FINAL REPORT

KY 90 Scoping Study
Barren County
KYTC Item No. 3-8819.00

Prepared for:

KENTUCKY TRANSPORTATION CABINET

Kentucky Transportation Cabinet
Central Office, Division of Planning
Highway District 3, Bowling Green

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KYTC Item No. 3-8819.00

EXECUTIVE SUMMARY

The Kentucky Transportation Cabinet (KYTC) initiated the KY 90 Scoping Study in Barren County to examine the need for and types of improvements necessary along KY 90 between Sanders Street in Cave City and US 68 (Veterans Outer Loop) in Glasgow, shown in **Figure ES-1**. The study serves as the first step in establishing project goals, completing an existing conditions analysis, identifying potential concerns, developing cost estimates, and evaluating preliminary alternatives along the 8.414-mile-long corridor.

Purpose and Need

The purpose of the KY 90 Improvement Project is to enhance regional mobility and to provide a safer, more efficient connection between Glasgow and I-65. For vehicles heading northbound on I-65 from Glasgow, KY 90 is the most direct connection. Signs on I-65 direct southbound vehicles to use KY 90 to access Glasgow. KY 90 also provides a link between the Barren River Lake State Park and the Mammoth Cave National Park. KY 90 is part of the National Truck Network (NTN).

Within the study corridor, KY 90 is functionally classified as a Rural Minor Arterial from Sanders Street in Cave City to Beaver Trail in Glasgow and an Urban Minor Arterial in Glasgow from Beaver Trail to US 68. The posted speed limit ranges from 45 to 55 miles per hour (mph). A review of the as-built plans found all the horizontal and vertical curves along KY 90 satisfy requirements for the functional classification and posted speed limits.

The current traffic volumes on KY 90 range between 7,600 and 9,000 vehicles per day (vpd) with 16 to 17 percent trucks. By 2040, traffic volumes are expected to grow to 12,000 vpd with 19 percent trucks. A volume to capacity (V/C) analysis indicates the two-lane road can accommodate the existing and future traffic demand.

Level of service (LOS) is a qualitative measure describing operational conditions within a traffic stream, based on factors such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. In rural areas, LOS C or better is desirable and in urban areas, LOS D or better is desirable. The urban segment of KY 90 in Cave City operates at LOS D. This portion of KY 90 has a signalized intersection at US 31W and no passing opportunities, which decreases the average travel speed and increases the percent time spent following in a platoon. In the rural segment south of Cave City, passing lanes are introduced along KY 90 which increases the average travel speed and decreases the percent time spent following. This portion of KY 90 operates at LOS C. By 2040, KY 90 is expected to operate at LOS E in Cave City and a LOS D south of Cave City. The less than desirable future LOS would suggest that improvements should be considered.

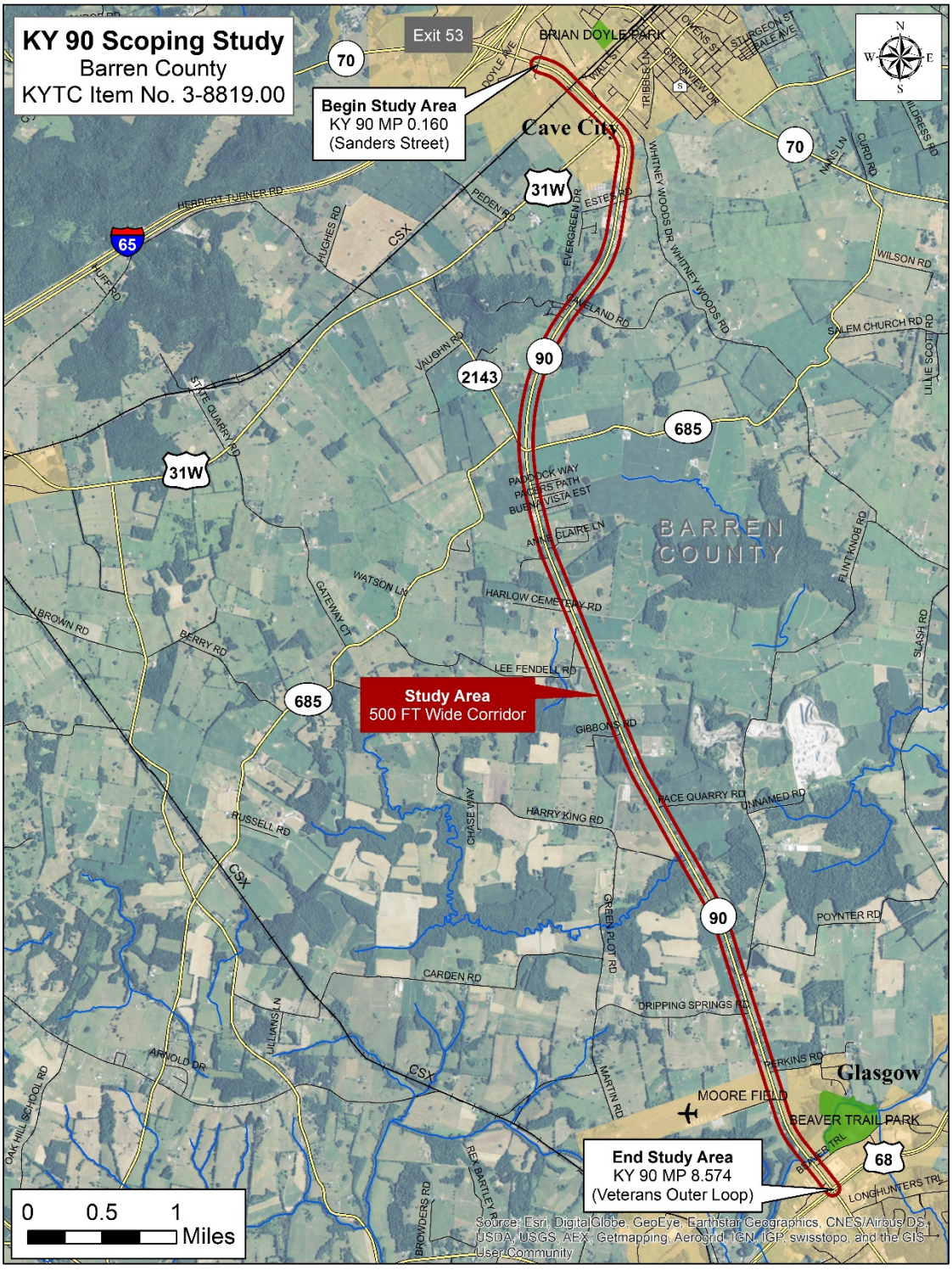

Figure ES-1: Study Area - KY 90 Scoping Study

Over the five-year period between January 1, 2011, and December 31, 2015, 204 crashes were reported along KY 90 in the study area. This includes three fatal crashes (1.5 percent), 47 injury collisions (23 percent), and 154 property damage only collisions (75.5 percent). Along the study corridor, 10 spots were found to have a critical crash rate factor (CRF) greater than 1.0[1].

Alternative Development

Spot improvements and corridor-wide improvements were both evaluated. Spot improvements generally include relatively low cost improvements that can be implemented individually as solutions to address existing roadway concerns. Five locations were identified as conceptual spot improvement projects.

The corridor-wide alternatives would result in the improvement of KY 90 along the entire study area. The corridor was divided into two sections – Section 1 is within the urban area of Cave City and Section 2 is within the rural area between Cave City and Glasgow.

- Section 1 had one preliminary alternative: a five-lane curb-and-gutter typical section with sidewalks and bike lanes. This matches the existing typical section north of Sanders Street.

- Section 2 had two preliminary alternatives: 2+1 typical section and four-lane depressed median.

2+1 Roadways

This concept provides a continuous three-lane cross section that is striped in a manner that provides passing lanes in alternating directions throughout the section. The 2+1 roadway concept has been found to improve operational efficiency and reduce crashes for two-lane highways[2]. A 2+1 road will generally operate two levels of service higher than a conventional two-lane highway serving the same traffic volume[3]. The concept provides a continuous three-lane cross section and the highway is striped in a manner as to provide for passing lanes in alternating directions throughout the section. This concept is an attractive cost savings option over widening two-lane roads to four-lanes where alternating passing lanes can obtain the desired level of service.

South of Cave City, KY 90 currently has three southbound and two northbound passing lanes that increase the average travel speeds and decrease the percent time following, which improves the LOS. This portion of KY 90 currently operates at a desirable LOS C. The 2040 average daily traffic (ADT) is projected to be 12,000 vpd with 19 percent trucks which will

[1] Per the Kentucky Transportation Center's (KTC) annual Analysis of Traffic Crash Data in Kentucky (2011-2015), a CRF greater than 1.00 indicates that crashes may be occurring more often than can be attributed to random occurrence.
[2] AASHTO's A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011
[3] http://transportation.ky.gov/Congestion-Toolbox/Documents/M_OpsEffects_2.pdf

operate at an undesirable LOS D south of Cave City. Building a 2+1 roadway would give KY 90 a desirable 2040 LOS C.

Given the limited number of roadways currently in operation in the United States, a comprehensive safety evaluation of 2+1 designs has not been completed. However, National Cooperative Highway Research Program (NCHRP) Project 20-7[4] evaluated the performance of 2+1 roadways in Europe and found the following results:

- In Germany, 2+1 roadways have been found to operate with crash rates 36 percent lower than conventional two-lane highways.
- Finland has estimated that 2+1 roads operate with crash rates 22–46 percent lower than conventional two-lane highways.

The optimum length of the passing lane (without tapers) is 0.5 to 1.0 miles. Lengths of less than half a mile are not recommended because they are not effective in reducing vehicle platooning. Three of the five existing passing lanes along KY 90 are less than half a mile in length. In total, the existing passing lanes are 2.4 miles long, which makes up 35 percent of KY 90 between Cave City and Glasgow. To achieve a desirable 2040 LOS, the existing passing lanes will need to be extended and additional passing lanes will need to be constructed, which would turn KY 90 into a 2+1 roadway.

Where the passing lanes are dropped on a 2+1 roadway, the taper length is 600 feet. These tapers are meant to be long to minimize the likelihood of head-on collisions. Signs and lane drop arrows are also used to alert vehicles in the passing lane that the lane is ending. Where lanes are added, shorter tapers of 200 feet in length are required. The recommended taper lengths are shown in **Figure ES-2**. Where necessary and appropriate, left turn lanes are placed between tapers in the flush median after traffic has been transitioned out of the passing lanes. An example is shown in **Figure ES-3** where a left turn lane is shown on KY 90 at the KY 685 intersection.

Public Involvement

Public engagement for the KY 90 Scoping Study was undertaken through a two-step process involving a meeting with project stakeholders and local officials, followed by a meeting with the general public. The local officials/stakeholders meeting was held on May 26, 2016. The purpose of the meeting was to present the results of the existing conditions analysis and to get feedback on conceptual improvement alternatives before the public meeting. On June 28, 2016, the project team held a public meeting at the Cave City Convention Center in Cave City. The purpose of the meeting was to provide information about the study and the improvements under consideration, discuss conceptual alternatives, and solicit input from the public. The meeting was co-hosted by KYTC District 3 and Central Office Planning.

[4] http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_275.pdf

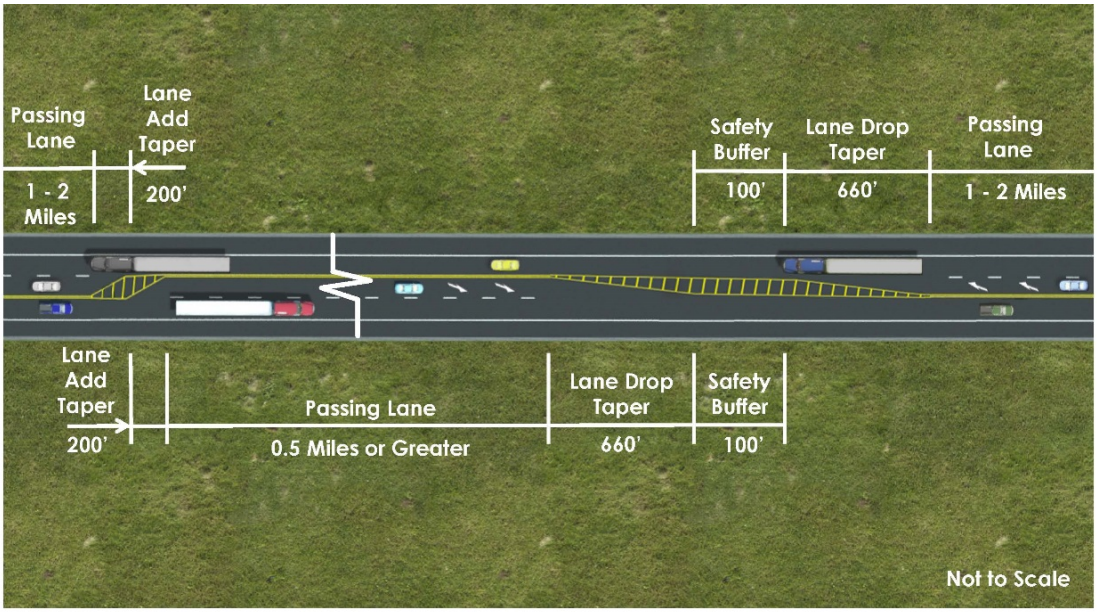

Figure ES-2: Recommended 2+1 Roadway Taper Lengths

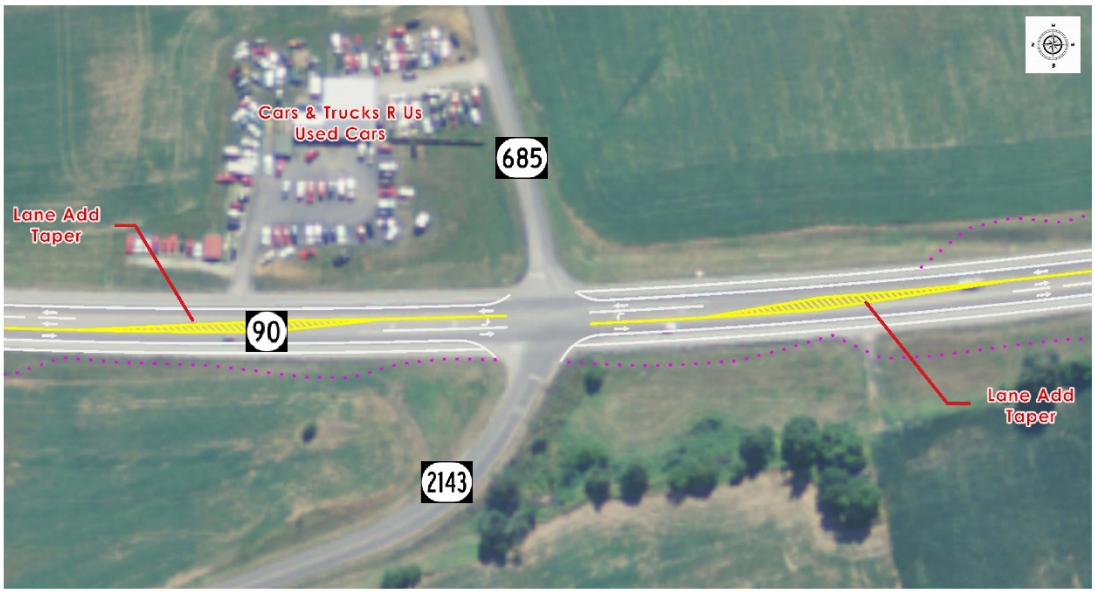

Figure ES-3: Left Turn Lanes on 2+1 Roadways (KY 90 intersection at KY 685)

Surveys were distributed to the local officials, stakeholders, and the public. Eight completed surveys were submitted from the local officials/stakeholders meeting and 48 completed surveys were submitted from the public meeting. The results of the survey are summarized as follows:

- Respondents were asked whether several transportation issues along KY 90 should be addressed as part of the project. Of the 11 options provided, safety and not enough passing lanes were selected most frequently.

- Respondents were asked if they felt improvements were needed along KY 90. Eighty-nine percent of respondents indicated improvements were needed.

- Respondents were asked if they prefer further consideration of the Spot Improvement alternative or the Corridor-wide Improvement. Sixty-seven percent of respondents preferred the Corridor-wide Improvement.

- Respondents were asked which Corridor-wide Improvement they prefer. Thirty-four respondents (64 percent) preferred Alternative 1 (2+1 Typical Section south of Cave City), 15 respondents (28 percent) preferred Alternative 2 (Four-Lane Depressed Median Typical Section south of Cave City), and four respondents (nine percent) wanted a different alternative. Alternative 1 was recommended as the preferred alternative from all eight local officials/stakeholders survey respondents.

- Respondents were asked if a shared-use path should be constructed along KY 90 between Cave City and Glasgow. Thirty respondents (58 percent) said "no" and 22 respondents (42 percent) said "yes."

In addition to the public engagement process, the project team held three meetings to coordinate on key issues. The project team consisted of representatives of the KYTC Central Office, KYTC District 3 Office, representatives of the Barren River Area Development District (BRADD), and the consultant.

Recommendations

Recommendations for the KY 90 Scoping Study were based on their ability to meet the purpose and need, the existing conditions analysis, the input received, and the alternative development process detailed in this report. The project team chose Alternative 1 as the preferred alternative to move forward to Phase 1 design, shown in **Figure ES-4**.

The proposed typical section in Section 1 (Cave City) is a five-lane typical section with curb-and-gutter, sidewalks, and bike lanes. It matches the existing typical section north of Sanders Street.

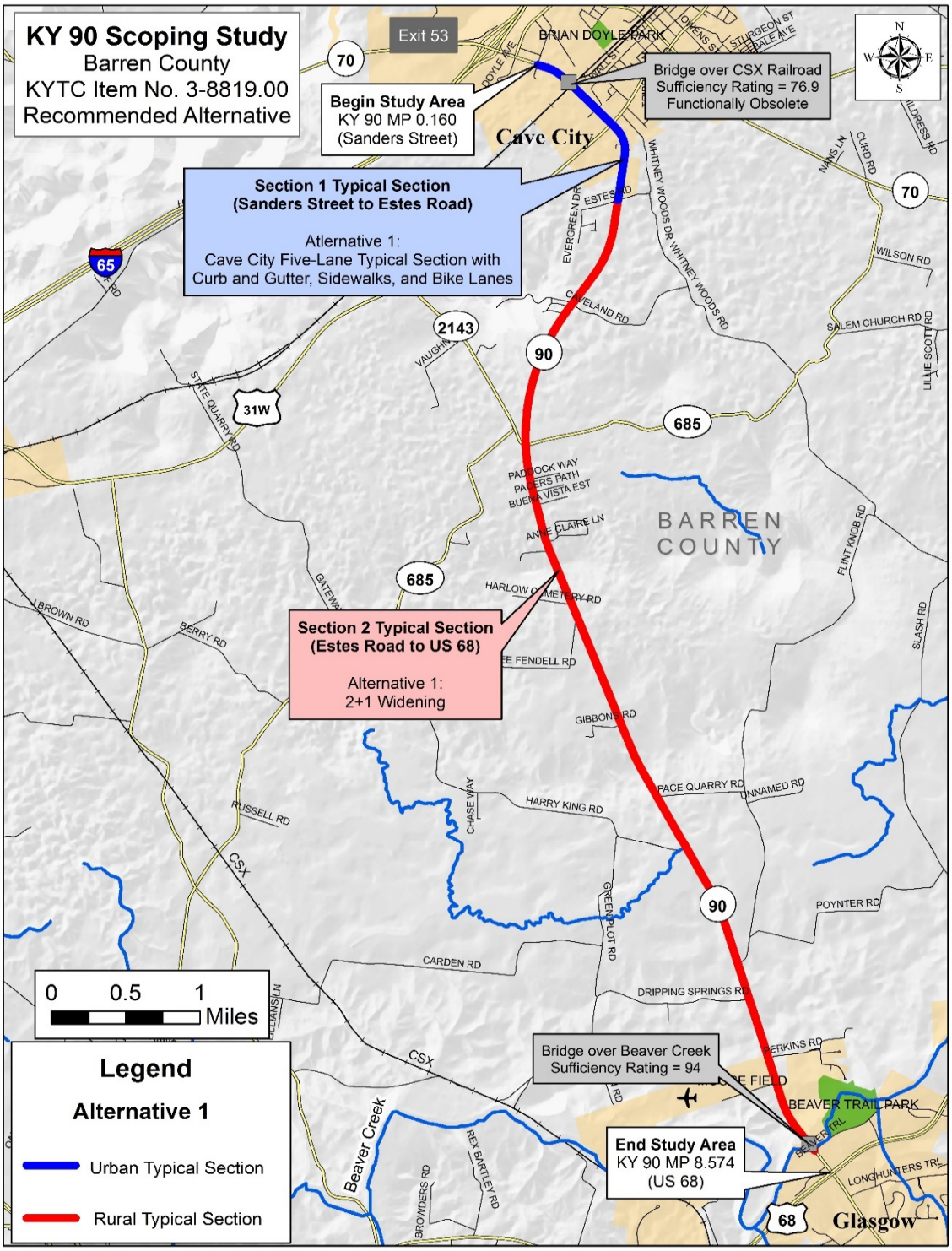

Figure ES-4: Recommended Alternative

A 2+1 typical section is proposed in Section 2. In a localized construction section, the 2+1 widening occurs on one side of the road so traffic can be maintained during construction and most existing mainline pavement can be reused. The widening throughout the corridor should shift from one side of the road to the other, depending upon existing conditions, to minimize right-of-way and environmental impacts, and reduce earthwork. It is assumed that after the widening is complete, a final pavement surface course and final striping will be placed over the entire roadway. Reduced shoulder widths and lane widths should be considered for the 2+1 typical section in Phase 1 design. This can enhance safety by reducing travel speeds and will further reduce right-of-way impacts and construction costs.

The project team chose Alternative 1 as the preferred alternative because it:

- Satisfies the purpose and need of the project;
- Addresses the top two transportation issues from survey respondents (safety and not enough passing lanes);
- Provides acceptable LOS through year 2040;
- Was selected as the preferred alternative from the majority of the public survey respondents and all of the local officials/stakeholders' survey respondents;
- Can be built within the 2016 Highway Plan budget;
- Provides a corridor wide improvement (Cave City to Glasgow), which meets the intent of the project description in the 2016 Highway Plan;
- Provides the most design flexibility which reduces right-of-way impacts, environmental impacts, and construction costs; and
- Does not require widening or replacing the bridge over Beaver Creek.

