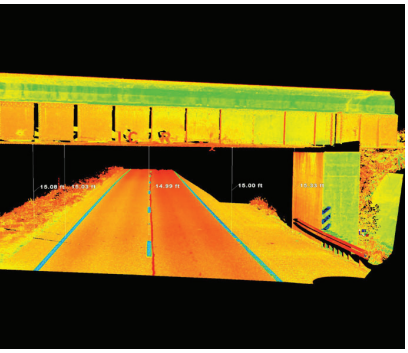
June, 2020

Western Kentucky Parkway Upgrade Study Final Report

KENTUCKY TRANSPORTATION CABINET

Hopkins, Muhlenberg, and Ohio Counties, KY

HMB Professional Engineers, Inc.



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Introduction

The Western Kentucky Parkway Upgrade Study was initiated by the Kentucky Transportation Cabinet (KYTC) to identify and evaluate potential improvement options to upgrade a portion of the parkway to interstate standards for inclusion into the interstate system. The portion under consideration for this study is between I-69 / Edward T. Breathitt Pennyrile Parkway (EBP) in Hopkins County (MP 38.326) and I-165 (formerly William H. Natcher Green River Parkway [WNP]) in Ohio County (MP 77.143). This includes interchanges with KY 175 (Exit 48), KY 181 (Exit 53), US 431 (Exit 58), and US 231 (Exit 75). Though not numbered as exits, the ramps associated with the Kentucky State Police (KSP) Post No. 2 and the Beaver Dam Rest Area (Huck's) are included as part of the study considerations. The system interchanges with I-69 and I-165 are not included as part of the evaluation area. KYTC and the Federal Highway Administration (FHWA) concurred at the Western Kentucky Parkway Upgrade Scoping Meeting, held April 23, 2019, that both system interchanges were felt to be appropriate as configured and did not require additional consideration at this time. **Figure ES-1** depicts the study area location for reference.

Study Objective and Goals

Objective

The *Objective* of the Western Kentucky Parkway (WKP) Upgrade Study is to identify and evaluate potential improvement options to upgrade a portion of the WKP to interstate standards between I-69 in Hopkins County (MP 38.326) and I-165 in Ohio County (MP 77.143) for inclusion into the interstate system.

Study Goals

To achieve the desired outcomes noted above, the following goals were identified:

- Consider system linkage – connectivity between I-69 and I-165
- Evaluate safety
- Identify roadway deficiencies – relative to interstate standards
- Prepare upgrade options and planning-level cost estimates

Study Design Considerations

According to the FHWA memorandum "Revisions to the Controlling Criteria for Design and Documentation for Design Exceptions" dated May 5, 2016, there are ten (10) criteria considered controlling for the design features that define the operational and safety performance of a highway. These include:

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

In this study, these design features for the WKP were evaluated for compliance with AASHTO and KYTC design criteria for an interstate facility. **Table ES-1** summarizes the design standards and notes the guidelines for each of the identified design features noted above.

Figure ES-1. Study Area

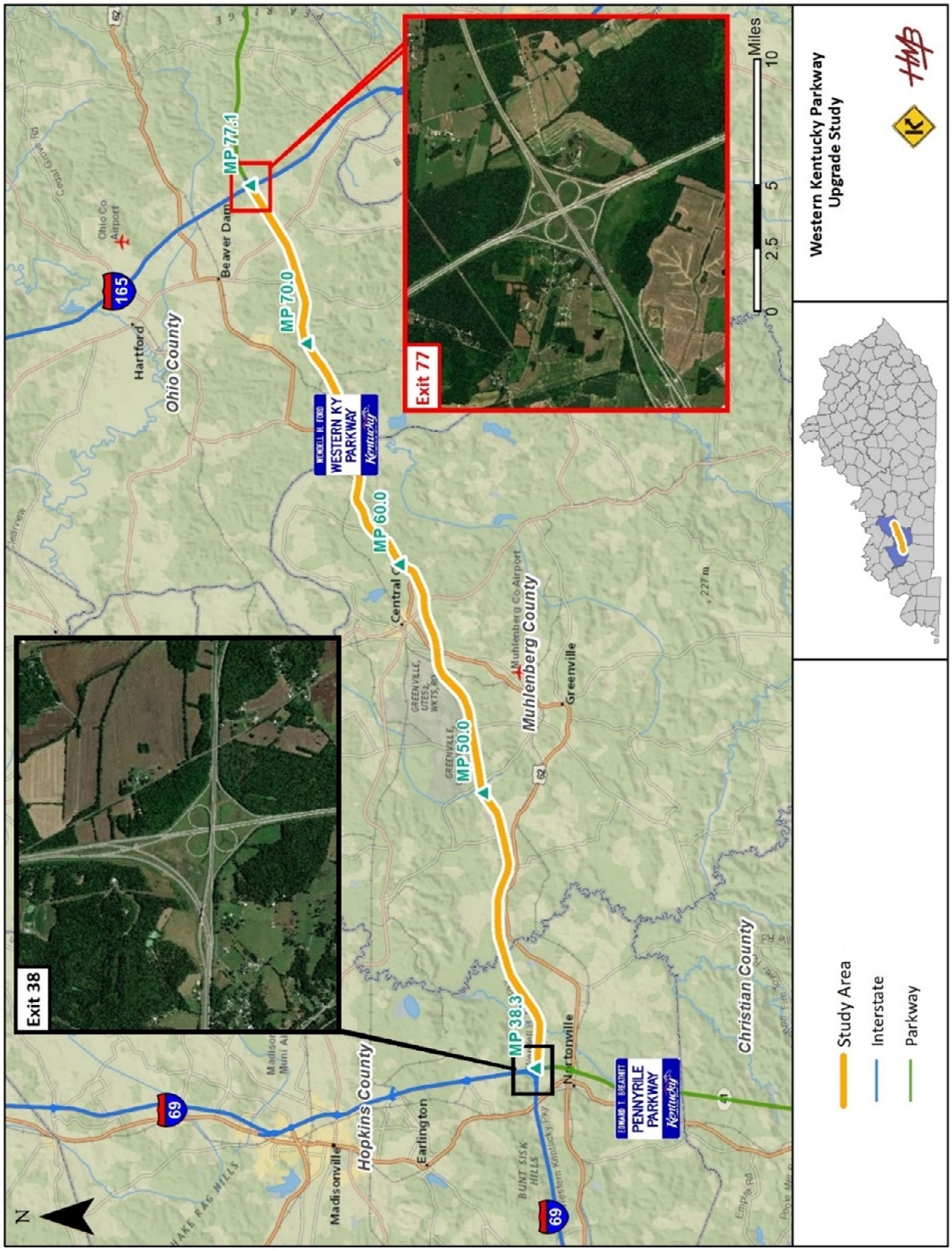

Table ES-1. Design Criteria for Rural, 4-Lane Interstate Facilities

Design Element	Governing Agency	Reference	Mainline	Ramps	Loops	Design Exception	Design Variance	Other Considerations
Design Speed	AASHTO	2018 Green Book	70 mph	35 mph	20 mph	✔		
Lane Width	AASHTO	2018 Green Book	12'	14'	15'	✔		
Inside Shoulder	AASHTO	2018 Green Book	4'	2'-4'		✔		
Outside Shoulder								
Tuck DDHV <= 250	AASHTO	2018 Green Book	10'	8'-10'		✔		
Truck DDHV > 250	AASHTO	2018 Green Book	12'			✔		
Median Width	AASHTO	Roadside Design Guide	30'-60'	N/A			✔	
Median Turnarounds	AASHTO	2018 Green Book	May be spaced at 3 to 4 mile intervals or as needed					✔
Clear Zone	AASHTO	Roadside Design Guide	30'-46'	10'-14'			✔	
Guardrail Height	KYTC	KYTC Standard Drawings	31"				✔	
Horizontal Alignment								
Superelevation	AASHTO	2018 Green Book	8% Max					
Minimum Radius	AASHTO	2018 Green Book	1810'	314'	134'	✔		
Cross Slopes	AASHTO	A Policy on Design Standards - Interstate System	Greater than 1.5%			✔		
Vertical Alignment								
Vertical Grade	AASHTO	A Policy on Design Standards - Interstate System/2018 Green Book	4%	4% - 8%		✔		
Crest Vertical Curves - Stopping Sight Distance	AASHTO	2018 Green Book	730'	250'	76'	✔		
Sag Vertical Curves - Head Light Sight Distance	AASHTO	2018 Green Book				✔		
Bridges and Overpasses								
Bridge Width <= 200 feet	AASHTO	A Policy on Design Standards - Interstate System	37.5'	N/A		✔		
Bridge Width > 200 feet	AASHTO	A Policy on Design Standards - Interstate System	31'	N/A		✔		
Overpass Vertical Clearance	AASHTO	A Policy on Design Standards - Interstate System	16'	N/A		✔		
Overhead Sign Vertical Clearance	AASHTO	2009 MUTCD	17'			✔		
Divergence Angle	AASHTO	2018 Green Book	2 to 5 degrees				✔	
Speed Change Lanes	AASHTO	2018 Green Book	Varies depending on the design speed of the entering or exiting curve				✔	
Interchange Spacing	AASHTO	2018 Green Book	2 miles				✔	
Interchange Control of Access	AASHTO	A Policy on Design Standards - Interstate System	300'				✔	

Study Information

A range of data was collected to inform the study process. The data and findings include the following:

Committed and Identified Projects

A summary of study area projects was compiled based on reviews of Kentucky's FY 2018 – FY 2024 and FY 2020 – FY 2026 Highway Plans and KYTC's Continuous Highway Analysis Framework (CHAF) database. No other phases of this project are identified in Kentucky's Fiscal Year (FY) 2020 – 2026 Highway Plan. There are other projects that are within the study area that would affect the study. These include multiple projects to address pavement condition of the WKP and interchange modifications at US 431, US 231, KY 1245, and at I-165. These are upcoming opportunities to address certain deficiencies that are already programmed.

Traffic Volumes and Analysis

According to functional classification criteria, the WKP is currently identified as an Expressway. Current year (2019) average annual daily traffic (AADT) volumes range from 10,000 – 11,200. Future year (2045) AADT volumes range from 13,000 – 14,500. The level of service evaluation that assesses roadway operation was found to be acceptable in both years at LOS A.

Crash Analysis

As part of this study, historical crash data was analyzed to identify high crash locations. Historical crash records were extracted from the Kentucky State Police's (KSP) *Collision Database* for a five-year period (January 1, 2014 – December 31, 2018). Seventy (70) high crash spots were identified using the Critical Crash Rate methodology defined in *Analysis of Crash Data in Kentucky (2014-2018)*. This means that there are 70 identified locations where the critical crash rate is greater statistically than the average crash rate (greater than 1.0) for similar roadways and represents a rate above which crashes may be occurring in a non-random fashion. An evolving analysis method was also used to evaluate crash patterns that is based on the Highway Safety Manual (HSM). Excess Expected Crashes (EEC) is a measure used to predict crash amounts. Positive EEC values indicate more crashes have occurred than expected in the segment. If the EEC is negative, it indicates that there are less crashes than expected. There was a total of 246.66 EEC per mile along the mainline of the WKP. This means more crashes occurred than what was predicted for that roadway type. Reviewing the type and severity of crashes, most of the crashes were single vehicle collisions, with almost one-third of those involving an animal. Looking at the detailed crash reports, there appeared to be a number of crashes that occurred during inclement weather with water pooling or snow / ice on the road.

Study Meetings

The project team consisting of KYTC, the Green River Area Development District (GRADD), the Pennyrile Area Development District (PADD), and the consultant met twice to discuss progress and next steps. Also, during the study, local officials and stakeholders were engaged to obtain their input and keep them informed of the process. At the first meeting, the project team presented the study purpose, project background, crash and traffic analysis, existing conditions, and next steps. Feedback was requested through comment forms. All respondents noted their support of the project. At the second (and final) meeting, the project team presented the study objectives and goals, study background, crash and traffic analysis update, the work item summary, and next steps. Attendees were given the opportunity to ask questions and provide input on the study findings.

Summary of Key Findings

Mainline Geometry / Typical Section

Design Speed/ Superelevation	26 horizontal curves do not meet a 70 mph design speed based on the relationship between each curve's radius and its superelevation rate. The maximum allowable side friction factor (0.10) for 70 mph was not exceeded.
Lane Width	Lane widths are 12 feet which meets minimum guidelines for an interstate facility.
Shoulder Width	Left shoulder widths are 4-foot and right shoulder widths are 10-foot which meets minimum guidelines for an interstate facility.
Median Width	Median is a 30-foot depressed median which does not meet minimum guidelines according to one set of criteria. However, another set of criteria based on AADT, states a median barrier is optional.
Clear Zones	113 locations do not meet minimum clear zone requirements for an interstate facility.
Guardrail Placement and Condition	All guardrail end treatments are adequate for an interstate facility. All field measurements of guardrail heights were below the KYTC standard of 31 inches.
Horizontal Alignment	All mainline horizontal curves meet minimum guidelines for an interstate facility.
Cross Slopes	Seven measured locations have a cross slope less than the standard for an interstate facility.
Vertical Grade	Grade meets design criteria for rural sections in rolling terrain.
Vertical Curves	Four sag vertical curves do not meet headlight sight distance criteria.

Bridges and Overpasses

Bridges Less Than or Equal to 200 Feet	Nine mainline bridges do not meet minimum width of 37.5 feet for an interstate facility.
Bridges Greater Than 200 Feet	Four mainline bridges do not meet minimum width of 31.0 feet for an interstate facility.
Structures with Curbs	Four bridges have railings / barriers that will need to be modified to meet guidelines for an interstate facility.
Vertical Clearance of Overpasses	Nine locations where overpass structures do not meet a minimum vertical clearance of 16 feet for an interstate facility.
Bridge Conditions	All WKP mainline and overpass bridges have NBI ratings per KYTC Bridge Inspection Reports that result in a bridge condition of "Fair" except for the abandoned railroad crossing at MP 68.570.
Overhead Signs and Trusses	All meet the minimum 17-foot vertical clearance for an interstate facility with the exception of the bridge mounted sign for Exit 58 Central City / Drakesboro, over the westbound lanes (16.83 feet).

Interchanges and Ramps

Design Speed	All interchange ramps meet the minimum criteria for design speed, except for the westbound on-ramp at Exit 58.
Lane Width	Interchange ramp lane widths range from 15 to 18 feet and meet guidelines for an interstate facility.
Shoulder Width	All ramps at interchanges meet shoulder width requirements for an interstate facility, with the exception of the ramps at Huck's.
Horizontal Alignment	All ramps meet minimum criteria for an interstate facility.
Vertical Grade	All ramps meet minimum criteria for an interstate facility.
Vertical Curves	All crest vertical curves on ramps at interchanges meet minimum requirements for stopping sight distance; however, two sag vertical curves do not meet minimum requirements for headlight sight distance.
Speed Change Lanes	12 ramps do not meet acceleration and deceleration lengths for an interstate facility.
Weaving Characteristics	The interchange between the WKP and US 431 (Exit 58) has less than minimum weaving distance for an interstate facility.
Interchange Configuration	The crash data did not show the interchange configuration for the following locations to be an issue: KSP Post No. 2, KY 175, KY 181, and Huck's. The interchange at US 431 is in a high crash rate spot (CRF = 5.70 and EEC = 8.73).
Interchange Spacing	Two segments do not meet the minimum spacing guidelines for interstate facilities in rural areas of 3 miles: I-69 (Exit 38) to KSP Post No. 2 (1.35 miles), and US 231 (Exit 75) to Huck's (1.01 miles).
Interchange Control of Access	Minimum criteria for interchange control of access was not met at the following locations due to less than required spacing between the ramp and access point: KY 175, KY 181, US 431, and US 231.

Summary of Improvement Options

In order to upgrade the WKP to interstate standards, a range of potential work items were investigated to address the deficiencies identified in this study. These were eventually grouped into the following Improvement Options:

- **No-Build:** The WKP would remain as it currently is (excluding committed projects identified in the Highway Plan) and would not be signed as I-569.
- **Necessary Upgrades and Spot Safety Improvements - $29,109,400:** The WKP would be upgraded to meet some, but not all, current interstate design criteria. Design exceptions and design variances would be required for design features that are not upgraded. Further investigation would be needed to determine if those design exceptions and design variances are acceptable to KYTC and FHWA.

All upgraded items that were included in recent programmatic agreements between KYTC and FHWA on the Edward T. Breathitt Parkway (EBP) and the William H. Natcher Green River Parkway (WNP) are included in this option. For those conversion agreements, mainline bridges that did not meet minimum width were not widened, which is also assumed for this option. The interchange reconfiguration at US 431 (Exit 58) that was investigated as a part of this study is included. Other items excluded from this option include:

  - Work addressing horizontal and vertical curves
  - Guardrail and guardrail end treatments that fall within the three scheduled pavement rehabilitation projects.
  - Work related to achieving minimum clear zone.
  - Median barrier installation due to the low volume of traffic and low frequency of cross-over crashes.
  - All additional operational and safety considerations with the exception of the interchange reconfiguration at US 431 (Exit 58).

- **Fully Compliant Reconstruction – $79,988,600:** This improvement option addresses all deficiencies identified through this study that would be considered design exceptions and design variances based on interstate design criteria. Similar to the Necessary Upgrades and Spot Safety Improvements option, all additional operational and safety considerations with the exception of the interchange reconfiguration at US 431 (Exit 58) are excluded.

While not necessarily required to upgrade the WKP to interstate standards, several locations and improvement concepts were identified as a result of this study. These additional operational and safety considerations include work items to address inside shoulder widening at Huck's, improvements to the Green River Bridge to address safety issues, and potential issues identified with the configuration of KSP Post No. 2's access ramps.

A detailed summary of the work items and costs are included in the following tables (**Table ES-2 and ES-3**) and figure (**Figure ES-2**). For the Fully Compliant Reconstruction, the highest cost method was assumed to address each design exception or design variance and was included in the estimated total of this improvement option. Further investigation is needed to determine if lower cost fully compliant construction options are feasible.

Table ES-2. Operational and Safety Considerations Work Item Summary

Map Symbol	Upgrade/Improvement Categories and Options	No. Locations or Milepoints	Work Item Cost	Design Exception	Design Variance	Other Considerations
■	**Inside Shoulder Widening - Huck's Gas Station**	75.08 - 76.42	$ 1,096,000			✓
⋈	**Green River Bridge**					
	Lighting		$ 375,900			✓
	KSP Post No. 2	1				
	Collector Distributor Road (Option 1)		$ 1,387,100			✓
	Relocate KYTC Maintenance Facility (Option 2)		$ 1,273,500			✓
Subtotal			$ 2,745,400 - $ 2,859,000			
Estimated Design and Environmental (15%)			$ 411,900 - $ 428,900			
Miscellaneous (15%)			$ 411,900 - $ 428,900			
TOTAL			$ 3,569,200 - $ 3,716,800			

PROGRAMMATIC AGREEMENT WITH KYTC AND FHWA MAY NOT ENCOMPASS ALL WORK ITEMS (ALL COSTS IN 2019 DOLLARS)

Table ES-3. Western Kentucky Parkway Work Items Summary

Map Symbol	Upgrade/Improvement Categories and Options	No. Locations or Milepoints	Work Item Cost	Design Exception	Design Variance	Other Considerations
	MAINLINE					
	Horizontal Curves					
	In high crash locations	18	$ 5,678,000	✓		
	Not in high crash locations	8	$ 2,704,400	✓		
	Vertical Curves	1	$ 476,800		✓	
	Cross Slopes (Flatter than 1.5%)	N/A	N/A	✓		
	Guardrail and Guardrail End Treatments (100%)					
		38.33 - 42.81	$ 670,000		✓	
	(Future Pavement Rehab Location)	42.81 - 45.95	$ 441,800		✓	
		45.95 - 65.68	$ 2,409,600		✓	
	(Future Pavement Rehab Location)	65.68 - 77.14	$ 1,408,300		✓	
	Clear Zones (Less than 30')	113				
	Re-grading **(Option 1)**		$ 8,922,100		✓	
	Guardrail **(Option 2)**		$ 2,766,700		✓	
	Median Width (Barrier Installation)	38.326 - 77.143				
	Cable Barrier **(Option 1)**		$ 5,621,800		✓	
	Double Face Guardrail **(Option 2)**		$ 5,661,400		✓	
	Median Turn Arounds	23	$ 124,000			✓
	STRUCTURES					
	Bridge Barrier/Width Compliance					
	Length <= 200' Overlay and Widening **(Option 1)**	11	$ 3,891,900	✓		
	Length <= 200' Superstructure Replacement **(Option 2)**	11	$ 5,457,700	✓		
	Length > 200' Overlay and Widening	4	$ 5,526,400	✓		
	Bridge Barrier Retrofit (Lewis Creek & Green River)	2	$ 483,300	✓		
	Vertical Clearances	9				
	Taper at 1" - 100' **(Option 1)**		$ 5,058,900	✓		
	Taper at 1" - 50' **(Option 2)**		$ 2,559,800	✓		
	Bridge Jacking **(Option 3)**		$ 5,904,000	✓		
	Abandoned Railroad Bridge	68.57	$ 150,000	✓		
	INTERCHANGES					
	Acceleration / Deceleration Lanes	12	$ 2,283,500		✓	
	Control of Access	4	$ 3,165,000		✓	
	Exit 58 - Interchange Reconfiguration	1	$ 10,546,600			✓
Subtotal			$ 22,391,800 - $ 61,529,600			
Estimated Design and Environmental (15%)			$ 3,358,800 - $ 9,229,500			
Miscellaneous (15%)			$ 3,358,800 - $ 9,229,500			
TOTAL			$ 29,109,400 - $ 79,988,600			
PROGRAMMATIC AGREEMENT WITH KYTC AND FHWA MAY NOT ENCOMPASS ALL WORK ITEMS						

Design Exception – deficiency that falls within FHWA's 10 controlling design criteria
Design Variance – deficiency that does not fall within the 10 controlling criteria but does not adhere to minimum AASHTO or KYTC guidelines

