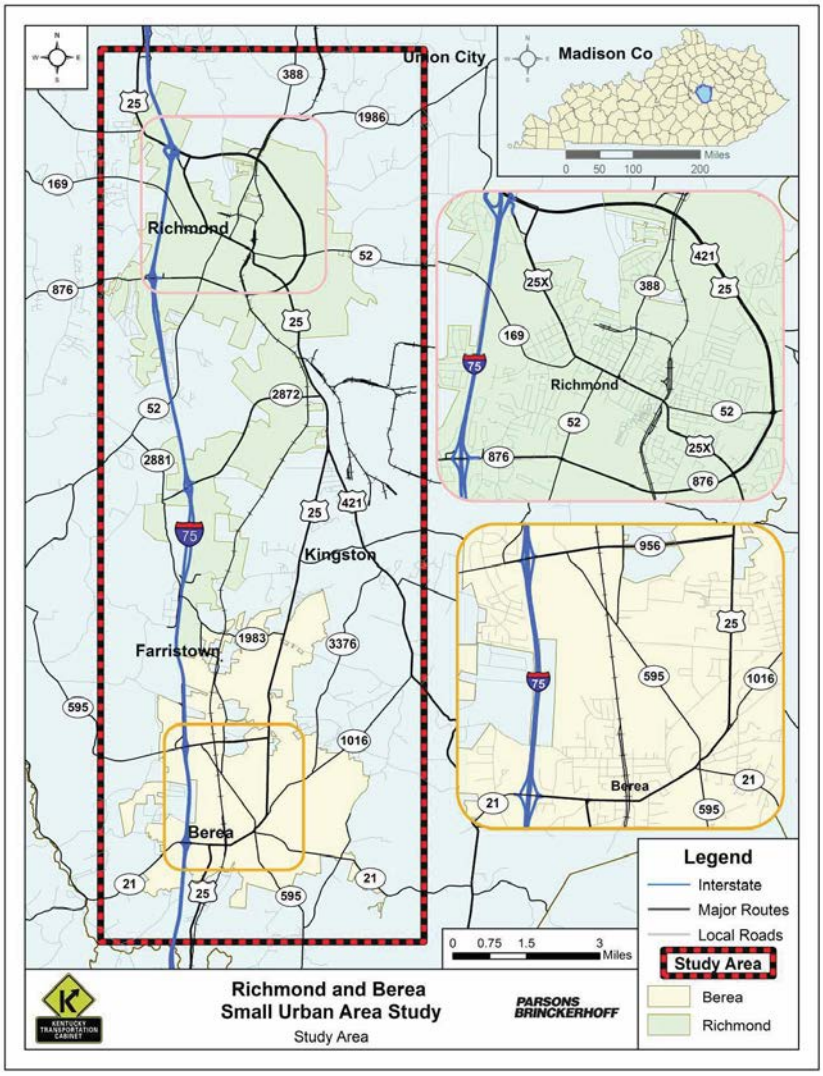
APPENDIX D:

GEOTECHNICAL OVERVIEW

GEOTECHNICAL OVERVIEW REPORT



Richmond and Berea
Small Urban Area (SUA) Study
Madison County, KY

LOCATIONS
(37.806960) (-84.337263)
(37.552959) (-84.224853)

Report No P-002-2016
February 2016

AEI
AMERICAN
ENGINEERS, INC.

January 25, 2016

Ms. Amy J. Thomas, PE
Senior Project Manager
Parsons Brinckerhoff
1792 Alysheba Way
Suite 230
Lexington, KY 40509

Re: Geotechnical Overview Report
Richmond and Berea
Small Urban Area (SUA) Study
Madison County, Kentucky
AEI Project No. 216-003

Dear Ms. Thomas:

American Engineers, Inc. Field Services Center is pleased to submit this geotechnical overview that details the results of our review of the above referenced study area.

The attached report describes the site conditions and near-surface geology and also details potential design recommendations for the proposed project. The Appendices to the report contains a karst potential map for the study area, area geologic map and also an oil and gas well approximate location of the southern portion of the study area.

We appreciate the opportunity to be of service to you on this project and hope to provide further support on this and other projects in the future. Please contact us if you have any questions regarding this report.

Respectfully,
AMERICAN ENGINEERS, INC.

