Value Engineering Study Report

Campbellsville Bypass

Kentucky Transportation Cabinet

Taylor County, Kentucky

Item Nos: 4-142.20 and 4-142.30

August 25–29, 2014

KENTUCKY TRANSPORTATION CABINET

HDR

Disclaimer

The information contained in this report is the professional opinions of the team members during the value engineering study. These opinions were based on the information provided to the team at the time of the study. As the project continues to develop, new information will become available and this information will need to be evaluated on how it may affect the recommendations and findings in this report. All costs displayed in the report are based on best available information at the time of the study and, unless otherwise noted, are in current year dollars. Any graphics, photos, drawings, maps, etc., used in the report were supplied by the study sponsor or developed during the time of the study.

Study Statistics

Original Cost: $42.2M

Number of Recommendations: 9

Recommended Cost Savings: $7.4M

Recommended Value Added: $4.5M

Total Number of Team Members: 7

FHWA Employees: 0

KYTC Employees: 2

Others: 5

Estimated Cost of Study: $59,500

Consultant Fee $49,500

KYTC Fee: $10,000 (assumed)

Contents

Appendixes

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Executive Summary

Introduction

This value engineering (VE) study report summarizes the events of the VE study conducted for Kentucky Transportation Cabinet (KYTC) and facilitated by HDR.

The subject of the study was Campbellsville Bypass in Taylor County. The VE study was conducted after the Environmental Impact Statement (EIS) was completed and final design was just slated to begin. The study was conducted August 25–29, 2014 with the presentation of findings on August 29, 2014.

The purpose of the study, through execution of the VE job plan, was to:

- Review and understand the various concepts of the project.
- Conduct a thorough review and analysis of the key project issues using a multidiscipline, cross-functional team.
- Give special emphasis in identifying opportunities to reduce the right-of-way impacts while maintaining and improving the performance and reducing costs of the project.

Project Description

The proposed highway project (Item Numbers: 4-142.20 and 4-142.30) involves the widening and reconstruction of Kentucky Route 55 (KY 55) in Adair and Taylor Counties, and a southeast bypass of Campbellsville in Taylor County, Kentucky. The project corridor is approximately 21 miles long, including approximately 14 miles of existing KY 55 and 7 miles for the bypass.

This VE study focused on the 7 miles of bypass that leaves the KY 55 corridor in the vicinity of KY 1625, turns eastward and is on new alignment to bypass the city of Campbellsville on the south and east sides and terminates northeast of the city at U.S. Route 68 (US 68). The project, which has an ultimate typical section of 4 lanes with center median and paved shoulders, will be constructed initially as a 2-lane roadway with shoulders. Right-of-way is being acquired for the ultimate section. Construction of this portion of the overall project will be under two construction contracts. Major project elements include:

- Seven miles of new roadway
- Two hundred twenty four acres of right-of-way
- Twenty two relocations
- Construction of four at-grade intersections
- Over 700,000 cubic yards of excavation
- Over 500,000 cubic yards of embankment
- Three bridge structures

The current total project cost estimate, as presented to the VE team, is $42.23 million. This includes construction costs of $23.86 million, right-of-way impacts of $17.15 million, and utility impacts of $1.22 million. After evaluation of this estimate, the VE team had concerns that the structure cost represented in the base

estimate ($85 per square foot [sf]) was significantly lower than what might be expected ($125/sf). To get a better understanding of the overall project cost, the VE team adjusted the base estimate to reflect this difference, resulting in a revised total cost of $44.64 million.

VE Recommendations

The VE team generated 33 ideas for the project. These concepts were compared and evaluated against the baseline developed by the project team. This comparison and evaluation resulted in nine recommendations.

Summary of Recommendations

No.	Description	Cost Delta ($M) (Increase)	Performance (%)	Value (%)
VE-1	Usable Shoulder Width	$0.70	0	2
VE-2	Bridge Shoulder Widths	0.80	-2	0
VE-3	Median Width	0.60	5	7
VE-4	Wise Road	1.70	1	5
VE-5	Cross Road Alignments	2.42	11	17
VE-6	Replace Bridge 1 and 2 with Culverts	1.20	1	4
VE-7	Replace Bridge 3 with Wagon Box	1.60	-1	2
VE-8	2+1 with 2+1	(4.50)	21	10
VE-9	2+1 with 4	(7.00)	12	-3

Because of the nature of the project and focus of the team, various recommendations presented are mutually exclusive and cannot all be implemented. Recommendations VE-4 and VE-7, along with VE-8 and VE-9, are examples of this mutual exclusivity. The VE team created three scenarios to illustrate how some of the potential combinations could be chosen for implementation.

Potential Scenarios

No.	Description	Cost Delta ($M) (Increase)	Scenario 1	Scenario 2	Scenario 3
VE-1	Usable Shoulder Width	$0.70			$0.70
VE-2	Bridge Shoulder Widths	0.80			
VE-3	Median Width	0.60		0.60	0.60
VE-4	Wise Road	1.70	1.70	1.70	1.70
VE-5	Cross Road Alignments	2.42	2.42	2.42	2.42
VE-6	Replace Bridge 1 and 2 with Culverts	1.20	1.20	1.20	1.20
VE-7	Replace Bridge 3 with Wagon Box	1.60			
VE-8	2+1 with 2+1	(4.50)	(4.50)		
VE-9	2+1 with 4	(7.00)		(7.00)	

The individual recommendations are summarized below in the VE punch list; the detailed information about each recommendation is included in Section 3 of this report.

Value Engineering Punch List

Item No. 4-142.20 and 4-142.30			Project County: Taylor			Date of Study: 08/25/2014 to 08/29/2014				VE # 201415
VE Alternative Number	VE Team Top Pick	Description	Activity (Y,N,UC-Date)	Implemented Life Cycle Cost Savings	Original Cost ($M)	Alternative Cost ($M)	Initial Cost Saving ($M)	Life Cycle Cost Savings (Total Present Worth)	FHWA Categories	Remarks
Recommendations										
VE-1		Usable Shoulder Width – Reduce the shoulder width from 12' (10' paved and 2' earth) to 10' (8' paved and 2' earth)			$10.6	$9.9	$0.7	N/A	Other	
VE-2		Bridge Shoulder Width – Reduce the shoulder width of the three structures from 10' outside and 6' inside to 4' inside and outside.			$5.8	$5.0	$0.8	N/A	Other	
VE-3		Reduced Median Width – Reduce the ultimate project median width from 40' to 28'.			$17.2	$16.6	$0.6	N/A	Environmental Other	
VE-4		Wise Road – Shift the alignment northward near Wise Road to eliminate a bridge and provide connections to Wise Road.			$19.4	$17.7	$1.7	N/A	Operations Environmental Other	
VE-5		Cross Road Alignments – Reconstruct Smith Ridge Road and KY 70 on their existing alignments at the proposed intersections with the bypass.			$2.5	$0.1	$2.4	N/A	Operations Environmental Other	
VE-6		Replace Bridge with Culvert – Replace bridges 1 and 2 with box culverts.			$4.0	$2.8	$1.2	N/A	Other	
VE-7		Replace Bridge 3 with Wagon Box – Replace bridge 3 with a 3-sided structure (wagon box) and culvert.			$10.0	$8.4	$1.6	N/A	Other	
VE-8		Construct 2+1 with 2+1 Right-of-Way – Purchase right-of-way and construct the initial project as an ultimate 2+1 facility.			$44.7	$49.2	($4.5M) (increase)	N/A	Safety Operations Environmental	
VE-9		Construct 2+1 with 4-lane Right-of-Way – Purchase ultimate 4-lane right-of-way but construct the initial project as a 2+1 facility rather than a 2-lane facility.			$44.7	$51.7	($7.0) (Increase)	N/A	Safety Operations	
Other Design Comments and/or Design Suggestions										
DC-1 Idea 2		Optimize Profile – As the design progresses and geotechnical data and newer survey data becomes available, the design team should look at how best to optimize the profile to balance the earthwork and reduce the right-of-way impacts.			N/A	N/A	N/A	N/A	Other	

Value Engineering Punch List

Item No. 4-142.20 and 4-142.30			Project County: Taylor			Date of Study: 08/25/2014 to 08/29/2014				VE # 201415
VE Alternative Number	VE Team Top Pick	Description	Activity (Y,N,UC-Date)	Implemented Life Cycle Cost Savings	Original Cost ($M)	Alternative Cost ($M)	Initial Cost Saving ($M)	Life Cycle Cost Savings (Total Present Worth)	FHWA Categories	Remarks
DC-2 Idea 7		Eliminate Wide Median – Consider eliminating the proposed wide median and use 4-foot stripped separation or barrier wall separation (11 feet total width). This could lessen earthwork and required right-of-way.			N/A	N/A	N/A	N/A	Other	
DC-3 Idea 28		Continuous Green Tee – The concept design as presented to the VE team did not include concepts for the diverging point of the bypass. As the design progresses, consider the use of a continuous green tee to improve operations.			N/A	N/A	N/A	N/A	Other	
DC-4 Idea 29		Offset Left Turns – As the design progresses, consider the use of offset left turn lanes for an improved line of sight for turning vehicles.			N/A	N/A	N/A	N/A	Other	
		Implementation Meeting:			Total Recommended/Value:	Category Totals:	Saf 0	Ops 0	Env 0	Con 0	Oth 0

VE Team Members

- John Broadus, HDR – Structures
- Joe Cochran, HDR – Roadway
- David Lee, HDR – Traffic
- Matt Newman, HDR – Roadway
- Don Owings, HDR – VE Team Leader
- Shawn Russell, KYTC – VE Coordinator
- Brent Sweger, KYTC – Quality Assurance Branch Manager

Certification

This is to verify that the Value Engineering Study was conducted in accordance with standard value engineering principles and practices.

Donald Owings, PE, CVS®
VE Team Leader

1 Introduction

This VE report summarizes the events of the VE study conducted for KYTC and facilitated by HDR. The subject of the study was the Campbellsville Bypass in Taylor County. The VE study was conducted after the EIS was completed and final design was just slated to begin.

1.1 Value Engineering Process

The VE team employed the six-phase VE Job Plan in analyzing the project. This process is recommended by SAVE International® and is composed of the following phases:

Investigation/Information Phase – The objective of this phase was to obtain a thorough understanding of the project's design criteria and objectives by reviewing the project's documents and drawings, cost estimates, and schedules.

As a result of the review and project presentation by the project team, the VE team made the following observations:

- **Cost Estimate.** The baseline cost per square foot of bridge was determined to be low; the baseline estimate was adjusted for the study.
- **Profile.** There was discrepancy between the stationing shown on cross sections, the profile, and the plans that were provided to the VE team for the study.
- **Right-of-way.** The right-of-way footprint shown on the plans did not match the cross sections, particularly in the vicinity of bridges 1 and 2.
- **Right-of-way.** Right-of-way acquisition as currently planned is for the ultimate 4-lane section.
- **Wise Road.** The vertical clearance shown on the profiles was significantly less than required to facilitate a new bridge over Wise Road.
- **KY 55 and US 68.** The intersection layouts and turning traffic forecasts were not yet complete. As a result, the intersections were not investigated.
- **Environmental.** The Corps of Engineers (USACE) Wildlife Management Area is within the footprint of the new alignment near bridge 1.
- **Environmental.** Historical structures and cemeteries are within or in close proximity to the new alignment.
- **Geotechnical.** No geotechnical field investigation has been conducted; slopes used were based on assumed conditions.
- **Pavement.** Pavement design has not been completed; therefore, VE team did not investigate the pavement.

Function Analysis Phase – The purpose of this phase was to identify and define the primary and secondary functions of the project. A Functional Analysis System Technique (FAST) was used to quickly define the functions of the project.

By using functional analysis and FAST diagramming, the team defined the basic function of this project as *improve mobility*. Key secondary functions were *create space* and *move earth*.

Analysis of the functions intended to be performed by the project helped the team focus on the purpose and need of the project and, consequently, how to craft recommended concepts that would provide the required functions.

Speculation/Creative – During this phase the team employed creative techniques such as team brainstorming to develop a number of alternative concepts that satisfy the project's various functions. The idea list was grouped by function or major project element. All of the ideas generated were recorded in Appendix D. This generated 33 individual ideas that were moved into the Evaluation Phase.

Evaluation – The purpose of this phase was to evaluate the alternative concepts developed by the VE team during the brainstorming sessions.

Although each project is different, the evaluation process for each VE effort can be thought of in its simplest form as a way of combining, evaluating, and narrowing ideas until the VE team agrees on the recommendations to be moved forward.

To assist in this effort, specific performance criteria were developed in cooperation with the project team. These criteria were weighted, using a paired comparison approach, and resulted in the criteria used to evaluate ideas and alternative concepts. These criteria are identified later in Appendix D.

A total of 13 ideas scored high enough to move forward into the Development Phase.

Development – This phase of the process takes the concepts or ideas that ranked the highest in the idea evaluation phase and further develops them into full VE recommendations. In many cases, it is possible that one or more ideas were combined to form an overall recommendation, which were evaluated further by the VE team.

In the case of this project, of the original 33 ideas that were generated during the speculation phase, 13 of those ideas were taken forward, combined, and developed further into 9 VE recommendations. For the development phase, narratives, drawings, calculations, and cost estimates were prepared for each recommendation.

Presentation – The VE team presented their finding in the form of an oral presentation on the final day of the study. The presentation can be found in Appendix E.

1.2 Scope of the Value Engineering Study

The purpose of the study, through execution of the VE job plan, was to:

- Review and understand the various concepts of the project.
- Conduct a thorough review and analysis of the key project issues using a multidiscipline, cross-functional team.
- Give special emphasis in identifying opportunities to reduce the right-of-way impacts while maintaining and improving the performance and reducing costs of the project.

2 Project Description

This project is a segment of a larger project defined by the KYTC as Heartland Parkway, which would extend from the Louie B. Nunn Cumberland Parkway in Taylor County to the Martha Layne Collins Blue Grass Parkway in Washington County.

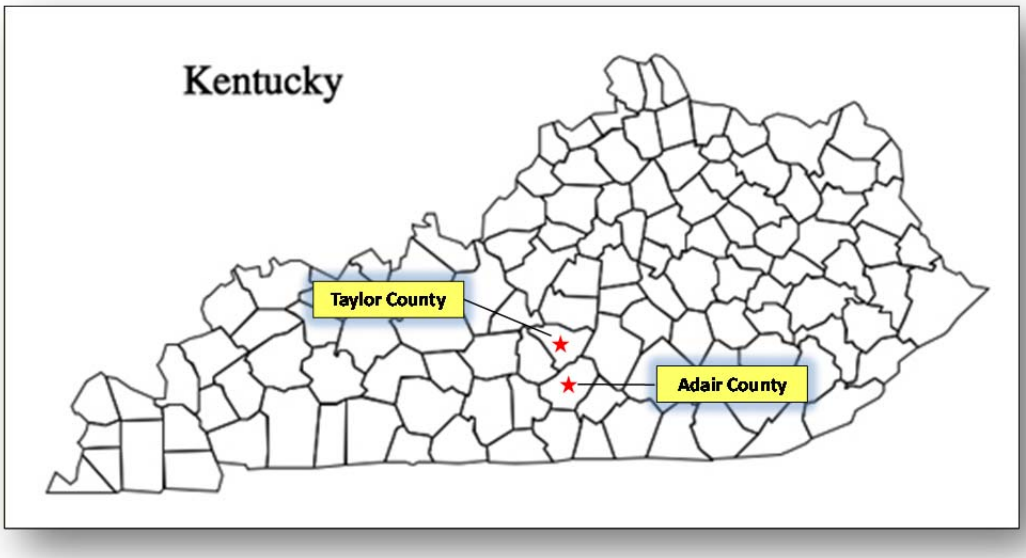
The Heartland Parkway corridor, between the Louie B. Nunn Cumberland and Martha Lane Collins Bluegrass parkways, runs through the heart of west-central Kentucky. The corridor can be characterized as both rural and urban, 2-lane and multilane, depending on location.

To create a wider, more uniform road within the corridor that would allow for growth and greater ease of long distance hauling and transportation, the roadway is undergoing major improvements. By widening the 2-lane sections to four lanes and bypassing the constricted urban areas, the roadway could become a major alternative to north-south travelers between and generally parallel to the I-65 and I-75 corridors.

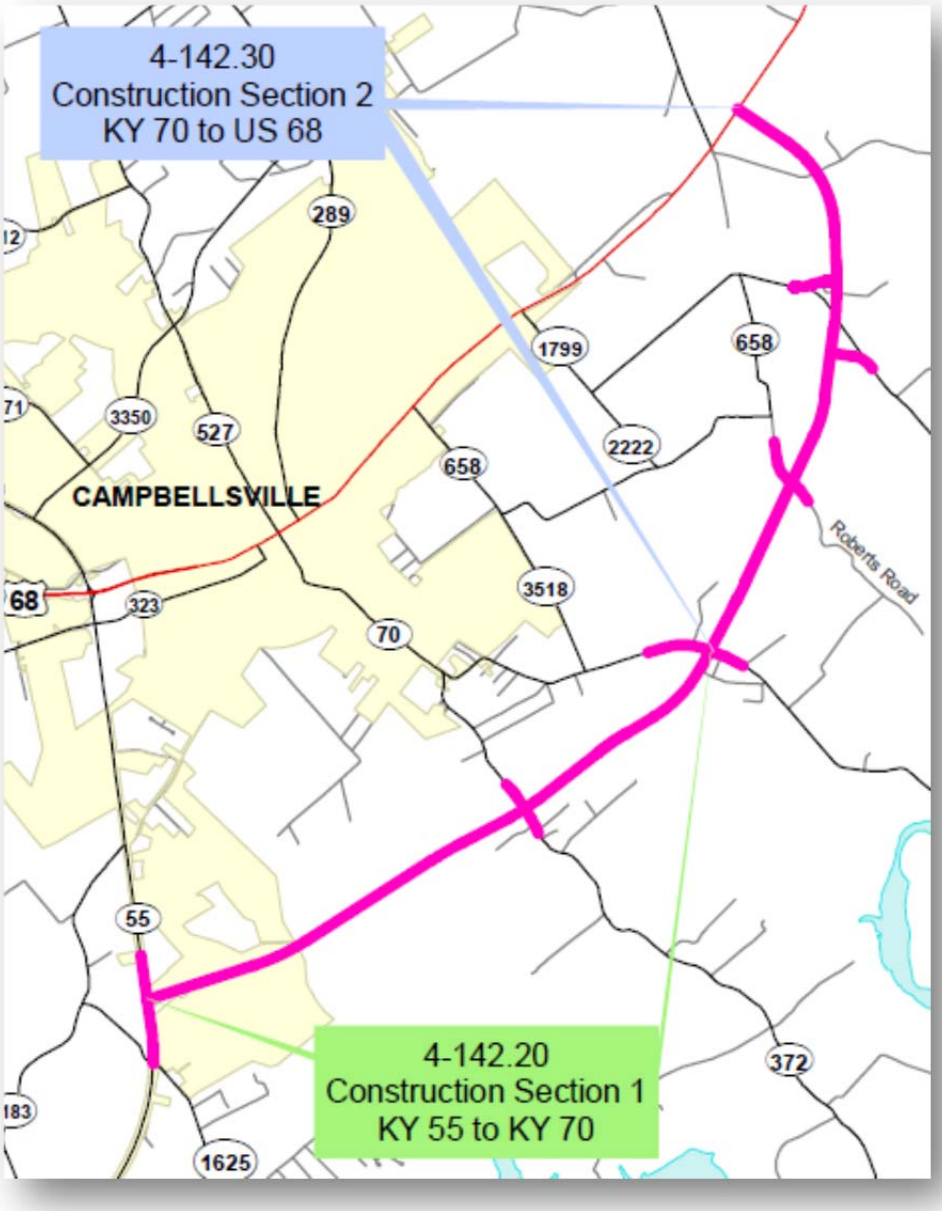
The overall goal of the corridor improvements are as follows:

- Improve regional access for economic development, existing industry, truck access, tourism, higher education, and agricultural economy
- Improve safety
- Improve highway capacity in certain locations
- Decrease delays through the communities
- Improve emergency response times.

The proposed highway project involves the widening and reconstruction of Kentucky Route 55 (KY 55) in Adair and Taylor Counties, and a southeast bypass of Campbellsville in Taylor County, Kentucky. The project corridor begins at the Columbia Bypass and continues northward to US 68. The project corridor is approximately 21 miles long, including approximately 14 miles of existing KY 55 and 7 miles for the bypass.



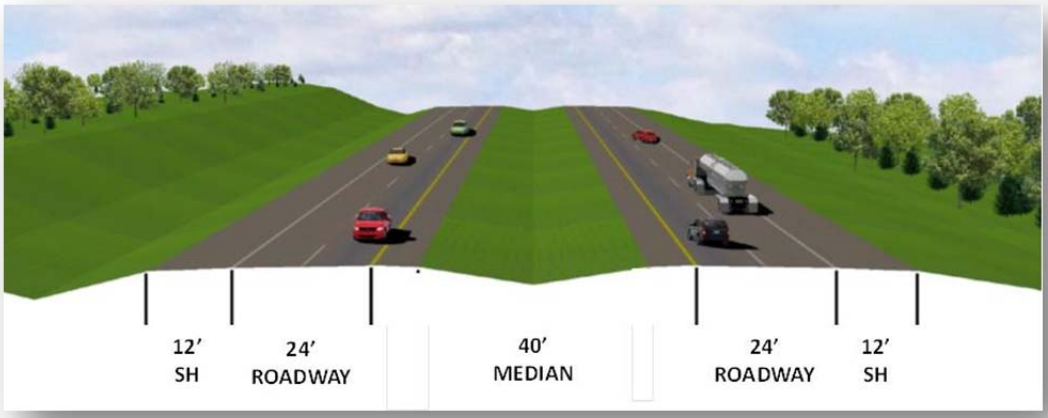
This VE study focused on the 7-miles bypass, which leaves the KY 55 corridor in the vicinity of KY 1625, turns eastward, and is on new alignment to bypass the city of Campbellsville on the south and east sides and terminates northeast of the city at US 68. The corridor is primarily through rural, agricultural land; however, at the southern terminus of the section's corridor, the Technology Park and the Campbellsville Sports Complex are under development. Additionally, USACE's Wildlife Management Area is within the Stone Quarry Creek portion of the corridor.



The bypass alignment will include an at-grade intersection at KY 55 where the bypass alignment begins. Along the new bypass alignment, at-grade intersections will be constructed at Smith Ridge Road (KY 372), KY 70, Roberts Road (KY 658), and a split intersection at Reed Chapel Road (KY 1799). The bypass alignment will terminate with an at-grade intersection at US 68.