Figure ES-2. Work Items Summary Map

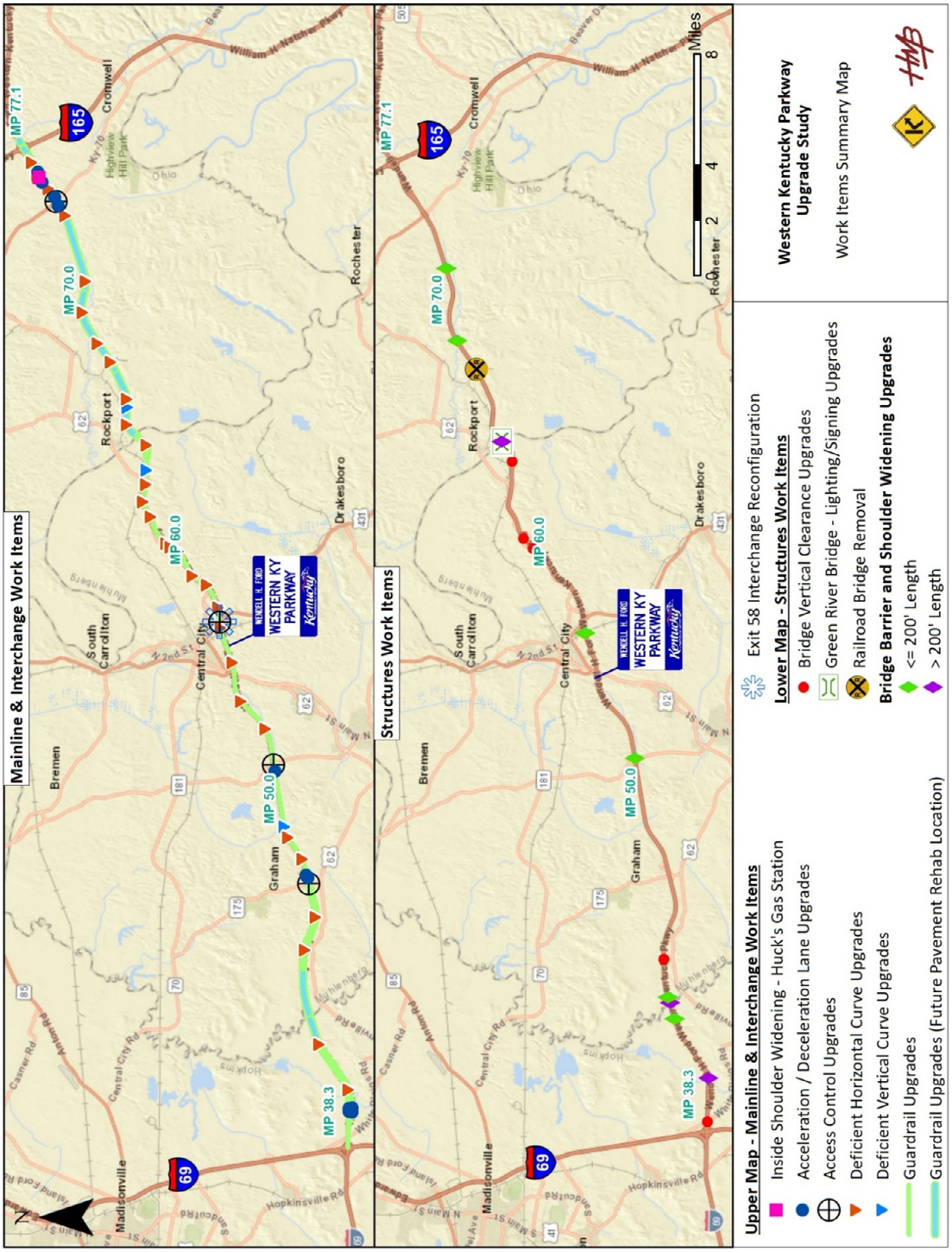

Figure ES-3. US 431 (Exit 58) Interchange Reconfiguration

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Chapter 1. Study Background

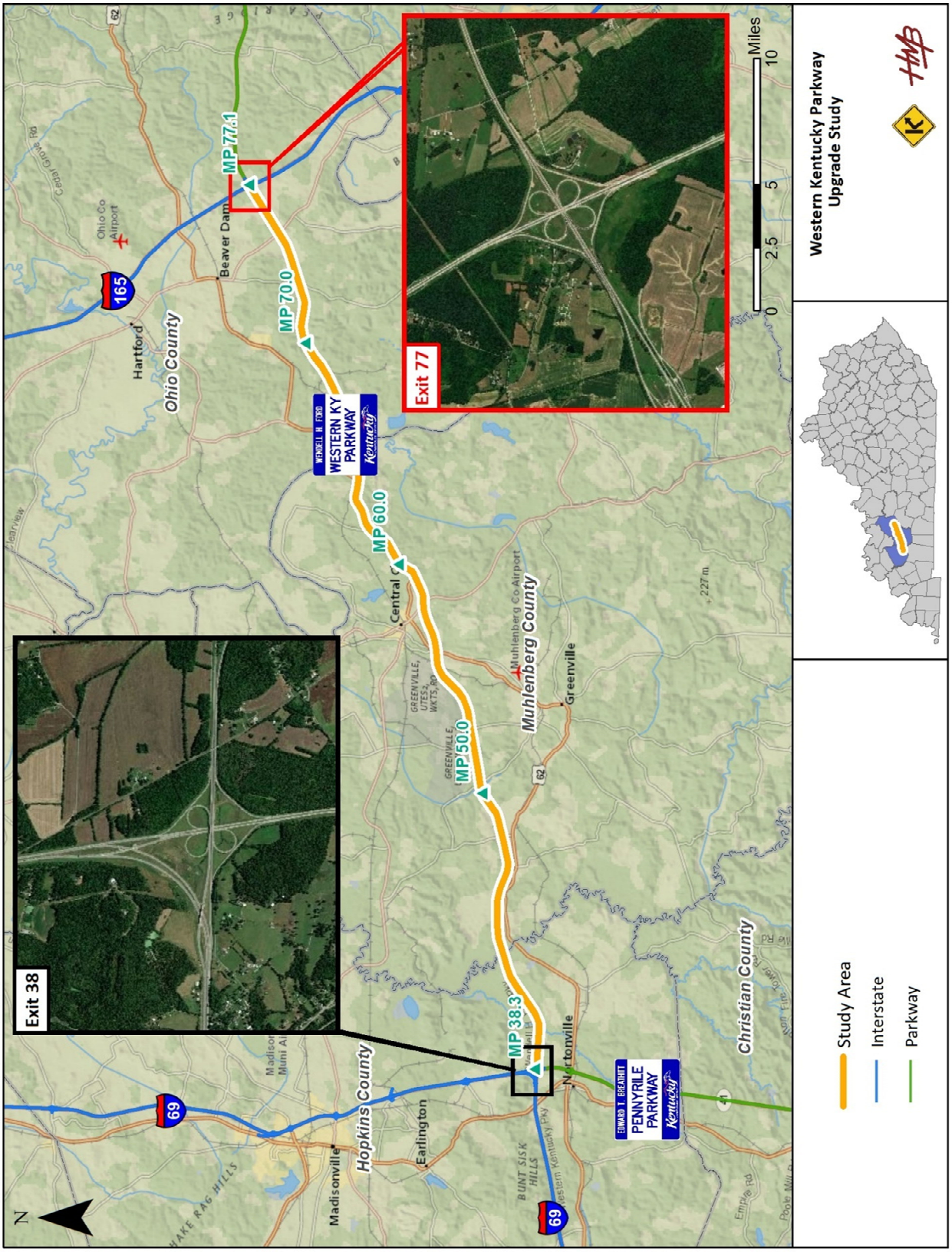
1.1 Introduction

The Western Kentucky Parkway Upgrade Study was initiated by the Kentucky Transportation Cabinet (KYTC) to identify and evaluate potential improvement options to upgrade a portion of the parkway to interstate standards for inclusion into the interstate system. The portion under consideration for this study is between I-69 / Edward T. Breathitt Pennyrile Parkway (EBP) in Hopkins County (MP 38.326) and I-165 (formerly William H. Natcher Green River Parkway [WNP]) in Ohio County (MP 77.143). This includes interchanges with KY 175 (Exit 48), KY 181 (Exit 53), US 431 (Exit 58), and US 231 (Exit 75). Though not numbered as exits, the ramps associated with the Kentucky State Police (KSP) Post No. 2 and the Beaver Dam Rest Area (Huck's) are included as part of the study considerations. The system interchanges with I-69 and I-165 are not included as part of the evaluation area. KYTC and the Federal Highway Administration (FHWA) concurred at the Western Kentucky Parkway Upgrade Scoping Meeting, held April 23, 2019, that both system interchanges were felt to be appropriate as configured and did not require additional consideration at this time. See **Figure 1** for a graphical depiction of the study area location.

The Wendell H. Ford Western Kentucky Parkway (WKP) is an east-west route connecting I-69 in Hopkins County to I-65 in Hardin County, a distance of 136 miles. The WKP opened in October 1963 as a toll road and was further extended to the I-24 interchange in 1968. Most recently, a portion of the WKP between I-24 (MP 0.000) and the EBP (MP 38.326) has been designated and signed a part of I-69.

In order to designate or construct an interstate, the FHWA may act only on requests submitted by a state transportation department. In addition, the route must be built to interstate standards, be a logical addition or connection, and coordinated with affected jurisdictions. In April 2019, Representative James Comer and Senator Mitch McConnell introduced federal legislation (House Resolution 2052) to designate a section of the WKP between I-69 and I-165 as a spur of I-69. The spur would be signed as I-569. Initially introduced as a stand-alone bill, the designation of this portion of the WKP as a spur of I-69 has been rolled into the draft version of *America's Transportation Infrastructure Act (ATIA) of 2019* (Senate Bill 2302, Section 1517 and 1519). At the time of this report it is shown as introduced to the Senate of the 116th Congress in July 2019. No phases of this project are identified in *Kentucky's Fiscal Year (FY) 2018 – 2024 Highway Plan*.

Figure 1. Study Area



1.2 Project History

Almost a half-century ago, Kentucky built a system of four-lane roadways connecting major economic centers throughout western Kentucky. These state-financed "parkways" were constructed as toll roads with the tolls ultimately removed in 1987 as the toll road bond debt was retired. In western Kentucky, the system included:

- Julian M. Carroll Purchase Parkway (JCP) between Fulton and I-24
- Wendell H. Ford Western Kentucky Parkway (WKP) between I-24 and I-65
- Edward T. Breathitt Pennyrile Parkway (EBP) between Hopkinsville and Henderson
- William H. Natcher Green River Parkway (WNP) between Bowling Green and Owensboro
- Audubon Parkway (AUP) between Henderson and Owensboro

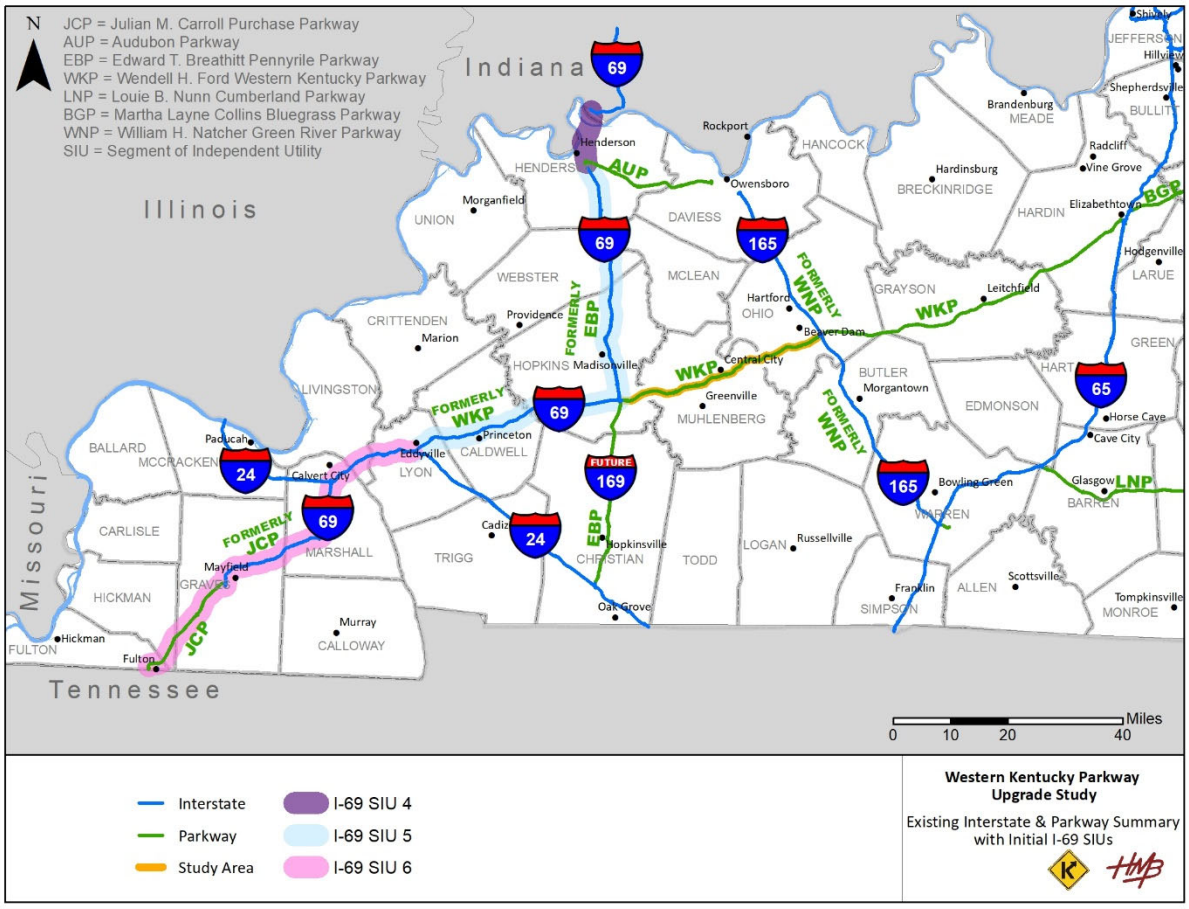
A map depicting these parkways is shown in **Figure 2**. These roadways became the backbone system of major arterial highways in western Kentucky and all are officially designated by the Federal Highway Administration (FHWA) as National Highway System (NHS) routes.

The FHWA initiated a planning process that evaluated the need for a transcontinental highway corridor, designated as I-69 through several studies including the FHWA 1995 Corridor 18 Feasibility Study and the Corridor 18 Special Issues Study (completed in 1997). From these studies, three I-69 Segments of Independent Utility (SIU) were identified in Kentucky. These include:

1. SIU 4: I-64 / I-164 north of Evansville, Indiana to the EBP at Henderson, Kentucky.
2. SIU 5: EBP from Henderson, Kentucky to the WKP, and the WKP from the EBP to I-24.
3. SIU 6: I-24 at the WKP interchange to the JCP interchange and the JCP to the Tennessee State Line.

The KYTC has worked closely with local officials and citizens, the Kentucky legislature, and Kentucky's Congressional Delegation to upgrade segments of Kentucky's parkways and federally designate them as interstates. At the time of this report portions of I-24, the WKP, JCP, and EBP have been designated/signed as I-69. The conversion agreement of the WNP to I-165 was signed in 2018. That agreement indicated that interstate signage could be placed with the commitment by KYTC to complete three outstanding interchange reconstruction projects (KY 69 [Exit 50] in Ohio County, US 231 [Exit 36] in Butler County, and US 231 [Exit 9] in Warren County). A study to upgrade the southern 34-mile section of the EBP from its end at I-24 near Hopkinsville to its merge with I-69 north at the I-69 / WKP interchange to interstate standards was completed in January 2015 (*Corridor Study for Interstate Deficiencies from I-24 to I-69 / Western Kentucky Parkway*). This route would be designated I-169. A map depicting the initial SIU of I-69 and the resulting signed routes is included for reference as **Figure 2**.

Figure 2. Existing Interstate & Parkway Summary with Initial I-69 SIUs



1.3 Committed and Identified Projects

A summary of study area projects was compiled based on reviews of *Kentucky's FY 2018 – FY 2024 Highway Plan* and KYTC's Continuous Highway Analysis Framework (CHAF) database. Based on this review, three projects along the WKP were identified in the Highway Plan and four projects were identified in the CHAF database. Projects are shown in **Figure 3** and identified by letter and number. These include:

<u>Committed</u>

A. KYTC Item No. 2-20035.00 – Address Pavement Condition of WKP from MP 42.807 to MP 43.424. Design and Construction phases are identified for FY 2023 for a total cost of $550,000.

B. KYTC Item No. 2-20036.00 – Address Pavement Condition of WKP from MP 43.424 to MP 45.950. Design and Construction phases are identified for FY 2023 for a total cost of $2,200,000.

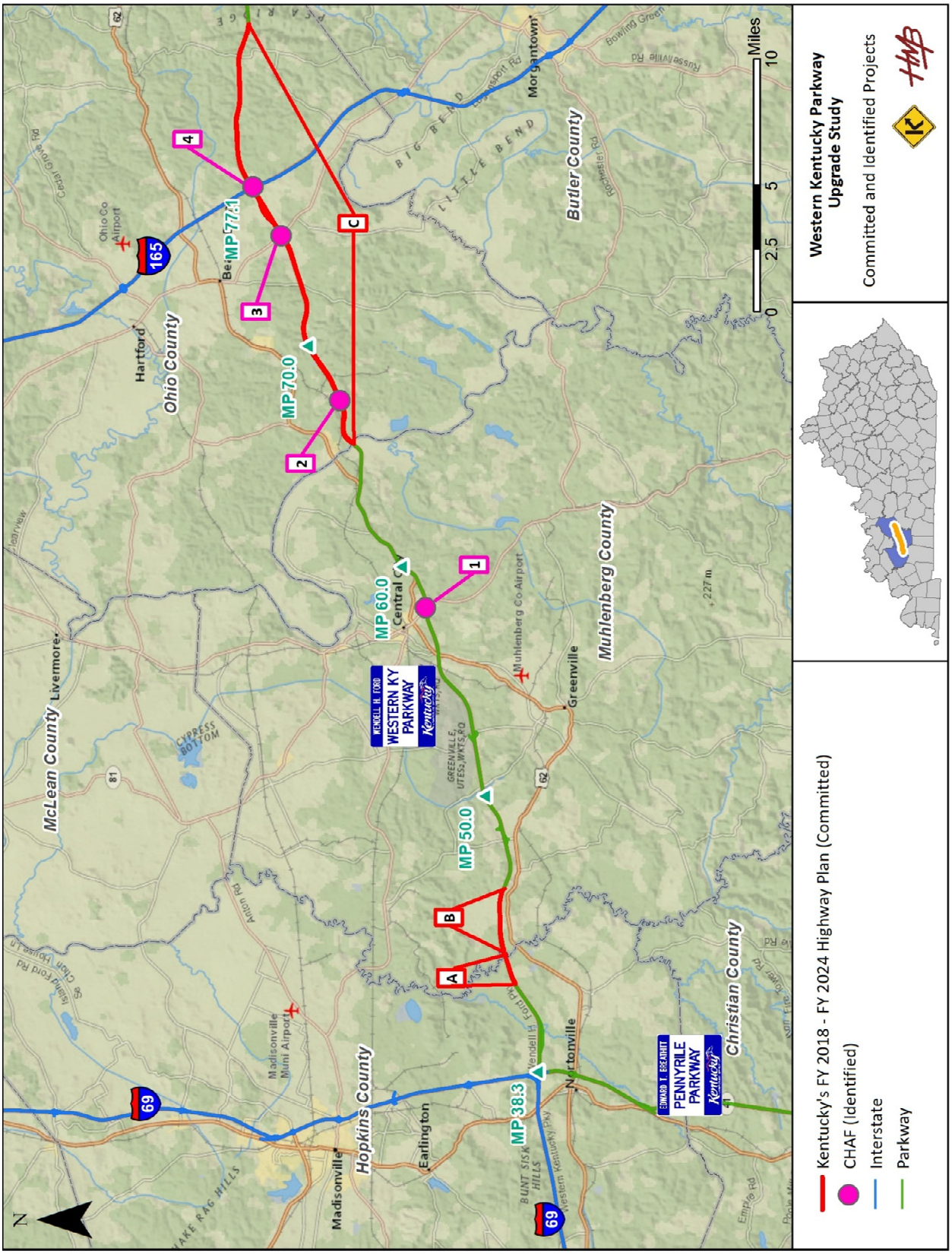
C. KYTC Item No. 2-20039.00 – Address Pavement Condition of WKP from MP 65.680 to MP 83.300. The construction phase is identified in the Highway Plan for FY 2020 for a total cost of

$16,596,000; however, since publication of the Highway Plan, construction for this project has been pushed back to 2022.

Identified

1. US 431 CHAF (IP20070096) – Reconstruct the US 431 interchange at the WKP.
2. KY 1245 CHAF (IP20060114) – Construct new interchange along the WKP at KY 1245 near Rockport.
3. US 231 CHAF (IP20070103) – Address safety and service concerns at the US 231 interchange with the WKP.
4. WKP / I-165 Interchange CHAF (IP20060115) – Improve safety and mobility at the WKP and I-165 interchange.

Figure 3. Committed and Identified Projects



Chapter 2. Planning Process

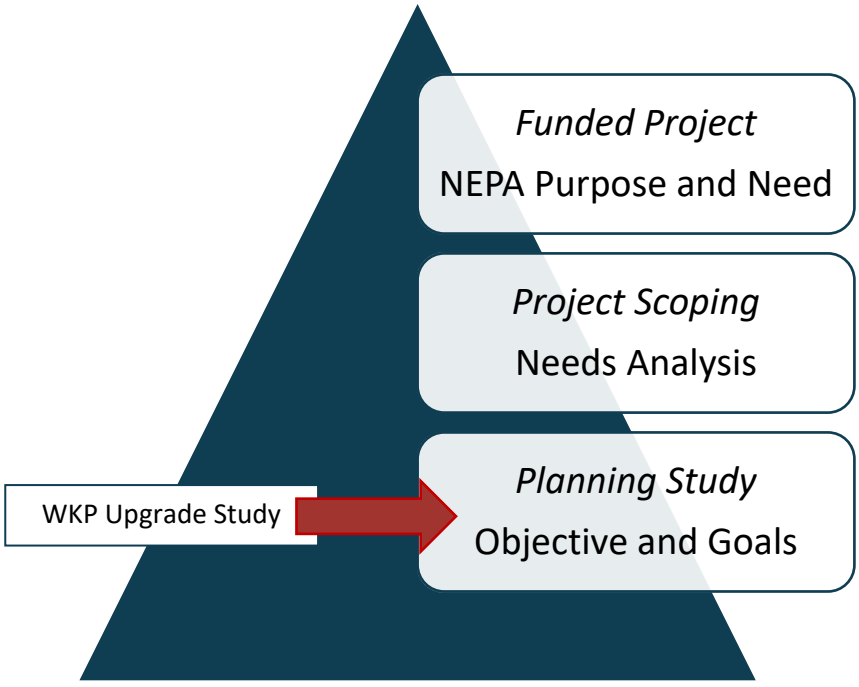
2.1 Study Objective and Goals

A planning study evaluates the factors that help define a potential project. Depending on the type of study, a project purpose and need(s) may be identified but stop short of producing a National Environmental Policy Act (NEPA) level Purpose and Need statement. Desired outcomes of the planning study include:

- Project Definition
- Project Justification
- Range of Feasible Improvement Options
- Next Steps

As the project evolves, so does the quality of the project's Purpose and Need. **Figure 4** illustrates conceptually how elements come together through a multi-step process to determine the project Purpose and Need. It is a simplified version of the steps and not all step are always necessary for project development. However, it sets the context for the stage of this study as presented in the following chapters of this report.

Figure 4. Evolution of Purpose and Need



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Study Goals

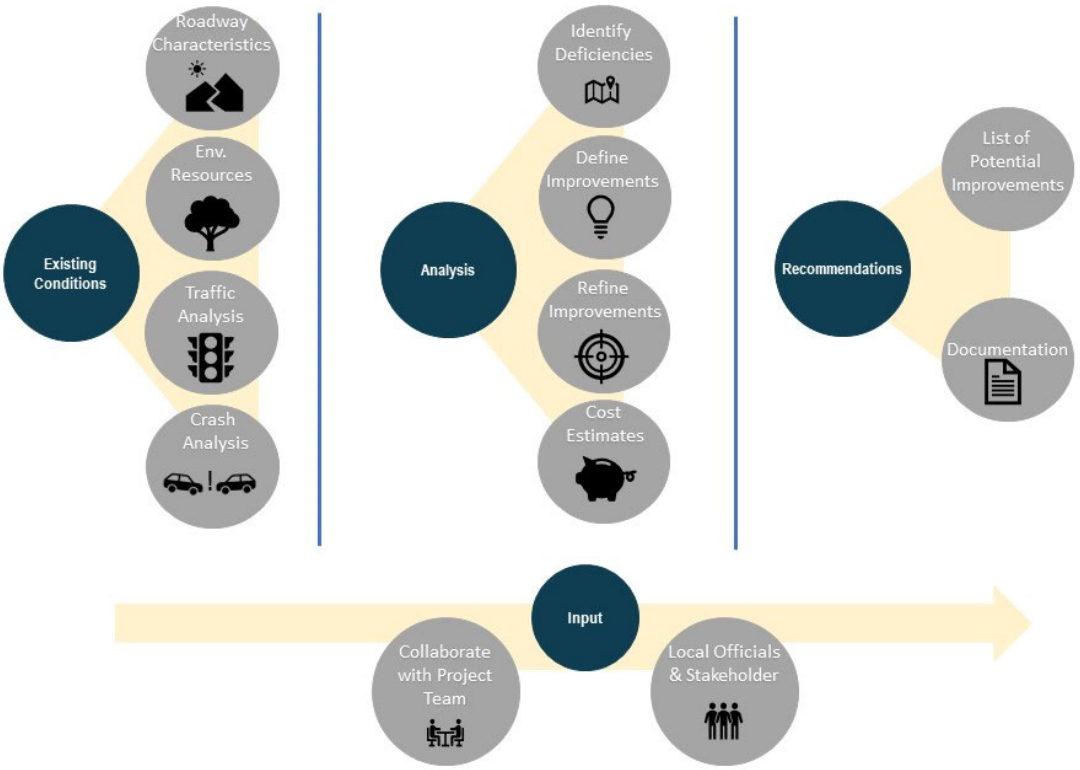
To achieve the desired outcomes noted at the beginning of this section, the following goals were identified:

- Consider system linkage – connectivity between I-69 and I-165
- Evaluate safety
- Identify roadway deficiencies – relative to interstate standards
- Prepare upgrade options and planning-level cost estimates

2.2 Study Process

Tailored to meet these objectives and goals, a planning process was developed for this study. The graphic in **Figure 5** illustrates the process.

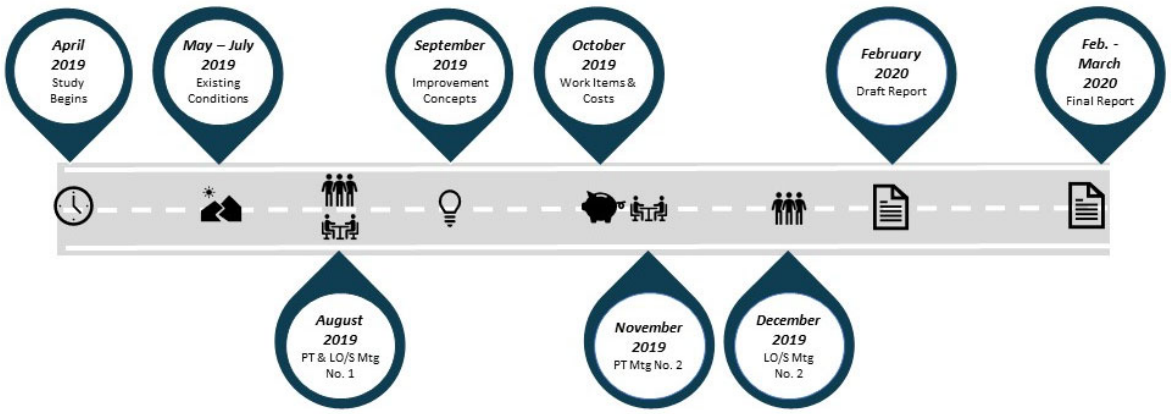
Figure 5. WKP Upgrade Study Planning Process



The initial step, as shown in **Figure 5,** is to collect information on existing conditions, including roadway characteristics (typical section, speed, geometry, interchanges), traffic volumes and capacity, crash history, and high-level environmental features. The second step involves using the collected data to identify deficiencies, developing concepts for potential improvements, then refining them in conjunction with determining planning-level cost estimates. The final step results in a list of potential improvement options necessary to upgrade the parkway to interstate standards. From this list, determinations of design exceptions and variances can be discussed in subsequent development phases between KYTC and FHWA.

The timeline for completion of this study is illustrated in **Figure 6.**

Figure 6. WKP Upgrade Study Timeline



PT = Project Team
LO/S = Local Officials / Stakeholder
Mtg = Meeting

2.3 Study Design Considerations

According to the FHWA memorandum "Revisions to the Controlling Criteria for Design and Documentation for Design Exceptions" dated May 5, 2016, there are ten (10) criteria considered controlling for the design features that define the operational and safety performance of a highway. A formal design exception is required when any of the 10 criteria are not met on NHS roadways defined as interstate facilities, other freeways, and roadways with a design speed greater than or equal to 50 mph (which includes the WKP). These criteria include:

1. Design Speed
2. Lane Width
3. Shoulder Width
4. Horizontal Curve Radius
5. Superelevation Rate
6. Stopping Sight Distance
7. Maximum Grade

8. Cross Slope
9. Vertical Clearance
10. Design Loading Structural Capacity

In this study, the design features of the WKP were evaluated for compliance with AASHTO and KYTC design criteria for an interstate facility. If a design feature of the WKP is found to be deficient, then a design exception or design variance is required if this feature is not upgraded to meet minimum interstate design criteria.

According to the *KYTC Highway Design Manual,* KYTC common geometric practices are not to be construed as a basis for determining design exceptions and the designer is to refer to AASHTO minimum design criteria for an interstate facility. If a design feature of the WKP does not meet these minimum design criteria and falls within FHWA's 10 controlling design criteria, then a design exception is required.

When determining design variances, both AASHTO and KYTC minimum design criteria are evaluated. Any design feature of the WKP that falls outside of FHWA's 10 controlling design criteria and does not meet AASHTO and KYTC minimum design criteria for an interstate facility will be considered a design variance. **Table 1** summarizes the FHWA and KYTC design criteria.

Additionally, operational and safety considerations were investigated as a part of this study. Although the improvements associated with this evaluation are not required as part of the upgrade process, each improvement would benefit the functionality of the WKP.

