

MEMORANDUM

TO: Dave Heil, PE
Transportation Engineer Specialist
Office of Project Development

FROM: Christian Wallover, PG
Branch Manager
Engineering Geology & Field Services Branch

BY: Sean House, PG
Deven Carigan
Maxwell Mickelson
Engineering Geology & Field Services Branch

DATE: July 3rd, 2024

SUBJECT: Nicholas County
FD04 091 0032 009-013P
Safety Improvements Along KY-32
From Lake Rd. (MP 9.5) to Scrubgrass Creek (MP 12.5)
Item # 09-8812.00
Mars # 1528401P
Geotechnical Overview Report

1.0 Project Description

The Kentucky Transportation Cabinet (KYTC) is conducting a study to identify and evaluate the KY-32 (Myers Rd) corridor in Nicholas County, stretching from Carlisle to just east of the intersection with CR-1100 (Scrubgrass Rd) at Scrubgrass Creek. The goal of this study is to identify practical, implementable solutions to improve safety and vehicle throughput for the congested KY-32 corridor. This overview will be utilized to identify geotechnical considerations for the study area.

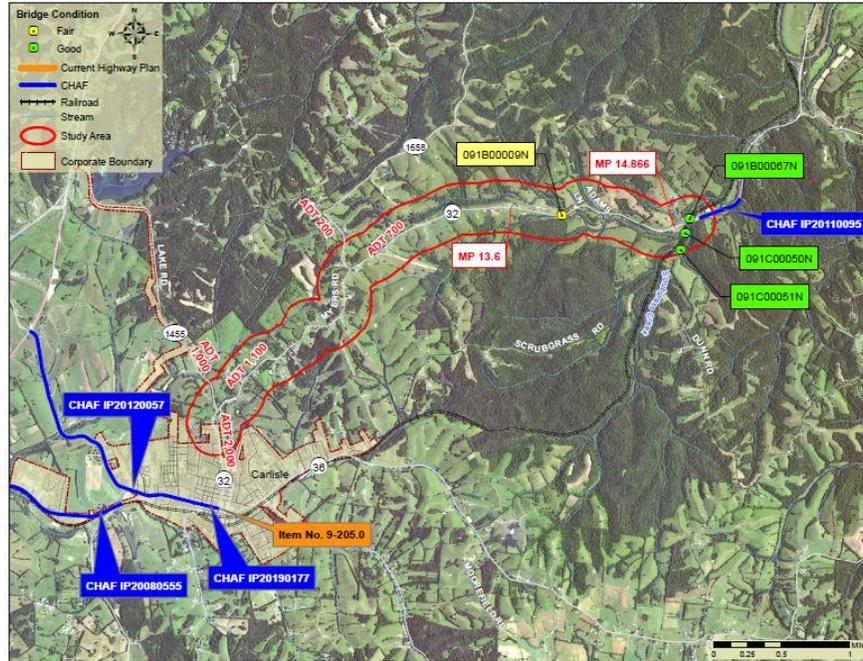


Figure 1: Project location and corridor of KY 32

2.0 Scope of Work

The scope of work for this study consists of performing a geotechnical overview for the proposed study area based upon research of available published data and the Geotechnical Branch's experience with highway design and construction within the region. General geotechnical and geologic characteristics of the study area have been identified and are discussed in this report. The following sources were used to perform a literature search:

- Geologic Map of the Moorfield Quadrangle, Northeastern Kentucky (GQ# 1510), by Perry B. Wigley, published by the USGS, 1978;
- Generalized Geologic Map for Land-Use Planning: Nicholas County, Kentucky of Parts of Carlisle and Moorfield Quadrangles (GQ#s 1450 & 1510), by Daniel I. Carey and Richard A. Smith, published by the USGS, 2006;
- USGS Professional Paper 1151-H: The Geology of Kentucky: Physiography by Wayne L. Newell
- Available ArcMap Datasets and Layers
- USGS Professional Paper 1151-H: The Geology of Kentucky: Ordovician System
- USGS Professional Paper 1151-H: The Geology of Kentucky: Quaternary System
- USGS Professional Paper 1151-H: The Geology of Kentucky: Physiography

2.1 Topography and Drainage

The project study area is located within the Outer Bluegrass Physiographic Region. The topography throughout most of the project site is characterized by rolling hills and moderate local relief, leading to the Licking River Valley at the eastern portion of the study area. Typical vertical

relief is on the magnitude of 100 feet, gradually lowering in elevation west to east from approximately 940' AMSL in Carlisle to approximately 600' AMSL in the Scrubgrass Creek tributary to the Licking River. The eastern portion of the alignment crosses several small streams and runs alongside Scrubgrass Creek.



Figure 2: Typical topography of the Outer Bluegrass region on KY-32

The region is characterized by thick, phosphatic residual soils of exceptional fertility, and sparse outcrops. Soils are thin over Ordovician and Silurian aged bedrock. Shales are common in the region, but poorly exposed. This is underlain by the Kope and Clays Ferry Formations and is known as the Eden Shale Belt.