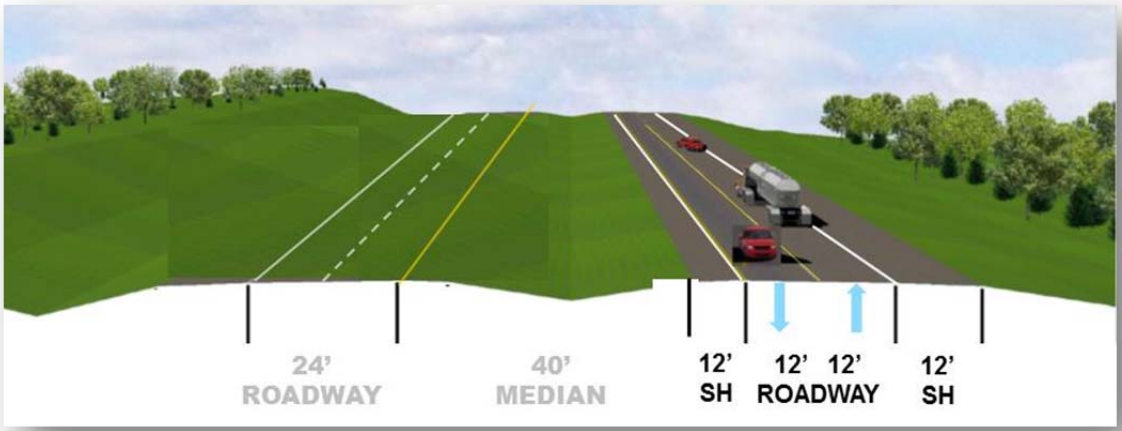
Classified as a rural arterial the proposed bypass will be designed to a design speed of 55 miles per hour (mph) with the following:

- Four-lane roadway
- Twelve-foot lanes
- Twelve-foot outside shoulder (10' paved plus 2' earth)
- Six-foot inside (4' paved plus 2' earth)
- Access spacing of 1200 feet
- Forty-foot median



While the ultimate typical section for the bypass would be four lanes (two lanes in each direction) the initial construction will build one side of the ultimate section, providing for a single lane in each direction. This initial typical section will include:

- Twelve-foot lanes, one each direction
- Twelve-foot shoulders (10' paved plus 2' earth)



The project, which has an ultimate typical section of 4 lanes with center median and paved shoulders, will be initially constructed as a 2-lane roadway with shoulders. Right-of-way is being acquired for the final section. Construction of the bypass portion is anticipated to be constructed under two construction contracts. While construction funding has not yet been secured, it is anticipated the first section to be constructed will be KY 55 to KY 70 beginning in 2018.

3 Recommendations

3.1 Introduction

Evaluation of the 33 ideas generated by the team resulted in 9 individual recommendations to the original concept. The VE recommendation documents in this section are presented as written by the team during the VE study. While they have been edited from the draft VE report to correct errors or better clarify the recommendation, they represent the VE team's findings during the VE study.

3.1.1 FHWA Functional Benefit Criteria

FHWA requires the DOT's to evaluate each approved recommendation in terms of the project feature or features that recommendation benefits. If a specific recommendation can be shown to provide benefit to more than one feature described below, count the recommendation in *each category that is applicable*. These same criteria can be found on each of the individual recommendations that follow.

- **Safety:** Recommendations that mitigate or reduce hazards on the facility
- **Operations:** Recommendations that improve real-time service and/or local, corridor, or regional levels of service of the facility.
- **Environment:** Recommendations that successfully avoid or mitigate impacts to natural and or cultural resources.
- **Construction:** Recommendations that improve work zone conditions, or expedite the project delivery.
- **Other:** Recommendations not readily categorized by the above performance indicators.

3.2 Individual Recommendations

Each recommendation consists of a summary of the original concept, a description of the suggested change, a listing of its advantages and disadvantages, a cost comparison, change in performance, and a brief narrative comparing the original design with the recommendation. Sketches, calculations, and performance measure ratings are also presented. The cost comparisons reflect a comparable level of detail as in the original estimate. Final recommendations can be found beginning on page 3-3.

VE RECOMMENDATION NO. 1: USABLE SHOULDER WIDTH	Idea No. 22

Baseline Concept

The current baseline concept is based on a 12-foot shoulder width (10' paved and 2' earth).

Recommendation Concept

The recommended concept is to modify the shoulder width to a 10-foot shoulder (8' paved and 2' earth).

Advantages	Disadvantages
• Reduces roadway costs • Reduces structure costs • Reduces right-of-way footprint • More consistent with ultimate typical section • Satisfies minimum standards for shoulder width for 4-lane divided arterial for future construction.	• None noted

Cost Summary	Cost
Baseline Concept	$ 10.6M
Recommendation Concept	$ 9.9M
Savings	$ 0.7M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
				✓

VE RECOMMENDATION NO. 1: USABLE SHOULDER WIDTH	Idea No. 22

Discussion/Sketches/Photos

Baseline Concept

As shown on Figure 1-1, the current baseline concept is based on a 12-foot shoulder width (10' paved and 2; earth). Because the baseline alternative is for 2-lane initial construction, the 12' shoulder width would be provided on both sides of the roadway.

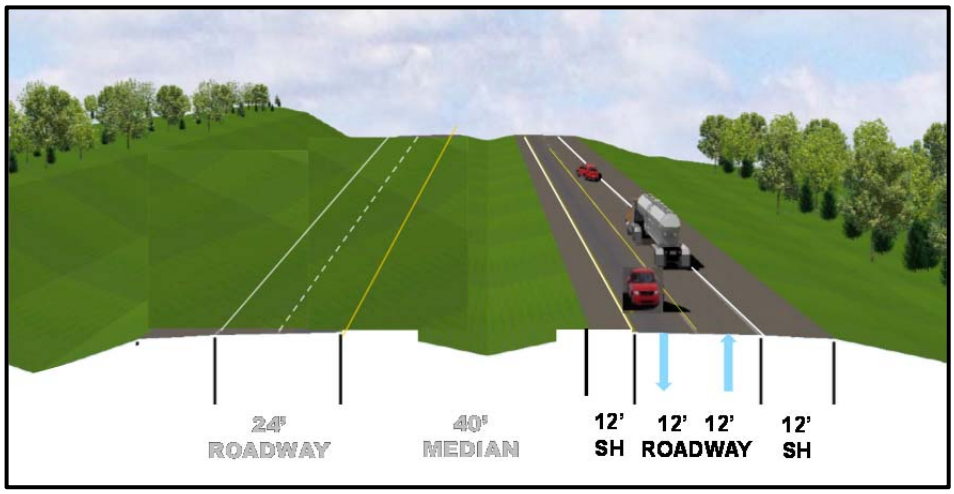


Figure 1-1

VE Recommendation

The purpose of the recommendation is to modify the shoulder width to a 10-foot shoulder (8' paved and 2' earth).

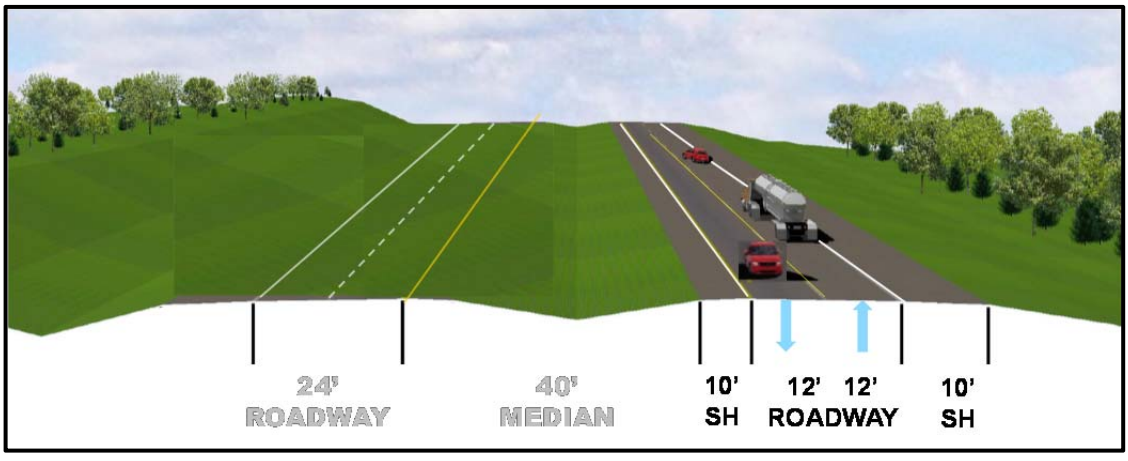


Figure 1-2

It is noted that the approved Design Executive Summary (DES) recommended that additional discussion of shoulder widths be held during Phase 2 design as a result of input from the KYTC Division of Design in Design Memo 2-14.

VE RECOMMENDATION NO. 1: USABLE SHOULDER WIDTH	Idea No. 22

It should also be noted that the minimum usable shoulder per Design Memo 2-14 is 6 feet, with the graded shoulder being 8 feet (6' paved and 2' unpaved). However, the VE team was briefed that typically District 4 prefers shoulders wider than 6 feet paved. Therefore, it was recommended that the 10 feet (8' paved and 2' earth) be considered. This has the additional benefit of meeting the minimum standards for a divided arterial if the roadway is widened to four lanes in the future.

Cost Analysis

Baseline

SECTION 1	LENGTH	DL WIDTH	SH WIDTH	DL COST	SH COST	TOTAL
ML - EX TO TEE	0	24	20	$60	$52	$0
ML - TEE TO BR1	3850	24	20	$60	$52	$1,060,889
ML - BR1 TO BR2	3075	24	20	$60	$52	$847,333
ML - BR2 TO KY 372	3550	24	20	$60	$52	$978,222
ML - KY 372 TO KY 70	5950	24	20	$60	$52	$1,639,556
KY 372 SMITH RIDGE	1450	24	4	$40	$40	$180,444
KY 70 ELKHORN RD	2175	24	4	$40	$40	$270,667
TURN LANES						$500,000
TOTAL						**$5,477,111**
SECTION 2						
ML - POB TO BR3	12700	24	20	$60	$52	$3,499,556
ML - BR3 TO POE	2450	24	20	$60	$52	$675,111
KY 658	1650	24	4	$40	$40	$205,333
KY 1799 RT	1175	24	4	$40	$40	$146,222
KY 1799 LT	1060	24	4	$40	$40	$131,911
TURN LANES						$500,000
TOTAL						**$5,158,133**

VE Proposed

SECTION 1	LENGTH	DL WIDTH	SH WIDTH	DL COST	SH COST	TOTAL
ML - EX TO TEE	0	24	16	$60	$52	$0
ML - TEE TO BR1	3850	24	16	$60	$52	$971,911
ML - BR1 TO BR2	3075	24	16	$60	$52	$776,267
ML - BR2 TO KY 372	3550	24	16	$60	$52	$896,178
ML - KY 372 TO KY 70	5950	24	16	$60	$52	$1,502,044
KY 372 SMITH RIDGE	1450	24	4	$40	$40	$180,444
KY 70 ELKHORN RD	2175	24	4	$40	$40	$270,667
TURN LANES						$500,000
TOTAL						**$5,097,511**
SECTION 2						
ML - POB TO BR3	12700	24	16	$60	$52	$3,206,044
ML - BR3 TO POE	2450	24	16	$60	$52	$618,489
KY 658	1650	24	4	$40	$40	$205,333
KY 1799 RT	1175	24	4	$40	$40	$146,222
KY 1799 LT	1060	24	4	$40	$40	$131,911
TURN LANES						$500,000
TOTAL						**$4,808,000**

VE RECOMMENDATION NO. 1: USABLE SHOULDER WIDTH	Idea No. 22

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	Performance	Baseline	Alternative
Mainline Operations Slight change in operations due to narrower shoulder - still within acceptable standards	Rating	5	5
	Weight	26	
	Contribution	130	130
Local Operations No change to baseline	Rating	5	5
	Weight	21	
	Contribution	105	105
Maintainability No change to baseline	Rating	5	5
	Weight	14	
	Contribution	70	70
Construction Impacts No change to baseline	Rating	5	5
	Weight	10	
	Contribution	50	50
Environmental Impacts No change to baseline	Rating	5	5
	Weight	24	
	Contribution	120	120
Project Schedule No change to baseline	Rating	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	500
	Net Change in Performance		**0%**

VE RECOMMENDATION NO. 2: BRIDGE SHOULDER WIDTHS	Idea No. 17

Baseline Concept

The three bridges in the baseline concept have estimates based on a bridge width of 42 feet for the initial 2-lane build. This appears to be two 12' lanes with a 6' inside shoulder and a 10' outside shoulder and then an additional 2' for barriers.

Recommendation Concept

Reduce shoulder widths on bridge from 10' outside and 6' inside to 4' outside and 4' inside.

Advantages	Disadvantages
• Reduces overall bridge cost by approximately $832,500. • Reduces long-term maintenance cost	• Provides a non-uniform travel way section with a “funneling affect” at the bridges. • Slight reduction in main line operations due to inability for disabled vehicles to pull off roadway within bridge limits. • Limits phasing options for future rehabilitation, particularly in the initial 2-lane configuration. • Decrease in bridge sufficiency rating of approximately 7 points.

Cost Summary	Cost
Baseline Concept	$5.8M
Recommendation Concept	$5.0M
Savings	$0.8M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
				✓

VE RECOMMENDATION NO. 2: BRIDGE SHOULDER WIDTHS	Idea No. 17

Discussion/Sketches/Photos

It is not 100 percent clear whether or not the intent was to have an asymmetrical bridge for the 2-lane interim condition. Based on the provided cost estimates and plan views, it appears that the bridges to be built for the 2-lane interim condition are planned to be the required geometry for the 4-lane ultimate condition – meaning that the shoulder on one side would only be 4 feet wide even though the roadway approach leading to the bridge is planned to be built with 10-foot shoulders on both sides for the 2-lane interim condition. If this was an oversight and the intent was to build the interim 2-lane bridges with 10' shoulders on both sides, then the anticipated cost savings would be double what is shown above.

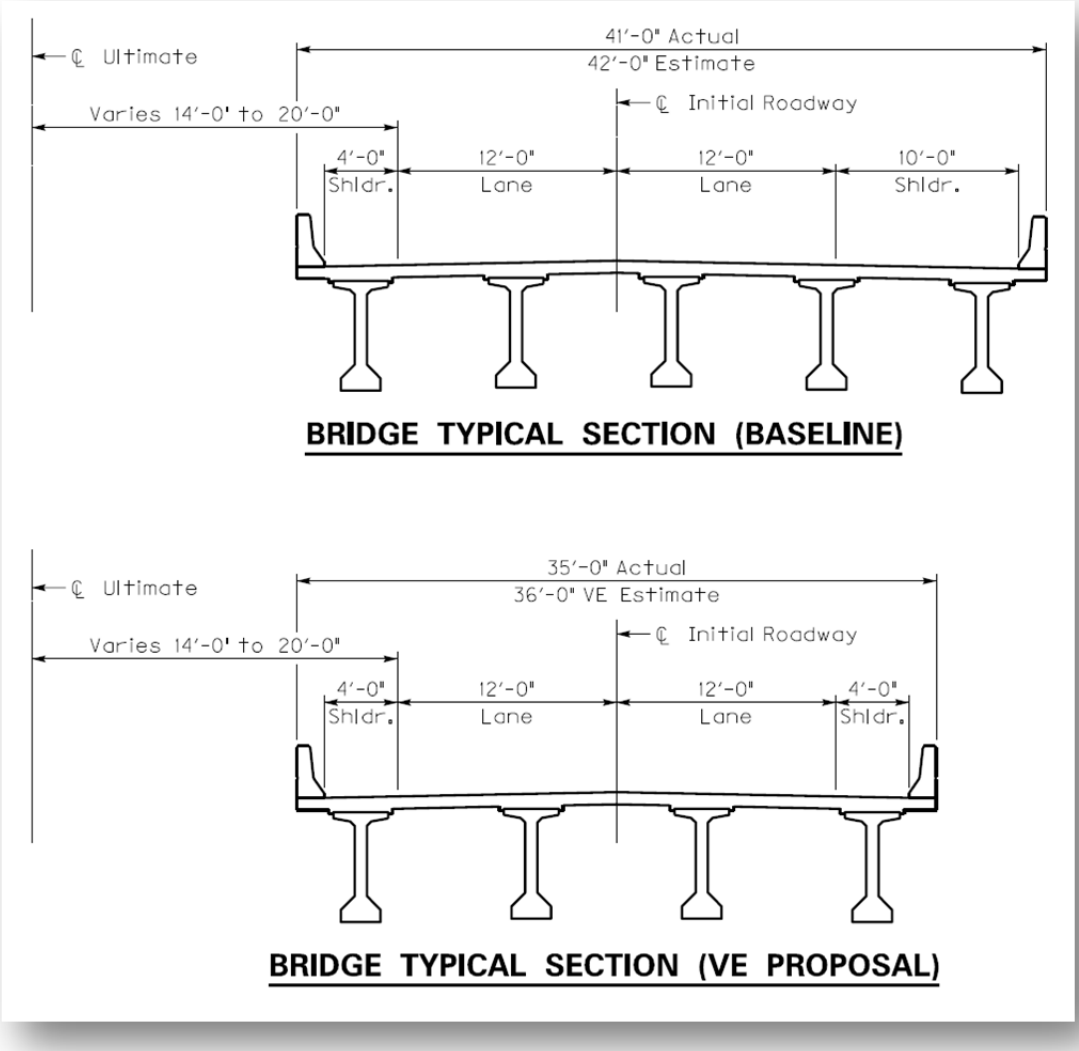


Figure 2-1: Bridge Typical Sections

KYTC Design Memo 2-14 states: “The minimum useable shoulder widths should be continued across all new structures. Per AASHTO Guidance, on long bridges (in excess of 200'') it may be acceptable to have bridge shoulder widths less than the approach roadway shoulder widths.” Chapter 7 of AASHTO (page 447) further states: “On long bridges, offsets to parapet, rail, or barrier should be at least 1.2 m [4 feet] measured from the edge of the traveled way on both sides of the roadway.”

VE RECOMMENDATION NO. 2: BRIDGE SHOULDER WIDTHS	Idea No. 17

All three bridges currently being proposed in the baseline design are more than 200 feet in length (Bridge 1 = 400'; Bridge 2 = 360'; Bridge 3 = 350'). This provision is most often implemented on long bridges that also have long individual spans, which typically consist of bridge types that are much more expensive per square foot of bridge. For example, the new Kentucky Lakes bridge (3600-feet-long with 500-foot main span) that is now under construction is a 4-lane structure (divided by median barrier) with 4-foot inside and outside shoulders. While it is not common to take advantage of this provision for bridges similar in size and type to the ones being proposed on this project, doing so would still be in compliance with AASHTO.

The primary advantage with this option is a reduction in up-front capital cost as well as a reduction in long-term maintenance costs. There are a few disadvantages associated with “hour-glassing” at the bridges. However, it appears that the baseline is already planned to have hour-glassing on one side (at least until the 4-lane ultimate section is built). While difficult to quantify, the narrowing of the shoulders at the bridges could lead to an increase in accidents. This reduced width would result in a 7 point reduction in each bridge’s sufficiency rating. However, if the approach roadway were equally narrow, then the reduction would only be 2 points. In addition, 4-foot-wide shoulders would not be sufficient to accommodate disabled vehicles. The narrower width also reduces the flexibility for maintaining traffic during future rehabilitations.

BRIDGE CONSTRUCTION COST - 2-LANE INTERIM

	BASELINE				VE PROPOSAL			
	Length (feet)	Width (feet)	Unit Cost	Cost	Length (feet)	Width (feet)	Unit Cost	Cost
SECTION 1								
ML - BR1	400	42	$125	$2,100,000	400	36	$125	$1,800,000
ML - BR2	360	42	$125	$1,890,000	360	36	$125	$1,620,000
SUBTOTAL				**$3,990,000**				**$3,420,000**
SECTION 2								
ML - BR 3	350	42	$125	$1,837,500	350	36	$125	$1,575,000
SUBTOTAL				**$1,837,500**				**$1,575,000**
TOTAL				**$5,827,500**				**$4,995,000**
						SAVINGS		**$832,500**

Note: The baseline cost estimate as provided to the VE team utilized a bridge cost of $85/sf, which was deemed too low, especially considering Bridge 1 and Bridge 2 are 93' and 76' tall, respectively. The baseline and VE proposal costs have been normalized to a bridge unit price of $125/sf.

VE RECOMMENDATION NO. 2: BRIDGE SHOULDER WIDTHS	Idea No. 17

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	Performance	Baseline	Alternative
Mainline Operations Reduced shoulder width for length of bridge	Rating	5	4.5
	Weight	26	
	Contribution	130	117
Local Operations No change to baseline	Rating	5	5
	Weight	21	
	Contribution	105	105
Maintainability Slightly less bridge to maintain	Rating	5	5.25
	Weight	14	
	Contribution	70	73.5
Construction Impacts No change to baseline	Rating	5	5
	Weight	10	
	Contribution	50	50
Environmental Impacts No change to baseline	Rating	5	5
	Weight	24	
	Contribution	120	120
Project Schedule No change to baseline	Rating	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	490.5
	Net Change in Performance		**-2%**

VE RECOMMENDATION NO. 3: MEDIAN WIDTH	Idea No. 6

Baseline Concept

The baseline design for the project is to purchase right-of-way based on a bypass typical section of four 12-foot lanes, a 40-foot depressed median, and 12-foot outside shoulders.

Recommendation Concept

Reduce the median width to 28 linear feet.

Advantages	Disadvantages
• Reduces right-of-way impacts • Reduces right-of-way costs • Reduces long term maintenance • *Reduces earthwork for ultimate roadway design* • *Improves signal operations at connections – if used for ultimate roadway design* *NOTE: Italic and underlined apply to ultimate build out only.*	• *Reduces future median width for turning lanes and auxiliary lanes* • *Reduces spacing between opposing directions*

Cost Summary	Cost
Baseline Concept	$17.2M
Recommendation Concept	$16.6M
Savings	$0.6M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
		✓		✓

VE RECOMMENDATION NO. 3: MEDIAN WIDTH	Idea No. 6

Discussion/Sketches/Photos

The purpose of this recommendation is to reduce right-of-way acquired for the project.

Baseline Concept

The baseline design is to purchase right-of-way using a 40-foot depressed median for the typical section for the bypass. Proposed right-of-way areas and residential relocations required for a 40-foot median were provided with the study information.

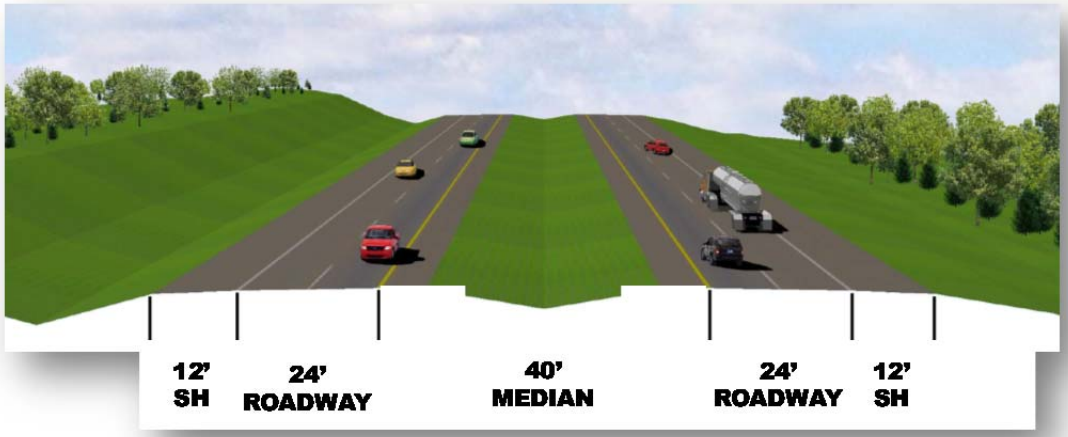


Figure 3-1

VE Recommendation

The VE recommendation is to reduce the median width from 40 feet to 28 feet, which satisfies the clear-zone requirements and is being used on other KYTC projects. Changing the median width and right-of-way to accommodate a 28-foot median reduces the overall right-of-way area required, thus reducing initial costs and long-term maintenance. An added benefit to this concept is a reduction to the overall foot print for the project, reducing environmental impacts.

