APPENDIX D

GEOTECHNICAL OVERVIEW

Report of Geotechnical Overview

New Corridor Study from I-71 to AA Highway

Boone, Kenton, Campbell, Gallatin, Grant and Pendleton Counties, Kentucky

P-002-2019

April 1, 2019

Prepared for:

Kentucky Transportation Cabinet

Prepared by:

Stantec Consulting Services Inc.

Stantec Consulting Services Inc.
3052 Beaumont Centre Circle, Lexington KY 40513-1703

April 1, 2019

File: rpt_001_let_178568021

Attention: Mr. Michael Carpenter, PE
Kentucky Department of Highways Division of
Structural Design Geotechnical Branch
1236 Wilkinson Boulevard
Frankfort, Kentucky 40601

Reference: **Geotechnical Overview**
New Corridor Study from I-71 to AA Highway
Boone, Kenton, Campbell, Gallatin, Grant and Pendleton Counties, Kentucky
P-002-2019

Dear Mr. Carpenter,

Enclosed is the geotechnical overview for the proposed Planning Study overview for the referenced project. The geotechnical overview is based upon research of available published data and preliminary alignments being considered for the study area. The scope of work performed, and results of the overview are presented in the accompanying report.

Stantec appreciates the opportunity to work with the Kentucky Department of Highways on this project. If you have any questions or comments pertaining to the contents of this report, please contact us.

Sincerely,

STANTEC CONSULTING SERVICES INC.

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1.0 PROJECT DESCRIPTION

The Kentucky Transportation Cabinet (KYTC) is considering a potential corridor in Northern Kentucky which would connect I-71 with the AA Highway. A study is being pursued which involves seven corridor alternatives. For purposes of this study, a 2,000-foot width of each of the alternatives is being considered. The preliminary alignment showing all the corridor alternatives are shown in Figure R-1.

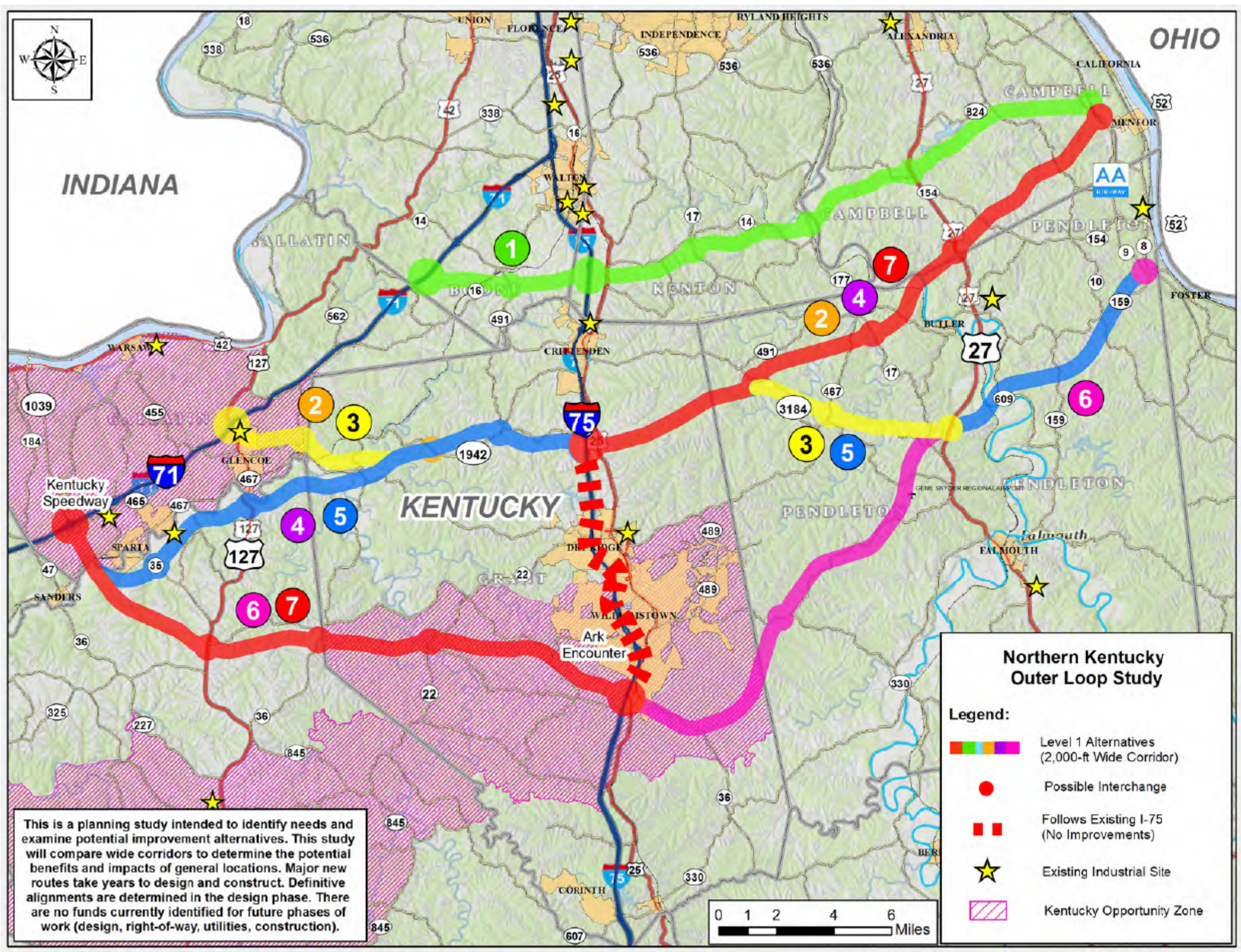


Figure R-1. I-71 to AA Highway Potential Corridors

2.0 SCOPE OF WORK

The scope of work for this study consists of performing a geotechnical overview for the potential corridors based upon research of available published data and Stantec'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. Stantec personnel, using a variety of sources, performed a literature search that included reviews of the following sources:

- Available topographic and geologic mapping of the project area published by the United States Geological Survey (USGS) and the Kentucky Geological Survey (KGS);
- Kentucky Geologic Map Information Service http://kgs.uky.edu/kgsmap/kgsgeoserver/viewer.asp;
- KYTC Geotechnical Data, published by the KGS and KYTC, http://kgs.uky.edu/kgsmap/kytcLinks.asp;
- KYTC Projects Nearby (Identified by KYTC Report Number):

Corridor Alternative	Report Number	County	Route	Item Number
1	L-011-1985-1978	Boone	I-71	06.0012.02
1	S-049-2001-2004	Kenton	I-71	099-44.10
1	S-092-2002	Campbell	US 27	06-046.20
1	L-019-2011	Campbell	US 27	06-046.20
1	R-038-1985	Campbell	KY 9	06-0000.00
2	L-007-2012	Gallatin	KY 16	06-0000.00
2	L-004-1981	Grant	I-75	6-017.1
2	S-154-1999	Grant	KY 1994	6-72.00/6-72.01
2	S-006-1987	Grant	KY 1942	6-195.0
2	S-038-1974	Pendleton	KY 467	6-168.0
2	S-049-1975	Pendleton	KY 17	06-0177.00
7	L-012-1985	Gallatin	I-71	06-0012.20
7	S-139-2001	Gallatin	US 35	06-0333.17
7	R-039-1985	Pendleton	KY 9	06-0000.00
7	L-055-2017	Pendleton	KY 1853	-

- United States Department of Agriculture, Soil Conservation Service (SCS) Soil Survey Publications for affected counties;
- Earthquakes in Kentucky, Hazards, Mitigation, and Emergency Preparedness, Kentucky Geological Survey and Kentucky Division of Emergency Management, Special Publication 17, Series XII, 2014;
- Physiographic Regions, published by KGS, http://kgs.uky.edu/kgsweb.

3.0 PHYSIOGRAPHIC AND STRATIGRAPHIC SETTING

3.1 TOPOGRAPHY AND DRAINAGE

The potential roadway corridors are located in the Outer Bluegrass physiographic region of Kentucky. The Outer Bluegrass is characterized by highly dissected topography including deeper valleys with few areas of flat land. Subsurface conditions are characteristic of Ordovician age bedrock being mostly composed of interbedded limestone and shale.

Surface drainage is directed towards named and unnamed tributaries of the Licking River to the east of I-75, and to Eagle Creek located east of I-71 within the western portion of the alignments. The Ohio River is situated between three-fourths to two miles east of the AA Highway near the potential tie-in locations of the alignments with this roadway. A topographic map depicting the alternative roadway corridors is included as Figure 1 in Appendix A.

3.2 STRATIGRAPHY

Available geologic mapping indicates that much of this region of northern Kentucky where the study corridor alternatives have been proposed is underlain by Upper Ordovician age bedrock. The following formations are present across the region in descending order of lithology. The Bull Fork Formation, Bellevue Tongue of Grant Lake Limestone, the Fairview Formation, and the Kope Formation. In addition, the geologic mapping shows various Quaternary deposits that include alluvium, terrace deposits and high-level fluvial deposits. These deposits are generally associated with the larger creeks or rivers that are present in this region. The geologic mapping of the area is presented as Figure 2 in Appendix B.

3.3 FAULTING IN THE AREA

A review of the geologic mapping of the corridor areas depicted in Figure 2 and located across Gallatin, Owen, Grant, Pendleton, Boone, Kenton, and Campbell Counties does not indicate the presence of any known fault lines which would affect roadway construction in the region.

3.4 SOILS AND UNCONSOLIDATED MATERIALS

Residual soils are the predominant soil type found within the study areas for the various corridor alternatives. Soil descriptions contained herein are based upon SCS soil surveys and on Stantec's knowledge of the study area. Residual soils have derived in-place from a weathering process of the parent shale, and limestone rock formations. These soils consist of plastic clays and sandy silty clays and include abundant rock remnants within the soil matrix.

Alluvial deposits are mapped within the flood plain of the major drainage courses, including the Licking River, Eagle Creek, and many other tributaries to these major streams. These deposits consist of clays, silts, sands, and gravels with varying thicknesses up to approximately 75 feet within the major stream flood plains. The regional geologic mapping also suggests the presence of terrace deposits which include larger fragments such as cobbles, pebbles and locally slabs of limestone and siltstone. In addition, there are finite areas of glacial drift deposits located near the flood plains of the Licking River and the Ohio River. These deposits include silt, clay, gravel, and conglomerates of these particles. The drift deposits are generally unconsolidated without evident bedding or sorting.

