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Geotechnical Site Characterization of Transportation Construction Sites and Structures

Assessment Of Karst Activity At Highway Construction Sites In Greene And Jefferson Counties, Missouri, Using The Electrical Resistivity Method

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16. Abstract

Two-dimensional (2-D) electrical resistivity data were acquired across and in proximity to active sinkholes at two Missouri Department of Transportation (MoDOT) highway-construction sites. Construction site #1 is located in Greene County, Missouri; site #2 is located in Jefferson County, Missouri. Two relatively dense grids ("1A" and "1B") of electrical resistivity data were acquired at Greene County site #1 as part of a geotechnical investigation of a proposed interchange. Several active sinkholes with exposed throat diameters on the order of 1.5 ft had been discovered during a routine visual inspection of the site, and the District Geologist decided that a geophysical investigation was warranted prior to routine boring. The primary objective of the electrical resistivity study was to determine if substantive air-filled karstic cavities were present in the subsurface. Secondary objectives were to estimate depth to bedrock and identify anomalous subsurface conditions that might compromise the integrity of the proposed intersection or complicate construction. The electrical resistivity data proved to be of significant utility. Substantive air-filled voids were not imaged on the resistivity profiles. A depth to bedrock structure contour map was generated for the site, and prominent clay-filled and apparently inactive karstic cavities were identified beneath segments of proposed new roadway. A relatively dense grid of electrical resistivity data was also acquired at Jefferson County site #2. These electrical resistivity data were acquired because a previously unmapped, oval-shaped, clay-filled, sinkhole (approximately 50 ft x 35 ft x 15 ft; length x width x height) near the centerline of the proposed southbound lanes effectively "emptied" overnight after overlying soil had been stripped by earth moving equipment. The supervising geologist authorized the acquisition of the geophysical data in order to image the subsurface immediately beneath and adjacent to the sinkhole. The primary concern was that the sinkhole was underlain by a large air-filled cavity. The interpretation of the resistivity data indicated the reactivated sinkhole was not underlain by a substantive cavity. Rather, the soil in the sinkhole appears to have "flowed" into the subsurface through solution-widened system of joints that do not underlie the sinkhole and probably do not pose a significant risk in terms of catastrophic collapse under load.

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ASSESSMENT OF KARST ACTIVITY AT HIGHWAY CONSTRUCTION SITES IN GREENE AND JEFFERSON COUNTIES, MISSOURI, USING THE ELECTRICAL RESISTIVITY METHOD

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ABSTRACT

Two-dimensional (2-D) electrical resistivity data were acquired across and in proximity to active sinkholes at two Missouri Department of Transportation (MoDOT) highway-construction sites. Construction site #1 is located in Greene County, Missouri; site #2 is located in Jefferson County, Missouri.

Two relatively dense grids (“1A” and “1B”) of electrical resistivity data were acquired at Greene County site #1 as part of a geotechnical investigation of a proposed interchange. Several active sinkholes with exposed throat diameters on the order of 1.5 ft had been discovered during a routine visual inspection of the site, and the District Geologist decided that a geophysical investigation was warranted prior to routine boring. The primary objective of the electrical resistivity study was to determine if substantive air-filled karstic cavities were present in the subsurface. Secondary objectives were to estimate depth to bedrock and identify anomalous subsurface conditions that might compromise the integrity of the proposed intersection or complicate construction. The electrical resistivity data proved to be of significant utility. Substantive air-filled voids were not imaged on the resistivity profiles. A depth to bedrock structure contour map was generated for the site, and prominent clay-filled and apparently inactive karstic cavities were identified beneath segments of proposed new roadway.

A relatively dense grid of electrical resistivity data was also acquired at Jefferson County site #2. These electrical resistivity data were acquired because a previously unmapped, oval-shaped, clay-filled, sinkhole (approximately 50 ft x 35 ft x 15 ft; length x width x height) near the centerline of the proposed southbound lanes effectively “emptied” overnight after overlying soil had been stripped by earth moving equipment. The supervising geologist authorized the acquisition of the geophysical data in order to image the subsurface immediately beneath and adjacent to the sinkhole. The primary concern was that the sinkhole was underlain by a large air-filled cavity. The interpretation of the resistivity data indicated the reactivated sinkhole was not underlain by a substantive cavity. Rather, the soil in the sinkhole appears to have “flowed” into the subsurface through solution-widened system of joints that do not underlie the sinkhole and probably do not pose a significant risk in terms of catastrophic collapse under load.

INTRODUCTION

Relatively dense grids of 2-D electrical resistivity profiles were acquired in proximity to active sinkholes at two Missouri Department of Transportation (MoDOT) construction sites. Site #1 is located in Greene County, Missouri, at the proposed intersection of Route 125 over Route 60 (Figures 1 and 2). Site #2 is located in Jefferson County, Missouri, near the northbound centerline of new Route 21, approximately 0.4 miles north of the existing interchange of Route A and new Route 21 (Figures 1 and 3).

Resistivity data were acquired at both sites with the intent of imaging and characterizing the shallow subsurface in proximity to visually-identified sinkholes. MoDOT was particularly interested in determining if either study area was underlain by substantive air-filled cavities that could ultimately compromise the integrity of overlying planned roadway or pose a threat to construction crews.

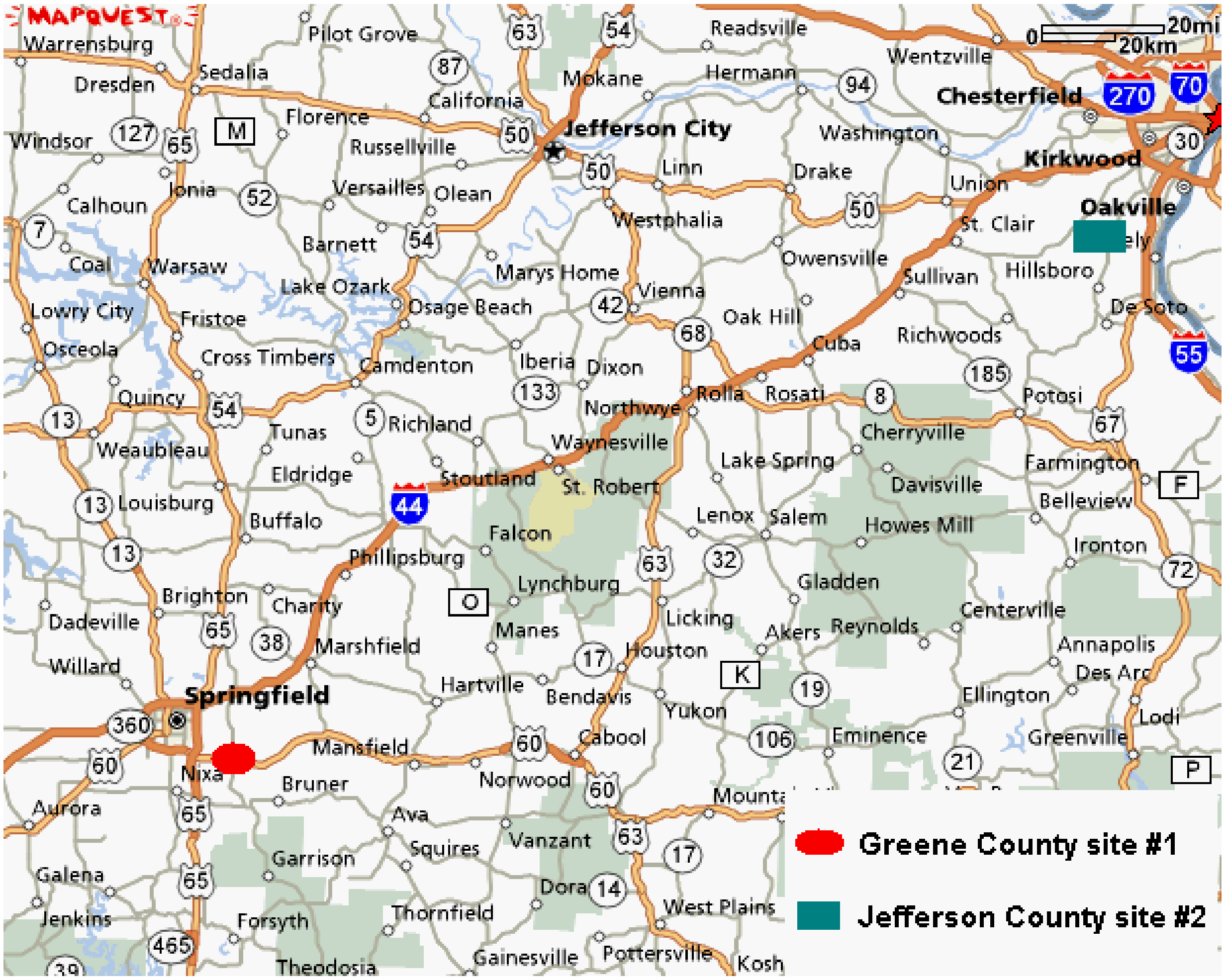

Figure 1: Map of southern Missouri showing locations of Greene County and Jefferson County sites.