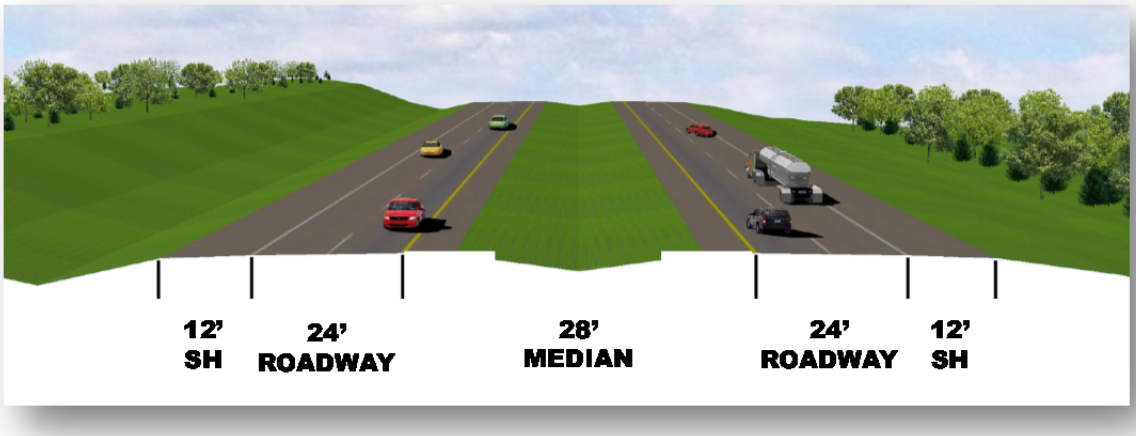


Figure 3-2

VE RECOMMENDATION NO. 3: MEDIAN WIDTH	Idea No. 6

Cost Analysis

The right-of-way cost is based on the proposed right-of-way areas using the costs provided in the baseline estimate. Residential relocations are assumed to be the same since most appear at intersections with side roads or along side roads.

The right-of-way areas required for this concept was calculated using a linear approach, reducing the overall right-of-way footprint as determined by the length of project, multiplied by the 12-foot reduction in median width. The length of project assumed is 6.6 miles for this calculation.

	ROW AREA	RESID RELOC	AREA UNIT COST	RES UNIT COST	TOTAL
Baseline	223.72	22	$57,000	$200,000	**$17,152,040**
Recommended	214.12	22	$57,000	$200,000	**$16,604,840**
Net Reduction	9.60	0			**$547,200**

VE RECOMMENDATION NO. 3: MEDIAN WIDTH	Idea No. 6

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	Performance	Baseline	Alternative
Mainline Operations While median is narrower it is still within standards and no operational degradation should be seen	Rating	5	5
	Weight	26	
	Contribution	130	130
Local Operations Slight decrease in maintenance	Rating	5	5
	Weight	21	
	Contribution	105	105
Maintainability Eliminates structure	Rating	5	5.2
	Weight	14	
	Contribution	70	72.8
Construction Impacts No change to baseline	Rating	5	5
	Weight	10	
	Contribution	50	50
Environmental Impacts Decrease in ROW impacts	Rating	5	6
	Weight	24	
	Contribution	120	144
Project Schedule No change to baseline	Rating	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	526.8
	Net Change in Performance		**5%**

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

Baseline Concept

The current baseline concept has the bypass crossing Wise Road at a location that attempts to minimize right-of-way taking. Due to the grade differential at this location, a bridge is provided over Wise Road.

Due to the bridge, the PDT determined not to provide access to Wise Road at this crossing.

Recommendation Concept

The recommended concept is to relocate this section of the bypass to the north to cross Wise Road at an elevation that allows an at-grade intersection. A modification of this alternative was considered during the Phase 1 study (referred to as the "light blue" alternative).

During our analysis, another alternative was considered (Idea No. 4) that would eliminate the structure by adjusting the profile grades on both the bypass and Wise Road. After further evaluation, this idea was eliminated.

Advantages	Disadvantages
• Eliminates structure • Improves access to Wise Road • Eliminates the need for a channel change	• Introduces intersection at Wise Road • May result in additional relocations • Increases earthwork • May have to revisit Environmental Assessment if "light blue" alternative is used.

Cost Summary	Cost
Baseline Concept	$11.2M CN + $8M right-of-way + $0.2M Utilities = $19.4 (Section 2 only)
Recommendation Concept	$9.3M CN + $8.2M right-of-way + $0.2M Utilities = $17.7 (Section 2 only)
Savings	-$1.9M CN + $0.2M right-of-way = $1.7M Total Saving

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
	✓	✓		✓

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

Discussion/Sketches/Photos

As shown on Figure 4-1, the current baseline concept crosses Wise Road at a location that requires a structure due to the grade differential and steep slopes adjacent to Wise Road. In addition, the grade of Wise Road in this vicinity is approximately 10 percent (downgrade to the lower right in photo). Access to the bypass from Wise Road is not provided.

An additional impact is the existing stream which flows to the south behind the homes which front on Wise Road. The current alignment is essentially on top of the stream and requires a channel change to relocate the stream.

Figure 4-2 shows the current baseline bypass profile at this location. For information, the proposed grades on the bypass on either side of the structure are -2.5 percent and +3.75 percent.

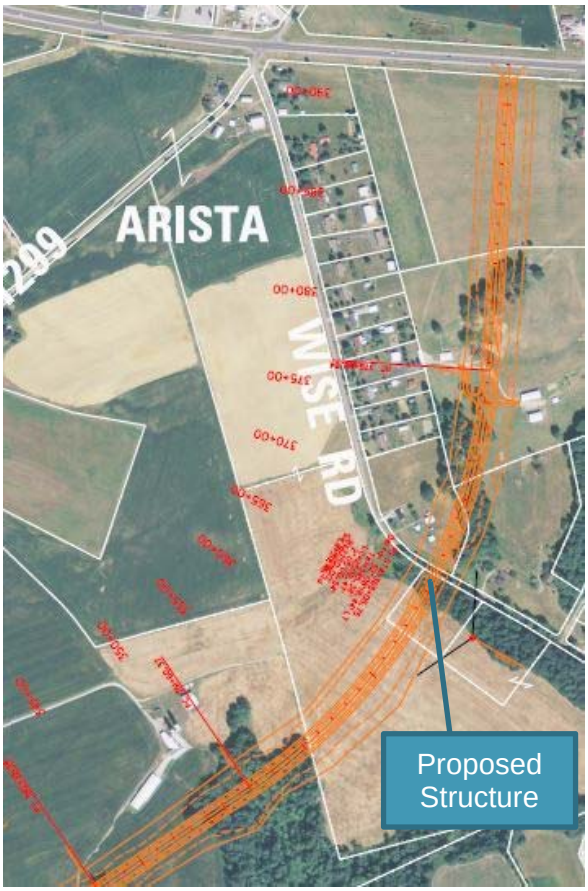


Figure 4-1

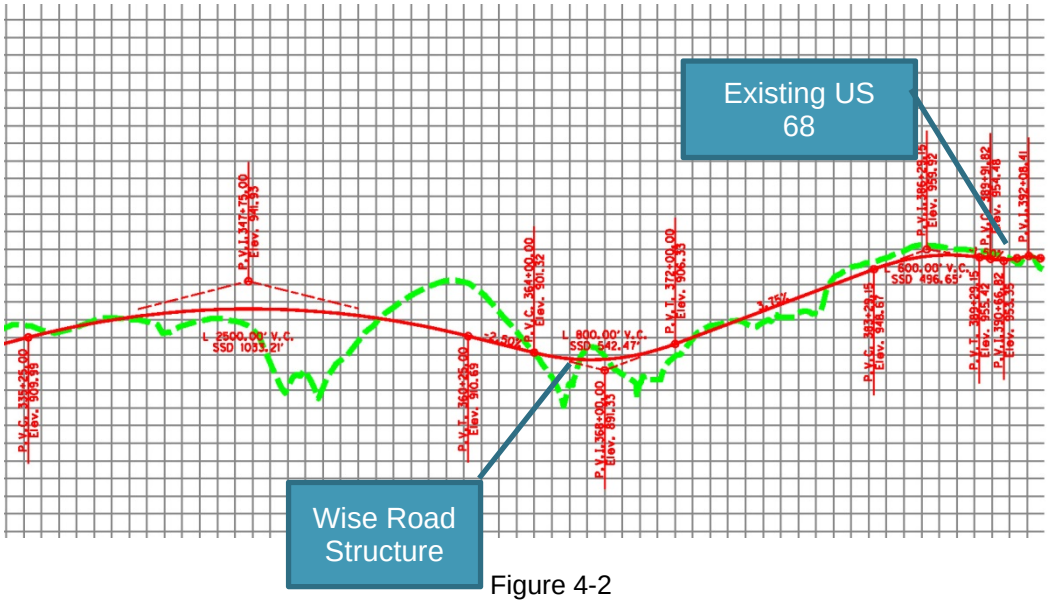


Figure 4-2

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

VE Recommendation

The purpose of the recommendation is to eliminate the structure at Wise Road. Several alternatives were considered, including:

- Adjusting the profile on both the bypass and Wise Road (raising Wise Road and lowering the bypass).
- Shifting the bypass alignment to the north to allow the intersection of the bypass with Wise Road at an elevation that allows an at-grade intersection. Several intersection locations were considered, including a modification of the "light blue" alternative, which was considered during the Phase 1 design (see Figure 4-3).

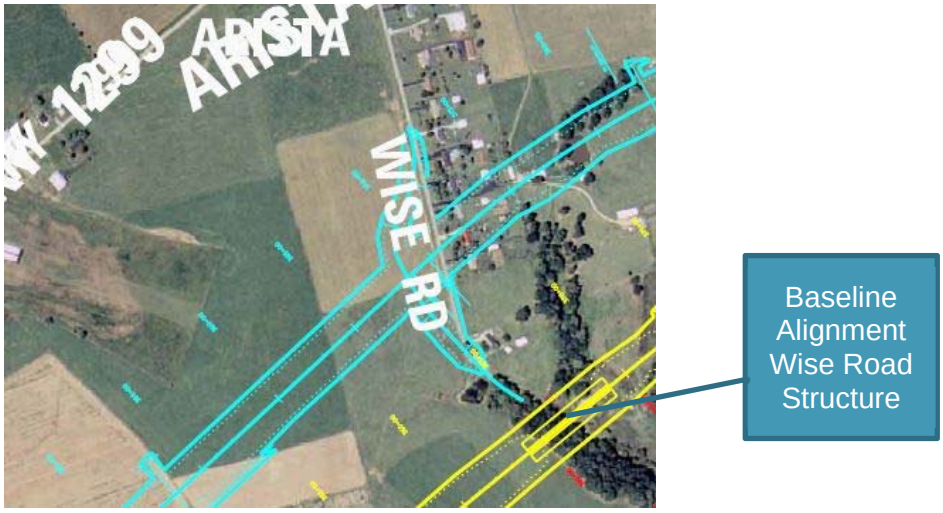


Figure 4-3

After evaluation, the team focused on an adjustment that shifted the alignment to the north by lengthening the radius of the curve (from 2,500 feet to 5,100 feet). This modification crosses Wise Road approximately half way between the "yellow" (baseline) and "light blue" alternative.

In addition to the advantage of eliminating the structure, this alternative eliminates the need for the channel change associated with the baseline design. The major disadvantage of this alternative is one additional right-of-way taking and minor impacts to two other adjacent properties.

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

The proposed recommendation is shown on Figure 4-4.

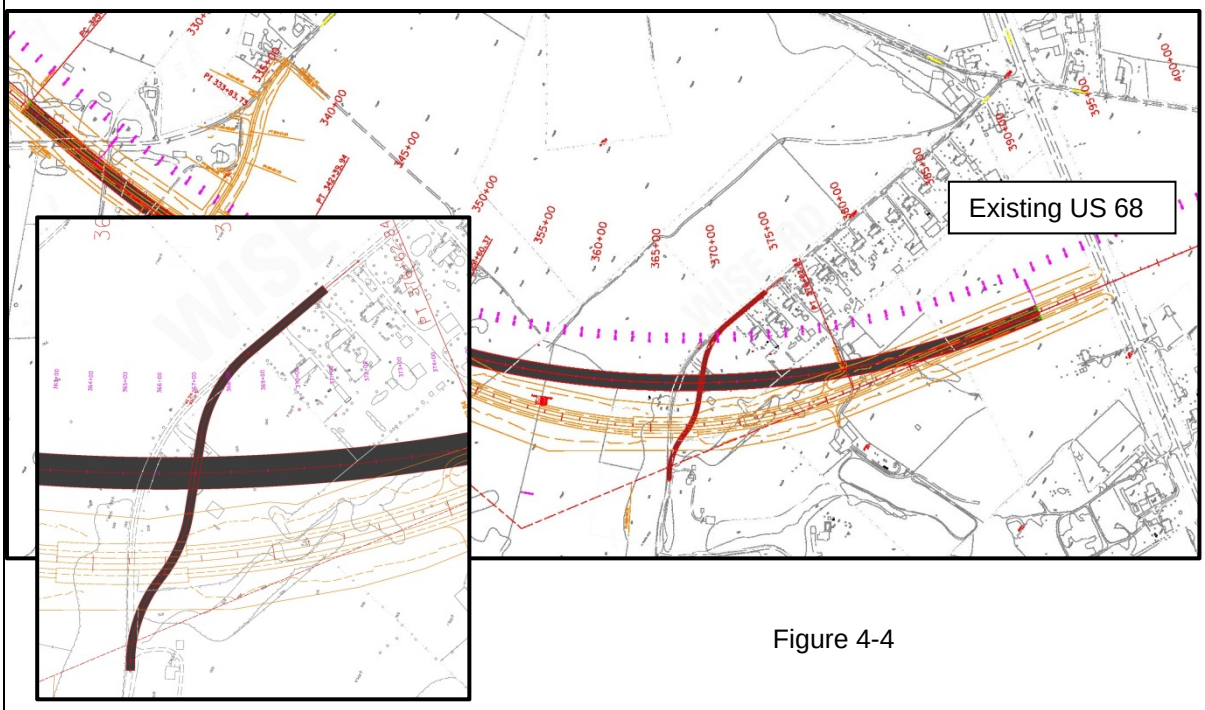


Figure 4-4

Figure 4-5 shows the recommended bypass profile at this location. For comparison, the proposed grades on the bypass on either side of the structure are -2.85 percent and +3.70 percent (similar to baseline).

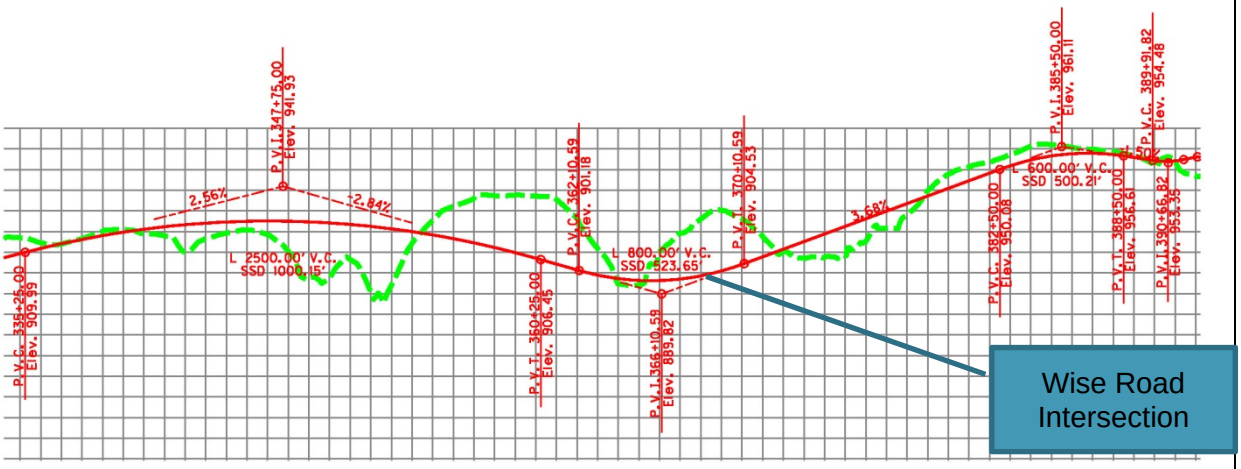


Figure 4-5

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

The challenge to this alternative was to meet acceptable design criteria for Wise Road, south of the bypass intersection, with maximum grade and sight distance being the most significant issues. Based on our analysis, we believe these criteria can be achieved, but further verification should be made prior to moving forward with this recommendation. It is noted that sight distance for Wise Road is based on a 25 mph design speed. The recommended Wise Road profile is shown on Figure 4-6.

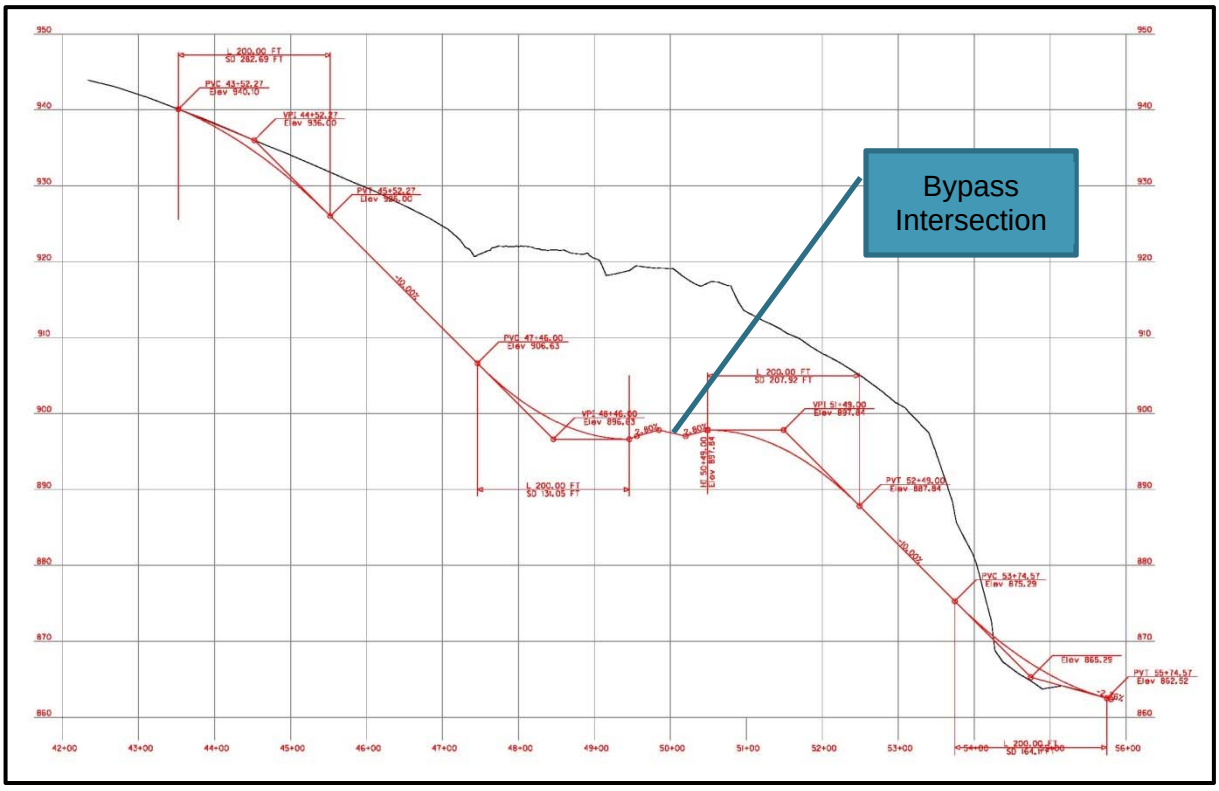


Figure 4-6

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

Cost Analysis

Earthwork

Earthwork costs are determined using the same procedure as the baseline.

	CUT	FILL	NET		
Baseline					
Section 2					
ML - POB TO 350+00	150,566	163,792	-13,226		
ML - 350+00 TO POE	113,387	52,000	61,387		
Approaches	67,775	10,298	57,477		
TOTAL	**331,728**	**226,090**	**105,638**	$5	**$1,658,640**
Recommended					
Section 2					
ML - POB TO 350+00	150,566	163,792	-13,226		
ML - 350+00 TO POE	143,000	64,000	79,000		
Approaches	67,775	10,298	57,477		
TOTAL	**361,341**	**238,090**	**123,251**	$5	**$1,806,705**

Pavement

The pavement cost is based on the differential project length (between baseline and alternative) and pavement cost/foot from the baseline estimate. Approach costs are assumed to be the same.

Baseline							
Section 2							
Total Mainline		15150					$4,674,667
Total Approaches		3885					$483,467
TOTAL							**$5,158,133**
Pavement Cost - Mainline ($/LF)							$309
Pavement Cost - Approaches ($/LF)							$124
Recommended							
Section 2							
Total Mainline		15355					$4,737,921
Total Approaches		5035					$626,578
TOTAL							**$5,364,499**

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

Right-of-way

The right-of-way cost is determined using the same procedure as the baseline. It is assumed that the alternative increases the number of takings by one parcel. The total area of right-of-way acquired is assumed to be the same even though the length of the project is reduced slightly.

Baseline			
Section 2			
RW	108	$57,000	$6,156,000
RESIDENTS	9	$200,000	$1,800,000
BUSINESS		$500,000	$0
TOTAL			**$7,956,000**
Recommended			
Section 2			
RW	108	$57,000	$6,156,000
RESIDENTS	10	$200,000	$2,000,000
BUSINESS		$500,000	$0
TOTAL			**$8,156,000**

Cost Summary

The total project costs are determined using the same procedure as the baseline.

Assumptions

- Miscellaneous costs are determined as 30 percent of total of earthwork, pavement, and structures
- Because the purpose of this alternative is to eliminate the structure, structure cost is zero.
- Utility costs are assumed to be identical to baseline.