3.5 REGIONAL SEISMICITY

Seismicity within the Commonwealth of Kentucky varies widely depending on location. The western portion of the state is dominated by the New Madrid and Wabash Valley source zones, while the southeastern portion of the state is mostly affected by the Eastern Tennessee seismic zone. In general, the New Madrid zone has historically been the most active with many documented historical seismic events. Central and northern portions of the state experience less frequent earthquakes because the source zones are quite distant from these areas. Figure R- 2 depicts seismic events with magnitudes of 3 or greater (through 2008) and seismic zones in and around Kentucky.

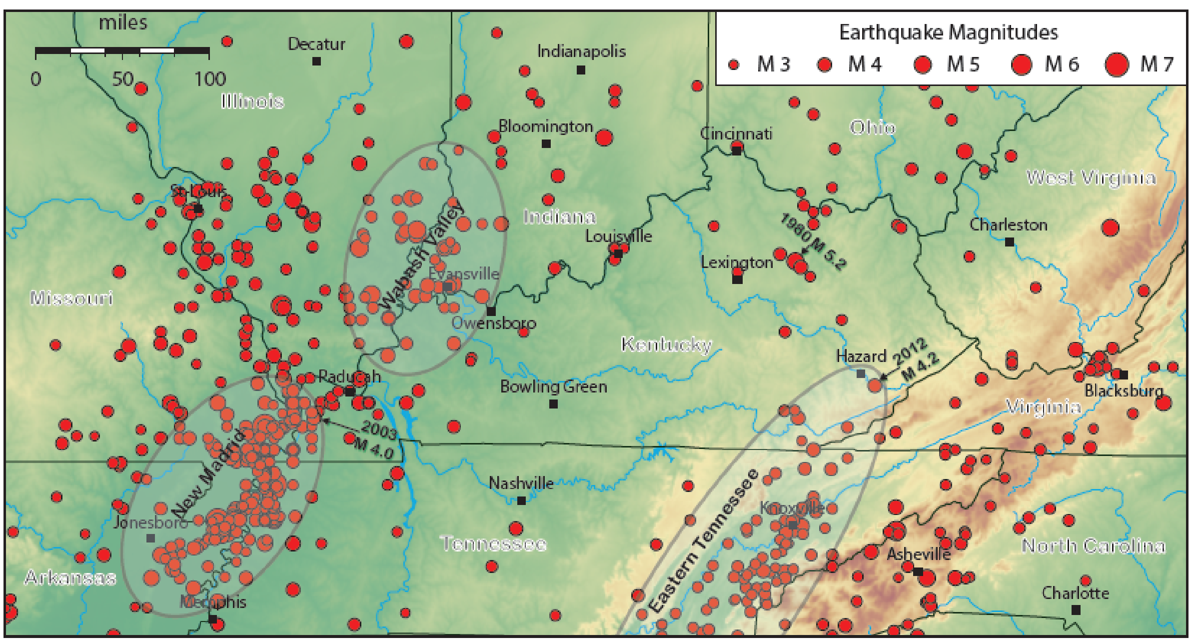


Figure R-2. **Earthquake epicenters and seismic zones in and around Kentucky**

The seismic hazard for a bridge site shall be characterized by the acceleration response spectrum for the site and the site factors for the relevant site class. A comprehensive geotechnical investigation will be required to determine the site class. However, based on anticipated depths to bedrock at/near stream locations, Site Class B/C can be expected. The 2017 AASHTO LRFD Bridge Design specifications provide guidelines for selecting a seismic performance category and a soil profile type for bridge sites. This information establishes the elastic seismic response coefficient and spectrum for use in further structural design and analyses. Refer to Section 3.10.2 of the AASHTO guidelines for specifications. The corridor alternatives will be likely affected by seismic activity from the New Madrid and Wabash Valley source zones and/or “local” seismic events such as the Sharpsburg 5.2-magnitude earthquake registered in 1980.

3.6 LANDSLIDES

A review of the database contained in the Kentucky Geologic Service website shows landslide locations of either documented roadway sites or of features observed from LiDAR imagery that appeared to be landslides, but which were not field verified. In general, landslide-prone areas are mapped in southern Kenton County and throughout Campbell County, but mostly near the Ohio River. Other documented slides were dealt with by the KYTC along US 25 which is the route that generally parallels I-75 in Grant and Kenton Counties. A map prepared from the Kentucky Geological Survey website shows the locations of the slides across the several counties where the seven roadway alternatives are being considered.

Most of the potential corridors being considered by this study will traverse farm and wooded land, as well as partially developed parcels, specific locations of landslides directly affecting the corridor alternatives were not identified as part of this study. However, there are several slides that have been reported near the banks of the Licking River and other water courses within the region. Furthermore, roadway construction within the Kope Formation and areas of steep terrain have been known to be prone to landslides and will need to be constructed with close compliance to the KYTC standard specifications for road construction.

4.0 GEOTECHNICAL CONSIDERATIONS

4.1 GENERAL

The alternative roadway corridors being considered for this study will cross a variety of topographic settings which include well-dissected uplands, rolling terrain, and several streams and associated valleys. Several interchanges or at-grade crossings, and bridge structures will be required for all seven potential corridors. For purposes of taking a closer look at the potential alignments, each individual corridor alternative was plotted on the topographic map for the northern Kentucky region. These maps showing each individual corridor alignment are included in Appendix D.

For improved safety where existing roadways will tie-in to the new connector or vice versa, some of the current highways may require widening and/or realignments. The revisions to the interchanges will include: providing necessary clear zones, addressing geometric deficiencies in the roadway, and adjusting the alignment. As the interchanges are reworked, the Project Team should keep in mind the geotechnical considerations that are included in Section 4 as they pertain to existing utilities, cut slopes, embankments, widening of existing structures as well as construction of new structures.

4.2 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. In general, if joint/fracture angles are high (as measured from horizontal), steeper cut slopes can be constructed, and an acceptable level of stability can be maintained. If discontinuities exhibit low angles and steep cut slopes are utilized, large block failures may occur along the open cut face.

As noted in Section 3, many portions of the alternate roadway alignments will encounter bedrock associated with the Kope Formation. This bedrock unit consists of 75 to 80 percent shale which is interbedded with thin layers of limestone. This type of bedrock weathers and slumps readily when exposed, hence cuts in these types of nondurable shales and shallow cuts in bedrock may be best constructed on 2H:1V slopes. In several areas, roadway construction may also encounter bedrock belonging to the Fairview Formation. This formation includes interbedded limestones, approximate 50 percent, and shales. Existing cuts along the AA Highway were constructed using pre- split 1H:1V slopes below the RDZ line on approximate 30-foot intervals of vertical height with 18 to 20-foot intermediate benches. These types of cuts could be anticipated within any of the selected corridor alternatives. Some of the photographs included in Appendix A (Observation IDs 11 and 16) show existing cut slopes that appear to be on 2H:1V grades, and which also exhibit some vegetation growth on the slopes.

Two photographs included in Appendix A (Observation IDs 17 and 18) show a roadside cut interval along the AA Highway that appear to have been constructed using the noted guidelines for pre-split slopes. Slope configurations along the corridors will be dependent on many factors, including but not limited to, roadway grade, geology and bedrock durability which will be evaluated during a geotechnical exploration.

Slope configurations for soil cuts and materials within the RDZ zone are generally constructed on a 2H:1V or flatter, and where the cut slope are ± 10 feet in height or greater, these will require slope stability analyses to meet adequate factors of safety guidelines.

4.3 EMBANKMENT CONSIDERATIONS

It is anticipated that a large portion of rock excavations will encounter non-durable shales, and for this reason close compliance with the KYTC Standard Specifications for Road Construction will need to be followed to ensure adequate compaction for roadway embankments constructed from this rock type. Select rock types for use as rock embankment, rock road bed, channel lining, etc., would be durable limestone. Foundation soils are likely to be plastic clays with varying contents of gravel and rock remnants and silty sands.

Embankments constructed of durable rock materials generally exhibit adequate stability at 2H:1V slope configurations. However, flatter embankment slopes may be required for tall embankments constructed from nondurable shales or in areas where embankments are founded on alluvial materials. Based upon a review of geotechnical reports for the AA Highway and other regional roads, 3H:1V embankment slopes appear to be the adequate fill slopes for most embankments built out of non-durable shales. Alluvial soils can be expected along major drainage courses such as the Licking River, Eagle Creek, and other tributaries of these. In areas such as these, granular embankment material and/or retaining walls may be necessary depending on the proposed alignment.

Low shear strengths and high settlement potentials are generally associated with alluvial deposits. Consolidation settlements and short-term embankment stability problems are common for roadway embankments in alluvial floodplains, and controlled embankment construction rates and/or flatter embankment side slopes and or partial rock embankment should be anticipated for these areas.

4.4 STRUCTURES

It is anticipated that several bridges and other drainage structures will be constructed for any of the seven corridor alternatives being considered as part of this study. Based on Stantec's knowledge of the area, and a review of geotechnical reports conducted for existing structures

it is evident that most of the bridges across the region are likely supported by rock bearing foundation systems, which could be a spread footing or steel H-piles driven to bedrock. Culverts along the proposed alignment may be replaced or widened. It can be anticipated the culverts within the project corridor are likely supported by either a non-yielding or yielding foundation system depending upon the location along the proposed alignment. A detailed geotechnical investigation will be required to determine the foundation support systems.

4.5 SATURATED, SOFT OR UNSTABLE AREAS

Based on topographic mapping and literature reviewed, the alignment will cross or be near ponds, drainage swales or stream channels. Any saturated, soft, or unstable areas encountered within embankment foundation limits should be drained and stabilized utilizing non-erodible granular embankment or durable limestone from roadway excavation. The rock platform shall be underlain with Geotextile fabric. Ponds should be drained, and any soft or saturated material should be removed and/or stabilized. Additional rock may be required to stabilize soft soils and to maintain positive drainage. Based on observations, various farm ponds exist within most of the corridors being considered. Depending on the project alignment, these ponds will require treatment if they are located within the construction limits.

