

# Value Engineering Study Report

**KY 210 Widening Improvements – 4-80154.00**  
From Hodgenville to Campbellsville

*Larue, Green & Taylor Counties, Kentucky*

**Workshop Dates: September 16-20, 2024**

**Report Date: December 13, 2024**

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## **Disclaimer**

The information contained in this report is based on the professional opinions of the Value Engineering (VE) team members as developed during the study. These opinions are based on the information that was provided to the team at the time of the study. As the project continues to develop, alternatives and findings should be reevaluated as new information is received.

All costs displayed in the report are based on best available information at the time of the study and, unless otherwise noted, used the estimate as provided to the VE team. All drawings, graphics, maps, photos, etc., used in the report were supplied by the study sponsor or developed during the study.

The disposition of alternatives is based on the information in this report; it is independent of the resolutions generated after the study. HDR has no participation, direct or indirect, in such decisions.

For any alternatives that are accepted by the owner and design team as a result of this VE study, the responsibility for implementation into the design rests with the designer of record.



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## Acronyms and Abbreviations

2+1	2 through lanes and one alternating passing lane configuration
ATCS	Adaptive Traffic Control System
CCTV	closed circuit television
CE	Categorical Exclusion
CIP	cast in place
CSB	Cement Stabilized
CVS	Certified Value Specialist
CY	cubic yard
DDI	diverging diamond interchange
DMS	dynamic message sign
FAST	Function Analysis System Technique
FHWA	Federal Highway Administration
FRP	fiberglass-reinforced plastic
GRS	geosynthetic reinforcement soil
IMR	Interchange Modification Report
ITS	Intelligent Traffic System
KYTC	Kentucky Transportation Cabinet
LDCA	Location and Design Concept Acceptance
LF	linear feet
LOS	level of service
LRE	long range estimate
MOT	maintenance of traffic
MSE	mechanically stabilized earth
MVDS	microwave vehicle detection sensor
OBG	optional base group
SF	square feet
SIS	strategic intermodal system
SR	State Road
SY	square yard
TSM&O	Traffic System Management and Operation
VE	Value Engineering
VMA	Value Methodology Associate



# Executive Summary

## Introduction

This report summarizes the events and results of the virtual VE study conducted by HDR Engineering, Inc. for the Kentucky Transportation Cabinet (KYTC) on the KY 210 Widening Improvements – 4-80154.00 project in Larue, Green & Taylor Counties, Kentucky. The VE study consisted of a 5-day workshop that was conducted virtually with a multidisciplinary team on .

## Baseline Project Overview

The purpose of the project is to explore and provide feasible solutions to decrease congestion, reduce travel time, increase passing opportunities and improve safety. The ultimate preferred alternative that best addresses the purpose and needs of the project includes:

- Widen roadway to a 2+1 typical section for the entire 24.5-mile project length
- Spot Improvements at 7 locations of high crash frequency including:
  - Lincoln Parkway (KY 1618 / KY 210 Intersection)
  - KY 470 / KY 210 Intersection
  - OO Despain Road, MY 14.8 (LaRue), KY 462 area – Unimproved section of KY 210
  - KY 569 west past Little Brush Creek
  - Gaddie Road / Big Pitman Creek / Garnett Road
  - KY 744
  - Middle Pitman Creek / KY 883

This baseline concept had an estimated construction cost of approximately \$52.8 million.

## VE Study Objectives and Timing

The primary objective of the study, through execution of the Value Methodology Job Plan (see Appendix A), was to evaluate the project scope and approach based on updated 2024 Highway Plan budgeting assumptions and identify recommendations to accomplish the project functions to best meet the purpose and needs.

The VE study was conducted while the project was in various degrees of design development between 10% and 25% completion.

## VE Alternatives

The VE team generated 40+ ideas for the project. These concepts were compared against the baseline project as it was developed at the time of the VE workshop. The concepts that performed the best were further developed by the VE team and resulted in 10 VE



alternatives being developed. The VE alternatives consider multiple aspects of total value including assessing the impacts to performance, cost, time, and risk in comparison to the baseline concept. The cost and performance trade-offs for each VE alternative are summarized below in Table 1; the developed information about each is included in Section 7.2.

**Table 1. Summary of Alternatives**

Alt No.	Alternative Title	Cost Savings or (Cost Added)	Performance/Risk
<b>Improve Passing Opportunities</b>			
IPO-1	Provide passing lanes at select locations in lieu of continuous 2+1 throughout	\$20,110,000	Improved (M, CI, EI) Reduced (MO)
IPO-2	Confine typical section to existing flowlines	\$403,000	Improved (MO, LO, Risk) Reduced (M)
<b>Spot Improvement Modifications</b>			
SI-1	Install lighting at select high-crash frequency locations. Consider solar / LED	(\$288,000)	Improved (MO, LO) Reduced (M)
SI-2	Revise Lincoln Parkway intersection with KY 210 with prioritized movements	\$12,000	Improved (MO, LO)
SI-3	Use barn roof fill slope to limits of clear zone and eliminate guard rail	\$1,414,000	Improved (MO, LO, M) Reduced (EI)
<b>Typical Section Modifications</b>			
TS-1	Provide drainage for existing subgrade with French drain in lieu of daylighting shoulders	\$1,507,000	Improved (M)
TS-2	Revise limits of cement stabilized base	\$2,075,000	No change
TS-3	Maintain 2' stone base shoulder width at guard rail locations	\$179,000	Improved (Schedule) Reduced (M)
TS-4	Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections	\$422,000	Reduced (MO, M)
TS-5	Use granular embankment and geotextile for sliver fills	\$2,368,000	Reduced (M)

Note: Because the cost data depicted above represents savings, a number in parentheses represents a cost increase. Performance Attribute Legend: M – Maintainability, C – Construction Impacts, EI – Environmental Impacts.



## Implementation of VE Alternatives

Project Team representatives reviewed the information in the Draft VE Study Report and discussed the VE Alternatives to determine which should be accepted and implemented into the project.

Of the 10 alternatives developed and presented in the Draft VE Study Report, nine were selected for either full or partial acceptance into the project. Please note that acceptance of alternatives denotes intent to implement, based on current information, in the given project development phase. It is recognized that future conditions may change this disposition.

The table below summarizes the implementation disposition of all the VE Alternatives, the rationale for the acceptance or rejection, and all comments received by the various project team reviewers and stakeholders. Additionally, to help facilitate implementation discussions, a VE Approval Form is included as Appendix E.

**Table 2. Summary of Alternative Implementation**

Alt No.	Alternative Title	Implement Status	Decision Rationale / Comments
<b>Improve Passing Opportunities</b>			
IPO-1	Provide passing lanes at select locations in lieu of continuous 2+1 throughout	Accept	The Project Development Team would like to accept this alternative and will try to incorporate passing lanes at select locations in lieu of a continuous 2+1 Roadway through out the project. Mr. Siwula discussion with D4 Team concerning positive data being collected on the safety benefits of the 4 foot flush medians when using 2+1 roadway types. There is potential to save money through providing passing lanes at select locations and still provide a 4 foot flush median. After further discussion at the end of the meeting the Project Team decided that it would greatly benefit the project to look at reducing the typical section for the entire project and not just for Section 2, they will look for natural passing zones to provide passing opportunities.
IPO-2	Confine typical section to existing flowlines	Accept	The Project Development Team would like to accept this alternative to further plan development. The PDT will look at areas where can eliminate R/W impacts as much as possible. Some discussion made concerning any constructability issues, Eric and Johnathan felt that there should not be any constructability issues with this alternative. This alternative would be selective based on the side slopes, since would not want to compromise the maintainability of the slopes where guardrail would be required.



**Table 2. Summary of Alternative Implementation**

Alt No.	Alternative Title	Implement Status	Decision Rationale / Comments
<b>Spot Improvement Modifications</b>			
SI-1	Install lighting at select high-crash frequency locations. Consider solar / LED	Accept	The PDT would like to accept this alternative and consider lighting installation at select high-crash locations. District 4 has never included lighting on a project as a safety mechanism except for at interchanges and roundabouts. There was discussion of the possibility of using solar lights so the maintenance tasks are minimized. The District to work with the local municipality on this inclusion into the project.
SI-2	Revise Lincoln Parkway intersection with KY 210 with prioritized movements	Accept	The PDT would like to accept this alternative and look at designing a small roundabout (may not be a mini-roundabout) but would be as small as necessary at this location (potentially 120 to 130 ft diameter roundabout). There was some discussion concerning the KYTC Maintenance/Construction employees that use this intersection enroute to the maintenance barn and they indicated that it is often difficult to make a left turn at this location.
SI-3	Use barn roof fill slope to limits of clear zone and eliminate guard rail	Accept	The PDT would like to accept this alternative and look at utilizing a barn roof fill slope to the limits of the clear zone to eliminate guardrail. The team noted that there could potentially be more maintenance on any 4:1 slopes for this option but would strategically consider the barn roof fill slope only at locations where that would not be an issue. There was some concern that Right of Way plans have already been completed for Section 2 and that any changes will have to be reviewed carefully. It was also noted that this project is leaning towards a waste project and could also potentially help with wasting material during construction. There was also some concern with the potential 4:1 slope to the clear zone distance and then becoming a 2:1 slope outside the clear zone and vehicles not being able to traverse the 2:1 slope.
<b>Typical Section Modifications</b>			
TS-1	Provide drainage for existing subgrade with French drain in lieu of daylighting shoulders	Accept	The PDT would like to accept this alternative and evaluate during final design. Several team members stated that they have utilized this approach on other projects and that it



**Table 2. Summary of Alternative Implementation**

Alt No.	Alternative Title	Implement Status	Decision Rationale / Comments
			has worked well, with some time savings during construction.
TS-2	Revise limits of cement stabilized base	Accept	The PDT would like to accept this alternative and modify the plans to bring the stabilized base to the edge of the shoulder instead of daylighting to the slope.
TS-3	Maintain 2' stone base shoulder width at guard rail locations	Accept	The PDT would like to accept this alternative and modify the typical section to show utilizing 2 ft of shoulder width behind the guardrail. The design already includes utilizing the 7 ft guardrail posts.
TS-4	Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections	Reject	The PDT would like to reject this alternative. There are other locations within the District where the paved shoulder width was reduced to 4 ft and there have been safety issues in those locations. They have also received much criticism from the locals with the reduced shoulder widths.
TS-5	Use granular embankment and geotextile for sliver fills	Accept	The PDT would like to accept this alternative and evaluate during final design. It was noted that this technique was utilized in Adair County and has worked really well.



## Acknowledgements

The VE team wishes to express its appreciation to the KYTC project team members and the Stantec design team representatives for the excellent support they provided throughout the study. We hope that the alternatives and design considerations provided will assist in the management decisions necessary to move the project forward through the project delivery process.

## VE Team Members

The VE study was facilitated by a Certified Value Specialist (CVS) from HDR. Multiple representatives and members of the KYTC project team also participated in the VE process to provide insight into the project's background and design development, as well as their requirements for the project and expectations for the VE study. Their support of this study is greatly appreciated, and the results provided herein reflect the information they provided throughout the study.

The VE team included the following. See Appendix B for additional details of all workshop attendees.

- Eric Farmer, KYTC
- Johnathon Arnold, KYTC
- Chuck Childers, HDR
- Chris Smith, HDR
- Adam Hedges, HDR
- Chad Wallace, HDR
- Mark Watson, HDR



# 1 Introduction

This VE report summarizes the events of the virtual VE study conducted for KYTC and facilitated virtually by HDR. The subject of the study was KY 210 Widening Improvements – 4-80154.00. The VE study was conducted on September 16 – 20, 2024 while the project was in various degrees of design and scope development.

## 1.1 Scope of VE Study

Value is expressed as the relationship between functions and resources, where function is measured by the performance attributes defined by the customer, and resources are measured in materials, labor, price, and time required to accomplish that function. VE focuses on improving value by identifying the most resource-efficient way to reliably accomplish a function that meets the performance expectations of the customer.

The primary objectives of the study, through execution of the Value Methodology Job Plan (Appendix A), were to:

- Conduct a thorough review and analysis of the key project functions using a multidiscipline, cross-functional team.
- Evaluate the project scope relative to updated budgetary information and project funding scenarios.
- Improve the value of the project through innovative measures aimed at improving the performance while reducing costs of the project.

With this process, the VE team identified the essential project functions and alternative ways to achieve those functions; the team then selected the optimal recommendations to develop into workable solutions for value improvements.

## 1.2 Evaluation of the Baseline Concept

During the course of the VE study, a number of analytical tools and techniques were applied to develop a better understanding of the baseline concept. A major component of this analysis was Value Metrics which seeks to assess the elements of cost, performance, time, and risk as they relate to project value. As part of this process, the project team representatives identified a number of Performance Requirements, defined as the essential, non-discretionary aspects of the project, and Performance Attributes, those aspects of a project's scope that may possess a range of potential values. These were used throughout the study to identify, evaluate, and document alternatives.

In addition to typical requirements such as applicable KYTC standards and design requirements, the following project constraints and controlling decisions were identified:

- The 2022 Highway Plan allocated \$27 million for the project. This has been updated to a total of \$98.9 million in the 2024 Highway Plan.

The VE team identified and defined the following performance attributes for this project and then evaluated the baseline concept as it pertains to these attributes. The following



performance attributes were used throughout the study to identify, evaluate, and document ideas and recommendations:

- Mainline Operations (MO) - An assessment of traffic operations and safety on the main line within the project limits.
- Local Operations (LO) - An assessment of traffic operations and safety on the local roadway infrastructure.
- Maintainability (M) - An assessment of the long-term durability, longevity, and maintainability of all roadway elements.
- Construction Impacts (CI) - An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to existing utilities; impacts to businesses and residents relative to access during construction.
- Environmental Impacts (EI) - An assessment of the permanent impacts to environmentally-sensitive resources. Attribute also considers the qualitative impacts of right of way acquisition and other property impacts.



## 2 Information Phase

The VE team received the documentation and drawings from the project design team as shown in Table 3. The design team also introduced the project and its characteristics on the first day of the study. Project details and challenges as presented by the design team are summarized below.

### 2.1 Information Provided to VE Team

Table 3 lists the project documents provided to the VE team for use during the study.

**Table 3. Information Provided to the VE Team**

<b>Document/Drawing/Schematic</b>	<b>Document Date</b>
Design Executive Summary	11/25/20
VE Study Kick-off Presentation	9/16/24
Joint Inspection Estimates (Section 2)	2/27/24
Quantities Estimate (Sections 1 and 3)	N/A

### 2.2 Purpose and Need

Purpose of the project is to explore and provide feasible solutions to decrease congestion, reduce travel time, increase passing opportunities and improve safety along this 24.5-mile segment of KY 210 from KY 1618 in Hodgenville to KY 883 in Campbellsville.

The corridor was segmented into three sections, as shown in the figure below, to explore feasible options within each.

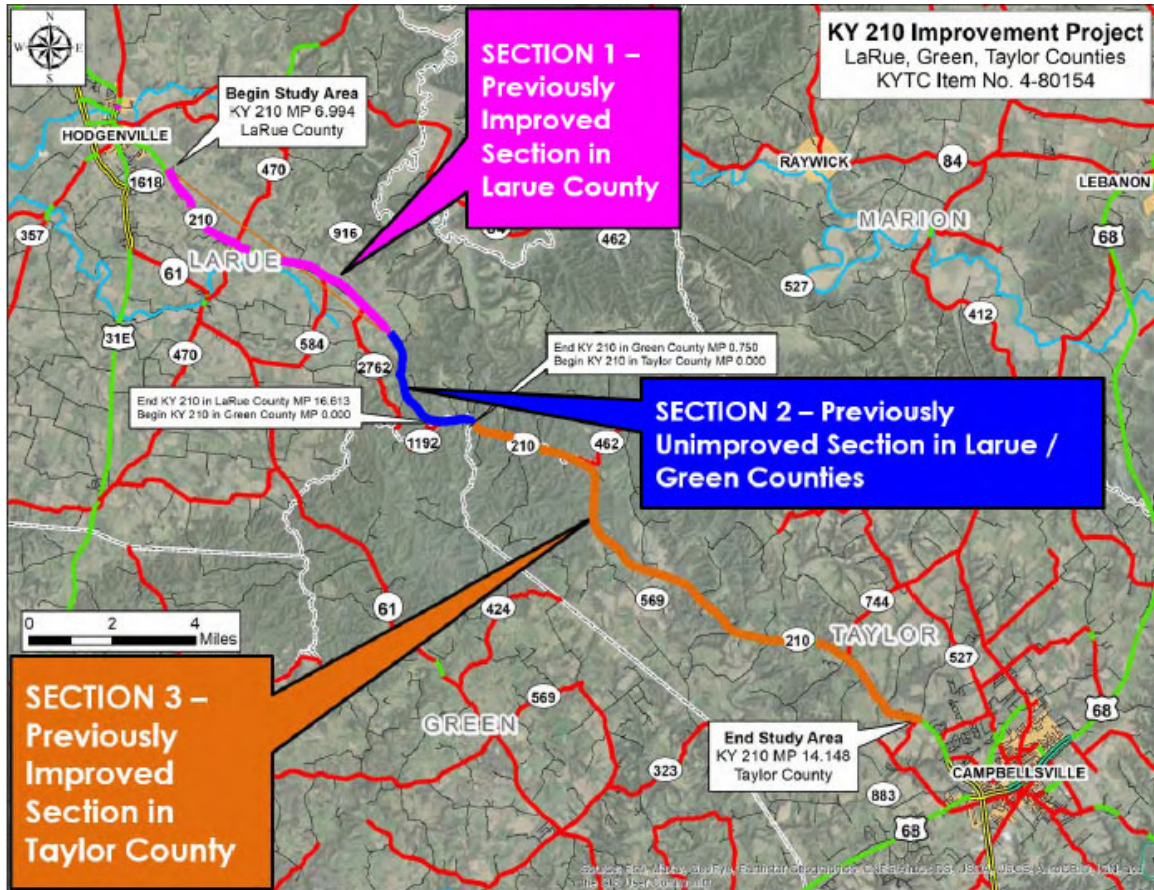
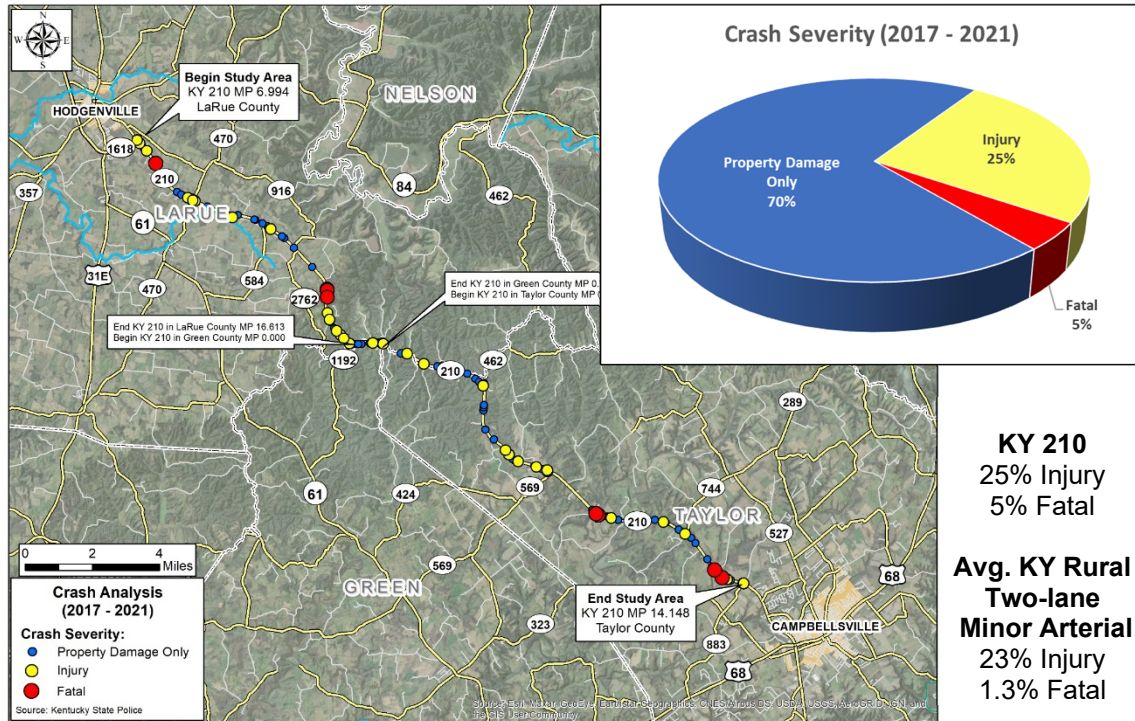


Figure 1. Project Location and Section Designations

## 2.3 Project History / Information

The project stretches from its northwestern termini in Hodgenville (KY 1618) to its southeastern termini in Campbellsville (KY 210) for over 24.5 miles through portions of LaRue, Green, and Taylor counties. The project is comprised of three sections: Section 1 in LaRue County, Section 2 traveling through portions of each county, and Section 3 in Taylor County. Section 2 is the most distinguishable of the three sections given much of it has not been modified in the last 25 years or more while the other sections have been improved to “super two-lane” facilities during that time with realignments and expanded cross-sections to better accommodate travel speeds for the route. The project is expected to bring the facility to a comprehensive 60 mph (miles per hour) design speed for the length of the facility relative to the existing facility design speeds varying from 50 mph (Section 2) to 55 mph (Section 3) to 60 mph (Section 1).

There were several iterations prior to coming to what is currently known as the baseline of the project, though much of the baseline is still in the planning stages with improvements to Section 2 established as the foundational portion of the overall project. Prior to comprehensive funding needs being estimated, the project approach was comprised of Section 2 “2+1” configuration improvements including one through lane per direction with an alternating center passing lane and a variety of spot improvements. Since then, considerations have been made to obtain funding that comprehensively addresses project needs throughout the corridor.



**Figure 2. Crash Locations and Severity**

Section 2 improvements have already entered the design phase. Section 1 and Section 3 improvements have been limited to either spot improvements based on greatly reduced funding availability or more recent corridor-wide considerations of “2+1” improvements for all sections. I

Safety improvements considered are in response to numerous, non-animal, fatal or severe crashes relative to conflicts at local road intersections or passing attempts without necessary passing distance for the maneuver.

## 2.4 Baseline Build Alternative

The preferred ultimate alternative consists of a corridor-wide, 2+1 or three-lane typical section striped to provide alternating passing opportunities for the entire corridor (Sections 1, 2, and 3).

The following intersections are also being evaluated for possible spot improvements along the corridor:

- Lincoln Parkway
- KY 569
- KY 470
- KY 744
- Middle Pitman Creek
- Little Brush Creek
- KY 883

Spot improvement locations were identified through the crash analysis. Spot improvements could be advanced independently or in combination with an ultimate build alternative.



## 2.5 Constraints and Baseline Considerations

As part of the project briefing, the VE team was given the following project constraints and controlling factors that needed to be considered when evaluating ideas. In addition to typical requirements such as applicable KYTC standards and design requirements, the following project constraints and controlling decisions were identified:

- The 2022 Highway Plan allocated \$27 million for the project. This has been updated to a total of \$98.9 million in the 2024 Highway Plan.

Additional considerations and project information as identified by the project designer were as follows:

- KY 210 project has sections in which the existing plans were designed with a design speed of 50 mph and 55 mph
- Original intent was to tie in all fill and cut slopes within right of way. However, geotechnical recommendations show many locations need to maintain a maximum of 2.5:1 or 3:1. Due to slope recommendations, more right of way and earthwork was required.
- Section 2 pavement cost increased due to 52% of Section 2 now being full depth construction

## 2.6 Project Cost Estimate

At the time of the VE study, a detailed cost estimate for the ultimate preferred alternative was not available. A summary of parametric costs by section was developed as follows:

- Section 1 – Larue Improved Section - \$13,000,000
- Section 2 – Larue / Green Unimproved Section - \$15,600,000
- Section 3 – Taylor Improved Section - \$30,000,000

The VE team was provided with Joint Inspection Estimate for Section 2 and quantity estimates for Section 1 and 3. An abbreviated estimate developed from these is shown in Table 4. See Appendix C for additional estimate and project cost assumptions.

**Table 4. Cost Estimate – Baseline Concept**

Cost Item	Cost	Percent of Total	Cumulative Percentage
Pavement - Section 3	\$23,798,485	43%	43%
Pavement - Section 1	\$11,214,425	20%	63%
Pavement - Section 2	\$5,977,099	11%	74%
Earthwork - Section 3	\$4,887,255	8.9%	83%
Earthwork - Section 2	\$4,661,795	8.4%	92%
Traffic Items - Section 2	<u>\$1,811,844</u>	3.3%	95%
Earthwork - Section 1	\$1,731,014	3.1%	98%



**Table 4. Cost Estimate – Baseline Concept**

<b>Cost Item</b>	<b>Cost</b>	<b>Percent of Total</b>	<b>Cumulative Percentage</b>
Mobilization - Section 2	\$585,017	1.1%	99%
Drainage - Section 2	\$549,659	1.0%	100%

A summary of the spot improvement costs based on the preferred alternative at each location is provided below:

<b>Spot</b>	<b>Location</b>	<b>Cost</b>
1	Lincoln Parkway	\$500,000
2	KY-470	\$400,000
3	Little Brush Creek	\$200,000
4	KY-569	\$500,000
5	KY-744	\$600,000
6	Middle Pitman Creek	\$100,000
7	KY-883	\$600,000



## 3 Project Analysis

### 3.1 VE Focus Points and Observations

Prior to the VE study and during the Information Phase, a number of activities were conducted to better understand the baseline concept. The following summarizes key focus points and observations identified during these sessions and during the VE team's initial analysis.

- Realignment / offline improvements at select locations in Section 2 to improve geometrics and accommodate MOT / construction
  - Alternative alignments
  - Maintain alignment vs. construction impacts
- Existing condition / Base Case have locations that do not meet the 60 mph design speed
- Continuous 2+1 configuration throughout project limits vs. piece-meal passing opportunities at select locations
  - Relatively recent improvements made in Section 1 and 3
  - Limited passing opportunities in Section 1 and 3 currently existing
- Side slope grades
  - Geotechnical recommendations vs. roadway footprint
- Alternative improvements at the crash-focused spot locations
- Additional improvements at other spot locations (geometric vs. crash-focused locations)
  - Alternative access control points / closures at passing lane transitions / neck downs
- Utility and Pipe crossings
  - Road closure vs. alternative construction methods
- Edge of pavement / Survey Information
- Base case proposes 8' outside shoulders (partial depth pavement) vs. reduced widths
- Base case proposing removal and reinstallation of guard rail in select location vs. total replacement
- Alternative project packaging and phasing based upon funding availability, project priorities, ease of construction, etc.
- Daylighting subgrade drainage and concrete stabilization quantities vs. boxing out the shoulders (French drains)
- Extending side slopes and grades and footprint/ROW vs. installing guard rail
- Relevancy / Applicability of spot improvements with continuous 2+1 configuration

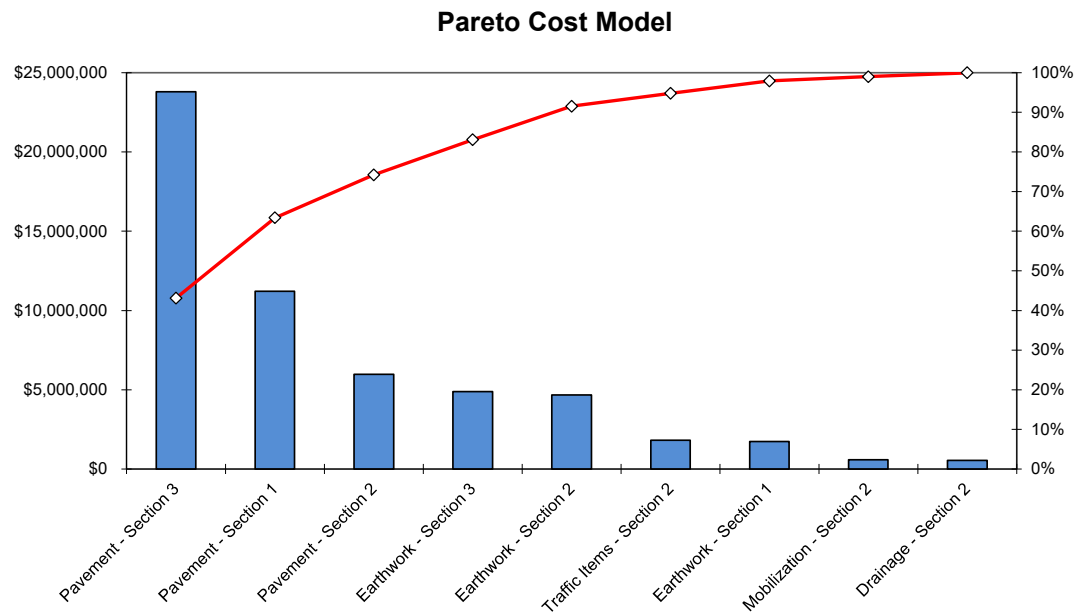


## 3.2 Cost Model

The VE facilitator 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 design team’s estimated costs, and the percent of total project cost for the significant cost items (Figure 3).

The cost model allows the team to focus on project elements with the highest degree of impact and utilize their time most effectively.

**Figure 3. Cost Model**



## 3.3 Risk Analysis

During the Information Phase individual risks were identified by the project and VE teams. The VE team sought to mitigate, through the VE process, those risks that pose the biggest impacts to the project cost or schedule.

The first step was to identify project-specific risks. The team then qualitatively evaluated the likelihood of each risk occurring and its potential impact to cost, schedule, or performance. The risks identified were qualified using a calculated indexing scheme that took into account the range of probability and impact in terms of the qualitative ratings (very low to very high). The expected total severity of each of the individual risks are calculated from the indexed values associated with the qualitatively-defined probabilities and impacts as shown in Figure 4, below.



**Figure 4. Risk Index Values**

Threats						Opportunities							
Probability	VH	0.2	0.4	0.6	0.8	1	VH	0.2	0.4	0.6	0.8	1	
	H	0.16	0.32	0.48	0.64	0.8	H	0.16	0.32	0.48	0.64	0.8	
	M	0.12	0.24	0.36	0.48	0.6	M	0.12	0.24	0.36	0.48	0.6	
	L	0.08	0.16	0.24	0.32	0.4	L	0.08	0.16	0.24	0.32	0.4	
	VL	0.04	0.08	0.12	0.16	0.2	VL	0.04	0.08	0.12	0.16	0.2	
		VL	L	M	H	VH		VL	L	M	H	VH	
		Impact							Impact				

Tornado diagrams were then utilized to visually demonstrate the relative ranking of risks against one another in terms of the anticipated project impact. Threats are plotted on the right of the central axis, while opportunities are plotted to the left. The highest threats or opportunities are located at the top of the tornado diagram, while the lowest risk threats or opportunities are at the bottom.

The greatest opportunities should actively be exploited and capitalized. The greatest threats require proactive risk management and the appropriate risk response strategies should be implemented. The tornado diagrams display the risks prior to response and implementation of risk response strategies in the form of VE alternatives.

**Figure 5. Risk Ranking**



The risk analysis performed in conjunction with this VE study highlights the risks most in need of management and key delivery stakeholder attention by producing tornado diagrams.



Project management and the design team should utilize this information to proactively manage project risk as the project is developed.

**Table 5. Risk Register**

Risk Information			Risk Exposure		
Risk ID	Threat/ Opportunity	Risk Description	Probability	Impact	Severity
1	Threat	Budget Limitations / Funding Availability	Very High	High	0.8
2	Threat	Utility Relocations / Impacts	High	High	0.64
3	Threat	Subsurface Conditions / Geotechnical	Medium	High	0.48
4	Threat	Existing Shoulder Conditions / Availability	Low	Medium	0.24
5	Threat	Additional Spot Location Improvements	Low	Low	0.16
6	Threat	Edge of Pavement Location / Quantities	Medium	Medium	0.36
7	Threat	Estimate Assumptions / Contingencies	High	Low	0.32
8	Threat	Contractor Interest / Availability / Bidding	Low	Low	0.16
9	Threat	Project Phasing / Contract Scope Packaging	Medium	Medium	0.36
10	Threat	New Albany Shale Encountered	Low	High	0.32

### 3.4 Value Metrics

The value metrics process was used as an analysis tool to evaluate the baseline project and the VE alternatives. Value metrics is a system of techniques predicated on the theory that value is an expression of the relationship between the performance of a function and the cost of acquiring it. It provides a standardized means of identifying, defining, evaluating, and measuring performance. Performance is quantified in terms of how well a set of attributes contribute to the overall functional purpose of a given project.

The basic equation used for calculating value is:

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

In other words, value is equivalent to the relationship of the resources needed to provide a certain level of performance for a given function. Performance is defined as a set of requirements and attributes of a project's scope that are pertinent to the project's purpose and need. Participant responses are elicited for a series of paired comparisons in which the performance of alternatives are compared, with consideration of the project purpose and



need, while taking into account the relative intensity of preference of one criterion over another.

