Subsidence Review

Weirs Creek Solar Project
Hopkins and Webster Counties, Kentucky

July 2023

CLIENT

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EXECUTIVE SUMMARY

Tetra Tech, Inc. (Tetra Tech) has prepared this Subsidence Review for the proposed 2,113-acre solar site (Project Area). Tetra Tech reviewed the locations of underground and surface mines, mine permits, and applicable permit revisions. The review identified two underground coal mines within the Project Area. This critical issues analysis (CIA) identified underground mining and subsidence as potential concerns for the Project.

The historical mining in the area was of the West Kentucky No. 9 (No. 9) and West Kentucky No. 13 (No. 13) seams. The No. 9 in the project area was mined by two different mining companies, the Webster County Coal Corporation, known as the Dotiki Mine and the Island Creek Coal Corporation, known as the Providence No. 1 Mine. The No. 9 seam is the deeper seam and it is Tetra Tech's opinion that they are unlikely to impact the No. 13 due to the pillar sizes and extraction. As a result, the No. 9 and No. 13 seams were reviewed independently of each other.

Approximately 63.7 percent (1016 acres) of the Project Area has been undermined by the No. 9 seam, with 36.3 percent (580 acres) of no known No. 9 underground mining activity. Regarding the No. 13 seam, approximately 19.5 percent (310 acres) of the Project Area has been undermined, with 11.2 percent (179 acres) of undeveloped areas available for future mining, and 61.9 percent (988 acres) of no known No. 13 underground mining activity.

Mining-induced subsidence is caused when a seam of coal is extracted and overlying rock strata caves into the voids left by mining such that there is movement on the ground surface. The probability of subsidence is greater in areas where the coal extraction ratio is high. Subsidence potential can be classified into three general categories:

Category 1 – Subsidence probably occurred during or soon after mining.

Category 2 – Subsidence unlikely due to support areas remaining within the mine.

Category 3 – Subsidence may occur in the future if it has not already occurred.

Based upon review of the available mine maps, it is Tetra Tech's opinion that none of the areas evaluated for either the No. 9 or No. 13 are classified as Category 1.

Subsidence is unlikely for areas classified as Category 2. It is Tetra Tech's opinion that areas overtop the No. 9 mining in the Project Area are unlikely to subside and therefore classified as Category 2. No further review is required for areas that are only impacted by No. 9 mining. Reviewing No. 9 mining independently of the No. 13 seam mining, the Category 2 area of the No. 13 were identified in approximately 146 acres or approximately 9.1 percent of the Project Area.

There is the potential for future subsidence within areas classified as Category 3 within the area mined for the No. 13. Areas classified as Category 3 are based on the amount of coal removed. Category 3 areas were identified in approximately 165 acres or approximately 10.3% percent of the Project Area.

If subsidence were to occur, it is estimated that the ground surface could exhibit a drop of 60 percent of the seam height mined. Therefore, a seam mining height of 4 to 9 feet could exhibit a ground surface drop of 2.4 to 5.4 feet. There are mitigation options to build over areas classified as Category 3. Mitigation options include using these areas only for non-structural construction (such as roads, drainage, piping or overhead transmission) or using structural designs capable of withstanding the maximum estimated strains from the potential subsidence.

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ACRONYMS/ABBREVIATIONS

Acronym/Abbreviation	Definition
AML	Abandoned Mine Lands
bgs	Below ground surface
CIA	Critical Issues Analysis
CMIS	Coal Mine Information System
gob	garbage of bituminous
KYAML	Kentucky Abandoned Mine Lands
KGS	Kentucky Geologic Survey
KEEC SMIS	Kentucky Energy and Environment Cabinet Surface Mining Information System
MSHA	Mine Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
USGS	United States Geological Survey
WKy	West Kentucky

1.0 INTRODUCTION

NextEra Energy Resources (NextEra) proposes to develop the Weirs Creek Solar Project (Project) on approximately 2,113 acres of land in Hopkins and Webster Counties, Kentucky and has contracted with Tetra Tech, Inc. (Tetra Tech) to review and report on the potential for subsidence due to mines the underlie the Project Area. Underground mining was identified as a potential risk for the proposed Project due to the potential for subsidence.

Tetra Tech reviewed publicly available information from the Kentucky Geological Survey (University of Kentucky), the Kentucky Energy and Environment Cabinet Surface Mining Information System, Kentucky Abandoned Mine Lands, Kentucky Surface Mine Viewer, U.S. Office of Surface Mining Mine Map Repository, and the U.S. Department of Labor Mine Safety and Health Administration (MSHA) including:

- Permits and inspection reports; and
- Documents and maps pertaining to abandoned and active mines in the Project Area.

Tetra Tech's data review sought to identify the following documented information:

- Depth to coal seam;
- Coal seam height;
- Coal pillar size and location;
- Extraction ratios; and
- Presence or absence of flooding.

This report includes a detailed description of the aspects of past mining, methods that were used to remove the coal, description of the general types of subsidence, methodology of review, professional opinion on the potential for subsidence and type of subsidence, and mitigation recommendations.

2.0 BACKGROUND OF MINING

Kentucky is one of the top five coal-producing states in the United States. Coal mining began in Kentucky in Lee County in 1790 with 20 tons of coal production recorded. Between 1790 and 2001, 8.36 billion tons of coal have been produced in Kentucky. The Western Kentucky coal fields have produced more than 2.58 billion tons of coal. (Kentucky Geological Survey)

Mining in Hopkins County began in the 1950s and continued into the early 1980s with the Weirs Creek Company and Island Creek Coal Company. The mining began at the surface outcrop of the WKy No 13 coal seam and followed the coal seam to the north and east. This mining occurred in the Nebo and Coiltown Quadrangle.

The presence of the lower coal seam, the WKy No 9, which led to the development of underground mining operations in the area. In the late 1980s the The WKy 9 was approximately 60 inches of coal and was located approximately 150ft below the surface, at the Island Creek Coal Company surface mine, southwest of Providence, KY.

The typical methods of underground mining are:

- **Room and pillar mining**: a method of mining where mine entries (rooms) are excavated through the coal seam. The unmined coal (coal pillars) remain in place to support the roof. Large areas, or "rooms," of coal were mined with columns, or "pillars," of coal left in place as roof support;

- **Retreat mining**: a method of mining in which the pillars used to support the roof are removed. The mine roof collapses as the mining progresses towards the entrance. This allows for generally 80 to 90 percent recovery of the coal seam; and
- **Longwall mining**: a method of mining where "panels" (rectangular blocks of coal as wide as the mining machinery and as long as 10,000 or more feet) are extracted. As a longwall miner advances and removes all of the coal along a panel, the roof behind the miner's path is allowed to collapse.

Room and pillar mining was the primary mining conducted in this area of the Illinois Coal Basin in western Kentucky. The schematic in **Figure 1** shows multiple mining methods. Room and pillar mining is typical of many underground mining methods, such as Shaft mines, Slope mines, and Drift mines.

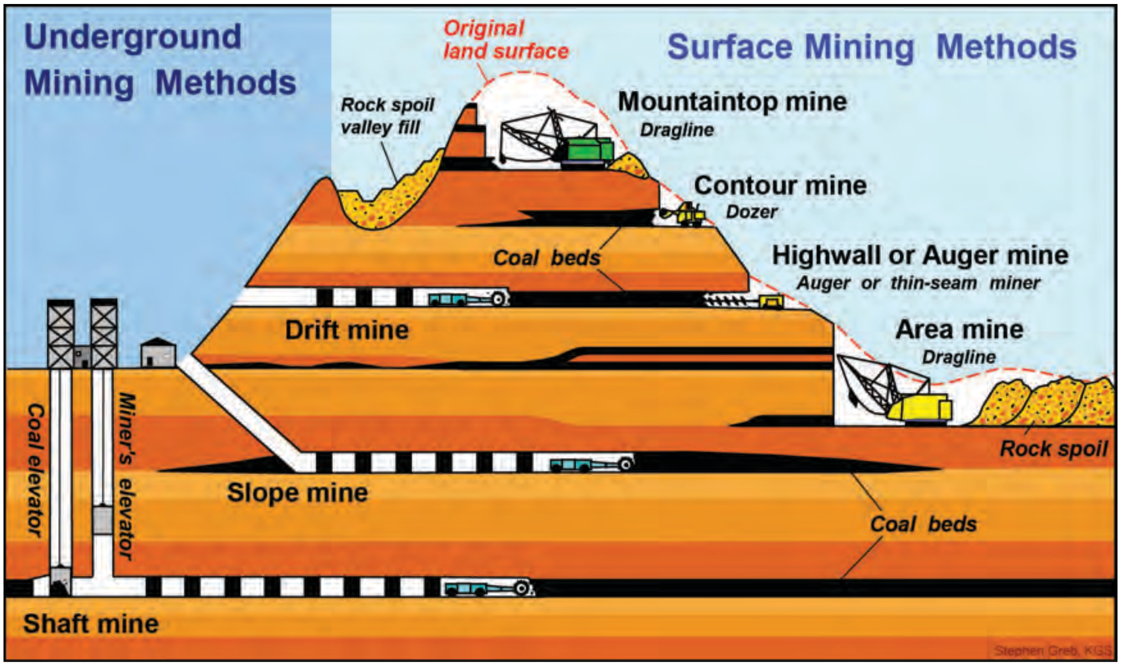

Figure 1: Underground and Surface Mining Methods (www.uky.edu)

Depending on the type of underground mining conducted, some coal may remain to structurally support the overlying geology and ground surface. However, depending on the amount of coal that was removed, the remaining coal can erode to the point of collapse. This loss of support is transferred to the ground surface that then drops (Illinois Mine Subsidence Insurance Fund 2017, **Figure 3**). This is referred to as subsidence.

Closed, sealed, or abandoned underground mines typically contain water that has infiltrated through the ground surface from precipitation. Some of this water can accumulate within the mine openings. Depending on the depth of the mine and dip of the rocks (angle that a rock surface makes with a horizontal plane), the mine can become fully flooded with water. Mines that are flooded are less prone to subsidence because the water provides some buyoancy to support the overlying rocks and ground surface.

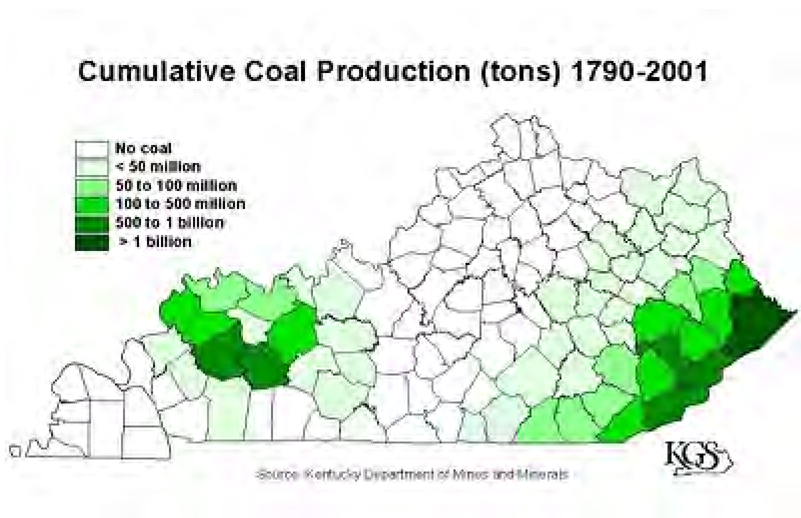

Figure 2: Approximate extent of Kentucky Coal Mining (www.uky.edu)

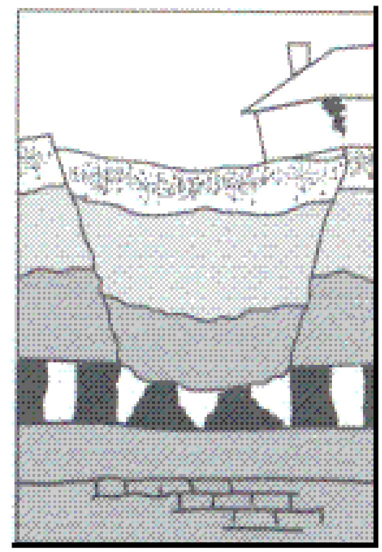

Figure 3: Schematic of Subsidence (Illinois Mine Subsidence Insurance Fund 2017)

3.0 TYPES OF SUBSIDENCE

The United States Geological Survey (USGS) reports that land subsidence is a wide-ranging problem with over 17,000 square miles having been directly affected by subsidence (USGS 2020). Land subsidence is most often caused by human activities, such as large groundwater withdraws (resulting in drainage of soils) and underground mining. The USGS (2020) reports that at least 80 percent of the documented subsidence across the country has occurred because of large groundwater withdraws. Another common cause of land subsidence and sinkholes is associated with karst geology (Weary 2015). Subsidence due to karst is caused by the dissolution of the bedrock. Weary (2015) reports that at least 18 percent of the ground surface within the United States has the potential to subside due to karst geology.

Mine subsidence occurs in one of two physical forms: a trough or a sinkhole. A trough is a shallow, often broad, dish-shaped depression that develops when the overburden sags downward into a mine opening in response to roof collapse, the crushing of mine pillars, or the punching (pushing) of pillars into the mine floor (Bruhn et al. 1977). There can also be areas of surface heave around the edges of the subsidence troughs. Trough subsidence typically occurs in areas of overburden (depth from ground surface to mined coal) that are more than 100 feet deep. The depth and extent of the trough are closely related to the dimensions and thickness of the extracted coal.

Figure 4: Typical cracking of walls/foundation due to Trough Subsidence (Duquesne Energy Initiative 2020)

Figure 5: Typical surface expression of Sinkhole Subsidence (IDNR 2020a)

A sinkhole is a depression in the ground surface that occurs due to localized collapse of the overburden directly into a mine opening (a room or entry). This is often called "chimney" type subsidence. Boundaries between the ground surface and the vertical walls of the sinkhole are often abrupt, and because sinkhole diameter generally increases with depth, the sinkhole profile may initially resemble an open bottle with the top at the ground surface. Erosion of soil at the sinkhole's periphery may increase the diameter near the ground surface to create an hourglass profile. Sinkhole subsidence typically occurs in areas of shallow overburden, primarily 100 feet or less (Bruhn et al. 1977).

To further elaborate on the risk of subsidence, specifically as it relates to subsidence over room and pillar mining, Tetra Tech has used the resource, "Subsidence Over Room and Pillar Mining". The following excerpt is from the text:

> *Under room and pillar mining if the extraction ratio is low, (i.e., < 50%) a pillar can support the overburden without collapse and there will be no surface subsidence whatsoever. In other words, if the pillar sizes are properly determined to support the overburden weight, the roof strata cannot cave and there will be no surface subsidence, provided the entry width is small and properly reinforced so that a continuous roof fall leading to piping or the total collapse of the roof does not occur. Under the prevailing mining conditions in the US if only development mining is employed in room and pillar mining (i.e., no pillar extraction), the extraction ratio is usually less than 50% and generally no surface subsidence will occur. If pillar mining is employed, surface subsidence may occur, depending on the extraction ratio and the size of the remnant pillars (or stumps) left in the gob.*

Tetra Tech investigated the publicly available records as well as the files provided by NextEra. The mine maps of the Dotiki Mine did not show any evidence of pillar extraction. Through our investigations, Tetra Tech has learned that pillar punching, or chimney subsidence, is not uncommon for this region.

4.0 MINE SUBSIDENCE CLASSIFICATIONS

In an analysis of underground mines, subsidence potential can be classified into the following three general categories:

Category 1 refers to areas where nearly full extraction of the coal seam occurred as a result of retreat mining or longwall mining, and there is very low probability of extensive future subsidence. The limits and extents of subsidence are relatively predictable where retreat or longwall mining are employed because subsidence normally occurs soon after mining, although future subsidence can occur at the edges of these areas due to failure of adjacent supporting pillars. Subsidence is unlikely to occur in areas classified as **Category 1** because subsidence probably occurred during or soon after mining.

Category 2 refers to areas where the mine configuration and pillars are adequately designed to provide permanent support to the ground surface. The amount of coal removed in these areas is generally low to moderate. These areas, although mined, generally remain stable over the long term and typically include main entries and haulage routes as well as low-extraction-ratio room and pillar areas of the mines where retreat mining did not occur. Subsidence is unlikely to occur in areas classified as **Category 2**.

Category 3 refers to areas underlain by room and pillar mines with a high percentage of coal removed and where retreat mining was not performed. In **Category 3** areas, it is uncertain whether subsidence already occurred, so subsidence may occur in the future. In these areas, entries were driven through the coal, and the pillar sizes were smaller than what would generally be required to provide permanent support. The pillars were designed with a low factor of safety (caused by the high extraction ratio), and there would be an elevated risk of pillar, roof, or floor failure. If subsidence already occurred, the possibility of future subsidence is very unlikely. However, if subsidence has not previously occurred, the possibility of future subsidence remains high. Of the three categories, **Category 3** would have the highest probability and risk for future subsidence.

For all subsidence categories, the extent of the potential area impacted by subsidence due to mine roof collapse can be defined using a specific angle from the coal seam to the ground surface where, if potential roof failure would occur, the surface would be impacted. The potential subsidence-affected area can be directly overhead but could also be offset a certain horizontal distance from the roof failure location. The angle, termed the “angle of draw,” can vary depending on the overburden rock type and depth to the mined seam. Indiana Department of Labor Bureau of Mines and Mine Safety accepts 30 degrees as the “angle of draw” for the coal seams in their region.

5.0 MINE DOCUMENT REVIEW

Tetra Tech reviewed publicly available sources and previous reports completed for NextEra. Tetra Tech reviewed the available sources for the depth to coal, coal seam thickness, coal pillar size, pillar configuration, and extraction ratio.

Some of the mining was done before the Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-97) was enacted, which set detailed permitting, mining and reclamation standards and regulations for all future coal mining activities. Despite this, Tetra Tech was able to gather some information on the location of the mining relative to the Project Area.

