Value Engineering Study Report

KY 536 EXTENSION – 6-352.00

CAMPBELL COUNTY, KY

VE Number: 202501

Workshop Dates: January 13 – 17, 2025

Report Date: April, 2025

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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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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 536 Extension project in Campbell County, KY. The VE study consisted of a 5-day workshop that was conducted virtually with a multidisciplinary team on January 13 – 17, 2025.

Baseline Project Overview

The project will extend KY 536 approximately 3.9 miles east from its current terminus at US 27 to KY 9 as illustrated on Figure 1. The proposed roadway will have two (2) 11-foot (ft) lanes with additional turn lanes provided at major intersections. Truck climbing lanes will be included where warranted. The new roadway will have a functional classification of rural collector, with a primary purpose to serve intra-county travel. Because the roadway will intersect perpendicular to or be parallel with six (6) other roadways (including US 27 and KY 9), appropriate intersections or connectors to these roads are included in the project.

This baseline concept had an estimated construction cost of approximately $59.6 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 the hybrid preferred alternative 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 at the preliminary stage of project development.

VE Alternatives

The VE team generated 50+ 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 14 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.

Table 1. Summary of Alternatives

Alt No.	Alternative Title	Cost Savings or (Cost Added)	Performance/Risk
Local Road Crossings and ML Connection Access			
LR-1	Use arch culvert in lieu of bridge at Jerry Wright	$1,615,200	Improved (M)
LR-2	Provide intersection at Jerry Wright in lieu of grade separation	$2,297,000	Improved (M) Reduced (MO, LO)
LR-3	Use connectors to KY 536 at Persimmon Grove in lieu of bridge for grade separation	$3,542,000	Improved (M) Reduced (LO, EI)
LR-4	Use frontage road or local driveway for Gas Access Road	$139,000	Improved (MO, E)
LR-5	Use signalized intersection at KY-9 in lieu of MUTs	$332,000	Improved (MO, M, EI) Reduced (LO)
KY 536 Horizontal Alignment			
A-1	Realign KY 536 closer to Stonehouse Road	$3,724,000	Improved (EI, M)
A-2	Realign west connection and connect to US-27 to the south	$3,711,000	Improved (EI) Reduced (LO)
Roadway Profile and Cross Section			
PX-1	Reduce profiles throughout and increase roadway grades	TBD	Improved (E, M) Reduced (MO)
PX-2	Reduce footprint with steeper side slopes	TBD	Improved (EI) Reduced (MO, M)
PX-3	Provide 8’ shoulders on all bridges	$1,483,000	Improved (M)
Truck Climbing Lane			
TC-1	Adjust profile and eliminate truck climbing lane	$1,141,000	Improved (EI, M) Reduced (MO)
TC-2	Reduce shoulders at truck climbing lane	$92,000	Improved (EI, M) Reduced (MO)
Stream Crossings and Culverts			
SC-1	Realign culverts and shorten structure lengths/size	$358,000	Improved (M, EI)
Roadway Structural Section			
S-1	Reduce thickness of AC pavement in typical structural section	$2,005,000	Reduced (M)

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

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.

- Brian Donnelly, KYTC
- Sharon James, KYTC
- Anthony Damron, KYTC
- Adam Hedges, HDR
- Jared McCammon, HDR
- Mark Watson, HDR

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
LR-1	Use arch culvert in lieu of bridge at Jerry Wright	A	Redesign required. Historical Note: In 2001, reconstruction of Jerry Wright Rd to provide an at-grade intersection was considered but ultimately not advanced due to its negative effect on the residents along the existing road.
LR-2	Provide intersection at Jerry Wright in lieu of grade separation	R	Does not provide any savings over recommendation LR-1 when the additional 30,000 cubic yards of excavation is taken into consideration

Table 2. Summary of Alternative Implementation

Alt No.	Alternative Title	Implement Status	Decision Rationale / Comments
LR-3	Use connectors to KY-536 at Persimmon Grove in lieu of bridge for grade separation	A	An acceptable design should be achievable, but undesirable features may be unavoidable. Additional design and survey is required for the south side connection and new drainage structure. The mainline grade change will require redesign of the north connector. Preliminary calculations show a larger culvert opening will be required than was shown in the VE Draft Report. Historical Notes: During Phase 1 design it was found that a south side connection produces more cut and takes more length to tie in than the north side connector. This option also increased stream impacts. In 2005 the project team had a shorter 3-span bridge here with a 25X8 box culvert. In 2013 the project team decided that a longer 5 span bridge was preferred to a bridge and culvert combination because the cost of the 320' RCBC did not provide any savings over shortening the bridge and also increased the stream impact. Later in 2023 the team decided that the 5 span bridge would continue to be advanced and access provided from the mainline to Persimmon Grove Pike with a connector road to the north.
LR-4	Use frontage road or local driveway for Gas Access Road	R	With the additional right of way cost and the future maintenance this recommendation does not provide any savings and is therefore rejected.
LR-5	Use signalized intersection at KY-9 in lieu of MUTs	A	Development of a functional access management design required additional survey and roadwork on KY 9 between the MUTs including milling and resurfacing of traffic lanes, removal of the existing median and replacing with full depth pavement, and drainage accommodations. A potential additional savings of at least $100K could be realized with this alternate. It should also be noted that the existing KY 9 median is more narrow than desirable to convert them into MUT left turn lanes. During the design process a new signal was added on KY 9 just north of the proposed KY 536 intersection which eliminated the project team's desire to avoid a signal at this location. Historical Note: The project team agreed to change intersection from signalized to RI/RO with MUTs on KY 9 at PLG held 5/19/23.
A-1	Realign 536 closer to Stonehouse Road	R	Moving the route closer to Twelve mile creek has major impacts to the flood plain, therefore this recommendation is rejected.

Table 2. Summary of Alternative Implementation

Alt No.	Alternative Title	Implement Status	Decision Rationale / Comments
A-2	Realign west connection and connect to US-27 to the south	R	Moving the intersection at US 27 to the south destroys the corridor that goes from US 42 in Boone County all the way to AA Highway in Campbell County. Since this is considered a three county corridor, it is very important to consider the impacts for the entire corridor, therefor this recommendation is rejected.
PX-1	Reduce profiles throughout and increase roadway grades	A	Redesign required. Please note that these vertical changes to minimize earthwork will result in additional segments of the corridor that will show significant truck speed reduction and/or have steep grades on both sides of proposed intersections. And will also require additional work at the intersections.
PX-2	Reduce footprint with steeper side slopes	FS	Further Study. Redesign required. It may be worth considering the use of 2.5:1 fill with GR or a 4:1 to 2.5:1 "barn-roof" typical at large structures such as RCBC's and the arch at Jerry Wright Road to reduce structure length. Historical Note: At the more recent design team meetings (2023 and later), 4:1 slopes were to be used throughout the corridor except at the bridge approaches. Note: Since this project is an excess material project, steepening the slopes may require the purchase of additional waste sites which could minimize the savings and increase the undesirable use of guardrail.
PX-3	Provide 8’ shoulders on all bridges	A	Redesign required. Please note that the cost savings would likely apply to the bridge deck only and the savings realized would be less than shown here. Historically, the structure division has not wanted a reduced shoulder width used unless the bridge length is longer to justify the width reduction and subsequent safety reduction. Historical Note: The project team discussed the bridge shoulder width after the 2023 PL&G Inspection when the mainline shoulders were reduced from 10' paved to 8' (2' paved). The team had decided that 10' shoulders were still desirable on the bridges instead of matching the rest of the mainline shoulder width.

Table 2. Summary of Alternative Implementation

Alt No.	Alternative Title	Implement Status	Decision Rationale / Comments
TC-1	Adjust profile and eliminate truck climbing lane	FS	Further Study. This option should be considered and balanced with implementation of VE Alternative PX-1, which will result in other parts of the corridor where TCLs are warranted. It was suggested that the project team make note of locations that TCL warrants are met. Where viable, the project team will consider including adequate Right of Way to account for future TCL's. The team will also examine whether building the shoulder out wide enough to accommodate a future TCL in these areas will help with the overall project earthwork balance. Historical Note: Design team was asked to study warrants for and add TCL if met in 2023. Results showed a 18 mph reduction.
TC-2	Reduce shoulders at truck climbing lane	FS	Further Study. Redesign required. Any locations selected for future TCL development will account for a 11 ft TCL and a 4 ft shoulder (2 ft paved).
SC-1	Realign culverts and shorten structure lengths/size	FS	Further Study. Depending on location, some suggestions are not feasible.
S-1	Reduce thickness of AC pavement in typical structural section	A	Redesign required. Previous pavement design was advanced by the project team and the pavement design was approved in August 2024. A new design will require resubmission, review and approval.
LR-1	Use arch culvert in lieu of bridge at Jerry Wright	A	Redesign required. Historical Note: In 2001, reconstruction of Jerry Wright Rd to provide an at-grade intersection was considered but ultimately not advanced due to its negative effect on the residents along the existing road.
LR-2	Provide intersection at Jerry Wright in lieu of grade separation	R	Does not provide any savings over recommendation LR-1 when the additional 30,000 cubic yards of excavation is taken into consideration

Acknowledgements

The VE team wishes to express its appreciation to the KYTC project team members and the GRW 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.

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 the KY 536 Extension project in Campbell County, KY. The VE study was conducted on January 13 – 17, 2025 while the project was in the preliminary stage of design 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:

- Impacts to the floodplain are to be avoided while meeting drainage requirements.

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.

1.3 Value Opportunities and Focus Points

The primary opportunities for value improvement resulting from the VE team's analysis of the baseline project using the tools and techniques of the Value Methodology were as follows:

- Load Road Crossings and ML Connection Access
  - Grade Separations vs. Intersections/Alternate Routing
  - Local movements / Connection accommodations
- KY 536 Horizontal Alignment
  - Right of Way Impacts
  - Stream Impacts / Culverts
  - Terrain / Topography vs. Earthwork
- Roadway Profile and Cross Section
  - Roadway Character / Purpose and Need
  - Right of Way and Earthwork impacts
- Truck Climbing Lane
  - Benefit vs. Cost Analysis
- Stream Crossings and Culverts
  - Stream Impacts / Mitigations vs. Structure Costs & Maintenance
- Pavement Design

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

Document/Drawing/Schematic	Document Date
Preliminary Line and Grade Plans	11/7/2023
Manuscript Plans	N/A
Public Hearing Report Memos	3/4/2023
Cost Estimate	10/10/2023

2.2 Project Overview and Location

The project will extend KY 536 approximately 3.9 miles east from its current terminus at US 27 to KY 9 as illustrated on Figure 1. The proposed roadway will have two (2) 11-foot (ft) lanes with additional turn lanes provided at major intersections. Truck climbing lanes will be included where warranted. The new roadway will have a functional classification of rural collector, with a primary purpose to serve intra-county travel. Because the roadway will intersect perpendicular to or be parallel with six (6) other roadways (including US 27 and KY 9), appropriate intersections or connectors to these roads are included in the project.

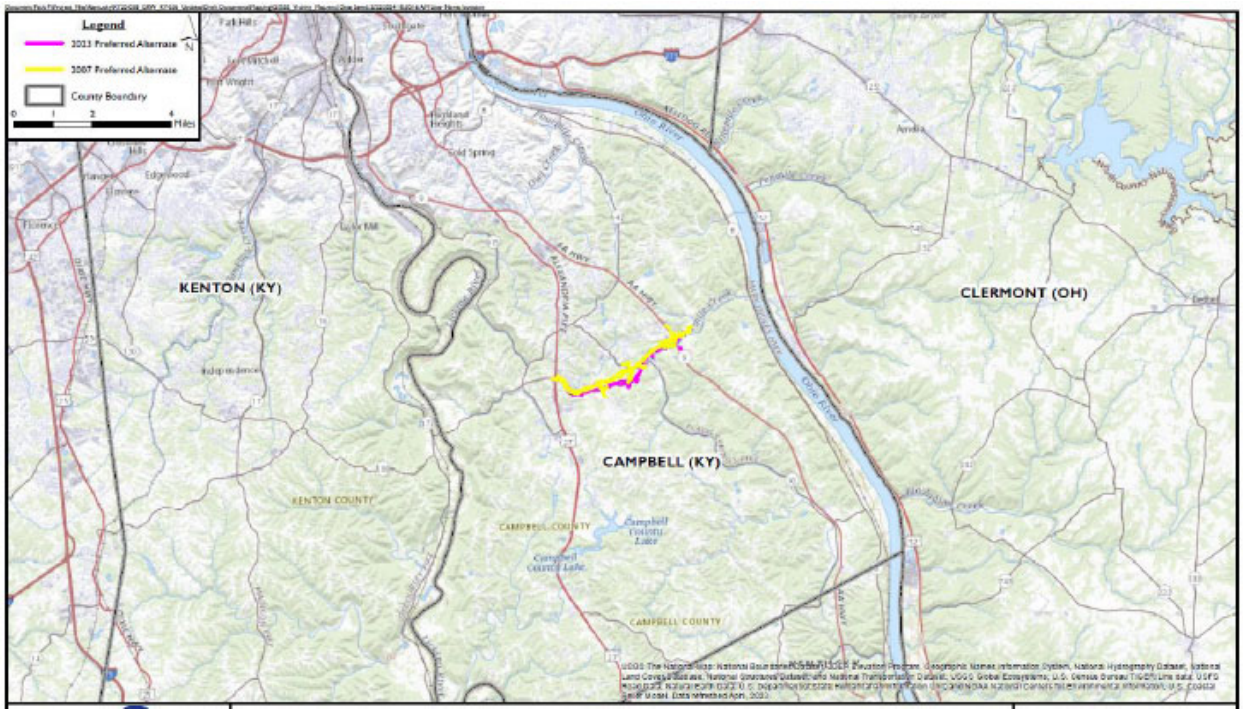


Figure 1. Project Location

2.3 Project History / Information

In 1999, the project was initially scoped for the development of viable alternate extensions of KY 536 eastward across open terrain, connecting US 27 with KY 9. Results of studies and public involvement yielded two (2) options known as “North Alternate A” and “South Alternate A”, the latter intersecting at KY 9 several thousand feet south of North Alternate A, south of the KY 9 bridge over Twelvemile Creek. From these, a third alternate was chosen as preferred, tagged as “North Alternate B”, which included a slight mainline shift, north of North Alternate A, to minimize disturbance of Four and Twelvemile Road.

In 2013, preliminary design resumed offering a new alignment that became known as the Hybrid Alternate. The overall design objective of the project restart was to reduce costs from the finalized North Alternate B. This alignment would utilize the western third of the South Alternate A and the eastern third of the North Alternate B alignments with a centrally located crossover connecting the two in the center third of the corridor. Two (2) bridges, one over KY 9 and one over Lower Grandview Road, were eliminated and the typical section reduced to two 11’ lanes. This alternative was carried out through preliminary design without involvement of environmental restudies. At the end of preliminary design, the project was stopped once again due to lack of funding.

In 2022, KYTC re-initiated design after securing funding through the FY 2025 right-of-way phase resulting in development of the 2023 Alternate. Design refinements have resulted in a near balanced earthwork total and minimization of impacts to crossroads in efforts to streamline cost. The 2023 Alternate is considered the preferred alternative by the Design Team.

2.4 Project Scope

The following summarizes the primary scope of work items for this project:

- 2 Lane mainline connection between US 27 and KY 9, 3 Bridges
- Access to Persimmon Grove Parkway, Barr's Branch, Gas Access Rd and KY 10
- Right Turn Lane and Left Turn Lane at Persimmon Grove Pike and KY 10
- WB Truck Climbing Lane
- Right Turn Lane additions: EB Creektrace Rd, NB US 27, SB KY 9
- Median U-Turn (MUT) additions on KY 9, Median treatment and LTLs
- Mill and Resurface at connections to existing roads
- Existing pond treatment/Proposed Stormwater Detention
- New San Sewer possible
- Utility Relocations - Power, Water, Gas

2.5 Project Cost Estimate

The VA team was provided a copy of the project's cost estimate prepared by GRW Engineers on 10/10/23. The estimate includes 20% mark-ups for contingency and totaled $59,623,637.

The estimate used to estimate the costs for the VE Alternatives and allowed for a relative comparison against the baseline design.

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
Roadway Excavation	$15,865,991	33%	33%
Roadway Structural Section	$8,222,445	17%	51%
Persimmon Grove Pike Bridge	$6,224,000	13%	64%
Box Culverts	$4,563,000	9.6%	74%
KY-10 / Brush Creek Bridge	$4,239,000	8.9%	82%
Traffic Safety	$3,388,149	7.1%	90%
Jerry Wright Road Bridge	$2,485,000	5.2%	95%
Drainage	$1,750,569	3.7%	99%
Mob/Demob	$699,807	1.5%	100%

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.

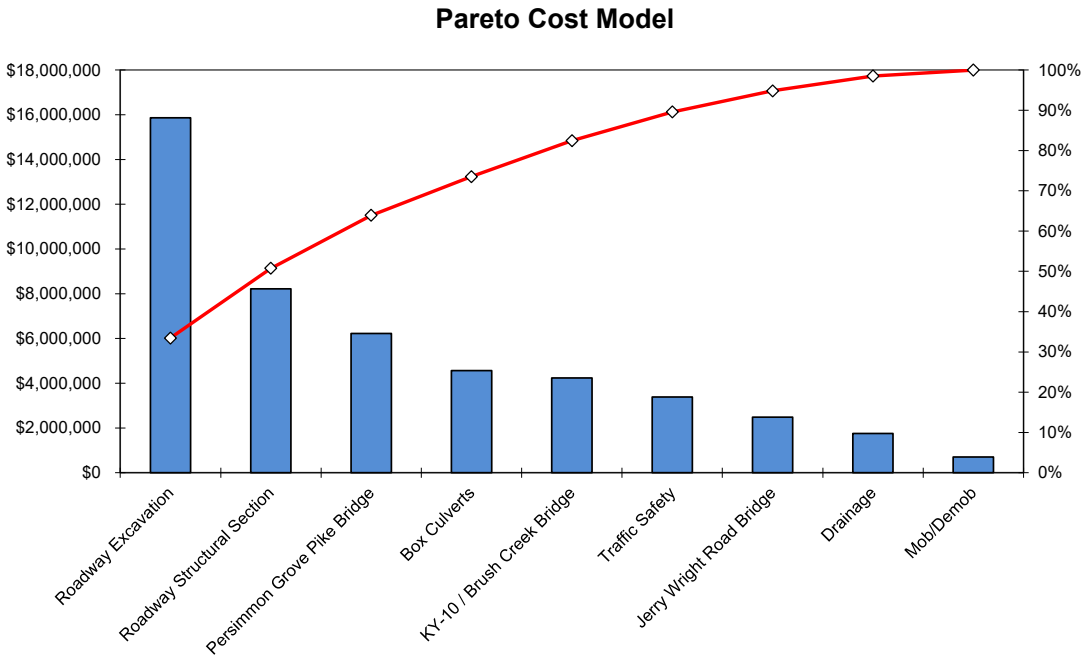
- Local connections from mainline
  - Improve roadway grades and terrain / reduce impacts
  - Is the connection necessary / required?
  - Alternative locations for connections / routing
- Intersection treatments (MUTs, RTL/LTL)
- Stream alignments and culvert size optimizations
  - Bar's Branch
  - Unnamed Creek length / alignment and sanitary sewer (sta. 130+00)
- Abandonment of existing gas lines / new gas line at Sta. 140+00
- Profile analysis. ML vertical alignment adjustments vs. bridge lengths and earthwork quantities
- Connections to residential properties / driveways
- Connection to Highway AA intersection design (MUTs) from South to KY 536 operations
- Perforated pipe underdrain system
- Quantities of base and AC pavement / pavement structural section
  - KY-9 MUT structural section unknowns
  - Pavement design of connectors vs. mainline
- Considerations for future expansion / capacity improvements in the future at intersections
- Truck climbing lane justification
- Tangent section vs. curves for ML alignment
- Earthwork reduction opportunities
- Alternative structure types / layouts
- Coordination of utility relocations with roadway improvements (Access, grades, fill, etc.)

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 2).

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

Figure 2. 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 3, below.