Resistivity profiling is commonly used to image the shallow subsurface (depths <100 ft) in karst terrain because soil, carbonate rock, clay infill and air-filled cavities can normally be readily differentiated and mapped on 2-D resistivity profiles. Clays in Missouri are normally characterized by low apparent resistivities (variable, depending on moisture content, purity, and unit shape/size, but usually less than 100 ohm-m). Weathered to intact limestone is generally characterized by higher apparent resistivites (typically more than 400 ohm-m, but variable depending on layer thickness, moisture content and impurities). Air-filled voids are generally characterized by very high apparent resistivities (typically >2000 ohm-m, but variable depending on the conductivity of the encompassing strata and size/shape of void). (The term “apparent resistivities” is used here because the resistivity values output during processing have been laterally and vertically averaged.)

The resistivity tool frequently provides a superior combination of spatial resolution and depth of investigation in karst terrain than any other non-invasive geophysical imaging technique. The resolution provided by the resistivity technique is a function of the electrode spacing, and other factors including subsurface heterogeneity and conductivity contrasts. During processing, the subsurface is subdivided into pixels with lateral dimensions equal to the electrode spacing and vertical dimensions that are typically 25% (at shallowest depths) to 100% (at greatest depths) of the electrode spacing. Pixel size is one estimate of maximum spatial resolution. Additionally, the processing software assumes the subsurface is uniformly layered; hence lateral smoothing (mixing) will occur in non-layered strata. The depth of investigation is a function of the length of the 2-D array employed. Maximum depths of investigation are typically 20 to 25% of the array length, varying primarily as a function of subsurface conductivities.

The utility of 2-D resistivity profiling in karst terrain is well-established, but the tool is not as commonly employed by State DOTs as its usefulness might suggest, probably because many DOT geotechnical personnel are not familiar with the utility of this cost-effective technology.

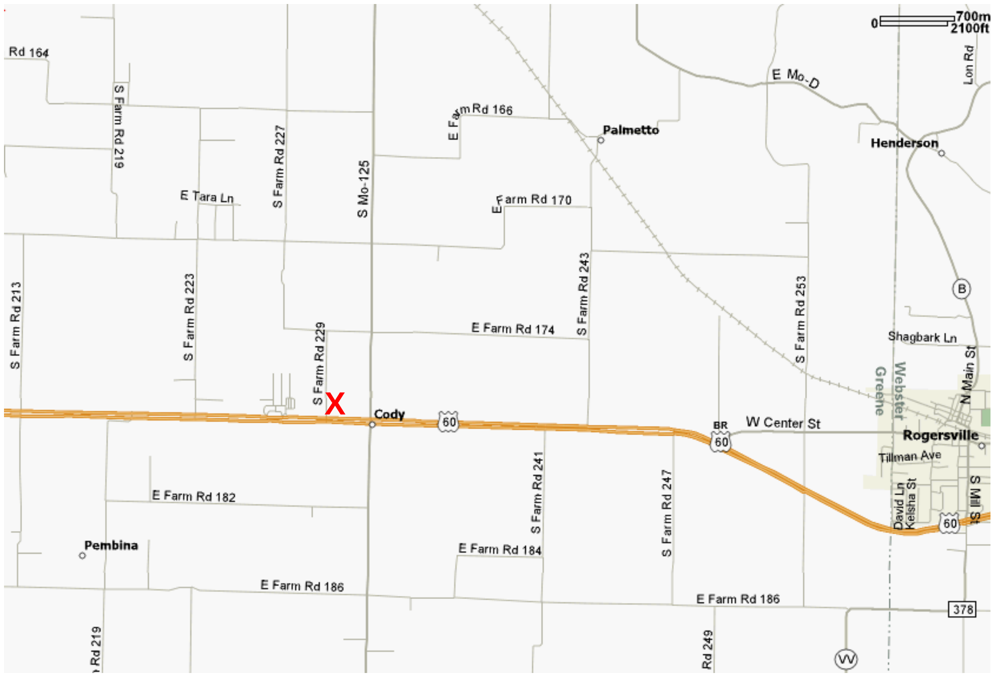

Figure 2: Greene County site #1 is located at the proposed intersection of Route 125 over Route 60.

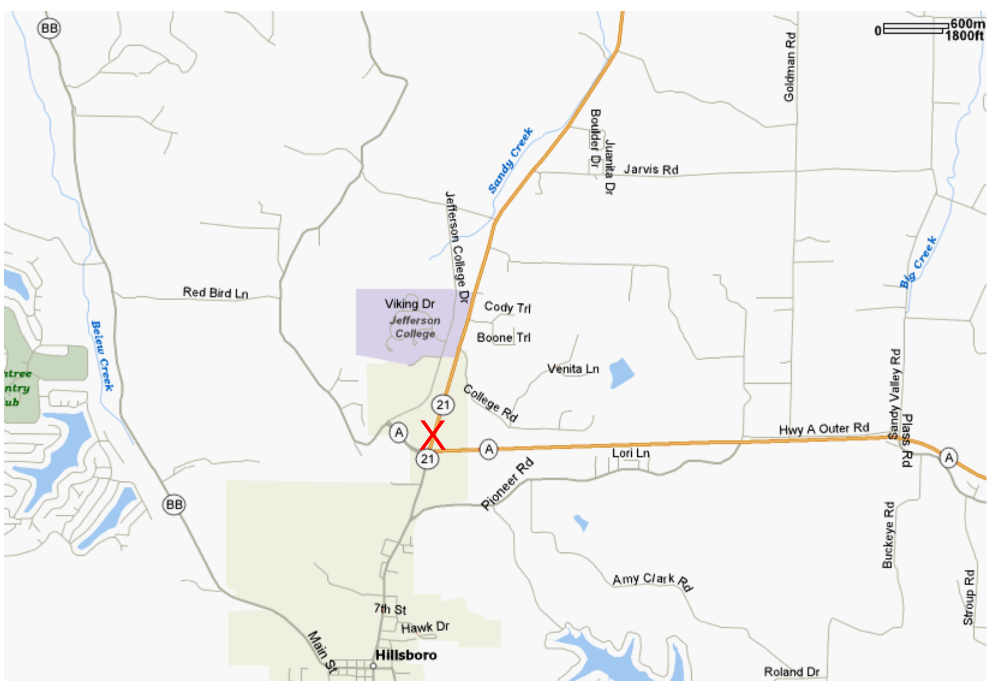

Figure 3: Jefferson County site #2 encompasses the proposed southbound lanes of new Route 21, approximately 0.4 miles north of the existing interchange of Route A and new Route 21.

