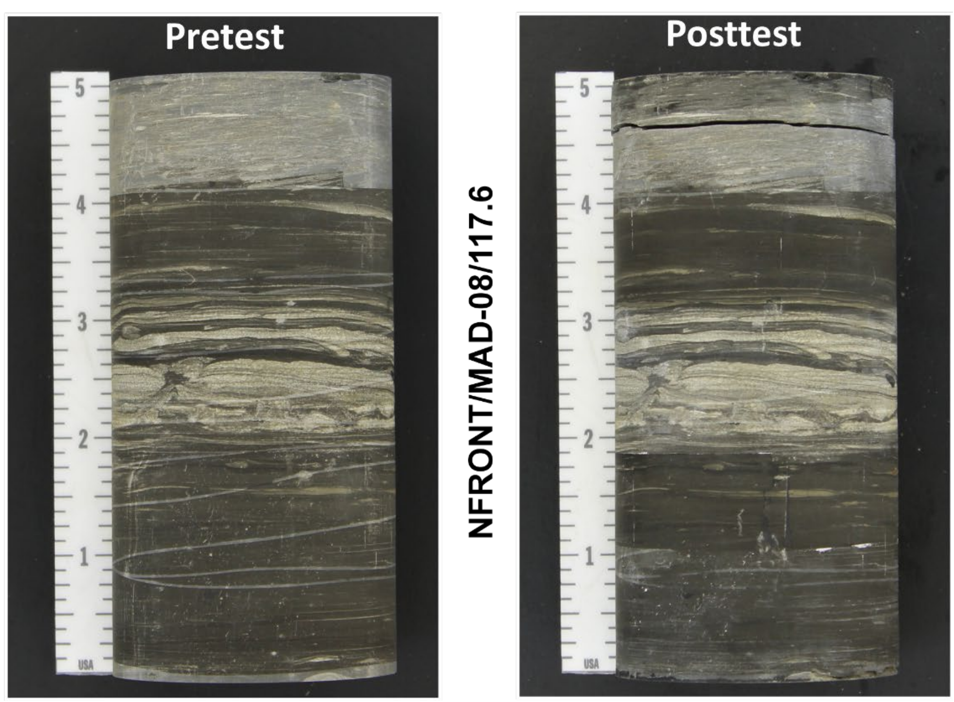


Figure D-3. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-08/117.6.

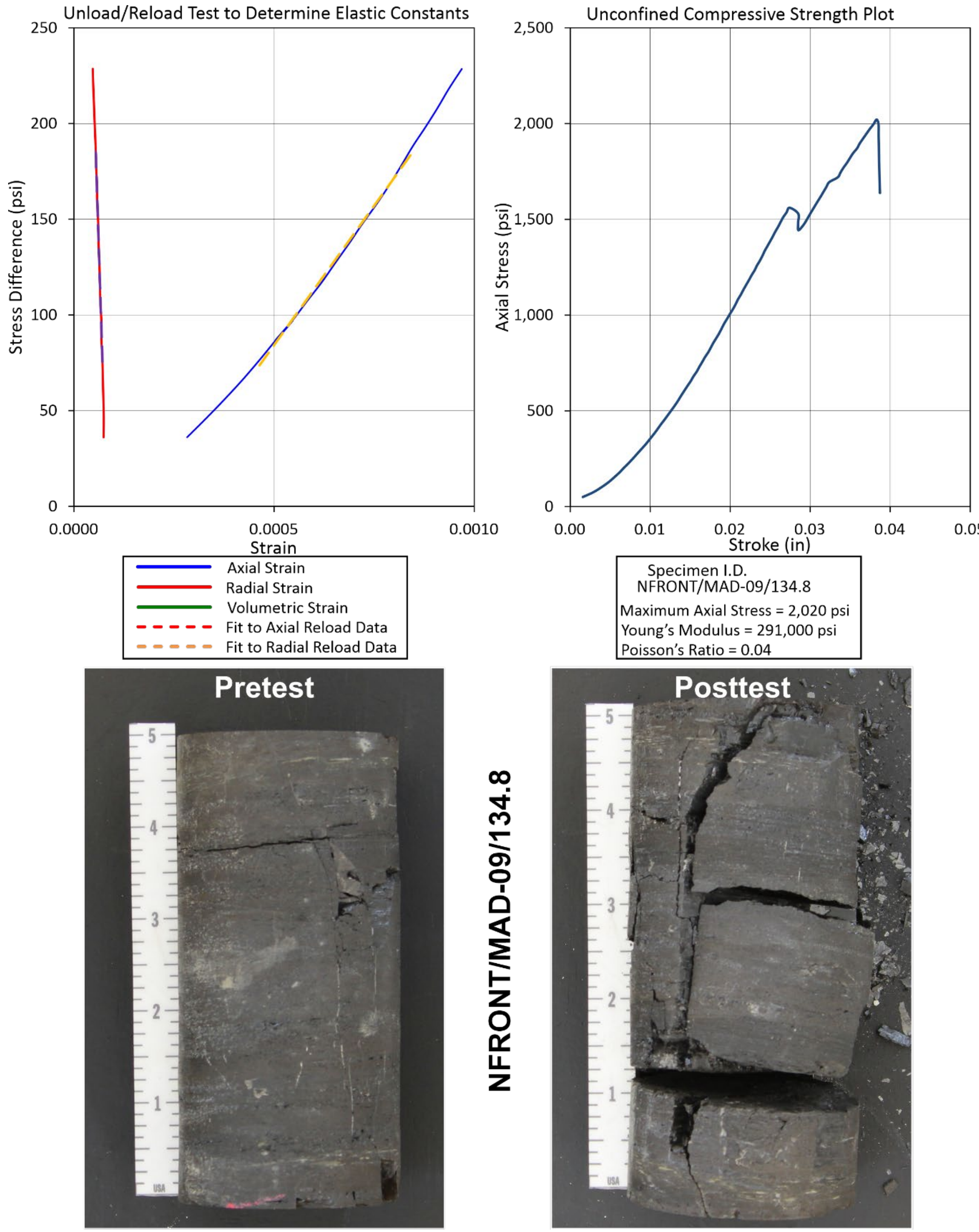


Figure D-4. Unconfined Compression and Constant Strain Rate Test Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-09/134.8.