	Earthwork	Structures	Pavement	Misc (30%)	SUBTOTAL	ROW	UTILITY	TOTAL
Baseline								
Section 2	$1,658,640	$1,837,500	$5,158,133	$2,596,282	$11,250,555	$7,956,000	$160,710	**$19,367,265**
Recommended								
Section 2	$1,806,705	$0	$5,364,499	$2,151,361	$9,322,565	$8,156,000	$160,710	**$17,639,275**
						SAVINGS		**$1,727,990**

VE RECOMMENDATION NO. 4: WISE ROAD	Idea Nos. 4, 13

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	Performance	Baseline	Alternative
Mainline Operations Added conflict point to mainline (intersection) Intersection is in middle of horizontal curve	*Rating*	5	4
	Weight	26	
	Contribution	130	104
Local Operations Improved local access	*Rating*	5	5.5
	Weight	21	
	Contribution	105	115.5
Maintainability Eliminates structure	*Rating*	5	7
	Weight	14	
	Contribution	70	98
Construction Impacts Wise road may need to be closed to construct	*Rating*	5	4
	Weight	10	
	Contribution	50	40
Environmental Impacts Reduces channel change Slight increase in ROW	*Rating*	5	5
	Weight	24	
	Contribution	120	120
Project Schedule No change to baseline	*Rating*	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	502.5
	Net Change in Performance		1%

VE RECOMMENDATION NO. 5: CROSS ROAD ALIGNMENTS	Idea No. 8

Baseline Concept

The proposed design for Smith Ridge Road places 1,450 feet of new alignment to the northeast of the existing roadway.

The proposed design for KY 70 places 2,175 feet of new alignment to the north of the existing roadway.

The proposed design for KY 658 places 1,070 feet of new alignment to the north of the existing roadway on the west side of the proposed bypass and places 565 feet of new alignment to the south of the existing roadway on the east side of the proposed bypass.

Recommendation Concept

Construct proposed Smith Ridge Road along the existing alignment. This option is presented using the initial 2-lane bypass typical section for the main line template. Tie-in to Smith Ridge Road can be accomplished within 100 feet to the left side of the proposed bypass and 150 feet to the right side of the proposed bypass. Construction would require either temporary widening or short term road closure to bring grades up to the proposed bypass crossing (an existing grade to proposed grade difference of approximately 1.50 foot).

Construct proposed KY 70 along the existing alignment. This option is presented using the initial 2-lane bypass typical section for the main line template. Tie-in to KY 70 can be accomplished within 215 feet to the left side of the proposed bypass and 235 feet to the right side of the proposed bypass. Construction would require either temporary widening or short term road closure to bring grades up to the proposed bypass crossing (an existing grade to proposed grade difference of approximately 1.20 foot).

Constructing the proposed KY 658 on existing alignment was reviewed for this concept and eliminated from further consideration. It was deemed not feasible due to an existing meandering alignment and the adverse skew to the proposed bypass.

Advantages	Disadvantages
• Reduction in right-of-way take • Potential reduction in relocations • Potential reduction in utility impacts • Could allow for quicker tie-ins to existing alignments.	• Increased conflicts during construction

Cost Summary	Cost
Baseline Concept	$0.85M Construction + $1.7M Right-of-Way = $2.5M
Recommendation Concept	$0.13M + $0.0 Right-of-Way = $0.13M
Savings	$2.4M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
		✓		

VE RECOMMENDATION NO. 5: CROSS ROAD ALIGNMENTS	Idea No. 8

Discussion/Sketches/Photos

VE Recommendation

The purpose of this recommendation is to construct the proposed cross roads intersecting the bypass on existing alignment. Several cross roads were considered, including:

- Smith Ridge Road
- KY 70
- KY 658

After evaluation, the team focused efforts on Smith Ridge Road and KY 70 as the most viable to benefit from this concept. KY 658 was deemed not as feasible due to the existing geometry of the road and the adverse skew to the main line.

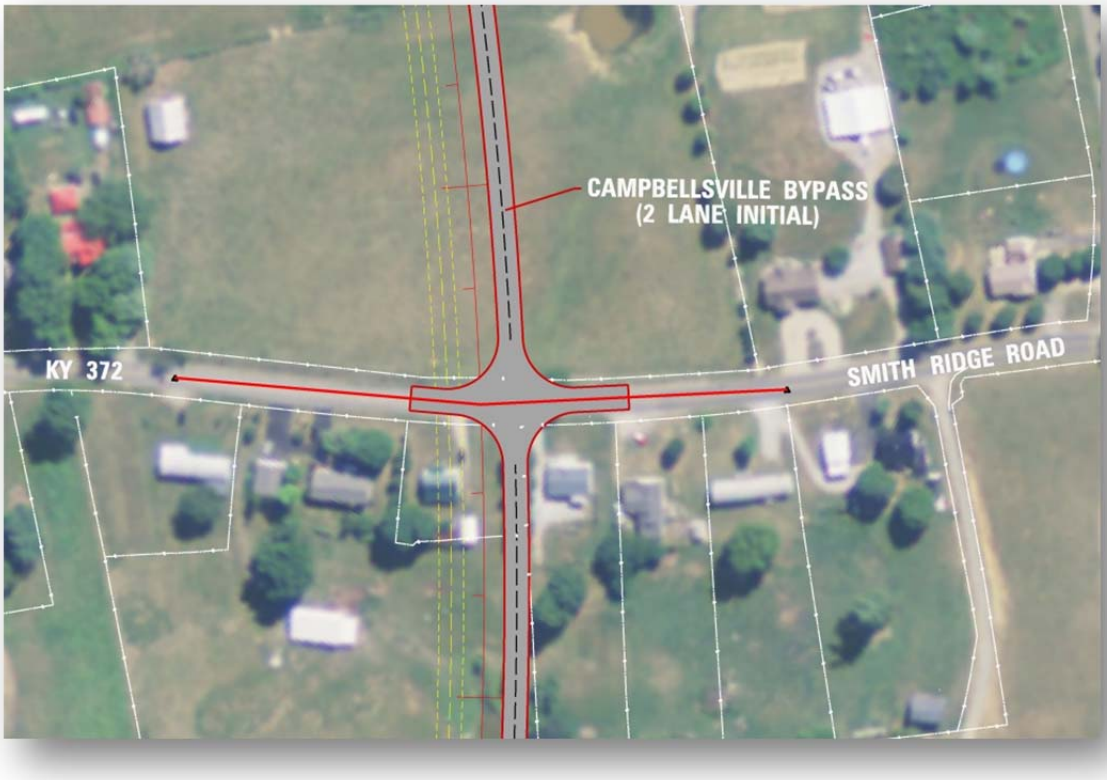


Figure 5-1. Smith Ridge Road

As shown in Figure 5-1, above, this concept proposes constructing the Smith Ridge Road connection to the proposed bypass on the existing alignment.

Advantages this concept offers over the baseline design include significant reductions in right-of-way requirements (no residential acquisitions versus seven for the baseline), a reduction in earthwork (eliminates 46,000 cubic yards [CY] of embankment for a new alignment), and a reduction in proposed pavement requirements (13,500 square yards [SY] vs. 2,350 SY).

Another advantage to constructing Smith Ridge Road on the existing alignment includes a reduction in utility impacts, which we did not include in this concept's cost estimate.

VE RECOMMENDATION NO. 5: CROSS ROAD ALIGNMENTS	Idea No. 8

A challenge with this concept is maintenance of traffic during construction. As described by the project team, Smith Ridge Road is used by lake-bound vehicles, many with boats in tow. Impacts during construction were considered with this concept. While short term closures would be most efficient for construction, this may not be feasible so part width construction or temporary widening may be required.

Figure 5-2. KY 70

As shown in Figure 5-2, above, this concept proposes constructing the KY 70 connection to the proposed bypass on the existing alignment.

Advantages this concept offers over the baseline design include reductions in right-of-way requirements (no new right-of-way required, utilize existing or proposed bypass right-of-way), a reduction in earthwork (eliminates 17,000 CY of excavation for a new alignment), and a reduction in proposed pavement requirements (7,700 SY vs. 1,600 SY).

Another advantage to constructing KY 70 on the existing alignment includes a reduction in utility impacts, which we did not include in this concept's cost estimate.

Impacts during construction were considered with this concept. While short term closures would be most efficient for construction, this may not be feasible so part width construction or temporary widening may be required.

VE RECOMMENDATION NO. 5: CROSS ROAD ALIGNMENTS	Idea No. 8

Cost Analysis

Earthwork

Earthwork costs are determined using the same procedure as the baseline.

	CUT	FILL	NET		
Baseline					
KY 70	17,460	865	16,595		
Smith Ridge Road	9,871	46,117	-36,246		
TOTAL	27,331	46,982	-19,651	$5	**$136,655**
Recommended					
KY 70	307	229	78		
Smith Ridge Road	101	142	-41		
TOTAL	408	371	37	$5	**$2,040**

Pavement

The pavement cost is based on paved area of side road and pavement cost per square yard provided in the baseline estimate.

	SQ YD PAVED		
Baseline			
KY 70	7,733		
Smith Ridge Road	5,156		
TOTAL	12,889	$40	**$515,556**
Recommended			
KY 70	1,582		
Smith Ridge Road	782		
TOTAL	2,364	$40	**$94,578**

Right-of-way

The right-of-way cost is based on proposed right-of-way areas and residential relocations using the costs provided in the baseline estimate.

VE RECOMMENDATION NO. 5: CROSS ROAD ALIGNMENTS	Idea No. 8

	ROW AREA	RESID RELOC	AREA UNIT COST	RES UNIT COST	
Baseline					
KY 70	2.34	0			
Smith Ridge Road	2.98	7			
TOTAL	**5.32**	**7**	**$57,000**	**$200,000**	**$1,703,240**
Recommended					
KY 70	0	0			
Smith Ridge Road	0	0			
TOTAL	**0**	**0**	**$57,000**	**$200,000**	**$0**

Cost Summary

The total project costs are determined using the same procedure as the baseline.

Assumptions

- Miscellaneous costs are determined as 30 percent of total of earthwork, pavement, and structures (same as baseline).
- Utility costs were not easily extracted from the baseline estimate for side roads so are not included in the estimates for this analysis; however, a reduction to impacts would be anticipated using the concept.

	Earthwork	Pavement	Misc (30%)	SUBTOTAL	ROW	TOTAL
Baseline						
KY 70 & Smith Ridge Road	$136,655	$515,556	$195,663	$847,874	$1,703,240	$2,551,114
Recommended						
KY 70 & Smith Ridge Road	$2,040	$94,578	$28,985	$125,603	$0	$125,603

VE RECOMMENDATION NO. 5: CROSS ROAD ALIGNMENTS	Idea No. 8

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	Performance	Baseline	Alternative
Mainline Operations No change to baseline	Rating	5	5
	Weight	26	
	Contribution	130	130
Local Operations Slight improvement - straight alignment	Rating	5	5.5
	Weight	21	
	Contribution	105	115.5
Maintainability No change to baseline	Rating	5	5
	Weight	14	
	Contribution	70	70
Construction Impacts Cross Roads will need to be build under traffic Length of alignment is shorter Considered as no change	Rating	5	4.5
	Weight	10	
	Contribution	50	45
Environmental Impacts Significant reduction in ROW along cross roads - potential reduction in relocations	Rating	5	7
	Weight	24	
	Contribution	120	168
Project Schedule No change to baseline	Rating	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	553.5
	Net Change in Performance		**11%**

VE RECOMMENDATION NO. 6: REPLACE BRIDGE 1 AND BRIDGE 2 WITH CULVERTS	Idea No. 18

Baseline Concept

A 400-foot-long bridge is planned at approximate Station 105+50 (Bridge 1) and a 360-foot-long bridge is planned at approximate Station 140+10 (Bridge 2).

Recommendation Concept

Replace the planned Bridge 1 and Bridge 2 with reinforced concrete box culverts.

Advantages	Disadvantages
• Eliminates two bridges that would be in the state system • Reduces overall project cost by approximately $1,170,000 • Reduces long-term maintenance costs • Eliminates winter icing common on bridge decks	• Would require additional right-of-way over baseline • Increased earthwork • Increased environmental impacts (temporary – increased material hauling and permanent increased footprint and impedance of wildlife crossing)

Cost Summary	Cost
Baseline Concept	$3,990,000
Recommendation Concept	$2,820,000
Savings	$1,170,000

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
				✓

VE RECOMMENDATION NO. 6: REPLACE BRIDGE 1 AND BRIDGE 2 WITH CULVERTS	Idea No. 18

Discussion/Sketches/Photos

The logic for establishing the bridge limits in the baseline were not fully understood. An attempt was made to lay out a theoretical bridge with 2:1 spill slopes in the profile for Bridge 1 and Bridge 2 based on the bridge limits shown in the provided MicroStation files. This was then used as the basis for calculating the additional earthwork needed if the bridges were to be replaced by box culverts.

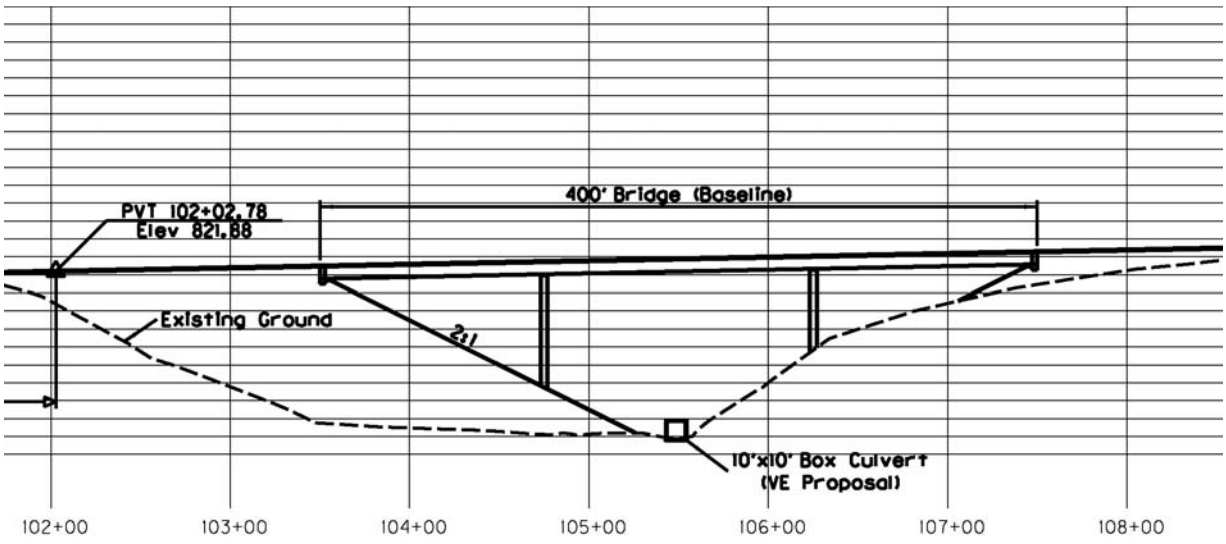


Figure 6-1. Bridge 1 Profile

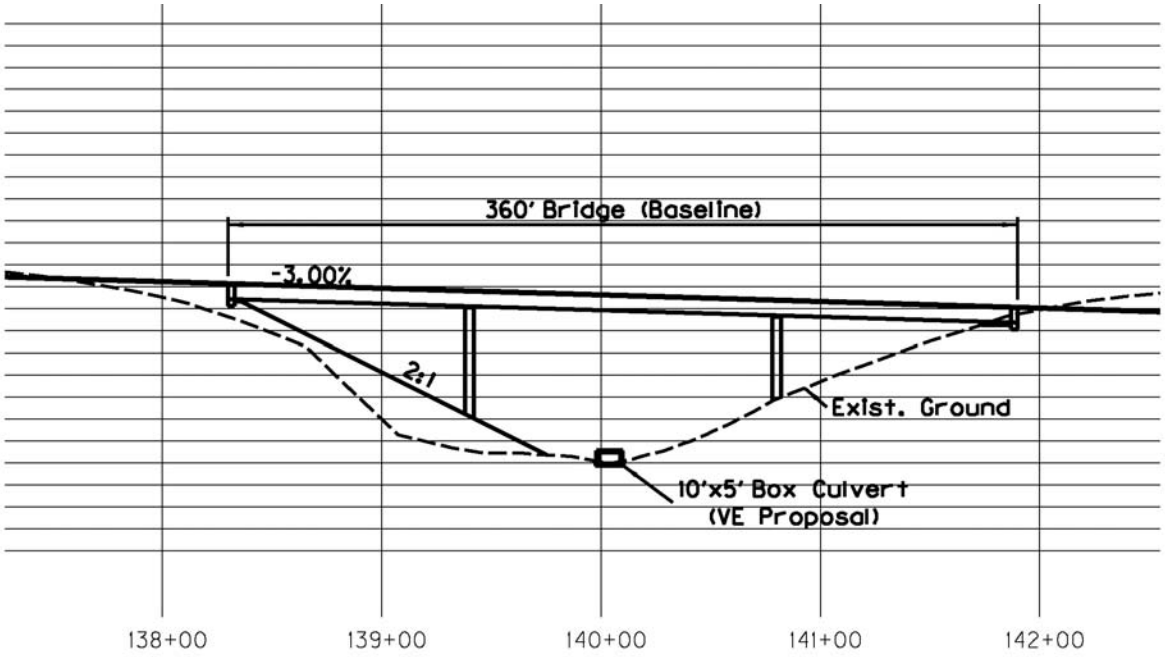


Figure 6-2. Bridge 2 Profile

VE RECOMMENDATION NO. 6: REPLACE BRIDGE 1 AND BRIDGE 2 WITH CULVERTS	Idea No. 18

The deep valleys at Bridge 1 and Bridge 2 are dictating the long bridge lengths. However, the actual drainage area contributing to each bridge is relatively small, 865 acres and 180 acres, respectively. This means the flows can be handled through relatively small box culverts. The required box culvert sizes have been roughly estimated to be a 10' x 10' box at Bridge 1 and a 10' x 5' box at Bridge 2.

The greatest advantage is the capital cost savings of approximately $1,170,000. However, the two biggest variables in this savings are the anticipated cost per square foot for the bridges and the cost per cubic yard for the embankment. When using the originally assumed baseline cost of $85/sf for the bridges and $5/cubic yard for the embankment, this VE proposal is approximately the same cost as the baseline. However, we feel that $85/sf is significantly less than what the actual cost will be to build these bridges, especially considering how tall they will be. The cost savings shown are based on using a more realistic price of $125/sf for the bridges. Other advantages include there would be significantly less inspection and maintenance required over the life of the structures. Eliminating the bridges also eliminate the icing potential in the wintertime.

Most of the disadvantages are related to the increased footprint required for the large fill sections. These include increased right-of-way and more tree\vegetation clearing, as well as enclosing the natural stream into a long culvert.

BASELINE CONSTRUCTION

Cost Item	Quantity	Unit	Unit Price	Cost
Bridge 1	16800	SF	$125	$2,100,000
Bridge 2	15120	SF	125	1,890,000
Total				**$3,990,000**
VE Proposal Construction Cost				
Culvert 1				
10' x 10' Box Culvert	400	LF	$1,600	$640,000
Wing walls	1	LS	50,000	50,000
Embankment	194000	CY	5	970,000
Main line Pavement	1067	SY	60	64,000
Shoulder Pavement	889	SY	52	46,222
Subtotal 1				$1,770,222
Culvert 2				
10' x 5' Box Culvert	340	LF	$1,200	$408,000
Wing walls	1	LS	30,000	30,000
Embankment	102000	CY	5	510,000
Main line Pavement	960	SY	60	57,600
Shoulder Pavement	800	SY	52	41,600
SUBTOTAL 2				$1,047,200
Total				**$2,817,422**

Savings	**$1,172,578**

Note: The baseline cost estimate as provided to the VE team utilized a bridge cost of $85/sf, which was deemed too low, especially considering Bridge 1 and Bridge 2 are 93' and 76' tall, respectively. The baseline and VE proposal costs have been normalized to a bridge unit price of $125/sf.

VE RECOMMENDATION NO. 6: REPLACE BRIDGE 1 AND BRIDGE 2 WITH CULVERTS	Idea No. 18

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	Performance	Baseline	Alternative
Mainline Operations Continuous shoulder section	*Rating*	5	5
	Weight	26	
	Contribution	130	130
Local Operations No change to baseline	*Rating*	5	5
	Weight	21	
	Contribution	105	105
Maintainability Eliminates the two bridges	*Rating*	5	7
	Weight	14	
	Contribution	70	98
Construction Impacts No change to baseline	*Rating*	5	5
	Weight	10	
	Contribution	50	50
Environmental Impacts Impacts from the fill foot print will be greater than the impacts from the bridge. Potential of additional ROW Wildlife Passage impaired	*Rating*	5	4
	Weight	24	
	Contribution	120	96
Project Schedule No change to baseline	*Rating*	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	504
	Net Change in Performance		1%

VE RECOMMENDATION NO. 7: REPLACE BRIDGE 3 WITH WAGON BOX	Idea No. 20

Baseline Concept

The concept is to span over a small drainage way and Wise Road with a traditional bridge (350' in length and 42' in width).

Recommendation Concept

Replace the bridge with a “Wagon Box” structure (a 3-sided reinforced concrete structure) and a 60-inch pipe.

During the VE study it was also mentioned that the baseline bridge structure could be shortened, but this option was not studied in detail. It is recommended that the design team investigate this.

Advantages	Disadvantages
• Eliminates bridge • Reduces maintenance costs • Eliminates winter icing • Improves operations – full shoulders on main line • Reduces design cost	• May require additional right-of-way beyond what is shown in current concept plans • Increased earthwork (although there is sufficient cut quantities in section 2 such that the extra embankment doesn’t factor into the price estimate) • Increased environmental impacts • Requires closing Wise Road during construction

Cost Summary	Cost
Baseline Concept	$10M Construction
Recommendation Concept	$8.4M Construction
Savings	$1.6M

FHWA Function Benefit

Safety	*Operations*	*Environment*	*Construction*	*Other*
	✓	✓		✓

VE RECOMMENDATION NO. 7: REPLACE BRIDGE 3 WITH WAGON BOX	Idea No. 20

Discussion/Sketches/Photos

The wagon box structure would provide for a minimum 14'-6" clearance from Wise Road to the top inside of the structure. It would be 28 feet wide to accommodate 11' lanes and 4' shoulders. (The existing road is approximately 15 feet wide). The 60-inch pipe would be located next to the structure to accommodate drainage. It should be noted that the profile would have to be raised in this area to accommodate the clearance criteria, and it should accommodate the future 4-lane construction. However, the profile would have to be raised anyway with the baseline bridge concept due to inadequate clearance over Wise Road as it is currently designed. The wagon box concept offers the advantage of not having to raise the profile as high as would be necessary to get the minimum clearance under the baseline bridge concept.