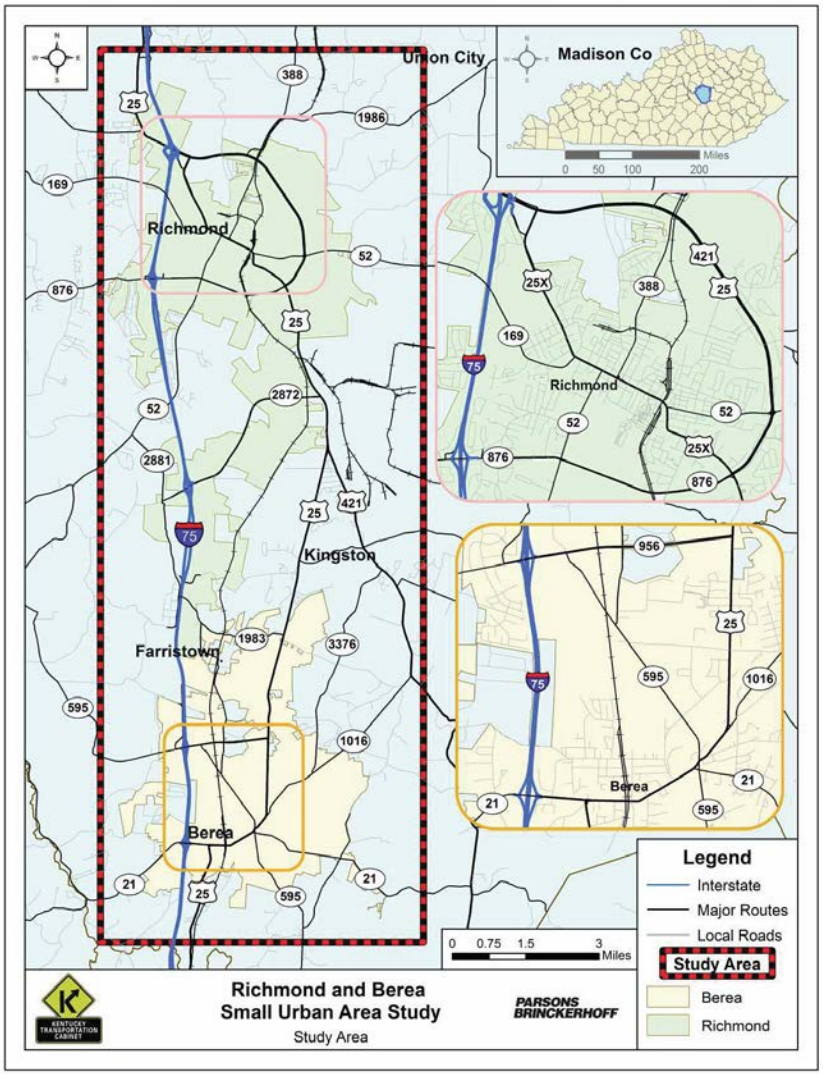
Brad High, PG
Project Geologist

William Broyles, PE
Senior Geotechnical Engineer

Geotechnical Overview Report

Richmond and Berea

Small Urban Area Study



Geotechnical Overview
Richmond and Berea
Small Urban Area Study
Madison County, Kentucky

1. Project Description

The study area includes a band along I-75 from about three miles north of downtown Richmond south to about two miles south of downtown Berea. The westernmost extent of the study area lies about one mile west of I-75 and the easternmost extent of the area lies about five to six miles east of I-75. The project is a Small Urban Area (SUA) study for the cities of Richmond and Berea, Kentucky along with a portion of the surrounding unincorporated area of Madison County. Approximate coordinates for the northwestern section of the study areas are 37.806960, -84.337263 and approximate coordinates for the southeastern section of the study area are 37.552959, -84.224853. The purpose of the SUA is to identify and analyze transportation issues related to safety, operations and congestion in the study area with consideration of both short and long term improvements.

The purpose of this project will be to provide engineering services for the completion of a Small Urban Area (SUA) planning study for the Richmond and Berea, Kentucky small urban areas along with a portion of the surrounding unincorporated area of Madison County.