It was not assumed that any design exceptions or variances would or would not be accepted in the programmatic agreement between KYTC and FHWA; rather a list of potential improvements is provided in this study that would upgrade each design feature to meet minimum design criteria for an interstate facility.

Applicable references used to make these determinations include:

- "A Policy on Geometric Design of Highways and Streets, 7th Edition" (American Association of State Highway and Transportation Officials, 2018 Edition) referred to as the *2018 Green Book.*
- "A Policy on Design Standards – Interstate System" (American Association of State Highway and Transportation Officials, dated May 2016).
- "AASHTO Roadside Design Guide" (American Association of State Highway and Transportation Officials, 4th Edition 2011) referred to as the *Roadside Design Guide.*
- "Highway Capacity Manual" (Transportation Research Board, 6th Edition) referred to as the *HCM.*
- "Manual of Uniform Traffic Control Devices for Streets and Highways" (Federal Highway Administration, 2009 Edition with Revision Numbers 1 and 2 incorporated, dated May 2012) referred to as the *MUTCD.*
- Kentucky Transportation Cabinet Highway Design Manual (KYTC, March 2017) referred to as the *KYTC Design Manual.*

Throughout the remainder of the report, reference material will be referenced by its common practice name as italicized above.

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

Design Element	Governing Agency	Reference	Mainline	Ramps	Loops	Design Exception	Design Variance	Other Considerations
Design Speed	AASHTO	2018 Green Book	70 mph	35 mph	20 mph	✔		
Lane Width	AASHTO	2018 Green Book	12'	14'	15'	✔		
Inside Shoulder	AASHTO	2018 Green Book	4'	2'-4'		✔		
Outside Shoulder								
Tuck DDHV <= 250	AASHTO	2018 Green Book	10'	8'-10'		✔		
Truck DDHV > 250	AASHTO	2018 Green Book	12'			✔		
Median Width	AASHTO	Roadside Design Guide	30'-60'	N/A			✔	
Median Turnarounds	AASHTO	2018 Green Book	May be spaced at 3 to 4 mile intervals or as needed					✔
Clear Zone	AASHTO	Roadside Design Guide	30'-46'	10'-14'			✔	
Guardrail Height	KYTC	KYTC Standard Drawings	31"				✔	
Horizontal Alignment								
Superelevation	AASHTO	2018 Green Book	8% Max					
Minimum Radius	AASHTO	2018 Green Book	1810'	314'	134'	✔		
Cross Slopes	AASHTO	A Policy on Design Standards - Interstate System	Greater than 1.5%			✔		
Vertical Alignment								
Vertical Grade	AASHTO	A Policy on Design Standards - Interstate System/2018 Green Book	4%	4% - 8%		✔		
Crest Vertical Curves - Stopping Sight Distance	AASHTO	2018 Green Book	730'	250'	76'	✔		
Sag Vertical Curves - Head Light Sight Distance	AASHTO	2018 Green Book				✔		
Bridges and Overpasses								
Bridge Width <= 200 feet	AASHTO	A Policy on Design Standards - Interstate System	37.5'	N/A		✔		
Bridge Width > 200 feet	AASHTO	A Policy on Design Standards - Interstate System	31'	N/A		✔		
Overpass Vertical Clearance	AASHTO	A Policy on Design Standards - Interstate System	16'	N/A		✔		
Overhead Sign Vertical Clearance	AASHTO	2009 MUTCD	17'			✔		
Divergence Angle	AASHTO	2018 Green Book	2 to 5 degrees				✔	
Speed Change Lanes	AASHTO	2018 Green Book	Varies depending on the design speed of the entering or exiting curve				✔	
Interchange Spacing	AASHTO	2018 Green Book	2 miles				✔	
Interchange Control of Access	AASHTO	A Policy on Design Standards - Interstate System	300'				✔	

Chapter 3. Roadway Characteristics

The WKP operates very similar to an interstate today and has a posted speed limit of 70 mph throughout the study corridor. There are areas, however, where this parkway does not meet minimum design criteria based on AASHTO guidelines and KYTC common practices for an interstate facility as presented in **Table 1** in the previous chapter. These areas are summarized in the following sections. The evaluation of the existing roadway characteristics throughout this corridor was based on as-built plans, KYTC Highway Information System (HIS) data, statewide LiDAR data, and limited field review and observations. Traffic and crash analysis are referenced throughout this chapter and presented in more detail in **Chapters 5** and **6**, respectively. For more in-depth information on design elements and design criteria, refer to **Appendix A**.

3.1 Mainline Characteristics

Mainline roadway characteristics of the WKP are as follows:

Terrain

According to the HIS database the terrain for the WKP is flat; however, as-built plans for the corridor utilize design criteria for rolling terrain. To be consistent with as-built plans for this corridor, rolling terrain is used to analyze roadway geometry.

Design Speed

There are 26 horizontal curves that do not meet the interstate design criteria for a 70 mph design speed on the WKP according to the $e_{max} = 8\%$ superelevation table in the *2018 Green Book*. However, the side friction factor for each of these curves does not exceed 0.10, which is the maximum allowable side friction factor for a 70 mph design speed. Four sag vertical curves do not meet the minimum criteria for headlight sight distance for a 70 mph design speed.

Lane Width

All lane widths on the WKP meet minimum guidelines for an interstate facility.

Shoulder Widths

All shoulder widths on the WKP meet minimum guidelines for an interstate facility.

Median Width

In areas where the eastbound and westbound lanes of the WKP are not bifurcated there is an existing depressed median width of 30 feet. Although the minimum median width for interstate facilities is not met according to *A Policy on Design Standards – Interstate System*, when consulting the *Roadside Design Guide* and considering the current AADT throughout the corridor it states that a median barrier is optional for this type of roadway. According to the crash analysis that was conducted as a part of this study, there were three median crossover crashes throughout this corridor.

Median Turnarounds

There are 23 median turnarounds located along this section of the WKP. Twelve are gravel and do not appear to be maintained. It is KYTC common practice to eliminate these types of median turnarounds. The remaining 11 were evaluated for compliance/safety based on drainage, sight distance, the crash analysis, and AASHTO and KYTC guidelines.

Clear Zones

According to the *Roadside Design Guide*, based on the design speed and AADT of the WKP the clear zone required is 30 to 34 feet when sideslope is 1V:6H or flatter and 38 to 46 feet when the sideslope is steeper than 1V:6H and flatter than or equal to 1V:4H. All median slopes are 1V:6H or flatter with the exception of the areas where the eastbound and westbound lanes are bifurcated. The outside sideslopes that are not protected by guardrail vary from 1V:6H to 1V:4H. There are 113 identified locations outside of the roadway along this corridor that do not meet minimum clear zone requirements for interstate facilities.

Guardrail Placement and Condition

All guardrail end treatments on the WKP are adequate for an interstate facility. According the *KYTC Standard Drawings and Active Sepias* any new guardrail shall be installed at a height of 31 inches. It has been common practice in Kentucky for recent 3R projects, that guardrail with a height of 27 inches has been deemed adequate and left in place. Based on a limited field review of the existing guardrail heights: 44% measured less than 27 inches, 56% measured 27 inches or greater, and all field measurements taken were less than the most recent KYTC standard of 31 inches for guardrail height.

Horizontal Alignment

Information was extracted from the as-built plans of the WKP in order to assess whether the horizontal curves meet minimum standards for a 70 mph design speed.

Superelevation Rate

There are 26 horizontal curves that do not meet the interstate design criteria for a 70 mph design speed on the WKP according the $e_{max} = 8\%$ superelevation table in the *2018 Green Book* based each curve's horizontal radius and corresponding superelevation rate. However, the side friction factor for each of these curves does not exceed 0.10, which is the maximum allowable side friction factor for a 70 mph design speed. Of the 26 horizontal curves that do not meet a 70 mph design speed based on the superelevation table used, 18 are located in high crash spots.

Degree of Horizontal Curvature

The current interstate design criteria indicate the minimum horizontal curvature radius for a design speed of 70 mph for a rural interstate is 1,810 feet, which equates to approximately 3°10' of curvature. All mainline horizontal curves on the WKP meet these minimum criteria.

Cross Slopes

According to *A Policy on Design Standards – Interstate System*, the normal cross slope of the traveled way is 2.0% and shall not be less than 1.5%. A review of the as-built plans shows that driving lane cross slopes on the WKP are 1.56%, while the shoulder cross slopes are 4.17%. However, a limited field review revealed the cross slope to be less than 1.5% in the following locations: MP 38.68, MP 38.84, MP 44.11, MP 44.95, MP 51.25, MP 73.82, MP 74.12. All locations in which the cross slope measured less than 1.5% fall within a high crash spot. Additional field review will be required to identify all locations on the WKP where the cross slopes are less than 1.5%.

Vertical Alignment

The topography has some effect on horizontal alignment, but its effect on a roadway's vertical alignment is even more substantial. It has been established that the WKP was designed and constructed utilizing design criteria for rolling terrain. The vertical alignment elements are as follows based on rolling terrain.

Vertical Grade

The maximum grade utilized on WKP is 4%, which meets the interstate design criteria for rural sections through rolling terrain.

Vertical Curves

All crest vertical curves within the study area on the WKP meet stopping sight distance design criteria for 70 mph, however, four sag vertical curves do not meet headlight sight distance (HLSD) design criteria for interstates. The minimum headlight sight distance needed for a 70 mph design speed is 730 feet. The sag vertical curves that do not meet this minimum criteria are as follows:

- MP 50.3 (HLSD 721 feet)
- MP 61.1 (HLSD 635 feet)
- MP 64.3 (HLSD 726 feet)
- MP 66.8 (HLSD 707 feet)

Of the deficient sag vertical curves, only one falls within a high crash spot (MP 64.3). The headlight sight distance for this sag vertical curve is four feet less than the minimum required, and, therefore, it is unlikely that the high rate of crashes in this area is due to a headlight sight distance issue.

3.2 Bridges and Overpasses

The summary of key findings related to the bridges and overpasses on the WKP are as follows:

Bridges Less Than or Equal to 200 feet

Nine mainline bridges that are less than or equal to 200 feet in length do not meet the 37.5-foot minimum width required by *A Policy on Design Standards – Interstate System*:

- Pond River Relief MP 42.80 (eastbound and westbound)
- Pond River Relief MP 43.60 (eastbound and westbound)
- KY 181 MP 52.60 (westbound only)
- Railroad Crossing MP 57.60 (eastbound and westbound)
- KY 369 MP 72.50 (eastbound and westbound)

Bridges Greater Than 200 feet

Four mainline bridges that are greater than 200 feet in length do not meet the 31.0-foot minimum width required by *A Policy on Design Standards – Interstate System*:

- Drakes Creek MP 40.30 (westbound only)
- Pond River MP 43.40 (eastbound only)
- Green River MP 65.70 (eastbound and westbound)

Structures with Curbs

There are four bridges along the WKP that have railings / barriers that will need to be modified in order to meet interstate standards. The Green River bridges were constructed with brush block curb, while the Lewis Creek bridges were constructed with a railing on top of the barrier. Both will need to be modified to meet current standards.

Vertical Clearance of Overpasses

There are nine locations where overpass structures along the WKP do not meet the minimum vertical clearance of 16 feet required by interstate standards:

- KY 813 MP 38.70 (eastbound and westbound)
- Henry Oats Rd MP 44.98 (eastbound and westbound)
- Monsanto Haul Rd MP 61.39 (westbound only)
- Howerton Rd MP 61.90 (westbound only)
- Rockport Paradise Rd MP 64.86 (westbound only)
- Abandoned Rail Crossing MP 68.58 (eastbound and westbound)

Crash Worthy Pier Protection

A limited field review was conducted and found that all overpass structures along the WKP have sufficient pier protection according to KYTC standards. More field measurements may be required to confirm the findings of this study.

Bridge Conditions

All WKP mainline and overpass bridges have NBI ratings per KYTC Bridge Inspection Reports that result in a bridge condition of “Fair” except for the abandoned railroad crossing at MP 68.570. As mentioned previously, there is a vertical clearance issue with both the eastbound and westbound lanes of the WKP. It is recommended that this bridge be removed since it is no longer in use, is in poor condition, and there is a vertical clearance issue.

Overhead Signs

All overhead signs meet the minimum 17-foot vertical clearance requirement for interstate facilities with the exception of the bridge mounted sign for Exit 58 Central City / Drakesboro (16.83 feet) over the westbound lanes.

3.3 Interchanges and Ramps

The summary of key findings related to the interchanges and ramps on the WKP are as follows:

Design Speed

All interchange ramps along the WKP meet the minimum interstate criteria for design speed except for the westbound on-ramp at Exit 58. The minimum radius for this ramp does meet a design speed of 25 mph if coupled with a superelevation rate of 8%, but with a measured superelevation rate of 4% this curve's design speed is less than 15 mph.

Lane Width

Interchange ramp lane widths along the WKP range from 15 feet to 18 feet and meet AASHTO guidelines for interstate facilities.

Shoulder Width

All ramps at interchanges along the WKP meet shoulder width requirements based on AASHTO guidelines for interstates with the exception of the ramps at Huck's. The ramps here consist of an 18-foot lane, 4-foot outside shoulder, and 2-foot inside shoulder. According to the *2018 Green Book*, the lane widths on these ramps can be dropped to 14 feet based on the traffic conditions on the WKP. The existing pavement is wide enough to accommodate a 14-foot lane, 6-foot outside shoulder, and 4-foot inside shoulder; therefore, the deficient shoulder widths at these locations can be addressed through restriping. Further field investigation will be required to confirm the findings of this study.

Horizontal Alignment

All ramps along the WKP meet minimum radius criteria in accordance with AASHTO guidelines for interstate facilities.

Vertical Grade

All ramps along the WKP meet AASHTO guidelines for maximum vertical grade for interstate facilities.

Vertical Curves

All crest vertical curves on-ramps at interchanges along the WKP meet minimum requirements for interstates facilities for stopping sight distance; however, two sag vertical curves do not meet minimum requirements for headlight sight distance. The eastbound and westbound on-ramps at Exit 75 have vertical curves that do not meet headlight sight distance design criteria for a design speed of 50 mph on the ramps. However, there is high mast lighting at this interchange, and it is also likely that vehicles will not be traveling at high speeds through these vertical curves since they occur just as vehicles are entering the ramp near the approach.

Speed Change Lanes

There are 12 ramps that do not meet the minimum criteria for acceleration and deceleration lengths for interstate facilities according to AASHTO guidelines:

- KSP Post No. 2 (all four ramps)
- KY 175 (Exit 48) (eastbound and westbound on-ramps)
- KY 181 (Exit 53) (eastbound and westbound on-ramps)
- US 231 (Exit 75) (eastbound and westbound on-ramps)
- Huck's (eastbound and westbound on-ramps)

Weaving Characteristics

The interchange between the WKP and US 431 (Exit 58) has less than the minimum weaving distance recommended for interstates according to AASHTO guidelines. It currently operates at LOS A and is expected to operate at LOS A in the design year 2045 (as determined in **Chapter 5**). According to the crash analysis conducted as a part of this study (and presented in **Chapter 6**), this spot has been identified as a high crash rate spot (CRF = 5.70 and EEC = 8.73).

Interchange Configuration

- **KSP Post No. 2 –** The ramps at KSP Post No. 2 enter and exit the WKP from the left. There is an entrance for a KYTC maintenance facility located on the westbound off-ramp. The exit for this facility is on the eastbound on-ramp (exit). According to the crash analysis conducted as a part of this study, the placement of these ramps and entrances have no adverse effect on the operation or safety of the WKP.
- **KY 175 –** The KY 175 interchange is split with two ramps serving the eastbound lanes in a traditional diamond configuration with terminals on KY 175, and two ramps serving the westbound lanes with terminals on KY 2693 (Graham Cypress Road). There was no indication from the crash analysis that this interchange configuration has an adverse effect on the operation or safety of the WKP.
- **KY 181 –** The KY 181 interchange is configured as a folded diamond with the eastbound on-ramp and westbound off-ramp located in the southwest and northwest quadrants respectively as loop ramps. There was no indication from the crash analysis that this interchange configuration has an adverse effect on the operation or safety of the WKP.
- **US 431 –** The US 431 interchange consists of four loop ramps with on and off-ramps forming a short weaving section on the WKP. According to the crash analysis conducted as a part of this study, this spot has been identified as a high crash rate spot (CRF = 5.70 and EEC = 8.73).
- **Huck's –** The ramps at Huck's enter and exit the WKP from the left. According to the crash analysis conducted as a part of this study, the placement of these ramps and entrances have no adverse effect on the operation or safety of the WKP.

Interchange Spacing

There are two segments in between interchanges within the study corridor that do not meet minimum spacing according to AASHTO guidelines:

- I-69 (Exit 38) to KSP Post No. 2 (1.35 miles)
- US 231 (Exit 75) to Huck's (1.01 miles)

The ramp terminals between these interchanges do meet the minimum length between ramp entrance and exit terminals of 1600 feet. There was no indication from the crash analysis that the spacing of these interchanges has an adverse effect on the operation or safety of the WKP.

Interchange Control of Access

Minimum design criteria for interchange control of access was not met at the following locations:

- KY 175 (53 feet between the eastbound on-ramp and the nearest access point)
- KY 181 (access point located directly across from westbound ramps)
- US 431 (access point located directly across from westbound off-ramp)
- US 231 (47 feet between the westbound off-ramp and nearest access point, 116 feet between the eastbound on-ramp and nearest access point)

The US 431 interchange would meet minimum control of access criteria with its new configuration that has been investigated as a part of this study.

Chapter 4. Natural and Human Environmental Resources

A database search for environmental resources was performed for the potential improvements to the WKP. These improvements include reconstructing the US 431 interchange and options to upgrade the control of access at each of the other three interchanges within this corridor. The locations evaluated are identified in **Figure 7**.

The database search focused on the four interchanges within the corridor, since any improvements to these are the most likely to extend outside of KYTC's existing right-of-way. Key findings include:

- Various streams and wetlands are likely to be impacted. However, no streams surrounding the interchanges were listed as a Special Use Water.
- Numerous underground storage tank sites were located in the areas surrounding the interchanges. One in particular, at the US 231 interchange, is located directly adjacent to the WKP Parkway westbound off-ramp.
- Soils are representative of USDA prime farmland.
- One church is near the US 231 interchange; however, it is not expected that modifications to the interchange would impact the church.
- There are potential low-income areas within the area of impact, as identified by the Environmental Protection Agency (EPA).

Mapping of environmental resources identified in the project area are provided in **Figure 7**. Should the project move forward into design, and the NEPA process begin, these resources will be field verified and a determination on potential impacts will be made. As the project progresses and design continues to evolve, these resources will be verified and evaluated, then shared with the project team and taken into consideration during the decision-making process.

The Pennyrile Area Development District prepared an *Environmental Justice Review*, dated April 2020, that reviewed the socioeconomic characteristics within the study area. The full report is included in **Appendix B** and summarized below. Data from the U.S. Census Bureau's *2017 American Community Survey* was utilized for the analysis. The following five categories were reviewed:

- Population by Persons of Minority
- Population Age 65 and Over
- Population by Persons with Disabilities
- Population Below Poverty
- Population with Limited Proficiency

While it is not anticipated that improvements will require residential or commercial property acquisitions, the findings in **Table 2** are focused on the four interchanges within the corridor and identifies all census block groups surrounding these interchanges and highlights where percentages were higher than the Kentucky state average.

Figure 7. Environmental Impact Overview

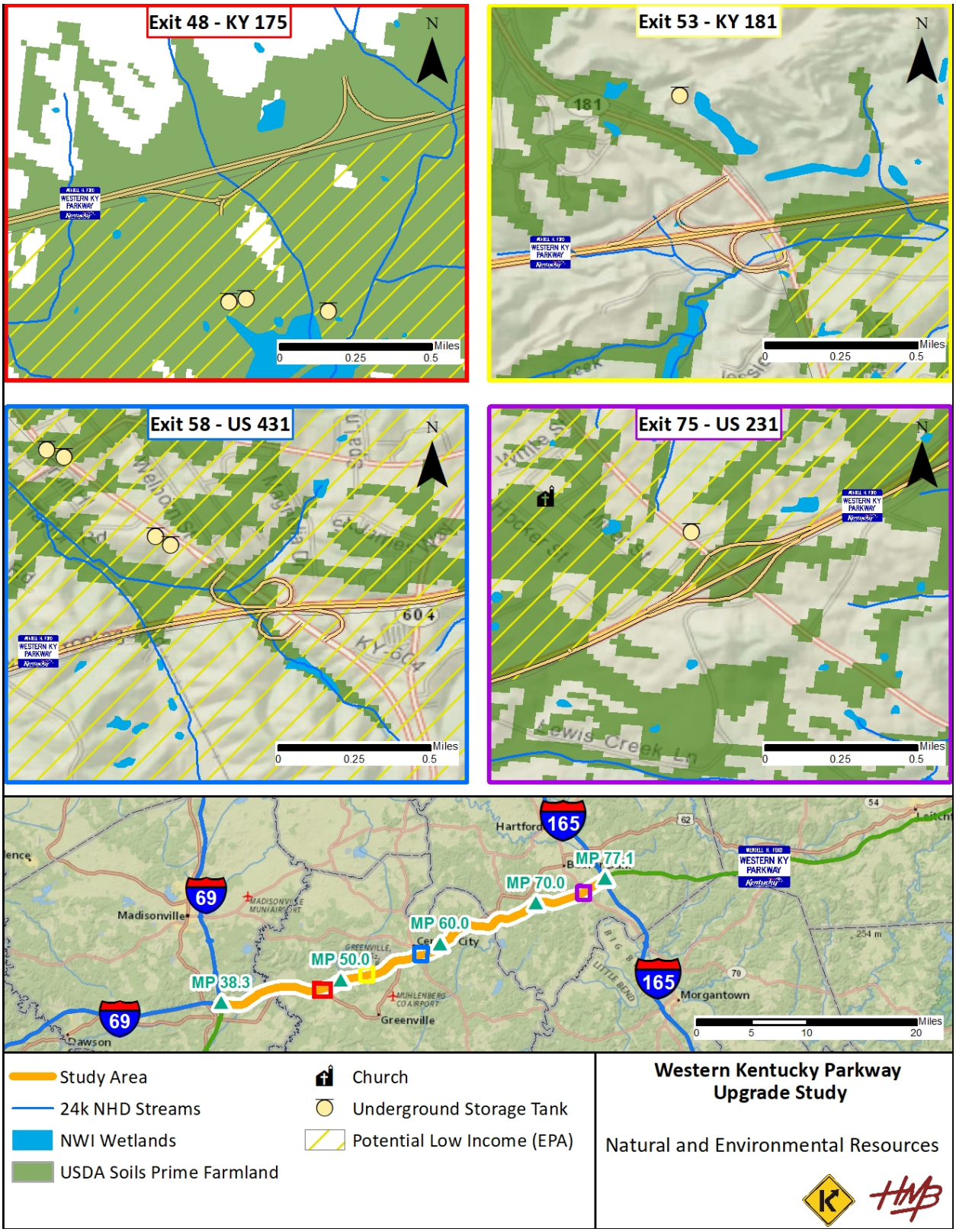


Table 2. Environmental Justice Summary by Interchange

Interchange	Census Tract	Block Group	Population by Persons of Minority (Percent)	Population Age 65 and Over (Percent)	Population by Persons with Disabilities (Percent)	Population Below Poverty (Percent)	Population with Limited English Proficiency (Percent)
Kentucky			12.70	15.20	16.99	18.30	2.08
Muhlenberg County			7.41	18.06	23.07	20.50	0.04
Ohio County			3.74	17.55	21.52	21.30	0.86
Exit 48 (KY 175)	9604	2	1.90	31.61	29.04	21.71	0.00
	9604	3	1.07	22.48	41.95	6.37	0.00
Exit 53 (KY 181)	9602	5	8.06	17.02	28.10	19.13	0.00
	9604	1	0.38	12.37	9.23	19.03	0.00
	9604	5	0.34	11.60	35.75	16.64	0.00
Exit 58 (US 431)	9601	1	2.46	13.15	27.50	39.22	0.00
	9602	3	36.77	31.04	30.79	59.54	0.00
Exit 75 (US 231)	9205	1	6.81	10.50	24.71	22.95	0.00
	9205	2	7.60	22.46	13.49	18.79	0.00

Significantly higher percentage than Kentucky average. See Appendix B in the *Environmental Justice Review* for methodology.

Above the Kentucky average but not significantly higher.

Chapter 5. Traffic Volumes and Analysis

5.1 Traffic Volumes

Traffic volumes were collected and evaluated for the mainline WKP segments and ramps between I-69 and I-165. The ramps included in the evaluation are KY 175 (Exit 48), KY 181 (Exit 53), US 431 (Exit 58), and US 231 (Exit 75). Two additional interchanges (KSP Post No. 2 and Huck's) are located in the study area but are not designated with an Exit number. As noted in **Chapter 1**, the system interchanges with I-69 and I-165 are not included as part of the evaluation area. Existing traffic volumes (annual average daily traffic or AADT) were either counted as a part of this study or obtained through the KYTC Traffic Count Reporting System. Future year traffic forecasts were prepared for the design year (2045). As the study is focused on improvement upgrade options that do not increase capacity for the parkway, the No Build and Build traffic forecasts are assumed to be the same for evaluation purposes. Existing and future year traffic volumes are illustrated on **Figure 8**. For additional information on existing and future year traffic volumes and forecast methodology, refer to the *WKP Upgrade Study Traffic Forecast Report* in **Appendix C**.

5.2 Functional Classification

Functional classification is a method of categorizing different roadways based on how they are intended to be used for travel. Functional classification is assigned based on guidance from *Federal Highway Administration – Highway Functional Classification Concepts, Criteria and Procedures (2013)*. This is especially important to understand for this study as the objective includes consideration of potential improvement options to upgrade the WKP to interstate standards. Currently shown in **Figure 9**, the WKP is identified as an Expressway.

5.3 Truck Routes and Weight Classification

The WKP is an important link in Kentucky's freight network, carrying between 23 to 35 percent trucks in the study area. To determine the designations and weight classes for truck traffic in the study area, information was gathered from the KYTC HIS database. Shown on **Figure 10** are the Kentucky Highway Freight Network designations and on **Figure 11** the Kentucky Highway Truck Weight Class maximums.