The following pages describe the steps in the value metrics process.

### 3.4.1 Performance Attributes

Performance attributes are an integral part of the value analysis process. The performance of each project must be properly defined and agreed on by the project team, VE team, and representatives at the beginning of the study. These attributes represent those aspects of a project's scope and schedule that possess a range of potential values.

Performance attributes can generally be divided between project scope components (highway operations, environmental impacts, maintainability, 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 must meet 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.



**Table 6. Performance Attributes and Description**

Performance Attribute	Description of Attribute	Baseline Concept
Main Line Operations	<p>An assessment of traffic operations and safety on the main line within the project limits.</p> <p>Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, and lane and shoulder widths.</p>	<p>Existing: Section 1: L, from 60 mph existing design speed, 2-12', &amp; 12' shldr            Section 2: L,G,T from 50 mph existing design speed, 2-11', &amp; 8' shldr            Section 3: T, from 55 mph existing design speed, 2-11', &amp; 8' shldr            Section 3 Rural Arterial, 4900 ADT, 6500 DADT (2040), 15% Trucks            Sections 1 &amp; 2 Rural Arterial, 6200 ADT, 8200 DADT (2040), 14% Trucks, Section 3</p> <p>Changing to 3-11' lanes &amp; 8' shoulders, adding passing lanes, 60 mph design speed, Rolling Terrain            Changing from 12' shoulders to 8' shoulders            Spot improvements at select intersections to reduce conflicts and improve safety</p>
Local Operations	<p>An assessment of traffic operations and safety on the local roadway infrastructure. Local Operations include frontage roads as well as cross roads.</p> <p>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.</p>	<p>Operational improvements at 7 intersection locations including access closures, turning lanes, and intersection geometric improvements.            Minor local roadway improvements to accommodate construction / MOT.</p>
Maintainability	<p>An assessment of the long-term maintainability of the facilities and equipment. Maintenance considerations include the overall durability, longevity, and maintainability of structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.</p>	<p>Retaining majority of existing pavement in Sections 1 and 3.            Full depth reconstruction of pavement in Section 2 where geometry dictates.            Retaining existing structures (mostly in Section 3).            High friction surfaces may require additional maintenance.</p>



**Table 6. Performance Attributes and Description**

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 existing utilities; impacts to businesses and residents relative to access, visual effects, noise, vibration, dust, and construction traffic; environmental impacts.	Maintaining 1 lane in each direction throughout (except for brief temporary closures outside of peak times as necessary).
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; impacts to shore edge; impacts to cultural, recreational and historic resources.	CE Level 3. Majority of project is within existing ROW footprint. Acquisition of 1 residential property and small acquisitions to accommodate alignment shifts.

### 3.4.2 Performance Attribute Matrix

The performance attribute matrix was used to determine the relative importance of the performance attributes for the project. The project and VE team evaluated the relative importance of the performance attributes that would be used to evaluate the creative ideas.

These attributes were compared in pairs asking the question: “Which one is more important to the purpose and need of the project?” (e.g., A or B, A or C, A or D, etc.) The letter code (e.g., “A”) was entered into the matrix for each pair. After all pairs were discussed they were tallied (after normalizing the scores by adding a point to each attribute) and the percentages calculated. These scores were then used to calculate the value of each alternative during the VE team’s performance evaluation scoring.



**Figure 6. Performance Attribute Matrix**

Paired Comparison						Total points	% of Total
Main Line Operations	A	A3	A3	A	A3	11.0	52%
Local Operations		B	B	B	B	4.0	19%
Maintainability			C	C	C	3.0	14%
Environmental Impacts				D	E	1.0	5%
Construction Impacts					E	2.0	10%
<b>Total</b>						<b>21.0</b>	<b>100%</b>
<p><b><i>Without emphasis on preference</i></b></p> <p>A = A is of greater importance</p> <p>A/B = A and B are of equal importance</p> <p style="text-align: center;"><b>OR</b></p> <p><b><i>With emphasis on preference</i></b></p> <p>A# = A is of greater importance with # preference emphasis</p> <p>A/B = A and B are of equal importance</p> <p style="text-align: right;"><b><i>How Important</i></b></p> <p style="text-align: right;">3 - Major Preference</p> <p style="text-align: right;"><b>WITH</b> 2 - Medium Preference</p> <p style="text-align: right;">A - Minor Preference</p>							



# 4 Function Analysis Phase

## 4.1 Overview

Function analysis results in a unique view of the project. It transforms project elements into functions, which help guide the VE team in considering the functional concepts of the project— independent of the current design. Functions are defined in verb-noun statements to reduce the needs of the project to their most elemental level (Table 7). Identifying the functions of the major design elements of the project allows a broader consideration of alternative ways to accomplish the functions.

The primary functions identified by the VE team for the project were to **Improve Operations** and **Improve Safety** by **Increasing Passing Opportunities** and **Reducing Conflicts** by **Widening Roadway** while **Reducing Impacts**.

Table 7. Random Function Identification

Project Element	Functions
Project Need (Higher-Order)	Improve Mobility
Project Purpose (Basic)	Improve Operations
	Improve Safety
	Reduce Impacts
	Improve Maintainability
	Accommodate Future Improvements
	Establish Footprint
	Reduce Travel Times
	Separate Traffic
	Increase Passing Opportunities
	Reduce Congestion
Pavement Structural Section	Improve Reliability
	Support Load
	Accommodate Geotechnical Conditions
	Maintain Existing Pavement
	Support Widening
Striping	Improve Surface
	Delineate Traffic
2+1 Improvements	Identify Boundary
	Increase Capacity
	Promote Safe Passing



**Table 7. Random Function Identification**

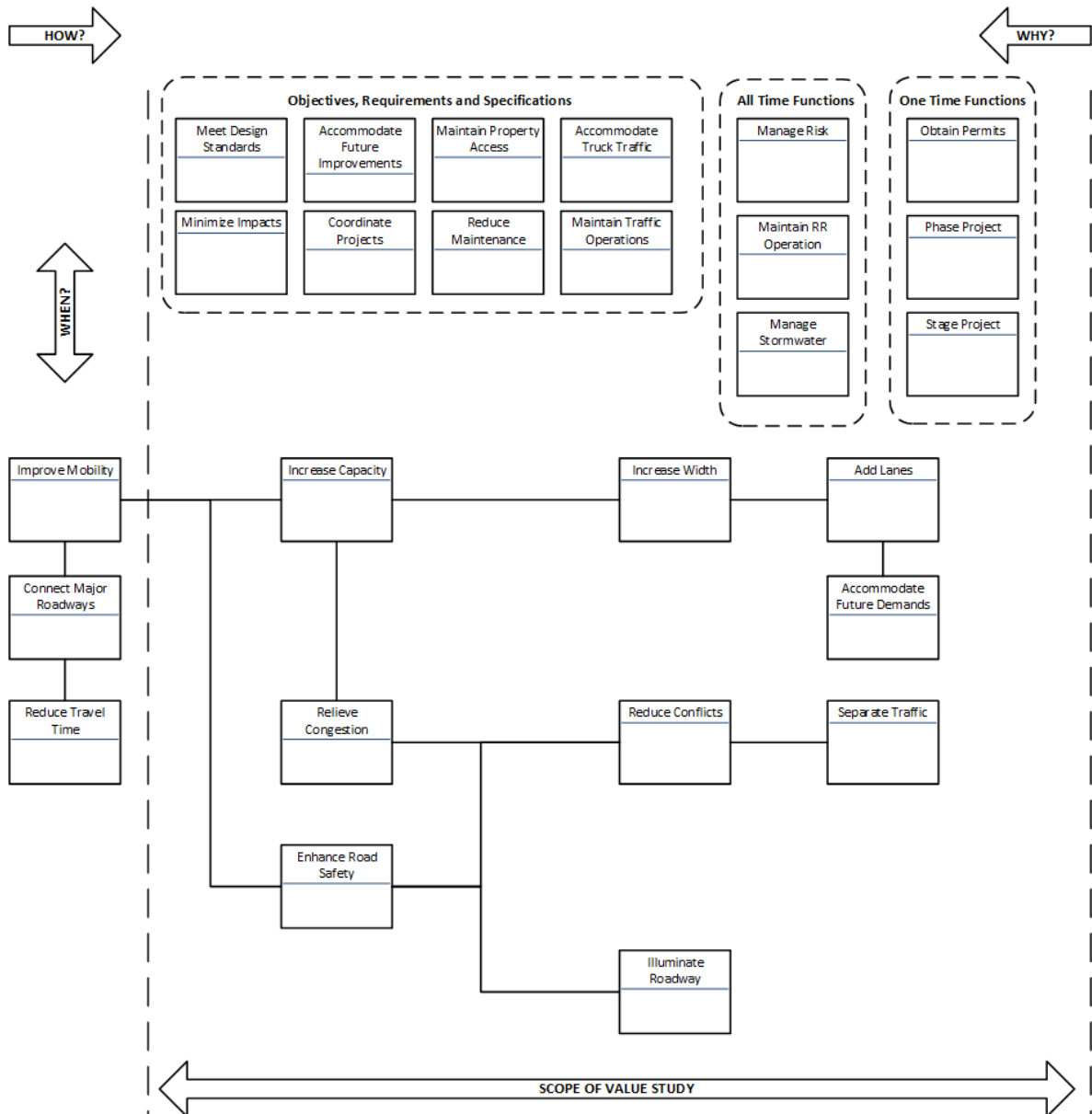
<b>Project Element</b>	<b>Functions</b>
Drainage Facilities	Convey Runoff
	Reduce Maintenance
Shoulders	Permit Recovery
	Create Refuge
	Maintain Traffic
	Bypass Obstructions
	Increase Width
	Reduce Width
Clear Zone	Permit Recovery
	Remove Obstacles
Side Slope (Recoverable)	Permit Recovery
	Match Grades
	Increase Footprint
Side Slope (Traversable)	Prevent Accident
	Match Grades
	Increase Footprint
Traffic Barrier	Separate Flow
	Deflect Force
	Manage Construction
Intersections	Separate Traffic
	Control Access
	Improve Geometrics
	Reduce Conflict Points
	Improve Wayfinding
Miscellaneous	Stage Construction
	Stabilize Subgrade
	Manage Risk
	Deliver Project
	Enhance Aesthetics
	Manage Traffic
	Accommodate Footprint



## 4.2 Function Analysis System Technique Diagram

The Function Analysis System Technique or “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 (Figure 7) provided the VE team with an understanding of which functions offer the best opportunity for cost or performance improvement.

Figure 7. FAST Diagram





## 5 Creativity Phase

During the Creativity Phase, the VE team 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 are recorded in Table 8. The final disposition of each idea is included at the end of Section 6.

**Table 8. Creative Idea List**

Idea No.	Description
<b>Function: Improve Operations</b>	
2	Improve Section 2 to 2+1 and spot improvements only in Section 1 and 3
5	Revise existing geometry to support 60 mph design speed throughout project
7	Provide dedicated passing lane / truck lane at select locations in Section 1 and 3 in lieu of continuous 2+1 throughout
8	Provide 2+1 improvement in Sections 2 and 3 only
30	Widen the existing structures to provide continuous 2+1 throughout
39	Revise Lincoln Parkway intersection with KY 210 with prioritized movements
41	Modify intersection at Lincoln Parkway with stop conditions for minor movements and priority for major movements
<b>Function: Improve Safety</b>	
6	Eliminate the high friction surface application
9	Install lighting at select high-crash frequency locations. Consider solar / LED
10	Install delineators / barriers to prevent passing at select high-crash frequency locations
12	Install active advance warning system for oncoming traffic at passing zones
19	Improve the superelevation of select curves in Section 3 in lieu of friction course
24	Improve signage / information to drivers of upcoming passing opportunities
25	Improve signage at all spot locations with flashing beacons and lighted signs
26	Provide a refuge area (two stage) for left turning traffic onto KY 210 (i.e. at KY 470 and 569)
28	Provide spot improvements at Middle Pitman Creek and KY 883 in lieu of 2+1 widening
29	Relocate the driveway at Middle Pitman Creek to improve sight distance
37	Provide emergency truck stopping capabilities in Section 2
<b>Function: Mitigate Risk</b>	
3	Defer improvements of 2+1 configuration in select locations to future phases
21	Perform additional surveys to verify edge of full-depth pavement



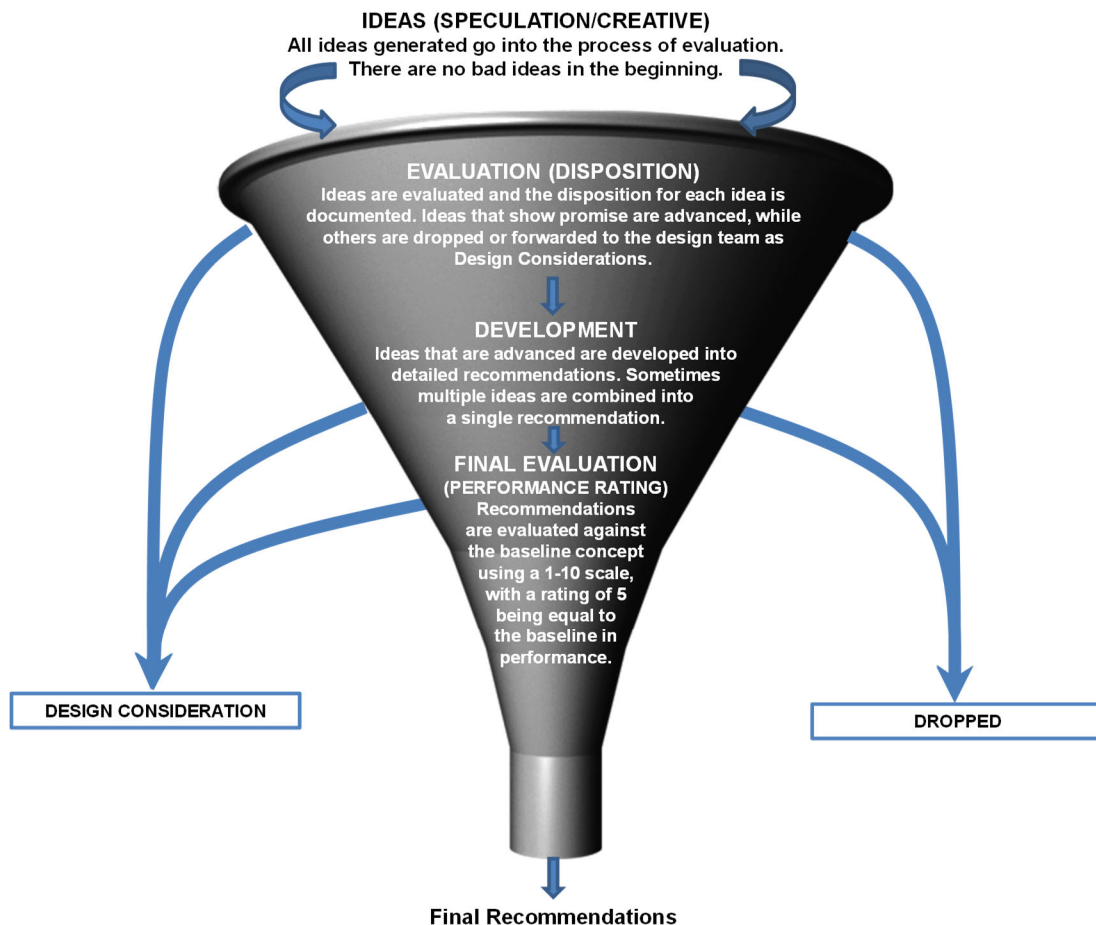
**Table 8. Creative Idea List**

Idea No.	Description
31	Increase geotechnical investigation relative to identifying potential for New Albany Shale / sulfuric acid
36	Increase onsite disposal of excavated spoils in lieu of offsite disposal / hauling
38	Detour traffic to alternative state routes during construction
40	Revise the rumble strip and striping configuration to provide striping on high side of groove
42	Defer the water line utility work in Section 2 to contractor in lieu of by others
44	Pursue additional funding opportunities for safety improvements
<b>Function: Reduce Impacts</b>	
4	Reduce the design speed at select locations
13	Provide drainage for existing subgrade with French drain in lieu of daylighting shoulders
15	Eliminate fill over existing benched side slopes
16	Use granular embankment and geotextile for sliver fills in lieu of benching side slopes
17	Use barn roof fill slope to limits of clear zone and eliminate guard rail
18	Steepen side slopes to maximum allowable grade
20	Eliminate removal and reset of existing guardrail (Section 2 - R7) and replace with new
22	Reduce width of shoulders at select locations
45	Revise typical section to fit within existing flow lines in Section 1 and 3
<b>Function: Separate Traffic</b>	
1	Restripe 2+1 for left turn lanes at select spot improvement locations
11	Improve shoulders and provide widened bulb out / passing blister at select high-crash frequency locations for select spot improvements as interim / early phase
43	Reduce / eliminate 3' buffer zone between opposing traffic lanes in 2+1
<b>Function: Support Loads</b>	
14	Maintain 2' stone base shoulder width at guard rail locations
23	Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections
27	Provide full depth shoulders at key intersections to support right turn movements
32	Maximize the AC pavement and reduce quantities of cement stabilized base
33	Revise limits of cement stabilized base in the typical sections
34	Maximize the quantity of rock base and reduce the thickness of AC
35	Provide alternative subbase treatment (geogrid, etc.) in lieu of CSB

## 6 Evaluation Phase

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 alternatives to be forwarded. Figure 8 depicts the typical information flow for this part of the Value Methodology Job Plan.

Figure 8. VE Process Information Flow



### 6.1 Evaluation Process

The evaluation process begins by going through the ideas brainstormed during the Creativity Phase. Considering the information provided to the VE team at the time of the study and the constraints and controlling decisions that were also given to them, the team discussed the ideas and documented their advantages and disadvantages based on their relationship to the baseline concept.

The VE team also compared each idea with its baseline concept to determine whether the performance of the attribute (as introduced in Section 3.3) was better than, equal to, or worse than the baseline concept.



Each idea was then carefully evaluated, with the VE team reaching consensus on the overall ranking of the idea (ranking values 0 through 3, as defined below).

3 = Advance for further development

2 = Design consideration; include as a comment or consideration for design team

1 = Poor Opportunity/dropped from further development

0 = Unacceptable impact/fatal flaw

This ranking resulted in the initial disposition of the idea. Those ideas ranked as a 3 were developed further; low-ranking ideas (those ranked 0 or 1) were dropped from further consideration; and those that were ranked 2 were brought forward as ideas the design team should pursue.

Once ideas were evaluated, the VE facilitator held a mid-point review] to validate the evaluation results and ensure the ideas moving forward aligned with the goals and objectives of the project. Some ideas that were originally scored a 3 were dropped from further consideration as they did not meet the long-term vision of the project.

## 6.2 Evaluation Summary

All of the ideas that were generated during the Creativity Phase using brainstorming techniques are detailed in Table 9.



**Table 9. Idea Evaluation Summary Table**

Idea #	Description	Advantages	Disadvantages	Rating
<b>Function: Improve Operations</b>				
IO-1	Improve Section 2 to 2+1 and spot improvements only in Section 1 and 3	<ul style="list-style-type: none"> <li>Section 1 and 3 have been recently improved and have less grades and sight distance issues</li> </ul>	<ul style="list-style-type: none"> <li>Limited passing opportunities through the corridor</li> </ul>	1-Poor Opportunity
IO-2	Revise existing geometry to support 60 mph design speed throughout project	<ul style="list-style-type: none"> <li>Removes design exceptions</li> </ul>	<ul style="list-style-type: none"> <li>Increases cost and impacts</li> </ul>	1-Poor Opportunity
IO-3	Provide dedicated passing lane / truck lane at select locations in Section 1 and 3 in lieu of continuous 2+1 throughout	<ul style="list-style-type: none"> <li>Reduces impacts and costs</li> </ul>	<ul style="list-style-type: none"> <li>Reduced opportunities for passing</li> <li>Reduces consistency of roadway</li> </ul>	3-Good Opportunity
IO-4	Provide 2+1 improvement in Sections 2 and 3 only		<ul style="list-style-type: none"> <li>Limits passing opportunities through project limits</li> </ul>	1-Poor Opportunity
IO-5	Widen the existing structures to provide continuous 2+1 throughout	<ul style="list-style-type: none"> <li>Increase width of roadway to accommodate 2+1</li> </ul>	<ul style="list-style-type: none"> <li>Increase costs</li> </ul>	1-Poor Opportunity
IO-6	Revise Lincoln Parkway intersection with KY 210 with prioritized movements	<ul style="list-style-type: none"> <li>Improved traffic operations</li> <li>Improved safety</li> <li>Improves transition area / traffic calming</li> </ul>	<ul style="list-style-type: none"> <li>Potential ROW impacts</li> <li>Increase initial costs</li> </ul>	3-Good Opportunity
IO-7	Modify intersection at Lincoln Parkway with stop conditions for minor movements and priority for major movements		<ul style="list-style-type: none"> <li>Atypical design</li> <li>Driver expectation</li> </ul>	1-Poor Opportunity
<b>Function: Improve Safety</b>				
IS-1	Eliminate the high friction surface application	<ul style="list-style-type: none"> <li>Reduces maintenance</li> </ul>	<ul style="list-style-type: none"> <li>May not address wet weather / road departure crashes</li> </ul>	2-Good idea for design team to pursue
IS-2	Install lighting at select high-crash frequency locations. Consider solar / LED	<ul style="list-style-type: none"> <li>Improves driver awareness and visibility</li> </ul>	<ul style="list-style-type: none"> <li>Increases maintenance</li> <li>Light pollution / impacts to properties</li> </ul>	3-Good Opportunity



**Table 9. Idea Evaluation Summary Table**

Idea #	Description	Advantages	Disadvantages	Rating
IS-3	Install delineators / barriers to prevent passing at select high-crash frequency locations	<ul style="list-style-type: none"> <li>Prevents drivers from attempting to pass</li> </ul>	<ul style="list-style-type: none"> <li>Increases maintenance / potential barrier strikes</li> <li>Reduces clear zone</li> </ul>	1-Poor Opportunity
IS-4	Install active advance warning system for oncoming traffic at passing zones	<ul style="list-style-type: none"> <li>Improves driver awareness</li> </ul>	<ul style="list-style-type: none"> <li>Requires periodic maintenance</li> <li>Warning system / monitor system may not be commercially available</li> <li>Requires utility connection / power</li> </ul>	2-Good idea for design team to pursue
IS-5	Improve the superelevation of select curves in Section 3 in lieu of friction course	<ul style="list-style-type: none"> <li>Reduces maintenance on friction course</li> <li>Reduces reliance on surface treatment for operational benefits</li> </ul>	<ul style="list-style-type: none"> <li>Increases MOT</li> <li>Increase initial costs</li> <li>May increase ROW impacts</li> </ul>	2-Good idea for design team to pursue
IS-6	Improve signage / information to drivers of upcoming passing opportunities	<ul style="list-style-type: none"> <li>Improved driver awareness</li> <li>Less potential for passing attempts outside of passing zones</li> </ul>		2-Good idea for design team to pursue
IS-7	Improve signage at all spot locations with flashing beacons and lighted signs	<ul style="list-style-type: none"> <li>Improved driver awareness</li> <li>Less potential for passing attempts outside of passing zones</li> </ul>		2-Good idea for design team to pursue
IS-8	Provide a refuge area (two stage) for left turning traffic onto KY 210 (i.e. at KY 470 and 569)	<ul style="list-style-type: none"> <li>Provides area for turning traffic</li> </ul>		2-Good idea for design team to pursue
IS-9	Provide spot improvements at Middle Pitman Creek and KY 883 in lieu of 2+1 widening	<ul style="list-style-type: none"> <li>Reduced cost and impacts</li> </ul>	<ul style="list-style-type: none"> <li>Continuity of 2+1 configuration</li> </ul>	2-Good idea for design team to pursue



**Table 9. Idea Evaluation Summary Table**

Idea #	Description	Advantages	Disadvantages	Rating
IS-10	Relocate the driveway at Middle Pitman Creek to improve sight distance	<ul style="list-style-type: none"> <li>Improves sight distance / turning movement from driveway</li> </ul>	<ul style="list-style-type: none"> <li>Potential ROW impacts</li> <li>May conflict with side slope improvements in this location</li> </ul>	1-Poor Opportunity
IS-11	Provide emergency truck stopping capabilities in Section 2		<ul style="list-style-type: none"> <li>Grades max at 6% do not require</li> </ul>	1-Poor Opportunity
<b>Function: Mitigate Risk</b>				
MR-1	Defer improvements of 2+1 configuration in select locations to future phases	<ul style="list-style-type: none"> <li>Provides programming for future improvements</li> <li>Provides interim improvements sooner</li> </ul>	<ul style="list-style-type: none"> <li>Delays passing opportunities improvements to the future</li> </ul>	1-Poor Opportunity
MR-2	Perform additional surveys to verify edge of full-depth pavement	<ul style="list-style-type: none"> <li>Reduces milling and identifying EOP during construction</li> <li>Improves quantity / bid accuracy</li> </ul>	<ul style="list-style-type: none"> <li>Increase project development time and cost</li> </ul>	2-Good idea for design team to pursue
MR-3	Increase geotechnical investigation relative to identifying potential for New Albany Shale / sulfuric acid	<ul style="list-style-type: none"> <li>Reduces risk</li> </ul>		2-Good idea for design team to pursue
MR-4	Increase onsite disposal of excavated spoils in lieu of offsite disposal / hauling	<ul style="list-style-type: none"> <li>Reduces permitting requirements to Contractor</li> <li>Reduces hauling / roadway impacts</li> </ul>	<ul style="list-style-type: none"> <li>Requires area applicable for spoils disposal</li> </ul>	2-Good idea for design team to pursue
MR-5	Detour traffic to alternative state routes during construction	<ul style="list-style-type: none"> <li>May reduce construction schedule</li> </ul>	<ul style="list-style-type: none"> <li>Increases travel times</li> </ul>	1-Poor Opportunity
MR-6	Revise the rumble strip and striping configuration to provide striping on high side of groove	<ul style="list-style-type: none"> <li>Improves longevity / maintenance of striping</li> <li>Improve visibility</li> </ul>	<ul style="list-style-type: none"> <li>Minor cost impact</li> </ul>	2-Good idea for design team to pursue



**Table 9. Idea Evaluation Summary Table**

Idea #	Description	Advantages	Disadvantages	Rating
MR-7	Defer the water line utility work in Section 2 to contractor in lieu of by others	<ul style="list-style-type: none"> <li>Reduces risk relocation is done before letting</li> <li>Project letting schedule benefits</li> </ul>	<ul style="list-style-type: none"> <li>Potential ownership issues</li> <li>Potential increase costs</li> </ul>	2-Good idea for design team to pursue
MR-8	Pursue additional funding opportunities for safety improvements	<ul style="list-style-type: none"> <li>Reduces risk</li> </ul>		2-Good idea for design team to pursue
<b>Function: Reduce Impacts</b>				
RI-1	Reduce the design speed at select locations	<ul style="list-style-type: none"> <li>Reduces earthwork quantities</li> <li>Allows for maintaining existing profiles (reduced impacts)</li> </ul> Potential traffic calming	<ul style="list-style-type: none"> <li>Drivers may exceed design speeds</li> </ul>	1-Poor Opportunity
RI-2	Provide drainage for existing subgrade with French drain in lieu of daylighting shoulders	<ul style="list-style-type: none"> <li>Reduces CSB / subgrade quantities</li> </ul>	<ul style="list-style-type: none"> <li>Increase construction complexity / drainage installation</li> </ul>	3-Good Opportunity
RI-3	Eliminate fill over existing benched side slopes			1-Poor Opportunity
RI-4	Use granular embankment and geotextile for sliver fills in lieu of benching side slopes	<ul style="list-style-type: none"> <li>Reduce earthwork quantities</li> </ul>	<ul style="list-style-type: none"> <li>Potential increase in maintenance / erosion</li> </ul>	3-Good Opportunity
RI-5	Use barn roof fill slope to limits of clear zone and eliminate guard rail	<ul style="list-style-type: none"> <li>Allows onsite spoils disposal</li> <li>Reduces maintenance and guard rail strikes</li> </ul>	<ul style="list-style-type: none"> <li>May require additional area / ROW</li> </ul>	3-Good Opportunity
RI-6	Steepen side slopes to maximum allowable grade	<ul style="list-style-type: none"> <li>Reduce footprint / impacts / cost</li> </ul>	<ul style="list-style-type: none"> <li>Potential increase in maintenance / erosion</li> </ul>	1-Poor Opportunity
RI-7	Eliminate removal and reset of existing guardrail (Section 2 - R7) and replace with new			2-Good idea for design team to pursue
RI-8	Reduce width of shoulders at select locations	<ul style="list-style-type: none"> <li>Reduces cost and impacts</li> </ul>	<ul style="list-style-type: none"> <li>Reduce safety and reduced refuge area</li> </ul>	1-Poor Opportunity



**Table 9. Idea Evaluation Summary Table**

Idea #	Description	Advantages	Disadvantages	Rating
RI-9	Revise typical section to fit within existing flow lines in Section 1 and 3	<ul style="list-style-type: none"> <li>• Reduce cost and impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Reduced shoulder widths in areas</li> <li>• Reduces consistency of roadway section</li> </ul>	3-Good Opportunity
<b>Function: Separate Traffic</b>				
ST-1	Restripe 2+1 for left turn lanes at select spot improvement locations	<ul style="list-style-type: none"> <li>• Eliminates duplicated work at spot locations</li> <li>• Improves roadway consistency through the corridor</li> </ul>	<ul style="list-style-type: none"> <li>• 2+1 and left turn lane striping/transitions may not correct issues causing crashes</li> </ul>	1-Poor Opportunity
ST-2	Improve shoulders and provide widened bulb out / passing blister at select high-crash frequency locations for select spot improvements as interim / early phase	<ul style="list-style-type: none"> <li>• Reduced cost and impacts (over proposed spot improvements)</li> </ul>	<ul style="list-style-type: none"> <li>• Limited distance for passing at speed</li> <li>• Driver expectancy impacts / learning curve</li> </ul>	1-Poor Opportunity
ST-3	Reduce / eliminate 3' buffer zone between opposing traffic lanes in 2+1	<ul style="list-style-type: none"> <li>• Reduce cost and impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Reduces separation between opposing traffic</li> <li>• Buffer makes construction easier with extra space</li> </ul>	1-Poor Opportunity
<b>Function: Support Loads</b>				
SL-1	Maintain 2' stone base shoulder width at guard rail locations	<ul style="list-style-type: none"> <li>• Reduces base quantities</li> </ul>	<ul style="list-style-type: none"> <li>• Potential increase in maintenance / erosion</li> </ul>	3-Good Opportunity
SL-2	Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections	<ul style="list-style-type: none"> <li>• Reduces cost and impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Increase maintenance</li> <li>• Potential erosion</li> </ul>	3-Good Opportunity
SL-3	Provide full depth shoulders at key intersections to support right turn movements	<ul style="list-style-type: none"> <li>• Provides support for traffic to use the shoulders</li> </ul>	<ul style="list-style-type: none"> <li>• Increase cost</li> <li>• Limited traffic volumes to justify</li> </ul>	1-Poor Opportunity
SL-4	Maximize the AC pavement and reduce quantities of cement stabilized base		<ul style="list-style-type: none"> <li>• Limited cost benefit</li> </ul>	1-Poor Opportunity



**Table 9. Idea Evaluation Summary Table**

Idea #	Description	Advantages	Disadvantages	Rating
SL-5	Revise limits of cement stabilized base in the typical sections	<ul style="list-style-type: none"> <li>• Reduced quantities and costs</li> </ul>		3-Good Opportunity
SL-6	Maximize the quantity of rock base and reduce the thickness of AC		<ul style="list-style-type: none"> <li>• Limited cost benefit</li> </ul>	1-Poor Opportunity
SL-7	Provide alternative subbase treatment (geogrid, etc.) in lieu of CSB	<ul style="list-style-type: none"> <li>• Reduces AC quantities</li> <li>• Reduce roadway excavation</li> <li>• Reduce construction time</li> </ul>	<ul style="list-style-type: none"> <li>• Potential cost increase for geogrid</li> </ul>	2-Good idea for design team to pursue



## 7 Development Phase

This phase of the Value Methodology Job Plan takes the ideas that ranked the highest in the Evaluation Phase and further develops them into VE Alternatives. In many cases, it is possible that one or more ideas were combined to form an overall alternative, which was then evaluated further by the VE team.

In the case of this project, of the 42 ideas that were generated during the Creativity Phase, 10 of those ideas were evaluated high enough to be taken forward, combined, and developed further. Some of the ideas were deemed more appropriate as a design consideration for the project team, rather than developed into a VE alternative (Section 7.5). For the Development Phase, narratives, drawings, calculations, and cost estimates were prepared for each alternative.

