KENTUCKY TRANSPORTATION CABINET

# Western Kentucky Parkway Upgrade Study

Final Report • May 2022

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# Executive Summary

The Kentucky Transportation Cabinet (KYTC) initiated this planning study to identify and evaluate potential improvements that would be necessary to upgrade the Wendell H. Ford Western Kentucky Parkway (WKP) to meet current Interstate design standards. The study area, shown in **Figure ES1**, extends from Interstate 165 (I-165) in Ohio County (MP 76.758) through Grayson and Butler counties to continues to I-65 in Hardin County (MP 136.443)

State and local officials have expressed interest in redesignating this eastern portion of the WKP as an Interstate. Converting this portion of the highway would link two Interstates (I-65 and I-165) and would provide a signed east to west Interstate connection between Central and Western Kentucky. This study outlines what may be required to accomplish the redesignation for the WKP. It will identify and evaluate short-term and long-term improvement strategies to upgrade the WKP to current (2021) Interstate design standards. The study also identifies improvement strategies to address specific traffic operations and safety issues identified during the process. The goals of this study are to:

- Evaluate existing mainline, interchange, ramp, and bridge conditions to identify deficiencies with respect to Interstate design standards
- Evaluate existing traffic and safety conditions
- Develop a list of proposed improvements needed to meet Interstate design standards
- Evaluate proposed improvements with respect to traffic, safety, environment, and cost
- Develop a list of prioritized recommended improvements based on technical evaluation and KYTC and FHWA input

## Interstate Design Standards

FHWA identifies ten controlling design criteria that define the operational and safety performance of an Interstate. A Design Exception (DE) can be requested when design features do not meet those standards if there is not an associated safety issue. The ten controlling criteria apply to high speed (≥50 mph) National Highway System routes and include:

1. Design Speed
2. Lane Width
3. Shoulder Width
4. Horizontal Curve Radius
5. Superelevation Rate
6. Stopping Sight Distance[1]
7. Maximum Grade
8. Cross Slope
9. Vertical Clearance
10. Design Loading Structural Capacity

This study evaluates the design features of the WKP for compliance with FHWA's ten controlling criteria as well as the American Association of State Highway Transportation Officials (AASHTO) and KYTC design guidelines for non-controlling criteria. **Table ES1** summarizes the guidelines used for the design standards for each mainline, structure, ramp, or loop feature. Items with an asterisk are part of FHWA's ten controlling criteria whereas those without an asterisk are KYTC standards. A Design Variance (DV) can be requested for design features that do not meet the KYTC or AASHTO guidelines if they are not one of the ten controlling criteria and if there are no safety issues present. The project team evaluated each design feature with respect to the listed official reference. A technical analysis was conducted to determine study recommendations.

1 Applies to the horizontal and vertical alignment except in the case of vertical sag curves.

**Figure ES1: Study Area**

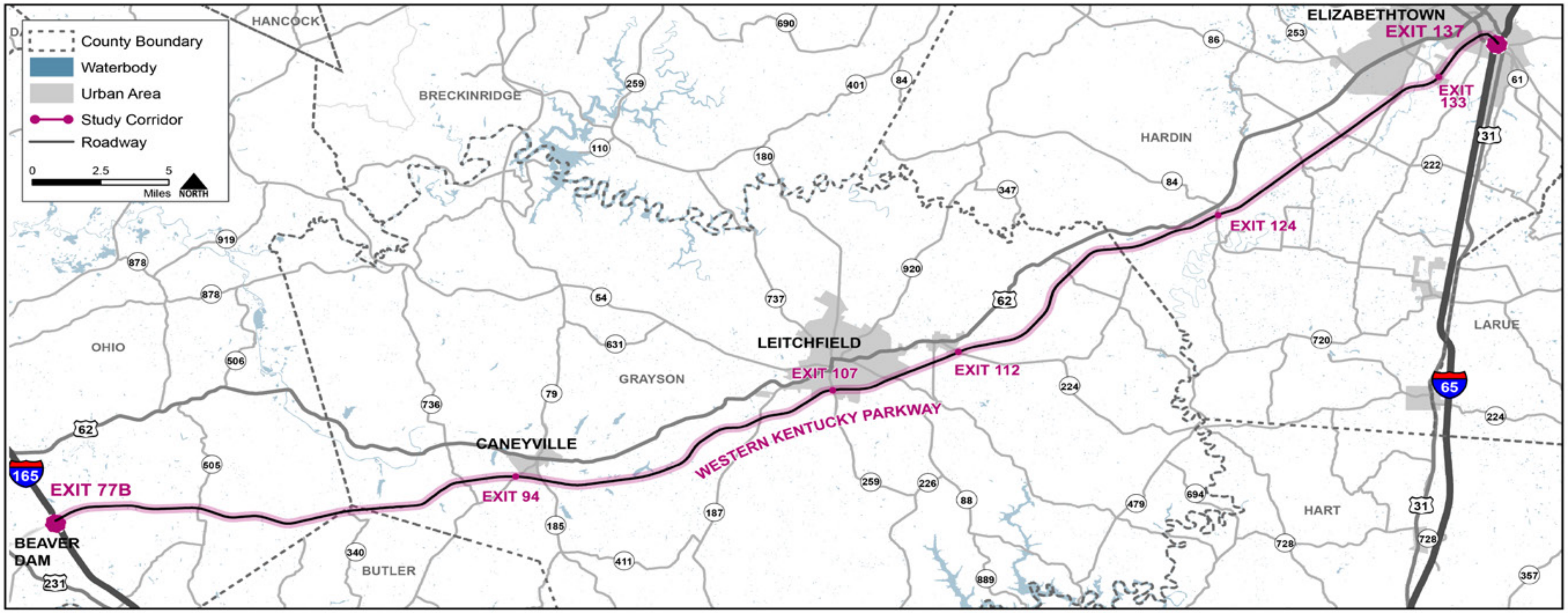

**Table ES1: Interstate Design Criteria for Rural, 4-Lane Interstate Facilities**

| Design Element | Governing Agency | Reference | Mainline | Ramps | Loops |
|---|---|---|---|---|---|
| Design Speed* | AASHTO | A Policy on Geometric Design of Highways & Streets (Green Book), 2018 | 70 mph | 35 mph | 20 mph |
| Lane Width* | AASHTO | Green Book, 2018 | 12' | 14' | 15' |
| Inside Shoulder* | AASHTO | Green Book, 2018 | 4' | 2'-4' | |
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| Truck DDHV ≤ 250 | AASHTO | Green Book, 2018 | 10' | 6'-10' | |
| Truck DDHV > 250 | AASHTO | Green Book, 2018 | 12' | | |
| Median Width | AASHTO | Roadside Design Guide, 2011 / A Policy on Design Standards - Interstate System (Interstate Design Guide), 2016 | 30' (Roadside Design Guide)/50' (Interstate Design Guide) | N/A | |
| Median Turnarounds | AASHTO | Green Book, 2018 | May be spaced at 3 to 4-mile intervals or as needed | | |
| Clear Zone | AASHTO | Roadside Design Guide, 2011 | 30'-46' | 10'-18' | |
| Guardrail Height | KYTC | KYTC Standard Drawings | 31" | | |
| Horizontal Alignment | | | | | |
| Superelevation* | AASHTO | Green Book, 2018 | 8% Max | | |
| Minimum Radius* | AASHTO | Green Book, 2018 | 1810' | 314' | 134' |
| Cross Slopes* | AASHTO | 2016 Interstate Design Guide | Greater than 1.5% | | |
| Vertical Alignment | | | | | |
| Maximum Vertical Grade* | AASHTO | 2016 Interstate Design Guide/2018 Green Book | 4% | 4%-6% | 6%-8% |
| Crest Vertical Curves – Minimum Stopping Sight Distance* | AASHTO | Green Book, 2018 | 730' | 250' | 115' |
| Sag Vertical Curves - Minimum Head Light Sight Distance | AASHTO | Green Book, 2018 | | | |
| Bridges and Overpasses | | | | | |
| Bridge Width ≤ 200 feet | AASHTO | 2016 Interstate Design Guide | 37.5' | N/A | |
| Bridge Width > 200 feet | AASHTO | 2016 Interstate Design Guide | 31' | N/A | |
| Minimum Overpass Vertical Clearance* | AASHTO | 2016 Interstate Design Guide/KYTC Highway Design Manual | 16' (Interstate Design Guide)/16.5' (KYTC Highway Design Manual) | N/A | |
| Minimum Overhead Sign Vertical Clearance* | AASHTO | Manual on Uniform Traffic Control Devices (MUTCD), 2009 | 17' | | |
| Divergence Angle | AASHTO | Green Book, 2018 | 2 to 5 degrees | | |
| Speed Change Lanes | AASHTO | Green Book, 2018 | Varies depending on the design speed of the entering or exiting curves | | |
| Interchange Spacing | AASHTO | Green Book, 2018 | 1 mile (Urban); 2 miles (Rural) | | |
| Interchange Control of Access | AASHTO | A Policy on Design Standards - Interstate System, 2016 | 300' | | |

*FHWA Design Controlling Criteria**

## Committed Projects

There are seven pavement rehabilitation projects in the study area included in *Kentucky's Fiscal Year (FY) 2020 – FY 2026 Highway Plan*, and six projects in the vicinity of the study area in the KYTC Continuous Highway Analysis Framework (CHAF) database, listed below. Item No. 4-20016.00 was let for construction in October 2021 and Item No. 4-20001.00 was combined with 4-20002.00 and 4-20003.00 and was let in April 2022.

**Kentucky FY 2020 – FY 2026 Highway Plan Projects**

- 2-80201.00 - Western Kentucky Parkway - Reconstruct interchange at US 431 at Central City
- 4-20001.00 – Address pavement deficiencies from MP 111.25 – 112.4
- 4-20002.00 – Address pavement condition from MP 112.4 – 114.8
- 4-20003.00 – Address pavement condition from MP 114.8 – 116.95
- 4-20016.00 – Address pavement condition from MP 120.93 – 132.4 – ESTIMATED COMPLETION END OF 2022

**CHAFs**

- IP20130047 – Address need for new interchange access to the WKP at KY-505.
- IP20100007 – Construct a truck parking facility for overnight parking of semi tractor trailers (location to be determined)
- IP20060115 – Improve safety and mobility of the WKP (WK9001) and the William Natcher Parkway (WN9007) interchange to address interstate standards.
- IP20070103 – Address safety and service concerns of the WK-9001 and US 231 interchange near Beaver Dam.
- IP20060114 – Address need for additional parkway access at KY 1245 near Rockport on the WKP.

Some of the recommendations from this study could possibly be included in future resurfacing, restoration, and rehabilitation (3R) projects, as well as any other future projects within the study boundaries.

## Traffic Volumes and Operations

According to functional classification criteria, the WKP is currently identified as a Rural Freeway Expressway. Current year (2020) Average Annual Daily Traffic (AADT) volumes range from 9,080 – 34,600 vehicles per day (vpd). Future year (2045) AADT volumes range from 11,640 – 44,380 vpd. A screening process was used to evaluate level of service (LOS) along the corridor. Based on this screening analysis, the WKP currently operates at an acceptable level of service and is operating below capacity. In the future year of 2045, the majority of the WKP is expected to operate at an acceptable LOS, with the exception of two segments between the I-65 and US 31W Bypass interchange in Elizabethtown, which will operate at LOS D.

## Safety

A historical crash analysis was performed to examine traffic safety trends and to identify potential safety issues. Five years of data (2015 to 2019) was used. 2020 crash data was not used due to changes in driver behavior and traffic volumes during the COVID-19 pandemic. Within the five-year period, 919 crashes were reported in the study area. Of the total crashes, 816 (89%) occurred on the mainline and 103 (11%) occurred on interchange ramps. There were 12 fatal crashes and 23 serious injury crashes (3.8% combined) over the five-year period. The severity type involving the most crashes (728, 79.4%) were property damage only crashes. A majority of crashes in the study area (635, 69.1%) were single-vehicle crashes. This is consistent with the low volume rural nature of the majority of the roadway. Rear-end crashes and sideswipe crashes were the other two major crash categories. The angle crashes had the highest average severity of all the categories with ten of the 38 involving a fatality or injury (3 fatal, 2 severe injury, and 5 minor injury). It was also noted that commercial vehicles were involved in 11% of all reported crashes, which is a lower percent than the total truck percentage of traffic volume on the WKP.

KYTC uses a performance metric called Excess Expected Crashes (EEC) to evaluate the need for safety improvements on state highways. EEC compares the number of observed crashes on a highway to the number of expected crashes using a crash prediction model for that highway type. A positive EEC indicates that more crashes are occurring than the model would have predicted, meaning that improvements may be warranted. A negative EEC indicates that fewer crashes are occurring than expected. The WKP within each county experiences a mixture of positive and negative EEC values. The area of western Hardin County and eastern Grayson County is more concentrated with fatal and injury crashes compared to other segments of the WKP within the study area. 211 crashes occurred in this area including five fatal crashes and five serious injury crashes. The overall EEC for the study area was a negative value of -9.82 crashes per year. The EEC for KAB (fatal, serious injury, minor injury) crashes total +3.02 crashes per year and the EEC for CO (possible injury, property damage only) crashes total -12.84 crashes per year. These results indicate that overall, the WKP is operating better than would be predicted for a rural freeway / parkway with similar traffic volumes, but it is experiencing more injury and fatal crashes. One caveat to the EEC data is that there are some segments of the corridor in western Grayson County that do not have calculated EEC values.

## Study Recommendations

Existing conditions along the WKP were evaluated with regards to three areas: mainline, structures, and interchanges and ramps. The conditions along the WKP were compared to Interstate standards and a list of potential improvement concepts was developed. An iterative process was used, in which the initial list of potential improvement concepts was shared with the project team to obtain feedback. Based on that feedback, the consultant team investigated certain locations further with respect to crashes, record plans, or other available data to determine which improvement concepts would need to be constructed before Interstate conversion (initial conversion), and which could possibly be granted a DE or DV but would be necessary for full interstate compliance. DEs and DVs can be granted when the element that does not meet Interstate standards does not contribute to a safety issue at that location. Planning level construction cost estimates were developed for the refined list of improvement concepts, which was presented and discussed in the final project team meeting. Based on feedback, a finalized list of recommended improvement concepts was developed. **Tables ES2** and **ES3** show the total costs (in 2021 dollars) for initial conversion and full compliance. An additional 15% is added to the construction cost to account for design and environmental related costs, and another 15% is added to the construction cost to account for any miscellaneous construction costs. **Table ES4** gives a summary of the improvement concepts recommended as part of this study. The table includes the construction cost in 2021 dollars, and whether the improvement would likely be needed prior to Interstate conversion, or for full compliance to Interstate standards.

**Table ES2: Cost Estimates for Initial Conversion to Interstate Design Standards**

| Total Initial Conversion Cost (2021 $) | Low | High |
|---|---|---|
| Total Initial Conversion Cost (2021 $) | $56,520,299 | $64,164,689 |
| Total Initial Conversion Construction Cost | $43,477,153 | $49,357,453 |
| Design + Environmental (15%) | $6,521,573 | $7,403,618 |
| Miscellaneous (15%) | $6,521,573 | $7,403,618 |

**Table ES3: Cost Estimates for Full Compliance with Interstate Design Standards**

| Total Full Compliance Cost (2021 $) | Low | High |
|---|---|---|
| Total Full Compliance Cost (2021 $) | $102,591,683 | $127,136,073 |
| Total Full Compliance Construction Cost | $78,916,679 | $97,796,979 |
| Design + Environmental (15%) | $11,837,502 | $14,669,547 |
| Miscellaneous (15%) | $11,837,502 | $14,669,547 |

**Table ES4: Summary of Recommended Improvements to Upgrade the Cumberland Expressway to Interstate Standards**

| Category | Subcategory | Miles | Cost (2021$) | Initial Conversion | Full Compliance | Requires DE | Requires DV | Safety Issue |
|---|---|---|---|---|---|---|---|---|
| **Mainline** | | | | | | | | |
| Shoulders | Widen inside shoulder to consistent 4 foot minimum | 17.147 | $2,546,000 | ✓ | | | | Yes |
| Superelevation | Increase superelevation (locations with safety issues) | 7.32 | $10,309,000 | ✓ | | | | Yes |
| | Increase superelevation (locations without safety issues) | 1.86 | $1,208,000 | | ✓ | ✓ | | No |
| Headlight Sight Distance | Increase curve length | 0.552 | $1,608,000 | | ✓ | | ✓ | No |
| Guardrail | Replace damaged guardrail | 13.8 | $2,565,240 | ✓ | | | | No |
| | Regrade crash cushions | - | $10,000 | ✓ | | | | No |
| | Raise guardrail height to 31 inches at areas with safety issues | 4.986 | $1,401,413 | ✓ | | | | Yes |
| | Replace all guardrail less than 31 inches | 25.7 | $4,949,360 | | ✓ | | | No |
| Clear Zone | Add guardrail where clear zone is not met | 12.818 | $2,443,766 | | ✓ | | ✓ | Yes |
| **Interchanges** | | | | | | | | |
| Ramps - Accel/ Decel | Exit 94 (KY 79) Increase WB accel length to 580’ | 1 | $184,000 | ✓ | | | | No |
| | Exit 107 (KY 259) Increase EB decel length to 390’ | 1 | $52,000 | ✓ | | | | Yes |
| | Exit 124 (KY 84) Increase WB accel length to 580’ | 1 | $187,000 | ✓ | | | | No |
| Lane Width | Exit 137 (I-65) Increase EB cloverleaf off ramp lane width to 15 feet | 1 | $148,000 | ✓ | | | | No |
| Superelevation | Add auxiliary speed signs | 6 | $30,000 | ✓ | | | | Yes |
| Control of Access | Increase control of access to 300 feet (rural) or 100 feet (urban) | 5 | $5,370,000 | ✓ | | | | Yes |
| Interchange Spacing / Reconfiguration | Exit 137 (I-65) Phase 1: Add auxiliary lanes and increase superelevation / bridge clearances | N/A | $11,000,000 | ✓ | | | | Yes |
| | Exit 137 (I-65) Phase 2: Provide direct connection from I-65 SB to US 31W Bypass | N/A | $5,500,000 | | ✓ | | | Yes |
| | Exit 137 (I-65) Phase 3A: Provide direct connection from I-65 NB and Lincoln Parkway to US 31W | N/A | $31,000,000 | | ✓ | | | Yes |
| | Exit 137 (I-65) Phase 3B: Braid movements from I-65 NB, SB, and Lincoln Pkwy to provide direct connection to US 31W | N/A | $18,000,000 | | ✓ | | | Yes |

*DE = Design Exception, DV = Design Variance*

**Table ES4: Summary of Recommended Improvements to Upgrade the Cumberland Expressway to Interstate Standards**

| Bridges | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Category | Subcategory | Miles | Cost (2021$) | Initial Conversion | Full Compliance | Requires DE | Requires DV | Safety Issue |
| Bridge Railing | Replace metal railing | 6 | $526,000 | ✓ | ✓ | | | Yes |
| Bridge Width | If Bridge Length <=200ft widen 1.0 foot<br>If Bridge Length >200ft widen 7.5 feet | 6 | $2,169,600 | ✓ | ✓ | | | Yes |
| Bridge Vertical Clearance | Replace bridge or lower pavement to achieve minimum vertical clearance | 7 | $8,719,300 | ✓ | | | | Yes |
| | Replace bridge to achieve minimum vertical clearance | 7 | $14,599,600 | ✓ | | | | Yes |

## Additional Safety and Operational Improvement Recommendations

A list of additional safety and operational improvements was developed to recommend improvements for locations that meet the design criteria but have a noted safety or operational deficiency that should be addressed. **Table ES5** shows the total cost (in 2021 dollars) of these improvements with an additional 15% added for design and environmental related costs, and another 15% for miscellaneous construction costs. **Table ES6** shows a summary of these recommendations.

**Table ES5: Cost Estimates for Additional Safety and Operational Improvements**

| Description | Cost |
|---|---|
| Total Operational and Safety Improvement Cost (2021 $) | $10,393,318 |
| Total Operational and Safety Improvement Construction Cost | $7,994,860 |
| Design + Environmental (15%) | $1,199,229 |
| Miscellaneous (15%) | $1,199,229 |

**Table ES6: Summary of Recommended Additional Safety and Operation Improvements**

| Additional Safety and Operational Improvements | | | | |
|---|---|---|---|---|
| Category | Subcategory | Length | Cost | Possible Design Related Safety Issue |
| Shoulders and Cable Median Barrier | Widen outside shoulders to 12 feet | 3.326 | $894,526 | Yes |
| | Add cable median barrier | 54.094 | $6,750,000 | Yes |
| Median Turnarounds | Remove median turnarounds | N/A | $132,000 | No |
| | Pave median turnaround | N/A | $10,000 | No |
| Interchange Ramp Improvements | Improve ramp terminal at Exit 107 (KY 259) WB ramp | N/A | $10,000 | Yes |
| | US31 Bypass SB to EB Loop Ramp - Add High Friction Surface Treatment | 0.32 | $198,333 | Yes |

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# Glossary of Terms

| Full Name | Abbreviation |
|---|---|
| American Association of State Highway Transportation Officials | AASHTO |
| A Policy on Design Standards – Interstate System, 2016 | Interstate Design Guide |
| A Policy on Geometric Design of Highways & Streets, 2018 | Green Book |
| Area Development District | ADD |
| Average Annual Daily Traffic | AADT |
| Census Bureau American Community Survey | ACS |
| Crash Data Analysis Tool | CDAT |
| Design Exception | DE |
| Design Hourly Volume | DHV |
| Design Variance | DV |
| Excess Expected Crashes | EEC |
| Federal Highway Administration | FHWA |
| Geographic Information System | GIS |
| Headlight Sight Distance | HLSD |
| High Friction Surface Treatment | HFST |
| Highway Capacity Manual, 6th Edition | HCM 6 |
| Highway Information System | HIS |
| Highway Safety Manual | HSM |
| Intermodal Surface Transportation and Efficiency Ace of 1991 | ISTEA |
| Infrastructure Investment and Jobs Act (IIJA) | IIJA |
| Kentucky Transportation Cabinet | KYTC |
| Kentucky Transportation Center | KTC |
| Level of Service | LOS |
| Manual on Uniform Traffic Control Devices, 2009 | MUTCD |
| National Wetland Inventory | NWI |
| Outstanding State Resource Water | OSRW |
| Resurfacing, Restoration, and Rehabilitation | 3R |
| Roadside Design Guide, 4th Edition (including 2012 and 2015 errata), 2011 | Roadside Design Guide |
| United States Department of Transportation | USDOT |
| Volume to Capacity Ratio | V/C |

# 1 Introduction

The Kentucky Transportation Cabinet (KYTC) initiated this planning study to identify and evaluate potential improvements that would be necessary to upgrade the Wendell H. Ford Western Kentucky Parkway (WKP) from milepoint (MP) 76.758 to MP 136.796 to meet current Interstate design standards. The study includes both short- and long-term improvement strategies that KYTC could use to further project development and implementation. Members of the project team included the KYTC State Highway Engineer's Office, KYTC Districts 2 and 4, KYTC Central Office Divisions of Planning and Highway Design, Federal Highway Administration (FHWA), the Green River and Lincoln Trail Area Development Districts, and the WSP USA Inc. Consultant Team, including HDR Inc. and TSW Design Group.

## 1.1 Study Background & Study Area

The Western Kentucky Parkway Upgrade Study identified highway elements or characteristics that do not adhere to Interstate design standards and developed possible improvements to bring the highway into compliance with those standards. The study addressed the highway mainline, bridges, ramps, and cross-streets, considering the standards and guidelines that apply to each.

The WKP is an east-west highway that formerly ran from Interstate 24 (I-24) in Eddyville to United States Route 31W (US 31W) in Elizabethtown. In 2011, the western 38 miles of highway from I-24 to the Pennyrile Parkway were converted to Interstate 69 (I-69). Upgrades were made, and new signage was installed to support the conversion. Today the WKP runs from the Pennyrile Parkway (I-69) to US 31W in Elizabethtown. The total length of the WKP is approximately 99 miles. It provides an important high-speed connection between Central and Western Kentucky and was originally constructed in the 1960s as a four-lane divided highway toll road. Tolls were charged until 1987, when the construction bonds were paid off. More recently, there have been efforts related to converting the portion from I-69 to I-165 near Beaver Dam (39 miles) to an Interstate system. This includes proposed Federal legislation as well as a conversion study completed by KYTC in 2020.

The study area, shown in **Figure 1**, extends from I-165 in Ohio County (MP 76.758) through Grayson and Butler counties to US 31W in Hardin County (MP 136.796). From west to east, the interchanges are: I-165, Kentucky Route (KY) 79, KY 259, KY 224, KY 84, KY 3005 (Ring Road), US 31W Bypass, and I-65. The WKP then ends at an intersection with US 31W just east of I-65. The cities within the study area include Beaver Dam, Caneyville, Leitchfield, and Elizabethtown.

This study addresses the final 60 miles of the WKP from I-165 to US 31W in Elizabethtown. There are state and local officials that have expressed interest in redesignating this eastern portion of the WKP to an Interstate. Converting this portion of the highway would link two Interstates and would provide a signed east to west Interstate connection between Central and Western Kentucky. This study outlines what may be required to accomplish the redesignation for the WKP. **Figure 2** shows the different phases of the WKP conversion.

**Figure 1: WKP Interstate Conversion Context WKP S**

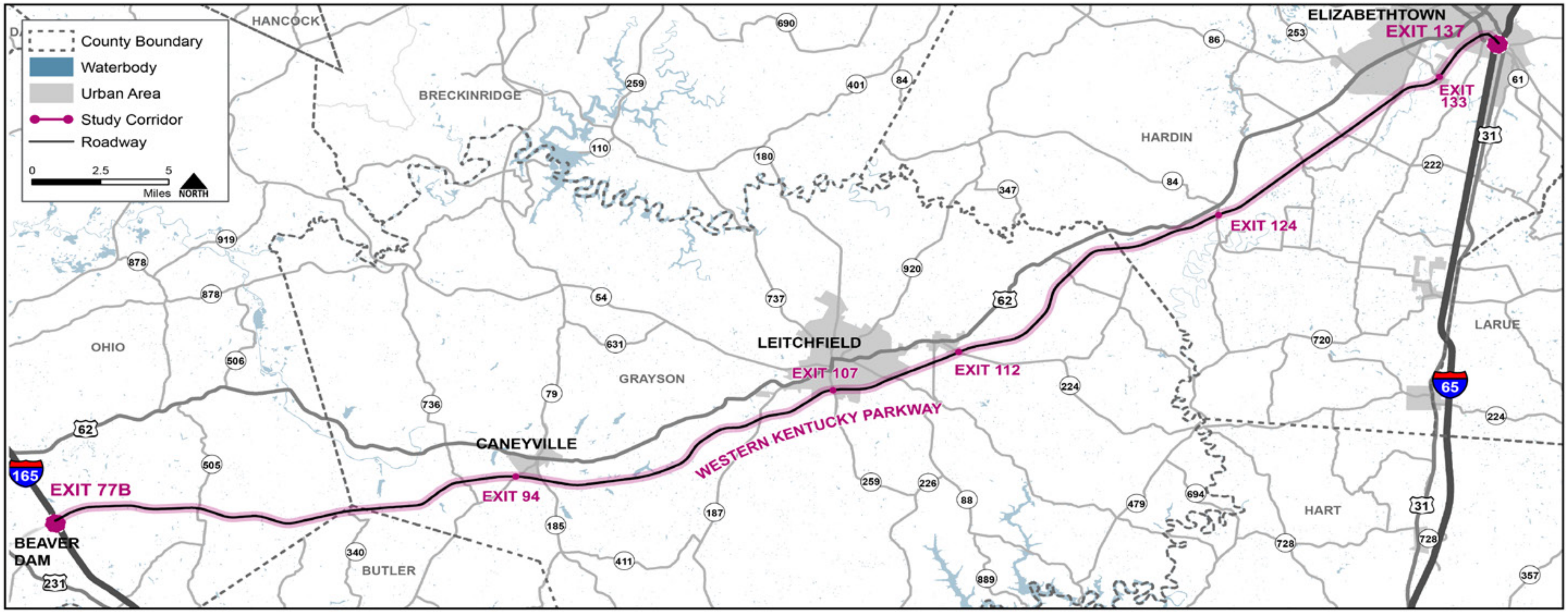
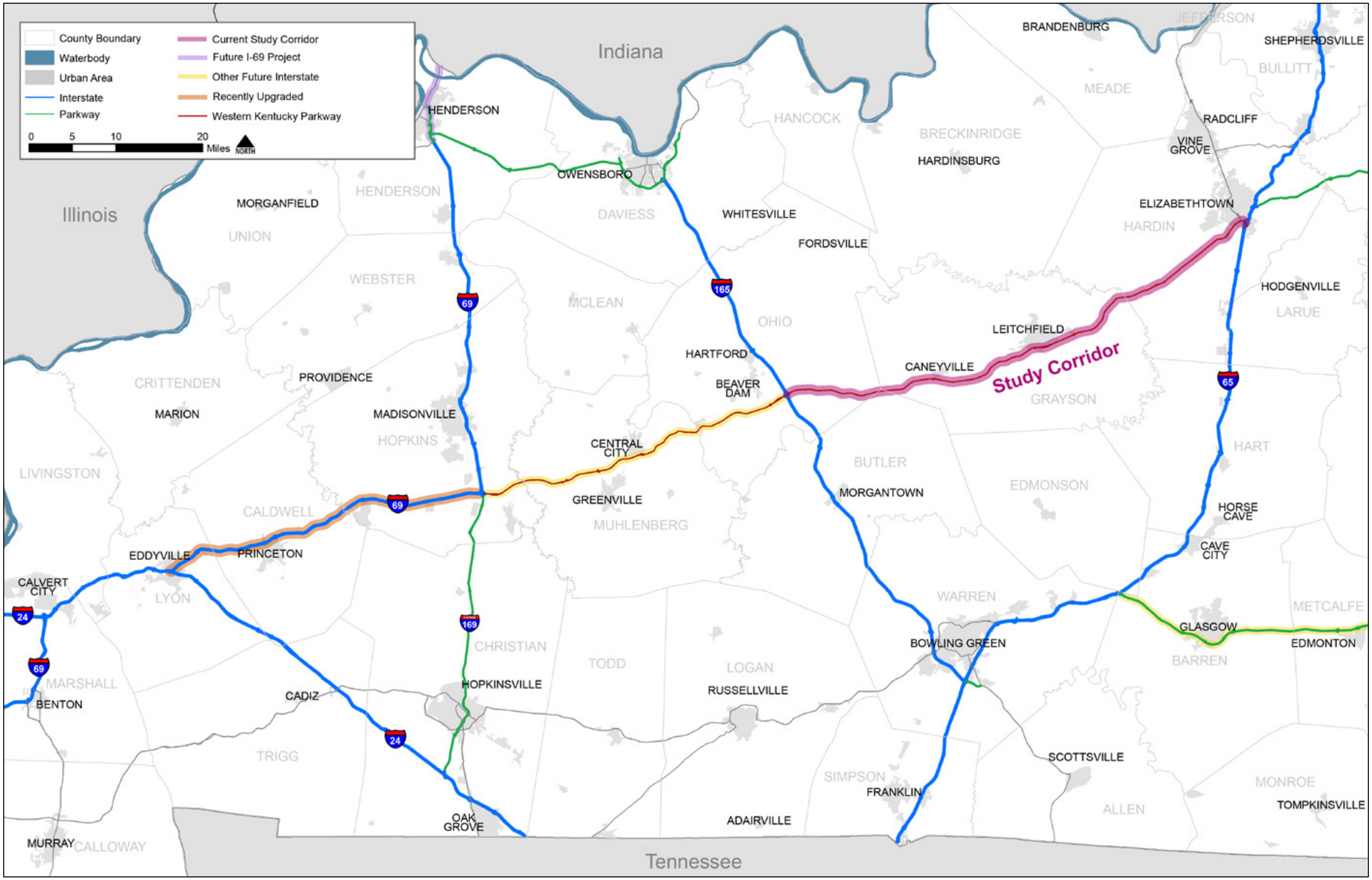


**Figure 2: WKP Interstate Conversion Context**



## 1.2 2021 Infrastructure Investment and Jobs Act

The Infrastructure Investment and Jobs Act (IIJA)[1] enacted in November 2021, increases transportation funding – both formula funds that flow to each state and competitive grant funds. The IIJA, which is also referred to as the Bipartisan Infrastructure Law (BIL), has a major focus on operations and maintenance of the existing highway system. Upgrading the WKP to Interstate standards is in line with this goal as it would improve the highway, including safety performance, but would not involve the construction of a new highway or new capacity. The upgrade would also better connect rural and urban parts of the state including major manufacturing areas. Improving these connections and linking rural areas more effectively is another theme of the IIJA. Therefore, funds from the IIJA could be pursued to provide upgrades discussed in this study.