GREENE COUNTY SITE #1

Greene County Site #1 is located at the proposed intersection of Route 125 over Route 60 (Figures 1 and 2). During a preliminary site inspection, the DOT district geologist identified several active sinkholes which were manifested as narrow-throated (1.5 ft diameter) tubular-voids of visually-undetermined depth. Maintenance records also indicated that relatively small volumes of fill had been placed into subsidence features within the existing DOT ROW on an irregular and as needed basis.

The district geologist was concerned that the small active sinkholes might be connected to one or more larger air-filled voids that could compromise the integrity of the planned intersection and authorized the acquisition of two grids of electrical resistivity profiles (grids “1A” and “1B”; Figure 4). The primary objective was to locate any and all substantive air-filled cavities. It was anticipated that such cavities would have developed along solution-widened joints, so the resistivity profiles were oriented west-east (W-E) effectively perpendicular to the NNW-trending dominant joint system (Figure 4).

Resistivity grid “1A” consisted of 11 W-E traverses, spaced at 25 ft intervals (Figure 4). The grid encompasses the current Route 60 ROW, the current Route 125 ROW and the area across which a planned westbound Route 60 exit ramp will extend. The 2-D profiles were acquired using a 68-channel SuperSting Resistivity unit, a dipole-dipole array configuration and an electrode spacing of 5 ft. Representative 2-D profiles are displayed as Figures 5, 6 and 7. The processed profiles consist of rectangular pixels with widths of 5 ft and heights that vary from 2 ft (minimum depth) to 5 ft (maximum depth). During processing each pixel was assigned an average “resistivity” value. The pixel size is one estimate of the upper end of spatial resolution.

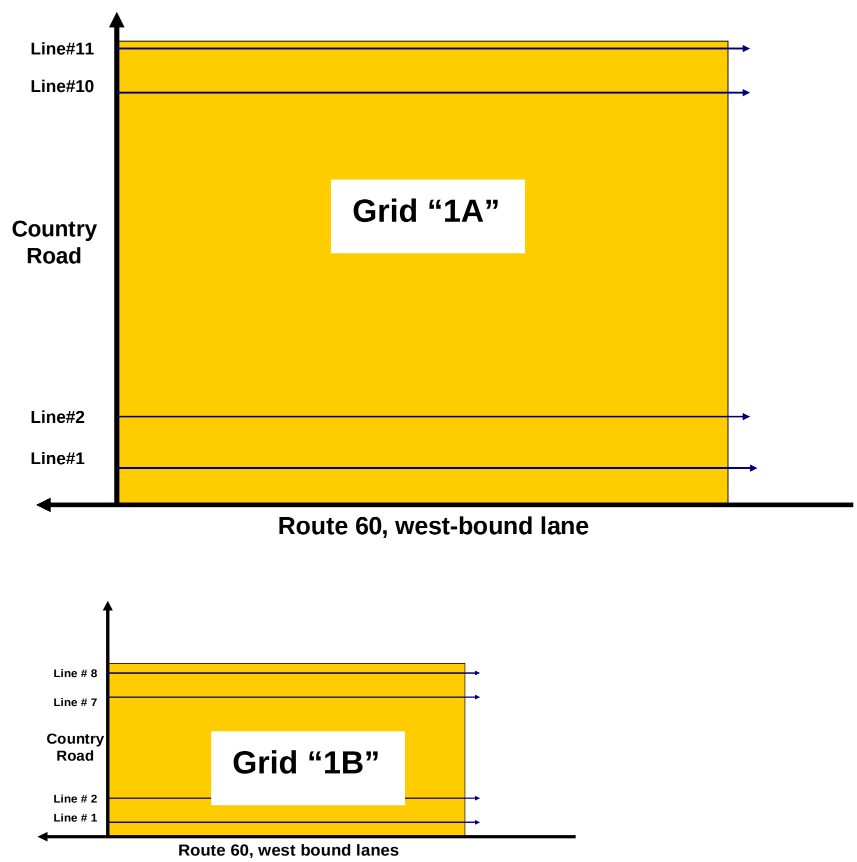

Figure 4: Two grids of electrical resistivity profiles were acquired at the Greene County site. Grid “1A data, consisting of 11 profiles spaced at 25 ft intervals, were acquired using 68 electrodes spaced at 5 ft intervals. Grid “1B’ data, consisting of 8 profiles spaced at 10 ft intervals were acquired using 40 electrodes spaced at 3 ft intervals.

The interpretation of the resistivity profiles was relatively straightforward in terms of differentiating and mapping lithologic units. Units with resistivities greater than 405 ohm-m were mapped as limestone; units with resistivities less than 105 ohm-m were mapped as moist soil or clay; units with resistivities greater than 105 ohm-m but less than 405 ohm-m were interpreted as transitional zones probably consisting of moderately to intensely fractured and/or weathered limestone with clay in-fill (Figures 5, 6 and 7).

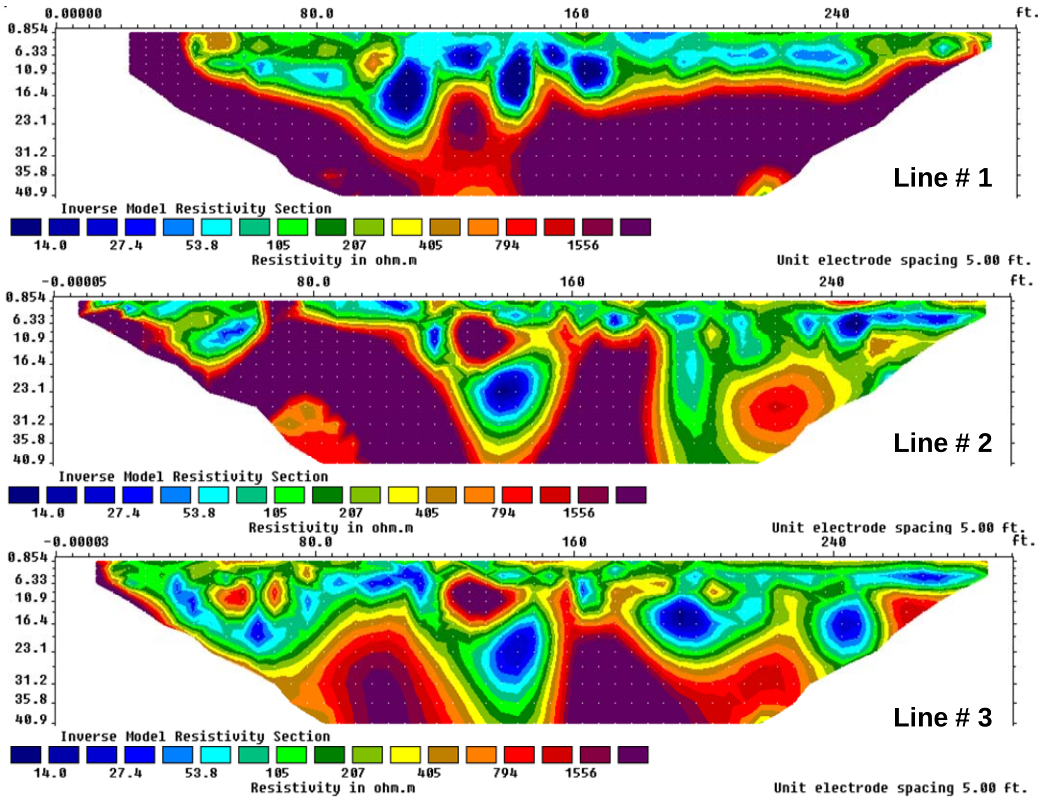

Figure 5: Grid "1A" electrical resistivity profiles 1, 2 and 3 (Figure 4).