Each alternative consists of a summary of the baseline concept, a description of the suggested change, a listing of its advantages and disadvantages, discussion of schedule and risk impacts (if applicable), a cost comparison, change in performance, and a brief narrative comparing the baseline design with the alternative. Sketches, calculations, and performance measure ratings are also presented. The cost comparisons reflect a comparable level of detail as in the baseline estimate.

### 7.1 Summary of VE Alternatives

The alternatives developed by the VE team are shown in Table 10. The table summarizes each alternative's cost impact and performance trade-offs. The alternatives are organized by category based on the project feature/project location or aspect of the project being addressed.

The alternatives identified all consider multiple aspects of total value, including assessing the impacts to performance, cost, time, and risk in comparison to the baseline concept. The potential of each alternative summarized in Table 10 is based on the following:

- Initial Cost Savings Potential – A quantified indication of the alternative's impact to the project's initial cost in comparison with the baseline concept. Initial cost savings are conceptual and reflective of the VE team's parametric estimation of possible savings and represent orders of magnitude cost impact of the VE alternative. Because the cost data depicted represent savings, a number in parentheses represents a cost increase.]
- Performance/Risk – A qualitative summary of the performance impacts of the VE alternative in comparison with the baseline concept. Performance attributes include the following: MO – Main Line Operations, LO – Local Operations, M – Maintainability, CI – Temporary Construction Impacts, and EI – Environmental Impacts. Refer to the Project Analysis section of this report for additional explanation of the performance attributes identified. Certain alternatives include a qualitative summary of the result of VE alternative to change the probability or degree of magnitude/impact on the project's total risk exposure relative to the baseline concept.



**Table 10. Summary of Alternatives**

<b>Alt No.</b>	<b>Alternative Title</b>	<b>Cost Savings or (Cost Added)</b>	<b>Performance/Risk</b>
<b>Improve Passing Opportunities</b>			
IPO-1	Provide passing lanes at select locations in lieu of continuous 2+1 throughout	\$20,110,000	Improved (M, CI, EI) Reduced (MO)
IPO-2	Confine typical section to existing flowlines	\$403,000	Improved (MO, LO, Risk) Reduced (M)
<b>Spot Improvement Modifications</b>			
SI-1	Install lighting at select high-crash frequency locations. Consider solar / LED	(\$288,000)	Improved (MO, LO) Reduced (M)
SI-2	Revise Lincoln Parkway intersection with KY 210 with prioritized movements	\$12,000	Improved (MO, LO)
SI-3	Use barn roof fill slope to limits of clear zone and eliminate guard rail	\$1,414,000	Improved (MO, LO, M) Reduced (EI)
<b>Typical Section Modifications</b>			
TS-1	Provide drainage for existing subgrade with French drain in lieu of daylighting shoulders	\$1,507,000	Improved (M)
TS-2	Revise limits of cement stabilized base	\$2,075,000	No change
TS-3	Maintain 2' stone base shoulder width at guard rail locations	\$179,000	Improved (Schedule) Reduced (M)
TS-4	Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections	\$422,000	Reduced (MO, M)
TS-5	Use granular embankment and geotextile for sliver fills	\$2,368,000	Reduced (M)

## 7.2 Individual Alternatives

Based on the evaluation process, individual alternatives were developed. Each alternative consists of a summary of the baseline concept, a description of the alternative, a listing of its advantages and disadvantages, and a brief narrative that includes justification, sketches, photos, assumptions, and calculations as developed by the VE team..

## **VE ALTERNATIVE IPO-1**

### **Provide Passing lanes at select locations in lieu of continuous 2+1 throughout**

---

#### **Description of Baseline Concept:**

The baseline concept for KY 210 is to upgrade the typical section from the current 2-lane configuration(s) to a “2+1” configuration throughout the entirety of the project area.

#### **Description of Alternative Concept:**

This alternative proposes a compromise between the existing 2-lane typical cross-section(s) and the “2+1” cross-section by retaining the proposed “2+1” cross-section throughout Section 2 and recommending passing lanes intermittently in Sections 1 and 3 without the entire corridor being widened. This creates opportunities to pass however at a lower frequency.

#### **Advantages:**

- Reduces construction costs
- Provides passing opportunities to accomplish operational concerns
- Allows for future implementation of “2+1” concept

#### **Disadvantages:**

- Does not provide the consistent “2+1” typical cross-section
- May require more passing opportunities to fully address capacity concerns

#### **Discussion:**

The baseline configuration is costly across all three sections as it requires roadway widening to accommodate the additional lane (resulting in 3 11' lanes) and shoulders (8' on each side). The main objective of this configuration is to provide alternating passing lanes in each direction. These passing lanes will provide improved operations and help reduce platooning and unsafe passing as is present on the 2-lane configuration.

Main objectives of the project are to improve operations and safety, which are currently facilitated through much of the roadway length in providing safe passing opportunities. Reducing the scope from a complete “2+1” widening to occasional passing lanes may help to achieve the project goals at a lower overall cost.

As shown in the sketch, there are ample areas to fit 1.5-2.0 mi (as recommended per research) passing lane opportunities in either direction across sections 1 and 3. However, it could be possible that in these sections some of the widening options could be reduced to maintain safe passing areas along segments where there is adequate sight distance. Further analysis could dictate the application of that in either or both directions. In addition to the passing lanes, signage should be included to alert drivers of distance to the next passing lane or safe passing opportunity to improve awareness and decision-making.

#### **Discussion of Schedule Impacts:**

Potential for reduced construction time due to a lower overall project footprint and extent.

#### **Discussion of Risk Impacts:**

The primary risk associated with this alternative is that it limits the extensiveness of the operational improvements present with the baseline concept.

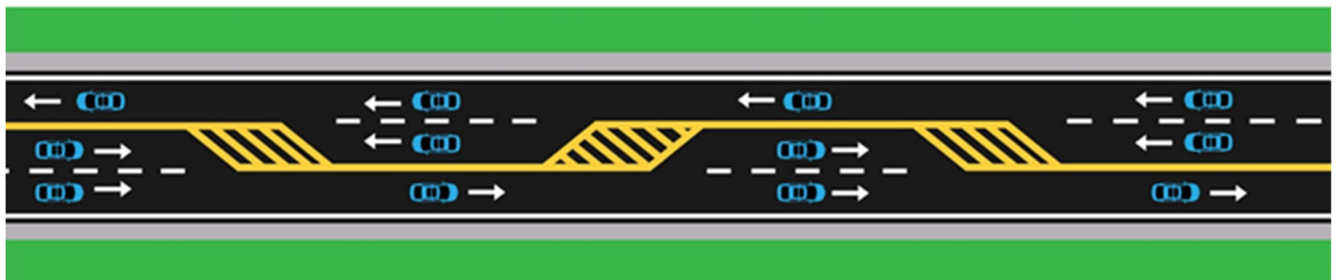
## VE ALTERNATIVE IPO-1

### Provide Passing lanes at select locations in lieu of continuous 2+1 throughout

#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> Reduced. Mainline operations are potentially reduced from baseline with less passing lanes throughout the corridor.
<b>Local Operations</b> Improved. Local operations may ease for turning movements to and from local roads and driveways where multiple lanes must be crossed.
<b>Maintainability</b> Improved. Maintainability is expected to increase with less overall pavement and roadway to be maintained when compared to baseline.
<b>Construction Impacts</b> Improved. Construction impacts would be reduced with a smaller footprint of construction.
<b>Environmental Impacts</b> Improved. Environmental impacts would be somewhat reduced from smaller project footprint.

#### Baseline Concept Sketch



## VE ALTERNATIVE IPO-1

Provide Passing lanes at select locations in lieu of continuous 2+1 throughout

### VE Alternative Concept Sketch



- NB Passing Lane
- SB Passing Lane
- Section 2 – Maintained as Continuous 2+1
- 

Each passing lane is approximately 1.5mi in length per the TTI recommendation from research, with approx. 4mi between each per direction. This allows to easily fit 3 or 4 in each direction, could potentially fit another if needed.

## VE ALTERNATIVE IPO-1

Provide Passing lanes at select locations in lieu of continuous 2+1 throughout

### Assumptions and Calculations:

#### LENGTH AND SPACING OF PASSING LANES

Based on the research conducted, recommendations for the following values of length and spacing of passing lanes are shown in Table 17. The values in the table were developed based on the premise of minimizing cost and percent time delay. These values are generally longer than those values of Harwood and Hoban, reflecting current higher speed limits for rural roads than the speed limits present during their research (10). Conversion of Super 2 roadways to four-lane highways should be considered when traffic volumes exceed 6000 ADT for level terrain and 5000 ADT in rolling terrain.

**Table 17. Recommended Values of Length and Spacing by ADT and Terrain.**

ADT (vpd)		Recommended Passing Lane Length (mi)	Recommended Distance Between Passing Lanes (mi)
Level Terrain	Rolling Terrain		
≤ 1950	≤ 1650	0.8-1.1	9.0-11.0
2800	2350	0.8-1.1	4.0-5.0
3150	2650	1.2-1.5	3.8-4.5
3550	3000	1.5-2.0	3.5-4.0

Reference: <https://static.tti.tamu.edu/tti.tamu.edu/documents/4064-1.pdf>

Using the known costs from the baseline condition, a percentage of the costs were assumed based on the percentage of passing lane length as compared with the segment length from the baseline condition. Table below shows this percentage.

Segment	# of Passing Lanes	Length of Passing (mi)	Total Length (mi)	% Passing
3	5	7.5	13.55	55%
1	2	3	7.64	39%

**VE ALTERNATIVE IPO-1**

**Provide Passing lanes at select locations in lieu of continuous 2+1 throughout**

**Initial Cost Estimate**

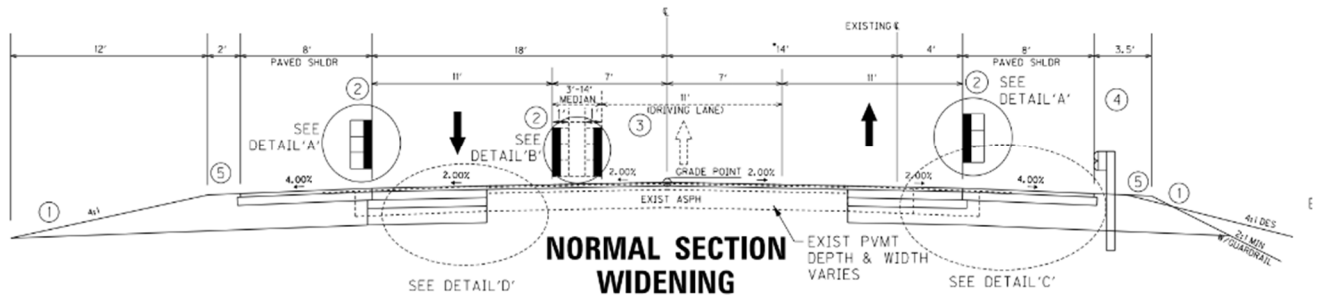
<i>CONSTRUCTION ELEMENT</i>		<i>BASELINE CONCEPT</i>			<i>ALTERNATIVE CONCEPT</i>		
<i>Description</i>	<i>Unit</i>	<i>Qty</i>	<i>Cost/Unit</i>	<i>Total</i>	<i>Qty</i>	<i>Cost/Unit</i>	<i>Total</i>
Pavement - Section 3		1.00		\$23,798,485	0.55		\$ 13,174,538
Pavement - Section 1		1.00		\$11,214,425	1.00		\$ 11,214,425
Pavement - Section 2		1.00		\$5,977,099	0.39		\$ 2,347,028
Earthwork - Section 3		1.00		\$4,887,255	0.55		\$ 2,705,522
Earthwork - Section 2		1.00		\$4,661,795	1.00		\$ 4,661,795
Traffic Items - Section 2		1.00		\$1,811,844	1.00		\$ 1,811,844
Earthwork - Section 1		1.00		\$1,731,014	0.39		\$ 679,718
Mobilization/Demob - Section 2		1.00		\$585,017	1.00		\$ 585,017
Drainage - Section 2		1.00		\$549,659	1.00		\$ 549,659
<b>SUB-TOTAL</b>				\$55,216,593			\$37,729,546
<b>PROJECT MARK-UPS</b>	15%			\$8,282,489			\$5,659,432
<b>TOTAL (Rounded)</b>				\$63,499,000			\$43,389,000
						<b>SAVINGS</b>	<b>\$20,110,000</b>

## VE ALTERNATIVE IPO-2

### Confine typical section to existing flowlines

#### Description of Baseline Concept:

The baseline concept places a typical section along the alignment and does not deviate from it through the entire length of the project. This results in unnecessary cuts that could otherwise be avoided by modifying the typical sections through a shortened and/or steepened fore slope.



#### Description of Alternative Concept:

The alternative concept would flex the fore slope length and slope in areas that would allow the proposed roadway template to follow the alignment but stay within the existing defined flow lines. This alternative mainly applies to Sections 1 & 3.

#### Advantages:

- Reduce Right of Way impacts
- Reduce Utility impacts
- Reduce environmental impacts
- Reduce pipe extensions

#### Disadvantages:

- Could reduce clear zone
- Reduces consistency of roadway
- More technical to lay out in the field vs. typical section all throughout

#### Discussion:

The existing roadway template is generally (2) 11' or 12' lanes, with 10' shoulders. The existing fore slopes are fairly flat with adequate drainage for the roadway. The baseline sits on top of the existing template well with minimal fill on the fore slopes. In many areas the baseline 12' fore slope results in a ditch being forced beyond the existing flow line, resulting in "sliver" cuts occurring. These can be eliminated through the use of a variable length and slope fore slope.

#### Discussion of Schedule Impacts:

The overall project will benefit from the implementation of this alternative. Keeping the proposed roadway template within the existing flow lines makes permitting for environmental much simpler, reduces schedule risks due to utility impacts, and creates less excavation for the contractor to perform.

## VE ALTERNATIVE IPO-2

### Confine typical section to existing flowlines

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#### Discussion of Risk Impacts:

Utility impacts are a big risk on every project of this type. By keeping the roadway footprint narrow, the risk of impacting existing utilities are greatly reduced. The roadway remains within an existing disturbed area, so encountering rock or unknown materials is less likely, reducing the risk of a change order from the contractor. Some areas will have to be compared to crash history to make sure clear zone does not come into play in certain areas.

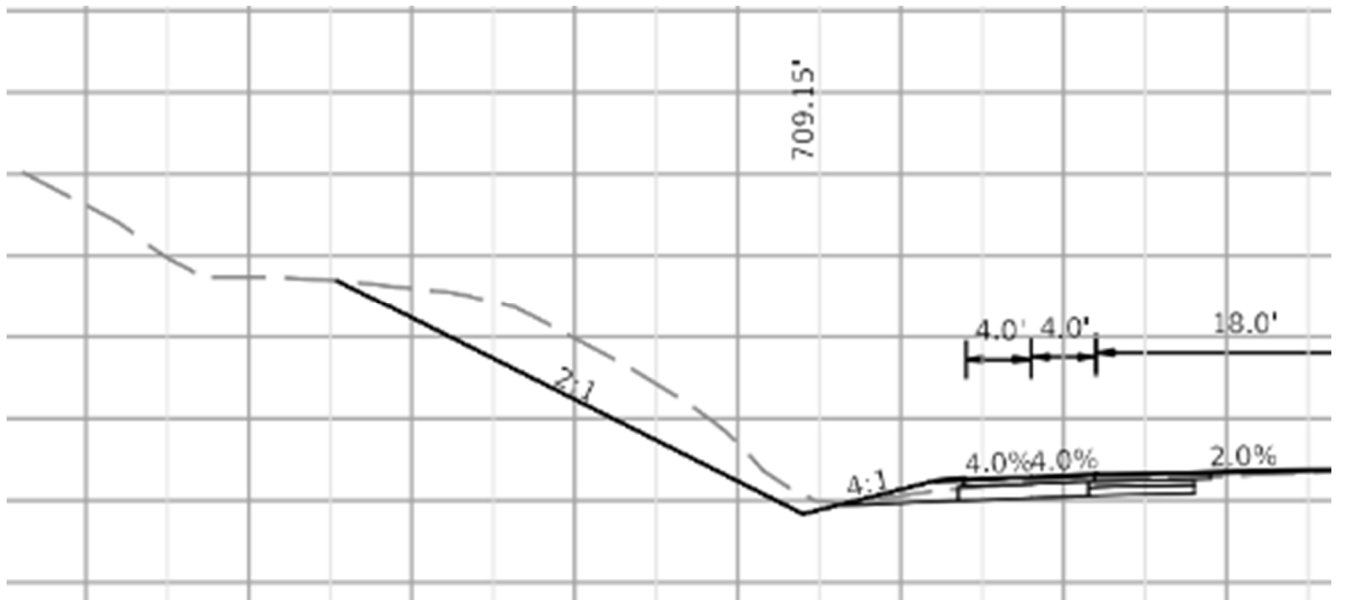
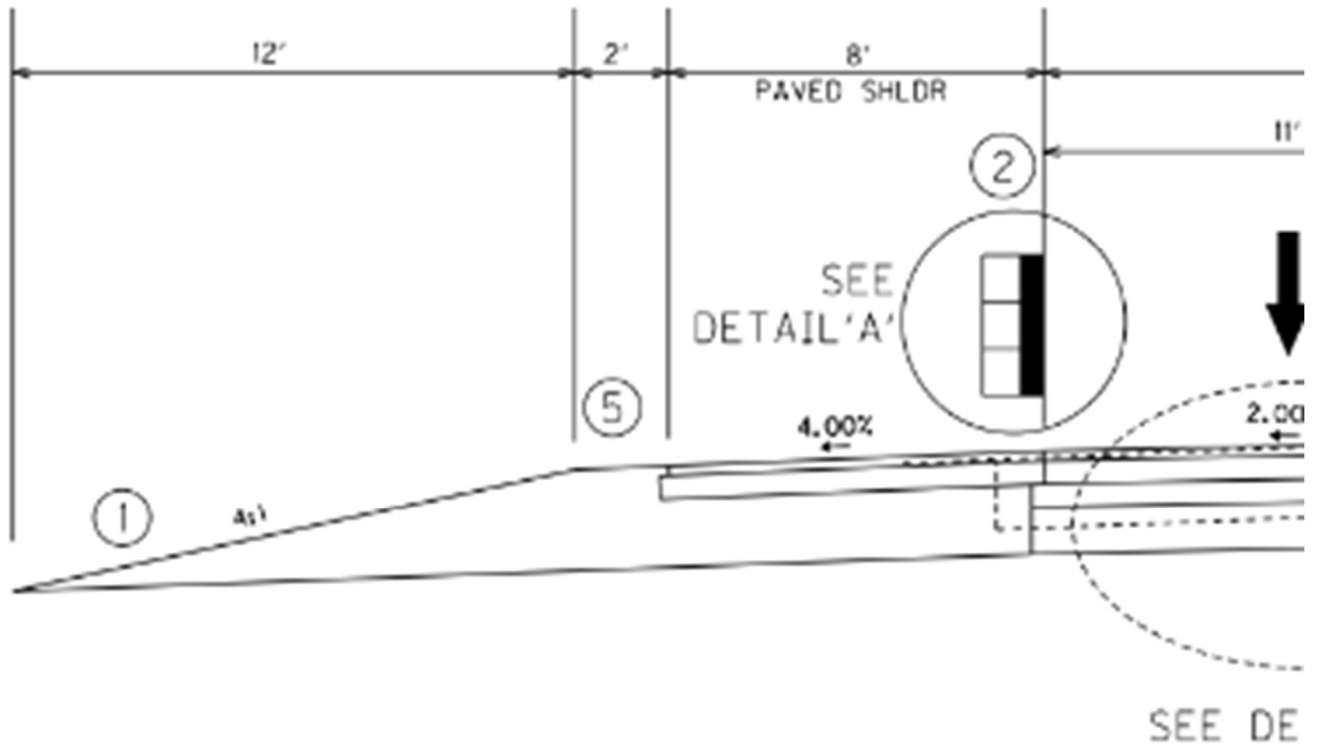
#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> No Change. Mainline will operate the same as baseline, except for the potential reduction of clear zone in some areas.
<b>Local Operations</b> No Change. Local roads will see little to no effect from the alternative.
<b>Maintainability</b> No Change. Foreslopes will remain within a recoverable range, so no additional maintenance concerns are present.
<b>Construction Impacts</b> Improved. Construction could potentially be expedited by eliminating the "sliver" backslopes in the baseline.
<b>Environmental Impacts</b> Improved. Environmental impacts could be greatly reduced due to the alternative residing within the existing roadway template.

VE ALTERNATIVE IPO-2

Confine typical section to existing flowlines

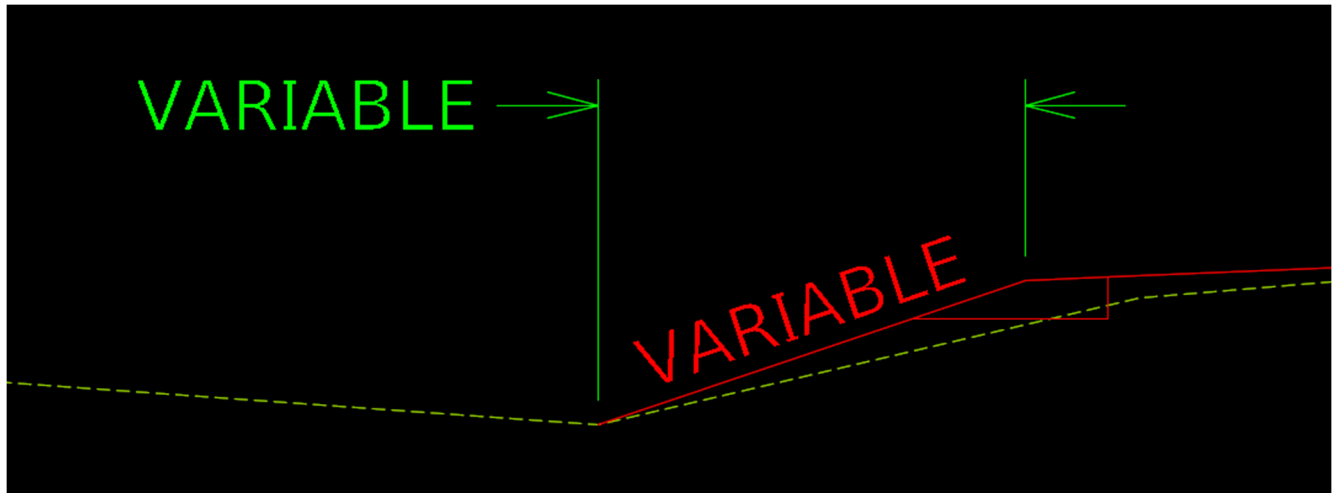
Baseline Concept Sketches



**VE ALTERNATIVE IPO-2**

**Confine typical section to existing flowlines**

**VE Alternative Concept Sketch**



**Assumptions and Calculations:**

It is assumed that the fore slope will only be altered in areas that would result in adequate ditch depth and remove the “sliver” cuts from baseline. Cross sections are not available for Section 1, so assumptions have been made for the quantities that would be eliminated. As a standalone concept only evaluating the cross sections for earthwork, the savings are minimal. However, when considering the potential utility and Right of Way impacts once those are known, the alternative case could result in large savings.

**Initial Cost Estimate**

CONSTRUCTION ELEMENT		BASELINE CONCEPT			ALTERNATIVE CONCEPT		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Roadway Excavation	CUYD	7,500	\$ 13.41	\$ 100,575	7,500	\$ -	\$ -
Utility Impacts	LS	1	\$ 200,000	\$ 200,000			\$ -
Right of Way Impacts	LS	1	\$ 50,000	\$ 50,000			\$ -
<b>SUB-TOTAL</b>				\$350,575			\$0
<b>PROJECT MARK-UPS</b>		15%		\$52,586			\$0
<b>TOTAL (Rounded)</b>				\$403,000			\$0
						<b>SAVINGS</b>	<b>\$403,000</b>

## VE ALTERNATIVE SI-1

### Install lighting at high-frequency crash locations

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#### Description of Baseline Concept:

The baseline concept does not feature roadway lighting throughout the entirety of the project area.

#### Description of Alternative Concept:

Install roadway lighting in specific high crash frequency or increased crash risk areas. Primarily utilize solar lighting options to offset costs for wiring/power.

#### Advantages:

- Illuminates roadway to improve driver visibility
- Improves safety at known crash or risk locations

#### Disadvantages:

- Additional cost to project

#### Discussion:

Roadway lighting can help to improve roadway safety by reducing nighttime crashes by up to 38% based on FHWA studies.

The safety analysis shows 38 nighttime crashes over the past 5-year period (detailed in the safety analysis summary). These crashes were distributed throughout the corridor and of various severities and crash types. While some of these crashes were animal collisions, which lighting may still have advantages in prevention). While the FHWA study and others show a reduction of up to 38% of crashes, it is likely not appropriate to assume the full benefit based on the baseline conditions. The baseline scenario will improve safety throughout the corridor with the 2+1 configuration as it will provide passing opportunities to eliminate the need for passing in the oncoming lanes.

If then it was assumed that the lighting would have 50% of the available benefit (19% nighttime crash reduction) to account for the baseline configuration safety improvements, this would result in a reduction in approximately 7 crashes over a 5-year period. Then if applied to the average societal crash costs (blended for all severities - \$164,303), the cost savings due to crash reduction is approximately \$1.18M.

Assuming the cost of a light pole (either solar or powered or combination) is \$10,000 (KTC research estimate of \$5,000-\$6,000 per pole, so it was increased to be conservative and account for increased cost for solar options) and the installation of approximately 25 lights along the corridor. The overall cost would result in \$288,000 added to the baseline concept.

However, if this added cost were compared against the crash cost savings, the benefit-cost ratio is 4.1-to-1 or a savings of approximately \$900,000. This is accounting for conservative estimate of benefits for the crash benefit and only accounting for 5-years of crashes for a 20- or 30-year project lifespan. The estimate of the number of lights and the locations is a preliminary estimate and will likely need to be adjusted and/or increased throughout the project to provide optimal conditions. Even so, if the lighting were to double or triple in number and/or cost it would still show significant benefit for crash cost savings.

## VE ALTERNATIVE SI-1

### Install lighting at high-frequency crash locations

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#### Discussion of Schedule Impacts:

This concept is a bit of additional effort but should have negligible schedule impacts to overall project.

#### Discussion of Risk Impacts:

There is little risk to adding lighting to the project. If solar lighting is used there is less overall risk in that it is not a powered utility and is mainly self-sustaining. If powered, the power lines run adjacent to the roadway and should not require significant runs to implement. The highest risk of this alternative is that light poles can provide a safety hazard in the format of a fixed object adjacent to the roadway (in the clear zone), but the benefit of the lights significantly offsets this risk.

#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> Improved. Driver awareness and visibility will be increased
<b>Local Operations</b> Improved. Slight Improvement. Intersection lighting will improve visibility and may help reduce crashes.
<b>Maintainability</b> Reduced. Added elements of the light poles, solar panels, and equipment would increase the maintenance on the corridor.
<b>Construction Impacts</b> Reduced. Slight decrease. Additional installation required.
<b>Environmental Impacts</b> No Change. Environmental Impacts should not be a concern even from a light pollution since applications will be spread out through the corridor.

# VE ALTERNATIVE SI-1

## Install lighting at high-frequency crash locations

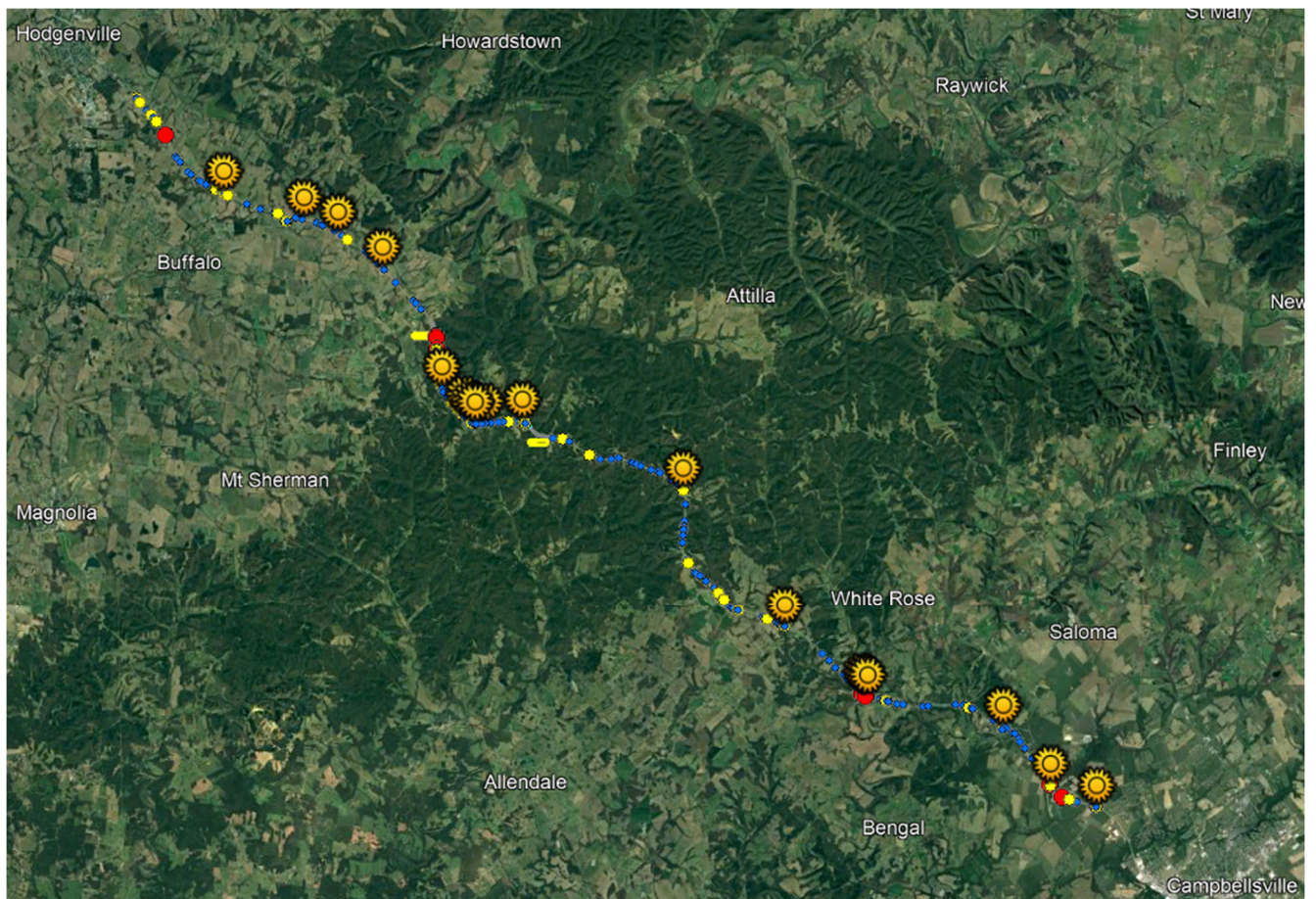
### Baseline Concept Sketch

Existing conditions.



### VE Alternative Concept Sketch

Potential lighting locations based on intersections, curves, and crash frequency:



## VE ALTERNATIVE SI-1

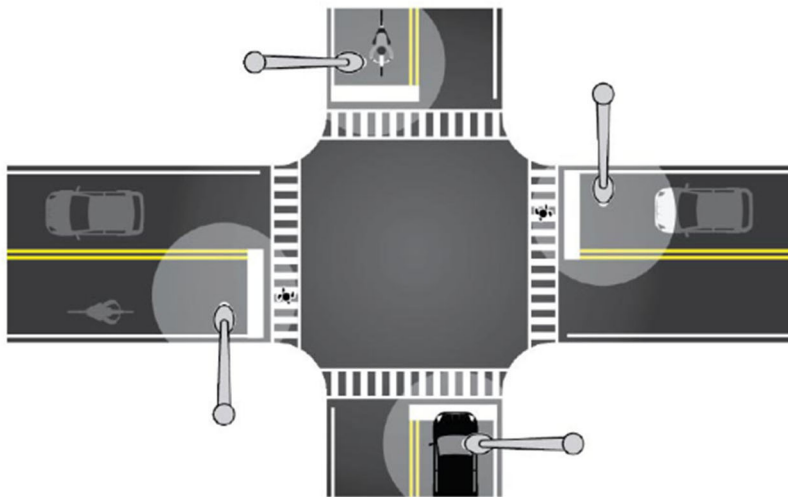
### Install lighting at high-frequency crash locations

FHWA Safety Guidance on Lighting Recommendations:

#### Lighting

The number of fatal crashes occurring in daylight is about the same as those that occur in darkness. However, the nighttime fatality rate is three times the daytime rate because only 25 percent of vehicle miles traveled (VMT) occur at night. At nighttime, vehicles traveling at higher speeds may not have the ability to stop once a hazard or change in the road ahead becomes visible by the headlights. Therefore, lighting can be applied continuously along segments and at spot locations such as intersections and pedestrian crossings in order to reduce the chances of a crash.