5.1 PUBLICLY AVAILABLE RESOURCES

Mine Map Information Request

The Kentucky Mine Mapping Information System was utilized for finding mine maps for the areas under the Project Area. The state requires any maps older than 2004 to be requested via email. The state file number was utilized to find maps associated with the known mining operations within the Project Area. The request from the state yielded 260 items in the first request. The second request also yielded hundreds of items, but this time imbedded in layers of folders, some of which were six layers deep. The maps and other files were reviewed for GPS coordinates, pillar sizes, evidence of pillaring, abandoned sections or mining areas, documented roof falls, indications of surface subsidence, and more.

The Kentucky Mine Mapping Information System provides a Mine Report associated with the state file number or permit number that is searched using the database. The Mine Report provides Kentucky Coal Production data, specifically the coal mined per year for each state file number. Additionally, any maps newer than 2004 are found in the Mine Report. The maps have a title and a purpose documented, as well as other items, that were used for identifying the maps and relevancy to this work effort.

The Surface Mining Information System was one publicly available resource used for finding information on the mine permit for each mining operation. The system was not very user friendly and proved to be unreliable for obtaining information.

To determine the maps available and confirm permit numbers and state file numbers, a search was conducted using the interactive, web-based map available to the public on the Kentucky Coal Mine Maps database. This is a resource for the Kentucky Mine Mapping Information System and is an ArcGIS supported web map. The online map allows the user to select a location and find the georeferenced maps available for that specific location. This resource provides county names, mine portals, available mine maps, mined out areas, and more. Within those layers, the map provides details such as map outline, permit number, mining company, and more.

The Kentucky Coal Resource Information website, supported by the Kentucky Office Energy Policy and the Kentucky Geological Survey was another resource used to confirm the maps available. This resource and the previous linked to the same online web map which is the Kentucky Coal Mine Maps database.

Mine Permits

The Kentucky Energy and Environment Cabinet utilizes the Department of Natural Resources File Management System for document management and public access for documents such as mine permits. The website is set up as a “doctree”, which utilizes a dropdown menu to select each section of the permit (or other document being reviewed).

Karst

To assess the presence of karst in the Project Area and the surrounding area, Tetra Tech reviewed the University of Kentucky’s Kentucky Geological Survey Sinkhole Mapping website. The site provides the public access to Download Sinkhole Data by County. The user can select the county and determine if there are mapped sinks in those counties. Neither Webster nor Hopkins Counties have recorded sinkhole data.

Exploration Drilling Data

For a review of the depth to coal and the strata present in the area under the Project Area, Tetra Tech used the Kentucky Geological Survey using the Earth Resources Seam Reports. The Seam Reports are available for each borehole drilled. The records are available in a downloadable format. For many of the boreholes, the coal seams are tagged with their names. Also available are oil, gas, and groundwater wells. These other three items were not reviewed with this scope of work.

Another resource from the Commonwealth of Kentucky is the Kentucky Geologic Map Service. This interactive web map shows the location of all boreholes available for review. This interactive map was used as a quick reference to assess the location of boreholes against the approximate Project Area.

Tetra Tech used the information available from the University of Kentucky database to review lithological data from boreholes drilled in proximity to the Project Area. The lithological information from the boreholes shows a small vertical section of the formations, including coal seams and other rock formations, below the surface. Tetra Tech selected four boreholes to evaluate depth to coal seam from the surface. The four boreholes were labeled the NEBO0257, NEBO0039, NEBO0253, and the NEBO0015. These boreholes are highlighted in yellow in **Figure 6**.

Figure 6: Borehole Locations (Google Earth)

The NEBO0257 borehole lithology denotes the WKy No 13 seam located 245.5 ft to 253.3 ft below the surface. The next recoverable seam was the WKy No 9 seam located 359.5 ft to 363.4 ft below the surface. In this instance, the borehole tagged an existing mine workings where the coal had been mined out previously. (location: 37.392792, -87.686851, drilled in 1984 by Consol with Island Creek Coal Co.)

The NEBO0039 borehole lithology denotes the WKy No 13 seam located 282.0 ft to 291.0 ft below the surface. The next recoverable seam was the WKy No 9 seam located 391.0 ft to 396.0 ft below the surface. (location: 37.391538, -87.670921, drilled in 1951 by Island Creek)

The NEBO0253 borehole lithology denotes the coal seams located at 319.7 ft to 326.6 ft below the surface. Although unlabeled, the coal seam is most likely the WKy No 13 coal seam due to the presence of two shale bands within the coal deposit, similar to what is recorded at the other two boreholes described above. (location: 37.421264, -87.700378, drilled in 1988 by J. Smith Coal)

The NEBO0015 borehole lithology denotes the WKy No 13 coal seam located at 529 ft to 536.5 ft below the surface. About 15 ft below the No 13 was the No 11 with a thickness of approximately 1 ft. The next recoverable seam was the WKy No 9 seam located 636.8 ft to 642.4 ft below the surface. (location: 37.431134, -87.687606, drilled in 1964 by Western Ky Coal with Island Creek)

Subsidence Complaints - General

Tetra Tech requested information through Kentucky's Open Records Request Form. The request provided 16 folders of information relating to subsidence. Specifically, the information provided included a report from the department defining subsidence that has occurred in western Kentucky and associated with the mine permit numbers associated with the underground mines which operated below the Project Area. The incidences of subsidence reviewed were initially identified by individuals and submitted through the Commonwealth of Kentucky Energy and Environment Cabinet Department of Natural Resources public complaint process. All the complaints reviewed by Tetra Tech had been received by Kentucky and were at least initially investigated. Many of the investigations were completed with copies of the final responses available. However, some were still under investigation and did not have the final response available. The subsidence investigations which had latitude and longitude provided are shown in **Appendix D**.

Subsidence Complaints – Investigation Summary Report

Most notably, the investigation into the Wade Williams C.R.I. No. 22-01-0006 was prepared in a 24-page report completed by Owen Michels, Environmental Scientist V, in the Complaints and Technical Investigations Section of the Division of Mine Reclamation and Enforcement. The report described that the individual Mr. Wade Williams had initially contacted the Madisonville Regional Office of the Kentucky Division of Mine Reclamation and Enforcement (DMRE) in March of 2022 to file a Citizen's Request for Inspection (C.R.I.) regarding subsidence occurring in his farm field. The site was inspected within 3 days and an investigation was initiated. The final report was prepared and released to the public on March 1, 2023.

The Williams report identified the coal beds mined under the subsidence area as the No. 9 and the No. 13 seams. The mining was conducted by Webster County Coal LLC under the permit number 917-5013. This permit number is the same as the permit number under the northwest section of the [Weirs Creek Solar] Project Area. The No. 9 seam was mined in 1973-1974 and is located 412 feet below the surface. The No. 13 seam was mined in 2014 and is located 312 feet below the surface.

As a note, the report, which is the most recent information available, states that the permit 917-5013 is in O2 status, which means there are coal reserves that remain within the permitted area and that the mining operations have temporarily ceased (Michels 2023).

The report further describes the subsidence, similar to the descriptions in section ***3.0 Types of Subsidence***. **Figure 7**, pulled directly from the Michels report and originally from the Kendorski report, has been included in this report due to the relevancy of the diagram.

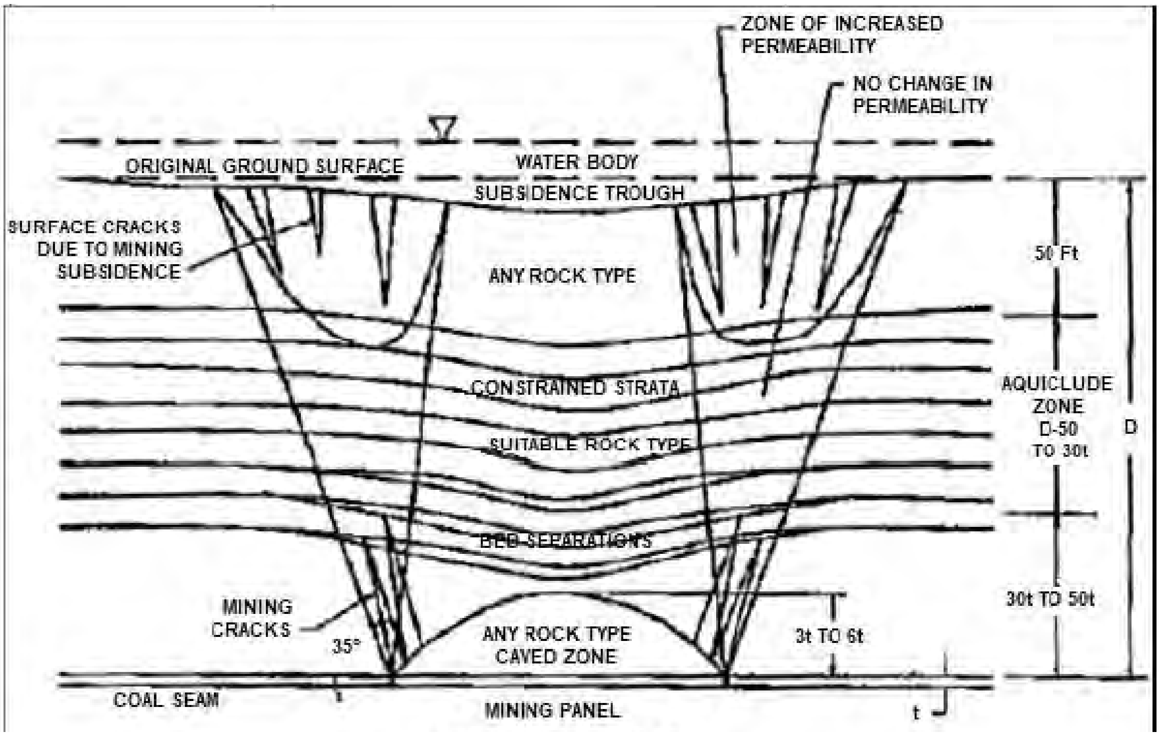

Figure 7: Subsidence Trough Description (Kendorski)

Comment on Investigation Summary Report

Common features associated with subsidence over underground coal mines, especially as seen in this area and reported by DMRE, is the saturation of the mine pillars and the presence of underclays in the floor of the coal mine. **Figure 8**, also pulled from the Michels report, is shown below. The subsidence can result in an impacted area with a small footprint, but substantial drop in subsided earth. This type of subsidence is shown in **Figure 8**. Or, the subsidence can result in a larger footprint with a smaller depth of impact, or a less dramatic drop due to the more gradual change over a larger area. This type of impact is shown in **Figure 9**.

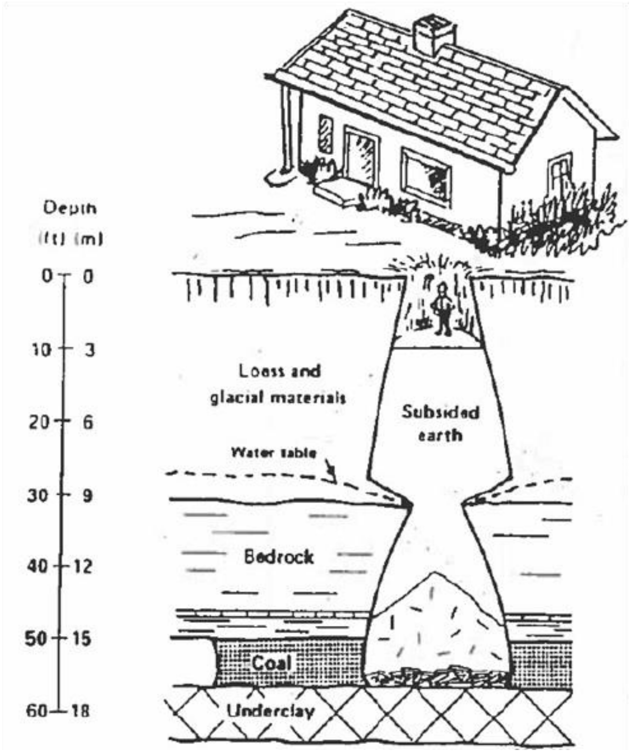

Figure 8: Simplified drawing of chimney subsidence (Michels)

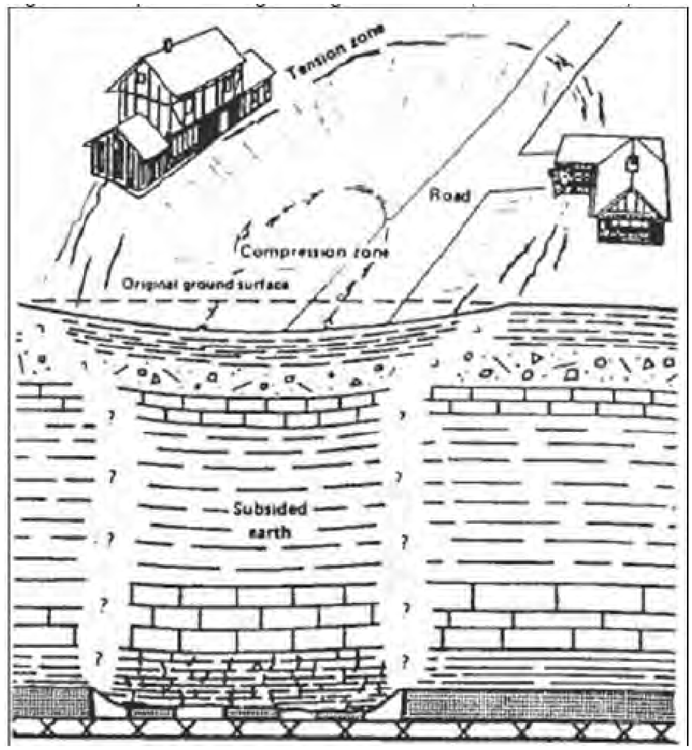

Figure 9: Simplified drawing of trough subsidence (Michels)

5.2 PREVIOUS REPORTS AND ASSESSMENTS

Tetra Tech reviewed the provided reports and assessments from NextEra. The most recent was the report prepared by Donald Lumm, titled *Coal Resources on NextEra Controlled Properties in the Vicinity of Weirs Creek, Hopkins County, Kentucky*. The report was dated April 10, 2023. The report includes detailed information and summaries of the lithological data and the coal mining activities completed in and around the Project Area.

Tetra Tech reviewed the Alliance Coal 2021 and 2022 Annual Reports. The 2021 report discusses the closure of the Dotiki mining complex, operated by the Alliance Coal subsidiary Webster County Coal, LLC. The annual report indicates that the Dotiki mining is an underground operation utilizing continuous miners and accessed by slope and shaft. The 2021 Annual Report states that the Dotiki mine closure was due to a “significant cost control initiative” which “included the closure of higher cost per ton production”.

According to the 2021 Annual Report, there remains 76 million tons of resources (27.6 m tons owned and 48.4 m tons leased), including both measured and indicated resources. The coal reserves are located in the Illinois Basin. (Alliance) Tetra Tech reviewed the status of the mine as defined in the Kentucky SMIS database and found that the mine status for permit number 9175013 is “Active Temporary Cessation”.

Tetra Tech reviewed the “Providence Solar geotechnical review” PowerPoint presentation previously prepared by Barr Engineering and provided by NextEra. The Differential InSAR Review showed two zones of potential subsidence, north and east of the Project Area. (Barr)

Within the Barr Engineering PowerPoint summary, there is mention of two types and sizes of pillars. The Production Panel pillars are defined as having a bottom of coal (BOC) depth of 600 ft with an extraction ratio of 0.60. The Mains Development pillars are defined as having a BOC depth of 550 ft with an extraction ratio of 0.54. (Barr)

Tetra Tech reviewed the Environmental Critical Issues Analysis, Providence Solar Project complete in October 2021 by ECT. The CIA reported that there was no karst or limestone geology within the Project Area. There is no indication of potential for sinkholes related to native geology.

Tetra Tech reviewed the “KY, Providence 150MWac Solar” map provided by NextEra, and dated September 18, 2022. The map indicates the locations of Areas 1 thru 6, with Areas 1 thru 4 being the highest likelihood for utilization for solar arrays.

Tetra Tech reviewed the NextEra Exclusive Stage1 Providence Solar GR215265 report prepared by Terracon. The site ranges between 370 and 470 feet MSL. The report shows that the USGS indicates that the site is mapped in an evaporite basin, but Terracon does not anticipate karst to pose a risk to site development.

Subordination, Non-Disturbance and Attornment Agreements were also provided and included in this review.

6.0 PROJECT AREA SITE VISIT

Tetra Tech conducted one site visit to the Project Area on Tuesday, April 18, 2023. Bob Kudlawiec, P.E. and Steve Gardner, P.E. reviewed the site conditions, access, and interconnect location. The vicinity in and around the proposed project site were traversed by vehicle to observe general ground conditions and surface constructions. Active and inactive mine portal installations were observed.

The route of travel for the site visit was Highway 120 out of Providence to Donaldson Road. Then 1089 back to 41 and Schmetzer Crossing. Then along Greenwood Road to Shade Tree Road to Nebo-Dixon Road. The primary land use is agricultural with flat to gently rolling terrain and numerous country homes with patches of woodland. There are also a few small industrial sites in the vicinity such as welding or equipment rebuild shops.

The Project Area is predominately agricultural fields and rural residential properties. Restricted sites included the Dotiki Mine portal buildings and supply yard warehouse buildings. Remaining undeveloped natural habitat within the vicinity of the Project Area is primarily limited to the edge of agricultural fields, sparse woodlands, several ponds, roadway and field ditches, and some visible wetlands.

7.0 RESULTS

Tetra Tech reviewed the mine maps and delineated areas according to subsidence potential within the Project Area. Based on the maps reviewed, approximately 63.7 percent (1,016 acres) of the Project Area has been undermined by the No. 9 seam and 19.5 percent (310 acres) has been undermined by the No. 13 seam with an additional 11.2 percent (179 acres) that had been developed but was not mined. All mines used room and pillar extraction methods. None of the underground mines have documented retreat mining within the Project Area, however, some areas had higher extraction percentages and these areas have likely experienced subsidence and should not be of concern.