Figure 8. Existing and Future Traffic Volumes

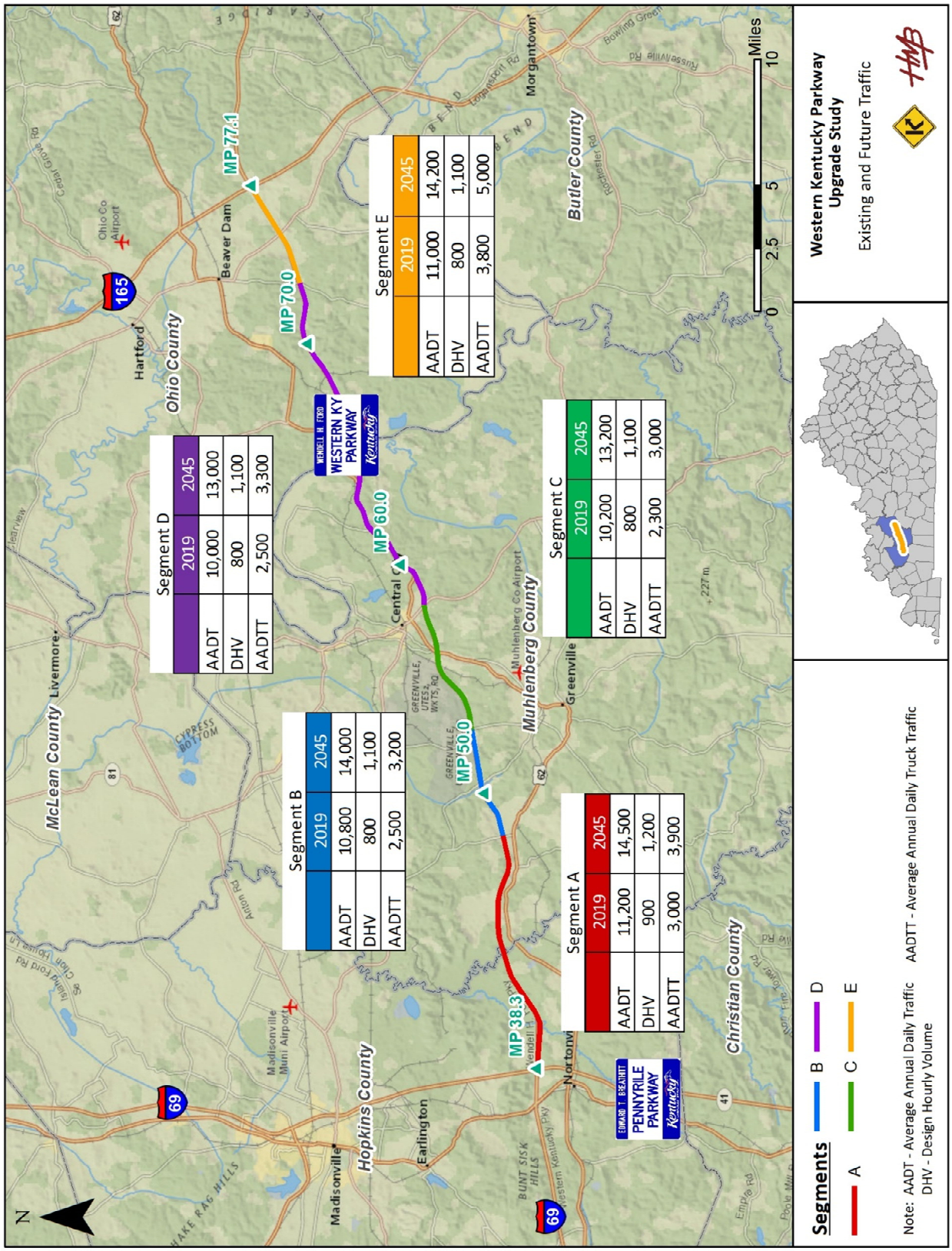


Figure 9. Functional Classification

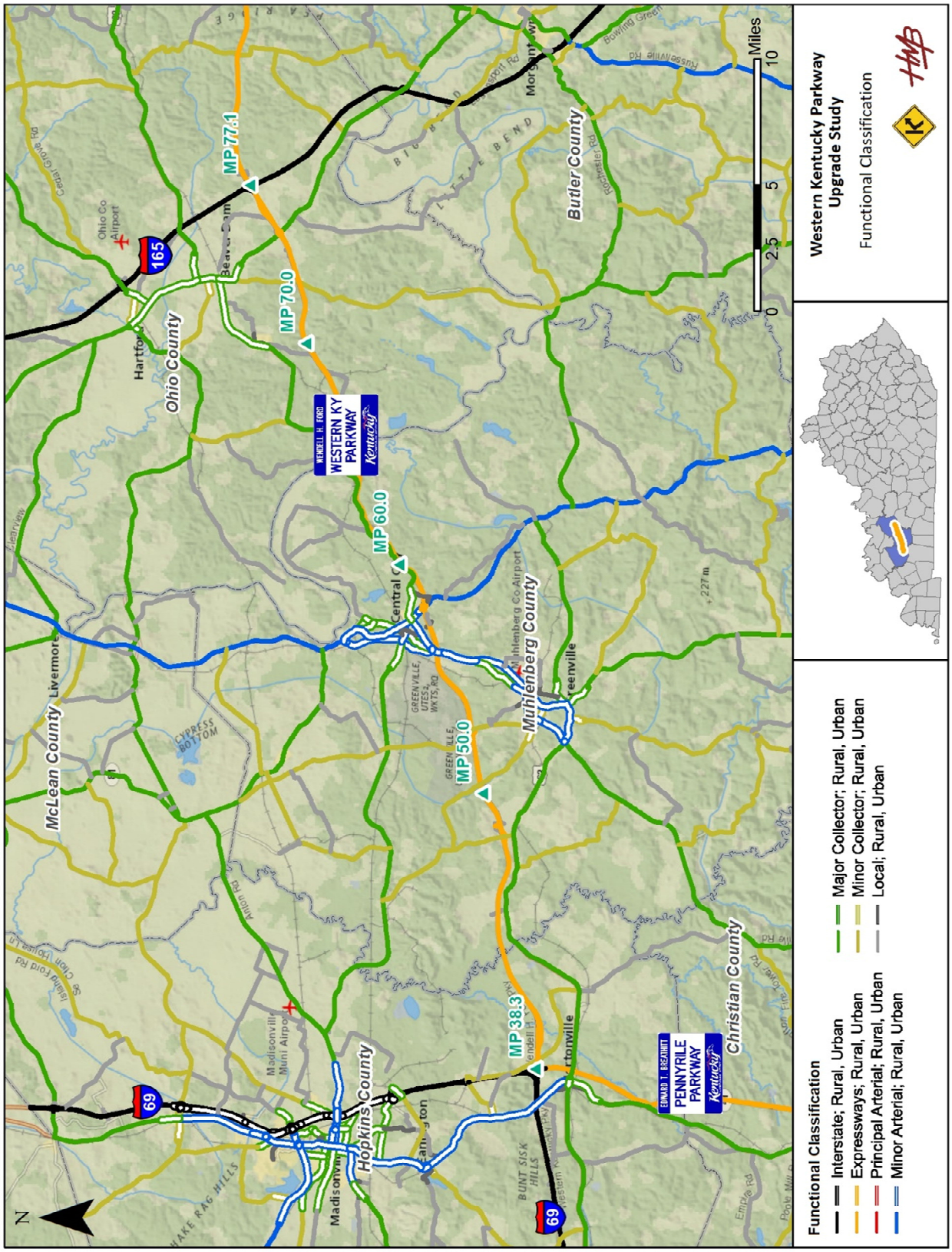


Figure 10. Kentucky Highway Freight Network

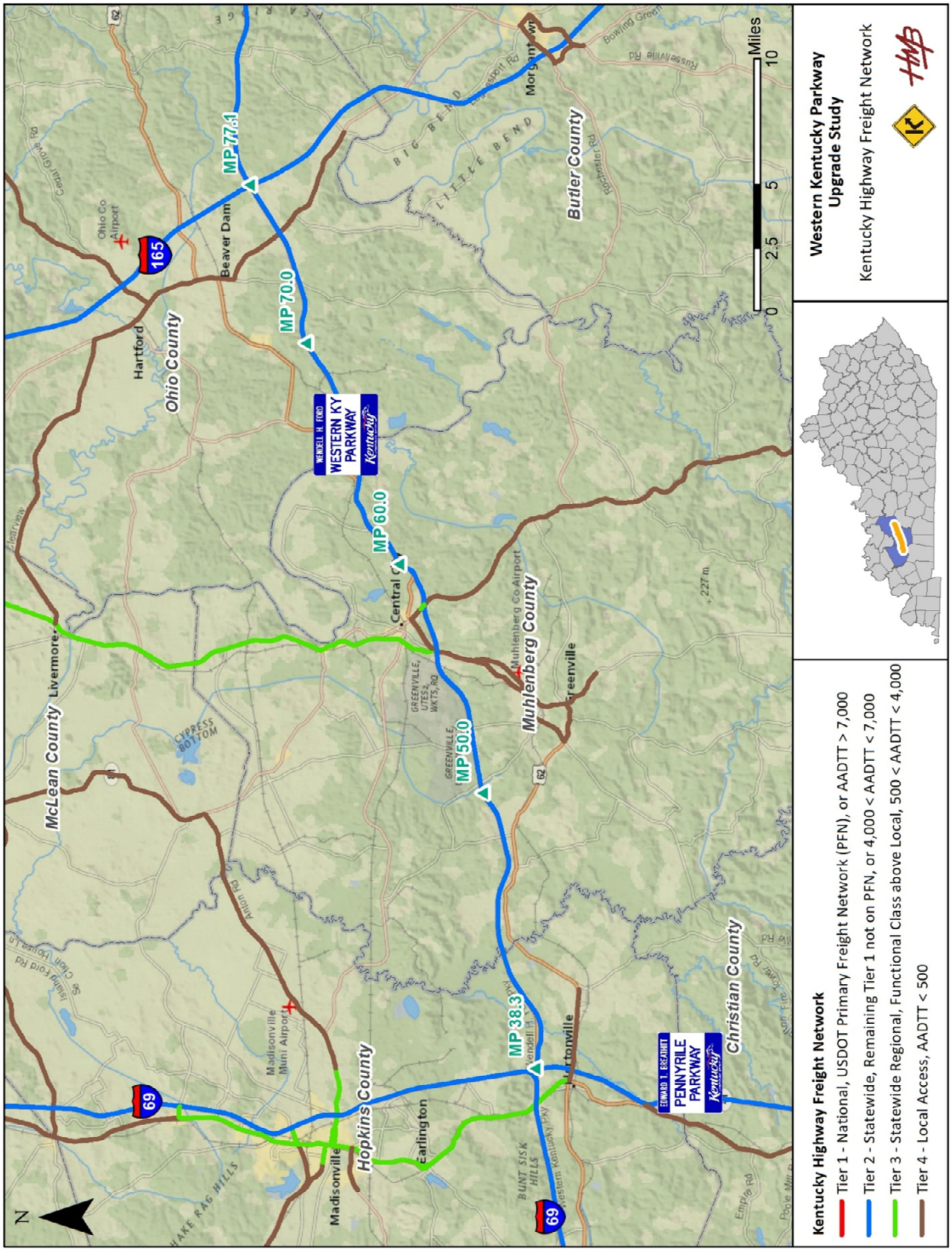
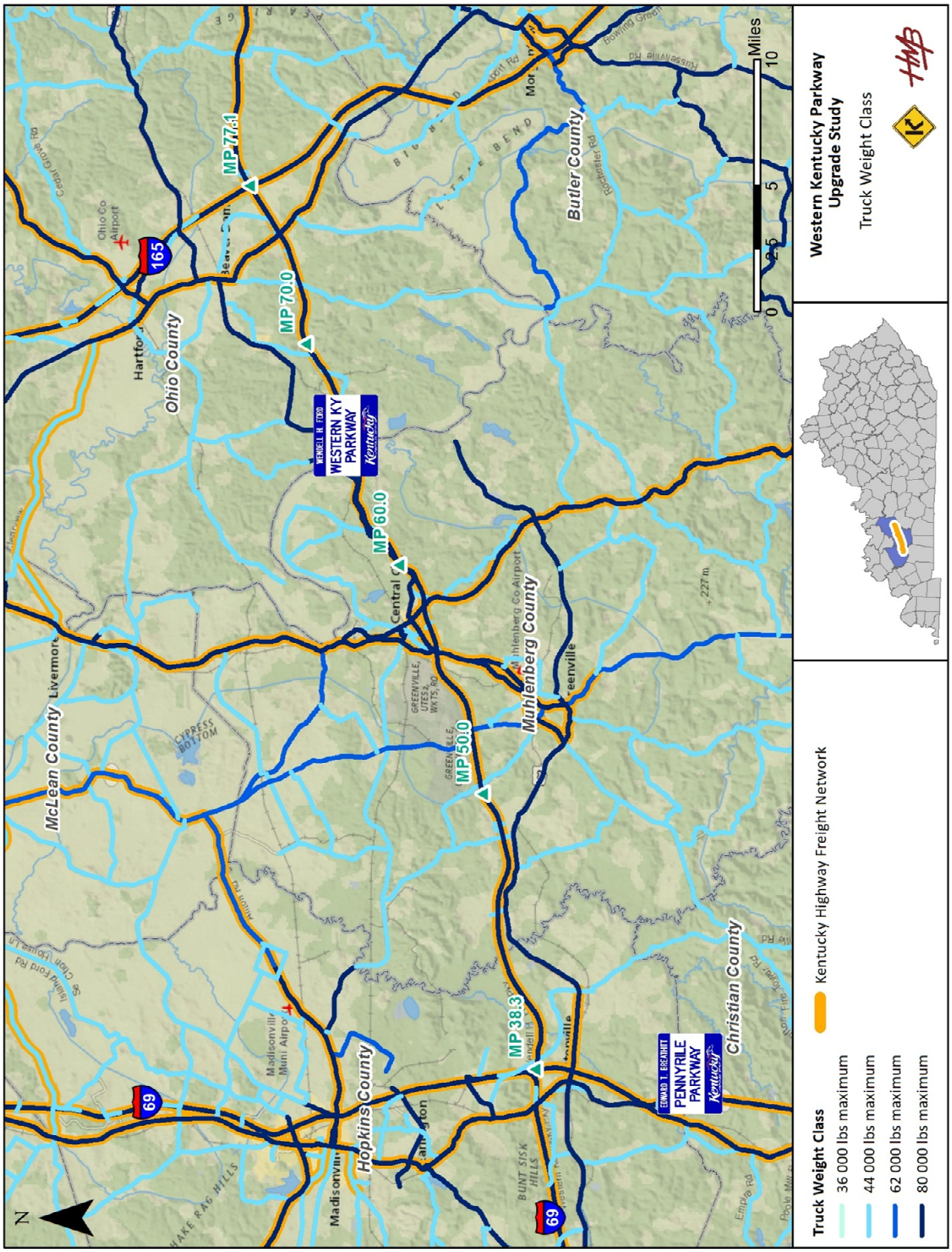


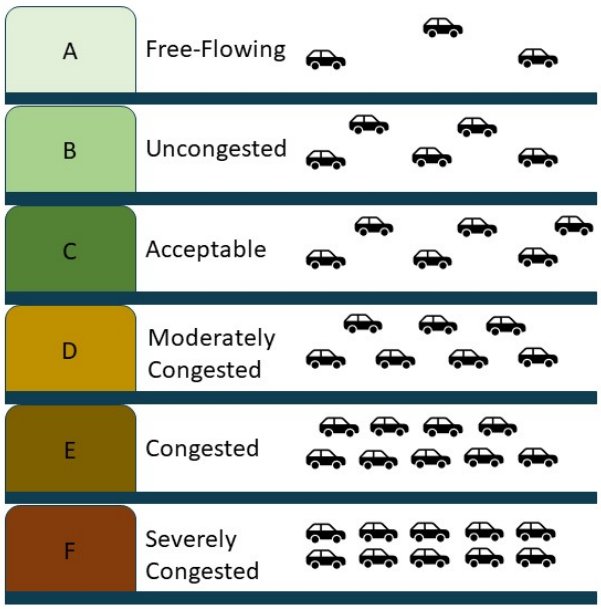
Figure 11. Kentucky Highway Truck Weight Class



5.4 Operational Analysis

A level of service (LOS) analysis was performed for mainline WKP segments and identified study area ramps using *Highway Capacity Software (HCS7)*. LOS is a qualitative measure of determining the operational characteristics of a roadway facility. It is used to define the quality of traffic operations based on measures such as vehicle speed, travel time, comfort and convenience, maneuverability, congestion, and delay. There are six levels of service for each type of facility. The levels are designated by letters, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Acceptable operations for roadways in rural areas are LOS C or better. **Figure 12** presents a graphical depiction of LOS for reference.

Figure 12. Level of Service (LOS) Designations



In addition to providing the range of traffic flow according to letter grade, other reported performance measures are density and volume to capacity ratio (V/C). Density is defined as the number of vehicles occupying a length of roadway at a given instant of time. For a basic freeway segment, a density equal to or less than 11 pc/mi/ln results in a LOS A whereas a density greater than 45 results in a LOS F. A V/C ratio represents the proportion of traffic demand using the roadway for a designated time period in relation to its theoretical capacity to serve the demand. A V/C ratio equal to or greater than 0.9 in rural areas and 1.0 in urban areas indicates the road is operating at or above its theoretical design capacity.

The levels of service, density and V/C ratios were determined for an Existing (2019) as well as a Future (2045) scenario for the corridor.

Existing (2019)

For the Existing (2019) scenario all segments and ramps along the study corridor of the WKP operate at a LOS A with densities ranging from 3.7 to 7.0 for the segments and 2.4 to 10.7 for the ramps, and V/C ratios ranging from 0.12 to 0.22 for the segments and 0.03 to 0.21 for the ramps. **Table 3** presents these along with the traffic volumes for each segment and ramp analyzed. Output from the analysis software is included in **Appendix C**.

Future (2045)

All segments and ramps along the study corridor of the WKP for the Future (2045) scenario are expected to operate at a LOS A with densities ranging from 5.1 to 7.2 for the segments and 5.0 to 10.7 for the ramps, and V/C ratios ranging from 0.16 to 0.22 for the segments and 0.05 to 0.21 for the ramps. **Table 4** presents these along with the traffic volumes for each segment and ramp analyzed. Output from the analysis software is included in **Appendix C**.

Table 3. Existing (2019) Traffic Volumes, LOS, and V/C Ratio

Segment Analysis									
Segment No.	Direction	Route (Begin Milepoint)	Route (End Milepoint)	Directional AADT (vpd)	Directional DHV (vph)	Directional Truck DHV (vph)	LOS	Density (pc/mi/ln)	Design Hour v/c Ratio
A1	Eastbound	I-69 (38.326)	KSP Post No. 2 (39.670)	5,600	450	120	A	7.0	0.22
	Westbound			5,600	450	120	A	4.3	0.13
A2	Eastbound	KSP Post No. 2 (39.670)	KY 175 (48.049)	5,600	450	120	A	6.9	0.22
	Westbound			5,600	450	120	A	4.2	0.13
B	Eastbound	KY 175 (48.049)	KY 181 (52.518)	5,400	400	90	A	6.1	0.19
	Westbound			5,400	400	90	A	3.8	0.12
C	Eastbound	KY 181 (52.518)	US 431 (57.959)	5,100	400	90	A	6.1	0.19
	Westbound			5,100	400	90	A	3.7	0.12
D	Eastbound	US 431 (57.959)	US 231 (74.583)	5,000	400	100	A	6.1	0.19
	Westbound			5,000	400	100	A	3.7	0.12
E1	Eastbound	US 231 (74.583)	Huck's (75.65)	5,500	400	140	N/A[1]		
	Westbound			5,500	400	140			
E2	Eastbound	Huck's (75.65)	I-165 (76.747)	5,500	400	140	A	7.2	0.22
	Westbound			5,500	400	140	A	4.1	0.13
Ramp Analysis									
Interchange	Exit No.	Ramp No.	Ramp	Directional AADT (vpd)	Directional DHV (vph)	Directional Truck DHV (vph)	LOS	Density (pc/mi/ln)	Design Hour v/c Ratio
KY 175	48	1	Eastbound Off-Ramp	700	100	40	A	10.6	0.12
		2	Eastbound On-Ramp	500	50	10	A	5.4	0.05
		3	Westbound Off-Ramp	500	50	10	A	6.9	0.03
		4	Westbound On-Ramp	700	100	40	A	3.1	0.08
KY 181	53	5	Eastbound Off-Ramp	800	70	20	A	9.7	0.08
		6	Eastbound On-Ramp	500	70	20	A	6.8	0.08
		7	Westbound Off-Ramp	500	80	20	A	5.6	0.06
		8	Westbound On-Ramp	800	80	20	A	2.4	0.06
US 431	58	9	Eastbound On-Ramp	1,300	120	30	A	5.8	0.21
		10	Eastbound Off-Ramp	1,400	120	20			
		11	Westbound On-Ramp	1,400	150	20	A	3.7	0.17
		12	Westbound Off-Ramp	1,300	150	30			
US 231	75	13	Eastbound Off-Ramp	1,100	130	10	A	9.6	0.10
		14	Eastbound On-Ramp	1,600	130	50	A	8.2	0.16
		15	Westbound Off-Ramp	1,600	120	50	A	6.5	0.10
		16	Westbound On-Ramp	1,100	120	10	A	4.8	0.07
Huck's	N/A	17	Eastbound Off-Ramp	800	100	30	A	10.7	0.11
		18	Eastbound On-Ramp	800	100	30	A	8.6	0.11
		19	Westbound Off-Ramp	800	100	30	A	7.2	0.07
		20	Westbound On-Ramp	800	100	30	A	6.2	0.07

Note 1. Segment length is too short to analyze as a basic segment.

Table 4. Future (2045) Traffic Volumes, LOS, and V/C Ratio

Segment Analysis									
Segment No.	Direction	Route (Begin Milepoint)	Route (End Milepoint)	Directional AADT (vpd)	Directional DHV (vph)	Directional Truck DHV (vph)	LOS	Density (pc/mi/ln)	Design Hour v/c Ratio
A1	Eastbound	I-69 (38.326)	KSP Post No. 2 (39.670)	7,250	600	160	A	7.0	0.22
	Westbound			7,250	600	160	A	5.8	0.18
A2	Eastbound	KSP Post No. 2 (39.670)	KY 175 (48.049)	7,250	600	160	A	6.9	0.22
	Westbound			7,250	600	160	A	5.7	0.18
B	Eastbound	KY 175 (48.049)	KY 181 (52.518)	7,000	550	130	A	6.1	0.19
	Westbound			7,000	550	130	A	5.2	0.16
C	Eastbound	KY 181 (52.518)	US 431 (57.959)	6,600	550	130	A	6.1	0.19
	Westbound			6,600	550	130	A	5.2	0.16
D	Eastbound	US 431 (57.959)	US 231 (74.583)	6,500	550	140	A	6.1	0.19
	Westbound			6,500	550	140	A	5.1	0.16
E1	Eastbound	US 231 (74.583)	Huck's (75.65)	7,100	550	200	N/A[1]		
	Westbound			7,100	550	200			
E2	Eastbound	Huck's (75.65)	I-165 (76.747)	7,100	550	200	A	7.2	0.22
	Westbound			7,100	550	200	A	5.7	0.18
Ramp Analysis									
Interchange	Exit No.	Ramp No.	Ramp	Directional AADT (vpd)	Directional DHV (vph)	Directional Truck DHV (vph)	LOS	Density (pc/mi/ln)	Design Hour v/c Ratio
KY 175	48	1	Eastbound Off-Ramp	900	120	50	A	10.6	0.12
		2	Eastbound On-Ramp	650	70	20	A	5.4	0.05
		3	Westbound Off-Ramp	650	70	20	A	9.6	0.05
		4	Westbound On-Ramp	900	120	50	A	4.7	0.10
KY 181	53	5	Eastbound Off-Ramp	1,050	90	30	A	9.7	0.08
		6	Eastbound On-Ramp	650	90	30	A	6.8	0.08
		7	Westbound Off-Ramp	650	100	30	A	7.3	0.07
		8	Westbound On-Ramp	1,050	100	30	A	3.9	0.07
US 431	58	9	Eastbound On-Ramp	1,700	160	40	A	5.8	0.21
		10	Eastbound Off-Ramp	1,800	160	30			
		11	Westbound On-Ramp	1,800	190	30	A	5.0	0.21
		12	Westbound Off-Ramp	1,700	190	40			
US 231	75	13	Eastbound Off-Ramp	1,500	170	20	A	9.6	0.10
		14	Eastbound On-Ramp	2,100	170	80	A	8.2	0.16
		15	Westbound Off-Ramp	2,100	160	80	A	8.3	0.13
		16	Westbound On-Ramp	1,500	160	20	A	6.3	0.10
Huck's	N/A	17	Eastbound Off-Ramp	1,000	130	40	A	10.7	0.11
		18	Eastbound On-Ramp	1,000	130	40	A	8.6	0.11
		19	Westbound Off-Ramp	1,000	120	40	A	9.1	0.09
		20	Westbound On-Ramp	1,000	120	40	A	7.8	0.09

Note 1. Segment length is too short to analyze as a basic segment.

Chapter 6. Crash Analysis

As part of this study, historical crash data was analyzed to identify locations along the portion of the WKP in the study area that could be considered high crash locations. Historical crash records were extracted from the Kentucky State Police's (KSP) *Collision Database* for a five-year period (January 1, 2014 – December 31, 2018).

6.1 Crash Analysis Methods

The statistical crash analysis was performed based on methods that compare existing crash rates with crash rates of similar types of facilities. These methods included the Critical Crash Rate method and the Excess Expected Crashes method. Statewide crash rates and methodologies were provided by the Kentucky Transportation Center (KTC) and found in *Analysis of Traffic Crash Data in Kentucky (2014-2018)*. Detailed crash reports were analyzed for specific locations as needed as the study progressed.