4.6 COAL SEAMS/MINING

Based on the available geologic mapping, there are no coal seams mapped near the project alignment.

4.7 GAS AND OIL WELLS

Based on the available geologic mapping, there are no oil and gas wells which are directly located within the corridor alternatives.

4.8 WATER WELLS AND SPRINGS

Based on available information, there are some groundwater and other local wells which are shown within/near the proposed study area. These locations should be inventoried, and their locations verified. If impacted during construction, special construction will be required to close the wells, and spring boxes and/or granular material may be required in the vicinity of springs.

4.9 MUNICIPAL SOLID WASTE LANDFILL

A portion of the Alternative 3 and 5 roadway corridors is near the Pendleton County Landfill (operated by Rumpke Waste and Recycling). As part of the siting requirements for a solid waste landfill, the minimum buffer zone would be 250 feet from any property line.

Any encroachment on the buffer zone could limit future expansion of the landfill. Obtaining additional right-of -way in this area could be difficult. Construction over and through existing landfilled areas would be costly when compared to other corridor options.

As part of the landfill permitting process, groundwater monitoring wells are required at the facility. Results from the groundwater monitoring program should be evaluated for constituents which could affect construction in the vicinity of the landfill.

4.10 KARST CONDITIONS

A review of the geologic mapping of the northern Kentucky study area where the roadway corridors are being considered indicates that there is a low potential for karst activity or new development of sinkhole occurrences.

5.0 CONCLUSIONS

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

5.2. Geotechnical drilling will be needed for any new bridge or reinforced concrete box culvert structures as well as any necessary retaining walls and roadway cuts and fills. In widening or structure replacement situations, additional geotechnical explorations may be necessary to supplement information for existing structures. It is anticipated that conventional spread footing and/or pile foundation systems can be utilized for bridge structures.

5.3. Because there are portions of the potential corridors that may involve roadway widening and at tie-in locations, pavement structure and California Bearing Ratio (CBR) information on existing pavements should be obtained to assist the design team. It should be anticipated that chemically or mechanically stabilized roadbed will be required on most new roadway construction because CBR values are expected to be 6 or less.

5.4. Once alignment and sections are identified, then open faced logging of exposed cuts and/or drilling should be performed in accordance with KYTC guidelines. Sampling of foundation soils should be performed for embankment situations of sufficient height to evaluate stability.

5.5 Any potential roadway construction near the area of the existing landfill should stay within the existing or proposed right-of-way. This may require the use of retaining walls or steepened slopes. Construction within the landfill facility will increase the cost significantly.

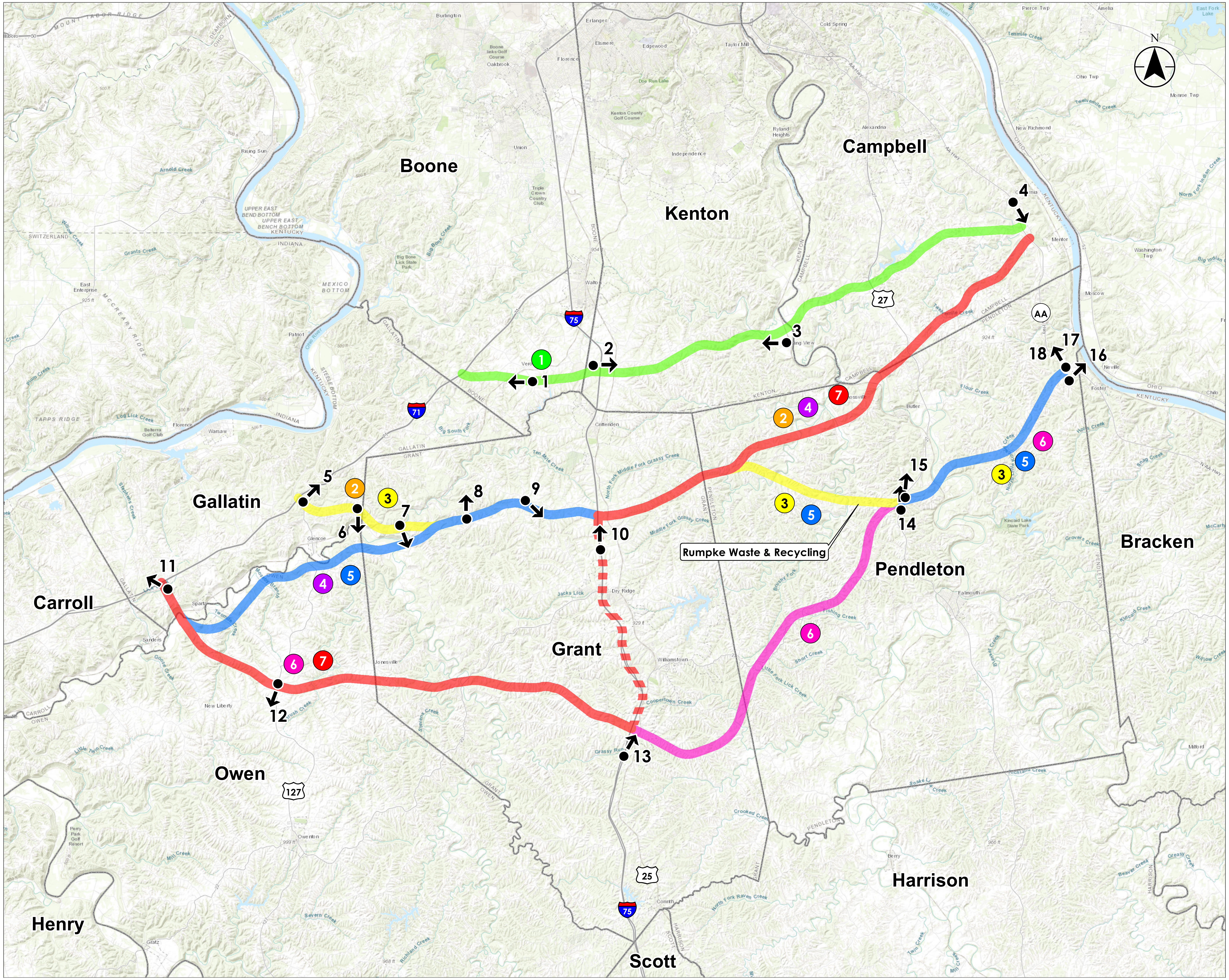
5.6. Water wells, monitoring wells and springs exist along/near the proposed corridor. The design team should inventory and survey active wells and springs. In addition, results from groundwater monitoring program at the landfill site should be reviewed to assess any potential effects on construction.

5.7 The potential for karst conditions within the northern Kentucky area where these corridor alternatives are located is low. If any open sinkholes or other karst activity are encountered, then treatment should be performed in accordance with Section 215 of the current edition of the Standard Specifications for Road and Bridge Construction.

5.8. The information presented in this overview should be reviewed in the general nature in which it was intended. A thorough geotechnical exploration of the selected 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

USGS Topographic Map and Field Photographs



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Legend

Location of Photograph and Direction Taken

2000-Foot Corridors

- Alternative 1
- Alternative 2
- Alternative 3
- Alternative 4
- Alternative 5
- Alternative 6
- Alternative 7
- Follow Existing I-75 (No Improvements)

0 2 4 6 Miles

1:126,720 (At original document size of 22x34)

Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
2. Basemap Sources: ESRI World Topographic Map and ESRI World Street Map
3. Photographs taken at various key locations of the seven alternatives are included with the topographic map in Appendix A.

Project Location 178568019

Bracken, Boone, Campbell, Gallatin, Grant, Kenton, Owen, and Pendleton Counties, Kentucky

Prepared by WSW on 2019-02-01
Technical Review by LA on 2019-02-01

Client/Project

Northern Kentucky Outer Loop Study

Figure No.

1

Title

Northern Kentucky Outer Loop Study
Topographic Map

C:\Temp\NKY_OuterLoopStudy\mxds\NKY_OuterLoopStudy_TopographicMap.mxd Revised: 2019-02-01 By: SWheatley

Verona_927AM_01.jpg

Observation ID: 1

General Location : KY 491 (Boone Co.)

Latitude and Longitude Coordinates:

38.809547, -84.653153

Remarks:

View towards the west of KY 491 near potential Interchange with Alternative 1 Corridor

38_49_078_-84_36_235.jpg

Observation ID: 2

General Location : I-75 (Kenton Co.)

Latitude and Longitude Coordinates:

38.818839, -84.606514

Remarks:

Vicinity of I-75 near potential Interchange with Alternative 1 Corridor.

Morning View 432PM.jpg

Observation ID: 3

General Location : KY 177 (Kenton Co.)

Latitude and Longitude Coordinates:

38.830836, -84.458253

Remarks:

Existing intersection of KY 177 and KY 14 just south of potential interchange of KY 177 with Alternative 1 corridor.

California_IMG_2360.jpg

Observation ID: 4

General Location : AA Highway (Campbell Co.)

Latitude and Longitude Coordinates:

38.913111, -84.282861

Remarks:

View of AA Highway near potential Interchange with Alternative 1 Corridor.

Glencoe_1138AM_01.jpg

Observation ID: 5

General Location : I-71 (Gallatin Co.)

Latitude and Longitude Coordinates:

38.738789, -84.829894

Remarks:

Existing cut slope just east of US 127 near the Interchange with I-71 and potential Interchange with Alternative 2 corridor.

Glencoe_1128AM_01.jpg

Observation ID: 6

General Location : KY 16 (Gallatin Co.)

Latitude and Longitude Coordinates:

38.734589, -84.788253

Remarks:

View towards the south of potential Interchange of KY 16 with Alternative 2 Corridor.

Dry_Ridge_1051AM_01.jpg

Observation ID: 7

General Location : KY 1942 (Grant Co.)

Latitude and Longitude Coordinates:

38.724331, -84.756019

Remarks:

View of KY 1942 towards the southeast near potential crossing of Alternative 2 corridor over Ten Mile Creek.

Dry_Ridge_1026AM_01.jpg

Observation ID: 8

General Location : KY 1942 (Grant Co.)

Latitude and Longitude Coordinates:

38.727633, -84.704658

Remarks:

View from KY 1942 towards the east near potential Interchange with Alternative 2 corridor.