Figure 3. Risk Index Values

Threats

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

Impact

Opportunities

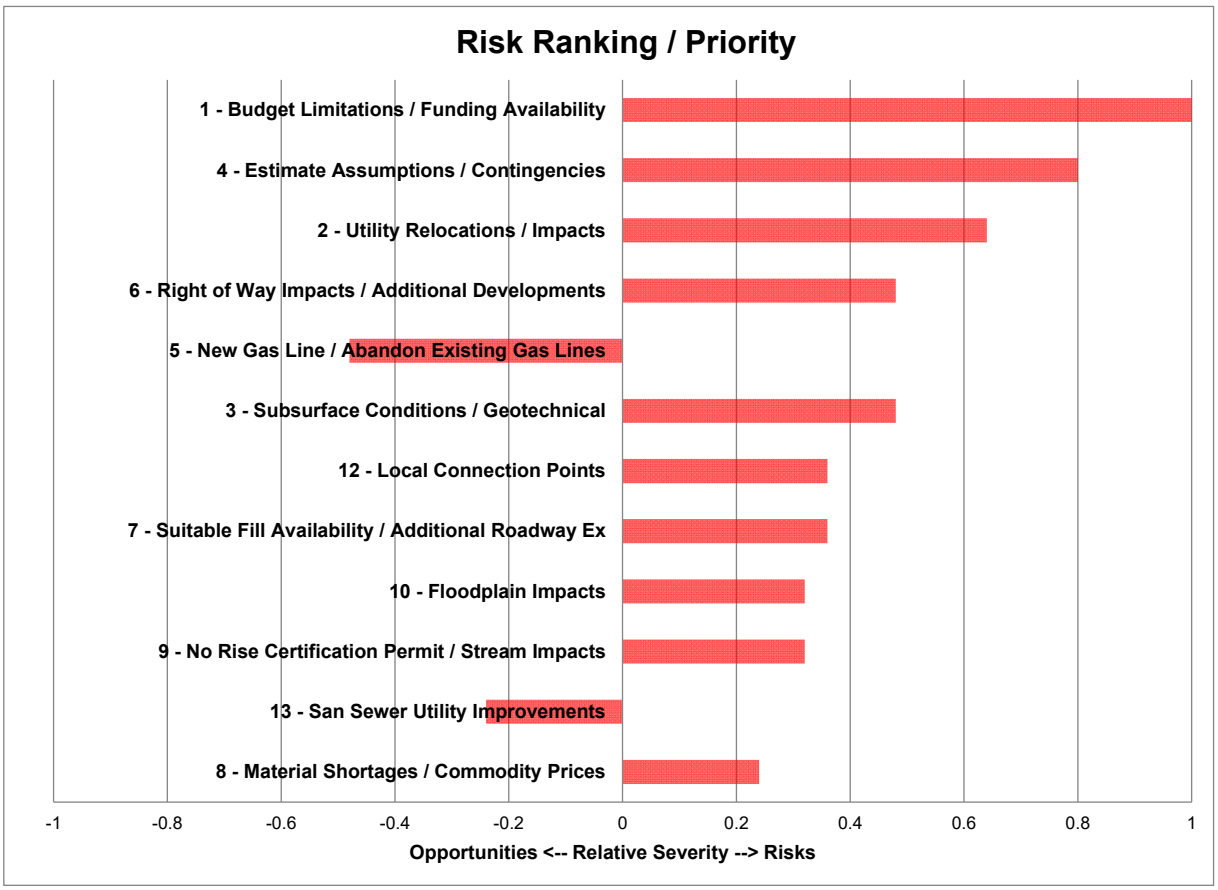
Probability	VL	L	M	H	VH
VH	0.2	0.4	0.6	0.8	1
H	0.16	0.32	0.48	0.64	0.8
M	0.12	0.24	0.36	0.48	0.6
L	0.08	0.16	0.24	0.32	0.4
VL	0.04	0.08	0.12	0.16	0.2

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 4. 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					
1	Threat	Budget Limitations / Funding Availability	Very High	Very High	1
2	Threat	Utility Relocations / Impacts / Construction Coordination	High	High	0.64
3	Threat	Subsurface Conditions / Geotechnical	High	Medium	0.48
4	Threat	Estimate Assumptions / Contingencies	Very High	High	0.8
5	Opportunity	New Gas Line / Abandon Existing Gas Lines	High	Medium	-0.48
6	Threat	Right of Way Impacts / Additional Developments	High	Medium	0.48
7	Threat	Suitable Fill Availability	Medium	Medium	0.36
8	Threat	Material Shortages / Commodity Prices	Low	Low	0.16
9	Threat	No Rise Certification Permit / Stream Impacts	Low	Medium	0.24
10	Threat	Floodplain Impacts	Low	Medium	0.24
12	Threat	Local Connection Points vs. Terrain	Medium	Medium	0.36
13	Opportunity	San Sewer Utility Improvements	Medium	Low	-0.24

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.

The VE team, along with the project team, identified and defined the performance attributes for this project and then defined the baseline concept as it pertains to these attributes. The performance attributes shown in Table 6 were used throughout the study to identify, evaluate, and document ideas and alternatives.

Typical standardized project performance attributes are shown below. The VE team, along with the project team, identified and defined the performance attributes for this project and then defined the baseline concept as it pertains to these attributes (Table 6). The following performance attributes were used throughout the study to identify, evaluate, and document ideas and alternatives.

Table 6. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept
Main Line Operations	An assessment of traffic operations and safety on the main line within the project limits. 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.	-New East-West Connection from US 27 to KY9/Highway AA -4 mile extension with 11' lanes with 8' shoulders with 2' paved -Rural Collector with 55 mph design speed -24' clear zone -1,200' maximum between access points -Right Turn Lanes / Left Turn Lanes at select local connection locations -Signalized intersection at US 27 -Truck climbing lane (2,000') at Sta. 130+00 -Grade separations at Jerry Wright, Persimmon Grove, and KY-10 -Guard rail at bridge approaches only (grades of 4:1 elsewhere) -Reduction of tangent sections for speed reduction
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure. Local Operations include frontage roads as well as cross roads. 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.	-Median U-turns provided on KY-9 -Local connections to Persimmon Grove, Gas Access Road, Bar's Branch, KY-10, Stonehouse Road -Signalized intersection at US 27 -Closure of Stonehouse Road and providing alternate connections to select locations -Driveway access to mainline by permit -Steep grades for local connections at select locations

Table 6. Performance Attributes and Description

Performance Attribute	Description of Attribute	Baseline Concept
Maintainability	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.	-Three new bridges -New drainage culverts at crossings with streams -4 miles of AC Pavement -Limited guard rail to bridge approaches -Limited roadway lighting assumed -Channel lining and erosion control on drainage -Pond treatments and stormwater detentions -Perforated pipe underdrain system -Berm ditches in large fill locations -4:1 fill slopes, 6:1 cut slopes
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.	-BMPs and erosion control measures required due to terrain -Temporary closures to accommodate construction in select locations (US 27, KY-9)
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.	-Residential property takes along Stonehouse Road -ROW acquisition for new roadway (121 acres) -10 residential and 2 commercial relocations -Stream relocations / realignments at crossings -Utility relocations (power, water, gas) -Potential visual impacts with elevated roadway due to terrain

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 5. Performance Attribute Matrix

Performance Attributes Criteria Matrix

Paired Comparison

						Total points	% of Total
Main Line Operations	**A**	**A**	**A**	**A**	**A2**	**6.0**	**38%**
Local Operations		**B**	**B**	**D**	**B**	**3.0**	**19%**
Maintainability			**C**	**D**	**C**	**2.0**	**13%**
Environmental Impacts				**D**	**D**	**4.0**	**25%**
Construction Impacts					**E**	**1.0**	**6%**
					Total	**16.0**	**100%**

Without emphasis on preference

A = A is of greater importance

A/B = A and B are of equal importance

OR

With emphasis on preference

A# = A is of greater importance with preference emphasis #

A/B = A and B are of equal importance

How Important

3 - Major Preference

WITH *2 - Medium Preference*

A - Minor Preference

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

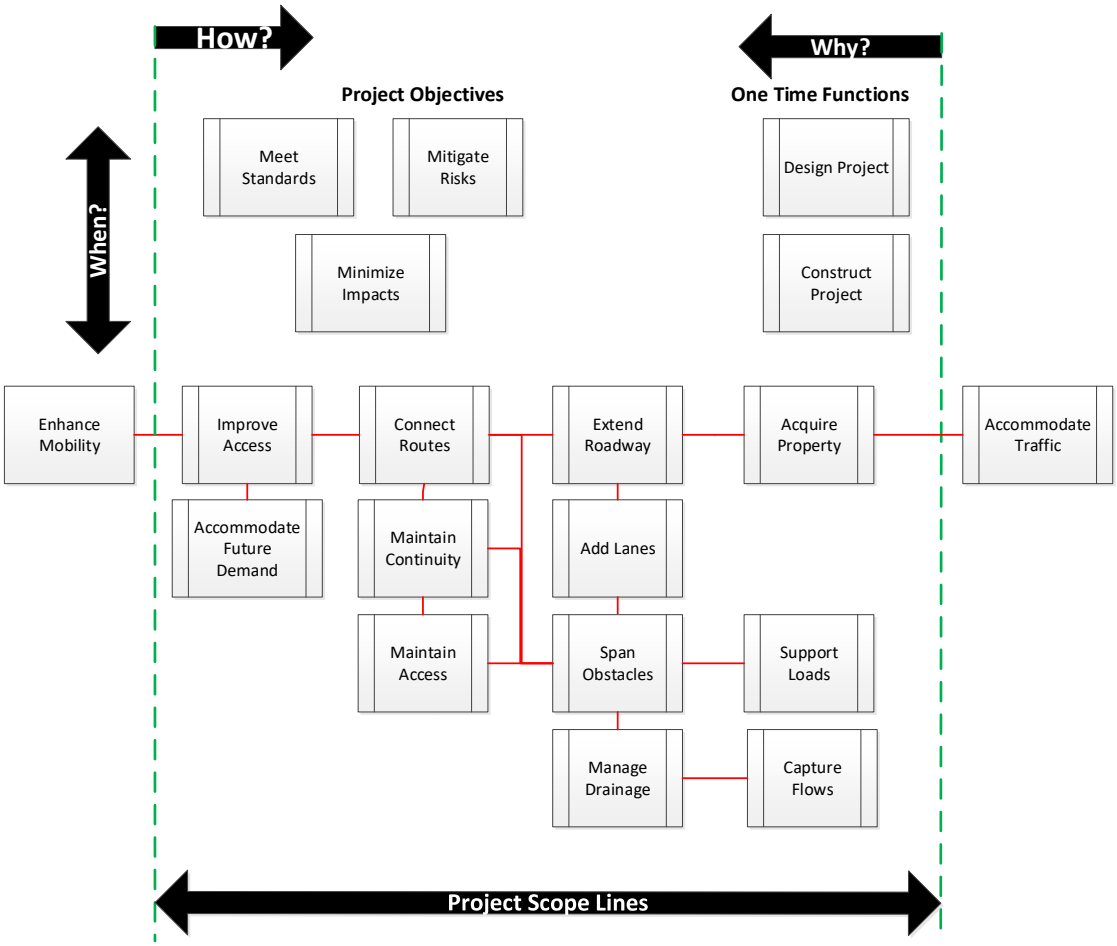
Project Element	Functions	
Purpose and Need		
	Reduce	Travel Times
	Connect	Mainline Routes
	Improve	Safety
	Maintain	Continuity (Local)
	Minimize	Impacts
	Meet	Standards
	Accommodate	Grades
	Reduce	Conflicts
	Accommodate	Future Demand/Growth
	Improve	Response Times
	Improve	Access
	Minimize	Maintenance
Bridges		
	Span	Obstacles
	Separate	Traffic
	Maintain	Continuity
	Support	Loads
	Reduce	Impacts
	Reduce	Earthwork
	Maintain	Hydraulic Flow
	Maintain	Existing (Local Roads)
	Accommodate	Grades/Profiles
Drainage / Detention Basins		
	Convey	Flows
	Reduce	Maintenance
	Capture	Flows
	Remove	Sediment
	Control	Erosion
	Pave	Ditches

Roadway		
	Accommodate	Grades
	Minimize	Earthwork
	Minimize	Enviornmental Impacts
	Control/Limit	Access
	Accommodate	Geotechnical
	Stabilize	Soil
	Reduce	Utility Impacts
Right of Way		
	Create	Space
	Acquire	Properties
	Remove	Obstacles
Earthwork / Roadway Excavation		
	Remove	Material
	Establish	Grades
	Maintain	Profiles
	Reduce	Guard Rail
	Dispose	Material (Onsite)
Stonehouse Road / 1997 Removal		
	Improve	Maintenance
	Maintain	Access
	Reduce	Paved Areas

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 6) provided the VE team with an understanding of which functions offer the best opportunity for cost or performance improvement.

Figure 6. 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
Function: Accommodate Grades	
29	Revise profile of KY 536 west of KY 10 bridge and eliminate truck climbing lanes
30	Reduce shoulders at truck climbing lane
34	Reduce total distance of truck climbing lane
Function: Connect Routes	
2	Provide E-W connection with rural route in lieu of grade separated highway
7	Realign west connection and connect to US-27 to the south
31	Shift KY 536 alignment to the north at Persimmon Grove with tangent section in lieu of curve
32	Realign KY 536 to the north
Function: Control Traffic	
5	Use R-cuts in lieu of median U-turns at KY-9 connection
6	Use signalized intersection at KY-9 in lieu of MUTs
8	Construct roundabout for intersection at US-27
9	Provide R-cuts at intersection with US-27 in lieu of signalized intersection
53	Connect R-cut with right turn lane for SB KY-9
Function: Maintain Access	
19	Relocate connection point for Persimmon Grove to the south of KY 536
21	Shift local connector point and reroute at Persimmon Grove
22	Use connectors to KY 536 at Persimmon Grove in lieu of grade separation
23	Combine connection to Barr's Branch and Gas Access
24	Use frontage road to connect Bar's Branch and Gas Access
Function: Reduce Impacts	
1	Realign culverts and shorten structure lengths/size
3	Reduce design speeds at select locations and reduce cross-section accordingly
4	Increase superelevation to 8% in lieu of 6%
10	Use arch culvert in lieu of bridge at Jerry Wright

Table 8. Creative Idea List

Idea No.	Description
13	Reduce vertical profile at Jerry Wright
14	Shift alignment to the south at Jerry Wright
15	Construct retaining walls at stream crossings and reduce stream impacts and pipe lengths
16	Reduce footprint with steeper side slopes
18	Reduce profiles throughout and increase roadway grades
27	Realign KY 536 closer to Stonehouse Road
28	Shift alignment of KY 536 to avoid conflict with Gas Line #2
33	Maintain Stonehouse Road east of KY 9 as-is in lieu of realignment
37	Use culvert for Brush Creek and reduce Persimmon Grove bridge accordingly
43	Span streams/pipes with structures to reduce impacts stream mitigations
Function: Reduce Maintenance	
25	Abandon and remove Bar's Branch to the north of KY 536
47	Eliminate underdrain system and daylight shoulders in fill sections
52	Provide benching for large fill sections
Function: Reduce Risk	
17	Balance earthwork within smaller segments
38	Explore alternative funding sources with federal grants, etc.
39	Update the traffic analysis with more recent data
40	Update the geotechnical investigation at proposed alignment. Optimize soil stabilization in lieu of assuming throughout.
41	Accommodate new gas line conflict and assume other three existing are abandoned
42	Expand footprint at US-27 for future intersection improvements
51	Provide roadway lighting at intersections and MUTs
Function: Separate Traffic	
11	Provide intersection at Jerry Wright in lieu of grade separation
12	Eliminate grade separation at Jerry Wright and reroute
20	Eliminate grade separation at Persimmon Grove
26	Provide intersection at KY-10 in lieu of grade separation
48	Reduce width of shoulders on all proposed bridges to 8' in lieu of 10'
Function: Span Obstacles	
35	Increase span lengths for Persimmon Grove bridge and reduce bents
36	Cover sanitary line at Persimmon Grove in lieu of spanning with structure
Function: Support Loads	

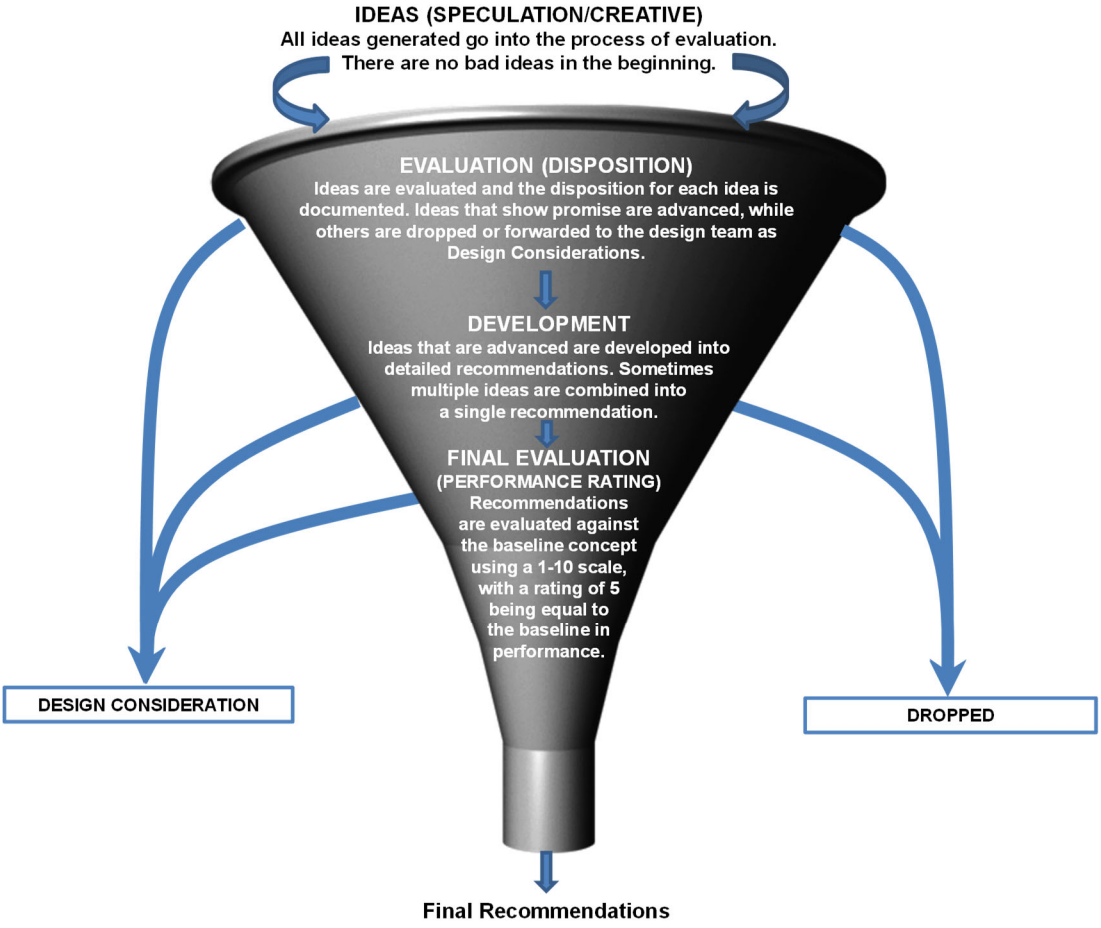
Table 8. Creative Idea List

Idea No.	Description
44	Reduce thickness of AC pavement in typical structural section
45	Use Class 3 AC spec in lieu of Class 2 for surface pavement
46	Use ML base aggregate spec for entrance pavement in lieu of separate spec
49	Match typical section of other segments of KY 536

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 7 depicts the typical information flow for this part of the Value Methodology Job Plan.

Figure 7. 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.

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating
Function: Accommodate Grades				
29	Revise profile of KY 536 west of KY 10 bridge and eliminate truck climbing lanes	• Reduce impacts and cost	• Conflicts with slow moving vehicles	3
30	Reduce shoulders at truck climbing lane	• Reduce impacts and cost	• Less recovery and refuge area • Truck lane to be used as refuge	3
34	Reduce total distance of truck climbing lane	• Reduce impacts and cost	• Reduces distance for safe passing/merging • Conflicts with slow moving vehicles	1
Function: Connect Routes				
2	Provide E-W connection with rural route in lieu of grade separated highway	• Reduces roadway length (more direct route) • Reduced ROW • Reduces drainage piping/culverts	• Through traffic required to use 27 to continue on KY 536	3
7	Realign west connection and connect to US-27 to the south	• Reduces roadway length (more direct route) • Reduced ROW impacts • Reduces drainage piping/culverts	• Potential Brush Creek impacts • Potential KY-10 impacts	1
31	Shift KY 536 alignment to the north at Persimmon Grove with tangent section in lieu of curve	• Reduces roadway length (direct route)	• Increase in ROW impacts and acquisitions	1
32	Realign KY 536 to the north	• Improves access to KY 536 from KY 9 • Improves movements for trucks	• Turn lane conflict on KY-9	1

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating
Function: Control Traffic				
5	Use R-cuts in lieu of median U-turns at KY-9 connection	• Movements consolidated to intersection Reduced ROW Reduced earthwork	• Conflict points on KY-9 Poor visibility during fog events	3
6	Use signalized intersection at KY-9 in lieu of MUTs	• Provides traffic calming feature	• US 27 traffic volumes conflict with KY 536 through Potential ROW impacts and acquisitions	1
8	Construct roundabout for intersection at US-27	• Reduce conflicts Separates traffic movements Improves intersection phasing	• KY 536 through traffic required to U-turn ROW impacts Increase pavement	1
9	Provide R-cuts at intersection with US-27 in lieu of signalized intersection	• Reduces merging/weaving	• Increase in ROW/earthwork	2
53	Connect R-cut with right turn lane for SB KY-9	• Potential to improve grades	• Increase ROW acquisition / takes	1
Function: Maintain Access				
19	Relocate connection point for Persimmon Grove to the south of KY 536	• Potential to improve grades Reduced earthwork / paving	• Skewed intersection with Persimmon Distance and grades may preclude	1
21	Shift local connector point and reroute at Persimmon Grove	• Eliminates bridge at Persimmon Improves profile grades for connection Reduces earthwork	• Requires new culvert Increase ROW take Eliminates Persimmon Grove throughput	3
22	Use connectors to KY 536 at Persimmon Grove in lieu of grade separation	• Reduce pavement Removes conflict point on KY 536	• Increase ROW impacts Grading/pavement for local road from Barr's Branch	3

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating
23	Combine connection to Barr's Branch and Gas Access	•	•	Combine
24	Use frontage road to connect Bar's Branch and Gas Access	• Reduce drainage features and structure costs	• Some stream impacts may increase • Increase in earthwork and ditches	3
Function: Reduce Impacts				
1	Realign culverts and shorten structure lengths/size	• Reduces clear zone slightly	• Limited impacts to cross-section / cost	Combine with 2
3	Reduce design speeds at select locations and reduce cross-section accordingly	• Promotes realignment and curve radii		Combine with 2
4	Increase superelevation to 8% in lieu of 6%	• Reduce structure costs • Increase onsite borrow disposal	• Operational / clearance impacts on Jerry Wright	3
10	Use arch culvert in lieu of bridge at Jerry Wright			Combine with 13
13	Reduce vertical profile at Jerry Wright	• Avoids pond	• Increase residential property take	1
14	Shift alignment to the south at Jerry Wright	• Reduce mitigation costs for stream impacts • Reduce environmental impacts	• Increase wall / structure costs	3
15	Construct retaining walls at stream crossings and reduce stream impacts and pipe lengths	• Reduce ROW • Reduce earthwork • Reduce culverts / drainage piping	• Increase maintenance and erosion potential • May need guard rail • May need retaining walls or benching	3