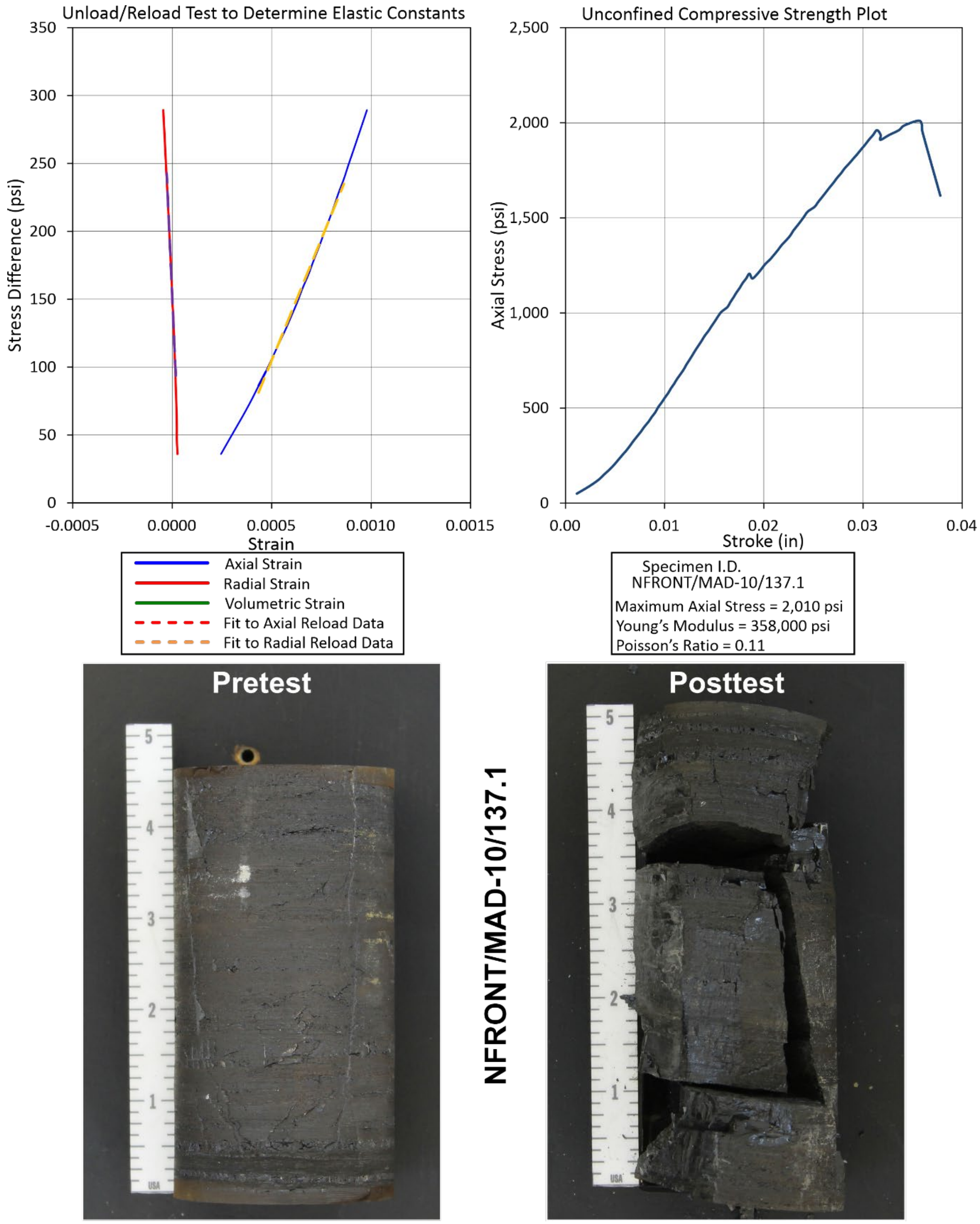


Figure D-5. Unconfined Compression and Constant Strain Rate Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-10/137.1.

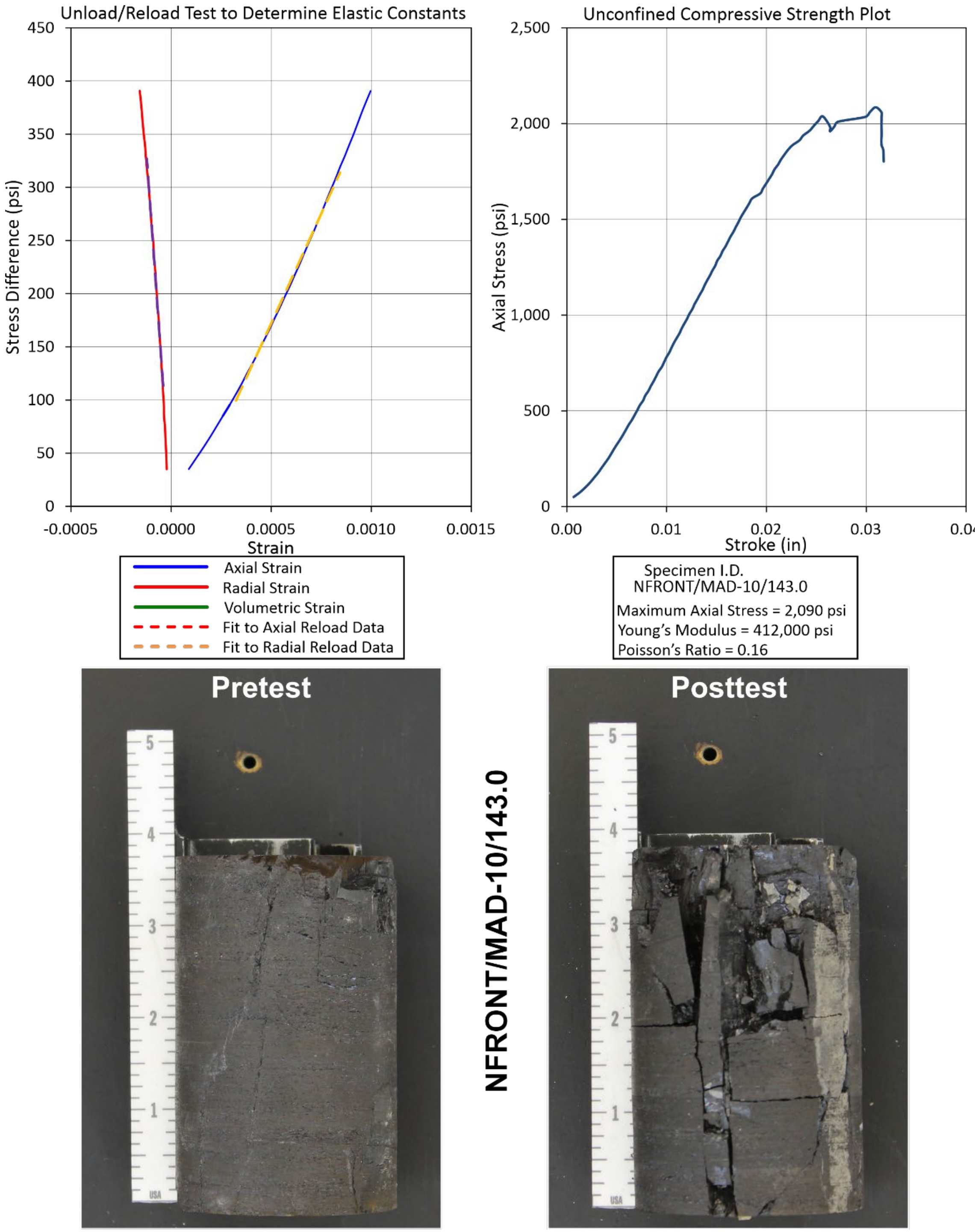
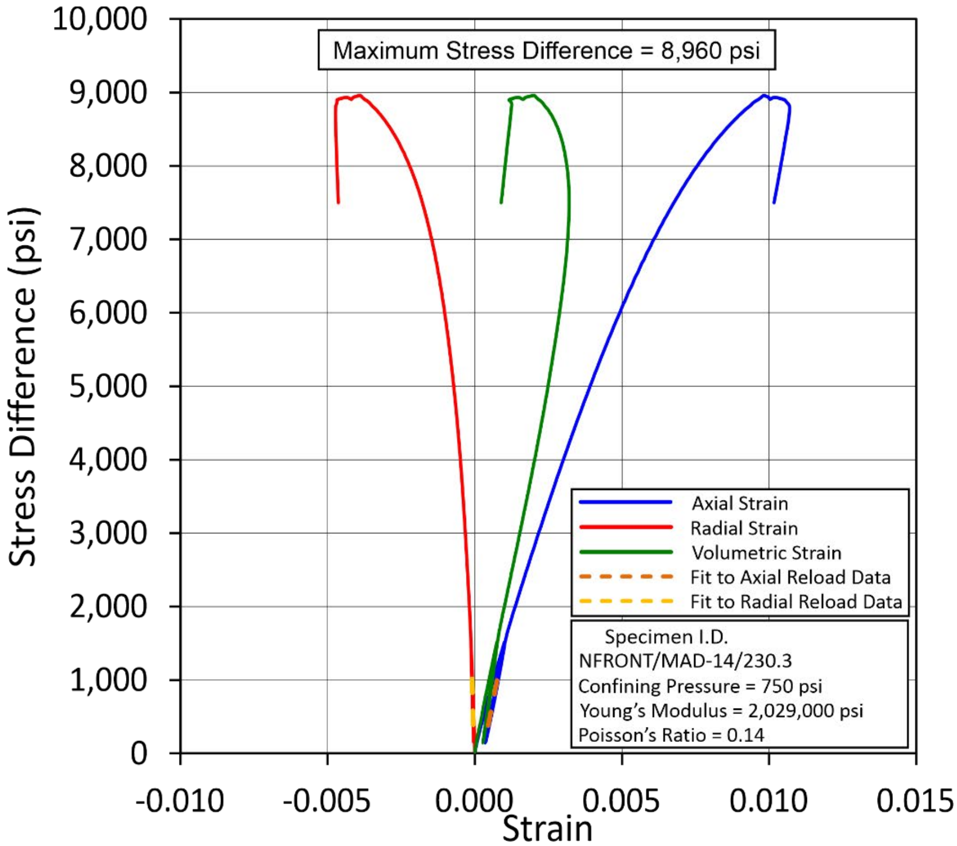