Dry_Ridge_1012AM_2to4COMB.jpg

Observation ID: 9

General Location : KY 1942 (Grant Co.)

Latitude and Longitude Coordinates:

38.738361, -84.659675

Remarks:

View from KY 1942 towards the south near potential Interchange with Alternative 2 corridor.

Dry Ridge 1212PM.jpg

Observation ID: 10

General Location : I-75 (Grant Co.)

Latitude and Longitude Coordinates:

38.708350, -84.602561

Remarks:

View of Bannister Pike overpass over I-75 NB. Location is about 1.3 miles south near potential Interchange with Alternative 2 corridor.

Observation ID: 11

General Location : KY 1039 (Gallatin Co.)

Latitude and Longitude Coordinates:

38.687528, -84.933647

Remarks:

View of KY 1039 exit ramp cut slope near potential Interchange with Alternative 6 Corridor.

Sparta_1219PM_1-2COMB.jpg

Observation ID: 12

General Location : US 127 (Pendleton Co.)

Latitude and Longitude Coordinates:

38.630100, -84.850211

Remarks:

View of west side of US 127 SB near potential Interchange with Alternative 6 Corridor.

Sparta_1243PM_0103COMB.jpg

Williamstown 1204PM.jpg

Observation ID: 13

General Location : I-75 NB (Grant Co.)

Latitude and Longitude Coordinates:

38.584300, -84.586625

Remarks:

View of I-75 NB cut slope near potential Interchange with Alternative 6 Corridor.

Butler 202PM.jpg

Observation ID: 14

General Location : US 27 (Pendleton Co.)

Latitude and Longitude Coordinates:

38.729594, -84.372436

Remarks:

View of US 27 NB near potential Interchange with Alternative 6 Corridor.

Butler 203PM.jpg

Observation ID: 15

General Location : US 27 (Pendleton Co.)

Latitude and Longitude Coordinates:

38.737072, -84.369011

Remarks:

View of US 27 NB near potential Interchange with Alternative 6 Corridor.

Foster 250PM.jpg

Observation ID: 16

General Location : AA Highway (Pendleton Co.)

Latitude and Longitude Coordinates:

38.805503, -84.242264

Remarks:

View of existing cut slope of KY 159 near its intersection with the AA Highway and close to the potential Interchange with Alternative 6 Corridor.

Observation ID: 17

General Location : AA Highway (Pendleton Co.)

Latitude and Longitude Coordinates:

38.813092, -84.243775

Remarks:

View of AA Highway cut slope near potential Interchange with Alternative 6 Corridor.

Foster 254PM_2.jpg

Observation ID: 18

General Location : AA Highway (Pendleton Co.)

Latitude and Longitude Coordinates:

38.813553, -84.244386

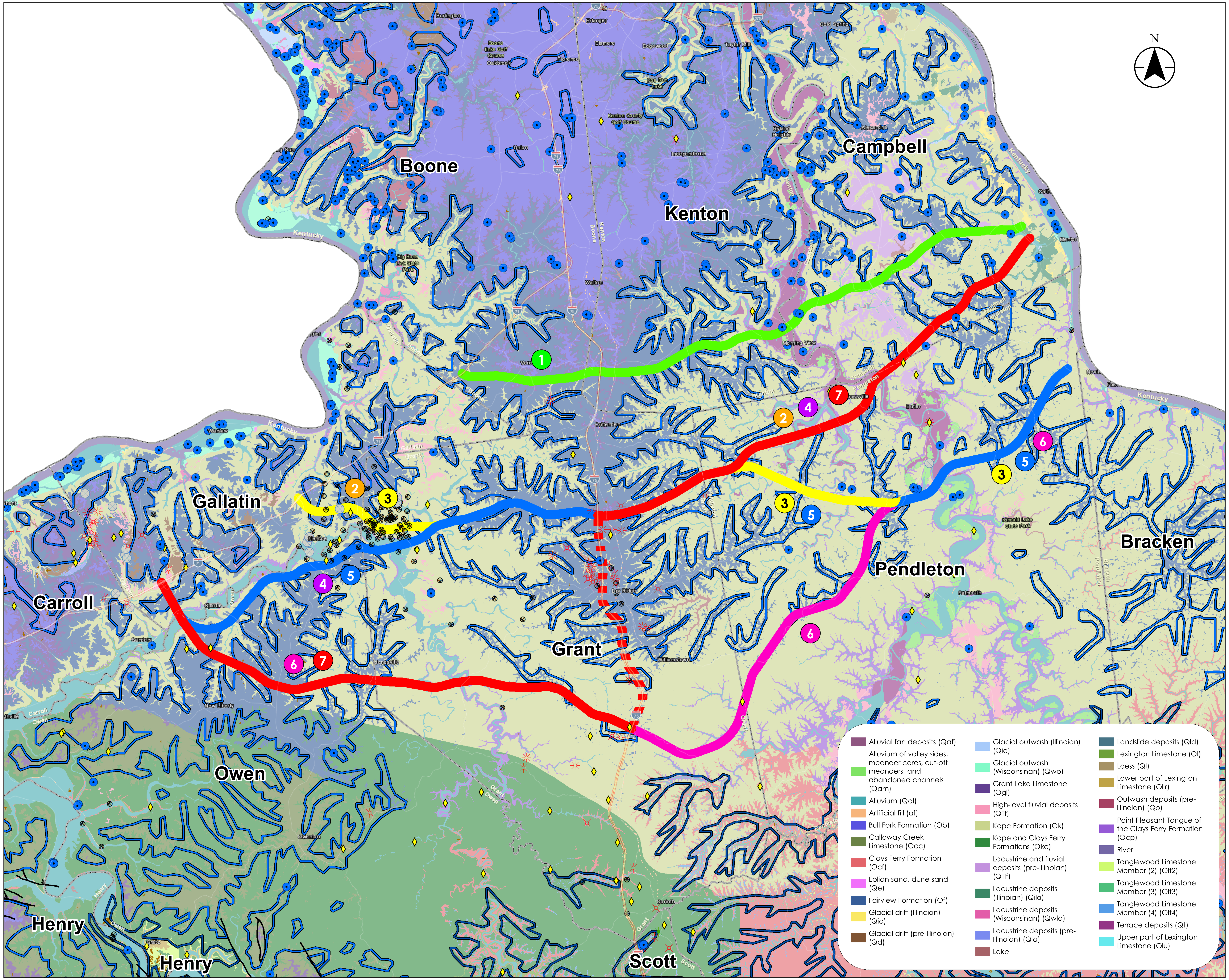
Remarks:

View of AA Highway cut slope near potential Interchange with Alternative 6 Corridor.

Foster 255PM.jpg

APPENDIX B

USGS Geologic Map



Stantec

Legend

Location of Photograph and Direction Taken
KGS landslide inventory data
Groundwater Well
Coal Bed Methane Gas Well
Dry and Abandoned Well
Gas Well
Location
Oil and Gas Well
Oil Well
Service or Secondary Recovery Well
Other Well

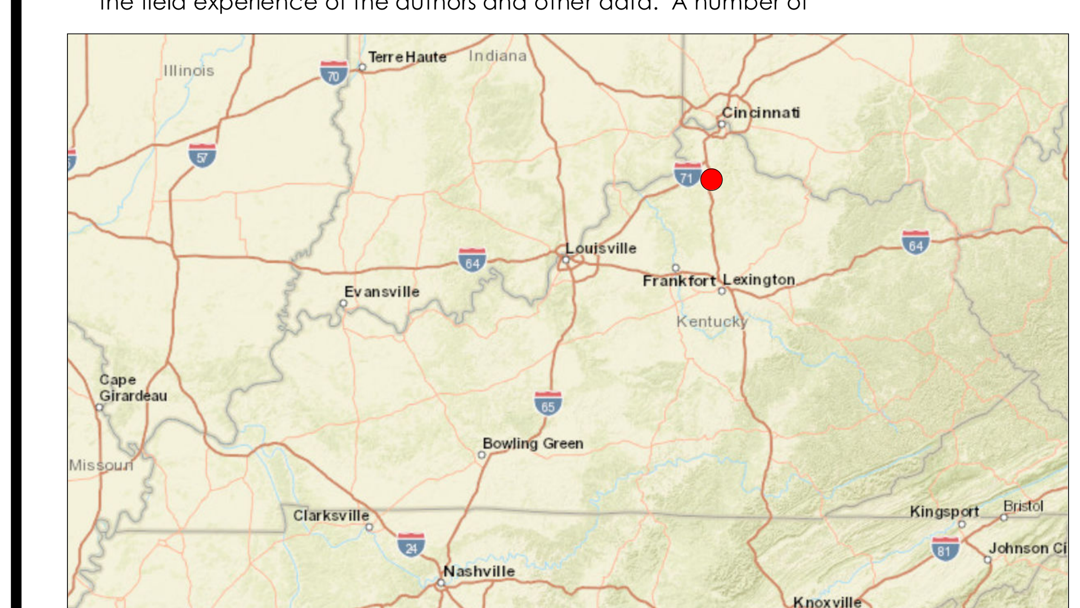
2000-Foot Corridors

Alternative 1
Alternative 2
Alternative 3
Alternative 4
Alternative 5
Alternative 6
Alternative 7
Follow Existing I-75 (No Improvements)
Fault
Sinkhole
Areas Underlain by Bedrock with High Potential for Karst Development
Areas Underlain by Bedrock with Moderate Potential for Karst Development
1:24,000 geologic map landslides
Landslide areas derived from LiDAR
Landslide areas derived from aerial photography

0 2 4 6 Miles
1:126,720 (At original document size of 22x34)

Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky FIPS 1600 Feet
2. Basemap Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community
3. The Karst Occurrence GIS polygon coverages for Kentucky were compiled from a digital version of the 1:500:000-scale geologic map of Kentucky (Noger, M.C., 1988). Because of the 1:500,000 scale of the source map, these coverages should NOT be used for evaluating karst geologic hazards or hydrogeology at scales larger than 1:500,000. The classification of the potential for karst development was based on the field experience of the authors and other data. A number of



Project Location
Bracken, Boone, Campbell, Gallatin, Grant, Kenton, Owen, and Pendleton Counties, Kentucky