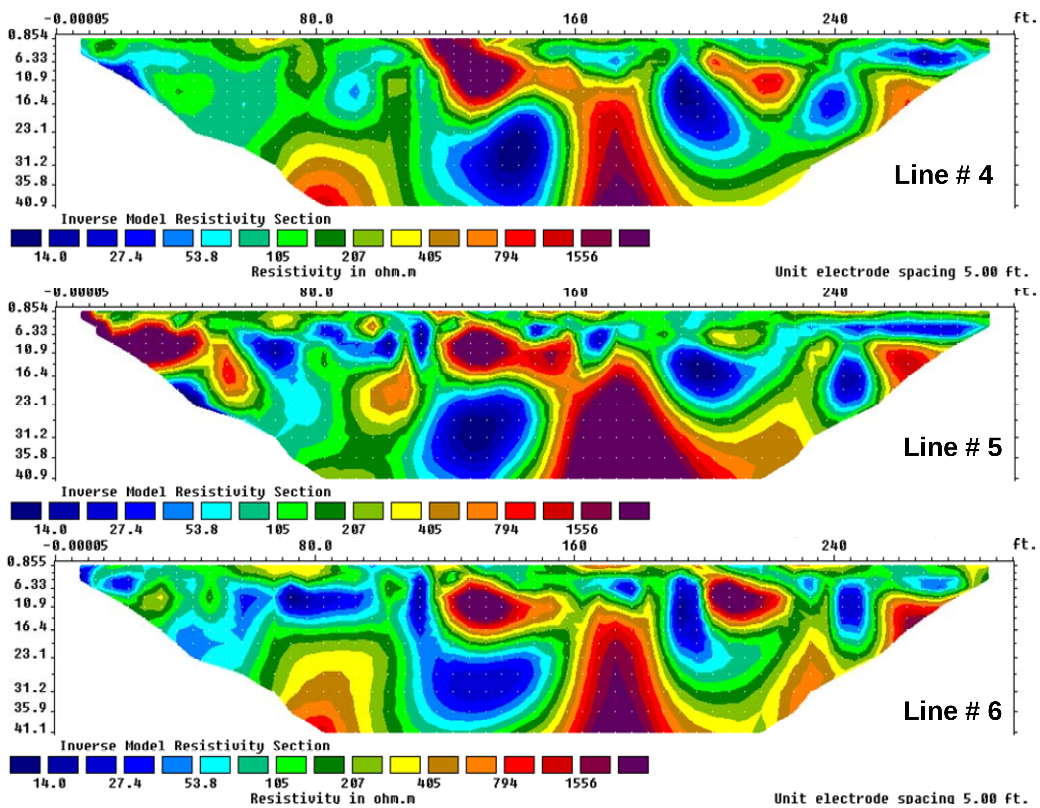

Figure 6: Grid "1A" electrical resistivity profiles 4, 5 and 6 (Figure 4).

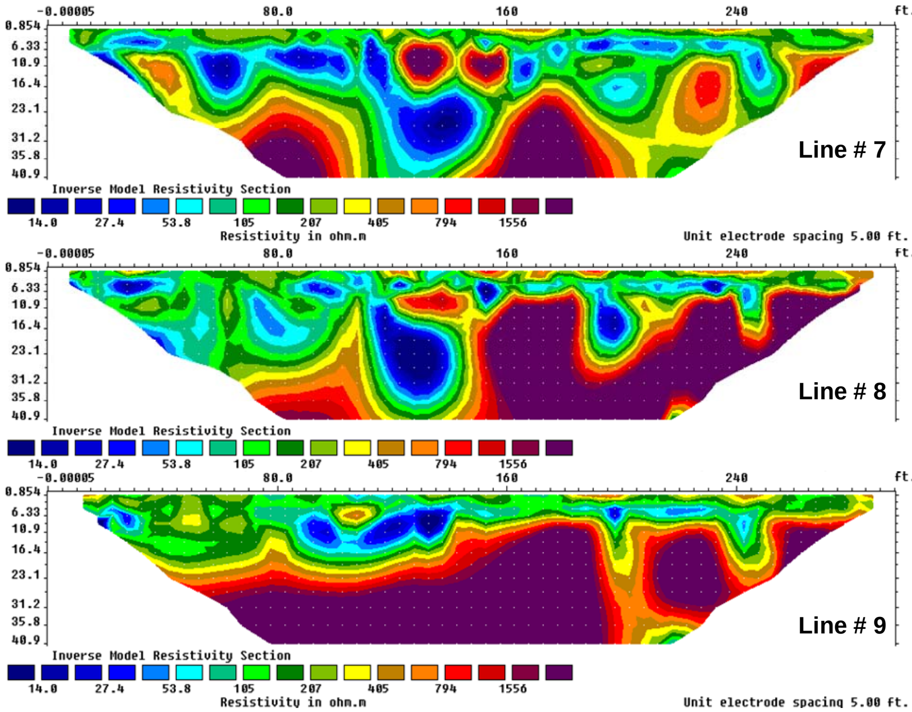

Figure 7: Grid “1A” electrical resistivity profiles 7, 8 and 9 Figure 4)

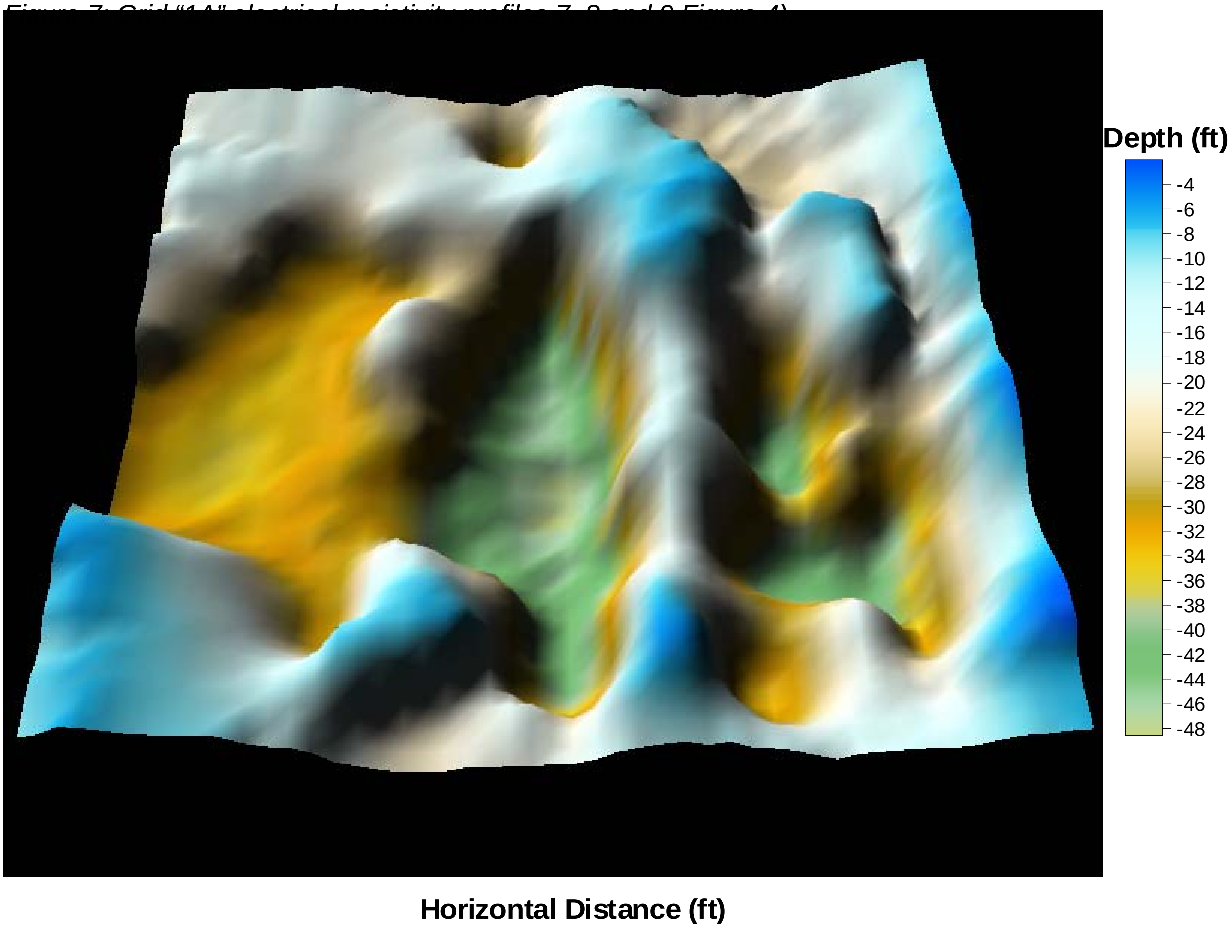

Figure 8: Grid “1A” contour map showing interpreted depth to bedrock.