## 1.3 Committed & Proposed Projects

KYTC provided a list of committed and proposed projects that could potentially address some of the Interstate standard design deficiencies in the study area. There are seven pavement rehabilitation projects in the study area included in Kentucky's Fiscal Year (FY) 2020 – FY 2026 Highway Plan, and six projects in the vicinity of the study area in the KYTC Continuous Highway Analysis Framework (CHAF) database, listed below. Item No. 4-20016.00 was let for construction in October 2021 and Item No. 4-20001.00 was combined with 4-20002.00 and 4-20003.00 and was let in April 2022.

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- IP20060114 – Address need for additional parkway access at KY 1245 near Rockport on the WKP.

## 1.4 Study Objective

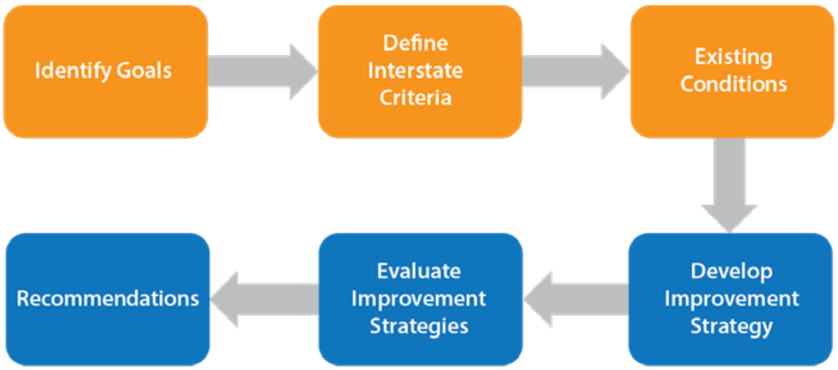
The objective of the WKP Upgrade Study is to identify and evaluate short-term and long-term improvement strategies to upgrade the WKP to current (2021) Interstate design standards. The study also identifies improvement strategies to address specific traffic operations and safety issues identified during the process.

## 1.5 Study Process

The study process consists of six major elements:

- Identify the goals of the study
- Define Interstate geometric design criteria
- Examine the existing conditions and identify locations that do not meet Interstate standards
- Develop potential improvement strategies
- Evaluate the improvement strategies based on the study goals
- Provide a prioritized list of short-term and long-term improvement recommendations

Figure 3: Study Process




The subsequent chapters of this report detail these steps, with additional information provided in the appendices.

## 1.6 Study Goals

The goals of the study are to:

- Evaluate existing mainline, interchange, ramp, and bridge conditions to identify deficiencies with respect to Interstate design standards
- Evaluate existing traffic and safety conditions
- Develop a list of proposed improvements needed to meet Interstate design standards
- Evaluate proposed improvements with respect to traffic, safety, environment, and cost
- Develop a list of prioritized recommended improvements based on technical evaluation and KYTC and FHWA input

2 Applies to the horizontal and vertical alignment except in the case of vertical sag curves.

## 1.7 Study Design Characteristics

FHWA identifies ten controlling design criteria that define the operational and safety performance of an interstate. The American Association of State Highway Transportation Officials (AASHTO) provides the standards for these criteria. A Design Exception (DE) can be requested when design features do not meet those standards and there is not an associated safety issue. The ten controlling criteria apply to high speed (≥50 mph) National Highway System routes and include:

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This study evaluates the listed design features of the WKP for compliance with FHWA's ten controlling criteria as well as AASHTO and KYTC design criteria for non-controlling criteria. **Table 1** summarizes the guidelines used for the design standards for each mainline, structure, ramp, or loop feature. Also included in this table is the design standard reference document. Items with an asterisk are part of the ten controlling criteria whereas those without an asterisk are KYTC standards. A Design Variance (DV) can be requested for standards that are not met if they are not one of the ten controlling criteria and there are no safety issues present. Locations with identified design-related safety issues may need to be addressed prior to interstate conversion. The project team evaluated each design feature with respect to the listed official reference. A technical analysis was conducted to determine study recommendations.

**Table 1: Interstate Design Criteria for Rural, 4-Lane Interstate Facilities**

| Design Element | Governing Agency | Reference | Mainline | Ramps | Loops |
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| Clear Zone | AASHTO | Roadside Design Guide, 2011 | 30’-46’ | 10’-18’ | |
| Guardrail Height | KYTC | KYTC Standard Drawings | 31” | | |
| Horizontal Alignment | | | | | |
| Superelevation* | AASHTO | Green Book, 2018 | 8% Max | | |
| Minimum Radius* | AASHTO | Green Book, 2018 | 1810’ | 314’ | 134’ |
| Cross Slopes* | AASHTO | Interstate Design Guide, 2016 | Greater than 1.5% | | |
| Vertical Alignment | | | | | |
| Maximum Vertical Grade* | AASHTO | Interstate Design Guide, 2016 / Green Book, 2018 | 4% | 4%-6% | 6%-8% |
| Crest Vertical Curves – Minimum Stopping Sight Distance* | AASHTO | Green Book, 2018 | 730’ | 250’ | 115’ |
| Sag Vertical Curves - Minimum Head Light Sight Distance | AASHTO | Green Book, 2018 | | | |
| Bridges and Overpasses | | | | | |
| Bridge Width ≤ 200 feet | AASHTO | Interstate Design Guide, 2016 | 37.5’ | N/A | |
| Bridge Width > 200 feet | AASHTO | Interstate Design Guide, 2016 | 31’ | N/A | |
| Minimum Overpass Vertical Clearance* | AASHTO | Interstate Design Guide, 2016 / KYTC Highway Design Manual | 16’ (Interstate Design Guide) / 16.5’ (KYTC Highway Design Manual) | N/A | |
| Minimum Overhead Sign Vertical Clearance* | AASHTO | Manual on Uniform Traffic Control Devices (MUTCD), 2009 | 17’ | | |
| Divergence Angle | AASHTO | Green Book, 2018 | 2 to 5 degrees | | |
| Speed Change Lanes | AASHTO | Green Book, 2018 | Varies depending on the design speed of the entering or exiting curves | | |
| Interchange Spacing | AASHTO | Green Book, 2018 | 1 mile (Urban); 2 miles (Rural) | | |
| Interchange Control of Access | AASHTO | Interstate Design Guide, 2016 | 100’ (Urban); 300’ (Rural) | | |

**FHWA Design Controlling Criteria*

# 2 Existing Geometric Conditions

To assess compliance with the Interstate design standards, a detailed inventory of the existing physical and geometric design characteristics was completed. The inventory assessed three main areas: mainline, structures, and interchanges (and ramps) using the following sources:

- KYTC Highway Information System (HIS) data
- KYTC record plans and bridge inspection reports
- Google Earth aerial imagery and Street View
- Field review

A detailed account of the existing conditions is provided in **Appendix A**.

## 2.1 Mainline

Mainline roadway characteristics of the WKP are detailed below.

### 2.1.1 Terrain

The WKP terrain is defined as "Rolling." ***The 2018 Green Book*** defines Rolling terrain as natural slopes that consistently rise above and fall below the road grade, and occasional steep slopes that offer some restriction to normal horizontal and vertical roadway alignment.

### 2.1.2 Design Speed

The mainline design speed of the WKP is 70 mph throughout the study area and is consistent with design speed for other interstates.

### 2.1.3 Lane Width

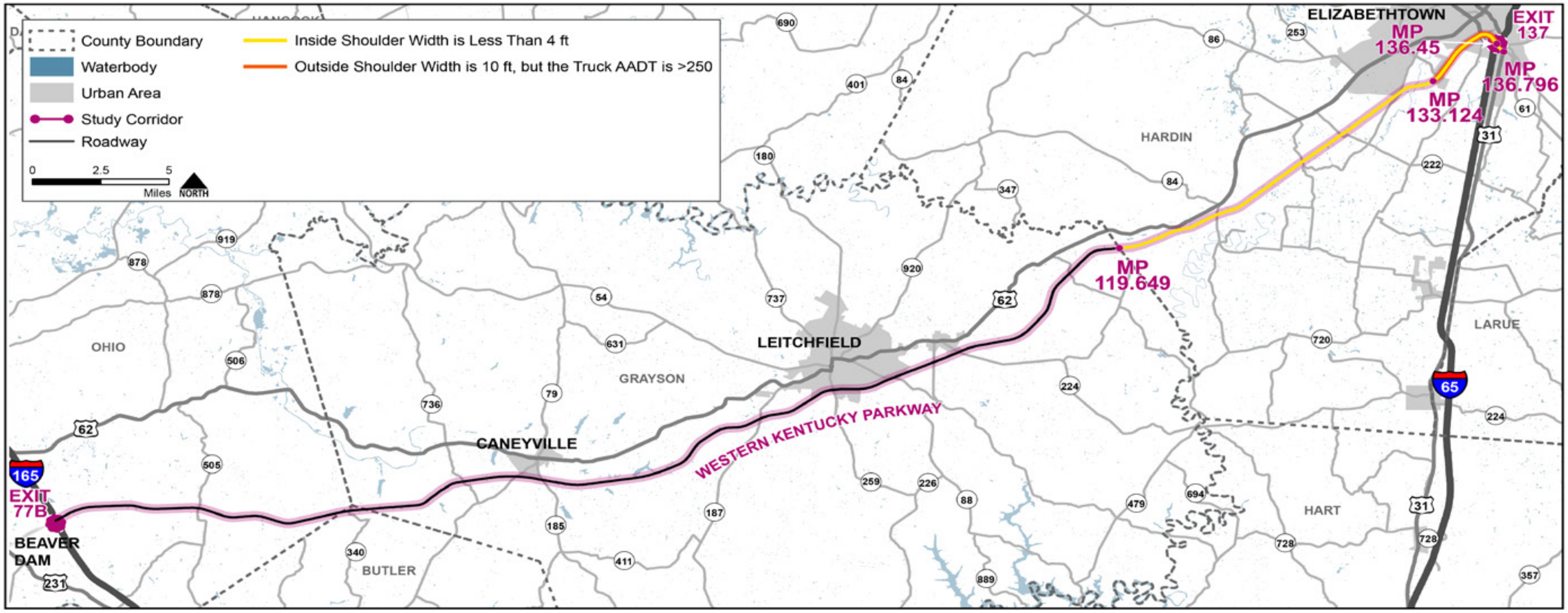
According to the ***2018 Green Book***, the mainline lane width design requirement for 70 mph is 12 feet minimum. According to HIS data, the minimum 12-foot lane width is maintained through the WKP mainline.

### 2.1.4 Shoulder Widths

Interstate standards for shoulder width are dependent on location and usage. For the inside shoulder, the *2018 Green Book* requires a minimum paved four-foot-wide shoulder. One segment (MP 119.649 to 136.796), totaling approximately 17 miles has a three-foot paved inside shoulder and does not meet Interstate standards.

Where the truck Daily Design Hourly Volume (DDHV) is less than or equal to 250 vehicles per day (vpd), the minimum paved outside shoulder width should be 10 feet wide, while segments with truck DDHV greater than 250 are recommended to have a 12-foot paved shoulder width. Truck DDHV exceeds 250 vpd from MP 133.833 to 136.796. The WKP has a 10-foot-wide paved outside shoulder throughout the study area. This does not include shoulders on bridges, which are discussed in Section 2.2. **Figure 4** shows the limits of substandard inside shoulders and locations where the DDHV exceeds 250 within the study area.

**Figure 4: Study Area Existing Substandard Shoulder Conditions**



### 2.1.5 Median Width

The ***2011 Roadside Design Guide*** requires a mainline highway with design speed of 70 mph to maintain a median width of between 30 feet and 60 feet, where median barriers remain optional depending on traffic density and safety concerns. Median widths less than 30 feet require median barriers to be installed. The ***2016 Interstate Design Guide***, states that median widths should be at least 50 feet wide as a minimum, with 60 feet in width preferred for rural areas with level or rolling terrain. The WKP maintains the 30-foot depressed median width required by the ***Roadside Design Guide*** for most of the study area, making barriers optional. Only 1.847 miles of the WKP is along a bifurcated section, satisfying the requirements of both the ***Roadside Design Guide*** and the ***Interstate Design Guide***. There are currently no median barriers on the section of the WKP in the study corridor.

A review of the crash data along the study corridor revealed that there were 88 crashes flagged as median cross-over crashes over the five-year period from 2015 to 2019. The crashes are shown in **Figure 5.** The majority of these crashes (66) were single-vehicle crashes where a vehicle crossed the median. In addition, most of these median crossover crashes (53) were property damage only crashes or possible injury crashes (15), but there were six fatal crashes, four serious injury crashes, and ten minor injury crashes. Of the six fatal crashes identified as median crossover, three were angle crashes, two were head on crashes, and one was a single-vehicle crash. The median cross-over crashes occur throughout the study area, but there are several areas that have a higher density including in Hardin County near the interchange with KY 84.

### 2.1.6 Median Turnarounds

The ***2018 Green Book*** states that median turnarounds may be provided where interchange spacing exceeds five miles to avoid excessive adverse travel for emergency and law enforcement vehicles. There are 26 median turnarounds in the study area. These were evaluated for compliance / safety based on drainage, sight distance, the crash analysis, and AASHTO and KYTC guidelines. Of the 26 median turnarounds, 12 are not needed **(Figure 6)** based on the ***2018 Green Book*** and KYTC guidelines, meaning the spacing is less than three miles from another median turnaround or interchange where interchanges are more than five miles apart (Green Book guidance) and is not located at a county line (KYTC guidance). It should also be noted that two of the 26 median turnarounds identified are unpaved turnarounds located at crash cushions protecting bridge piers and are not practical to remove. It was noted by the district that maintenance crews use these locations at the crash cushions as turnarounds even though they are not considered official median turnarounds.

### 2.1.7 Clear Zones

The ***2011 Roadside Design Guide*** provides a range for the minimum clear zone requirement for an interstate based on design speed, traffic volume, and roadside slope. For a 70 mph roadway, slopes of 6H:1V or flatter require a median width of 30 to 34 feet, with steeper slopes (4:1 to 5:1) requiring up to 38 to 46 feet. Since current typical sections were not available along the study area, a foreslope of 4:1 was assumed.. Google Earth measurements were taken from the edge of the traveled way to the nearest visible obstruction (grade, rock cut, tree line, etc.). Based on the analysis, approximately 54.5 miles along the WKP do not meet clear zone requirements.

**Figure 5: Median Crossover Crashes**

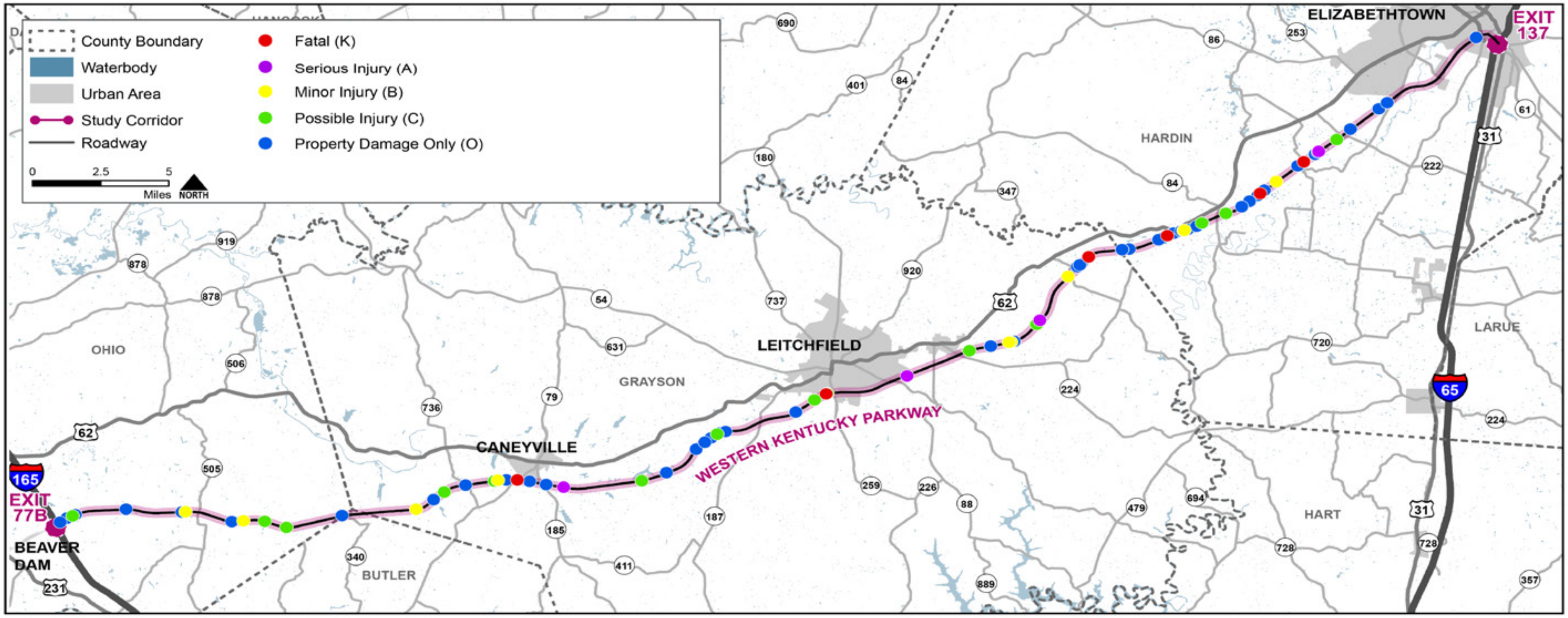
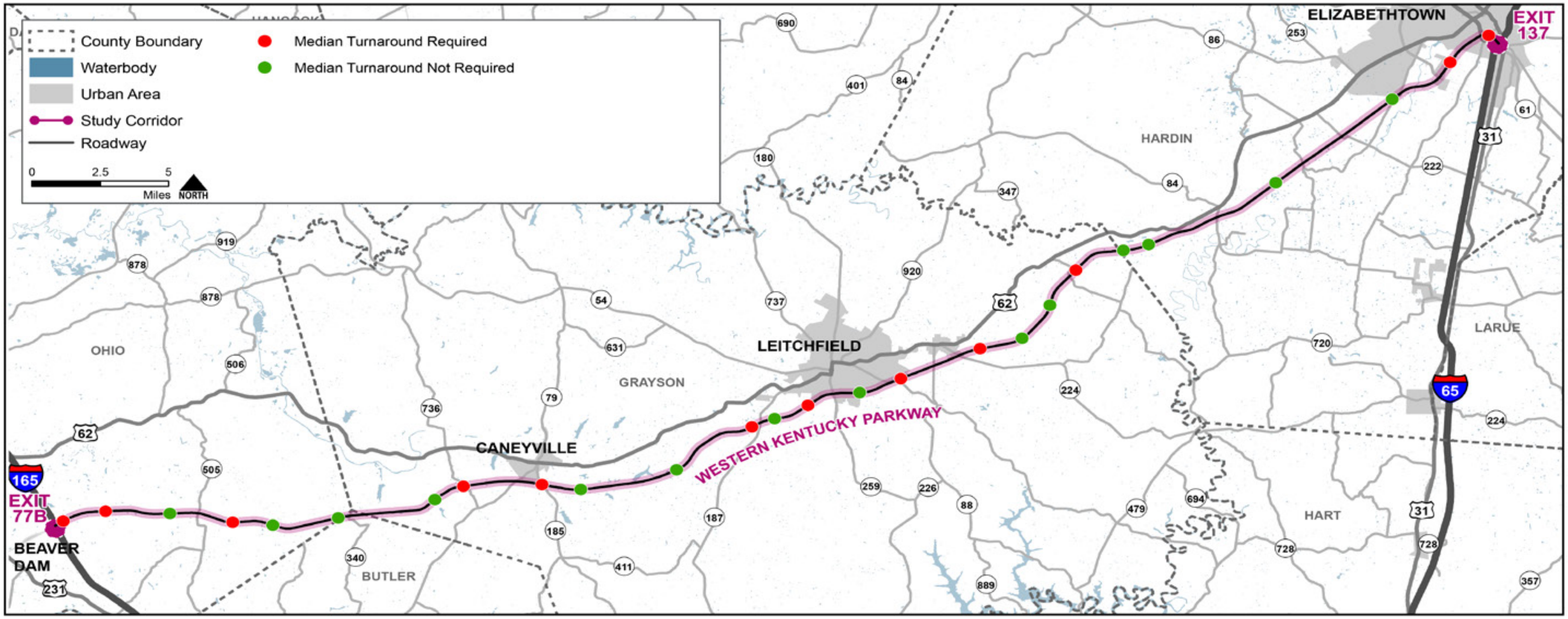


**Figure 6: Median Turnaround Locations**



### 2.1.8 Guardrail Placement and Condition

The ***2011 Roadside Design Guide*** and the ***KYTC Highway Design Manual*** provide guidance on the application and situation of guardrail placement. According to the ***2020 KYTC Standard Drawings and Active Sepias***, any new guardrail shall be installed at a height of 31 inches from the edge of the paved shoulder. The previously accepted height for guardrail was 27 inches, and KYTC has allowed this guardrail to remain on Resurfacing, Restoration, and Rehabilitation (3R) Projects.

Data on guardrail placement and condition were gathered during field review by sampling heights for guardrail and noting end treatments and build condition. Guardrail height measurements were taken to assess whether the height was appropriate. Approximately 3% of existing guardrail installed is at least 31 inches in height. Approximately 44% of the guardrail measured were less than 27 inches in height and 53% were between 27 and 31 inches in height. Approximately 23% of the existing guardrail has damage and needs to be repaired / replaced. Additionally, there were two locations where the grading at crash cushion treatments in advance of bridges was deficient and needs to be regraded.

### 2.1.9 Horizontal Alignment

#### DEGREE OF HORIZONTAL CURVATURE

According to the ***2018 Green Book***, the minimum horizontal curvature of a 70 mph design speed rural interstate is 1,810 feet with $e_{max}$ = 8.0%, as shown in the Green Book superelevation **Table 3-7**, equating to 3°10' of curvature. All mainline horizontal curves throughout the WKP meet the minimum radius criteria, but not superelevation criteria.

#### SUPERELEVATION RATE

The superelevation rate has two standard requirements per the ***2018 Green Book***. The first Interstate standard requires the maximum superelevation rate for a rural interstate with 70 mph mainline to be 8.0% or less. The highest observed superelevation rate for the WKP mainline is 8.3%, which does not satisfy the superelevation requirement. The second Interstate standard requirement is dependent on the horizontal radius and the minimum superelevation for that radius. Based on HIS data, 62 curves along the WKP had either no superelevation or superelevation rates that do not meet the Interstate standard. The record plans were consulted for all 62 locations and indicated that 26 locations were constructed without superelevation that meets the 70 mph design speed. Record plans were considered to be the most accurate for determining locations that do not meet Interstate standards. **Figure 7** shows these locations that do not meet the superelevation requirements. A detailed survey should be completed to collect the most accurate existing superelevation data.

#### NORMAL CROWN AND CROSS SLOPES

The minimum rate of cross slope applicable to the traveled way is determined by drainage needs. Cross slopes are added to help mitigate roadway conditions during rain, snow, or ice events. The ***2016 Interstate Design Guide*** requires a minimum cross slope of 1.5%. Typical cross slope (normal crown) values fall between a 1.58% and 2% slope. Any slope higher than 2% falls under the superelevation rate in the text above. The minimum horizontal radius for a normal crown for interstates is 14,500 feet. All normal crown and cross slopes along the study corridor meet Interstate standards.

### 2.1.10 Vertical Alignment

**VERTICAL GRADE**

The *2016 Interstate Design Guide* states that the maximum vertical grade is 4.0% for a design speed of 70 mph for rolling terrain. HIS data indicated a vertical grade greater than 4.0% at 23 locations. However, a review of the record plans indicated that all of these locations were constructed with grades less than or equal to 4.0%. Therefore, it is expected that these locations would meet Interstate requirements if a more detailed survey were performed. Record plans were considered the most accurate source for determining locations that do not meet Interstate standards for this study. If an Interstate upgrade project were to move forward, a detailed survey should be completed to verify the existing vertical grade data.

**VERTICAL CURVES**

According to the ***2018 Green Book***, to meet Interstate standards vertical curves must meet stopping sight distance for crest vertical curves and headlight sight distance for sag vertical curves. The required stopping sight distance is 730 feet for a 70 mph facility. All crest vertical curves along the WKP meet the stopping sight distance Interstate standard. Two sag vertical curves do not meet the headlight sight distance requirement. The first located at MP 87.788 in the WB direction and MP 87.807 in the EB direction has headlight sight distances (HLSD) of 646 feet and 610 feet, respectively. The second, located at MP 104.067 has a HLSD of 702 feet. **Figure 7** shows the existing horizontal and vertical curves that do not meet Interstate standards.

## 2.2 Structures

Within the study area, structures were reviewed for compliance with the ***2016 Interstate Design Guide***. The existing bridges and culverts are shown in **Figure 8**. The analysis included a review of 16 bridges carrying the mainline over other roadways or waterways, 25 bridges for other roadways that crossed over the WKP, seven box culverts (with spans greater than 20 feet as measured along the roadway centerline), and six overhead sign structures. Twin bridges carry the WKP over a CSX Transportation railroad facility at MP 132.574. No railroad facilities cross over the WKP.

The structures data was sourced from a combination of KYTC bridge inspection report records, KYTC bridge inventories, and field verification measurements. Data for bridge width, vertical clearance, bridge condition rating, and bridge railing were taken from the KYTC bridge inspection report records. Bridges with a reported vertical clearance of less than 16.5 feet were verified with field measurements. **Appendix A** provides additional details.