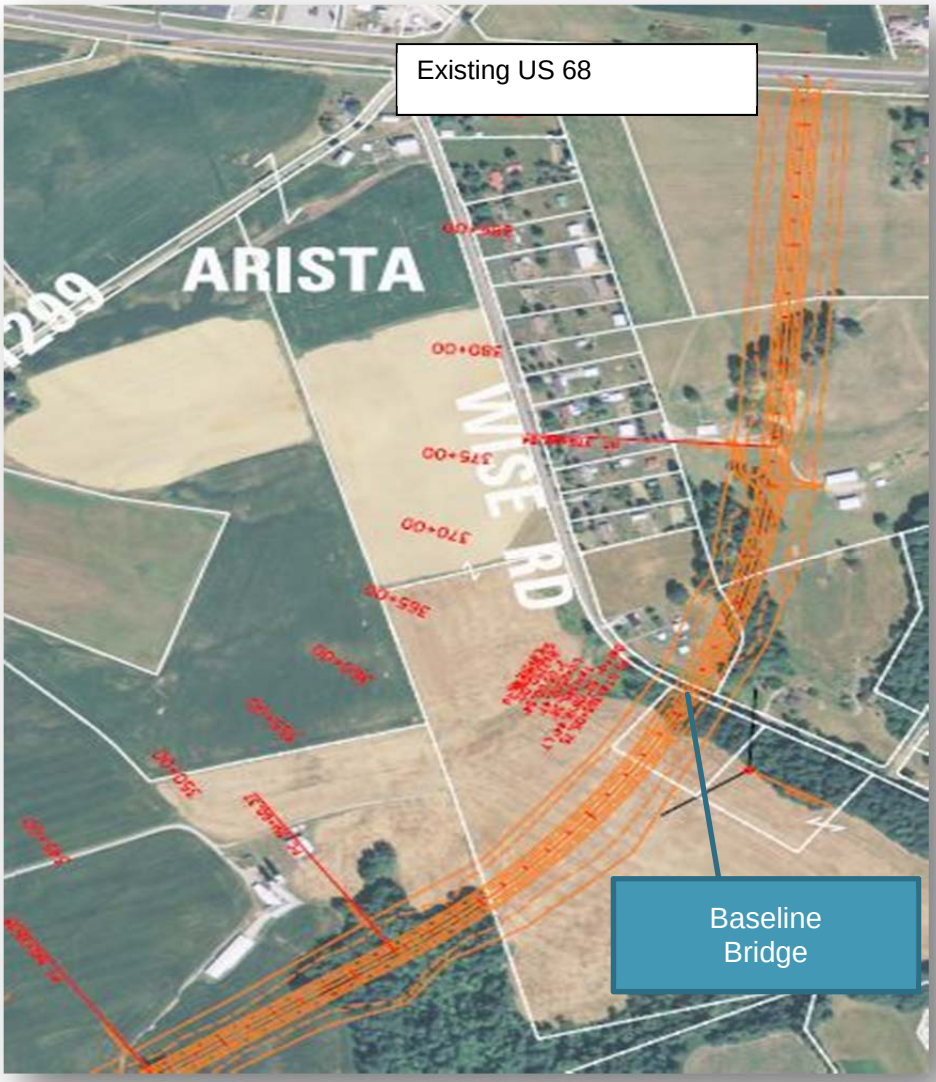


Figure 7-1

VE RECOMMENDATION NO. 7: REPLACE BRIDGE 3 WITH WAGON BOX	Idea No. 20

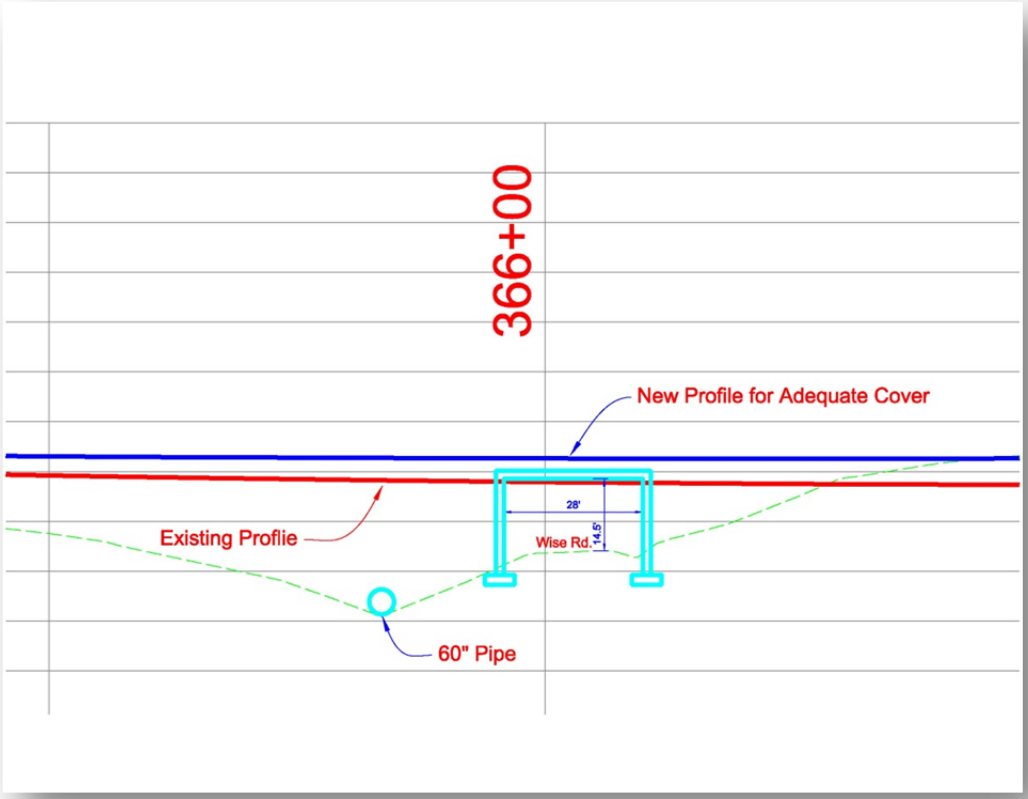


Figure 7-2

Cost Analysis

Earthwork

Baseline

SECTION 2	cut	fill	net	unit cost	
ML - 350+00 TO BR3	124,234	42,095	82,139		
ML - BR3 TO POE	50,104	44,149	5,955		
TOTAL	**174,338**	**86,244**	**88,094**	$5	**$871,690**

Recommended

SECTION 2	cut *	fill	net	unit cost		
ML - 350+00 TO BR3	124,234	42,095	82,139			
Bridge 3 Fill In		15,000				
ML - BR3 TO POE	50,104	44,149	5,955			
TOTAL	**174,338**	**101,244**	**73,094**	$5	**$871,690**	**
				Net Difference	**$0**	

***Cut numbers would be affected by raising the profile as well, but since the profile has to raise for the baseline condition as well, net effect is zero.**

**** Cost remains the same due to cut qnt still being higher**

VE RECOMMENDATION NO. 7: REPLACE BRIDGE 3 WITH WAGON BOX	Idea No. 20

Structures

Baseline	length	width	cost/sf	total
Bridge	350	42	$125	**$1,837,500**
commended	Qnt	Unit	cost/unit	total
Wagon Box Barrel	88	LF	$4,000	$352,000
Wagon Box Wings	4	EA	$40,000	$160,000
60" Pipe	150	LF	$120	$18,000
			Total	**$530,000**
			Net Difference:	**($1,307,500)**

Pavement

Baseline

Section 2		LENGTH	DL WIDTH	SH WIDTH	DL COST	SH COST	TOTAL
ML - POB TO BR3		12700	24	20	$60	$52	$3,499,556
ML - BR3 TO POE		2450	24	20	$60	$52	$675,111
TOTAL							**$4,174,667**

Recommended

Section 2		LENGTH	DL WIDTH	SH WIDTH	DL COST	SH COST	TOTAL
ML - POB TO BR3		12700	24	20	$60	$52	$3,499,556
Bridge 3		350	24	20	$60	$52	$96,444
ML - BR3 TO POE		2450	24	20	$60	$52	$675,111
TOTAL							**$4,271,111**
						Net Difference:	**$96,444**

Summary

INITIAL - 2 LN	Earthwork	Structures	Pavement	MISC (30%)	ROW	UTILITY	Total
SECTION 2							
Baseline	$1,658,640	$1,837,500	$4,174,667	$2,301,242	$7,956,000	$160,710	
Recommended	$1,658,640	$530,000	$4,271,111	$1,937,925	$7,956,000	$160,710	
Net Difference	**$0**	**-$1,307,500**	**$96,444**	**-$363,317**	**$0**	**$0**	**-$1,574,372**
						Savings	**$1,574,372**

VE RECOMMENDATION NO. 7: REPLACE BRIDGE 3 WITH WAGON BOX	Idea No. 20

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	*Performance*	*Baseline*	*Alternative*
Mainline Operations No change to baseline	*Rating*	5	5
	Weight	26	
	Contribution	130	130
Local Operations Minor change	*Rating*	5	5
	Weight	21	
	Contribution	105	105
Maintainability Eliminates structure	*Rating*	5	6
	Weight	14	
	Contribution	70	84
Construction Impacts Will require closure of Wise Road to construct	*Rating*	5	4
	Weight	10	
	Contribution	50	40
Environmental Impacts Will fill drainage - requiring large culvert	*Rating*	5	4.5
	Weight	24	
	Contribution	120	108
Project Schedule No change to baseline	*Rating*	5	5
	Weight	5	
	Contribution	25	25
Total Performance		500	492
Net Change in Performance			-2%

VE RECOMMENDATION NO. 8: CONSTRUCT 2+1 WITH 2+1 LANE RIGHT-OF-WAY	Idea No. 11

Baseline Concept

The original design is to build two lanes initially with the right-of-way and ultimate design set to allow expansion to four lanes with a depressed median.

Recommendation Concept

Design one side of the ultimate four lanes with 2+1 (alternating passing lanes) design. Purchase right-of-way for an ultimate design with 2+1.

Advantages	Disadvantages
• Improves operations (level of service) over two lanes by providing safe places to pass • Pushes the need to expand capacity further into the future (may not be needed) • Less expensive construction than a four-lane ultimate design • Safer passing conditions than 2-lane design • Less right-of-way than base concept	• Increases cost over initial two-lane construction

Cost Summary	Cost
Original Concept	$27.5M CN + $17.2M right-of-way
Recommendation Concept	$34.5M CN + 14.7 right-of way
Cost Added	$7M Increase CN + 2.5M right-of-way savings = $4.5M Increase

FHWA Function Benefit

Safety	Operations	Environment	Construction	Other
✓	✓	✓		

VE RECOMMENDATION NO. 8: CONSTRUCT 2+1 WITH 2+1 LANE RIGHT-OF-WAY	Idea No. 11

Discussion/Sketches/Photos

The traffic forecast shows an approximate opening day average daily traffic (ADT) of 5,000 vehicles and future ADT of 9,000 vehicles. Considering traffic operational performance, these volumes do not warrant the construction of four travel lanes. However, providing opportunities to pass can have a signifcant effect on level of service (LOS) compared to a 2-lane roadway, as is proposed for initial construction. LOS on a 2-lane highway is measured by average travel time and percent time spent following. As traffic volume increases, the opportunities to pass decrease, thus degrading the LOS. Providing alternating passing lanes (2+1) reduces frustration by allowing travellers to get around slow moving vehicles. Additionally, many drivers feel uncomfortable passing on a typical 2-lane roadway and will not do so even when there is an adequate gap. The 2+1 design helps better accommodate them by providing passing within a designated lane without the risk of oncoming traffic.

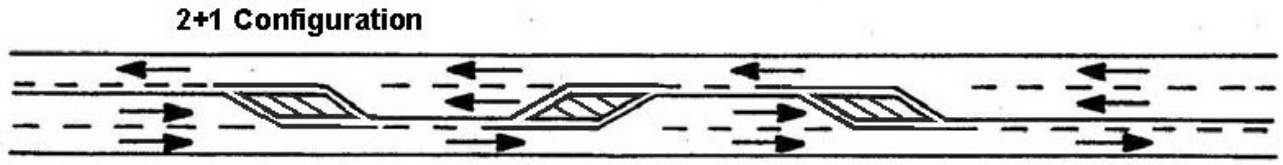


Figure 8-1

This recommendation has passing lane lengths that range in length of approximately 3,700 to 6,300 feet. There are transition areas when approaching and departing the significant intersections along the corridor. The VE team assumed that the three lane section would be continued across each of the three bridges. Under the studied scenario, there are a total of six locations, three in each direction, where passing lanes can be built. Transitions will need to be designed at the approach and departure of each significant intersection. Minor access points are not addressed because there will be minor impacts at those locations. Change of land use

VE RECOMMENDATION NO. 8: CONSTRUCT 2+1 WITH 2+1 LANE RIGHT-OF-WAY	Idea No. 11

and access permitting will need to be tightly controlled to ensure safe operation in the future.

This alternate is higher cost than the 2-lane design; however, it is functionally superior and is less expensive than the construction of a 4-lane facility. This design will accommodate traffic needs well beyond the 20-year design life.

There will be less right-of-way needed compared to the original design. There would need to be an additional 12 feet of pavement compared to the initial 2-lane construction. The design team would need to decide whether to leave this in place and modify (shift) the utlimate additional two lanes, or to take out the 12 feet of width and keep the original 4-lane alignment.

For development of this recommendation, the typical section was assumed to have three 12-foot travel lanes and a 4-foot flush median. Shoulders are 8' paved in one direction and 4' the other. The structures would be widened 16 feet to accommodate the passing lane and median. The project team has the option to reduce the cross section, such as reducing the shoulder widths, to reduce construction costs.

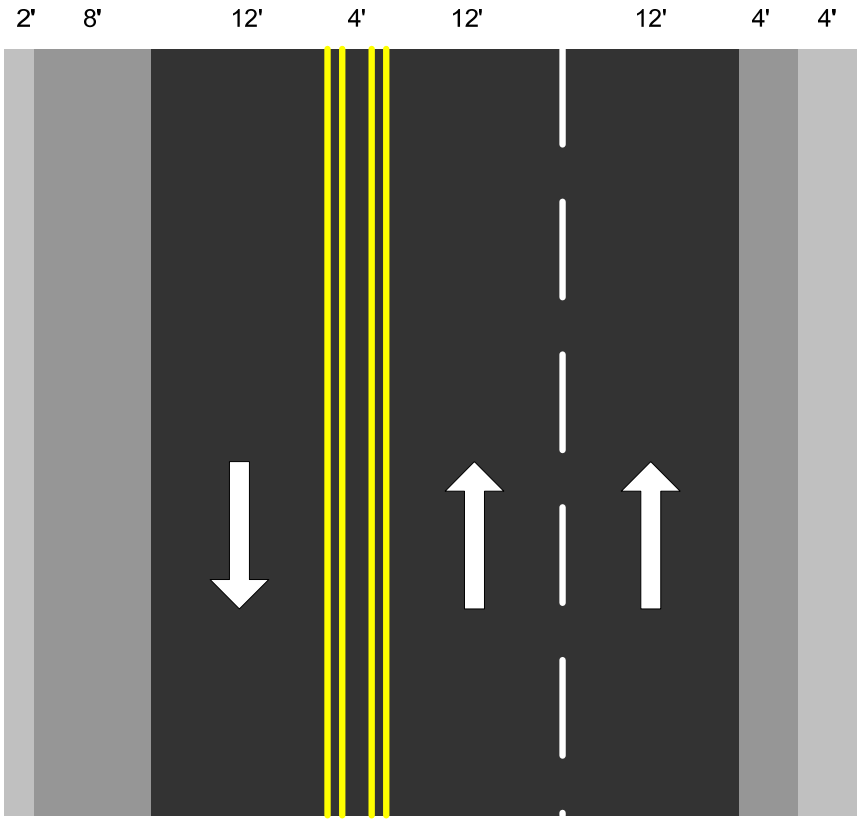


Figure 8-2

Cost Breakdown

Structure Cost

400LF x 16’ x $125 = $800,000

360LF x 16’ x $125 = $720,000

350LF x 16’ x $125= $700,000

Total Increase in Structure Cost = $2,220,000

VE RECOMMENDATION NO. 8: CONSTRUCT 2+1 WITH 2+1 LANE RIGHT-OF-WAY	Idea No. 11

Roadway Cost

Earthwork

Main line earthwork for original 2 lane =655,563 CY

Unit cost of earthwork = $5

Total cost increase of main line earthwork is 655,563 CY x $5 x 15%= $491,672.25

Pavement

Baseline

Main line pavement length 31,575 LF

Main line 2-lane pavement width is 24 LF

Main line 2-lane shoulder width is 20 LF

VE Alternative

Recommended main line pavement width is 40 LF

Recommended main line shoulder pavement width is 12 LF

Main line pavement unit cost $60 per SY

Main line shoulder pavement unit cost $52 per SY

Recommended pavement cost increase is

(31,575 LF x 16 LF x $60 per CY / 9) - (31,575 LF x 8 LF x $52 per CY / 9) = $1,908,533

Right-of-Way Cost

Right-of-way is reduced by approximately 54 feet in width for the entire length of the corridor.

54' x 35,100LF /43,560 = 43.5 acres

43.5 acres x $57,000/acre = $2,479,500 savings

Yellow = Passing Lane Southbound

Blue = Passing Lane Northbound

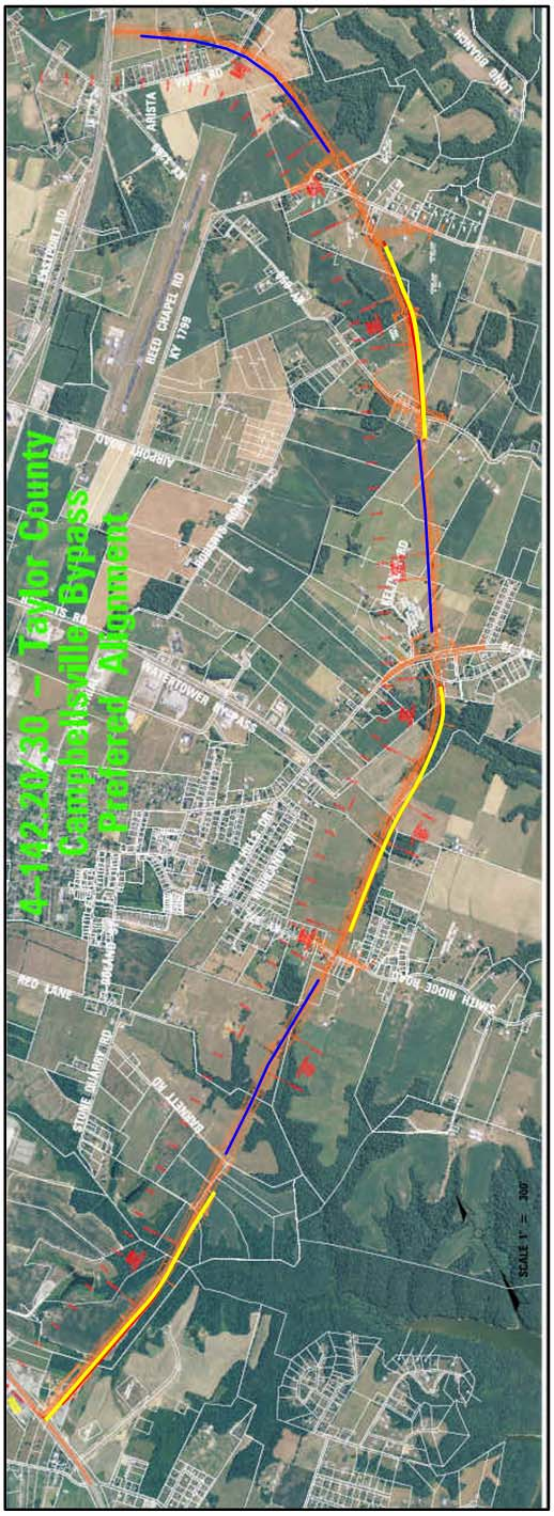


Figure 8-3

VE RECOMMENDATION NO. 8: CONSTRUCT 2+1 WITH 2+1 LANE RIGHT-OF-WAY	Idea No. 11

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	*Performance*	*Baseline*	*Alternative*
Mainline Operations Provides passing opportunities	*Rating*	5	8
	Weight	26	
	Contribution	130	208
Local Operations Increased intersection distance	*Rating*	5	4.75
	Weight	21	
	Contribution	105	99.75
Maintainability Increased surface (pavement and structure)	*Rating*	5	4
	Weight	14	
	Contribution	70	56
Construction Impacts No change to baseline	*Rating*	5	5
	Weight	10	
	Contribution	50	50
Environmental Impacts Requires less ROW	*Rating*	5	7
	Weight	24	
	Contribution	120	168
Project Schedule No change to baseline	*Rating*	5	5
	Weight	5	
	Contribution	25	25
	Total Performance	500	606.75
	Net Change in Performance		**21%**

VE RECOMMENDATION NO. 9: CONSTRUCT 2+1 WITH ULTIMATE 4-LANE RIGHT-OF-WAY	Idea No. 10

Baseline Concept

The original design is to build two lanes initially within the right-of-way and ultimate design set to allow expansion to four lanes with a depressed median.

Recommendation Concept

Design one side of the ultimate four lanes with 2+1 (alternating passing lanes) design. Purchase right-of-way for the ultimate four lane design.

Advantages	Disadvantages
• Improves operations (LOS) over two lanes by providing safe places to pass • Pushes the need to expand capacity further into the future (may not be needed) • Less expensive construction than a 4-lane ultimate design • Safer passing conditions than 2-lane design • May be more politically acceptable over a 2-lane design	• Increases cost over initial 2-lane construction • Increases cost of ultimate 4-lane construction should it be needed in the future

Cost Summary	Cost
Original Concept	$27.5M CN + 17.2M right-of-way
Recommendation Concept	$34.5M CN + 17.2M right-of-way
Cost Added	$7M Increase CN

FHWA Function Benefit

Safety	Operations	Environment	Construction	Other
✓	✓			

VE RECOMMENDATION NO. 9: CONSTRUCT 2+1 WITH ULTIMATE 4-LANE RIGHT-OF-WAY	Idea No. 10

Discussion/Sketches/Photos

The traffic forecast shows an approximate opening day ADT of 5,000 vehicles and future ADT of 9,000 vehicles. Considering traffic operational performance, these volumes do not warrant the construction of four travel lanes. However, providing opportunities to pass can have a signifcant effect on LOS compared to a 2-lane roadway, as is proposed for initial construction. LOS on a 2-lane highway is measured by average travel time and percent time spent following. As traffic volume increases, the opportunities to pass decrease, thus degrading the LOS. Providing alternating passing lanes (2+1) reduces frustration by allowing travelers to get around slow moving vehicles. Additionally, many drivers feel uncomfortable passing on a typical 2-lane roadway and will not do so even when there is an adequate gap. The 2+1 design helps better accommodate them by providing passing within a designated lane without the risk of oncoming traffic.

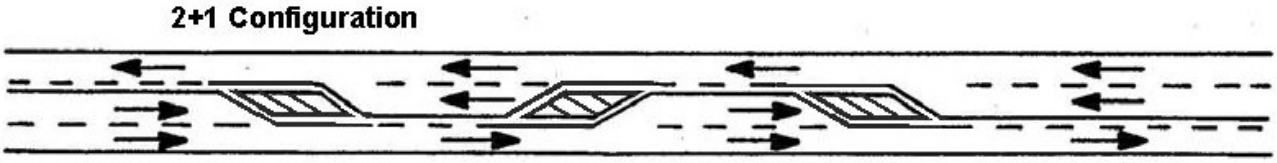


Figure 9-1

This recommendation has passing lane lengths that range in length of approximately 3,700 to 6,300 feet. There are transition areas when approaching and departing the significant intersections along the corridor. The VE team assumed that the three lane section would be continued across each of the three bridges. Under the studied scenario, there are a total of six locations, three in each direction, where passing lanes can be built. Transitions will need to be designed at the approach and departure of each significant intersection. Minor

VE RECOMMENDATION NO. 9: CONSTRUCT 2+1 WITH ULTIMATE 4-LANE RIGHT-OF-WAY	Idea No. 10

access points are not addressed because there will be minor impacts at those locations. Change of land use and access permitting will need to be tightly controlled to ensure safe operation in the future.