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating
16	Reduce footprint with steeper side slopes	• Reduce ROW • Reduce earthwork • Reduce culverts / drainage piping	• Steepens roadway grades • Reduces sight distances • May impact design speed	3
18	Reduce profiles throughout and increase roadway grades	• Reduce ROW acquisition • May reduce earthwork • Curves may reduce speeds	• May need walls in select locations	3
27	Realign KY 536 closer to Stonehouse Road	• Avoid conflict / utility relocation costs	• Requires profile raise for cover over gas line	1
28	Shift alignment of KY 536 to avoid conflict with Gas Line #2	• Reduce scope / impacts	• Intersection alignment slightly shifted	2
33	Maintain Stonehouse Road east of KY-9 as-is in lieu of realignment	•	• Increase stream impacts and mitigation costs	1
37	Use culvert for Brush Creek and reduce Persimmon Grove bridge accordingly	• Reduced stream impacts and mitigation costs • Reduced earthwork Reduce ROW impacts/costs	• Increase structure costs	3
43	Span streams/pipes with structures to reduce impacts stream mitigations	• Reduce maintenance	•	2
Function: Reduce Maintenance				
25	Abandon and remove Bar's Branch to the north of KY 536	• Reduce piping and earthwork	• Maintenance issues and geotechnical conditions preclude	1
47	Eliminate underdrain system and daylight shoulders in fill sections	• Reduce risk • Reduce potential for erosion / maintenance	• Increase earthwork • May increase ROW	2
52	Provide benching for large fill sections		• Defer to contractor	1

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating
Function: Reduce Risk				
17	Balance earthwork within smaller segments	• Reduce risk	• Project benefit to cost may challenge funding availability	2
38	Explore alternative funding sources with federal grants, etc.	• Reduce risk		2
39	Update the traffic analysis with more recent data	• Reduce risk		2
40	Update the geotechnical investigation at proposed alignment. Optimize soil stabilization in lieu of assuming throughout.	• Reduce risk		2
41	Accommodate new gas line conflict and assume other three existing are abandoned	• Future expansion benefit	• Increase cost Increase ROW impacts	1
42	Expand footprint at US-27 for future intersection improvements	• Improve visibility and driver awareness	• May add cost	2
51	Provide roadway lighting at intersections and MUTs	• Improves driver awareness and visibility	• Added cost	3
Function: Separate Traffic				
11	Provide intersection at Jerry Wright in lieu of grade separation	• Reduce structure costs	• Requires rerouting to alternate access	Combine with 12
12	Eliminate grade separation at Jerry Wright and reroute	• Reduce structure costs	• Grades and topography may preclude	1
20	Eliminate grade separation at Persimmon Grove		• Grades and topography may preclude • Increases stream impacts	1
26	Provide intersection at KY-10 in lieu of grade separation	• Reduce structure costs	• Reduced refuge / recovery area	3
48	Reduce width of shoulders on all proposed bridges to 8' in lieu of 10'	• Reduces number of bents Reduces impacts	• Increase structure depth	2

Table 9. Idea Evaluation Summary Table

Idea #	Description	Advantages	Disadvantages	Rating
Function: Span Obstacles				
35	Increase span lengths for Persimmon Grove bridge and reduce bents	• Reduce structure size	• Increase earthwork	2
36	Cover sanitary line at Persimmon Grove in lieu of spanning with structure	• Reduce pavement costs	• Potential increase maintenance	3
Function: Support Loads				
44	Reduce thickness of AC pavement in typical structural section	• Reduced paving costs	• Increased maintenance	1
45	Use Class 3 AC spec in lieu of Class 2 for surface pavement		• Minimal cost difference	1
46	Use ML base aggregate spec for entrance pavement in lieu of separate spec			Combine with 44
49	Match typical section of other segments of KY 536	• Reduce impacts and cost	• Conflicts with slow moving vehicles	3

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 7.3). 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 the table below. 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 the table below 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

Alt No.	Alternative Title	Cost Savings	Performance/Risk
Local Road Crossings and ML Connection Access			
LR-1	Use arch culvert in lieu of bridge at Jerry Wright	$1,615,200	Improved (M)
LR-2	Provide intersection at Jerry Wright in lieu of grade separation	$2,297,000	Improved (M) Reduced (MO, LO)
LR-3	Use connectors to KY 536 at Persimmon Grove in lieu of bridge for grade separation	$3,542,000	Improved (M) Reduced (LO, EI)
LR-4	Use frontage road or local driveway for Gas Access Road	$139,000	Improved (MO, E)
LR-5	Use signalized intersection at KY-9 in lieu of MUTs	$332,000	Improved (MO, M, EI) Reduced (LO)
KY 536 Horizontal Alignment			
A-1	Realign KY 536 closer to Stonehouse Road	$3,724,000	Improved (EI, M)
A-2	Realign west connection and connect to US-27 to the south	$3,711,000	Improved (EI) Reduced (LO)
Roadway Profile and Cross Section			
PX-1	Reduce profiles throughout and increase roadway grades	TBD	Improved (E, M) Reduced (MO)
PX-2	Reduce footprint with steeper side slopes	TBD	Improved (E) Reduced (MO, M)
PX-3	Provide 8’ shoulders on all bridges	$1,483,000	Improved (M)
Truck Climbing Lane			
TC-1	Adjust profile and eliminate truck climbing lane	$1,141,000	Improved (EI, M) Reduced (MO)
TC-2	Reduce shoulders at truck climbing lane	$92,000	Improved (E, M) Reduced (MO)
Stream Crossings and Culverts			
SC-1	Realign culverts and shorten structure lengths/size	$358,000	Improved (M, EI)
Roadway Structural Section			
S-1	Reduce thickness of AC pavement in typical structural section	$2,005,000	Reduced (M)

VE ALTERNATIVE LR-1
Use arch culvert in lieu of bridge at Jerry Wright

Description of Baseline Concept:

The baseline concept for the KY 536 corridor is to bridge over Jerry Wright Rd with a 201 ft long – 3 span bridge, ranging in height from 35 ft to 40 ft tall and constructed between two fill sections. The baseline concept does not provide access to KY 536 from Jerry Wright Rd but does not cut off use of Jerry Wright Rd.

Description of Alternative Concept:

The alternative proposes constructing an arch culvert in lieu of a bridge at the KY 536 and Jerry Wright Rd crossing. The alternative provides use of Jerry Wright Rd through using the arch culvert to cross under the proposed KY 536 roadway, however, still restricts access to KY 536.

Advantages:

- Reduce structure costs
- Increase onsite borrow disposal

Disadvantages:

- Operational / clearance impacts on Jerry Wright Rd

Discussion:

The baseline concept proposes a costly bridge constructed in the center of a proposed fill section to avoid cutting off Jerry Wright Rd.

It is noted that Jerry Wright Rd is approximately 20 ft wide and supports a low AADT.

The alternative could provide a less costly structure to cross Jerry Wright Rd without cutting off local traffic. Additionally, new potential options to better balance/reduce earthwork by providing additional onsite borrow disposal, adjusting KY 536 profile grades, and optimizing vertical curve length and locations.

Discussion of Schedule Impacts:

Possible schedule savings on the mainline construction by eliminating the construction of a bridge, however, there is potentially additional impacts to traffic operations on Jerry Wright Rd to accommodate construction of the arch culvert.

Discussion of Risk Impacts:

The conflicts with construction phasing and maintenance of traffic for the construction of the Arch Culvert would need to be resolved. Additionally, the quality of soil to be disposed of onsite would need to be determined and deemed usable.

VE ALTERNATIVE LR-1

Use arch culvert in lieu of bridge at Jerry Wright

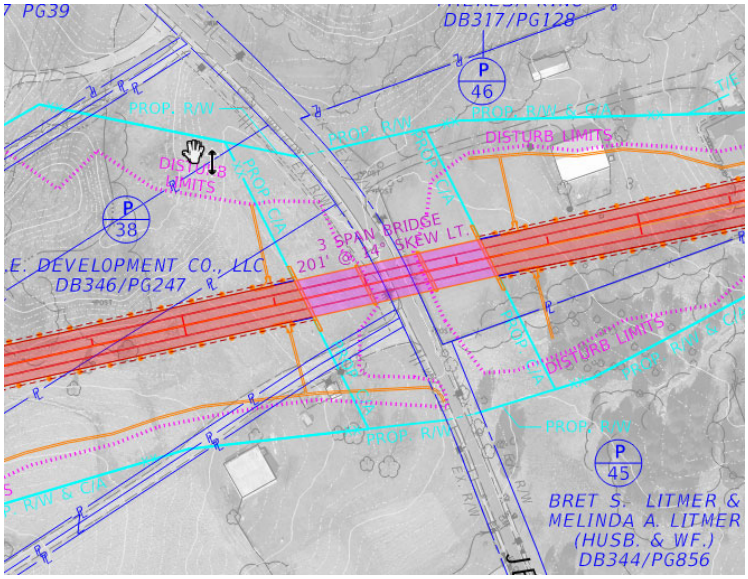
Performance Assessment:

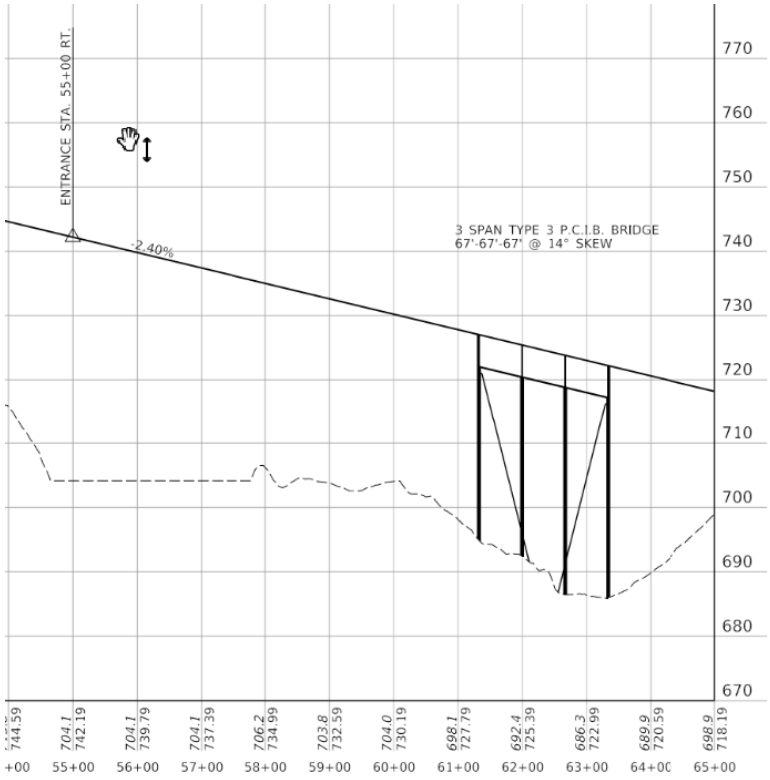
Attributes and Rating Rationale
Mainline Operations – No Change from baseline concept.
Local Operations – No change to the local operations from the baseline concept, although a different structure is proposed, they will operate the same.
Maintainability – Increased maintainability by proposing a smaller and less costly structure to maintain in the future. The alternative would also provide easier access for maintenance and future rehab projects.
Construction Impacts – Increased construction impacts, although the alternative does provide a more easily constructed structure it will introduce additional construction and maintenance of traffic phasing on Jerry Wright Rd.
Environmental Impacts – Reduced from a social environmental impact because an arch culvert potentially be more appealing than a 40’ tall bridge, to the public.

VE ALTERNATIVE LR-1

Use arch culvert in lieu of bridge at Jerry Wright

Baseline Concept Sketch

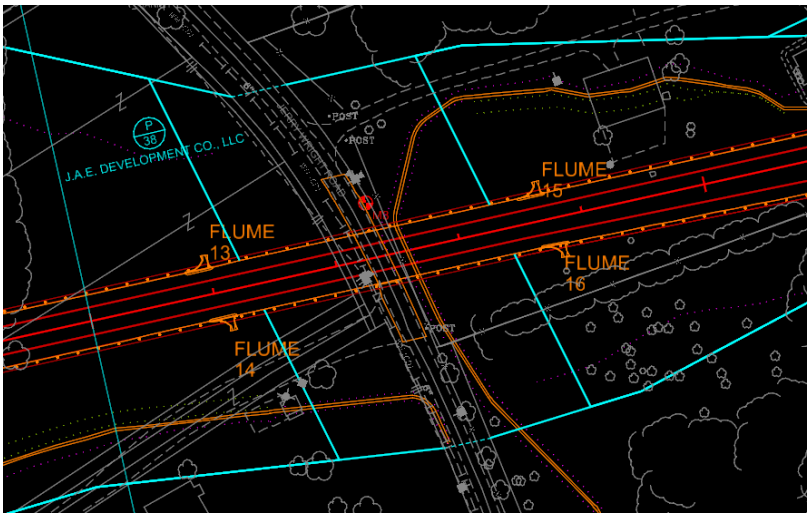


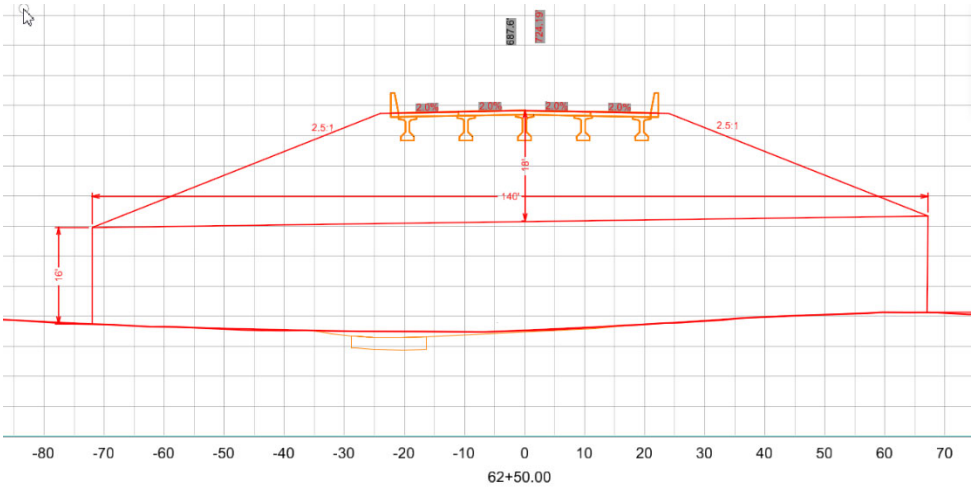


VE Alternative Concept Sketch

VE ALTERNATIVE LR-1

Use arch culvert in lieu of bridge at Jerry Wright





Assumptions and Calculations:

- Assumed 16’ vertical clearance on Jerry Wright Rd.
- Assumed 24’ wide road on Jerry Wright Rd (11’ lanes and 2’ shoulder)
- Assumed 2.5:1 side slopes on KY 536
- An approximated 42,500 CY of additional fill to construct.
- An approximated 1,000 SY in additional pavement structure.

VE ALTERNATIVE LR-1

Use arch culvert in lieu of bridge at Jerry Wright

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
3-Span Bridge	LS	1	$ 2,500,000	$ 2,500,000			
CL2 ASPH SURF 0.38B PG64-22	TON			$ -	83	$ 79.38	$ 6,589
CL2 ASPH BASE 1.0D PG64-22	TON			$ -	220	$ 78.88	$ 17,354
CL2 ASPH BASE 1.0D PG64-22	TON			$ -	220	$ 78.88	$ 17,354
CL2 ASPH BASE 1.0D PG64-22	TON			$ -	248	$ 78.88	$ 19,562
CRUSHED STONE BASE	TON			$ -	288	$ 36.37	$ 10,475
LIME STABILIZED ROADBED	SQYD			$ -	1,000	$ 5.74	$ 5,740
16' x 24' Arch Culvert	LF			$ -	140	$ 7,700.00	$ 1,078,000
SUB-TOTAL				$2,500,000			$1,155,073
PROJECT MARK-UPS	20%			$500,000			$231,015
TOTAL (Rounded)				$3,000,000			$1,386,000
						SAVINGS	**$1,614,000**

VE ALTERNATIVE LR-2
Provide intersection at Jerry Wright in lieu of grade separation

Description of Baseline Concept:

KY 536 alignment crosses over Jerry Wright Rd with a 3-span bridge with no connections.

Description of Alternative Concept:

This alternative would align the grades of KY 536 and Jerry Wright Road to provide an at-grade, side street STOP controlled intersection in lieu of grade separation. The concept would propose a combination of lowering the profile of mainline KY 536 at Jerry Wright Rd., as well as raising the profile of Jerry Wright Rd itself.

Advantages:

- Eliminates of cost of a structure
- Provide access to KY 536 to Jerry Wright Rd.
- Reduces embankment paced.

Disadvantages:

- Introduction of side street stop condition and resulting conflict points from traffic entering KY 536.
- Potential to introduce “cut-through” or bypass traffic from KY 536 onto a minor route.
- Potential for either rear-end crashes involving vehicles slowing to turn onto Jerry Wright Rd., or need for turn lane construction.
- Possibly need additional ROW to lower cut on west approach.
- Material used for embankment in baseline will need to be relocated.

Discussion:

Adjust PVI at STA 44+10, and lower KY 536 grade approaching Jerry Wright Rd. Additionally, raise the grade on Jerry Wright Rd by 5-10 feet. Construct an at-grade minor intersection

Discussion of Schedule Impacts:

Improved schedule, particularly if contractor elects to only have one bridge crew on the project.

Discussion of Risk Impacts:

Would require temporarily diverting Jerry Wright Rd during construction duration, but would allow continuity of segments for earthwork hauling.

VE ALTERNATIVE LR-2

Provide intersection at Jerry Wright in lieu of grade separation

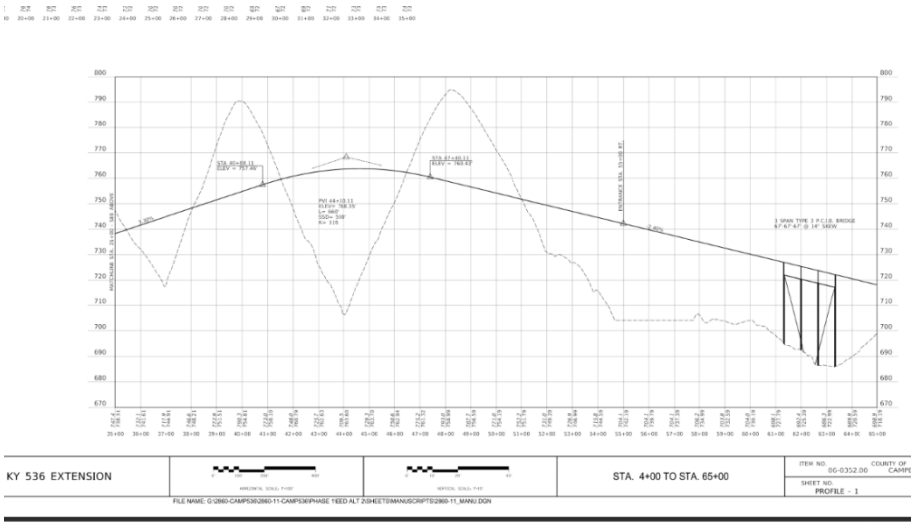
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Minor reduction: Some conflicts introduced by low-volume side street traffic. Positive impact of removing bridge end “bumps”
Local Operations Improved: Access provided to Jerry Wright Rd.
Maintainability Increased: No structure to maintain in future.
Construction Impacts Improved: No bridge construction, continuity of project segments.
Environmental Impacts No change from baseline.

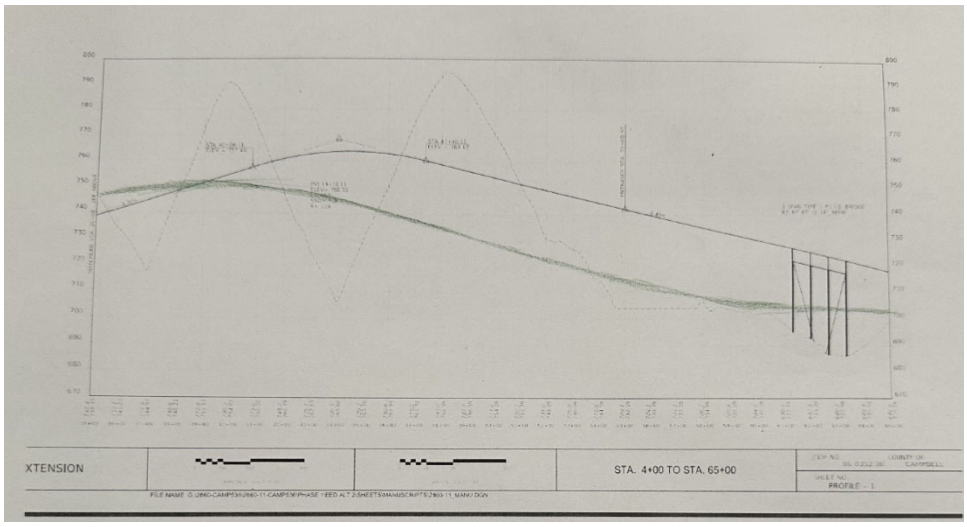
VE ALTERNATIVE LR-2

Provide intersection at Jerry Wright in lieu of grade separation

Baseline Concept Sketch



VE Alternative Concept Sketch



Assumptions and Calculations:

Embankment/Excavation for proposed profile will net excess material vs baseline and to be placed elsewhere on the project. Additional excavation quantity of 30,000 CUYD assumed.