The interpretation of the resistivity data was used to generate a geologic model of the study area. The model consists of a basal limestone unit which constitutes geophysical bedrock (Figure 8). The depth to the top of geophysical bedrock varies from ground surface (e.g. west end of profile 1; Figures 5 and 8) to in excess of 40 ft (e.g. profile 6; Figures 6 and 8). This bedrock unit appears to be dissected by at least four prominent solution-widened NNW-trending joints (Figure 8). The solution-widened joints of most concern to MoDOT are those that underlie the planned westbound off-ramp. These features are of concern because they are in-filled with thick clays that could densify or be subject to piping under load.

Bedrock is interpreted as overlain by soil or clay, and in places (e.g. profile 6; Figures 6 and 9) by relatively continuous limestone lenses (outliers) and intervening clay. The limestone outliers are interpreted as the remnants of karstic processes.

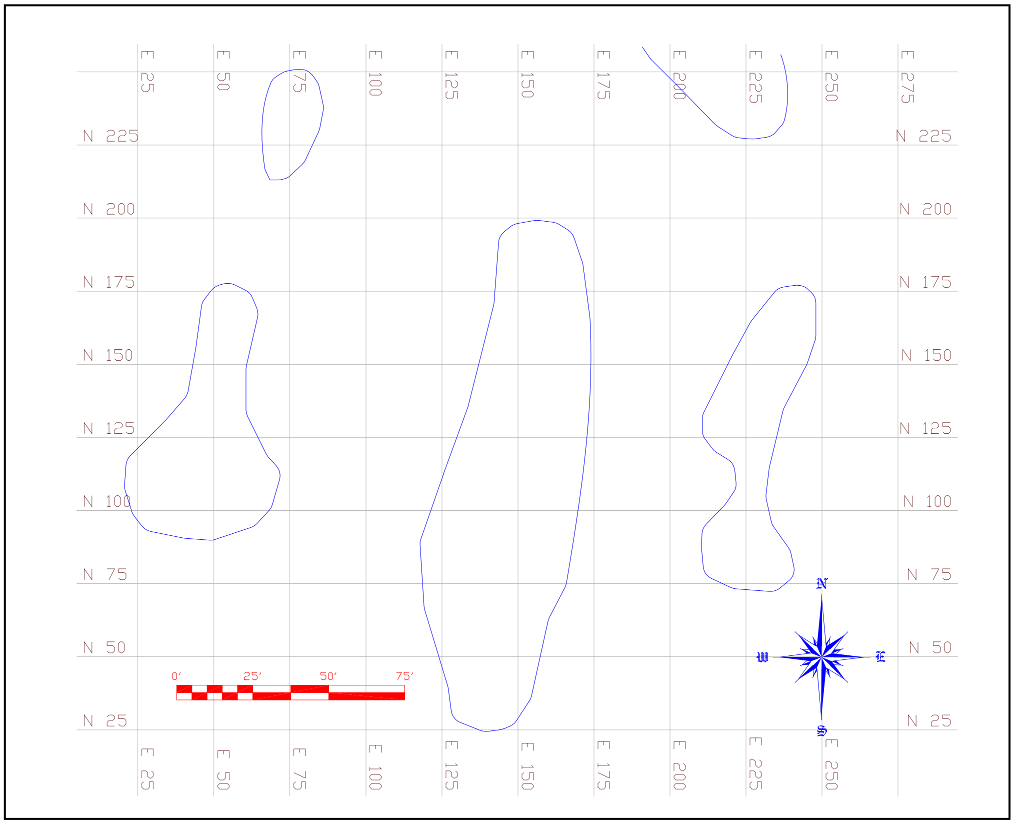

Figure 9: Grid "1A" map showing interpreted location of shallow limestone lenses.

The geologic model correlates reasonably well to the borehole data that were acquired on the basis of the interpretation of the geophysical data (Table 1). Borehole and geophysical depths to bed-rock at bore-holes are relatively consistent at borehole locations 1, 3, 5, 10, and 13-20, considering the resolution provided by the resistivity data (pixel size) and the fact that the borings were not placed exactly on-line. Boreholes 4, 6 and 9-12 are thought to have encountered limestone outliers imaged on the resistivity profiles; the driller's report suggests borehole 7 was terminated in a boulder. Boreholes 2 and 8, in contrast, penetrated multiple feet of strata described as stiff to very stiff clay with limestone gravel, cobbles and boulders. The top of these intervals corresponds to the top of what is interpreted as remnant limestone on the resistivity profiles. Our preferred explanation is that the zones described as stiff to very stiff clay with limestone gravel, cobbles and boulders in boreholes 2 and 8, are actually weathered remnant limestone. However, it is conceivable that the signature of anomalously low resistivity soil has simply been misinterpreted as indicative of remnant limestone.

The second grid (grid "1B") of resistivity profiles acquired at the Greene County site Resistivity grid "1B" consisted of 8 W-E traverses, spaced at 10 ft intervals (Figure 4). The grid encompasses the current Route 60 ROW. These 2-D profiles were acquired using a 40-channel SuperSting Resistivity unit with a dipole-dipole array configuration. However, an electrode spacing of 3 ft. was employed, providing for better spatial resolution but less depth of investigation. For comparison purposes, a representative grid "1B" 2-D profile and the corresponding grid "1A" profile are presented as Figure 10. The two profiles appear to correlate very well, the grid "1B" data simply providing better resolution but less depth of investigation. There was no evidence of substantive air-filled voids on any of the grid "1B" profiles.

Borehole number: location	Borehole depth (ft) to bedrock (BR) or remnant R)	Tie Point: Resistivity Profile(s)	Resistivity depth (ft) to bedrock (BR) or remnant (R)	Comments
1: 304+67.8 387.2 LT	18.4	Profile 9 Station 3	16	Estimate extrapolated. Resistivity control does not extend to bedrock at station 3 on profile 9.
2: 304+73.2 286.7 LT	1 (remnant)	Profile 5 Station 8	1' (remnant)	Stiff clay with limestone gravel, cobbles and boulders, and hard and soft limestone (1' to 20.5'). Probably limestone remnant.
3: 304+74.6 336.9 LT	25.0	Profiles 7-8 Station 10	>10	Bedrock is not imaged on either profile 7 or 8 in proximity to station 10.
4: 304+86.1 311.9 LT	11.7 (remnant)	Profile 6 Station 21	11 (remnant)	
5: 304+86.2 361.8 LT	10.5	Profile 8-9 Station 22	14	Bedrock is shallow on profile 9 (est. 14 ft), but inot imaged on line 8 in proximity to station 22.
6: 304+86.8 286.8 LT	4.2 (remnant)	Profile 5 Station 22	4 (remnant)	
7: 305+07.8 251.0 LT	4.1 (TD in boulder)	Profile 4 Station 43	>20	Bedrock is not imaged on line 4 (>20 ft) in proximity of station 43.
8: 304+90.7 205.1 LT	1 (remnant)	Profile 2 Station 26	3 (remnant)	Stiff to very stiff clay with limestone gravel, cobbles and boulders was encountered.
9: 305+16.2 336.9 LT	22.3 (remnant)	Profile 7 Station 51	24 (remnant)	
10: 305+18 255.0 LT	9.5	Profile 3 Station 53	6 (remnant)	
11: 305+23.8 274.5 LT	11.3 (remnant)	Profile 5 Station 59	11 (remnant)	
12: 305+29.2 266.6 LT	13.3 (remnant)	Profiles 4-5 Station 64	16 (remnant)	
13: 305+41.3 215.7 LT	20.7 (clay 24.8-41.6)	Profiles 2-3 Station 76	6 to 27	Bedrock is at an estimated depth of 6 ft on profile 2, and at an estimated depth of 27 ft on line 3.
14: 305+44.7 351.4 LT	32.6	Profile 8 Station 80	32	
15: 305+45.1 350.3 LT	37.9	Profile 8 Station 80	32	
16: 305+27.0 256.9	41.5	Profiles 3-4 Station 62	>30	>30 on both profiles 3 and 4.
17: 305+31.7 216.8	25.2 (clay 30.7-41.5)	Profile 2-3 Station 67	17 to 30	Bedrock is at an estimated depth of 17 ft on profile 2, and at a depth of >30 ft on line 3.
18: 305+72.1 234.0 LT	12.8	Profile 3 Station 107	15	
19: 305+86.2 286.8 LT	26.7	Profile 5 Station 121	>40	
20: 305+96.1 361.8	28.4	Profiles 8-9 Station 131	26 to 40	Bedrock is at estimated depth of 26 ft on profile 9 and at estimated depth of 40 ft on profile 8.