This alternate is higher cost than the 2-lane design; however, it is functionally superior and is less expensive than the construction of a 4-lane facility.

It was assumed that no additional right-of-way would be needed compared to the original design. There would need to be an additional 12 feet of pavement compared to the initial 2-lane construction. The design team would need to decide whether to leave this in place and modify (shift) the utlimate additional two lanes, or to take out the 12 feet of width and keep the original 4-lane alignment.

For development of this recommendation, the typical section was assumed to have three 12-foot travel lanes and a 4-foot flush median. Shoulders are 8' paved in one direction and 4' the other. The structures would be widened 16 feet to accommodate the passing lane and median. The project team has the option to reduce the cross section, such as reducing the shoulder widths, to reduce construction costs.

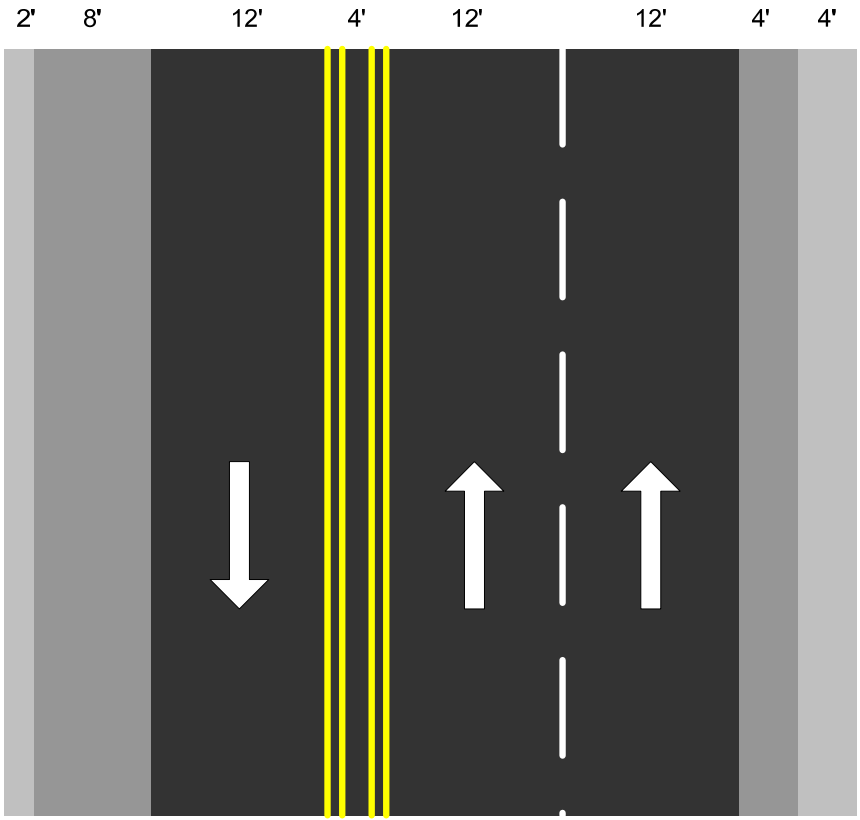


Figure 9-2

Cost Breakdown

Structure Cost

400LF x 16’ x $125 = $800,000

360LF x 16’ x $125 = $720,000

350LF x 16’ x $125= $700,000

Total Increase in Structure Cost = $2,220,000

VE RECOMMENDATION NO. 9: CONSTRUCT 2+1 WITH ULTIMATE 4-LANE RIGHT-OF-WAY	Idea No. 10

Roadway Cost

Earthwork

Main line earthwork for original 2 lane =655,563 CY

Unit cost of earthwork = $5

Total cost increase of main line earthwork is 655,563 CY x $5 x 15%= $491,672.25

Baseline

Main line pavement length 31,575 LF

Main line 2 lane pavement width is 24 LF

Main line 2 lane shoulder width is 20 LF

VE Alternative

Recommended main line pavement width is 40 LF

Recommended main line shoulder pavement width is 12 LF

Main line pavement unit cost $60 per SY

Main line shoulder pavement unit cost $52 per SY

Recommended pavement cost increase is

(31,575 LF x 16 LF x $60 per CY / 9) - (31,575 LF x 8 LF x $52 per CY / 9) = $1,908,533

Right-of-Way Cost

Right-of-way costs remain unchanged with this recommendation.

Yellow = Passing Lane Southbound
Blue = Passing Lane Northbound

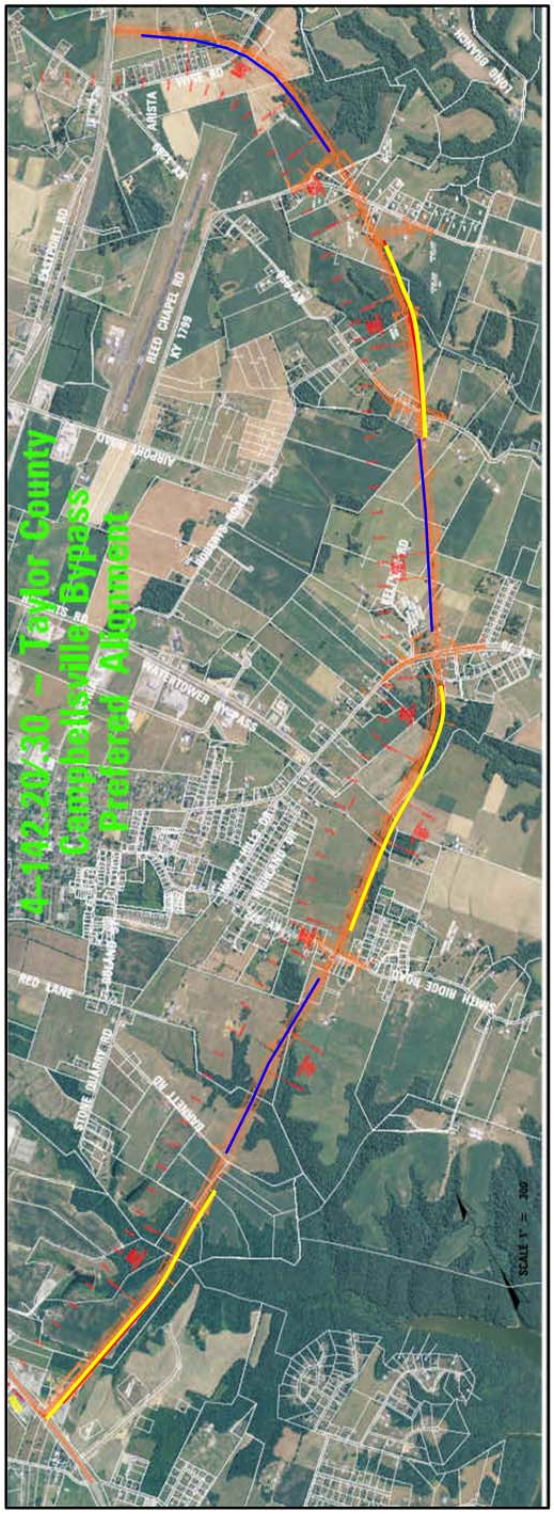


Figure 9-3

VE RECOMMENDATION NO. 9: CONSTRUCT 2+1 WITH ULTIMATE 4-LANE RIGHT-OF-WAY	Idea No. 10

PERFORMANCE MEASURES Attributes and Rating Rationale for Proposal	*Performance*	*Baseline*	*Alternative*
Mainline Operations Provides passing opportunities	*Rating*	5	8
	Weight	26	
	Contribution	130	208
Local Operations Increased intersection distance	*Rating*	5	4.75
	Weight	21	
	Contribution	105	99.75
Maintainability Increased surface (pavement and structure)	*Rating*	5	4
	Weight	14	
	Contribution	70	56
Construction Impacts No change to baseline	*Rating*	5	5
	Weight	10	
	Contribution	50	50
Environmental Impacts No change to baseline	*Rating*	5	5
	Weight	24	
	Contribution	120	120
Project Schedule No change to baseline	*Rating*	5	5
	Weight	5	
	Contribution	25	25
Total Performance		500	558.75
Net Change in Performance			12%

Appendix A. Study Participants

					VE Study Attendees *Campbellsville Bypass*			
August 2014								TELEPHONE / CELL
25	26	27	28	29	NAME	ORGANIZATION	POSITION/DISCIPLINE	E-MAIL
✓	✓			✓	Bottoms, Brad	KYTC – District 4	Project Manager	270.766.5066 bradley.bottoms@ky.gov
✓	✓	✓			Broadus, John	HDR	Structures	502.909.3254 john.broadus@hdrinc.com
✓	✓	✓	✓	✓	Cochran, Joe	HDR	Roadway	859.539.2630 joe.cochran@hdrinc.com
				✓	Ferguson, Joseph	KYTC		270.766.5066 joseph.ferguson@ky.gov
				✓	Gnau, Randy	M.E.C.		502.875.3787 rgnau@mccconsultants.com
				✓	Gulick, Bill	KYTC		 bill.gulick@ky.gov
				✓	Hornbeck, Josh	KYTC District 4		270.766.5066 josh.hornbeck@ky.gov
				✓	Layson, Andrew	M.E.C.		502.875.3787 alayson@mecconsultants.com
✓				✓	Kelly, Taylor	QK4	Consultant – PM	502.229.2226 tkelly@qk4.com

VE Study Attendees
Campbellsville Bypass

August 2014					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	CELL
25	26	27	28	29				E-MAIL	
✓	✓	✓			Lee, David	HDR	Traffic	502.909.3255	
								david.lee@hdrinc.com	
				✓	Martin, David	KYTC		502.782.4898	
								charles.martin@ky.gov	
				✓	Moore, John	KYTC			
								johnw.moore@ky.gov	
✓	✓	✓		✓	Newman, Matt	HDR	Roadway	502.909.3258	
								matt.newman@hdrinc.com	
✓	✓	✓	✓	✓	Owings, Don	HDR	Team Leader/Facilitation	503.423.3856	360.601.3061
								donald.owings@hdrinc.com	
✓	✓	✓	✓	✓	Russell, Shawn	KYTC	Construction	502.782.4926	
								shawn.russell@ky.gov	
✓					Springer, Tom	QK4	Consultant – Environmental		502.585.2222
								tspringer@qk4.com	
✓	✓	✓	✓	✓	Sweger, Brent	KYTC		502.782.4912	
								berent.sweger@ky.gov	

Appendix B. Pareto Cost Models

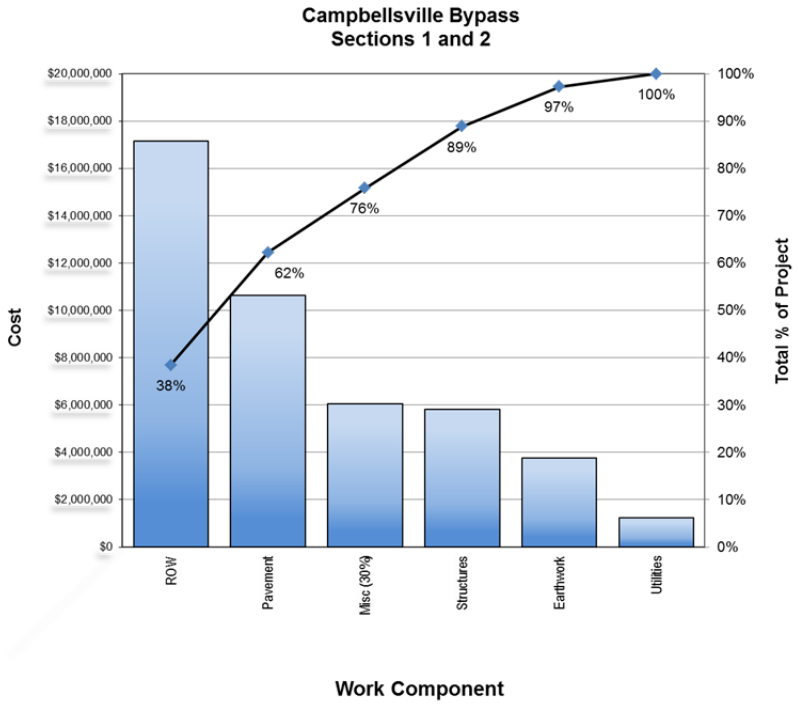
The VE team leader prepared a cost model from the cost estimate, which was provided by the project team. The model was organized to identify major construction elements or trade categories, the designer's estimated costs, and the percent of total project cost for the significant cost items (see Table B-1). After evaluation of this estimate, the VE team had concerns that the structure cost represented in the base estimate ($85/sf) was significantly lower than what might be expected ($125/sf).

The cost models reflect this change and clearly show that right-of-way is still the major cost driver for the project.

Table B-1. Cost Model – Baseline Concept

Cost Item	Cost	Cumulative (%)	% of Total
Right-of-Way	$17,152,040	41	40.6
Pavement	10,635,244	66	25.2
Miscellaneous (30%)	6,064,827	76	13.6
Structures	5,827,500	89	13.1
Earthwork	3,753,345	97	8.4
Utilities	1,222,030	100	2.7

Figure B-1. Cost Model



Appendix C. Function Analysis

Function analysis results in a unique view of the study project. It transforms project elements into functions, which moves the VE team mentally away from the original design and takes it toward a functional concept of the project. Functions are defined in verb-noun statements to reduce the needs of the project to their most elemental level (see Table C-1). Identifying the functions of the major design elements of the project allows a broader consideration of alternative ways to accomplish the functions.

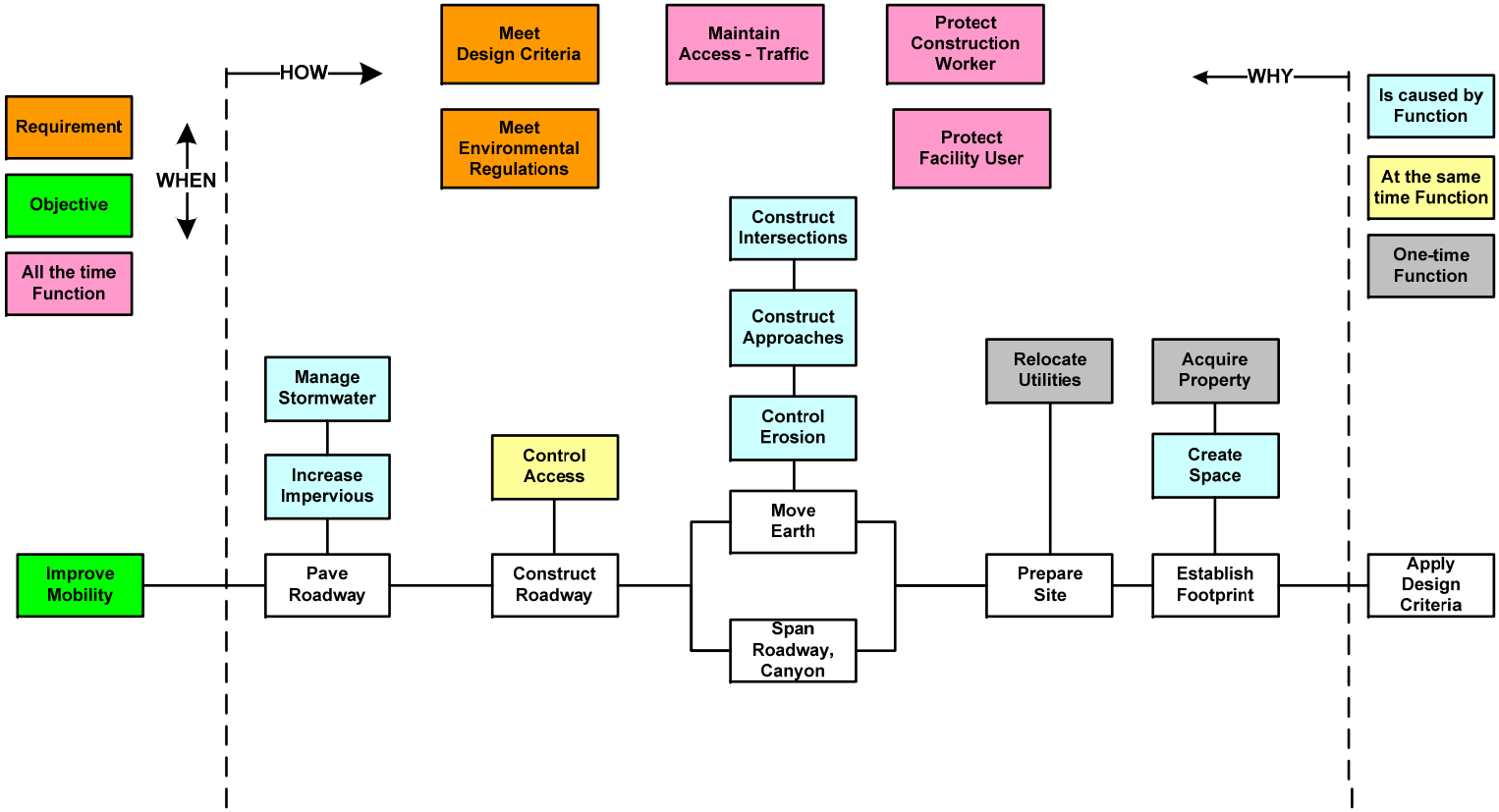
Table C-1. Functional Analysis Noun-Verb Statements

Major Items	Verb	Noun
Right-of-way Acquisition	Create	Space
Pavement	Support	Load
Miscellaneous Construction	Minor	Items
Structures	Span Span	Roadway Water
Earthwork	Support Raise	Load Roadway
Utilities	Prepare Maintain	Site Service

FAST Diagram

The FAST diagram arranges the functions in logical order so that when read from left to right, the functions answer the question "How?" If the diagram is read from right to left, the functions answer the question "Why?" Functions connected with a vertical line are those that happen at the same time as, or are caused by, the function at the top of the column. The FAST diagram provided the VE team with an understanding of which functions offer the best opportunity for cost or performance improvement.

Figure C-1. Functional Analysis System Technique (FAST) Diagram



Appendix D. Creative List and Evaluation

During the speculation/creative phase the VE team, as a group, generated ideas on how to perform the various functions. The idea list was grouped by function or major project element. All of the ideas generated were recorded in Table D-1, below. The final disposition of each idea is included at the end of this Appendix.

Table D-1. Creative Idea List

Idea No.	Description
Item: Right-of-way ***Function: Create Space***	
1.	Purchase only right-of-way necessary for 2 lane section
2.	Adjust Profile
3.	Consider using walls
4.	Wise Road to make at grade
5.	Design as 2-lane with right-of-way for future + 1 or passing lanes
6.	Reduce median section
7.	Eliminate median – with or without barrier separation
8.	Construct cross roads on existing alignments
9.	Eliminate north side of Smith Ridge
10.	Construct as a 2+1 with 4 lane ultimate right-of-way
11.	Construct as a 2+1 with 2+1 right-of-way
12.	Realign parallel to Wise Road – using Wise as frontage.
13.	Reinvestigate light blue option at Wise Road
Item: ***Function: Earthwork***	
14.	Adjust profile
15.	Adjust horizontal alignment
16.	Use raised median rather than depressed
Item: Bridge ***Function: Span (Canyon, Roadway)***	
17.	Reduce shoulder widths
18.	Replace bridges (1 and 2) with culverts
19.	Shorten bridge 3 length
20.	Replace bridge 3 with large box culvert
21.	Replace bridge 3 (Wise Road) with at-grade intersection

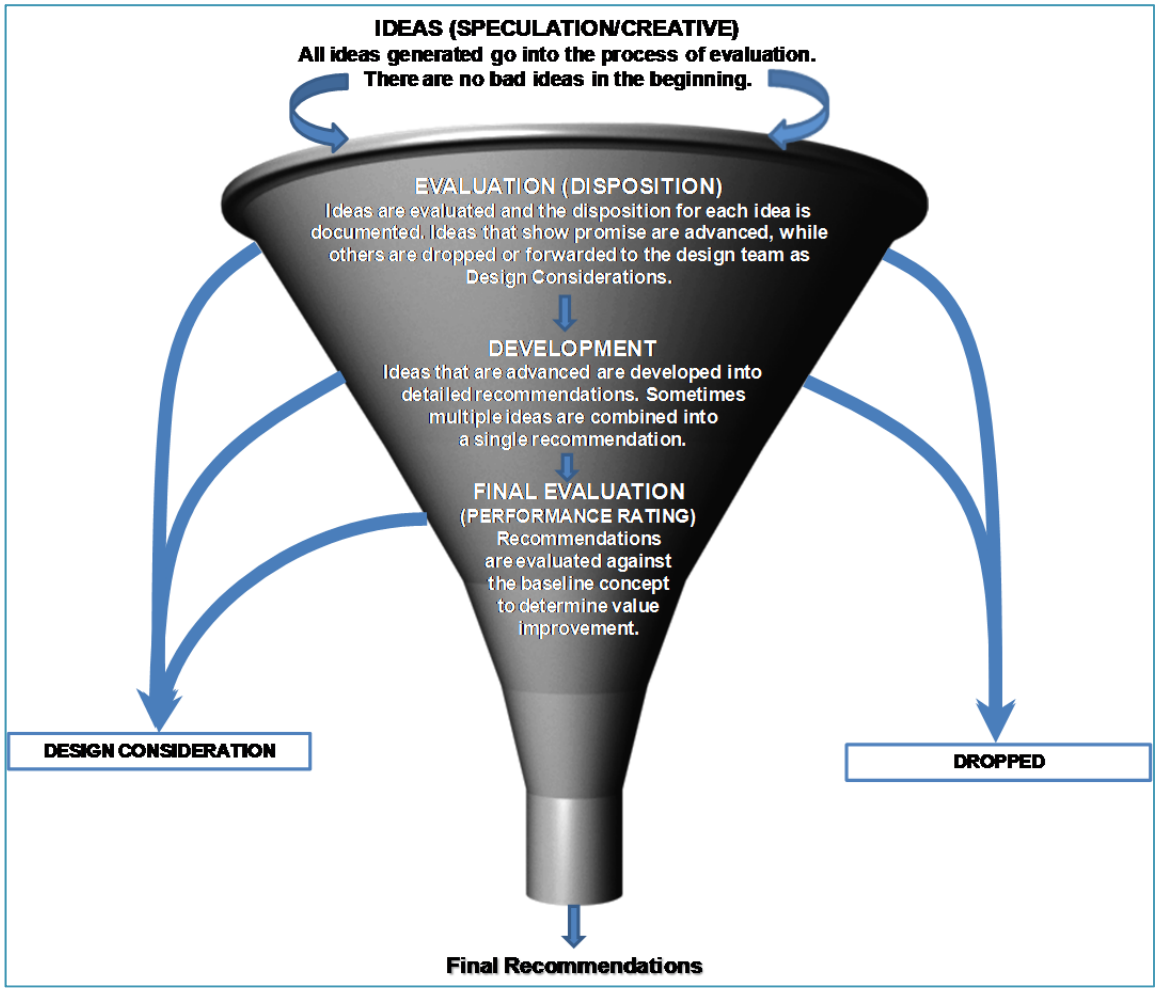
Table D-1. Creative Idea List

Idea No.	Description
Item: Pavement ***Function: Provide surface***	
22.	Reduce usable shoulder width
23.	Construct 2 lanes with climbing/passing lanes
24.	Reduce paved width on shoulders to 4 feet – earth beyond for a 4 and 8 total.
25.	Plan Section rather than crown
26.	2-12 foot lanes and 2-7 feet paved shoulders
27.	Use 11 foot lanes
Item: Intersections ***Function: Control Movements***	
28.	Continuous Green T at end intersection
29.	Off set left turn lanes
30.	Move Reed Chapel (south leg) closer to north leg.
31.	Connect Reed Chapel south leg to match north leg – use frontage road.
Item: Other	
32.	Bridge Estimate
33.	Right-of-way width at BR 1

Idea Evaluation

Although each project is different, the evaluation process for each VE effort can be thought of in its simplest form as a way of combining, evaluating, and narrowing ideas until the VE team agrees on the recommendations to be forwarded. Figure D-1 depicts the typical information flow for the VE process.