VE ALTERNATIVE LR-2

Provide intersection at Jerry Wright in lieu of grade separation

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
3-Span Bridge over Jerry Wright Rd	LS	1	$ 2,485,000	$ 2,485,000	0		$ -
201ft Additional Roadway	mi			$ -	0.038	$ 4,923,925	$ 187,109
201 ft Additional Paving	mi			$ -	0.038	$ 2,090,971	$ 79,457
Roadway Excavation	CUYD	1,485,761	$ 10.14	$ 15,065,617	1,515,761	$ 10.14	$ 15,369,817
200 ft Jerry Wright Rd Roadway	mi			$ -	0.038	$ 4,923,925	$ 187,109
200 ft Jerry Wright Rd Paving	mi			$ -	0.038	$ 2,090,971	$ 79,457
SUB-TOTAL				$17,550,617			$15,902,949
PROJECT MARK-UPS	20%			$3,510,123			$3,180,590
TOTAL (Rounded)				$21,061,000			$19,084,000
						SAVINGS	**$1,977,000**

VE ALTERNATIVE LR-3

Use connectors to KY 536 at Persimmon Grove in lieu of bridge for grade separation

Description of Baseline Concept:

The baseline concept provides a bridge across Persimmon Grove Pike and a connector approach road to provide access to KY 536. The topography requires this structure to be a 508 LF 5-Span bridge and approximately 40' high over Persimmon Grove Pike. This bridge accounts for about 10% of the project's total construction cost, at a cost of over $6 million.

Description of Alternative Concept:

The alternative concept proposes to eliminate this bridge and instead construct the roadway on embankment across Persimmon Grove Pike. This will eliminate the through traffic on Persimmon Grove, so a second connector approach road will be constructed from the south side. A box culvert will need to be constructed for Brush Creek, assuming a 12'x8' RCBC like the proposed structure at 12-Mile Creek.

Advantages:

- Provide a large cost reduction to the project.
- Allows an opportunity to lower the profile across Persimmon Grove Pike to reduce earthwork, if desired. Lowering the mainline profile improves the grades from each approach connection.

Disadvantages:

- For through traffic along Persimmon Grove Pike users will have to divert up to KY 536 and then continue down the opposite side.
- This alternative will require additional ROW acquisition.
- Stream impacts from a box culvert that is required on Brush Creek.

Discussion:

The concept for this alternative first came about by the bridge having such a large cost to the project. A review of the adjacent section of KY 536 also shows that no approach roads were grade separated, therefore removal of the bridge here will match the characteristics of that section. As far as the traffic, the presumption is that the through movement would be a small percentage of the overall traffic volumes. However, the north-south movement is still possible. Since the baseline concept also spans Brush Creek, a box culvert will be constructed at that stream crossing. This creates a stream impact not included with the baseline concept. The fee associated with stream impacts is estimated at $700/LF.

Discussion of Schedule Impacts:

Not a significant impact on schedule.

Discussion of Risk Impacts:

The sizing for the box culvert will be critical since it will be the only method for conveying the stream flow.

A roadway has less risk than a bridge, both during construction and during operations and maintenance.

VE ALTERNATIVE LR-3

Use connectors to KY 536 at Persimmon Grove in lieu of bridge for grade separation

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations There may be some reduction since a left-turn lane and right-turn lane would be desired.
Local Operations There is a reduction in local operations for the throughput along Persimmon Grove Pike. For all traffic desiring to connect to KY 536 this alternative would be a slight increase in operations.
Maintainability Increased as the bridge maintenance and inspection costs are removed. The additional pavement may require resurfacing but a lower cost and ease of maintenance compared to the bridge.
Construction Impacts No change in construction impacts. Traffic will have to be maintained when the closure occurs, but constructing the bridge would also provide periods of closure.
Environmental Impacts Additional stream impact at Brush Creek and additional ROW required.

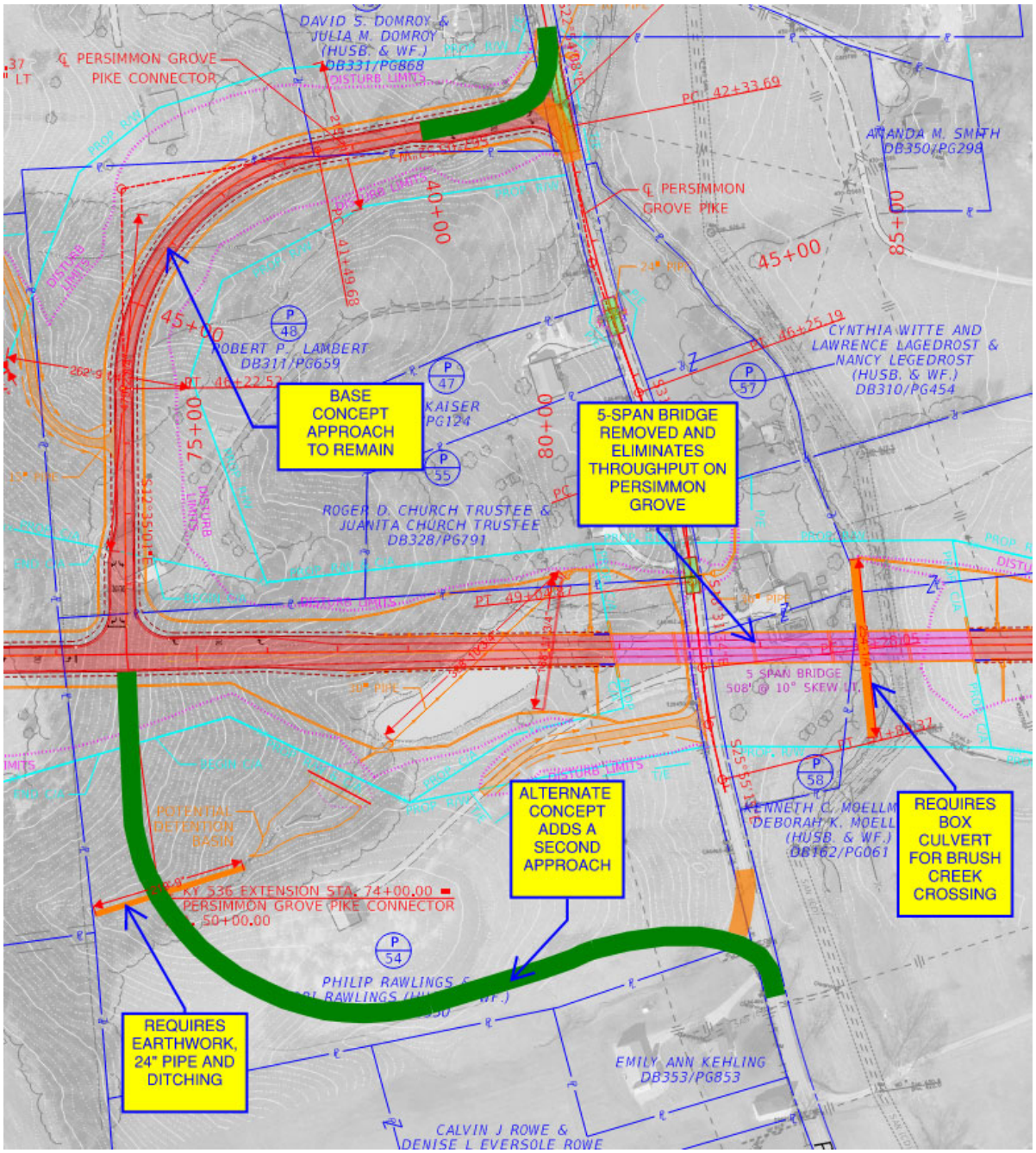
VE ALTERNATIVE LR-3

Use connectors to KY 536 at Persimmon Grove in lieu of bridge for grade separation

Baseline Concept Sketch

The baseline concept is shown on the alternative sketch below. The baseline roadway (red) is to remain. The bridge (pink) is to be removed and replaced with additional roadway.

VE Alternative Concept Sketch



VE ALTERNATIVE LR-3

Use connectors to KY 536 at Persimmon Grove in lieu of bridge for grade separation

Assumptions and Calculations:

It is assumed that the alternative concept provides a feasible connection to KY 536. Profile grades may be an issue as they were with the baseline concept. The approach may need to be lengthened to account for the elevation. However, the assumption is also that the mainline profile can be lowered to improve these connections.

Earthwork will mostly be embankment for this alternative so is not considered as additional cost. The baseline concept overall has additional material to waste, and this would provide another location to do so.

Removing the bridge would also reduce paving along KY 536 by maintaining the mainline typical section instead of the widened bridge approach section. This was considered a minor cost reduction and is not estimated as a separate line item.

The second connection shown from the south side of KY 536 would be approximately 1200 LF as sketched. For an initial cost, the cost per mile for roadway and paving costs will be used to estimate the cost for the additional roadway.

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
5-Span Bridge at Persimmon Grove Pike	LS	1	$ 6,224,000	$ 6,224,000			$ -
12'x8' RCBC at Brush Creek	LS			$ -	1	$ 800,000	$ 800,000
Brush Creek Stream Impact Fee	LF			$ -	255	$ 700	$ 178,500
Construct Second Approach from South	LS			$ -	1	$ 1,594,295	$ 1,594,295
Mainline Pavement in place of Bridge	LS			$ -	1	$ 665,000	$ 665,000
24" Pipe	LF			$ -	225	$ 131	$ 29,475
24" Pipe Culvert Headwall	EA			$ -	2	$ 2,608	$ 5,216
SUB-TOTAL				$6,224,000			$3,272,486
PROJECT MARK-UPS	20%			$1,244,800			$654,497
TOTAL (Rounded)				$7,469,000			$3,927,000
						SAVINGS	**$3,542,000**

VE ALTERNATIVE LR-4
Use frontage road or local driveway for Gas Access Road

Description of Baseline Concept:

The baseline concept of KY 536 includes approach road connections on the south side at both Barr's Branch Road and Gas Access Road. These approach roads provide 2-11' lanes and a pavement design with 13.75" of asphalt, 5" crushed stone base, and 8" lime stabilized roadbed. Each connection is approximately 770' long. The approaches are stop controlled at KY 536 and the through traffic on the mainline does not stop. The approaches are spaced at 1200', which is the project goal for minimum access spacing.

Description of Alternative Concept:

This alternative proposes two options for changes to the Gas Access Road. "Option 1" combines these two connections to KY 536 by constructing a 12'-wide frontage road from near the residence on Gas Access Road, along the south side of KY 536 and sharing the proposed entrance for Parcel 73. "Option 2" will maintain the baseline concept alignment, however, reduces the roadway to an entrance driveway.

Advantages:

- Option 1 removes an access point from the mainline, reducing potential conflicts from slow and turning vehicles.
- Option 1 also reduces the proposed ROW required.
- Option 1 removes the Gas Access Road from requiring future maintenance as the entrance will become the property owner's responsibility.
- Both options will lower the overall project costs related to the baseline Gas Access Road since the pavement quantity required for these connections is reduced by providing a narrower roadway and a lesser pavement section. Option 1 would require about 10% more paving than Option 2.

Disadvantages:

- May create additional traffic on Barr's Branch Road.

Discussion:

The existing Gas Access Road is an 11'-wide driveway serving three residences and the gas facility at the south end of the driveway. The alignment for the baseline concept severs the Gas Access Road so that the two of the residences of the north side will access their property via KY-10. The remaining residence and gas facility do not require the full 2-lane approach road design since it will have very low traffic volume. By identifying them as entrances instead, they can be constructed using the entrance typical section and built within temporary easements that revert to the property owner when complete.

Discussion of Schedule Impacts:

Not expected to have much of an impact on the schedule compared to the baseline concept.

Discussion of Risk Impacts:

No risks identified.

VE ALTERNATIVE LR-4

Use frontage road or local driveway for Gas Access Road

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Increases for “Option 1” since a conflict point on mainline is removed. No change in mainline operations for “Option 2” as both access points are as in baseline concept.
Local Operations Reduces speed on the connections from Gas Access Road with the narrower entrance design.
Maintainability Increased since it removed Gas Access Road from requiring future maintenance.
Construction Impacts Little or no change to construction; However, reduced paving operations.
Environmental Impacts No change from baseline concept.

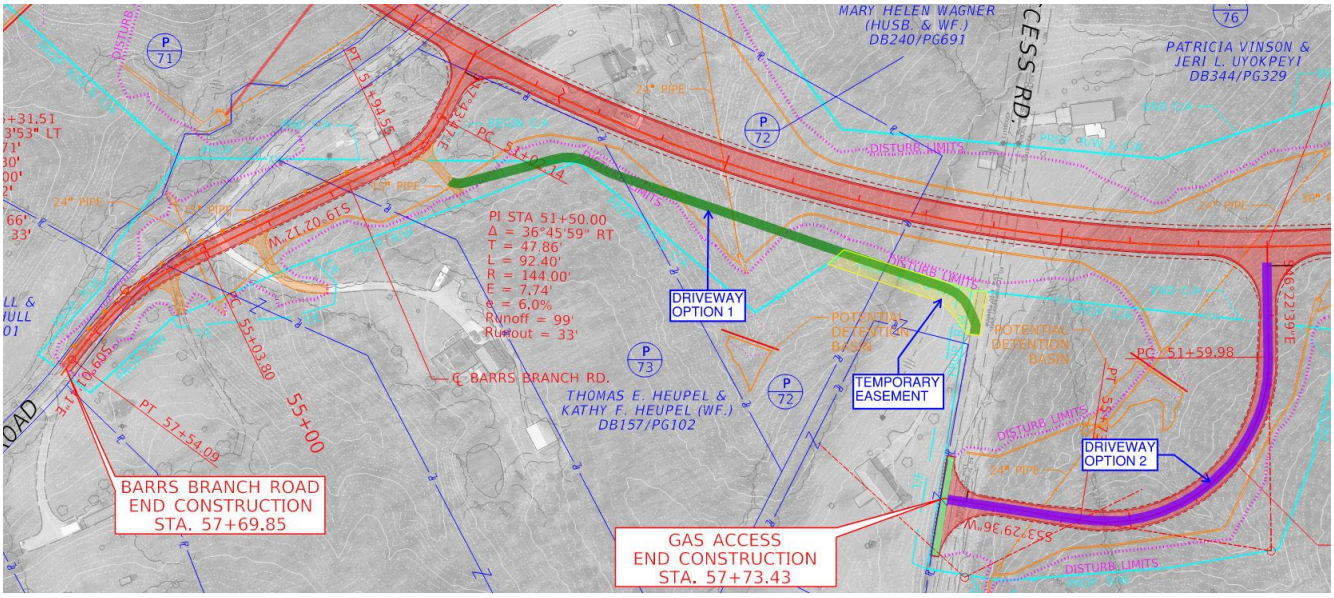
VE ALTERNATIVE LR-4
Use frontage road or local driveway for Gas Access Road

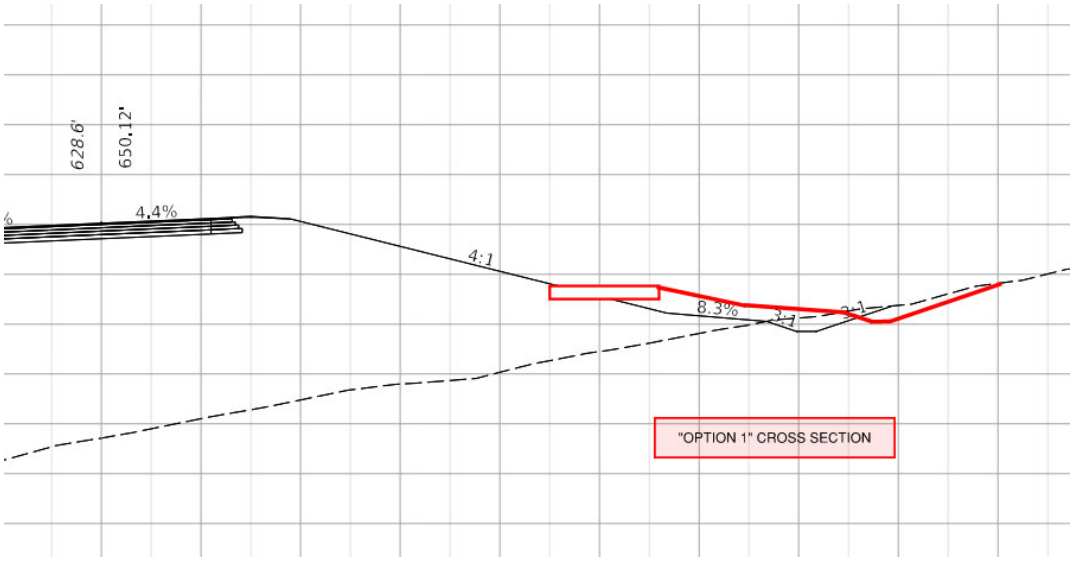
Baseline Concept Sketch

The baseline concept is shaded in red in the sketch below.

VE Alternative Concept Sketch

“Option 1” is the green alignment. “Option 2” is the magenta alignment.





VE ALTERNATIVE LR-4
Use frontage road or local driveway for Gas Access Road

Assumptions and Calculations:

It is assumed that the driveway to the gas facility is very low-volume and does not have daily traffic. It is also assumed that the gas facility is only utilized by light-duty or medium-duty vehicles, thus it would be practical to use the typical section for entrances.
Earthwork is not considered a driving factor between the base and alternate concepts.
Gas Access Rd Paving Area Base Concept = 750' x 22.5' x (13.75" Asphalt and 5" CSB)
Gas Access Rd Paving Area Alternate Option 2 = 750' x 12.25' x (3.5" Asphalt and 4" CSB)
*Option 2 will be used for cost comparison since it will provide more construction cost savings than Option 1.

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Asphalt - Approach Road	Tons	1,418	$ 79.0	$ 112,022		$ 79.0	$ -
Crushed Stone Base	Tons	767	$ 36.4	$ 27,919	236	$ 36.4	$ 8,590
Asphalt - Entrance Option 2	Tons		$ 79.0	$ -	197	$ 79.0	$ 15,563
SUB-TOTAL				$139,941			$24,153
PROJECT MARK-UPS	20%			$27,988			$4,831
TOTAL (Rounded)				$168,000			$29,000
						SAVINGS	**$139,000**

VE ALTERNATIVE LR-5
Use signalized intersection at KY-9 in lieu of MUTs

Description of Baseline Concept:

The baseline concept utilized a Median U-Turn (MUT) concept at the intersection which eliminates all turns at the KY 9 intersection from both minor and major approach. All KY9 movements must go through the intersection and utilize the U-turns to then turn left, all KY 536/ 1997 movements must turn right then U-turn to accomplish left turns and through movements.

Description of Alternative Concept:

Replace the MUT intersection with a standard signalized intersection. Accommodate turning movements and remove U-turn loons.

Advantages:

- More conventional intersection type
- Accommodates turning movements at intersection
- Might be easier for heavy vehicles
- Utilize existing geometry on KY-9
- Negates the need for U-turn loon construction

Disadvantages:

- Introduces additional conflict points
- Could increase in delay on KY-9
-

Discussion:

The baseline concept is an innovative intersection which reduces conflict points but adds out of direction travel and requirement of U-turns to make any left turn movement and through movements from KY 536/ Stonehouse Rd. This alternative considers replacing that with a traditional signalized intersection which adds more intersection conflicts but is more typical for drivers and allows turning traffic to/from KY 536.

Discussion of Schedule Impacts:

Improved schedule as no additional construction required on KY9 for U-turn loons.

Discussion of Risk Impacts:

Potential safety impact with the introduction of a signal. MUT intersection eliminates many conflict points but introduces out of direction travel and U-turn movements which can create high speed differentials.