The mining that was conducted in the Wky No, 9 seam by Dotiki and Island Creek was fairly deep, at depths greater than 240 feet. Any potential subsidence that may occur in the future should be minimal in nature with little to no surface impact. The Wky No. 9 subsidence, if it was to occur, would extend only to 180 feet toward the surface and experience mining surface deformation. The primary cause for subsidence would be due to water accumulation in the mine and degradation of the mine floor, resulting in pillar punching and chimney subsidence on the surface. This subsidence would be localized and extremely difficult to predict.

Regarding the previous summary provided by Barr Engineering, Tetra Tech cross-checked the locations of the two zones against the updated Project Area, provided in April 2023. The areas identified on the Differential InSAR Review are not within the Project Area and have no impact on the Project.

Tetra Tech's conclusions after reviewing the ECT report on Environmental CIA and the Terracon report titled NextEra Exclusive Stage1 are that the native geology does not exhibit karst or limestone formations and any documented sinkholes or subsidence zones are most likely related to past mining activities.

7.1 WEST KENTUCKY #13

The West Kentucky #13 coal seam, also known as the Baker coal seam, was mined in the Project Area. The Dotiki Mine was operated by the Webster County Coal LLC from 2000 until 2019. The mine was closed, despite an additional lease existing through 2024. The closure was driven by the high cost per ton (Alliance). The Dotiki Mine is still shutdown and is currently abandoned. This was confirmed in a phone call by the Director of Kentucky Division of Mine Safety, Tim Fugate, on May 15, 2023. However, the status of the mine is officially, "Active Temporary Cessation" according to the publicly available information from the Kentucky's permitting database.

Mine Name	Dotiki	Dotiki
Company	Webster County Coal LLC	Webster County Coal LLC
Permit Number	9175013	9175023
Permit Expires	9/11/2024	4/30/2025
SFN	08987	08987
Mine Type	Underground	Underground
Seam Name	WKy No 13	WKy No 13
Seam Thickness	82 inches	82 inches
Quad	Nebo, Providence	Nebo
Mine Status	Active Temporary Cessation	Reclamation Only

7.2 WEST KENTUCKY #9

The West Kentucky No. 9 seam, also known as the Springfield coal bed was mined in the Project Area. Mining of this seam occurred from 1969 to 1991. (Dunn) The Webster County Coal Corporation and Island Creek Coal mined in this area.

The Island Creek Coal Company was purchased by Consol and then eventually closed with final abandonment maps submitted in 1991. This mine was originally developed as a surface coal operation and then transitioned to an underground coal operation as the mining advanced and continued to follow the coal seams as the deposit dipped to the northeast. Both the WKy 9 and WKy 13 were mined in this area.

Mine Name	Dotiki	Providence No. 1 Mine
Company	Webster County Coal Corporation	Island Creek Coal Company
Permit Number	7175000, 9175013	6545400
SFN	08987	08983
Mine Type	Underground	Underground
Seam Name	WKy No 9	WKy No 9, WKy No. 13
Seam Thickness	56 inches	56 inches
Quad	Nebo, Providence	Nebo, Providence
Mine Status	Permit Released	*Final Abandonment plan submitted in 1991*

7.3 WEST KENTUCKY #11

The West Kentucky No. 11 coal seam was mined to the southwest of the Project Area. It was not mined within the Project Area. It is generally considered too thin to be economically recovered.

8.0 POTENTIAL IMPACTS TO STRUCTURES

The potential impacts to structures from subsidence are generally classified as cosmetic, functional, or structural. Cosmetic damage refers to slight problems where only the physical appearance of the structure is affected, such as cracking in plaster or drywall. Functional damage refers to situations where the structure's use has been impacted, such as jammed doors or windows. A significant impact on structural integrity is classified as structural damage. This includes situations where entire foundations require replacement due to severe cracking of supporting walls and footings. Most of the potential impacts to structural integrity that result in structural damage have occurred in areas of low overburden, such as where the mine depth is less than 100 feet (Bruhn et al. 1977).

Within **Category 3** areas, it is estimated that the ground surface could exhibit a drop of 60 percent of the coal seam height mined. Therefore, a seam mining height of 4 to 9 feet within the Project Area could exhibit a surface depression of 2.4 to 5.4 feet. The surface extent of the depression depends on numerous factors such as the type of rock overlying the mine and how many coal pillars failed within the mine.

Some examples of structures that have experienced subsidence from abandoned mines in Kentucky include: The Dollar General in Providence, KY (Hughes 2022) and a Walmart (French 2022). Kentucky implemented a mitigation plan of grouting mine voids at these locations to minimize future movement and continue use of the structure.

As stated earlier, there are several causes of subsidence, both man-made and natural. Subsidence due to karst is similar in impacts to mining-induced subsidence. Both can cause sinkholes that occur abruptly or depressions that develop over time. Tetra Tech reviewed publicly available resources to determine if karsts were a potential concern for the area. According to the University of Kentucky's Kentucky Geological Survey Sinkhole Mapping website, there is no recorded sinkhole data for either Hopkins or Webster County.

9.0 MITIGATION RECOMMENDATIONS

Additional studies are not recommended for areas marked as **Category 2**.

The potential for subsidence within areas classified as **Category 3** within the 165 identified acres can be reduced by means of avoidance or mitigation. Additional studies can be conducted to further identify areas that have the potential for subsidence, but the potential for subsidence may still be inconclusive due to many variables. If there are specific structures of concern that would have a low tolerance for ground movement, exploration drilling could give an indication of the condition of the mine and the presence of voids or collapsed roof. If there is collapsed material, then subsidence has already occurred, and no other mitigation actions are needed. However, exploratory drilling is not an economical investigative tool over a large area.

However, there are mitigation options to build over areas classified as **Category 3**. Mitigation options include using these areas only for non-structural construction (such as roads, drainage, piping or overhead transmission) or using structural designs capable of withstanding the maximum estimated strains from the potential subsidence.

The allowable stress of Project components can be evaluated versus expected strain from subsidence. This would require coordination with Project engineering staff and also involve detailed modeling to further define the expected subsidence and maximum strain predicted to occur from subsidence. Detailed layouts of structures overlying mine workings would be needed for the modeling to be able to measure the size of each pillar under the structures. Alternate types of foundations can be designed to allow for some ground movement. If, however, a structural/foundation design cannot tolerate any ground movement (such as high-pressure pipelines or power generating turbines and if the construction of these facilities cannot be moved) filling the mine voids with a cement-based grout can mitigate the issue.

10.0 CONCLUSIONS

Tetra Tech reviewed the mine maps and delineated areas according to subsidence potential within the Project Area (**Appendix A, B**). Based on the available maps, it appears that coal pillars were left as support in the three mines. In planning for these mining operations, pillar sizing was designed to offer long-term ground support and little to no planned ground subsidence.

Based upon review of the available mine maps, it is Tetra Tech's opinion that subsidence is unlikely for areas marked as **Category 2** overlying the Dotiki No.13 seam mine, the Dotiki No. 9 seam mine and the Providence No. 1, No. 9 seam mine. There is the potential for future subsidence within areas classified as **Category 3** overlying the Dotiki No. 13 seam mine. However, there are mitigation options to build over areas classified as **Category 3**. Mitigation options include using these areas only for non-structural construction (such as roads, drainage, piping or overhead transmission) or using structural designs capable of withstanding the maximum estimated strains from the potential subsidence.

The mines listed are classic room and pillar mines without secondary retreat mining practices that are generally intended to prevent or minimize surface subsidence, however, there is limited higher extraction areas that more than likely have already subsided. There is still minimal risk of future surface subsidence over such mines, particularly after abandonment and the mines continue to flood, causing floor degradation and the potential of pillar punching leading to chimney subsidence on the surface.

It should be noted that subsidence reviews are not an exact science and professional judgement was used to assess the many variables that exist and is the subject to those limitations and information provided by third parties in preparation of this report.

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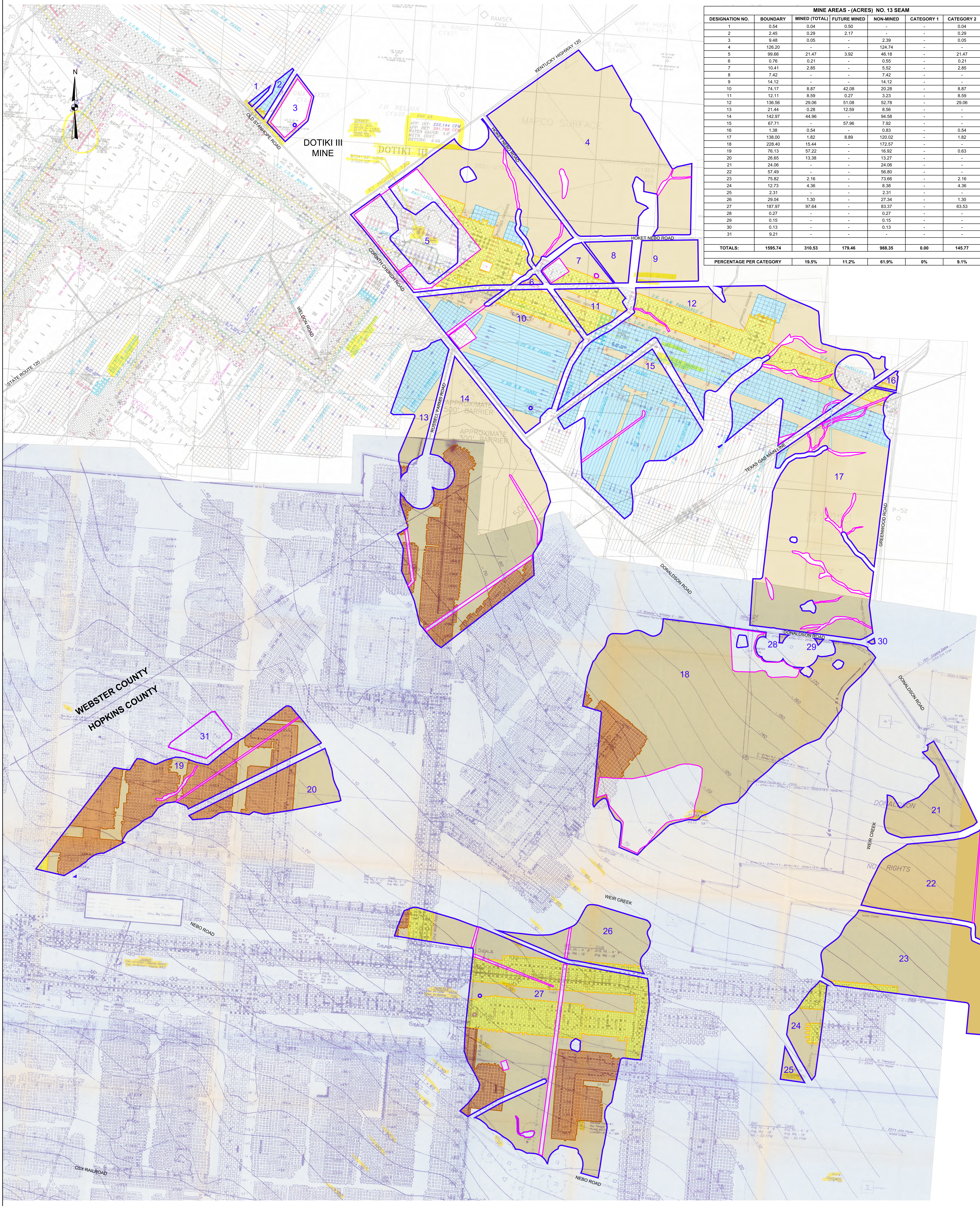

MINE AREAS - (ACRES) NO. 13 SEAM							
DESIGNATION NO.	BOUNDARY	MINED (TOTAL)	FUTURE MINED	NON-MINED	CATEGORY 1	CATEGORY 2	CATEGORY 3
1	0.54	0.04	0.50	-	-	0.04	-
2	2.45	0.29	2.17	-	-	0.29	-
3	9.48	0.05	-	2.39	-	0.05	-
4	126.20	-	-	124.74	-	-	-
5	99.66	21.47	3.92	46.18	-	21.47	-
6	0.76	0.21	-	0.55	-	0.21	-
7	10.41	2.85	-	5.52	-	2.85	-
8	7.42	-	-	7.42	-	-	-
9	14.12	-	-	14.12	-	-	-
10	74.17	8.87	42.08	20.28	-	8.87	-
11	12.11	8.59	0.27	3.23	-	8.59	-
12	136.56	29.06	51.08	52.78	-	29.06	-
13	21.44	0.28	12.59	8.56	-	-	0.28
14	142.97	44.96	-	94.58	-	-	44.96
15	67.71	-	57.96	7.92	-	-	-
16	1.38	0.54	-	0.83	-	0.54	-
17	138.00	1.82	8.89	120.02	-	1.82	-
18	228.40	15.44	-	172.57	-	-	15.44
19	76.13	57.22	-	16.92	-	0.63	56.59
20	26.65	13.38	-	13.27	-	-	13.38
21	24.06	-	-	24.06	-	-	-
22	57.49	-	-	56.80	-	-	-
23	75.82	2.16	-	73.66	-	2.16	-
24	12.73	4.36	-	8.38	-	4.36	-
25	2.31	-	-	2.31	-	-	-
26	29.04	1.30	-	27.34	-	1.30	-
27	187.97	97.64	-	83.37	-	63.53	34.11
28	0.27	-	-	0.27	-	-	-
29	0.15	-	-	0.15	-	-	-
30	0.13	-	-	0.13	-	-	-
31	9.21	-	-	-	-	-	-
TOTALS:	**1595.74**	**310.53**	**179.46**	**988.35**	**0.00**	**145.77**	**164.76**
PERCENTAGE PER CATEGORY		**19.5%**	**11.2%**	**61.9%**	**0%**	**9.1%**	**10.3%**

Legend	
OUTER BOUNDARY AREA	
EXCLUSION AREA	
CATEGORY 1 (LONGWALL OR RETREAT) SUBSIDED AREA	
CATEGORY 2 (MINED AREA ≥ 50% EXTRACTION) SUBSIDENCE UNLIKELY TO OCCUR	
CATEGORY 3 (MINED AREA - 75% EXTRACTION) SUBSIDENCE IS POSSIBLE	
FUTURE MINED AREA (PROJECTED MINING)	
NON-MINED AREA	