178568019
Prepared by WSW on 2019-02-01
Technical Review by LA on 2019-02-01

Client/Project
Northern Kentucky Outer Loop Study

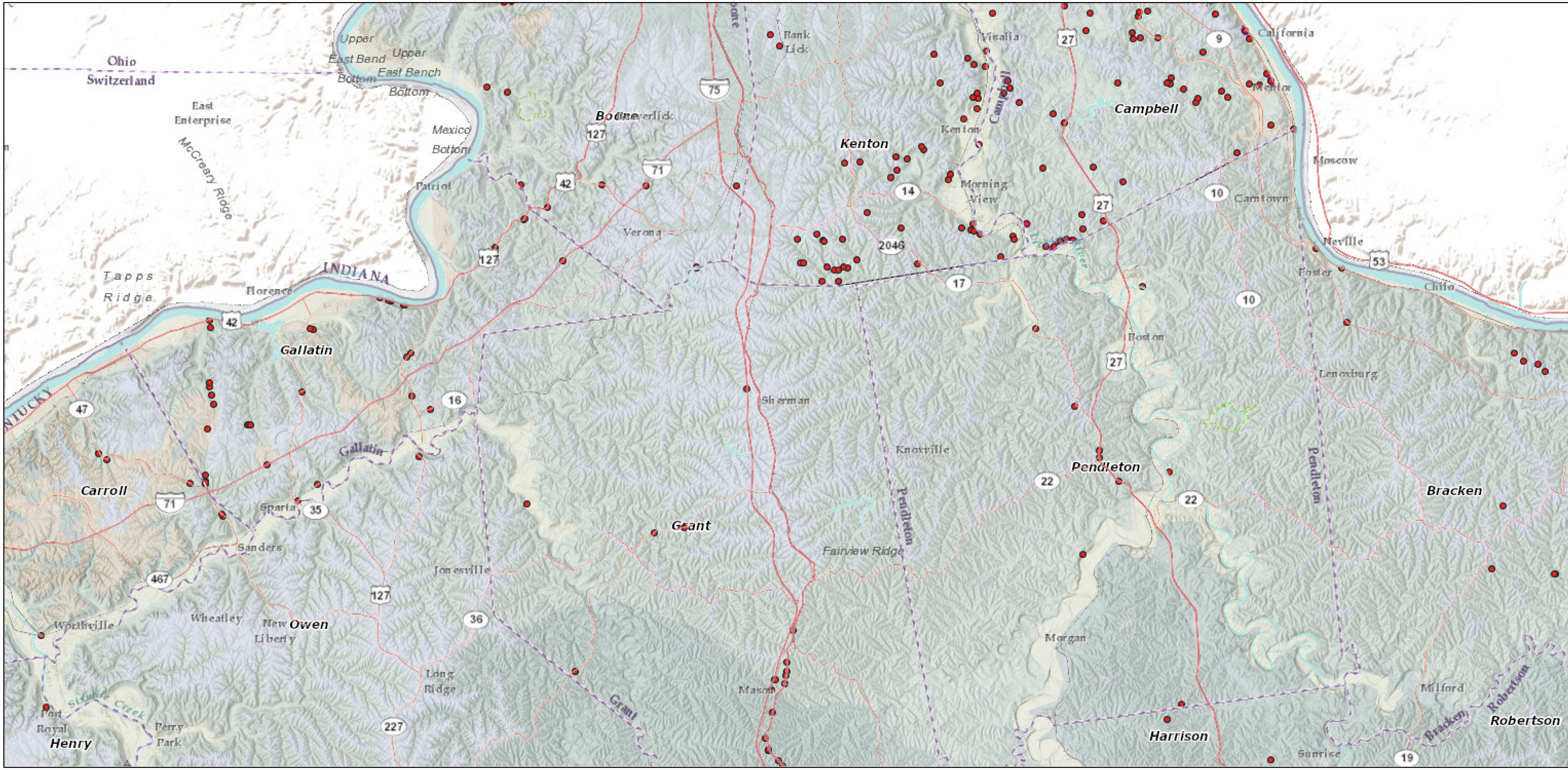
Figure No.
2

Title
Northern Kentucky Outer Loop Study Geologic Map

APPENDIX C

KGS Landslide Information Map

Kentucky Geologic Map Information Service



January 29, 2019

Legend

Location of Possible or Actual Landslides

Figure No.
3

Title
KGS Landslide Information Map

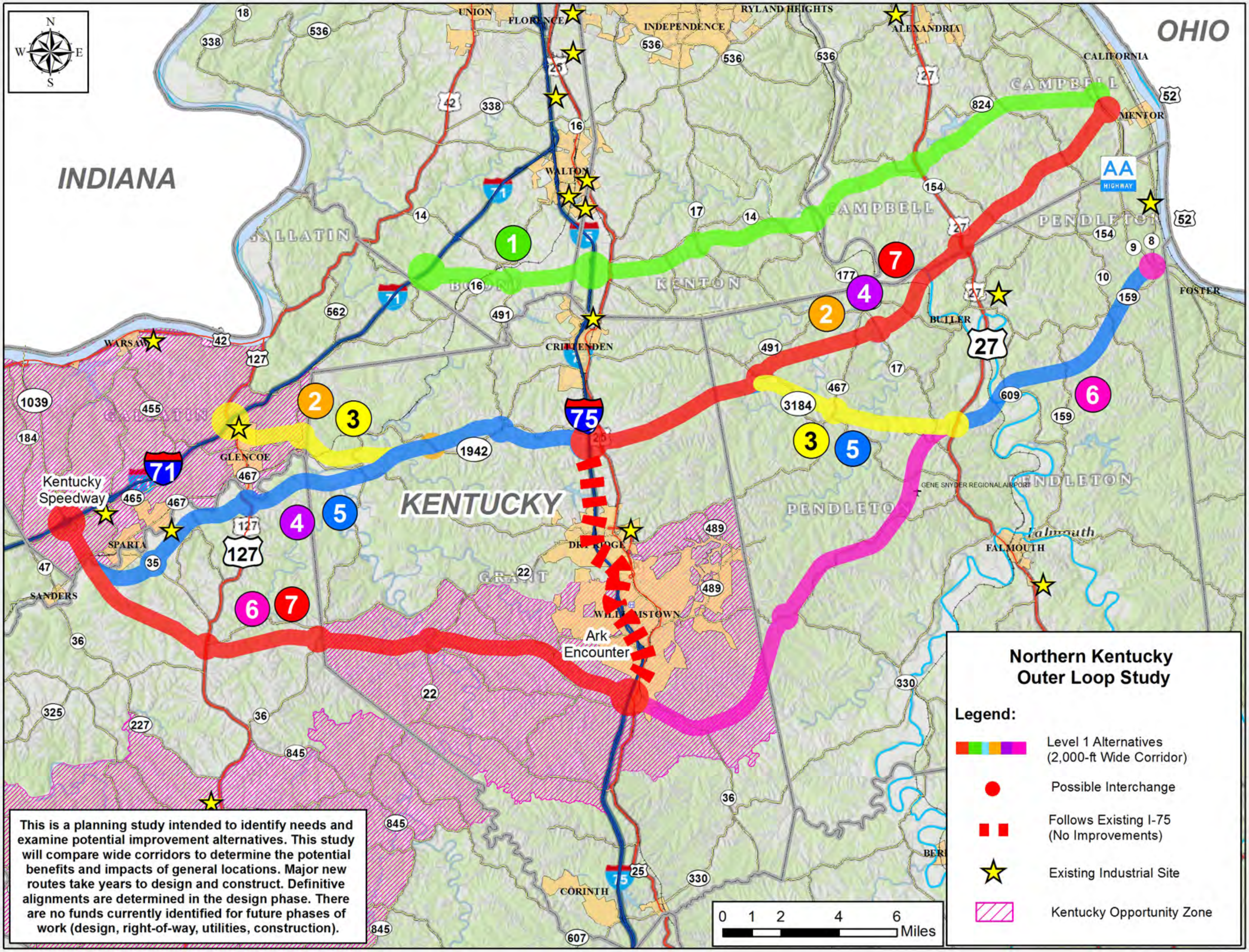
1:288,895

0 3.5 7 14 mi
0 5 10 20 km

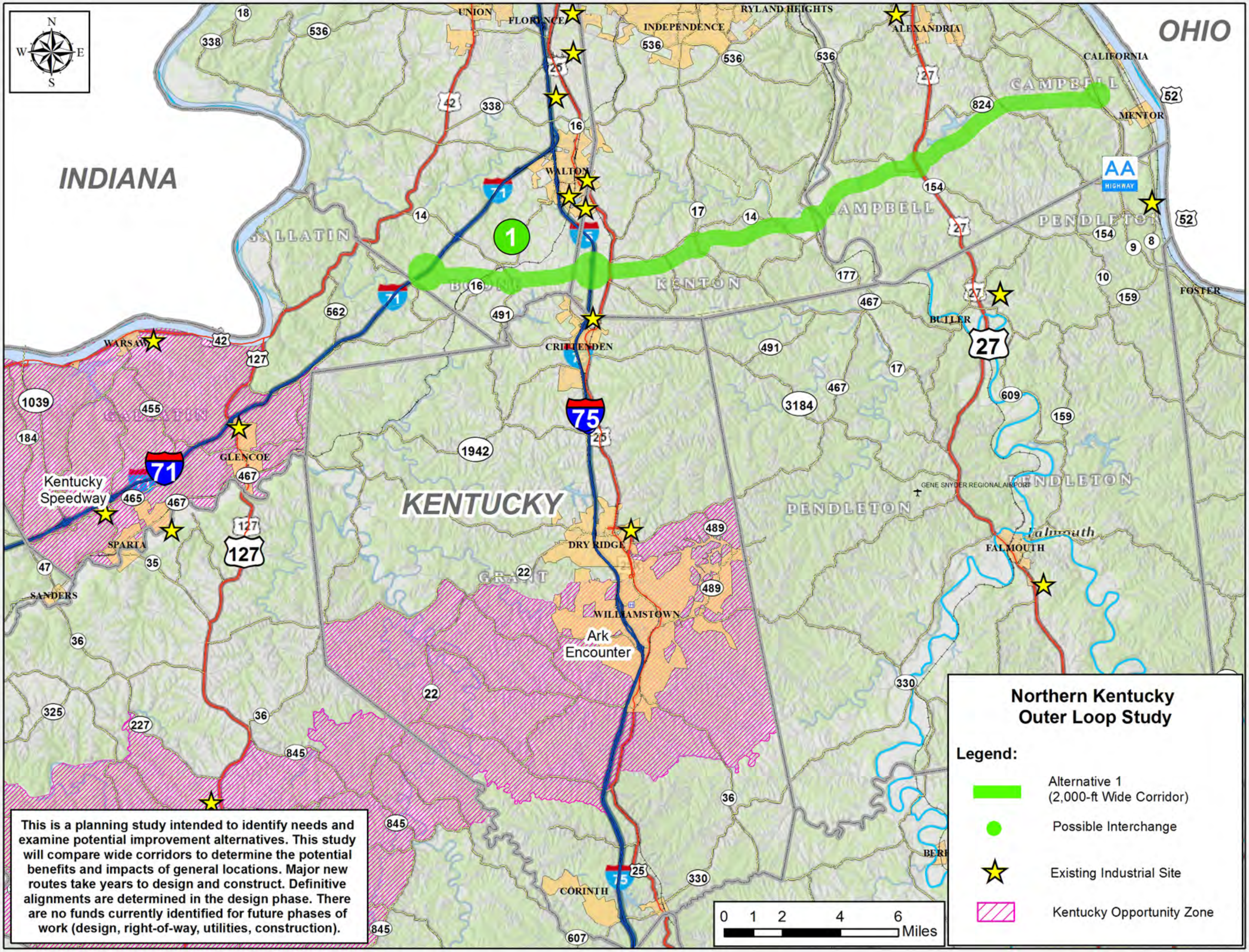
Kentucky DGI, KyFromAbove Partners
Kentucky Geological Survey
Sources: Esri, USGS, NOAA
KyFromAbove Partners, DGI
Sources: Esri, Garmin, USGS, NPS