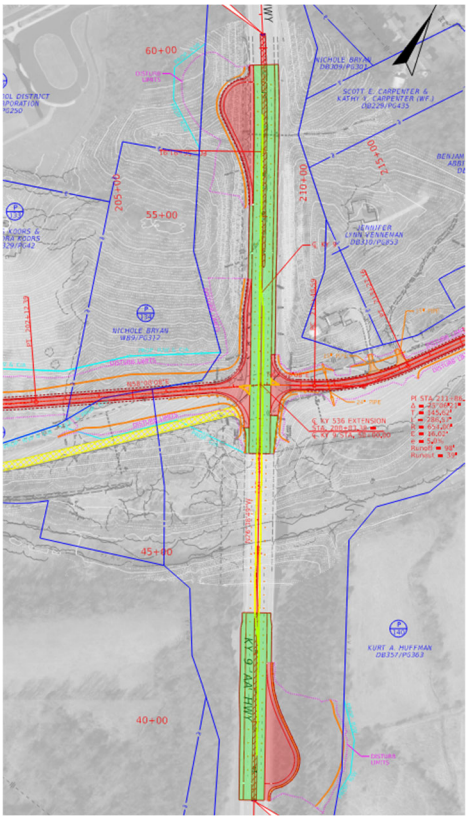
VE ALTERNATIVE LR-5
Use signalized intersection at KY-9 in lieu of MUTs

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Improves access to KY 536
Local Operations Introduces more typical intersection Direct crossing from KY 536 & KY 1997 May incur through movement delay on KY9
Maintainability Less pavement to maintain Signal Operations and Maintenance costs
Construction Impacts Removes U-turn loon construction
Environmental Impacts Less ROW Less Pavement/ Earthwork

VE ALTERNATIVE LR-5
Use signalized intersection at KY-9 in lieu of MUTs

Baseline Concept Sketch



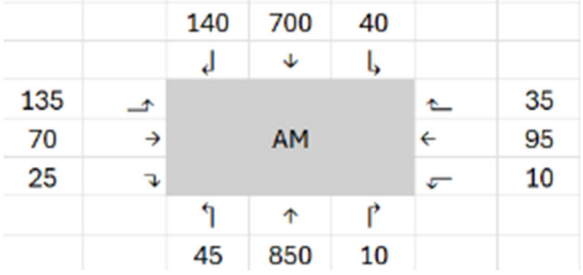
VE Alternative Concept Sketch

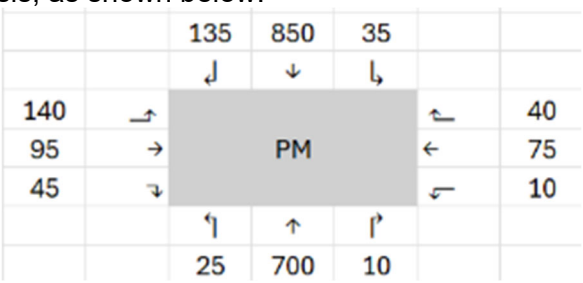
VE ALTERNATIVE LR-5

Use signalized intersection at KY-9 in lieu of MUTs

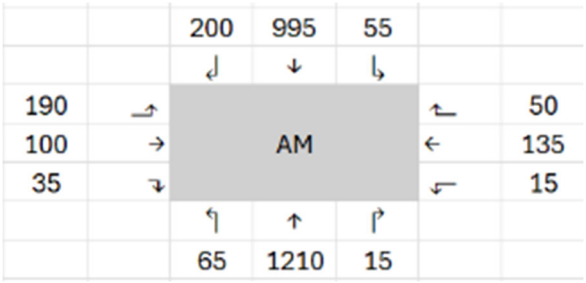
Assumptions and Calculations:

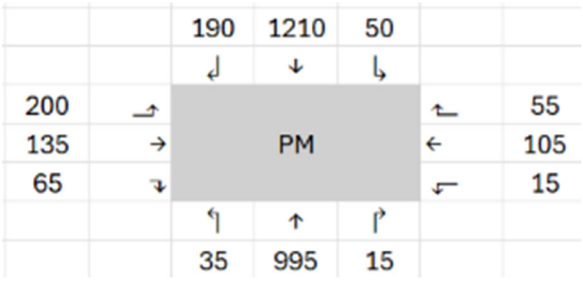
The base traffic data was developed in March 2002 with traffic projections for the corridor and intersections for 2000 and 2020. The traffic projections from this report were conservative and the 2020 projections were higher than realized volumes in multiple locations. There was an update to the traffic forecasts for the adjacent project on KY 536 in Kenton County.
The 2020 DHV volumes were used for an initial analysis, as shown below:





The projected growth from the 2020 projections and the 2045 revised projections along KY 536 through the project section was applied to the 2020 intersection volumes to provide a conservative analysis. (Approximately 42% growth. 2020: 5200 ADT | 2045: 7400 ADT). These grown volumes are shown below (rounded):





The intersection was analyzed using Synchro 11.

		2020		2045	
		AM	PM	AM	PM
KY9 & KY 536	Signal	C (26.5)	C (24.3)	D (35.9)	D (40.3)
	MUT (U-turn Delay)	C (20.3) E (44.9)	C (24.9) D (27.2)	F (194.7) F (291.1)	F (121.5) F (534.9)
	MUT (2 stage U-turn)	B (14.9) C (16.6)	B (14.1) C (18.9)	E (46.3) E (49.2)	C (24.5) F (77.0)

Should the projected volumes be realized, the MUT concept would struggle to meet acceptable LOS/delay thresholds during the peak periods (with either assumption of U-turn or two-stage turning movements).

VE ALTERNATIVE LR-5

Use signalized intersection at KY-9 in lieu of MUTs

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
ASPH BASE 1.00D PG 76-22	TON	5,271	$ 98.98	$ 521,696			$ -
ASPH SURF 0.50A PG 76-22	TON	1,778	$ 105	$ 186,304			$ -
Roadway Excavation	CUYD	1,852	$ 10	$ 18,778			$ -
Reconstruct Signal System				$ -			$ -
Install Traffic Signal				$ -	1	$ 450,000	$ 450,000
SUB-TOTAL				$726,778			$450,000
PROJECT MARK-UPS	20%			$145,356			$90,000
TOTAL (Rounded)				$872,000			$540,000
						SAVINGS	**$332,000**

Description of Baseline Concept:

The baseline configuration as it approaches Stonehouse Road utilizes a cross-country alignment and connects to KY9 near the existing Stonehouse connection location. The baseline proposes a closure of Stonehouse Road and assumes takings of multiple properties along the route.

Description of Alternative Concept:

Realign the proposed KY 536 to be closer to the existing Stonehouse Road to utilize the area better as the ROW takes are already proposed and minimize the additional row/ earthwork required by the baseline concept.

Advantages:

- Reduce ROW
- Reduce Earthwork
- Follow existing ground profile more closely
- Curves may reduce speeds

Disadvantages:

- May require retaining walls to avoid stream impacts

Discussion:

The focus of this concept was to re-examine the design through the eastern section of the corridor where the baseline is closing Stonehouse Road, building new alignment, and providing access to properties that are not being taken by the required earthwork/ROW. The goal of this configuration is to try to utilize some of the existing geometry and/or move the proposed roadway closer to the existing Stonehouse Road to eliminate some earthwork/ ROW if possible.

Discussion of Schedule Impacts:

Depending on ROW phase and Stonehouse closing, this option could be more difficult as it will impact the properties and Stonehouse more directly, but likely could be conducted to require no schedule changes to baseline. Additionally, the proposed anticipates less ROW and construction so could have improvements to the schedule.

Discussion of Risk Impacts:

Unknown alignment changes which could result in geotechnical or drainage issues beyond the effort of realignment. Anticipated that this may require retaining walls to eliminate stream impacts.

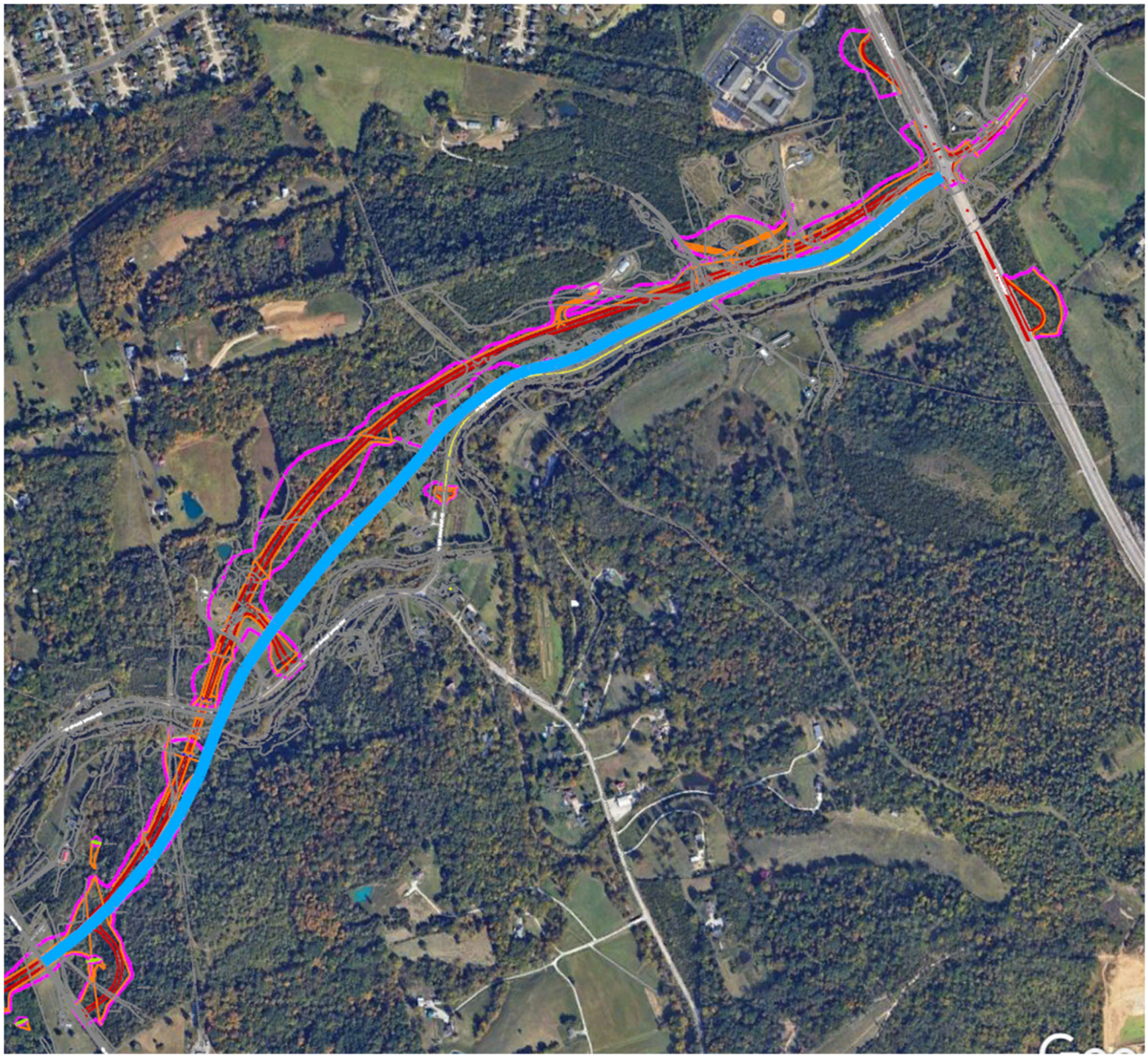
VE ALTERNATIVE A-1
Realign 536 closer to Stonehouse Road

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Negligible change. Reduction in vertical profile with additional horizontal curvature introduced.
Local Operations Negligible change. Maintains alignment close to Stonehouse which reduces local connection lengths. Improves the alignment at the intersection with KY9.
Maintainability No change.
Construction Impacts Improved. Less earthwork/ ROW. Can utilize existing Stonehouse Rd for construction staging/ access.
Environmental Impacts Potential decline. Potential stream mitigations required

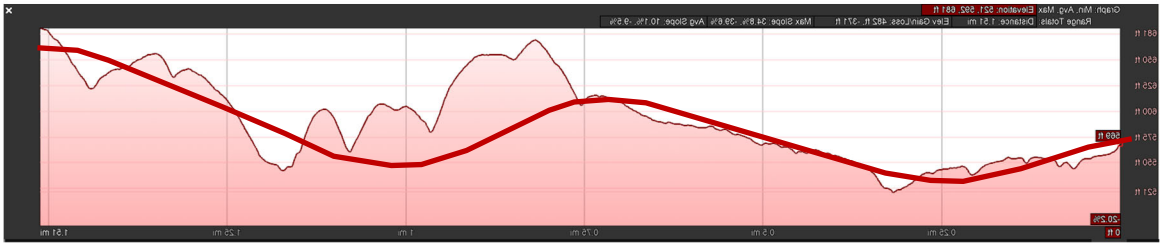
VE ALTERNATIVE A-1
Realign 536 closer to Stonehouse Road

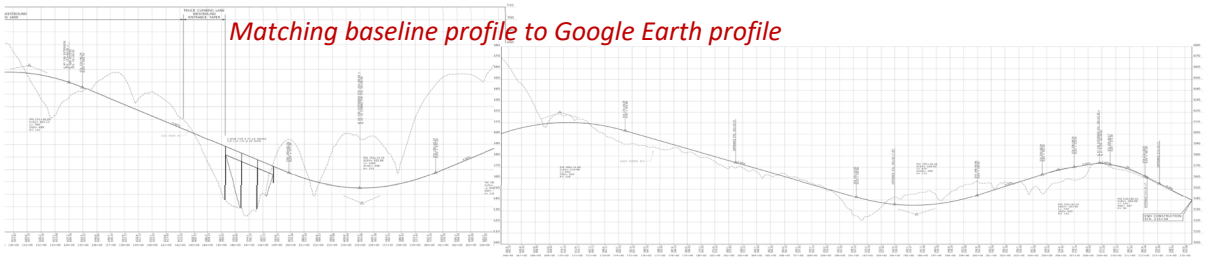
VE Alternative Concept Sketch



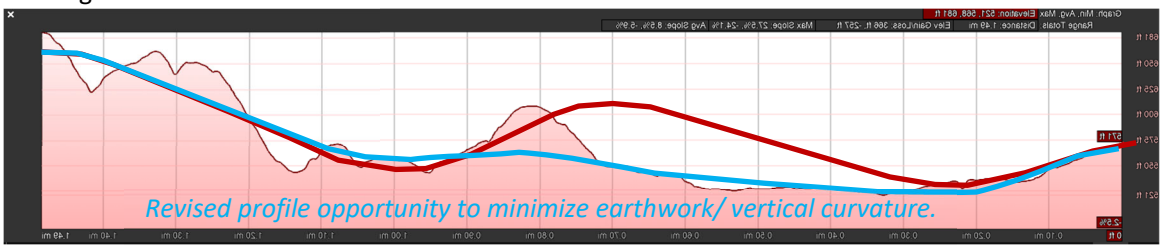
VE ALTERNATIVE A-1
Realign 536 closer to Stonehouse Road

Baseline Elevation Profile





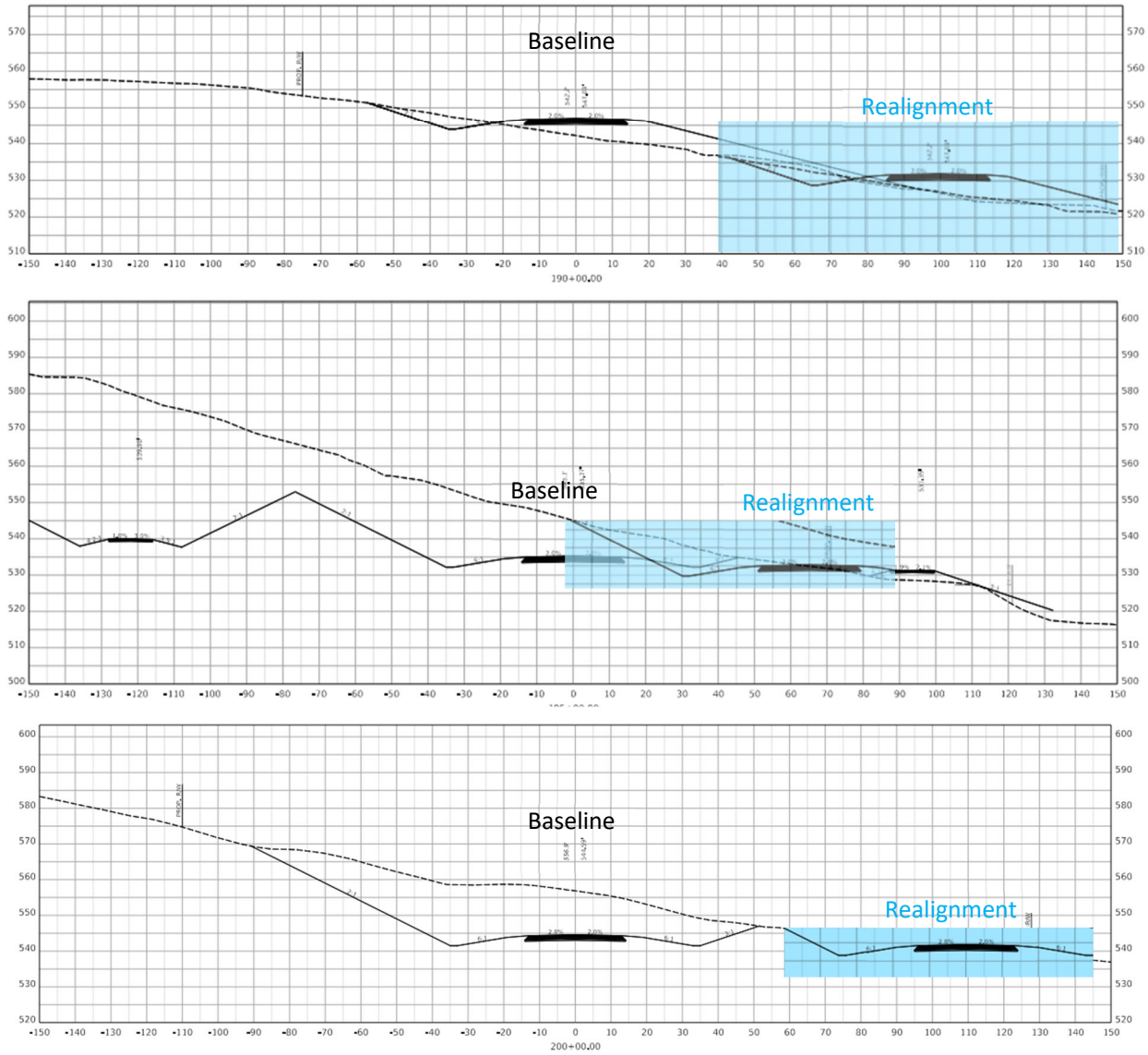
Realignment Elevation Profile



VE ALTERNATIVE A-1
Realign 536 closer to Stonehouse Road

Assumptions and Calculations:

Example Relocation XS at several stations



- **Based on select station locations, assume ~40% of earthwork for this section of roadway**
- **Assumed that retaining walls might be required to mitigate stream impacts**
  - **~1/3 of the roadway length may require walls**
  - **Assumed $40/sf of wall at 5-6ft in height throughout**

VE ALTERNATIVE A-1
Realign 536 closer to Stonehouse Road

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Paving Cost (per mi)	mi	1.50	$ 2,090,971	$ 3,136,456	1.48	$ 2,090,971	$ 3,094,637
Roadway Cost (per mi)	mi	1.50	$ 4,923,925	$ 7,385,888	1.48	$ 4,923,925	$ 7,287,409
Roadway Excavation	CUYD	572,614	$ 10	$ 5,806,311	229,046	$ 10.14	$ 2,322,524
Retaining Walls (Assume 5-6ft)	LF			$ -	2,602	$ 200	$ 520,439
				$ -			$ -
SUB-TOTAL				$16,328,655			$13,225,009
PROJECT MARK-UPS	20%			$3,265,731			$2,645,002
TOTAL (Rounded)				$19,594,000			$15,870,000
						SAVINGS	**$3,724,000**

VE ALTERNATIVE A-2
Realign west connection and connect to US-27 to the south

Description of Baseline Concept:

The baseline concept connects KY 536 on the western end of the project area (at US27) at the intersection of the current KY 536 terminus. This causes multiple curves at the start of the project corridor to avoid residential developments.

Description of Alternative Concept:

Connect the proposed KY 536 section to US 27 further south of the current intersection to eliminate some of the roadway length and curvature present at the western end of the project corridor.

Advantages:

- Reduces Roadway length
- Potentially reduces Earthwork
- Eliminates large box culvert and several longer drainage pipes
- Reduces ROW
- Creates 2 3-leg intersections on US 27

Disadvantages:

- Creates offset for KY 536 alignment
- Unknown alignment details
- Adds additional intersection (likely signalized)

Discussion:

The baseline concept maintains continuity for KY 536 from its current terminus into the proposed project, in doing so requires additional drainage and curvature that likely is not required if the connection point was further south on US 27.

The trade-offs by not making the route continuous (which it currently is not in other counties) is potentially negated by the cost savings for shorter roadway length, less earthwork, and fewer drainage structures.

Discussion of Schedule Impacts:

Reduces project impacts which should result in improvements to the project schedule.

Discussion of Risk Impacts:

Unknown roadway alignment, topography, etc.

VE ALTERNATIVE A-2

Realign west connection and connect to US-27 to the south

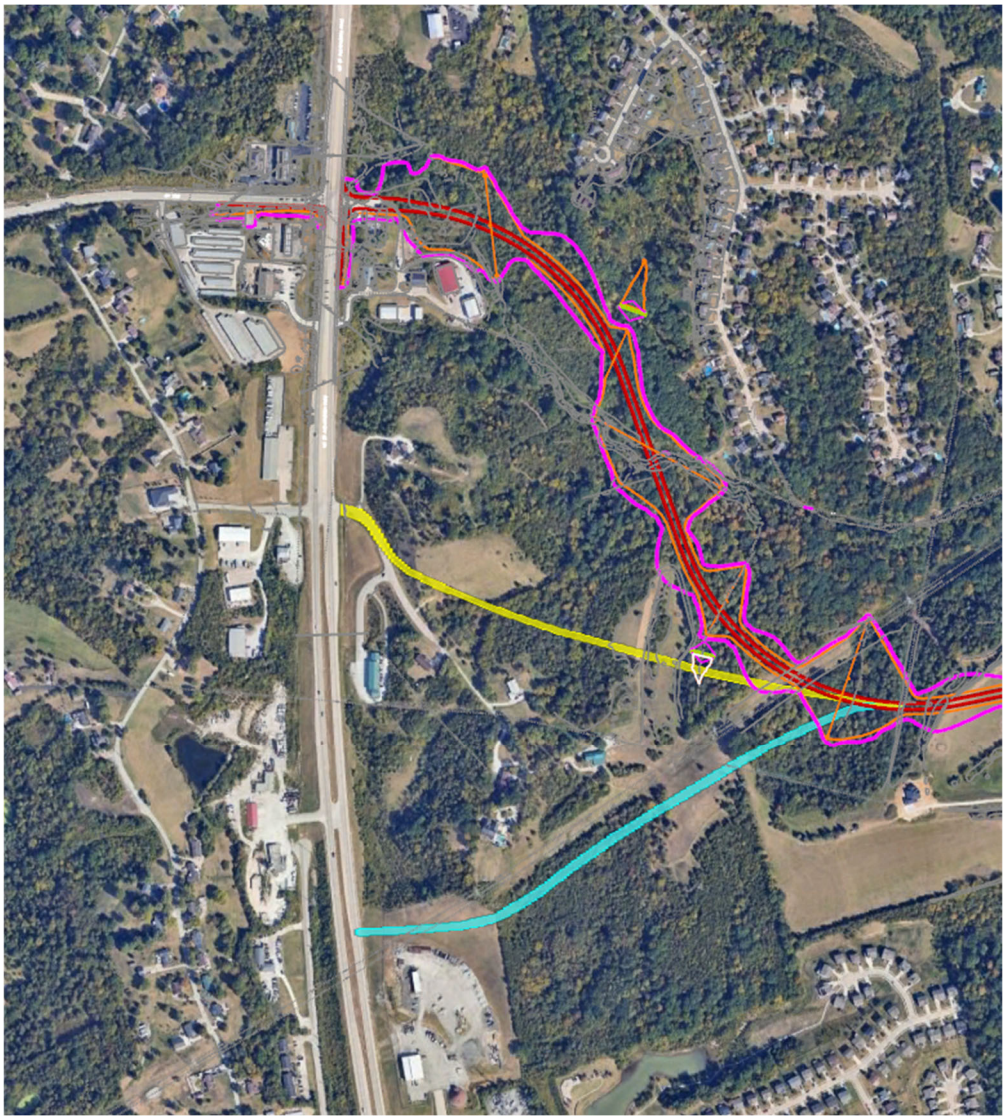
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Slight decline due to the required jog on US 27 vs continuity. Removal of multiple curves benefits drivability.
Local Operations Negligible change. Adds another intersection on US 27, but less complex with fewer phases (if both were signalized)
Maintainability Improved. Less Roadway length and drainage structures to maintain
Construction Impacts Slight Improvement. Less roadway length, Less ROW and earthwork.
Environmental Impacts Improvement. Reduced number of creek/ stream crossings.