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NEXTERA

DOTIKI MINE III, NO. 13 SEAM

MINED AREAS

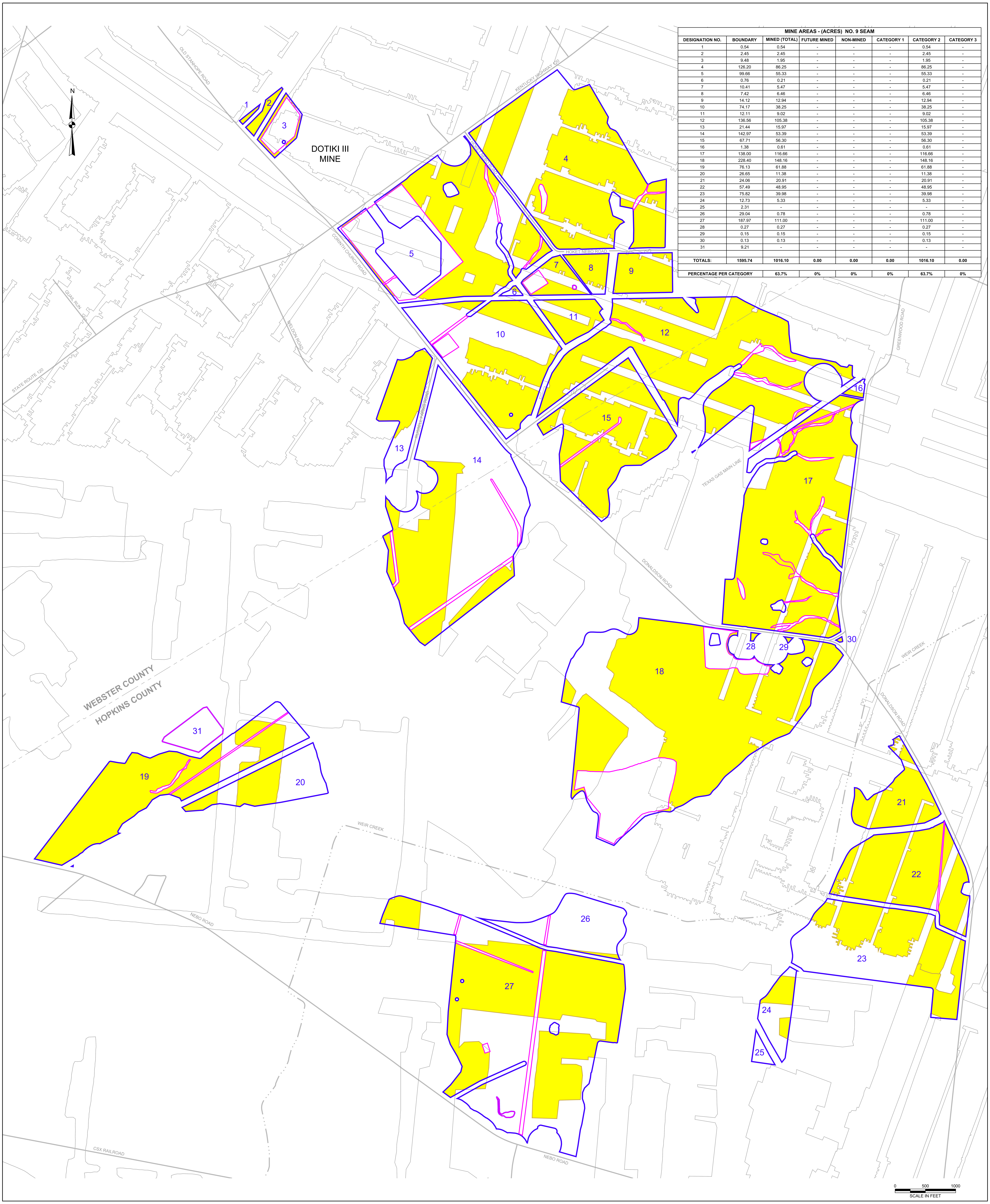
WEBSTER AND HOPKINS COUNTY, KENTUCKY

DATE:	07/28/2023
PROJECT NO.:	212C-PB-02454
DESIGNED BY:	RPK
DRAWN BY:	JL
CHECKED BY:	AM

EXHIBIT 1

SHEET 1 OF 2

MINE AREAS - (ACRES) NO. 9 SEAM							
DESIGNATION NO.	BOUNDARY	MINED (TOTAL)	FUTURE MINED	NON-MINED	CATEGORY 1	CATEGORY 2	CATEGORY 3
1	0.54	0.54	-	-	-	0.54	-
2	2.45	2.45	-	-	-	2.45	-
3	9.48	1.95	-	-	-	1.95	-
4	126.20	86.25	-	-	-	86.25	-
5	99.66	55.33	-	-	-	55.33	-
6	0.76	0.21	-	-	-	0.21	-
7	10.41	5.47	-	-	-	5.47	-
8	7.42	6.46	-	-	-	6.46	-
9	14.12	12.94	-	-	-	12.94	-
10	74.17	38.25	-	-	-	38.25	-
11	12.11	9.02	-	-	-	9.02	-
12	136.56	105.38	-	-	-	105.38	-
13	21.44	15.97	-	-	-	15.97	-
14	142.97	53.39	-	-	-	53.39	-
15	67.71	56.30	-	-	-	56.30	-
16	1.38	0.61	-	-	-	0.61	-
17	138.00	116.66	-	-	-	116.66	-
18	228.40	148.16	-	-	-	148.16	-
19	76.13	61.88	-	-	-	61.88	-
20	26.65	11.38	-	-	-	11.38	-
21	24.06	20.91	-	-	-	20.91	-
22	57.49	48.95	-	-	-	48.95	-
23	75.82	39.98	-	-	-	39.98	-
24	12.73	5.33	-	-	-	5.33	-
25	2.31	-	-	-	-	-	-
26	29.04	0.78	-	-	-	0.78	-
27	187.97	111.00	-	-	-	111.00	-
28	0.27	0.27	-	-	-	0.27	-
29	0.15	0.15	-	-	-	0.15	-
30	0.13	0.13	-	-	-	0.13	-
31	9.21	-	-	-	-	-	-
TOTALS:	**1595.74**	**1016.10**	**0.00**	**0.00**	**0.00**	**1016.10**	**0.00**
PERCENTAGE PER CATEGORY		**63.7%**	**0%**	**0%**	**0%**	**63.7%**	**0%**



OUTER BOUNDARY AREA

EXCLUSION AREA

CATEGORY 2 (NO. 9 SEAM)
(MINED AREA > 50% EXTRACTION)
SUBSIDENCE UNLIKELY TO OCCUR

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NEXTERA

DOTIKI MINE III, NO. 9 SEAM

MINED AREAS

WEBSTER AND HOPKINS COUNTY, KENTUCKY

DATE:	07/28/2023
PROJECT NO.:	212C-PB-02454
DESIGNED BY:	RPK
DRAWN BY:	JL
CHECKED BY:	AM

EXHIBIT 2

SHEET 2 OF 2

NEBO 257 ST KY 1/24000
CO.NO.P-171
ELEV 387.00 ELEV BY UNKNOWN
SCALE 1: 10.00 TYPE

INTRVL MLS WK9 BY YEAR 84
ENGLISH
DDH:2(AIRSHAFT)

SURFACE	001	9.74 F
BROWN SANDSTONE	540	3.90 F
GRAY SANDSTONE	540	27.85 F
GRAY SHALE	124	0.49 F
GRAY LIMESTONE	900	6.01 F
GRAY SANDY SHALE	324	14.37 F
COAL	020	0.32 F
GRAY SANDY SHALE	324	25.01 F
GRAY SANDSTONE	540	0.49 F
GRAY SANDY SHALE	324	3.41 F
COAL W/SH STKS	028	0.97 F
GRAY SANDY SHALE	324	14.62 F
SHALE	104	0.00 F
GRAY SANDY SHALE	324	58.46 F
SS W/SH STKS	503	18.51 F
LIME SS	510	3.90 F
LIMESTONE	900	0.97 F
LIME SHALE	204	1.95 F
SANDY SHALE	304	27.28 F
SHALE	104	9.74 F
SANDY SHALE	304	15.59 F
SHALE	104	1.95 F
COAL	020	1.95 F
GRAY SHALE	124	0.97 F
COAL	020	4.87 F
FIRECLAY	107	0.97 F
LIME SHALE	204	13.64 F
GRAY LIMESTONE	900	4.87 F
LIME SHALE	204	0.97 F
LIME SHALE	204	8.77 F
COAL	020	282.57 F
SANDY SHALE	304	292.31 F
SHALE	104	9.74 F
SANDY SHALE	304	1.95 F
GRAY SANDSTONE	540	22.41 F
SANDY SHALE	304	22.41 F
SHALE	104	8.77 F
BLACK SLATE	114	1.95 F
OPEN MINE	005	3.90 F

MINE

NEBO 39 ST KY 1/24000
CO.NO.P-12
ELEV 378.00 ELEV BY TOPO
SCALE 1: 10.00 TYPE

INTRVL MLS WK9 BY YEAR 51
ENGLISH
DDH:P-12

NEBO 253 ST KY 1/24000
CO.NO.02-A5-18-88
ELEV 0.00 ELEV BY UNKNOWN
SCALE 1: 10.00 TYPE

INTRVL UNK UNK BY YEAR 88
ENGLISH
DDH:02-A5-18-88

NEBO 15 ST KY 1/24000
CO.NO.P-34
ELEV 435.00 ELEV BY OTHER
SCALE 1: 10.00 TYPE

INTRVL CTG WK9 BY RITCHI YEAR 64
ENGLISH
DDH:P-34

001 9.00 F
324 25.42 F
904 6.83 F
124 0.67 F
324 4.00 F
324 10.50 F
124 6.50 F
020 0.75 F
127 2.67 F
124 11.17 F
543 6.83 F
324 37.17 F
324 4.00 F
124 14.83 F
129 14.75 F
020 0.25 F
127 2.83 F
324 68.83 F
124 4.33 F
124 30.08 F
124 1.00 F
124 0.92 F
020 0.42 F
124 4.83 F
324 0.50 F
124 3.92 F
324 3.08 F
124 4.75 F
324 1.42 F
124 20.58 F
904 4.42 F
124 4.50 F
020 0.17 F
124 1.58 F
904 0.83 F
127 9.92 F
904 0.58 F
324 4.83 F
154 3.67 F
904 4.58 F
334 18.42 F
324 4.50 F
334 10.08 F
324 5.83 F
334 16.50 F
324 71.67 F
124 36.58 F
124 6.33 F
544 6.08 F
124 7.33 F
324 6.17 F
124 1.42 F
124 0.25 F
020 0.62 F
W13 B W13 8
124 0.04 F
020 1.17 F
W13 8
124 0.73 F
020 4.54 F
W13 2
124 0.10 F
020 0.23 F
W13 B W13 2
127 0.21 F
904 15.35 F
020 0.96 F
W11 B
029 0.08 F
124 0.21 F
020 0.42 F
W11 B
124 5.00 F
904 3.42 F
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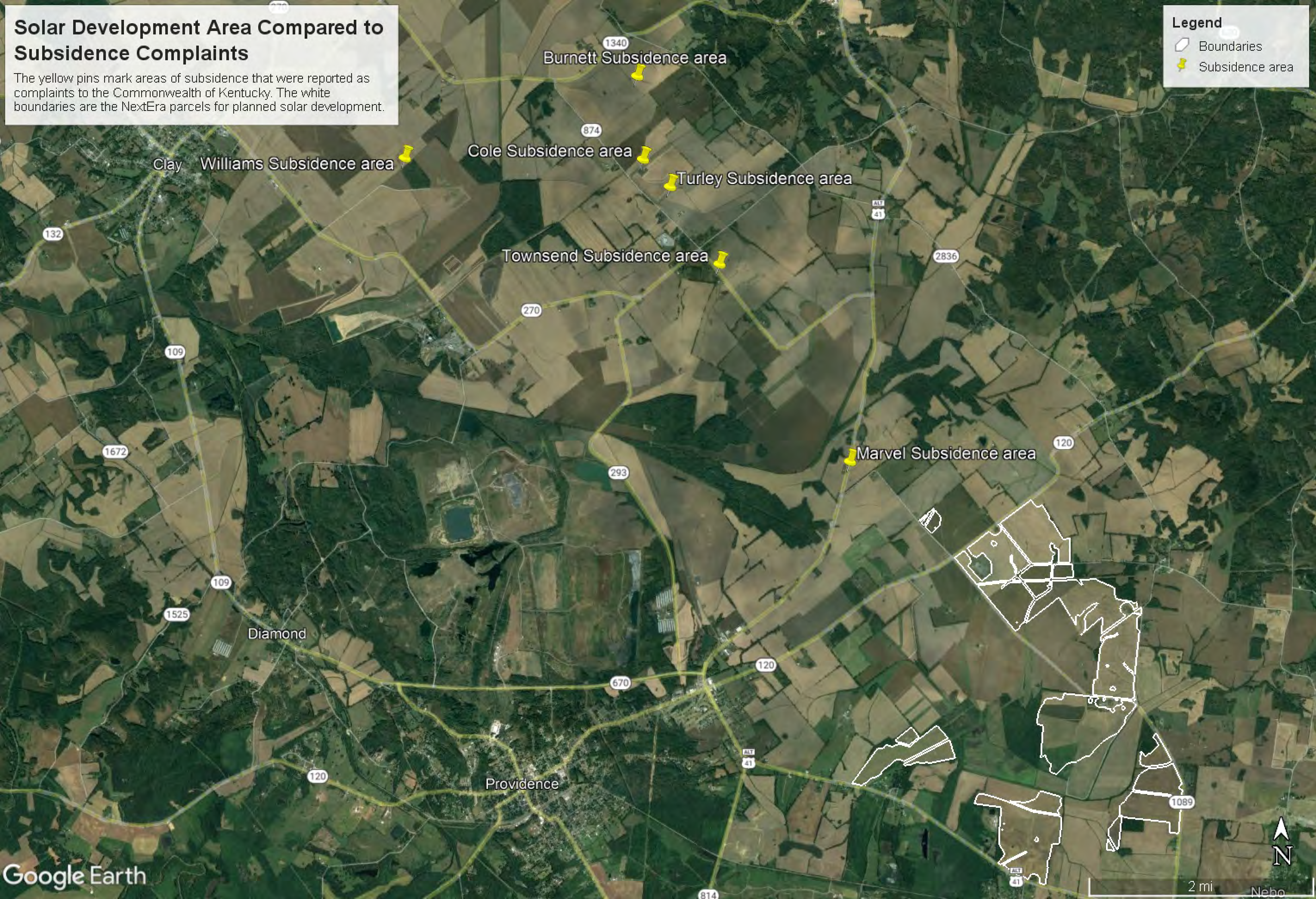
020 5.60 F
WK9 B
124 4.56 F



Solar Development Area Compared to Subsidence Complaints

The yellow pins mark areas of subsidence that were reported as complaints to the Commonwealth of Kentucky. The white boundaries are the NextEra parcels for planned solar development.

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WADE WILLIAMS REPORT
C.R.I. No. 22-01-0006, WEBSTER COUNTY
WEBSTER COUNTY COAL LLC, PERMIT NO.917-5013
OWEN MICHELS, ENVIRONMENTAL SCIENTIST V
MARCH 1, 2023

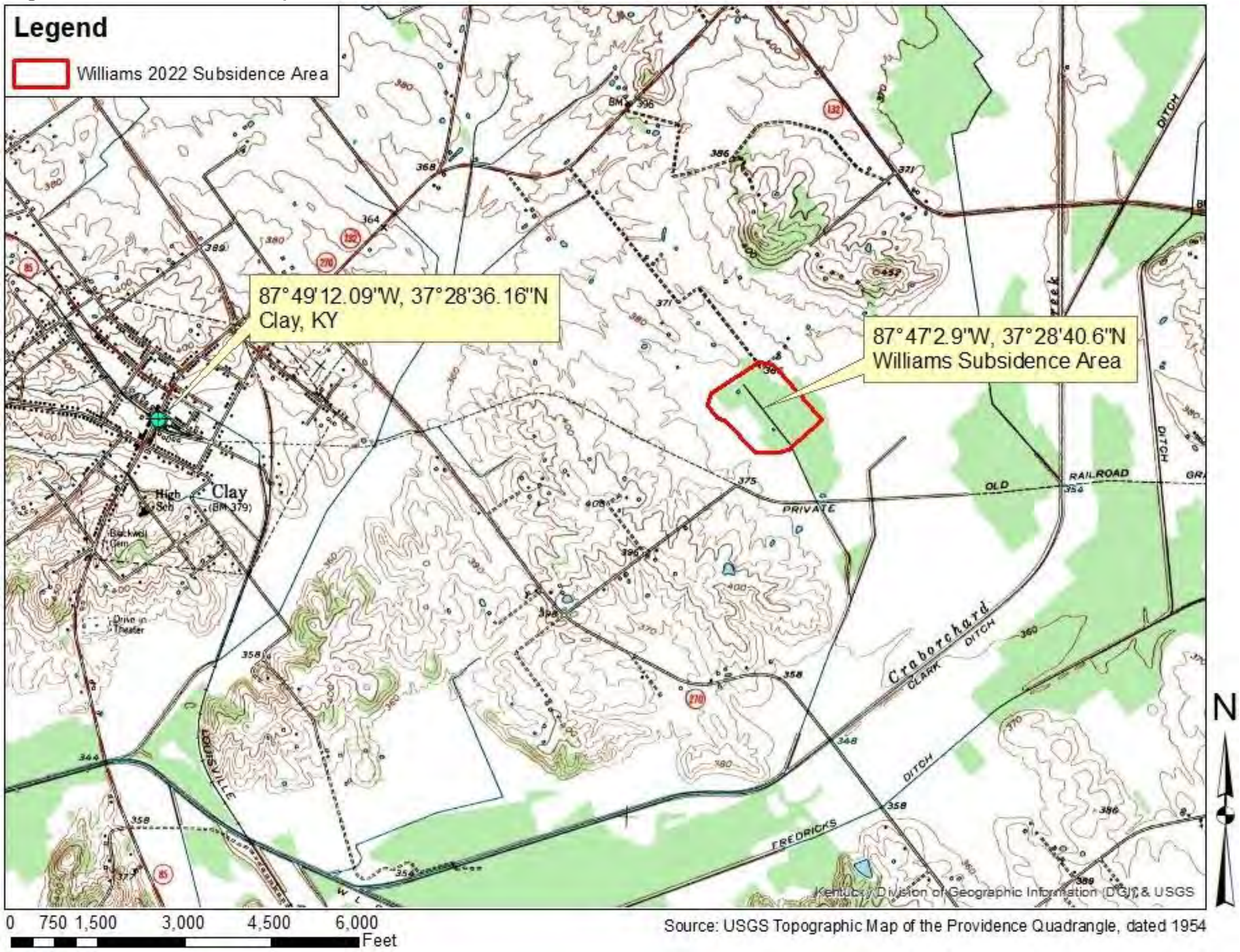
This report was prepared by Owen Michels, Environmental Scientist V, in the Complaints and Technical Investigations Section of the Division of Mine Reclamation and Enforcement. Mr. Michels graduated from the University of Kentucky with a B.S. in forestry and from Auburn University with an M.S. in forestry. Mr. Michels began working for the Commonwealth of Kentucky, Department for Natural Resources, in December of 2008. His initial position was with the Division of Mine Reclamation and Enforcement as a mine inspector out of the Middlesboro Regional office, where he performed inspections of mine sites to ensure compliance with all state and federal environmental regulations. In 2017, Mr. Michels joined the Division of Mine Permits, performing regulatory reviews of coal mining permit applications. Mr. Michels then began working for the Complaints and Technical Investigations Section of the Division of Mine Reclamation and Enforcement in 2019, where his primary duties have been investigations of surface and groundwater issues related to mining, including background monitoring, possible impact to water wells, landslides, acid mine drainage and discharges from underground mines.

Background:

On March 28, 2022, Mr. Wade Williams contacted the Madisonville Regional Office of the Kentucky Division of Mine Reclamation and Enforcement (DMRE) to file a Citizen's Request for Inspection (C.R.I.). Mr. Williams stated that he was concerned that there was subsidence occurring in his farm field. Preliminary information regarding this C.R.I was obtained by Inspector/Environmental Control Supervisor Leland Steely during a site visit on March 29, 2022. At the time of this site visit, Mr. Williams expressed his concern about a low area in the crop field that holds water and is causing crop damage. Due to the nature of the complaint, technical assistance was requested from the Regional Engineer on April 1, 2022. The C.R.I was later reassigned to Owen Michels with the DMRE Complaints and Technical Investigations Section in Frankfort.

The Williams property is located north of Carroll Sugg Road, near Clay, in Webster County (Figure 1).