This geotechnical overview was conducted in relative accordance with a copy of Scope of Work for Geotechnical Overviews for Planning Studies provided by KYTC Planning Division, as well as Section 801 of the Kentucky Transportation Cabinet Geotechnical Manual. The study was conducted during January, 2016 and included geologic research of available geologic and topographic quadrangle maps, soil survey of Madison County, Kentucky, as well as online resources

available from the Kentucky Geological Survey and the United States Geological Survey. Past reports from geotechnical investigations of portions of the existing roadways and structures in the area were also reviewed in preparation of the overview. This geotechnical overview is intended to indicate general geotechnical concerns associated with roadway construction in the study area. A table of available reports reviewed is included at the conclusion of this report.

2. Site Geology

United States Geological Survey (USGS) 7.5-minute geologic quadrangle maps were reviewed for the study area. The Kentucky Geologic Map Information online along with the following maps were reviewed:

- *Geologic Map of the Union City Quadrangle, Madison and Clark Counties, Kentucky, USGS, 1967*
- *Geologic Map of the Moberly Quadrangle, Madison and Estill Counties, Kentucky, USGS 1968*
- *Geologic Map of the Bighill Quadrangle, East-Central Kentucky, USGS, 1971*
- *Geologic Map of the Berea Quadrangle, East-Central Kentucky, USGS 1967*
- *Geologic Map of the Richmond South Quadrangle, Madison County, Kentucky, USGS 1966*
- *Geologic Map of the Richmond North Quadrangle, Madison and Fayette Counties, Kentucky, USGS 1967*

Available geologic mapping indicates the study area is underlain primarily by, in order of descending order of lithology, Quaternary-aged alluvium and terrace deposits, the Lee, Newman Limestone, Borden, New Albany Shale, Boyle Dolomite, Crab Orchard and Brassfield Dolomite, Drakes, Ashlock and Calloway Creek Limestone Formations. These formations range in age from lower Pennsylvanian to Upper Ordovician age.

Mapping indicates the Quaternary-aged alluvium and terrace deposits consist of variably graded sand, silt, clay and gravel. The Lee Formation is comprised of mudstone, shale and siltstone with lesser instances of sandstone and coal. A conglomeratic sandstone member also may be encountered near the base of the formation in some parts of the study area. The Newman Limestone contains mostly micrograined to coarse grained oolitic limestone with lesser instances of shale.

The Borden Formation is the thickest mapped unit in the area and is comprised of shale with lesser instances of siltstone, mudstone and limestone. Portions of the formation comprised of shale or mudstone are fairly nonresistant to weathering, or nondurable and form to weather to long slopes and may be problematic in steep cuts.

The New Albany Shale Formation is often used as a marker bed in the region since the formation is readily identifiable and consistently present in the area. The black shale of the New Albany is carbonaceous and contains sparse finely crystalline pyrite. While the New Albany Shale is typically durable, when exposed in open cuts or near the surface when utilized as fill acidic runoff may result due to the presence of the pyrite within the bedded material when exposed to water.

The Boyle Dolomite, Crab Orchard Brassfield Dolmite and Drakes Formations consist of dolomite and mudstone. The mudstone of these formations will generally be nondurable and will deteriorate rapidly where exposed to weather.

The remaining formations, the Ashlock and Calloway Creek Limestone, are comprised mostly of limestone with lesser instances of mudstone and shale. These formations will likely be encountered at lower elevations in the area.

Geologic mapping indicates the study area to be dissected by a series of faults that generally trend northwest to southeast in the northern part of the study area and southwest to northeast in the southern part. Named faults in the study area include the Richmond Fault in the Richmond North quadrangle and the Tate Creek Fault in the Richmond South and Moberly quadrangles. Karst potential mapping provided by the Kentucky Geologic Survey indicates that the study area exhibits karst potential ranging from non-karst to medium karst or karst prone. Numerous closed depressions were also indicated on karst potential mapping. The majority of closed hachures on topographic mapping indicating surface depressions along with the medium karst potential areas lie west of Interstate 75 and north of Berea. A karst potential map of the study area is included in the Appendix. Regional dip of the study area was reviewed based on structure contours drawn on the base marker beds on geologic mapping. Regional dip of the study areas was determined to trend relatively toward the east and southeast at rate ranging from about 30 to 60 feet per mile, or one-half to one percent. Geotechnical reports reviewed indicate that the residual soils within the study typically classify as low to moderate plasticity clays with USCS Classifications of CL or CH and lesser instances of silt, or ML. Geotechnical reports also indicate depths to bedrock will vary greatly dependent upon local geology, however normally will not exceed 15 feet beneath the existing ground surface in most areas. Published mapping indicated both active and abandoned quarries to lie within each quadrangle at the time the mapping was completed.