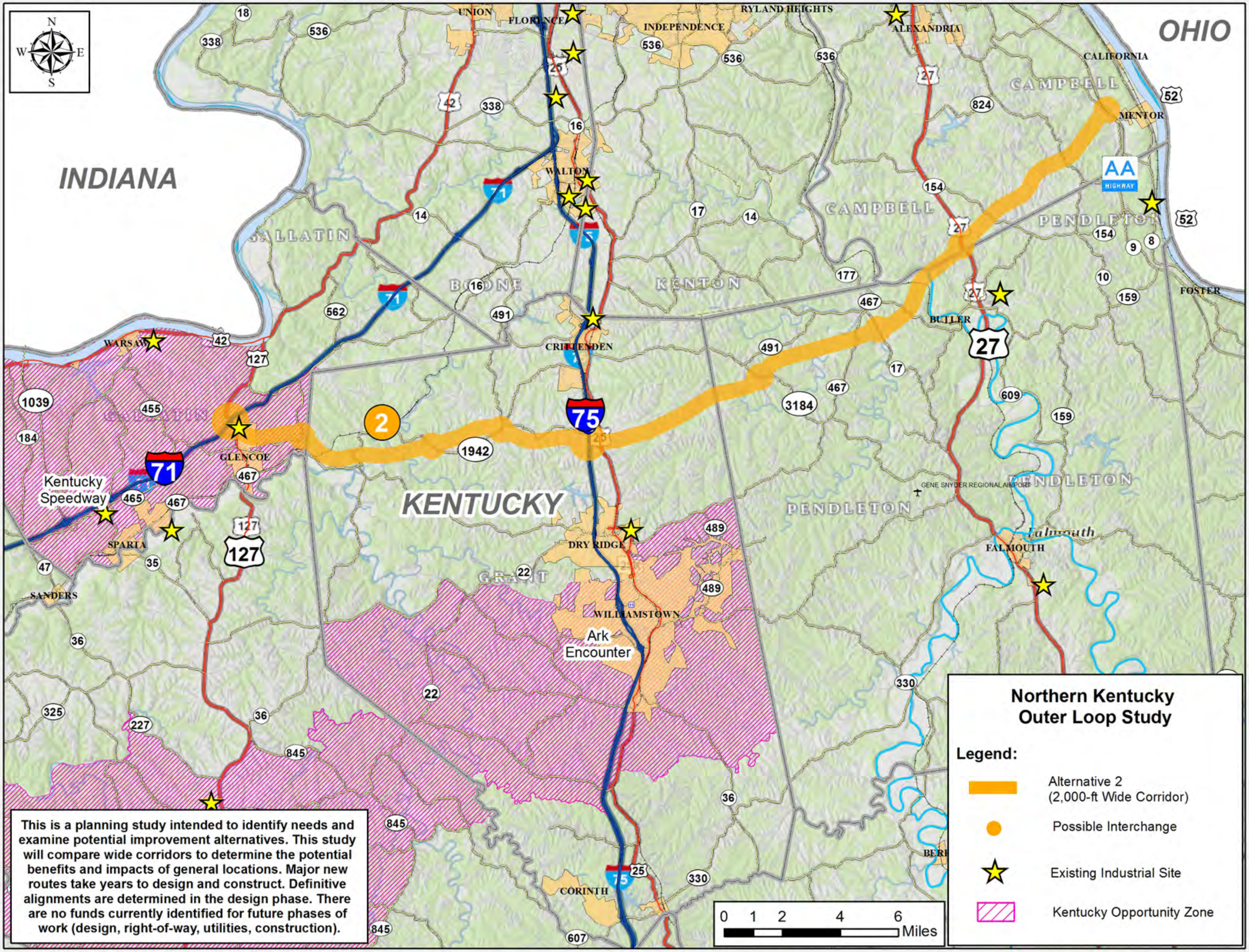
APPENDIX D

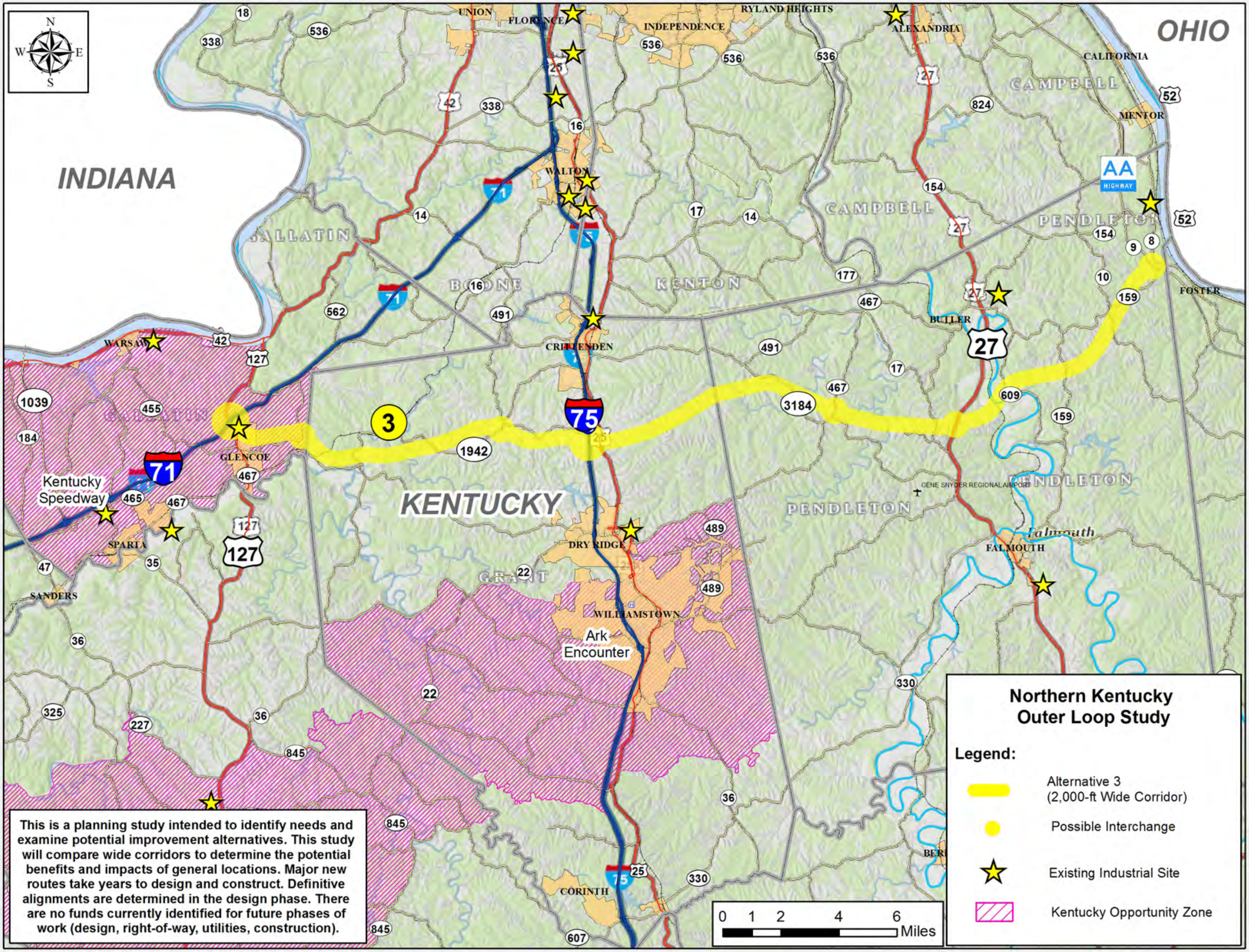
Northern Kentucky Outer Loop Study Alternatives



Northern Kentucky Outer Loop Study
Legend:
Level 1 Alternatives (2,000-ft Wide Corridor)
Possible Interchange
Follows Existing I-75 (No Improvements)
Existing Industrial Site
Kentucky Opportunity Zone
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).
0 1 2 4 6 Miles
INDIANA
OHIO
KENTUCKY
Kentucky Speedway
Ark Encounter
UNION
FLORENCE
INDEPENDENCE
RYLAND HEIGHTS
ALEXANDRIA
CALIFORNIA
MENTOR
WALTON
CRITTENDEN
WARSAW
GLENCOE
SPARTA
SANDERS
DRY RIDGE
WILLIAMSTOWN
BUTLER
FALMOUTH
FOSTER
CORINTH
GALLATIN
BOONE
KENTON
CAMPBELL
PENDLETON
GRANT
GENE SNYDER REGIONAL AIRPORT
AA HIGHWAY
1
2
3
4
5
6
7