If the project moves forward, a shared-use path merits further consideration in Phase 1 design. The local officials in Glasgow, Cave City and/or Barren County will need to agree to maintain the shared-use path before it moves further in design. The addition of a shared-use path reduces design flexibility. Many of the homes and businesses along KY 90 are adjacent to the existing roadway right-of-way. Widening to the west and constructing the shared-use path to the east would affect properties on both sides of the road. Thus, where the shared-use path is included, all the widening is done to the east, which increases earthwork and right-of-way impacts. The increased right-of-way impacts will increase the project timeline considerably. The addition of the shared-use path to the 2+1 typical section is estimated to require three additional home relocations, one additional business relocation, a new pedestrian bridge over Beaver Creek, and an additional $9.0 million in total project cost ($5.1 million of which is directly related to the construction). An alternative that may be considered would be the inclusion of a shoulder

bikeway. However, a similar maintenance agreement with the local municipalities would be required to provide a debris-free area for cyclists to operate.

Cost estimates for Alternative 1 with and without the shared-use path are shown in **Table ES-1.** The cost estimates are based on approximate earthwork volumes, pavement areas, and structures affected. These major project construction items were used to estimate the construction costs for the alternatives under consideration. Typical paving sections were determined for cost estimating purposes. A digital terrain model of the recommended alternative was created to approximate disturbed limits for the improvements which were used to determine right-of-way costs, number of utilities affected, and to estimate the number of relocations.

Alternative	Description	2016 Cost Estimates (millions)				
		Design	Right-of-Way	Utility	Construction	Total
2016 Highway Plan	**Major Widening from Sanders Street in Cave City to US 68 (Glasgow Outer Loop) in Glasgow**	**$2.2**	**$6.0**	**$3.5**	**$27.5**	**$39.2**
Alternative 1	Five-Lane Urban Typical Section in Cave City and 2+1 Typical Section South of Cave City	$2.0	$2.5	$10.0	$20.5	$35.0
Alternative 1b	Five-Lane Urban Typical Section in Cave City and 2+1 Typical Section with Shared-Use Path South of Cave City	$2.6	$5.8	$10.0	$25.6	$44.0

Table ES-1: Alternative 1 Cost Estimates

1.0 INTRODUCTION

The KY 90 Scoping Study, Kentucky Transportation Cabinet (KYTC) Item Number 3-8819.00, was initiated by KYTC to evaluate the need for and impacts of transportation improvements along KY 90 in Barren County. The project includes an examination of the 8.414-mile route between Sanders Street in Cave City (MP 0.160) and US 68 (Veterans Outer Loop) in Glasgow (MP 8.574).

The KY 90 project is listed in the 2016 KYTC Six-Year Highway Plan. The project is currently funded through the utility phase with Federal Surface Transportation Program (STP) funds with $2.2 million for design in 2016, $6.0 million for right-of-way acquisition in 2017, and $3.5 million for utility relocation in 2017. The construction phase is funded outside the two-year biennium with $27.5 million in State Priority Project (SPP) funds in 2019.

1.1 STUDY AREA

The study area for the KY 90 Scoping Study is a 500-foot wide corridor, shown in red on **Figure 1**, centered along existing KY 90. The study corridor serves primarily residential homes and farmland except for the portion in Cave City, which serves commercial businesses. The study area is bounded to the northwest by Sanders Street in Cave City and to the southeast by US 68 in Glasgow. KY 90 provides a north-south connection through Barren County and provides the most direct regional connection for areas between Glasgow and vehicles heading northbound on I-65. KY 90 also provides a link between the Barren River Lake State Park and the Mammoth Cave National Park.

1.2 COMMITTED PROJECTS

There are seven additional projects listed in the 2016 KYTC Six-Year Highway Plan in Barren County. These, along with the KY 90 project, are shown in **Figure 2**. None of the proposed projects connect to KY 90 in this study area. Outside of the Six- Year Plan projects, there is one project on KYTC's Unscheduled Needs List (UNL) that has an active Project Identification Form (PIF) and two projects that have been labeled inactive within the KY 90 study limits:

- PIF 03 005 D0090 1685.0 – Major Widening from Sanders Street in Cave City to US 68 in Glasgow. This is the current project under consideration with Item Number 3-8819.00.

- PIF 03 005 D0090 3.00 (Inactive) – Major Widening to 4 Lanes from Sanders Street in Cave City to Glasgow Bypass. On May 2, 2014, the Barren River Area Development District (BRADD) Regional Transportation Council (RTC) voted this project to be marked as inactive.

- PIF 03 005 D0090 3.80 (Inactive) – Reconstruct intersections at Flint Knob Road and Dripping Springs Road for turn lanes and improved sight distance. On May 2, 2014, the BRADD RTC voted this project to be marked as inactive.

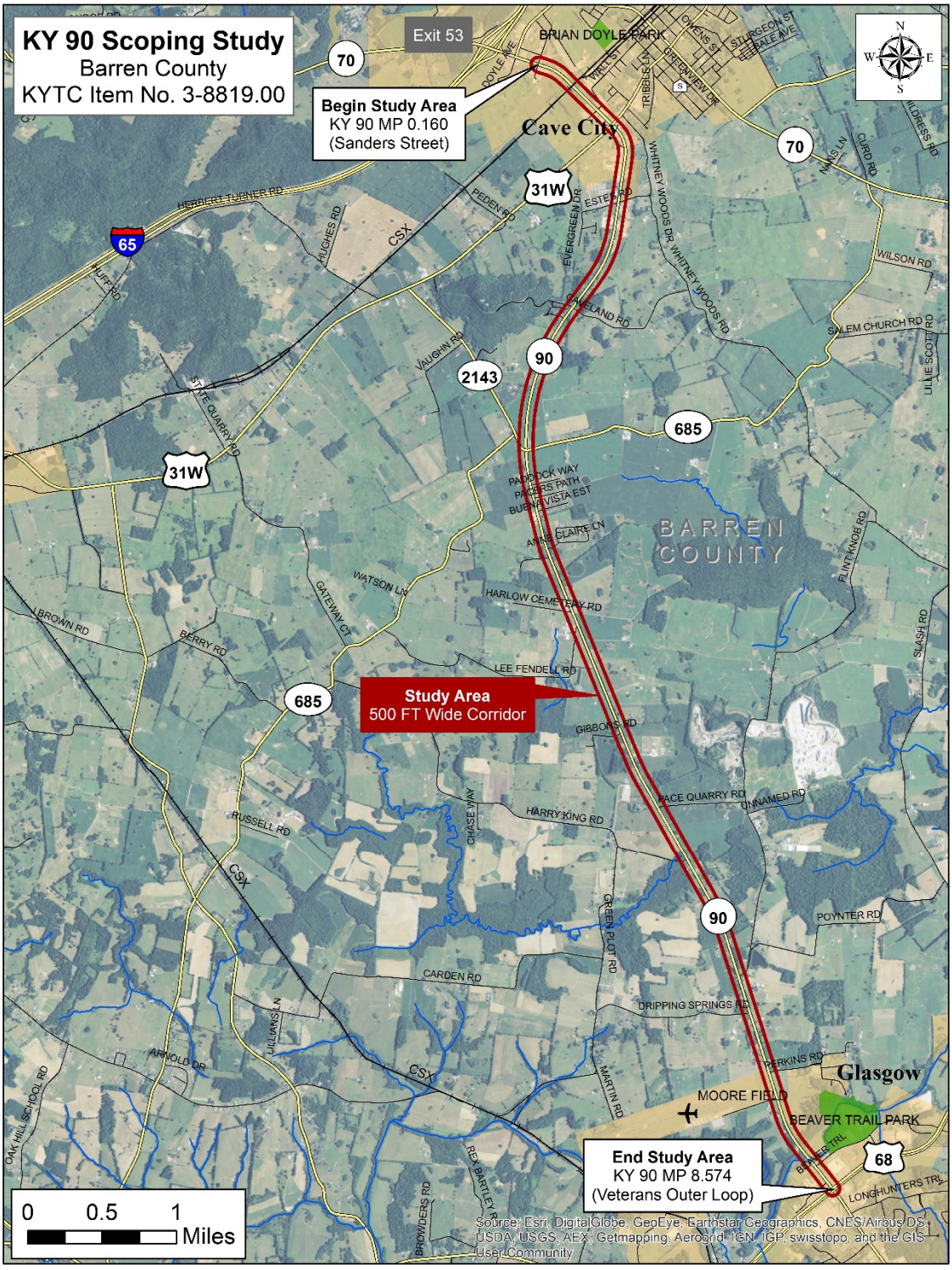

Figure 1: Study Area - KY 90 Scoping Study

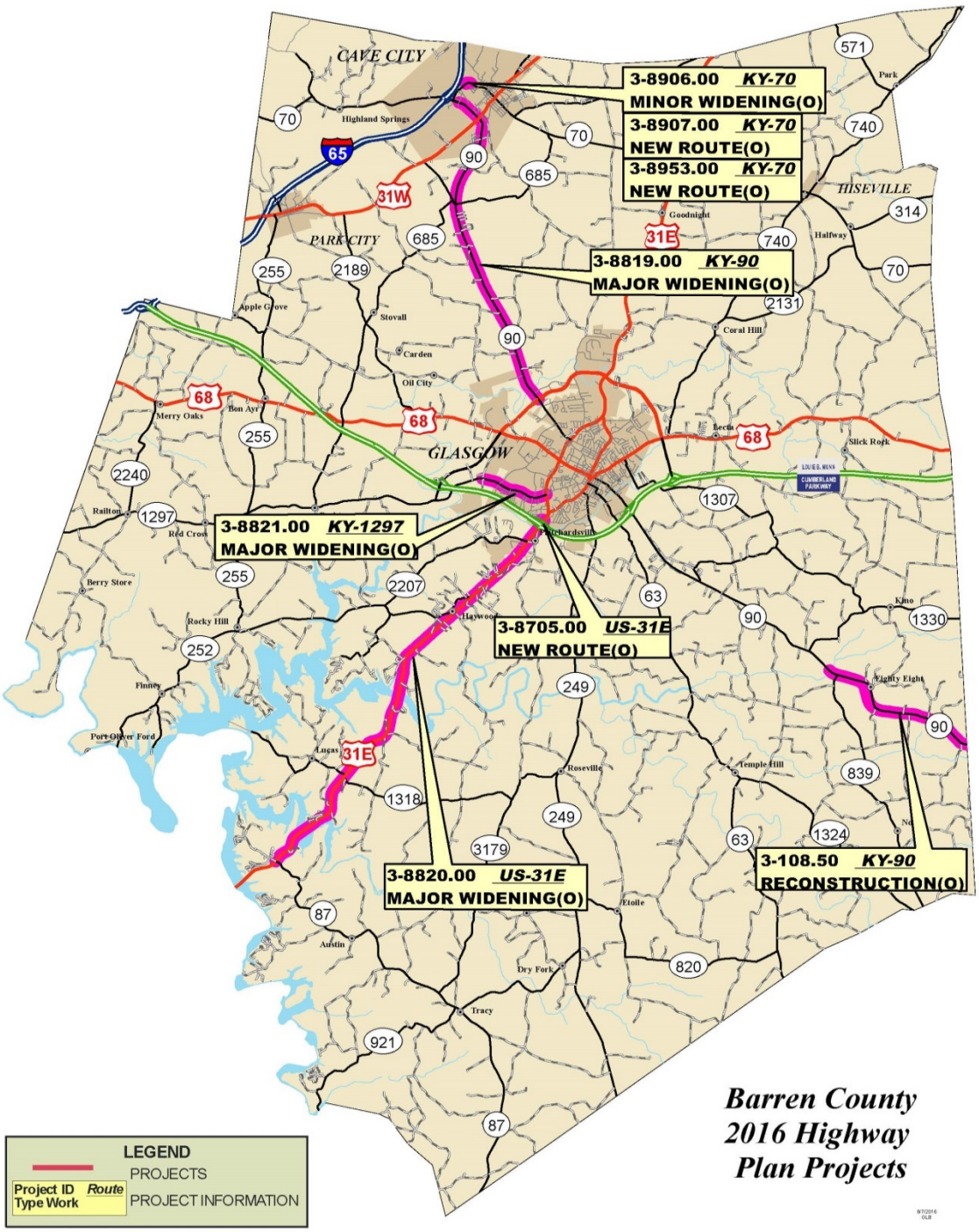

Figure 2: Barren County 2016 Highway Plan Projects
(Source: KYTC Division of Program Management)

2.0 EXISTING CONDITIONS

Conditions of the existing transportation network are examined in the following section. The information compiled includes current roadway facilities and geometrics, crash history, and traffic volumes within the study area. Data for this section were collected from the KYTC's Highway Information System (HIS) database, KYTC's Traffic Count Reporting System, aerial photography, as-built plans, and from field inspection. A summary of this information is included in **Table 1**.

Section	Begin Milepoint	End Milepoint	Section Length (miles)	Functional Classification	AADT (Year) [1]	Truck % [1]	Terrain	Speed Limit	Facility Type	Lane Widths	Shoulder Widths
1	0.160	0.676	0.516	Rural Minor Arterial	9,000 vpd (2015)	17.1%	Rolling	45 mph	2 Lanes*	12'	10' **
	Sanders Street	Baker Hale Street									
2	0.676	0.819	0.143		7,600 vpd (2013)						
	Baker Hale Street	US 31W									
3	0.819	1.364	0.545		8,900 vpd (2014)						
	US 31W	Estes Road									
4	1.364	3.186	1.822					55 mph			
	Estes Road	KY 685									
5	3.186	8.422	5.236		8,400 vpd (2013)	16.1%					
	KY 685	Beaver Trail									
6	8.422	8.574	0.152	Urban Minor Arterial							
	Beaver Trail	Veterans Outer Loop									

[1] Source: KYTC Traffic Count Reporting System - annual average daily traffic (AADT) volumes in vehicles per day (vpd)
* SB Passing Lanes from MP 1.495 - MP 2.153, MP 3.764 - MP 4.069, and MP 5.097 - MP 5.491.
NB Passing Lanes from MP 5.491 - MP 5.755 and MP 7.322 - 8.160
**Where there are passing lanes the adjacent shoulder is two feet.

Table 1: KY 90 Existing Conditions Summary from KYTC HIS Database

2.1 ROADWAY SYSTEM

Functional classification is the grouping of roads, streets, and highways into integrated systems ranked by the level of mobility for through movements and access to adjoining land. This grouping acknowledges that roads serve multiple functions and it provides a basis for comparing roads. Functional classification can be used for, but is not limited to, the following purposes:

- Provide a framework for highways serving mobility and connecting regions and cities within a state.
- Provide a basis for assigning jurisdictional responsibility according to the roadway's importance.
- Provide a basis for development of minimum design standards according to function.
- Provide a basis for evaluating present and future needs.
- Provide a basis for allocation of limited financial resources.

Figure 3 shows the functional classification of roadways within the study area. Within the study corridor, KY 90 is functionally classified as a Rural Minor Arterial from Sanders Street in Cave City to Beaver Trail in Glasgow and an Urban Minor Arterial in Glasgow from Beaver Trail to US 68. The posted speed limit ranges from 45 to 55 mph.

2.2 ROADWAY GEOMETRIC CHARACTERISTICS

As part of the study effort, a review of existing geometrics along KY 90 and adjacent roadways was performed and compared against geometric standards in *AASHTO's A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011*, commonly referred to as the "Green Book."

The estimated lane widths and passing lane locations from KYTC's HIS database are shown on **Figure 4**. Current Green Book design guidelines suggest a minimum of 12-foot-wide lanes on rural arterial roadways with an ADT over 2,000 vehicles per day (vpd) and speeds between 45 and 55 mph (Green Book Table 7-3). KY 90 has 12-foot-wide lanes throughout the study area, which meets the minimum recommendations from the Green Book. For roadways to be reconstructed, a 22-foot traveled way may be retained where the alignment is satisfactory and there is no crash pattern suggesting the need for widening.

Estimated shoulder widths from KYTC's HIS database are shown on **Figure 5**. In the study area, KY 90 has ten-foot-wide paved shoulders. Where there are passing lanes, the adjacent paved shoulder is narrowed to two feet. This meets the minimum recommendations from the Green Book. Eight-foot shoulder widths are recommended for rural arterial roadways with an ADT higher than 2,000 vpd, but the paved shoulder width may be a minimum of two-feet (Green Book Table 7-3).