### 2.2.1 Bridge Width

The ***2016 Interstate Design Guide*** defines the minimum bridge width on routes within the Interstate System and on routes to be incorporated into this System. For rural 4-lane Interstate facilities the mainline minimum clear bridge width for bridges in excess of 200 feet in length is 31 feet, and the minimum clear bridge width for mainline bridges less than or equal to 200 feet is 37.5 feet. This evaluation does not include bridges that pass over the WKP or box culvert structures on the WKP. A summary of the existing WKP bridges which do not meet these requirements for Interstate bridge width is provided in **Table 2.**

**Figure 7: Study Area Existing Superelevation and Vertical Curve / Headlight Sight Distance Conditions**

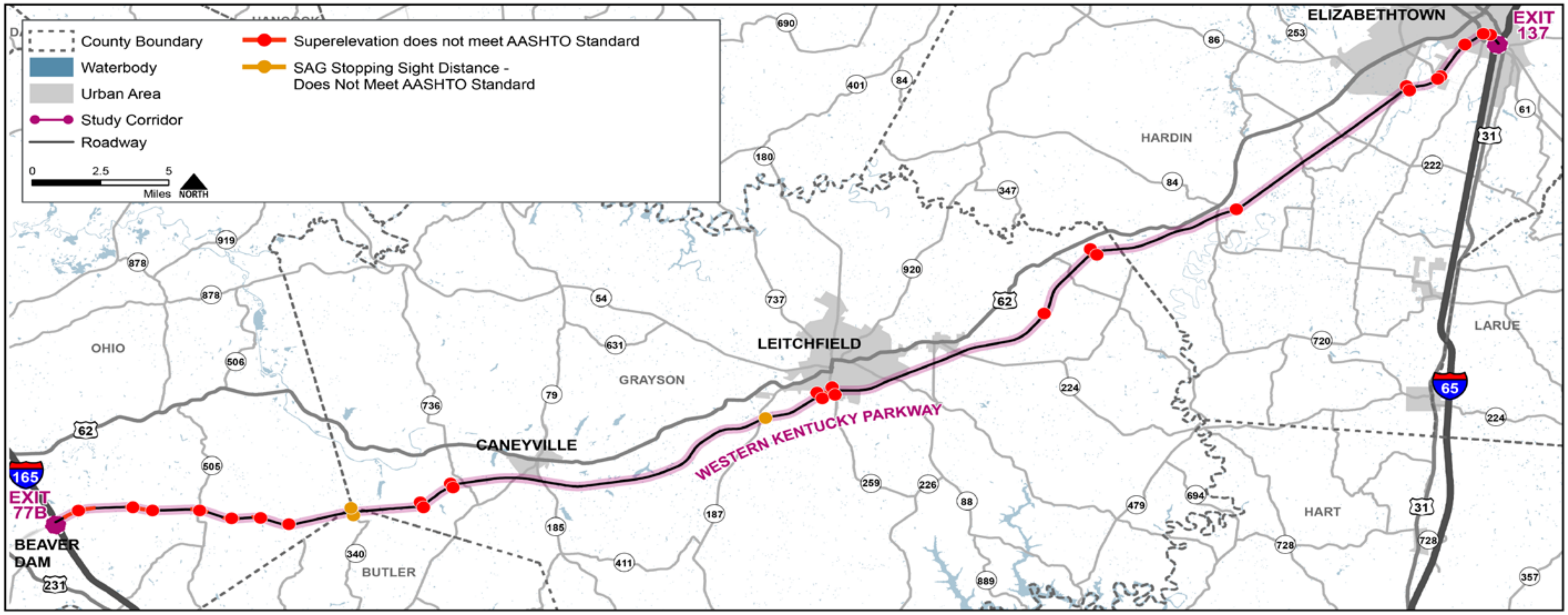


Figure 8: Study Area Existing WKP Structures

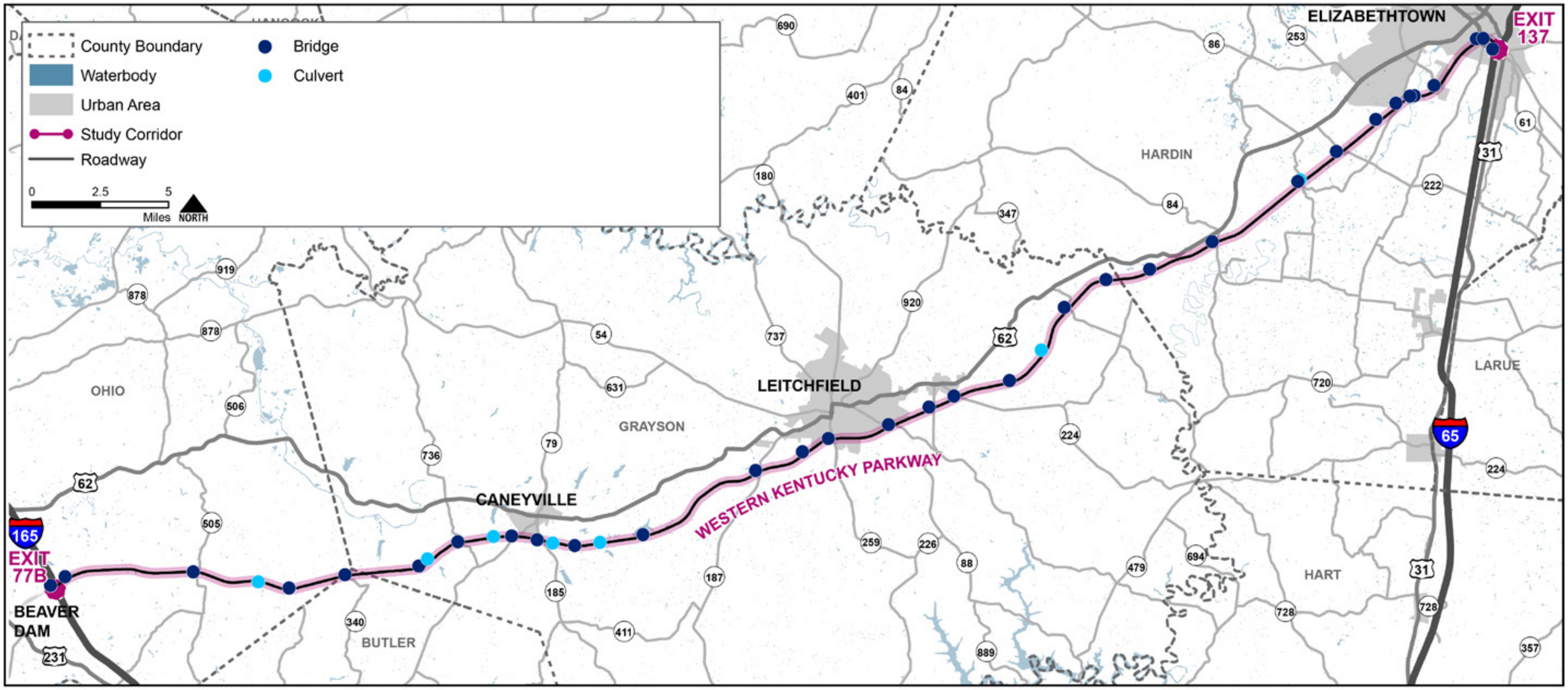



Table 2: Existing Bridges with Deficient Width for Interstate Standards

| Bridge ID | Milepoint | County | Bridge Length (ft) | Bridge Width (ft) |
|---|---|---|---|---|
| 092B00072L | 76.766 | Ohio | 249.00 | 41.99* |
| 092B00072R | 76.770 | Ohio | 249.00 | 41.99* |
| 043B00026L | 104.011 | Grayson | 156.00 | 29.86 |
| 043B00026R | 104.040 | Grayson | 156.00 | 29.86 |
| 047B00093R | 132.417 | Hardin | 210.00 | 29.86 |
| 047B00093L | 132.419 | Hardin | 210.00 | 29.86 |
| 047B00092R | 132.574 | Hardin | 173.00 | 29.86 |
| 047B00092L | 132.579 | Hardin | 173.00 | 29.86 |

*Three-lane facility in weaving area

### 2.2.2 Vertical Clearance

The ***2016 Interstate Design Guide*** defines the minimum vertical clearance to structures in rural areas at 16 feet. This vertical clearance applies to all travel lanes, auxiliary lanes, shoulders, and collector-distributor roads. KYTC bridge inspection reports were reviewed for existing structure vertical clearance. The KYTC bridge inspection reports include a measurement of vertical clearance over the travel lanes only. Vertical clearance is only considered for bridge structures over the WKP. Vertical clearance for bridges carrying mainline WKP over other roadways was not considered as part of this study.

Field verification measurements were taken at locations that were not recently reconstructed and had clearances less than or equal to 16.5 feet as recorded in the KYTC bridge inspection reports, which only recorded measurements over the driving lanes (**Table 3**) as well as for existing bridges with reinforced concrete haunched beams. The term haunched beams refers to reinforced concrete deck girder bridges with a variable depth cross-section which typically increases in depth closer to the piers or supports creating a situation where the vertical clearance over the shoulder is less than the clearance over driving lanes. All field verification measurements less than or equal to 16.5 feet are shown in **Table 4**. Field verification measurements found that eleven bridges had vertical clearance less than 16 feet and are shown in bold red italicized text. Locations with less than 16.5 feet of vertical clearance may require further investigation when constructing any future 3R projects to verify the 16-foot minimum vertical clearance is maintained after any pavement overlays occur.

**Table 3: Existing Bridge Vertical Clearance Less than or Equal to 16.50 Feet – Bridge Inspection Report**

| Bridge ID | Milepoint | County | Vertical Clearance (ft) |
|---|---|---|---|
| 092B00136N | 77.382 | Ohio | 14.75 |
| 043B00023N | 94.257 | Grayson | 15.96 |
| 043B00003N | 111.841 | Grayson | 15.51 |
| 043B00078N | 117.423 | Grayson | 15.60 |
| 047B00168N | 120.987 | Hardin | 16.00 |
| 047B00043N | 123.429 | Hardin | 15.17 |
| 047B00167N | 127.258 | Hardin | 16.42 |
| 047B00045N | 129.041 | Hardin | 14.50 |
| 047B00090N | 131.831 | Hardin | 14.75 |
| 047B00171N | 133.409 | Hardin | 16.50 |
| 047B00153R | 135.689 | Hardin | 16.00 |
| 047B00108L | 135.699 | Hardin | 15.40 |

**Table 4: Existing Bridge Vertical Clearance Concerns – Field Confirmed Measurements**

| | | | | Vertical Clearance at Edge of Shoulder (ft)[2] | | | |
|---|---|---|---|---|---|---|---|
| Bridge ID | Milepoint | County | Vertical Clearance over Driving Lanes[1] | EB Outside | EB Inside | WB Outside | WB Inside |
| 092B00136N | 77.382 | Ohio | 14.75[3] | | | | |
| 016B00034N | 87.842 | Butler | 17.27 | 14.50 | 16.17 | 19.50 | 17.75 |
| 043B00023N | 94.257 | Grayson | 15.96 | 13.92 | 15.50 | 15.33 | 15.83 |
| 043B00073N | 105.884 | Grayson | 16.55 | 14.92 | 16.42 | 15.50 | 16.33 |
| 043B00003N[5] | 111.841 | Grayson | 15.51 | 14.50 | 14.92 | 14.50 | 15.50 |
| 043B00078N | 117.423 | Grayson | 15.60 | 15.17 | 16.00 | 14.17 | 15.50 |
| 047B00168N | 120.987 | Hardin | 16.00[4] | | | | |
| 047B00043N[6] | 123.429 | Hardin | 15.17 | 15.75 | 16.17 | 14.75 | 15.00 |
| 047B00167N | 127.258 | Hardin | 16.42[4] | | | | |
| 047B00045N[6] | 129.041 | Hardin | 14.50 | 15.33 | 14.75 | 14.75 | 14.67 |
| 047B00090N | 131.831 | Hardin | 14.75 | 15.83 | 16.67 | 15.92 | 14.58 |
| 047B00171N | 133.409 | Hardin | 16.50[4] | | | | |
| 047B00153R | 135.689 | Hardin | 16.00 | >16.50 | >16.50 | >16.50 | 15.33 |
| 047B00108L | 135.699 | Hardin | 15.40 | >16.50 | >16.50 | >16.50 | 16.17 |

[1] *From KYTC Bridge Inspection Reports*

[2] *From field measurements*

[3] *Bridge rated in poor condition, assumed replacement will be necessary, no field measurements taken*

[4] *Bridge replaced in 2012 / 2013, no field measurements taken*

[5] *Being improved by 4-20001.00*

[6] *Being improved by 4-20016.00*

### 2.2.3 Bridge Railing

The KYTC bridge inspection reports note the railing adequacy for all existing bridges. **Table 5** and **Figure 9** note existing bridges carrying mainline WKP which do not meet ***2016 Interstate Design Guide*** standards for bridge railing or railing transitions. The substandard bridge railing at these locations are typically due to the lack of non-crashworthy metal railing and at some locations include a small curb at the edge of the bridge deck. The analysis did not include any bridges that pass over the WKP or box culverts on the WKP.

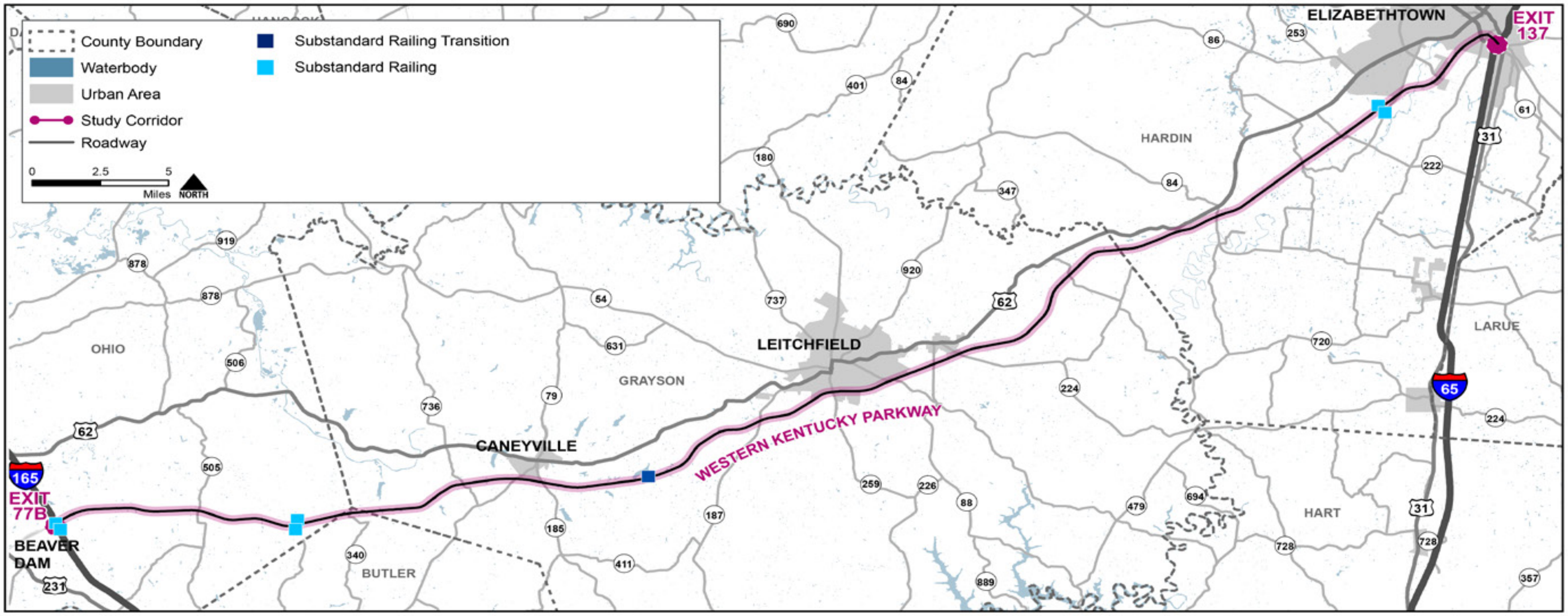
**Table 5: Existing Bridges Railing**

| Bridge ID | Milepoint | County | Substandard Railing** | Substandard Railing Transition** |
|---|---|---|---|---|
| 092B00072L | 76.766 | Ohio | X | - |
| 092B00072R | 76.770 | Ohio | X | - |
| 092B00130L | 85.717 | Ohio | X | - |
| 092B00130R | 85.744 | Ohio | X | - |
| 043B00027L* | 99.121 | Grayson | - | X |
| 047B00094L | 130.886 | Hardin | X | - |
| 047B00094R | 130.894 | Hardin | X | - |

**Bridge railing reviewed by District after reports were obtained and deemed to meet the standard*

***Railing and Transition data obtained from KYTC Bridge Inspection Reports*

**Figure 9: Study Area Existing Railing and Transition Conditions**



### 2.2.4 Bridge Condition Rating

Bridge condition ratings, along with other factors, are used by KYTC to help assess maintenance, rehabilitation, and replacement needs. KYTC bridge inspection reports follow National Bridge Inspection Standard (NBIS) reporting requirements and note the bridge condition and health index for all existing structures. The bridge condition is determined by using the lowest rated National Bridge Inventory (NBI) condition rates for the deck, superstructure, and substructure components. These ratings are based on a 0 to 10 scale and can be classified as follows:

- Good – Lowest component rating is greater than or equal to 7
- Fair – Lowest component is rated as 5 or 6
- Poor – Lowest component rating is less than or equal to 4

A review of the bridge condition ratings of all structures carrying mainline WKP and structures that cross over WKP revealed that three existing bridges and one box culvert on the WKP are rated in “Poor” condition. There are 22 bridges and one box culvert rated in “Good” condition and there are 16 bridges and five box culverts rated in “Fair” condition. **Figure 10** provides the location of these structures along the WKP.

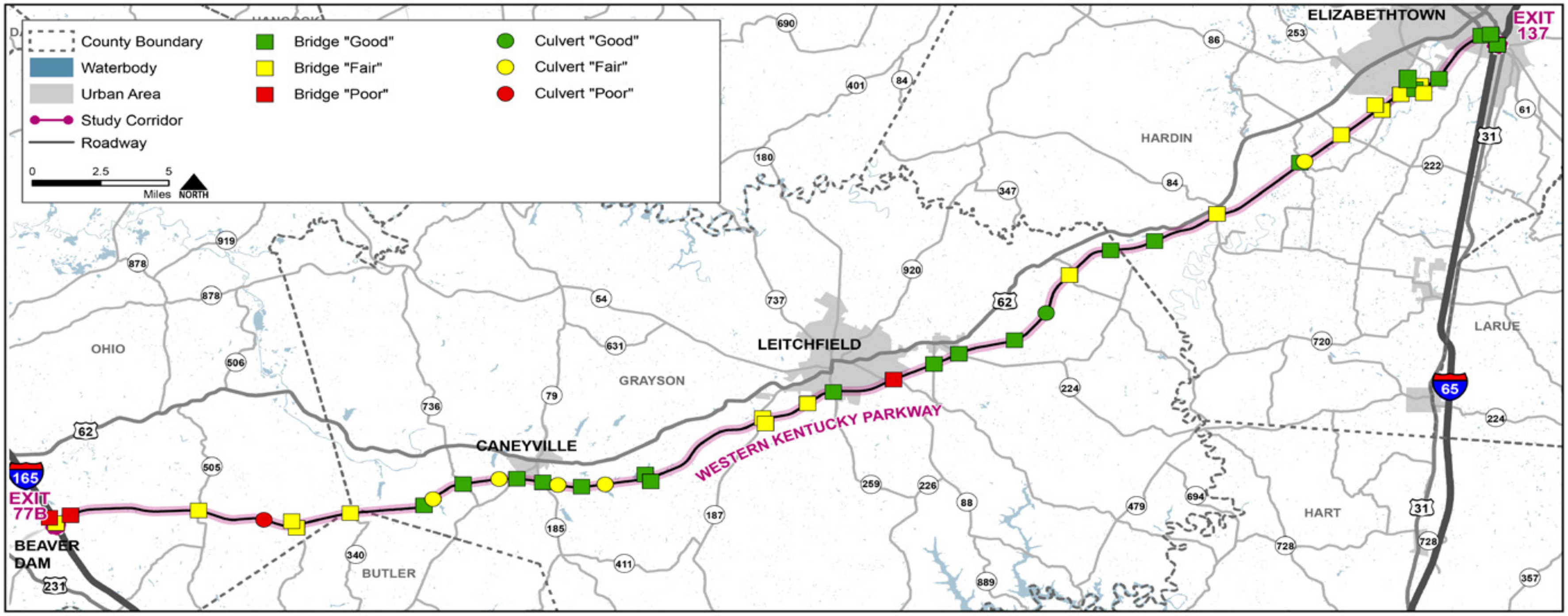
### 2.2.5 Overhead Sign Vertical Clearance

The 2016 *Interstate Design Guide* defines the minimum vertical clearance for overhead signs at 17 feet. This vertical clearance applies to all travel lanes, auxiliary lanes, shoulders, and collector-distributor roads. Field measurements were obtained for the six overhead signs on the WKP. All overhead signs met the 17-foot minimum and in fact all exceeded 19 feet of clearance. **Table 6** shows the locations of each overhead sign.

**Table 6: Existing Overhead Sign Locations**

| Milepoint | County | Description |
|---|---|---|
| 76.75 | Ohio | Cantilever sign over weave lane, WB |
| 76.82 | Ohio | Cantilever sign over weave lane, EB |
| 77.12 | Ohio | Truss-mounted sign over WB lane |
| 135.80 | Hardin | Truss-mounted sign over EB lane |
| 136.08 | Hardin | Truss-mounted sign over EB lane |
| 136.37 | Hardin | Truss-mounted sign over mainline |

**Figure 10: Study Area Existing Structure Condition Ratings**



## 2.3 Interchanges & Ramps

### 2.3.1 Design speed

The design speed for all ramps along the WKP meet the minimum Interstate standards set forth in the *2018 Green Book*.

### 2.3.2 Lane width

According to the *2018 Green Book*, the lane width standard for Interstate ramps is 14 feet for diamond interchange ramps and 15 feet for cloverleaf interchange loop ramps. There is one ramp, the eastbound cloverleaf exit ramp at the I-65 interchange, that does not meet this standard.

### 2.3.3 Shoulder width

Interstate standards from the *2018 Green Book* specify a 6- to 10-foot outside shoulder and a 2- to 4-foot inside shoulder for ramps with a design speed under 40 mph. For ramps with a design speed over 40 mph, the outside paved shoulder width must be 8 to 10 feet and the inside paved shoulder width must be 1 to 6 feet. Since the WKP falls under Traffic Condition A – predominantly passenger vehicles, but some consideration for SU trucks, the paved travel way should be at least 17 feet wide. All ramps along the WKP meet Interstate standards.

### 2.3.4 Horizontal Alignment

Record plan data indicated that six ramps do not meet the ***2018 Green Book*** minimum radii for an interstate ramp. These locations are listed in **Table 7**. The minimum radii varies based on ramp design speed and superelevation.

**Table 7: Ramp Horizontal Alignment**

| Exit | Intersecting Route | Ramp | Design Speed (mph) | Superelevation | Existing Radius (ft) | Required Radius (ft) |
|---|---|---|---|---|---|---|
| 94 | KY 79 | EB Entrance | 45 | 10% | 430 | 540 |
| 107 | KY 259 | EB Entrance | 45 | 4% | 2,290 | 3,860 |
| 107 | KY 259 | WB En-trance | 45 | 4% | 1,146 | 2,220 |
| 107 | KY 259 | EB Exit | 45 | 2.5% | 955 | 1,960 |
| 107 | KY 259 | WB Exit | 45 | 4.4% | 1,146 | 2,220 |
| 112 | KY 224 | EB Exit | 45 | 5.9% | 1,255 | 1,285 |

### 2.3.5 Vertical Grade

According to the ***2016 Interstate Design Guide***, the maximum vertical grade for Interstate ramps must be between 4% and 8% based on the design speed of the ramp. All ramps meet the vertical grade standard for Interstates along the WKP.

### 2.3.6 Vertical Curves

Five sag vertical curves do not meet the **2018 Green Book** required HLSD for ramps, but the interchange has lighting along each, satisfying that requirement. Therefore, all vertical curves for ramps along the WKP meet the minimum standards for an Interstate. Appendix A shows the stopping sight distance requirements and calculated stopping sight distance on each ramp.

## 2.3.7 Acceleration and Deceleration Lanes

The acceleration and deceleration lanes require a certain length depending on the design speed of the entering and exiting curves on the ramp. **Table 8** shows the Interstate standards from the *2018 Green Book* for lane length based on the design speed. To determine the design speed for the interchange ramps, the geometrics were reviewed and compared to the *2018 Green Book* standards. Three ramps do not meet the Interstate standard for acceleration or deceleration lane length. The ramps not meeting the Interstate standard are shown in **Table 9**.

**Table 8: Minimum Acceleration / Deceleration Lane Length Requirements, AASHTO Green Book 2018**

| Auxiliary Speed (mph) | Minimum Acceleration Lane Length (ft) | Minimum Deceleration Lane Length (ft) |
|---|---|---|
| 25 | 1,420 | 550 |
| 30 | 1,350 | 520 |
| 35 | 1,230 | 490 |
| 40 | 1,000 | 440 |
| 45 | 820 | 390 |
| 50 | 580 | 340 |

**Table 9: Locations That Do Not Meet Acceleration / Deceleration Lane Length Standards**

| Exit | Intersecting Route | Ramp | Auxiliary Speed (MPH) | Existing Length (ft) | Required Length (ft) |
|---|---|---|---|---|---|
| 94 | KY 79 | WB Entrance | 45 | 325 | 1,420 |
| 107 | KY 259 | EB Exit | 45 | 330 | 390 |
| 124 | KY 84 | WB Entrance | 45 | 475 | 580 |

### 2.3.8 Weaving Characteristics

Exit 137 (I-65) in Hardin County, a cloverleaf interchange, is the only interchange with weaving characteristics within a single interchange. ***2018 Green Book*** standards do not recommend cloverleaf interchanges because of the short weaving distance. The ***2018 Green Book*** requires a minimum of 1,600 feet for a weaving section between a service-to-service interchange. The weaving section between Exit 137 westbound and Exit 136 is 1,450 feet, which does not meet the minimum Interstate standard of 1,600 feet.

### 2.3.9 Control of Access

According to the ***2016 Interstate Design Guide***, control of access for interchanges must be at least 300 feet as measured from the end of the ramp terminus radius / taper to the near side of the nearest access point for rural locations and 100 feet for urban locations to meet Interstate standards. Five access points, listed in Table 10, do not meet the Interstate requirements.

**Table 10: Control of Access Distance**

| Exit | Intersecting Route | Ramp | Existing Length (ft) | Required Length (ft) |
|---|---|---|---|---|
| 94 | Morgantown Road | WB Entrance | 180 | 300 |
| 124 | KY 84 | EB Entrance | 50 | 300 |
| 124 | KY 84 | EB Exit | 120 | 300 |
| 124 | KY 84 | WB Entrance | 160 | 300 |
| 136 | US 31W Bypass | EB Exit | 0 | 100 |

### 2.3.10 Interchange Spacing

The 2018 *Green Book* requires interchange spacing to be at least 2 miles from crossing roadway to crossing roadway in rural areas, and 1 mile from crossing roadway to crossing roadway in urban areas. Two interchanges do not meet Interstate spacing standards along the WKP at Exit 136 and Exit 137, which are 0.74 miles apart. **Figure 11** shows the weaving section between Exit 136 and Exit 137 that does not meet standards due to interchange spacing.

Figure 11: Exit 136 (US 31W) and Exit 137 (I-65) Weaving Section

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# 3 Traffic Volumes and Operations

The traffic analysis addressed three major topics: traffic volumes, traffic operations, and traffic safety. The first two topics are covered in this chapter, while traffic safety is presented in the next chapter. The traffic volume work included examining historical and existing (2020) traffic volumes as well as forecasting future traffic to the design year of 2045. The traffic operations analysis included a capacity screening to examine if there are any operational issues in 2020 or 2045.

## 3.1 Existing (2020) Volumes

The existing traffic volume work included developing Average Annual Daily Traffic (AADT) volumes, design hour volumes (DHV), and truck percentages. While the project team selected 2020 as the baseline analysis year, it was agreed that the existing volumes would not be based on the 2020 traffic counts. This decision was made because of the reductions in traffic volumes and changes in travel patterns experienced during the COVID-19 pandemic. Instead, the existing (2020) volumes were developed using the moderate pre-pandemic growth trends and counts taken in 2017 through 2019. Details for the volume forecasting work are presented in the Western Kentucky Parkway Traffic Forecast Report in **Appendix B**.

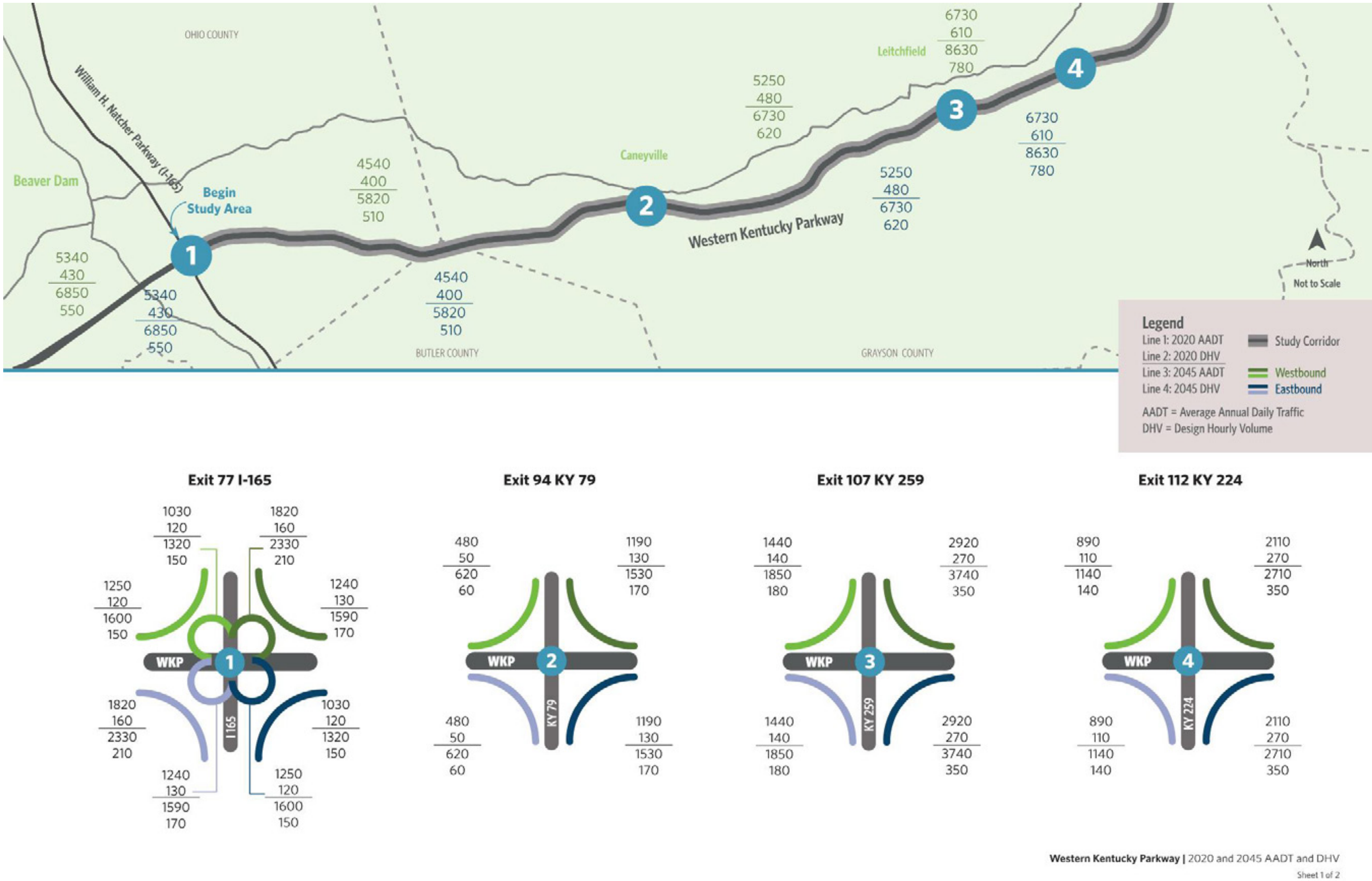
### 3.1.1 2020 AADT volumes

Current and historical average AADT information was obtained from KYTC for all mainline and ramp count stations. The period of 2009 to 2019 was selected to estimate historical growth trends because the data were complete, consistent, and represented the recent travel trends in the study area. The average traffic growth for this time period was 1.6%. This growth rate was applied to the most recent AADT values from before 2020 to generate the initial baseline (2020) AADT volumes. Subsequently, the mainline AADT values were divided in half based on an assumed 50 / 50 directional split, except at the north end where the volumes in the two directions started to vary. These directional split assumptions were based on a review of the hourly volume counts. Finally, the AADT volumes were balanced through the system, with minor adjustments at ramps to generally match observed mainline counts. The resulting 2020 AADT mainline directional volumes (**Figure 12**) range from a low of 4,540 (9,080 for both directions) in Ohio and Grayson counties between Exit 77 (I-165) and Exit 94 (KY 79) to a high of 17,300 (34,600 for both directions) in Hardin County between Exit 136 (US 31W Bypass) and Exit 137 (I-65).