Adequate lighting (i.e., at or above minimum acceptable standards) is based on research recommending horizontal and vertical illuminance levels to provide safety benefits to all users of the roadway environment. Adequate lighting can also provide benefits in terms of personal security for pedestrians, wheelchair and other mobility device users, bicyclists, and transit users as they travel along and across roadways.



Source: FHWA



Safety Benefits:

**Lighting can reduce crashes up to:**

**42%**

for nighttime injury pedestrian crashes at intersections.<sup>1</sup>

**33-38%**

for nighttime crashes at rural and urban intersections.<sup>1</sup>

**28%**

for nighttime injury crashes on rural and urban highways.<sup>1</sup>

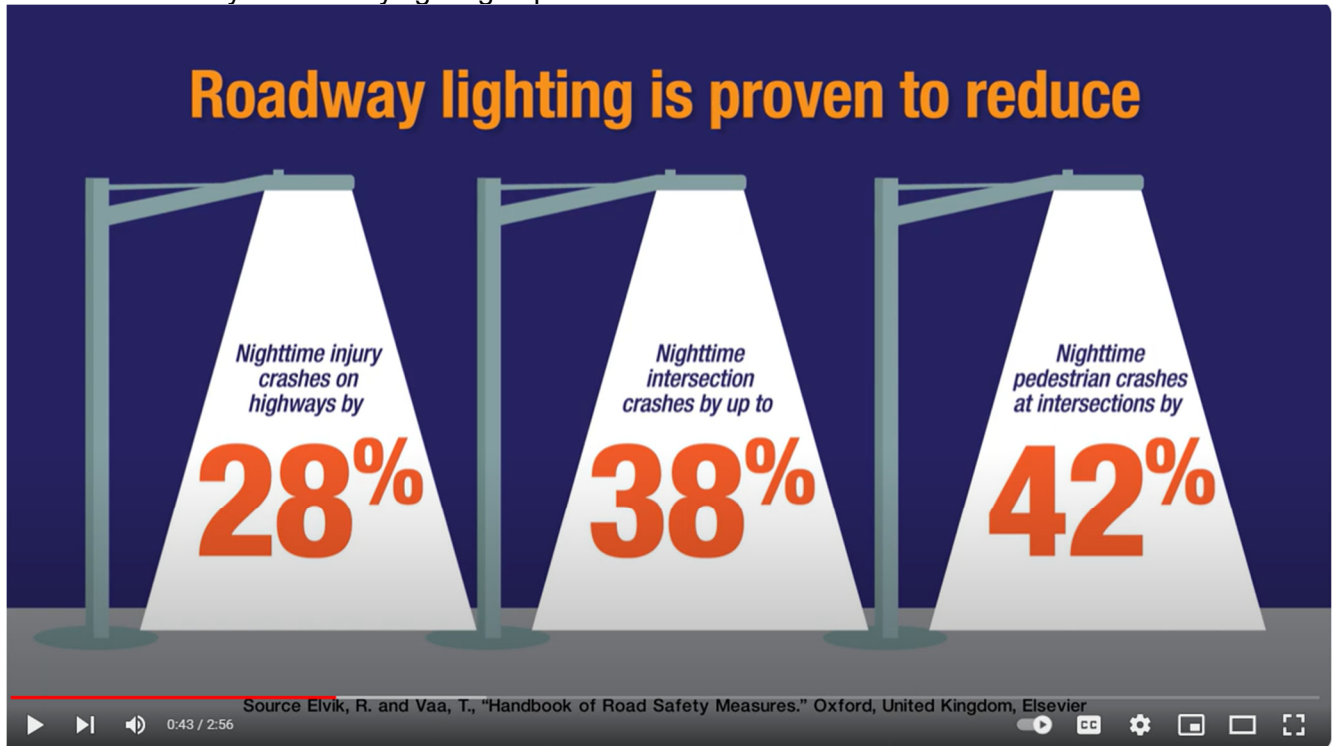
Reference: <https://safety.fhwa.dot.gov/provencountermeasures/lighting.cfm>

## VE ALTERNATIVE SI-1

### Install lighting at high-frequency crash locations

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FDOT Case study of roadway lighting improvements:



Reference: <https://www.youtube.com/watch?v=E0A6Ha5eQmo>

## VE ALTERNATIVE SI-1

### Install lighting at high-frequency crash locations

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Minnesota Study on Rural Roadway Lighting (Primarily at intersections):

#### **Literature Search**

1. The previously published safety research suggested that the installation of intersection lighting has resulted in 25 to 50 percent reductions in the night crash rate and 20 to 30 percent reductions in the night crash / total crash ratio.
2. A report prepared by the Federal Highway Administration documenting the effectiveness of various types of intersection and traffic control improvements found that intersection lighting had the highest benefit-cost ratio (21:1).

#### **Final Conclusions**

13. The results of the comparative and before versus after crash analyses suggest that street lighting does improve safety at rural intersections by reducing the frequency of all nighttime crashes, by reducing the frequency of both single and multiple vehicle crashes, and by reducing the severity of nighttime crashes. As a result, street lighting at rural intersections should be added to the traffic engineer's toolbox and agencies should be

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encouraged to increase the use of this strategy to address safety issues and improve motorist guidance.

14. A number of Minnesota counties indicated (in the survey of usage) that rumble strips and overhead flashing beacons were frequently used strategies for addressing rural intersection safety issues. It should be noted that recent case study research found that neither of these strategies has resulted in statistically significant crash reductions. Therefore, the data suggests that the use of street lighting to reduce nighttime crashes at rural intersections would likely be far more effective than either rumble strips or overhead flashing beacons.

Reference: <https://www.lrrb.org/pdf/199917.pdf>

## VE ALTERNATIVE SI-1

### Install lighting at high-frequency crash locations

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KYTC is utilizing solar lighting on recent project in D5:

<https://www.whas11.com/article/news/local/solar-power-lights-being-installed-across-louisville-highways-to-prevent-copper-wire-theft-interstate-64-portland/417-0c727782-921a-4cf8-9bf4-2a26905afb1b>

KTC Research on roadway lighting effectiveness and costs:

#### **4.1.4 Cost of Roadway Lighting**

One justification for highway lighting is in terms of a cost savings for property damage due to crash reductions. Although estimates vary, the savings can be enough to pay for a lighting installation in a few years.

Conventional roadway lighting usually refers to cobrahead lighting systems. General estimates place conventional lighting at \$5,000 - \$6,000 per pole. High-mast systems cost more per unit than conventional cobraheads. High-mast units cost a minimum of \$30,000 - \$40,000. However, with high-mast units, there are anywhere from 6 to 12 separate luminaires and maybe one-sixth as many lighting assemblies. With design and maintenance costs factored in, high-mast units generally have a 20 percent long-range savings over conventional methods (7).

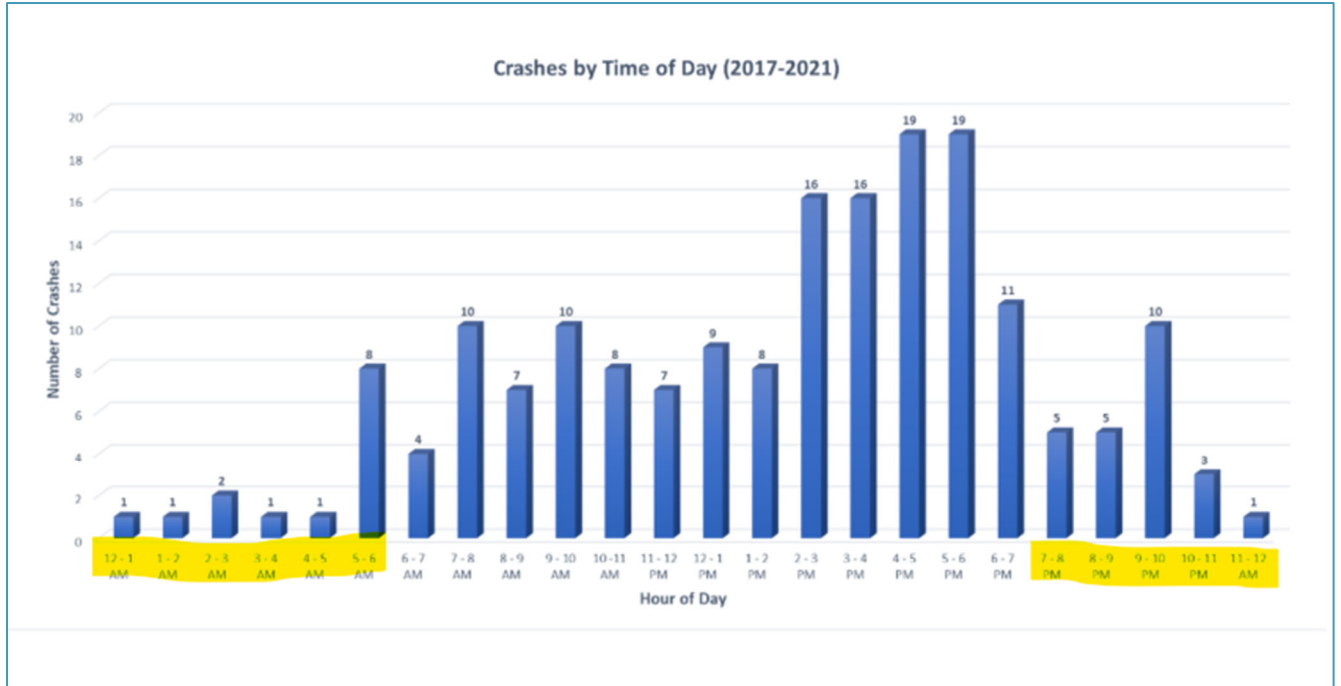
Where applicable, vertically lamped median-mounted lighting systems can reduce costs over traditional cobrahead lighting systems at a ratio of one median mount fixture for every two cobrahead fixtures. Besides a reduction in installation costs and energy consumption, a major benefit is 50 percent less maintenance. The median mount fixtures require that only one lane be closed, with all repairs made from that lane. The time required is cut in half, making the cost for closing the road 50 percent less. While the initial investment for a median mount lighting system may average 25 percent more, the cost can be justified by the savings incurred in operating and maintenance costs each year (8).

Reference:

[https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1238&context=ktc\\_researchreports](https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1238&context=ktc_researchreports)

**VE ALTERNATIVE SI-1**

**Install lighting at high-frequency crash locations**



Crash Cost Assumptions. From Mike Vaughn – KYTC HSIP, specific for district:

Severity Distribution			Severity Distribution		
	D-4	Roadway Departure		D-4	Intersection
Severity Code	# of Crashes	Total Cost	Severity Code	# of Crashes	Total Cost
K	142	\$1,456,976,564	K	77	\$790,050,672
A	382	\$227,152,820	A	281	\$167,094,090
B	694	\$124,963,535	B	909	\$163,677,022
C	855	\$97,311,628	C	1395	\$158,771,604
O	3962	\$42,436,150	O	11716	\$125,487,616
Weighted Average Costs			Weighted Average Costs		
	KA	\$3,213,987		KA	\$2,673,589
	KAB	\$1,485,298		KAB	\$884,627
	KABC	\$919,636		KABC	\$480,689
	KABCO	\$322,923		KABCO	\$97,724
	AB	\$327,246		AB	\$277,959
	ABC	\$232,744		ABC	\$189,378
	ABCO	\$83,466		ABCO	\$43,006
	CO	\$29,011		CO	\$21,681

**VE ALTERNATIVE SI-1**

**Install lighting at high-frequency crash locations**

Combining Roadway Departure (RD) and Intersection crash frequency creates a blended rate of \$164,303 for KABCO rate. This was used for crash cost savings estimation.

Crashes (5-year period)		Lighting		Benefit: Cost
Crashes	38	Light Poles	25	
Crash Reduction	0.18	Light Pole Costs	\$10,000	
	7			
Crash Costs (KABCO)	\$164,303			
<b>Crash Cost Savings</b>	<b>+\$1,186,267</b>	<b>Lighting Cost</b>	<b>-\$288,000</b>	<b>+\$898,267 (Ratio 4.1:1)</b>

**Assumptions and Calculations:**

Assumed to install approx. 18-25 lights throughout the corridor. Primarily focusing on intersections but also curves with crash history.

Assumed cost of \$10,000 per light. Conservative estimate to allow for cost increases and potential increased costs for solar lighting.

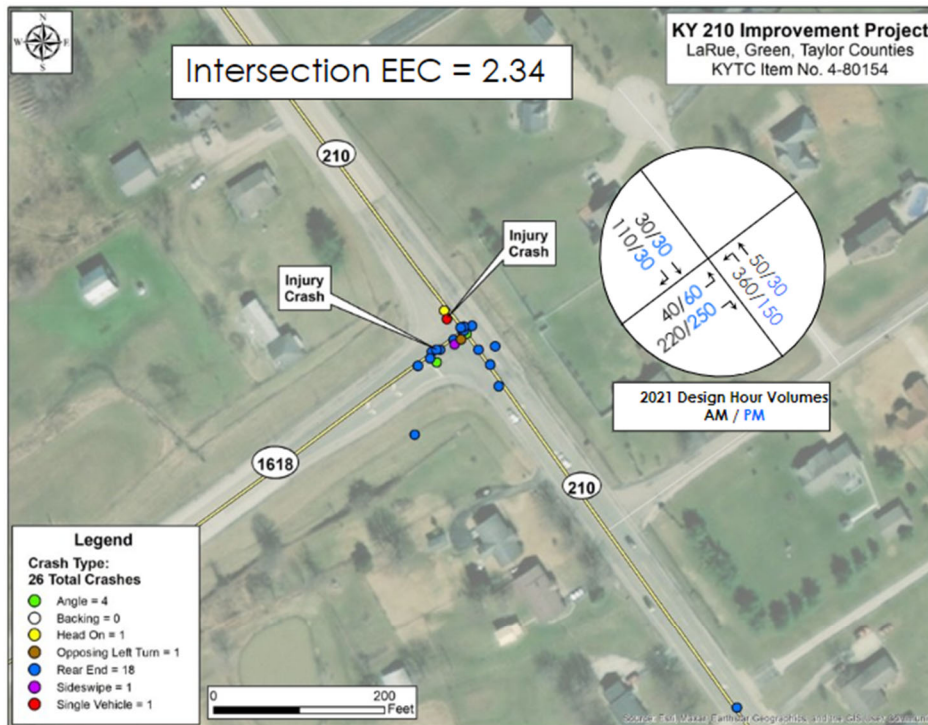
Nighttime crashes throughout the corridor account for approximately 38 of 264 crashes (14.4%). The lighting improvement would likely result in a reduction of these crashes.

**Initial Cost Estimate**

CONSTRUCTION ELEMENT		BASELINE CONCEPT			ALTERNATIVE CONCEPT		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Lights on Poles				\$ -	25	\$ 10,000	\$ 250,000
<b>SUB-TOTAL</b>				\$0			\$250,000
<b>PROJECT MARK-UPS</b>	15%			\$0			\$37,500
<b>TOTAL (Rounded)</b>				\$0			\$288,000
						<b>SAVINGS</b>	<b>(\$288,000)</b>

**Description of Baseline Concept:**

The existing condition consists of KY 1618 intersecting with KY 210. The movement from KY 1618 to KY 210 south is the dominant turning movement. The baseline concept is for minor widening to be constructed on the southwest portion of the intersection and re-striping to occur to re-direct traffic to a new pattern. The through movement will then be from KY 210 south onto KY 1618, with KY 210 north becoming a stop/yield condition. The through movement consists of a 25 mph curve. The estimated cost for the baseline improvement is \$500,000.



**Crash History**

- 26 Crashes (2017 – 2021)**
- 18 Rear End (69%), 4 Angle, 1 Opposing Left, 1 Head On, 1 Sideswipe, 1 Single Vehicle
  - 2 Injury (1 Rear End, 1 Single Vehicle)
  - 3 Nighttime
  - 3 Wet Roadway

**Spot Improvements**

- Intersection Reconfiguration

**Spot Improvement #1**  
**KY 210 at Lincoln Pkwy (KY 1618)**



**Reconstruct Intersection with a 25 MPH Curve**

## **VE ALTERNATIVE SI-2**

### **Revise Lincoln Parkway Intersection with KY 210**

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#### **Description of Alternative Concept:**

The alternative concept is to place a 95' ICD roundabout at the existing intersection location. The roundabout will accommodate a WB-67 design vehicle as preliminarily laid out. Additional truck aprons are provided for off-tracking. Lighting is already present at the location, so minimal work will be required to meet the lighting requirements.

#### **Advantages:**

- Improved traffic operations
- Improved safety
- Improved transition area / traffic calming
- Street lighting already present

#### **Disadvantages:**

- Potential ROW / utility impacts

#### **Discussion:**

The baseline concept is developed to place the priority movement as the turn from KY 210 to KY 1618. Based on turn counts, this is an appropriate solution. However, upon review the baseline striping configuration, the VE Team sees an opportunity to make the movement flow more intuitively utilizing a roundabout. The baseline striping configuration is very unorthodox and could confuse drivers considering the turning movement is 90°. Nighttime drivers are a concern with such a large amount of striping in a congested intersection.

A roundabout makes the turning movement much more intuitive, and with roundabouts becoming more prevalent in District 4, drivers will instinctively know how to get where they need to go. Traffic operations in general will benefit with the implementation of a roundabout versus a stop controlled intersection. Safety is also improved over a stop controlled intersection by construction of a roundabout due the splitter islands alerting motorists that something is coming up ahead instead of entering a stop controlled intersection in a 90° curve. Roundabouts are also very effective traffic calming measures which would be a benefit through this densely populated stretch of KY 210. Street lighting is already present at the intersection, so upgrades may be necessary, but the electric source is already present.

#### **Discussion of Schedule Impacts:**

The alternative concept of implementing a mini roundabout will impact MOT to a higher degree than just performing basic widening and striping at the intersection. There are viable detours in the area, so some turning movements can be detoured temporarily during construction to increase efficiency. If ROW and utility impacts occur, the area of the project could be delayed for construction until allocation/relocation occurs.

#### **Discussion of Risk Impacts:**

The largest risks involved to implement a mini roundabout are ROW and utility impacts. These could potentially increase the budget as well as schedule.

## VE ALTERNATIVE SI-2

### Revise Lincoln Parkway Intersection with KY 210

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#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> Mainline will operate much more smoothly with a roundabout versus the baseline striping reconfiguration.
<b>Local Operations</b> Local operations will not be directly impacted via the alternative, but the less traveled north approach of KY 210 will operate more efficiently than the baseline.
<b>Maintainability</b> A roundabout could potentially create more maintenance concerns versus just striping alone, with the greatest maintenance risk being the truck aprons cracking over time.
<b>Construction Impacts</b> Construction impacts will be larger when constructing a roundabout, however there are viable local detours etc. that can be put into place to mitigate.
<b>Environmental Impacts</b> The baseline and alternative have equivalent minimal environmental impacts.

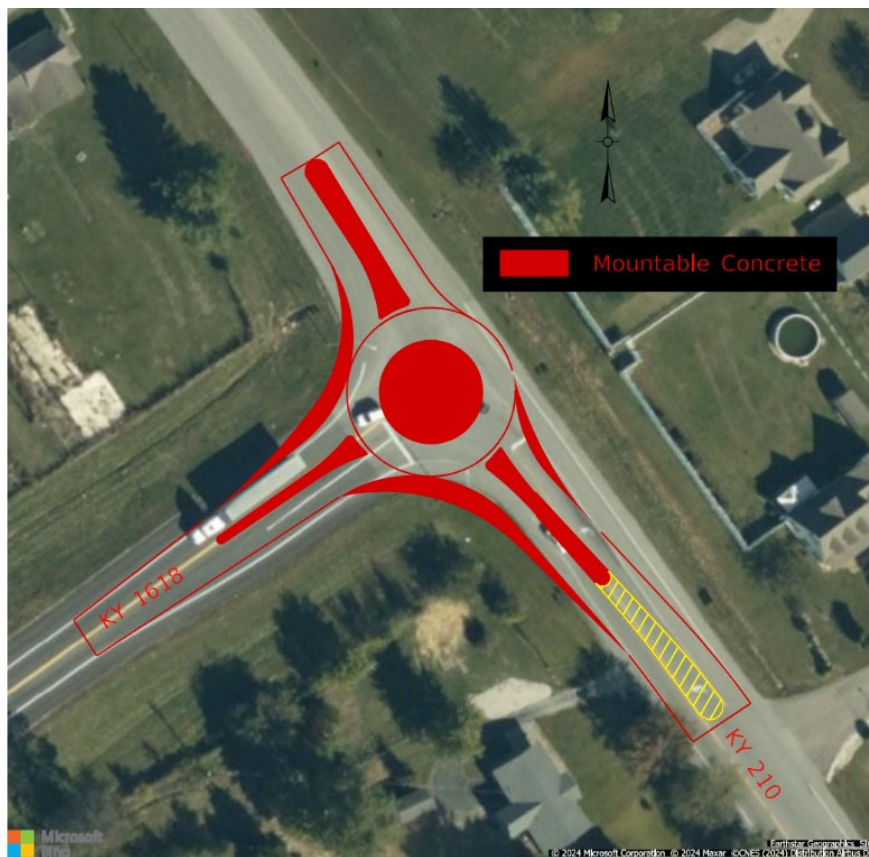
**VE ALTERNATIVE SI-2**  
**Revise Lincoln Parkway Intersection with KY 210**

**Baseline Concept Sketch**



**Reconstruct  
Intersection  
with a 25  
MPH Curve**

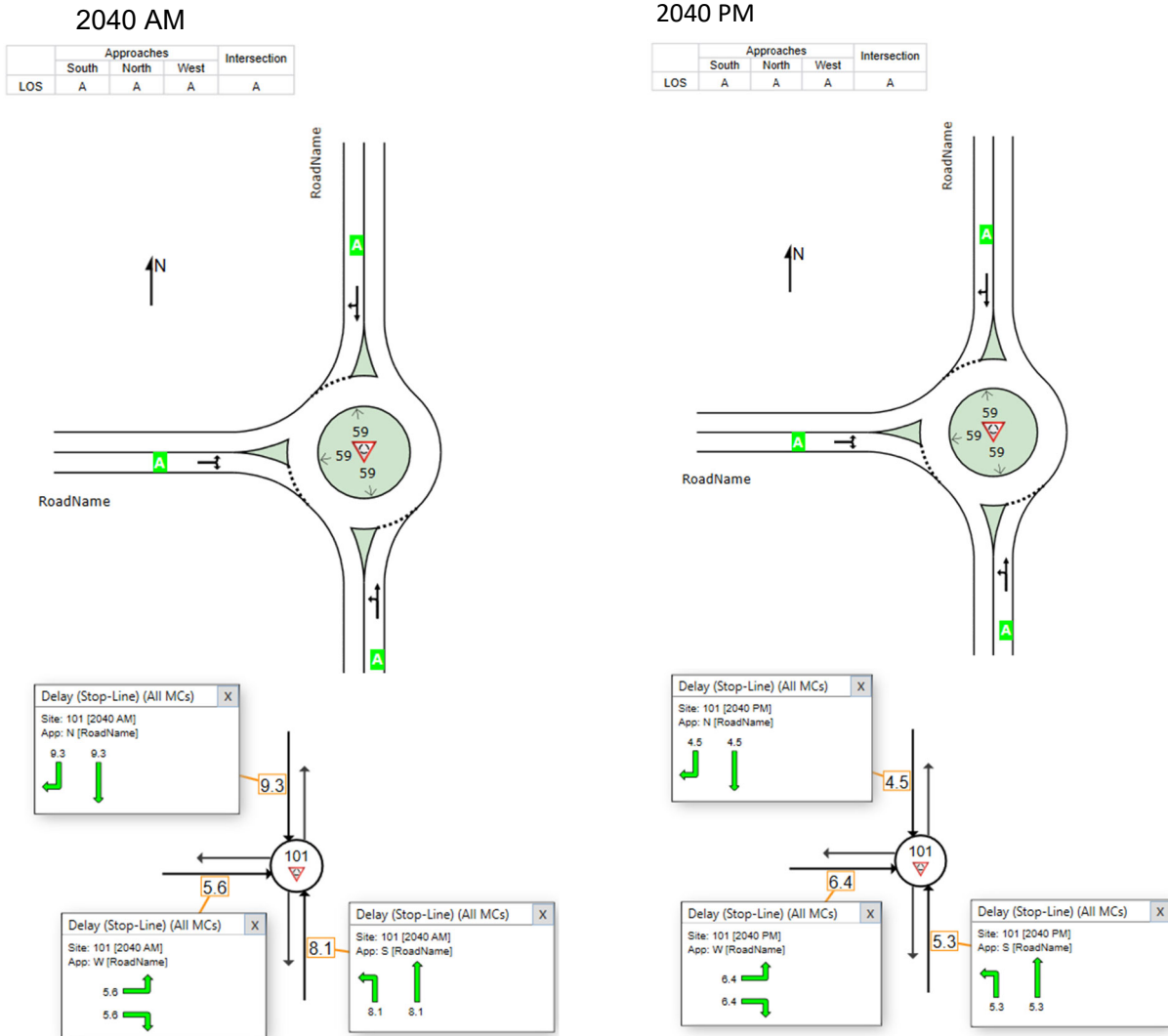
**VE Alternative Concept Sketch**



# VE ALTERNATIVE SI-2

## Revise Lincoln Parkway Intersection with KY 210

Operational Analysis Results:  
Using SIDRA 9.1 with HCM6 default parameters. 2040 AM and PM peak volumes. 10% trucks:



### Assumptions and Calculations:

A detailed estimate of the baseline concept was not available, however, for comparison purposes, the VE team assumes the reconfigured intersection would cost approximately \$500,000.

A roundabout at the location will require leveling & wedging to create positive drainage for the pavement. An assumed depth of 3" across the project limits is used. Concrete islands and truck aprons will be poured in a colored and stamped configuration. The concrete thickness is 8". The additional full depth widening required in the northwest and southwest quadrants will be: 12" #2 stone, 6" CSB, 3" Asphalt Base, 3" Asphalt Base, and 1.5" Asphalt Surface. Excess pavement outside identified pavement edges to be removed and sewn in grass. Lighting is required, and it's assumed an additional cost will be associated with lighting upgrade for the roundabout at the location.

**VE ALTERNATIVE SI-2**

**Revise Lincoln Parkway Intersection with KY 210**

**Initial Cost Estimate**

<i>CONSTRUCTION ELEMENT</i>		<i>BASELINE CONCEPT</i>			<i>ALTERNATIVE CONCEPT</i>		
<b>Description</b>	<b>Unit</b>	<b>Qty</b>	<b>Cost/Unit</b>	<b>Total</b>	<b>Qty</b>	<b>Cost/Unit</b>	<b>Total</b>
Provide 25 mph curve	LS			\$ 500,000			
Asphalt Surface	Ton			\$ -	184	\$ 105.00	\$ 19,320
Asphalt Base	Ton			\$ -	53	\$ 100	\$ 5,300
Crushed Stone Base	Ton			\$ -	290	\$ 35.00	\$ 10,150
#2 Stone	Ton			\$ -	280	\$ 40	\$ 11,200
Concrete Median (8")	SQYD			\$ -	931	\$ 120	\$ 111,720
Leveling and Wedging	Ton			\$ -	472	\$ 130	\$ 61,360
Striping/Signage	LS			\$ -	1		\$ 40,000
Lighting	LS			\$ -	1		\$ 100,000
Erosion Control	LS			\$ -	1		\$ 25,000
Embankment in Place	CUYD			\$ -	2,000	\$ 20	\$ 40,000
<b>SUB-TOTAL</b>							\$424,050
<b>PROJECT MARK-UPS</b>	15%			Included			\$63,608
<b>TOTAL (Rounded)</b>				\$500,000			\$488,000
						<b>SAVINGS</b>	<b>\$12,000</b>

## **VE ALTERNATIVE SI-3**

### **Use barn roof fill slope to limits of clear zone and eliminate guard rail**

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#### **Description of Baseline Concept:**

The baseline concept involves using a 3.5' wide crushed stone base shoulder in areas where guardrail is warranted. The fill slope extends down at a 2:1 from the crushed stone base shoulder breakover. In Section 2 there is 11,312.5' guardrail set up to be placed. There are 147,918 cubic yards of excess material left over from Section 2 alone.

#### **Description of Alternative Concept:**

Section 3.3.4 of the Roadside Design Guide describes a typical section ("barn roof") that utilizes a 4:1 sloped area adjacent to the travel lane/shoulder that achieves the clear zone for a 60 mph design speed, 36' for the project corridor volumes, then proceeds down to existing ground at a 2:1 slope.

#### **Advantages:**

- Allows onsite use of excess materials
- Reduces long term guardrail maintenance
- Less area to permit for waste site
- Easier long term roadside maintenance

#### **Disadvantages:**

- May require additional Right of Way in areas
- May require additional pipe/box culvert extensions
- Could impact additional environmental resources

#### **Discussion:**

Balancing cut/fill is nearly impossible when widening an existing facility as the grade has mostly been set and is restricted due to various developments along the alignment. There are 147,918 cubic yards of excess material to be discarded by the contractor in Section 2 alone. Guardrail is a continuous maintenance issue as strikes occur. Using a "barn roof" typical section, a true 36' clear zone can be achieved by using a 4:1 slope outside the crushed stone base shoulder breakover. This means a driver has 36' beyond the edge of travel lane to correct their course prior to reaching a critical slope. Contractors are required to permit waste areas, and the less waste the contractor must haul off, the more economical the work can be performed. The balance will be much closer wasting material in the existing guardrail locations. Some additional Right of Way may be necessary over the baseline, but if project schedule/budget is at risk for the alternative, guardrail could always be implemented as originally designed. Culvert extensions will likely have to be extended farther than baseline to achieve the alternative slopes, so very large structures may not be as economical to extend. Long term maintenance of a 4:1 slope is much preferable versus guardrail against the edge of paved shoulder with a 2:1 slope on the other side.

#### **Discussion of Schedule Impacts:**

The alternative would expedite the schedule as the contractor's mass haul would be more favorable by wasting material locally onsite instead of trucking to an additionally permitted waste site.

## VE ALTERNATIVE SI-3

### Use barn roof fill slope to limits of clear zone and eliminate guard rail

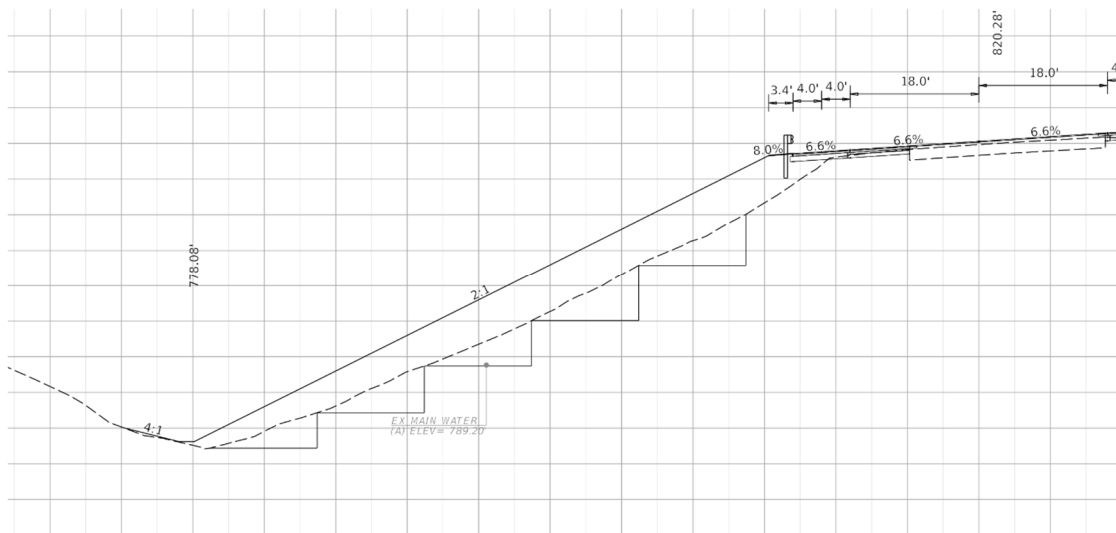
#### Discussion of Risk Impacts:

The additional area required for the “barn roof” typical section will need to be cleared environmentally, which increases the scope of work over using guardrail and tying down as soon as possible. More environmental clearance brings more risk into the project. There is also the risk involved with acquiring additional Right of Way.