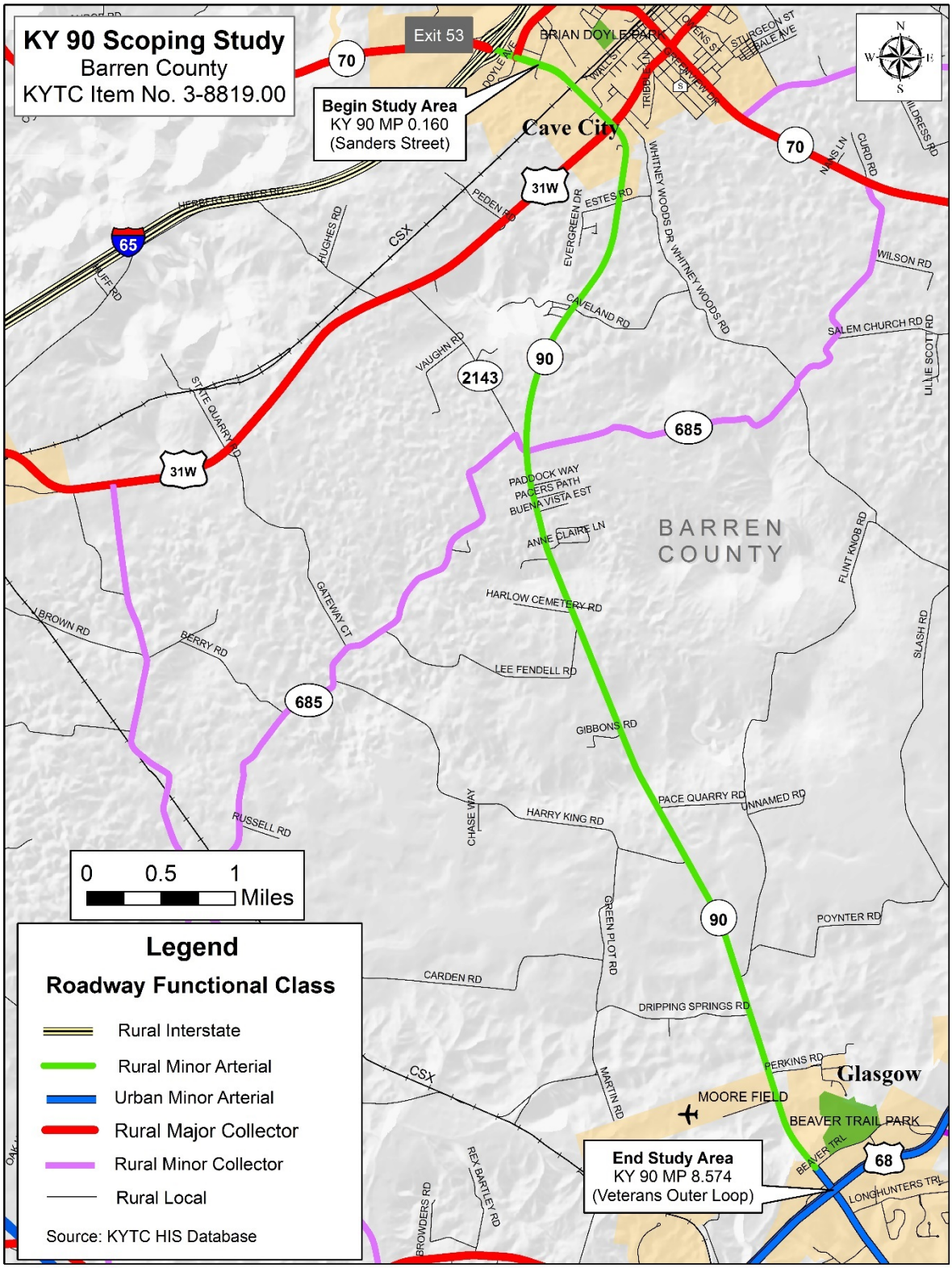

Figure 3: Functional Classification

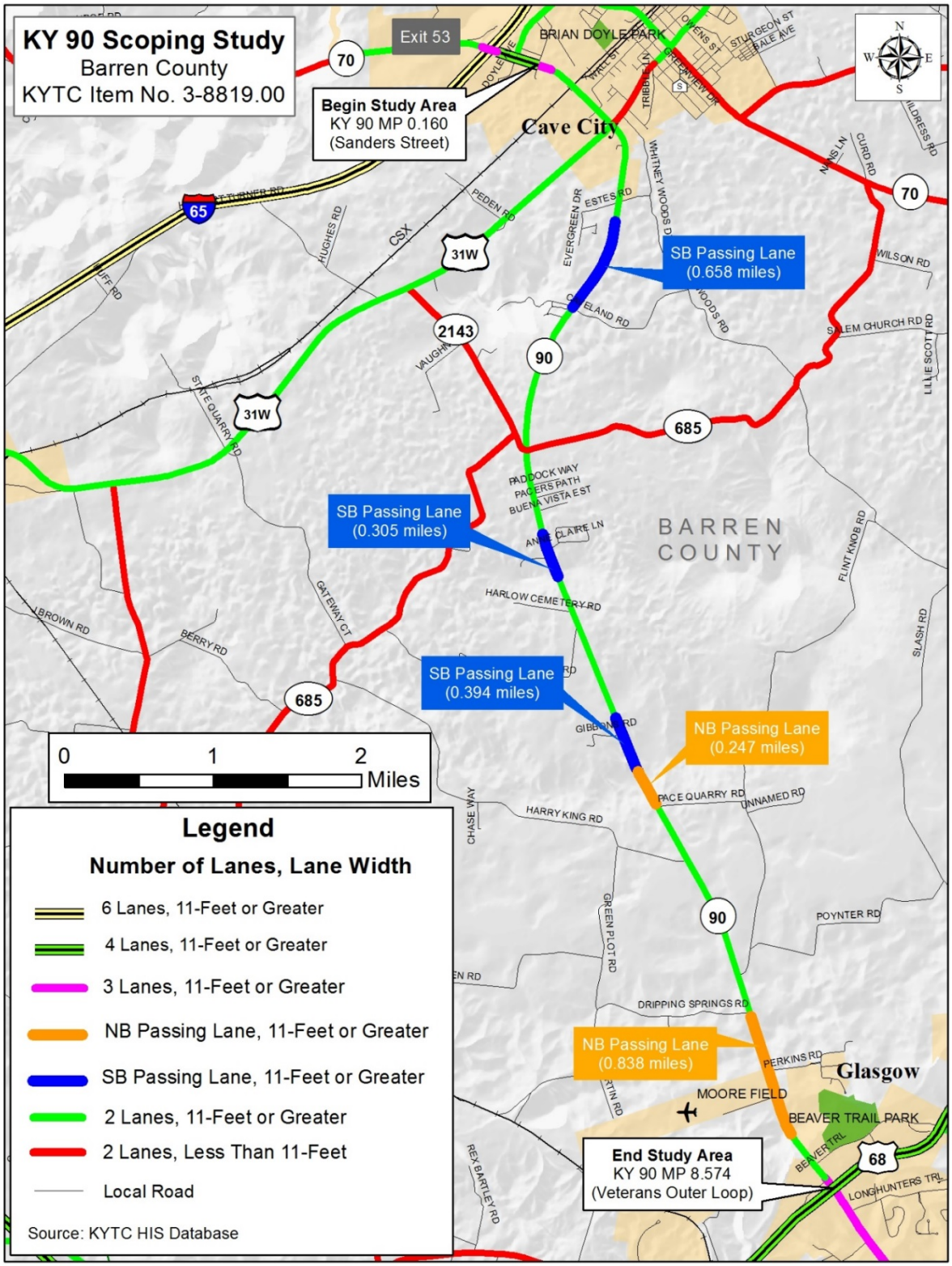

Figure 4: Lane Widths and Passing Lanes

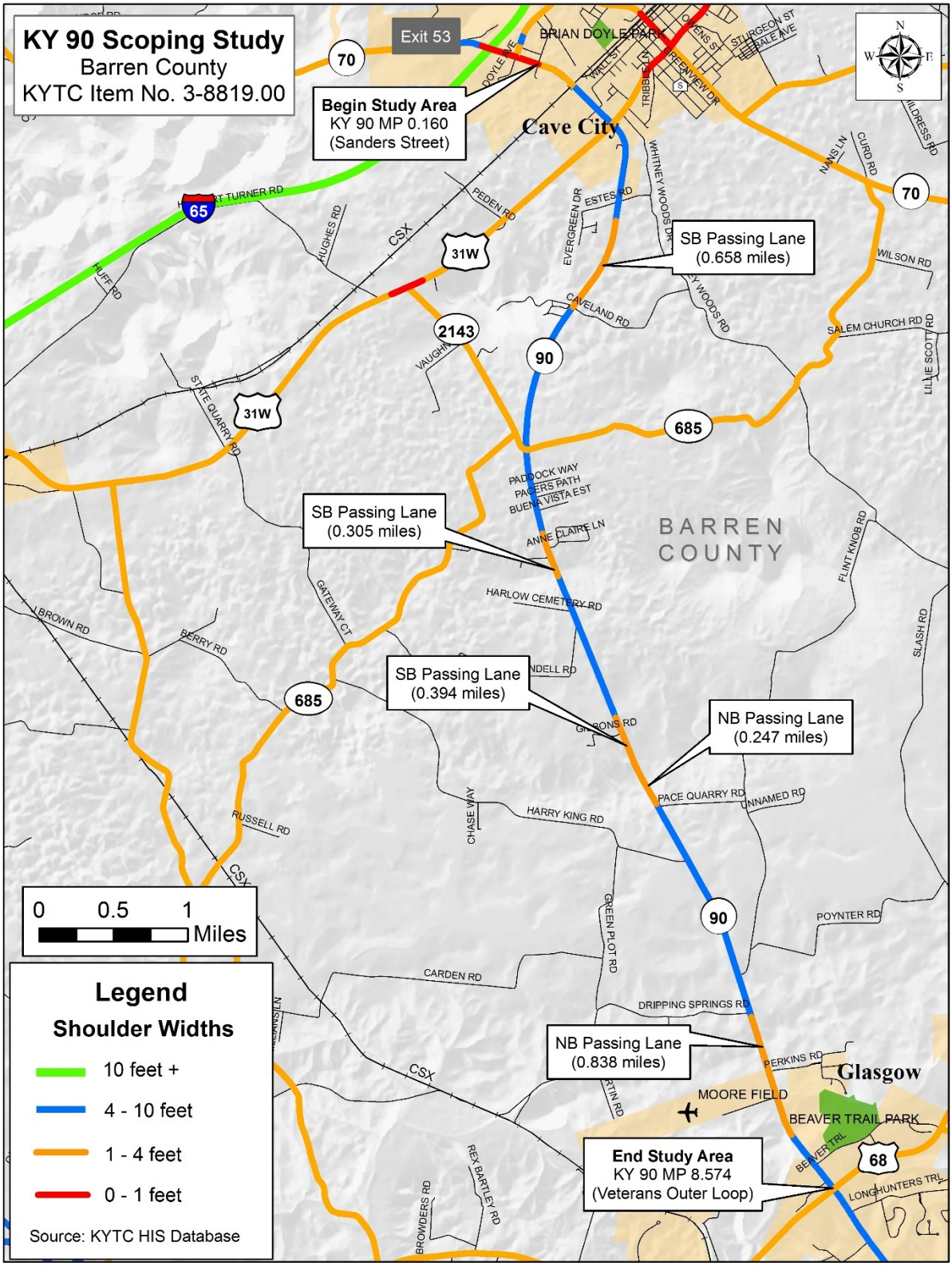

Figure 5: Shoulder Widths

A review of the as-built plans found all the horizontal and vertical curves along KY 90 satisfy requirements for the existing functional classification and posted speed limits. The steepest grade along the study area is five percent which equals the maximum desirable grade for a 55 mph rural arterial in rolling terrain. The detailed geometric analysis and standards for KY 90 are in **Appendix A**.

2.3 STRUCTURES

Two bridges are located along the study corridor, shown in **Figure 6**. From the KYTC Bridge Data Miner, existing structure sufficiency ratings were identified during 2011 bridge inspections. This rating assigns individual structures with a measure of "sufficiency" to remain in service. The higher sufficiency rating a bridge has, the better the condition of the bridge. Bridges considered structurally deficient or functionally obsolete with a sufficiency rating less than 50.0 are regularly considered for rehabilitation or replacement funding. Those considered functionally obsolete with a sufficiency rating of 80.0 or less are regularly considered for rehabilitation funding. Bridges are considered structurally deficient if significant load carrying elements are found to be in poor condition due to deterioration and/or damage, or the adequacy of the waterway opening provided by the bridge is determined to be extremely insufficient to the point of causing overtopping with intolerable traffic interruptions. Bridges are considered functionally obsolete if they do not meet current geometric design standards (such as lane or shoulder widths).

The bridge over the CSX railroad near the beginning of the study area in Cave City (MP 0.411) has a sufficiency rating of 76.9 and is considered functionally obsolete due to narrow shoulder widths that do not meet current design standards. The only other structure on the study portion of the corridor is the bridge over Beaver Creek north of US 68. This bridge has a sufficiency rating of 94.

2.4 OTHER MODAL USERS

There are no bike lanes, sidewalks, or transit routes along the study area portion of KY 90. However, bicycle lanes and sidewalks are currently provided on KY 90 north of Sanders Street.

KY 90 in Barren County serves primarily residents and farmland. As a result, large farming equipment regularly use KY 90, which adversely affects traffic operation.

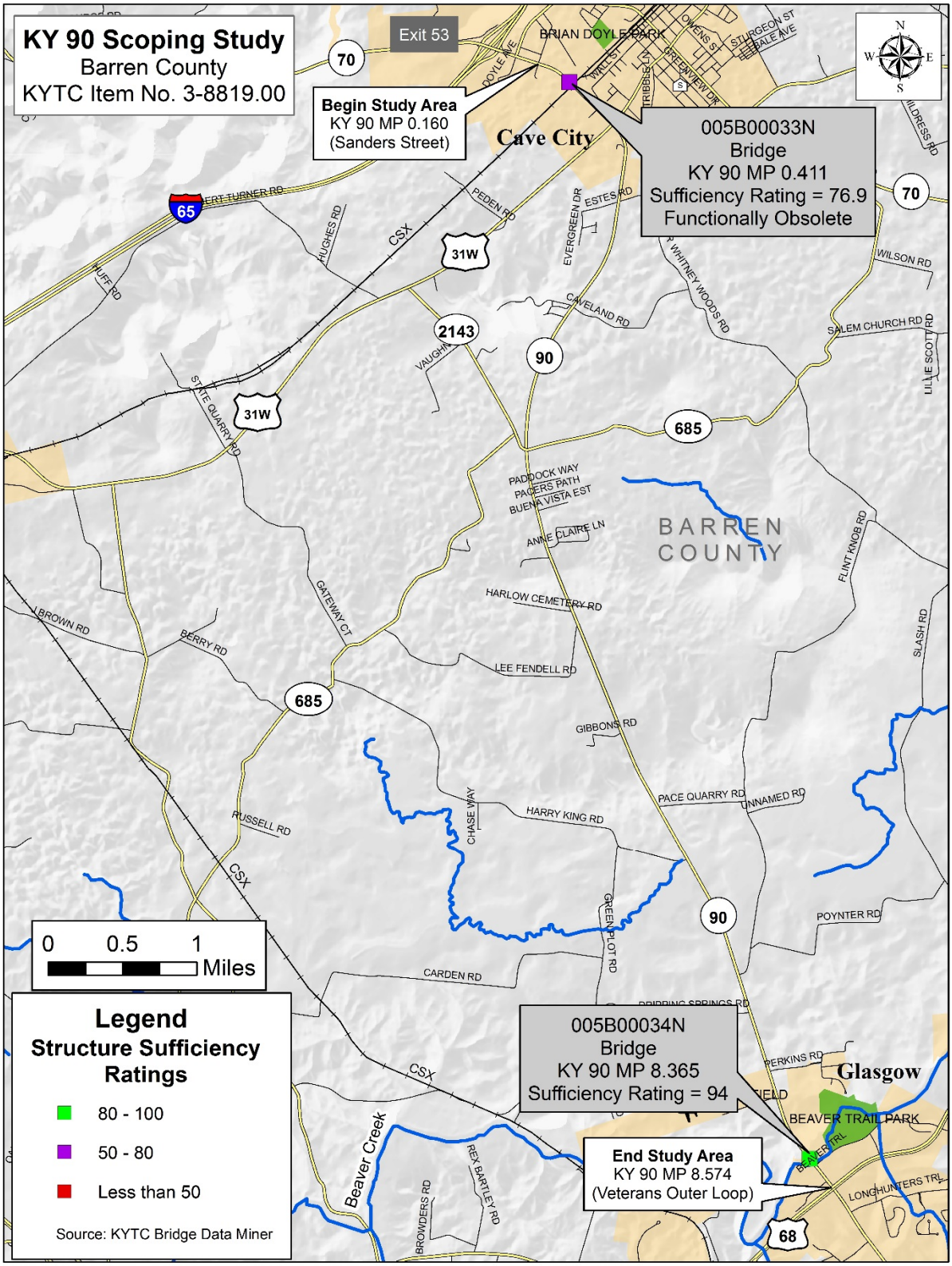

Figure 6: Structure Locations

2.5 EXISTING TRAFFIC ANALYSIS (YEAR 2015)

The most recent average daily traffic (ADT) volumes from KYTC's traffic count stations are shown on **Figure 7**. The traffic volumes on KY 90 range between 7,600 and 9,000 vehicles per day (vpd) with 16 to 17 percent trucks.

To evaluate the adequacy of roadway segments, existing ADT volumes were compared to the road's theoretical capacity. This is the preferred KYTC methodology for evaluating the adequacy of roadway segments. A volume-to-capacity ratio (V/C) represents the proportion of traffic demand for using the roadway for the designated time period in relation to its capacity to serve the demand. A V/C greater than 1.0 indicates the road is congested (i.e., operating near or above its design capacity). V/C ratios were estimated along KY 90 based on the estimated 2015 daily traffic volumes from KYTC's Traffic Forecast Report, included in **Appendix B**. After performing a V/C analysis using Highway Capacity Manual (HCM) procedures, all roadway segments currently operate at less than capacity with a V/C no greater than 0.49, as shown in **Table 2**.

Description	Begin Milepoint	End Milepoint	Existing (2015)			
			ADT [1]	% Trucks [1]	LOS	V/C
Sanders Street to Estes Road	0.160	1.369	9,000	17%	D	0.49
Estes Road to US 68	1.369	8.574	9,000	17%	C	0.47

[1] Appendix B - KYTC Traffic Forecast Report

Table 2: 2015 Traffic Analysis Summary

Level of service (LOS) is a qualitative measure describing operational conditions within a traffic stream, based on factors such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. For two-lane highways serving moderately developed areas, such as KY 90 in Cave City, LOS is determined based on the percentage of the average travel speed compared to the free flow speed. For two-lane highways serving as intercity routes or primary connectors, such as KY 90 between Cave City and Glasgow, LOS is determined based on two parameters – average travel speed and percent time spent following in a platoon. In rural areas, LOS C or better is desirable and in urban areas LOS D or better is desirable. The urban portion of KY 90 in Cave City operates at LOS D. This portion of KY 90 has a signalized intersection at US 31W and no passing opportunities, which decreases the percent of free-flow speed. South of Cave City, passing lanes are introduced along KY 90, which increases the average travel speed and decreases the percent time spent following. This rural portion of KY 90 operates at LOS C. Therefore, all sections of KY 90 currently operate at an acceptable LOS.

The results of the V/C and LOS analysis indicate KY 90 can adequately accommodate the existing traffic demand. Table 2 presents the estimated 2015 ADT, truck percentage, LOS, and V/C for each segment from KYTC's. The estimated 2015 ADT and truck percentage are from KYTC's Traffic Forecast Report which do not exactly match the ADT's shown in Figure 7.

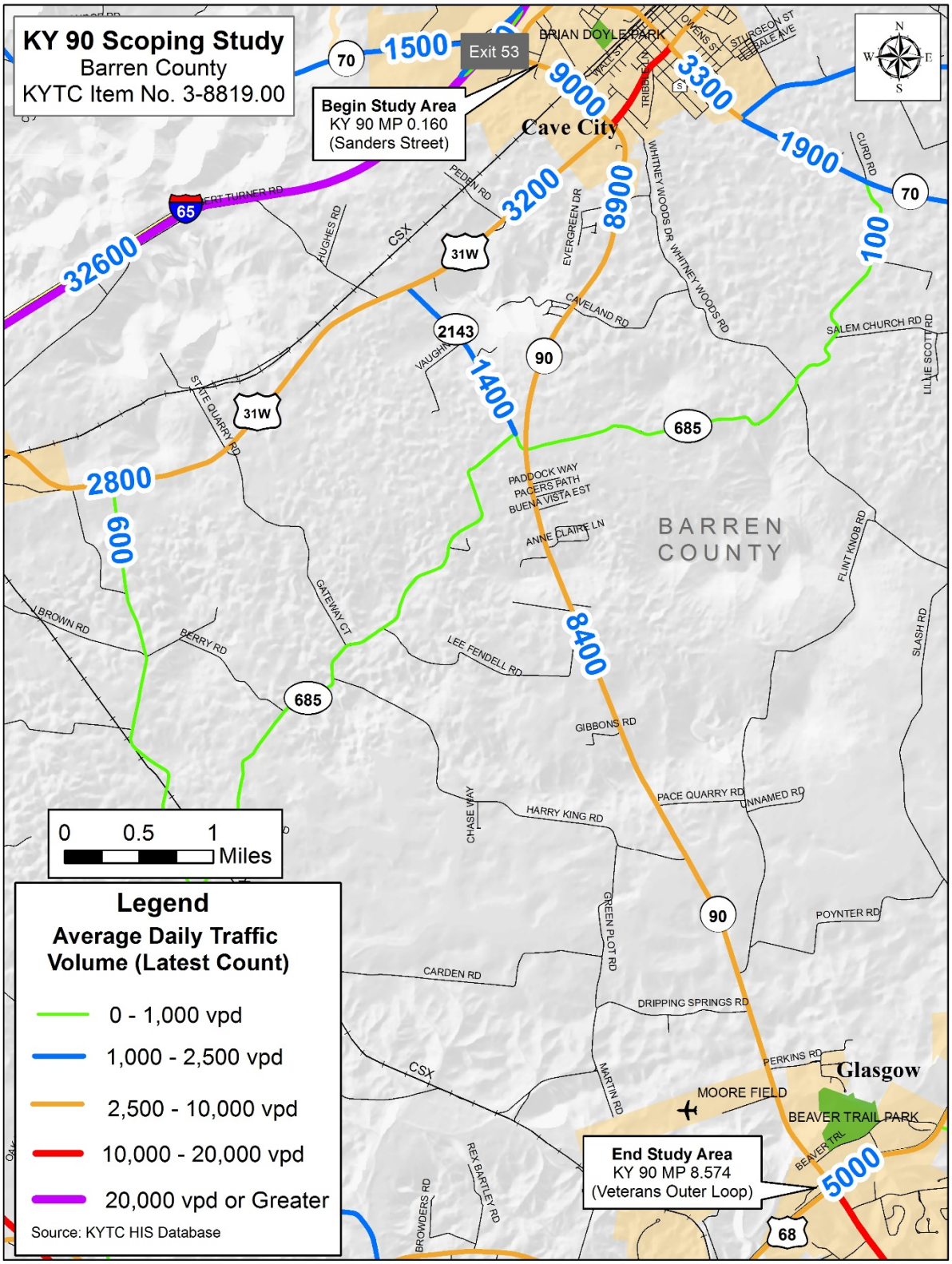

Figure 7: Current ADT Volumes from KYTC's Traffic Count Stations (In vehicles per day, vpd)

2.6 CRASH HISTORY

To quantify safety concerns, a crash analysis was performed for the study portion of KY 90. Historical crash data from the Kentucky State Police collision database were collected along the study area for a five-year period between January 1, 2011, and December 31, 2015. The crash records and locations are included in **Appendix C**.

2.6.1 Crash Severity

Over the analysis period, there were 204 reported crashes along the 8.414-mile corridor. Of these, three crashes resulted in fatalities and 47 resulted in injuries. **Figure 8** summarizes the distribution of crashes by severity.

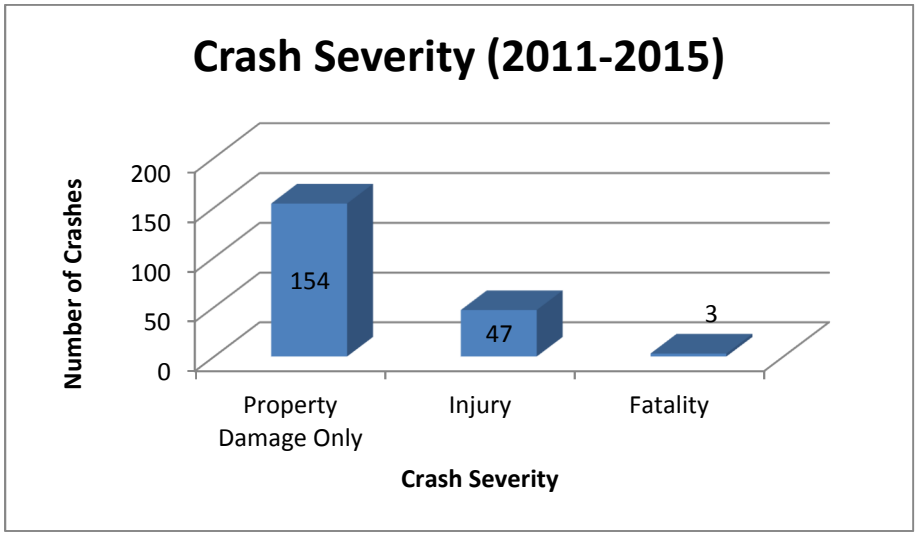

Figure 8: Distribution of Crashes by Severity

The percentages of fatal and injury collisions along KY 90 are slightly higher than similar roads in Kentucky. Based on the most recent statewide crash data compiled in the Kentucky Transportation Center research report *Analysis of Traffic Crash Data in Kentucky (2011-2015)*[5], injury crashes along rural minor arterials generally comprise 20.8 percent of total crashes; along the study portion of KY 90, injury crashes comprise 23.0 percent of the total reported crashes. Fatal crashes along rural minor arterials generally comprise 1.0 percent of total crashes; along the study portion of KY 90, fatal crashes comprise 1.5 percent of the total reported crashes.

[5] Green, Eric R., Kenneth R. Agent, and Jerry G. Pigman. "Analysis of Traffic Crash Data in Kentucky (2011-2015)." (2016).

2.6.2 Crash Type

To better understand the crash history along this corridor, the crash types were examined. **Figure 9** and **Figure 10** demonstrate the distribution of crashes by crash type. Rear end crashes were the most commonly reported crash type (72 crashes, 35 percent) and are concentrated at intersections and entrances along the study area. Single vehicle crashes were the second most commonly reported crash type (53 crashes, 26 percent) and are predominately run-off the road collisions south of Cave City. Other common types of crashes included angle (32 crashes, 16 percent) and sideswipe crashes (32 crashes, 16 percent).

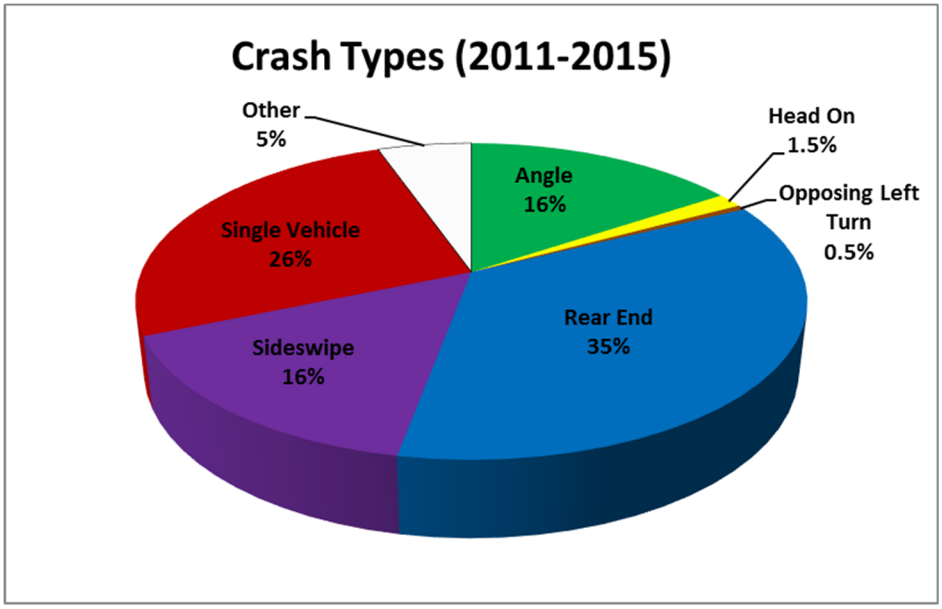

Figure 9: Distribution of Crashes by Type

2.6.3 Critical Rate Factor

Crashes were geospatially referenced and compared to statewide data to identify locations experiencing above average crash rates. The methodology is defined in the Kentucky Transportation Center research report *Analysis of Traffic Crash Data in Kentucky* (2011-2015). When analyzing crashes, typically two different lengths of roadway sections are evaluated, segments and spot locations. As defined in the methodology report, roadway segments vary in length and are divided where geometry or traffic volumes change. For each segment, the number of crashes, traffic volume, rural/urban, number of lanes, and segment length were evaluated to determine the critical rate factor (CRF)[6].