Figure D-1. VE Process Information Flow



Evaluation Process

A tiered evaluation process was used to evaluate the ideas generated by the team. The process involves an initial ranking of the idea using a "Gut Feel Index" which takes into consideration the constraints, controlling decisions and the advantages and disadvantages based on their relationships to the original concept.

Each idea was then carefully evaluated, with the VE team reaching consensus on the overall ranking of the idea (ranking values 1 through 5, as defined below).

5 = Great Opportunity

4 = Good Opportunity

3 = Design Consideration (comparable to project team's approach)

2 = Minor Value Degradation

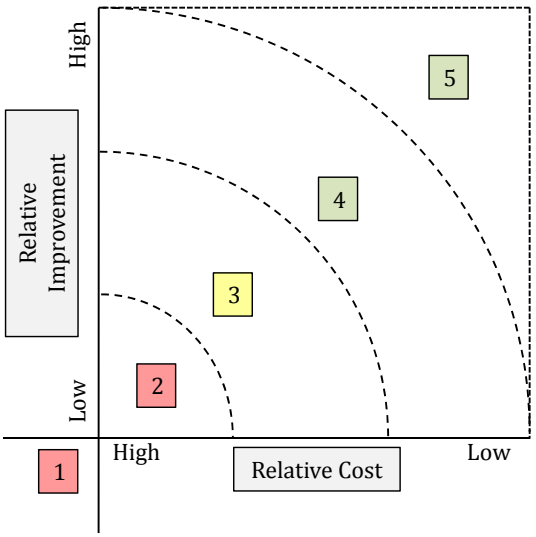
1 = Major Value Degradation

0 = Withdrawn (unacceptable impact, doesn't meet the project purpose and need, or is already a design requirement)

Gut Feel Index (GFI)

Rating Scale

1. Unacceptable Impact/Fatal Flaw
2. Poor Opportunity
3. Some Opportunity
4. Good Opportunity
5. Great Opportunity



Note: Ideas rated 4 or more will move forward for further development. Ideas with a rating of 3 may be developed.

This ranking resulted in the initial disposition of the idea. High-ranked ideas (those ranked four or higher) were developed further; low-ranked ones (those ranked two or lower) were dropped from further consideration; and those that were considered to be equivalent to the baseline (ranked three) were documented as design considerations.

The initial ranking of the ideas can be found in the following evaluation forms.

Idea Evaluation

Item: Right-of-way
Function: Create Space

Idea Number	Description	Advantages	Disadvantages
1	Purchase only right-of-way necessary for 2 lane section.	• Potential reduction on cost – 30-40% (right-of-way) • Fewer relocations • Less right-of-way impacts • Potential to reduce schedule – time to acquire right-of-way • May reduce impacts on EJ parcels. • Slight reduction in utility impacts • Reduces obligations to maintain unused properties until such time roadway is widened. • May reduce overall cost enough to advance Section 2 sooner (any phase) than anticipated.	• May not be politically acceptable. • Not preserving corridor (development) • Potential higher cost in future (land costs) • May have to revisit same property owner in future (may be significant time between). • Area would not be available to contractor for use as borrow or surplus material source.

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
		⇧		⇧	

Justification/Comments/Disposition:	
Rating: 5	*Current traffic projections do not warrant a 4-lane section*

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
2	Optimize Profile	• Reduce excavation and embankment - balance • Potential reduction in cost • May improve construction impact at cross roads • May allow for elimination of Bridge 3 (Wise Road) • Potential to reduce right-of-way impacts	• Potential to increase right-of-way impacts

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧	⇔	⇩	⇔	⇔	⇔

Justification/Comments/Disposition:

Rating: 3 — *Design team should continue to modify profile to balance quantities and optimize geometry, drainage, etc.*

Idea Number	Description	Advantages	Disadvantages
3	Consider using walls in lieu of embankment	• Reduces right-of-way foot print • Reduces right-of-way cost • May reduce relocations	• Increased Maintenance • May increase cost of construction • Increased design cost – if over standard height • May not be acceptable to abutting owners

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧	⇔	⇩	⇔	⇔	⇔

Justification/Comments/Disposition:

Rating: 2

Ranking Scale: 5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
4	Make Wise Road at grade – raise Wise road and lower main line.	• Eliminates Bridge. • Increases access to adjacent properties.	• Reduces access spacing. • Adds intersection to main line. • May make construction more difficult. • May not have acceptable grades east of Wise Road. • May not have acceptable grades on Wise Road. • Will need to accommodate drainage that is currently using Wise Road ditch. • Increased earthwork. • Increase right-of-way and potential relocations.

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇩	⇧	⇧	⇩	⇩	⇔

Justification/Comments/Disposition:
Rating: 4

Ranking Scale: 5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
5	Design and construct as 2-lane with right-of-way for future + 1 or passing lanes.	• Potential reduction on cost – 30-40% (right-of-way) • Fewer relocations • Less right-of-way impacts • Potential to reduce schedule – time to acquire right-of-way • May reduce impacts on EJ parcels. • Slight reduction in utility impacts • Reduces obligations to maintain unused properties until such time roadway is widened. • May reduce overall cost enough to advance Section 2 sooner (any phase) than anticipated.	• May not be politically acceptable. • Not preserving corridor (development) • Potential higher cost in future (land costs) • May have to revisit same property owner in future (may be significant time between). • Area would not be available to contractor for use as borrow or surplus material source.

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
		⇧		⇧	

Justification/Comments/Disposition:	
Rating: 5	*Alternative concept to Idea 1*

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
6	Purchase right-of-way for future reduced median section – to 28 feet consistent width.	• Reduced right-of-way – impacts and costs • *Reduced earthwork* • *Improved signal operations at connections – if used.* • *Reduced long term maintenance – reduced right-of-way.*	• *Reduced future median width for turning lanes and aux lanes.* • *Reduced spacing between opposing directions*

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
		⇧		⇧	

Justification/Comments/Disposition:	
Rating: 5	

Idea Number	Description	Advantages	Disadvantages
7	Purchase right-of-way as if no median – with stripping - 4 feet separation with barrier wall separation – 11 feet	• Reduced right-of-way – impacts and costs • Accommodates future 4 lane section • *Reduced earthwork* • *Improved signal operations at connections – if used.* • *Reduced long term maintenance – reduced right-of-way.*	• May not be acceptable for access reasons – with barrier. • Not traditionally done in Kentucky. • *Reduced future median width for turning lanes and aux lanes.* • *Reduced spacing between opposing directions* • *Will need to have median drainage system – with barrier.*

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
		⇧		⇧	

Justification/Comments/Disposition:	
Rating: 3	Not traditionally done in Kentucky but should be considered as design moves forward.

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
8	Construct cross roads on existing alignments – Smith Ridge, KY 70 and KY 658, providing for quicker tie-ins.	• Reduction in right-of-way take • Potential reduction in relocations • Potential reduction in utility impacts • Could allow for quicker tie-ins to existing alignments.	• Increased conflicts during construction

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
			⇩	⇧	

Justification/Comments/Disposition:

Rating: 4

Idea Number	Description	Advantages	Disadvantages
9	Eliminate north side of Smith Ridge intersection.	• Reduction in right-of-way • Eliminates conflict point on main line • Eliminate potential thru traffic	• May not be politically acceptable • Increases traffic on KY 70

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧	⇩			⇧	

Justification/Comments/Disposition:

Rating: 2.5

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description		Advantages		Disadvantages	
10	Construct as a 2+1 with 4 lane ultimate right-of-way		• May be politically acceptable over a 2-lane facility. • Improved operations • Pushes out time for future expansion.		• Increased cost over current design (2-lane) • Increases cost to build 4-lane section. • Increased impervious	
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
	⇧		⇩	⇩	⇩	
Rating: 4						

Ranking Scale: 5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
11	Construct as a 2+1 with 2+1 right-of-way	• May be politically acceptable over a 2-lane facility. • Improved operations • Potential reduction on cost – 30-40% (right-of-way) • Fewer relocations • Less right-of-way impacts • Potential to reduce schedule – time to acquire right-of-way • May reduce impacts on EJ parcels. • Slight reduction in utility impacts • Reduces obligations to maintain unused properties until such time roadway is widened. • May reduce overall cost enough to advance Section 2 sooner (any phase) than anticipated.	• Increased cost over current design (2-lane) • Increased impervious • May not be politically acceptable. • Not preserving corridor (development) • Potential higher cost in future (land costs) • May have to revisit same property owner in future (may be significant time between). • Area would not be available to contractor for use as borrow or surplus material source.

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧		⇩	⇩	⇧	

Justification/Comments/Disposition:

Rating: 4

Ranking Scale: 5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
12	Realign parallel to Wise Road – using Wise as frontage.	• Eliminate structure • Improves access to Wise Road • Potential reduction in earthwork • Eliminates the need for a channel change.	• Complicates intersection at US 68 and 1299 • May make future connect to the north of US 60 more difficult. • May have right-of-way facility impacts at the intersection with US 60 • Closer to airport • Introduces Intersection (Wise Road) • May result in addition relocations • Will have to revisit Environmental Assessment

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇩Minor	⇧	⇧	⇩Minor	⇩Minor	

Justification/Comments/Disposition:	
Rating: 2	*May be a good idea but reopening the Environmental Assessment would require public input – this may not be acceptable to the project team. Idea 13 preferred*

Idea Number	Description	Advantages	Disadvantages
13	Reinvestigate light blue option at Wise Road	• Eliminate structure • Improves access to Wise Road • Potential reduction in earthwork • Eliminates the need for a channel change.	• Closer to airport • Introduces Intersection (Wise Road) • May result in addition relocations • Will have to revisit Environmental Assessment

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇩	⇧	⇧		⇩	

Justification/Comments/Disposition:	
Rating: 4	

Ranking Scale: 5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Function: Earthwork

Idea Number	Description	Advantages	Disadvantages
14	Adjust Profile	• Reduce excavation & embankment - balance • Potential reduction in cost • May improve construction impact at cross roads • May allow for elimination of Bridge 3 (Wise Road) • Potential to reduce right-of-way impacts	• Potential to increase right-of-way impacts

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧	⇔	⇩	⇔	⇔	⇔

Justification/Comments/Disposition:	
Rating: 3	*See Idea No. 2*

Idea Number	Description	Advantages	Disadvantages
15	Adjust horizontal alignment	• Reduction in earthwork	• Would require Environmental Assessment to be reopened. • Violates a constraint given the VE team. • Likely not acceptable to project team.

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧	⇔	⇩	⇔	⇔	⇔

Justification/Comments/Disposition:	
Rating: 1	*Not within constraints given to the VE team*

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
16	Use raised median rather than depressed		

Main Line Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
⇧	⇔	⇩	⇔	⇔	⇔

Justification/Comments/Disposition:	
Rating: 5	*See Idea 6 – considered an alterative (raised or depressed)*

Item: Bridge
Function: Span (Canyon, Roadway)

Idea Number	Description	Advantages	Disadvantages
17	Reduce shoulder widths on bridge – from 10 and 4 to 4 and 4	• Reduced cost • Reduced maintenance costs	• Reduction in operations • Limits phasing options for future rehabs in the two lane option • Decrease in bridge sufficiency rating

Main Line Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
⇩					

Justification/Comments/Disposition:	
Rating: 4	

Ranking Scale: 5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description		Advantages		Disadvantages	
18	Replace bridges (1 and 2) with culverts		• Eliminates Bridges • Reduces maintenance costs • Eliminates winter icing • Improved operations – full shoulders		• Would require additional right-of-way beyond what is shown in current concept plans • Increased earthwork • Increased environmental impacts	
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
	⇧		⇧		⇩	
Justification/Comments/Disposition:						
Rating: 4						

Idea Number	Description		Advantages		Disadvantages	
19	Shorten bridge 3 length		• Reduced costs • Reduced maintenance		• Construction impacts to Wise Road	
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
			⇧		⇩	
Justification/Comments/Disposition:						
Rating: 5	*Profile as shown to VE team does not provide adequate clearance over Wise Road. Need to verify length of bridge.*					

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
20	Replace bridge 3 with large box culvert	• Eliminates Bridges • Reduces maintenance costs • Eliminates winter icing • Improved operations – full shoulders	• May require additional right-of-way beyond what is shown in current concept plans • Increased earthwork • Increased environmental impacts • Require closing Wise Road during construction

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
⇧		⇧	⇩	⇩	

Justification/Comments/Disposition:	
Rating: 4	*Profile as shown to VE team does not provide adequate clearance over Wise Road.*

Idea Number	Description	Advantages	Disadvantages
21	Replace bridge 3 (Wise Road) with at-grade intersection	• Removes bridge • Provided local connectivity	• May not be able to make grades work • Will require cut through stream • Increases earthwork

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*

Justification/Comments/Disposition:	
Rating: 2	*After review the VE Team preferred Idea 13*

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Item: Pavement
Function: Provide surface

Idea Number	Description	Advantages	Disadvantages
22	Reduce usable shoulder width from 10 and 2 to 8 and 2	• Reduced roadway costs • Reduced structure costs • Reduced right-of-way footprint • Better aligns with ultimate typical section	

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*
				⇧	

Justification/Comments/Disposition:	
Rating: 5	*Follow current KYTC design memo which allows 6 and 2, but District preference is 8 and 2*

Idea Number	Description	Advantages	Disadvantages
23	Construct 2 lanes with climbing/passing lanes		

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*

Justification/Comments/Disposition:	
Rating: 5	*See idea 5.*

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description		Advantages		Disadvantages	
24	Reduce paved width on shoulders to 4 feet – earth beyond for a 4 and 8 total.		• Reduced pavement cost		• Increased maintenance costs	
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
	⇩		⇩			
Justification/Comments/Disposition:						
Rating: 2	*Idea 22 preferred*					

Idea Number	Description		Advantages		Disadvantages	
25	Plane section rather than crown		• Allows future flexibility for design with urban typical			
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
Justification/Comments/Disposition:						
Rating: 2	*Only advantageous for a four lane urban typical*					

Idea Number	Description		Advantages		Disadvantages	
26	2-12 foot lanes and 2-7 feet paved shoulders					
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
Justification/Comments/Disposition:						
Rating: 3	*See Idea 24.*					

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description		Advantages		Disadvantages	
27	Use 11 foot lanes					
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
	Justification/Comments/Disposition:					
Rating: 2	*Based on projected truck percentage and classification of roadway and traffic projections, recommend using 12-foot lanes.*					

Item: Intersections
Function: Control Movements

Idea Number	Description		Advantages		Disadvantages	
28	Continuous Green T at end intersection					
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
	Justification/Comments/Disposition:					
Rating: 3	*No current concept design at the intersection – consider as design moves forward*					

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description		Advantages		Disadvantages	
29	Off set left turn lanes		• Improves sight distance for turning vehicles		• Increased construction costs	
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
Justification/Comments/Disposition:						
Rating: 3	*Design team to consider for left turn lanes on bypass*					

Idea Number	Description		Advantages		Disadvantages	
30	Move Reed Chapel (south leg) closer to north leg.		• Shortens south approach • Eliminates some proximity damages • Could reduce right-of-way		• May need to shift north leg to maintain 1200 foot spacing	
	Main Line Operations	***Local Operations***	***Maintainability***	***Construction Impacts***	***Environmental Impacts***	***Project Schedule***
Justification/Comments/Disposition:						
Rating: 3	*After further investigation the concept alignment was determined to have the least overall impact – historic properties, etc.*					

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Idea Number	Description	Advantages	Disadvantages
31	Connect Reed Chapel south leg to match north leg – use frontage road.	• Aligns two legs of intersection	• Non favorable geometry in south leg • May add relocation – potential EJ • May increase right-of-way costs

Main Line Operations	*Local Operations*	*Maintainability*	*Construction Impacts*	*Environmental Impacts*	*Project Schedule*

Justification/Comments/Disposition:	
Rating: 3	*After further investigation the concept alignment was determined to have the least overall impact – historic properties, etc.*

Ranking Scale:
5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor value degradation
1 = Major value degradation
0 = Withdrawn (unacceptable impact, doesn't meet purpose and need, or is already a design requirement)

= Advanced as recommendation
= Forwarded as design consideration
= Dropped from future consideration

Performance Attributes: ⇧ Improvement, ⇔ No change, ⇩ Degradation

Those ideas that move forward from this initial evaluation are developed before being evaluated a second time. This second evaluation uses a unique performance-based process to identify the alternative solution(s) that provide the greatest overall value. This process uses a value matrix tool to evaluate the alternatives against a set of performance attributes (identified and defined with project team and KYTC staff) and their relative importance to each other. This approach results in a list of alternative(s) with the highest value that reflects the technical, political, and social environment elements associated with the project.

The following is a general discussion and overview of the performance-based VE process that will be used on the Campbellsville Bypass Project.

Performance-based Process

Using performance attributes is an integral part of the VE process. It provides the cornerstone of the VE process by providing a systematic and structured means of considering the relationship of a project's performance and cost as they relate to value. Project performance must be properly defined and agreed on by the stakeholders at the beginning of the value study. The performance attributes and requirements developed are then used throughout the study to identify, evaluate, and document alternatives.

Introduction

The methodology described herein measures project value by correlating the performance of project scope and schedule to the project costs. The objective of this methodology is to prescribe a systematic, structured approach to study and optimize a project's scope, schedule, and cost.

Value engineering has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that VE can play with regard to improving project performance. Project costs are fairly easy to quantify and compare through traditional estimating techniques. Performance is not so easily quantifiable.

The VE team leader led the team through the methodology, using the power of the process to distill subjective thought into an objective language that everyone can relate to and understand. The dialogue that developed formed the basis for the VE teams' understanding of the performance requirements of the project and to what degree the current design concept was meeting those requirements. From this baseline, the VE team can focus on developing alternative concepts that will quantify both performance and cost and contribute to overall project value.

Performance-based VE yields the following benefits:

- Builds consensus among project stakeholders (especially those holding conflicting views)
- Develops a better understanding of a project's goals and objectives
- Develops a baseline understanding of how the project is meeting performance goals and objectives
- Identifies areas where project performance can be improved through the VE process

- Develops a better understanding of a VE alternative's effect on project performance
- Develops an understanding of the relationship between performance and cost in determining value
- Uses value as the true measurement for the basis of selecting the right project or design concept
- Provides decision-makers with a means of comparing costs and performance (i.e., costs vs. benefits) in a way that can assist them in making better decisions.

Methodology

The application of performance-based VE consists of the following steps:

1. Identify key project (scope and delivery) performance attributes and requirements for the project.
2. Establish the hierarchy and impact of these attributes on the project.
3. Establish the baseline of the current project performance by evaluating and rating the effectiveness of the current design concepts.
4. Identify the change in performance of alternative project concepts generated by the study.
5. Measure the aggregate effect of alternative concepts relative to the baseline project's performance as a measure of overall value improvement.

The primary goal of value engineering is to improve the value of the project. A simple way to think of value in terms of an equation is as follows:

$$Value = \frac{Performance}{Cost}$$

Assumptions

Before embarking on the details of this methodology, some assumptions need to be identified. The methodology described in the following steps assumes the project functions are well established. Project functions are defined as what the project delivers to its users and stakeholders; a good reference for the project functions can be found in the environmental document's purpose and need statement. Project functions are generally well defined prior to the start of the VE study. In the event that project functions have been substantially modified, the methodology must begin anew (Step 1).

Step 1 – Determine the Major Performance Attributes

Performance attributes can generally be divided between project scope components (highway operations, environmental impacts, and system preservation) and project delivery components. It is important to make a distinction between performance *attributes* and performance *requirements*. Performance requirements are mandatory and binary in nature. All performance requirements MUST be met by any VE alternative concept being considered. Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and

construction of a new bridge, a performance requirement might be that the bridge meets all current seismic design criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives could be acceptable that had different durations.

The VE team leader will initially request representatives from project team and external stakeholders identify performance attributes that they feel are essential to meeting the overall need and purpose of the project. Usually four to seven attributes are selected. It is important that all potential attributes be thoroughly discussed.

The information that comes out of this discussion will be valuable to both the VE team and the project owner. It is important that each attribute be discretely defined and be quantifiable in some form. By quantifiable, it is meant that a useable scale must be delineated with values given on a scale of 0 to 10. A “0” indicates unacceptable performance, while a “10” indicates optimal or ideal performance.

The vast majority of performance attributes that typically appear in transportation VE studies have been standardized. This standardized list can be used “as is” or adopted with minor adjustments as required.

The performance attributes and description used on this project are shown below.

Table D-2. Performance Attributes and Description – Campbellsville Bypass

Performance Attribute	Description of Attribute
Main Line Operations	An assessment of traffic operations and safety within the project limits. Operational considerations include main line and intersection level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, lane and shoulder widths, intersection spacing and access control
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure (cross streets). Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane and shoulder widths; bicycle and pedestrian operations and access.
Maintainability	An assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the overall durability, longevity and maintainability of pavements, structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to businesses and residents relative to access, visual, noise, vibration, dust and construction traffic; environmental impacts. Includes an assessment of temporary environmental impacts related to water quality, air quality, soil erosion, and local flora and fauna.

Table D-2. Performance Attributes and Description – Campbellsville Bypass

Performance Attribute	Description of Attribute
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts (i.e., environmental justice, business, residents); impacts to cultural, recreational and historic resources.
Project Schedule	An assessment of the total project delivery as measured from the time of the VE study to completion of construction.

Step 2 – Determine the Relative Importance of the Attributes

Once the group agreed on the project's performance attributes, the next step was to determine the relative importance in relation to each other. This was accomplished through the use of an evaluative tool termed in this report as the "Performance Attribute Matrix." This matrix compares the performance attributes in pairs, asking the question: "An improvement in which attribute will provide the greatest benefit to the project relative to purpose and need?"