VE ALTERNATIVE A-2

Realign west connection and connect to US-27 to the south

VE Alternative Concept Sketch



Assumptions and Calculations:

- Baseline: 3575 ft length
- Yellow Option: 2670 ft length
- Blue Option: 2620 ft length.
    - Blue option is likely more optimal due to ROW and proximity to KYTC facility and transmission lines and what seems to be less earthwork required, but further from existing KY 536 connection point.

VE ALTERNATIVE A-2

Realign west connection and connect to US-27 to the south

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Conc Box Culvert 8x5		1	$ 1,589,000.00	$ 1,589,000	0		$ -
Culvert Pipe - 66in		428	$ 366	$ 156,858	0		$ -
Headwall for 66in		2	$ 13,198	$ 26,395	0		$ -
Culvert Pipe - 36in		220	$ 207	$ 45,540	0		$ -
Headwall for 36in		2	$ 2,792	$ 5,584	0		$ -
Paving Cost (per mi)		0.68	$ 2,090,971	$ 1,415,762	0.50	$ 2,090,971	$ 1,037,565
Roadway Cost (per mi)		0.68	$ 4,923,925	$ 3,333,908	0.50	$ 4,923,925	$ 2,443,311
SUB-TOTAL				$6,573,046			$3,480,876
PROJECT MARK-UPS	20%			$1,314,609			$696,175
TOTAL (Rounded)				$7,888,000			$4,177,000
						SAVINGS	**$3,711,000**

VE ALTERNATIVE PX-1
Reduce profiles throughout and increase roadway grades

Description of Baseline Concept:

The baseline concept uses a max profile grade of 4.60% on mainline and a max profile grade of 8% on approaches and connectors.

Description of Alternative Concept:

The alternative is to revise the profile by increasing the grade in areas where flatter slopes were utilized as well as optimizing vertical curves based on the increased grades.

Advantages:

- Reduce ROW
- Reduce earthwork
- Reduce culverts / drainage piping

Disadvantages:

- Steepens roadway grades
- Reduces sight distances
- May impact design speed

Discussion:

The baseline concept has balanced the earthwork on the project; however, the alternative would optimize the vertical alignment in areas not utilizing steeper grades to reduce earthwork. The alternative would reduce the footprint of the project and reduce the ROW required to construct. Additionally, lowering the profile and increasing the grade would result in shorter pipes and culverts by moving the toe of the side slopes in. By lowering the profile there is potential to reduce the grades on the approach and connector roads.

Steeping grades on the roadway could result in reduced sight distance in vertical curves and could potentially impact design speed to accommodate required sight distance.

It is noted that the design team is allowed to design a max profile grade of 4.75%.

Discussion of Schedule Impacts:

No impact on schedule.

Discussion of Risk Impacts:

There is a potential increased risk in drivers speeding when increasing the grade, however, maintaining grades flatter than 4.75% shouldn't result in increased speeding.

VE ALTERNATIVE PX-1

Reduce profiles throughout and increase roadway grades

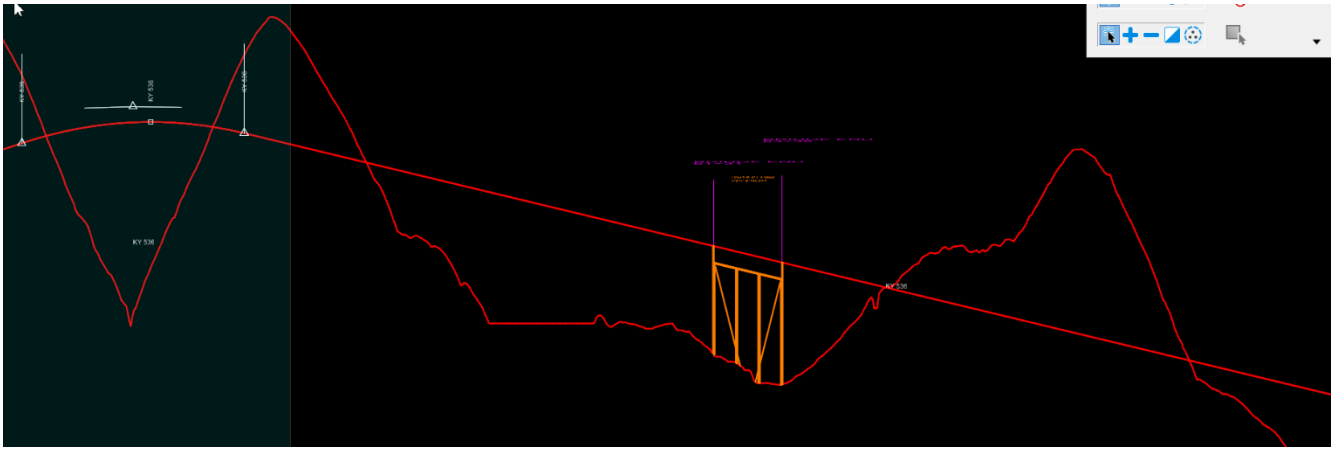
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations – Increased mainline operations by steeping the grades.
Local Operations – Reduced by lowering the mainline profile the approaches and connector roads profile grades can potentially be reduced.
Maintainability – No change from baseline concept.
Construction Impacts – No change from baseline concept.
Environmental Impacts – Reduced environmental impacts from a reduction in ROW

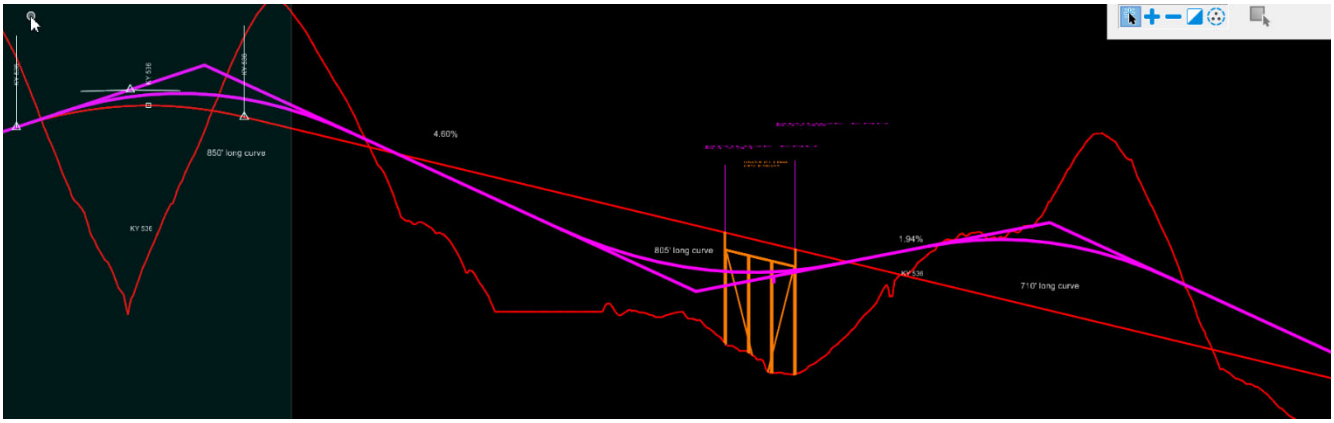
VE ALTERNATIVE PX-1

Reduce profiles throughout and increase roadway grades

Baseline Concept Sketch



VE Alternative Concept Sketch



Assumptions and Calculations:

- Assumed vertical curve lengths as labeled in the drawing above.
- Calculations are based on a percent reduction in profile area.

Design	Fill Material (SQFT)	Cut Material (SQFT)	Percent Reduction in Fill	Percent Reduction in Cut
Alt	89400	19400	6.78%	47.28%
baseline	95900	36800		

VE ALTERNATIVE PX-2
Reduce footprint with steeper side slopes

Description of Baseline Concept:

The baseline concept for KY 536 proposes side slopes in fill sections to be constructed at 4:1 (unless approaching bridges in which case side slopes transition to 2.5:1) until outside of the clear zone and then barndoor slope to the toe of the slope, to eliminate the need for guardrail and onsite material disposal.

Description of Alternative Concept:

The alternative proposes constructing the side slopes, in select fill sections, at 2.5:1 to reduce the overall footprint of the project in specific locations.

Advantages:

- Reduce ROW
- Reduce earthwork
- Reduce culverts / drainage piping

Disadvantages:

- Increase maintenance and erosion potential
- May need guard rail
- May need retaining walls or benching

Discussion:

Although the baseline concept eliminates the need for guardrail and provides onsite disposal of material, it results in expensive right of way purchases, potentially excessive cut to balance project, and lengthy culverts.

The alternative proposes steepening slopes in select locations, still within the geotechnical recommendations, and reduces the footprint of project, resulting in reduced Right of Way, potentially less earthwork, and reduced culvert/pipe lengths. Although this could result in benching or retaining walls and additional guardrail, the reduction in right of way and potential adjustments to earthwork could allow for savings.

Discussion of Schedule Impacts:

No impact to scheduling.

Discussion of Risk Impacts:

- There is a potential risk of increased maintenance/erosion if soil is not stable or of good quality.
- There is a potential risk when introducing barriers within the clear zone like guardrail.

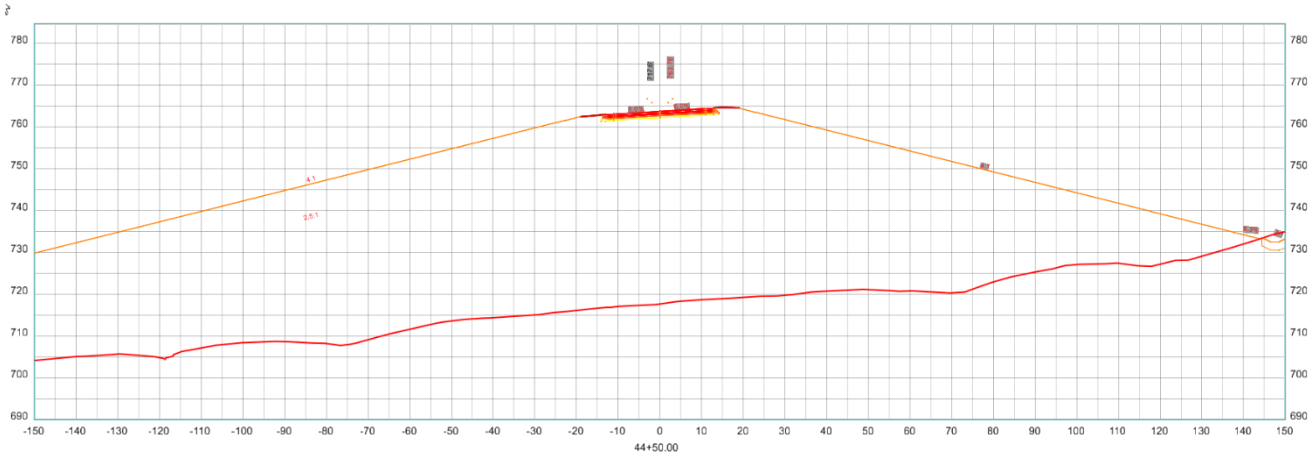
VE ALTERNATIVE PX-2
Reduce footprint with steeper side slopes

Performance Assessment:

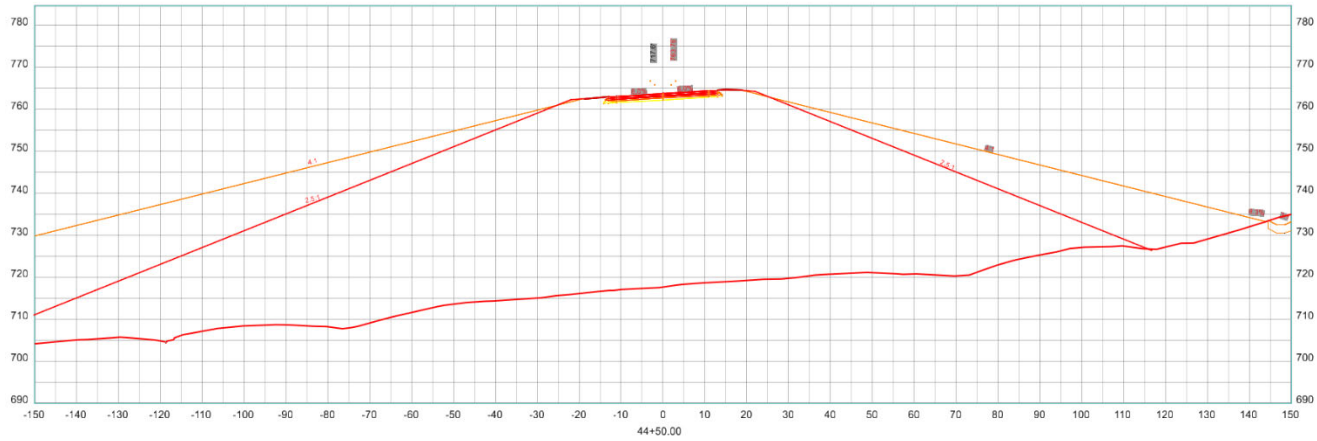
Attributes and Rating Rationale
Mainline Operations – No change from baseline concept.
Local Operations – No change from baseline concept.
Maintainability – Increased maintainability because there is an increased risk of erosion and maintenance on steeper side slopes.
Construction Impacts – Increased construction impacts due to additional temporary erosion control needed to construct steeper side slopes.
Environmental Impacts – Reduced environmental impacts by reducing the amount of ROW needed to construct. Additionally, by steepening side slopes we are reducing the area of disturbance.

VE ALTERNATIVE PX-2
Reduce footprint with steeper side slopes

Baseline Concept Sketch



VE Alternative Concept Sketch



Assumptions and Calculations:

- Assumed Locations
  - Station 26+00 to 31+50, assumed depth of 40 ft
  - Station 40+00 to 46+00, assumed depth of 50 ft
  - Station 106+50 to 124+00, assumed depth of 20’ over a ridge
  - Station 132+00 to 133+00, assumed depth of 35’

VE ALTERNATIVE PX-2

Reduce footprint with steeper side slopes

Station Range	Design	AVG Fill Material (SQFT)	Percent Reduction
Station 26+00 to 31+50	Alt	4,455.536	39.39%
	baseline	7,351.602	
Station 40+00 to 46+00	Alt	4,672.84	43.50%
	baseline	8,270.905	
Station 106+50 to 124+00	Alt	1,664.163	48.64%
	baseline	3,239.933	
Station 132+00 to 133+00	Alt	4,584.309	34.45%
	baseline	6,993.251	

VE ALTERNATIVE PX-3
Provide 8’ shoulders on all bridges

Description of Baseline Concept:

The baseline concept includes three proposed bridges for grade separations of cross roadways and spanning streams and utilities. The bridges all have the same typical section, carrying two 11’ travel lanes and a 10’-wide shoulder on each side.

Description of Alternative Concept:

The alternative concept proposes reducing the 10’-wide shoulders to 8’-wide, which will match the full shoulder width of the roadway. This reduces the total width of the bridges from ~44.5’ to 40.5’, a 9% reduction of bridge deck area.

Advantages:

- Cost reduction of the bridges, which is one of the major costs to the project.
- Also eliminates the need to taper the roadway shoulder to match the bridge width, reducing pavement quantities and providing a consistent should width.

Disadvantages:

- Provides less space on the bridge shoulders for stalled vehicles, water and snow, and less distance from edge of pavement to the barrier.

Discussion:

The KYTC Highway Design Manual directs us to maintain the full approach roadway width across all new structures. For this project that means two 11’ travel lanes and an 8’ usable shoulder on each side. Providing an additional 2’ of shoulder may provide slight safety and operation benefits, though perhaps those benefits do not outweigh the cost. The bridges are also in tangent sections, so sight distance should not be impacted.

Discussion of Schedule Impacts:

No schedule impacts.

Discussion of Risk Impacts:

No risk impacts.

VE ALTERNATIVE PX-3
Provide 8’ shoulders on all bridges

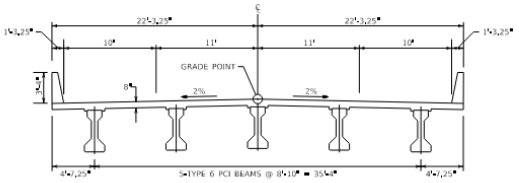
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Slightly reduced due to having less refuge and recovery area on the bridge shoulders.
Local Operations No change from the base concept.
Maintainability Increased due to the fact the bridge deck area will be about 9% less.
Construction Impacts No change to construction as this is a new route and part-width construction is not likely.
Environmental Impacts No change from the base concept.

VE ALTERNATIVE PX-3
Provide 8’ shoulders on all bridges

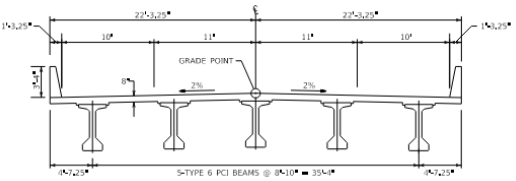
Baseline Concept Sketch

KY 536 OVER JERRY WRIGHT ROAD
STA. 61+31 - 63+35



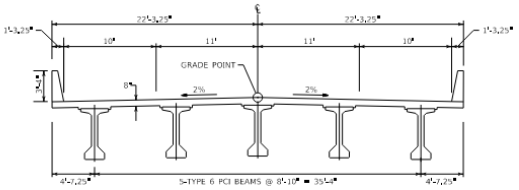
BRIDGE SECTION

KY 536 OVER PERSIMMON GROVE PIKE
STA. 80+82 - 85+85



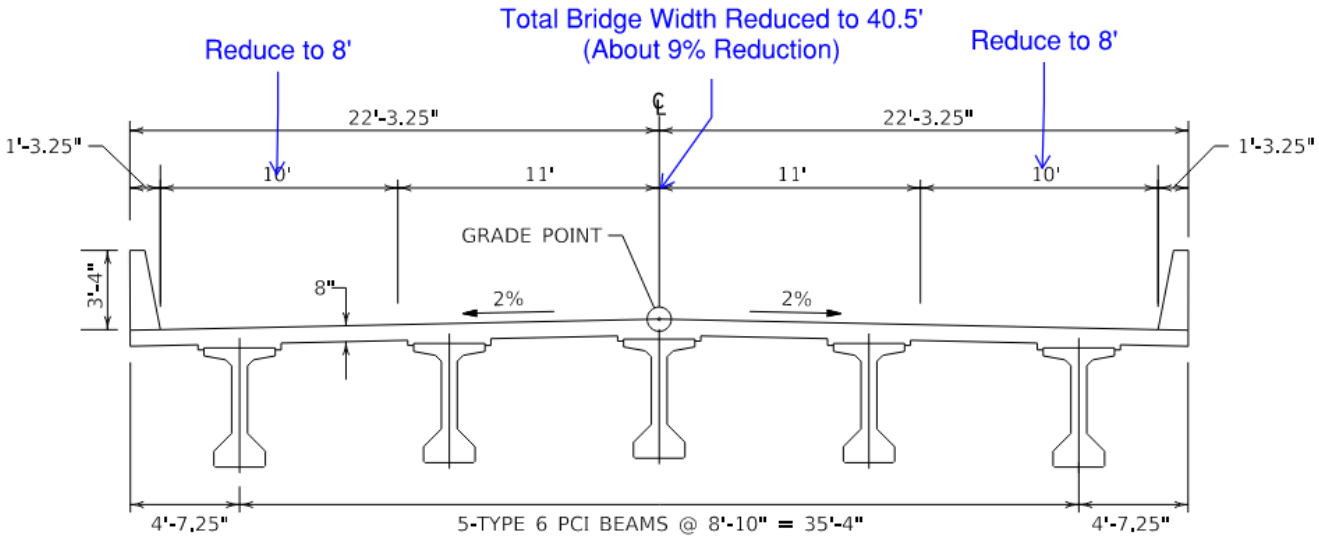
BRIDGE SECTION

KY 536 OVER KY 10
STA. 145+26 - 148+74



BRIDGE SECTION

VE Alternative Concept Sketch



Assumptions and Calculations:

For cost comparisons, the current bridge cost estimates were used.

VE ALTERNATIVE PX-3
Provide 8’ shoulders on all bridges

The alternate bridge width is 40.5’, compared to the base concept of 44.5’. That is about 9%. Therefore, all the bridge costs were simply reduced by 9%. If the bridge width reduction also allows the removal of a beam or a beam size reduction, then that would provide additional savings - though the assumption for this alternate is that does not happen.