3. Topography and Drainage

Most of the study areas lie within the Outer Bluegrass physiographic region of central Kentucky, while the southern portion of the county includes the outer edge of the Eastern Kentucky Coal Field (McGrain and Currens, 1978). Topography of the study area may best be described as ranging from gently rolling or hilly near Richmond to mountainous in the vicinity of Bighill. Surface runoff in the area typically drains in a dendritic patter or is intercepted by surface depressions and sinkholes. In general, low-lying areas in karst terrain or

sinkhole plains will tend to exhibit soft, silty and wet soils. These areas will also be more prone to sinkhole collapse during and following construction of any new roadway or structures.

Underground drainage is a function of surface and groundwater flows that are controlled by the nature of these rocks and the associated surface features. Slopes generally control the runoff from precipitation and stream drainage, with ridgelines forming drainage boundaries. Underground water in most watersheds and drainage basins tend to follow the lay of the land. Yet, in areas containing soluble limestone or karst regions, the underground drainage may differ from the boundary of its surface watershed; flowing through caves, cracks or faults in the rocks beneath surface ridges. This phenomenon is typically referred to as misbehaved karst drainage (Kentucky Division of Water).

4. Geotechnical Considerations

- Subgrade soils which lie within the study area are anticipated to have a design CBR value ranging from 3 to 6. Chemical treatment, such as lime or cement stabilization may be desired to effectively stabilize road subgrades. Some past geotechnical reports indicate sufficient quantities of rock from roadway excavation may be available for stabilization for specific sites.

- Wet areas could require stabilization for embankment construction. Likewise, subgrade soils under existing pavements could be very wet and might require stabilization if pavements are removed due to grade changes, etc.

- Any open sinkholes or solution cavities identified within the construction limits that are not utilized for drainage purposes should be filled and/ or capped in accordance with Section 215 of the current edition of the Standard Specifications for Road and Bridge Construction.

- Sinkholes were noted within the study area during review of geologic mapping. Any sinkholes utilized for drainage purposes for new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize siltation of open sinkholes and adhere to KYTC Drainage policy.

- High plasticity clays may be encountered within the study area. High plasticity clays tend to shrink and swell with corresponding changes in moisture content. These areas will best be delineated after a thorough geotechnical investigation and subsequent lab testing. Treatment methods will vary dependent upon lateral and vertical extent of any high plasticity clays. Chemical treatment of subgrade soils such as lime or cement is one method to minimize the shrink/ swell potential of expansive clays.

- Any new structures or existing structures scheduled for widening as part of the roadway realignment are likely to be designed for nonyielding foundations or H-piles on bedrock. Specific site investigations will be required for any new structures or additions to existing structures once locations are known.

- The New Albany Shale Formation is known to be present near the surface within the study area and may be encountered during any new construction. The New Albany Shale Formation is often pyritic in nature which can produce acidic runoff when exposed to water. Site specific treatment should be anticipated as directed by the Engineer to minimize the potential for acidic runoff where the New Albany Shale is encountered.

- If encountered, the New Albany Shale shall be encased in the embankments with a minimum of 2 ½ feet (measured perpendicular to the fill slope) of non-durable gray shale and/or clay soil on the bottom and side slopes and a minimum of four feet cover (from finish grade) of non-durable shale and/or soil on top of the embankment. The embankment encasement shall be constructed in a maximum of 8-inch lifts. A minimum ½ feet of topsoil should be spread loosely and/or loosely compacted on the outside of these slopes for vegetation. Adequately vegetate these slopes immediately after completion to prevent erosion.

- The cut slopes in the New Albany Shale shall be over-excavated a minimum of 4 ½ feet and shall be serrated. A minimum of four feet (measured perpendicular to the slope) of clay soil shall be compacted horizontally on the serrated cut slopes. Compact this material in maximum 8-inch (loose thickness) lifts. A minimum ½ feet of topsoil should be spread loosely and/or loosely compacted on the outside of these slopes for vegetation. Adequately vegetate these slopes immediately after completion to prevent erosion. If the New Albany Shale is not disturbed, mitigation is not required.