Critical Crash Rate

KYTC uses a systematic procedure to identify locations having high crash rates. The actual number of crashes, as obtained from the KYOPS database, occurring within a roadway segment is used to calculate the Actual Crash Rate using the number of crashes, roadway length, AADT, and the number of years for which crash data is being examined. Using an analysis procedure from the Kentucky Transportation Center and referenced in *The Analysis of Traffic Crash Data in Kentucky (2014-2018)*, Actual Crash Rates are compared to the Critical Crash Rate for similar types of Kentucky roadways. The Critical Crash Rate is the rate which is greater statistically than the average crash rate for similar roadways and represents a rate above which crashes may be occurring in a non-random fashion. This ratio of Actual Crash Rate to the Critical Crash Rate is the Critical Crash Rate Factor (CRF). Thus, a CRF greater than 1.0 indicates crashes may be occurring more often than can be attributed to random occurrence. This procedure is used as a screening technique indicating locations where further analysis may be needed. It is not a definitive statement of a crash problem, nor a measurement of a crash problem.

Crashes were analyzed as "segments" of variable length based on where traffic volume changes, as well as 0.3-mile "spots." Based on this analysis, there were 70 high crash spots identified throughout the corridor, and two high crash segments. An overview of the high crash spot locations is presented in **Figure 13**, and an overview of the segment CRFs is presented in **Table 5**. CRFs highlighted in red in the table are values that are above the 1.0 threshold.

Table 5. Critical Rate Factors by Roadway Segment (2014-2018)

Location				2019 AADT (vpd)	Crashes				Critical Rate Factor (CRF)
Segment	County	Begin Milepoint	End Milepoint		Fatal	Injury	PDO	Total	
1	Hopkins/Muhlenberg	38.326	48.330	11,200	2	17	180	199	**1.20**
2	Muhlenberg	48.330	52.545	10,800	2	10	41	53	**0.71**
3	Muhlenberg	52.545	57.970	10,200	0	10	80	90	**1.02**
4	Muhlenberg/Ohio	57.970	74.580	10,000	1	46	176	223	**0.94**
5	Ohio	74.580	77.143	11,000	0	11	26	37	**0.75**

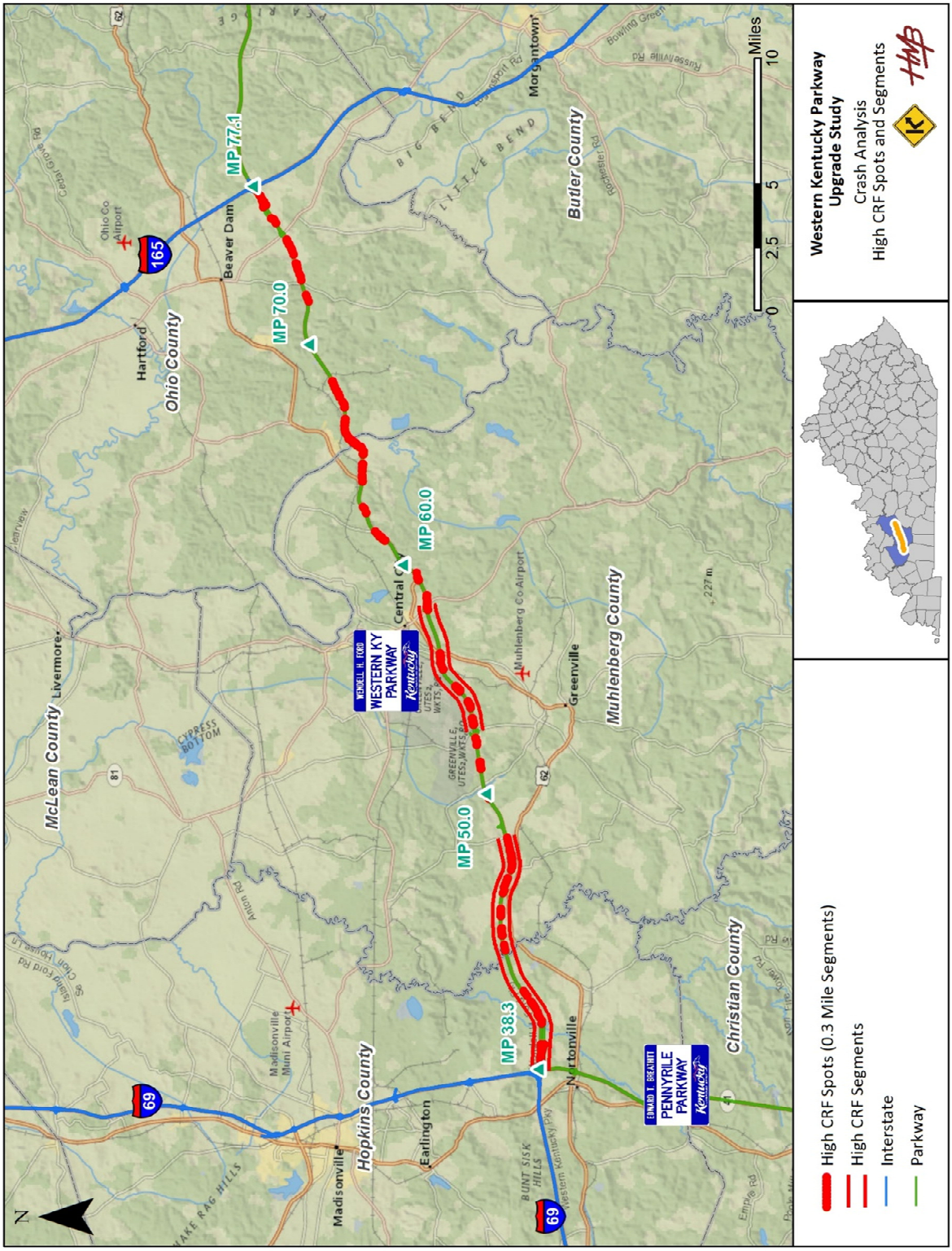
Excess Expected Crashes

KYTC crash analysis methodology has been evolving, transitioning from the Critical Crash Rate method and progressing toward the Excess Expected Crashes (EEC) methodologies based on the AASHTO Highway Safety Manual (HSM) procedures. HSM methods allow for the ability to estimate potential crash frequency on roadways, and the potential effects that differences in roadway characteristics have on crashes (e.g. a 3-foot shoulder versus a 10-foot shoulder). Elements needed for EEC analysis include crash history, AADT, segment length, facility type, and other roadway characteristics such as grade and shoulder width. KTC has been conducting data collection and research into the process and application of this method for Kentucky and has developed Kentucky-specific safety performance functions (SPF) to use in these analysis procedures. These equations are used to determine a predicted amount of crashes for a specified segment of road. These predicted crashes are compared with an observed amount of crashes that are adjusted per the Empirical Bayes method to determine the excess amount of crashes expected to have occurred in the segment. The mathematical difference between these is otherwise known as EEC. If the EEC is positive, it indicates more crashes have occurred than expected in the segment. If the EEC is negative, it indicates that there are less crashes than expected. KTC provided the EEC along with the factors and formulas to use for each segment of the study corridor. KTC uses a tool called CDAT (Crash Data Access Tool) which accesses crash data from 2013 to 2017.

EEC analysis uses historical observed crash data for a specified time period and segment length. The segments are based on KYTC's traffic count segments, and these typically change when there is a change in roadway characteristic or breakpoint such as an intersecting road. The analysis was completed for the WKP study corridor but did not include intersecting roads. The number of crashes for each segment was broken down based on severity as well and is shown alongside the EEC. These severities are classified based on the FHWA KABCO Injury Classification Scale. Each state may have slight variances in the definitions of these classifications. Kentucky defines KABCO as follows:

- K – Fatal: indicates the person was killed as a result of the collision and died within 30 days of the collision.

Figure 13. High CRF Spots (0.3 Miles) and Segments



- A – Incapacitating: any non-fatal injury which prevents the person from walking, driving, or normally continuing the activities he / she could perform prior to the collision and does require medical attention. Includes severe lacerations, broken limbs, skull fracture, internal injuries, unconsciousness when leaving the scene, or inability to leave scene without assistance.
- B – Non-incapacitating: evident to observers at the collision scene such as minor lacerations, bruises, and abrasions.
- C – Possible Injury: claim of injury and / or pain that is not evident to the eye. Includes momentary unconsciousness, limping, nausea, and hysteria.
- O – No Injury detected (property damage only).

There was a total of 244.78 EEC along the mainline of the WKP. An overview of the EEC by segment is presented in **Table 6.**

Table 6. CDAT Excess Expected Crashes by Segment (2013-2017)

ID	County	Begin Milepoint	End Milepoint	Length	2019 AADT	K	A	B	C	O	Total	EEC
SEGMENT 1	Hopkins	38.326	43.424	5.098	11200	1	1	0	4	85	91	43.30
SEGMENT 1a	Muhlenberg	43.424	48.330	4.906	11200	1	1	6	5	87	100	50.38
SEGMENT 2	Muhlenberg	48.330	52.545	4.215	10800	2	1	3	6	40	52	19.86
SEGMENT 3	Muhlenberg	52.545	57.970	5.425	10200	0	1	3	5	76	85	38.51
SEGMENT 4	Muhlenberg	57.970	65.675	7.705	10000	0	6	6	13	81	106	44.87
SEGMENT 4a	Ohio	65.675	74.580	8.905	10000	1	3	9	8	93	114	46.07
SEGMENT 5	Ohio	74.580	77.143	2.563	11000	0	2	4	1	10	17	1.79
					Totals	5	15	31	42	472	565	244.78

CRF and EEC Comparison

To further analyze the crash data, a comparison between the CRF and EEC methodologies was performed. For each high CRF spot (greater than 1.0), an EEC analysis was performed for the same segment. Higher CRFs generally correlated to higher EEC and vice-versa, however the two cannot be directly compared. This is because the EEC analysis was based on CDAT data from 2013-2017 and did not include the intersection-ramps. Furthermore, as AADT goes up, CRF goes down. However, the opposite is true with EEC; as AADT goes up, the EEC goes up. The EEC value for each spot is presented alongside the CRFs in **Table 7.** The results are formatted so that relatively higher values are a darker shade of red.

Table 7. Directional Critical Rate Factors and Excess Expected Crashes

Location			Crashes						
Begin Milepoint	End Milepoint	Direction	2019 AADT	Fatal	Injury	PDO	Total	Critical Rate Factor (CRF)	Excess Expected Crashes (EEC)
38.681	38.981	WB	5600	0	0	5	5	**1.60**	**2.28**
38.681	38.981	EB	5600	0	0	8	8	**2.56**	**3.96**
39.091	39.391	WB	5600	0	1	3	4	**1.28**	**1.72**
39.091	39.391	EB	5600	0	1	7	8	**2.56**	**3.96**
40.175	40.475	WB	5600	0	0	5	5	**1.60**	**2.28**
40.552	40.852	WB	5600	0	0	9	9	**2.88**	**4.52**
40.879	41.179	EB	5600	0	0	4	4	**1.28**	**1.72**
40.879	41.179	WB	5600	0	0	4	4	**1.28**	**1.72**
41.400	41.700	EB	5600	0	1	4	5	**1.60**	**2.28**
43.438	43.738	WB	5600	0	0	5	5	**1.60**	**2.28**
44.053	44.353	EB	5600	1	0	3	4	**1.28**	**1.72**
44.053	44.353	WB	5600	0	0	6	6	**1.92**	**2.84**
44.865	45.165	WB	5600	0	2	4	6	**1.92**	**2.84**
44.865	45.165	EB	5600	0	0	7	7	**2.24**	**3.40**
45.714	46.014	WB	5600	0	2	2	4	**1.28**	**1.72**
46.107	46.407	WB	5600	0	0	6	6	**1.92**	**2.84**
46.710	47.010	EB	5600	0	2	5	7	**2.24**	**3.40**
47.047	47.347	EB	5600	0	0	5	5	**1.60**	**2.28**
47.047	47.347	WB	5600	0	2	4	6	**1.92**	**2.84**
47.365	47.665	WB	5600	0	1	4	5	**1.60**	**2.28**
47.365	47.665	EB	5600	0	1	5	6	**1.92**	**2.84**
47.777	48.077	EB	5600	0	0	4	4	**1.28**	**1.72**
47.777	48.077	WB	5600	0	0	6	6	**1.92**	**2.84**
49.764	50.064	WB	5400	0	0	6	6	**1.95**	**2.82**
50.989	51.289	WB	5400	0	2	2	4	**1.30**	**1.71**
50.989	51.289	EB	5400	0	1	4	5	**1.63**	**2.26**
51.933	52.233	WB	5400	0	1	3	4	**1.30**	**1.71**
52.744	53.044	EB	5100	0	1	4	5	**1.68**	**2.24**
52.744	53.044	WB	5100	0	0	5	5	**1.68**	**2.24**
53.432	53.732	WB	5100	0	0	4	4	**1.34**	**1.70**
53.432	53.732	EB	5100	0	2	3	5	**1.68**	**2.24**
54.212	54.512	EB	5100	0	0	3	3	**1.01**	**1.15**
54.212	54.512	WB	5100	0	1	3	4	**1.34**	**1.70**
55.366	55.666	EB	5100	0	1	3	4	**1.34**	**1.70**
55.366	55.666	WB	5100	0	0	7	7	**2.35**	**3.32**
55.698	55.998	EB	5100	0	0	6	6	**2.01**	**2.78**

Table 7. Directional Critical Rate Factors and Excess Expected Crashes (cont.)

Location				Crashes					
Begin Milepoint	End Milepoint	Direction	2019 AADT	Fatal	Injury	PDO	Total	Critical Rate Factor (CRF)	Excess Expected Crashes (EEC)
55.698	55.998	WB	5100	0	1	11	12	**4.02**	**6.03**
57.718	58.018	EB	5100	0	2	2	4	**1.34**	**1.70**
57.718	58.018	WB	5100	0	1	16	17	**5.70**	**8.73**
58.134	58.434	EB	5000	0	1	2	3	**1.02**	**1.15**
58.134	58.434	WB	5000	0	1	6	7	**2.37**	**3.30**
59.066	59.366	WB	5000	0	1	5	6	**2.03**	**2.76**
61.071	61.371	EB	5000	0	1	3	4	**1.35**	**1.69**
61.496	61.796	WB	5000	0	2	2	4	**1.35**	**1.69**
62.565	62.865	WB	5000	0	0	3	3	**1.02**	**1.15**
63.875	64.175	EB	5000	0	0	3	3	**1.02**	**1.15**
64.297	64.597	WB	5000	0	2	1	3	**1.02**	**1.15**
64.297	64.597	EB	5000	0	2	5	7	**2.37**	**3.30**
64.952	65.252	EB	5000	0	1	3	4	**1.35**	**1.69**
64.952	65.252	WB	5000	0	1	3	4	**1.35**	**1.69**
65.290	65.590	EB	5000	0	0	3	3	**1.02**	**1.15**
65.290	65.590	WB	5000	0	1	5	6	**2.03**	**2.76**
65.597	65.897	WB	5000	0	2	1	3	**1.02**	**1.15**
65.597	65.897	EB	5000	0	1	5	6	**2.03**	**2.76**
65.999	66.299	WB	5000	0	2	3	5	**1.69**	**2.23**
66.391	66.691	EB	5000	0	1	2	3	**1.02**	**1.15**
66.391	66.691	WB	5000	0	1	2	3	**1.02**	**1.15**
67.092	67.392	EB	5000	0	1	4	5	**1.69**	**2.23**
67.598	67.898	WB	5000	0	1	3	4	**1.35**	**1.69**
68.012	68.312	WB	5000	0	2	3	5	**1.69**	**2.23**
71.702	72.002	EB	5000	0	0	4	4	**1.35**	**1.69**
72.582	72.882	EB	5000	0	2	3	5	**1.69**	**2.23**
73.024	73.324	EB	5000	0	1	3	4	**1.35**	**1.69**
73.024	73.324	WB	5000	0	0	5	5	**1.69**	**2.23**
73.638	73.938	EB	5000	0	0	5	5	**1.69**	**2.23**
74.036	74.336	WB	5000	0	1	6	7	**2.37**	**3.30**
75.085	75.385	WB	5000	0	2	1	3	**1.02**	**1.15**
75.875	76.175	EB	5500	0	0	4	4	**1.29**	**1.71**
75.875	76.175	WB	5500	0	1	4	5	**1.61**	**2.27**
76.285	76.585	EB	5500	0	1	3	4	**1.29**	**1.71**

6.2 High-Level Crash Analysis

Aside from these two crash analysis methods, a high-level crash analysis was performed by analyzing the historical crash information provided by the KSP Collision Database and plotting all crashes along the corridor during the 5-year time period by their mile point and geographic coordinates. This involved analyzing statistics such as manner of collision, collision severity, daylight vs. dark conditions, weather conditions, directional analysis, and others in order to find trends or help determine what could be causing crashes along the corridor.

Overall, there were 672 crashes within the 5-year timeframe in the study area. Overall statistics are summarized in **Figure 14** below. An overview map of the overall crash distribution density is presented in **Figure 15**. A more in-depth list of all crashes as well as Directional Analysis statistics and maps showing crash locations by manner and severity can be found in **Appendix D.**

Figure 14. Crash Statistics Infographic

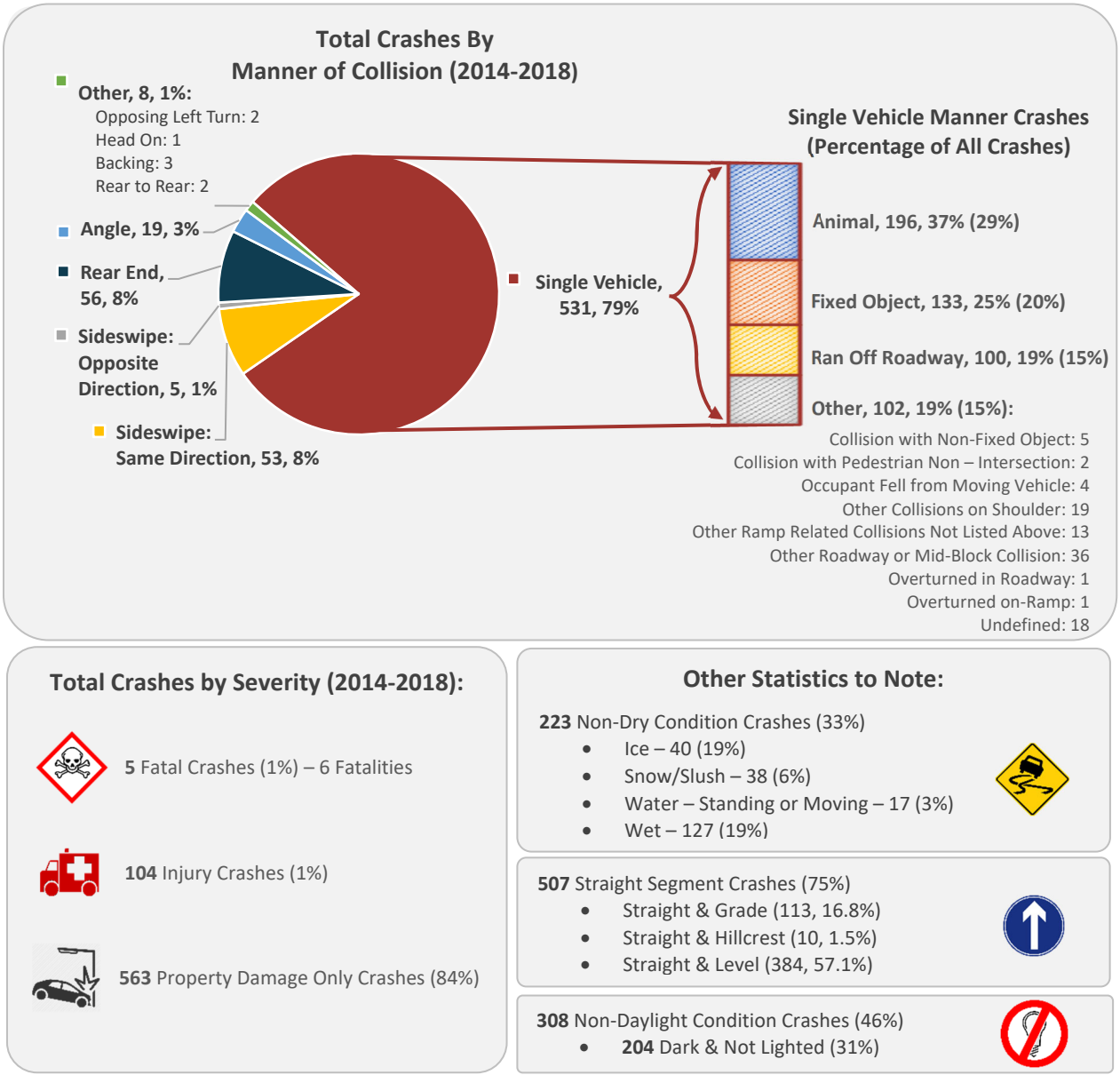
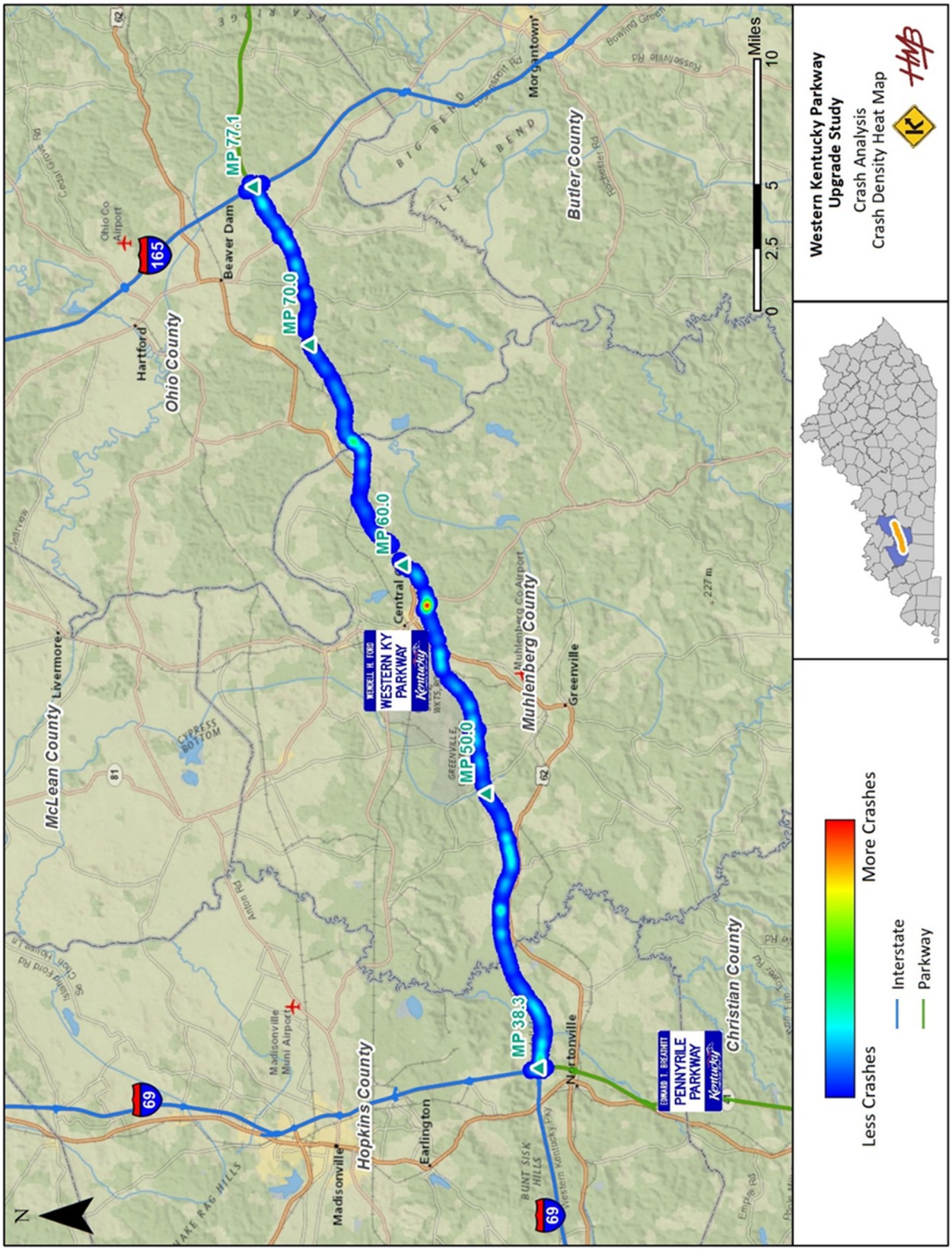


Figure 15. Crash Density Heat Map



6.3 Detailed Crash Reports

Detailed crash reports were not analyzed for the entirety of the study corridor. However, based on the data compiled through the crash rate analysis and the high-level evaluation of contributing factors, several areas were identified that warranted additional review. These included:

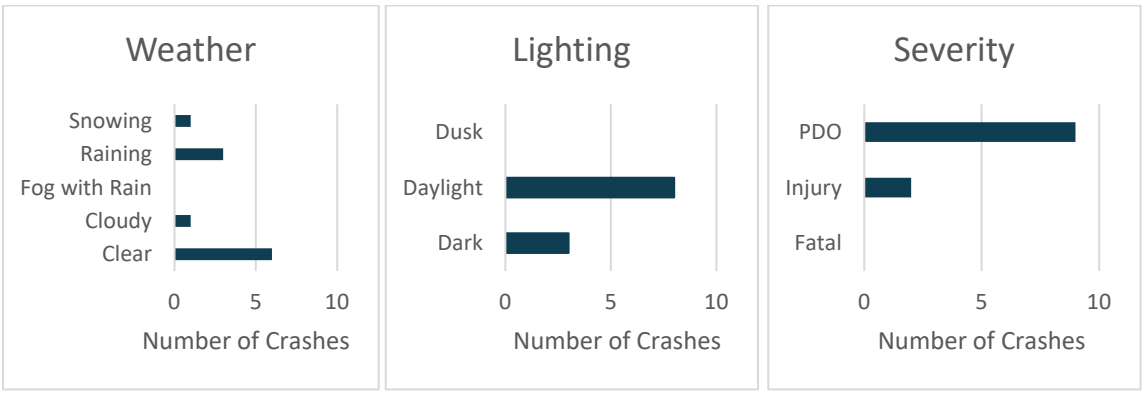
- KSP Post No. 2 (MP 39.241 – MP 40.186)
- Huck's (MP 74.922 – 76.547)
- Green River Bridge (MP 65.290 – 65.735)
- Median Crossover
- Fatal Crashes

The crash reports for these locations were provided by KYTC. The findings are presented for each location in the following text.

KSP Post No. 2

Eleven (11) crashes were identified as occurring in the area of the KSP Post No. 2. **Figure 16** provides details regarding weather, lighting, and severity.