#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> Mainline operations will be improved by providing a clear zone that has no obstructions, including guardrail.
<b>Local Operations</b> Local operations will be improved by having better sight distance by removing guardrail from main line.
<b>Maintainability</b> Nuisance guardrail strikes will not be an issue since the guardrail will be gone from the edge of paved shoulder. The 26' 4:1 slope at the shoulder breakover will be easily maintainable for years to come.
<b>Construction Impacts</b> Construction operations will be more efficient due to waste materials be disposed of locally on site.
<b>Environmental Impacts</b> Environmental impacts could be greater due the construction limits extending farther out that the baseline.

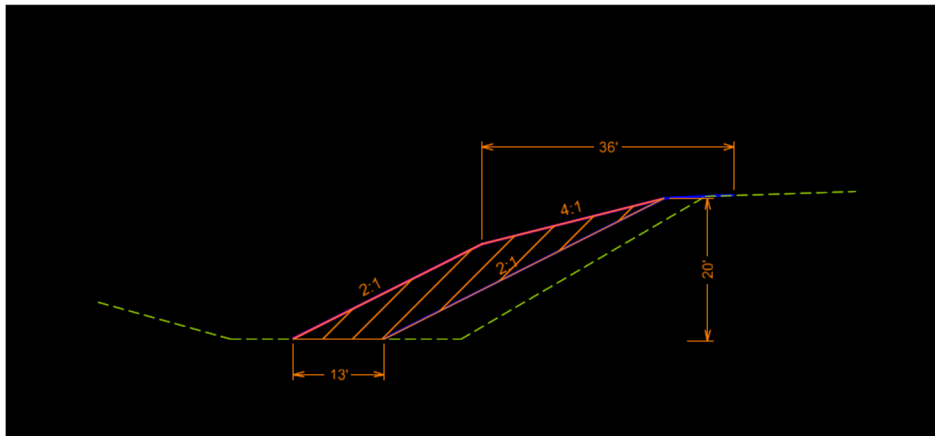
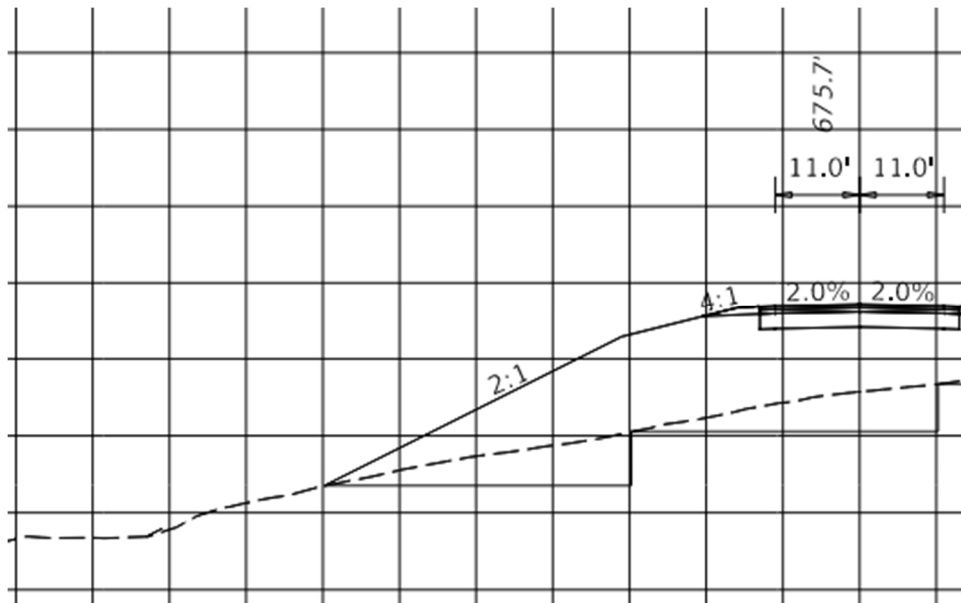
#### Baseline Concept Sketch



## VE ALTERNATIVE SI-3

### Use barn roof fill slope to limits of clear zone and eliminate guard rail

#### VE Alternative Concept Sketch



#### Assumptions and Calculations:

It is assumed that all guardrail will be removed from the project other than what is necessary to shield locations such as bridge railing and areas needed to wrap for a length of need issue. Using the length of guardrail set up on Section 2 and assuming an average fill height of 20' by looking through the cross sections, there is the potential to waste 90,000+ cubic yards of additional material on site instead of hauling off as excess. While Section 1 and 3 do not have as much terrain requiring critical slopes, the same instance applies where guardrail is being used in the baseline. Sections 1 & 3 have less critical slope locations, so the benefit is slightly less, however there's still opportunity for savings and construction efficiency. There is a total of 194,000 cubic yards that could be potentially wasted on-site if using the proposed alternative. Assuming \$2/cubic yard savings, that equates to \$388,000 in value. There will be approximately \$50,000 added back by the cost of extending pipes in these areas to accommodate the slopes. There is also potential in Section 2 for additional ROW (~4.2 acres) which is assumed to cost an additional \$20,000.

**VE ALTERNATIVE SI-3**

**Use barn roof fill slope to limits of clear zone and eliminate guard rail**

**Initial Cost Estimate**

<i>CONSTRUCTION ELEMENT</i>		<i>BASELINE CONCEPT</i>			<i>ALTERNATIVE CONCEPT</i>		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Roadway Excavation	CUYD	194,000	\$ 13.41	\$ 2,601,540	194,000	\$ 11.41	\$ 2,213,540
Additional Right of Way	LS			\$ -	1	\$ 20,000	\$ 20,000
Additional Pipe Extensions	LS			\$ -	1	\$ 50,000	\$ 50,000
Guardrail	LS	1		\$ 911,165	0		
<b>SUB-TOTAL</b>				\$3,512,705			\$2,283,540
<b>PROJECT MARK-UPS</b>	15%			\$526,906			\$342,531
<b>TOTAL (Rounded)</b>				\$527,000			\$2,626,000
						<b>SAVINGS</b>	<b>\$1,414,000</b>

## **VE ALTERNATIVE TS-1**

### **Install French drains to drain subgrade in lieu of daylighting shoulders**

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#### **Description of Baseline Concept:**

The cross-sections show daylighting the excavation outside of the shoulder construction and refilling with geotextile fabric wrapped Dense Graded Aggregate (DGA) to provide drainage for the subgrade throughout much of the project.

#### **Description of Alternative Concept:**

Instead of daylighting the excavation past the shoulder, construct lateral French drains throughout the project at specified spacing to provide drainage for the subgrade.

#### **Advantages:**

- Reduces cost due to reducing project quantities of excavation and DGA

#### **Disadvantages:**

- Increases complexity of construction
- Requires additional drainage installation

#### **Discussion:**

The VE team recommends eliminating the process of daylighting the shoulders in order to provide drainage for the subgrade. Instead of this process, install lateral French drains at specified spacing along both shoulders to provide the necessary drainage for the subgrade.

#### **Discussion of Schedule Impacts:**

The time for construction could be impacted negatively by a small degree. The daylighting of the excavation is a simpler process and could be completed more quickly. However, this would also require installation of DGA to reconstruct the removed material outside of the shoulder. Installing French drains at specified spacing would be time consuming. However, this time would be offset somewhat by less excavation and rebuilding of the slope throughout the project.

#### **Discussion of Risk Impacts:**

There is some risk of ponding water in the subgrade if the French drains become damaged or clogged over time. This risk would be very minimal in normal circumstances.

## VE ALTERNATIVE TS-1

### Install French drains to drain subgrade in lieu of daylighting shoulders

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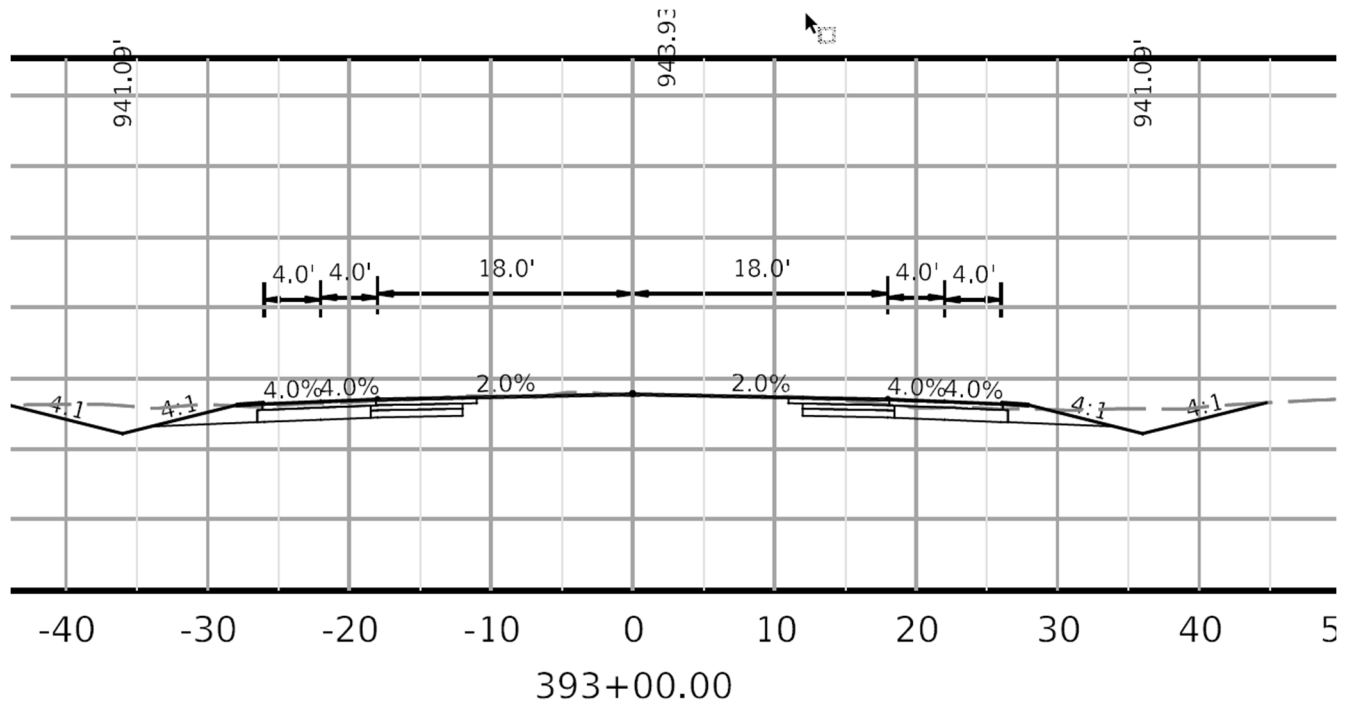
#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> Mainline operations are not affected.
<b>Local Operations</b> Local operations are not affected.
<b>Maintainability</b> Maintenance is not impacted unless the French drains become damaged.
<b>Construction Impacts</b> This change could increase the construction timeline slightly
<b>Environmental Impacts</b> Not applicable

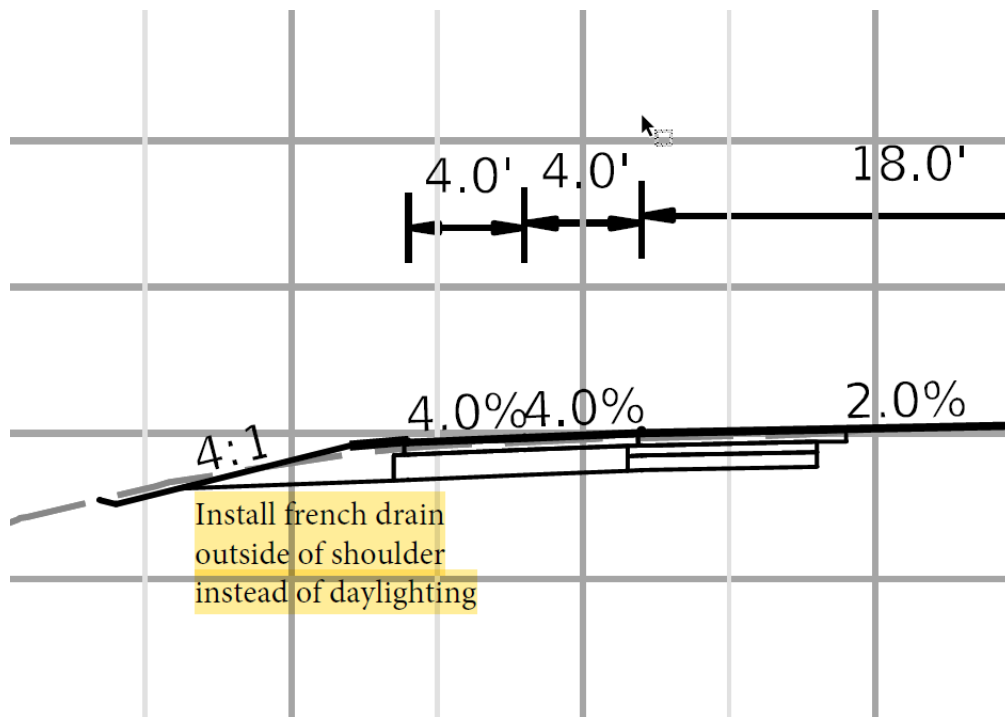
# VE ALTERNATIVE TS-1

## Install French drains to drain subgrade in lieu of daylighting shoulders

### Baseline Concept Sketch



### VE Alternative Concept Sketch



## VE ALTERNATIVE TS-1

### Install French drains to drain subgrade in lieu of daylighting shoulders

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#### Assumptions and Calculations:

Section 1 length is 36,655 feet and Section 3 length is 66,553 feet.

Total centerline length is 103,208 feet and for both shoulders is 206,416 feet.

Assume the average area of daylighting outside shoulder is 10 feet wide and 8 inches deep.

Total volume is  $(206416 \times 10 \times 8/12) / 27 = 50,967$  cy of excavation.

DGA required for excavation replacement @2.07 tons / cy = 105,502 tons

Calculations for lateral (French) drains is based on Standard Spec 209.03.02 (A)

Spacing per Spec is 100 feet apart giving  $206,416 / 100 = 2064$  drains.

Each drain average is 10 feet long, 1.5 feet wide and 9 inches deep.

Volume of each drain  $(10 \times 9/12 \times 1.5) / 27 = 0.42$  cy

Total excavation for all drains is  $2064 \times 0.42 = 867$  cy

Crushed aggregate #57 used for the drains @1.7 tons / cy = 0.7 tons

Total tons of #57s needed for drains is  $2064 \times 0.7 = 1,445$  tons

After calculations for full length daylighting of sections 1 & 3, we will assume that 40% of the shoulders are daylighted and will be affected by this change. Quantities will be adjusted.

#### Initial Cost Estimate

CONSTRUCTION ELEMENT		BASELINE CONCEPT			ALTERNATIVE CONCEPT		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Roadway Excavation	CY	20,287	\$ 15	\$ 304,305	347	\$ 30.00	\$ 10,410
DGA BASE	TON	42,200	\$ 25	\$ 1,042,340			\$ -
CRUSHED AGGREGATE NO 57	TON			\$ -	578	\$ 45	\$ 26,010
<b>SUB-TOTAL</b>				\$1,346,645			\$36,420
<b>PROJECT MARK-UPS</b>	15%			\$201,997			\$5,463
<b>TOTAL (Rounded)</b>				\$1,549,000			\$42,000
					<b>SAVINGS</b>		<b>\$1,507,000</b>

## **VE ALTERNATIVE TS-2**

### **Revise limits of cement stabilized base**

---

#### **Description of Baseline Concept:**

The baseline concept for the subgrade stabilization on the KY 210 widening project shows the subgrade treatment extending out to the toe of the crushed stone base shoulder.

#### **Description of Alternative Concept:**

The alternative proposes reducing or limiting the width of the subgrade stabilization treatment to not extend beyond the edge of the asphalt paved shoulder.

#### **Advantages:**

- Reduced construction costs for the subgrade treatment
- Decreases construction time

#### **Disadvantages:**

- Lessened subgrade strength beneath the crushed stone base shoulder

#### **Discussion:**

The alternative focuses on the use and cost analysis of the cement stabilization option. The baseline project did include the option of crushed aggregate in lieu of the cement treatment, and this alternative could also be applied to the aggregate application. The use of “bleeders” can be used to provide positive subgrade drainage in the aggregate application.

The reduced limits of the stabilization area should not result in any negative impacts to project performance.

#### **Discussion of Schedule Impacts:**

The alternative would result in positive impacts to the baseline. Construction times would decrease with the decreasing stabilization areas.

#### **Discussion of Risk Impacts:**

None noted

## VE ALTERNATIVE TS-2

### Revise limits of cement stabilized base

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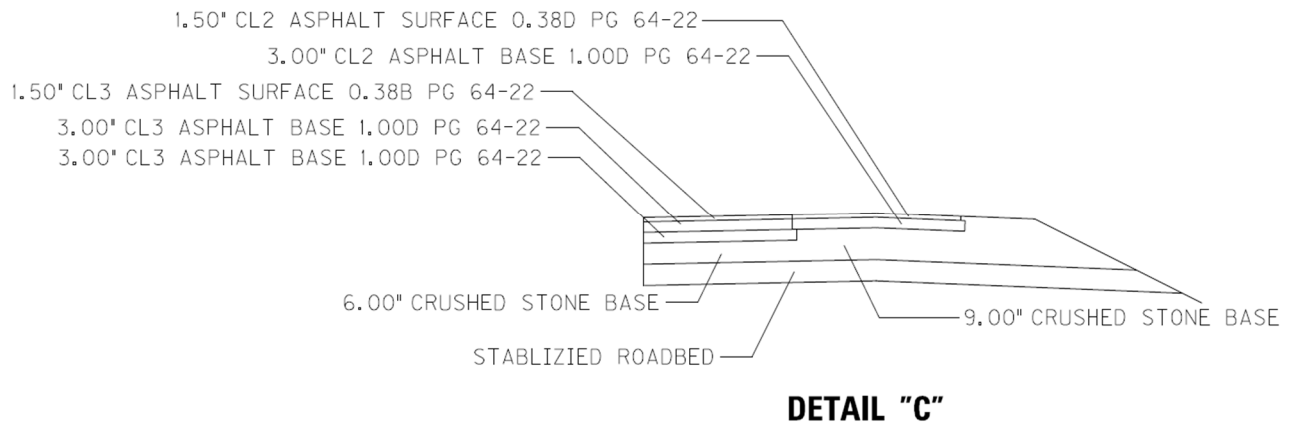
#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> <ul style="list-style-type: none"><li>No Change. No impact to final project configuration.</li></ul>
<b>Local Operations</b> <ul style="list-style-type: none"><li>No change. No impact to final project configuration.</li></ul>
<b>Maintainability</b> <ul style="list-style-type: none"><li>No Change. No impact to final project configuration.</li></ul>
<b>Construction Impacts</b> <p>Reduced impact. Quicker construction times.</p>
<b>Environmental Impacts</b> <ul style="list-style-type: none"><li>No Change. No impact to final project configuration.</li></ul>

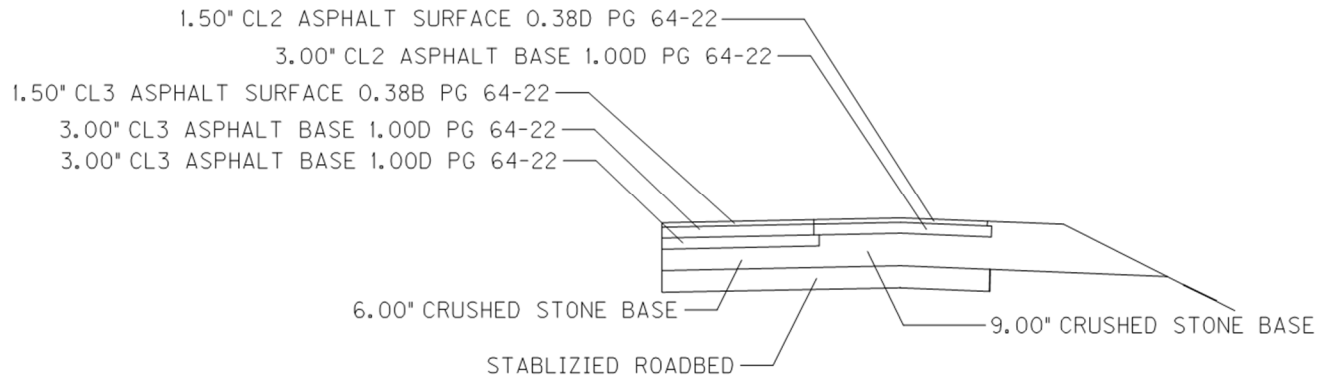
## VE ALTERNATIVE TS-2

### Revise limits of cement stabilized base

#### Baseline Concept Sketch



#### VE Alternative Concept Sketch



**Assumptions and Calculations:** For calculations, I could not extract exact square yards of material out past edge of asphalt base, so going to assume an average width of 5.5' on each side of the roadway. I looked at many cross sections and measured the length from edge of paved shoulder to the x-y tie and got an average of 5.5' throughout the project.

Application rates: Cement 54.76 lb/sy, Sand 5 lb/sy, curing seal 2 lb/sy (pulled from section 2 estimate)

	UNIT	QTY	\$	project length (ft)	Reduction in width (1 side)	SQYD (Both Shldrs)	application rate	Total Savings
Cement Stabilized Roadbed		56729	78270	4.011	17625	5.5	21541.67	21541 sqyd
Asphalt Curing Seal	TON	80	806.68		17625	5.5	21541.67 2 lb/sy	21.5 ton
Sand for Blotter	TON	197	39.98		17625	5.5	21541.67 5 lb/sy	54 ton
Cement	TON	2143	232.77		17625	5.5	21541.67 54.76 lb/sy	590 ton

Calculated savings of \$279,000 over the span of 3.3 miles for section 2, equates to a savings of \$84,545/mile. This would roughly total a combined savings of \$2,071,363 for the entire 24.5 mile project corridor.

**VE ALTERNATIVE TS-2**

**Revise limits of cement stabilized base**

**Initial Cost Estimate**

<i>CONSTRUCTION ELEMENT</i>		<i>BASELINE CONCEPT</i>			<i>ALTERNATIVE CONCEPT</i>		
<i>Description</i>	<i>Unit</i>	<i>Qty</i>	<i>Cost/Unit</i>	<i>Total</i>	<i>Qty</i>	<i>Cost/Unit</i>	<i>Total</i>
Cement Stabilized Roadbed - section	SQYD	78,270	\$ 4.01	\$ 313,941	56,729	\$ 4.01	\$ 227,483
Asphalt Curing Seal - section 2	TON	80	\$ 807	\$ 64,534	59	\$ 807	\$ 47,210
Sand For Blotter - section 2	TON	197	\$ 40	\$ 7,876	143	\$ 40.00	\$ 5,720
Cement - section 2	TON	2,143	\$ 233	\$ 498,826	1,553	\$ 233	\$ 361,849
SECTION 2 ONLY				\$ -			\$ -
<b>SUB-TOTAL</b>				\$885,178			\$642,262
<b>PROJECT MARK-UPS</b>	15%			\$132,777			\$96,339
<b>TOTAL (Rounded)</b>				\$1,018,000			\$739,000
						<b>SAVINGS</b>	<b>\$279,000</b>

## **VE ALTERNATIVE TS-3**

### **Maintain 2' stone base shoulder width at guard rail locations**

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#### **Description of Baseline Concept:**

The baseline concept for the KY 210 widening project reconfigures the roadway to a 2+1 alternating roadway design. In locations that will require guardrail per MUTCD specifications, an 8' paved shoulder is proposed, along with a 3.5' crushed stone base shoulder. The guardrail design proposes 7' guardrail posts to be used throughout the corridor where guardrail is required.

#### **Description of Alternative Concept:**

This alternative concept proposes reducing the 3.5' crushed stone base shoulder to a 2' crushed stone base shoulder, while maintaining 7' guardrail posts and 8' paved shoulders.

#### **Advantages:**

- Reduced cost in crushed stone base, asphalt seal coat, and asphalt seal aggregate
- Allows for consistent shoulder size throughout the project

#### **Disadvantages:**

- Potential increase in maintenance costs

#### **Discussion:**

The baseline alternative creates additional costs from the unnecessary crushed stone base beyond requirements. The reduction of 1.5' of crushed stone base in guardrail locations lowers costs while maintaining minimum standards.

The 2' crushed stone base shoulder as proposed in standard areas of the project would remain consistent throughout the project, potentially reducing labor costs and time associated with the modification of construction equipment to create the larger shoulder areas.

It is noted that due to the decreased width in the crushed stone base shoulder, there is an increased potential in maintenance costs due to erosion having a higher chance of affecting the shoulder pavement in these areas.

#### **Discussion of Schedule Impacts:**

Possible schedule savings due to decreased time in equipment adjustment and/or modification to accommodate a brief shoulder width adjustment to 3.5'.

#### **Discussion of Risk Impacts:**

There is no impact with project risks.

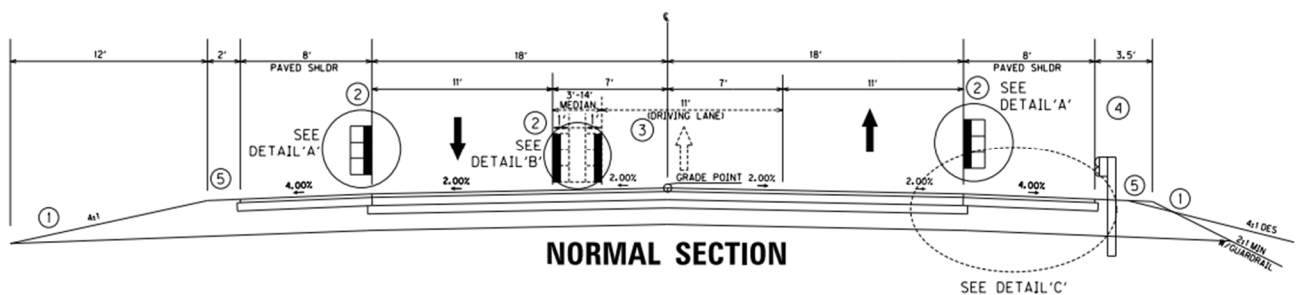
## VE ALTERNATIVE TS-3

### Maintain 2' stone base shoulder width at guard rail locations

#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> No change from baseline concept.
<b>Local Operations</b> No change from baseline concept.
<b>Maintainability</b> There is a slightly reduced impact on maintainability due to the increased potential of erosion affecting the pavement.
<b>Construction Impacts</b> There is an increased impact on the constructability of the crushed stone base shoulder due to the consistency of the width throughout the project.
<b>Environmental Impacts</b> While less material is being used, there is a greater potential of erosion occurring in these areas due to water runoff conditions.

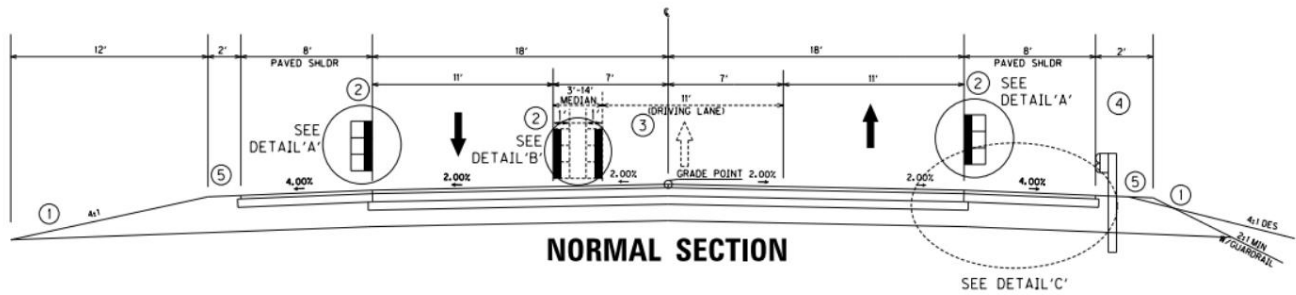
#### Baseline Concept Sketch



## VE ALTERNATIVE TS-3

### Maintain 2' stone base shoulder width at guard rail locations

#### VE Alternative Concept Sketch



#### Assumptions and Calculations:

- Only calculating quantities between the edge of pavement and break at slope.
- No other changes to the Typical Section or Roadway Plans in Section 2, showing 10,287.5 LF of guardrail being placed, excluding end treatments.
- Assuming 2+1 conditions through all three (3) sections.
- Assuming no guardrail in Section 1 due to no current guardrail in Section 1.
- Assuming guardrail to be placed in existing areas in Section 3, approximately 26,175 LF.
- Crushed Stone Base shoulder depth is  $9.00'' + 3.00'' + 1.50'' = 13.50''$ .
- The only decrease in Crushed Stone Base width is in guardrail areas associated with Section 2 of the KY 210 Widening Project, including Remove & Reset locations.
- End treatments are not included in the reduction of width.
- Crushed Stone Base is assumed at 2.07 TON/CUYD.
- Asphalt Seal Coat application rate is assumed at 2.40 LB/SQYD.
- Asphalt Seal Aggregate application rate is assumed at 20 LB/SQYD.

#### Initial Cost Estimate

CONSTRUCTION ELEMENT		BASELINE CONCEPT			ALTERNATIVE CONCEPT		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Crushed Stone Base (Section 2, guardrail section only)	TON	3,103	\$ 30	\$ 93,835	1,775	\$ 30.00	\$ 53,250
Asphalt Seal Aggregate (Section 2, guardrail section only)	TON	40	\$ 119	\$ 4,744	23	\$ 119	\$ 2,714
Asphalt Seal Coat (Section 2, guardrail section only)	TON	5	\$ 1,027	\$ 4,927	3	\$ 1,027	\$ 2,818
Crushed Stone Base (Section 1, guardrail area only)	TON	0	\$ 30	\$ -	0	\$ 30	\$ -
Asphalt Seal Aggregate (Section 1, guardrail area only)	TON	0	\$ 119	\$ -	0	\$ 119	\$ -
Asphalt Seal Coat (Section 1, guardrail area only)	TON	0	\$ 1,027	\$ -	0	\$ 1,027	\$ -
Crushed Stone Base (Section 3, guardrail area only)	TON	7,821	\$ 30	\$ 234,630	4,474	\$ 30	\$ 134,220
Asphalt Seal Aggregate (Section 3, guardrail area only)	TON	102	\$ 119	\$ 12,106	58	\$ 119	\$ 6,926
Asphalt Seal Coat (Section 3, guardrail area only)	TON	12	\$ 1,027	\$ 12,540	7	\$ 1,027	\$ 7,168
<b>SUB-TOTAL</b>				\$362,781			\$207,096
<b>PROJECT MARK-UPS</b>	15%			\$54,417			\$31,064
<b>TOTAL (Rounded)</b>				\$417,000			\$238,000
						<b>SAVINGS</b>	<b>\$179,000</b>

## **VE ALTERNATIVE TS-4**

### **Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections**

---

#### **Description of Baseline Concept:**

The baseline concept of the KY 210 widening project shows the proposed paved asphalt shoulders, 8' in width throughout the entire length of the project. Beyond the edge of the shoulders, a proposed 2' crushed stone base shoulder is to be used with application of a chip and seal treatment.

#### **Description of Alternative Concept:**

The alternative proposes a reduction of the 8' paved asphalt shoulder, down to a 4' paved asphalt shoulder and 4' crushed stone base shoulder to maintain the total width of usable shoulder. The crushed stone base portion of the shoulder would receive the chip and seal treatment. This is to be applied to the shoulders along the sections of proposed 2+1 roadway where there are dual passing lanes. The lane direction with no passing lane will receive the proposed 8' asphalt paved shoulder.

#### **Advantages:**

- Reduces the costs of materials associated with asphalt base and asphalt surface
- Maintain same typical footprint
- No effect on rumble strip warrants

#### **Disadvantages:**

- Increased maintenance costs long term
- Increased risk with erosion

#### **Discussion:**

The baseline concept has higher costs associated with a larger quantity of asphalt material. This alternative will significantly reduce the amount of asphalt.

Potential concerns with the shoulder drop-off at the edge of the 4' paved shoulder will be minimized with the use of a chip and seal treatment.

Road users will still maintain the same amount of shoulder area for refuge.

#### **Discussion of Schedule Impacts:**

Less asphalt material will lead to improved construction time. The additional crushed stone base on the shoulder will require more time but can be done in conjunction with the proposed shoulder stone in the baseline concept.

#### **Discussion of Risk Impacts:**

Main risk involved with future maintenance costs and maintaining a smooth transition between the edge of the asphalt paved shoulder and CSB shoulder. Chip and seal treatment will extend the longevity of this transition.

Risk involved with road users running off on the CSB shoulder and trying to regain location on the road. The CSB would not be as forgiving as an asphalt shoulder.