Surface drainage follows a dendritic pattern, believed to be the result of bedrock with fairly uniform resistance to erosion. In general, groundwater above the river valley is insignificant but hillside seeps and springs are common as groundwater can travel between rock strata and joints.

The flow regime flows in four distinct watersheds, such that the project can be divided into quadrants. The current roadway serves as the north-south divide as it runs along the ridgetops. The east-west divide lies near mile marker 12 (near the intersection with 1658), where the elevation is the highest in the studied section. In the western side of the east-west divide, surface water flows to the south and then west on both sides of the current roadway – eventually converging outside of the project area west of Carlisle into Brushy Fork. To the east of the east-west divide, surface flow is generally towards KY 32 and to the west towards Scrubgrass Creek, which then

enters the Licking River just northeast outside of the project area. In the eastern portion of the project, the road crosses tributaries to Scrubgrass Creek then runs alongside Scrubgrass Creek at the eastern end.

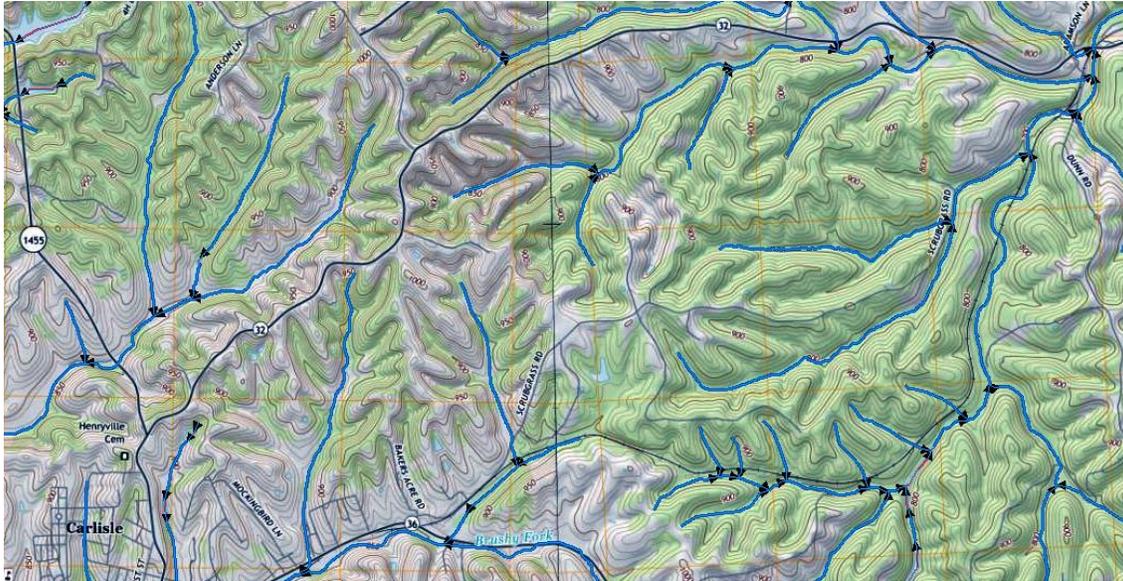


Figure 3: Streams are blue lines and flow paths indicated with black arrows.

2.2 Stratigraphy

The study corridor begins in the eastern portion of the Carlisle Quadrangle (GQ #1450) and ends in the western portion of the Moorfield Quadrangle (GQ #1510). Geologic mapping indicates almost the entire project area to be underlain by Upper and Middle Ordovician aged bedrock. In descending order, they are the Kope and Clays Ferry Formations (Okc), undivided, and the Nicholas Bed of the Tanglewood Limestone Member of the Lexington Limestone (Oltn). A small portion, and easternmost part, of the alignment encounters alluvium (Qal).



Figure 4: Geologic map of project area

The Kope and Clays Ferry Formations (Okc) is the upper most rock formation in the study corridor. The formation consists of interbedded limestone, shale, and siltstone. Limestone composes about 50% of the formation, varies from micro-grained to coarse-grained in beds 1 inch to 3 feet thick. Clastic to bioclastic. Varying areas of cross-bedding, shale interbedding, and fossils. Shale composes about 40% of the formation, limy, uneven bedding from 1 inch to 4 feet thick, mostly 4 to 6 inches thick as interbeds. When exposed to the elements it typically exhibits a very low resistance to weathering. Siltstone composes about 10% of the formation, micrograined, limy, in even beds 1 to 12 inches thick.



Figure 5: Exposed wall of Kope Formation near mile marker 12.3 on KY-32.

Beneath the Kope and Clays Ferry Formations lies the Tanglewood Member (Oln) of the Lexington Limestone. The Tanglewood Limestone is fine- to very coarse-grained, thin to thick beds, commonly cross-bedded.



Figures 6 & 7: Exposed Nicholas Bed of the Tanglewood Member of the Lexington Limestone with eroded shale bed and fracturing near mile marker 14.8 on KY-32.

Drilling logs from two (2) 2020 reports, L-136-2019 and L137 -2019, on landslides along this segment of KY 32 reported depths to auger refusal from approximately 7 to 18' and rock encountered as limestone or shale, weathered or not specified.