### 3.1.2 2020 DHV Volumes

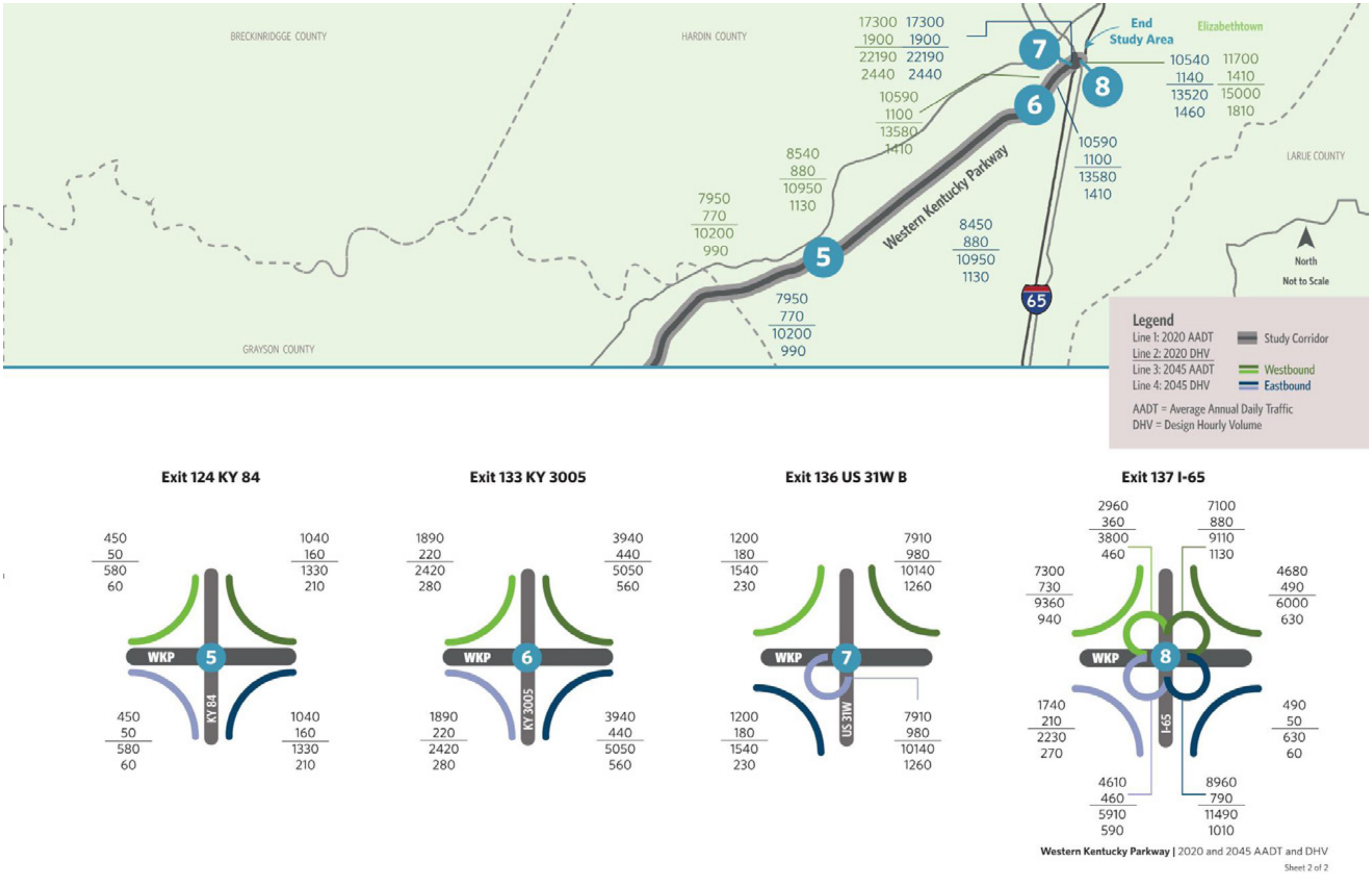
Traffic volumes along much of the WKP tend to be relatively consistent throughout the day with limited peaking. In the more urban areas, such as near Elizabethtown, there is some moderate directional peaking. Considering the WKP and taking the limited peaking into account, it was determined that a single DHV for each freeway direction was the most appropriate approach for assessing traffic conditions. Therefore, a single directional DHV was calculated for each segment and ramp instead of separate AM and PM peak hour volumes. Hourly factors (K-factors) obtained from KYTC as well as hourly counts were used to generate DHV's for each mainline section and ramp. The volumes were balanced through the system, using minor adjustments at specific ramps to generally match observed counts. The project team agreed that the resulting final calculated DHVs for each segment were conservatively high, yet still reasonable, for this planning study. The directional DHVs (**Figure 12**) ranged from a low of 400 (800 for both directions) in Ohio and Grayson counties between Exit 77 (I-165) and Exit 94 (KY 79) to a high of 1,900 (3,800 for both directions) in Hardin County between Exit 136 (US 31W Bypass) and Exit 137 (I-65).

**Figure 12: 2020 and 2045 AADT and DHV**




*Note: North is "up."*

**Figure 12 (continued): 2020 and 2045 AADT and DHV**




*Note: North is "up."*

### 3.1.3 Truck Volumes

Truck data was obtained from KYTC to estimate Average Annual Daily Truck Traffic (AADTT) and truck DHVs for each segment of the WKP. The final balanced directional AADTTs ranged from a low of 1,410 (2,820 in both directions) in Grayson County between Exit 107 (KY 259) and Exit 112 (KY 224) to a high of 3,210 (6,420 in both directions) in Hardin County between Exit 136 (US 31W Bypass) and Exit 137 (I-65). The final directional truck DHVs ranged from a low of 110 (220 in both directions) in Grayson County between Exit 107 (KY 259) and Exit 112 (KY 224) to a high of 290 (580 in both directions) in Hardin County between Exit 136 (US 31W Bypass) and Exit 137 (I-65) (**Figure 13**). Mainline truck percentages on the WKP range from 18% to 39% for daily volumes and from 15% to 32% for DHVs.

## 3.2 Future (2045) Volumes

Traffic volumes were projected to the 2045 design year to be consistent with AASHTO policy which calls for forecasts to be at least 20 years beyond the year in which the project plans, specifications, and estimates for construction are approved. The forecast includes projections for AADT, DHV, and truck volumes. Details for the volume forecasting work are presented in the Western Kentucky Parkway Traffic Forecast Report in **Appendix B**.

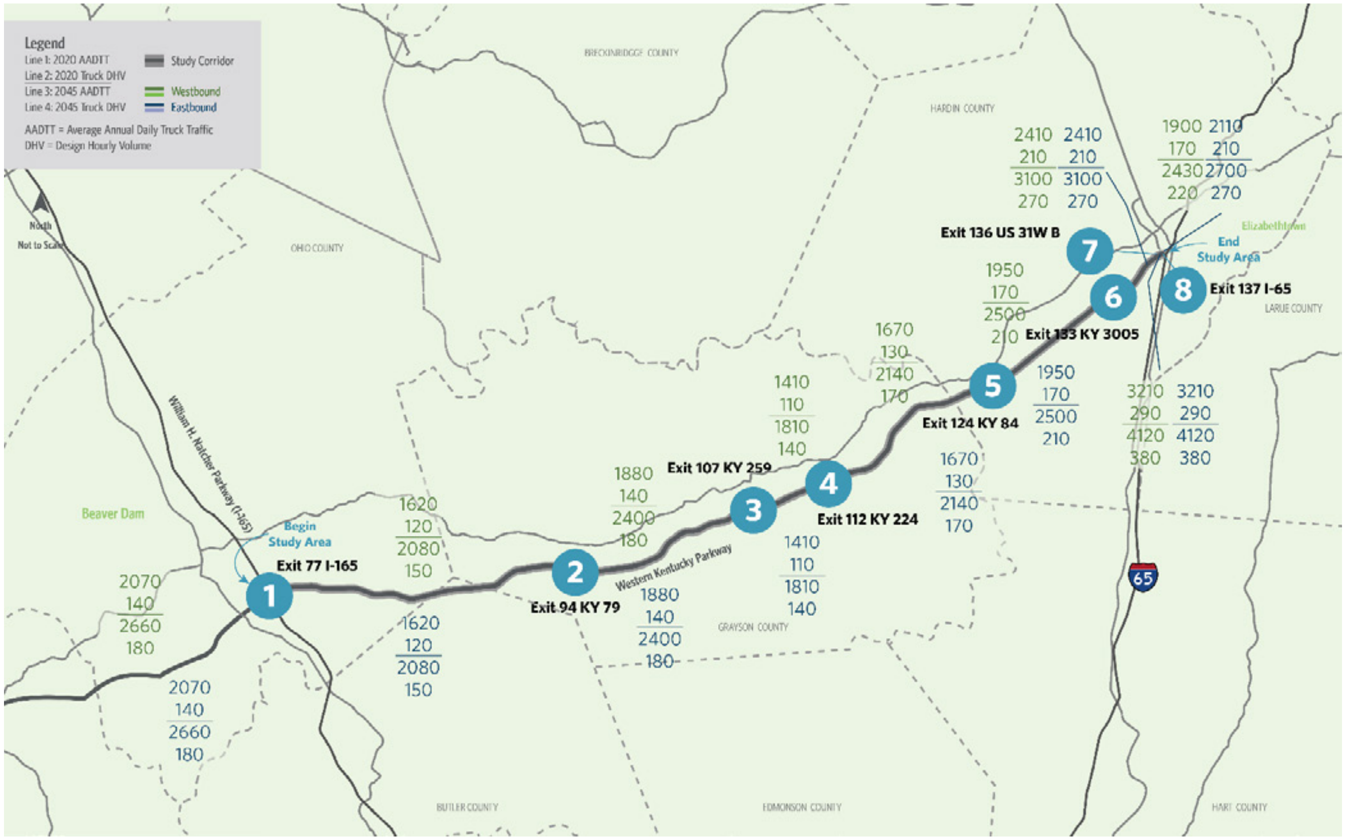
### 3.2.1 Traffic Growth Rate

The traffic growth rate was based on three factors: historical traffic growth, Kentucky Statewide Traffic Model (5971_KYSTMv19) forecasts, and projected population growth. The historical traffic growth on the WKP averaged 1.6% per year from 2009 to 2019. The Kentucky Statewide Traffic Model (5971_KYSTMv19) projected no growth on the corridor over the next 25 years. The projected population growth in the counties within the study area averaged 1.2% growth per year. Given the higher historical growth, the modest projected population growth, and the flat statewide travel demand model projections, a 1.0% annual growth rate for AADT, DHV, and truck volumes was selected for the study. This growth rate is sufficient to test traffic operational performance in the study area over the next 25 years.

### 3.2.2 2045 Volumes

The projected 2045 AADT, DHVs, and truck volumes are presented in **Figure 12** and **Figure 13**. The highest volumes are again in Hardin County between Exit 136 (US 31W Bypass) and Exit 137 (I-65) with a directional peak AADT and DHV of 22,190 and 2,440 respectively (44,380 and 4,880 in both directions). The AADTT and truck DHVs also peaked in Hardin County between Exit 136 (US 31W Bypass) and Exit 137 (I-65) at 4,120 and 380 respectively (8,240 and 760 in both directions).

**Figure 13: AADTT and Truck DHV**




## 3.3 Traffic Operational Analysis

The traffic operational analysis was conducted using the capacity screening methodology from the *Planning and Preliminary Engineering Applications Guide to the Highway Capacity Manual*[3] (**NCHRP Report 825, 2016**) to evaluate the potential for operational issues. Given that the volumes on the WKP appeared to be below the capacity of the facility even in the highest volume areas, this screening approach was determined to be the most appropriate method for quickly and effectively determining if a detailed traffic operational analysis was needed for the study.

***NCHRP Report 825*** uses Level of Service (LOS) as a performance measure to determine if further traffic operational analysis is needed. LOS, as applied in this study, is a qualitative measure used to indicate the traffic performance of a highway segment. LOS uses an A through F letter rating system. LOS A represents low vehicle density, free-flow conditions with little or no delay and LOS F represents over-capacity conditions with long delays and long queues. Volume-to-capacity (v/c) is another performance metric that is correlated to LOS. The v/c ratio used in this analysis is based on the LOS D volume threshold and provides a way of identifying where a highway segment may be near the LOS D threshold as discussed in the next section.

3 http://www.trb.org/NCHRP/Blurbs/174958.aspx

**Table 11: Adjusted Peak Hour Service Volume Thresholds**

| | Service Volume Thresholds (veh/hr/ln) by Truck % | | | | |
|---|---|---|---|---|---|
| LOS | 15% | 17% | 19% | 30% | 32% |
| A – C | 1,250 | 1,210 | 1,180 | 1,020 | 990 |
| D | 1,530 | 1,480 | 1,440 | 1,240 | 1,210 |
| E | 1,740 | 1,680 | 1,640 | 1,410 | 1,380 |

### 3.3.1 Capacity Screening

***NCHRP Report 825*** presents a service volume approach to examining capacity on freeways. The method uses information from the ***Highway Capacity Manual 6th Edition (HCM 6)*** to develop peak hour directional value thresholds for LOS A-C, LOS D, and LOS E. These values are based on an estimate of 12% trucks in the peak hour (design hour). The WKP has truck percentages that range between 15% and 32% in the peak hour, therefore, new lower thresholds were derived for each of the truck percentages. The adjusted customized thresholds are presented in **Table 11**.

For this analysis LOS D was selected as the "capacity" threshold to provide a conservative capacity test for further evaluation. The DHVs calculated previously were compared to the LOS D threshold to determine if any segments warranted further analysis. **Table 12** presents the results of the analysis for eastbound and westbound and **Figure 14** graphs the demand volume and the LOS D threshold service volume for the eastbound and westbound directions. Using the LOS D threshold in the NCHRP analysis, the highest mainline volume to capacity (V/C) ratio is 0.80 with all portions of the freeway expected to operate at LOS C or better in 2045. The analysis methodology and results for both directions are provided in **Appendix C**. In addition to the mainline analysis, a check was made for all ramp facilities in both directions comparing the ramp volumes to the capacity of a single lane ramp (approximately 2,000 vehicles per hour per the **HCM 6**). No issues were identified, with the highest ramp volume reaching 1,260 vehicles per hour in 2045.

With the section between the US 31W Bypass interchange and I-65 screening with a V/C ratio of 0.80, a more detailed analysis was performed in the eastbound and westbound directions using ***HCM 6 methodologies. Highway Capacity Software, version 7 (HCM7)*** was used to perform this more detailed analysis at these locations. **Table 13** presents the results of this analysis for merge, diverge, and weaving situations. This analysis shows that in 2045 the parkway in the eastbound direction between the US 31W Bypass and I-65 will operate at LOS D and the diverge from the parkway to I-65 southbound will operate at LOS D.

Based on this screening analysis, the WKP currently operates at an acceptable level of service and is operating below capacity. In the future year of 2045, the majority of the WKP is expected to operate at an acceptable LOS, with the exception of two segments between the I-65 and US 31W Bypass interchange in Elizabethtown, which will operate at LOS D.

**Table 12: WKP Capacity Screening Analysis (2045 Volumes)**

| Eastbound | | Type | Lanes | Speed Limit (mph) | Truck % | 2045 DHV (veh/hr, all lanes) | 2045 DHV (pcphpl) | Max Capacity for LOS D (pcphpl) | V/C Ratio | LOS Estimate |
|---|---|---|---|---|---|---|---|---|---|---|
| Segment Start | Segment End | | | | | | | | | |
| West of I-165 | I-165 | Basic | 2 | 70 | 32 | 550 | 275 | 1,210 | 0.23 | LOS A-C |
| I-165 | KY 79 | Basic | 2 | 70 | 30 | 510 | 255 | 1,240 | 0.21 | LOS A-C |
| KY 79 | KY 259 | Basic | 2 | 70 | 30 | 620 | 310 | 1,240 | 0.25 | LOS A-C |
| KY 259 | KY 224 | Basic | 2 | 70 | 17 | 780 | 390 | 1,480 | 0.26 | LOS A-C |
| KY 224 | KY 84 | Basic | 2 | 70 | 17 | 990 | 495 | 1,480 | 0.33 | LOS A-C |
| KY 84 | KY 3005 | Basic | 2 | 70 | 19 | 1,130 | 565 | 1,440 | 0.39 | LOS A-C |
| KY 3005 | US 31W By-pass | Basic | 2 | 70 | 19 | 1,410 | 705 | 1,440 | 0.49 | LOS A-C |
| US 31W By-pass | I-65 | Basic | 2 | 70 | 15 | 2,440 | 1,220 | 1,530 | 0.80 | LOS A-C |
| I-65 | US 31W | Basic | 2 | 55 | 15 | 1,810 | 905 | 1,530 | 0.59 | LOS A-C |

| Westbound | | Type | Lanes | Speed Limit (mph) | Truck % | 2045 DHV (veh/hr, all lanes) | 2045 DHV (pcphpl) | Max Capacity for LOS D (pcphpl) | V/C Ratio | LOS Estimate |
|---|---|---|---|---|---|---|---|---|---|---|
| Segment Start | Segment End | | | | | | | | | |
| US 31W | I-65 | Basic | 2 | 55 | 15 | 1,460 | 730 | 1,530 | 0.48 | LOS A-C |
| I-65 | US 31W Bypass | Basic | 2 | 70 | 15 | 2,440 | 1,220 | 1,530 | 0.80 | LOS A-C |
| US 31W By-pass | KY 3005 | Basic | 2 | 70 | 19 | 1,410 | 705 | 1,440 | 0.49 | LOS A-C |
| KY 3005 | KY 84 | Basic | 2 | 70 | 19 | 1,130 | 565 | 1,440 | 0.39 | LOS A-C |
| KY 84 | KY 224 | Basic | 2 | 70 | 17 | 990 | 495 | 1,480 | 0.33 | LOS A-C |
| KY 224 | KY 259 | Basic | 2 | 70 | 17 | 780 | 390 | 1,480 | 0.26 | LOS A-C |
| KY 259 | KY 79 | Basic | 2 | 70 | 30 | 620 | 310 | 1,240 | 0.25 | LOS A-C |
| KY 79 | I-165 | Basic | 2 | 70 | 30 | 510 | 255 | 1,240 | 0.21 | LOS A-C |
| I-165 | West of I-165 | Basic | 2 | 70 | 32 | 550 | 275 | 1,210 | 0.23 | LOS A-C |

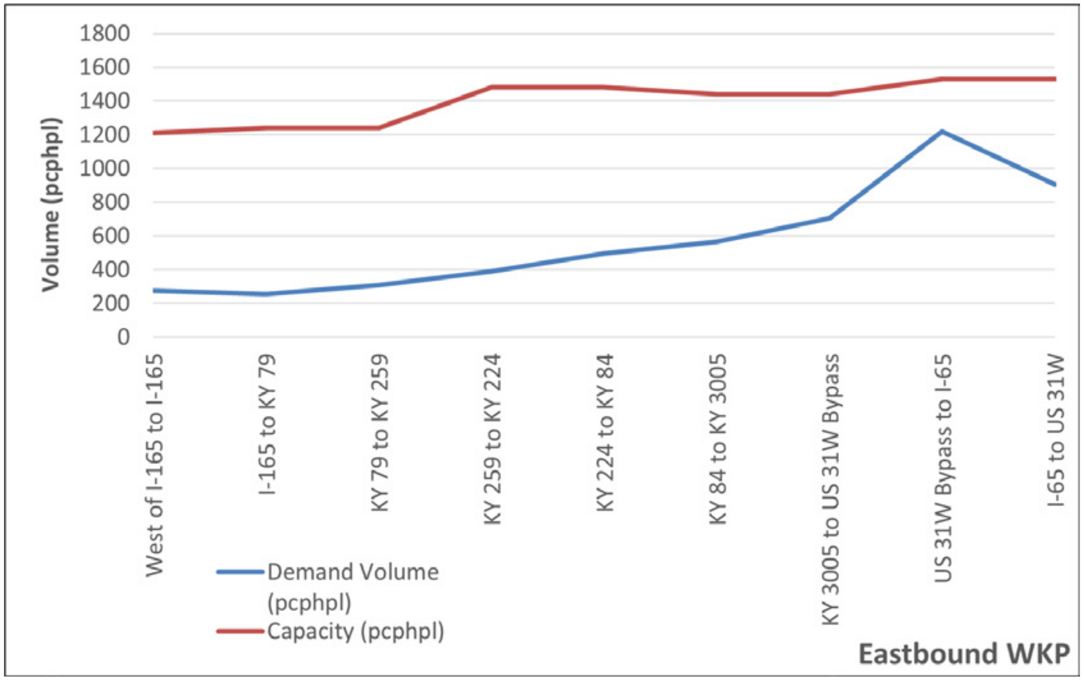
*Note: veh/hr = vehicles per hour; pcphpl = passenger cars per hour per lane; LOS = Level of Service; V/C = volume to capacity*

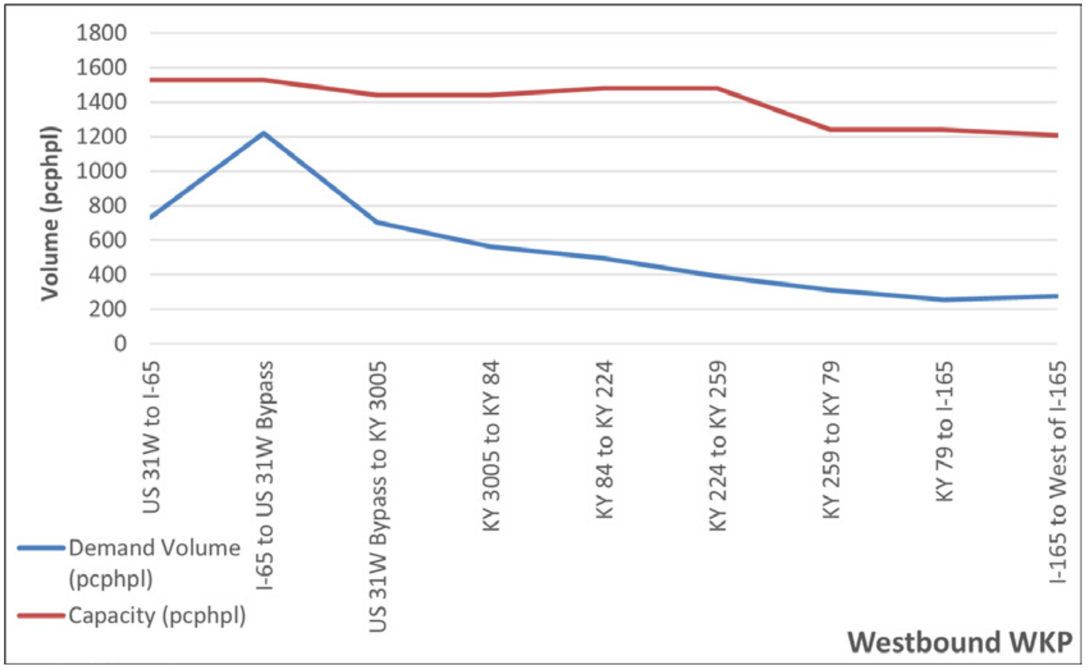
**Table 13: Highway Capacity Manual* 2045 Analysis Results**

| Segment | Direction | Movement | V/C | | Average Speed (mph) | | Average Density (pc/mi/ln) | | Level of Service |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mainline | Ramp | Mainline | Ramp | Mainline | Ramp | |
| US 31W Bypass Ramp to WKP | EB | Merge | 0.70 | 0.85 | 58.3 | 58.3 | 27.2 | 26.3 | C |
| WKP between US 31W Bypass and I-65 | EB | Basic | 0.69 | | 55.9 | | 28.4 | | D |
| WKP Ramp to I-65 SB | EB | Diverge | 0.70 | 0.18 | 55.9 | 55.9 | 28.4 | 29.8 | D |
| WKP Weave at I-65 | EB | Weave | 0.76 | | 50.6 | | 23.6 | | C |
| I-65 SB Ramp to WKP | WB | Merge | 0.70 | 0.63 | 58.2 | 58.2 | 27.3 | 26.7 | C |
| WKP between I-65 and US 31W Bypass | WB | Basic | 0.69 | | 63.6 | | 24.0 | | C |
| WKP Ramp to US 31W Bypass | WB | Diverge | 0.70 | 0.85 | 52.8 | 52.8 | 30.0 | 27.2 | C |

**HCS7 software used to obtain results*

**Figure 14: 2045 Per Lane DHVs Compared to LOS D Service Volume Threshold**



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# 4 Safety

## 4.1 Historic Crash Analysis

A historical crash analysis was performed to examine traffic safety trends and to identify potential safety issues on the WKP. The crash data was derived using data from the Kentucky Transportation Center (KTC) Crash Data Analysis Tool (CDAT) database. Five years of data (2015 to 2019) were used in the analysis. It should be noted that the 2020 crash data was not used due to changes in driver behavior and traffic volumes during the COVID-19 pandemic.

Within the five-year analysis period, 919 crashes were reported in the study area. Of the total crashes, 816 (89%) occurred on the mainline and 103 (11%) occurred on interchange ramps. A breakdown of the crashes by severity is presented in **Table 14**. As shown, there were 12 fatal crashes and 23 serious injury crashes (3.8% combined) over the five-year period. Most crashes (728, 79.4%) were property damage only crashes.

**Table 14: WKP Crash Severity (2015-2019)**

| Severity of Crash | Mainline | Ramps | Total | Percent |
|---|---|---|---|---|
| Fatal Injury (K) | 11 | 1 | 12 | 1.3% |
| Serious Injury (A) | 21 | 2 | 23 | 2.5% |
| Minor Injury (B) | 61 | 2 | 63 | 6.7% |
| Possible Injury (C) | 86 | 7 | 93 | 10.1% |
| Property Damage Only (O) | 637 | 91 | 728 | 79.4% |
| Total | 816 | 103 | 919 | 100.0% |

An examination of the crashes by manner of collision is presented in **Table 15**. Most crashes in the study area (635, 69.1%) were single-vehicle crashes. This is consistent with the low volume rural nature of the majority of the roadway. Rear-end crashes and sideswipe crashes were the other two major crash categories. The angle crashes had the highest average severity of all the categories with ten of the 38 involving a fatality or injury (3 fatal, 2 severe injury, and 5 minor injury). It was also noted that commercial vehicles were involved in 11% of all reported crashes, which is a lower percent than their proportion of traffic volume on the WKP.

**Table 15: WKP Crashes by Manner of Collision (2015-2019)**

| Manner of Collison | Mainline | Ramps | Total | Percent |
|---|---|---|---|---|
| Single Vehicle | 584 | 51 | 635 | 69.1% |
| Rear End | 99 | 35 | 134 | 14.6% |
| Sideswipe, Same Direction | 78 | 14 | 92 | 10.0% |
| Backing | 2 | 2 | 4 | 0.4% |
| Angle | 37 | 1 | 38 | 4.2% |
| Sideswipe, Opposite Direction | 2 | 0 | 2 | 0.2% |
| Head On | 12 | 0 | 12 | 1.3% |
| Rear-to-Rear | 2 | 0 | 2 | 0.2% |
| Total | 816 | 103 | 919 | 100.0% |

A further investigation of the single-vehicle crashes, **Table 16**, showed that the majority of the single-vehicle crashes involved either an animal (31.5%), guardrail / barrier (18.7%), or an embankment, rock cut, or ditch (24.3%). Of the single vehicle crashes, the type that had the highest severity was the Embankment / Rock Cut / Ditch category. One of these crashes was fatal and seven resulted in serious injury.

**Table 16: Single Vehicle Crashes by Type (2015-2019)**

| Category | Crashes | Percent |
|---|---|---|
| Animal, Deer | 200 | 31.5% |
| Guardrail, Barrier, Rail | 119 | 18.7% |
| Embankment, Rock Cut, Ditch | 154 | 24.3% |
| Overturned | 28 | 4.4% |
| Other Moveable Object | 12 | 1.9% |
| Tree | 9 | 1.4% |
| Other Object Not Fixed | 1 | 0.2% |
| Unknown (Code Issue) | 12 | 1.9% |
| Other | 100 | 15.7% |
| Total | 635 | 100.0% |

A review of crashes by time of day, **Figure 15**, shows that crashes peak in the morning, mid-afternoon, and late afternoon, with the largest number of crashes occurring between 5:00 and 6:00 pm. This crash peaking pattern is generally consistent with traffic volume patterns in the corridor. A review of crashes involving animals (**Figure 16**) with respect to the time of day, yielded a high number of crashes between 7:00 and 8:00 am and between 5:00 and 11:00 pm. This increase in animal crashes during these timeframes can be attributed to increased deer activity in the sunrise and sunset/early nighttime periods throughout the year.