**VE ALTERNATIVE TS-4**

**Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections**

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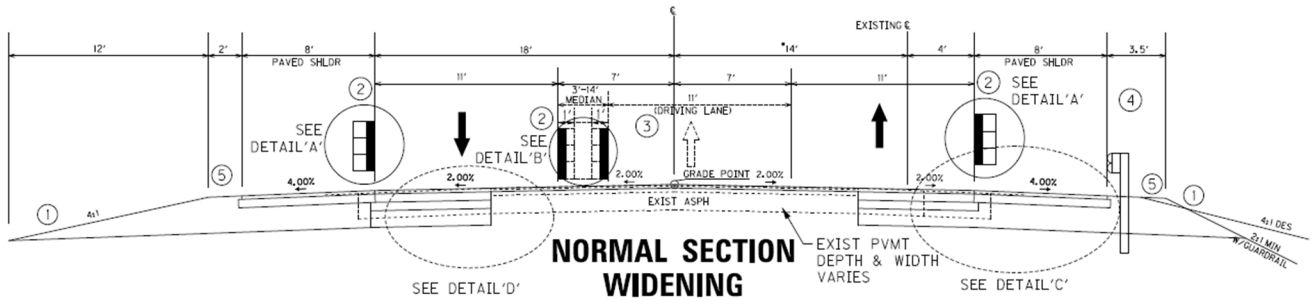
**Performance Assessment:**

<b>Attributes and Rating Rationale</b>
<b>Mainline Operations</b> No change. Road users still have same usable shoulder width. No effect on warrants for rumble strips.
<b>Local Operations</b> No Change
<b>Maintainability</b> Decreased. More shoulder stone/area to maintain with maintenance crews in the future.
<b>Construction Impacts</b> Decrease construction time. Less asphalt will result in quicker construction times.
<b>Environmental Impacts</b> No Change.

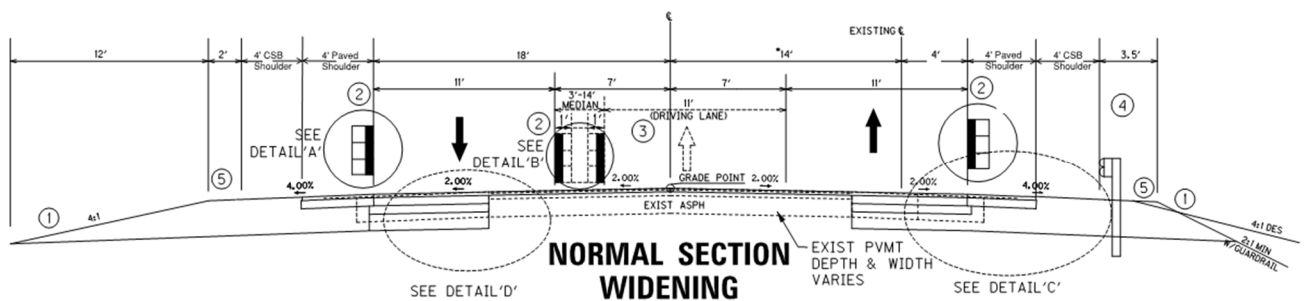
## VE ALTERNATIVE TS-4

Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections

### Baseline Concept Sketch



### VE Alternative Concept Sketch



### Assumptions and Calculations:

Guardrail stays in same location/offset distance

Maintain same typical width

Maintain same subgrade stabilization typical

Total passing lane length of 19.4 miles using the supplied striping layout concept factor of 7.13 miles of passing over the span of 9 miles

102432	Length	Width (ft)	Depth (in)	Application Rate (LB/SY)	Square Yards	Tons
Asphalt Base - Reduction	102432	4	3	-	45525.33	7511.68
Asphalt Surface - Reduction	102432	4	1.5	-	45525.33	3755.84
Asphalt Material for Tack - Reduction	102432	4	-	0.7	45525.33	35.8512
Asphalt seal coat - Additional	102432	4	-	2.4	45525.33	122.9184
Asphalt seal aggregate - Additional	102432	4	-	20	45525.33	1024.32
Crushed stone base - Additional	102432	4	4.5	115	45525.33	11779.68

**VE ALTERNATIVE TS-4**

**Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections**

**Initial Cost Estimate**

<i>CONSTRUCTION ELEMENT</i>		<i>BASELINE CONCEPT</i>			<i>ALTERNATIVE CONCEPT</i>		
<b>Description</b>	<b>Unit</b>	<b>Qty</b>	<b>Cost/Unit</b>	<b>Total</b>	<b>Qty</b>	<b>Cost/Unit</b>	<b>Total</b>
Asphalt Base - Reduction	ton	15,022	\$ 81.00	\$ 1,216,782	7,511	\$ 81.00	\$ 608,391
Asphalt Surface - Reduction	ton	7,510	\$ 89	\$ 668,390	3,755	\$ 89	\$ 334,195
Asphalt Material for Tack - Reduction	ton	72	\$ 800	\$ 57,600	36	\$ 800.00	\$ 28,800
Asphalt seal coat - Additional	ton	0	\$ 1,027	\$ -	123	\$ 1,027	\$ 126,304
Asphalt seal aggregate - Additional	ton	0	\$ 119	\$ -	1,024	\$ 119	\$ 121,856
Crushed stone base - Additional	ton	0	\$ 30	\$ -	11,779	\$ 30	\$ 356,197
<b>SUB-TOTAL</b>				\$1,942,772			\$1,575,743
<b>PROJECT MARK-UPS</b>	15%			\$291,416			\$236,361
<b>TOTAL (Rounded)</b>				\$2,234,000			\$1,812,000
					<b>SAVINGS</b>		<b>\$422,000</b>

## **VE ALTERNATIVE TS-5**

### **Use granular embankment and geotextile for sliver fills**

---

#### **Description of Baseline Concept:**

The baseline concept for the KY 210 widening project reconfigures the roadway to a 2+1 alternating roadway design. In locations that will require benching to widen the roadway in fill sections, structural fill is proposed.

#### **Description of Alternative Concept:**

This alternative concept proposes a structural fill such as #2 stone over fabric in areas which require extensive roadway excavation in cut and fill slopes. Any permanent seeding, including crown vetch and erosion control blanket, along with roadway excavation quantities for removing and replacing soil would be eliminated in these areas.

#### **Advantages:**

- Reduced cost in erosion control items
- Reduced cost in roadway excavations
- Reduced erosion potential

#### **Disadvantages:**

- Potential increase in maintenance costs

#### **Discussion:**

The baseline alternative creates additional costs from roadway excavation associated with benching of slopes with fill material. After the material is placed, erosion control is necessary to maintain the slope's structural integrity.

The granular embankment slopes as proposed would only be in areas where minimum roadway excavation would occur, and some benching areas. This would eliminate roadway excavation quantities and some erosion control quantities.

Maintenance of sloped areas where granular embankment is proposed would increase, and therefore increase potential maintenance costs due to spraying. Right-of-Way mowing operations would be hindered due to the decrease in continuous 3:1 slopes in all sections, creating more difficult mowing areas.

#### **Discussion of Schedule Impacts:**

Possible schedule savings due to decreased time in benching and moving waste material and bringing in new material to fill slopes.

#### **Discussion of Risk Impacts:**

Risks associated with increasing runoff in these areas will need to be resolved and confirmed that local streams and pipe sections will not be impacted.

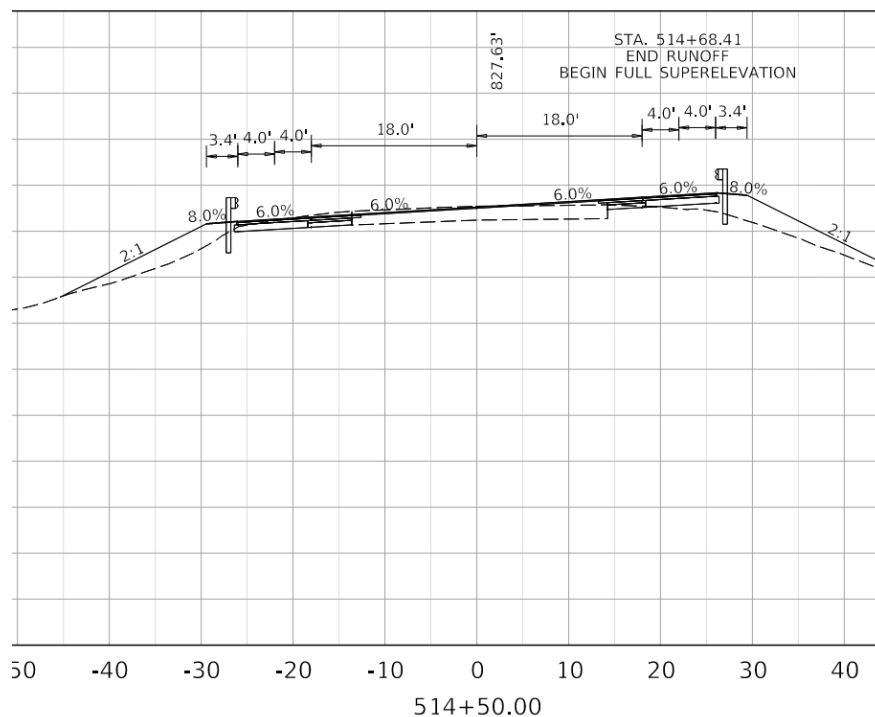
## VE ALTERNATIVE TS-5

### Use granular embankment and geotextile for sliver fills

#### Performance Assessment:

Attributes and Rating Rationale
<b>Mainline Operations</b> No change from baseline concept.
<b>Local Operations</b> No change from baseline concept.
<b>Maintainability</b> There is a slightly reduced impact on maintainability due to spraying efforts often associated with granular embankment areas.
<b>Construction Impacts</b> There is an increased impact on the constructability of the crushed stone base shoulder due to the elimination of repetitive roadway excavation in fill areas.
<b>Environmental Impacts</b> While less material is being moved and wasted, there is a greater potential of rainwater runoff occurring in these areas due to an increased Manning's coefficient associated with granular embankment.

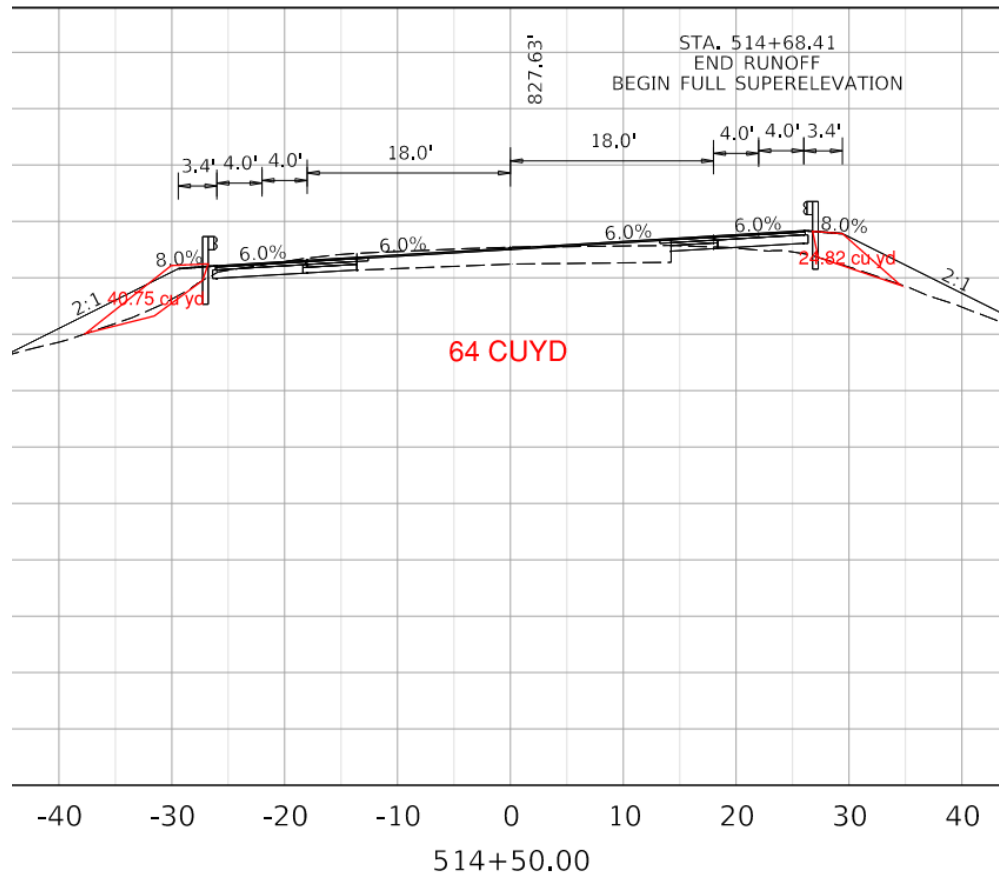
#### Baseline Concept Sketch



## VE ALTERNATIVE TS-5

### Use granular embankment and geotextile for sliver fills

#### VE Alternative Concept Sketch



#### Assumptions and Calculations:

- Assuming that cut & fill areas maintain relatively same area for 25' in either direction.
- All calculations were based on cross sections from Section 2 between STA 515+00 to 615+00.
- Assuming that the lengths of each section are as follows:
  - Section 1 = 36,655 LF
  - Section 2 = 17,570 LF
  - Section 3 = 66,553 LF
- An average over this area was calculated at the following rates:
  - Roadway Excavation Baseline: 2.2 CUYD / LF
  - Roadway Excavation Alternative: 0.59 CUYD / LF
  - Granular Embankment Baseline: 0 CUYD / LF
  - Granular Embankment Alternative: 0.25 CUYD / LF
  - Fabric – Geotextile Class 1 Baseline: 0 SQYD / LF
  - Fabric – Geotextile Class 1 Alternative: 2.85 SQYD / LF
  - Erosion Control Blanket Baseline: 2.0 SQYD / LF
  - Erosion Control Blanket Alternative: 0 SQYD / LF
  - Crown Vetch Baseline: 2.0 SQYD / LF
  - Crown Vetch Alternative: 0 SQYD / LF
  - Permanent Seed & Protect Baseline: 4.58 SQYD / LF

## VE ALTERNATIVE TS-5

### Use granular embankment and geotextile for sliver fills

- Permanent Seed & Protect Alternative: 0 SQYD / LF
- Did not include areas where fill is directly under roadway due to compaction concerns.
- Did not include areas where fill is at or above 5' due to stability concerns.
- Did not include areas where reducing cut would reduce sight distance.
- Calculations for Section 1 are assumed at half of the calculations for Section 2, under the assumption that there are fewer cut/fill areas per mile where this would apply.
- Calculations for Section 3 are equal the calculations for Section 2, under the assumption that there are roughly the same amount of cut/fill areas per mile where this would apply.

#### Initial Cost Estimate

CONSTRUCTION ELEMENT		BASELINE CONCEPT			ALTERNATIVE CONCEPT		
Description	Unit	Qty	Cost/Unit	Total	Qty	Cost/Unit	Total
Roadway Excavation (Slopes Only, Section 1)	CUYD	40,320	\$ 15.00	\$ 604,800	10,813	\$ 15.00	\$ 162,195
Fabric - Geotextile Class 1 (Slopes Only, Section 1)	SQYD	0	\$ 2	\$ -	52,233	\$ 2	\$ 104,466
Granular Embankment (Slopes Only, Section 1)	CUYD	0	\$ 60	\$ -	4,582	\$ 60	\$ 274,920
Erosion Control Blanket (Slopes Only, Section 1)	SQYD	36,655	\$ 6	\$ 219,930	0	\$ 6	\$ -
Crown Vetch (Slopes Only, Section 1)	SQYD	36,655	\$ 0	\$ 10,997	0	\$ 0	\$ -
Permanent Seeding (Slopes Only, Section 1)	SQYD	167,880	\$ 1	\$ 125,910	0	\$ 1	\$ -
Roadway Excavation (Slopes Only, Section 2)	CUYD	38,654	\$ 15.00	\$ 579,810	10,367	\$ 15.00	\$ 155,505
Fabric - Geotextile Class 1 (Slopes Only, Section 2)	SQYD	0	\$ 2	\$ -	50,075	\$ 2	\$ 100,150
Granular Embankment (Slopes Only, Section 2)	CUYD	0	\$ 60	\$ -	4,393	\$ 60	\$ 263,580
Erosion Control Blanket (Slopes Only, Section 2)	SQYD	35,140	\$ 6	\$ 210,840	0	\$ 6	\$ -
Crown Vetch (Slopes Only, Section 2)	SQYD	35,140	\$ 0	\$ 10,542	0	\$ 0	\$ -
Permanent Seeding (Slopes Only, Section 2)	SQYD	80,470	\$ 1	\$ 60,353	0	\$ 1	\$ -
Roadway Excavation (Slopes Only, Section 3)	CUYD	146,417	\$ 15.00	\$ 2,196,255	39,266	\$ 15.00	\$ 588,990
Fabric - Geotextile Class 1 (Slopes Only, Section 3)	SQYD	0	\$ 2	\$ -	189,676	\$ 2	\$ 379,352
Granular Embankment (Slopes Only, Section 3)	CUYD	0	\$ 60	\$ -	16,638	\$ 60	\$ 998,280
Erosion Control Blanket (Slopes Only, Section 3)	SQYD	133,106	\$ 6	\$ 798,636	0	\$ 6	\$ -
Crown Vetch (Slopes Only, Section 3)	SQYD	133,106	\$ 0	\$ 39,932	0	\$ 0	\$ -
Permanent Seeding (Slopes Only, Section 3)	SQYD	304,813	\$ 1	\$ 228,610	0	\$ 1	\$ -
<b>SUB-TOTAL</b>				\$5,086,614			\$3,027,438
<b>PROJECT MARK-UPS</b>	15%			\$762,992			\$454,116
<b>TOTAL (Rounded)</b>				\$5,850,000			\$3,482,000
						<b>SAVINGS</b>	<b>\$2,368,000</b>





## 7.3 FHWA Functional Benefit Criteria

Each year, state departments of transportation are required to report on VE recommendations to the Federal Highway Administration (FHWA). In addition to cost implications, FHWA requires state departments of transportation to evaluate each approved recommendation in terms of the project features that alternative benefits. If a specific alternative can be shown to provide benefit to more than one feature described below, count the alternative in each category that is applicable. These same criteria can be found on each of the individual alternatives 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.
- **Right-of-way:** Recommendations that lower the impacts or costs of right-of-way

Table 11. FHWA Benefit Analysis Table

Alt No.	Safety	Operations	Environment	Construction	Right of Way
IPO-1			Improved	Improved	Improved
IPO-2	Improved	Improved	Improved		Improved
SI-1	Improved	Improved			
SI-2	Improved	Improved			
SI-3	Improved				
TS-1				Improved	
TS-2				Improved	
TS-3				Improved	
TS-4				Improved	
TS-5				Improved	

## 7.4 VE Strategy

VE studies result in the development of a number of alternatives to a baseline concept. While each alternative is developed as an independent and unique concept, typically the cumulative impact of a selected combination of alternatives provides the best value solution for the project. This is due to the fact that some alternatives may be competing ideas or different ways to address the same issue. Some alternatives are developed to answer a



question raised by a decision maker or to resolve an open issue and found not to be beneficial to the ultimate project.

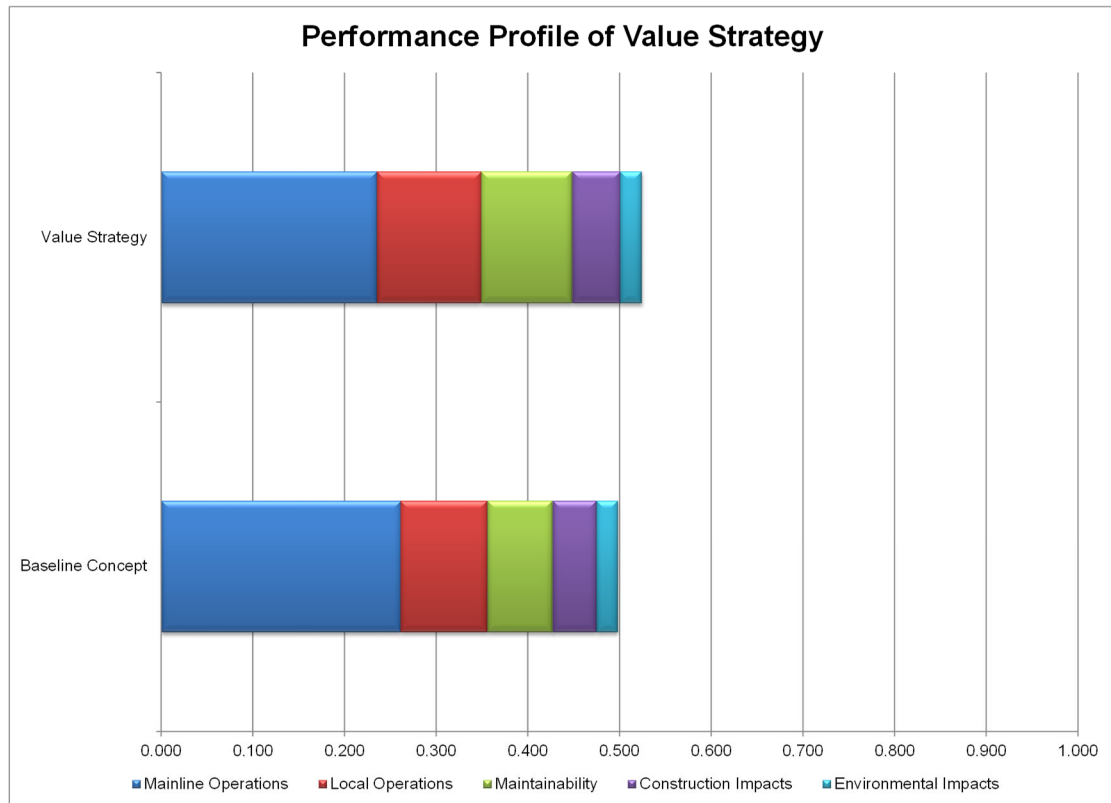
As a result of these factors, the VE team developed a VE strategy that represents a possible combination of the developed alternatives to assist the decision makers in their evaluation of them and the overall results of the VE study. The VE strategy is based on factors that include improved performance, likelihood of implementation, cost savings, or any combination of project’s performance attributes. This information is a guide and is not intended to reject the other alternatives from stakeholder consideration.

**Table 12. Summary of VE Strategy**

Strategy Description	Cumulative Cost Savings	Schedule Savings	Cumulative Performance Change	Cumulative Value Change
VE Team Selected Combination (VE Alts IPO-1, -2; SI-1,-2,-3; TS-1, -2, -3)	~\$25M	TBD	+5%	+110%

### 7.4.1 Compare Performance – Baseline Concept and VE Strategies

The VE team compared Baseline Concept to the VE Strategy using the performance attributes. The total performance scores reflect the performance rating for each attribute multiplied by its overall priority (weight) expressed using a ratio scale. The chart below compares the total performance scores for the baseline concept and VE Strategy.





## 7.4.2 Rating Rationale

The rating rationale for the performance of the baseline concept as compared to the VE Strategy developed by the VE team is provided below.

**Table 13. VE Strategy Performance Rating Rationale**

VE Strategy 1	Includes VE Alts:		
VE Team Selected Combination	IPO-1, 2; SI-1, 2, 3; TS-1, 2, 3		
PERFORMANCE MEASURES	Performance	Baseline	Recommendation
Attributes and Rating Rationale for Recommendation			
<b>Main Line Operations</b>	<b>Rating</b>	5	4.5
Reduce continuity of 2+1 configuration, but still provides passing opportunities in Section 2 and periodic passing lanes in Section 1 2. Lighting improves visibility and driver awareness, thus reducing crash potential. Roundabout at Lincoln Pkwy reduces conflicts while maintaining traffic flows. Reduces/eliminates guard rail.	<b>Weight</b>	52.3	
	<b>Contribution</b>	261.5	235.4
<b>Local Operations</b>	<b>Rating</b>	5	6
Removing guard rail improves sight distances at local road. Roundabout at Lincoln Parkway provides a yield condition in lieu of stopping. Lighting improves visibility.	<b>Weight</b>	19.0	
	<b>Contribution</b>	95	114
<b>Maintainability</b>	<b>Rating</b>	5	7
Barn roof fill slopes improves maintenance by eliminating guard rail conflicts with slope maintenance. French drains add an element to be maintained (minor impact). Reducing 2+1 extent reduces pavement to be maintained. Adding lighting will increase maintenance and may be deferred to counties.	<b>Weight</b>	14.2	
	<b>Contribution</b>	71	99.4
<b>Environmental Impacts</b>	<b>Rating</b>	5	5
No significant change.	<b>Weight</b>	4.7	
	<b>Contribution</b>	23.5	23.5
<b>Construction Impacts</b>	<b>Rating</b>	5	5.5
Reduced continuity of 2+1 will reduce traffic impacts. Reduces earthwork and work adjacent to active traffic. Reduced construction traffic / hauling.	<b>Weight</b>	9.5	
	<b>Contribution</b>	47.5	52.3
<b>Total Performance</b>		<b>499</b>	<b>525</b>
<b>Net Change in Performance</b>		<b>5%</b>	

## 7.4.3 Compare Value

The cost and elements were compared and normalized for the Baseline Concept and the VE Strategy using the following tables. These tables illustrate how cost scores were derived. In this comparison, a lower score is desirable as the project will benefit from lower costs.

**Table 14. Comparison of Cost Values**

Strategy Description	Cost	Cost Score
Baseline Concept	\$50,000,000	0.667

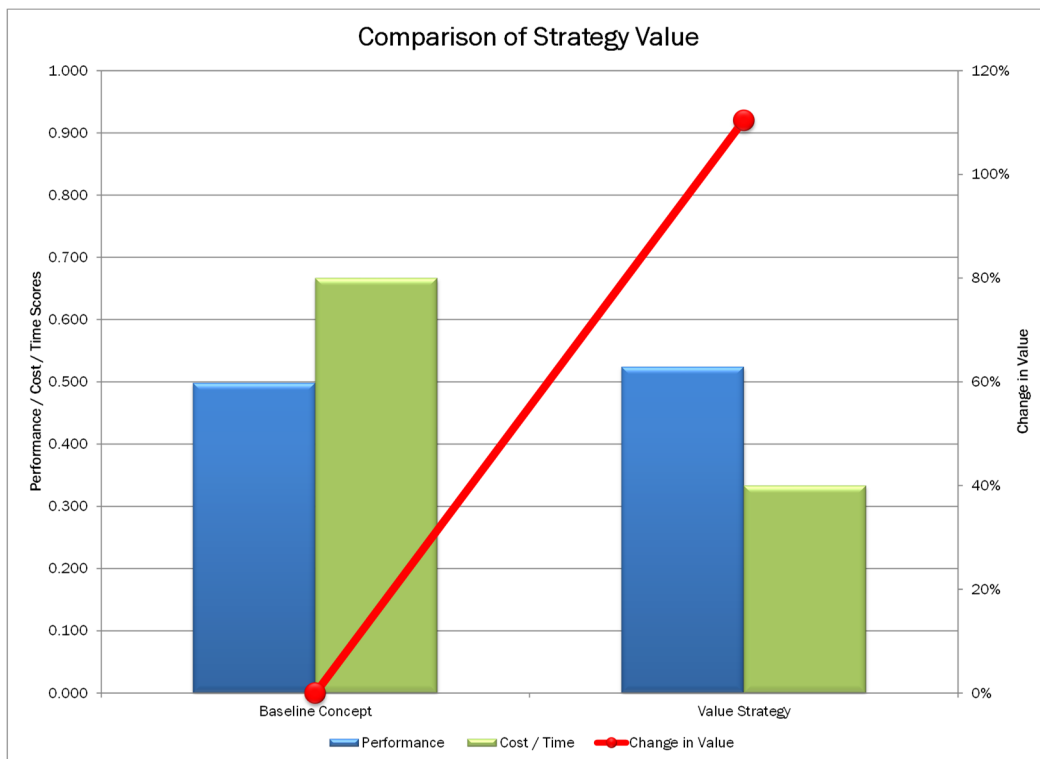


VE Strategy	\$25,000,000	0.333
Totals	\$75,000,000	1.000

Once relative scores for Performance and Cost have been derived, the next step is to synthesize a value index for the Baseline Concept and the VE Strategy. A Value Matrix was prepared which facilitated the comparison of the Baseline and the VE Strategy by organizing and summarizing this data into a tabular format. The performance scores for the Strategy were divided by the total schedule and cost scores for the Strategy to derive a value index. The value indices for the VE Strategy were then compared against the value index of the Baseline Concept and the difference is expressed as a percent ( $\pm$ ) deviation.

**Table 15. Value Matrix**

Strategy Description	Performance Score	Change in Performance	Cost Score	Schedule Score	Value Index
Baseline Concept	.499	N/A	0.667	TBD	N/A
VE Strategy	.525	+5%	0.333	TBD	+110%



**Figure 9 - Comparison of Value - Baseline Concept and VE Strategy**



## 7.5 Additional Design Considerations

The VE team generated the following design suggestions for the project design team’s consideration. These items represent ideas that were generated during the Creative Phase of the VE study, but were not chosen for development as VE alternatives. However, they may provide additional value improvement for the project in the form of risk mitigations or document clarifications.

**Table 16. Design Considerations**

<b>Comment No.</b>	<b>Description</b>
DC-1	Install active advance warning system for oncoming traffic at passing zones
DC-2	Improve the superelevation of select curves in Section 3 in lieu of friction course application
DC-3	Eliminate removal and reset of existing guardrail (Section 2 - R7) and replace with new
DC-4	Perform additional surveys to verify edge of full-depth pavement
DC-5	Improve signage / information to drivers of upcoming passing opportunities
DC-6	Improve signage at all spot locations with flashing beacons and lighted signs
DC-7	Provide a refuge area (two stage) for left turning traffic onto KY 210 (i.e. at KY 470 and 569)
DC-8	Provide spot improvements at Middle Pitman Creek and KY 883 in lieu of 2+1 widening
DC-9	Increase geotechnical investigation relative to identifying potential for New Albany Shale / sulfuric acid
DC-10	Provide alternative subbase treatment (geogrid, etc.) in lieu of CSB
DC-11	Increase onsite disposal of excavated spoils in lieu of offsite disposal / hauling
DC-12	Revise the rumble strip and striping configuration to provide striping on high side of groove
DC-13	Defer the water line utility work in Section 2 to contractor in lieu of by others
DC-14	Pursue additional funding opportunities for safety improvements



## Appendix A. Value Methodology Process

Value Methodology is a systematic process using a multidisciplinary team to improve the value of a project through the analysis of its functions. This process incorporates, to the extent possible, the values of design, construction, maintenance, contractor, state, local, and federal approval agencies, other stakeholders, and the public.

The primary objective of a Value Engineering (VE) study is value improvement. Value improvements might relate to scope definition, functional design, constructability, coordination (both internal and external), or the schedule for project development.

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

### Pre-VE Study

**Preparation Phase** - Prior to the start of a VE study, the Project Manager, and the VE facilitator carry out the following activities:

- Initiate study – Identify study project and define study goals
- Organize study – Conduct pre-VE study meeting and select team members
- Prepare data – Collect and distribute data and prepare cost models.

### Workshop Phases

**Information** – The team reviews and defines the current conditions of the project and identifies the goals of the study.

**Function Analysis** – The team defines the project functions using a two-word active verb/measurable noun context. The team reviews and analyzes these functions to determine which need improvement, elimination, or creation to meet the project's goals.

**Creativity** – The team employs creative techniques to identify other ways to perform the project's function(s).

**Evaluation** – The team follows a structured evaluation process to select those ideas that offer the potential for value improvement while delivering the project's function(s) and considering performance requirements and resource limits.

**Development** – The team develops the selected ideas into alternatives (or proposals) with a sufficient level of documentation to allow decision makers to determine if the alternative should be implemented.

**Presentation** – The VE facilitator develops a report and/or presentation that documents and conveys the adequacy of the alternative(s) developed by the team and the associated value improvement opportunity.

### Post-Study

**Implementation Phase** - The project team is then charged with reviewing the report and may hold a Disposition Meeting with management and other stakeholders, to determine which alternatives will be implemented in the design. The project team then tracks their implementation into the plans.



## Performance-Based Value Engineering

The following is a general discussion and overview of the Performance-Based VE process. Ideas that have been introduced and warrant further consideration, will be documented with their advantages and disadvantages; each idea will then be carefully evaluated against project-specific attributes.

Performance measures an integral part of the VE process. It provides the cornerstone of the VE process by giving a systematic and structured way 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 VE study. The performance attributes and requirements that are developed are then used throughout the study to identify, evaluate, and document alternatives.

### Introduction

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 related to improving project performance. Project costs are relatively easy to quantify and compare through traditional estimating techniques. Performance is not so easily quantifiable.

The VE facilitator will lead the team and external stakeholders 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 develops forms the basis for the VE teams understanding of the performance requirements of the project and to what degree the current design concept is 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. Establish the hierarchy and impact of these attributes on the project.



Establish the baseline of the current project performance by evaluating and rating the effectiveness of the current design concepts.

Identify the change in performance of alternative project concepts generated by the study.

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. If 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 facilitator 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. Most 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.

Typical standardized project performance attributes are shown below. Specific definitions of each attribute can be found below.