- Adequate drainage will be of primary concern with any new design or new construction in the area to minimize environmental impacts by surface runoff into the underlying karst network. Proper management of surface water will also lessen the occurrence of sinkhole dropouts during construction. Mitigation of surface runoff should be performed by silt checks, silt traps, sediment basins and lined ditches where appropriate. Siltation of sinkholes should be avoided, especially those to remain open after construction.

- Roadway embankments and cut slopes will be required for construction of the new roadway. Based on prior experience with residual soils weathered from the geologic formations which underlie the study area, embankments constructed at 2H:1V or flatter will likely provide an acceptable factor of safety for embankments less than 60 feet in height. Soil cuts in the residual soils can be problematic due to softening of the clays upon exposure in the cuts. Likewise, a review of area geology indicates nondurable shale may be encountered in some areas which typically require flatter slopes to be stable. Soil cut slopes should not be steeper than 2H:1V. Based on review of the KYTC Geotechnical Manual, typical cutslope configurations for massive limestone will vary from ½H:1V to ¼H:1V. During design of cut slopes in bedrock, the presence of joints, fractures, solution features and crossbedding should be taken into consideration. Final cut and fill slope geometries should be determined after conducting site specific geotechnical investigations.

- Oil or gas wells, many of which have been abandoned, were identified through review of online mapping review of the study area. The wells noted were concentrated in the southern part of the study area. Any oil or gas wells identified prior to or during construction should be closed in accordance with Section 708 of the current edition of the Standard Specifications for Road and Bridge Construction. Approximate locations of mapped wells in the southern portion of the study area are indicated on a drawing at the conclusion of this report. Locations were derived from the oil and gas well database on the Kentucky Geological Survey database online.

- Numerous water wells and springs were indicated to lie within the study area upon review of online mapping. Any water wells, cisterns, manholes or catch basins not incorporated into any new design and identified prior to or during construction should be closed in accordance with Section 708 of the current edition of the Standard Specifications for Road and Bridge Construction.

- A list of previously completed Geotechnical Investigations which were reviewed and are proximate to the study area is included below. These reports can be accessed through the KYTC Geotechnical Branch Database.

List of Projects & Reports

Project ID	Project Type	Route	Project Description
R-047-2000	Roadway	I-75	Madison County Rest Area
R-012-1996	Roadway	!-75	I-75 Northbound Rest Area
R-013-1996	Roadway	I-75	I-75 Southbound Rest Area
R-003-1995	Roadway	I-75	Berea-Richmond Rd (I-75), Section 1
S-090-1990	Structure	I-75	I-75 over Tate Creek
R-023-1998	Roadway	I-75	I-75 (Congleton Lane)
S-019-1998	Structure	I-75	I-75 Bridge over KY 595
R-003-2004	Roadway	I-75	I-75 Duncannon Rd Interchange
R-045-2003	Roadway	I-75	Duncannon Rd Sections I & II
S-045-1984	Structure	I-75	I-75/ KY 595 Interchange Culverts
P-003-1975	Planning	Bypass	Richmond Bypass

5. Summary

Karst terrain, pyritic shale, nondurable shale, soft soils and existing development in the study area will be likely be the most detrimental factors to any new construction in the area. Much of the study area is also developed which can mask the existence of karst features such as sinkholes and surface depressions. The soils and bedrock which underlie the study area are highly variable, with each formation presenting its own set of issues with regard to construction. Separate site specific studies and corresponding geotechnical investigations should be performed prior to construction of individual projects within the broader SUA study area. While any new construction within the study area will not likely be at any greater risk to ground subsidence or other impact from karst, pyritic shale, nondurable shale or soft soils than existing roadways and structures which