A letter code (e.g., "A") was entered into the matrix for each pair, identifying which of the two was more important. If a pair of attributes was considered to be of essentially equal importance, both letters (e.g., "A/B") are entered into the appropriate box. When all pairs had been discussed, the number of "votes" for each was tallied and a percentage (which was used as weighted multipliers later in the process) was calculated.

The result of this exercise for the Campbellsville Bypass is shown below.

PERFORMANCE ATTRIBUTE MATRIX

KYTC Campbellsville Bypass

Which attribute is more important to the project?							TOTAL	%
Mainline Operations	**A**	A	A	A	A/E	A	5.5	**26%**
Local Operations	**B**	B	B	B	B/E	B	4.5	**21%**
Maintainability	**C**	C	C	E	C		3.0	**14%**
Construction Impacts	**D**	E	D				2.0	**10%**
Environmental Impacts	**E**	E					5.0	**24%**
Project Schedule	**F**						1.0	**5%**
	Total						21.0	100%

Without emphasis on preference

A = A is of greater importance

A/B = A and B are of equal importance

As shown by the results, *Main Line Operations* followed by *Environmental* were determined to be the most important relative to the project's purpose and need, while *Construction Impacts* and *Project Schedule* were considered least important.

Step 3 – Establish the Performance Baseline for the Original Design

The next step in the process was to document the project-specific elements for the performance attributes developed in Step 1. This step establishes a baseline against which the VE alternative concepts can be compared. The baseline for Campbellsville is shown below.

Table D-3. Performance Attributes and Description – Campbellsville Bypass

Performance Attribute	Description of Attribute	Baseline Concept
Main Line Operations	An assessment of traffic operations and safety within the project limits. Operational considerations include main line and intersection level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, lane and shoulder widths, intersection spacing and access control	• Design (posted) speed 55 mph • 12-foot lanes • 12-foot outside shoulder (10' paved + 2' earth) • 6-foot inside (4' paved + 2' earth) • Varied media width - up to 40 feet • Classified as Rural Arterial • At-grade intersection at KY 55, Smith Ridge, KY 70, Reeds Chapel, and US 68.
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure (cross streets). Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane and shoulder widths; bicycle and pedestrian operations and access.	• 12-foot lanes • Offset alignments shown • No ped or bike accommodations • Barnett Road – cul de sac
Maintainability	An assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the overall durability, longevity and maintainability of pavements, structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.	• Asphalt pavement - assumed in the base estimate • Ability to mow side slopes • Designed to minimize guardrail

Table D-3. Performance Attributes and Description – Campbellsville Bypass

Performance Attribute	Description of Attribute	Baseline Concept
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to businesses and residents relative to access, visual, noise, vibration, dust and construction traffic; environmental impacts. Includes an assessment of temporary environmental impacts related to water quality, air quality, soil erosion, and local flora and fauna.	• New alignment • Local cross roads to remain open during construction – current design has local connections offset
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); right-of-way impacts (i.e., environmental justice, business, residents); impacts to cultural, recreational and historic resources.	• Wildlife Management Area – avoided under selected alternative • *de minimis* use at sports complex (4f) • 224 Acres of right-of-way • 22 residential relocations
Project Schedule	An assessment of the total project delivery as measured from the time of the VE study to completion of construction.	• CN not funded • Identified (Section 1) in 2018

Once the baseline definitions for the various attributes have been established, their total performance should be calculated by multiplying the attribute's weight (which was developed in Step 2) by its rating. While one could assign a 0 to 10 rating for each attribute, using the definitions and scales developed in Step 1, a baseline rating of 5 is typically used as a mid point so that alternatives can be evaluated – better than or worse than the baseline.

Total baseline performance is calculated by multiplying the attribute's weight (which was developed in Step 2) by its rating (5). The baseline design's total performance of 500 points can be calculated by adding all of the scores for the attributes. This numerical expression of the original designs performance forms the baseline against which all alternative concepts will be compared.

Step 4 – Evaluate the Performance of the VE Alternative Concepts

Once the performance of the baseline has been established for the original design concept, it can be used to help the VE team develop performance ratings for individual VE alternative concepts as they are developed during the course of the study. The performance measures form is used to capture this information. This form allows a side-by-side comparison of the original design and VE alternative concepts to be performed.

It is important to consider the alternative concept's impact on the entire project (rather than on discrete components) when developing performance ratings for the alternative concept.

Proposals were evaluated against the baseline for all attributes to compare and contrast the potential for value improvement. As discussed in Step 3, the baseline is given a rating of 5. The following ratings were used to evaluate the performance of the alternative concepts relative to the baseline concept.

Table D-4. Performance Attribute Rating Scale

Rating	Performance Attribute Scales
10	Alternative concept is extremely preferred
9	Alternative concept is very strongly preferred
8	Alternative concept is strongly preferred
7	Alternative concept is moderately preferred
6	Alternative concept is slightly preferred
5	***Concepts are equally preferred***
4	Baseline concept is slightly preferred
3	Baseline concept is moderately preferred
2	Baseline concept is strongly preferred
1	Baseline concept is very strongly preferred
0	Baseline concept is extremely preferred

Step 5 – Compare the Performance Ratings of Alternative Concepts to the Baseline Project

As the VE team develops alternatives, the performance of each is rated against the original design concept (baseline). Changes in performance are always based on the overall impact to the total project. Once performance and cost data have been developed by the VE team, the net change in value of the VE alternatives can be compared to the original design concept. The resulting "Value Matrix" provides a summary of these changes and allows a way for the project team to assess the potential impact of the VE recommendations on total project value.

The VE team groups the VE alternatives into a strategy (or strategies) to provide the decision-makers a clear picture of how the alternatives fit together into possible solutions. At least one strategy is developed to present the VE team's consensus of what should be implemented. Additional strategies are developed as necessary to

present other combinations to the decision-makers that should be considered. The strategy(s) of VE alternatives are rated and compared against the original concept. The performance ratings developed for the VE strategies are entered into the matrix, and the summary portion of the Value Matrix is completed. The summary provides details on net changes to cost, performance, and value, using the following calculations:

- % Performance Improvement = Δ Performance VE Strategy/Total Performance Original Concept
- Value Index = Total Performance/Total Cost (in Millions)
- % Value Improvement = ΔValue Index VE Strategy/Value Index Original Concept.

Appendix E. Report-out Presentation

Kentucky Transportation Cabinet – *KYTC*
Campbellsville Bypass
Value Engineering Study

August 25 – 29, 2014

Value Engineering Team

Objectives of the Study

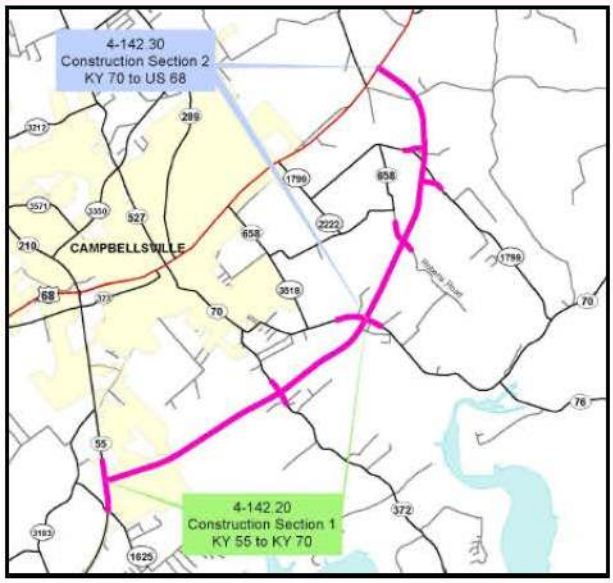
Through the application of the value engineering job plan the objective of the study process is to:

- Review and understand the various concepts of the Campbellsville Bypass project.
- Identify opportunities and develop recommendations to improve the project.

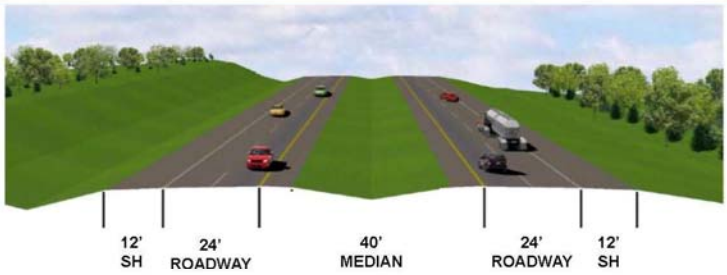
"If you do what you've always done,
you'll get what you've always gotten." ~ Henry Ford

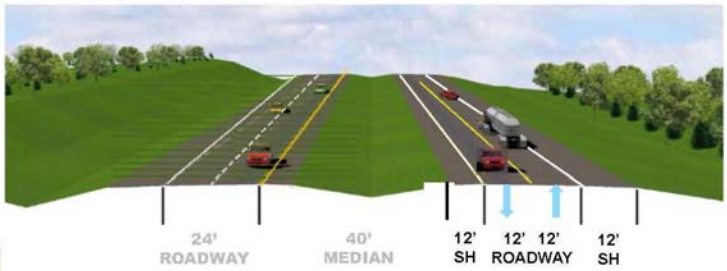
"Just because it hasn't been done doesn't mean it can't be done!"
~Beth Reed

Project Overview

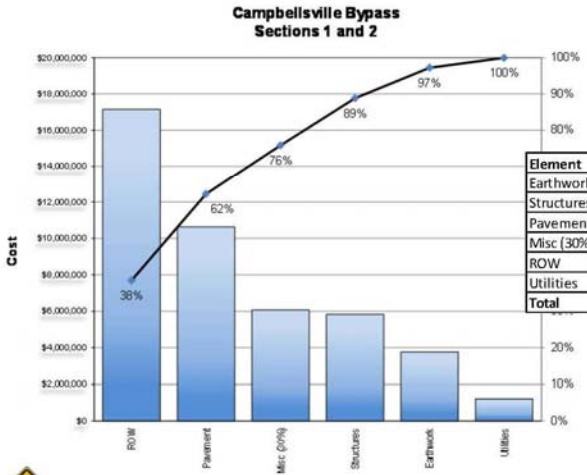


Project Overview





Preliminary Cost Estimate



Element	Section 1	Section 2	Total
Earthwork	$2,094,705	$1,658,640	**$3,753,345**
Structures	$3,990,000	$1,837,500	**$5,827,500**
Pavement	$5,477,111	$5,158,133	**$10,635,244**
Misc (30%)	$3,468,545	$2,596,282	**$6,064,827**
ROW	$9,196,040	$7,956,000	**$17,152,040**
Utilities	$1,061,320	$160,710	**$1,222,030**
Total	**$25,287,721**	**$19,367,265**	**$44,654,986**

Performance-based Value Engineering

Value Engineering has traditionally been perceived as an effective means for reducing project costs.

This paradigm only addresses one part of the value equation, often times at the expense of overlooking the role that VE can play with regard to improving project performance.

Performance Attributes

$$Value = \frac{Performance}{Cost}$$

Performance Attributes	
Performance Attribute	**Definition**
Mainline Operations	An assessment of traffic operations and safety within the project limits. Operational considerations include mainline and intersection level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, lane and shoulder widths, intersection spacing and access control
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure (cross streets). Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane and shoulder widths; bicycle and pedestrian operations and access.
Maintainability	An assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the overall durability, longevity and maintainability of pavements, structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to businesses and residents relative to access, visual, noise, vibration, dust and construction traffic; environmental impacts. Includes an assessment of temporary environmental impacts related to water quality, air quality, soil erosion, and local flora and fauna.
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts (i.e., environmental justice, business, residents); impacts to cultural, recreational and historic resources.
Project Schedule	An assessment of the total project delivery time as measured from the time of the VE Study to completion of construction.

Performance Attributes

PERFORMANCE ATTRIBUTE MATRIX

KYTC Campbellsville Bypass

Which attribute is more important to the project?							TOTAL	%
Mainline Operations	**A**	A	A	A	A/E	A	5.5	**26%**
Local Operations	**B**	B	B	B	B/E	B	4.5	**21%**
Maintainability	**C**	C	C	E	C		3.0	**14%**
Construction Impacts	**D**	E	D				2.0	**10%**
Environmental Impacts	**E**	E					5.0	**24%**
Project Schedule	**F**						1.0	**5%**
Total							21.0	100%

Without emphasis on preference

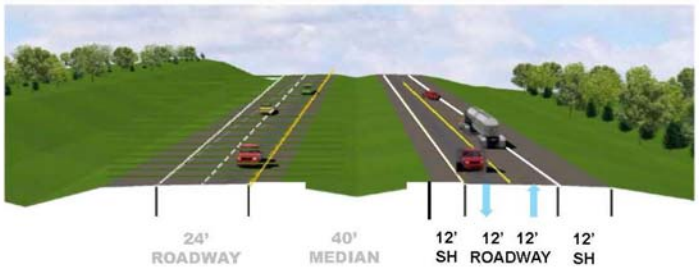
A = A is of greater importance

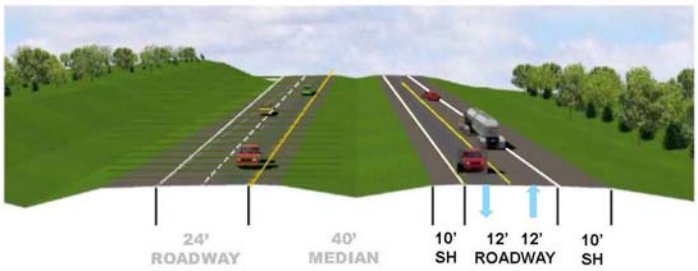
A/B = A and B are of equal importance

General Observations

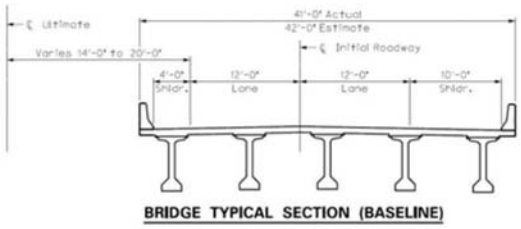
- Cost Estimate – Bridge, ROW
- Profile – sections .vs. profile .vs. plan .vs. stationing
- Wise Road – Vertical Clearance
- Terminal Intersections – were not investigated

Recommendation No. 1 – Usable Shoulder Width

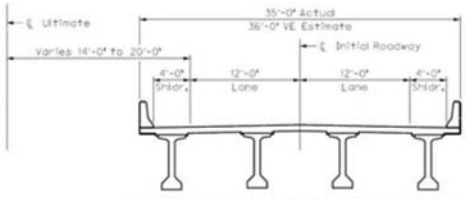




Recommendation No. 2 – Bridge Shoulder Widths

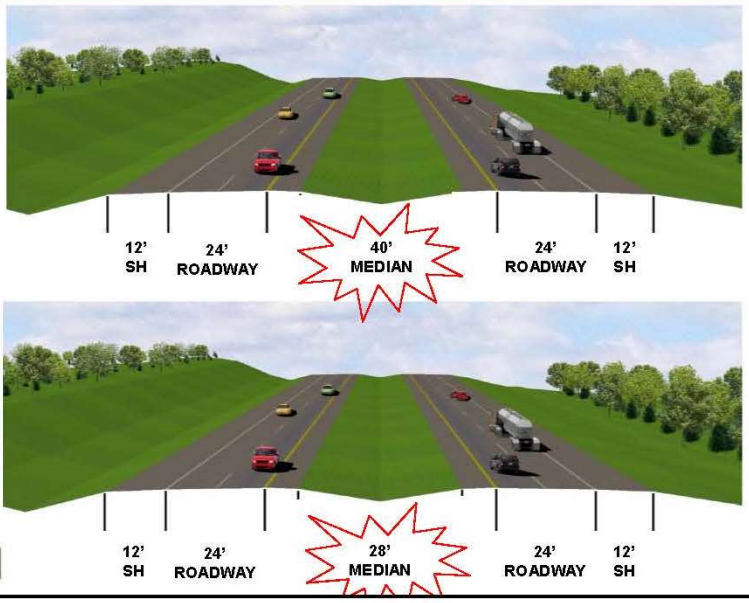


BRIDGE TYPICAL SECTION (BASELINE)



BRIDGE TYPICAL SECTION (VE PROPOSAL)

Recommendation No. 3 – Median Width

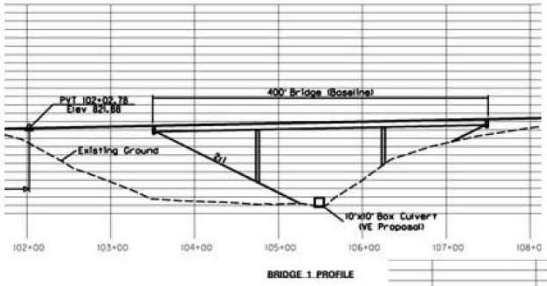


Recommendation No. 4 – Wise Road

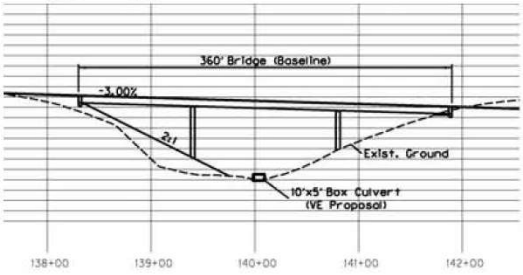
Recommendation No. 5 – Cross Road Alignments

KENTUCKY TRANSPORTATION CABINET

Recommendation No. 6 -Replace Bridge 1 & 2 w/Culverts



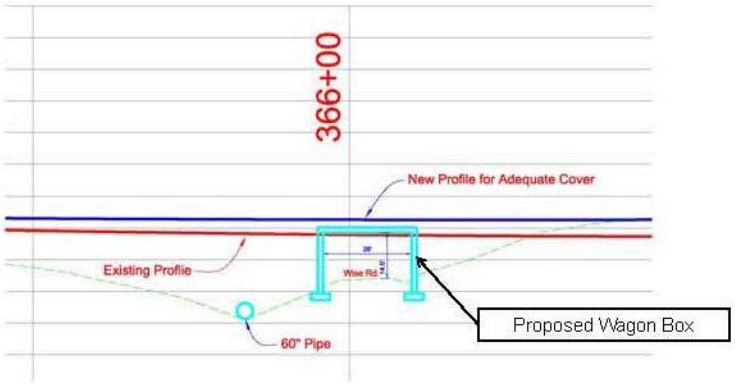
BRIDGE 1 PROFILE



BRIDGE 2 PROFILE

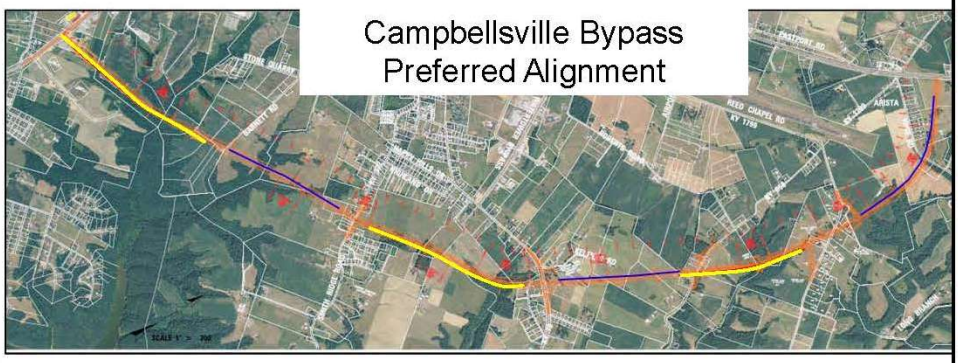
KENTUCKY TRANSPORTATION CABINET

Recommendation No. 7 – Replace Bridge 3 w/ Wagon Box



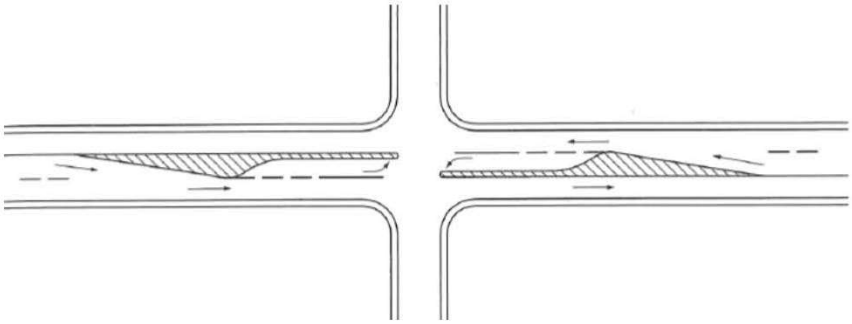
Recommendation No. 8 and 9
2+1 with 2+1 and 2+1 with 4

Recommendation No. 8 and 9
2+1 with 2+1 and 2+1 with 4



KENTUCKY TRANSPORTATION CABINET

Recommendation No. 8 and 9
2+1 with 2+1 and 2+1 with 4



KENTUCKY TRANSPORTATION CABINET

Summary of Recommendations

Summary of Recommendations KYTC Campbellsville Bypass			
No.	Description	Cost Delta (Increase)	% Value Improvement
1	Usable Shoulder Width	$0.70	2%
2	Bridge Shoulder Widths	$0.80	0%
3	Median Width	$0.60	7%
4	Wise Road	$1.70	5%
5	Cross Road Alignments	$2.42	17%
6	Replace Bridge 1 & 2 w/Culverts	$1.20	4%
7	Replace Bridge 3 W/Wagon Box	$1.60	2%
8	2+1 with 2+1	($4.50)	10%
9	2+1 with 4	($7.00)	-3%

Performance Summary

OVERALL PERFORMANCE *KYTC Campbellsville Bypass*				
No.	Description	% Change Performance	% Change Cost	% Value Improvement
1	Usable Shoulder Width	0%	2%	2%
2	Bridge Shoulder Widths	-2%	2%	0%
3	Median Width	5%	1%	7%
4	Wise Road	1%	4%	5%
5	Cross Road Alignments	11%	5%	17%
6	Replace Bridge 1 & 2 w/Culverts	1%	3%	4%
7	Replace Bridge 3 W/Wagon Box	-1%	4%	2%
8	2+1 with 2+1	21%	-10%	10%
9	2+1 with 4	12%	-16%	-3%

Scenarios

Potential Scenarios						
No.	Description		Cost Delta	Scenario 1	Scenario 2	Scenario 3
1	Usable Shoulder Width		($0.70)			($0.70)
2	Bridge Shoulder Widths		($0.80)			
3	Median Width		($0.60)		($0.60)	($0.60)
4	Wise Road		($1.70)	($1.70)	($1.70)	($1.70)
5	Cross Road Alignments		($2.42)	($2.42)	($2.42)	($2.42)
6	Replace Bridge 1 & 2 w/Culverts		($1.20)	($1.20)	($1.20)	($1.20)
7	Replace Bridge 3 W/Wagon Box		($1.60)			
8	2+1 with 2+1		$4.50	$4.50		
9	2+1 with 4		$7.00		$7.00	
	Total			**($0.82)**	**$1.08**	**($6.62)**

Questions?