Figure D-6. Unconfined Compression and Constant Strain Rate Test Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-10/143.0.

RESPEC



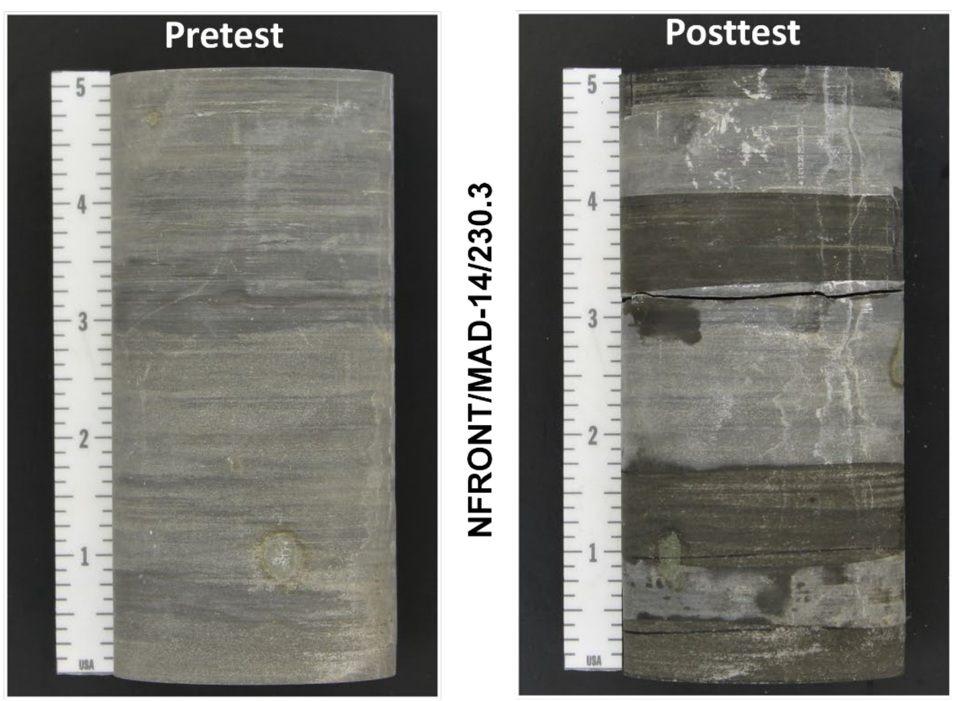


Figure D-7. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-14/230.3.