Figure 15: Manner of Collision by Time of Day (2015-2019)

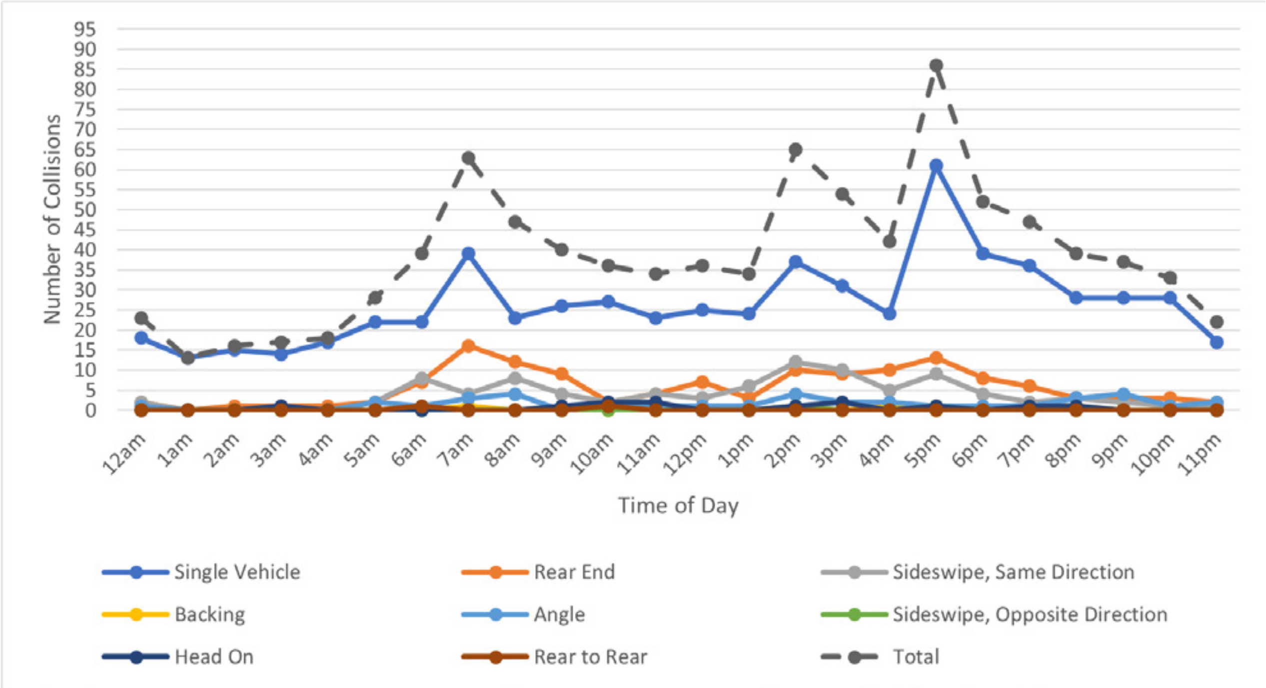
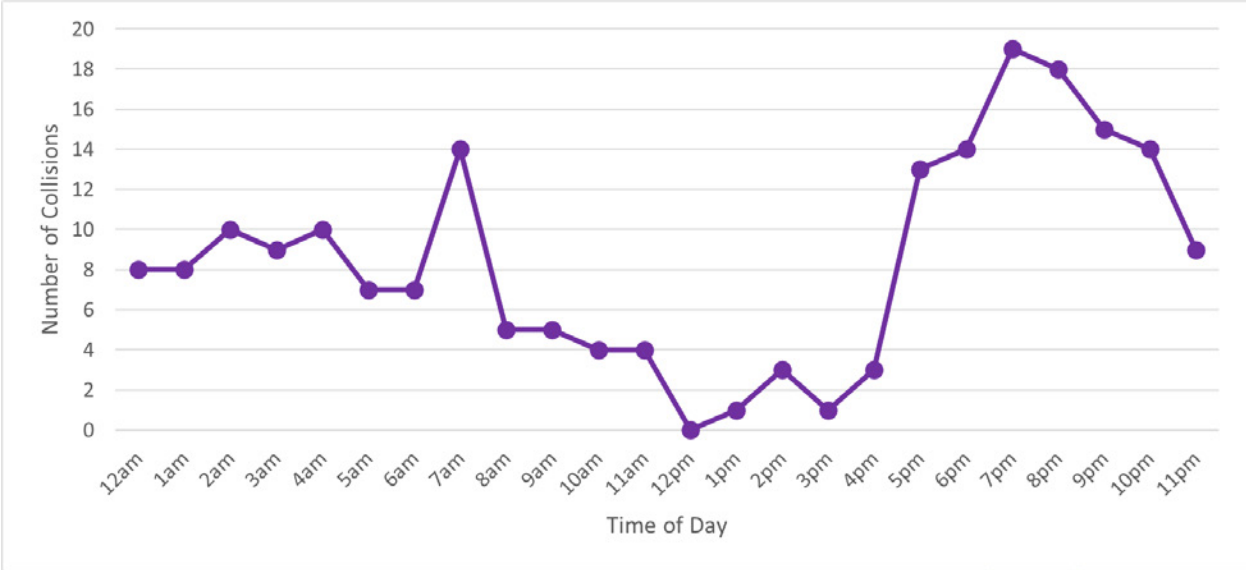
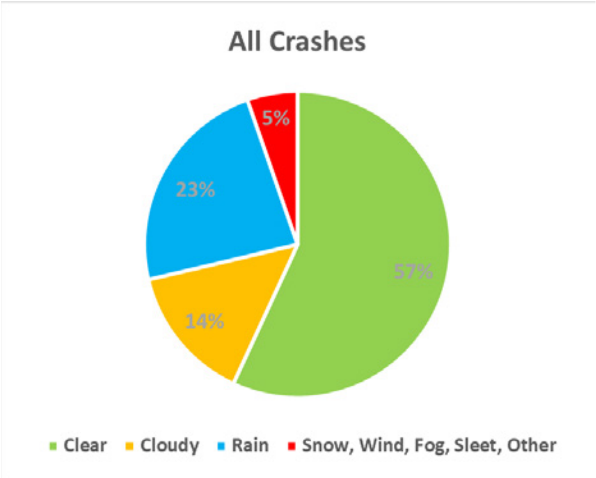


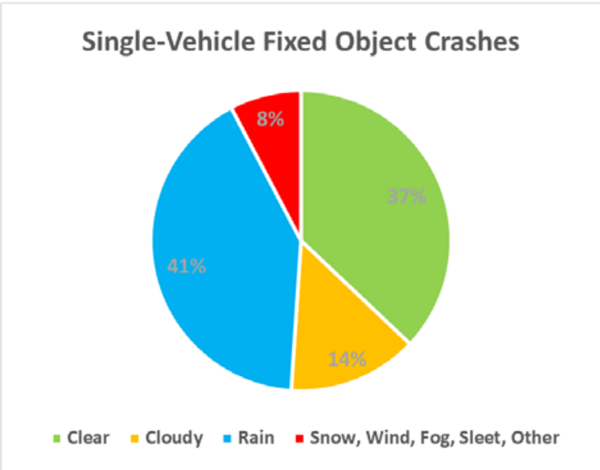

Figure 16: Animal Crashes by Time of Day (2015-2019)



For single vehicle crashes that involved the driver striking a fixed object, weather played an important role. **Figure 17** provides crashes by weather conditions for all crashes and for single vehicle fixed-object crashes only. The percent of these crashes occurring during inclement weather (rain, snow, sleet, fog, etc.) is 49% compared with 28% for all crashes.

**Figure 17: All Crashes and Single-Vehicle Fixed Object Crashes by Weather (2015-2019)**



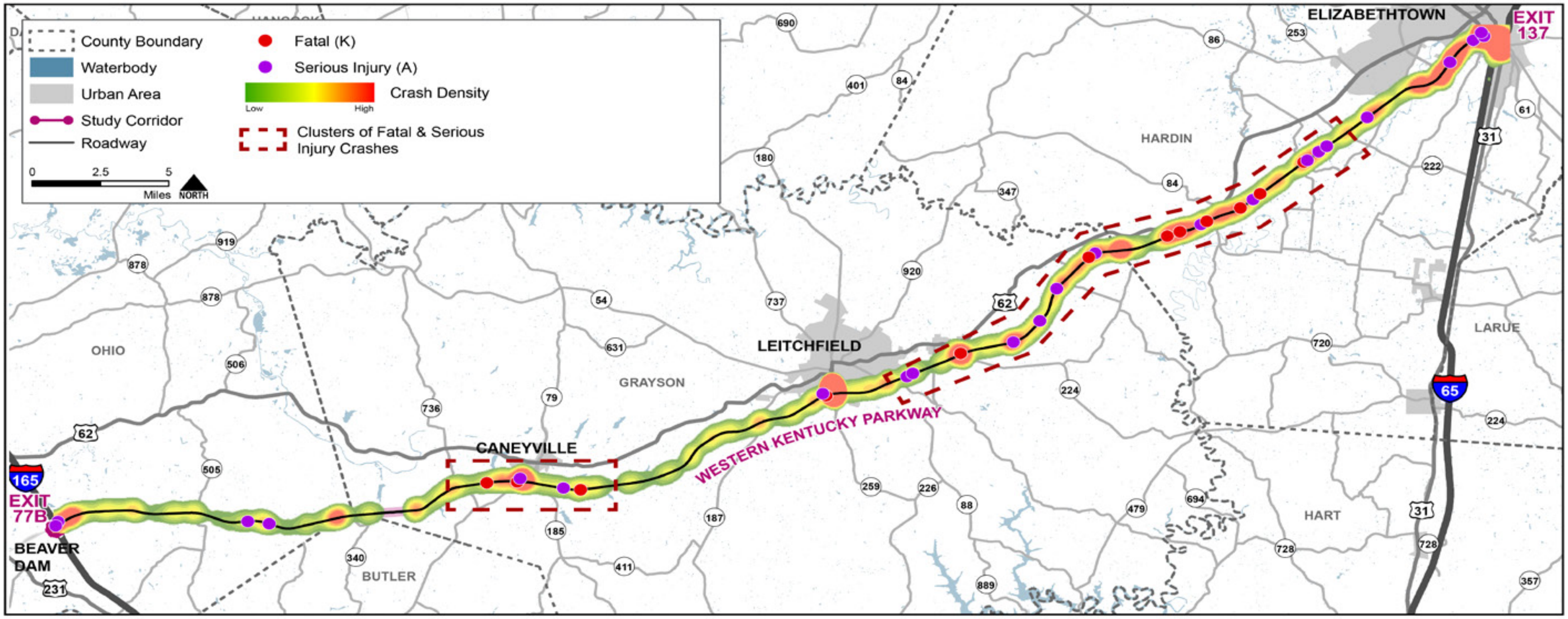

The location of crashes on the WKP was also examined as illustrated in **Figure 18**. Crashes were generally distributed throughout the study area, with higher clusters of fatal and injury crashes occurring in Hardin County and in eastern and western Grayson County. As discussed in Section 2.1.5, 88 median cross-over crashes occurred during the analysis period resulting in six fatal crashes. Of all the crashes that occurred within the study area during the analysis period, 56% were roadway departure, which includes vehicles exiting the roadway to the right or exiting into the median to the left.

During the investigation of specific design issues, the detailed crash data were used in several ways to identify potential safety related issues. First, the crash data and volume data were used to calculate crash rates for specific segments or locations such as a curve or bridge location. Second, the detailed environmental and human factors data for crashes in an area were examined to determine possible causation. For example, if crashes were related to wet weather or standing water, these items were noted. Finally, the crash type, severity and other factors were considered. For example, animal crashes were noted so that they did not impact unrelated design considerations.

## 4.2 Excess Expected Crashes

KYTC and KTC have developed a more refined statistical methodology based on the Highway Safety Manual (HSM) to rank the safety needs of projects. Excess Expected Crashes (EEC) is based on a crash prediction model estimating the number of crashes expected on an average roadway segment of a given type and length. It represents the number of excess crashes a segment is experiencing compared to other roadways of its type, adjusting for traffic volumes and a statistical correction. EEC is positive when more crashes are occurring than expected and negative when fewer crashes are occurring than expected.

**Figure 18: WKP Crash Density Map (2015-2019)**



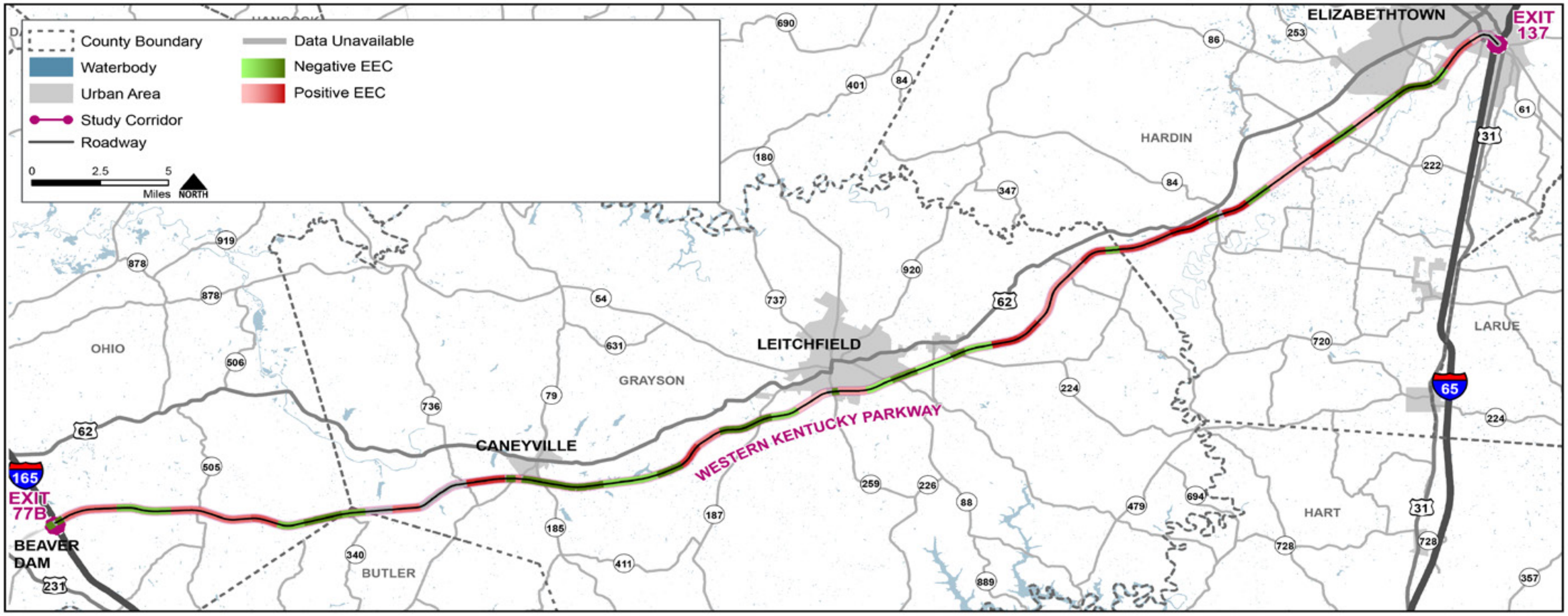
The EEC values for the WKP were obtained from KYTC and are color coded on **Figure 19**. As shown, the WKP within each county experiences a mixture of positive and negative EEC values. The area in western Hardin County and eastern Grayson County are more concentrated with higher than expected crashes than elsewhere within the study area. 211 crashes occurred in this area including five fatal crashes and five serious injury crashes. The overall EEC for the study area was a negative value of -9.82 crashes per year. The EEC for KAB (fatal, serious injury, minor injury) crashes total +3.02 crashes per year and the EEC for CO (possible injury, property damage only) crashes total -12.84 crashes per year. These results indicate that overall, the WKP is operating better than would be predicted for a rural freeway / parkway with similar traffic volumes, but it is experiencing more injury and fatal crashes. One caveat to the EEC data is that there are some segments of the corridor in western Grayson County that do not have calculated EEC values.

## 4.3 Summary of Safety Issues & Use of Safety Data

Overall, the WKP appears to be operating acceptably with regards to safety. This is most clearly demonstrated by the overall negative EEC using the rural interstate and parkway prediction equation. The current safety performance is in line with expectations for a rural interstate in Kentucky, although it should be noted that the study area experiences more than would be expected fatal and injury crashes for a similar type facility. One of the major safety issues flagged in the course of the review was the relationship between wet weather crashes and single-vehicle run-off-road crashes. In addition, there were locations in the WKP that were identified as having clusters of severe (Fatal (K) or Serious Injury (A)) crashes and areas where median cross-over crashes (such as near the KY 84 interchange) were more prevalent.

The crash data, EEC information, and crash rates (calculated using the crash and volume data) were all used to evaluate the deficient locations and the possible improvements to address them. A safety scoring system was developed to help clarify which locations seemed to have more substantial issues. Detailed investigation was also performed to determine if there was a relationship between a design issue and safety.

**Figure 19: Areas with Positive (Poor) and Negative (Good) Excess Expected Crashes (EEC)**



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# 5 Environmental Overview

Data was collected for an Environmental Overview (EO) based on existing geographic information system (GIS) datasets, state and federal agency databases, literature research, and archival data. Desktop research was performed to identify and locate areas of importance or concern that lie within 250 feet either side of the WKP. Once resources were identified, those resources were considered within the context of improvement concepts and the potential for those concepts to impact the identified resources. The detailed EO is attached as **Appendix D**.

The EO considered resources in the following categories: ecological resources; threatened and endangered species and important habitats; air quality and noise issues; Environmental Justice (EJ) / socioeconomic data; land use / farmland; hazardous materials; and historic and archaeological resources.

Improvement concepts were considered along the roadway mainline, at interchanges, at bridges and some additional safety and operational improvements. A key consideration for all improvement concepts was whether they occur outside of existing right-of-way. Those occurring outside of existing right-of-way or creating ground disturbance have greater potential to impact natural and socioeconomic resources. Concepts ultimately chosen during the design phase will require in-depth analysis and review to provide location approval (NEPA documentation) before transitioning to future phases of project development.

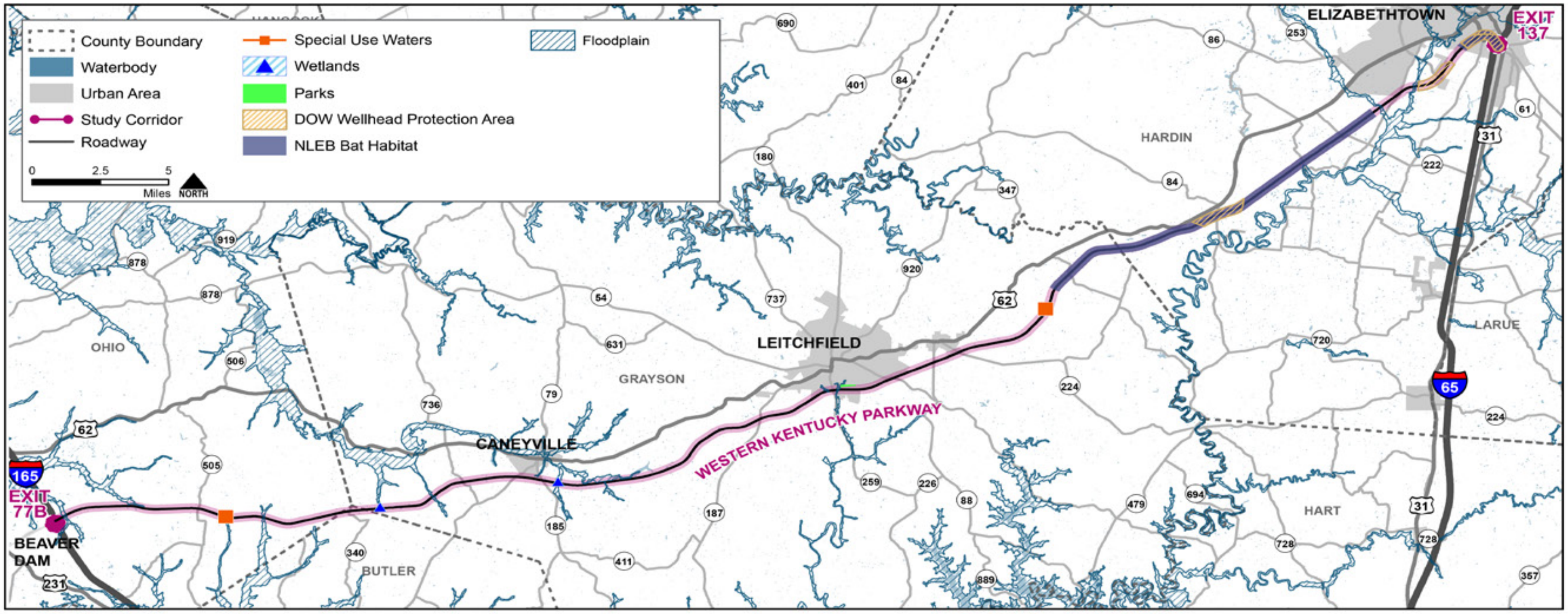
## 5.1 Natural Environment

The natural environment reviewed for the EO included ecological resources, threatened and endangered species and important habitats. Ecological resources were comprised of streams, wetlands, and floodplains. As anticipated for such a large study area, the potential to encounter natural environment resources are numerous. The desktop review identified that threatened and endangered species potential habitats are found throughout the study area; similarly, 85 stream crossings were readily identifiable within GIS datasets and 27 floodplain crossings were also identified. Wetland areas were much less prevalent, with only two wetland areas being identified on National Wetland Inventory (NWI) mapping (**Figure 20**), although NWI mapping should be considered limited in its coverage.

The nature of improvement concepts considered as a result of this study limit the potential impacts to these resources, as most will occur within existing right-of-way and within previously disturbed areas. The bulleted items below provide a brief summary of the potential natural environment impacts to consider as a result of the conceptual improvements which are discussed in the following subsections of the document:

- Mainline Improvements – Mainline improvements within the existing right-of-way are in areas of previous disturbance and would not be anticipated to create impacts to the identified natural environment resources.
- Interchanges –Lane width increases and ramp grade increases would not be anticipated to result in any impacts to the natural environment as they would occur within right-of-way. Other potential improvements, particularly rebuilding of interchanges which may require right-of-way acquisition may lead to impacts to the natural environment. Those impacts include impacts to floodplains, northern long-eared bat swarming 2 areas, and bat habitat through tree removal.
- Bridges –Natural environment impacts resulting from bridge railing replacement may include impacts to bat use of bridges and / or removal of trees (i.e., bat habitat). Four of these locations (at KY 720, KY 84, KY 222, and US 31W Bypass) may also impact Northern long-eared bat swarming 2 habitat. Potential floodplain impacts are also of concern for two streams crossed by the bridges over West Rhudes Creek and Valley Creek.
- Additional Safety and Operational Improvement Concepts – Due to the nature of these improvements, i.e., within existing right-of-way or previously disturbed areas, no natural environment impacts would be anticipated.

**Figure 20: Study Area Existing Environmental Conditions**



## 5.2 Human Environment

The human environment reviewed for the EO included air quality and noise issues; EJ / socioeconomic data; land use / farmland; hazardous materials; and historic and archaeological resources. As with the natural environment, the potential for the improvement concepts to impact human made considerations is limited by the fact that most improvements would likely occur within existing right-of-way or within previously disturbed areas. However, for archaeological resources, impacts within existing right-of-way or other ground disturbance may be an environmental constraint; any future design will need to consider archaeological resources in particular where ground disturbance occurs.

The bulleted items below provide a brief summary of the potential human impacts to consider relative to the conceptual improvements. Note that conceptual improvements are the same as those detailed within the main headings under the Natural Environment section above.

- Mainline Improvements – Mainline improvements occur within existing right-of-way and previously disturbed areas and would not be anticipated to create impacts to socioeconomic areas of consideration.
- Interchanges – Interchange improvements may occur outside of existing right-of-way and have the potential to create impacts to the human environment. The potential for impact is greatest for the conceptual interchange improvements that may occur outside of existing right-of-way and particularly nearest the eastern end of the WKP where many resources occur. Potential impacts due to any potential interchange improvements may include the following:
  - Changes in land use resulting from the acquisition of right-of-way.
  - Potential impact to a gas station entrance near Exit 94, KY 79.
  - Potential for acquisition of a residence near Exit 124, KY 84.
  - Potential impacts to cultural historic and archaeological resources, as a result of right-of-way acquisition, or for archaeological resources, due to ground disturbance.
  - Potential for traffic noise impacts near residential areas at US 31W near the eastern end of the WKP.
  - Potential for consideration of and / or impacts to well-head protection areas near the eastern end of the WKP. Two well-head protection areas occur in this location, one of which is near Exit 124, KY 84 and the other which encompasses the interchanges with I-65, US 31W, and KY 3005 (Ring Road.
- Bridges – Bridge railing replacement including concrete railings at locations throughout the study area create potential hazardous materials concerns. Bridge railings, whether entirely or partially constructed of concrete, can contain asbestos which if removed require appropriate handling and disposal if above certain levels of asbestos. Potential bridge widening of the bridges over the CSX Railroad and Gaither Station Road create concerns related to a well-head protection area. Bridge vertical clearance improvements being considered at many locations may also create a need for additional right-of-way and / or create potential for impact to archaeological resources.
- Additional Safety and Operational Improvement Concepts – These improvements (shoulder widening with cable median barrier addition, removal of median turnarounds, and interchange ramp improvements) would not be anticipated to create socioeconomic concerns as they would occur within existing right-of-way or previously disturbed areas.

The Green River Area Development District (GRADD) and Lincoln Trail ADD (LTADD) completed a socioeconomic study of the area, with an emphasis on EJ considerations. The Western Kentucky Parkway Interstate Upgrade Socioeconomic Report assessed the potential to encounter EJ populations within the study corridor (Appendix E). The report used 2018 U.S. Census Bureau American Community Survey (ACS) data, and numbers for LTADD were used as the reference thresholds in determining EJ populations. As a result of the analysis, the report identified 38 block groups with minority status and 30 block groups with poverty status, as defined by those having minority or low-income populations above the respective thresholds of LTADD as a whole. These block groups were distributed throughout the study area, with one exception. One segment of the corridor from the Grayson / Hardin County line approximately 12 miles to the east has a relatively low percent of its population (under 10%) in poverty. The full Socioeconomic Report is included in the EO in Appendix E.

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# 6 Development of Potential Improvement Concepts

Based on the results of the existing conditions, traffic, and safety analysis, along with input from the project team, a list of potential improvement concepts was developed for mainline, interchanges and ramps, and bridge locations that do not meet current Interstate standards. An iterative process was used, in which the initial list of potential improvement concepts was shared with the project team to obtain feedback. Based on that feedback, the consultant team investigated certain locations further with respect to crashes, record plans, or other available data to determine which improvement concepts would need to be constructed before Interstate conversion, and which could possibly be granted a DE or DV but would be necessary for full compliance. Planning level construction cost estimates were developed for the refined list, which was presented and discussed in the final project team meeting. Based on feedback, a finalized list was developed which is presented below. A list of additional safety and operational improvements was developed to recommend improvements for locations that meet the design criteria but have a noted safety or operational deficiency that could be addressed.

## 6.1 Mainline

### 6.1.1 Shoulder Width

There is one location along the study corridor with an inside shoulder width that does not meet the four-foot requirement. The location is listed in **Table 17** and shown in **Figure 21**.

The 17-mile section from MP 119.65 to 136.80 has a crash rate that is approximately equal to the statewide average. According to the Highway Safety Manual (HSM), a 1-foot shoulder deficiency is predicted to increase crashes in the segment by approximately 2%. Given that this section of roadway has experienced approximately 71 crashes per year, it is expected that the narrow shoulder width could result in 28 more crashes over a 20-year period. Using an average crash cost of $215,000 / crash this is an undiscounted cost $6.123 million. The cost of widening the inside shoulders at this location is approximately $2,546,000 and would likely be completed as part of the initial conversion due to safety issues in this area.

### 6.1.2 Horizontal Curvature

There are 26 curves along the WKP that do not appear to meet superelevation requirements. Where superelevation requirements are not met, the maximum allowable side friction factor can be calculated, and a DE could be requested if this value is less than the maximum allowable. The side friction factor was calculated using the superelevation found in KYTC record plans for the 26 locations that do not meet interstate standards. All 26 were found to be less than 0.1, which meets the acceptable friction factor of a maximum of 0.1. The improvement recommendations for superelevation are listed in **Table 18** and shown in **Figure 22**.