Figure 1. Location Map



Investigation:

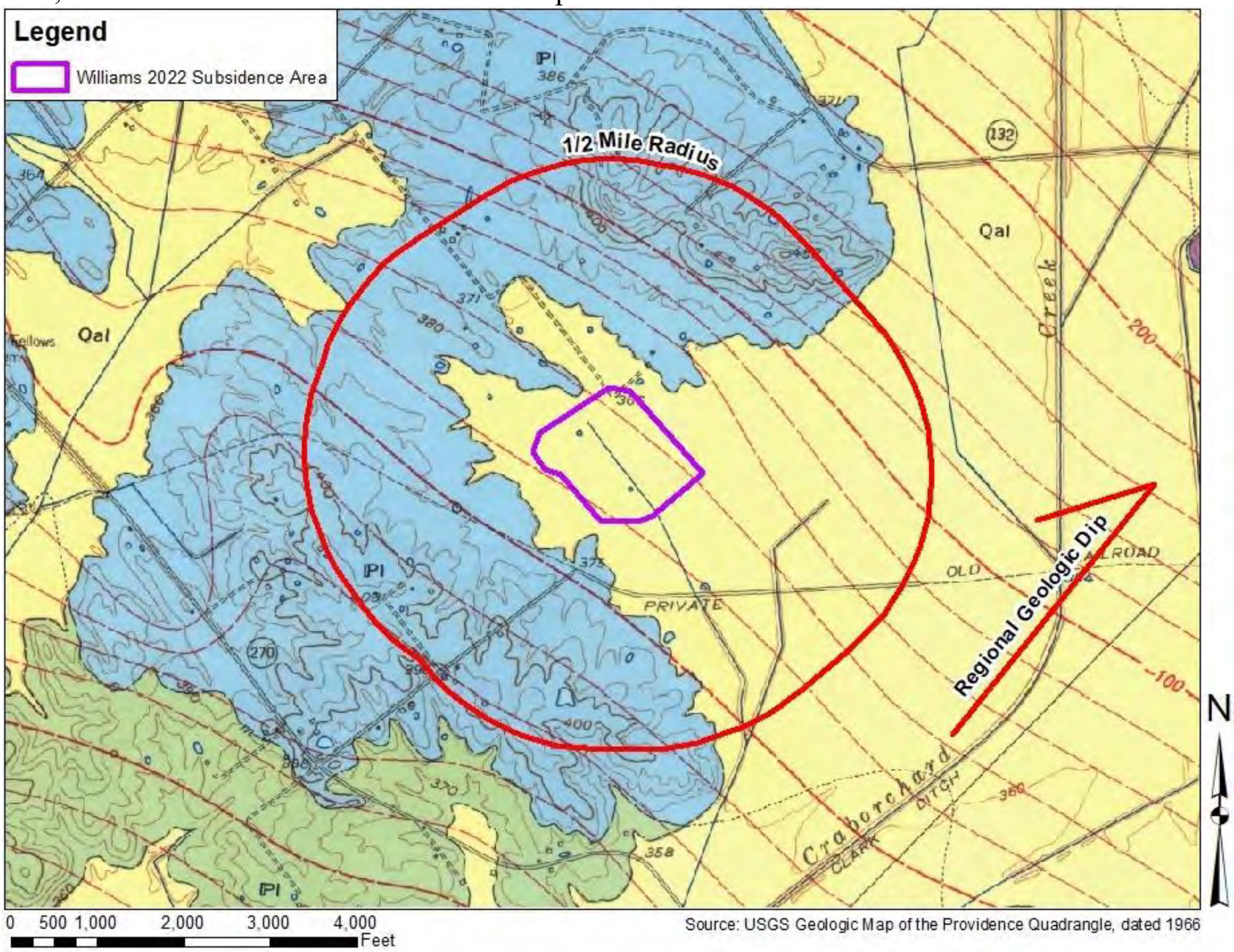
General Site Information

The Williams property is located in the Providence Quadrangle north of Carroll Sugg Road at approximately [redacted]. The regional geologic dip[1] is to the northeast (Figure 2). The Williams property is located within the Alluvium of the Quaternary period. As per LiDAR imagery[2], the Williams subsidence area is at approximately 362 feet above mean sea level (MSL).

---

[1] 'Geologic dip' refers to the angle at which the beds of rock in a given area are slanting from the horizontal.
[2] LiDAR is laser technology for obtaining accurate elevation and imagery data. Elevations are provided in feet above mean sea level (feet MSL).

Figure 2. Geologic Map. Note that the No. 9 and No. 13 coal seams are below drainage in this area, and are therefore not shown on the map.



The geologic map shown above was utilized in conjunction with LiDAR imagery and underground mine maps[3] to determine coal seam elevations near the Williams property. Table 1 lists the mapped[4] and unmapped coal seams, approximate elevations, and any documented mining present within the area of concern[5].

[3] Underground mine maps are obtained through Department for Natural Resources (DNR) ArcMap Geographic Information System (GIS) resources available to DMRE from the Kentucky Division of Mine Safety (DMS).

[4] 'Mapped coal seams' refers to coal seams identified by the United States Geological Survey *'Geologic Map of the Providence Quadrangle, Western Kentucky'* dated 1966.

[5] Due to the topography of the area surrounding the Williams property, the strata beneath the property is the most likely to influence the hydrology of the area of concern. However, any documented mining within a half mile radius was also reviewed when compiling the report.

Table 1. Coal beds and documented coal mining near the Williams property.

Coal bed	Elevation (feet MSL)	Documented coal mining	Relationship to the Williams Subsidence Area (362 feet MSL)
No. 9	-50’	Underground mined by Webster County Coal LLC., Permit No. 917-5013, SFN 08987, circa 1973-1974	412’ below the Williams property
No. 13	50’	Underground mined by Webster County Coal LLC., Permit No. 917-5023, SFN 08987, circa 2014	312’ below the Williams property

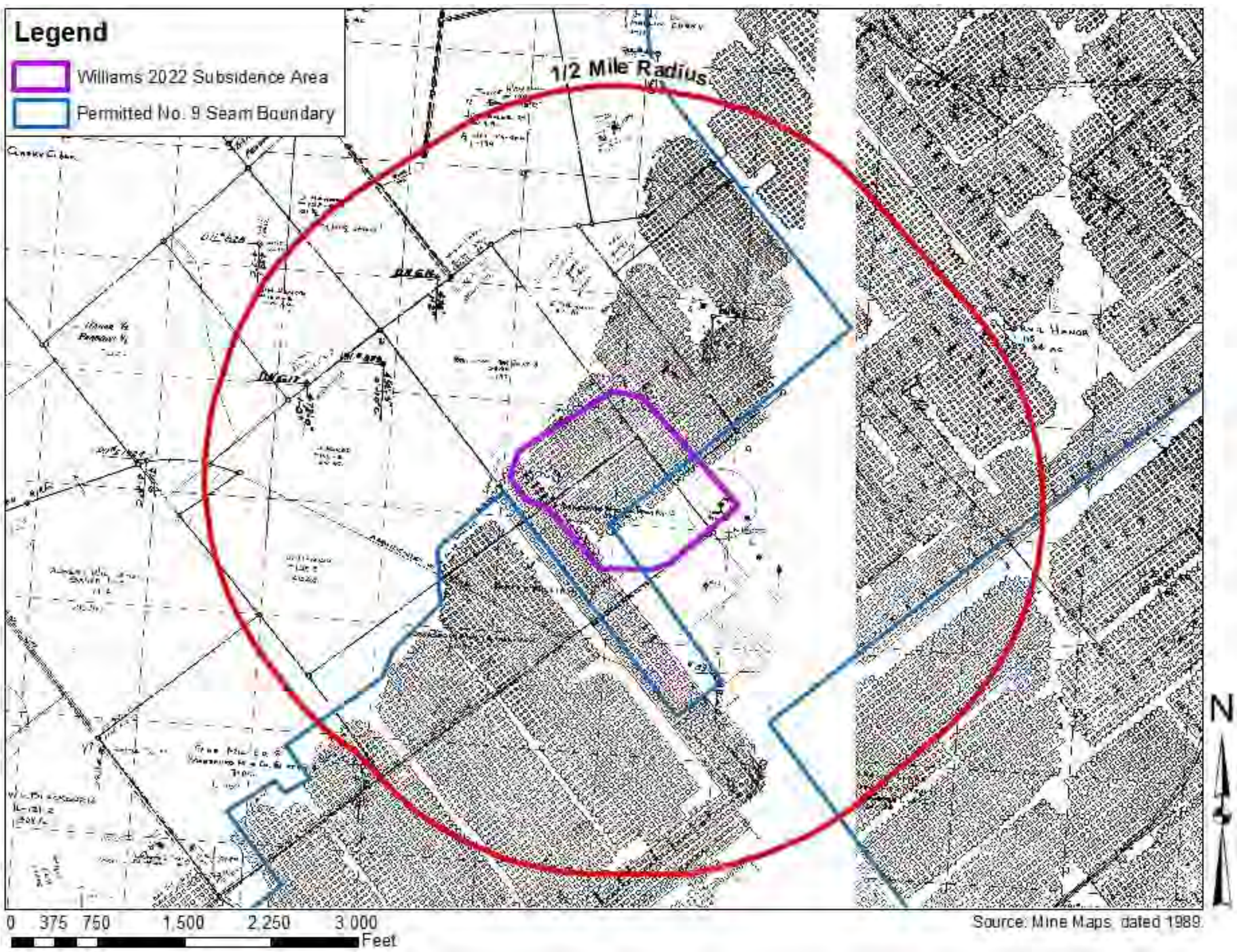
There are two coal seams within the area of concern, both containing documented mining. The No. 9 coal seam (also known locally as the WKY #9 seam) is located approximately 412 feet below the elevation of the Williams property. This seam contains underground mining permitted by Webster County Coal LLC, Permit No. 917-5013, and was conducted directly beneath the Williams property (Figure 3). The mining in this area took place from 1973 to 1974. See Table 2 for the transfer history of this permit. Note that the No. 9 seam mining in this area was conducted pre-law[6]. It was then added to Webster County Coal Corporation Permit No. 717-5000. A small part of the underground works in the No. 9 seam under the Williams subsidence area are still permitted under Webster County Coal LLC Permit No. 917-5013 (Figure 3). This permit is currently in O2 status[7], and remains under the jurisdiction of DMRE.

Table 2. Transfer history of Webster County Coal LLC, Permit No. 917-5013.

Permit Number	Company Name	Permit Dates
717-5000	Webster County Coal Corporation	9/11/1984 – 3/8/2000
917-5013	Webster County Coal LLC	3/8/2000 – Present

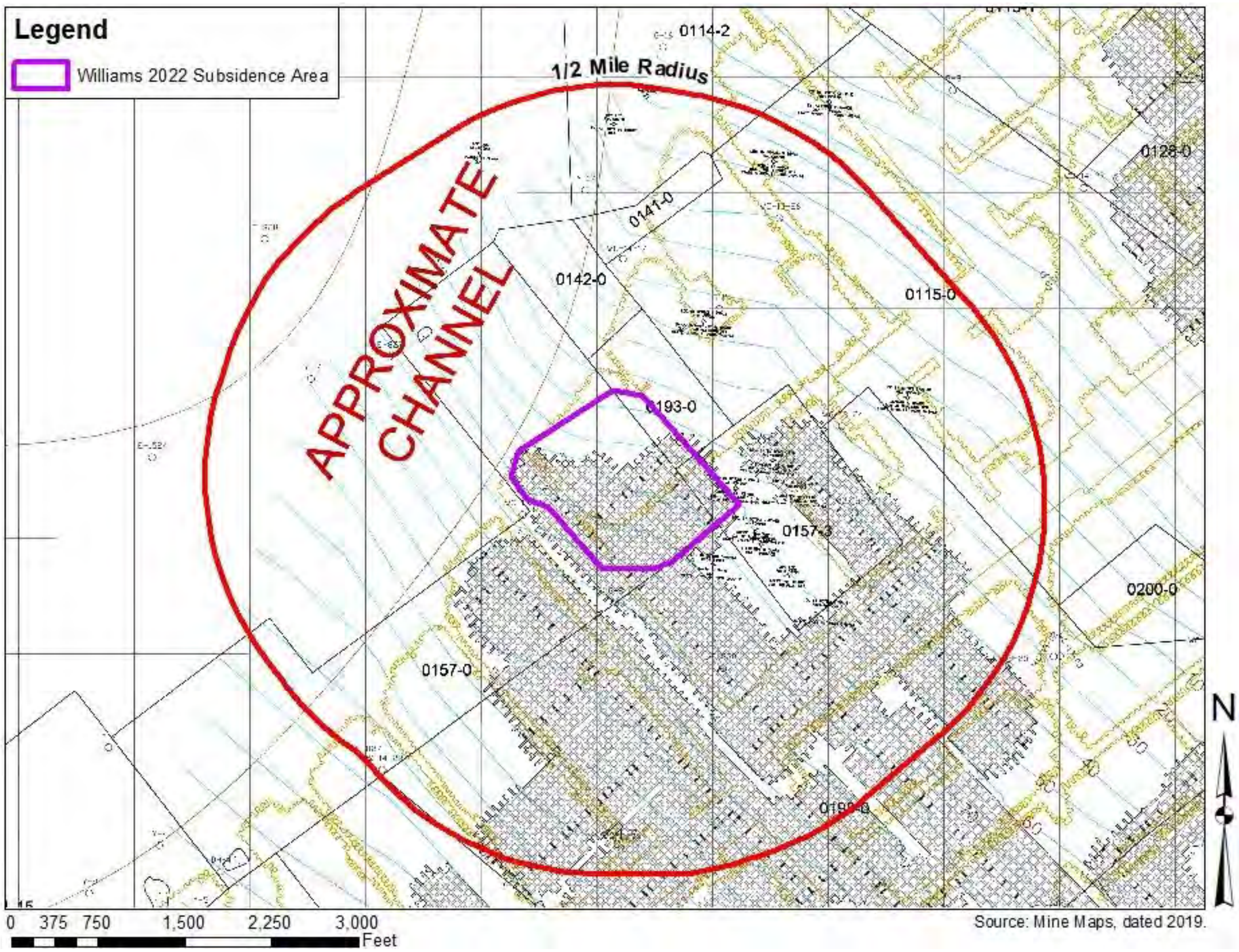
[6] Pre-law mining refers to coal mining conducted prior to the passage and implementation of the Surface Mining Control and Reclamation Act (SMCRA). SMCRA was signed into law on August 3, 1977, and was implemented in Kentucky on May 18, 1982.
[7] O2 status means that coal reserves remain within the permitted area, and that mining operations have temporarily ceased on the permit.

Figure 3. 1989 Mine Maps showing documented coal mining in the No. 9 seam within ½ mile radius of the Williams property, by Webster County Coal LLC, Permit No. 917-5013 from 1973-1974.



The No. 13 coal seam (also known locally as the WKY #13 seam) is located approximately 312 feet below the elevation of the Williams property. This seam contains underground mining permitted by Webster County Coal LLC, Permit No. 917-5023, and was conducted directly beneath the Williams property (Figure 4). The mining in this area took place in 2014. This permit is currently in A2 status[8], and remains under the jurisdiction of DMRE. This mining was also over permitted by Webster County Coal LLC, Permit No. 917-5013.

Figure 4. 2019 Mine Maps showing documented coal mining in the No. 13 seam within ½ mile radius of the Williams property, by Webster County Coal LLC, Permit Nos. 917-5023 and 917-5013.

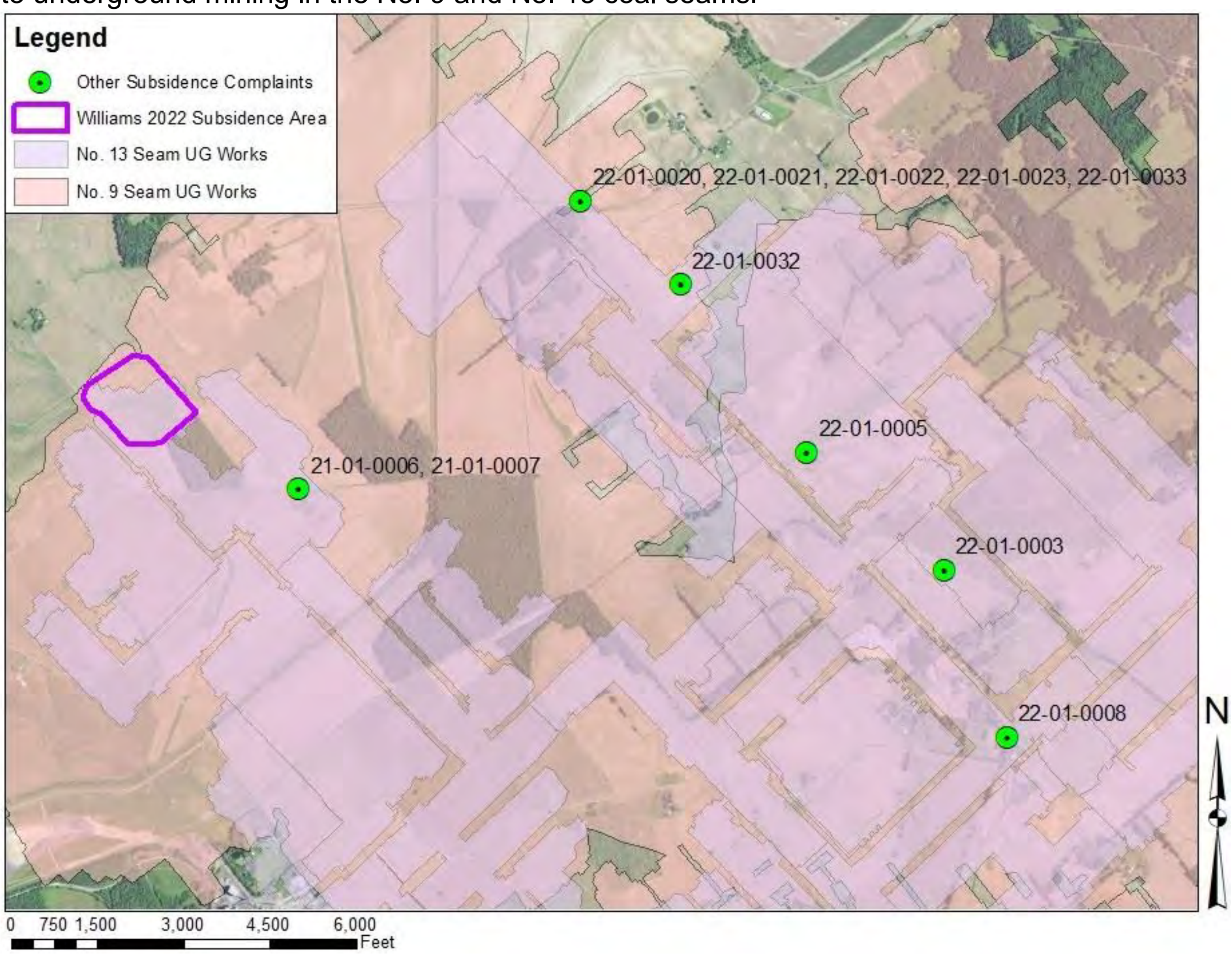


[8] A2 status means that coal removal is complete on the permit, and only reclamation activities may take place within the permitted area.