Table 1: Comparison of depths to bedrock as estimated from borehole and resistivity control, Greene County site "1A" (Figures 1, 2 and 4). Borehole depths to bedrock are referred to as estimated because some of the borings are believed to have terminated in what are interpreted as a limestone lenses (outliers).

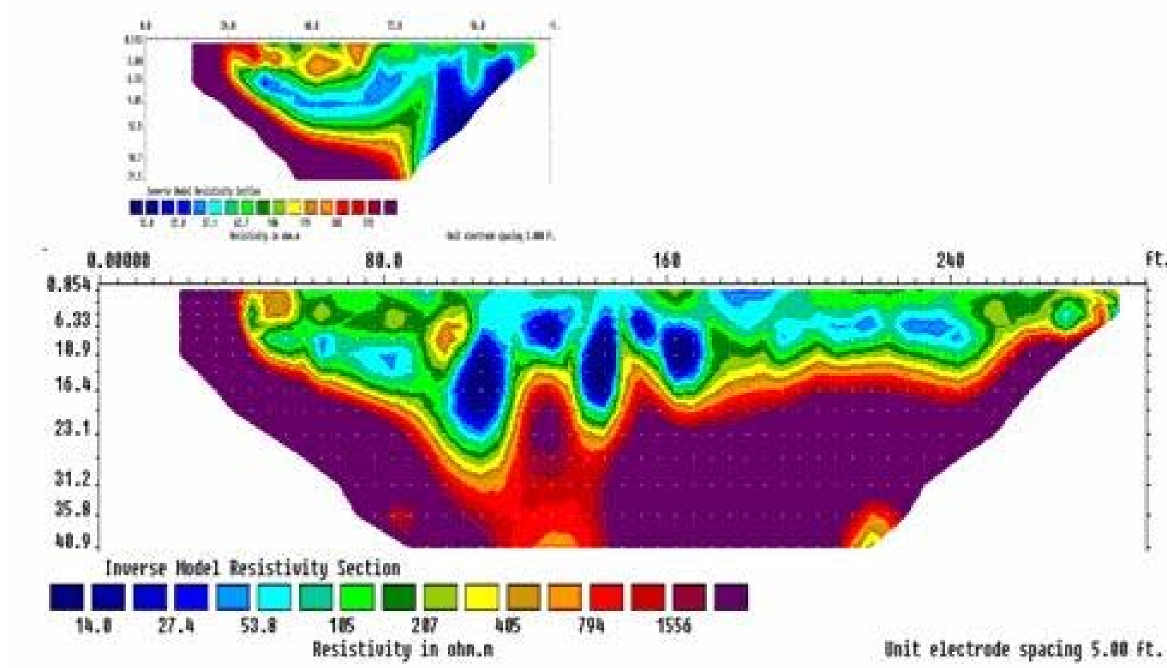

Figure 10: Comparison grid "1A" electrical resistivity profile 1 and grid "1B" electrical resistivity profile 1.

The electrical resistivity data were useful to MoDOT for several reasons. First, they supported the interpretation that the study area was not underlain by any substantive voids. Second, they provided a reasonably accurate map of depth to bedrock and also indicated bedrock was overlain in places by remnant limestone that could be misinterpreted during test boring as bedrock. Third, they established that the subsurface was extensively karsted and provided reliable images of the solution-widened joints.

JEFFERSON COUNTY SITE #2

Jefferson County Site #2 encompasses the northbound lanes of new Route 21, approximately 0.4 miles north of the existing interchange of Route A and new Route 21 (Figures 1 and 3). A relatively dense grid of electrical resistivity data was also acquired at this site because a large clay-filled previously-unidentified oval-shaped sinkhole (Figures 11-14) near the centerline of the northbound lanes emptied overnight. The "emptying" of the sinkhole was preceded by the stripping of topsoil (to limestone bedrock in much of the study area) and heavy rains, the run-off from which was channeled towards the sinkhole by pre-existing topography on the top of recently exposed rock.

The "emptied" sinkhole was oval-shaped, approximately 50 ft long, 35 ft wide and 15 ft deep (top of ponded water to top of sinkhole). The base of the sinkhole was not visible because it was covered with up to 2 ft of ponded water and up to 2 feet of soft clay which proved to have sufficient strength to support 8 ft long vertically-imbedded copper electrical resistivity electrodes (Figures 12-14).

The walls of the "emptied" sinkhole were both steep and weathered, supporting the thesis that the sinkhole was a pre-existing feature that had been rapidly emptied of clay, rather than a newly-developed catastrophic collapse feature (Figure 14). The upper ~5 ft of exposed "cap" rock was dissected in places by prominent NNW-trending and near-orthogonal solution-widened joints, but was otherwise relatively intact; the lower ~10 ft of exposed rock was much more intensely jointed and weathered.

Visually, the "emptied" sinkhole appeared similar to a second clay-filled sinkhole located several hundred feet to the southeast, near the eastern edge of the construction site (Figures 13 and 15). This second sinkhole had been essentially dissected by excavation equipment, and in cross-section appeared to have near-vertical walls and a relatively flat base comprised of intact limestone (Figure 15).

Figure 11: Aerial photograph of the Jefferson County site, prior to the "emptying" of the sinkhole. The approximate location of the sinkhole has been superposed on the photograph.

Figure 12: Photograph of the sinkhole, taken from a location immediately to the south of the feature.

Figure 13: Photograph of the emptied sinkhole, taken from a location immediately to the north of the feature. A second "infilled" sinkhole is observed in cross-section on the excavated rock face to the southeast of the study site.

Figure 14: Close-up photograph of the walls of the emptied sinkhole, taken from a location immediately to the south of the feature. The upper 5 ft of rock wall was jointed but not extensively fractured; the lower 10 ft (to water line) of rock wall was extensively fractured and could be readily dislodged with a shovel.

Figure 15: Close-up of second in-filled sinkhole, located approximately 500 ft SSE of the "emptied" sinkhole. The walls of the second sinkhole were fairly steep; the base was relatively flat.

The supervising MoDOT geologist visually inspected the "emptied" sinkhole. His principle concern, because of the speed with which a significant volume of clay had been "drained", was that the feature could be immediately underlain by a large air- or water-filled cavity or series of interconnected cavities that could pose a risk to construction crews or compromise the integrity of overlying new Route 21.

In an effort to image the subsurface below and in proximity to the "emptied" sinkhole to depths on the order of 80 ft, the supervising MoDOT geologist authorized the acquisition of a grid of electrical resistivity profiles (Figure 16). The resistivity profiles were oriented west-east (W-E) effectively perpendicular to the long axis of the oval-shaped sinkhole and the most prominent solution-widened joints, both of which trend northnorthwest. Profiles 1-17 were 420 ft long and spaced at 20 ft intervals. The resistivity data were acquired using a SuperSting resistivity unit with an electrode spacing of 12 ft. A suite of representative electrical resistivity profiles are presented as Figures 17, 18 and 19.