Figure 16. Additional Crash Information - KSP Post No. 2



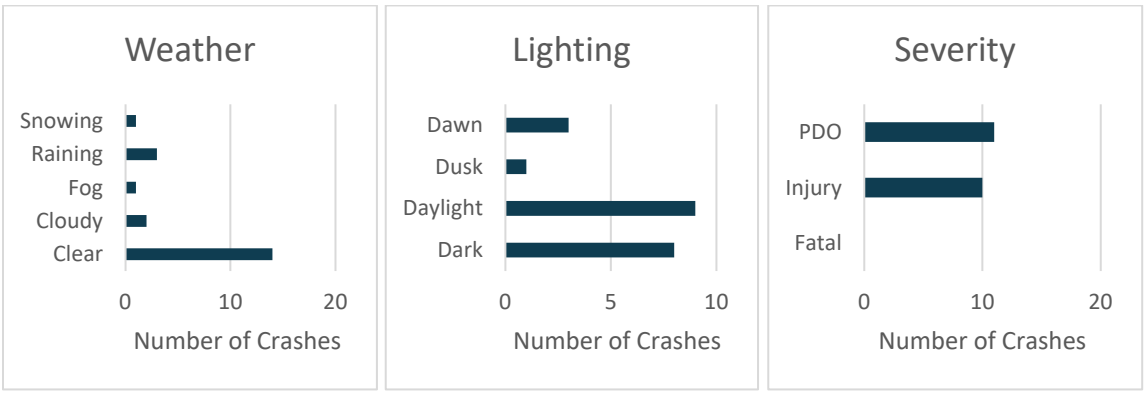
Note: PDO = Property Damage Only

Further review of the descriptions included in the reports did not show a correlation with ramp location / geometry that could be identified as a contributing factor to crashes occurring in this location. Two of the crashes involved factors associated with driver distraction. One crash occurred with an animal. Three involved some type of vehicle malfunction or issue. Three crashes that included inclement weather conditions which included rain or snow / slush on the roadway did not show the weather being a contributing factor to losing control of vehicle.

Huck's

Twenty-one (21) crashes were identified as occurring in the area associated with Huck's. **Figure 17** provides details regarding weather, lighting, and severity.

Figure 17. Additional Crash Information - Huck's



The data presented in **Figure 17** shows that the majority occurred during clear weather conditions. A review of the severity of the crashes (i.e. fatality, injury, or property damage only) showed there were almost as many injury crashes as there were property damage only.

Further review of the descriptions included in the reports yielded the following observations:

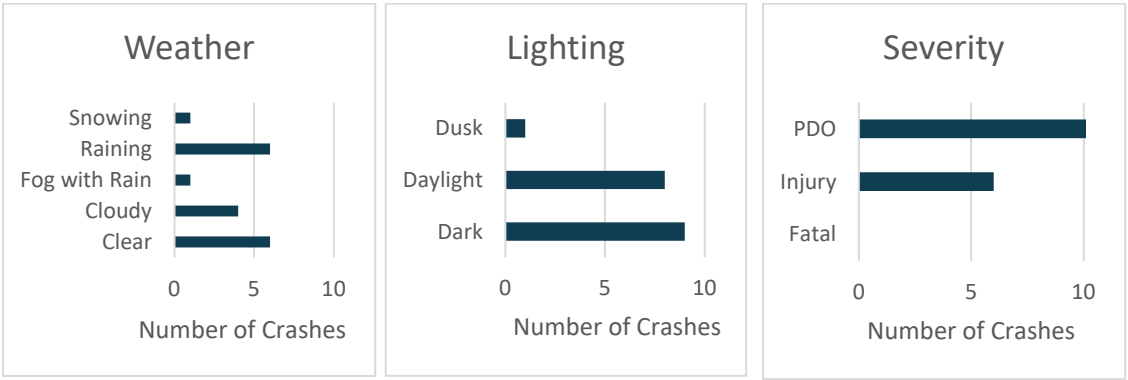
- One involved a crash with an animal
- Eight involved a distracted driver
- Two involved snow or water on the roadway and loss of control

Three out of twenty-one crashes involved vehicles exiting / entering the WKP from Huck's. One was a result of water pooling on the exit ramp. A second one involved a merging issue from Huck's to the WKP. The third one noted driver expectation, and it further detailed that the driver thought the exit would be on the right and then swerved left to get off the exit and hit another vehicle.

Green River Bridge

Eighteen (18) crashes were identified as occurring in the area associated with the Green River Bridge (MP 65.290 – MP 65.735). **Figure 18** provides details regarding weather, lighting, and severity.

Figure 18. Additional Crash Information - Green River Bridge



The data presented in **Figure 18** shows that the majority occurred during inclement weather conditions. There is no lighting at the bridge location though approximately the same number of crashes occurred during the daylight compared to dark conditions.

Further review of the descriptions included in the reports yielded the following observations:

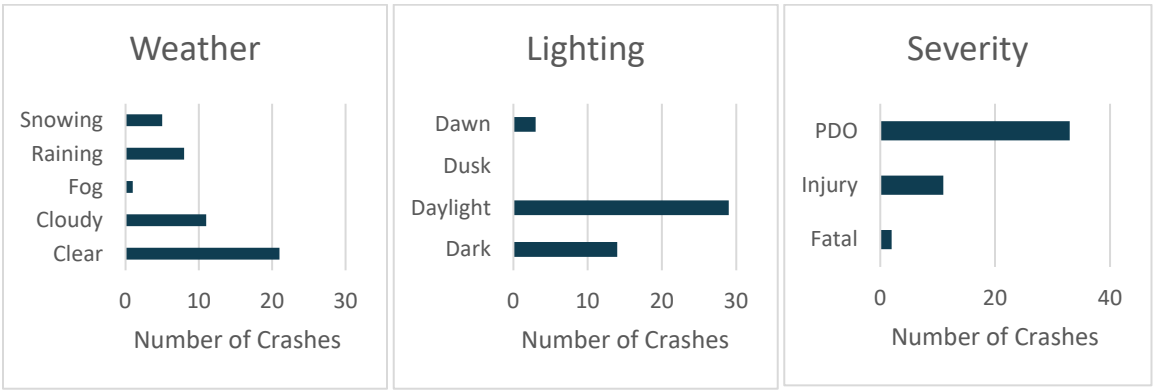
- Three involved crashes with animals
- Two involved objects either coming out of or falling out of vehicles
- Two involved a distracted driver
- Six involved water pooling on the roadway and loss of control

These observations paired with the weather, lighting, and severity details indicate that several crashes in this area can be attributed to water on the roadway. During the improvement options evaluation, measures to help address this issue were thus evaluated.

Median

Forty-six (46) crashes were identified as occurring in the areas associated with the median. **Figure 19** provides details regarding weather, lighting, and severity.

Figure 19. Additional Crash Information - Medians



Further review of the descriptions included in the reports showed that twenty (20) out of the forty-six (46) crashes resulted in a vehicle fully crossing the median. The remainder noted the final resting place of the vehicle either in the median or on a ramp. This information can be used to further determine the need for and locations of median barriers during the improvement options development and evaluation.

Fatal Crashes

Five fatal crashes involving six fatalities occurred within the study area during the timeframe studied. A review of contributing factors showed that the majority occurred during clear weather, dry conditions, and daylight. One did occur during rainy weather where the pavement was wet, and the vehicle reportedly hydroplaned. One other fatal crash involved a pedestrian who was running in the middle of the eastbound lanes of the WKP. These crashes and the contributing factors were considered during the development of improvement options.

Chapter 7. Phase 1 Meetings

Over the course of the study, the project team met twice to discuss progress and next steps. In addition, local officials and stakeholders were engaged to obtain their input and keep them informed of the process. The first round of meetings (Phase 1) are described below and the second round of meetings (Phase 2) are presented in the next chapter.

Project Team Meeting No. 1

The first project team meeting was held on August 19, 2019, where representatives from KYTC, Green River Area Development District (GRADD), Pennyrile Area Development District (PADD), and the consultant primarily discussed the project history, study purpose, crash and traffic analysis, existing conditions, and outlined the next steps. Key action items were to add animal hits back into the CRF analysis, review deficiencies relative to crash frequency and type, and develop improvement concepts to address identified deficiencies. More details from the meeting can be found in **Appendix E**.

Local Officials and Stakeholders Meeting No. 1

A local officials / stakeholder (LO/S) meeting was also held on August 19, 2019. Not including KYTC, GRADD, PADD and consultant staff, 18 LO/S representatives attended the meeting. The project team presented the study purpose, project background, crash and traffic analysis, existing conditions, and next steps. Comment forms were distributed and summarized following the meeting. Eleven comment forms were returned with all eleven respondents noting their support for the project. One representative did note their support was contingent on an exemption being granted for Huck's. More details from the meeting, including a list of attendees and the presentation can be found in **Appendix E**.

Chapter 8. Development of Potential Work Items and Costs to Address Deficiencies

In order to upgrade the WKP to interstate standards, a range of potential work items was investigated to address the deficiencies outlined in this study. Those deficiencies are categorized as follows:

- **Design Exception** – deficiency that falls within FHWA's 10 controlling design criteria.
- **Design Variance** – deficiency that does not fall within the 10 controlling criteria but does not adhere to minimum AASHTO or KYTC guidelines.
- **Other Considerations** – operational or safety considerations investigated as a part of this study.

This chapter describes each work item and provides information regarding the cost estimate methodology of each work item. All cost estimates provided were calculated in 2019 dollars.

8.1 Mainline

Horizontal Curves

As discussed in the previous chapter, there are 26 horizontal curves that do not meet a 70 mph design speed based on each horizontal curve's radius and superelevation rate. The radius for each of these curves meet minimum standards; however, the superelevation would need to be increased in order to achieve interstate design criteria for a 70 mph design speed. Based on previous 3R projects, horizontal curves which did not meet the criteria for design speed based on radius and superelevation would be evaluated by maximum allowable side friction factor. When the side friction factor was calculated for each curve, the results indicated that all 26 horizontal curves met the maximum allowable side friction factor for 70 mph.

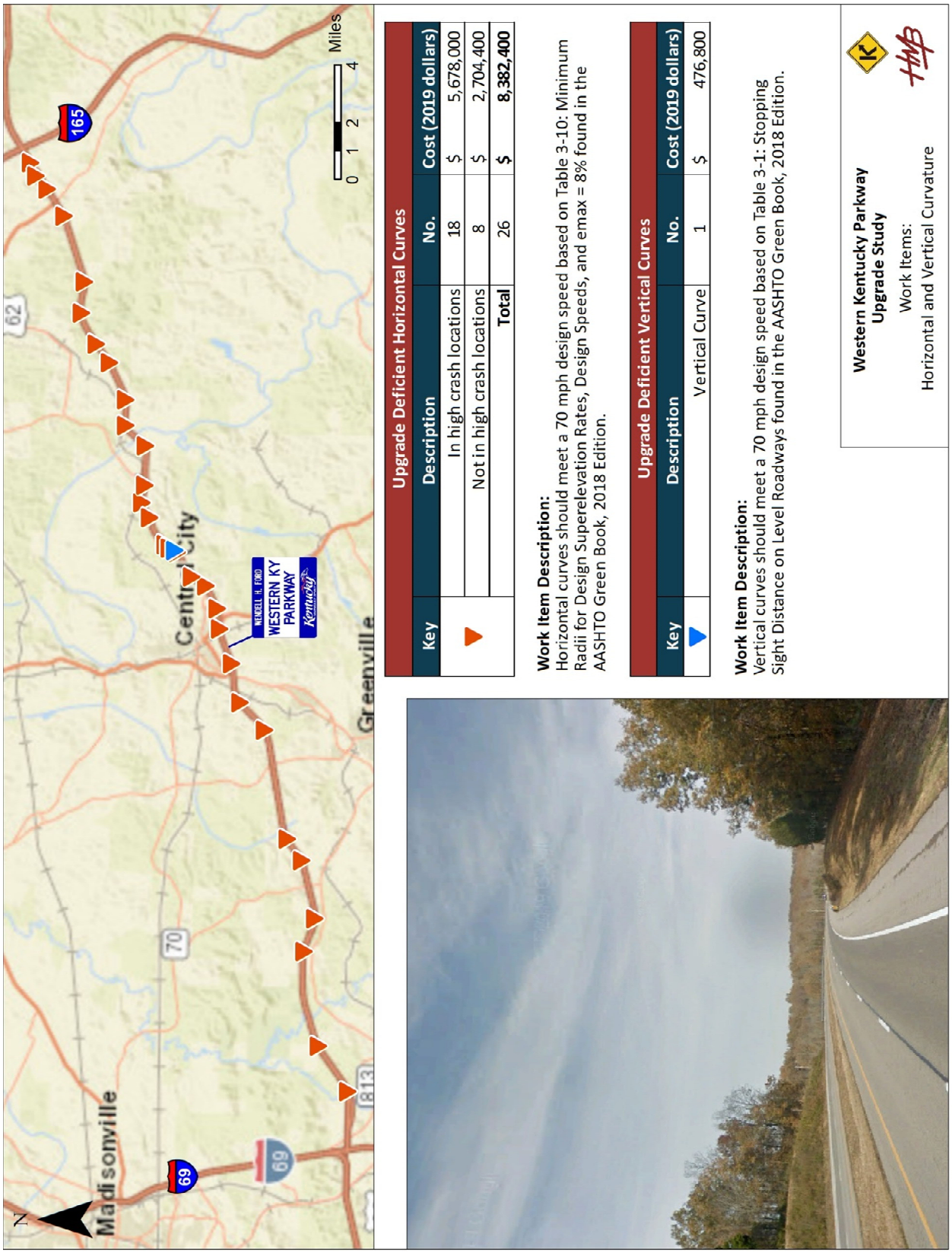
The crash analysis done as a part of this study determined that a high crash spot occurred within 18 of these 26 horizontal curves. Each of these curves may need to be investigated further through a detailed field survey.

Leveling and wedging, minor grading, and 1.5" of asphalt surface would be required to increase the superelevation and modify the cross slope transition. While it may not be necessary to correct each horizontal curve, quantities and estimates were developed for each. The planning-level cost estimate for this work item is $8,382,400 in 2019 dollars. This work item is illustrated in **Figure 20**.

Vertical Curves

There are four sag vertical curves that do not meet headlight sight distance for a 70 mph design speed. The headlight sight distance deficiency for three of those four vertical curves are negligible, and they do not have an adverse effect on the operation or safety of the WKP.

Figure 20. Horizontal and Vertical Curves Work Items



Upgrade Deficient Horizontal Curves			
Key	Description	No.	Cost (2019 dollars)
	In high crash locations	18	$ 5,678,000
	Not in high crash locations	8	$ 2,704,400
	Total	26	**$ 8,382,400**

Work Item Description:
Horizontal curves should meet a 70 mph design speed based on Table 3-10: Minimum Radii for Design Superelevation Rates, Design Speeds, and emax = 8% found in the AASHTO Green Book, 2018 Edition.

Upgrade Deficient Vertical Curves			
Key	Description	No.	Cost (2019 dollars)
	Vertical Curve	1	$ 476,800

Work Item Description:
Vertical curves should meet a 70 mph design speed based on Table 3-1: Stopping Sight Distance on Level Roadways found in the AASHTO Green Book, 2018 Edition.

Western Kentucky Parkway Upgrade Study
Work Items:
Horizontal and Vertical Curvature

The sag vertical curve located at MP 61.1 has a headlight sight distance of 635 feet. Its existing length is 800 feet, but in order to meet a minimum headlight sight distance of 730 feet, the length would need to be increased to 938 feet. The deficient sag vertical curve is not located in a high crash spot according to the crash analysis. Although the headlight sight distance is 95 feet less than what is required, there is no evidence to suggest that it has an adverse effect on the operation or safety of the WKP.

While it may not be necessary to correct this vertical curve, an improvement option was considered. Leveling and wedging, grading, and 1.5" of asphalt surface would be required to modify this vertical curve in order to meet minimum standards. The planning-level cost estimate for this work item is $476,800 and is further described in **Figure 20**.

Cross Slopes

As discussed in previous sections, there was a limited field review conducted that revealed several areas in which the traveled lane cross slope was less than 1.5%. A cost could not be associated with this work item because there was not enough information gathered to determine the extent of this deficiency. This will need to be further investigated through a detailed field survey, therefore, the planning-level cost estimate for this work item could not be determined. This work item is illustrated in **Figure 21**.

Clear Zone

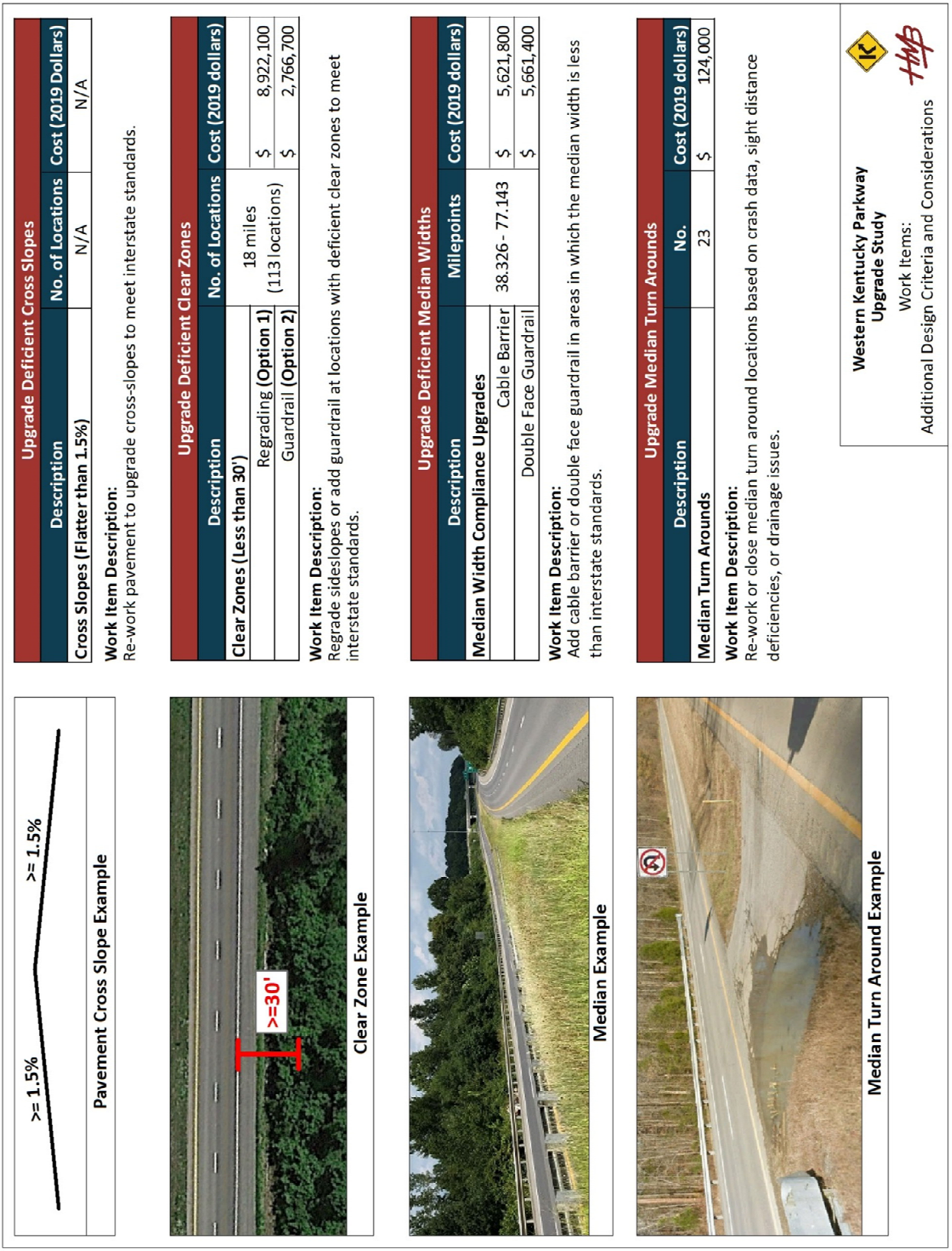
The desirable clear zone criteria for an interstate is not met at 113 locations outside of the roadway along the WKP. Two options were explored to address a deficient clear zone at each of these locations. Option 1 requires re-grading the ditch so that it is further from the edge of the WKP traveled way. Approximate earthwork quantities were calculated for each of these areas to arrive at a cost for this option. Option 2 requires the installation of guardrail and guardrail end treatments at all locations where the WKP does not meet minimum clear zone. The planning-level cost estimate for this work item is $8,922,100 for Option 1 and $2,766,700 for Option 2. This work item is illustrated in **Figure 21**.

Median Width

The existing median width of the WKP, excluding sections where the eastbound and westbound lanes are bifurcated, is 30 feet. This is less than the minimum median width required for an interstate facility. A cost was estimated for installing two different types of median barrier throughout the corridor, cable barrier and double face guardrail.

Although the median width of the WKP does not meet the minimum width required for an interstate facility, the AADT is less than 20,000 making a median barrier optional as long as the existing median is 30 feet wide. According to the crash analysis, installing a median barrier on the WKP historically may have impacted 20 out of 672 crashes. The planning-level cost estimates for the cable barrier is $5,621,800 and for double face guardrail is $5,661,400. This work item is illustrated in **Figure 21**.

Figure 21. Additional Design Criteria and Considerations Work Items



Median Turnarounds

The desirable frequency of median turnarounds is dependent on the location of county lines and interchanges throughout a corridor. It is important that their location provides adequate sight distance, and that the appropriate drop box inlets and pipes are installed to mitigate drainage issues. The work required for the median turnarounds on the WKP range from closing or relocating to installing appropriate drainage structures. The locations and recommendation for each median turnaround is shown in **Table 8**. A cost was associated with every median turnaround location. The planning-level cost estimate for this work item is $124,000 and is illustrated in **Figure 21**.

Guardrail and Guardrail End Treatments

A limited field review revealed that a significant portion of the guardrail installed along the WKP did not meet KYTC height requirement of 31 inches. However, based on previous 3R projects, guardrail with a height of 27 inches has been deemed adequate and left in place. Of those measurements taken, 44% were 27 inches or greater, and all field measurements were less than 31 inches.

A detailed field inventory would be required to determine where guardrail could remain in place and where it will need to be replaced. For the purposes of developing quantities and cost, it was assumed all guardrail and guardrail end treatments would be replaced to meet the minimum height of 31 inches.

As previously described in **Section 1.3**, there are three pavement rehabilitation projects scheduled within this corridor and any damaged or deficient guardrail could be addressed as a part of these projects. The cost to replace all guardrail and guardrail end treatments in these areas has been separated from the rest of the WKP study corridor. The planning-level cost estimate for this work item is $1,850,100 for those sections within one of the three pavement rehabilitation projects and $3,079,600 for the sections outside the limits of the pavement rehabilitation projects. This work item is illustrated in **Figure 22**.

8.2 Structures

Bridge Barrier / Width Compliance

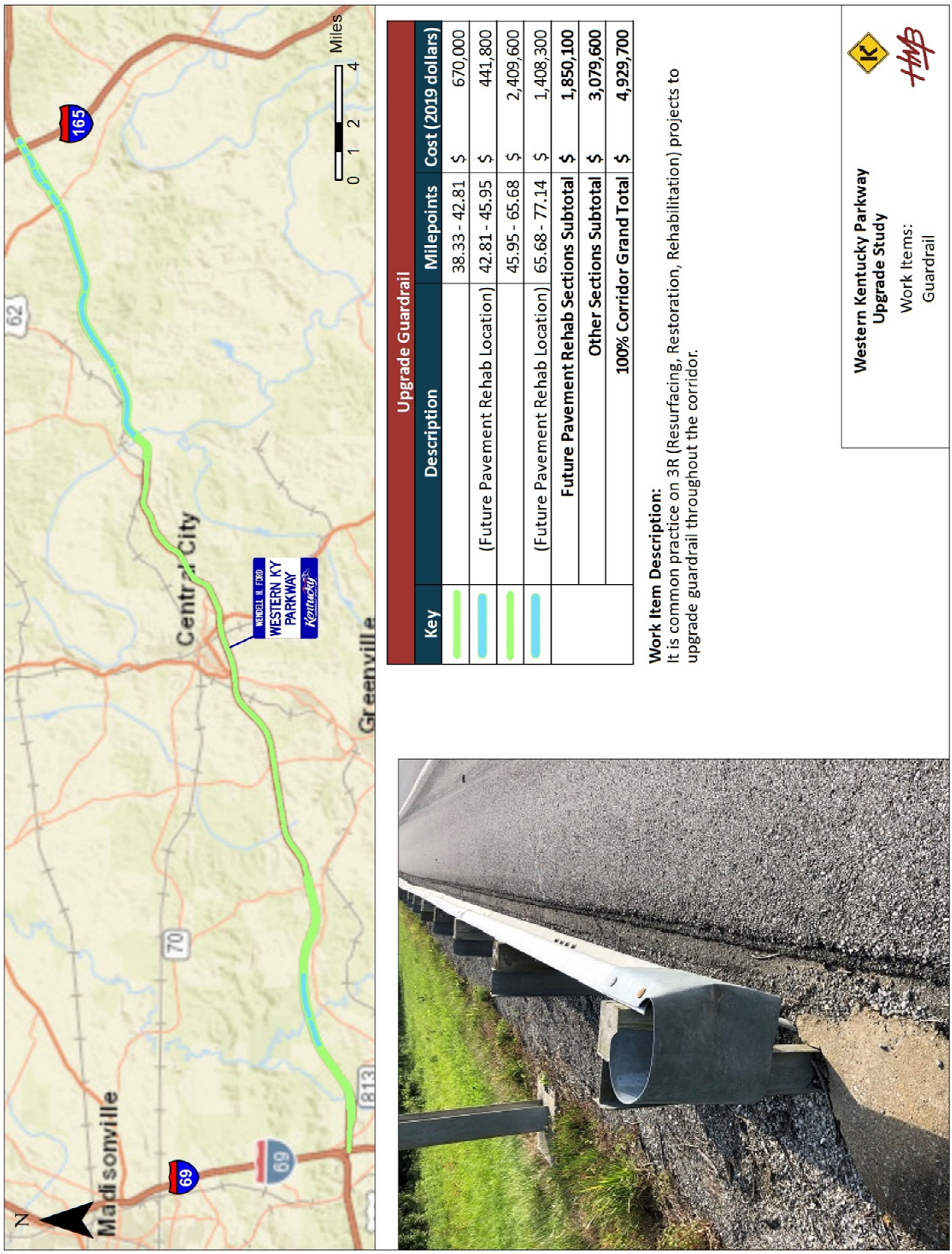
There are 13 mainline bridges on the WKP that do not meet minimum width requirements for an interstate facility.