A 2015 report, S-113-2015, for a bridge in Carlisle at the westernmost portion of this project reported depths to refusal between 0.1' to 13.2'. Rock cores obtained from this project revealed fossiliferous limestone with some shale laminations and partings, lightly weathered at the top. Recovery was from 94-100% and KY RQD values were from 26-82%.



Figure 8: Locations of area projects

2.3 Soils and Unconsolidated Materials

Residual soils are the predominant soil type found within this area. They are derived in-place from a weathering process of the parent limestone, dolomitic limestone, and shale. The USDA Websoil Survey has soils from Carlisle, KY to just west of Scrubgrass Creek, described as flaggy silty clay, 6 to 20 percent slopes, severely eroded. For the easternmost segment of the project, soils are more varied, being described as either very rocky, 20 to 35 percent slopes, or silt loams, 0 to 12 percent slopes, frequently flooded in gentler slopes and rarely flooded in steeper slopes.

A 2020 report, L-136-2019, provided drill logs from a landslide investigation in the western portion of KY 32. The soil is described as medium stiff, moist clay with rock fragments, to an approximate depth of 3.5' to 18'. And a 2019 report, R-042-2015, reported the soils at the westernmost portion, within Carlisle, as being USCS classifications CL, CH, ML and SC soils in equal distribution.

Silty clays are also present in the study area. They range in depth from 0.5-4.0 feet in depth on gentle to steep slopes and often contain cobbles, stones, or boulders from the thin limestone beds of the Upper Ordovician bedrock formations. These soils tend to contain more clay, due to the weathering of shale, and are not optimal for construction purposes.

Alluvium (Qal) in the eastern portion of the project consists of silt and gravel. Silt is generally clay-like. Gravel fragments vary from 2 to 25 mm in diameter.

2.4 Geologic Structures and Hazards

Karst features are known to be in the Outer Bluegrass Physiographic Region, and karst development should be anticipated in this project area. The western portion of the project is in close proximity to a mapped high karst prone area (Appendix D). Springs are common between the limestone and shale beds and can be observed in the field during heavy rain falls. Any discoveries of sinkholes or springs should be noted and inventoried.

Several landslides were noted during the field visit and have had corrective measures applied. In 2019, two landslides affected 200' and 185' of roadway at mile points 10.0 and 11.1. Details can be seen in reports L-136-2019 and L-137-2019. The driving force behind these instabilities can be attributed to groundwater movement, poor rock mass quality, over steepened slopes, and poor construction processes.

According to geologic mapping (GQ#1450 & 1510) (Appendix B) structural contours, drawn on tops of the Lexington Limestone and Fairview Formation, the underlying bedrock is dipping west-southwest. No faults or other significant structural features are noted in the study area.



Figure 9: Scarp at mile point 10.0

Figure 10: Slope infill near mile marker 13 on KY-32.

Figure 11: Rail correction with lagging near mile marker 11.2 on KY-32.

3.0 Geotechnical Considerations

The goal of this study is to help identify any geotechnical concerns that may affect improvements made to enhance safety on the KY-32 corridor. A site investigation was performed on June 18th, 2024 to help identify any current geotechnical deficiencies with the current alignment. Based on the available resources combined with a site investigation, small geotechnical concerns and considerations will be presented below.

3.1 Cut Slope Considerations

Cut slope configurations in rock are generally controlled by bedrock lithology, bedrock quality, results of Slake Durability Index (SDI) tests in shales and siltstones, and by the presence of any fractures and/or joints. Slope configurations for rock cuts in durable bedrock can generally be 1H:2V presplit slopes on approximate 30-foot intervals of vertical height with 18 to 20-foot intermediate benches or 15-foot overburden benches. Slope configurations for non-durable bedrock or soils are generally constructed on 2H:1V slopes or flatter.

The Kope Formation is the dominant rock formation in the project corridor. Highway projects that intersect the Kope Formation have typically experienced slope stability and maintenance issues associated with the deep Rock Disintegration Zones (RDZ) and the rapid slaking of the newly exposed bedrock. The disintegration mainly occurs in the shale component (50%) of the formation. Slope configurations of 2H:1V or flatter should be anticipated. As the shale in the Kope Formation erodes, large blocks of limestone beds can slide and potentially reach the road. To limit falling rock hazards, roadside ditch benches of 12 (non-interstate) or 18 (interstate) feet are often recommended.

Cut slopes on ridge flanks where deep deposits of colluvium have accrued should be avoided. These areas can be subjected to groundwater seepage, erosion, creep displacement, and expansion/contraction of the shales and residual soils. The removal of toe support can accelerate the rate of creep or cause outright slope failures.

3.2 Embankment Considerations

Most of the anticipated excavated materials should be suitable for use in project embankments constructed on 2H:1V slope configurations or flatter up to 20-feet tall. The material will most likely consist of non-durable shales. Embankments principally of non-durable shale (SDI less than 95 according to KM 64-513) should be constructed using special shale compaction methods. If this construction method is not followed the shale can break down in a few years, causing settlement and potential failures.

Avoiding steep hillside fills can reduce the risk stability issues. Foundation soils are likely to be shallow and consist of low plasticity clays. Any embankments built 20-feet or taller will require stability analyses and may require flatter slopes.