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
3-Span Bridge over Jerry Wright Rd	LS	1	$ 2,485,000	$ 2,485,000	1	$ 2,261,350	$ 2,261,350
5-Span Bridge over Persimmon Grove Pike	LS	1	$ 6,224,000	$ 6,224,000	1	$ 5,663,840	$ 5,663,840
3-Span Bridge over KY-10 & Brush Creek	LS	1	$ 4,239,000	$ 4,239,000	1	$ 3,857,490	$ 3,857,490
Approach Roadway Pavement	LS	1	$ 1,007,864	$ 1,007,864	1	$ 937,313	$ 937,313
SUB-TOTAL				$13,955,864			$12,719,993
PROJECT MARK-UPS	20%			$2,791,173			$2,543,999
TOTAL (Rounded)				$16,747,000			$15,264,000
						SAVINGS	**$1,483,000**

VE ALTERNATIVE TC-1
Adjust profile and eliminate truck climbing lane

Description of Baseline Concept:

The original design specifies using an 8 ft shoulder (2 ft paved) in areas where a truck climbing lane is being proposed. The project currently calls for at least 0.6 miles of truck climbing lane.

Description of Alternative Concept:

This alternative would eliminate the truck climbing lane and transitions. Design team to make attempts to lower the elevation peaks around STA 104+50 and STA 130+00 to minimize the upward grade.

Advantages:

- Reduce earthwork quantities and costs
- Potentially reduce ROW impacts

Disadvantages:

- Regular WB mainline conflicts with slow moving vehicles

Discussion:

Continue typical section throughout project with no provisions for a truck climbing lane. Although justifiable and common, the relatively short length of the proposed truck climbing lane and minimal time delay to any slowed vehicle may minimize the benefit of it's construction. Additionally, the profile may be able to be optimized West of KY 10 to reduce the uphill grade.

Discussion of Schedule Impacts:

Improved. Reduction in paved area, less earthwork.

Discussion of Risk Impacts:

No change to project risk.

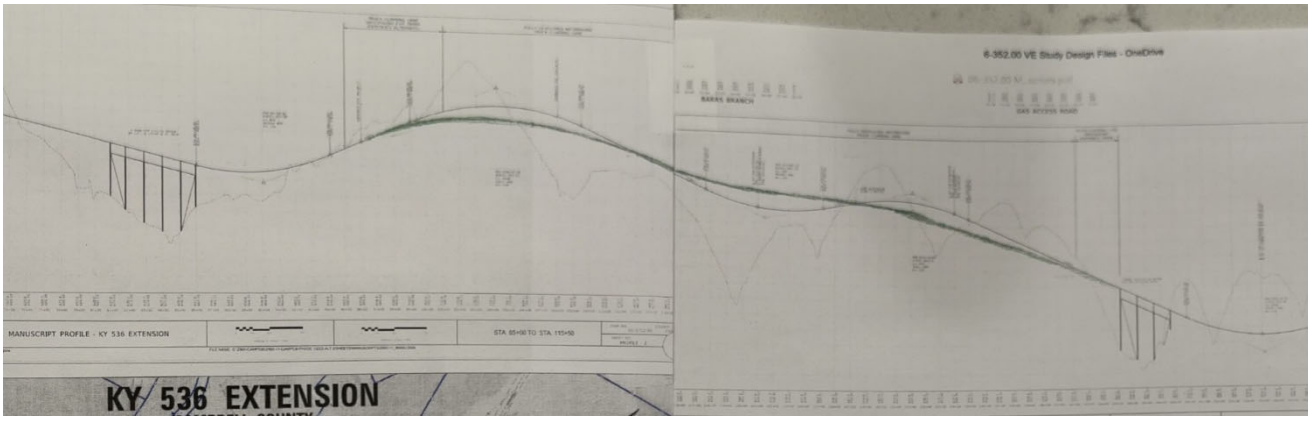
VE ALTERNATIVE TC-1
Adjust profile and eliminate truck climbing lane

Performance Assessment:

Attributes and Rating Rationale
Mainline Operations Reduced. Regular WB mainline conflicts with slow moving vehicles
Local Operations No change from baseline.
Maintainability Minimally improved. Less pavement to maintain.
Construction Impacts Minimally Improved. Less pavement to place.
Environmental Impacts No change from baseline.

VE ALTERNATIVE TC-1
Adjust profile and eliminate truck climbing lane

Baseline vs. VE Alternative Concept Sketch



Assumptions and Calculations:

Net reduction in Earthwork by approximately 20,000 CUYD.

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Paving Cost (per lane per mile)	mi	0.85	$ 880,000.00	$ 748,000	0		$ -
Roadway Excavation	CUYD	1,485,761	$ 10.14	$ 15,065,617	1,465,761	$ 10.14	$ 14,862,817
SUB-TOTAL				$15,813,617			$14,862,817
PROJECT MARK-UPS	20%			$3,162,723			$2,972,563
TOTAL (Rounded)				$18,976,000			$17,835,000
						SAVINGS	**$1,141,000**

VE ALTERNATIVE TC-2
Reduce shoulders at truck climbing lane

Description of Baseline Concept:

The original design specifies using an 8 ft shoulder (2 ft paved) in areas where a truck climbing lane is being proposed. The project currently calls for at least 0.6 miles of truck climbing lane.

Description of Alternative Concept:

This alternative recommends using a 4 ft shoulder (2 ft paved) which is allowable for truck climbing lanes based on AASHTO standards.

Advantages:

- Reduce earthwork quantities and costs
- Potentially reduce ROW impacts

Disadvantages:

- Does not provide a parking area for emergency situations in addition to the truck climbing lane.
- Less recovery and emergency refuge area.

Discussion:

The use of a 4 ft shoulder for a truck climbing lane is an acceptable and safe practice per AASHTO design policy and KYTC Highway Design Manual. Reducing the width of the shoulder through the truck climbing section would marginally reduce earthwork quantities and ROW by bringing in slopes. By only reducing shoulders in the truck climbing lane area, one mainline lane would still be clear in the event of an emergency breakdown and not cause traffic to be blocked.

Discussion of Schedule Impacts:

Minimal, if any. Possibly slightly accelerated schedule due to less earthwork.

Discussion of Risk Impacts:

Potential of truck lane impacts if slope slides occur rather than just shoulder.

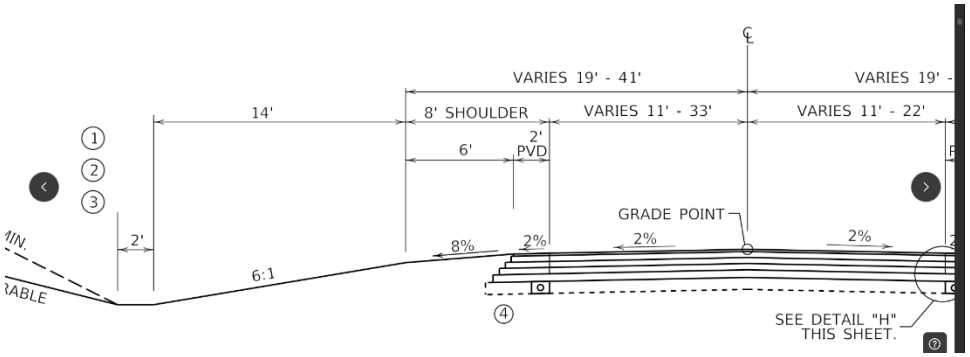
VE ALTERNATIVE TC-2
Reduce shoulders at truck climbing lane

Performance Assessment:

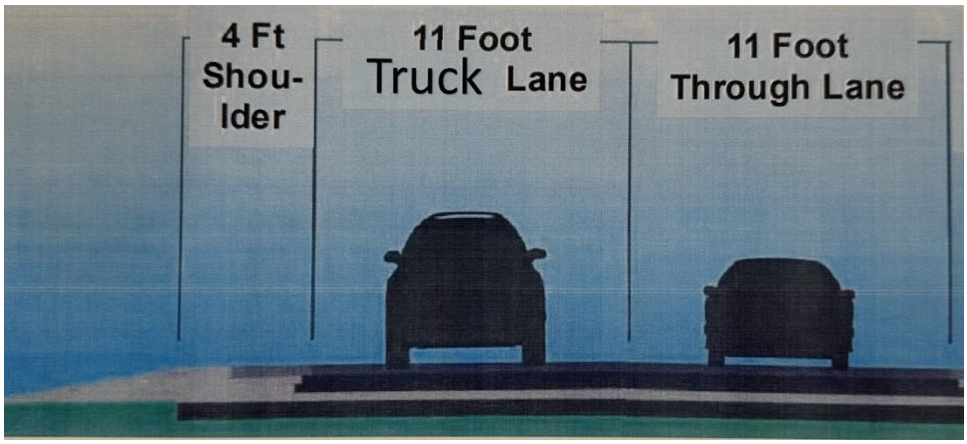
Attributes and Rating Rationale
Mainline Operations Rarely reduced, only to truck lane and only during emergency breakdown refuge.
Local Operations No change from baseline
Maintainability Slightly improved. Less shoulder to mow/maintain.
Construction Impacts Minimal. Slightly less earthwork, but potentially more difficult to break and compact smaller shoulder.
Environmental Impacts No change from baseline

VE ALTERNATIVE TC-2
Reduce shoulders at truck climbing lane

Baseline Concept Sketch



VE Alternative Concept Sketch



Assumptions and Calculations:

Reduces net earthwork by approximately 7,500 CUYD

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Roadway Excavation	CUYD	1,485,761	$ 10.14	$ 15,065,617	1,478,261	$ 10.14	$ 14,989,567
SUB-TOTAL				$15,065,617			$14,989,567
PROJECT MARK-UPS	20%			$3,013,123			$2,997,913
TOTAL (Rounded)				$18,079,000			$17,987,000
						SAVINGS	**$92,000**

VE ALTERNATIVE SC-1
Realign culverts and shorten structure lengths/size

Description of Baseline Concept:

The baseline concept includes over 4800 LF of pipe culverts ranging in size from 24”-66”. There are also three box culverts (8’x5’, 10’x6’, 12’x8’) on streams that measure approximately 1400 LF. Due to the natural topography of the project, most of these culverts are at skews and many at large skews and measure several hundred feet long.

Description of Alternative Concept:

The alternative concept looked throughout the project for the best opportunities to realign culverts to more of a perpendicular crossing. This typically creates additional earthwork for ditching and some channel change for larger structures in streams. For this alternative, culverts larger than 36” diameter were considered to be on a stream.

Advantages:

- Reduced culvert will provide cost savings for the project.
- Maintenance requirements will be reduced.

Disadvantages:

- Channel changes are necessary to shorten larger box culverts.

Discussion:

The handful of locations listed below were identified as potential culvert crossings that could be realigned and provide shorter lengths to provide cost savings to the project. This is without adjusting the side slopes and just using a more perpendicular crossing or otherwise relocating the inlet. Other culverts not listed here could still be revisited for final design. A sketch is only provided for the 8’x5’ RCBC, but stations and brief description is provided below.

Sta. 25+00 – 36" Pipe; Base concept 225 LF, Alternative 135.
Sta. 29+00 – 8'x5’ RCBC; Base 595 LF, Alternative 515 LF and 115 LF of minor channel change.
Sta. 37+00 – 30" Pipe; Base 313 LF, Alternative 212 LF.
Sta. 80+00 – 30" Pipe; Base 338 LF, Alternative 189 LF.
Sta. 125+00 – 24" Pipe; Base 360 LF, Alternative 280 LF.
Sta. 135+00 – 36" Pipe; Base 258 LF, Alternative 175 LF.

A separate option is to reduce the roadway side slopes from 4:1 to 2.5:1 in locations with long culverts. For example, Sta. 43+50 there is a 520 LF 36” Pipe. If revising side slopes to 2.5:1 this culvert could be reduced to 270 LF, a reduction of over $50k. However, the addition of guardrails would eliminate much of those savings. Since there is a project goal to waste excavation on site it makes this option undesirable. If the goal changes, or other locations are identified for waste sites, it would be prudent to revisit the side slopes at that time.

Discussion of Schedule Impacts:

The alternative concept does not have schedule impacts.

Discussion of Risk Impacts:

The alternative concept does not introduce additional risk to the baseline concept.

VE ALTERNATIVE SC-1
Realign culverts and shorten structure lengths/size

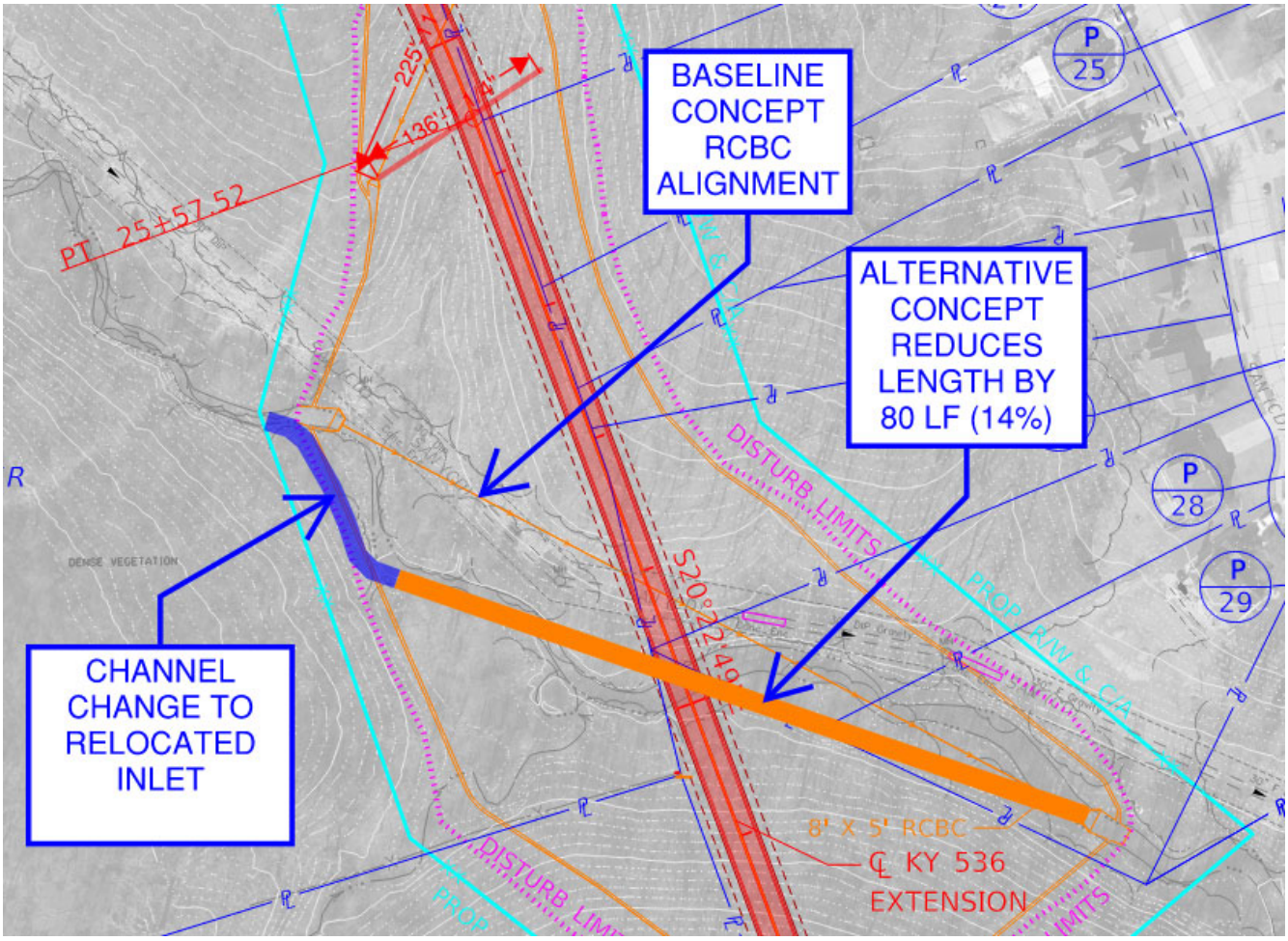
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations No change to the mainline operations.
Local Operations No change.
Maintainability Maintainability would have some increase due to the reduced lengths of culvert.
Construction Impacts Allows a shorter culvert construction but may add some additional grading at some locations.
Environmental Impacts For the list provided above, only the box culvert is considered on a stream. Relocating the inlet creates the need for a section of channel relocation, however that work could be eliminated with a “barn roof” roadway side slope. For the alternative concept, the cost associated with stream impact will be included.

Baseline Concept Sketch

Baseline concept of 8’x5’ RCBC is shown compared to the alternative concept in sketch below.

VE Alternative Concept Sketch



VE ALTERNATIVE SC-1

Realign culverts and shorten structure lengths/size

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
Sta. 25+00 – 36" Pipe	LF	225	$ 207.00	$ 46,575	135	$ 207.00	$ 27,945
Sta. 29+00 – 8'x5' RCBC	LF	595	$ 2,671	$ 1,589,007	515	$ 2,671	$ 1,375,308
Sta. 37+00 – 30" Pipe	LF	313	$ 155	$ 48,515	212	$ 155.00	$ 32,860
Sta. 80+00 – 30" Pipe	LF	338	$ 155	$ 52,390	189	$ 155	$ 29,295
Sta. 125+00 – 24" Pipe	LF	360	$ 132	$ 47,520	280	$ 132	$ 36,960
Sta. 135+00 – 36" Pipe	LF	258	$ 208	$ 53,664	175	$ 208	$ 36,400
SUB-TOTAL				$1,837,671			$1,538,768
PROJECT MARK-UPS	20%			$367,534			$307,754
TOTAL (Rounded)				$2,205,000			$1,847,000
						SAVINGS	**$358,000**

VE ALTERNATIVE S-1
Reduce thickness of AC pavement in typical structural section

Description of Baseline Concept:

The baseline concept proposes the following pavement schedule on mainline and approach roads:

- 1.5” CL 2 ASPH Surf 0.38B PG64-22
- 4.0” CL 2 ASPH Base 1.0D PG64-22
- 4.0” CL 2 ASPH Base 1.0D PG64-22
- 4.25” CL 2 ASPH Base 1.0D PG64-22
- 5.0” Crushed Stone Base
- 8.0” Lime Stabilized Roadbed

Description of Alternative Concept:

The alternative concept proposes reducing the baseline concept to the following:

- 1.5” CL 2 ASPH Surf 0.38B PG64-22
- 3.5” CL 2 ASPH Base 1.0D PG64-22
- 3.5” CL 2 ASPH Base 1.0D PG64-22
- 5.0” Crushed Stone Base
- 8.0” Lime Stabilized Roadbed

Advantages:
- Reduced pavement costs.

Disadvantages:
- Potential increase maintenance

Discussion:

The alternative was analyzed using KYTC’s web-based pavement design software and reduces the overall thickness of the pavement structure throughout. The alternative pavement design is based on the traffic forecast provided with an ADT of 6300 and a T% of 5%. The web-based software recommended using 7.5” of asphalt.

It is noted that overall asphalt thickness in other portions of the KY 536 corridor was constructed with approximately 8.5” of asphalt.

Discussion of Schedule Impacts:

No impact on schedule.

Discussion of Risk Impacts:

An increased risk in maintenance is a possibility, however based on the completed portions of the KY 536 corridor and the analysis completed by the web-based software, the alternative should meet performance criteria.

VE ALTERNATIVE S-1
Reduce thickness of AC pavement in typical structural section

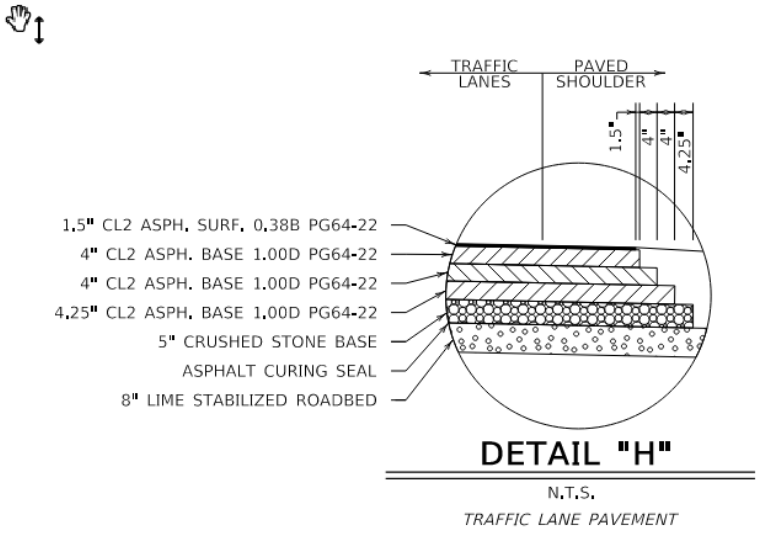
Performance Assessment:

Attributes and Rating Rationale
Mainline Operations – No change from baseline concept.
Local Operations – No change from baseline concept.
Maintainability – Increased potential for pavement maintenance.
Construction Impacts – No change from baseline concept.
Environmental Impacts – No change from baseline concept.