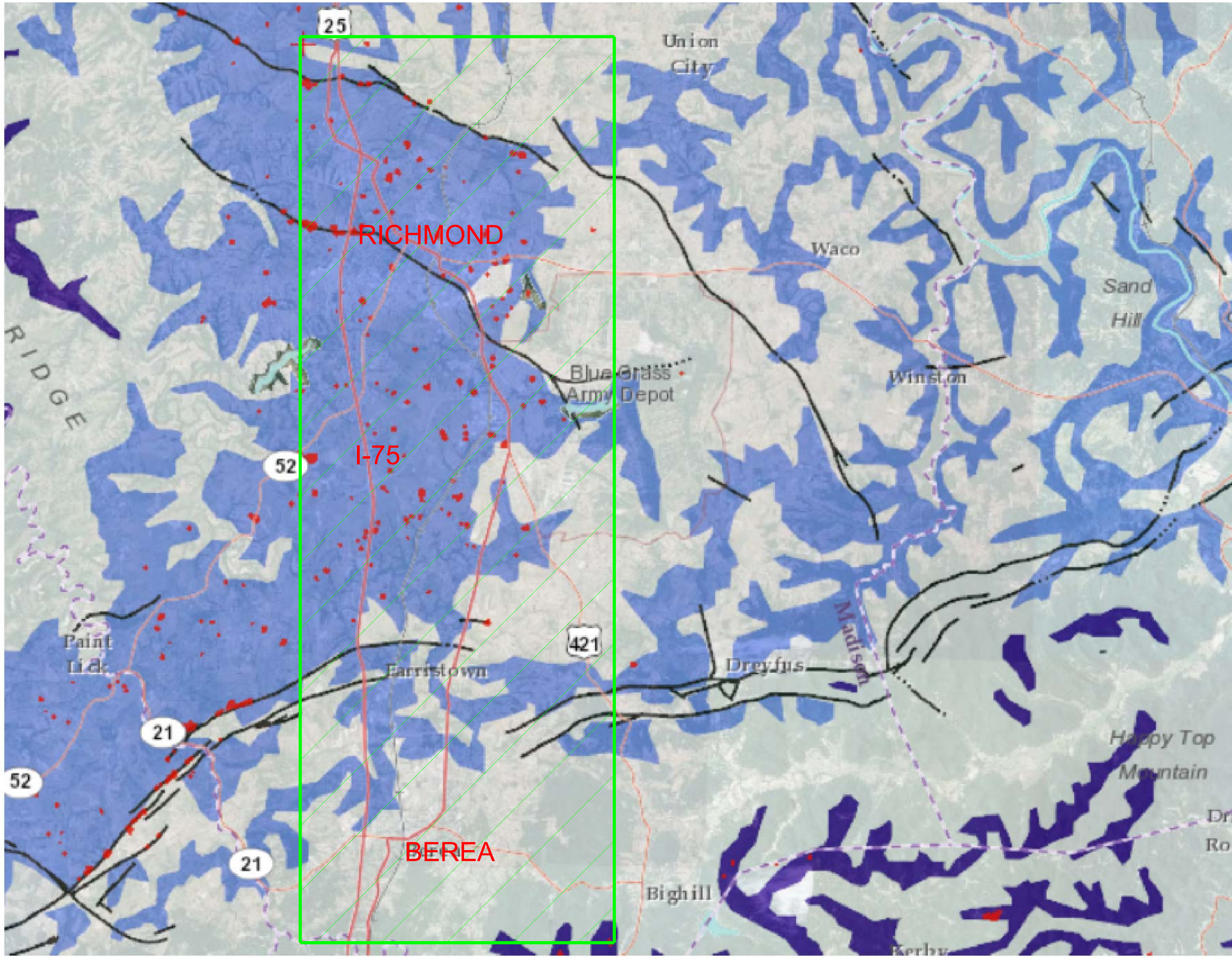
lie within the study area, a site specific geotechnical investigation will provide critical information with regard to karst potential, problematic soils and other pertinent information for design.

APPENDIX

Karst Potential Map

Geologic Map

Oil and Gas Well Locations Map



LEGEND

Karst Potential Units

- intense
- prone
- non-karst

APPROXIMATE STUDY AREA

SINKHOLE

REVISIONS

NO.	DATE	DESCRIPTION

GOELOGIC QUADRANGLE MAP

CLIENT: Parsons Brinckerhoff

PROJECT: Small Urban Area Study Richmond and Berea

AMERICAN ENGINEERS, INC.