3.3 Saturated, Soft, or Unstable Soils

Due to the nature of the Outer Bluegrass physiographic region and the presence of the Eden Shale belt much of the studied road section rests on bedrock, with very thin residual soils. Where soil is encountered high or low plasticity clays with high silt contents are anticipated. These types of soil can be moisture-sensitive and create subgrade problems where the roadway template is in a shallow fill or in cut conditions. Working platforms and subgrade improvement should be anticipated.

3.4 Water Wells and Springs

As previously noted, the uplands area contributes most or all of the ground water recharge to the streams in the area. An adequate subsurface drainage system may be required to help control artesian conditions and increase stability factors both during and following construction.

Water wells, both active and plugged, are in the vicinity of Carlisle near the beginning of the studied section. Their locations are noted in Figure 12. Springs may also be present within the study area and their locations would need to be noted and inventoried. If any springs or wells are encountered in the right-of-way, special construction will be required to close the wells. Spring boxes and/or granular material may be required in the vicinity of springs.

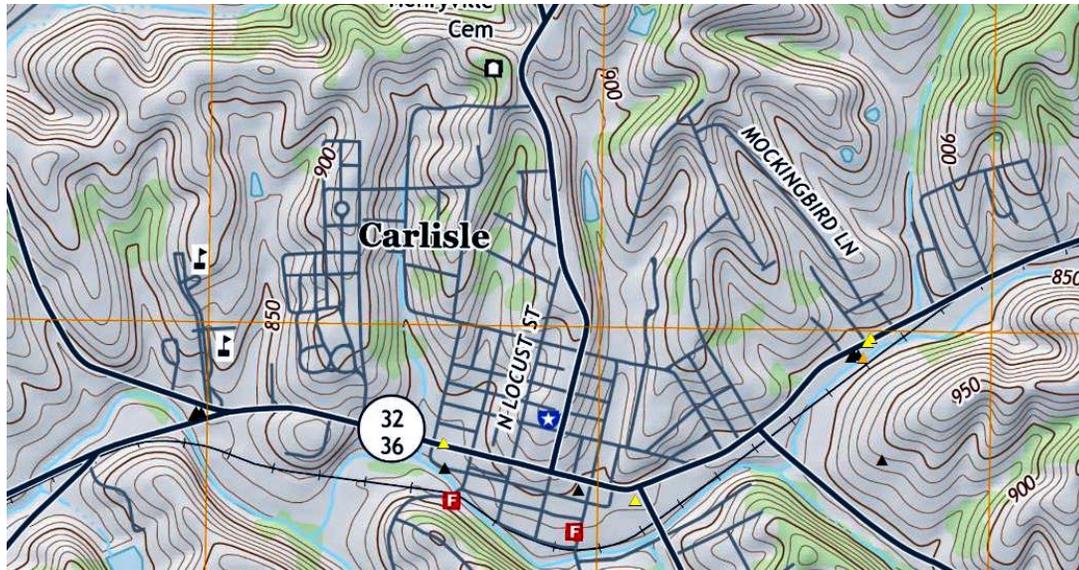


Figure 12: Spring and water wells in Carlisle, KY.

3.5 Karst Conditions

Geologic mapping and field observations does not indicate the presence of sinkholes (Appendix D). Any open sinkhole and/or solution cavities within the limits of construction, whether shown on the plans or not, that are not used for drainage purposes, shall be filled and/or capped in accordance with the current edition of Section 215 of the Standard Specifications for Road and Bridge Construction.

Any sinkholes utilized for drainage purposed for new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize situation of open sinkholes.

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 lesson 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. Situation sinkholes should be avoided, especially those to remain open after construction.

3.6 Structures

At this time, it is unknown as to whether the proposed roadway would require new and/or widened substructure elements. It can be anticipated that most of the bridges within the project study area are likely supported by rock bearing foundation systems. Culverts along the proposed alignments may be replaced or widened. The culverts within the study area are likely supported by either non-yielding or yielding foundation systems depending upon the location along the proposed alignment. A detailed geotechnical investigation will be required to determine the foundation support systems.

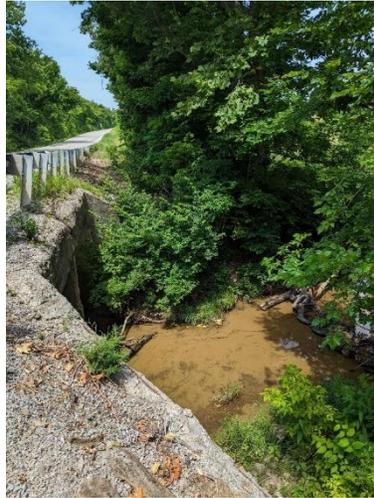


Figure 13: Culvert with exposed bedrock near mile marker 14 on KY-32.

4.0 Conclusions

The purpose of this overview was to provide a general summary of the bedrock, soil, and geomorphic features likely to be encountered within the proposed alignment; and to identify geotechnical features that may have an adverse impact on the project.