RESPEC

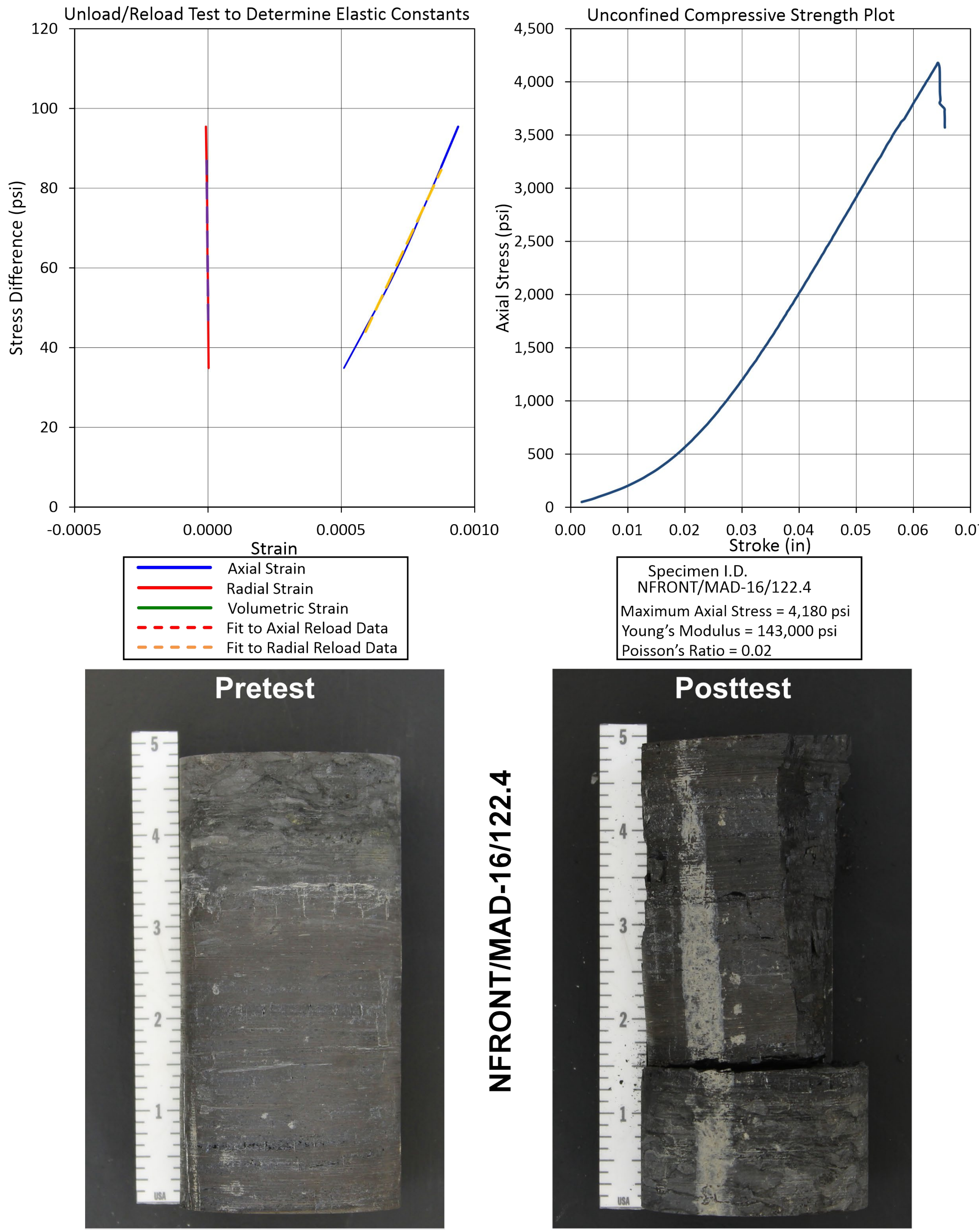
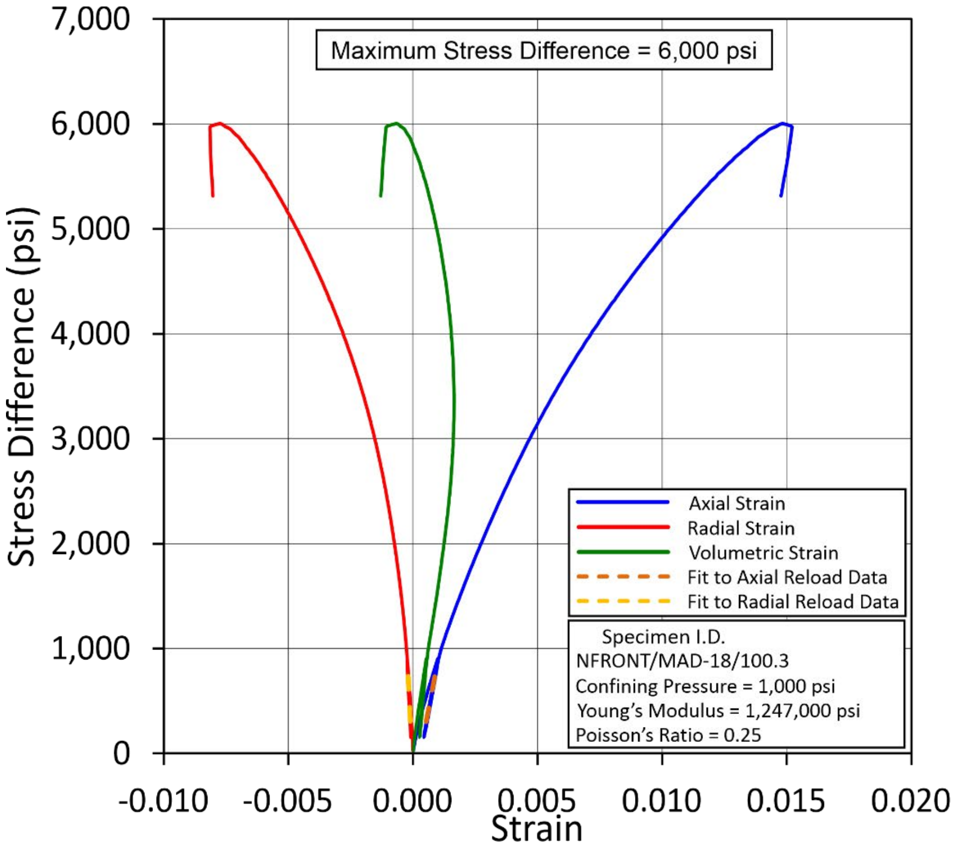


Figure D-8. Unconfined Compression and Constant Strain Rate Test Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-16/122.4.



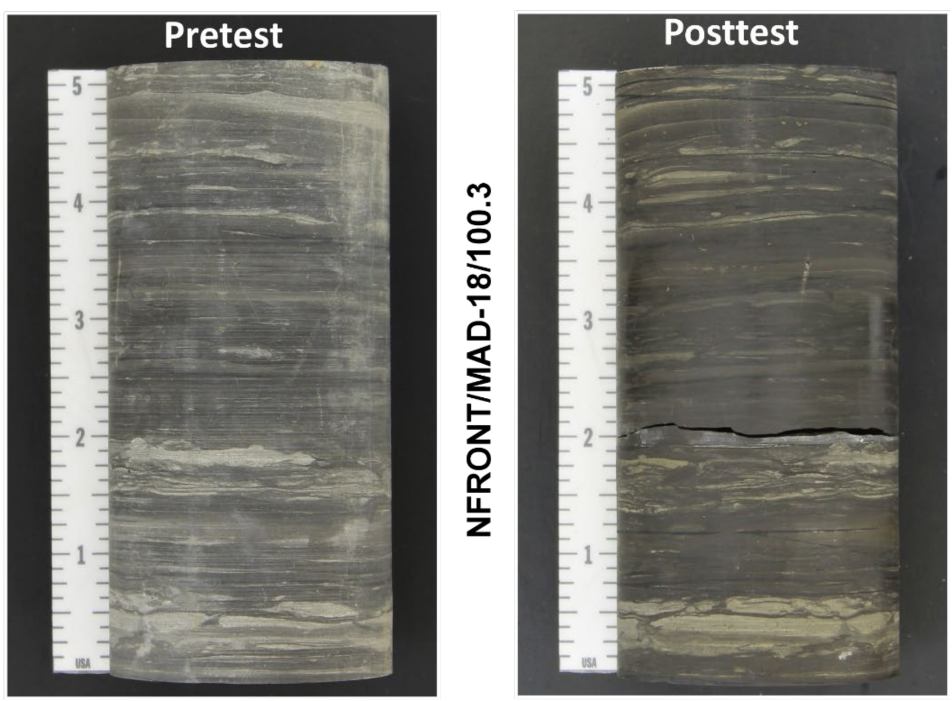


Figure D-9. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-18/100.3.