**Table 17: Mainline Shoulder Recommendations**

| Improvement | Direction | Length (mi) | Begin MP | End MP | Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Exception | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|
| Widen inside shoulder to consistent 4' minimum (Currently varies from 2' to 4') | Both | 17.15 | 119.65 | 136.80 | $2,546,000 | ✓ | | | Yes – Crash rate is greater than statewide average |

**Figure 21: Shoulder Width Improvement Locations**

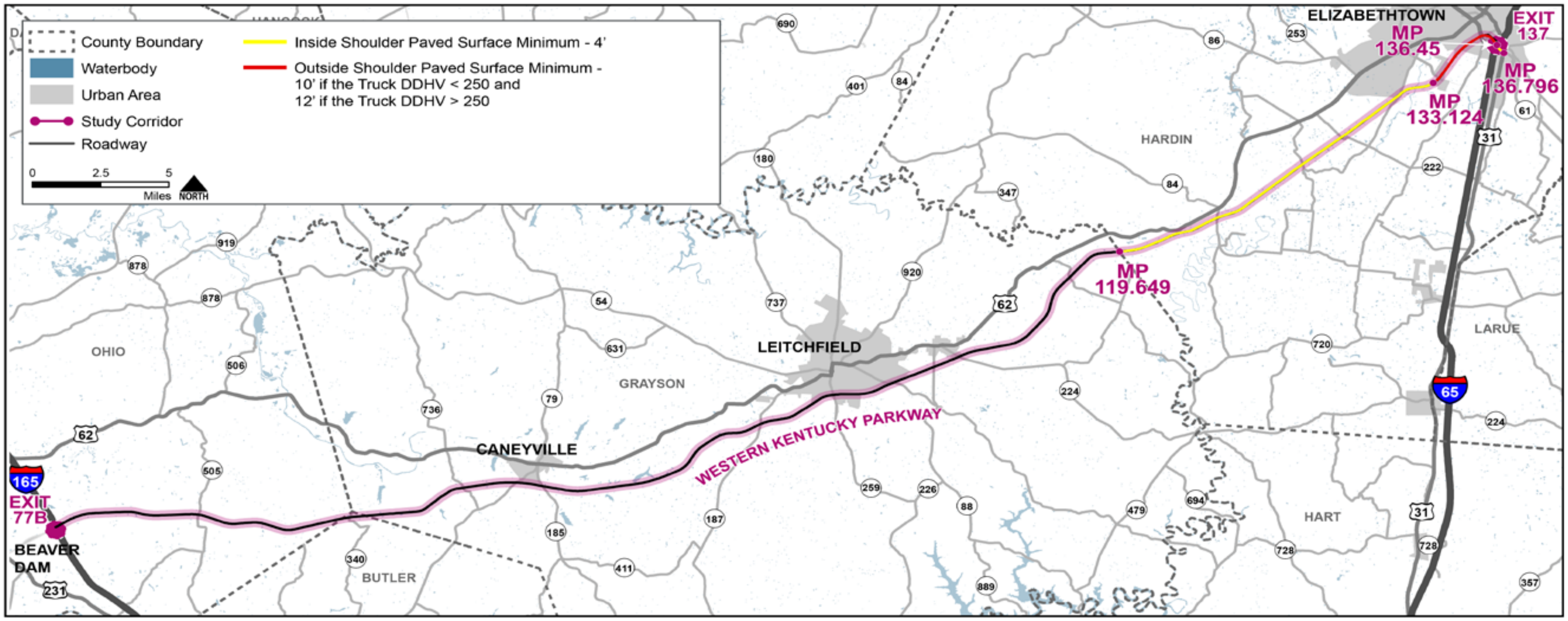


Table 18: Superelevation Improvements

| Improvements | Record Plan Value | Design Standard (%) | Deficiency (%) | Direction | Length (mi) | Begin MP | End MP | Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Exception | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adjust superelevation | NC | 2.0 | 3.58 | Both | 1.31 | 77.03 | 78.33 | $658,000 | ✓ | | | Yes |
| Adjust superelevation | RC | 2.6 | 0.60 | EB | 0.51 | 79.41 | 79.92 | $196,000 | ✓ | | | Yes |
| Adjust superelevation | NC | 2.0 | 0.42 | EB | 0.59 | 79.92 | 80.51 | $187,000 | ✓ | | | Yes |
| Adjust Superelevation | RC | 2.6 | 0.60 | Both | 0.66 | 81.82 | 82.48 | $255,000 | | ✓ | ✓ | - |
| Adjust Superelevation | NC | 3.4 | 4.98 | EB | 0.59 | 83.08 | 83.67 | $853,000 | | ✓ | ✓ | - |
| Adjust Superelevation | NC | 3.4 | 4.98 | EB | 0.60 | 84.12 | 84.72 | $863,000 | ✓ | | | Yes |
| Adjust Superelevation | NC | 4.6 | 6.18 | EB | 0.49 | 85.25 | 85.74 | $1,499,000 | ✓ | | | Yes |
| Adjust Superelevation | 5.2 | 6.6 | 1.40 | EB | 0.32 | 90.33 | 90.65 | $366,000 | ✓ | | | Yes |
| Adjust Superelevation | 5.2 | 6.6 | 1.40 | WB | 0.31 | 90.35 | 90.66 | $362,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.2 | 6.4 | 3.20 | EB | 0.19 | 91.79 | 91.98 | $600,000 | ✓ | | | Yes |
| Adjust Superelevation | 4.9 | 6.4 | 1.50 | WB | 0.17 | 91.79 | 91.97 | $430,000 | ✓ | | | Yes |
| Adjust Superelevation | 2.0 | 4.6 | 2.60 | WB | 0.14 | 106.51 | 106.65 | $340,000 | ✓ | | | Yes |
| Adjust Superelevation | 2.8 | 4.6 | 1.80 | EB | 0.19 | 106.57 | 106.76 | $342,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.4 | 5.0 | 1.60 | WB | 0.08 | 106.69 | 106.77 | $175,000 | ✓ | | | Yes |
| Adjust Superelevation | 2.8 | 5.2 | 2.40 | EB | 0.05 | 106.83 | 106.88 | $164,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.7 | 4.6 | 0.90 | EB | 0.05 | 115.52 | 115.57 | $50,000 | | ✓ | ✓ | - |

**Table 18: Superelevation Improvements (continued)**

| Improvements | Record Plan Value | Design Standard (%) | Deficiency (%) | Direction | Length (mi) | Begin MP | End MP | Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Exception | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adjust Superelevation | 3.6 | 5.2 | 1.60 | EB | 0.48 | 118.46 | 118.94 | $727,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.8 | 5.2 | 1.40 | WB | 0.48 | 118.46 | 118.94 | $733,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.2 | 4.4 | 1.20 | EB | 0.05 | 124.11 | 124.15 | $143,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.5 | 5.2 | 1.70 | EB | 0.36 | 131.97 | 132.33 | $507,000 | ✓ | | | Yes |
| Adjust Superelevation | 3.5 | 5.2 | 1.70 | WB | 0.34 | 131.98 | 132.31 | $505,000 | ✓ | | | Yes |
| Adjust Superelevation | 2.8 | 5.0 | 2.20 | EB | 0.03 | 133.25 | 133.28 | $286,000 | ✓ | | | Yes |
| Adjust Superelevation | 2.0 | 4.6 | 2.60 | WB | 0.03 | 133.43 | 133.46 | $271,000 | ✓ | | | Yes |
| Adjust Superelevation | 2.0 | 5.8 | 3.80 | EB | 0.04 | 134.99 | 135.03 | $353,000 | ✓ | | | Yes |
| Adjust Superelevation | 7.1 | 8.0 | 0.90 | EB | 0.57 | 135.60 | 136.17 | $602,000 | ✓ | | | Yes |
| Adjust Superelevation | 8.8 | 8.0 | -0.80 | WB | 0.56 | 135.61 | 136.17 | $50,000 | | ✓ | ✓ | - |

The locations with superelevation that do not meet the 70 mph design speed standard were investigated to determine whether there are possible design related safety issues. There were 22 locations that do have possible design related safety issues. A high density of wet roadway condition and roadway departure crashes were observed at these locations. The locations that should be investigated further are included in the cost for improvements to be made prior to Interstate conversion (**Table 18**). A DE could be requested for the remaining areas and they could possibly be upgraded as part of future 3R projects.

Planning level cost estimates were developed for each location where the superelevation does not meet the 70 mph design standard. The costs are based on the assumption that pavement wedging would be used to bring the superelevation up to standards, with locations that vary from the standard by more than 2.0% requiring earth work as well. The estimated cost to improve locations with possible design related safety issues is $10,309,000 in 2021 dollars. The cost to bring superelevation to full compliance is $11,517,000, which includes the initial conversion locations. A detailed survey of the WKP is recommended to determine which locations do not currently meet the design standard before making any improvements.

### 6.1.3 Vertical Curves

There are three sag curves that do not meet the HLSD requirement of 730 feet. The HLSD would need to increase by 84 feet, 120 feet, and 28 feet to meet Interstate standards for each of these curves. These locations are listed in **Table 19** and shown in **Figure 22**. The crash history does not indicate that there are safety concerns at these locations related to headlight stopping sight distance. The cost to improve the HLSD with pavement wedging and overlay is approximately $1,608,000.

### 6.1.4 Clear Zone

There are 238 locations along the WKP study corridor where the desired clear zone for an Interstate is not met, caused mostly by rock cuts and steep slopes. It is not desirable to have guardrail in front of rock cuts for maintenance purposes (the ***2011 Roadside Design Guide*** also notes that this moves the barrier closer to the roadway), therefore adding new guardrail is only recommended for locations where steep slopes are within the clear zone. A DV would be required at locations where rock cuts are within the clear zone. Headwalls within the clear zone also require guardrail or replacement with a safety headwall (which is preferable to guardrail as it is safer, however it is much more expensive and can require additional right of way). It is difficult to identify headwall locations via Google Earth and field review, therefore an additional 2,000 feet of guardrail was added to the estimate to account for headwalls. A detailed survey should be completed to determine the exact amount and location of new guardrail to address clear zone requirements. Based on review in Google Earth, approximately 12.818 miles of new guardrail is needed to address clear zone issues in the study area. The estimated cost for this is $2,477,400. The 12.818 miles of new guardrail in this section is located in areas without documented safety issues, and therefore can be categorized as full compliance.

### 6.1.5 Guardrail

Guardrail that is damaged, is recommended to be replaced prior to initial conversion. Additionally, guardrail that is less than 31 inches in height, and is located in a high crash rate area, should also be replaced with guardrail that meets the standard prior to initial conversion. Based on field review and review of crash data, there are 4.986 miles of guardrail located in high crash rate areas. The estimated cost of replacing this guardrail is approximately $1,401,413. All remaining guardrail that is less than 31 inches in height can possibly be replaced as part of future 3R projects. This is estimated to be 25.7 miles and cost $4,949,360. It was assumed that guardrail in locations with current pavement rehab projects would be replaced, and those locations were not included in the estimates. Additionally, the two locations prior to crash cushions where the grading is deficient should be regraded. The estimated cost for this is $10,000 if performed when replacing other damaged guardrail. A detailed inventory of guardrail should be completed prior to replacement. Guardrail improvement locations and cost estimates are listed in **Table 20**.

**Table 19: Vertical Curve Improvements**

| Improvements | Record Plan Value | Design Standard (ft) | Deficiency (ft) | Direction | Length (mi) | Begin MP | End MP | Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Variance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Increase HLSD of the curve by 84 feet | 646 | 730 | 84 | WB | 0.151 | 87.788 | 87.939 | $440,000 | | ✓ | ✓ | No* |
| Increase HLSD of the curve by 120 feet | 610 | 730 | 120 | EB | 0.137 | 87.807 | 87.944 | $399,000 | | ✓ | ✓ | No* |
| Increase HLSD of the curve by 28 feet | 702 | 730 | 28 | WB | 0.264 | 104.067 | 104.331 | $769,000 | | ✓ | ✓ | No* |

**Crashes at these locations do not appear to be related to headlight stopping sight distance (HLSD)*

**Figure 22: Horizontal and Vertical Curve Improvement Locations**

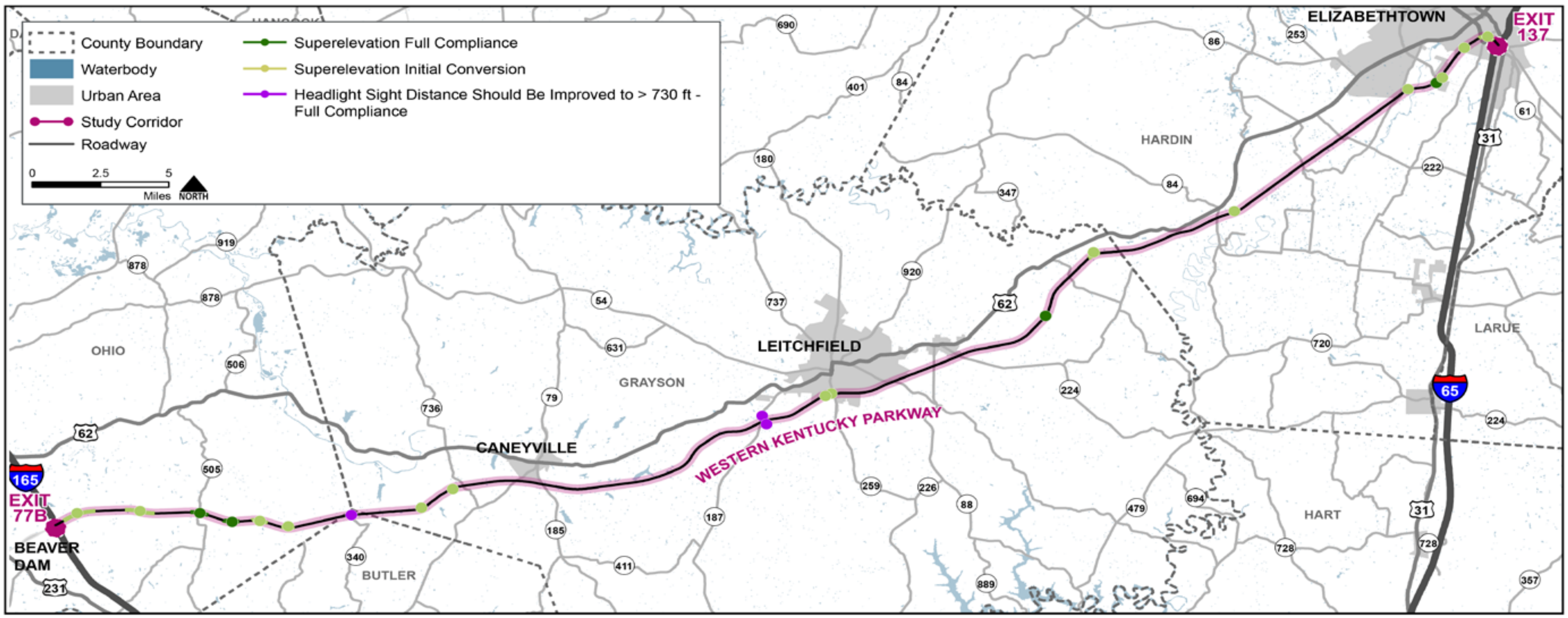


Table 20: Guardrail Improvement Recommendations

| Improvement | Direction | Length (mi) | Begin MP | End MP | Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Variance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|
| Replace damaged guardrail | Both | 13.8 | | | $2,565,240 | ✓ | | | N/A |
| Regrade in advance of crash cush-ions | - | - | - | - | $10,000 | ✓ | | | N/A |
| Add new guardrail to address safety issues | EB | 0.271 | 90.096 | 90.367 | $65,081 | ✓ | | | Yes |
| | EB | 0.038 | 92.156 | 92.194 | $22,022 | ✓ | | | Yes |
| | EB | 0.044 | 94.205 | 94.249 | $23,131 | ✓ | | | Yes |
| | EB | 0.064 | 100.771 | 100.835 | $26,827 | ✓ | | | Yes |
| | EB | 0.747 | 117.814 | 118.561 | $153,046 | ✓ | | | Yes |
| | EB | 0.103 | 132.932 | 133.035 | $34,034 | ✓ | | | Yes |
| | EB | 0.167 | 134.425 | 134.592 | $45,862 | ✓ | | | Yes |
| | EB | 0.073 | 134.696 | 134.769 | $28,490 | ✓ | | | Yes |
| | EB | 0.098 | 135.052 | 135.15 | $33,110 | ✓ | | | Yes |
| | EB | 0.082 | 135.469 | 135.551 | $30,154 | ✓ | | | Yes |
| | EB | 0.218 | 135.571 | 135.789 | $55,286 | ✓ | | | Yes |
| | EB | 0.039 | 135.882 | 135.921 | $22,207 | ✓ | | | Yes |
| | EB | 0.048 | 136.046 | 136.094 | $23,870 | ✓ | | | Yes |
| | WB | 0.284 | 103.987 | 104.271 | $67,483 | ✓ | | | Yes |
| | WB | 0.364 | 104.926 | 105.29 | $82,267 | ✓ | | | Yes |
| | WB | 0.683 | 107.702 | 108.385 | $141,218 | ✓ | | | Yes |
| | WB | 0.326 | 108.565 | 108.891 | $75,245 | ✓ | | | Yes |
| | WB | 0.196 | 108.931 | 109.127 | $51,221 | ✓ | | | Yes |

**Table 20: Guardrail Improvement Recommendations (continued)**

| Improvement | Direction | Length (mi) | Begin MP | End MP | Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Variance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|
| | WB | 0.048 | 109.29 | 109.338 | $23,870 | ✓ | | | Yes |
| | WB | 0.036 | 118.142 | 118.178 | $21,653 | ✓ | | | Yes |
| | WB | 0.049 | 118.523 | 118.572 | $24,055 | ✓ | | | Yes |
| | WB | 0.107 | 133.582 | 133.689 | $34,774 | ✓ | | | Yes |
| | WB | 0.058 | 133.935 | 133.993 | $25,718 | ✓ | | | Yes |
| | WB | 0.05 | 134.25 | 134.3 | $24,240 | ✓ | | | Yes |
| | WB | 0.046 | 134.332 | 134.378 | $23,501 | ✓ | | | Yes |
| | WB | 0.147 | 134.424 | 134.571 | $42,166 | ✓ | | | Yes |
| | WB | 0.054 | 134.757 | 134.811 | $24,979 | ✓ | | | Yes |
| | WB | 0.139 | 135.063 | 135.202 | $40,687 | ✓ | | | Yes |
| | WB | 0.086 | 135.251 | 135.337 | $30,893 | ✓ | | | Yes |
| | WB | 0.106 | 135.48 | 135.586 | $34,589 | ✓ | | | Yes |
| | WB | 0.158 | 135.627 | 135.785 | $44,198 | ✓ | | | Yes |
| | WB | 0.057 | 135.925 | 135.982 | $25,534 | ✓ | | | Yes |
| Add new guardrail to address clear zone issues* | Both | 12.818 | | | $2,443,766 | | ✓ | ✓ | No |
| Replace all guardrail less than 31 inches | Both | 25.7 | | | $4,949,360 | | ✓ | | No |

**As noted in the text, guardrail is not recommended at locations with rock cuts, therefore those locations will require a DV.*

## 6.2 Bridges / Culverts

Bridge improvements consist of upgrading railing to current crashworthy standards, widening to meet minimum clear width requirements, and adjusting geometrics to obtain minimum vertical clearance under an overpass. Several structures require both railing improvements and widening to meet clear width standards for interstates.

### 6.2.1 Bridge Railing

Six bridges carrying mainline WKP were identified as needing rail upgrades to meet ***Interstate Design Guide, 2016*** crash standards. Cost estimates were developed to remove the existing railing and replace it with a crash compliant bridge railing from the KYTC Standard Drawings list. The total cost to replace the railing for the relevant bridges is estimated to be $526,000. These locations are listed in **Table 21** and shown in **Figure 23**

A review of crash data at these bridges indicate that a possible design related safety issue could exist at two locations. Replacing the bridge railing at these two locations is recommended as part of an initial conversion with the other locations possibly being addressed with future 3R projects. Appendix F identifies the locations of these bridges.

### 6.2.2 Bridge Width

Eight bridges carrying mainline WKP were identified as needing widened to meet the Interstate design standard minimum clear width of 37.5 feet for structures less than or equal to 200 feet in length and 31.0 feet for structures longer than 200 feet in length on a two-lane bridge. These locations are listed in **Table 21** and shown in **Figure 23**.

Four bridges with lengths greater than 200 feet did not meet the minimum clear width of 31.0 feet (43.0 feet for three-lane structure). Bridges 047B00093L and 047B00093R were approximately 1-foot shy of the 31.0 feet requirement for a two-lane structure. Bridges 092B00072L and 092B00072R were approximately 1-foot shy of the 43.0 feet requirement for a three-lane structure and also needs substandard railing replaced (cost accounted for in railing improvement). The proposed method to increase the clear width of these four structures would involve using a concrete railing from the KYTC Standard Drawings that reduces the thickness of the barrier by approximately 6 inches per side, thus resulting in widening the clear width of the bridge by 1-foot to meet the clear width standard. The total cost of replacing this railing on all four structures to achieve 1-foot of widening is estimated to be $456,400.

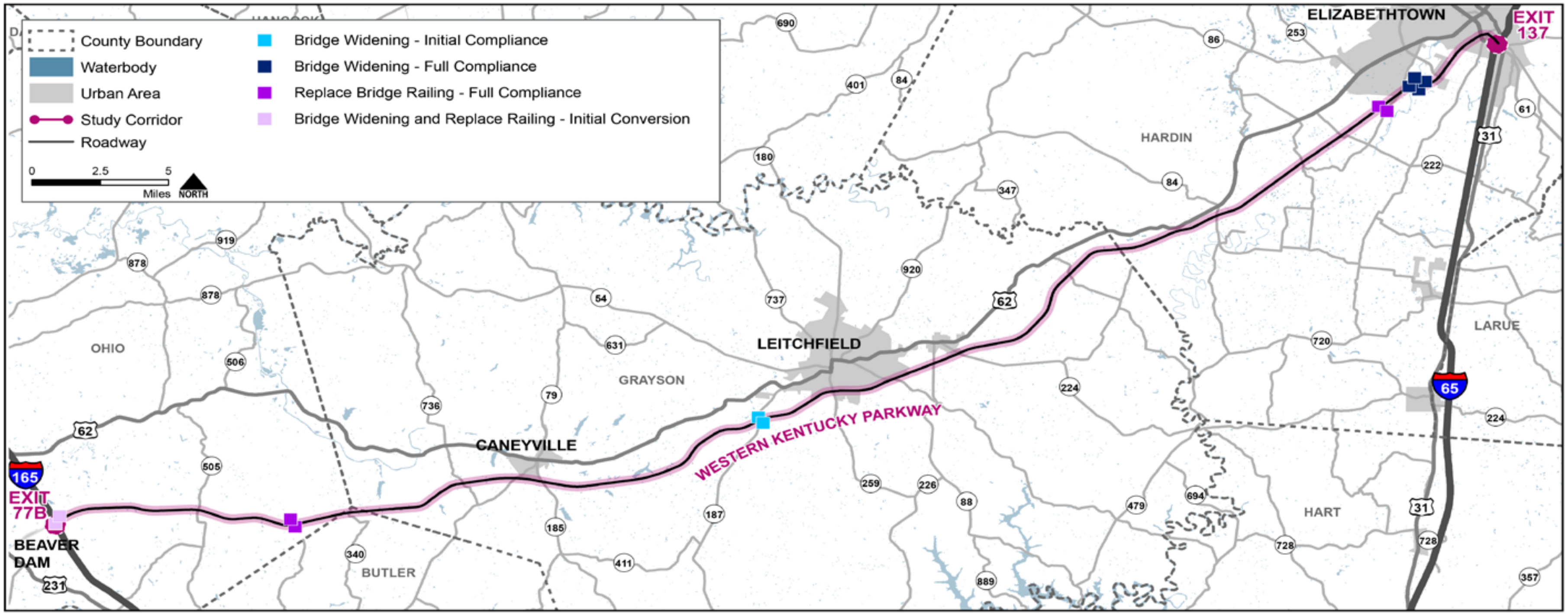
Four bridges with lengths less than 200 feet did not meet the minimum clear width of 37.5 feet. These four structures provide approximately 30 feet of clear width and will need to be widened by 7.5 feet to achieve the minimum clear width standard. The cost for widening these four structures to meet the minimum clear width, including additional beams, pier and abutment extension, and railing replacement, is estimated to be $1,957,400. A review of crash data at these bridges indicate that a possible design related safety issue could exist at two locations. Replacing the bridge railing, thus improving the clear width at these two locations is recommended as part of an initial conversion with the other locations possibly being addressed with future 3R projects.

**Table 21: Bridge Railing and Width Improvements**

| Subcategory | Length (ft) | Begin MP (miles) | End MP (miles) | Railing Improvement Cost (2021 $) | Bridge Widening Improvement Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Variance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|
| 092B00072L - Bridge over I-165 (Natcher Parkway) - Replace bridge railing* | 249 | 76.766 | 76.813 | $122,100 | | ✓ | | | Yes |
| 092B00072R - Bridge over I-165 (Natcher Parkway) - Replace bridge railing* | 249 | 76.77 | 76.817 | $122,100 | | ✓ | | | Yes |
| 092B00130L - Bridge over KY 2713 - Replace bridge railing | 116 | 85.717 | 85.739 | $67,600 | | | ✓ | | No |
| 092B00130R - Bridge over KY 2713 - Replace bridge railing | 116 | 85.744 | 85.766 | $67,600 | | | ✓ | | No |
| 047B00094L - Bridge over W. Rhudes Creek - Replace bridge railing | 130 | 130.886 | 130.911 | $73,300 | | | ✓ | | No |
| 047B00094R - Bridge over W. Rhudes Creek - Replace bridge railing | 130 | 130.894 | 130.919 | $73,300 | | | ✓ | | No |
| 043B00026L - Bridge over KY 187 - Widen bridge 7.5 feet | 156 | 104.011 | 104.041 | | $429,500 | ✓ | | | Yes |
| 043B00026R - Bridge over KY 187 - Widen bridge 7.5 feet | 156 | 104.04 | 104.07 | | $429,500 | ✓ | | | Yes |
| 047B00092L - Bridge over CSX rail and Gather St. Rd. - Widen bridge 7.5 feet | 173 | 132.579 | 132.612 | | $549,200 | | ✓ | | No |
| 047B00092R - Bridge over CSX rail and Gather St. Rd. - Widen bridge 7.5 feet | 173 | 132.574 | 132.607 | | $549,200 | | ✓ | | No |
| 047B00093L - Bridge over Valley Creek-Widen bridge 1.0 foot | 210 | 132.419 | 132.459 | | $106,100 | | ✓ | | No |
| 047B00093R - Bridge over Valley Creek – Widen bridge 1.0 foot | 210 | 132.417 | 132.457 | | $106,100 | | ✓ | | No |

**Includes widening bridge by 1.0 foot.*

**Figure 23: Locations Requiring Bridge Railing and Widening Improvements**



### 6.2.3 Bridge Vertical Clearance

Vertical clearance deficiencies were identified or measured between the WKP and an overpass structure at eleven locations within the study area. Three of these overpass structures will be improved to meet the 16-foot minimum vertical clearance standard by ongoing pavement rehab projects within Highway District 4. Project 4-20001.00 will address bridge 043B00003N and project 4-20016.00 will address bridges 047B00043N and 047B00045N. These three bridges have been removed from further analysis and cost estimating in this study resulting in a total of eight bridges being evaluated within the study area. In addition to the remaining eight structures with vertical clearance deficiencies, three structures (047B00168N, 047B00167N, 047B00171N) had clearance elevations between 16.0 feet and 16.5 feet, but were recently reconstructed. These locations warrant additional investigation when future 3R projects are developed.

All eight bridge locations are recommended to be part of the initial conversion of the WKP. Two categories of cost estimates were developed to improve the vertical clearance at these locations. High-end cost estimates were developed to replace the overpasses with new structures that provide 16.5 feet of vertical clearance over the driving lanes and shoulders. Low-end cost estimates were developed at locations where lowering the roadway grade underneath the overpass to achieve 16 feet in vertical clearance appeared feasible. These locations are shown in **Table 22** and **Figure 24**. The high-end cost of replacing all eight of these structures is estimated at $14,599,600. The cost of lowering the parkway grade at locations that appeared feasible combined with the locations where overpass replacement was required resulted in an overall low-end cost of $8,719,300. A more detailed survey of the overpass bridge and parkway underneath where the lowering of the WKP grade appeared feasible to achieve minimum vertical clearance is recommended during the design phase of future 3R projects. A review of the crash history at these locations did not indicate a safety issue related to the substandard clearance.

## 6.3 Interchanges & Ramps

### 6.3.1 Acceleration / Deceleration Lane Lengths

Two locations have acceleration lane lengths that do not meet the Interstate design standard of 580 feet length requirement for 50 mph ramps. These include the westbound acceleration lane from Exit 94 (KY 79) and the westbound acceleration lane from Exit 124 (KY 84). One location has a deceleration lane length that does not meet the 390-foot length requirement for 50 mph ramps. The deceleration lane not meeting Interstate standards is the eastbound ramp at Exit 107 (KY 259). A safety concern was identified at the KY 259 location only. The project team determined that these lengths should be increased to meet the requirement prior to initial conversion. The cost is estimated to be $423,000. These locations are listed in **Table 23** and shown in **Figure 25.**

### 6.3.2 Lane Width

There is one ramp, the cloverleaf at Exit 137 (I-65), that does not meet the 15-foot lane width requirement. No safety concerns were identified at this location. The project team determined that this ramp should be widened prior to initial conversion. The cost is estimated to be $187,000. This location is listed in **Table 24** and shown in **Figure 25.**

Table 22: Bridge Vertical Clearance Improvements

| Subcategory | Direction | Length (miles) | Begin MP (miles) | End MP (miles) | Replacement Cost (2021 $) | Lower Grade Cost (2021 $) | Initial Conversion | Full Compliance | Requires Design Exception | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|---|---|
| 092B00136N - KY 2712 Bridge over Parkway - Obtain min. vertical clearance | Both | 0.034 | 77.382 | 77.416 | $1,145,300 | - | ✓ | | | No |
| 016B00034N - KY 340 Bridge over Parkway - Obtain min. vertical clearance | Both | 0.041 | 87.842 | 87.883 | $1,279,300 | $450,000 | ✓ | | | No |
| 043B00023N - KY 79 Bridge over Parkway - Obtain min. vertical clearance | Both | 0.064 | 94.257 | 94.321 | $2,997,300 | $624,000 | ✓ | | | No |
| 043B00073N - McDonald Rd. Bridge over Parkway - Obtain min. vertical clearance | Both | 0.041 | 105.884 | 105.925 | $1,351,800 | $324,000 | ✓ | | | No |
| 043B00078N - KY 720 Bridge over Parkway - Obtain min. vertical clearance | Both | 0.036 | 117.423 | 117.459 | $1,207,000 | $849,000 | ✓ | | | No |
| 047B00090N - KY 1904 Bridge over Parkway - Obtain min. vertical clearance | Both | 0.054 | 131.831 | 131.885 | $1,666,900 | $375,000 | ✓ | | | No |
| 047B00153R / 047B00108L - US 31W Bypass over Parkway - Obtain min. vertical clearance | Both | 0.044 | 135.689 | 135.733 | $4,952,000 | - | ✓ | | | No |

**Figure 24: Bridge Vertical Clearance Improvements**

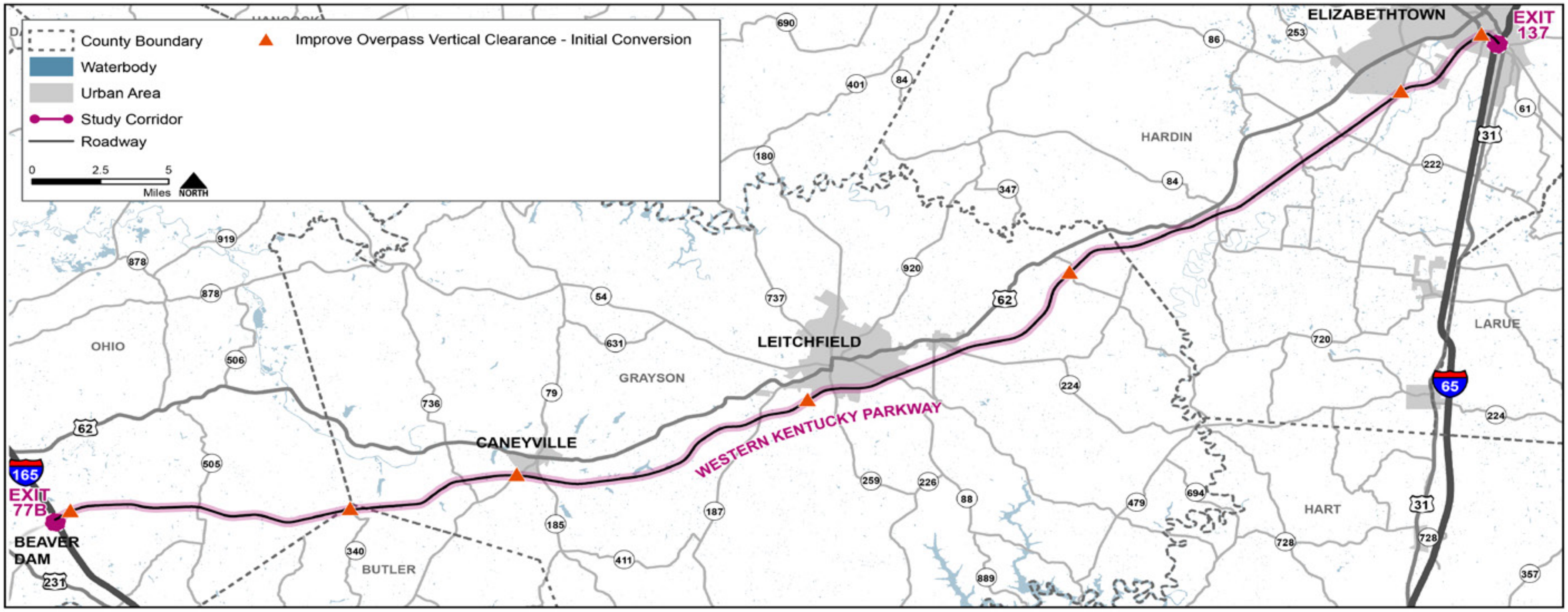


**Table 23: Acceleration and Deceleration Lane Length Improvements**

| Improvement | Measured Value (ft) | Design Standard (ft) | Deficiency (ft) | Direction | Cost (2021 $) | Initial Conversion | Full Compliance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|
| Exit 94 – KY 79 - Extend WB acceleration lane to 580 feet | 325 | 580 | 255 | WB | $184,000 | ✓ | | No |
| Exit 107 - KY 259 - Extend EB deceleration lane to 390 feet | 330 | 390 | 60 | EB | $52,000 | ✓ | | Yes |
| Exit 124 – KY 84 - Extend WB acceleration lane to 580 feet | 475 | 580 | 105 | WB | $187,000 | ✓ | | No |