Two improvement options were explored through this study to address the mainline bridges less than or equal to 200 feet that do not meet the minimum width required for an interstate facility. Improvement Option 1 consists of widening to meet minimum width and overlaying the bridge deck, while Improvement Option 2 consists of replacing the entire bridge superstructure. Improvement Option 2 was not considered for bridges greater than 200 feet because the cost would become exorbitant. A per square foot unit cost was calculated using 2017 bridge construction costs and assuming a 13% increase in costs per year to estimate a current year cost.

Table 8. Median Turnaround Recommendation

Milepoint	Pavement or Gravel	Drainage	Sideslopes (East/West)	Distance to Interchange Ramp (Miles)	Closest Interchange	Recommendation
38.775	Pavement	No pipe; No DBI; water	9%/7%	0.446	Exit 38	Close due to drainage issue and proximity to overpass causing sight distance issue
42.160	Pavement	Located in Crest; water	8%/Flat	3.828	Exit 38	Regrade to address drainage issue
42.890	Gravel	N/A	N/A	4.533	Exit 38	Close all gravel median turn arounds
43.350	Gravel	N/A	N/A	4.993	Exit 38	Close all gravel median turn arounds
44.950	Pavement	DBI in Sag to the east;	5%/Flat	2.700	Exit 48	Relocate to MP 44.65; Proximity to overpass causing sight distance issue
48.775	Pavement	DBI	Flat/Flat	0.050	Exit 48	Close due to proximity to WB off Ramp, Exit 48
50.390	Gravel	N/A	N/A	2.323	Exit 48	Close all gravel median turn arounds
54.790	Pavement	No pipe; No DBI	4%/Flat	2.238	Exit 53	Install DBI/Pipe to mitigate potential drainage issue
55.960	Gravel	N/A	N/A	1.996	Exit 58	Close all gravel median turn arounds
57.200	Gravel	N/A	N/A	0.757	Exit 58	Close all gravel median turn arounds
59.140	Gravel	N/A	N/A	1.17	Exit 58	Close all gravel median turn arounds
61.440	Pavement	DBI	Flat/4%	3.480	Exit 58	Close due to proximity to overpass causing sight distance issue; Crash directly attributed
64.780	Pavement	DBI	6%/3%	3.815	Exit 58	Relocate to MP 64.4; Proximity to overpass causing sight distance issue; Crash directly
65.350	Gravel	N/A	N/A	7.395	Exit 58	Close all gravel median turn arounds
65.810	Gravel	N/A	N/A	7.846	Exit 58	Close all gravel median turn arounds
67.340	Gravel	N/A	N/A	7.29	Exit 75	Close all gravel median turn arounds
67.370	Gravel	N/A	N/A	7.253	Exit 75	Close all gravel median turn arounds
68.200	Pavement	No pipe; No DBI	Flat/13%	6.141	Exit 75	Install DBI/Pipe to mitigate potential drainage issue
71.200	Pavement	No pipe; No DBI	7%/7%	3.430	Exit 75	Close due to frequency of median turn arounds in the area
74.140	Pavement	DBI	8%/8%	0.210	Exit 75	Relocate to MP 73.3 due to proximity to Exit 75
74.940	Pavement	No pipe; No DBI	3%/11%	0.060	Exit 75	Close due to proximity to Exit 75 & Huck's Truck Stop ramps
76.700	Gravel	N/A	N/A	0.071	Exit 77	Close all gravel median turn arounds
77.100	Gravel	N/A	N/A	0.334	Exit 77	Close all gravel median turn arounds

Figure 22. Guardrail and Guardrail End Treatment Work Items



Based on recent parkway to interstate conversion projects, existing bridges which do not meet minimum width would remain in place as long as the bridge barriers meet or are upgraded to current interstate standards. There are four bridges on the WKP with barriers that will need to be modified if the bridge widening alternatives are not considered. Recent construction costs were evaluated for retrofitting bridge barriers, and per linear foot unit costs were used to estimate the cost for upgrading the barriers on the Green River and Lewis Creek bridges. The planning-level cost estimate range for this work item is $483,000 to $10,984,100. These work items are illustrated in **Figure 23**.

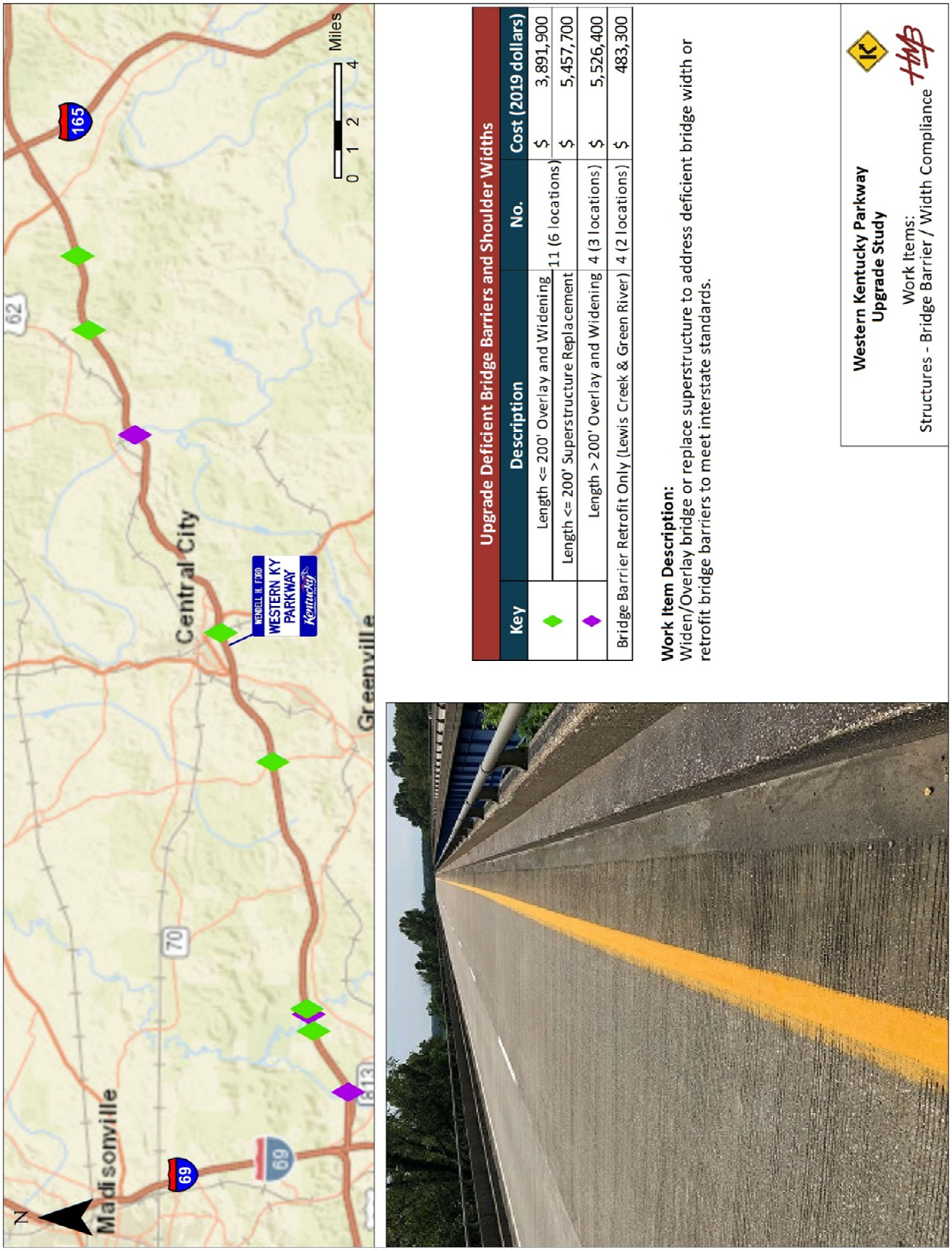
Vertical Clearance

Any overpass structure that crosses WKP is required to have a minimum of 16 feet of vertical clearance across the entire width of the roadway. There are nine locations throughout this corridor that do not meet that minimum. Three improvement options were explored at each of these locations to address deficient vertical clearance with the exception of the abandoned rail crossing at MP 68.57. There has been coordination with KYTC to determine the owner of this abandoned bridge. This information is still unknown, but due to the poor condition of this bridge and considering it is no longer in use it has been estimated for removal for the purposes of this study.

Improvement Option 1 and Improvement Option 2 both require a complete pavement dig out to achieve the minimum vertical clearance, but the lengths of their pavement tapers differ. KYTC common practice has been to use a pavement taper of 100 feet for every 1 inch of additional vertical clearance needed at an overpass bridge. However, on recent pavement rehabilitation projects for interstate facilities, that taper has been reduced to 50 feet for every 1 inch in order to reduce costs. Both improvement options were estimated assuming a full depth pavement replacement that includes 24 inches of crushed aggregate no. 2, 4 inches of crushed stone base, 12 inches of asphalt base, and 1.5 inches of asphalt surface. Improvement Option 3 includes jacking each bridge to meet minimum vertical clearance and any approach work required on each crossroad.

For the purposes of this study it was assumed that one improvement option would be selected to address vertical clearance at each bridge over the WKP. However, each of these overpass bridges will need to be evaluated individually to determine the best course of action at each location. The planning-level cost estimate range for this work item is $2,709,800 (which includes 1” - 50’ Taper and removal of the railroad bridge) to $6,054,000 (which includes bridge jacking and removal of the railroad bridge). These work items are illustrated in **Figure 24**.

Figure 23. Bridge Barrier / Width Work Items

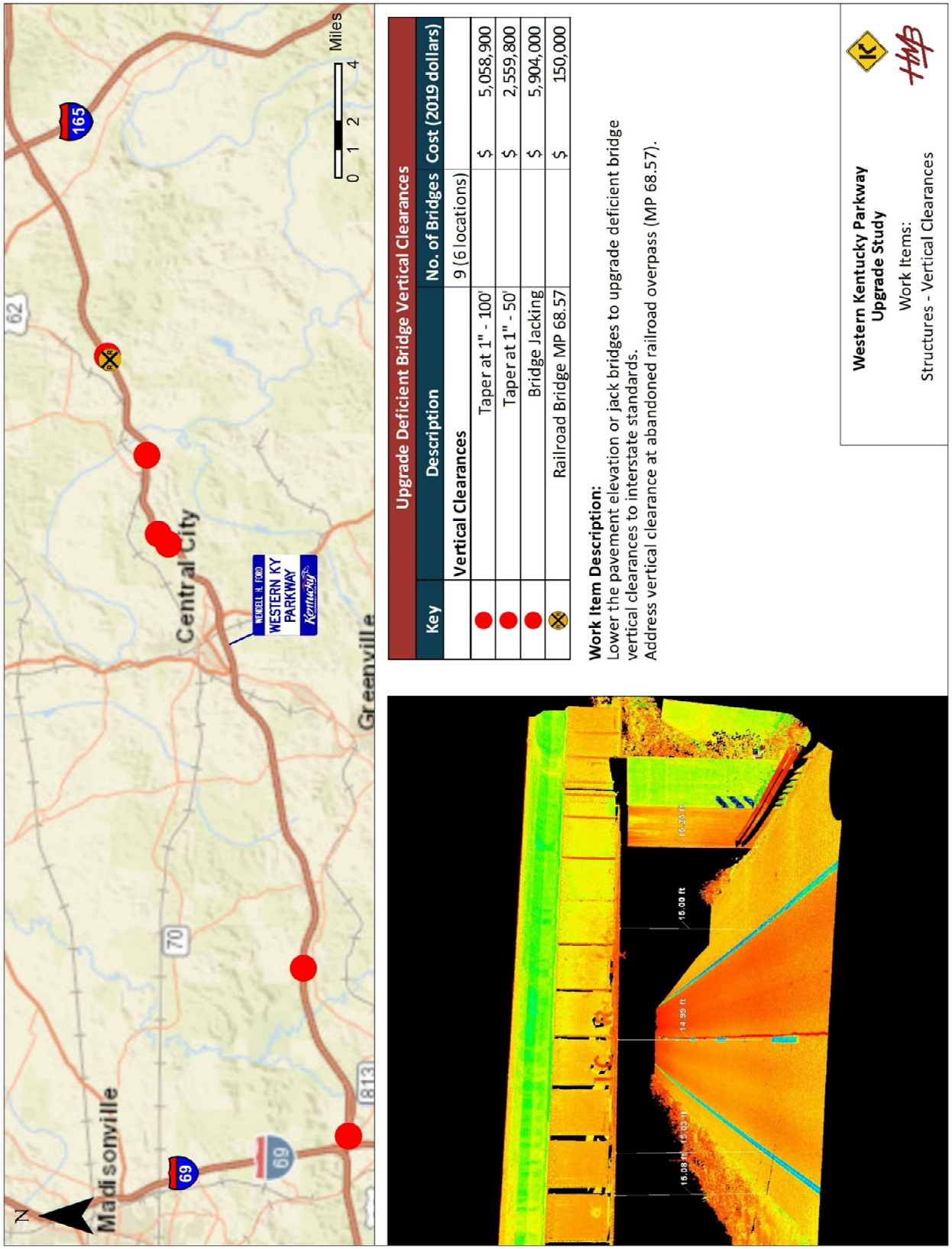


Upgrade Deficient Bridge Barriers and Shoulder Widths			
Key	Description	No.	Cost (2019 dollars)
◆	Length <= 200' Overlay and Widening	11 (6 locations)	$ 3,891,900
	Length <= 200' Superstructure Replacement		$ 5,457,700
◆	Length > 200' Overlay and Widening	4 (3 locations)	$ 5,526,400
Bridge Barrier Retrofit Only (Lewis Creek & Green River)		4 (2 locations)	$ 483,300

Work Item Description:
Widen/Overlay bridge or replace superstructure to address deficient bridge width or retrofit bridge barriers to meet interstate standards.

Western Kentucky Parkway Upgrade Study
Work Items:
Structures - Bridge Barrier / Width Compliance

Figure 24. Vertical Clearance Work Items



Upgrade Deficient Bridge Vertical Clearances			
Key	Description	No. of Bridges	Cost (2019 dollars)
	Vertical Clearances	9 (6 locations)	
●	Taper at 1" - 100'		$ 5,058,900
●	Taper at 1" - 50'		$ 2,559,800
●	Bridge Jacking		$ 5,904,000
⊗	Railroad Bridge MP 68.57		$ 150,000

Work Item Description:
Lower the pavement elevation or jack bridges to upgrade deficient bridge vertical clearances to interstate standards.
Address vertical clearance at abandoned railroad overpass (MP 68.57).

Western Kentucky Parkway Upgrade Study
Work Items:
Structures - Vertical Clearances

8.3 Interchanges

Acceleration / Deceleration Lanes

There are 12 speed change lanes that do not provide minimum distances for vehicles to accelerate or decelerate when vehicles are entering or exiting the WKP. For the purposes of estimating cost, the eastbound on-ramp and westbound off-ramp at the KSP Post No. 2 have been removed because they are addressed in the Collector Distributor Road / KYTC Maintenance Facility – KSP Post No. 2 improvement option later in this chapter.

For every ramp, the entering and exiting curve was evaluated to determine the design speed, and, in turn, the necessary length for that ramp's speed change lane per AASHTO guidelines. The cost of upgrading each of these acceleration and deceleration lanes includes widening with full depth pavement, grading, and 1.5 inches of asphalt surface for the entire width of the WKP within the work area. The planning-level cost estimate for this work item is $2,283,500. These work items are illustrated in **Figure 25**.

Control of Access

Minimum criteria for interchange control of access is not met at four locations along the WKP. Each of these locations was evaluated individually, and a cost was assigned based on solutions used on previous parkway to interstate upgrade projects. These costs to achieve minimum control of access for an interstate facility could vary depending on the programmatic agreement between KYTC and FHWA. The planning-level cost estimate for this work item is $3,165,000. The location of these work items is illustrated in **Figure 25**.

US 431 (Exit 58) Interchange Reconfiguration

The US 431 interchange was originally designed so that entering and exiting vehicles could pay a toll, but the toll booth has since been removed. It has been standard practice for KYTC to reconstruct these interchanges. A traditional diamond interchange configuration as illustrated in **Figure 26** was explored and estimated as a part of this study.

For the purposes of this improvement option, a ramp pavement design was assumed based on recent interchange projects in this area. The cost estimate includes full depth pavement for all ramps, grading, 1.5 inches of asphalt surface on the WKP within the work area, the widening of the mainline bridge over the railroad to accommodate the full length of the westbound on-ramp, and a contingency that covers miscellaneous work items, right of way, and utilities. The planning-level cost estimate for this work item is $10,546,600.

Figure 25. Acceleration / Deceleration Lanes and Control of Access Work Items

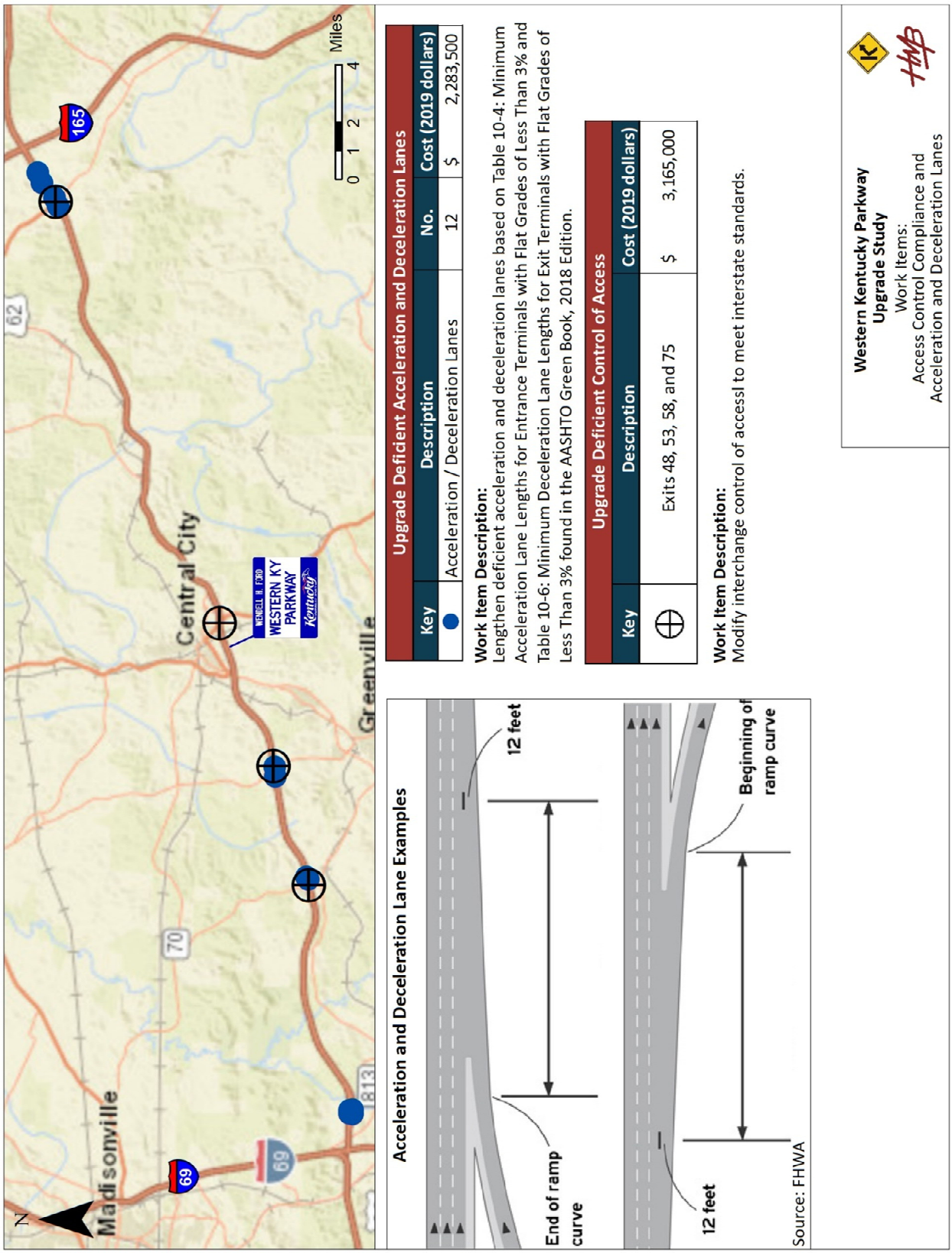


Figure 26. US 431 (Exit 58) Interchange Reconfiguration

8.4 Phase 2 Meetings

Project Team Meeting No. 2

The second and final project team meeting was held on November 25, 2019, where representatives from KYTC, GRADD, PADD, and the consultant primarily discussed updates to the crash and traffic analysis and work items. Key action items were to finalize the traffic forecast, request and then review detailed crash reports for Huck's, KSP, Green River bridge, fatal crashes and crossover crashes, provide a recommendation for potential median crossover removal, identify structures that would be more cost-efficient to replace instead of rehabilitate, and finalize materials for the LO/S Meeting No. 2. More details from the meeting can be found in **Appendix E**.

Local Officials and Stakeholders Meeting No. 2

A second and final LO/S meeting was held on December 13, 2019. Not including KYTC, GRADD, PADD and consultant staff, 12 LO/S representatives attended the meeting. The project team presented the study objectives and goals, study background, crash and traffic analysis update, work item summary, and next steps. More details from the meeting, including a list of attendees and the presentation can be found in **Appendix E**.

Chapter 9. Summary of Improvement Options

This chapter presents a summary of the identified work items to address the identified deficiencies grouped into two Build options:

- Necessary Upgrades and Spot Safety Improvements
- Fully Compliant Reconstruction

A third option that serves as a baseline for comparison is the No Build. The WKP would remain as it currently is (excluding committed projects identified in the Highway Plan) and would not be signed as I-569.

While not necessarily required to upgrade the WKP to interstate standards, several locations and improvement concepts were identified as a result of this study. These additional concepts are discussed later in this chapter. All costs associated with each improvement option were calculated in 2019 dollars.

9.1 Necessary Upgrades and Spot Safety Improvements

All improvement options that were included in recent programmatic agreements between KYTC and FHWA on the Edward T. Breathitt Pennyrile Parkway (EBP) and the William H. Natcher Green River Parkway (WNP) are included in this option. For those conversion agreements, mainline bridges that did not meet minimum width were not widened. Taking a similar approach for this study will result in a design exception for shoulder widths on 15 bridges along the WKP. Design variances will be required for all other items not included in this improvement option that do not meet minimum AASHTO or KYTC guidelines.

Any proposed work addressing horizontal and vertical curves has been excluded from this Improvement Option. Based on previous 3R projects, horizontal curves which do not exceed the maximum allowable side friction factor for the desired design speed are deemed adequate. A more in-depth field review may be required for curves that fall within a high crash spot considering the horizontal curve data was determined from the as-built plans alone. Past resurfacing or rehabilitation jobs could have caused the existing superelevation to be different from the as-built plans. The sag vertical curve on the WKP that does not meet headlight sight distance does not have an adverse effect on its operation or safety.

The guardrail and guardrail end treatments that fall within the three scheduled pavement rehabilitation projects have been excluded from this Improvement Option. It is assumed that any damaged guardrail and guardrail end treatments as well as guardrail that does not meet height requirements will be replaced as a part of these projects.

Any work related to achieving minimum clear zone outside of the roadway was excluded from this Improvement Option. Regrading to achieve clear zone would likely result in exorbitant costs and require additional right of way. Installing guardrail at these locations may have an adverse effect on the safety of the WKP.

Although the median width does not meet AASHTO guidelines, a median barrier is optional because of the low volume of traffic on the WKP. There were three median cross-over crashes according to the

crash analysis that was conducted as a part of this study. Both median barrier Improvement Options were excluded from this Improvement Option.

All operational and safety considerations that were investigated as a part of this study were excluded from this Improvement Option except for the interchange reconfiguration at US 431 (Exit 58). The total estimate for this Improvement Option including estimated design, environmental, and miscellaneous costs is **$29,109,400**.

9.2 Fully Compliant Reconstruction

This Improvement Option addresses all deficiencies identified through this study that would be considered design exceptions and design variances. All operational and safety considerations are excluded from this Improvement Option except for the interchange reconfiguration at US 431 (Exit 58).

The highest cost method to address each design exception or design variance was included in the estimated total of this Improvement Option. There are fully compliant options that fall within the range of costs outlined in **Table 9**; however, this provides an ultimate cost if the highest cost option was required for each work item. The total estimate for this option including estimated design, environmental, and miscellaneous costs is **$79,988,600.**

Table 9 and **Figure 27**, on the following pages, display a summary of the Build options including work item identification and costs.

9.3 Additional Operational and Safety Considerations

Through the study process, Huck's, the Green River Bridge, and KSP Post No.2 were identified where additional operational and / or safety considerations may be warranted. These work items are not necessarily required for conversion to an interstate but should be considered as potential additional projects. Further detail is provided in the following sections for each of these locations with a summary of costs provided in **Table 10**.