SCALE: NTS

DATE: 01-11-15

DRAWN BY: J. CHILDRESS

CHECKED BY: B. HIGH

FILE: T:/Geotech Support/KYTC/216-XXX Richmond - Berea SUA Geotechnical Overview/Support Information/Richmond Karst Map.dgn

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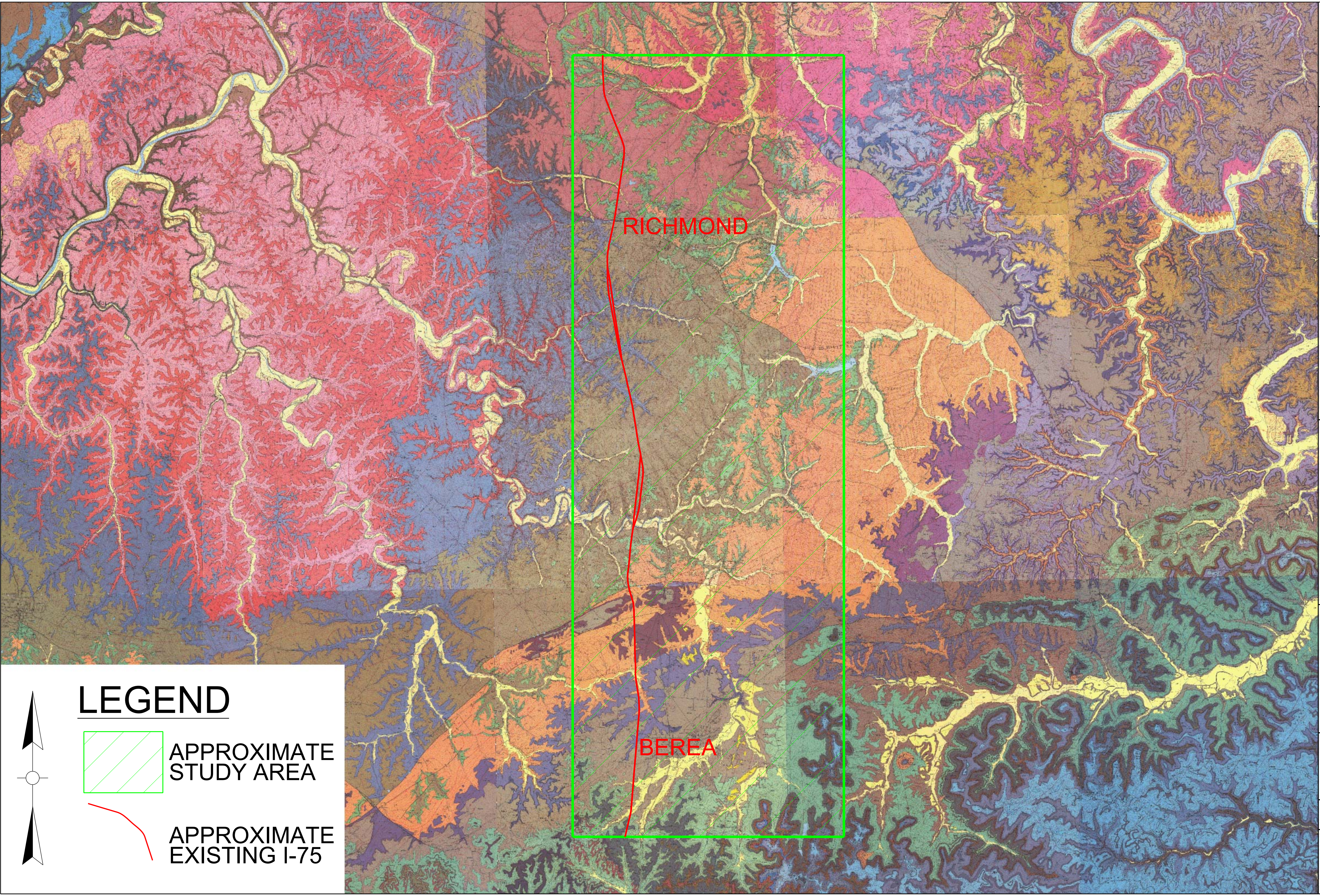