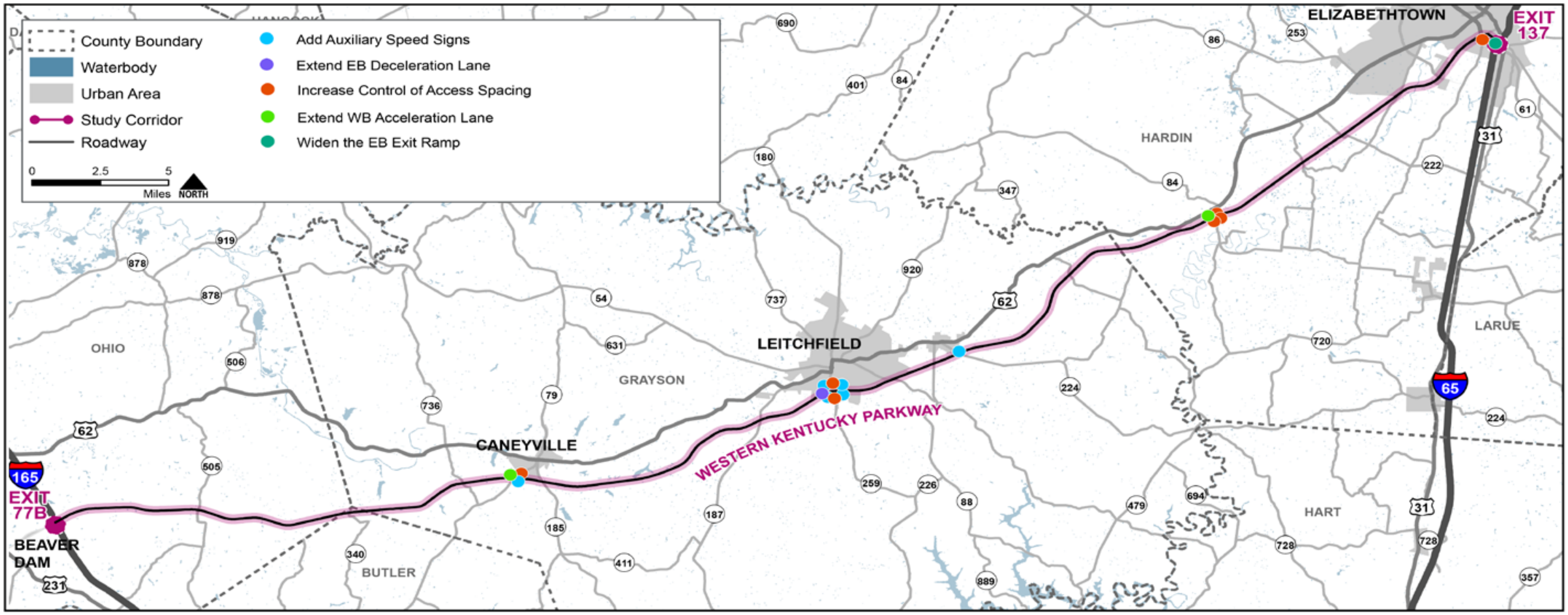
**Table 24: Ramp Lane Width Improvements**

| Improvement | Measured Value (ft) | Design Standard (ft) | Deficiency (ft) | Direction | Cost (2021 $) | Initial Conversion | Full Compliance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|
| Exit 137 – I-65 Interchange - Widen the EB exit off ramp lane width by 1 foot | 14 | 15 | 1 | EB | $148,000 | | ✓ | No |

**Table 25: Ramp Superelevation Improvements**

| Improvement | 70% of Mainline Speed (mph) | Actual Design Speed (mph) | Deficiency (mph) | Direction | Cost (2021 $) | Initial Conversion | Full Compliance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|
| Exit 94 – KY 79 – Add auxiliary speed signs for 40 MPH on the EB on ramp | 50 | 40 | 10 | EB | $5,000 | ✓ | | No |
| Exit 107 – KY 259 - Add auxiliary speed signs for 30 MPH on the EB on ramp | 50 | 30 | 20 | EB | $5,000 | ✓ | | No |
| Exit 107 - KY 259 - Add auxiliary speed signs for 30 MPH on the WB on ramp | 50 | 30 | 20 | WB | $5,000 | ✓ | | No |
| Exit 107 - KY 259 - Add auxiliary speed signs for 30 MPH on the EB off ramp | 50 | 30 | 20 | EB | $5,000 | ✓ | | No |
| Exit 107 - KY 259 - Add auxiliary speed signs for 30 MPH on the WB off ramp | 50 | 30 | 20 | WB | $5,000 | ✓ | | No |
| Exit 112 – KY 224 - Add auxiliary speed signs for 35 MPH on the EB off ramp | 50 | 35 | 15 | WB | $5,000 | ✓ | | No |

**Figure 25: Interchange Improvement Locations**



### 6.3.3 Horizontal Alignments for Ramps

Six ramps along the WKP do not meet radius or superelevation requirements, which the design team recommended addressing by adding auxiliary speed signs to meet Interstate standards. **Table 25** shows the locations and costs associated with these improvements. The estimated cost for adding signage is $30,000. These locations are also shown in **Figure 25.**

### 6.3.4 Control of Access

Five locations along the WKP, listed in **Table 26,** do not meet the control of access requirements for Interstate standards. The standard is 300 feet for rural areas and 100 feet for urban areas. The Exit 94, KY 79 interchange does not meet the 300 feet required to the north of the interchange, shown in **Figure 26**. The cost to close this entrance and reduce the entrance width of the gas station is $500,000, which includes the cost to purchase the entire property whose driveway will be closed, as it will become a landlocked property and will become the responsibility of the property owner to purchase land for a new entrance. The Exit 124, KY 84 interchange has 2 offset ramps in the eastbound direction, and both have entrances within the 300-foot distance that would need to be relocated. There is also an entrance to the north of the westbound ramps that would need to be relocated. **Figure 27** shows where these access points would be moved, with a total cost of $3,531,000 to relocate all three. Exit 136, US 31W Bypass has a driveway directly across from the eastbound exit ramp. This access point would be closed, and the road would connect to New Glendale Road, as shown in **Figure 28**. The estimated cost is $1,339,000.

**Figure 26: Exit 94, KY 79 Control of Access Improvement**

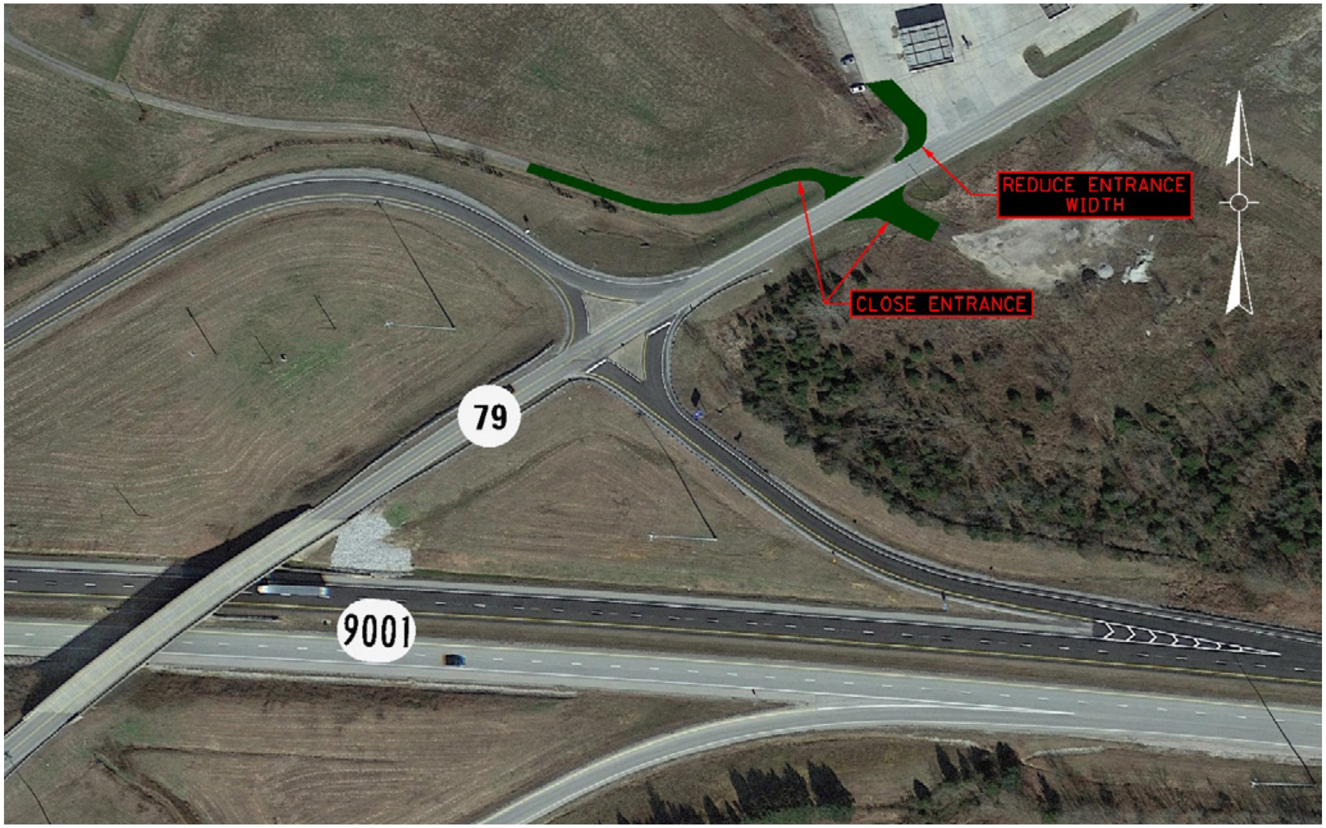


**Table 26: Control of Access Improvement Locations**

| Improvement | Measured Value (ft) | Design Standard (ft) | Deficiency (ft) | Direction | Cost (2021 $) | Initial Conversion | Full Compliance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|---|---|---|
| Exit 94 – KY 79 – Increase control of access spacing to 300 feet north of interchange | 180 | 300 | 120 | WB | $500,000 | ✓ | | No |
| Exit 124 – KY 84 – Increase control of access spacing to 300 feet south of interchange | 50 | 300 | 250 | EB | $2,000,000 | ✓ | | Yes |
| Exit 124 – KY 84 – Increase control of access spacing to 300 feet south of interchange | 120 | 300 | 180 | EB | $138,000 | ✓ | | No |
| Exit 124 – KY 84 – Increase control of access spacing to 300 feet north of interchange | 160 | 300 | 140 | WB | $1,393,000 | ✓ | | No |
| Exit 136 – US 31W Bypass – Increase control of access spacing to 100 feet south of interchange | 0 | 100 | 100 | EB | $1,339,000 | ✓ | | Yes |

**Figure 27: Exit 124, KY 84 Control of Access Improvement**

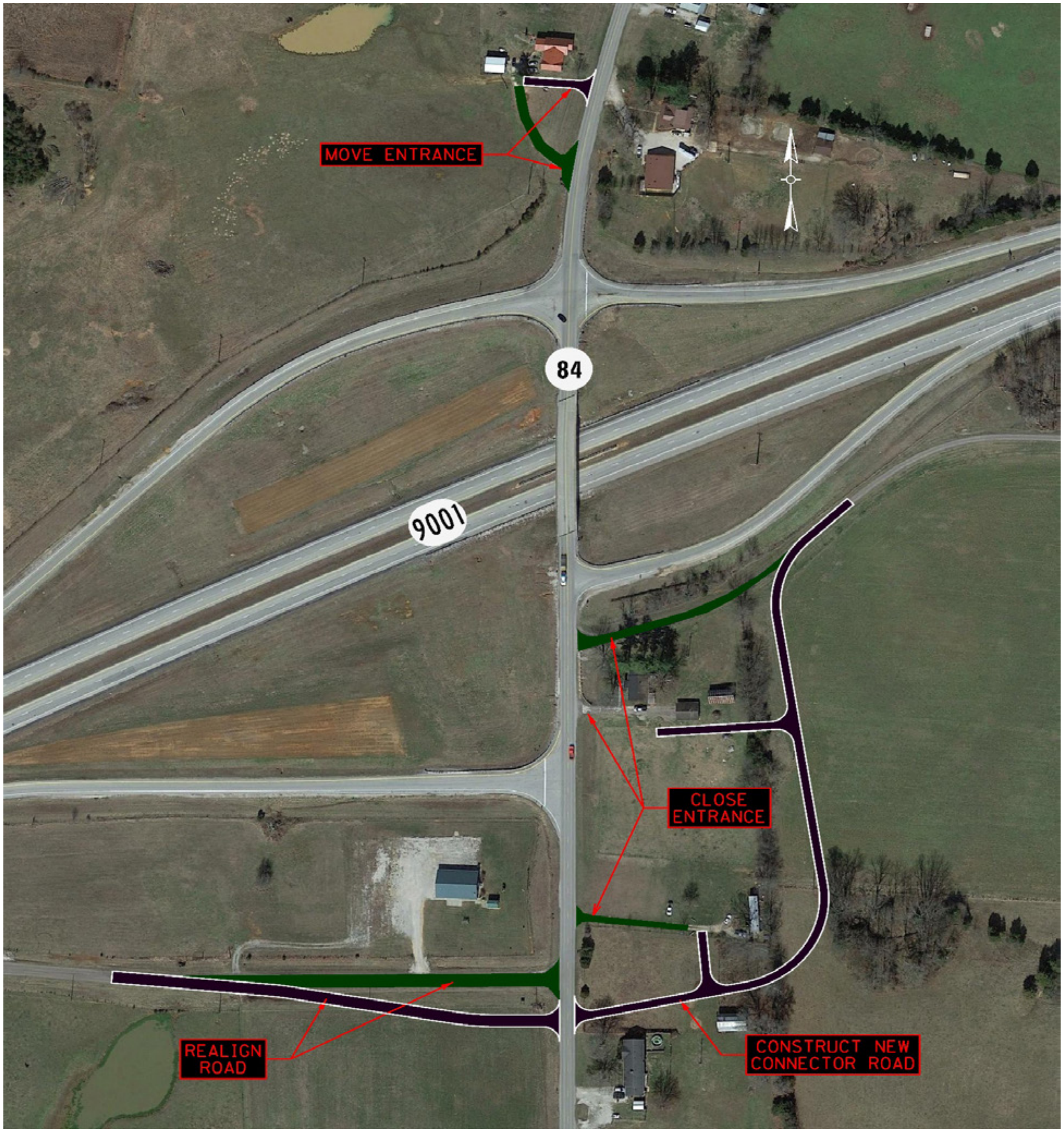


**Figure 28: Exit 136, US 31W Bypass Control of Access Improvement**

### 6.3.5 Interchange Spacing and Potential Improvement Concepts

Two interchanges along the WKP are less than one mile apart, which does not meet the Interstate standard for urbanized areas. Exit 136 (US 31W) and Exit 137 (I-65) are 0.7 mile apart. There are other Interstate standards that are not met in this area; therefore, a phased approach was used to address the various categories. Phase 1, **Figure 29**, addresses the interchange spacing, superelevation, and bridge vertical clearance standards that are not met by adding an auxiliary lane in each direction between the two interchanges, increasing the superelevation along the curve between the interchanges, and increasing the vertical clearance of the KY 1136 overpass bridge. The cost estimate for Phase 1 is $11,000,000 and would likely be required before conversion of the WKP to an Interstate. Phase 2, **Figure 30**, provides a direct connection from I-65 SB to US 31W Bypass, which would improve the weave between the two interchanges, improving safety. The cost estimate for Phase 2, assuming Phase 1 is completed, is $5,500,000. This would likely be able to be constructed after the Interstate conversion process is complete. There are two options for Phase 3, both of which would likely not need to be completed prior to Interstate conversion. Phase 3A, **Figure 31**, provides a direction connection from I-65 NB and the Lincoln Parkway to US 31W, eliminating the weave between the two interchanges in the westbound direction. The cost of Phase 3A, assuming Phases 1 and 2 are complete, is $31,000,000. Phase 3B, **Figure 32**, braids movements from I-65 NB, SB, and Lincoln Parkway to provide a direct connection to US 31W, also eliminating the weave in the westbound direction. The cost of Phase 3B, assuming Phases 1 and 2 are complete, is $18,000,000. **Table 27** shows the potential improvement concepts and costs associated to improve the Exit 136 and Exit 137 interchange system.

**Table 27: Potential Improvement Concepts for Exit 136 to Exit 137 Interchange Redesign**

| Phase | Potential Improvement Concept | Cost (2021 $) | Initial Conversion | Full Compliance | Possible Design Related Safety Issue |
|---|---|---|---|---|---|
| 1 | Add auxiliary lanes and increase superelevation / bridge clearances | $11,000,000 | ✓ | | Yes |
| 2 | Provide direct connection from I-65 SB to US 31W | $5,500,000 | | ✓ | Yes |
| 3A | Provide direct connection from I-65 NB and Lincoln Parkway to US 31W | $31,000,000 | | ✓ | Yes |
| 3B | Braid movements from I-65 NB, SB and Lincoln Park-way to provide direct connection to US 31W | $18,000,000 | | ✓ | Yes |

Figure 29: **WKP at I-65 / US 31W Bypass Phase 1 Potential Improvement**

**Figure 30: WKP at I-65 / US 31W Bypass Phase 2 Potential Improvement**

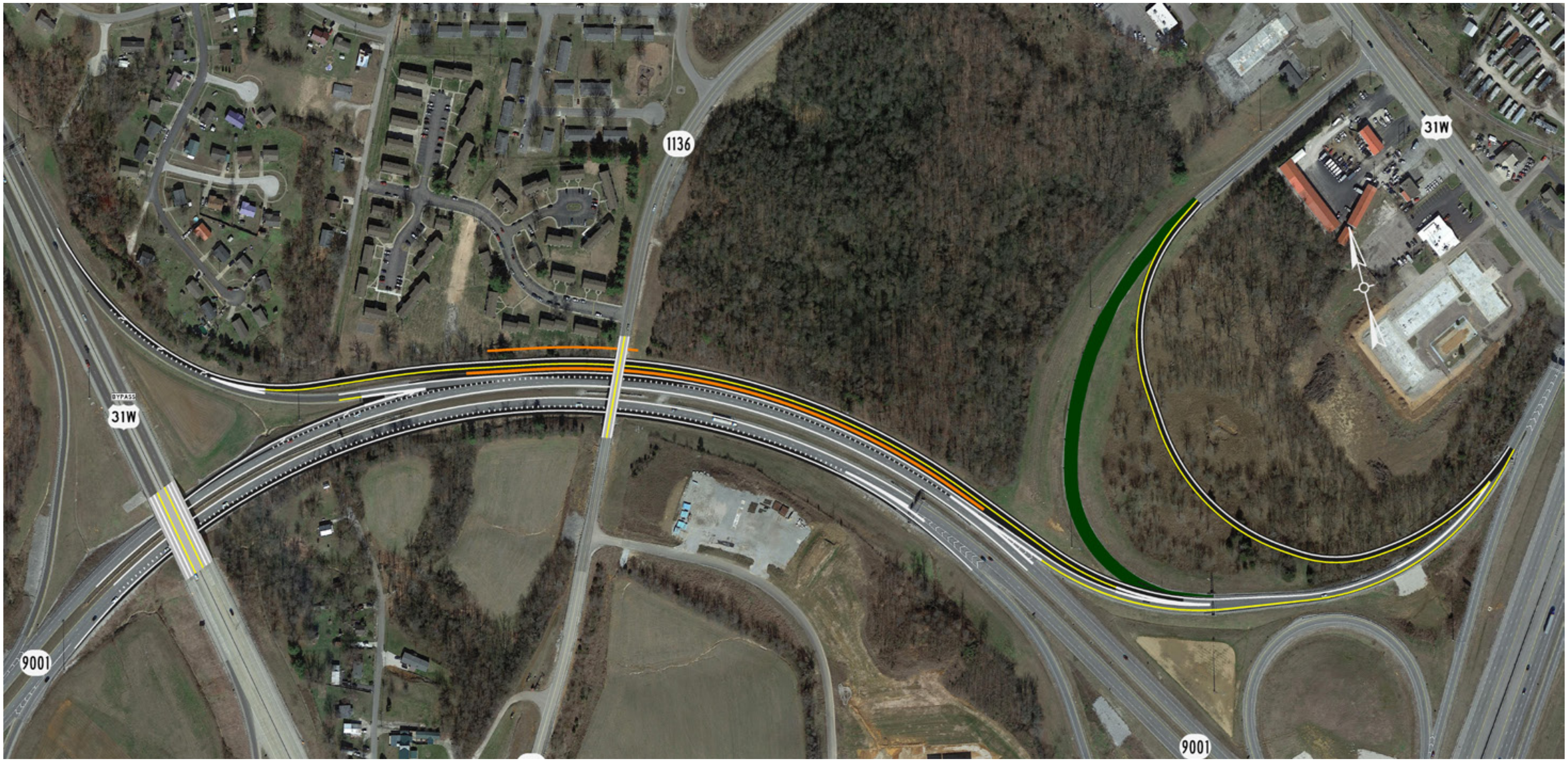


**Figure 31: WKP at I-65 / US 31W Bypass Phase 3A Potential Improvement**

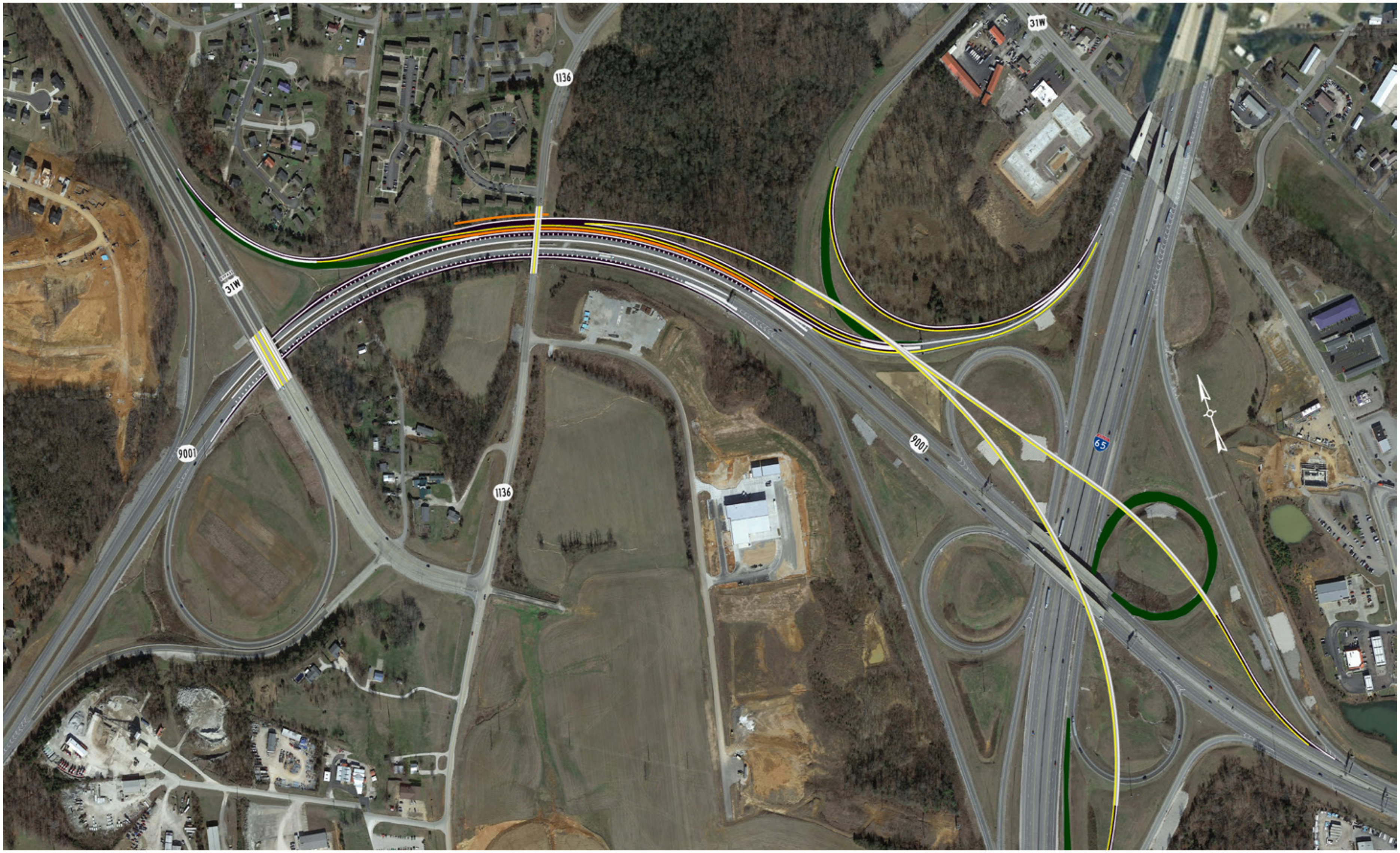
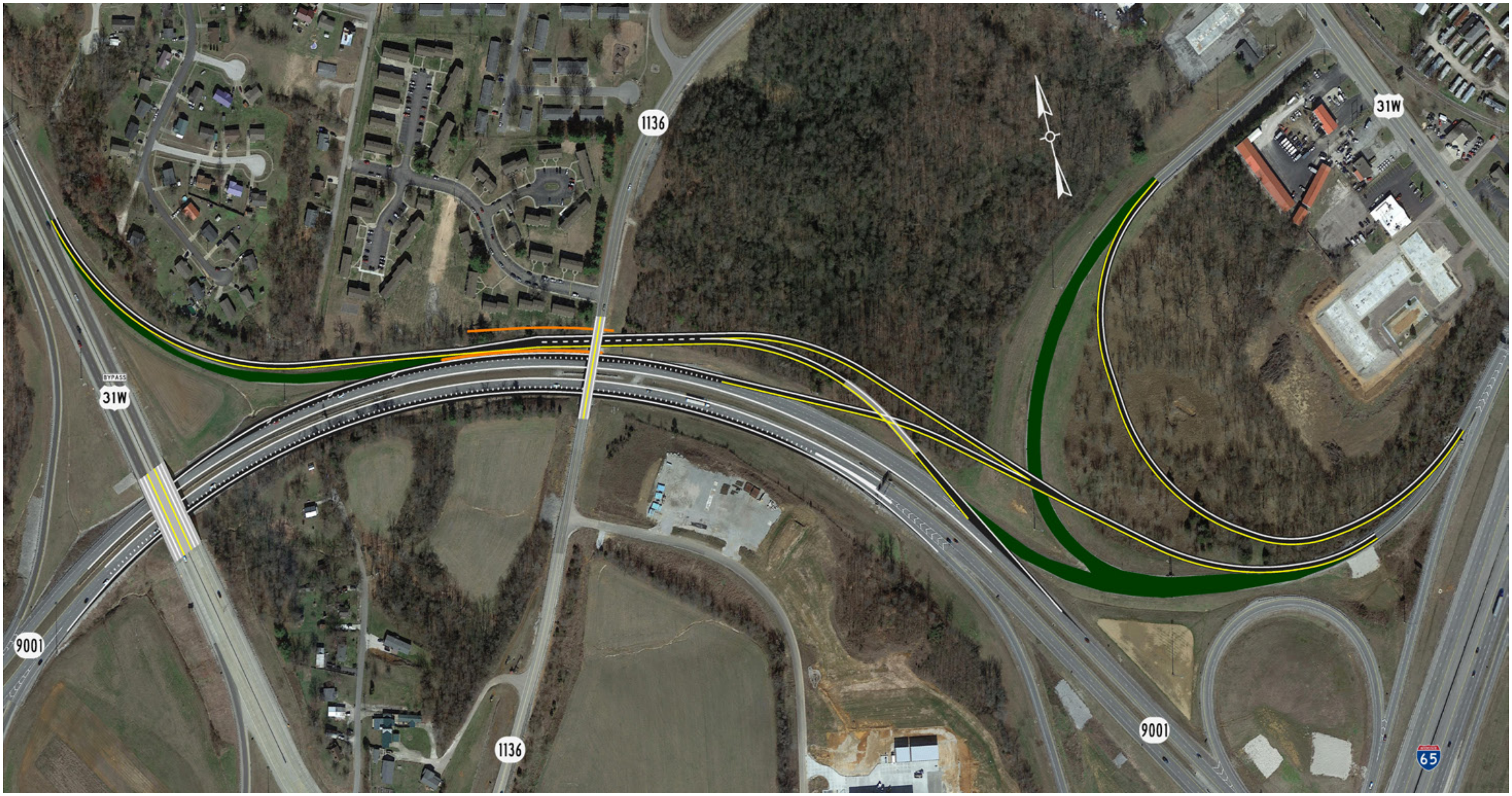


Figure 32: WKP at I-65 / US 31W Bypass Phase 3B Potential Improvement



## 6.4 Safety and Operational Improvements

### 6.4.1 Additional Improvement Locations

Additional improvements that would benefit safety and operations along the WKP within the study area were identified. These potential improvements are not required for the WKP to meet Interstate standards but are included as part of this study for further consideration by KYTC. **Figure 35** shows the locations of these improvements, and project sheets are included in **Appendix F**.