The area around the Williams property was searched for previous complaints or violations related to subsidence. Eleven other subsidence complaints have been filed relating to Webster County Coal LLC, Permit No. 917-5013 (Figure 5). All twelve complaints were filed within an approximately 18 month time span, and are located within less than three linear miles of each other. The five complaints located within the area of the northernmost point in Figure 5 have all been determined to contain subsidence caused by the underground mining associated with Webster County Coal LLC, Permit No. 917-5013. The other complaints are still under investigation, and no determination has been made.

One violation has been issued to Webster County Coal LLC, Permit No. 917-5013 for subsidence. Notice of Non-Compliance (NNC) 13-2539 was issued on October 18, 2022 for subsidence damage to State Highway 1340 near the northernmost subsidence complaints in Figure 5.

Figure 5. 2020 Aerial photograph showing other nearby subsidence complaints, and their relation to underground mining in the No. 9 and No. 13 coal seams.



June 20, 2022 site visit

A site visit was conducted by Environmental Scientist IV Steve Lewitt, Environmental Control Manager Randall Ousley, Environmental Scientist I Johnathan Stumpf, and Environmental Engineer II Terry Cates (hereafter referred to as DMRE staff), on June 20, 2022. Due to the recent dry weather in the area, no low lying wet areas were observed at the time of this site visit. The area investigated is shown in Figure 6.

DMRE staff obtained elevation data along transects through the area of concern. Elevation readings were obtained using an Arrow Gold RTK GNSS Receiver, which has survey grade accuracy down to 1 centimeter. A total of six transects were surveyed through the area of concern, and will be discussed later in this report. This concluded the June 20, 2022 site visit.

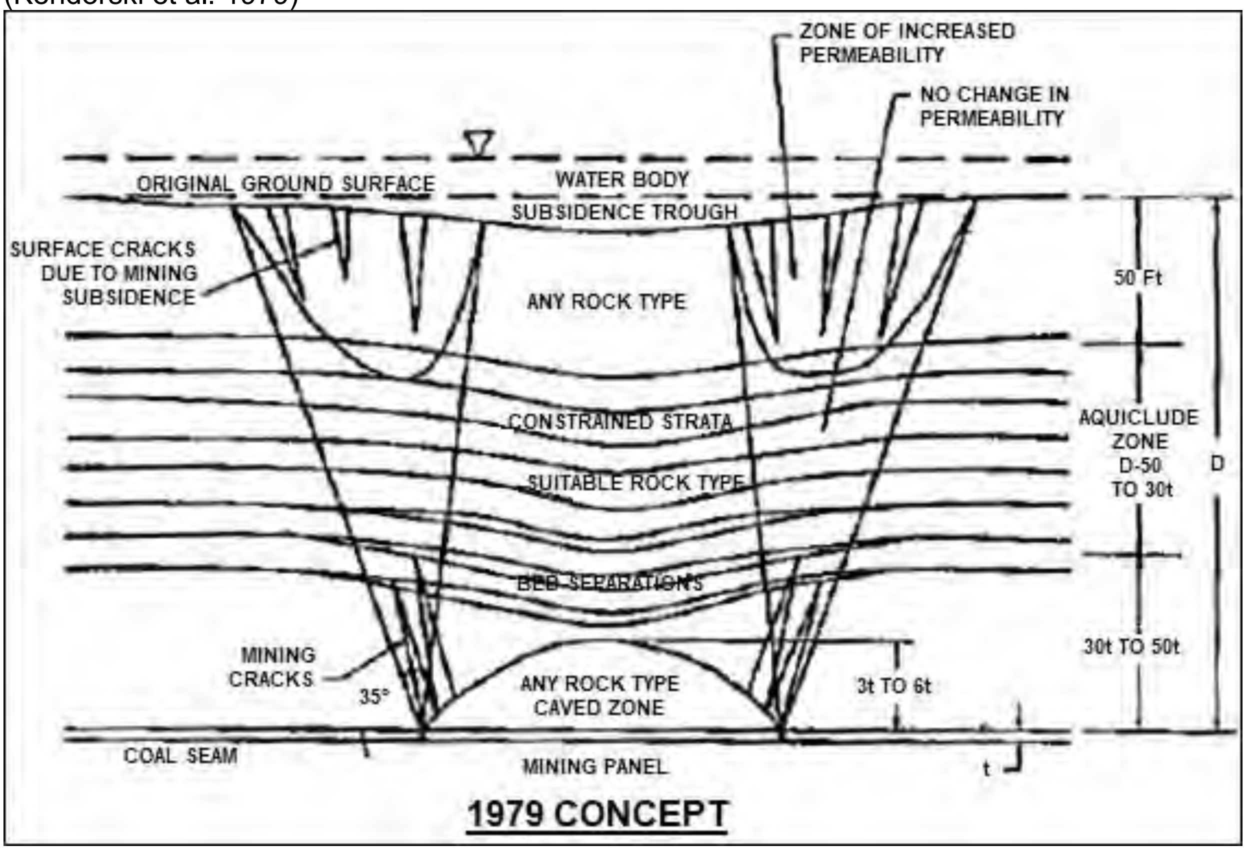
Figure 6. Site sketch of the Williams property investigated on June 20, 2022.

Discussion:

Subsidence

Mine subsidence occurs when the voids in an underground mine collapse and the overburden[9] material shifts—or readjusts—resulting in movement at the ground surface. This action is dependent on many factors, including the mining method utilized, the thickness of the coal seam, the depth of the overburden material, the physical properties of the overburden and floor material, and the topography of the area. Mine subsidence can occur concurrent with mining—or years later—dependent on these factors. Subsidence can affect the surface directly above the mined area, as well as areas extending beyond the vertical limits of the mined area, described as the 'angle of draw' (Lee and Abel 1983). The angle of draw is determined by the composition of the overburden and can be as much as 35° (Figure 7).

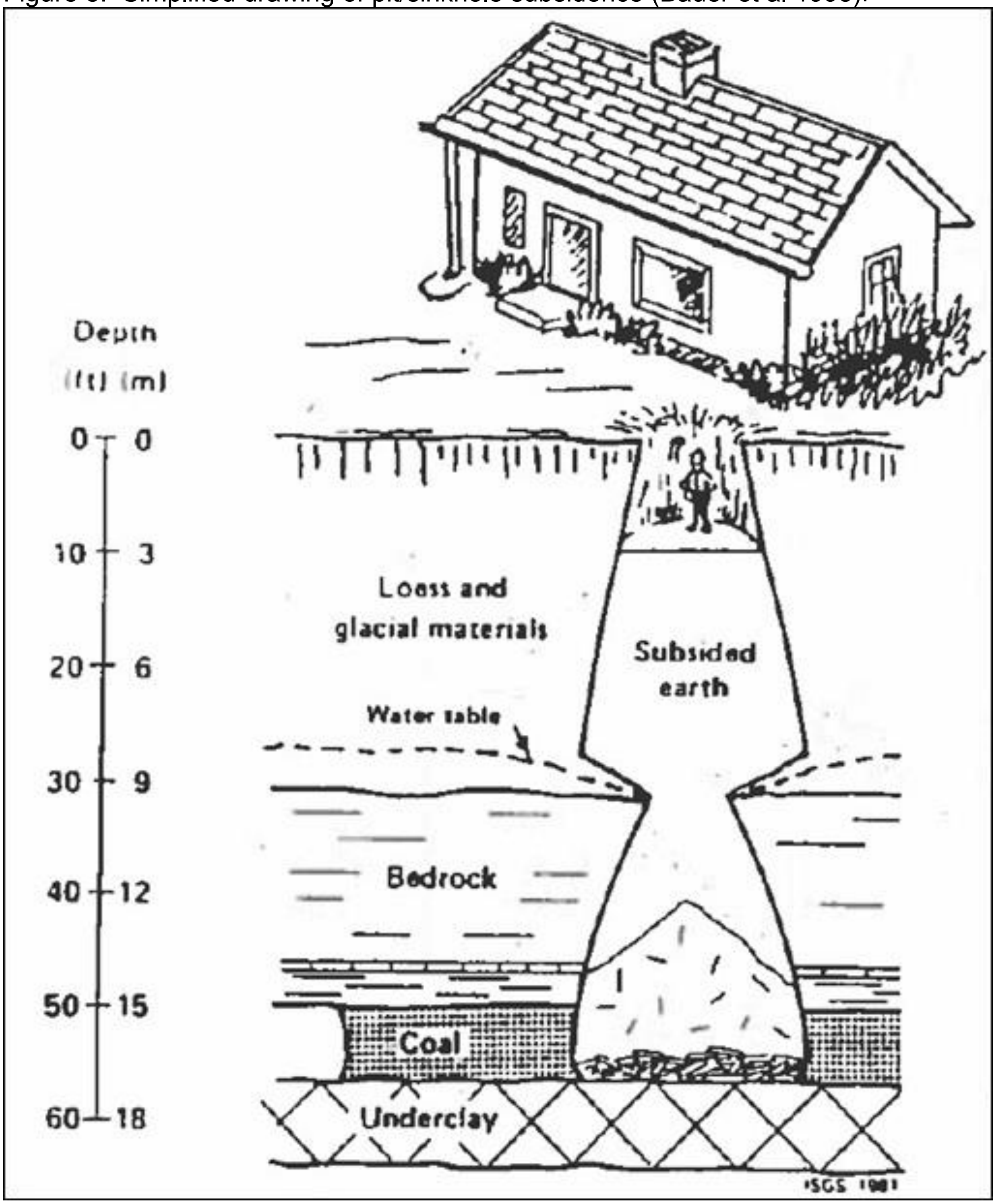
Figure 7: Diagram showing a generalized subsidence profile with the 35° angle of draw. (Kendorski et al. 1979)



[9] Overburden refers to the soil and/or rock material overlying a coal seam.

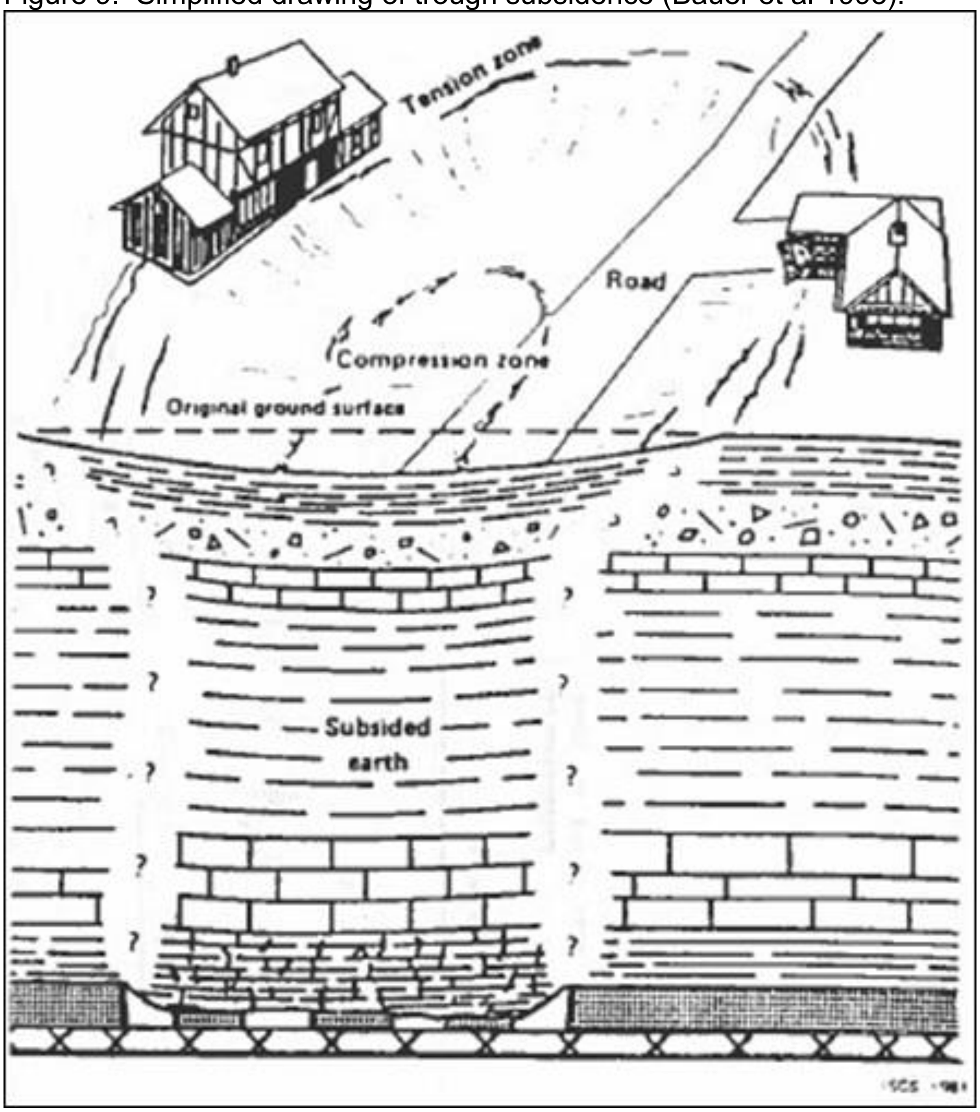
Generally there are two types of subsidence, sinkhole (pit) subsidence and trough (sag) subsidence (Kohli and Self). In sinkhole subsidence, the roof material over the entries fails and collapses into the void to approximately 2 times the entry width (Figure 8). For example, if a mine has an entry width of 20’, the roof failure could propagate up to 40’. If the thickness or strength of the overburden cannot support the gap caused by roof failure, a steep sided sinkhole may form. Most reports of sinkhole subsidence occur when the thickness of the overburden is less than 100 feet.

Figure 8: Simplified drawing of pit/sinkhole subsidence (Bauer et al 1993).



In trough subsidence, failure occurs within the mine which causes the entire overburden to sag and produce a trough on the surface (Figure 9). The two main ways in which the mine can fail are pillar failure and pillar punching. Pillar failure happens when the pillars are too small to support the overburden and get crushed from the pressure. This can happen instantaneously during retreat mining or over a long period of time as a result of the weathering of the coal pillars. Subsidence can also be caused by pillar punching into the fireclay (underclay) below the coal seam. The fireclay will generally have a lower compressive strength than the coal, especially if the mine gets flooded. The increased moisture content weakens the fireclay and the pillars sink or punch into the floor resulting in the sagging of the overburden which reaches the surface. Some features associated with trough subsidence are a general lowering of the surface, tension cracks in the tension zone, compression ridges in the compression zone and a tilted area in between the two. Structures which reside in these areas will exhibit damages such as cracks in concrete/masonry materials, cracks in sheet rock, bowing walls, buckling floors, and the entire structure being out of level.

Figure 9: Simplified drawing of trough subsidence (Bauer et al 1993).



Geologic Review of the Study Area

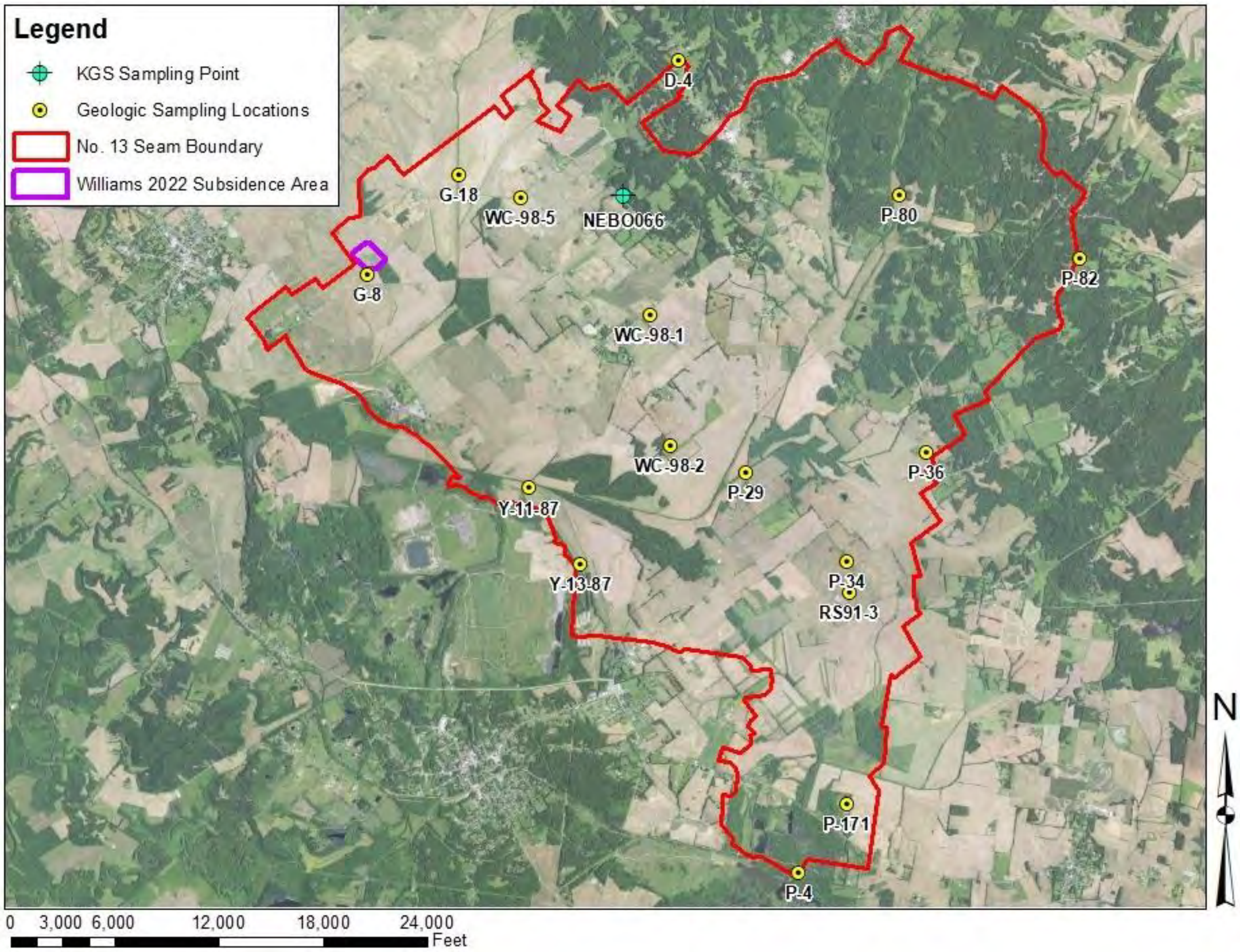
The No. 9 coal seam is located approximately 412 feet in elevation below the ground surface at the Williams property. This coal seam has been underground mined directly beneath the Williams property from 1973 to 1974. A small part of these mine works beneath the Williams property are currently permitted by Webster County Coal LLC, Permit No. 917-5013. The No. 13 coal seam is located approximately 100 feet above the No. 9 seam, and 312 feet in elevation below the ground surface at the Williams property. This coal seam has also been underground mined directly beneath the Williams property by Webster County Coal LLC, Permit No. 917-5023, and over permitted by Webster County Coal LLC, Permit No. 917-5013. This mining occurred in 2014.