[6] The CRF is one measure of the safety of a road, expressed as a ratio of the crash rate at the location compared to the critical crash rate for similar roadways throughout the state. A CRF of 1.00 or greater may indicate that crashes are occurring due to circumstances not attributed to random occurrence.

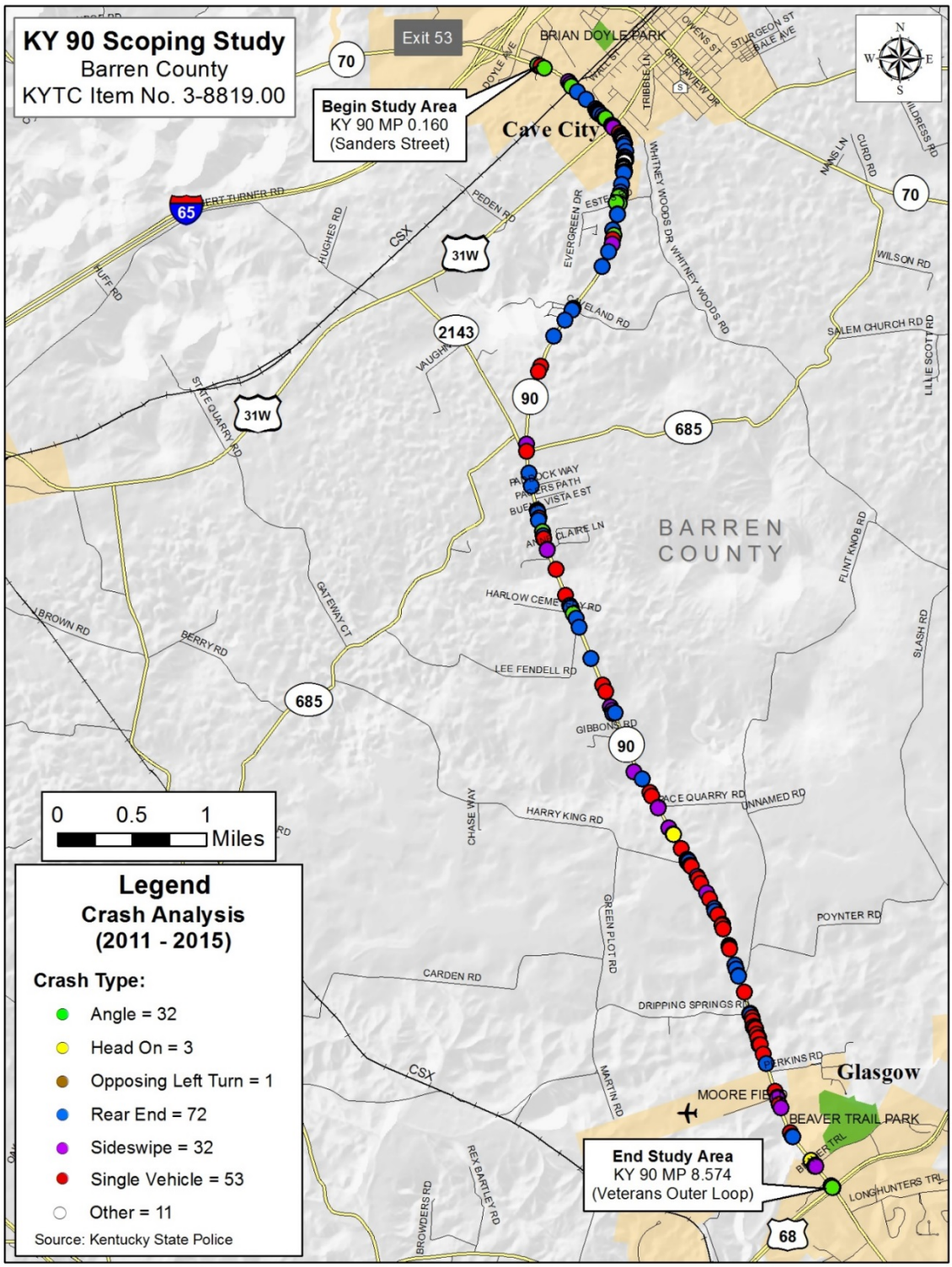

Figure 10: Distribution of Crash Type by Location

Analysts also conducted a spot analysis along KY 90. Spots were defined by observing 0.3-mile sections where crashes were concentrated. Crashes were again geospatially referenced and compared to statewide data to identify locations experiencing above average crash rates. The CRF was again used as a measure of the safety of a particular spot.

Analysis along KY 90 did not indicate any segments with a CRF over the 1.0 threshold. However, analysis indicated nine 0.3-mile long spot locations have a CRF greater than 1.0, as summarized in **Table 3** and shown in detail on **Figure 11**. Given the types of crashes (primarily rear end and angle collisions) and the locations of the high crash spots, it appears that a lack of turn lanes could be a contributing factor.

Spot[1]	Begin MP	End MP	Number of Crashes	Critical Rate Factor	Crash Types							
					Angle	Head On	Opposing Left Turn	Rear End	Sideswipe	Single Vehicle	Backing	Rear to Rear
1	0.160	0.460	11	1.27	7	0	0	0	3	1	0	0
2	0.460	0.760	15	1.79	4	0	0	7	1	1	2	0
3	0.760	1.060	27	3.16	4	0	1	10	4	2	5	1
4	1.060	1.360	15	1.67	4	0	0	7	1	1	2	0
5	1.360	1.660	9	1.00	3	0	0	2	2	2	0	0
6	5.900	6.200	16	1.94	1	1	0	7	2	5	0	0
7	6.800	7.100	9	1.09	1	0	0	5	1	2	0	0
8	7.100	7.400	11	1.33	1	0	0	2	3	5	0	0
9	7.400	7.700	9	1.09	0	0	0	2	0	7	0	0

[1] The length of a spot is defined to be 0.3 mile.

Table 3: High Crash Spots

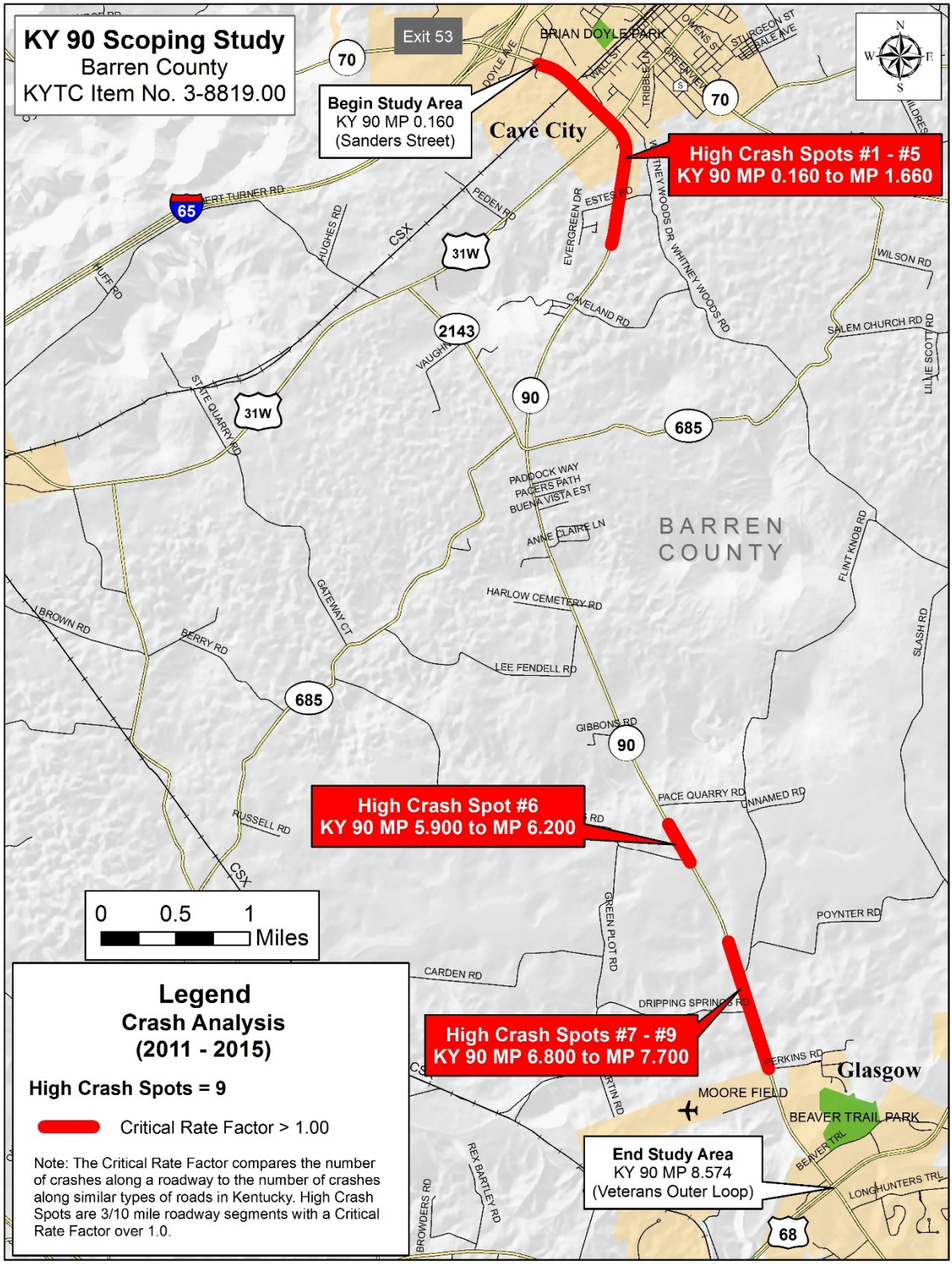

Figure 11: High Crash Spots

3.0 ENVIRONMENTAL OVERVIEW

An environmental overview was performed to identify environmental resources of significance, potential jurisdictional features, and other environmental areas of concern that should be considered during project development. Natural and human environment resources within the study area were identified from a literature/database review, as well as a windshield survey. The study area for the environmental overview is a 500-foot wide corridor centered on existing KY 90. The study area includes KY 90 between Sanders Street in Cave City and US 68 (Veterans Outer Loop) in Glasgow. The entire document is included in **Appendix D**.

More detailed environmental studies may be required as the project is further developed. If a future project is federally-funded, the National Environmental Policy Act (NEPA) requires that potential environmental impacts regarding jurisdictional wetlands, archaeological sites, cultural historic sites, and federally endangered species must be avoided if possible. If not, then minimization efforts are required. Mitigation for the unavoidable impacts may also be necessary.

3.1 NATURAL ENVIRONMENT

Natural environment resources include: surface streams; floodplains; wetlands; ponds; groundwater; threatened, endangered, and special concern species and habitat; woodland and terrestrial areas; and parks. Through a literature/database review and field reconnaissance, potentially sensitive resources that affect the natural environment were identified in the study area and are discussed in the following sections and presented in **Figure 12** and **Figure 13**.

USGS Streams

Beaver Creek and one intermittent stream (unnamed tributary to Turnhole Spring) are the only United States Geological Survey (USGS) streams located within the study area. Beaver Creek is not classified as Special Use Waters within the study area as defined by the Kentucky Division of Water (KDOW). It is designated as fully supporting warm water aquatic habitat (WAH) and drinking water supply (DWS).

Watersheds in the study area include Duff Branch-Green River Park City-Barren River and Little Beaver Creek-Beaver Creek-Barren River from north to south, respectively.

The study area lies within two Source Water Assessment and Protection Program (SWAPP) areas; the north portion associated with the Green River Valley Water District (Duff Branch watershed), and the south portion associated with the Glasgow Water Company (Little Beaver Creek-Beaver Creek watershed).

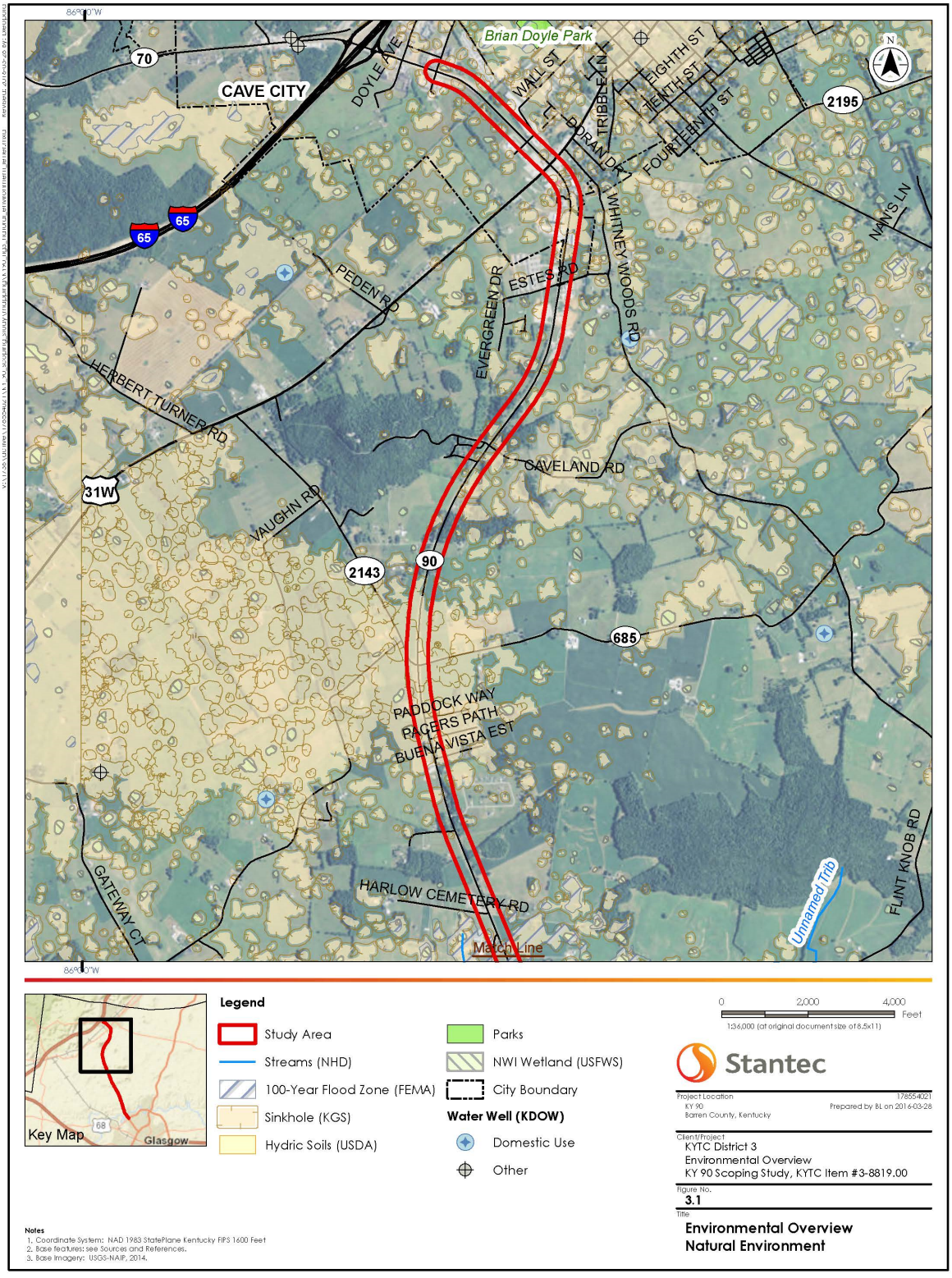

Figure 12: Natural Environment Part 1 (North)

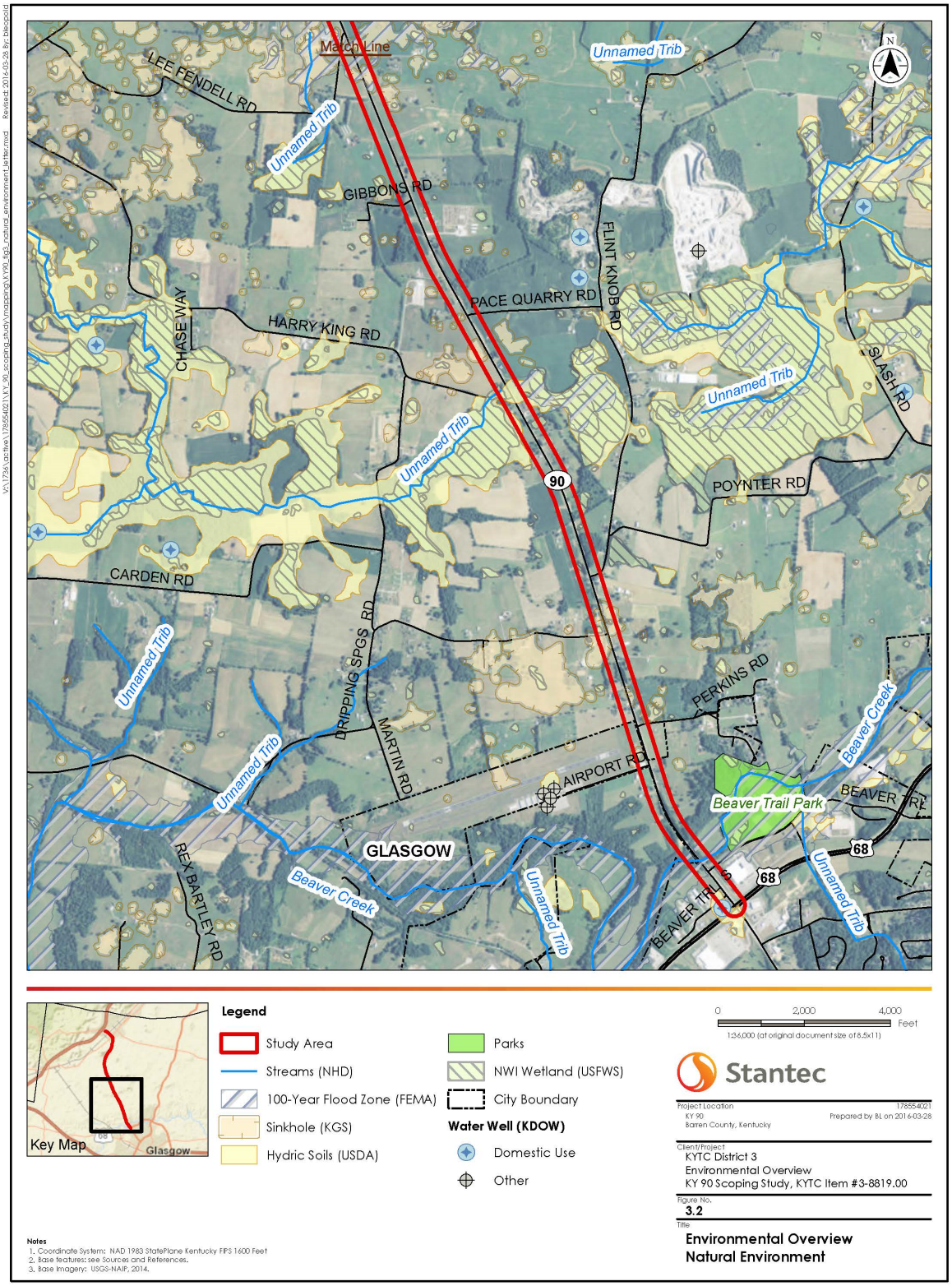

Figure 13: Natural Environment Part 2 (South)

Other Streams

No additional surface streams are mapped or evident in the study area due to the karst plain features of the area, including sinkholes, sinking creeks, and caverns.

Wetlands

Twelve National Wetlands Inventory (NWI) wetlands are mapped in the study area including two emergent, one forested, and nine ponds. Extensive wetland complexes are mapped adjacent to the study area south of Pace Quarry Road. Additional wetland areas were observed in select low-lying areas of the study area.

Hydric soils occur across approximately five percent of the study area, concentrated south of Pace Quarry Road and around the US 68 intersection. This soil type indicates the potential for additional non-NWI mapped wetlands to be present in the study area.

Ponds

Nine ponds are mapped (based on NWI data) within the study area. Several appear to be intermittent, occurring in sinkhole depressions and do not appear to hold water permanently.

USFWS Species List

The United States Fish and Wildlife Service (USFWS) species lists indicate Indiana bat (endangered), gray bat (endangered), and northern long-eared bat (threatened) are known to occur in Barren County. Three endangered mussels (fanshell, sheepnose, and snuffbox) and one threatened mussel (rabbitsfoot) are potentially in the study area. Kentucky cave shrimp (endangered) are known to occur in Barren County and are potentially in the study area.

The northern portion of the study area, north of Pace Quarry Road, lies within a known habitat designated area for northern long-eared bat. The nearest sensitive area is located approximately 3.5 miles west of the north project terminus. Potential summer roost and foraging habitat for Indiana bat and northern long-eared bat (woodlots and riparian woodlands) is present mostly in scattered woodlots south of Cave City. More extensive woodlots are present near Harry King Road and Beaver Creek at the south end of the study area. Of the four federally-listed mussel species included in the Information for Planning and Conservation (IPaC) report for the study area, only snuffbox and rabbitsfoot have the potential to occur as Beaver Creek may provide suitable habitat for these species that prefer small- to medium-sized creeks.

Habitat for gray bat and Kentucky cave shrimp may be present as several cave entrances are known in the study area vicinity.

KDFWR Species List

The Kentucky Department of Fish and Wildlife Resources (KDFWR) lists 50 additional State Threatened, Endangered, and Special Concern Species (beyond the eight species listed by USFWS, above) as occurring (either recently or historically) in Barren County. These include:

- Eight state-endangered species – one fish, six birds, and one reptile;
- Twenty state-threatened species – ten birds, one mussel, six invertebrates, one gastropod, one reptile, and one mammal;
- Nineteen state-special concern species – five fish, six birds, one reptile, three crustaceans, one gastropod, one mussel, and two mammals; and
- Two historical records of state-listed Upland Sandpiper and American Bittern.