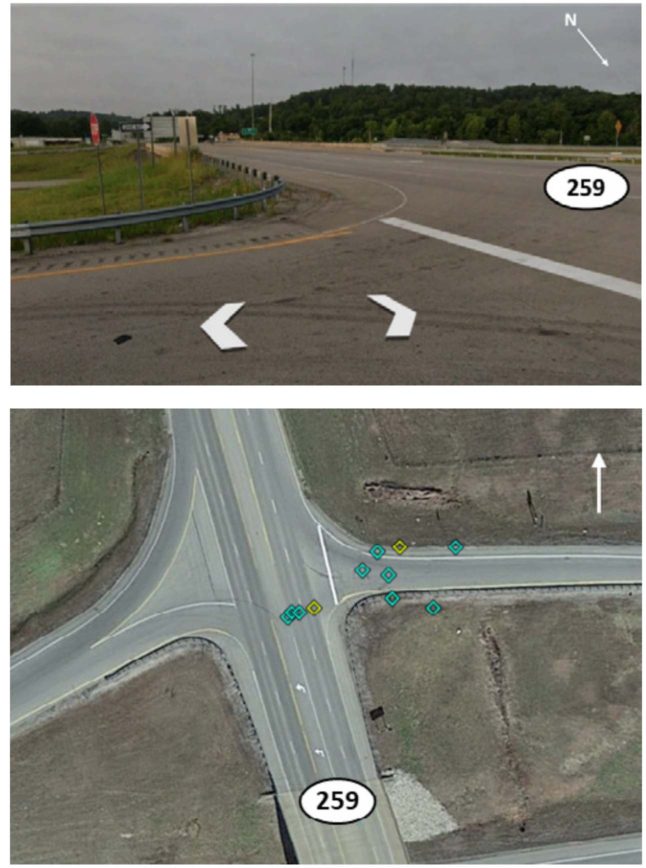
***WIDEN OUTSIDE SHOULDERS TO 12 FEET***

According to the **2018 Green Book**, the Interstate standard width for outside shoulders is ten feet, although 12-foot outside shoulder widths should be considered in sections where the truck DDHV is above 250 trucks. Most of the WKP within the study area carries less than the truck DDHV of 250, but the section from MP 133.833 to 136.796 has a truck DDHV over 250. The outside shoulders along this section could be widened to 12 feet with an estimated construction cost of $894,526. While this improvement would benefit safety, it is not driven by current safety concerns.

***RAMP TERMINAL DESIGN***

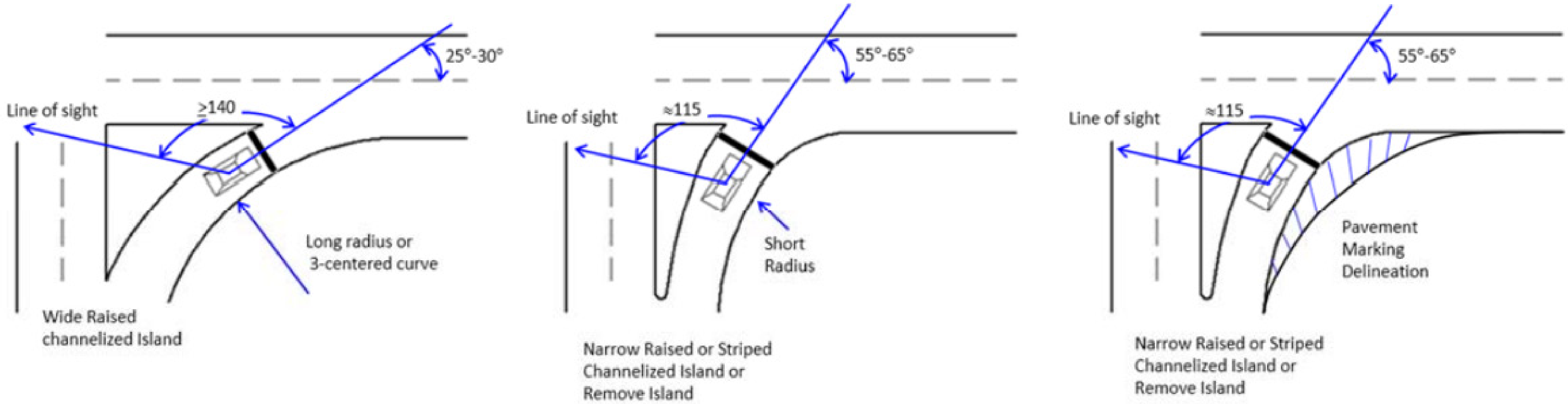
A high number of crashes were identified at the end of the westbound off-ramp to Exit 107 (KY 259). Many of these crashes appeared to be related to the ramp terminal design. **Figure 33** shows the location of crashes next to a Google Earth Street View image looking north from the channelized right turn lane. One potential improvement that could be considered for this location is to restripe the ramp terminal intersection as well as the approach and departure legs on the cross-street. KY 259 northbound just north of the intersection has a wide right lane. This could be restriped so that the intersection and cross-street all have 12-foot or even 11-foot lanes, clarifying where drivers are expected to travel. Additionally, the design could maintain a tight right-turn radius similar to the “Smart Right Turn” shown in **Figure 34**. The “Smart Right Turn” design approach has resulted in right turn crash reductions of 47% according to recent research.[4] The estimated construction cost for this improvement is $10,000.

**Figure 33: Exit 107 (KY 259) Westbound Off-Ramp Crashes and Sight Distance Issues**




4 Barua, U. “Safety Effect of Smart Right-Turn Design at Intersections.” ITE Journal, (November 2018) pp. 38-43.

**Figure 34: Potential Modification to Channelized Right Turn Design**

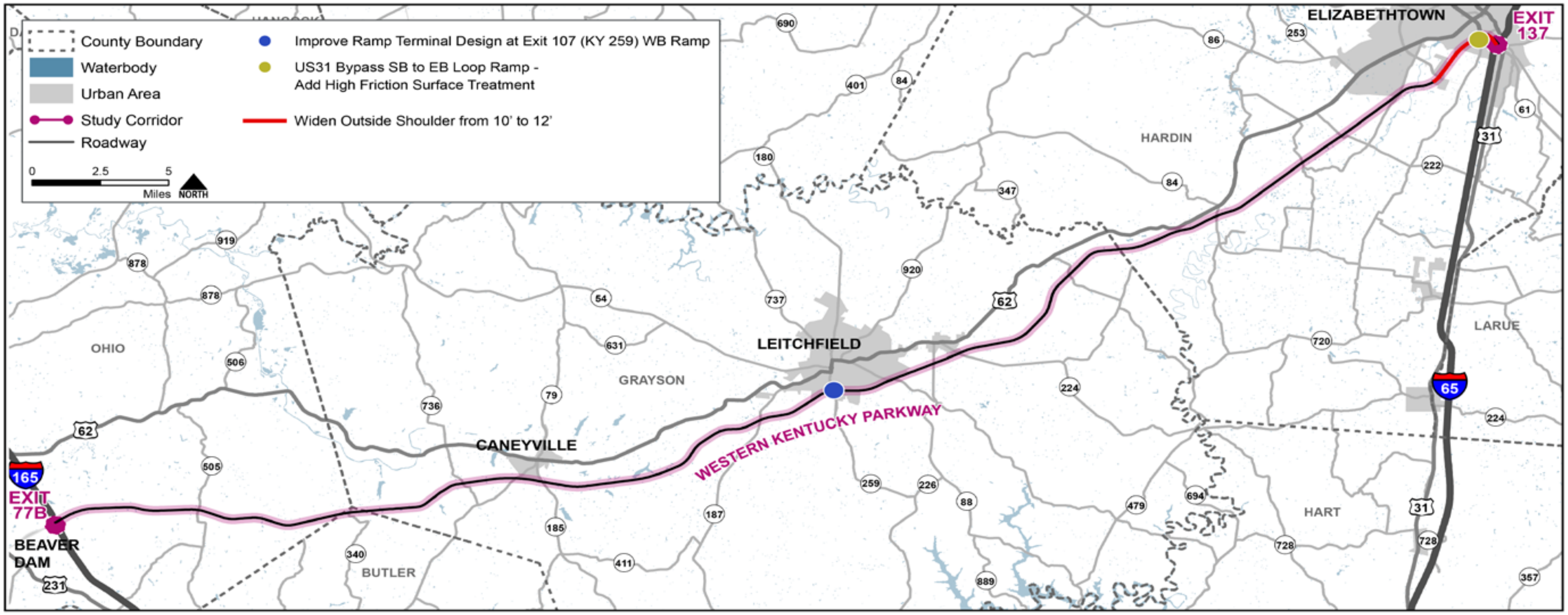



Source: Illinois Center for Transportation (2016)

### *SAFETY IMPROVEMENTS AT US 31 BYPASS*

The US 31 southbound to eastbound on-ramp to the WKP was flagged during project team discussions as a ramp where rollover crashes occur. To mitigate the rollover crashes, it is suggested to add high friction surface treatment (HFST) to the ramp. A review of the 2015 to 2019 crash data showed eight crashes on the ramp and eight crashes in the merging area. The crashes include one serious injury crash, one minor injury crash, one possible injury crash, and 12 property damage only crashes. Nine of the crashes occurred during wet roadway conditions. The severe injury crash involved a tractor trailer overturning in 2018. The minor injury crash involved a pick-up truck running off the road during wet weather conditions. Based on the number and severity of crashes on this ramp, HFST is recommended with an estimated cost of $198,333. It is also recommended that the ramp continue to be monitored.

**Figure 35: Additional Safety and Operational Improvement Locations**



### *ADD CABLE MEDIAN BARRIER*

Guidance in the ***2011 Roadside Design Guide*** for the placement of cable median barriers to prevent median crossover crashes and enhance safety is based on the roadway average daily traffic and the width of the median. This guidance for placement is classified into three categories; barrier recommended, barrier considered, barrier optional. From this guidance only one location falls within the barrier recommended category, which is from MP 133.833 to MP136.796 (see **Figure 36**). This section meets the median width and traffic volume thresholds for warranting barrier installation.

The remaining portion of the WKP falls within the barrier optional category due to the lower traffic volumes. A review of crash data (see **Figure 5)** was performed to determine where median crossover crashes occurred and a high-level benefit cost analysis was performed to determine where the addition of cable median barriers would be most beneficial. Crash data showed that there were 88 median crossover crashes from 2015 to 2019, including 10 fatal or serious injury. The data was examined to identify priority sections for considering additional median barrier to prevent these severe median-crossover crashes.

To evaluate the corridor, the areas with the highest number of severe cross-median crashes were selected. This screening resulted in three sections (See **Figure 36**) of the WKP being identified for analysis. Crash modification factors (CMFs) for cable median barrier were then applied to these three areas. The cable median barrier CMFs range by severity from 0.38 for fatal injury crashes (a reduction of 62%) to 2.08 for property damage only crashes (an increase of 108%). Based on using these CMFs it is expected that severe crashes would decrease in each of these areas, while total crashes would increase. Adding the cable median barrier in all three areas could potentially prevent 8 fatal and serious injury crashes over 10 years, while the number of total crashes (mainly property damage only) would increase by 80. **Table 28** provides the median cross-over crashes that occurred within each segment between 2015 and 2019.

The estimated construction cost of adding a median barrier for the given lengths is expected to be $6.75M (in 2021 dollars). The benefit cost ratio for the installations is presented in **Table 29**. This table provides cost and crash benefit information for the four cable median barrier segments and takes into account the ongoing future maintenance costs. This benefit cost analysis resulted in all three segments with a median cross-over crash history having a benefit cost ratio greater than 1.0. The 4th segment, although recommended for cable barrier installation based on the volume of traffic and median width did not have a positive benefit cost ratio due to the low number of preventable crashes.

**Table 28: Median Cross-Over Crashes by Segment**

| Cable Barrier Segment | Begin MP (miles) | End MP (miles) | Fatal Crash (K) | Serious Injury Crash (A) | Minor Injury Crash (B) | Possible Injury Crash (C) | Property Damage Only Crash (O) | Total Crashes |
|---|---|---|---|---|---|---|---|---|
| 1 | 123.630 | 133.042 | 2 | 1 | 1 | 2 | 11 | 17 |
| 2 | 112.042 | 123.177 | 2 | 1 | 5 | 3 | 21 | 32 |
| 3 | 94.442 | 106.801 | 1 | 1 | 0 | 4 | 9 | 15 |
| 4 | 133.124 | 136.450 | 0 | 0 | 0 | 0 | 1 | 1 |

**Table 29: Benefit Cost Analysis for Installing Cable Median Barrier (All values in 2019 Dollars)**

| Cable Median Barrier Segment[1] | Start MP | End MP | Length (miles) | Construction and Maintenance Cost (Millions)[2] | Prevented Severe (KA) Crashes (10 years) | Safety Benefit (Millions)[3] | Benefit / Cost Ratio[2] |
|---|---|---|---|---|---|---|---|
| 1 | 123.630 | 133.042 | 9.4 | $1.80 | 3.2 | $16.7 | 9.3 |
| 2 | 112.042 | 123.177 | 11.1 | $2.1 | 3.2 | $16.9 | 7.9 |
| 3 | 94.442 | 106.801 | 12.4 | $2.4 | 1.8 | $8.4 | 3.5 |
| 4 | 133.124 | 136.450 | 3.3 | $0.7 | 0 | $0 | 0.0 |
| Total | | | 36.2 | $7.0 | 8.2 | $42.0 | |

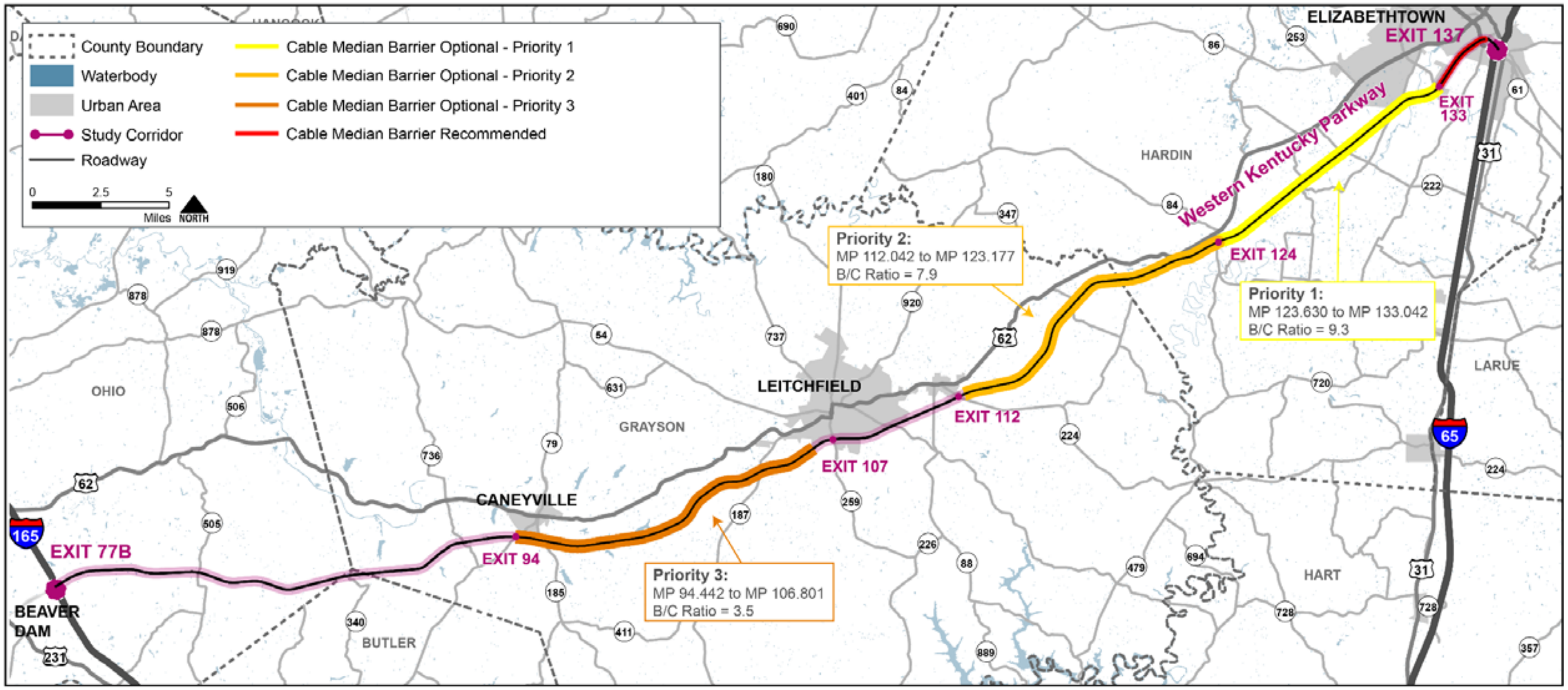
*NOTE: All costs in this table in 2019 dollars to match USDOT 2019 crash costs*

*1 Segment order based on benefit cost (highest to lowest)*

*2 This value includes 10 years of maintenance costs. The range varies depending on the selected barrier type.*

*3 10 years of predicted safety benefits. Value discounted to present value using 7% discount rate.*

**Figure 36: Cable Median Barrier Locations**



### 6.4.2 Median Turnarounds

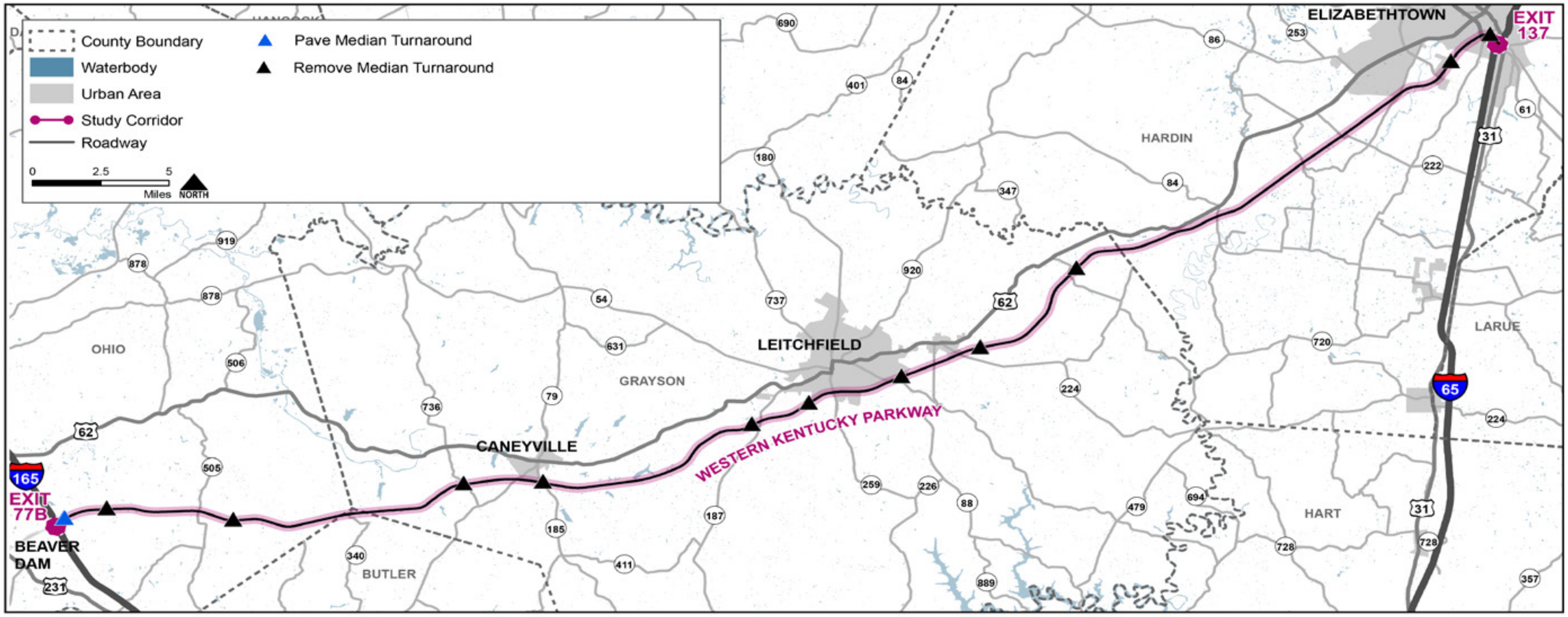
As noted in the existing conditions section, 26 median turnarounds exist along the WKP. Of the 26 median turnarounds, 12 are not required by Interstate standards, meaning the spacing is less than three miles from another median turnaround or interchange nor are the turnarounds located at a county line. Changes to the median turnarounds are not required as part of upgrading the WKP to an interstate, therefore, the cost of these changes are not included as part of the cost to upgrade the WKP, and are instead included as an additional operational recommendation. The KYTC districts requested to keep one of the 12 unrequired median turnarounds, keeping that median turnaround open for maintenance, snow and ice operations, dead animal and debris pickups, and emergency vehicle use. The total cost to remove 11 median turnarounds would be $132,000.

One of the turnarounds that are remaining is an unpaved turnaround prior to a crash cushion near an overpass. It is recommended to pave this median turnaround, as the district would like to keep it for maintenance purposes.  This would cost approximately $10,000. Median turnaround locations that are recommended for removal or pavement are listed in **Table 30** and shown in **Figure 37**.

**Table 30: Median Turnaround Recommendations**

| Improvement | Median Mile point | Median Turnaround Needed? | Condition | Cost (2021$) |
|---|---|---|---|---|
| Remove median turnaround | 78.709 | No | Not required by district | $12,000 |
| | 83.43 | No | Not required by district | $12,000 |
| | 92.314 | No | Not required by district | $12,000 |
| | 95.198 | No | Not required by district | $12,000 |
| | 103.681 | No | Not required by district | $12,000 |
| | 105.944 | No | Not required by district | $12,000 |
| | 109.577 | No | Not required by district | $12,000 |
| | 112.681 | No | Not required by district | $12,000 |
| | 117.771 | No | Not required by district | $12,000 |
| | 134.137 | No | Not required by district | $12,000 |
| | 135.949 | No | Not required by district | $12,000 |
| Pave median turnaround | 77.1 | Yes | Unpaved | $10,000 |

**Figure 37: Median Turnaround Improvement / Removal Locations**



## 6.5 Cost Estimates

Planning level construction cost estimates were developed in 2021 dollars for all of the improvements listed. Costs were separated into costs for initial conversion, these being improvements that should be made before the Parkway is converted to an Interstate (initial conversion), and costs for full compliance. The cost estimates for additional safety and operational improvements are shown separately, as those are not required for compliance with Interstate standards but are recommended as part of this study. An additional 15% is added to the construction cost to account for design and environmental related costs, and another 15% is added to the construction cost to account for any miscellaneous items. **Table 31** shows the cost estimates for all improvements likely to be required for initial conversion of the WKP to an interstate. A low and high range of cost estimates are shown. The low end of the range assumes the ability to lower the pavement under certain bridges to achieve vertical clearance, while the high range assumes those bridges will need to be replaced. **Table 32** shows the cost estimates for all improvements necessary for full compliance with Interstate design standards, with the same low to high range. In addition to the range in cost for structures, the low end of the range assumes the ultimate build out of the US 31W and I-65 interchanges will be Option 3B, while the high end assumes Option 3A. **Table 33** shows the cost estimates for the recommended safety and operational improvements.

**Table 31: Cost Estimates for Initial Conversion to Interstate Design Standards**

| Description | Low | High |
|---|---|---|
| Total Initial Conversion Cost (2021 $) | $56,520,299 | $64,164,689 |
| Total Initial Conversion Construction Cost | $43,477,153 | $49,357,453 |
| Design + Environmental (15%) | $6,521,573 | $7,403,618 |
| Miscellaneous (15%) | $6,521,573 | $7,403,618 |

**Table 32: Cost Estimates for Full Compliance with Interstate Design Standards**

| Description | Low | High |
|---|---|---|
| Total Full Compliance Cost (2021 $) | $102,591,683 | $127,136,073 |
| Total Full Compliance Construction Cost | $78,916,679 | $97,796,979 |
| Design + Environmental (15%) | $11,837,502 | $14,669,547 |
| Miscellaneous (15%) | $11,837,502 | $14,669,547 |

**Table 33: Cost Estimates for Additional Safety and Operational Improvements**

| Description | Cost |
|---|---|
| Total Operational and Safety Improvement Cost (2021 $) | $10,393,318 |
| Total Operational and Safety Improvement Construction Cost | $7,994,860 |
| Design + Environmental (15%) | $1,199,229 |
| Miscellaneous (15%) | $1,199,229 |

## 6.6 Recommendations

**Table 34** shows a summary of all of the recommendations to upgrade the WKP to Interstate standards. **Table 35** shows a summary of the additional safety and operational improvements recommended as part of this study. Detailed tables are included in **Appendix F**.

**Table 34: Summary of Recommended Improvements to Upgrade the WKP to Interstate Standards**

| Mainline | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Category** | **Subcategory** | **Miles** | **Cost (2021$)** | **Initial Conversion** | **Full Compliance** | **Requires DE** | **Requires DV** | **Safety Issue** |
| Shoulders | Widen inside shoulder to consistent 4 foot minimum | 17.147 | $2,546,000 | ✓ | | | | Yes |
| Superelevation | Increase superelevation (locations with safety issues) | 7.32 | $10,309,000 | ✓ | | | | Yes |
| | Increase superelevation (locations without safety issues) | 1.86 | $1,208,000 | | ✓ | ✓ | | No |
| Headlight Sight Distance | Increase curve length | 0.552 | $1,608,000 | | ✓ | | ✓ | No |
| Guardrail | Replace damaged guardrail | 13.8 | $2,565,240 | ✓ | | | | No |
| | Regrade crash cushions | - | $10,000 | ✓ | | | | No |
| | Raise guardrail height to 31 inches at areas with safety issues | 4.986 | $1,401,413 | ✓ | | | | Yes |
| | Replace all guardrail less than 31 inches | 25.7 | $4,949,360 | | ✓ | | | No |
| Clear Zone | Add guardrail where clear zone is not met | 12.818 | $2,443,766 | | ✓ | | | Yes |
| **Interchanges** | | | | | | | | |
| Ramps - Accel/ Decel | Exit 94 (KY 79) Increase WB accel length to 580’ | 1 | $184,000 | ✓ | | | | No |
| | Exit 107 (KY 259) Increase EB decel length to 390’ | 1 | $52,000 | ✓ | | | | Yes |
| | Exit 124 (KY 84) Increase WB accel length to 580’ | 1 | $187,000 | ✓ | | | | No |
| Lane Width | Exit 137 (I-65) Increase EB cloverleaf off ramp lane width to 15 feet | 1 | $148,000 | ✓ | | | | No |
| Superelevation | Add auxiliary speed signs | 6 | $30,000 | ✓ | | | | Yes |

*DE = Design Exception, DV = Design Variance*

**Table 34: Summary of Recommended Improvements to Upgrade the WKP to Interstate Standards**

| Mainline | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Category** | **Subcategory** | **Miles** | **Cost (2021$)** | **Initial Conversion** | **Full Compliance** | **Requires DE** | **Requires DV** | **Safety Issue** |
| Control of Access | Increase control of access to 300 feet (rural) or 100 feet (urban) | 5 | $5,370,000 | ✓ | | | | Yes |
| Interchange Spacing / Reconfiguration | Exit 137 (I-65) Phase 1: Add auxiliary lanes and increase superelevation / bridge clearances | N/A | $11,000,000 | ✓ | | | | Yes |
| | Exit 137 (I-65) Phase 2: Provide direct connection from I-65 SB to US 31W Bypass | N/A | $5,500,000 | | ✓ | | | Yes |
| | Exit 137 (I-65) Phase 3A: Provide direct connection from I-65 NB and Lincoln Parkway to US 31W | N/A | $31,000,000 | | ✓ | | | Yes |
| | Exit 137 (I-65) Phase 3B: Braid movements from I-65 NB, SB, and Lincoln Pkwy to provide direct connection to US 31W | N/A | $18,000,000 | | ✓ | | | Yes |
| **Bridges** | | | | | | | | |
| Bridge Railing | Replace metal railing | 6 | $526,000 | ✓ | ✓ | | | Yes |
| Bridge Width | Widen bridge 7.5 feet | 6 | $2,169,600 | ✓ | ✓ | | | Yes |
| Bridge Vertical Clearance | Replace bridge or lower pavement to achieve minimum vertical clearance | 7 | $8,719,300 | ✓ | | | | Yes |
| | Replace bridge to achieve minimum vertical clearance | 7 | $14,599,600 | ✓ | | | | Yes |

*DE = Design Exception, DV = Design Variance*

**Table 35: Summary of Recommended Additional Safety and Operation Improvements**

| Category | Subcategory | Length | Cost (2021) | Possible Design Related Safety Issue |
|---|---|---|---|---|
| Shoulders and Cable Median Barrier | Widen outside shoulders to 12 feet | 3.326 | $894,526 | Yes |
| | Add cable median barrier | 54.094 | $6,750,000 | Yes |
| Median Turnarounds | Remove median turnarounds | N/A | $132,000 | No |
| | Pave median turnaround | N/A | $10,000 | No |
| Interchange Ramp Improvements | Improve ramp terminal at Exit 107 (KY 259) WB ramp | N/A | $10,000 | Yes |
| | US31 Bypass SB to EB Loop Ramp - Add High Friction Surface Treatment | 0.32 | $198,333 | Yes |

# 7 Next Steps

Following completion of the study, KYTC will coordinate with FHWA to determine which items will be required for conversion of the Parkway to an interstate. The resulting project(s) will be considered a federal action and therefore it must adhere to the processes outlined in the National Environmental Policy Act (NEPA). This policy requires that environmental, social, and economic effects be assessed and considered in the decision-making process. The environmental process culminates in a FHWA-approved environmental document. These projects may require funding for all phases to be appropriated in future Kentucky Highway Plans.

## 7.1 Contacts

Written requests for additional information should be sent to the KYTC Division of Planning Director, 200 Mero Street, Frankfort, Kentucky 40622.

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KENTUCKY
TRANSPORTATION
CABINET

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