Geotechnical drilling will be needed for roadway cut/fills and structures. If a portion of this project will be a widening project, information on existing pavement structure should be obtained to assist the team in pavement design. Chemical modification may not be feasible so a granular subgrade could be utilized. Sampling of foundation soils should be performed for embankment situations.

The information presented in this overview should be reviewed in the general nature in which it was intended. A thorough geotechnical exploration of the proposed alignment and grade will be required to properly anticipate and plan for special requirements necessary for the design and construction of the proposed alignment.

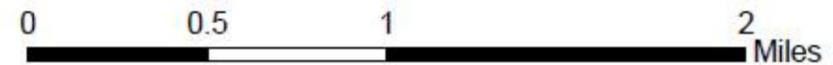
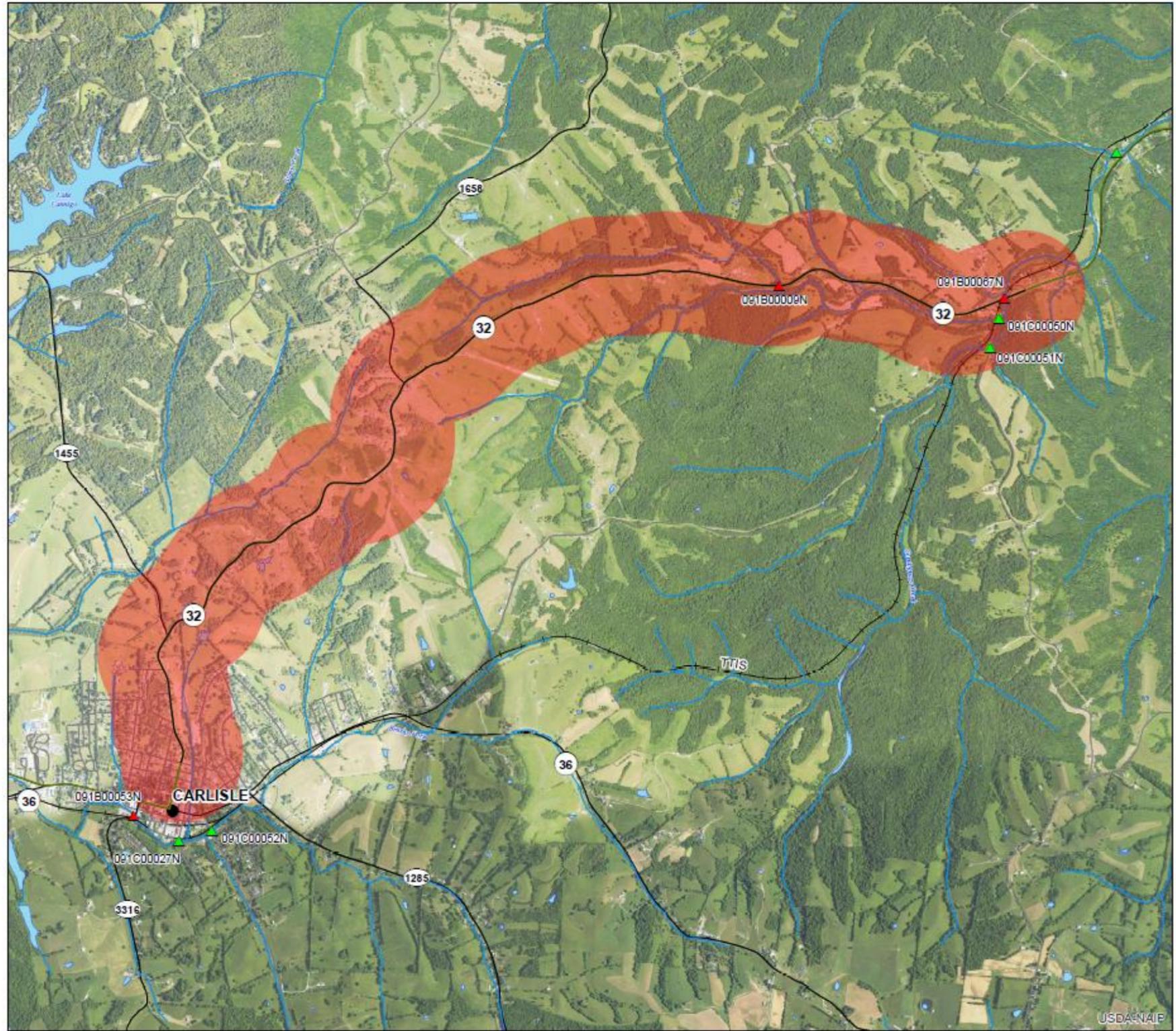
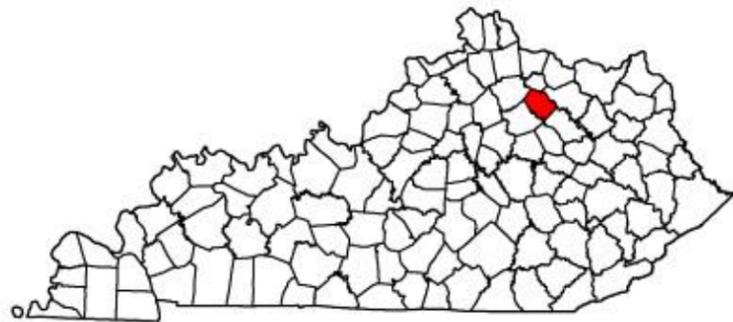
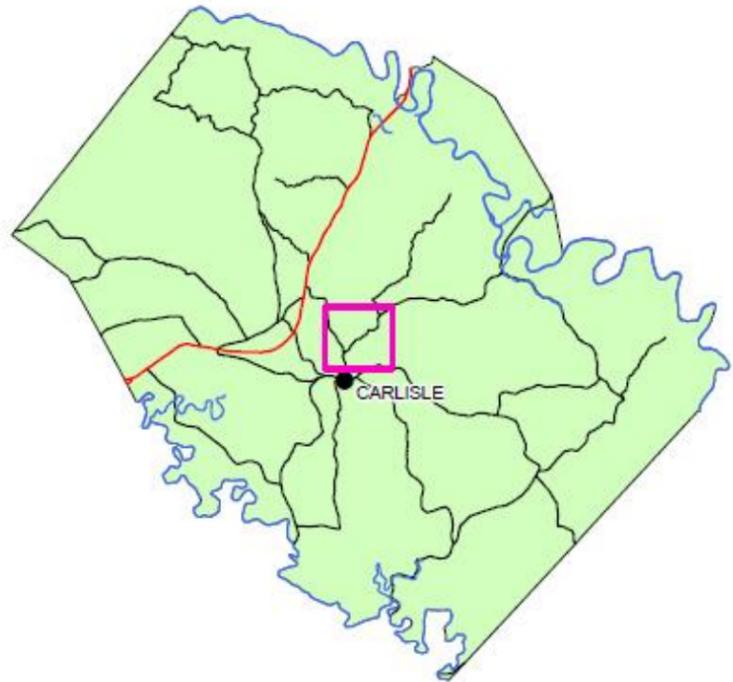
Appendix A