Northern Kentucky
Outer Loop Study
Legend:
Alternative 1
(2,000-ft Wide Corridor)
Possible Interchange
Existing Industrial Site
Kentucky Opportunity Zone
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).
0 1 2 4 6
Miles
INDIANA
OHIO
KENTUCKY
Kentucky
Speedway
Ark
Encounter
UNION
FLORENCE
INDEPENDENCE
RYLAND HEIGHTS
ALEXANDRIA
CALIFORNIA
MENTOR
WALTON
CRITTENDEN
WARSAW
GLENCOE
SPARTA
SANDERS
DRY RIDGE
WILLIAMSTOWN
CORINTH
BUTLER
FALMOUTH
FOSTER
GALLATIN
BOONE
KENTON
CAMPBELL
PENDLETON
GRANT
GENE SNYDER REGIONAL AIRPORT
1
71
75
27
127
AA
HIGHWAY


Northern Kentucky
Outer Loop Study
Legend:
Alternative 2
(2,000-ft Wide Corridor)
Possible Interchange
Existing Industrial Site
Kentucky Opportunity Zone
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).
0 1 2 4 6 Miles
N
S
E
W
OHIO
INDIANA
KENTUCKY
UNION
FLORENCE
INDEPENDENCE
RYLAND HEIGHTS
ALEXANDRIA
CALIFORNIA
CAMPBELL
MENTOR
WALTON
GALLATIN
BOONE
KENTON
PENDLETON
FOSTER
BUTLER
WARSAW
CRITTENDEN
GLENCOE
Kentucky
Speedway
SPARTA
SANDERS
DRY RIDGE
GRANT
WILLIAMSTOWN
Ark
Encounter
GENE SNYDER REGIONAL AIRPORT
Falmouth
FALMOUTH
CORINTH
AA
HIGHWAY
2
71
75
127
27
1942
3184

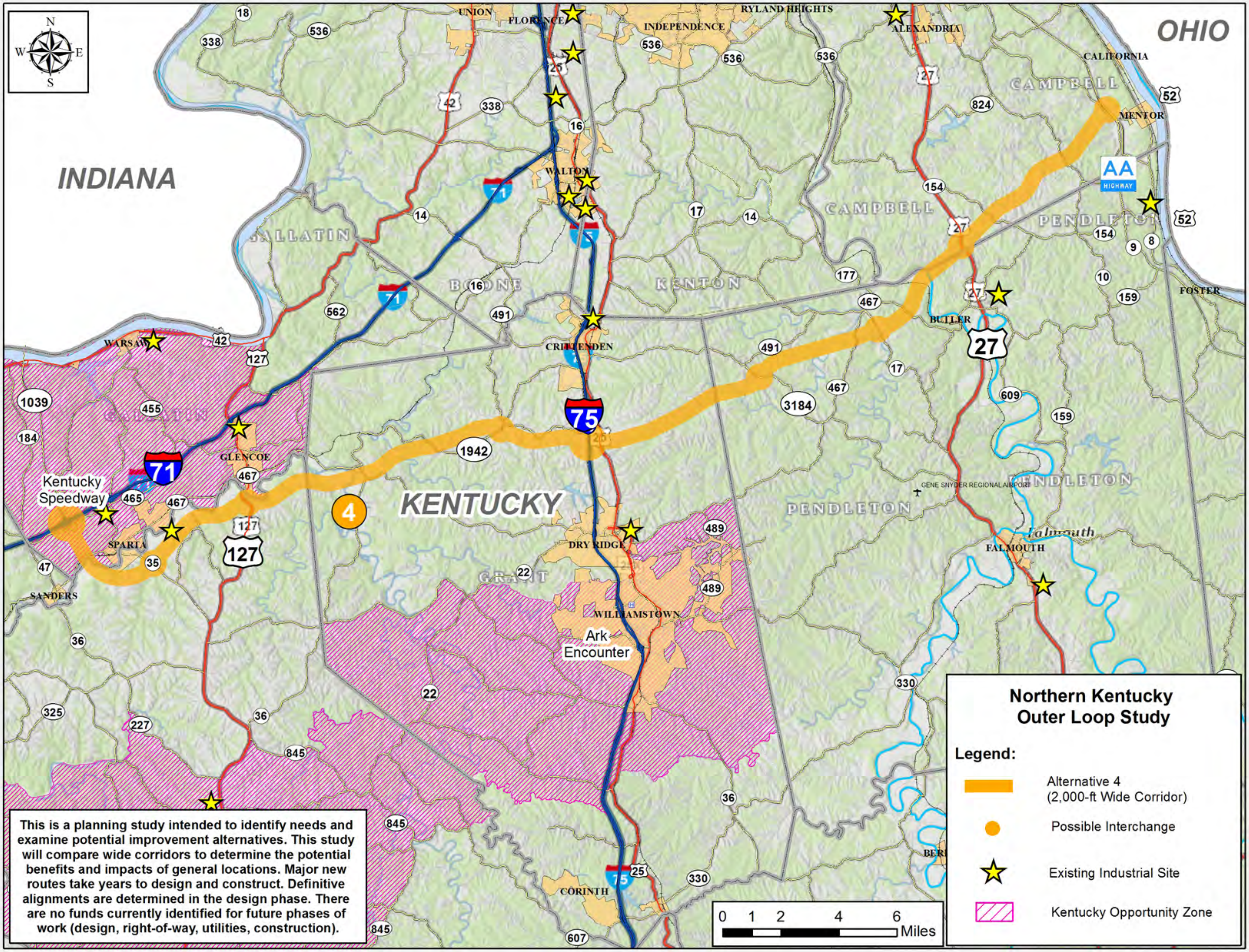


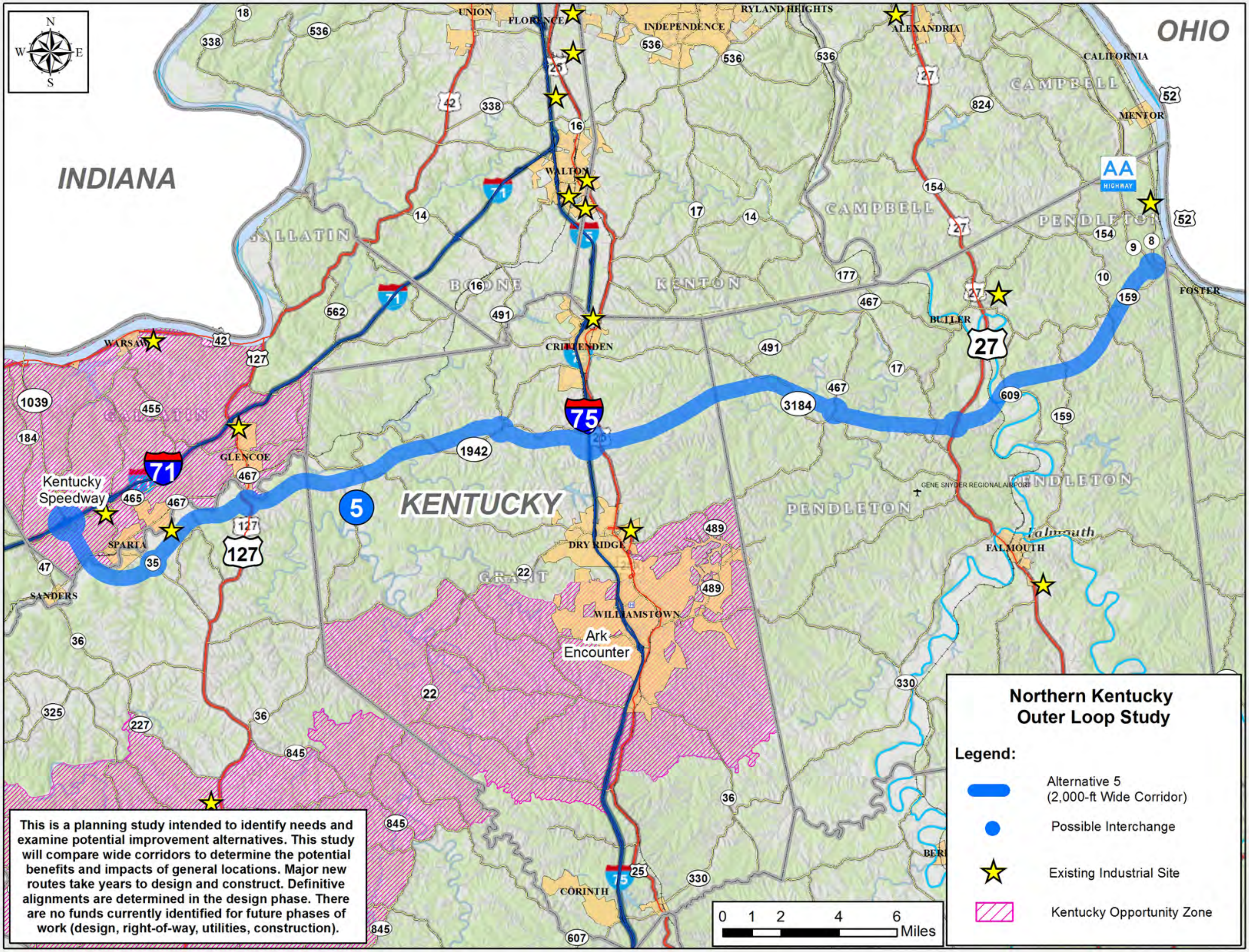
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).