Geological descriptions of the area contained in Webster County Coal LLC, Permit No. 917-5023 permit applications, which cover the No. 13 seam mining area, list the strata immediately above the No. 9 seam (roof) as different types of slates and shales, ranging from about 30 feet to 80 feet in thickness between the 16 geological sampling points utilized for that permit (Figure 10). Note that six of the sampling locations did not contain data for the No. 9 seam. The sample data describes the No. 9 coal seam as averaging 5.2 feet in thickness throughout the ten available sampling locations. The strata directly below the No. 9 coal seam (floor) is listed as clay, claystone or fireclay for all but two of the sampling locations, with an average thickness of 2.1 feet. Sites P-34 and P-36 have a layer of gray shale under the No. 9 coal seam, averaging 2.4 feet in thickness.

The geological data from the Webster County Coal LLC, Permit No. 917-5023 permit applications describes the strata immediately above the No. 13 seam (roof) as different types of slates and shales, ranging from less than 1 foot to over 130 feet in thickness between the 16 geological sampling points. The sample data describes the No. 13 coal seam as averaging 8.6 feet in thickness throughout the sixteen sampling locations. This includes one or more bands of other materials, such as claystone or shale, within the coal, averaging 1.9 feet of the seam thickness. The strata directly below the No. 13 coal seam (floor) is listed as clay, claystone or fireclay for all but three of the sampling locations, with an average thickness of 2.5 feet. Site G-18 has a nine foot layer of limestone under the No. 13 seam, while sites WC-98-5 and P-36 have a layer of gray shale under the No. 13 coal seam, averaging 1.2 feet in thickness.

The lithology of Kentucky Geological Survey Borehole NEBO066 (Appendix A) was compared to the geologic sampling points from Webster County Coal LLC, Permit No. 917-5023, and found to be similar. This borehole is located approximately 2.7 miles northeast of the Williams property, closer than most of the sampling points from the permit (Figure 10). This borehole contained nearly 80 feet of slates and shales above the No. 9 coal seam. The No. 9 coal seam was found to be 4.8 feet thick in this location, with 2.7 feet of fireclay beneath it. Over 160 feet of shale is located above the No. 13 seam at this location. The No. 13 seam is 8.2 feet thick here, with a 1.5 foot band of gray shale within it. The floor is comprised of a 9.8 foot thick gray clay.

Figure 10. 2020 Aerial photograph showing geologic sampling locations for Webster County Coal LLC, Permit No. 917-5023 and a nearby Kentucky Geological Survey borehole. Note that geologic information was unavailable for the No. 9 seam at the WC-98-1, WC-98-2, WC-98-5, D-4, P-4 and P-171 locations.



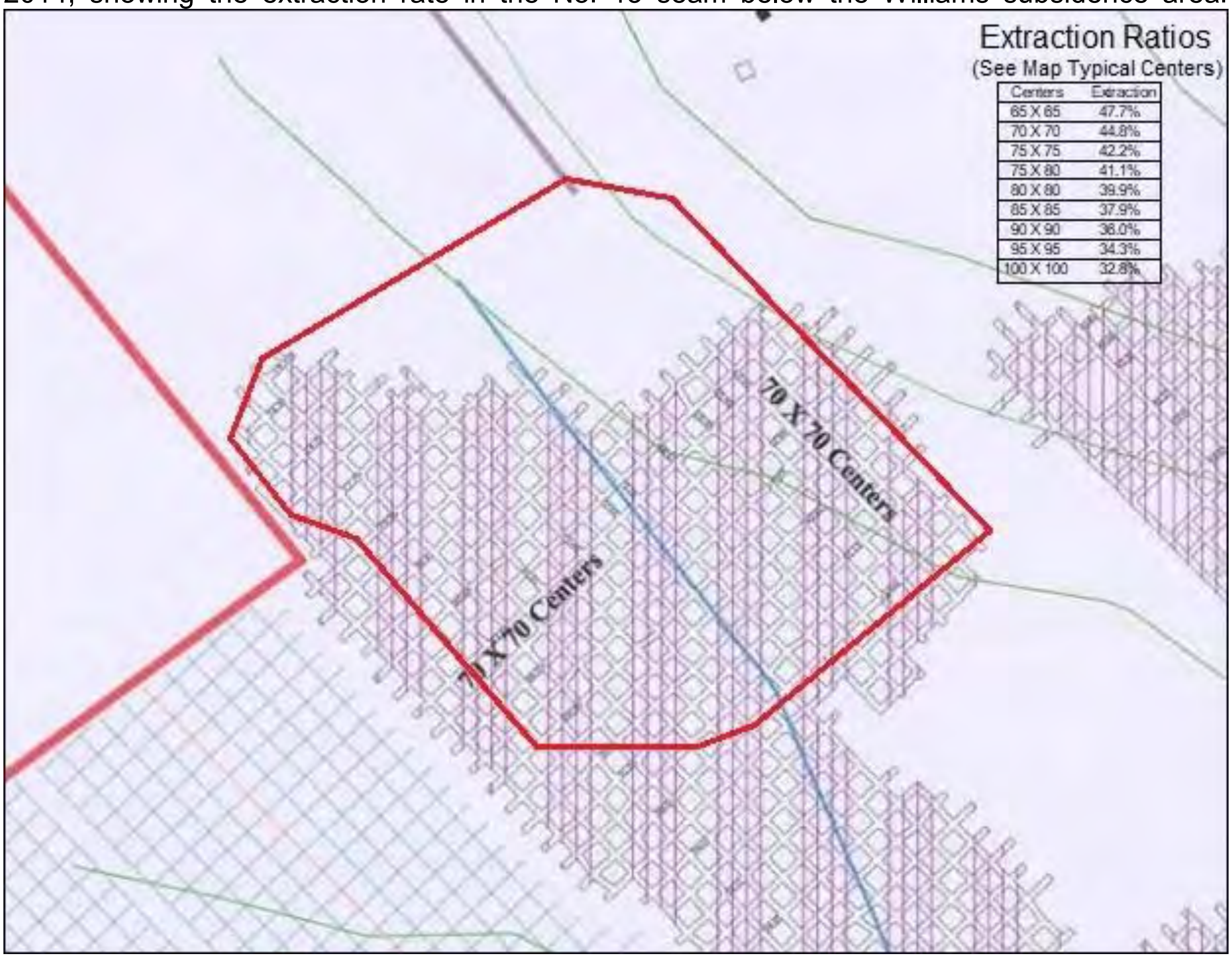
Permit Review

Due to the age of the mining in the No. 9 seam, a subsidence plan for this mining could not be found. The No. 9 seam mining directly beneath the Williams property was conducted pre-law, meaning that current mining regulations were not in place at that time, and a subsidence plan for the area would not have been required. Measurements performed on the underground mining map, dated 1989 showed the area to have entry widths of approximately 18 feet, and coal pillars of approximately 40 feet x 40 feet in size (Figure 11). This means that the extraction rate in the No. 9 seam beneath the Williams property was approximately 52.4%.

Figure 11. Webster County Coal LLC, Permit No. 917-5013 1989 Mine Map, dated 1989, showing the mining conducted in the No. 9 seam below the Williams subsidence area.

The subsidence protection plan in the Webster County Coal LLC, Permit No. 917-5013 Minor Revision #26 permit application, which over permitted the No. 13 seam underground mining previously permitted by Webster County Coal LLC, Permit No. 917-5023, states that an extraction ratio no greater than 50% will be utilized throughout the entirety of the mine. The extraction rate under the Williams property was approximately 44.8% according to the 2013 underground mine map submitted to DMRE and dated February 7, 2014 (Figure 12).

Figure 12. Webster County Coal LLC, Permit No. 917-5023 2013 Mine Map, dated February 7, 2014, showing the extraction rate in the No. 13 seam below the Williams subsidence area.

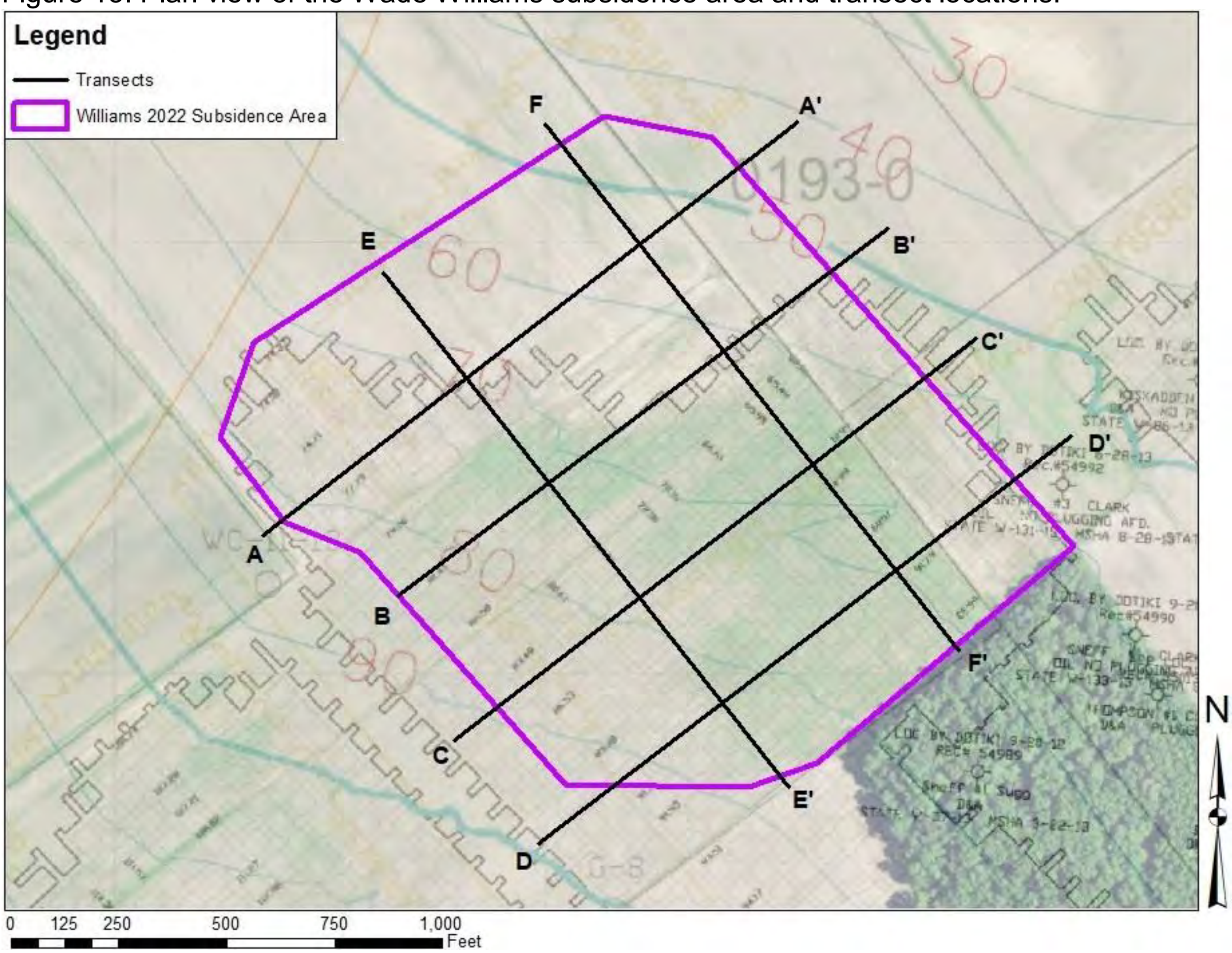


Webster County Coal LLC, Permit No. 917-5023 Minor Revision #15 addressed pumping water from the No. 13 seam underground works, and stated that pumping was being conducted on a nearly continuous basis, at a rate of approximately 500 gallons per minute. The document also stated that should pumping operations cease, the mine would fill with water Since the mine is no longer active, and water is no longer being pumped out, the floor is now likely saturated, significantly reducing its strength.

Survey Results

Data was collected at various points along the transects surveyed during the June 20, 2022 site visit. Points were logged at approximate distances of 20 to 30 feet, as well as at places where features, such as ditch lines, needed to be documented. At each point, the longitude, latitude and elevation were recorded using an Arrow Gold RTK GNSS Receiver that has a survey grade accuracy of 1 cm. The data was later processed to determine if there was any significant change in elevation. Along each profile line, the elevations that were collected in the field were compared to elevations acquired from LiDAR data from 2014 and 2020[10]. Profile lines of the three data groupings, 2014, 2020 and 2022, were drawn using AutoCAD software and are attached. Figure 13 shows a plan view of the transects surveyed on the Wade Williams property. Figures 14 through 19 show cross sections A-A' through F-F'.

Figure 13. Plan view of the Wade Williams subsidence area and transect locations.



[10] The point spacing for the 2014 LiDAR tile #N132E111 is 2.543feet. The point spacing for the 2020 LiDAR N132E111 is 1.600 feet.

Figure 14. Cross Section A-A' showing trough subsidence on the Williams property.

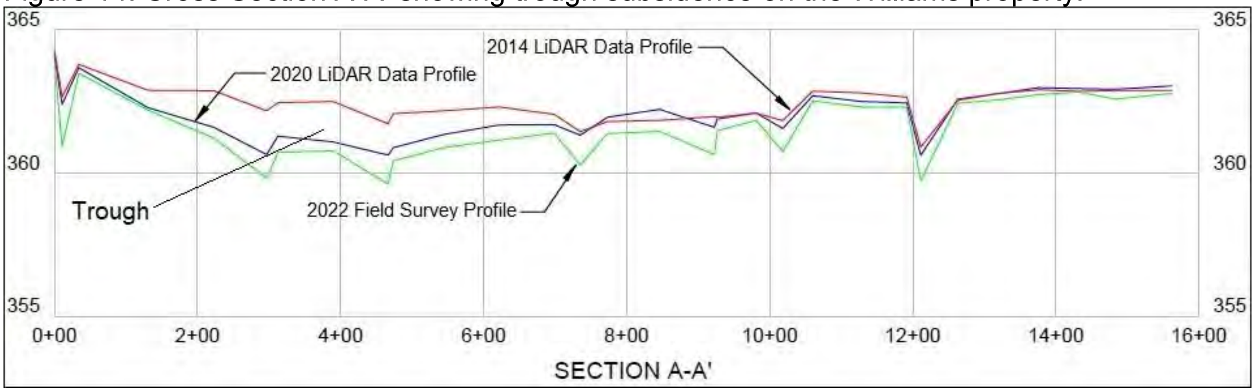


Figure 15. Cross Section B-B' showing trough subsidence on the Williams property.