Study Area Corridor

Nicholas Planning Study - Location Map

Legend

- State Roads
- Local Roads
- ▭ Project Location
- Rivers and Streams
- Waterbodies
- +— Active Railroad
- Study Area
- Bridges**
- ▲ City/County Maintained
- ▲ State Maintained



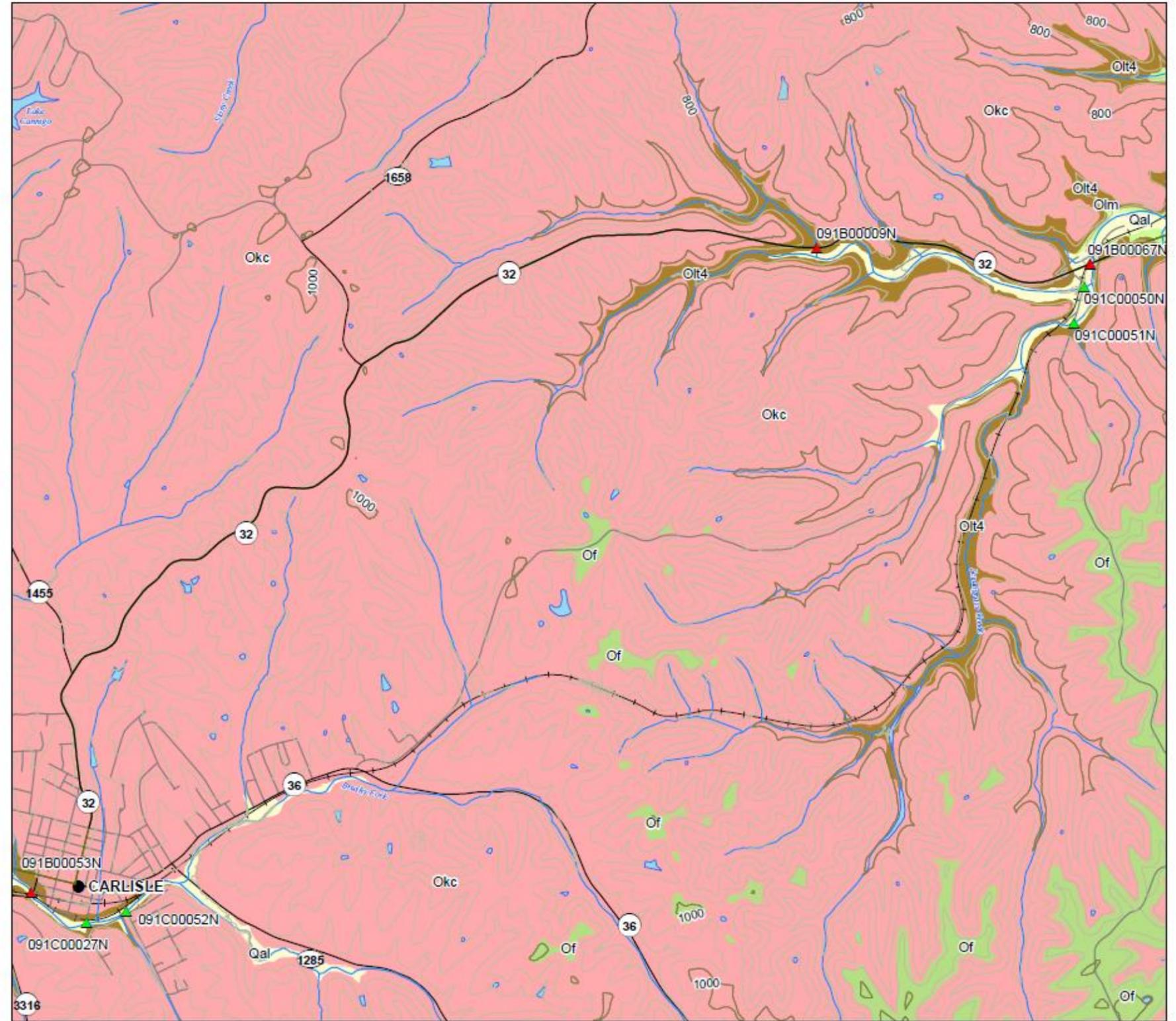
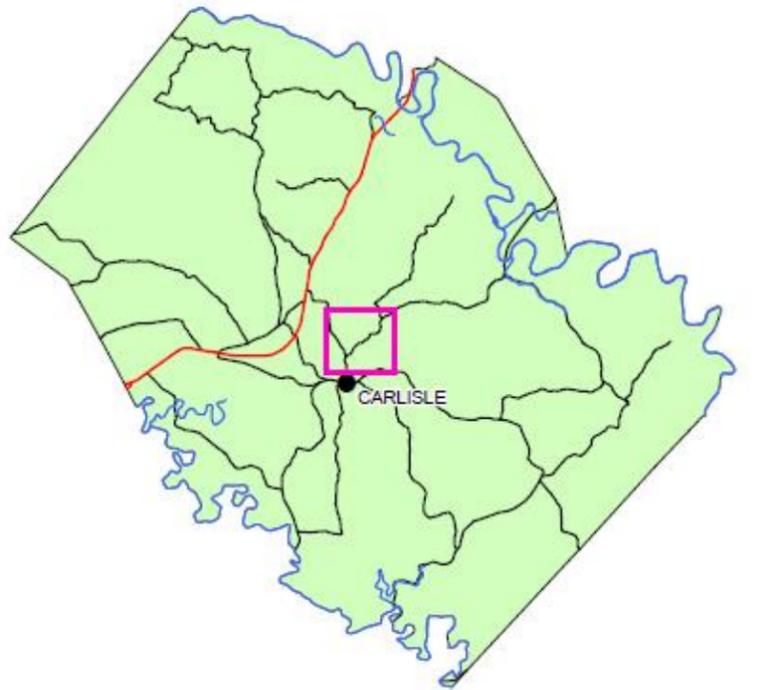
Appendix B