REVISIONS

NO. | DATE | DESCRIPTION

GOELOGIC QUADRANGLE MAP

CLIENT: Parsons Brinckerhoff

PROJECT: Small Urban Area Study Richmond and Berea

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SCALE: NTS

DATE: 01-11-15

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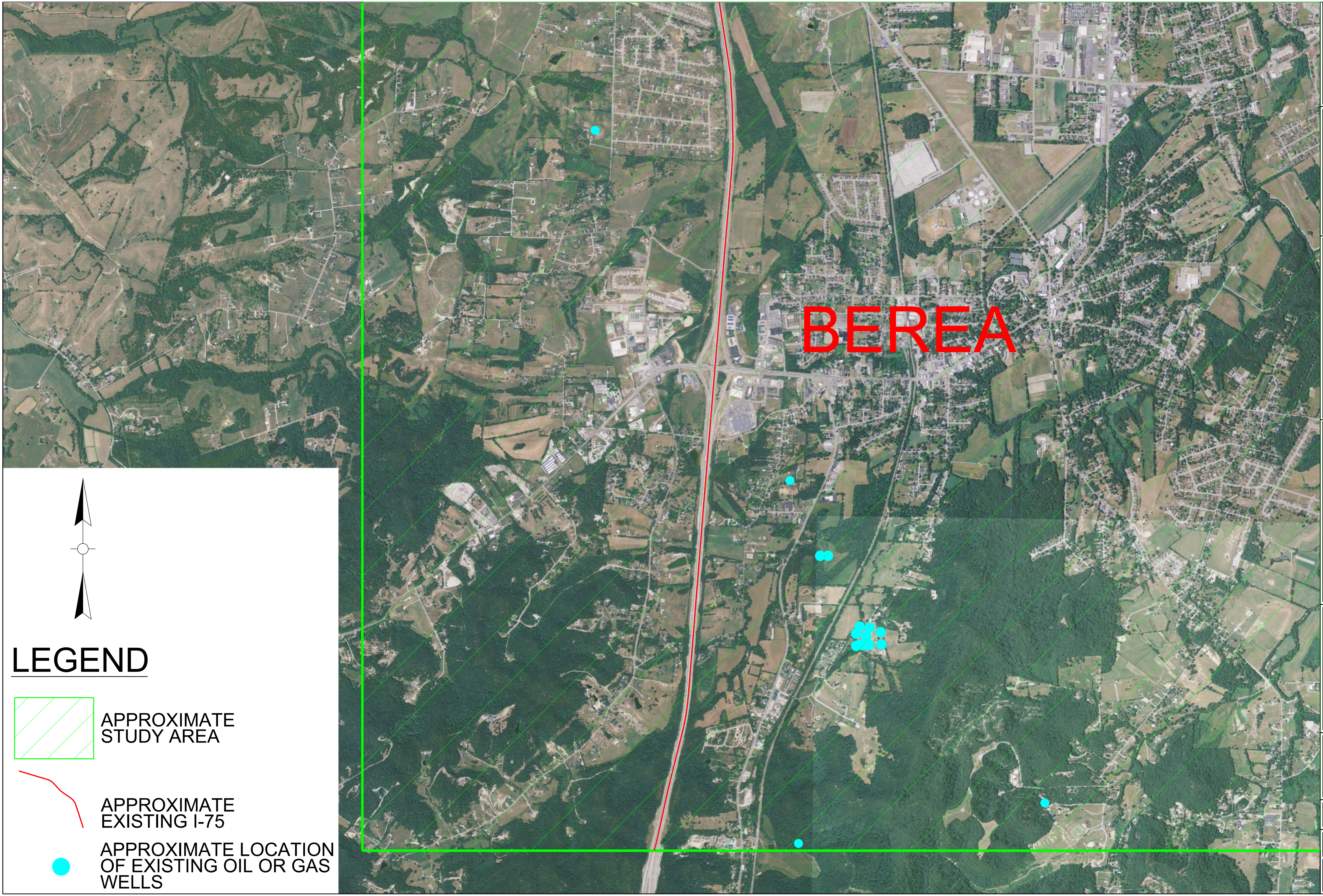
CHECKED BY: B. HIGH

FILE: T:/Geotech Support/KYTC/216-XXX Richmond - Berea SUA Geotechnical Overview/Support Information/Richmond GQ Map.dgn

SHEET: Q1



REVISIONS		
NO.	DATE	DESCRIPTION

SOUTHERN STUDY AREA OIL AND GAS WELL LOCATIONS

CLIENT: Parsons Brinckerhoff

PROJECT: Small Urban Area Study Richmond and Berea

PLANS PREPARED AND SUBMITTED BY:
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DATE: 01-11-15

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CHECKED BY: B. HIGH

FILE: T:/Geotech Support/KYTC/216-XXX Richmond - Berea SUA Geotechnical Overview/Support Information/ Richmond Oil Gas Map.dgn

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