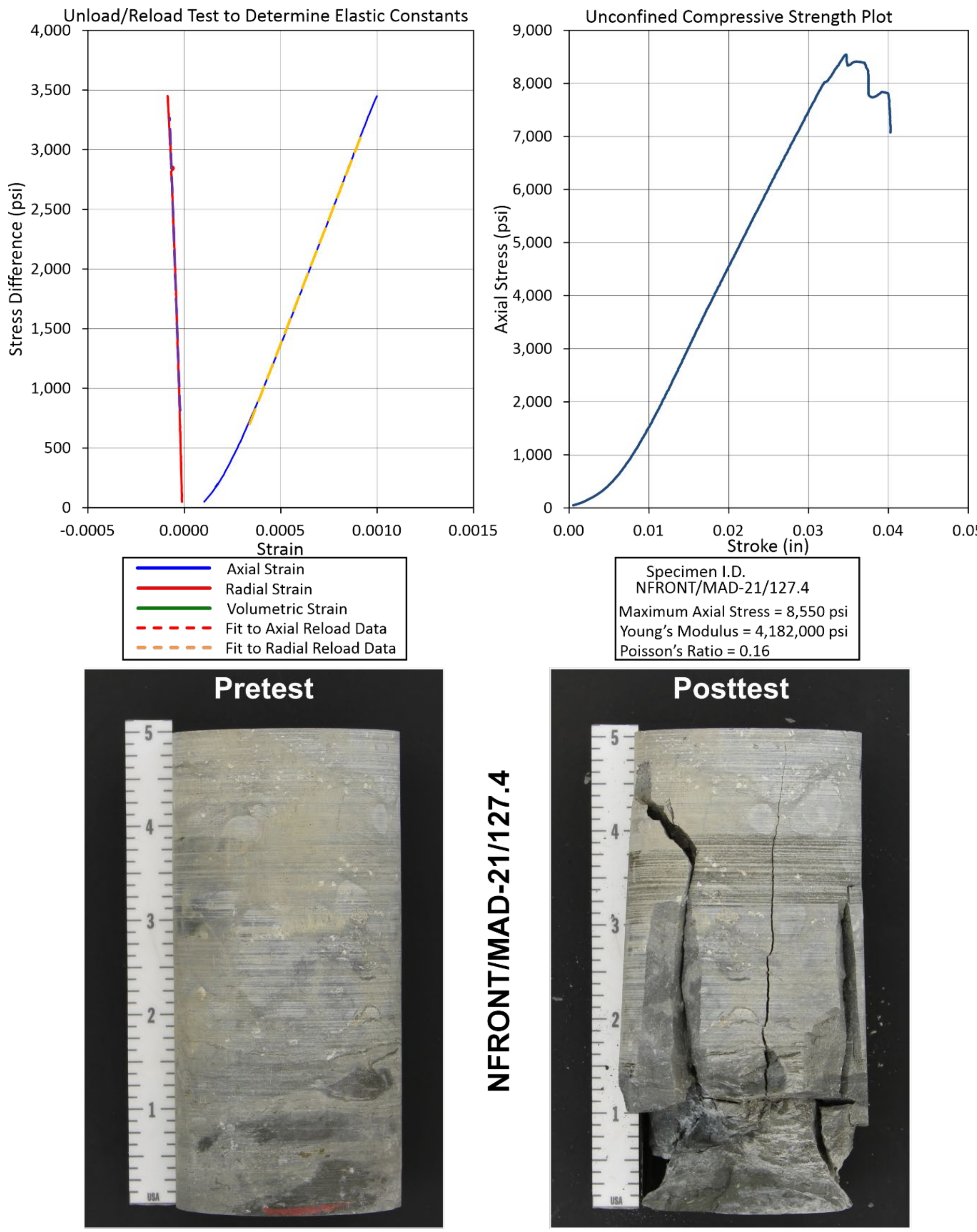
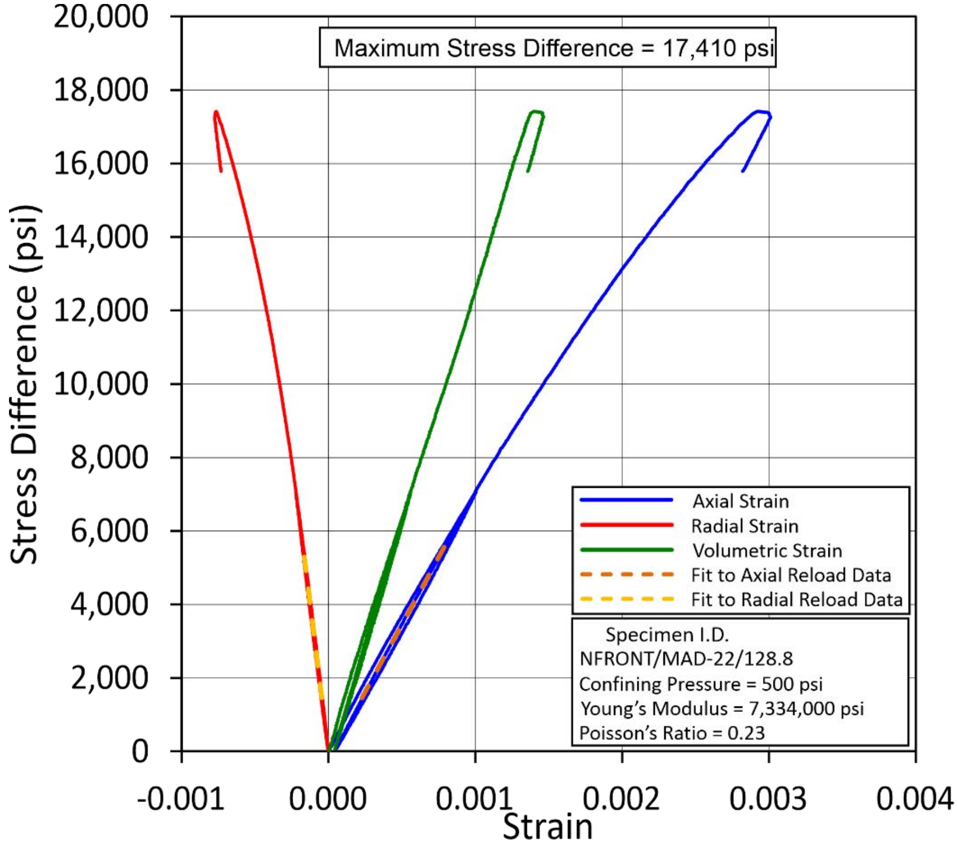


Figure D-10. Unconfined Compression and Constant Strain Rate Test Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-21/127.4.



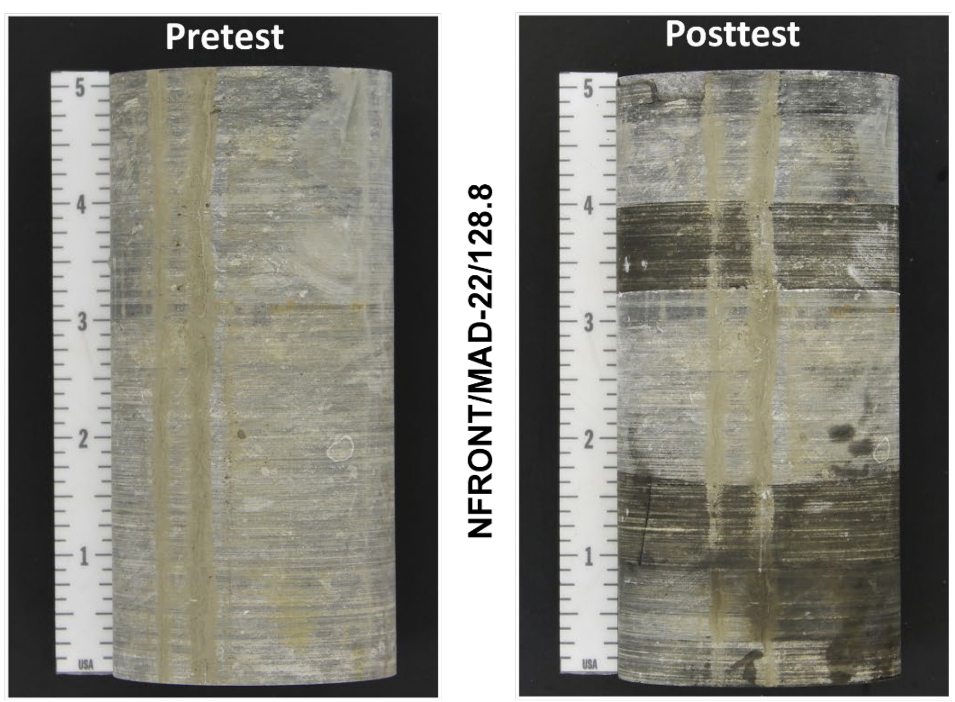


Figure D-11. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-22/128.8.