KSNPC Species Database

The Kentucky State Nature Preserves Commission (KSNPC) provided ten records for eight federal or state endangered, threatened, or special concern listed species within one-mile of the study area. These include:

- Three plants (one each state endangered, threatened and species of concern);
- One mussel (federal-species of management concern);
- One aquatic snail (state-species of concern);
- One fish (federal-species of management concern); and
- Two crustaceans (1 federal-endangered, 1 federal-species of management concern).

The KSNPC data response specifically highlights the project lies within the Green River Biosphere Reserve, associated with the Green River and the Mammoth Cave Systems, with emphasis upon prevention of erosion and sedimentation. Several cave-obligate organisms are known within five miles of the project. Due to the occurrence of numerous records of six bat species in the study area vicinity (capture and hibernacula), KSNPC recommends any project should include a thorough bat survey. The American chestnut (state threatened) is also known to occur within 0.5-mile of the study area.

See the USFWS and KDFWR sections above for additional discussion of these species and their habitats.

Groundwater

No water wells or springs are mapped within the study area, and no wellhead protection areas occur. The central portion of the study area contains extensive subsurface drainage associated with the Turnhole Spring karst basin, flowing to the northwest. This basin is listed as a KDOW Outstanding State Resource Water (OSRW) and Cold Water Habitat (CWH) designated use, and is known to harbor the federal-endangered Kentucky cave shrimp outside of the study area.

Karst

The project area is underlain by bedrock with moderate to high potential for karst. 116 sinkholes are mapped underlying approximately 14 percent of the study area. Sinkholes are most prominent in the northern half of the study area, north of Lee Fendell Road. Eight cave entrances are known within one-mile of the study area, four of which are within 1,500 feet. Due to the sensitive nature of this resource, location information is not included in this report. KYTC has a karst policy for use of specific drainage design (grass swales and detention basins) in roadway improvement projects.

Floodplain

A Federal Emergency Management Agency (FEMA) 100-Year floodplain occurs along Beaver Creek and within two sinkhole areas in the central part of the study area, one occurring around the Lee Fendell Road intersection and the other south of Pace Quarry Road.

Floodway

There is no Federal Emergency Management Agency (FEMA) designated floodway in the study area or vicinity.

Farmland

"Prime Farmland" soils (including soils classified "prime farmland if drained") occur across 54 percent of the project area principally associated with valley bottoms and drainage features. "Farmland of statewide importance" soils occur across an additional 37 percent of the study area, associated with narrow ridgetops, shoulders, and lower portions of slopes.

Oil and Gas Wells

Two oil/gas wells are mapped within the study area, both indicated as being dry and abandoned. An additional 18 wells are located within 0.25-mile of the study area, seven producing oil or gas and all located in the south half of the study area.

Section 4(f)

No Section 4(f) resources were identified in the study area through secondary source information or during field survey. No public use recreational facilities are present in the study area.

Section 6(f)

Based on current Land and Water Conservation Fund records, there are no Section 6(f) resources in the study area.

Air Quality

The study area is not located in a Non-attainment Area for 8-hour ozone (2008 standard) or a Maintenance area for PM 2.5 for the transportation-related criteria pollutants for which the EPA has established National Ambient Air Quality Standards. Two US EPA air emissions facilities are located within the study area, one each in Cave City and Glasgow.

Noise

Noise sensitive land use areas are few and scattered through the study area (Activity Category "B" and "C" land uses – consisting of several single and multi-family residences and two houses of worship). The study area is primarily rural and dominated by agricultural land uses, with commercial land uses concentrated at the north and south endpoints.

3.2 HUMAN ENVIRONMENT

Human environment is defined as what we live in and around and what we have built. Through a literature/database review and field reconnaissance, potentially sensitive resources that affect the human environment were identified and are discussed in the following sections and presented in **Figure 14** and **Figure 15**. The complete document is included in **Appendix D**.

Hazardous Materials

A database review shows 21 sites of potential concern occur within the study area, including one state hazardous waste (SHWS) record, three AIRS air emission records (manufacturing sites), six SPILLS records, one Resource Conservation and Recovery Act (RCRA) record, six underground storage tank (UST) sites, and one Environmental Data Resources (EDR) historical auto station record. An additional 20 records are mapped within 0.25 miles of the study area including five RCRA records. Field survey indicated five additional potential hazardous materials concern sites including four automotive sales and service businesses and one electrical substation.

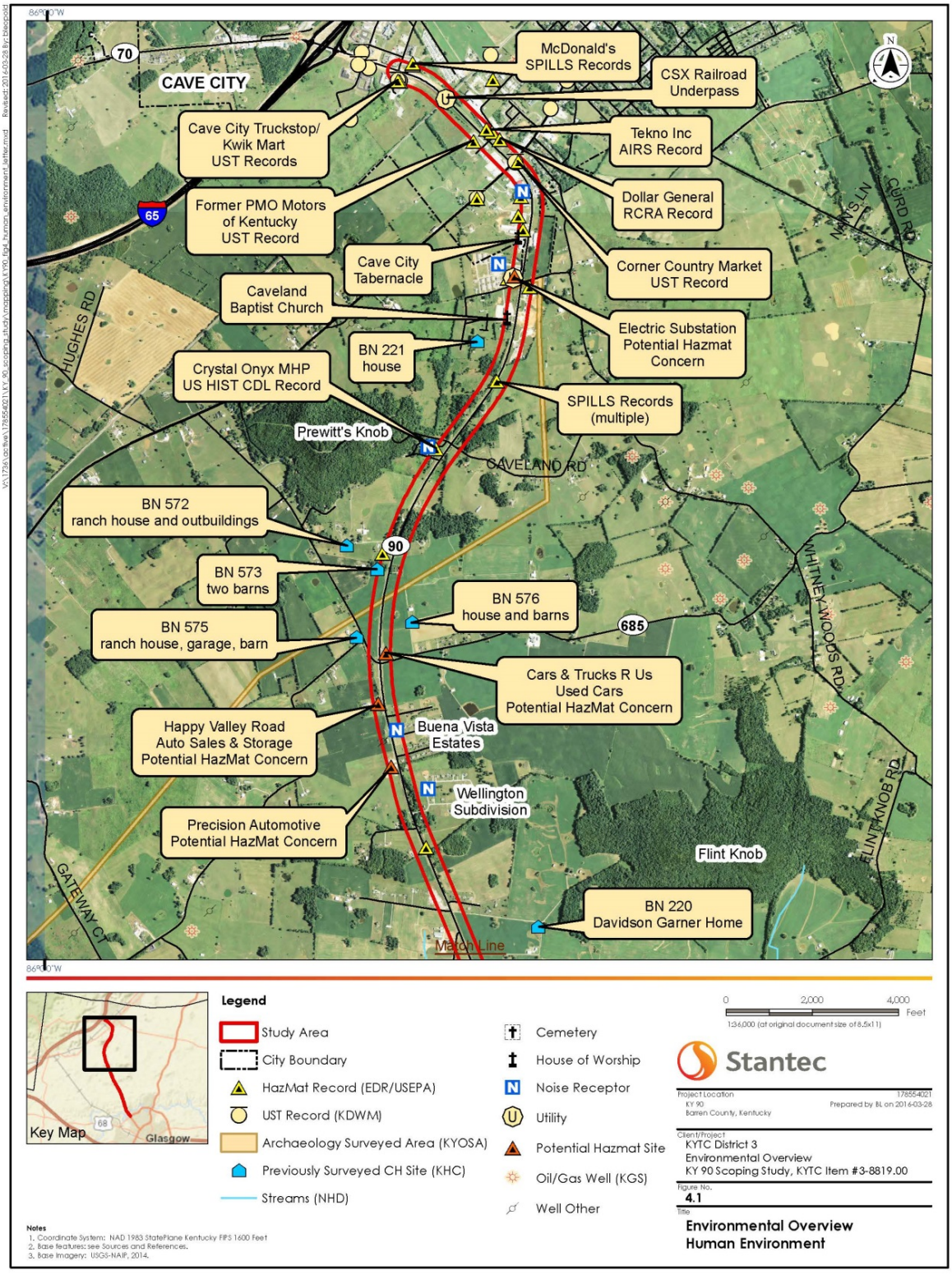

Figure 14: Human Environment Part 1 (North)

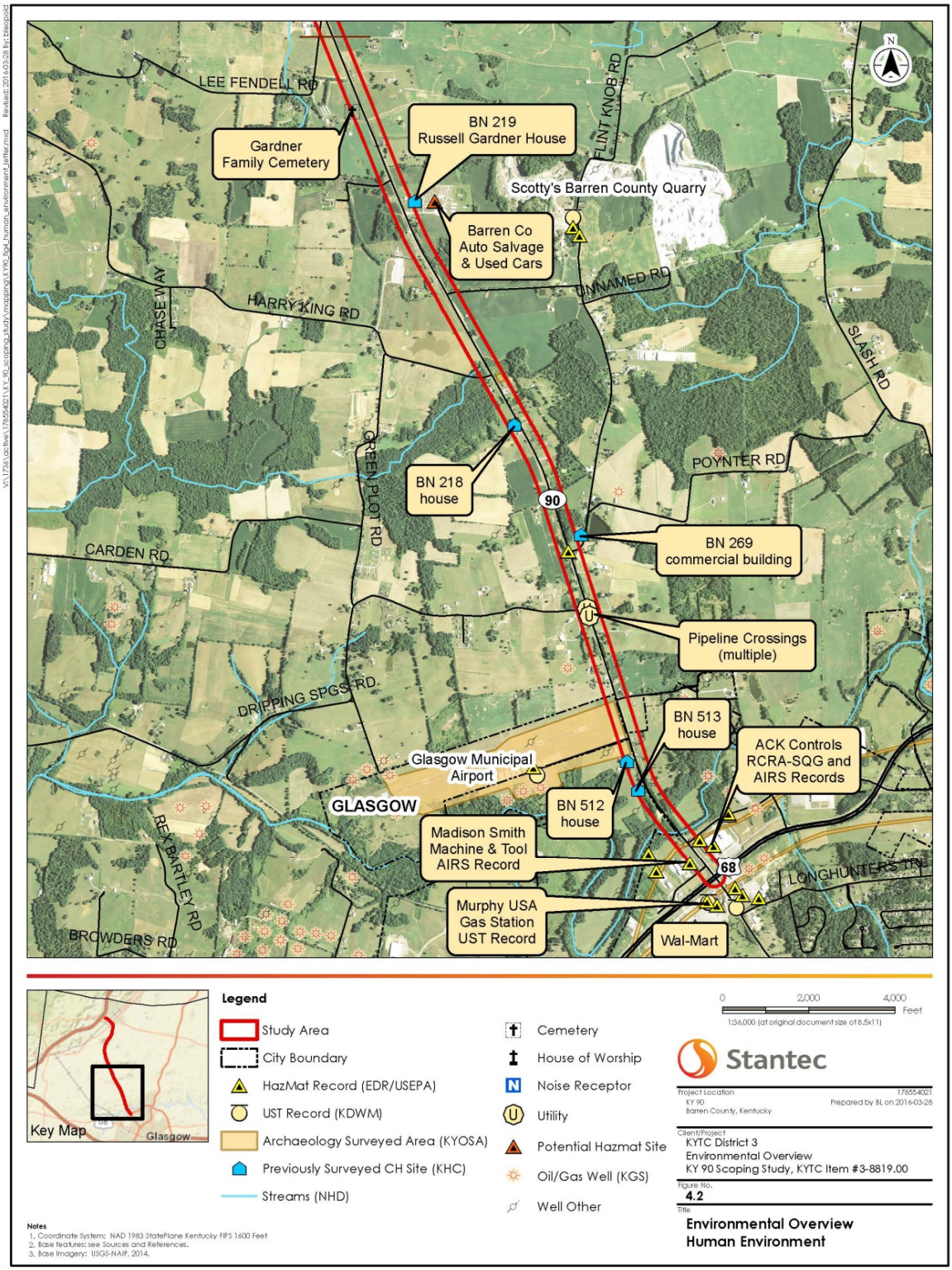

Figure 15: Human Environment Part 2 (South)

Field surveys indicate 26 potential hazardous materials sites are in or immediately adjacent to the study area, including five UST sites, one RCRA site, five automotive sales/service sites, and several additional sites of potential concern (including one SHWS record, five SPILLS sites, and one electrical substation). Sites of potential concern are concentrated in Cave City and the KY 90/US 68 intersection at the south end of the study area.

Socioeconomic Study

Socioeconomic issues pertaining to minority, elderly, disability, and low income (persons living in poverty) populations in the project study area were evaluated and documented by the Barren River Area Development District (BRADD) in a Socioeconomic Study completed in February 2016. A copy of the report is found in **Appendix E**. The study area includes portions of Census Tracts 9501, 9502, 9503, and 9505 in Barren County.

Overall, approximately 10.4 percent of the study area population is minority which is higher than the percentage in the county but less than the state. In addition, approximately 18.4 percent of the study area population is low income, which is lower than the percentages in the county and state.

During future phases of project development, a more detailed and robust analysis would be required for the NEPA documentation when assessing the potential for adverse and disproportionate impacts to poverty status, and minority populations. Environmental justice issues will be addressed further in accordance with KYTC policy during Phase 1 Design.

Archaeology

Based on a review of National Register of Historic Places (NRHP) and Office of State Archaeology (OSA) records, no archaeological sites listed on the NRHP are located in the study area. However, four previous archaeological surveys conducted in or adjacent to the study area have recorded six archaeological sites within 500 feet. Of the six sites, two were not evaluated for NRHP listing, and four were considered to be ineligible for NRHP. Historical map review indicated a number of structures located in or directly adjacent to the study area may be associated with unrecorded historic archaeological sites. The full report is included in **Appendix E**. Further study may be required once any recommended improvements are more defined.

Historic Resources

The Kentucky Heritage Council (KHC) database search indicated the following resources were identified in the study area vicinity:

- Four sites within the study area, NRHP status undetermined;
- Seven sites adjacent to the study area, NRHP status undetermined; and
- No NRHP-listed resources.

Due to the presence of previously surveyed historic resources in and adjacent to the study area and the significant number of rural agricultural properties in the study area vicinity, additional cultural historic properties with large potential boundaries are likely to be present. Existing historic properties should be avoided and additional cultural historic investigations are recommended for any proposed project activities.

Churches

There are two houses of worship (church, mosque, synagogue, etc.) located within the study area (Cave City Tabernacle and Caveland Baptist Church), both located in Cave City.

Schools

There are no primary or secondary schools located within the study area.

Cemeteries

One cemetery is located within the study area. It is a small family cemetery (Gardner/Harlow) located in an agricultural field in the center of the study area.

Public Services

Public service and utility facilities located within the study area include:

- CSX Railroad underpass in Cave City;
- Electric substation, intersection of KY 90 and Estes Road, south of Cave City;
- Two pipeline crossings marked at Dripping Springs Road (a total of five are indicated on USGS mapping), south portion of study area; and
- Glasgow Municipal Airport in Glasgow.

Residences and Businesses

Residential land use includes two apartment complexes in Cave City, scattered rural residential homes along KY 90, a few suburban residential developments on side roads in the center of the study area, and one mobile home park at Prewitts Knob Road. Commercial businesses are concentrated in Cave City, with two industrial facilities present in Glasgow. Individual business structures are scattered along the KY 90 corridor.

3.3 GEOTECHNICAL

A geotechnical overview of the study area was completed based upon research of available published data and experience with highway design and construction within the region. 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 roadway improvements. The complete document is included in **Appendix F**. The overview included:

- Karst topography/sinkholes and basins were noted along the alignment. Sinkholes or solution cavities identified within the construction limits that are not accepting drainage should be filled and/or capped in accordance with Section 215 of the current edition of KYTC's Standard Specifications for Road and Bridge Construction.

- Karst terrain in the study area will likely be the most detrimental factor to any new construction. Rock cuts can be problematic due to the karst topography. Solution features can cause the bedrock surface to be erratic.

- Numerous sinkholes and karst-related features exist within the region. The design team should inventory the sinkholes and other karst features, such as caves, along the proposed alignment. The inventory should note whether the sinkhole accepts drainage. Any sinkholes utilized for drainage purposes for the new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize siltation of open sinkholes.

- Geotechnical drilling will be critical for replacement or widened culverts, bridges, retaining walls, and design due to the karst potential. It is anticipated that conventional spread footing and/or pile foundation systems can be utilized for structures. However, if voids/caves are present, additional costs associated with karst mitigation should be anticipated.

- Because a portion of this project may be a widening project, information on pavement structure should be obtained to assist the team on pavement structure and California Bearing Ratio (CBR) information. Other projects in the vicinity have utilized mechanical or chemical stabilization and generally CBR values of approximately six or less.

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

- Several oil and gas wells have been drilled near/along the proposed corridor. Many have reportedly been abandoned. The Design Team should inventory and survey active wells. Additional costs could be incurred if the selected alignment disturbs a well site.

4.0 TRAFFIC FORECAST (YEAR 2040)

To project future traffic volumes along the study corridor, the KYTC Division of Planning examined historic traffic volumes along KY 90 and Census projections for Barren County. Based on the Kentucky State Data Center forecasts, an annual population growth rate of 0.7 percent is expected over the next 20 years. For this project, an annual traffic growth rate of 1.1 percent was used. The design year volumes were calculated by increasing current traffic volumes at 1.1 percent per year from 2015 to 2040. Based on a 24-hour classification count, a truck percentage of 17.1 percent was used. An annual growth rate of 0.5 percent was used for the truck volumes.

Appendix B includes the KYTC Traffic Forecast Report, which provides additional detail on the traffic forecast assumptions and findings. Based on the KYTC Traffic Forecast Report, the 2040 ADT is projected to be 12,000 vpd with 19 percent trucks.

To evaluate the adequacy of roadway segments, 2040 design hour volumes were compared to the road's theoretical capacity. V/C ratios were estimated along KY 90 based on the 2040 design hour volumes listed in the KYTC Traffic Forecast Report. After performing a V/C analysis using Highway Capacity Manual (HCM) procedures, all roadway segments are anticipated to operate at less than full capacity with a V/C no greater than 0.61.

For two-lane highways serving moderately developed areas, such as KY 90 in Cave City, LOS is determined based on the percent of free-flow speed. For two-lane highways serving as intercity routes or primary connectors, such as KY 90 between Cave City and Glasgow, LOS is determined based on two parameters – average travel speed and percent time spent following in a platoon. In rural areas, LOS C or better is desirable and in urban areas, LOS D or better is desirable. By 2040, if no roadway improvements are made, KY 90 is expected to operate at LOS E in the urban portion of Cave City and a LOS D in the rural portion south of Cave City.

The results of the v/c analysis indicate the two-lanes on KY 90 can adequately accommodate the future traffic demand. The less than desirable future LOS would suggest that improvements should be considered. **Table 4** presents current and 2040 ADT, truck percentage, LOS, and V/C for each segment.

Description	Begin Milepoint	End Milepoint	Existing (2016)				No Build (2040)			
			ADT	% Trucks	LOS [2]	V/C [1]	ADT	% Trucks	LOS [2]	V/C [1]
Sanders St to Estes Road	0.160	1.369	9,000	17%	D	0.49	12,000	19%	E	0.61
Estes Road to US 68	1.369	8.574	9,000	17%	C	0.47	12,000	19%	D	0.60

[1] The target volume to capacity (V/C) ratio is 0.9 for rural areas and 1.0 for urban areas.
[2] In rural areas a level of service (LOS) C or better is desirable. In urban areas a LOS D or better is desirable.

Table 4: 2040 Traffic Analysis Summary

5.0 PURPOSE AND NEED STATEMENT

As a result of the analysis of the existing conditions, project team input, and local officials/stakeholders input, a purpose and need statement for this study was developed to be used during future project development efforts, including design and environmental activities. The purpose and need statement establishes why KYTC is proposing to advance a transportation improvement and drives the process for improvements, alternative consideration, analysis, and selection.

> *The purpose of the KY 90 improvement project is to enhance regional mobility and to provide a safer, more efficient connection between Glasgow and I-65.*

The following needs were identified over the course of the study.

5.1 IMPROVE EFFICIENCY

KY 90 is classified as a Rural Minor Arterial for most the study area with a 45 to 55 mile per hour (MPH) posted speed limit and an average daily traffic (ADT) volume of 7,600 to 9,000 vehicles per day. Under existing traffic conditions, trucks contribute approximately 17 percent of daily traffic. Based on the KYTC Traffic Forecast Report, the 2040 ADT is projected to be 12,000 vpd with 19 percent trucks. The high truck percentage is a result of the study area's proximity to the I-65 interchange in Cave City. By 2040, KY 90 is expected to operate at LOS E in Cave City and a LOS D south of Cave City without roadway improvements. The less than desirable future LOS would suggest that improvements should be considered. Extending passing lanes would improve the LOS of vehicular traffic by providing more opportunities to pass slower moving trucks.

5.2 IMPROVE SAFETY

A detailed discussion of the crash analysis along KY 90 is found in Section 2.6. Over the five-year period between January 2011 and December 2015, there were 204 crashes reported on KY 90 between Sanders Street and US 68. This includes three fatal crashes and 47 injury collisions. The percentages of fatal and injury collisions along KY 90 are slightly higher than similar roads in Kentucky[7].

Of the 204 reported crashes, 72 (35 percent) were rear end collisions. A majority of the rear end collisions (54 crashes, 75 percent) were concentrated at intersections and entrances along the study area. The high number of these types of collisions supports the need for safety improvements such as turn lanes. Critical crash rate factors (CRF) were also calculated for the five-year study period. There are ten 0.3-mile long spots with CRF values greater than 1.0. Given the types of crashes and the locations of the high crash spots, it appears that turn lanes may be warranted.

5.3 ENHANCE REGIONAL MOBILITY

As stated previously, KY 90 provides the most direct regional connection between Glasgow and vehicles heading northbound on I-65. I-65 is a major north-south interstate highway that travels through Western Kentucky from Nashville, Tennessee in the south to Louisville, Kentucky in the north. Signs on I-65 direct southbound vehicles to use KY 90 to access Glasgow. KY 90 also provides a link between the Barren River Lake State Park and the Mammoth Cave National Park. It is also a part of the National Truck Network (NTN). Providing a safer, more efficient connection between these areas would improve mobility in Barren County and the surrounding areas.

6.0 PROJECT TEAM MEETING #1

Over the course of the study, the project team held three meetings to coordinate on key issues. The project team consisted of representatives of the KYTC Central Office, KYTC District 3 Office, representatives of the Barren River Area Development District (BRADD), and the consultant. Detailed summaries of each are presented in **Appendix G**.

The project team first met at the District 3 Office in Bowling Green, Kentucky, on February 2, 2016. The purpose of the meeting was to discuss the project purpose and history, the results of the existing conditions analysis, design considerations, and to get feedback from the project team before developing improvement alternatives. Key discussion items included the following:

- The project team approved the draft Purpose and Need Statement.