- Main Line Operations
- Local Operations
- Maintainability
- Construction Impacts



- Environmental Impacts

### Step 2 – Determine the Relative Importance of the Attributes

Once the group has agreed on the project’s performance attributes, the next step is to determine their relative importance in relation to each other. This is accomplished using 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”) is entered into the matrix for each pair, identifying which of the two is more important. If a pair of attributes is of essentially equal importance, both letters (e.g., “A/B”) are entered into the appropriate box. This, however, should be discouraged, as it has been found that in practice a tie usually indicates that the pairs have not been adequately discussed. When all pairs have been discussed, the number of “votes” for each is tallied and percentages (which will be used as weighted multipliers later in the process) are calculated. It is not uncommon for one attribute to not receive any “votes.” If this occurs, the attribute is given a token “vote,” as it made the list in the first place and should be given some degree of importance.

An example of this exercise is shown below.

PERFORMANCE ATTRIBUTE MATRIX						
[Project Name]						
Which attribute is more important to the project?					TOTAL	%
Main Line Operations	A	B	A	A	5.0	23.8%
Local Operations		B	B	B	5.5	26.2%
Maintainability			C	E	2.0	9.5%
Construction Impacts			D	E	1.5	7.1%
Environmental Impacts				E	4.0	19.0%
Project Schedule				F	3.0	14.3%
				<b>Total</b>	21.0	100%

**Without emphasis on preference**  
 A = A is of greater importance  
 A/B = A and B are of equal importance

For the example project above, the project owner, design team, and stakeholders determined that Main Line Operations, followed by Environmental, gave the greatest improvement relative to the projects purpose and need, while Construction Impacts and Project Schedule gave the least improvement.

### Step 3 – Establish the Performance Baseline for the Original Design



The next step in the process is 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. An example of project-specific elements is shown below.

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 study.

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 are evaluated against the baseline for all attributes to compare 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.

Rating	Performance Attribute Scale
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	<b>Baseline</b>
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 baseline 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 alternatives 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 baseline 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:

- $\% \text{ Performance Improvement} = \frac{\Delta \text{ Performance VE Strategy}}{\text{Total Performance Original Concept}}$
- $\text{Value Index} = \frac{\text{Total Performance}}{\text{Total Cost}}$
- $\% \text{ Value Improvement} = \frac{\Delta \text{ Value Index VE Strategy}}{\text{Value Index Original Concept}}$ .



# Appendix B. VE Workshop Agenda and Attendees

## Value Engineering Workshop Agenda

<b>Day 1</b>	<b>September 16, 2024</b>		
	<b>Objective for the day: Learn about VE and the project</b>		
<b>9:00 AM (EDT)</b>	<b>Workshop Kick-off Meeting</b>	<ul style="list-style-type: none"> <li>Study kickoff</li> <li>Team introductions</li> <li>Workshop objectives</li> </ul>	<b>All Audiences:</b> Project owner, management, stakeholders, designers, etc.
<b>9:15 AM</b>	<b>VE Process Overview</b>	<ul style="list-style-type: none"> <li>An instructional presentation on the principles of value Engineering and their application to the project</li> </ul>	<b>VE Facilitator</b>
<b>9:30 AM</b>	<b>Project Overview</b>	<ul style="list-style-type: none"> <li>Goals and objectives of the project</li> <li>Key project drivers, decisions, and constraints</li> <li>Project Scope / Design Overview</li> <li>Project challenges and VE focus areas</li> </ul>	<ul style="list-style-type: none"> <li>Areas for discussion:               <ul style="list-style-type: none"> <li>Roadway Design</li> <li>Traffic Analysis</li> <li>Structures</li> <li>Drainage/Hydraulics</li> <li>Utilities</li> <li>Environmental Conditions</li> <li>Staging/Phasing</li> </ul> </li> </ul>
			<b>Project Team/ Designer</b>
<b>11:00 AM</b>	<b>Break</b>		
<b>11:15 AM</b>	<b>Project Issues and Concerns</b>		<b>KYTC/Designer</b>
<b>11:30 AM</b>	<b>Define and Prioritize Performance Attributes</b>		<b>All Audiences</b>
<b>12:00 AM</b>	<b>Risk Assessment &amp; Risk Register Updates</b>		<b>All Audiences</b>
<b>Noon</b>	<b>Lunch</b>		
	<b>VE Project Engineering and Documentation Review</b>		
<b>1:00 PM</b>		<ul style="list-style-type: none"> <li>Review Available Project Documents</li> <li>Review Project schedule, including construction phasing/sequencing, work windows</li> <li>Cost Estimate / Cost Model Review and contingency assumptions</li> <li>Preliminary List of Project Issues and Value Opportunities</li> </ul>	<b>VE Team (offline)</b>
	<b>Value Metrics and Baseline Performance Rating</b>		
<b>2:00 PM</b>		<ul style="list-style-type: none"> <li>Rate performance attributes of baseline project</li> </ul>	
	<b>Risk Assessment &amp; Risk Register</b>		
		<ul style="list-style-type: none"> <li>Assign probabilities and impact ratings to risks</li> </ul>	<b>VE Team</b>
	<b>Discuss Project Issues and Value Opportunities</b>		



<b>Day 2</b>	<b>September 17, 2024</b>		
	<b>Objective for the day: Function Engineering, Brainstorming Ideas, and Evaluation</b>		
<b>8:00 AM</b>	<b>Virtual Meeting #2A</b>		
<b>8:00 AM</b>	<b>Function Analysis</b>	<ul style="list-style-type: none"> <li>• Random Function Identification</li> <li>• Build / Review FAST diagram</li> </ul>	<b>VE Team</b>
<b>9:00 AM</b>	<b>Brainstorming Ideas</b>	<ul style="list-style-type: none"> <li>• Brainstorm alternative ways to perform key functions</li> </ul>	<b>VE Team</b>
<b>Noon</b>	<b>Lunch</b>		
<b>1:00 PM</b>	<b>Evaluation of Ideas</b>	<ul style="list-style-type: none"> <li>• Score/Rate ideas based on predetermined criteria</li> </ul>	<b>VE Team</b>
<b>5:00 PM</b>	<b>Adjourn for the day</b>		
<b>Day 3</b>	<b>September 18, 2024</b>		
	<b>Objective for the day: Midpoint Review and Begin Developing</b>		
<b>8:00 AM</b>	<b>Develop Ideas into VE Alternatives</b>	<ul style="list-style-type: none"> <li>• Select ideas to develop further into Alternatives</li> <li>• Individual/team assignments</li> <li>• Review VE Alternative Development Process</li> </ul>	<b>VE Team</b>
<b>9:00 AM</b>	<b>Midpoint Review</b>		<b>KYTC / Designer Reps</b>
<b>10:00 AM</b>	<b>Develop Ideas into Recommendations</b>	<ul style="list-style-type: none"> <li>• Individual/team assignments</li> <li>• Development of recommendations:               <ul style="list-style-type: none"> <li>○ Test design feasibility</li> <li>○ Design Engineering</li> <li>○ Technical narratives</li> <li>○ Further discussion on advantages and disadvantages</li> <li>○ Cost Estimating</li> </ul> </li> </ul>	<b>VE Team (offline individual assignments)</b>
<b>5:00 PM</b>	<b>Adjourn for the day</b>		



<b>September 19, 2024</b>		
<b>Day 4</b>	<b>Objective for the day: Continue Development of VE Alternatives</b>	
<hr/>		
<b>8:00 AM</b>	<b>Continue Development of recommendations:</b> <ul style="list-style-type: none"> <li>• Technical narratives</li> <li>• Drawings/Sketches</li> <li>• Cost Estimating</li> </ul>	<b>VE Team</b>
<hr/>		
<b>1:00 PM</b>	<b>VE Team Review of VE Alternative Development</b> <ul style="list-style-type: none"> <li>• Peer review of recommendations</li> <li>• Outbrief Presentation Preparation/Review</li> </ul>	<b>VE Team</b>
<hr/>		
<b>5:00 PM</b>	<b>Adjourn</b>	
<hr/>		
<b>September 20, 2024</b>		
<b>Day 5</b>	<b>Objective for the day: Outbrief Presentation of Draft VE Study Results</b>	
<hr/>		
<b>8:00 AM</b>	<b>Strategies and Value Metrics</b> <ul style="list-style-type: none"> <li>• Development of VE Strategies (combination of Alternatives)</li> <li>• Evaluate performance and cost of VE strategies</li> </ul>	<b>VE Team</b>
<hr/>		
<b>10:00 AM</b>	<b>Presentation of VE Findings</b> <ul style="list-style-type: none"> <li>• Team presents VE Study Results and Value Proposals</li> <li>• Questions and answers</li> </ul>	<b>All Audiences:</b> Project owner, management, stakeholders, designers, etc.
<hr/>		
<b>12:00 PM</b>	<b>Adjourn</b>	
<hr/>		



# Appendix C. Project Estimate

**Section 1 – Larue County (Previously Improved Section)**

		Shoulders	Driving Lane
Existing Pavement width		20	24
Proposed Pavement width		16	36

Project Length	36655
----------------	-------

Overlay Width		24
Widening Driving Lanes Width		12
Widening Shoulders Width		16

Overlay Area		97746.66667	SY
Widening Driving Lanes Area		48873.33333	SY
Widening Shoulders Area		65164.44444	SY

Conversion	110
	115

inches

Overlay Mill (1.25")	1.25	6720	tons	65	\$/Ton		\$ 436,805.42
Overlay Surface (1.5")	1.5	8064	tons	83.3	\$/Ton		\$ 671,336.33

Driving Lanes

Widening Surface (1.5")	1.5	4032	tons	83.3	\$/Ton		\$ 335,668.16
Widening Base (6")	6	16128	tons	69.8	\$/Ton		\$ 1,126,070.92
Widening DGA (6")	6.75	18969	tons	24.7	\$/Ton		\$ 469,292.13

Shoulders

Widening Surface (1.5")	1.5	5376	tons	75.4	\$/Ton		\$ 405,247.91
Widening Base (6")	3	10752	tons	78.6	\$/Ton		\$ 844,795.12
Widening DGA (Full Depth)	17.479	65493	tons	24.7	\$/Ton		\$ 1,620,288.44

Earthwork

Cut		60811	CY	15	\$/CY		\$ 912,167.70
Fill		14021	CY	15	\$/CY		

Pavement+Earthwork **\$ 6,821,672.13**

KY55 2+1 Pavement+E-work 52.70%

**Project total** **\$ 12,945,439.76**

6.942234848 miles

lbs/SY*in
lbs/SY*in

	\$ 17,603,113.99
\$ 1,864,736.65 \$/mile	\$ 10,532,358.75
	\$ 11,467,641.25
	6.15

## Estimate 4-80154.00

Estimated Cost:\$13,585,416.16

Contingency: 15.00%

**Estimated Total: \$15,623,228.58**

***Base Date: 02/27/24***

Spec Year: 08

Unit System: E

Work Type: ASPHALT SURFACING NEW CONSTRUCTION

Highway Type: STATE ROUTE

Urban/Rural Type: RURAL

Season: SPRING

County: LARUE, GREEN, TAYLOR

Latitude of Midpoint: 37°28'07"

Longitude of Midpoint: 85°35'51"

District: 04

Federal Project Number: FD04 1550 C062 E143

State Project Number:

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
<u>Description</u>					
<u>Supplemental Description</u>					

Group 0001: Paving

0005	00003	51,929.000	TON	\$30.24092	\$1,570,380.73
CRUSHED STONE BASE					
0006	00008	78,270.000	SQYD	\$4.01133	\$313,966.80
CEMENT STABILIZED ROADBED					
0007	00020	479.000	TON	\$40.75450	\$19,521.41
TRAFFIC BOUND BASE					
0008	00100	317.000	TON	\$118.66109	\$37,615.57
ASPHALT SEAL AGGREGATE					
0009	00103	39.000	TON	\$1,026.86068	\$40,047.57
ASPHALT SEAL COAT					
0010	00190	2,440.000	TON	\$83.36656	\$203,414.41
LEVELING & WEDGING PG64-22					
0011	00212	7,945.000	TON	\$81.02617	\$643,752.92
CL2 ASPH BASE 1.00D PG64-22					
0012	00214	15,943.000	TON	\$89.26529	\$1,423,156.52
CL3 ASPH BASE 1.00D PG64-22					
0013	00221	391.000	TON	\$122.67416	\$47,965.60
CL2 ASPH BASE 0.75D PG64-22					
0014	00301	3,405.000	TON	\$88.56938	\$301,578.74
CL2 ASPH SURF 0.38D PG64-22					
0015	00356	68.000	TON	\$12.74050	\$866.35
ASPHALT MATERIAL FOR TACK					
0016	00358	80.000	TON	\$806.68148	\$64,534.52
ASPHALT CURING SEAL					
0017	00388	5,819.000	TON	\$114.38556	\$665,609.57
CL3 ASPH SURF 0.38B PG64-22					
0018	02084	230.000	SQYD	\$141.59770	\$32,567.47
JPC PAVEMENT-8 IN					
0019	02542	2,143.000	TON	\$232.77252	\$498,831.51
CEMENT					
0020	02702	197.000	TON	\$39.98017	\$7,876.09
SAND FOR BLOTTER					
0021	21289ED	15,300.000	LF	\$3.90977	\$59,819.48
LONGITUDINAL EDGE KEY					

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
<u>Description</u>					
<u>Supplemental Description</u>					
0022	24969ED	15,300.000	LF	\$2.98000	\$45,594.00
LONGITUDINAL SAW CUT					

Total for Group 0001:\$5,977,099.26

Group 0002: Roadway

0129	01987	132.000	EACH	\$12.37054	\$1,632.91
DELINEATOR FOR GUARDRAIL BI DIRECTIONAL WHITE					
0130	02003	3,640.000	LF	\$6.55283	\$23,852.30
RELOCATE TEMP CONC BARRIER					
0131	02159	8,813.000	LF	\$0.25208	\$2,221.58
TEMP DITCH					
0132	02160	4,406.000	LF	\$0.12745	\$561.54
CLEAN TEMP DITCH					
0133	02200	313,330.000	CUYD	\$13.40850	\$4,201,285.31
ROADWAY EXCAVATION					
0134	02268	102.000	LF	\$19.49013	\$1,987.99
REMOVE & REPLACE FENCE					
0135	02360	19.000	EACH	\$66.30840	\$1,259.86
GUARDRAIL TERMINAL SECTION NO 1					
0136	02367	8.000	EACH	\$4,353.61215	\$34,828.90
GUARDRAIL END TREATMENT TYPE 1					
0137	02369	7.000	EACH	\$1,033.86876	\$7,237.08
GUARDRAIL END TREATMENT TYPE 2A					
0138	02371	6.000	EACH	\$1,605.42625	\$9,632.56
GUARDRAIL END TREATMENT TYPE 7					
0139	02381	10,477.500	LF	\$1.55463	\$16,288.64
REMOVE GUARDRAIL					
0140	02383	250.000	LF	\$38.11334	\$9,528.34
REMOVE & RESET GUARDRAIL					
0141	02429	130.000	EACH	\$205.67467	\$26,737.71
RIGHT-OF-WAY MONUMENT TYPE 1					
0142	02430	4.000	EACH	\$168.11854	\$672.47
RIGHT-OF-WAY MONUMENT TYPE 1A					
0143	02432	100.000	EACH	\$95.40727	\$9,540.73
WITNESS POST					

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
<u>Description</u>					
<u>Supplemental Description</u>					
0144	02483	62.000	TON	\$70.20560	\$4,352.75
CHANNEL LINING CLASS II					
0145	02484	144.000	TON	\$68.72510	\$9,896.41
CHANNEL LINING CLASS III					
0146	02545	1.000	LS	\$95,000.00000	\$95,000.00
CLEARING AND GRUBBING					
0147	02562	1,500.000	SQFT	\$5.60327	\$8,404.91
TEMPORARY SIGNS					
0148	02585	331.000	LF	\$42.65287	\$14,118.10
EDGE KEY					
0149	02650	1.000	LS	\$200,000.00000	\$200,000.00
MAINTAIN & CONTROL TRAFFIC					
0150	02671	6.000	EACH	\$3,259.43069	\$19,556.58
PORTABLE CHANGEABLE MESSAGE SIGN					
0151	02690	18.000	CUYD	\$417.16184	\$7,508.91
SAFELOADING					
0152	02696	33,640.000	LF	\$0.27565	\$9,272.87
SHOULDER RUMBLE STRIPS					
0153	02701	8,813.000	LF	\$2.45287	\$21,617.14
TEMP SILT FENCE					
0154	02703	94.000	EACH	\$189.84749	\$17,845.66
SILT TRAP TYPE A					
0155	02704	94.000	EACH	\$256.94464	\$24,152.80
SILT TRAP TYPE B					
0156	02705	94.000	EACH	\$207.28767	\$19,485.04
SILT TRAP TYPE C					
0157	02706	94.000	EACH	\$0.71349	\$67.07
CLEAN SILT TRAP TYPE A					
0158	02707	94.000	EACH	\$2.00490	\$188.46
CLEAN SILT TRAP TYPE B					
0159	02708	94.000	EACH	\$1.92154	\$180.62
CLEAN SILT TRAP TYPE C					
0160	02726	1.000	LS	\$20,000.00000	\$20,000.00
STAKING					

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
<u>Description</u>					
<u>Supplemental Description</u>					
0161	02775	6.000	EACH	\$1,025.11921	\$6,150.72
ARROW PANEL					
0162	02898	2.000	EACH	\$2,514.00828	\$5,028.02
RELOCATE CRASH CUSHION					
0163	03171	7,528.000	EACH	\$26.54436	\$199,825.94
CONCRETE BARRIER WALL TYPE 9T					
0164	05950	8,961.000	SQYD	\$2.25784	\$20,232.50
EROSION CONTROL BLANKET					
0165	05952	298,982.000	SQYD	\$0.18485	\$55,266.82
TEMP MULCH					
0166	05953	224,238.000	SQYD	\$0.19858	\$44,529.18
TEMP SEEDING AND PROTECTION					
0167	05963	10.900	TON	\$1,296.02956	\$14,126.72
INITIAL FERTILIZER					
0168	05964	17.800	TON	\$1,433.23000	\$25,511.49
MAINTENANCE FERTILIZER					
0169	05985	340,010.000	SQYD	\$0.30964	\$105,280.70
SEEDING AND PROTECTION					
0170	05992	278.100	TON	\$62.27042	\$17,317.40
AGRICULTURAL LIMESTONE					
0171	06511	113,594.000	LF	\$0.28504	\$32,378.83
PAVE STRIPING-TEMP PAINT-6 IN					
0172	06542	43,069.000	LF	\$1.34258	\$57,823.58
PAVE STRIPING-THERMO-6 IN W					
0173	06543	70,525.000	LF	\$1.19771	\$84,468.50
PAVE STRIPING-THERMO-6 IN Y					
0174	06568	119.000	LF	\$13.85053	\$1,648.21
PAVE MARKING-THERMO STOP BAR-24IN					
0175	06569	4,957.000	SQFT	\$5.75141	\$28,509.74
PAVE MARKING-THERMO CROSS-HATCH					
0176	06610	165.000	EACH	\$26.86616	\$4,432.92
INLAID PAVEMENT MARKER-MW					
0177	06612	442.000	EACH	\$16.09052	\$7,112.01
INLAID PAVEMENT MARKER-BY					

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
<u>Description</u>					
<u>Supplemental Description</u>					
0178	08902	8.000	EACH	\$31,995.96000	\$255,967.68
CRASH CUSHION TY VI CLASS B TL3					
0179	10020NS	49,921.000	DOLL	\$1.00000	\$49,921.00
FUEL ADJUSTMENT					
0180	10030NS	125,389.000	DOLL	\$1.00000	\$125,389.00
ASPHALT ADJUSTMENT					
0181	20191ED	8.000	EACH	\$78.39953	\$627.20
OBJECT MARKER TY 3					
0182	20458ES403	35,038.000	LF	\$0.15071	\$5,280.58
CENTERLINE RUMBLE STRIPS					
0183	21802EN	11,312.500	LF	\$33.90689	\$383,571.69
G/R STEEL W BEAM-S FACE (7 FT POST)					
0184	24781EC	29,400.000	TON	\$2.96000	\$87,024.00
INTELLIGENT COMPACTION FOR ASPHALT					
0185	24814EC	3,959.000	LF	\$2.32674	\$9,211.56
PIPELINE INSPECTION					
0186	24891EC	2,236,293.000	SF	\$0.01256	\$28,087.84
PAVE MOUNT INFRARED TEMP EQUIPMENT					

Total for Group 0002:\$6,473,639.07

Group 0003: Drainage

0106	00440	392.000	LF	\$96.40120	\$37,789.27
ENTRANCE PIPE-15 IN					
0107	00441	363.000	LF	\$106.06005	\$38,499.80
ENTRANCE PIPE-18 IN					
0108	00462	829.000	LF	\$120.19254	\$99,639.62
CULVERT PIPE-18 IN					
0109	00464	497.000	LF	\$169.23019	\$84,107.40
CULVERT PIPE-24 IN					
0110	00466	53.000	LF	\$219.29484	\$11,622.63
CULVERT PIPE-30 IN					
0111	00470	36.000	LF	\$459.83234	\$16,553.96
CULVERT PIPE-48 IN					
0112	00472	30.000	LF	\$675.00000	\$20,250.00
CULVERT PIPE-60 IN					

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
<u>Description</u>					
<u>Supplemental Description</u>					
0113	00474	49.000	LF	\$751.26000	\$36,811.74
CULVERT PIPE-72 IN					
0114	00521	78.000	LF	\$218.22739	\$17,021.74
STORM SEWER PIPE-15 IN					
0115	00524	145.000	LF	\$195.67661	\$28,373.11
STORM SEWER PIPE-24 IN					
0116	01204	13.000	EACH	\$2,548.45675	\$33,129.94
PIPE CULVERT HEADWALL-18 IN					
0117	01208	11.000	EACH	\$2,633.82300	\$28,972.05
PIPE CULVERT HEADWALL-24 IN					
0118	01216	1.000	EACH	\$5,977.70219	\$5,977.70
PIPE CULVERT HEADWALL-48 IN					
0119	01220	2.000	EACH	\$5,964.00000	\$11,928.00
PIPE CULVERT HEADWALL-60 IN					
0120	01433	3.000	EACH	\$2,533.48278	\$7,600.45
SLOPED BOX OUTLET TYPE 1-18 IN					
0121	01450	3.000	EACH	\$3,823.94782	\$11,471.84
S & F BOX INLET-OUTLET-18 IN					
0122	01451	1.000	EACH	\$4,847.40727	\$4,847.41
S & F BOX INLET-OUTLET-24 IN					
0123	01490	4.000	EACH	\$5,829.48577	\$23,317.94
DROP BOX INLET TYPE 1					
0124	01650	3.000	EACH	\$3,751.74818	\$11,255.24
JUNCTION BOX					
0125	01761	1.000	EACH	\$5,353.61075	\$5,353.61
MANHOLE TYPE B					
0126	02607	3,499.000	SQYD	\$2.00000	\$6,998.00
FABRIC-GEOTEXTILE CLASS 2 FOR PIPE					
0127	03262	1.000	EACH	\$2,507.79785	\$2,507.80
CLEAN PIPE STRUCTURE					
0128	08100	2.800	CUYD	\$2,010.94983	\$5,630.66
CONCRETE-CLASS A					

Total for Group 0003:\$549,659.91

Group 0004: Demobilization/Mobilization

<u>Line #</u>	<u>Item Number</u>	<u>Quantity</u>	<u>Units</u>	<u>Unit Price</u>	<u>Extension</u>
	<u>Description</u>				
	<u>Supplemental Description</u>				
0104	02568 MOBILIZATION	1.000	LS	\$390,011.94720	\$390,011.95
0105	02569 DEMOBILIZATION	1.000	LS	\$195,005.97360	\$195,005.97

Total for Group 0004:\$585,017.92

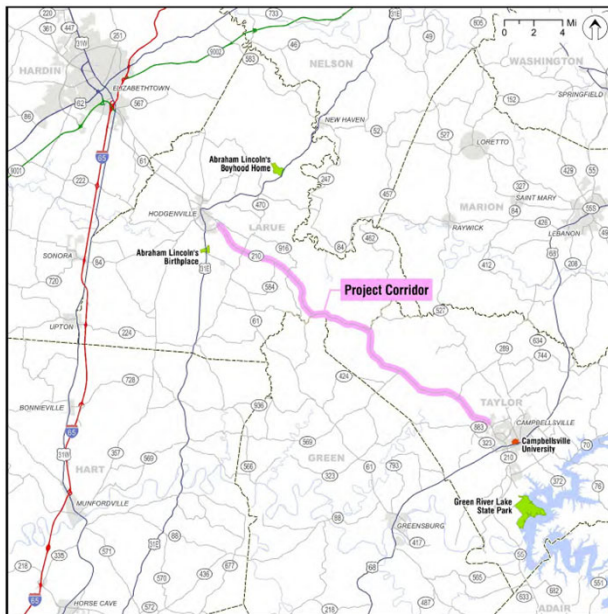




# Appendix D. Closing Presentation

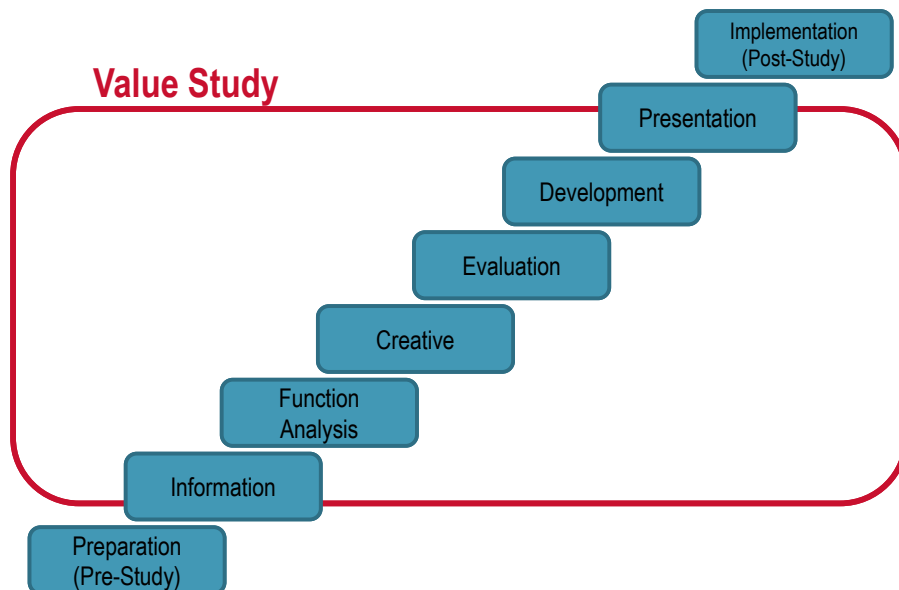
# VALUE ENGINEERING STUDY

**KY 210 Widening  
Hodgenville  
(KY 1618)  
to  
Campbellsville  
(KY 883)  
4-80154.00**



1

## **VE JOB PLAN**



2

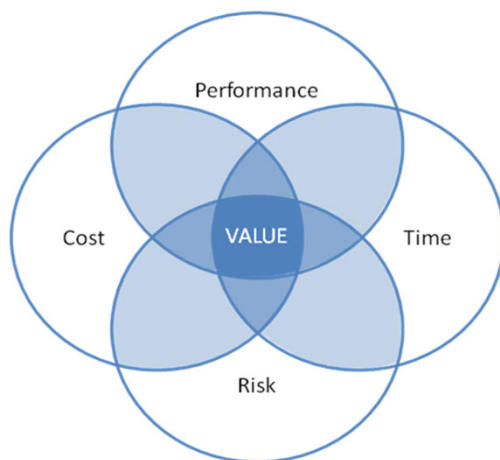
## VE Study Objectives – Key Functions

THROUGH APPLICATION OF THE VE JOB PLAN, THE OBJECTIVE OF THE VE STUDY WAS TO ASSESS AND/OR IMPROVE THE PROJECT, FOCUSING ON KEY FUNCTIONS: **IMPROVE OPERATIONS AND SAFETY BY INCREASING PASSING OPPORTUNITIES AND REDUCING CONFLICTS BY WIDENING ROADWAY WHILE REDUCING IMPACTS.**

3

## VE Study Overview – Value Metrics

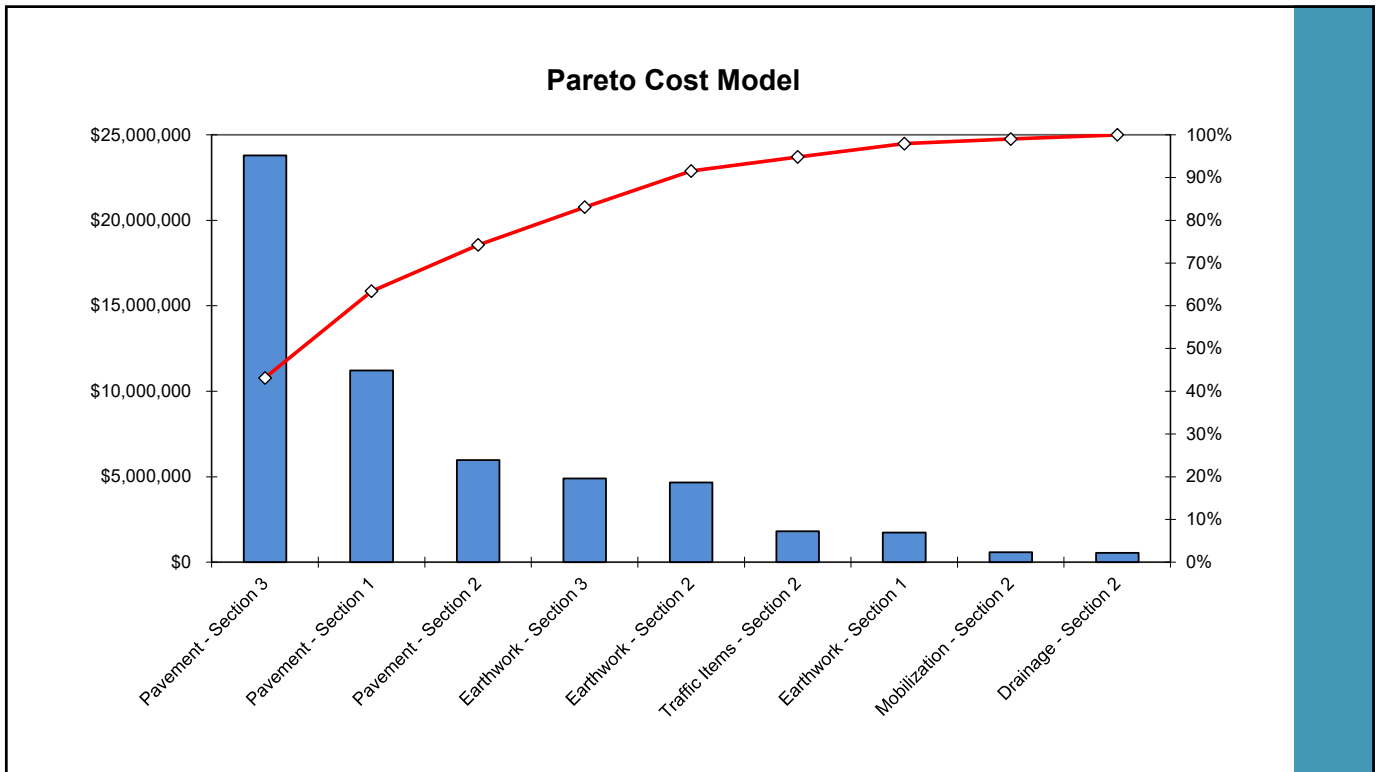
Value Engineering has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that VE can play with regard to improving project performance.



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

The equation is annotated with four arrows: two green arrows pointing upwards above the numerator 'Performance', and two arrows pointing downwards below the denominator 'Cost'—one green arrow pointing down and one red arrow pointing up.