Northern Kentucky Outer Loop Study

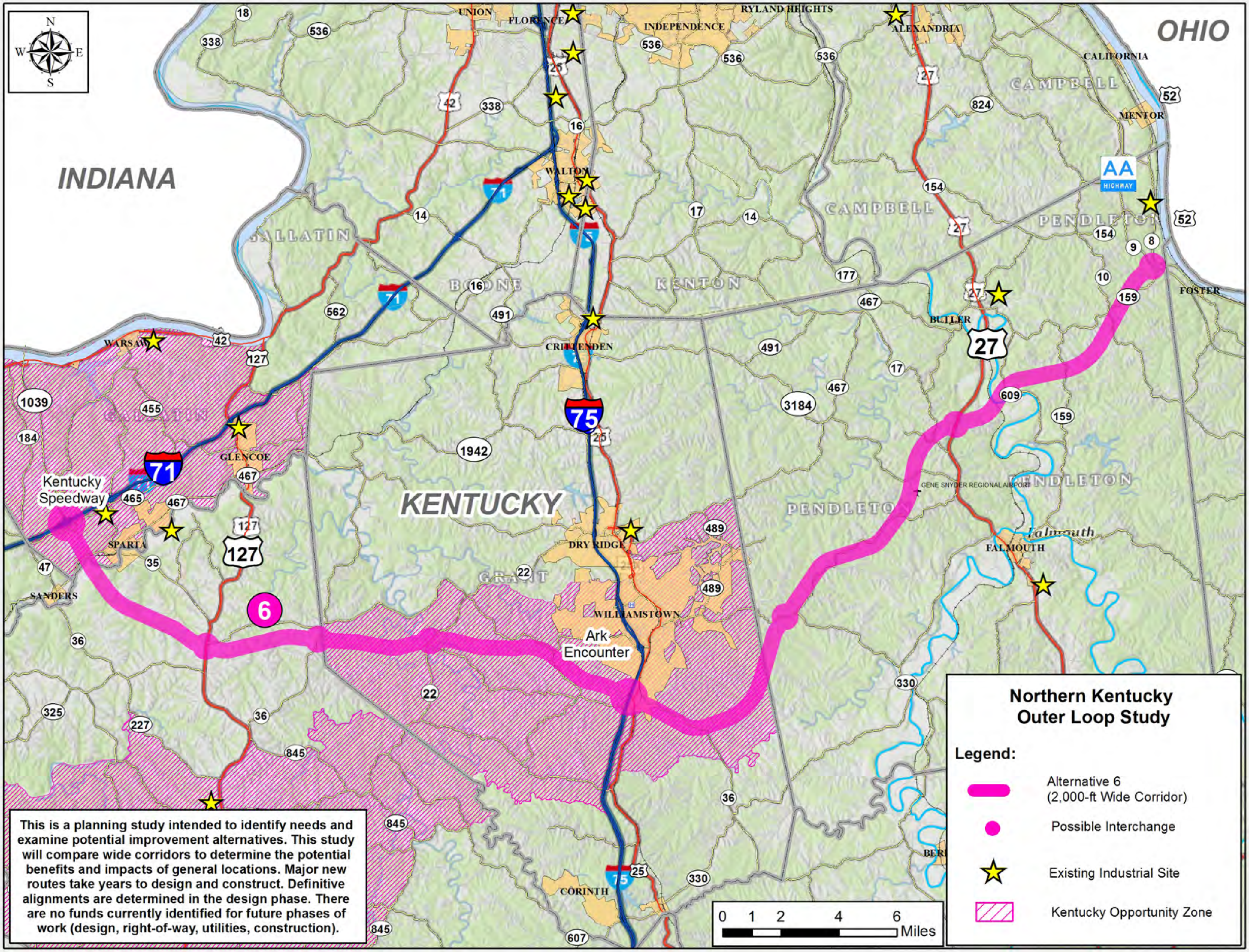
Legend:

- Alternative 3 (2,000-ft Wide Corridor)
- Possible Interchange
- Existing Industrial Site
- Kentucky Opportunity Zone

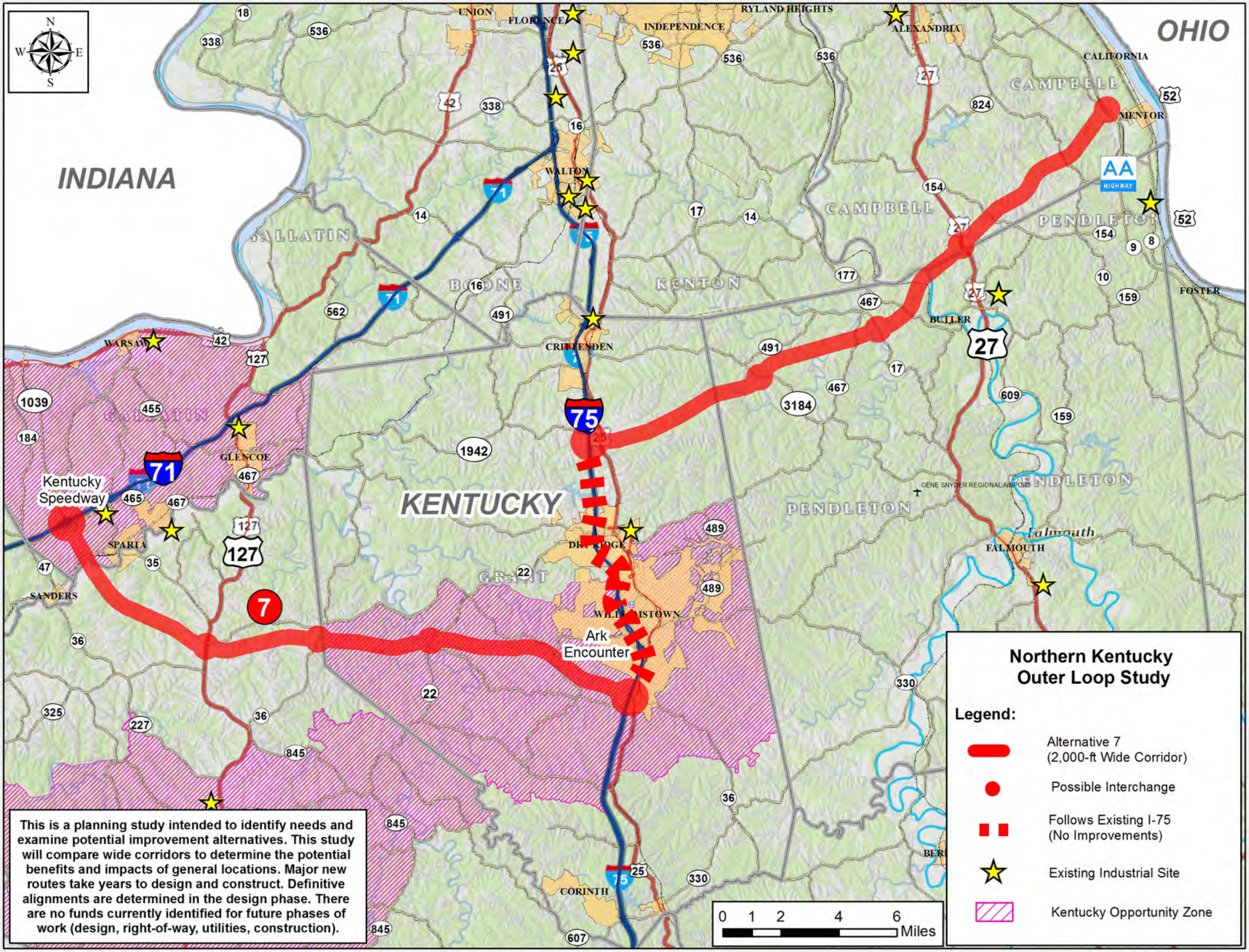

OHIO
INDIANA
KENTUCKY
Kentucky Speedway
Ark Encounter
UNION
FLORENCE
INDEPENDENCE
RYLAND HEIGHTS
ALEXANDRIA
CALIFORNIA
MENTOR
CAMPBELL
PENDLETON
GALLATIN
BOONE
KENTON
WALTON
CRITTENDEN
WARSAW
GLENCOE
SPARTA
SANDERS
DRY RIDGE
GRANT
WILLIAMSTOWN
CORINTH
BUTLER
FALMOUTH
FOSTER
GENE SNYDER REGIONAL AIRPORT
AA HIGHWAY
Northern Kentucky Outer Loop Study
Legend:
Alternative 4 (2,000-ft Wide Corridor)
Possible Interchange
Existing Industrial Site
Kentucky Opportunity Zone
0 1 2 4 6 Miles
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).



Northern Kentucky
Outer Loop Study
Legend:
Alternative 5
(2,000-ft Wide Corridor)
Possible Interchange
Existing Industrial Site
Kentucky Opportunity Zone
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).
0 1 2 4 6 Miles
OHIO
INDIANA
KENTUCKY
5
Kentucky Speedway
Ark Encounter
GALLATIN
BOONE
KENTON
CAMPBELL
PENDLETON
GRANT
UNION
FLORENCE
INDEPENDENCE
RYLAND HEIGHTS
ALEXANDRIA
CALIFORNIA
MENTOR
WALTON
CRITTENDEN
BUTLER
FOSTER
WARSAW
GLENCOE
SPARTA
SANDERS
DRY RIDGE
WILLIAMSTOWN
FALMOUTH
CORINTH
GENE SNYDER REGIONAL AIRPORT
AA HIGHWAY



This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).


OHIO
INDIANA
KENTUCKY
Kentucky Speedway
Ark Encounter
7
UNION
FLORENCE
INDEPENDENCE
RYLAND HEIGHTS
ALEXANDRIA
CALIFORNIA
MENTOR
WALTON
CRITTENDEN
BUTLER
WARSAW
GLENCOE
SPARTA
SANDERS
DRY RIDGE
WILLIAMSTOWN
FALMOUTH
CORINTH
FOSTER
GENE SNYDER REGIONAL AIRPORT
CAMPBELL
KENTON
BOONE
GALLATIN
GRANT
PENDLETON
Northern Kentucky Outer Loop Study
Legend:
Alternative 7 (2,000-ft Wide Corridor)
Possible Interchange
Follows Existing I-75 (No Improvements)
Existing Industrial Site
Kentucky Opportunity Zone
0 1 2 4 6 Miles
This is a planning study intended to identify needs and examine potential improvement alternatives. This study will compare wide corridors to determine the potential benefits and impacts of general locations. Major new routes take years to design and construct. Definitive alignments are determined in the design phase. There are no funds currently identified for future phases of work (design, right-of-way, utilities, construction).