[7] Kentucky Transportation Center research report Analysis of Traffic Crash Data in Kentucky (2011-2015)

- This study was to examine five initial improvement concepts: spot improvements, four-lane widening with a depressed median, four-lane widening with no median, 2+1 widening, and a three- or five-lane urban typical section in Cave City. Bicycle and pedestrian facilities should be considered for all alternatives.

- The four-lane widening with depressed median alternative will assume a 40-foot wide median.

- The four-lane widening with depressed median alternative will remove direct access to driveways, which could be considered unfavorable to the adjacent property owners.

- A traffic signal is proposed at the Sanders Street intersection.

- The project team decided to wait until after the preliminary alternatives were developed to hold a local officials meeting. Local officials in Glasgow were notified that the study is ongoing at the local officials meeting for the Glasgow Small Urban Area (SUA) Study on February 24, 2016. Local officials in Cave City were notified that the study is ongoing at the BRADD Meeting on February 24, 2016.

7.0 INITIAL CORRIDOR-WIDE IMPROVEMENT CONCEPTS

A range of corridor-wide concepts were developed based on the existing conditions analyses, traffic forecasts, and input received from the project team. Although the No Build Alternative does not satisfy the project purpose, it was carried forward as a baseline for comparison between other alternatives.

Five initial corridor wide concepts were examined, shown in **Figure 16**. The corridor-wide improvements were divided into two sections – Section 1 is the urban area that travels through Cave City and Section 2 is the rural area between Cave City and Glasgow.

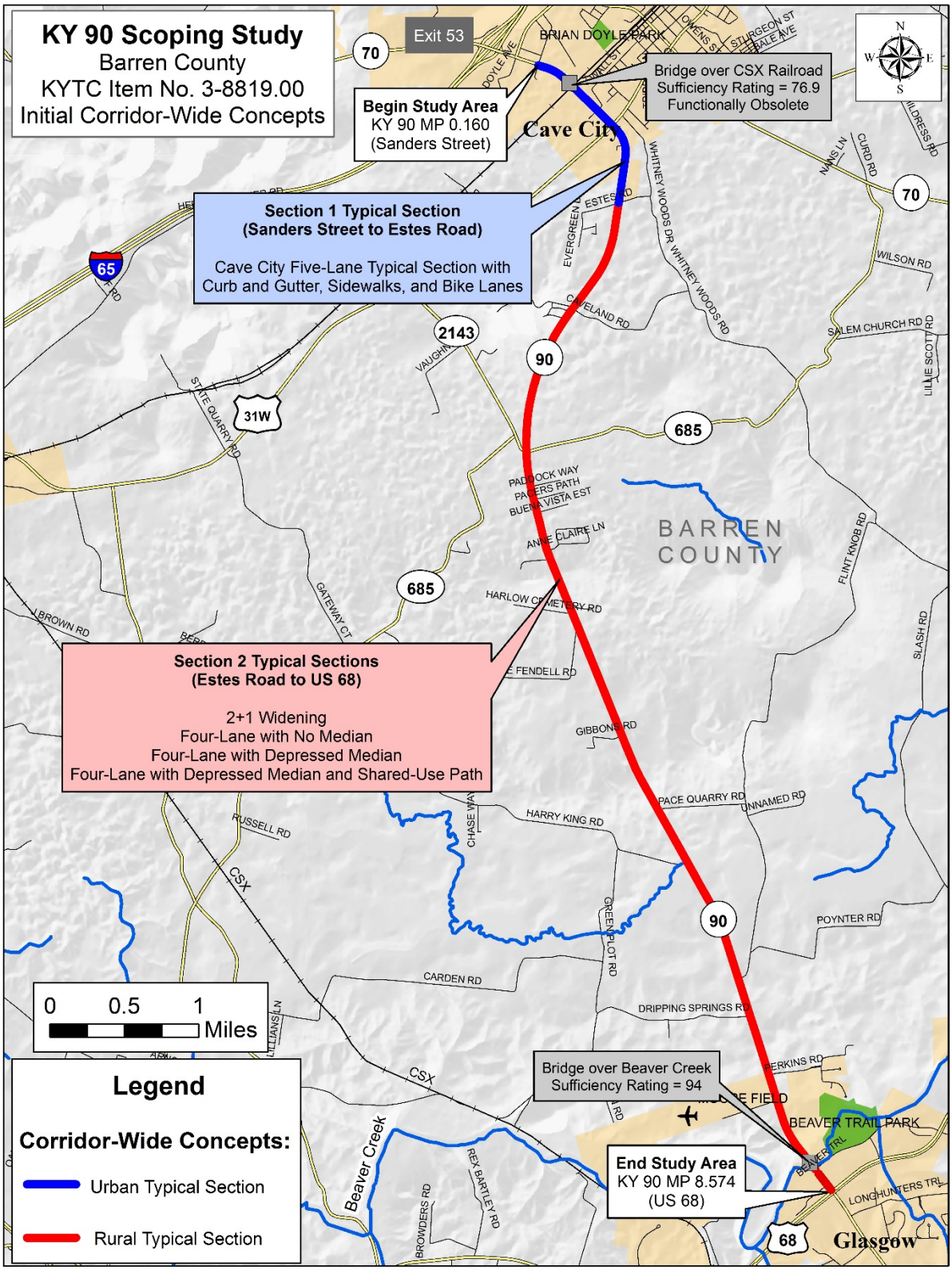

Figure 16: Initial Corridor-Wide Improvement Concepts

7.1 SECTION 1: CAVE CITY

One typical section was examined for Section 1 - a five-lane curb-and-gutter typical section with sidewalks and bike lanes, shown in **Figure 17**. This matches the existing typical section north of Sanders Street. This alternative will require replacement or widening of the bridge over CSX Railroad which has a sufficiency rating of 76.9 percent and is considered functionally obsolete. The two-way left turn lane removes left turning vehicles from the thru traffic stream and provides a refuge for vehicles turning into the opposing direction of traffic. This allows for easier access to businesses along KY 90 in Cave City and has been shown to reduce crashes by 35 percent.[8]

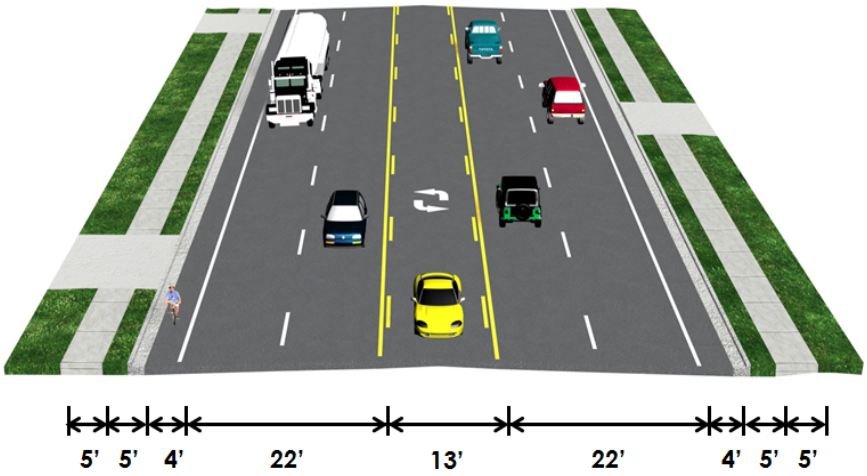

Figure 17: Cave City Five-Lane Typical Section

[8] Kirk, Adam, Jerry Pigman, and Barry House. " Quantification of the Benefits of Access Management in Kentucky" (2006).

7.2 SECTION 2: SOUTH OF CAVE CITY

Four typical sections were examined for Section 2, all of which reuse much of the existing road with widening taking place to either one side or the other to minimize right-of-way impacts and allow for easier maintenance of traffic.

7.2.1 2+1 Widening

The first improvement concept for Section 2 is a 2+1 typical section, which is a three-lane road consisting of two lanes in one direction and one lane in the other, shown in **Figure 18**. Even though the direction of the passing lane changes on a 2+1 road, the total pavement width remains constant; all that changes is the striping. This concept essentially extends the existing passing lanes such that the entire corridor has passing opportunities. The 2+1 concept would not require widening or replacing the bridge over Beaver Creek. KYTC District 8 recently opened Kentucky's first 2+1 roadway along a stretch of KY 55 north of Columbia in Adair County, and KYTC District 3 is evaluating the possibility of constructing a 2+1 roadway along portions of US 31W south of Bowling Green in Warren County.

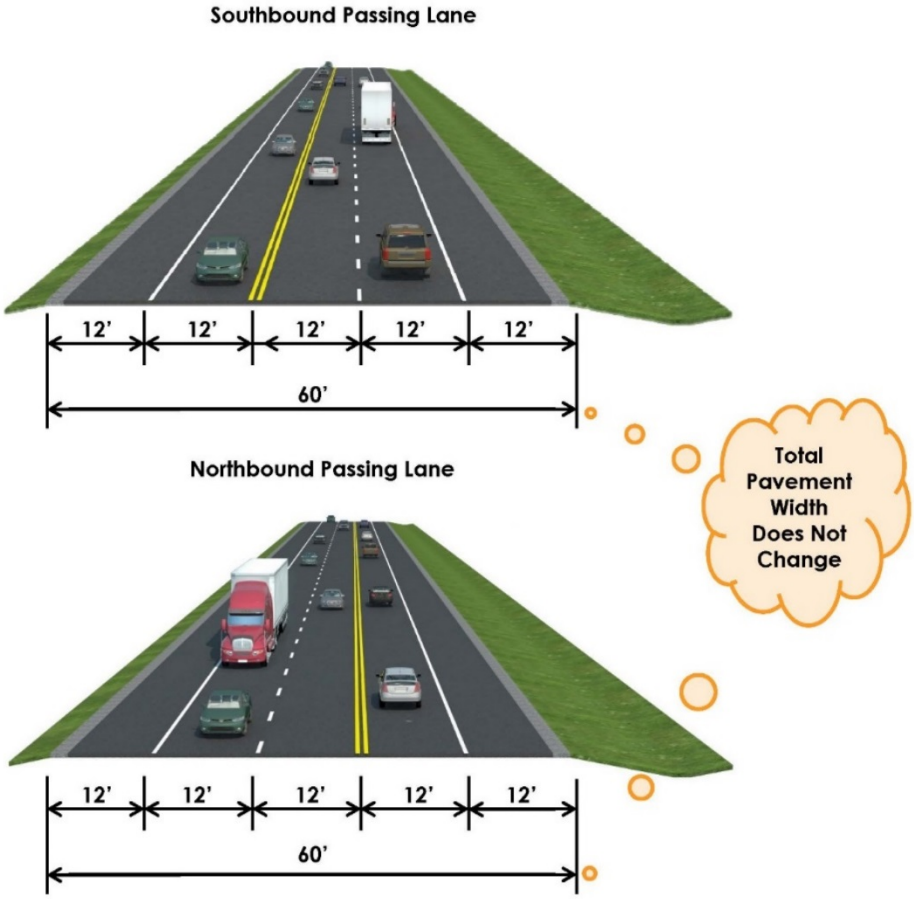

Figure 18: 2+1 Widening Typical Section

7.2.2 Four-Lane with No Median

The second improvement concept for Section 2 is a four-lane typical section, shown in **Figure 19**. The four-lane widening concept includes four 12-foot driving lanes and 12-foot shoulders. This alternative does not include a median. This concept would require widening or replacing the bridge over Beaver Creek.

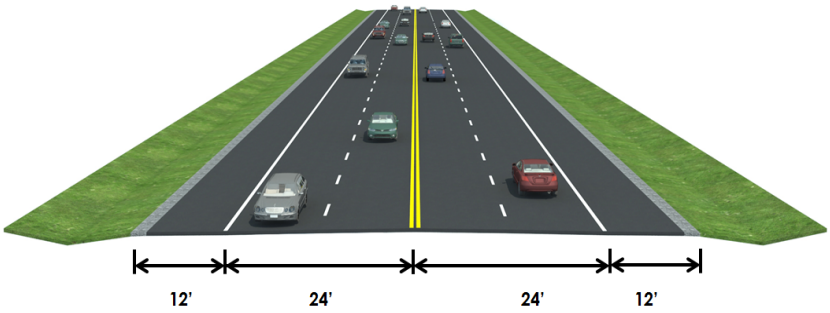

Figure 19: Four-Lane with No Median Typical Section

7.2.3 Four-Lane with Depressed Median

The third improvement concept for Section 2 is a four-lane depressed median alternative, shown in **Figure 20**. This alternative includes a 40-foot depressed median with 12-foot outside shoulders and six-foot inside shoulders. This concept would likely require constructing a new twin bridge over Beaver Creek.

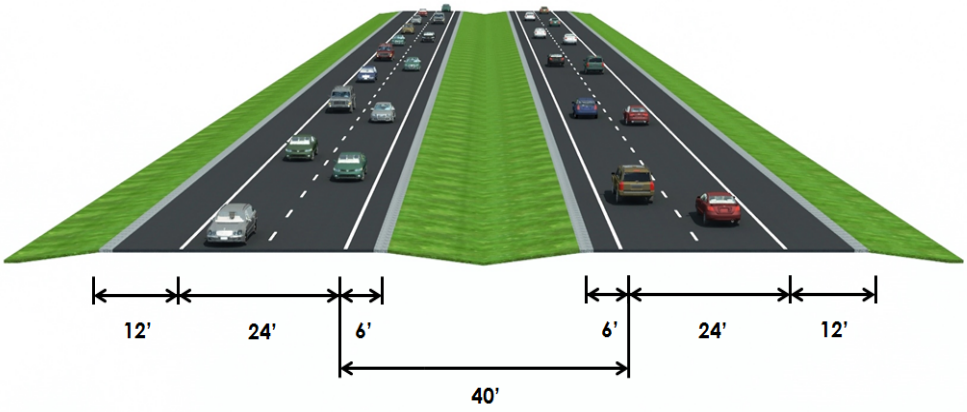

Figure 20: Four-Lane with Depressed Median Typical Section

7.2.4 Four-Lane with Depressed Median and Shared-Use Path

The fourth improvement concept for Section 2 is a four-lane depressed median alternative with a shared-use path, shown in **Figure 21**. The shared-use path was placed on the east side of KY 90 to align with Beaver Trail Park in Glasgow and Brian Doyle Park in Cave City. This also avoids impacts to the runway safety area (RSA) and aircraft approach to Runway 26 at the Glasgow Airport which sits just west of KY 90. This concept would likely require constructing a new twin bridge over Beaver Creek.

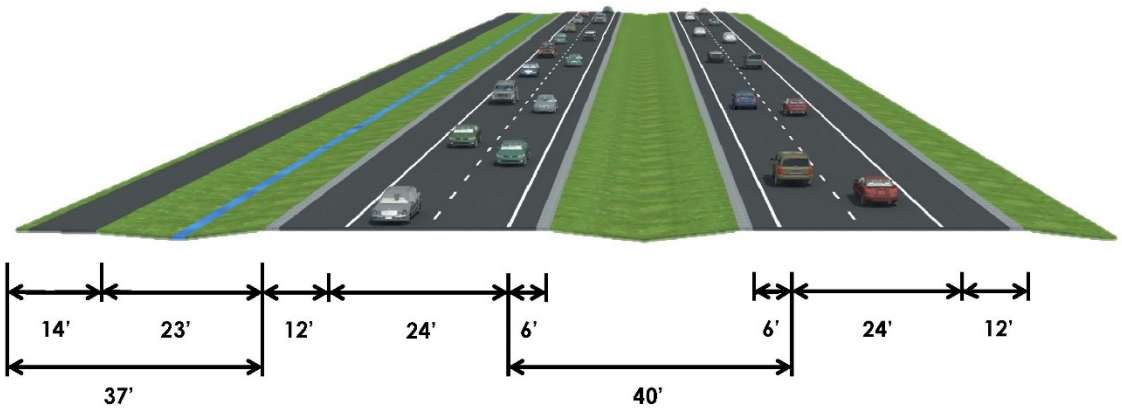

Figure 21: Four-Lane with Depressed and Shared-Use Path Typical Section

8.0 SPOT IMPROVEMENTS

In addition to corridor-wide improvements, spot improvements were also examined. Spot improvements generally include relatively low cost projects that can be implemented individually as solutions to address existing localized safety and geometric issues. Five locations were identified as candidate spot improvement projects, shown in **Figure 22**. These spots were identified based on the crash analysis and all are in high crash spots. Four of the spot improvements add turn lanes. However, turning movement counts were not collected as part of this study. Therefore, the conceptual improvements are based solely on the crash history. Counts and additional traffic analysis may be required in future project phases to verify turn lane warrants are met.

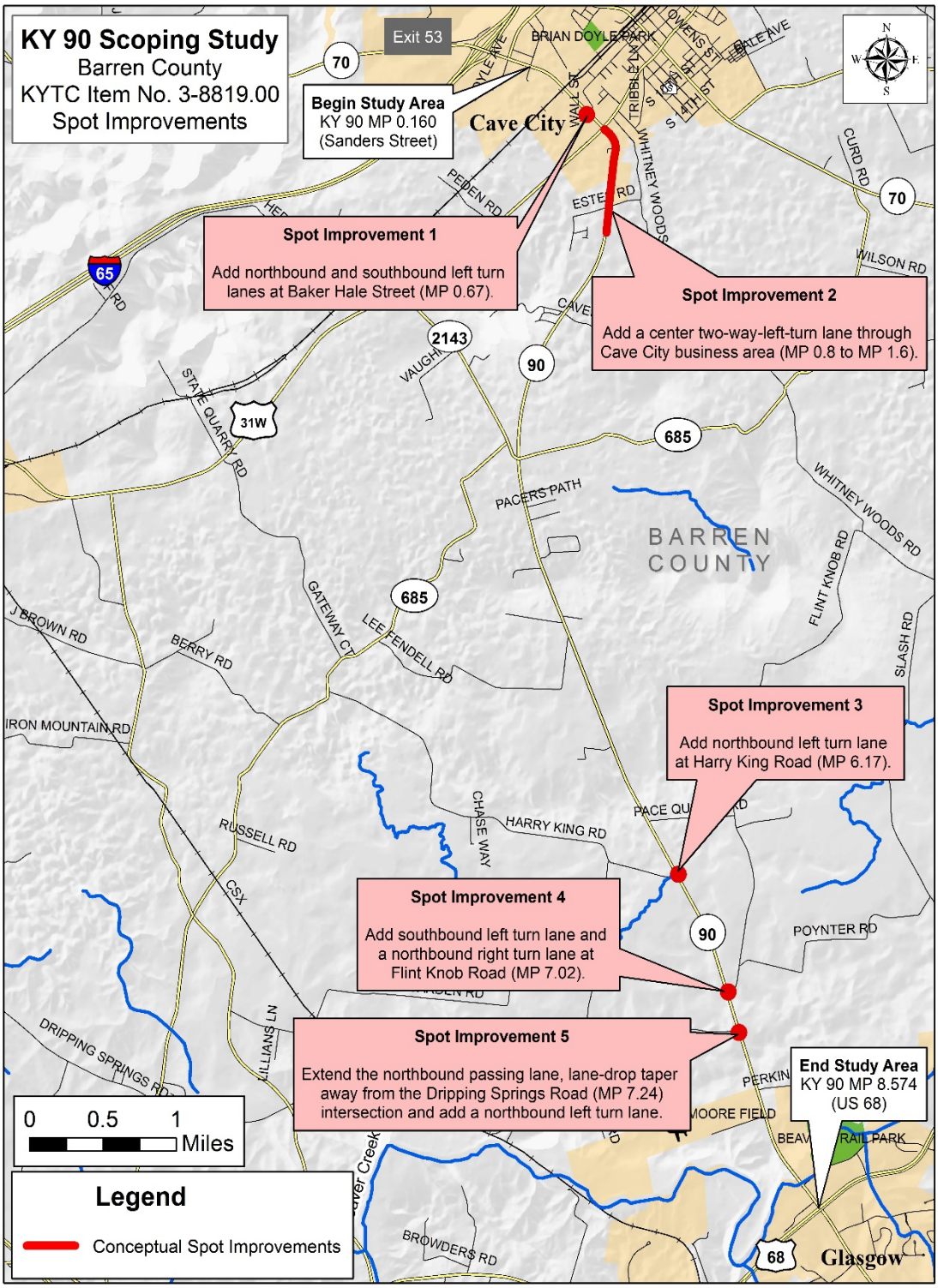

Figure 22: Spot Improvements

- **Spot Improvement 1 – Baker Hale Street (MP 0.67):** This concept involves adding northbound and southbound left turn lanes at Baker Hale Street. Over the five-year period between 2011 and 2015, there were 12 crashes on KY 90 at this intersection, including four (25 percent) rear end and four (25 percent) angle crashes, shown in **Figure 23**. This portion of KY 90 was identified as a high crash spot, with a critical rate factor (CRF) of 1.86.

- **Spot Improvement 2 – Cave City Business Area (MP 0.8-1.6):** This concept involves adding a center two-way left turn lane through the Cave City Business area. There were 37 crashes on this portion of KY 90 between 2011 and 2015, 17 (46 percent) of which were rear end, shown in Figure 23. This portion of KY 90 was identified as a high crash spot, with a CRF of 3.28.