Geologic Map

Nicholas Planning Study - Geologic Map

Legend

- State Roads
 - Local Roads
 - + + Active Railroad
 - Rivers and Streams
 - Waterbodies
 - Project Location
- Bridges**
- ▲ City/County Maintained
 - ▲ State Maintained
- Geologic Formations**
- Qal Alluvium
 - Of Fairview Formation
 - Okc Kope and Clays Ferry Formations
 - Olm Millersburg Member
 - Olt4 Tanglewood Limestone Member No. 4 (upper tongue)



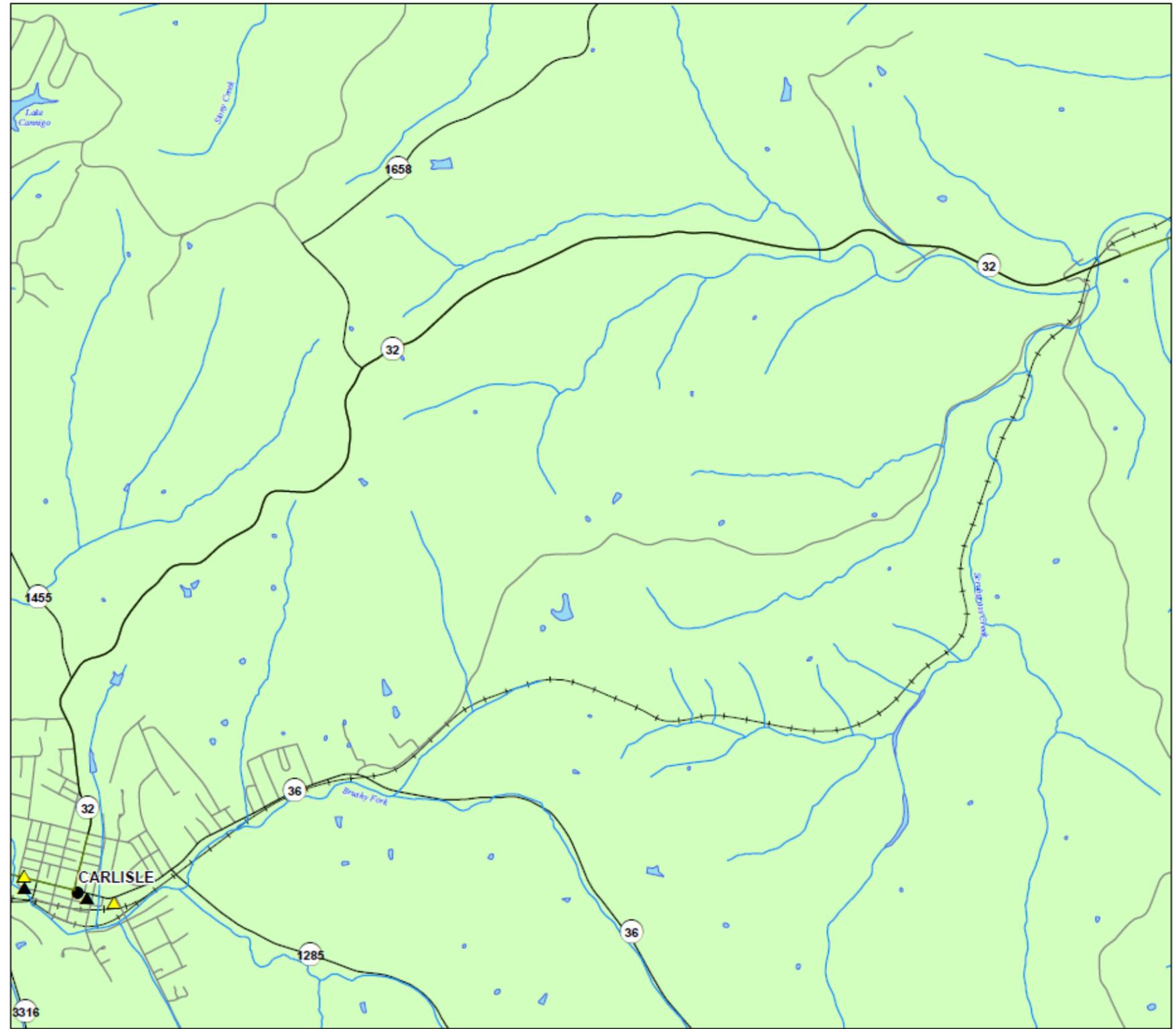
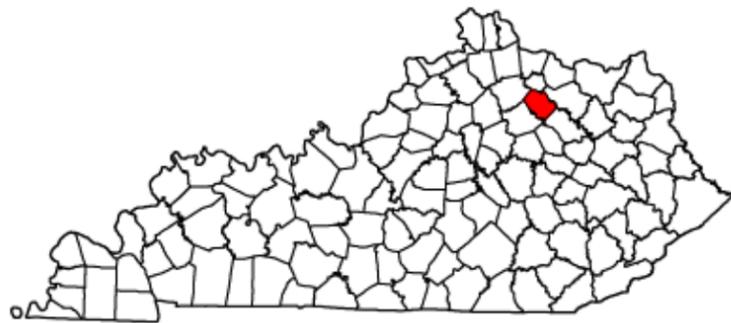
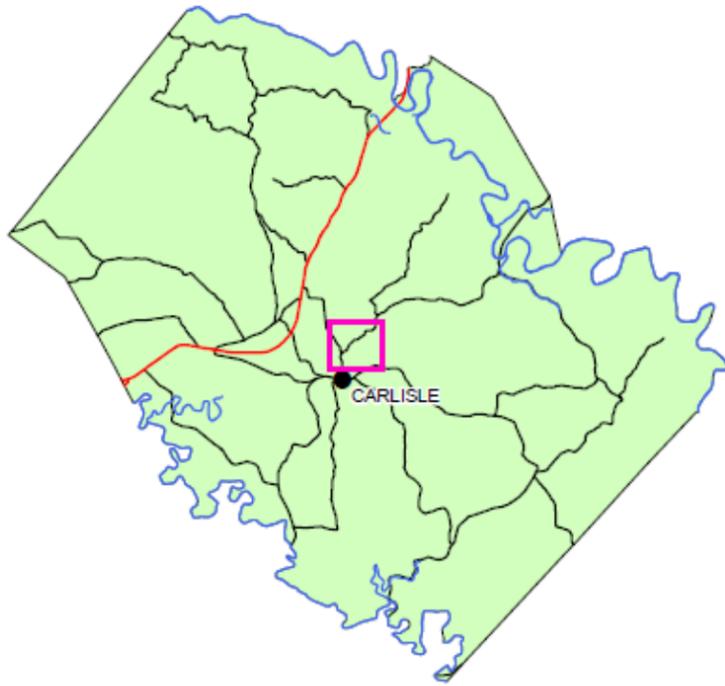
Appendix C

Water Wells and Springs

Nicholas Planning Study - Wells and Springs Map

Legend

- State Roads
 - Local Roads
 - Active Railroad
 - Rivers and Streams
 - Waterbodies
 - Project Area
- Groundwater Wells**
- Monitoring Wells
 - Plugged Wells



Appendix D
Karst Potential Map

Nicholas Planning Study - Karst Potential Map

Legend

- State Roads
 - Local Roads
 - + + Active Railroad
 - Rivers and Streams
 - Waterbodies
 - Project Area
- | Karst Potential | |
|---|---------|
| | INTENSE |
| | PRONE |
| | NONE |