Table 9. WKP Work Items Summary

Map Symbol	Upgrade/Improvement Categories and Options	No. Locations or Milepoints	Work Item Cost	Design Exception	Design Variance	Other Considerations
	MAINLINE					
	Horizontal Curves					
	In high crash locations	18	$ 5,678,000	✓		
	Not in high crash locations	8	$ 2,704,400	✓		
	Vertical Curves	1	$ 476,800		✓	
	Cross Slopes (Flatter than 1.5%)	N/A	N/A	✓		
	Guardrail and Guardrail End Treatments (100%)					
		38.33 - 42.81	$ 670,000		✓	
	(Future Pavement Rehab Location)	42.81 - 45.95	$ 441,800		✓	
		45.95 - 65.68	$ 2,409,600		✓	
	(Future Pavement Rehab Location)	65.68 - 77.14	$ 1,408,300		✓	
	Clear Zones (Less than 30')	113				
	Re-grading **(Option 1)**		$ 8,922,100		✓	
	Guardrail **(Option 2)**		$ 2,766,700		✓	
	Median Width (Barrier Installation)	38.326 - 77.143				
	Cable Barrier **(Option 1)**		$ 5,621,800		✓	
	Double Face Guardrail **(Option 2)**		$ 5,661,400		✓	
	Median Turn Arounds	23	$ 124,000			✓
	STRUCTURES					
	Bridge Barrier/Width Compliance					
	Length <= 200' Overlay and Widening **(Option 1)**	11	$ 3,891,900	✓		
	Length <= 200' Superstructure Replacement **(Option 2)**	**11**	$ 5,457,700	✓		
	Length > 200' Overlay and Widening	4	$ 5,526,400	✓		
	Bridge Barrier Retrofit (Lewis Creek & Green River)	2	$ 483,300	✓		
	Vertical Clearances	9				
	Taper at 1" - 100' **(Option 1)**		$ 5,058,900	✓		
	Taper at 1" - 50' **(Option 2)**		$ 2,559,800	✓		
	Bridge Jacking **(Option 3)**		$ 5,904,000	✓		
	Abandoned Railroad Bridge	68.57	$ 150,000	✓		
	INTERCHANGES					
	Acceleration / Deceleration Lanes	12	$ 2,283,500		✓	
	Control of Access	4	$ 3,165,000		✓	
	Exit 58 - Interchange Reconfiguration	1	$ 10,546,600			✓
Subtotal			$ 22,391,800 - $ 61,529,600			
Estimated Design and Environmental (15%)			$ 3,358,800 - $ 9,229,500			
Miscellaneous (15%)			$ 3,358,800 - $ 9,229,500			
TOTAL			$ 29,109,400 - $ 79,988,600			

PROGRAMMATIC AGREEMENT WITH KYTC AND FHWA MAY NOT ENCOMPASS ALL WORK ITEMS (ALL COSTS IN 2019 DOLLARS)

Design Exception – deficiency that falls within FHWA's 10 controlling design criteria
Design Variance – deficiency that does not fall within the 10 controlling criteria but does not adhere to minimum AASHTO or KYTC guidelines

Figure 27. WKP Work Items Summary Map

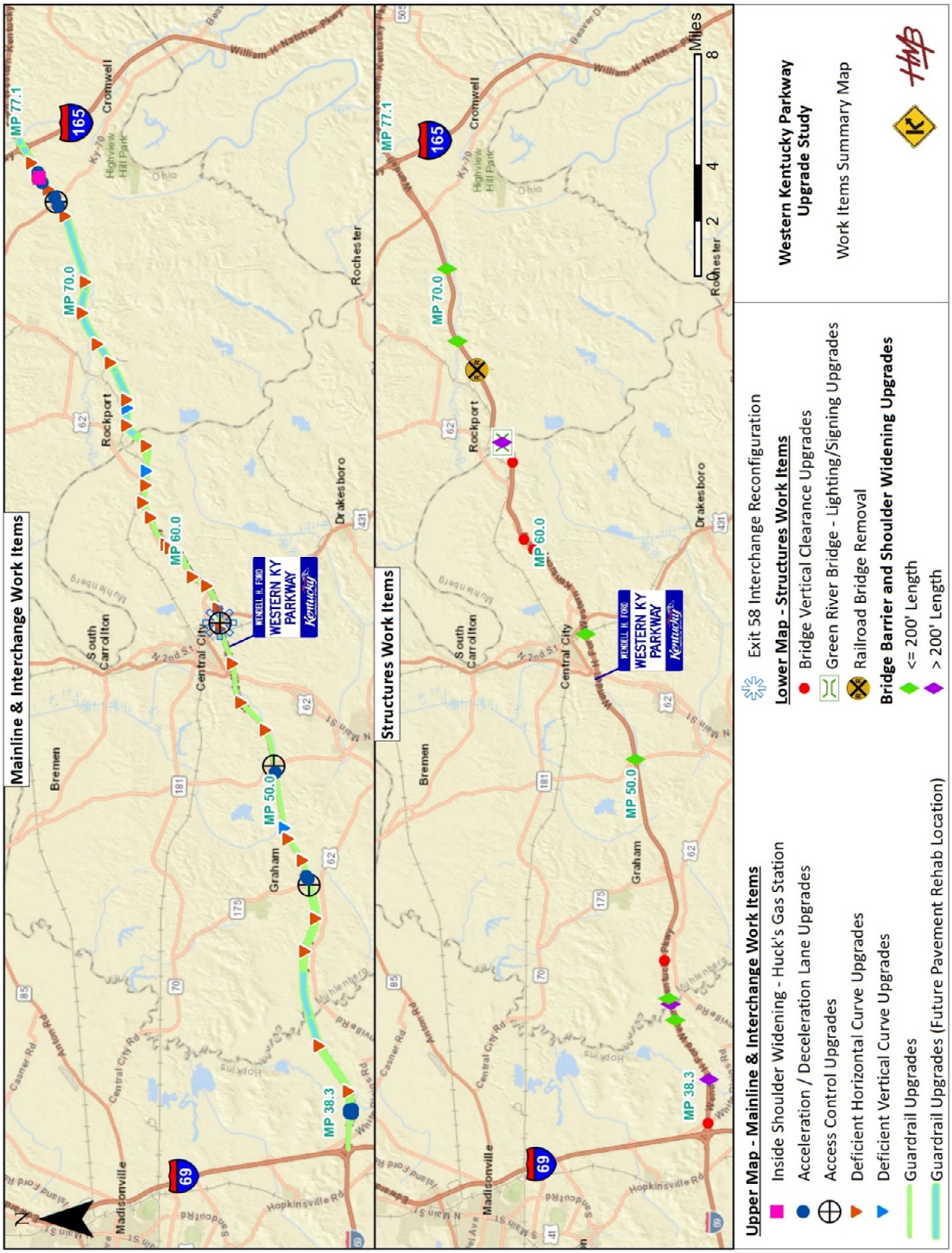


Table 10. Operational and Safety Considerations Work Item Summary

Map Symbol	Upgrade/Improvement Categories and Options	No. Locations or Milepoints	Work Item Cost	Design Exception	Design Variance	Other Considerations
■	**Inside Shoulder Widening - Huck's Gas Station**	75.08 - 76.42	$ 1,096,000			✓
⌧	**Green River Bridge**					
	Lighting		$ 375,900			✓
	KSP Post No. 2	1				
	Collector Distributor Road (Option 1)		$ 1,387,100			✓
	Relocate KYTC Maintenance Facility (Option 2)		$ 1,273,500			✓
Subtotal			$ 2,745,400 - $ 2,859,000			
Estimated Design and Environmental (15%)			$ 411,900 - $ 428,900			
Miscellaneous (15%)			$ 411,900 - $ 428,900			
		TOTAL	$ 3,569,200 - $ 3,716,800			

PROGRAMMATIC AGREEMENT WITH KYTC AND FHWA MAY NOT ENCOMPASS ALL WORK ITEMS (ALL COSTS IN 2019 DOLLARS)

Inside Shoulder Widening – Huck's

As discussed previously, the inside paved shoulder width on the WKP is a minimum of 4 feet which meets interstate requirements. Through the bifurcated section that contains KSP Post No. 2 the inside paved shoulder is 10 feet wide, while the inside paved shoulder width is 4 feet for the rest of the WKP, including the bifurcated section that contains Huck's. On previous 3R projects, it has been common practice to provide an inside paved shoulder of 10 feet along bifurcated sections of an interstate facility.

Although it is not an interstate requirement, quantities were calculated for widening the inside paved shoulder from 4 feet to 10 feet through the bifurcated section of the WKP around Huck's. These quantities include full depth pavement consistent with the pavement design of the WKP and any grading necessary for this widening. Unit costs for those quantities were pulled from average bid item prices for recent projects. The planning level cost estimate for this work item is $1,096,000. This work item is illustrated in **Figure 28**.

Green River Bridge

According to the crash analysis, a high number of crashes occurred on the bridges over the Green River and their approaches. Of the crashes on the bridge, 61% of them occurred at night. Installing lighting on the Green River bridges could help mitigate these crashes and improve safety. Quantities were calculated assuming that lighting was installed for the entire length of the Green River bridges and 1000 feet along each bridge approach. Unit costs for those quantities were pulled from average bid item prices for recent KYTC lighting projects. The planning level cost estimate for this work item is $375,900. The location of this work item and information is illustrated in **Figure 29.**

Figure 28. Inside Shoulder Widening – Huck's Work Item

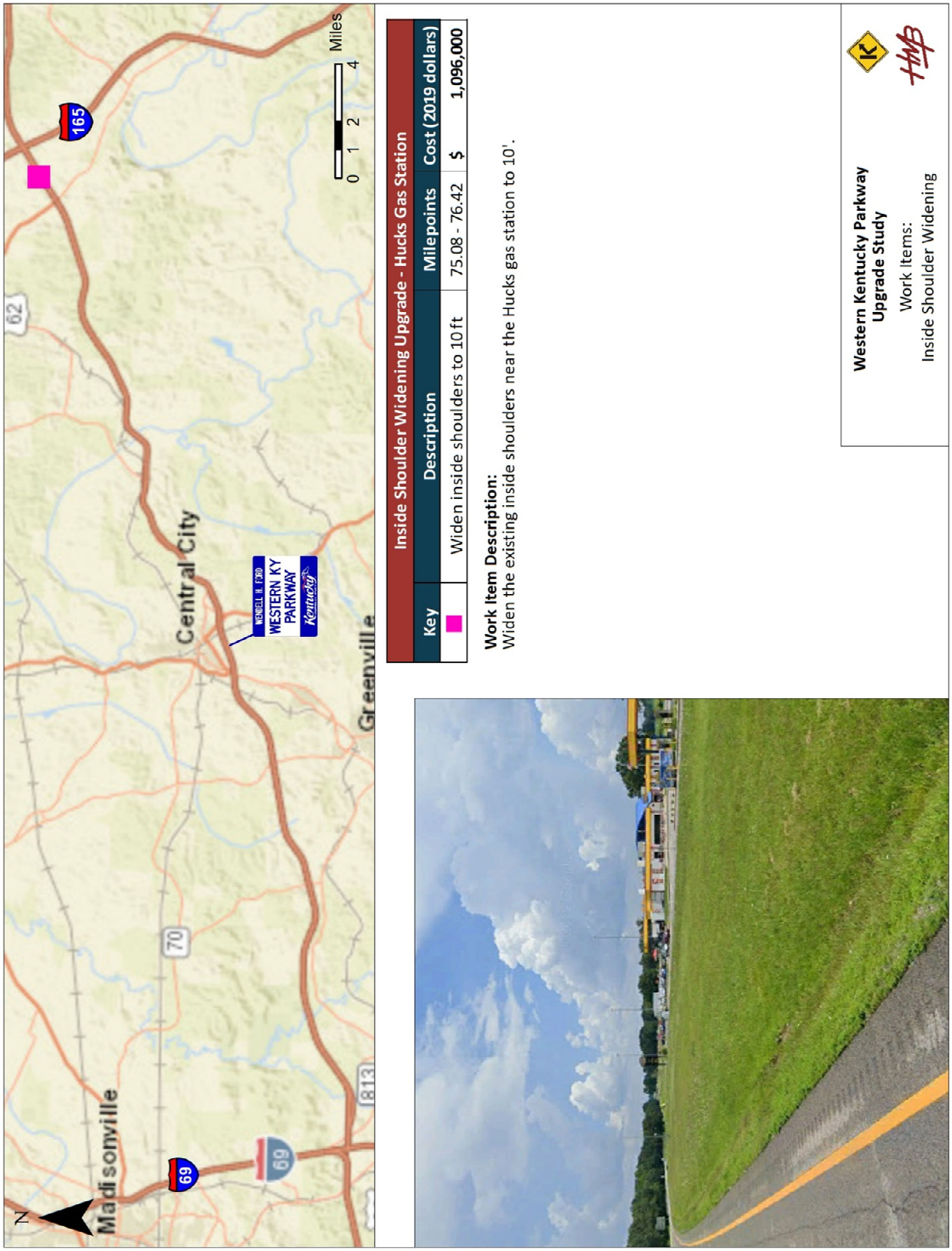
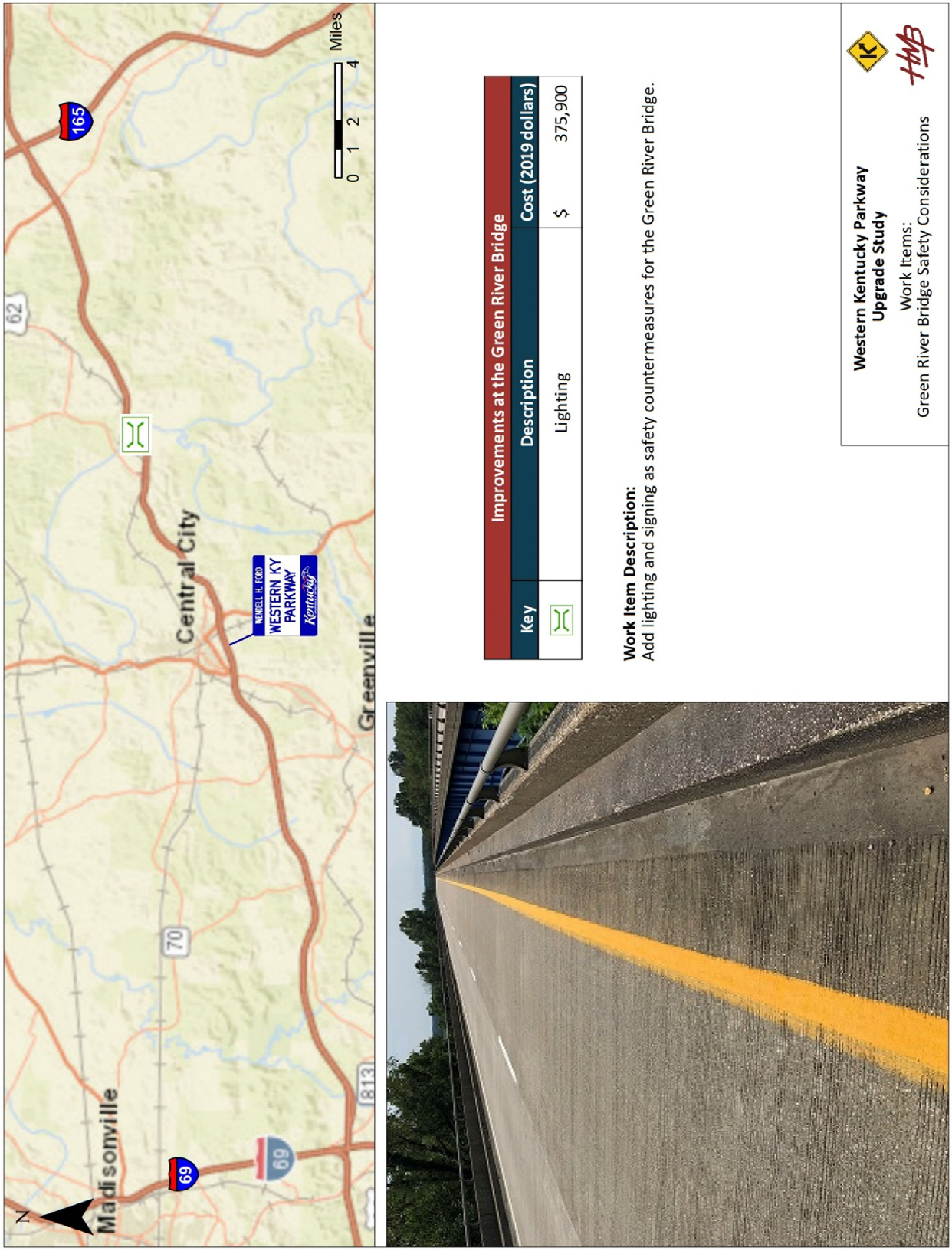


Figure 29. Green River Bridge Safety Considerations Work Item



Many of the crashes on the Green River Bridge and its approaches occurred during inclement weather conditions that resulted in water pooling on the roadway. As a part of this study, the as-built plans for the Green River bridges were reviewed to ensure that there was adequate drainage in place along and at the ends of each bridge. There appears to be adequate drainage in place, but a more in-depth field review may be necessary to determine if these drainage structures are functioning properly. It is possible that cleaning all drainage structures could prevent standing water on the Green River bridges, and this could potentially mitigate some of these crashes. An estimate to clean the drainage structures along these bridges was not included as this work item falls under maintenance.

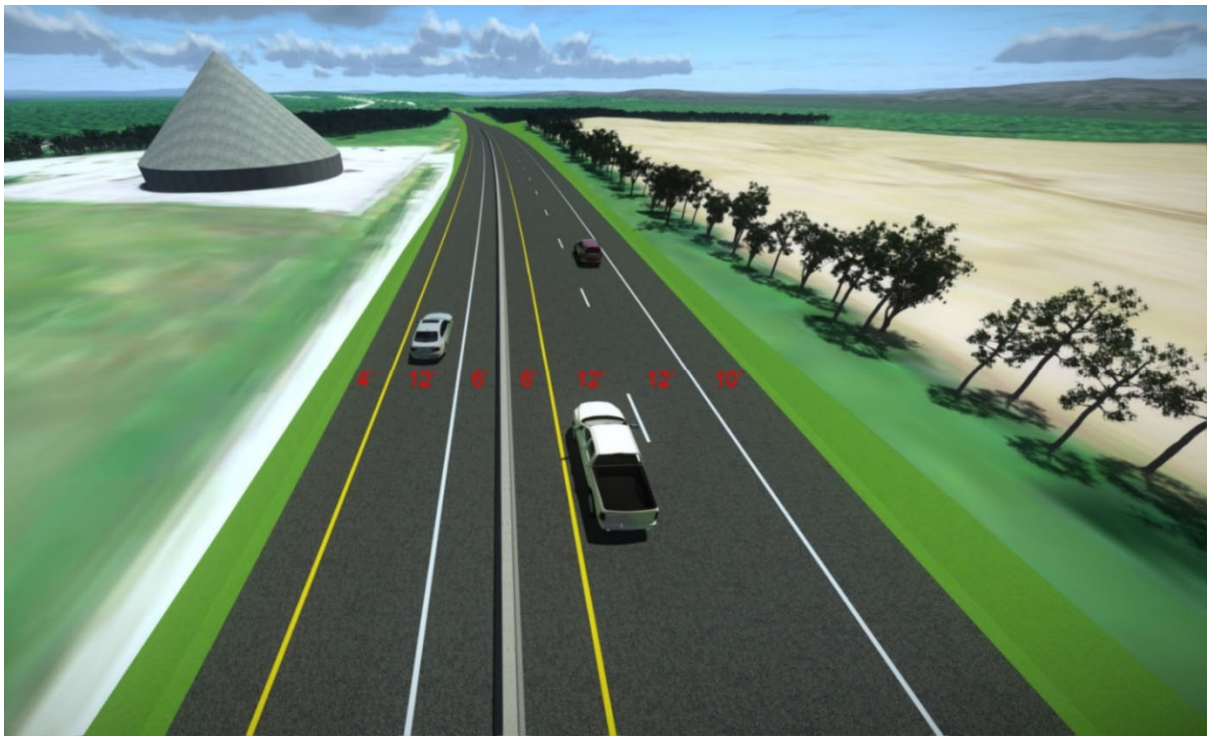
Collector Distributor Road / KYTC Maintenance Facility – KSP Post No. 2

An entrance for a KYTC Maintenance Facility is located on the westbound off-ramp and an exit for that facility located on the eastbound on-ramp of the KSP Post No. 2 interchange. Although the crash analysis indicates that the placement of these entrances has no adverse effect on the safety of the WKP, two improvement options were explored to mitigate any potential safety issues.

Improvement Option 1

Improvement Option 1 consists of constructing a collector distributor road that creates separation between the WKP travel lanes and the portion of the ramps where vehicles will be entering and exiting the KYTC Maintenance Facility. The collector distributor road was limited to a 12-foot travel lane, a 6-foot outside shoulder, and a 4-foot inside shoulder to minimize impacts to the maintenance facility. The typical section can be found in **Figure 30**.

Figure 30. Collector Distributer Road Typical Section

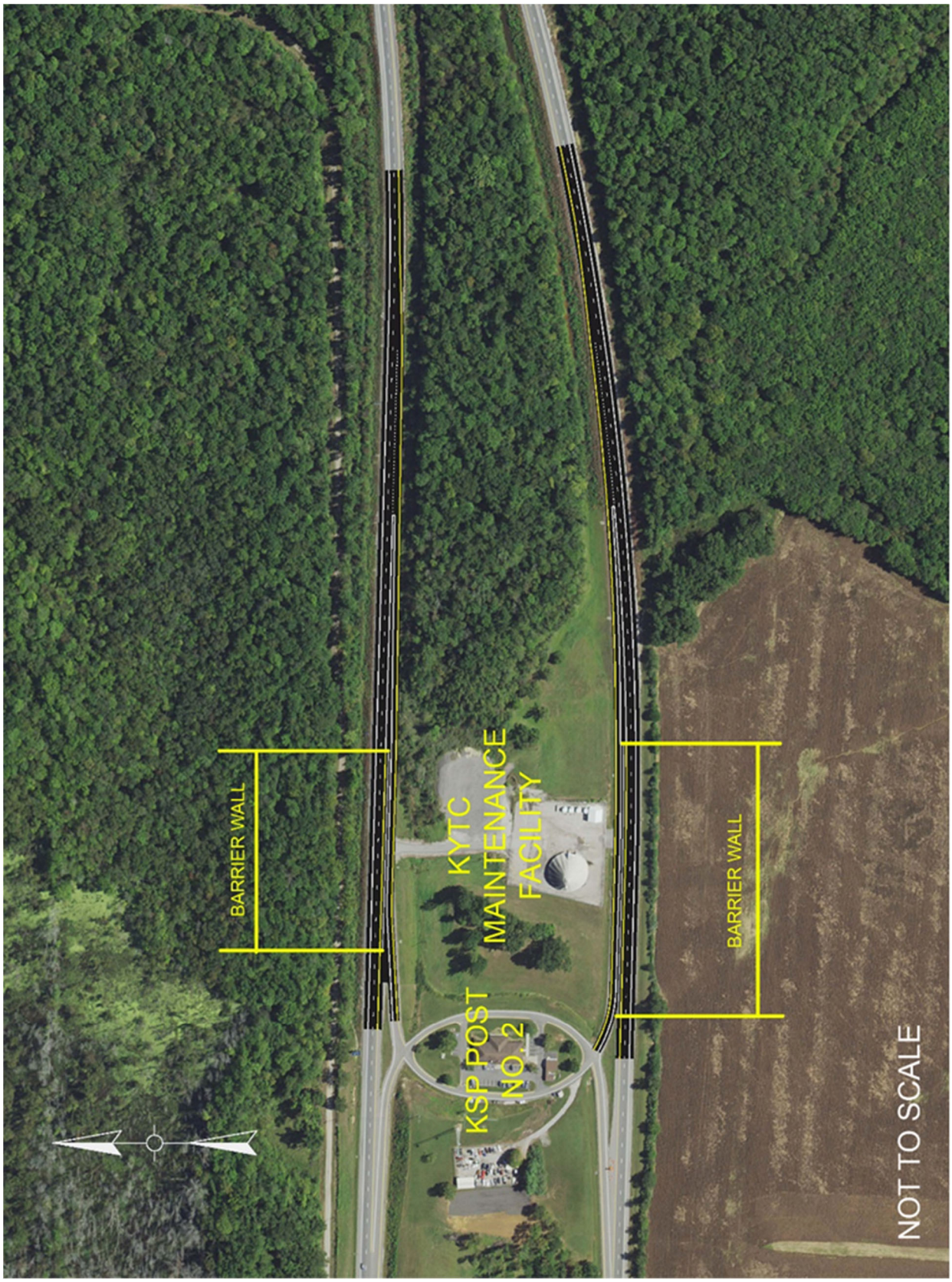


This will reduce the potential for a severe crash between vehicles traveling on the WKP and vehicles leaving the KYTC maintenance facility in the eastbound direction by allowing vehicles leaving the WKP in the westbound direction more time to decelerate before a vehicle entering the maintenance facility is encountered. The cost estimate for Improvement Option 1 includes widening with full depth pavement, concrete barrier wall, grading, 1.5 inches of asphalt surface for the entire width of the WKP within the work area, and a contingency that covers miscellaneous work items. The conceptual design for this improvement option is illustrated in **Figure 31**. The 2019 planning-level cost estimate for this work item is $1,387,100.

Improvement Option 2

Improvement Option 2 consists of relocating the KYTC Maintenance Facility. It includes both the construction cost to relocate the facility and the right of way costs for the facility's new location. Since the collector distributor road would include addressing the lengths of the westbound off-ramp and eastbound on-ramp speed change lanes at KSP Post No. 2, this cost was added to Improvement Option 2 so that an accurate cost comparison can be made. The planning-level 2019 cost estimate for this work item is $1,273,500.

Figure 31. Collector Distributor Road Improvement Option



Chapter 10. Next Steps

Following completion of the study, KYTC will have a conversation with FHWA to determine the work items that will be required for conversion of this section of parkway to interstate. The resulting project 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.

However, in the hierarchy of projects related to parkway conversions in Kentucky, this section of the WKP is behind the Edward T. Breathitt Pennyrile Parkway (EBP) and the William H. Natcher Green River Parkway (WNP) that were both previously studied. Three interchange projects associated with the conversion of the William H. Natcher Parkway (WNP) to I-165 still need to be completed. These include:

- Ohio County: KY 69 (Exit 50)
- Butler County: US 231 (Exit 36)
- Warren County: US 231 (Exit 9)

The FHWA allowed the WNP to be signed as I-165 as a courtesy to KYTC with the assurance of KYTC that these projects would be completed as soon as possible. The Edward T. Breathitt Pennyrile Parkway (EBP) has undergone a study for the portion from I-24 near Hopkinsville to the I-69 / WKP interchange. KYTC is currently in discussion with FHWA to complete a conversion agreement for this section. A commitment has been made to complete the conversion of the EBP before the conversion of this portion of the WKP. In addition to these commitments, funding will need to be obtained for the agreed-upon improvements once the conversion agreement is developed with FHWA. This includes funding for design (D), any identified right-of-way (R), any utility costs (U), and construction (C).

10.1 Contacts

Written requests for additional information should be sent to the KYTC Division of Planning Director, 200 Mero Street, Frankfort, Kentucky 40622. Additional information regarding this study can be obtained from the District 2 Project Manager at (270) 824-7080 or by mail at 1840 North Main Street, Madisonville, Kentucky 42431.