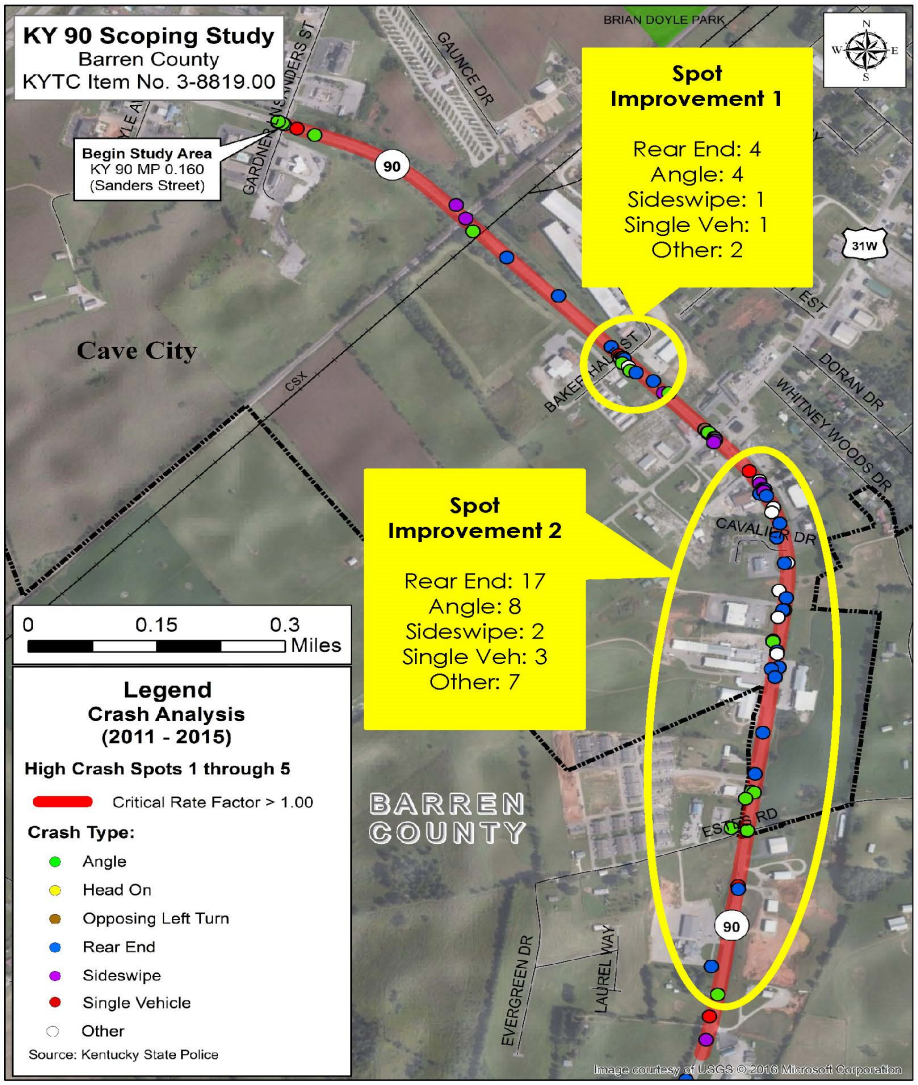

Figure 23: Crash History - Spot Improvements 1 & 2

- **Spot Improvement 3 – Harry King Road (MP 6.17):** This concept involves adding a northbound left turn lane at Harry King Road. Between 2011 and 2015, there were 16 crashes on KY 90 at this intersection, with seven (44 percent) rear end, shown in **Figure 24**. This portion of KY 90 was identified as a high crash spot, with a CRF of 2.01.

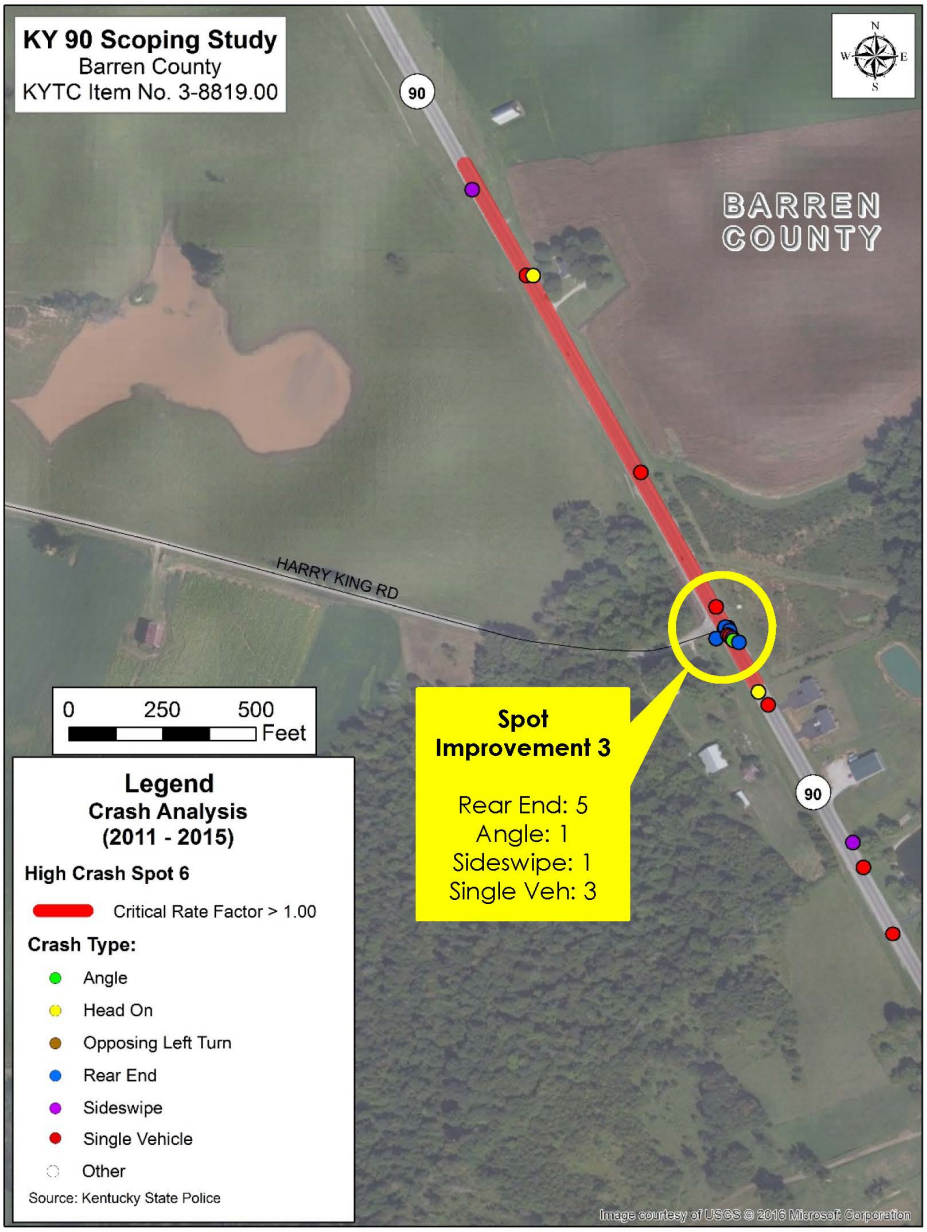

Figure 24: Crash History - Spot Improvement 3

- **Spot Improvement 4 – Flint Knob Road (MP 7.02):** This concept involves adding a southbound left turn lane and a northbound right turn lane at Flint Knob Road. There were nine crashes recorded on KY 90 at this intersection between 2011 and 2015, five (55 percent) of which were rear end, shown in **Figure 25**. This portion of KY 90 was identified as a high crash spot, with a CRF of 1.13.

- **Spot Improvement 5 – Dripping Springs Road (MP 7.24):** This concept involves decreasing the northbound passing lane, moving the lane-drop taper away from the Dripping Springs Road intersection to add a northbound left turn lane at Dripping Springs Road. There were 11 crashes recorded on KY 90 at this intersection between 2011 and 2015, five (45 percent) of which were single vehicle, shown in Figure 25. This portion of KY 90 was identified as a high crash spot, with a CRF of 1.38.

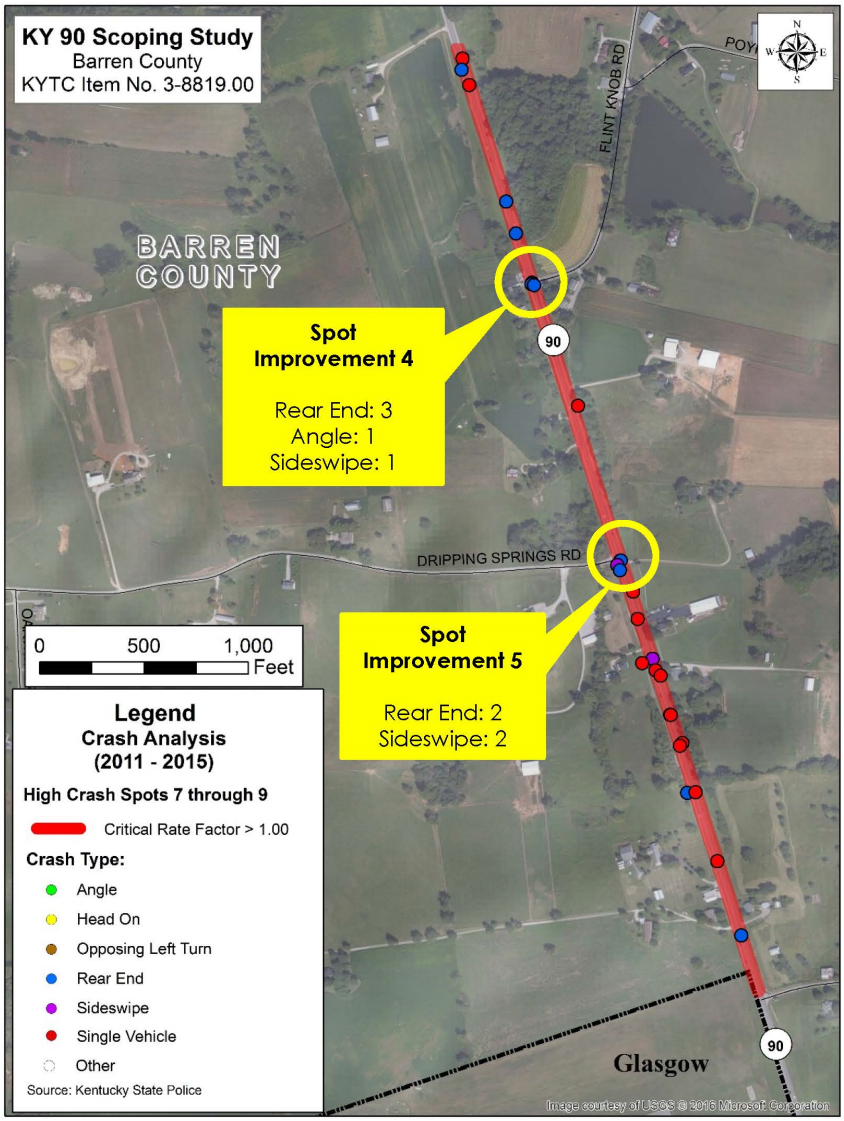

Figure 25: Crash History - Spot Improvements 4 & 5

9.0 PROJECT TEAM MEETING #2

The project team met at the KYTC District 3 Office in Bowling Green, Kentucky on April 28, 2016. The purpose of the meeting was to present the initial improvement concepts and discuss changes that should be considered. The meeting summary is included in **Appendix G**. Key discussion items included the following:

- The project team eliminated the four-lane, undivided typical section from further consideration due to safety concerns. KYTC's current design guidance on the use of medians suggests that flush or non-traversable medians should be provided on both new and existing multi-lane arterials.[9]

- An alternative to the shared-use path is a shoulder bikeway. However, shoulder bikeways require frequent cleaning to provide a safe and debris-free area for the cyclists to operate. If a shoulder bikeway is to be installed, KYTC would require a maintenance agreement with the appropriate governmental agency or agencies.

- The Cave Region Trails Initiative (CRTI), a regional effort to connect communities in the Mammoth Cave area with bicycle and pedestrian facilities, does not support a shared-use path along KY 90. They want to pursue a shared-use path along the CSX Railroad as a way to connect the City of Glasgow and the Mammoth Cave National Park in Park City. Currently, there are no existing or proposed bicycle and pedestrian facilities to connect to in Glasgow.

- The addition of a shared-use path reduces design flexibility, increases costs for right-of-way, utility relocation, and construction, and would require a new pedestrian bridge over Beaver Creek. The increased right-of-way and utility impacts will increase the project timeline considerably and increases the construction cost estimate by 17 to 25 percent.

- The project team suggested an additional alternative be developed, a 2+1 typical section with a shared-use path.

[9] http://transportation.ky.gov/Congestion-Toolbox/Documents/Kentucky%20Median%20Type%20Guidelines.pdf

10.0 REVISED CORRIDOR-WIDE ALTERNATIVES

In addition to the No-Build alternative and the spot improvements, the project team advanced four corridor-wide alternatives for further evaluation, shown in **Figure 26**. All four alternatives include the five-lane curb-and-gutter typical section with sidewalks and bike lanes through Cave City. This matches the existing typical section north of Sanders Street and will require replacement or widening of the bridge over CSX Railroad.

South of Cave City four alternatives were examined further:

- Alternative 1: 2+1 Widening
- Alternative 1b: 2+1 Widening with Shared-Use Path
- Alternative 2: Four-Lane with Depressed Median
- Alternative 2b: Four-Lane with Depressed Median and Shared-Use Path

Each alternative was modeled using InRoads. The existing digital terrain model (DTM) was developed using digital elevation models (DEM) because LiDAR data were not available in Barren County at the time of this study. All four alternatives attempt to maximize the use of the existing roadway to facilitate maintenance of traffic, reduce construction costs, and minimize right-of-way. Localized widening occurs on one side of the road so traffic can be maintained during construction and the existing mainline driving lane pavement can be reused. The widening shifts from one side of the road to the other, depending on existing condition, to minimize right-of-way and environmental impacts and reduce earthwork. After the widening is complete, it was assumed that a final pavement surface course would be placed over the entire road.

10.1 2+1 ROADWAYS

The 2+1 roadway concept has been found to improve operational efficiency and reduce crashes for two-lane highways[10]. The concept provides a continuous three-lane cross section and the highway is striped in a manner as to provide for passing lanes in alternating directions throughout the section. This concept is an attractive alternate to two- or four-lane roads with higher traffic volumes where continuously alternative passing lanes are needed to obtain the desired level of service.

[10] AASHTO's A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011

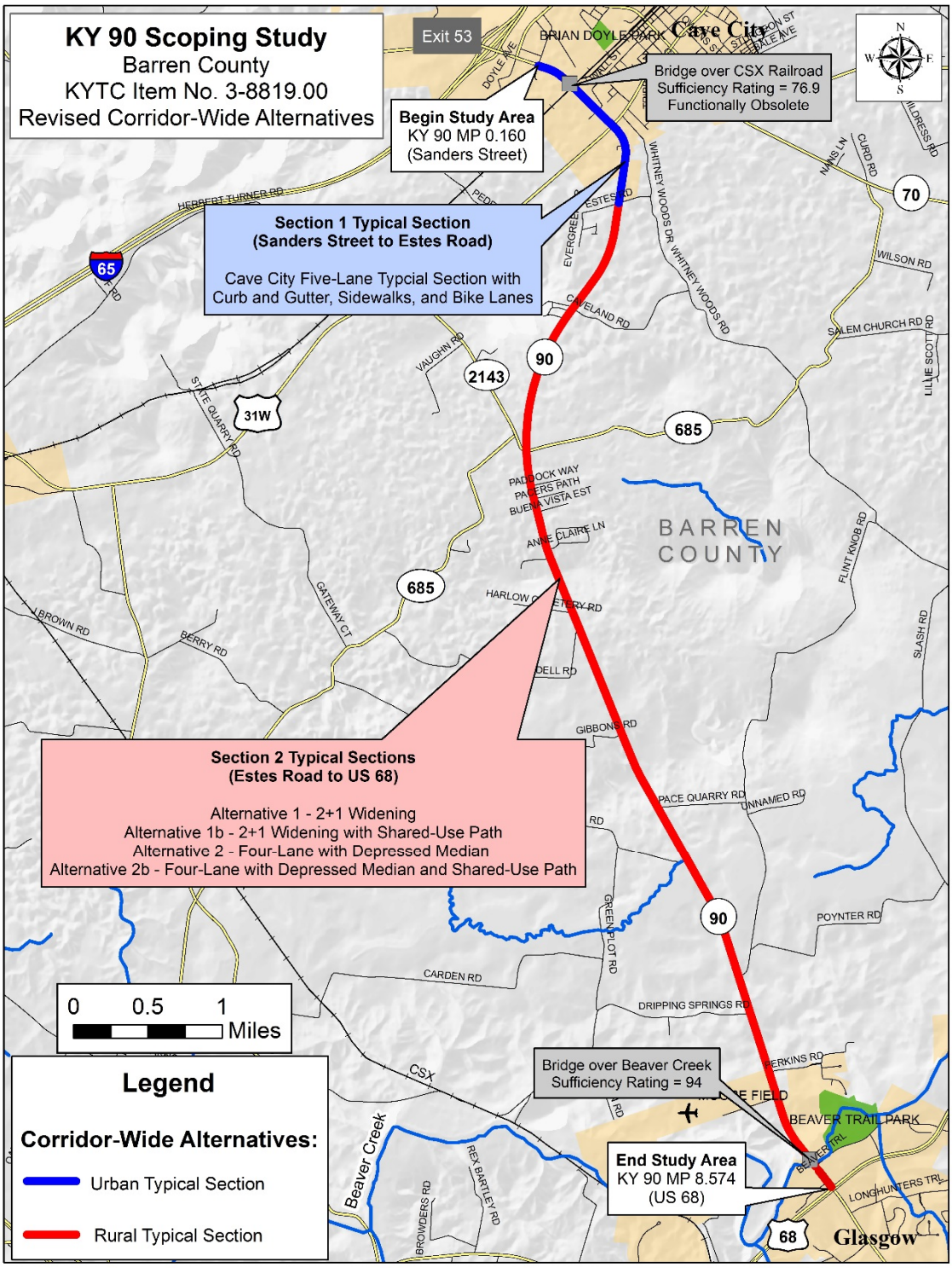

Figure 26: Revised Corridor-Wide Alternatives

Capacity Improvements

It has been found that 2+1 roads typically improve the traffic operational level of service for two-lane roads without increasing their capacity[11]. Under ideal or near ideal conditions, 2+1 roads can operate at level of service C or better for any traffic volume that does not exceed the capacity of a two-lane road. Capacity for a two-lane roadway under ideal conditions is 1,700 vehicles per hour in one direction, with total bi-directional volume not to exceed 3,200 vph (Highway Capacity Manual, 2010).

South of Cave City, KY 90 has three southbound and two northbound passing lanes that increase the average travel speeds and decrease the percent time following, which improves the LOS. This portion of KY 90 currently operates at a desirable LOS C. The 2040 ADT is projected to be 12,000 vpd with 19 percent trucks, which will operate at an undesirable LOS D south of Cave City. Building 2+1 roadway, which adds additional passing opportunities to those already present, would give KY 90 a desirable 2040 LOS C.

Safety Improvements

Comprehensive safety evaluation of 2+1 designs has not been completed within the United States. However, the National Cooperative Highway Research Program (NCHRP) Project 20-7[12] evaluated the performance of 2+1 roadways in Europe and found the following results:

- In Germany, 2+1 roads have been found to operate with crash rates 36 percent lower than conventional two-lane highways.
- Finland has estimated that 2+1 roads operate with crash rates 22 - 46 percent lower than conventional two-lane highways.

Design Considerations

The optimum length of the passing lane (without tapers) should be 0.5 to 1.0 mile. Lengths of less than half a mile are not recommended because they are not effective in reducing vehicle platooning. Three of the five existing passing lanes along KY 90 are less than half a mile in length. In total, the existing passing lanes are 2.4 miles long, which makes up 35 percent of KY 90 between Cave City and Glasgow. To achieve a desirable 2040 LOS, the existing passing lanes will need to be extended and additional passing lanes will need to be constructed, which would turn KY 90 into a 2+1 roadway.

Where passing lanes are dropped on the 2+1 roadway concept, the taper length is 660 feet. These tapers are long to minimize the likelihood of head on collisions. Signs and lane drop arrows are also used to alert vehicles in the passing lane that the lane is ending. Where lanes are added, shorter tapers are required (200 feet). The passing lane itself is typically half a mile or

[11] http://transportation.ky.gov/Congestion-Toolbox/Documents/M_OpsEffects_2.pdf
[12] Ingrid Potts, NCHRP Project 20-7/Task 139, "Application of European 2+1 Roadway Designs." (2003)

greater in length. The recommended taper lengths are shown in **Figure 27**. A potential signing and striping layout is shown in **Figure 28**. Where necessary and appropriate, left turn lanes are placed between tapers in the flush median after traffic has been transitioned out of the passing lanes. An example is shown in **Figure 29** where a left turn lane was added on KY 90 at the KY 685 intersection.