The interpretation of the resistivity data in the absence of borehole control was relatively straightforward. Units with resistivities in excess of 400 ohm-m were interpreted as intact limestone; units with resistivities less than 100 ohm-m were interpreted as clay-infill (or ponded water-clay infill in the base of the sinkhole); units with resistivities greater than 100 ohm-m but less than 400 ohm-m were interpreted as transitional zones probably consisting of wet fractured and/or weathered limestone and clay in-fill.

The uppermost ~20 ft of the subsurface in proximity and to the immediate south to the sinkhole is characterized mostly by resistivities of between 100 ohm-m and 400 ohm-m (Figures 17, 18 and 19). Lower resistivities are observed at the base of the sinkhole, presumably because of the presence of saturated clay and ponded water. Localized lenses of higher resistivity (>400 ohm-m) are observed in the shallowest subsurface (depths <10 ft). Overall, these resistivity values and patterns are very consistent with visual observations at the sinkhole, where remnant surficial soil and ~5 ft of jointed limestone overly at least ~10 ft of intensely weathered rock.

At depths below 20 ft, bedrock beneath and adjacent to the sinkhole (except immediately to the north of the feature) is characterized by resistivities in excess of 400 ohm-m, but less than 2000 ohm-m (Figure 17, 18 and 19). These resistivity values support the interpretation that the sinkhole is not underlain by either a large air- or fluid-filled cavity.

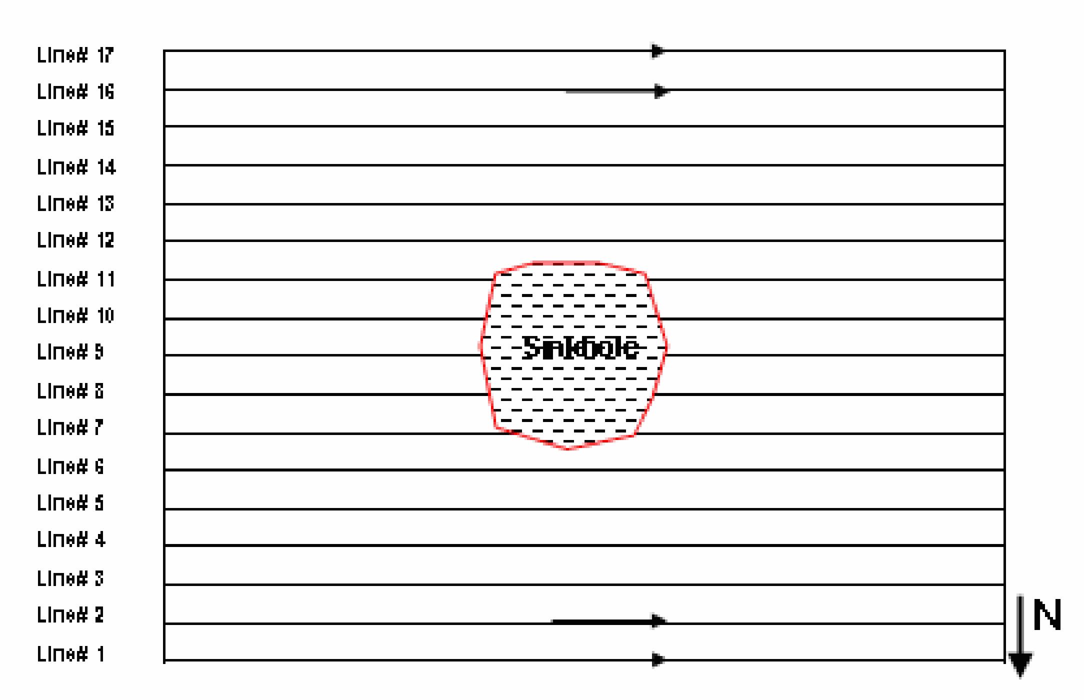

Figure 16: A single grid of electrical resistivity profiles was acquired at the Jefferson County site. The grid consisting of 17 profiles spaced at 25 ft intervals, were acquired using an electrode spacing of 12 ft.

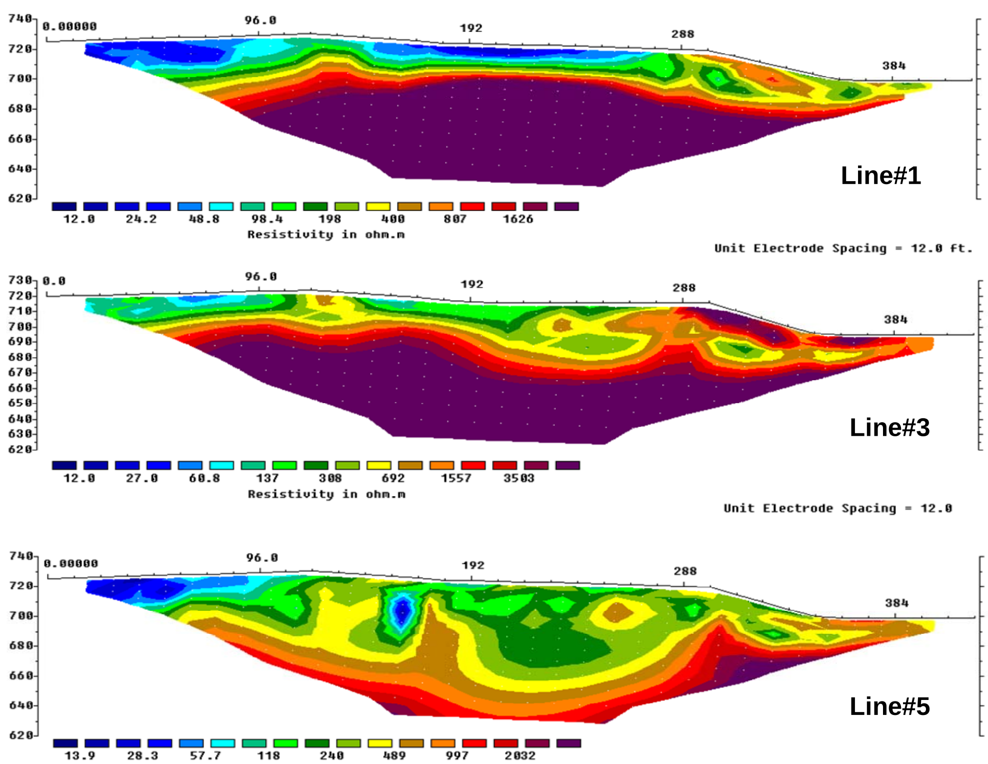

Figure 17: Electrical resistivity profiles 1, 3 and 5.