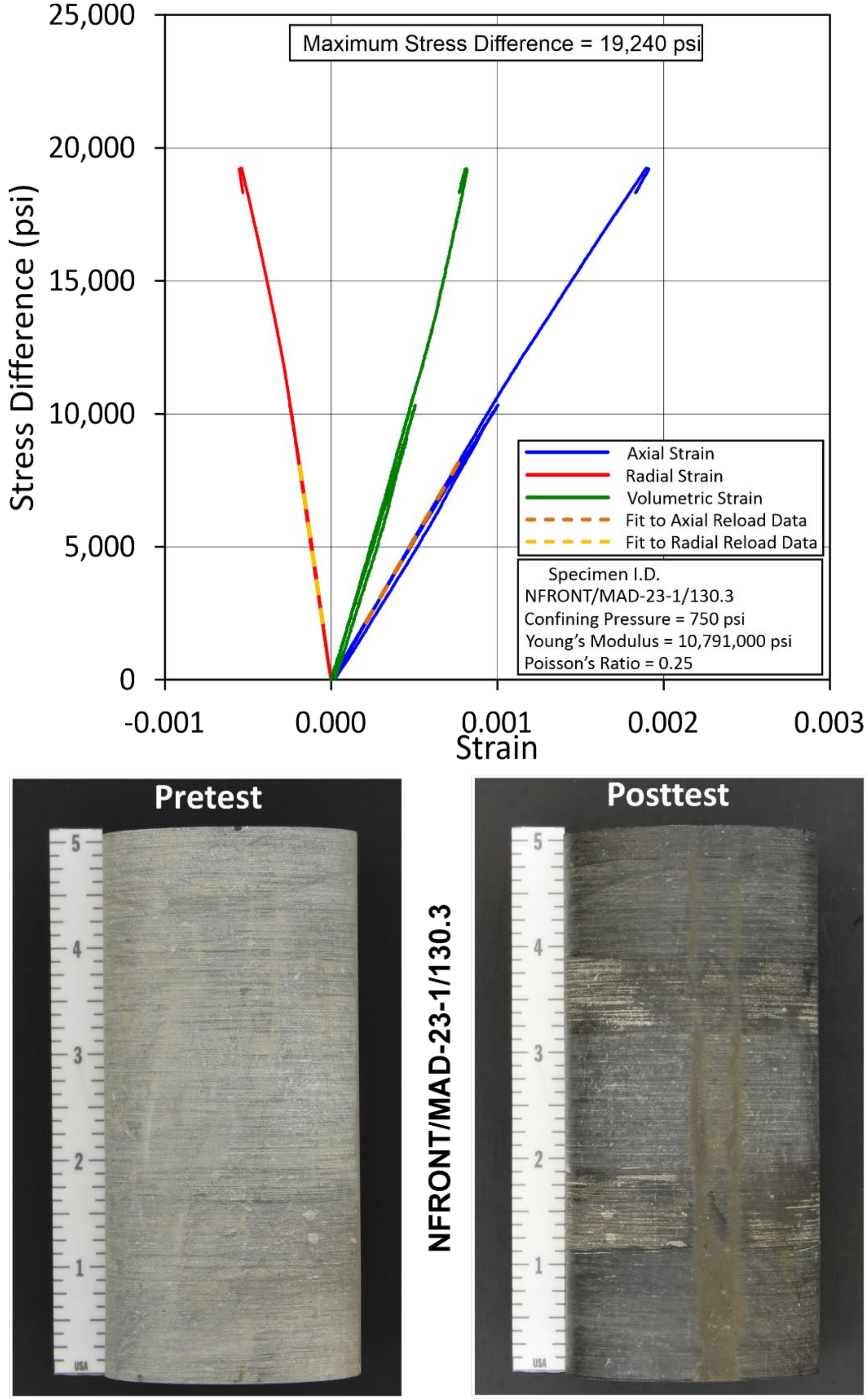
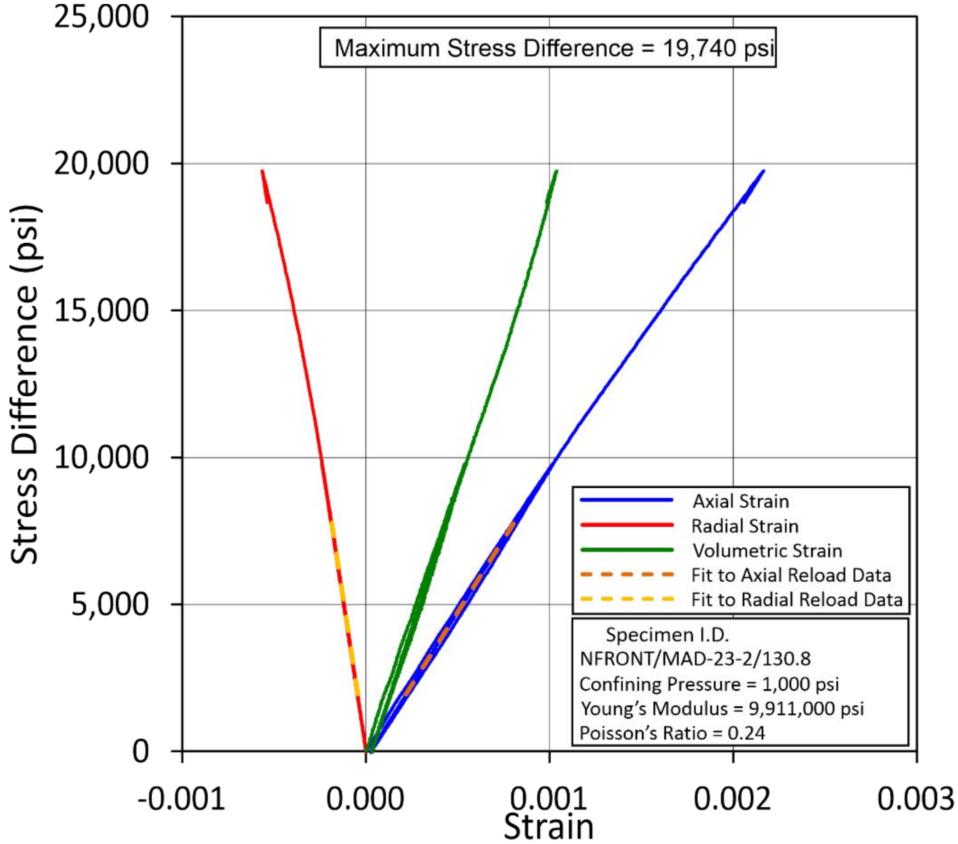


Figure D-12. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-23-1/130.3.