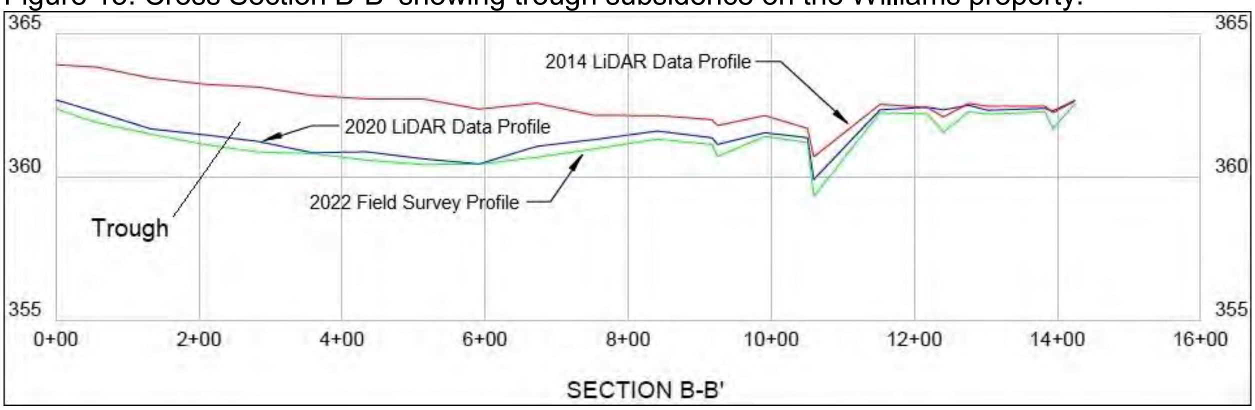
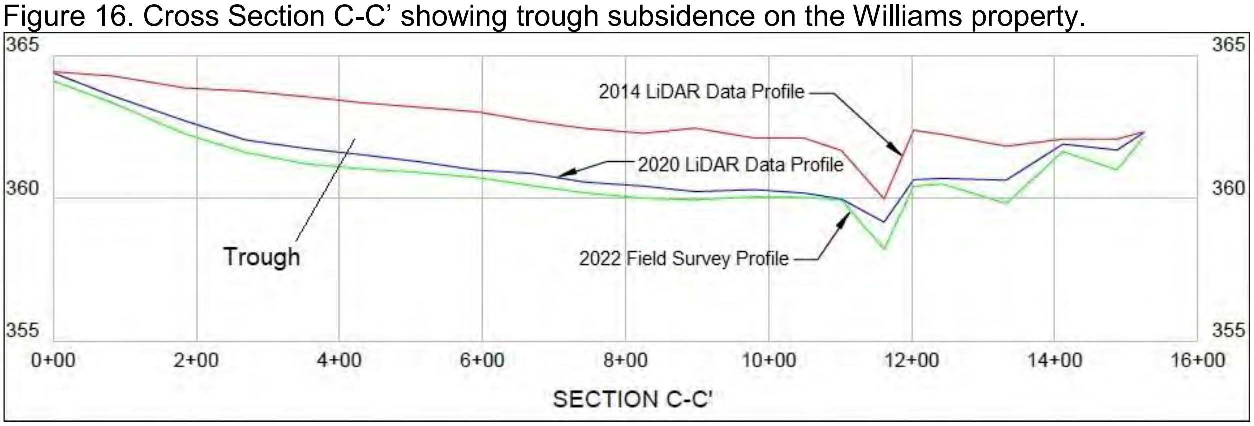


Figure 16. Cross Section C-C' showing trough subsidence on the Williams property.



Wade Williams,
ORM, March 1, 2023

Figure 17. Cross Section D-D' showing trough subsidence on the Williams property.

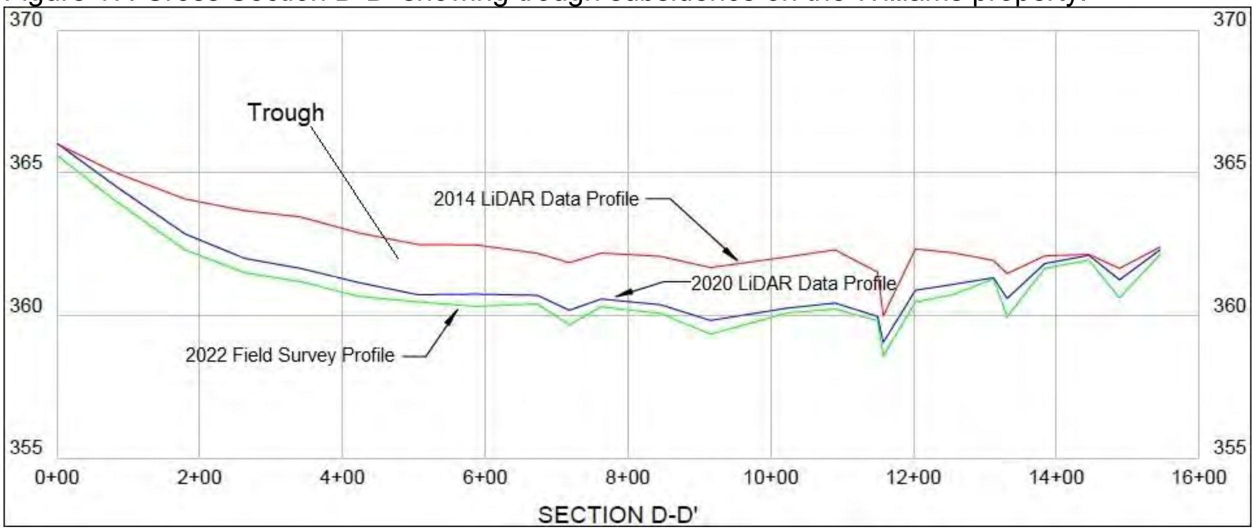


Figure 18. Cross Section E-E' showing trough subsidence on the Williams property.

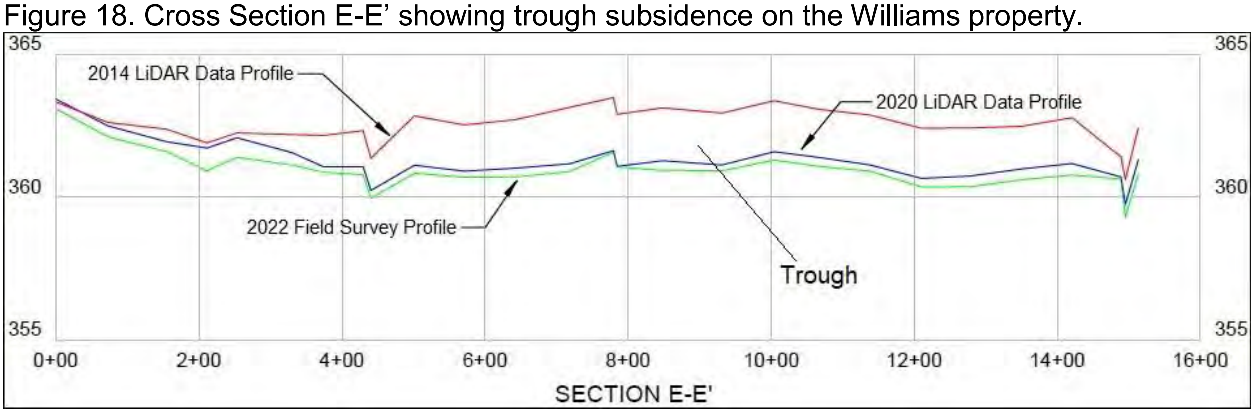
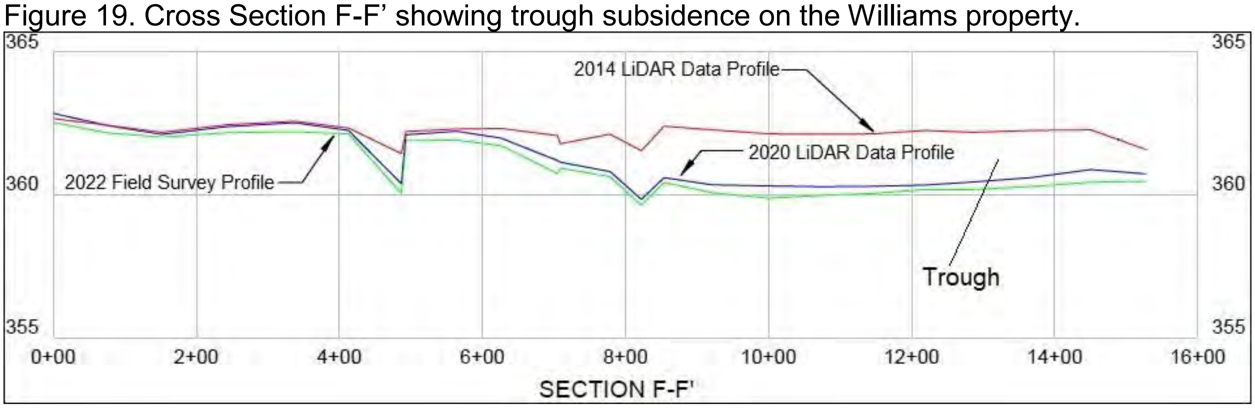


Figure 19. Cross Section F-F' showing trough subsidence on the Williams property.



Cross sections A-A' through F-F' indicate that trough subsidence has occurred above the underground works beneath the Williams property (Figures 14 through 19). Differences in the 2014 LiDAR data and the data collected during the June 20, 2022 site visit show that the surface elevation in this area is now two to three feet lower than it was in 2014. Mining in the No. 13 seam was conducted in 2014, and the landowners first noticed subsidence in the area in 2022.

Findings:

As discussed in this report, the following facts are presented:

1. DMRE staff conducted a site investigation on June 20, 2022 in response to the citizen complaint filed by Wade Williams for subsidence damage in his farm field.
2. There are two coal seams beneath the Williams property, both containing documented coal mining.
3. Underground mining in the No. 9 coal seam approximately 412 feet below the Williams property occurred from 1973 to 1974 and is currently permitted by Webster County Coal LLC, Permit No. 917-5013. This permit is currently in O2 status, and remains under the jurisdiction of DMRE, although most of the No. 9 seam beneath the Williams property has been released from the permit.
4. Webster County Coal LLC, Permit No. 917-5023, conducted underground mining in the No. 13 coal seam approximately 312 feet below the Williams property in 2014. This permit is currently in A2 status, and remains under the jurisdiction of DMRE. This mining was also over permitted by Webster County Coal LLC, Permit No. 917-5013.
5. The floor of the No. 13 seam mine is composed of approximately 2.5 feet of fireclay, or claystone, based on geologic sampling points from the Webster County Coal LLC, Permit No. 917-5013 permit and nearby KGS data. This is typically considered a weak floor strata, and can lead to subsidence issues, especially when saturated.
6. During mining approximately 500 gallons per minute of water was pumped from the No. 13 underground works. When mining was completed, and pumping stopped, the mine likely began to fill with water, saturating the floor of the mine.
7. The extraction rate beneath the Williams property was approximately 52.4% in the No. 9 seam and approximately 44.8% in the No. 13 seam, which followed approved mining plans.
8. Cross sections indicate that trough subsidence has occurred beneath the Williams property. Differences in the 2014 LiDAR data and the data collected during the June 20, 2022 site visit show that the surface elevation in this area is now two to three feet lower than it was in 2014.

Conclusions:

It is the conclusion of the author of this report that mining by Webster County Coal LLC, Permit No. 917-5013 has **adversely impacted** the Williams property. This determination is based on the following facts: Permit No. 917-5013 is the only mining beneath the Williams property, in both the No. 9 and No. 13 coal seams; differences in the 2014 LiDAR data and the data collected during the June 20, 2022 site visit show that the surface elevation in this area is now two to three feet lower than it was in 2014; and the observable damage appears consistent with the results of trough subsidence. No other reasonable cause for the damage at the Williams property could be determined.

3/1/2023

X Owen Michels

Signed by: Owen Michels

Owen Michels,
Environmental Scientist V

REFERENCES:

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Appendix A

KGS Borehole NEBO0066 Lithology Report

Wade Williams,
ORM, March 1, 2023

Lithology Report

Type of Report: Lithology Report
HoleID's Searched:
NEBO066

Total Number of HoleID's Searched: 1
Total Number of Records: 55

About The Lithology Report
This report lists the down hole rock units for each drill hole. Rock descriptions have been assigned **numeric codes** for standardization based on the system by Ferm and Weisenfluh. Depth and thickness data are in decimal feet. Seam, bench, and zone correlations have been determined by KGS geologists. They are continuously under revision.
Users should verify these assignments using independent methods.

Records Download:

Download Records:

Download ALL the retrieved records into a text or Microsoft Excel file:

Select the type of file for download:

COMMA DELIMITED TEXT FILE (.kgs extension*)

*** .kgs files:** use in a text editor or spreadsheet as if a delimited ".txt" file
****.xls files:** depending on browser configuration, file may automatically open inside browser window

DOWNLOAD LITHOLOGY REPORT

(large numbers of boreholes (+50 IDs) may take awhile to download)

Other Reports

HELP & MORE INFO ABOUT THESE REPORTS

PRINT THIS PAGE **(for best results, use LANDSCAPE orientation)**

(Row Color Change Represents a Change in Hole ID)

Hole ID: NEBO0066_KY

VIEW STRIP LOG (PDF) FOR THIS BOREHOLE

Hole ID	Quadrangle	LithCode	Lithology	Thickness (ft)	From (ft)	To (ft)	Seam Tag	Bench Tag	Zone Tag	Comment
NEBO0066_KY	Nebo	001	BROWN SURFACE CLAY	12.500	0.000	12.500				
NEBO0066_KY	Nebo	324	BROWN GRAY SANDY SHALE	10.500	12.500	23.000				
NEBO0066_KY	Nebo	124	DARK GRAY SHALE	22.500	23.000	45.500				
NEBO0066_KY	Nebo	020	BLACK COAL	2.000	45.500	47.500				
NEBO0066_KY	Nebo	127	GRAY FIRECLAY	2.500	47.500	50.000				
NEBO0066_KY	Nebo	330	LIGHT GRAY SANDY SHALE	13.000	50.000	63.000				
NEBO0066_KY	Nebo	320	DARK GRAY SANDY SHALE	57.000	63.000	120.000				
NEBO0066_KY	Nebo	020	BLACK COAL	0.500	120.000	120.500				
NEBO0066_KY	Nebo	127	GRAY FIRECLAY	1.500	120.500	122.000				
NEBO0066_KY	Nebo	330	LIGHT GRAY SANDY SHALE	13.000	122.000	135.000				
NEBO0066_KY	Nebo	124	DARK GRAY SHALE	25.167	135.000	160.167				
NEBO0066_KY	Nebo	020	BLACK COAL	0.500	160.167	160.667				
NEBO0066_KY	Nebo	127	GRAY FIRECLAY	1.333	160.667	162.000				
NEBO0066_KY	Nebo	124	DARK GRAY SHALE	17.000	162.000	179.000				
NEBO0066_KY	Nebo	020	BLACK COAL	0.500	179.000	179.500				
NEBO0066_KY	Nebo	127	GRAY FIRECLAY	1.500	179.500	181.000				
NEBO0066_KY	Nebo	134	LIGHT GRAY SHALE	10.000	181.000	191.000				
NEBO0066_KY	Nebo	124	DARK GREY SHALE	33.333	191.000	224.333				
NEBO0066_KY	Nebo	904	GRAY LIMESTONE	5.000	224.333	229.333				

Wade Williams,
ORM, March 1, 2023

Hole ID	Quadrangle	LithCode	Lithology	Thickness (ft)	From (ft)	To (ft)	Seam Tag	Bench Tag	Zone Tag	Comment
NEBO0066_KY	Nebo	114	BLACK SHALE	3.667	229.333	233.000				
NEBO0066_KY	Nebo	130	LIGHT GRAY CLAY	9.500	233.000	242.500				
NEBO0066_KY	Nebo	020	BLACK COAL	0.500	242.500	243.000				
NEBO0066_KY	Nebo	124	GRAY CLAY	2.000	243.000	245.000				
NEBO0066_KY	Nebo	324	GREY SANDY SHALE	44.000	245.000	289.000				
NEBO0066_KY	Nebo	320	GRAY SANDY SHALE	41.000	289.000	330.000				
NEBO0066_KY	Nebo	114	BLACK SHALE	4.500	330.000	334.500				
NEBO0066_KY	Nebo	124	GRAY CLAY	1.500	334.500	336.000				
NEBO0066_KY	Nebo	320	GRAY SANDY SHALE	82.000	336.000	418.000				
NEBO0066_KY	Nebo	124	GRAY SHALE	34.000	418.000	452.000				
NEBO0066_KY	Nebo	114	BLACK SHALE	2.500	452.000	454.500				
NEBO0066_KY	Nebo	020	BLACK COAL	0.500	454.500	455.000				
NEBO0066_KY	Nebo	124	GRAY CLAY	3.000	455.000	458.000				
NEBO0066_KY	Nebo	124	GRAY SHALE	24.000	458.000	482.000				
NEBO0066_KY	Nebo	904	GRAY LIMESTONE	5.000	482.000	487.000				
NEBO0066_KY	Nebo	124	DARK GRAY SHALE	29.000	487.000	516.000				
NEBO0066_KY	Nebo	134	LIGHT GRAY SHALE	2.000	516.000	518.000				
NEBO0066_KY	Nebo	904	GRAY LIMESTONE	3.500	518.000	521.500				
NEBO0066_KY	Nebo	330	LIGHT GRAY SANDY SHALE	21.500	521.500	543.000				
NEBO0066_KY	Nebo	320	GRAY SANDY SHALE	139.167	543.000	682.167				
NEBO0066_KY	Nebo	020	BLACK COAL	3.000	682.167	685.167	W13 B	W13 8		
NEBO0066_KY	Nebo	124	GRAY SHALE	1.500	685.167	686.667	W13 B			
NEBO0066_KY	Nebo	020	BLACK COAL	3.667	686.667	690.334	W13 B	W13 2		
NEBO0066_KY	Nebo	124	GRAY CLAY	9.833	690.334	700.167				
NEBO0066_KY	Nebo	224	GRAY LIMEY SHALE	6.833	700.167	707.000				
NEBO0066_KY	Nebo	124	LIGHT GREY SHALE	2.000	707.000	709.000				
NEBO0066_KY	Nebo	904	GRAY LIMESTONE	3.000	709.000	712.000				
NEBO0066_KY	Nebo	334	LIGHT GRAY SANDY SHALE	7.000	712.000	719.000				
NEBO0066_KY	Nebo	003	ZERO TAG	0.000	719.000	719.000	W11 B			
NEBO0066_KY	Nebo	334	LIGHT GRAY SANDY SHALE	7.500	719.000	726.500				
NEBO0066_KY	Nebo	904	GRAY LIMESTONE	3.500	726.500	730.000				
NEBO0066_KY	Nebo	330	LIGHT GRAY SANDY SHALE	10.000	730.000	740.000				
NEBO0066_KY	Nebo	320	DARK GRAY SANDY SHALE	66.833	740.000	806.833				
NEBO0066_KY	Nebo	114	BLACK SLATE	2.583	806.833	809.416				
NEBO0066_KY	Nebo	020	BLACK COAL	4.750	809.416	814.166	WK9 B			
NEBO0066_KY	Nebo	127	GRAY FIRECLAY	2.667	814.166	816.833				