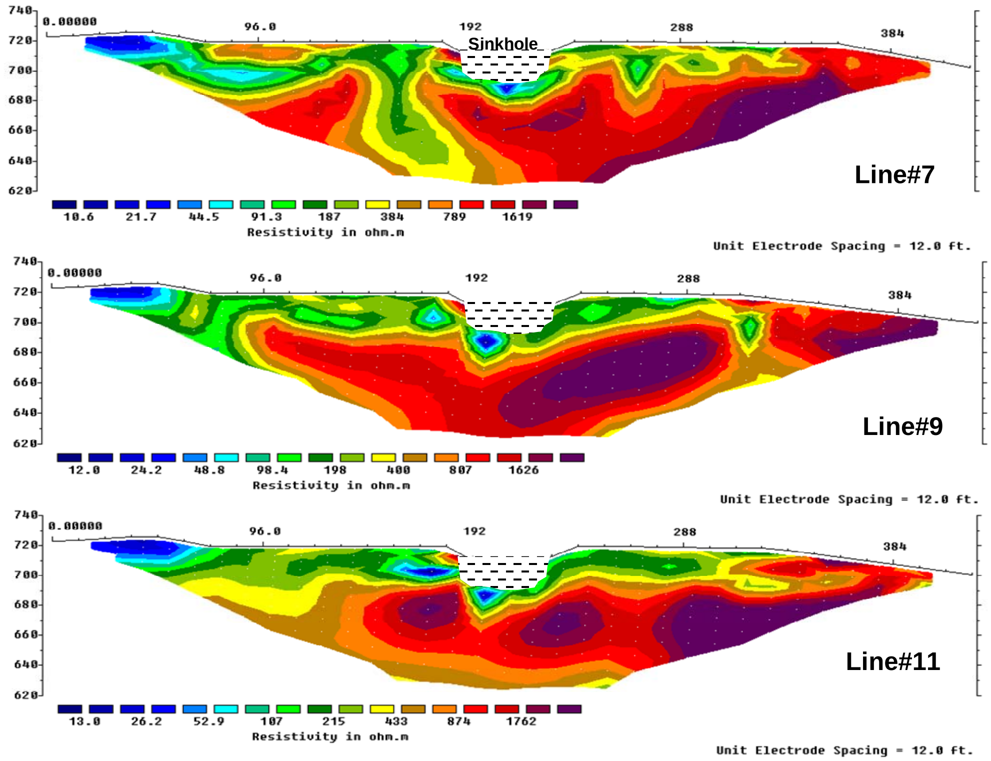

Figure 18: Electrical resistivity profiles 7, 9 and 11.

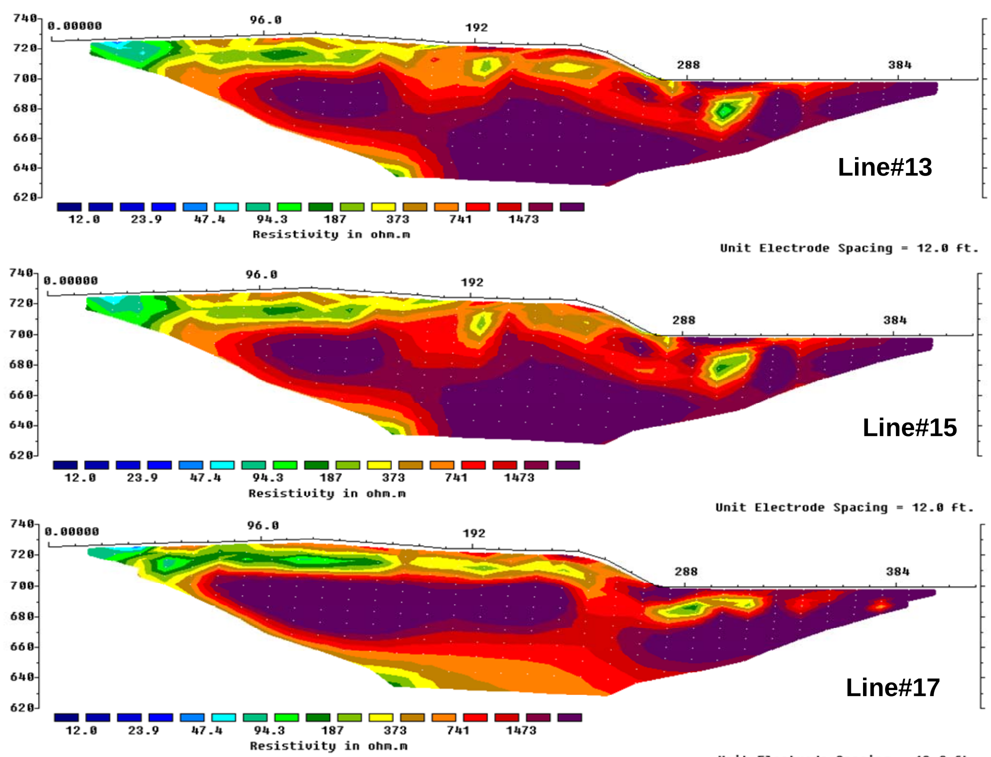

Figure 19: Electrical resistivity profiles 13, 15 and 17.

The subsurface immediately to the north and northeast of the sinkhole is characterized by a different pattern of resistivity values. More specifically, a vertical-trending narrow (<10 ft wide) zone consisting of anomalously low resistivity values (between ~127 and 400 ohm-m) is observed immediately to the east of the sinkhole on profile 8 (Figure 18). This feature is interpreted as a prominent clay-filled solution-widened joint or zone of intensely fractured rock with clay-infill, and extends across profiles 7, 6 and 5. A prominent zone of relatively low resistivities is also observed at depths of between 40 ft and 70 ft on profile 6 immediately to the north of the sinkhole (Figure 18).

The resistivity profiles support the interpretation that the ”emptied” sinkhole is not underlain by a substantive air- or fluid-filled cavity. Further, the geophysical data support the interpretation that the sinkhole was “drained” by rainfall runoff that flushed the clay into the subsurface through existing joint/fracture conduits immediately to the east of and in hydrologic communication with the sinkhole. The fact that the postulated conduit is now characterized by low resistivities and the observation that ponded water remained in the sinkhole days after the feature formed, suggests drainage stopped after the conduit became “choked” with clay.

CONCLUSIONS

The case studies demonstrate that electrical resistivity profiling can be successfully used to image the subsurface in karst terrain because the tool is ideally suited to differentiating surficial soil, clay, weathered rock, intact rock, and air-filled cavities. Clays in Missouri are normally characterized by low apparent resistivities (variable, depending on moisture content, purity, and unit shape/size, but usually less than 100 ohm-m). Relatively intact rock is characterized by higher apparent resistivites (typically more than 400 ohm-m, but variable depending on layer thickness, moisture content and impurities). Air-filled voids are generally characterized by very high apparent resistivities (typically >2000 ohm-M, but variable depending on the conductivity of the encompassing strata and size/shape of void). The term “apparent resistivities” is used here because the resistivity values output during processing have been laterally and vertically averaged.

The resolution provided by the resistivity technique is mostly a function of the electrode spacing. During processing, the subsurface is subdivided into pixels with lateral dimensions equal to the electrode spacing and vertical dimensions that are typically 1/4 (shallow depth) to ½ (greater depth) of the electrode spacing. Pixel dimensions can be considered one estimate of spatial resolution.

Two-dimensional (2-D) electrical resistivity profiles were acquired across and in proximity to active sinkholes at two Missouri Department of Transportation highway-construction sites. Construction site #1 is located in Greene County, Missouri; site #2 is located in Jefferson County, Missouri.

The primary objective of the Greene County resistivity study was to determine if substantive air-filled karstic cavities were present in the subsurface. Secondary objectives were to estimate depth to bedrock and identify anomalous subsurface conditions that might compromise the integrity of the proposed intersection or complicate construction. An inactive sinkhole in-filled with thick under-compacted clays for example, could represent a potentially problem in that the clays could densify under load resulting in roadway settlement. The drilling results conducted earlier at this site could not accurately define bedrock topography, because many of the drill holes were stopped short when they intersected limestone lenses situated above bedrock. This finding proves that auger drilling alone cannot be used for delineation of bedrock topography in the karst terrain but should be down in conjunction with electrical resistivity profiling. The electrical resistivity data proved to be of significant utility. Substantive air-filled voids were not imaged on the resistivity profiles and a depth to bedrock structure contour map was generated for the site. However, clay-filled inactive sinkholes were identified beneath a segment of the proposed new roadway.

A relatively dense grid of electrical resistivity data was also acquired at the Jefferson County site. These data were acquired because an oval-shaped sinkhole developed almost overnight near the centerline of the northbound lanes after overlying soil had been stripped to bedrock. The primary concern was concern that the sinkhole was underlain by a large air- or fluid-filled cavity. The interpretation of the resistivity data indicated the reactivated sinkhole was not underlain by a substantive void. Rather, the soil in the sinkhole appears to have “flowed” into the subsurface through solution-widened joints that do not pose a significant in terms of catastrophic collapse under load.