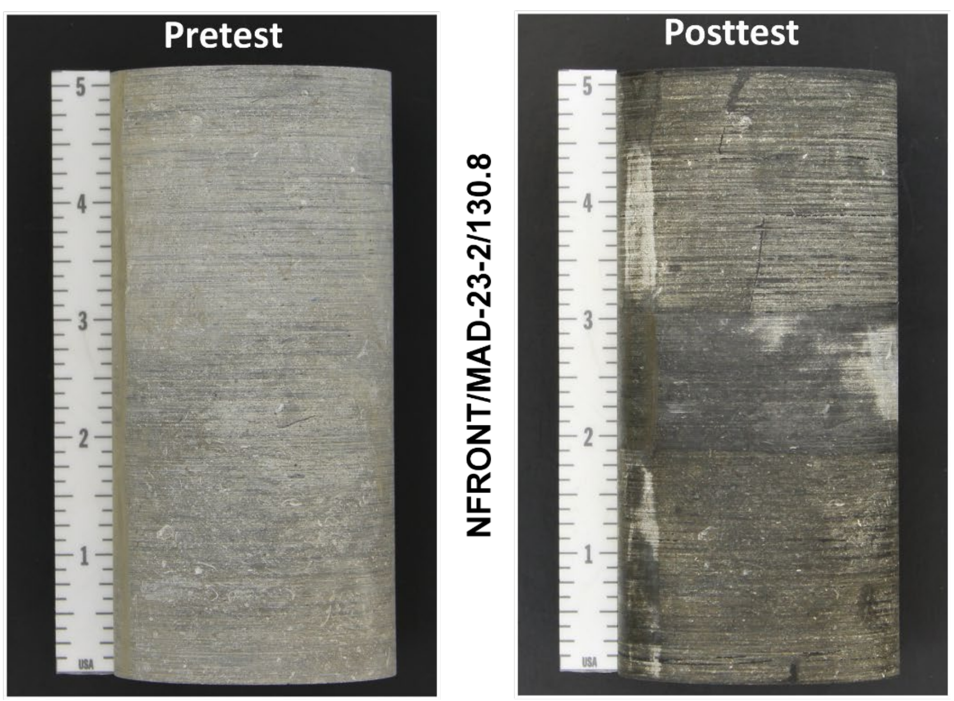


Figure D-13. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-23-2/130.8.

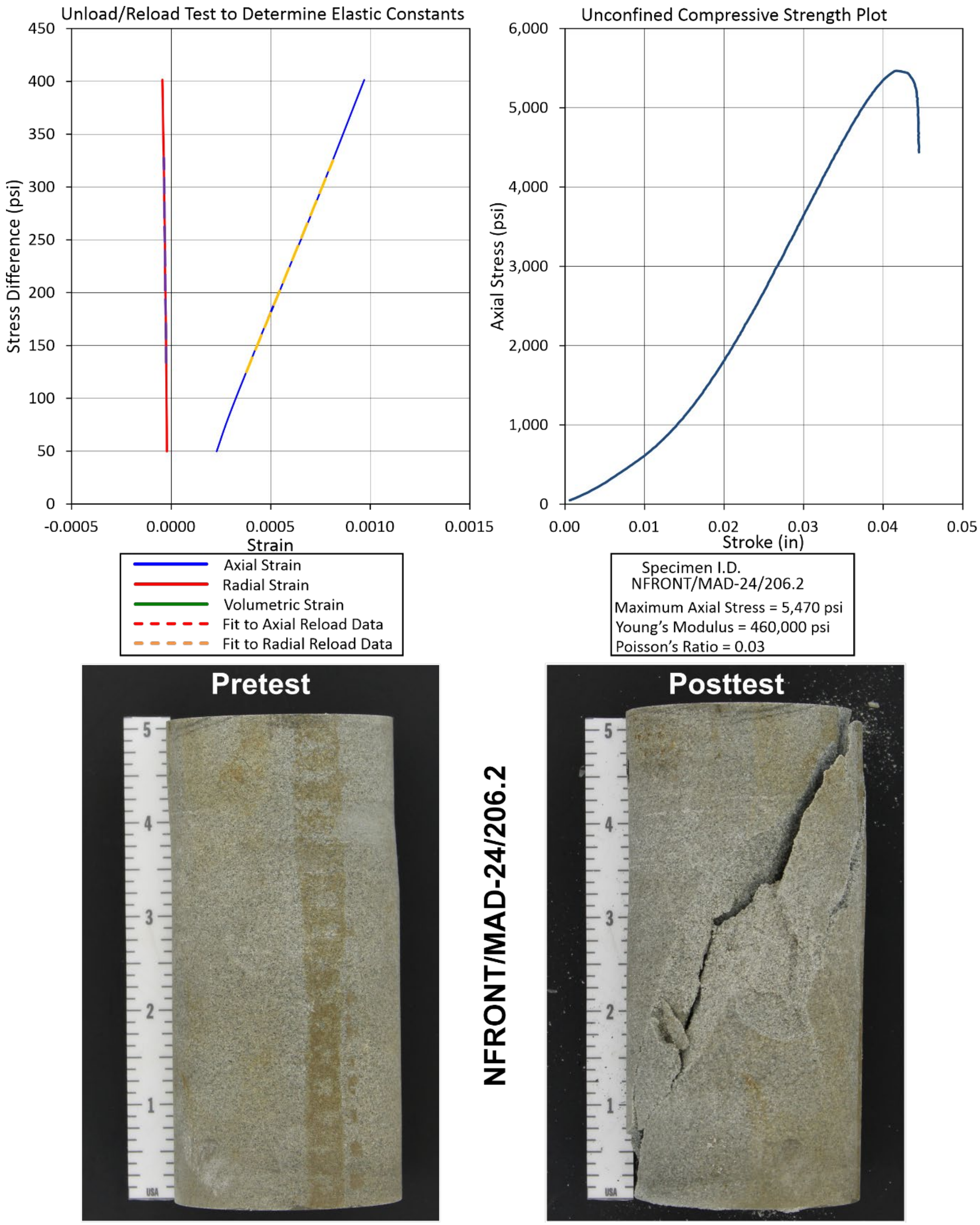


Figure D-14. Unconfined Compression and Constant Strain Rate Test Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-24/206.2.