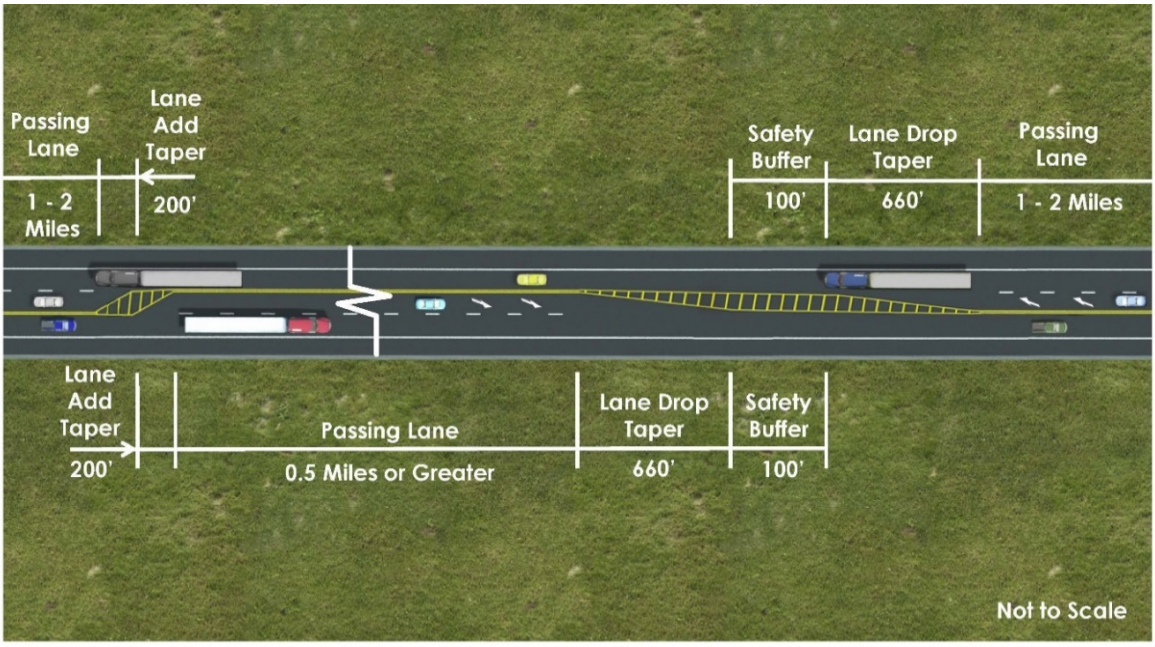

Figure 27: Recommended 2+1 Roadway Taper Lengths

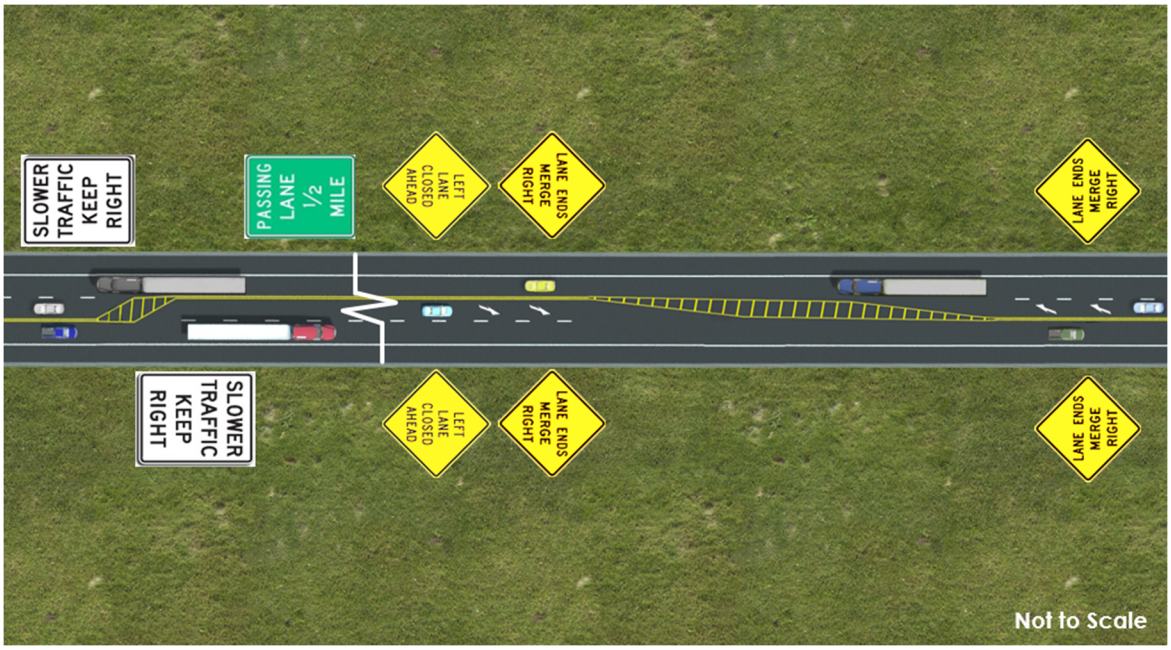

Figure 28: Potential 2+1 Roadway Signing and Striping Layout

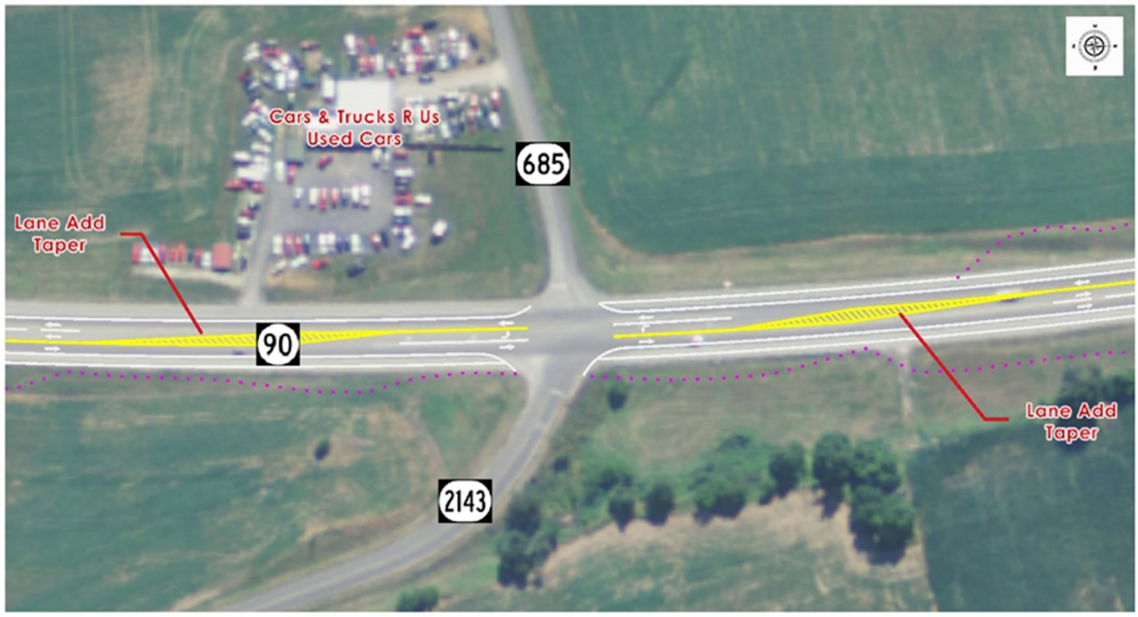

Figure 29: Left Turn Lanes on 2+1 Roadways (KY 90 intersection at KY 685)

10.2 EVALUATION MATRIX

The improvement concepts were reviewed for potential "red flags" to help with the evaluation process and provide KYTC with information that will be used to make final recommendations regarding alternative(s) to be carried forward for future development.

- All improvement concepts meet the purpose and need of the project.
- The No Build has an acceptable 2040 V/C ratio but an undesirable 2040 LOS.
- The Spot Improvements have an acceptable 2040 V/C ratio but an undesirable 2040 LOS.
- All the corridor wide alternatives have acceptable V/C ratios and LOS values.
- The addition of a shared-use path reduces design flexibility. Most of the homes and businesses along KY 90 are adjacent to the existing road. Widening to the west and constructing the shared-use path to the east would take the properties on both sides of the road. Thus, where the shared-use path is included, all the widening is done to the east, which increases earthwork and right-of-way impacts. The increased right-of-way impacts will increase the project timeline considerably.
- The addition of the shared-use path to the 2+1 typical section requires three additional home relocations, one additional business relocation, and a new pedestrian bridge over Beaver Creek.

- The addition of the shared-use path to the four-lane depressed median typical section requires six additional home relocations, one additional business relocation, and would require widening or replacing the bridge over Beaver Creek.

A summary of the complete evaluation matrix is shown in **Table 5**.

Alternative	Description	Project Limits		Satisfies Purpose and Need? (The project will enhance regional mobility and provide a safer, more efficient connection between Glasgow and I-65.)	2040 Traffic Analyses		Right-of-Way Impacts			
		BMP	EMP		V/C [1]	LOS [2]	Homes	Mobile Homes	Businesses	Barns
No Build	Do Nothing	0.160	8.574	No	0.60	E	0	0	0	0
Spot Improvements	Five Safety and Congestion Improvements	—	—	Yes	0.60	E	0	0	0	0
1	Five-Lane Urban Typical Section in Cave City and 2+1 Typical Section South of Cave City	0.160	8.365[3]	Yes	0.60	C	4	0	0	0
1b	Five-Lane Urban Typical Section in Cave City and 2+1 Typical Section with Shared-Use Path South of Cave City						7	0	1	0
2	Five-Lane Urban Typical Section in Cave City and Four-Lane Depressed Median Typical Section South of Cave City	0.160	8.574	Yes	0.25	B	13	2	3	6
2b	Five-Lane Urban Typical Section in Cave City and Four-Lane Depressed Median Typical Section with Shared-Use Path South of Cave City						19	0	4	5

[1] The target volume to capacity (V/C) ratio is 0.9 for rural areas and 1.0 for urban areas.
[2] In rural areas a level of service (LOS) C or better is desirable. In urban areas a LOS D or better is desirable.
[3] Alternative 1 does not require widening the bridge over Beaver Creek. Alternative 1 ends before the birdge at MP 8.365.

Table 5: Evaluation Matrix

10.3 COST ESTIMATES

Utilizing a digital terrain model (DTM) and horizontal and vertical alignments, approximate earthwork volumes, pavement lengths, and structures affected were calculated for the alternatives. These major project construction items were used to estimate the construction costs for the alternatives under consideration. Typical paving sections were determined for cost estimating purposes. The DTM was also utilized to approximate disturbed limits for the improvements which were used to determine right-of-way costs, number of utilities affected, and to estimate the number of relocations. District 3 provided the approximate right-of-way relocations and utility cost estimates. Property Valuation Administrator (PVA) data were also obtained to assist with this effort. Cost estimates for each alternative are shown in **Table 6**.

Alternative	Description	2016 Cost Estimates (millions)				
		Design	Right-of-Way	Utility	Construction	Total
2016 Highway Plan	**Major Widening from Sanders Street in Cave City to US 68 (Glasgow Outer Loop) in Glasgow**	**$2.2**	**$6.0**	**$3.5**	**$27.5**	**$39.2**
No Build	Do Nothing	$0.0	$0.0	$0.0	$0.0	$0.0
Spot Improvements	Five Safety and Congestion Improvements	$0.8	$1.3	$6.1	$7.8	$16.0
Alternative 1	5-Lane Urban Typical Section in Cave City and 2+1 Typical Section South of Cave City	$2.0	$2.5	$10.0	$20.5	$35.0
Alternative 1b	5-Lane Urban Typical Section in Cave City and 2+1 Typical Section with Shared-Use Path South of Cave City	$2.6	$5.8	$10.0	$25.6	$44.0
Alternative 2	5-Lane Urban Typical Section in Cave City and 4-Lane Depressed Median Typical Section South of Cave City	$4.1	$6.4	$17.0	$40.9	$68.4
Alternative 2b	5-Lane Urban Typical Section in Cave City and 4-Lane Depressed Median Typical Section with Shared-Use Path South of Cave City	$4.8	$9.4	$17.0	$47.7	$78.9

Table 6: Cost Estimates

11.0 PUBLIC INVOLVEMENT

Following the development of improvement concepts, the project team met with local officials, stakeholders, and interested members of the public. During the meetings, improvement concepts were presented and attendees were asked to provide feedback regarding their concerns and priorities. Summaries for all project meetings are found in **Appendix G**.

11.1 LOCAL OFFICIALS/STAKEHOLDERS MEETING

The project team reached out to local government representatives and other community groups early in the planning process. The following organizations were invited to participate as key stakeholders in the KY 90 Scoping Study:

- State Legislators
- Mayor of Cave City
- Judge Executive in Barren County
- Mayor of Glasgow
- Barren County Health Department
- Barren County Magistrates
- Joint City-County Planning Commission of Barren County
- Barren County Sheriff Department
- Glasgow Police Department
- Glasgow Fire Department
- Barren County Public Schools
- Caverna Independent Schools
- Glasgow-Barren County Emergency Management

The project team met with key stakeholders and local officials on May 26, 2016. In addition to the project team, the Mayor of Glasgow and the Mayor of Cave City attended along with representatives from the Glasgow Fire and Police Departments, Glasgow Independent Schools, Glasgow Public Works, Cave City Fire Department, Joint City-County Planning Commission, Barren County Sheriff's Office, Glasgow-Barren County Emergency Medical, and Caverna Independent Schools. The purpose of the meeting was to discuss the project purpose and history, the results of the existing conditions analysis, design considerations, and get feedback on the improvement alternatives. Surveys were distributed to the local officials and stakeholders. Completed surveys were submitted by eight attendees. The results of the survey are summarized as follows:

- Respondents were asked whether several transportation issues along KY 90 should be considered as a part of the project. Too few passing opportunities received the most responses. Safety and large trucks received the second most responses.

- Respondents were asked if they felt improvements were needed along the study portion of KY 90. Seven respondents (88 percent) indicated improvements were needed.

- Respondents were then asked which Corridor Wide Improvement they prefer. All eight respondents preferred Alternative 1 (2+1 Typical Section south of Cave City).

- Respondents were asked if a shared-use path should be constructed along KY 90 between Cave City and Glasgow. Four respondents answered "yes" and four respondents answered "no."

11.2 PUBLIC MEETING

After meeting with key stakeholders and local officials, the project team held a public meeting on June 28, 2016, at the Cave City Convention Center in Cave City, Kentucky. The purpose of the meeting was to provide information about the study and the projects under consideration, discuss conceptual alternatives, and solicit input from the public. The meeting was held in an open house format that included a formal presentation to explain the project. Attendees were provided a project information brochure, an explanation of the 2+1 concept, and a survey. All this information, including the presentation, was made available on the project website.

Ninety-eight members of the public attended the meeting and were asked to complete a survey to help the project team understand priorities from a local perspective. Completed surveys were submitted by 48 people through July 29, 2016. The results of the surveys are summarized as follows:

- Respondents were asked whether several transportation issues along KY 90 should be considered as a part of the project. Of the 12 options provided, safety and few passing opportunities received the most responses. Too much traffic, excessive speeds, and large trucks also received a high number of responses.

- Respondents were asked if they felt improvements were needed along the study portion of KY 90. Of the 47 responses, 42 (89 percent) indicated that improvements are needed.

- Attendees were asked if they prefer further consideration of the Spot Improvement alternative or the Corridor-wide Improvement. Of the 41 responses, 26 (63 percent) selected Corridor-wide Improvement and 15 (37 percent) selected Spot Improvements.

- Respondents were then asked which Corridor-wide Improvement they prefer. Of the 45 responses, 26 (58 percent) selected Alternative 1 (2+1 typical section south of Cave City), 15 (33 percent) selected Alternative 2 (four-lane depressed median typical section south of Cave City), and four (nine percent) wanted a different alternative.

- Attendees were asked if a shared-use path should be constructed along KY 90 between Cave City and Glasgow. Twenty respondents (59 percent) said "no" and 18 respondents (41 percent) said "yes."

12.0 FINAL PROJECT TEAM MEETING

The project team met for a final meeting at the District 3 Office in Bowling Green, Kentucky on August 25, 2016. The purpose of the meeting was to discuss the survey results from the local officials/stakeholders meeting held in May and the public meeting held in June and to determine the project team recommendations for the study. The meeting summary is included in **Appendix G**. Key discussion items included the following:

- The project team chose Alternative 1 (five-lane urban typical section in Cave City and 2+1 typical section south of Cave City) as the preferred alternative to move forward to Phase 1 design because it satisfies the purpose and need of the project, addresses the top two transportation issues identified along the study area (safety and not enough passing lanes), provides acceptable LOS through year 2040, and can be built within the 2016 Highway Plan budget.

- The project team recommended reduced shoulder widths and lane widths be considered in Phase 1 design. This can enhance safety by reducing travel speeds and will reduce right-of-way impacts and earthwork costs.

- The project team recommended a shared-use path be considered further in Phase 1 design. The local officials in Glasgow, Cave City and/or Barren County will need to agree to maintain the shared-use path before it can be advanced in design.

- An alternative to the shared-use path is a shoulder bikeway. This should be considered further in Phase 1 design.

13.0 CONCLUSIONS AND RECOMMENDATIONS

This section provides the recommendations for the KY 90 Scoping Study based on their ability to meet the purpose and need, the existing conditions analysis, the input received, and the alternative development process detailed in this report. The project team recommends Alternative 1 move forward to Phase 1 design, shown in **Figure 30**. The exhibits for Alternative 1 are shown in **Appendix H**.

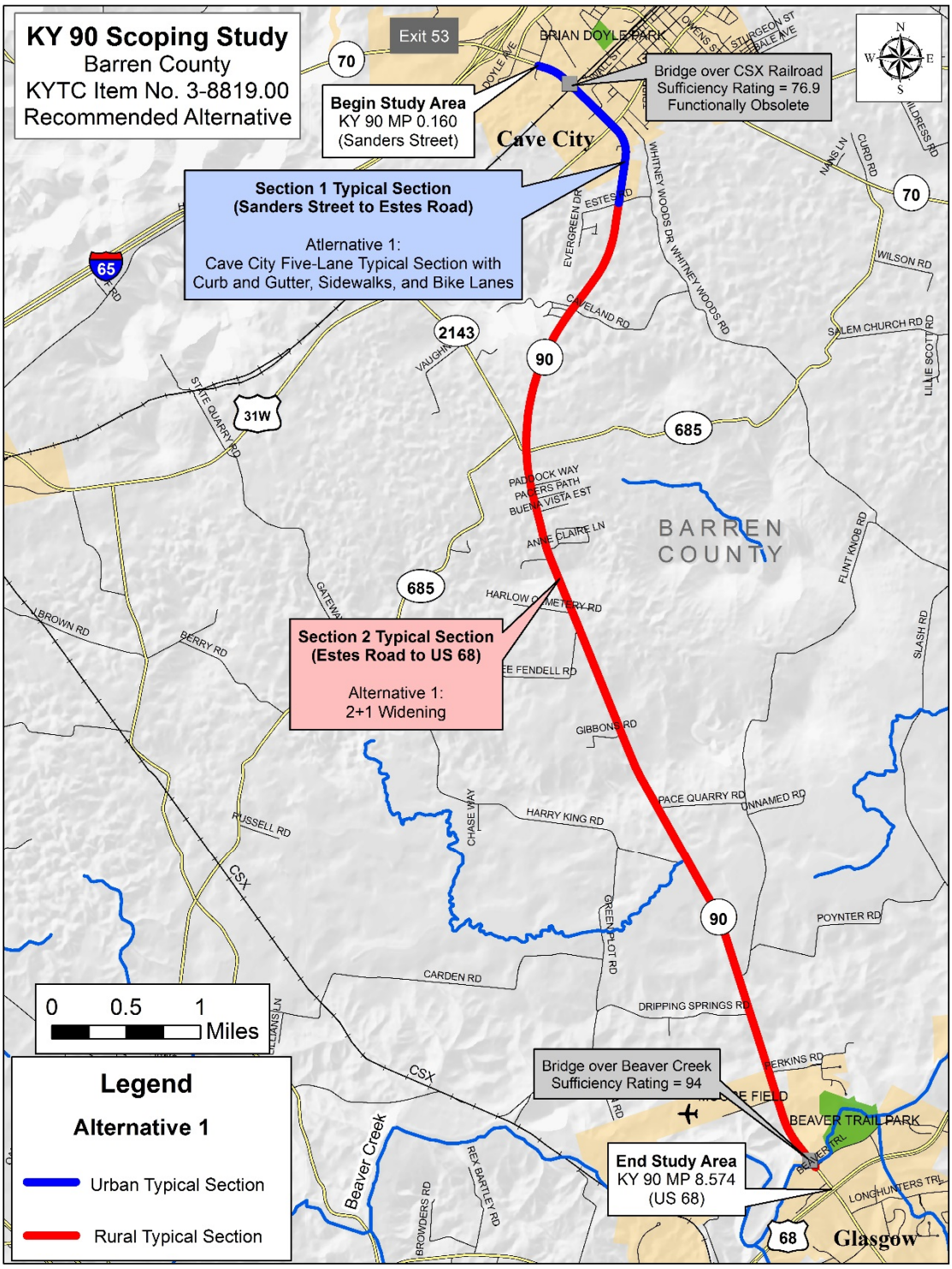

Figure 30: Recommended Alternative

The project team chose Alternative 1 as the preferred alternative because it:

- Satisfies the purpose and need of the project;
- Addresses the top two transportation issues from survey respondents (safety and not enough passing lanes);
- Provides acceptable LOS through year 2040;
- Was the preferred alternative from survey respondents;
- Was unanimously selected as the preferred alternative from all the local officials/stakeholders survey respondents;
- Can be built within the 2016 Highway Plan budget;
- Provides a corridor wide improvement, which meets the intent of the project description in the 2016 Highway Plan;
- Provides the most design flexibility, which reduces right-of-way impacts, environmental impacts, and earthwork costs; and
- Does not require widening or replacing the bridge over Beaver Creek.

Alternative 1 is divided into two sections. Section 1 is the urban area that travels through Cave City and Section 2 is the rural area between Cave City and Glasgow. The proposed typical section in **Section 1** is a five-lane typical section with curb-and-gutter, sidewalks, and bike lanes, as shown in Figure 17. It matches the existing typical section north of Sanders Street.

A 2+1 typical section is proposed in **Section 2**, as shown in Figure 18. The 2+1 widening occurs on one side of the road in localized construction zones so traffic can be maintained during construction and the majority of existing mainline pavement can be reused. The widening should shift from one side of the road to the other, depending on existing conditions, to minimize right-of-way and environmental impacts, and reduce earthwork. It is assumed that after the widening is complete, a final pavement surface course and final striping will be placed over the entire roadway. Reduced shoulder widths and lane widths should be considered for the 2+1 typical section in Phase 1 design. This can enhance safety by reducing travel speeds and will further reduce right-of-way impacts and earthwork costs.

A shared-use path shall be considered further in Phase 1 design. The local officials in Glasgow, Cave City and/or Barren County will need to agree to pay to maintain the shared-use path before it moves any further in design. As stated previously, the addition of a shared-use path reduces design flexibility. Widening to the west and constructing the shared-use path to the east, which would be required to avoid impacts to the Glasgow Airport, would affect properties on both sides of the road. Thus, where the shared-use path is included, all the widening is done

to the east, which increases earthwork and right-of-way impacts. The increased right-of-way impacts will increase the project timeline considerably. The addition of the shared-use path to the 2+1 typical section is estimated to require three additional home relocations, one additional business relocation, a new pedestrian bridge over Beaver Creek, and an additional $9.0 million in total project cost ($5.1 million in construction). An alternative that may be considered would be the inclusion of a shoulder bikeway. However, a similar maintenance agreement would be required to provide a debris-free area for cyclists to operate.

Cost estimates for Alternative 1 with and without the shared-use path are shown **Table 7**. District 3 provided the approximate right-of-way and utility cost estimates. Property Valuation Administrator (PVA) data were also obtained to assist with this effort.

Alternative	Description	2016 Cost Estimates (millions)				
		Design	Right-of-Way	Utility	Construction	Total
Alternative 1	5-Lane Urban Typical Section in Cave City and 2+1 Typical Section South of Cave City	$2.0	$2.5	$10.0	$20.5	$35.0
Alternative 1b	5-Lane Urban Typical Section in Cave City and 2+1 Typical Section with Shared-Use Path South of Cave City	$2.6	$5.8	$10.0	$25.6	$44.0

Table 7: Alternative 1 Cost Estimates

13.1 NEXT STEPS

The next phase for the project would be Phase 1 Design (Preliminary Engineering and Environmental Analysis) to further evaluate Alternative 1 for advancement. The 2016 Highway Plan includes $2.2 million for design in 2016, $6.0 million for right-of-way in 2017, and $3.5 million for utility relocation in 2017. The construction phase is outside the two-year biennium, with $27.5 million included in 2019.

14.0 CONTACTS/ADDITIONAL INFORMATION

Written requests for additional information should be sent to John Moore, Director, KYTC Division of Planning, 200 Metro Street, Frankfort, KY 40622. Additional information regarding this study can also be obtained from the District 3 Project Manager, Deneatra Henderson, at (270) 746-7898 (email at Deneatra.Henderson@ky.gov).