4



5

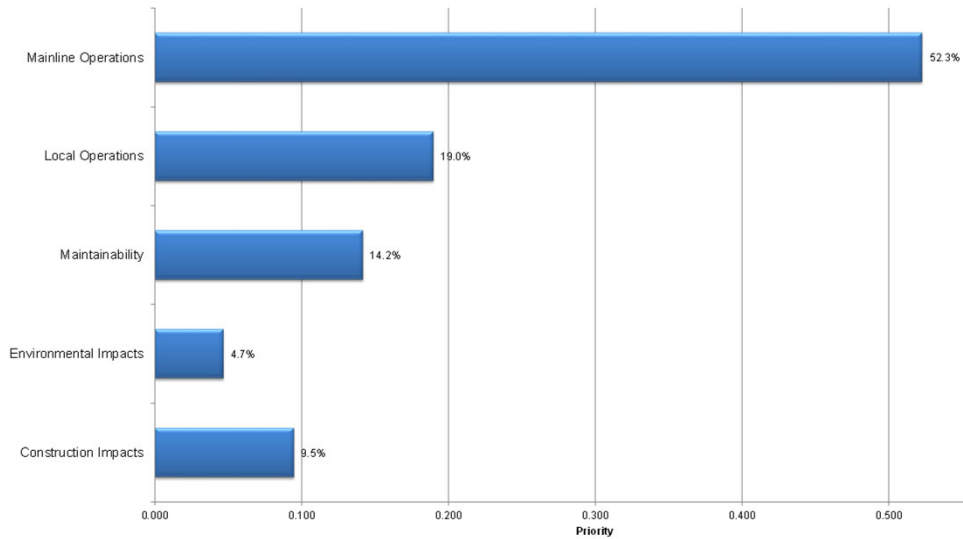
## PERFORMANCE REQUIREMENTS

### Performance Requirements

- Highway Design Standards
- Structural Design Standards
- Environmental Review Processes / Permits
- Maintain minimum operations during construction
- Utility Relocation Requirements
- Drainage Requirements
- Pavement Design Standards

6

# PERFORMANCE ATTRIBUTES AND PRIORITIES



An improvement to which attribute will provide the greatest benefit relative to the project's need and purpose?

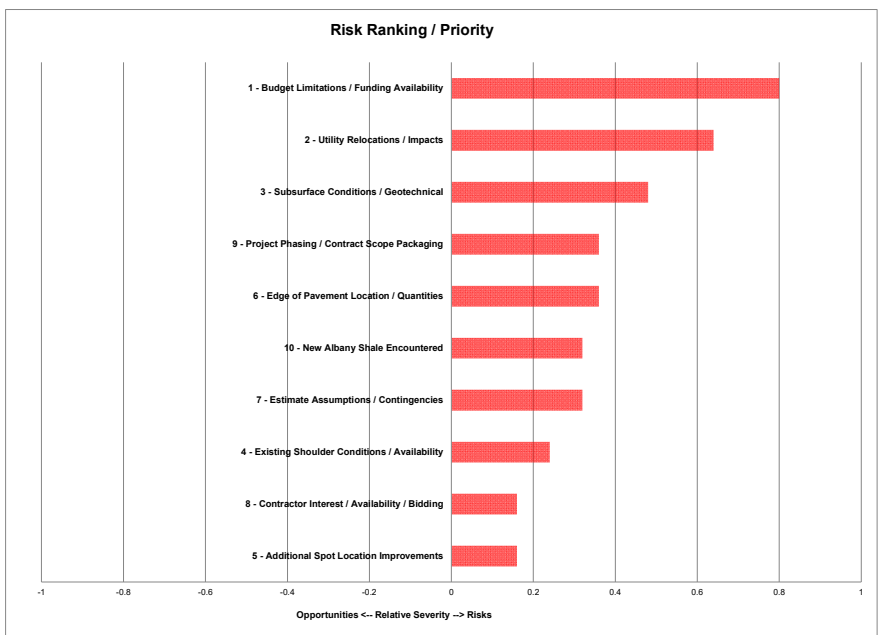


7

## Risk Review

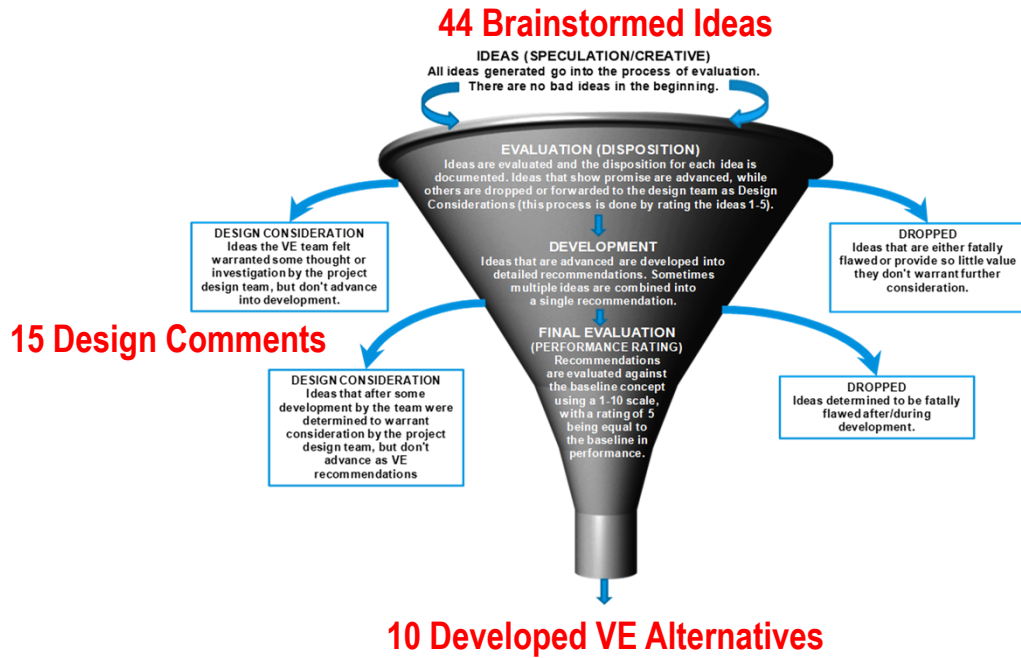
### Risk Assessment

- Identified uncertainties that may impact cost and/or schedule
- Qualitative analysis / Priorities
- VE Alternatives and specific Risk Mitigations



8

# Evaluation Process – Tiered Approach



9

## VALUE OPPORTUNITIES / VE FOCUS POINTS

- **Passing Opportunity Modifications**
  - Continuous 2+1 throughout the project limits vs. Select Locations
- **Spot Improvement Modifications**
  - Improve visibility / driver awareness
  - Spot Modification 1 - Lincoln Parkway configuration
  - Additional Spot Improvement Opportunities
- **Typical Section Modifications**
  - Reduced guard rail and material quantities
  - Initial cost savings potential vs. potential maintenance impacts (assume minor)

10

## DEVELOPMENT PHASE

### VE Alternative Development Content

- Baseline and Alternative Concept Narratives
- Advantages/Disadvantages
- Discussion/Justification
- Schedule and Risk Impacts
- Performance Attribute Comparison
- Sketches & Calculations
- Cost Estimates

11

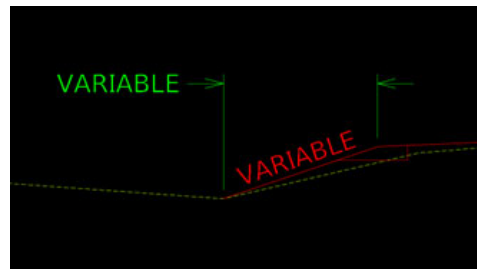
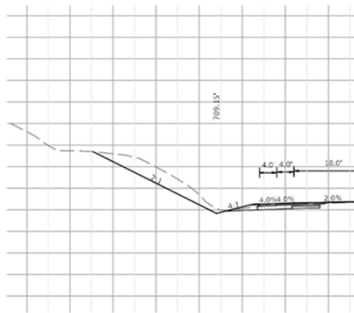
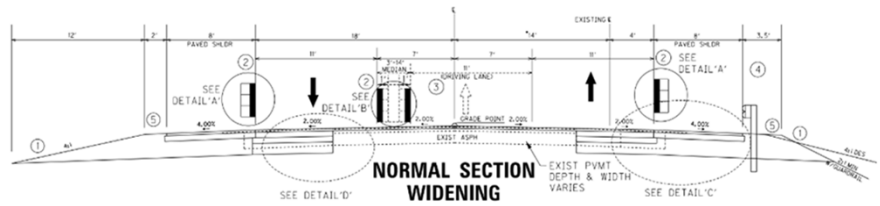
**PROVIDE  
PASSING LANES  
AT SELECT  
LOCATIONS IN  
LIEU OF  
CONTINUOUS  
2+1  
THROUGHOUT**



- NB Passing Lane
- SB Passing Lane
- Section 2 – Maintained as Continuous 2+1

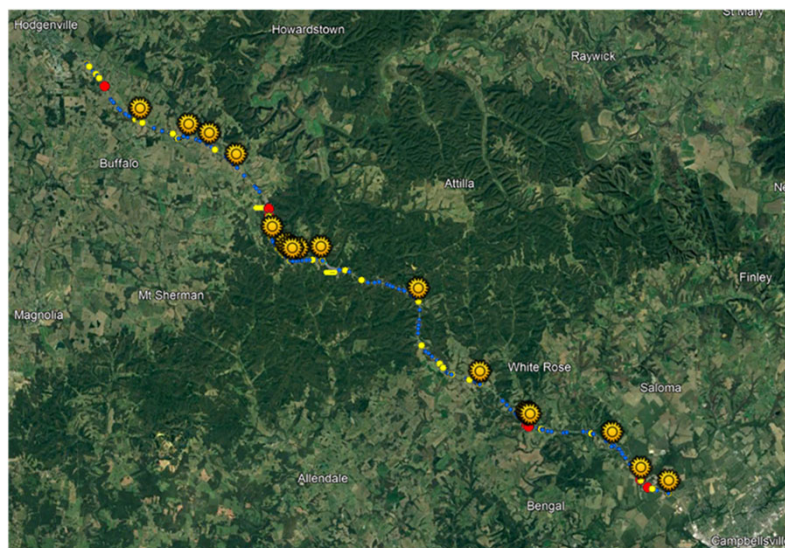
12

# REVISE TYPICAL SECTION TO FIT WITHIN EXISTING FLOW LINES IN SECTION 1 AND 3



13

# INSTALL LIGHTING AT SELECT LOCATIONS



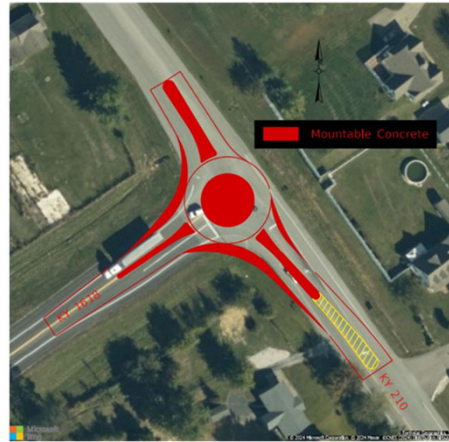
14

# REVISE LINCOLN PARKWAY INTERSECTION WITH KY 210



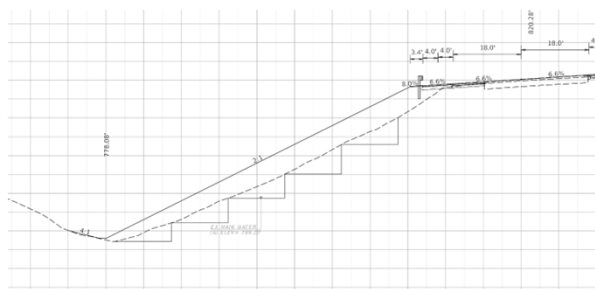
**Reconstruct Intersection with a 25 MPH Curve**

Baseline Concept

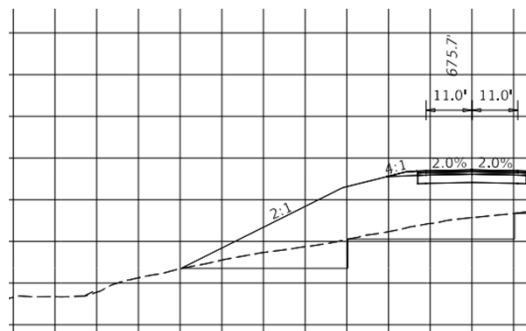


Proposed Concept

# USE BARN ROOF FILL SLOPE TO LIMITS OF CLEAR ZONE

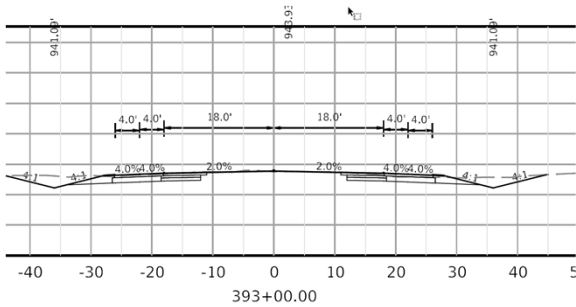


Baseline Concept

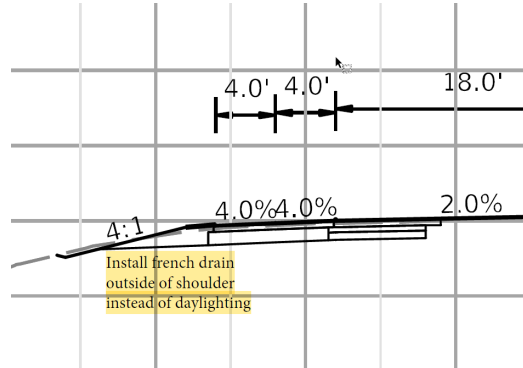


Proposed Concept

# PROVIDE DRAINAGE FOR EXISTING SUBGRADE WITH FRENCH DRAINS

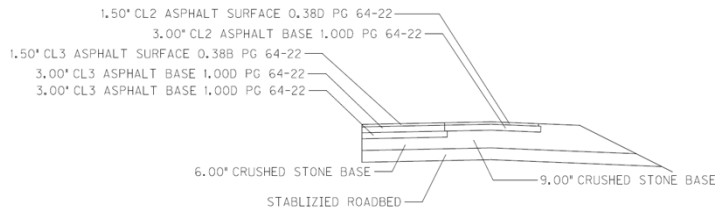


Baseline Concept



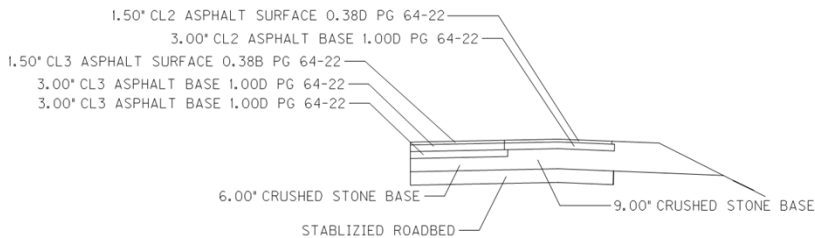
Proposed Concept

# REVISE LIMITS OF CEMENT STABILIZED BASE



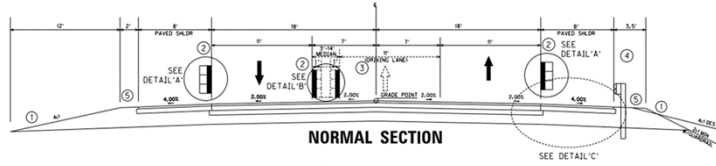
DETAIL "C"

Baseline Concept

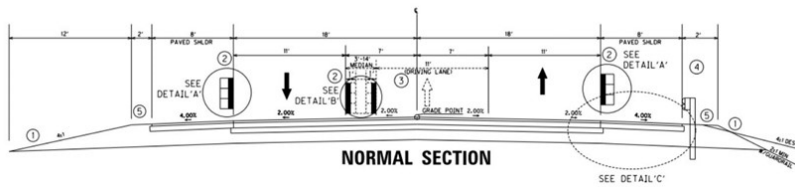


Proposed Concept

# MAINTAIN 2' STONE BASE SHOULDER WIDTH AT GUARD RAIL LOCATIONS



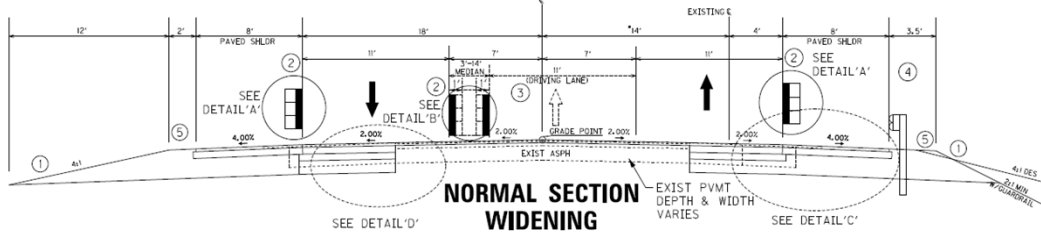
Baseline Concept



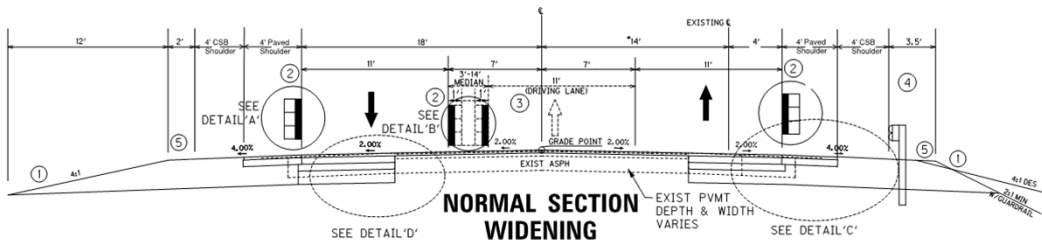
Proposed Concept

19

# USE 4' OF PAVED SHOULDERS AND 4' OF ROCK SHOULDERS WITH CHIP SEAL



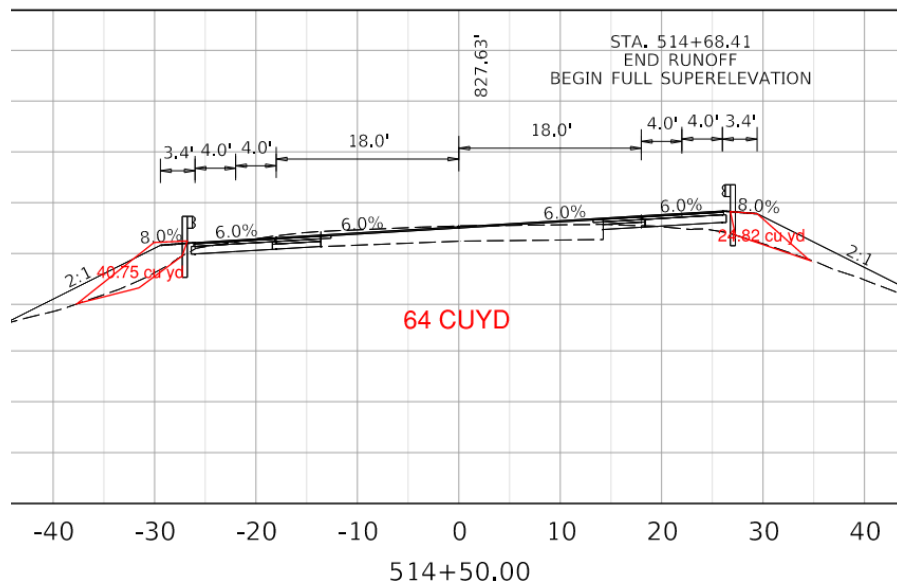
Baseline Concept



Proposed Concept

20

## USE GRANULAR EMBANKMENT AND GEOTEXTILE FOR SLIVER FILLS

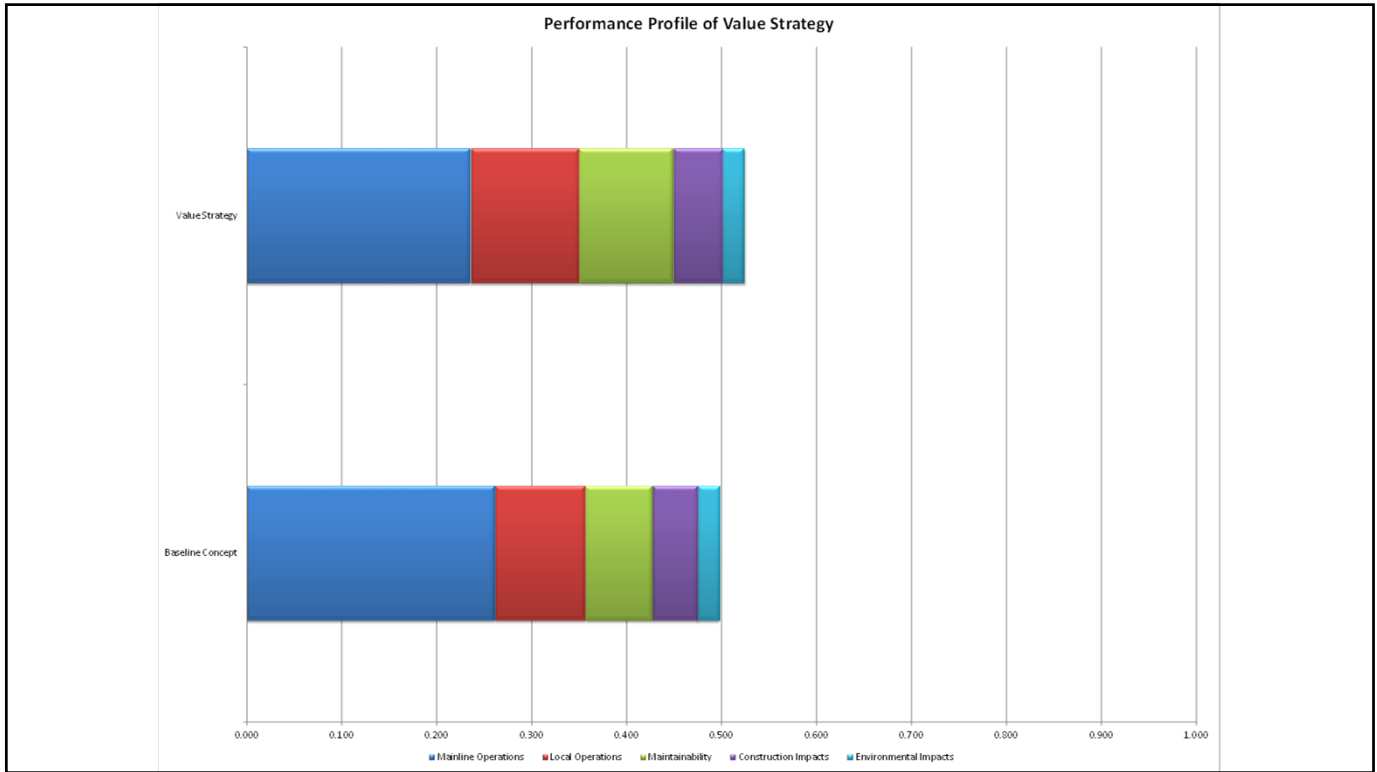


21

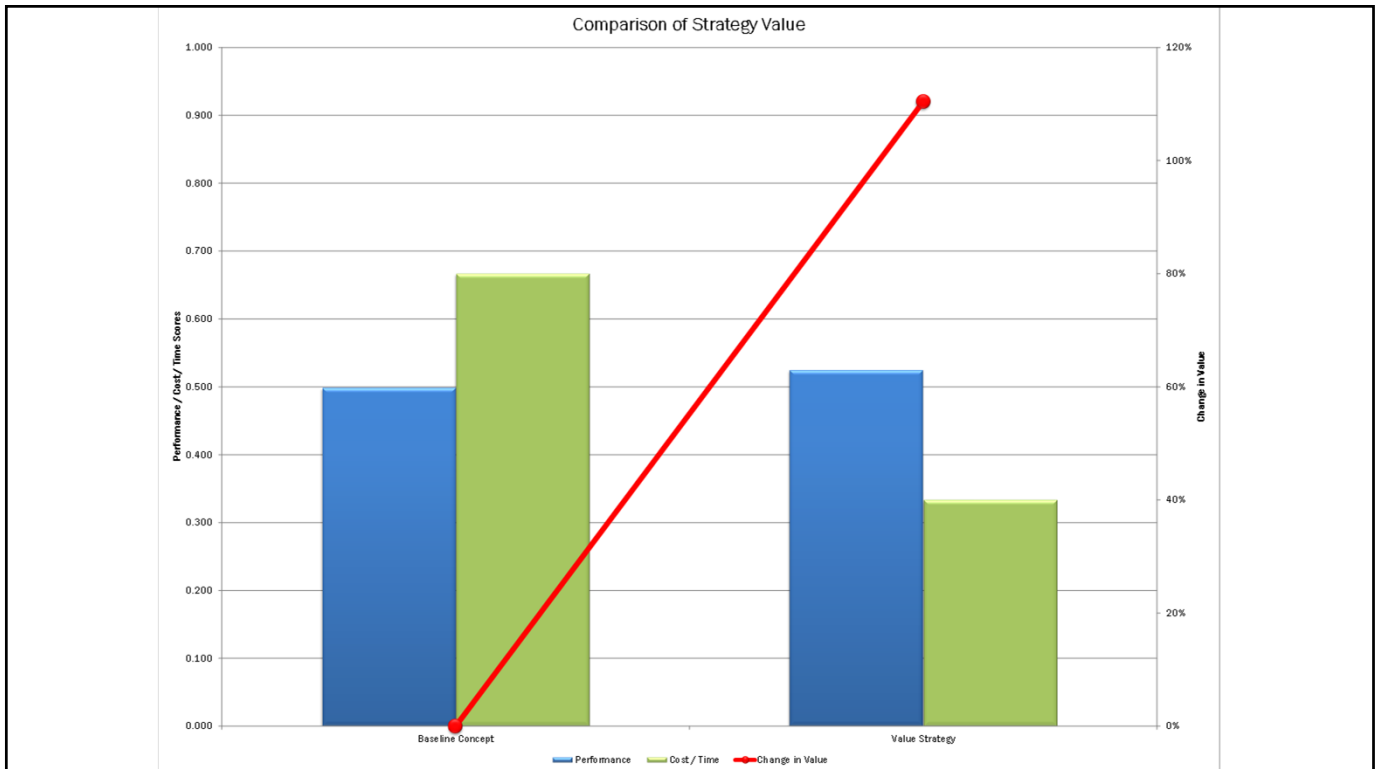
## TAKE AWAYS / VE STRATEGY

- VE Strategy = Combination of VE Alternatives into one cumulative set for evaluation
  - Does not preclude consideration of individual alternatives or alternatives not initially selected
- Includes VE Alts IPO-1, 2; SI-1, 2, 3; TS-1, 2, 3
- Total Cumulative Cost Savings Potential: ~\$25M

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23



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## ***Next Steps***

- Draft VE Report Submitted (October 4)
- Draft Report Review
  - Includes Implementation Action & Decisions
- Final VE Study Report

25



**KENTUCKY  
TRANSPORTATION  
CABINET**

26



# Appendix E. VE Implementation Approval Form



Alt No.	Alternative Title	Cost Savings or (Cost Added)	Preliminary Decision	Preliminary Decision Rationale	Design Team Comments
IPO-1	Provide passing lanes at select locations in lieu of continuous 2+1 throughout	\$20,110,000	Accept	<p>The Project Development Team would like to accept this alternative and will try to incorporate passing lanes at select locations in lieu of a continuous 2+1 Roadway through out the project. Mr. Siwula discussion with D4 Team concerning positive data being collected on the safety benefits of the 4 foot flush medians when using 2+1 roadway types. There is potential to save money through providing passing lanes at select locations and still provide a 4 foot flush median. *****After further discussion at the end of the meeting the Project Team decided that it would greatly benefit the project to look at reducing the typical section for the entire project and not just for Section 2, they will look for natural passing zones to provide passing opportunities.</p>	<p>Feels like this is a KYTC programmatic decision. We have considered isolated passing opportunities along other corridors but it feels like the intent from the Agency side was to provide a uniform and continuous 2+1 roadway section with alternating passing to replicate other projects (i.e. Heartland Parkway). If KYTC wants to go this route it is certainly something we could dive into further in Final Design.</p>
IPO-2	Confine typical section to existing flowlines	\$403,000	Accept	<p>The Project Development Team would like to accept this alternative to further plan development. The PDT will look at areas where can eliminate R/W impacts as much as possible. Some discussion made concerning any constructability issues, Eric and Johnathan felt that there should not be any constructability issues with this alternative. This alternative would be selective based on the side slopes, since would not want to compromise the maintainability of the slopes where guardrail would be required.</p>	<p>Agree - I think this needs to be considered when the project moves into final design. This is particularly relevant in the Taylor County Section where the existing typical section may not be as wide as Larue County.</p>



Alt No.	Alternative Title	Cost Savings or (Cost Added)	Preliminary Decision	Preliminary Decision Rationale	Design Team Comments
SI-1	Install lighting at select high-crash frequency locations. Consider solar / LED	(\$288,000)	Accept	The PDT would like to accept this alternative and consider lighting installation at select high-crash locations. District 4 has never included lighting on a project as a safety mechanism except for at interchanges and roundabouts. There was discussion of the possibility of using solar lights so the maintenance tasks are minimized. The District to work with the local municipality on this inclusion into the project.	This is an Agency call - may be a candidate for HSIP funding. Likely would need Solar type configurations and not sure KYTC's stance on these facilities.
SI-2	Revise Lincoln Parkway intersection with KY 210 with prioritized movements	\$12,000	Accept	The PDT would like to accept this alternative and look at designing a small roundabout (may not be a mini-roundabout) but would be as small as necessary at this location (potentially 120 to 130 ft diameter roundabout). There was some discussion concerning the KYTC Maintenance/Construction employees that use this intersection enroute to the maintenance barn and they indicated that it is often difficult to make a left turn at this location.	VE team brought us reduced Radii Roundabout. We considered a larger roundabout in preliminary engineering. Location does not have a history of crashes and the movement toward Hodgenville is pretty minor but certainly agree that Roundabout is the preferred intersection type from a safety and operations perspective. Open to renewed dialogue in Final Design.



Alt No.	Alternative Title	Cost Savings or (Cost Added)	Preliminary Decision	Preliminary Decision Rationale	Design Team Comments
SI-3	Use barn roof fill slope to limits of clear zone and eliminate guard rail	\$1,414,000	Accept	<p>The PDT would like to accept this alternative and look at utilizing a barn roof fill slope to the limits of the clear zone to eliminate guardrail. The team noted that there could potentially be more maintenance on any 4:1 slopes for this option but would strategically consider the barn roof fill slope only at locations where that would not be an issue. There was some concern that Right of Way plans have already been completed for Section 2 and that any changes will have to be reviewed carefully. It was also noted that this project is leaning towards a waste project and could also potentially help with wasting material during construction. There was also some concern with the potential 4:1 slope to the clear zone distance and then becoming a 2:1 slope outside the clear zone and vehicles not being able to traverse the 2:1 slope.</p>	<p>May be worth having discussion. As noted the primary savings would be for the elimination of Guardrail on the project - much of which is in Section 2 which has been designed with Right of Way Plans. If we move this direction then we are likely talking about a design modification and modification to Right of Way plans. The other issue is with the removal of guardrail the slopes beyond the clear zone or barn roof are non-traversable and non-recoverable which would make recovery on a steep fill difficult in the event that a vehicle goes past the slope break.</p>
TS-1	Provide drainage for existing subgrade with French drain in lieu of daylighting shoulders	\$1,507,000	Accept	<p>The PDT would like to accept this alternative and evaluate during final design. Several team members stated that they have utilized this approach on other projects and that it as worked well, with some time savings during construction.</p>	<p>This has been discussed at length with D4 delivery folks - KY 555 has been the most recent example. I believe on that project the team agreed to daylight the subgrade but use the french drain in critical locations where daylighting may impact utilities / underground constraints. Likely will discuss when this project moves to final design.</p>



Alt No.	Alternative Title	Cost Savings or (Cost Added)	Preliminary Decision	Preliminary Decision Rationale	Design Team Comments
TS-2	Revise limits of cement stabilized base	\$2,075,000	Accept	The PDT would like to accept this alternative and modify the plans to bring the stabilized base to the edge of the shoulder instead of daylighting to the slope.	Discuss in Final Design - KY 555 did not use a cement stabilized base under the CSB - agree the limits of this should be discussed in final design.
TS-3	Maintain 2' stone base shoulder width at guard rail locations	\$179,000	Accept	The PDT would like to accept this alternative and modify the typical section to show utilizing 2 ft of shoulder width behind the guardrail. The design already includes utilizing the 7 ft guardrail posts.	Makes sense for project team consideration - especially in sections 1 and 3 where the typical section has already been widening (consistent with previous 2+1 projects) and using the 7' posts.
TS-4	Use 4' of paved shoulders and 4' of rock shoulders in lieu of 8' paved in passing lane sections	\$422,000	Reject	The PDT would like to reject this alternative. There are other locations within the District where the paved shoulder width was reduced to 4 ft and there have been safety issues in those locations. They have also received much criticism from the locals with the reduced shoulder widths.	Project team discussion - this is inconsistent with previous 2+1 and given the geotechnical considerations of rock shoulders not holding up on some sections of this project this is not likely worth the savings
TS-5	Use granular embankment and geotextile for sliver fills	\$2,368,000	Accept	The PDT would like to accept this alternative and evaluate during final design. It was noted that this technique was utilized in Adair County and has worked really well.	This approach was utilized on KY 555 and likely needs to be discussed once this project advances to final design. 1:1 allowed on fills up to 3' and 1.5:1 on fills up to 10'