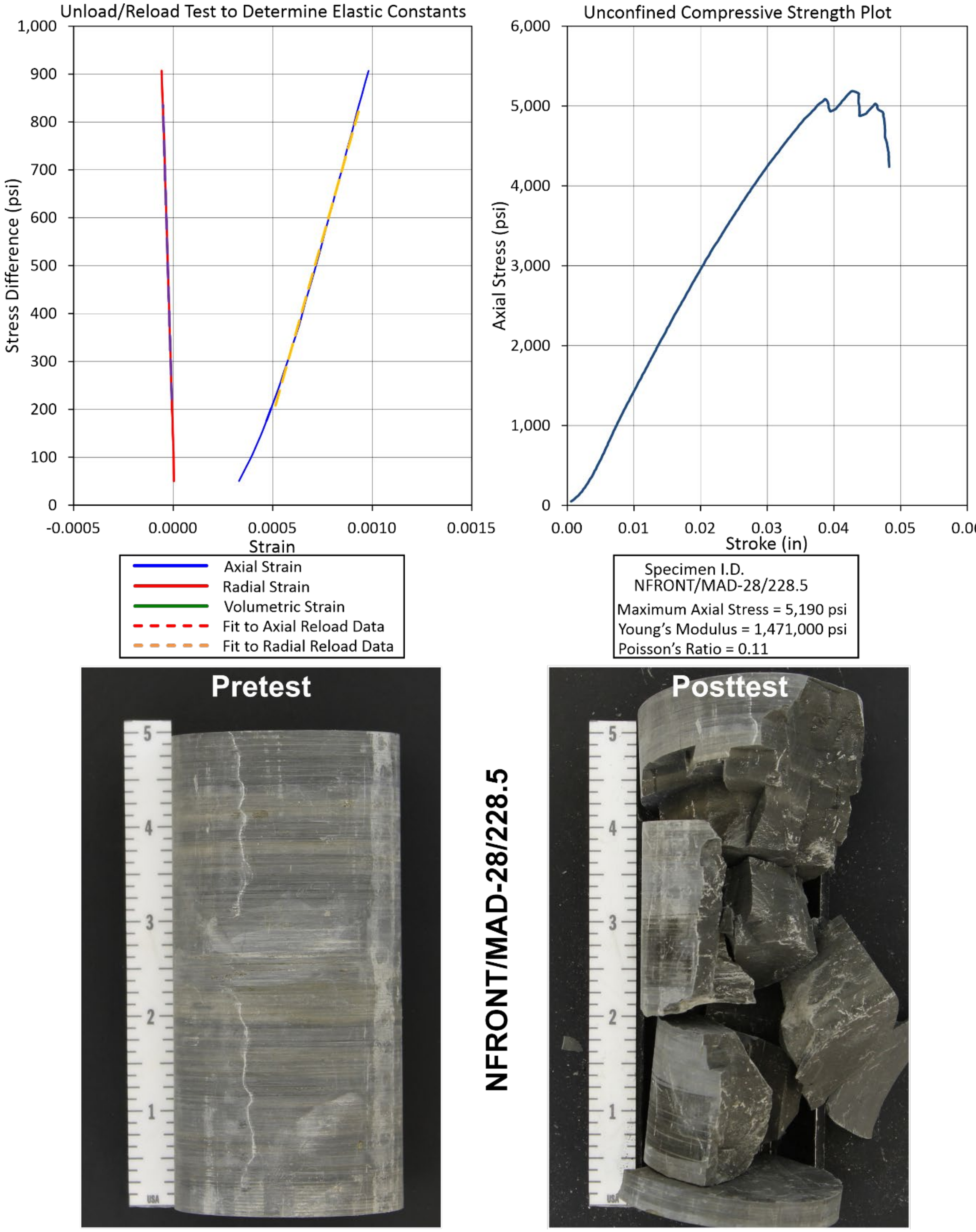


Figure D-15. Unconfined Compression and Constant Strain Rate Test Plots and Pre- and Posttest Photographs of Specimen NFRONT/MAD-28/228.5.

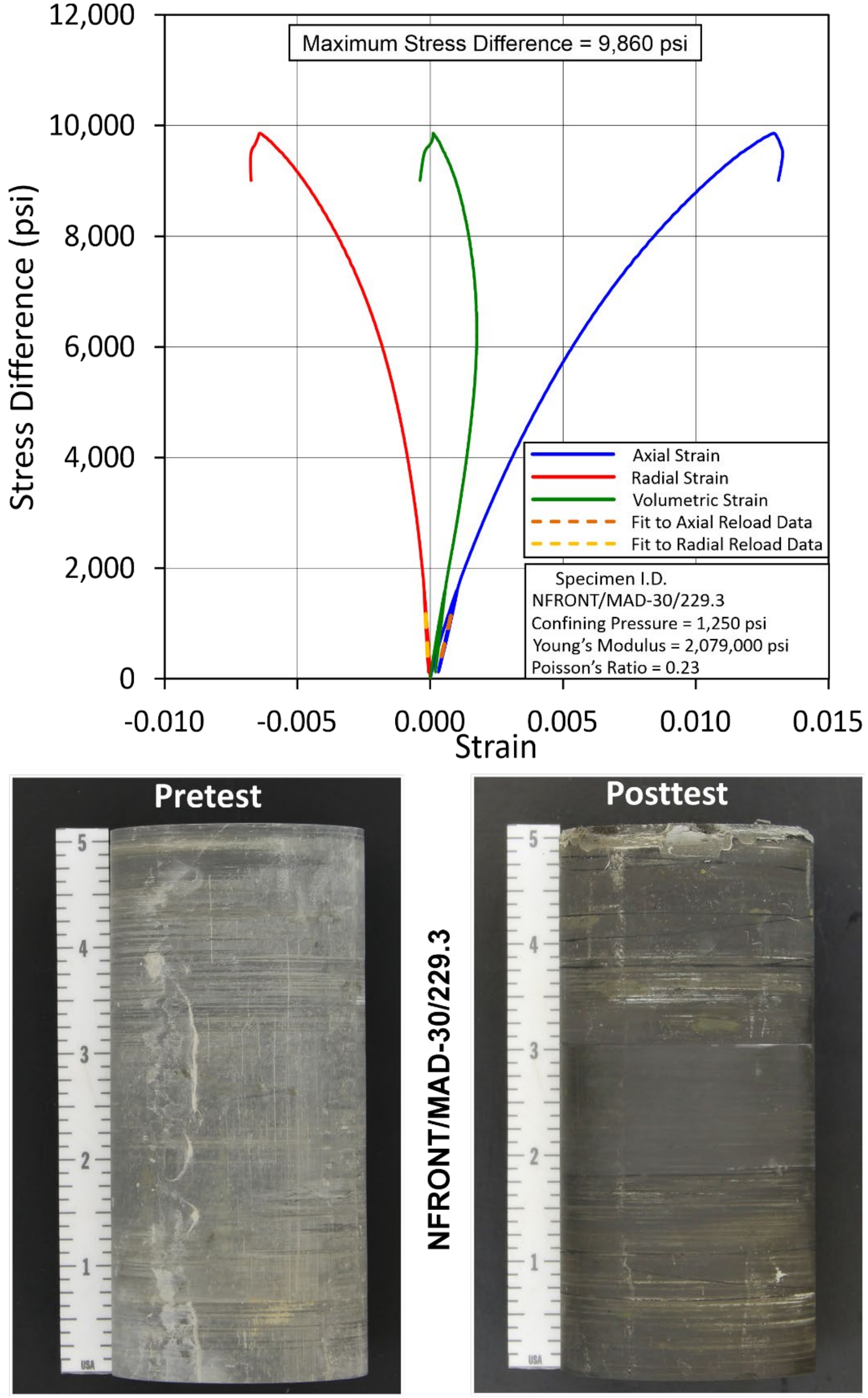


Figure D-16. Constant Strain Rate and Standard Triaxial Compression Test Plot and Pre- and Posttest Photographs of Specimen NFRONT/MAD-30/229.3.

COMMONWEALTH OF KENTUCKY
BEFORE THE KENTUCKY STATE BOARD
ON ELECTRIC GENERATION AND TRANSMISSION SITING

In the Matter of:

Electronic Application of Kentucky Municipal Energy Agency for a Certificate of Construction for an Approximately 75-Megawatt Merchant Electric Generating KYMEA Energy Center I and Transmission Line in Madisonville, Kentucky, Pursuant to KRS 278.700 and 807 KAR 5:110	)))))	Case No. 2024-00290

CERTIFICATION

This is to certify that I have supervised the preparation of the KYMEA's responses to the Siting Board Staff's Post-Hearing Data Requests and that the responses on which I am identified as a sponsoring witness are true and accurate to the best of my knowledge, information, and belief after reasonable inquiry.

3/2/2025
Date

Doug Buresh
Doug Buresh