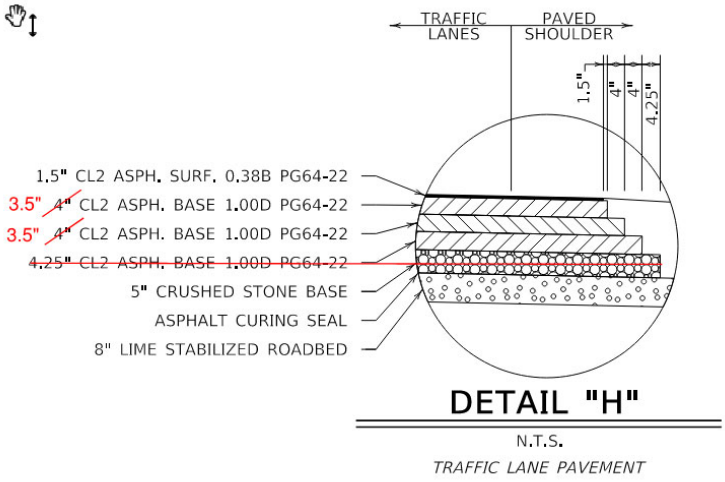
VE ALTERNATIVE S-1

Reduce thickness of AC pavement in typical structural section

Baseline Concept Sketch



VE Alternative Concept Sketch



Assumptions and Calculations:

- Assumed CBR of 1
- Assumed T% of 5% but later increased to 8% to be conservative.

VE ALTERNATIVE S-1

Reduce thickness of AC pavement in typical structural section

Initial Cost Estimate

CONSTRUCTION ELEMENT		*BASELINE CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Qty**	**Cost/Unit**	**Total**	**Qty**	**Cost/Unit**	**Total**
CL2 ASPH SURF 0.38B PG64-22	TON	7,219	$ 79.38	$ 573,051	7,219	$ 79.38	$ 573,051
CL2 ASPH BASE 1.0D PG64-22	TON	19,251	$78.88	$ 1,518,509	16,845	$78.88	$ 1,328,696
CL2 ASPH BASE 1.0D PG64-22	TON	19,251	$78.88	$ 1,518,509	16,845	$ 78.88	$ 1,328,696
CL2 ASPH BASE 1.0D PG64-22	TON	20,454	$78.88	$ 1,613,416	0	$78.88	$ -
CRUSHED STONE BASE	TON	38,450	$36.37	$ 1,398,427	38,450	$36.37	$ 1,398,427
LIME STABILIZED ROADBED	SQYD	86,604	$5.74	$ 497,107	86,604	$5.74	$ 497,107
SUB-TOTAL				$7,119,019			$5,125,976
PROJECT MARK-UPS	20%			$1,423,804			$1,025,195
TOTAL (Rounded)				$8,543,000			$6,151,000
						SAVINGS	**$2,392,000**

7.2 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 11. Summary of VE Strategy

Strategy Description	Cumulative Cost Savings	Schedule Savings	Cumulative Performance Change	Cumulative Value Change
VE Team Selected Combination (VE Alts LR-1, LR-3, LR-4, A-1, A-2, PX-3, TC-1, SC-1, S-1)	~$17.7M	TBD	+4%	+58%

7.2.1 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.

7.2.2 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 12. VE Strategy Performance Rating Rationale

PERFORMANCE MEASURES Attributes and Rating Rationale for Recommendation	*Performance*	*Baseline*	*Recommendation*
Main Line Operations	*Rating*	5	4
Elimination of truck climbing lane introduces potential conflicts with slow moving traffic. Introduces turn condition and short bypass on US-27. Potential impacts to design speed for realignments at east and west ends. Reduces conflict at Gas Access Road.	*Weight*	37.5	
	Contribution	187.5	150
Local Operations	*Rating*	5	4
Increases conflicts with local traffic on US-27 with additional intersections and movements. Introduces stop condition and conflict point at Persimmon Grove.	*Weight*	18.7	
	Contribution	93.5	74.8
Maintainability	*Rating*	5	7
Reduces structures requiring maintnance, reduces pavement requiring maintenance. May add guard rail or walls in select locations.	*Weight*	12.5	
	Contribution	62.5	87.5
Environmental Impacts	*Rating*	5	7
Eliminates drainage structures and stream impacts in select locations due to realignment. Reduces right of way and roadway footprint impacts.	*Weight*	25.0	
	Contribution	125	175
Construction Impacts	*Rating*	5	5
Reduced impacts to Jerry Wright Road traffic. Reduces Persimmon Grove traffic impacts.	*Weight*	6.2	
	Contribution	31	31
Total Performance		500	518
Net Change in Performance			4%

7.2.3 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 13. Comparison of Cost Values

Strategy Description	Cost	Cost Score
Baseline Concept	$50,000,000.00	0.602
VE Strategy	$33,000,000.00	0.398
Totals	$83,000,000.00	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 (±%) deviation.

Table 14. Value Matrix

Strategy Description	Performance Score	Change in Performance	Cost Score	Schedule Score	Value Index
Baseline Concept	.500	N/A	0.602	TBD	N/A
VE Strategy	.518	+4%	0.398	TBD	+58%

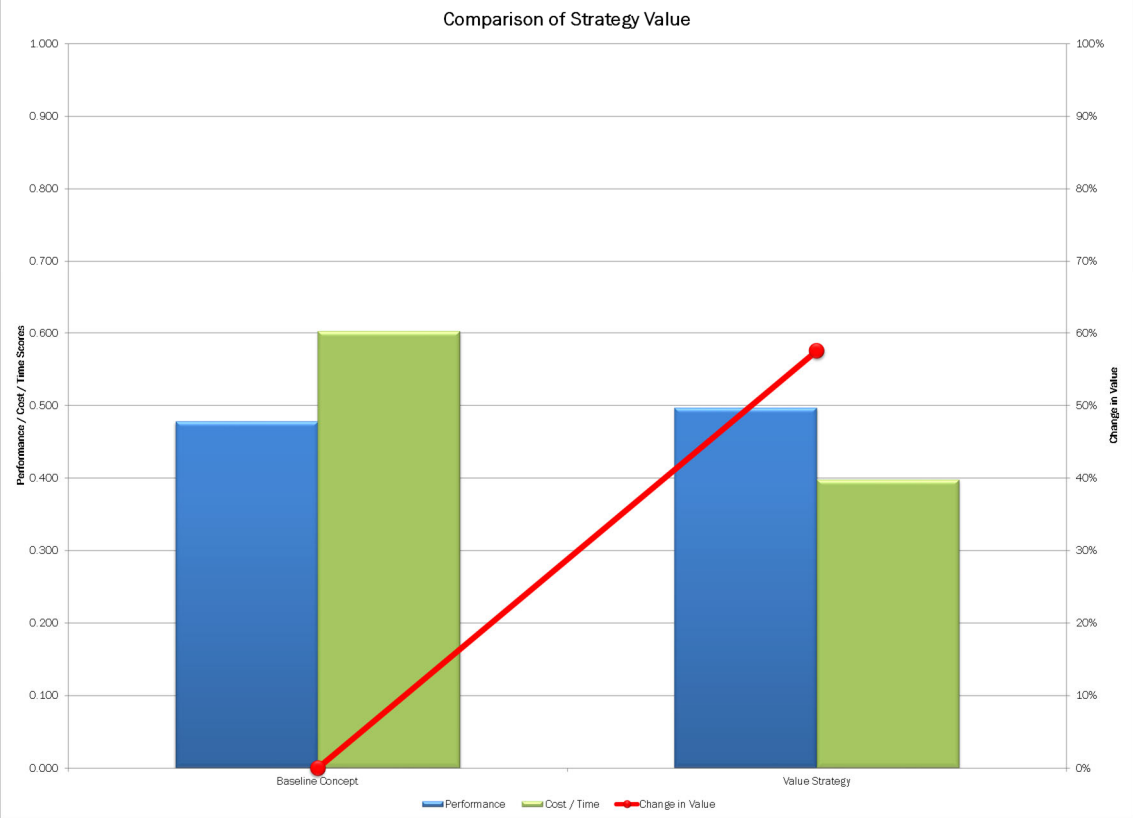


Figure 8 - Comparison of Value - Baseline Concept and VE Strategy

7.3 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 15. Design Considerations

Comment No.	Description
DC-1	Update the traffic analysis with more recent data
DC-2	Update the geotechnical investigation at proposed alignment. Optimize soil stabilization in lieu of assuming throughout.
DC-3	Accommodate new gas line conflict and assume other three existing are abandoned
DC-4	Provide roadway lighting at intersections and MUTs
DC-5	Cover sanitary line at Persimmon Grove in lieu of spanning with structure

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		A	5.0	**23.8%**
Local Operations		B		B	B	B/F	5.5	**26.2%**
Maintainability			C		E	F	2.0	9.5%
Construction Impacts				D	E	D/F	1.5	7.1%
Environmental Impacts					E	E	4.0	19.0%
Project Schedule						F	3.0	14.3%
						Total	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	*Baseline*
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:

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

Appendix B. VE Workshop Agenda and Attendees

Day 1	January 13, 2025 Objective for the day: Learn about VE and the project	
9:00 AM (EDT)	**Workshop Kick-off Meeting** • Study kickoff • Team introductions • Workshop objectives	**All Audiences:** Project owner, management, stakeholders, designers, etc.
9:15 AM *Information Phase*	**VE Process Overview** • An instructional presentation on the principles of value Engineering and their application to the project	**VE Facilitator**
9:30 AM *Information Phase*	**Project Overview** • Goals and objectives of the project • Key project drivers, decisions, and constraints • Project Scope / Design Overview • Project challenges and VE focus areas • Areas for discussion: ○ Roadway Design ○ Traffic Analysis ○ Structures ○ Drainage/Hydraulics ○ Utilities ○ Environmental Conditions ○ Staging/Phasing	**Project Team/ Designer**
11:00 AM	**Break**	
11:15 AM	**Project Issues and Concerns**	**KYTC/Designer**
11:30 AM	**Define and Prioritize Performance Attributes**	**All Audiences**
12:00 AM	**Risk Assessment & Risk Register Updates**	**All Audiences**
Noon	**Lunch**	
1:00 PM	**VE Project Engineering and Documentation Review** • Review Available Project Documents • Review Project schedule, including construction phasing/sequencing, work windows • Cost Estimate / Cost Model Review and contingency assumptions • Preliminary List of Project Issues and Value Opportunities	**VE Team (offline)**
2:00 PM	**Value Metrics and Baseline Performance Rating** • Rate performance attributes of baseline project **Risk Assessment & Risk Register** • Assign probabilities and impact ratings to risks **Discuss Project Issues and Value Opportunities**	**VE Team**
5:00 PM	**Adjourn for the day**	

Day 2	**January 14, 2025** **Objective for the day: Function Engineering, Brainstorming Ideas, and Evaluation**	
8:00 AM *Function Phase*	**Function Analysis** • Random Function Identification • Build / Review FAST diagram	**VE Team**
9:00 AM *Creative Phase*	**Brainstorming Ideas** • Brainstorm alternative ways to perform key functions	**VE Team**
Noon	**Lunch**	
1:00 PM *Evaluation Phase*	**Evaluation of Ideas** • Score/Rate ideas based on predetermined criteria	**VE Team**
5:00 PM	**Adjourn for the day**	
Day 3	**January 15, 2025** **Objective for the day: Midpoint Review and Begin Developing**	
8:00 AM	**Develop Ideas into VE Alternatives** • Select ideas to develop further into Alternatives • Individual/team assignments • Review VE Alternative Development Process	**VE Team**
9:00 AM	**Midpoint Review**	**KYTC / Designer Reps**

10:00 AM
Development Phase
	Develop Ideas into Recommendations
	• Individual/team assignments
	• Development of recommendations:
	  ○ Test design feasibility
	  ○ Design Engineering
	  ○ Technical narratives
	  ○ Further discussion on advantages and disadvantages
	  ○ Cost Estimating
		VE Team (offline individual assignments)

5:00 PM	**Adjourn for the day**	

Day 4	**January 16, 2025** **Objective for the day: Continue Development of VE Alternatives**	
8:00 AM *Development Phase*	**Continue Development of recommendations:** • Technical narratives • Drawings/Sketches • Cost Estimating	**VE Team**
1:00 PM *Development Phase*	**VE Team Review of VE Alternative Development** • Peer review of recommendations • Outbrief Presentation Preparation/Review	**VE Team**
5:00 PM	**Adjourn**	
Day 5	**January 17, 2025** **Objective for the day: Outbrief Presentation of Draft VE Study Results**	
8:00 AM *Presentation Phase*	**Strategies and Value Metrics** • Development of VE Strategies (combination of Alternatives) • Evaluate performance and cost of VE strategies	**VE Team**
10:00 AM	**Presentation of VE Findings** • Team presents VE Study Results and Value Proposals • Questions and answers	**All Audiences:** Project owner, management, stakeholders, designers, etc.
12:00 PM	**Adjourn**	

Appendix C. Project Estimate

Estimate 06-352.00

Estimated Cost:$49,686,364.31

Contingency: 20.00%

Estimated Total: $59,623,637.17

Base Date: 10/10/23

Spec Year: 08

Unit System: E

Work Type: GRADE & DRAIN WITH BRIDGE

Highway Type: STATE ROUTE

Urban/Rural Type: RURAL

Season: SUMMER

County: CAMPBELL

Latitude of Midpoint: 385616

Longitude of Midpoint: 842147

District: 06

Federal Project Number: FD04 1550 C019 E143

State Project Number:

Prepared by GRW Engineers on 10/10/23

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
Group 0001: PAVING					
0005	00001 DGA BASE	785.00	TON	$45.47	$35,693.95
0006	00003 CRUSHED STONE BASE	38,450.00	TON	$36.37	$1,398,426.50
0007	00013 LIME STABILIZED ROADBED	86,604.00	SQYD	$5.74	$497,106.96
0008	00014 LIME	1,413.17	TON	$230.59	$325,862.87
0009	00018 DRAINAGE BLANKET-TYPE II-ASPH	178.00	TON	$76.92	$13,691.76
0010	00020 TRAFFIC BOUND BASE	1,000.00	TON	$40.32	$40,320.00
0011	00100 ASPHALT SEAL AGGREGATE	451.00	TON	$122.77	$55,369.27
0012	00212 CL2 ASPH BASE 1.00D PG64-22	53,010.54	TON	$78.88	$4,181,471.40
0013	00219 CL4 ASPH BASE 1.00D PG76-22	5,270.72	TON	$98.98	$521,695.87
0014	00291 EMULSIFIED ASPHALT RS-2	54.00	TON	$754.81	$40,759.74
0016	00307 CL2 ASPH SURF 0.38B PG64-22	7,219.08	TON	$79.38	$573,050.57
0017	00335 CL4 ASPH SURF 0.50A PG76-22	1,778.22	TON	$104.77	$186,304.11
0018	00356 ASPHALT MATERIAL FOR TACK	108.00	TON	$12.62	$1,362.96
0019	00358 ASPHALT CURING SEAL	87.00	TON	$753.87	$65,586.69
0020	02069 JPC PAVEMENT-10 IN	1,696.00	SQYD	$118.78	$201,450.88
				Total for Group 0001:	$8,138,153.53
Group 0002: ROADWAY					
0021	02091 REMOVE PAVEMENT	8,705.00	SQYD	$6.64	$57,801.20
0022	02159 TEMP DITCH	8,525.00	LF	$0.24	$2,046.00
0023	02160 CLEAN TEMP DITCH	4,263.00	LF	$0.64	$2,728.32

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0024	02200 ROADWAY EXCAVATION	1,485,761.00	CUYD	$10.14	$15,065,616.54
0025	02223 GRANULAR EMBANKMENT	4,500.00	CUYD	$66.75	$300,375.00
0026	02242 WATER	400.00	MGAL	$0.22	$88.00
0027	02262 FENCE-WOVEN WIRE TYPE 1	39,302.00	LF	$10.40	$408,740.80
0028	02351 GUARDRAIL-STEEL W BEAM-S FACE	5,406.00	LF	$40.66	$219,807.96
0029	02360 GUARDRAIL TERMINAL SECTION NO 1	2.00	EACH	$99.22	$198.44
0030	02391 GUARDRAIL END TREATMENT TYPE 4A	16.00	EACH	$3,489.26	$55,828.16
0031	02404 SEPTIC TANK TREATMENT	8.00	EACH	$2,500.00	$20,000.00
0032	02429 RIGHT-OF-WAY MONUMENT TYPE 1	100.00	EACH	$228.43	$22,843.00
0033	02545 CLEARING AND GRUBBING (APPROXIMATELY 174 ACRES)	1.00	LS	$500,000.00	$500,000.00
0034	02483 CHANNEL LINING CLASS II	2,494.00	TON	$53.30	$132,930.20
0035	02484 CHANNEL LINING CLASS III	9,312.00	TON	$64.06	$596,526.72
0036	02555 CONCRETE-CLASS B (FOR FENCE POSTS)	33.00	CUYD	$631.69	$20,845.77
0037	02603 FABRIC-GEOTEXTILE CLASS 2	8,300.00	SQYD	$2.48	$20,584.00
0038	02650 MAINTAIN & CONTROL TRAFFIC	1.00	LS	$500,000.00	$500,000.00
0039	02677 ASPHALT PAVE MILLING & TEXTURING	4,518.36	TON	$14.10	$63,708.88
0040	02701 TEMP SILT FENCE	8,525.00	LF	$2.56	$21,824.00
0041	02702 SAND FOR BLOTTER	216.51	TON	$36.63	$7,930.76
0042	02703 SILT TRAP TYPE A	174.00	EACH	$163.74	$28,490.76
0043	02704 SILT TRAP TYPE B	174.00	EACH	$167.30	$29,110.20

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0044	02705 SILT TRAP TYPE C	174.00	EACH	$89.56	$15,583.44
0045	02706 CLEAN SILT TRAP TYPE A	174.00	EACH	$0.42	$73.08
0046	02707 CLEAN SILT TRAP TYPE B	174.00	EACH	$1.12	$194.88
0047	02708 CLEAN SILT TRAP TYPE C	174.00	EACH	$0.77	$133.98
0048	02726 STAKING	1.00	LS	$500,000.00	$500,000.00
0049	05950 EROSION CONTROL BLANKET	22,734.44	SQYD	$1.70	$38,648.55
0050	05952 TEMP MULCH	560,224.00	SQYD	$0.18	$100,840.32
0051	05953 TEMP SEEDING AND PROTECTION	420,588.67	SQYD	$0.20	$84,117.73
0052	05963 INITIAL FERTILIZER	38.00	TON	$1,004.04	$38,153.52
0053	05964 MAINTENANCE FERTILIZER	23.00	TON	$1,023.01	$23,529.23
0054	05985 SEEDING AND PROTECTION	707,540.12	SQYD	$0.21	$148,583.43
0055	05989 SPECIAL SEEDING CROWN VETCH	70,754.01	SQYD	$0.30	$21,226.20
0056	05992 AGRICULTURAL LIMESTONE	456.00	TON	$95.25	$43,434.00
0057	06514 PAVE STRIPING-PERM PAINT-4 IN	106,964.00	LF	$0.18	$19,253.52
0058	06600 REMOVE PAVEMENT MARKER TYPE V	10.00	EACH	$8.41	$84.10
0059	06612 INLAID PAVEMENT MARKER-BY	669.00	EACH	$23.48	$15,708.12
0060	25078ED THRIE BEAM GUARDRAIL TRANSITION TL-3	12.00	EACH	$3,045.98	$36,551.76

Total for Group 0002:$19,164,140.57

Group 0003: DRAINAGE

0061	00440 ENTRANCE PIPE-15 IN	599.00	LF	$76.57	$45,865.43

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0062	00441 ENTRANCE PIPE-18 IN	37.00	LF	$112.51	$4,162.87
0065	00464 CULVERT PIPE-24 IN	1,591.00	LF	$131.45	$209,136.95
0066	00466 CULVERT PIPE-30 IN	920.00	LF	$154.42	$142,066.40
0067	00468 CULVERT PIPE-36 IN	1,516.00	LF	$207.45	$314,494.20
0068	00469 CULVERT PIPE-42 IN	110.00	LF	$261.92	$28,811.20
0069	00470 CULVERT PIPE-48 IN	247.00	LF	$311.03	$76,824.41
0070	00473 CULVERT PIPE-66 IN	428.00	LF	$366.49	$156,857.72
0071	01000 PERFORATED PIPE-4 IN	41,140.00	LF	$8.61	$354,215.40
0072	01001 PERFORATED PIPE-6 IN	4,114.00	LF	$10.21	$42,003.94
0073	01010 NON-PERFORATED PIPE-4 IN	4,114.00	LF	$14.25	$58,624.50
0074	01011 NON-PERFORATED PIPE-6 IN	411.40	LF	$40.70	$16,743.98
0075	01021 PERF PIPE HEADWALL TY 1-6 IN	14.00	EACH	$622.00	$8,708.00
0076	01032 PERF PIPE HEADWALL TY 4-4 IN	138.00	EACH	$622.00	$85,836.00
0077	01208 PIPE CULVERT HEADWALL-24 IN	16.00	EACH	$2,607.89	$41,726.24
0078	01210 PIPE CULVERT HEADWALL-30 IN	10.00	EACH	$2,243.69	$22,436.90
0079	01212 PIPE CULVERT HEADWALL-36 IN	8.00	EACH	$2,791.78	$22,334.24
0080	01214 PIPE CULVERT HEADWALL-42 IN	2.00	EACH	$4,749.86	$9,499.72
0081	01216 PIPE CULVERT HEADWALL-48 IN	4.00	EACH	$4,579.93	$18,319.72
0082	01222 PIPE CULVERT HEADWALL-66 IN	2.00	EACH	$13,197.60	$26,395.20

Line #	Item Number / Description / *Supplemental Description*	Quantity	Units	Unit Price	Extension
0084	01691 FLUME INLET TYPE 2	12.00	EACH	$5,458.84	$65,506.08

Total for Group 0003:$1,750,569.10

Group 0004: BRIDGE- RCBC 8 x5 KY536 over Unnamed Creek

0085	03000 CONC BOX CULVERT STA. X+XX	1.00	LS	$1,589,000.00	$1,589,000.00

Total for Group 0004:$1,589,000.00

Group 0005: BRIDGE- RCBC 10 x6 KY536 over Barrs Branch Creek

0086	03000 CONC BOX CULVERT Sta. X+XX	1.00	LS	$2,506,000.00	$2,506,000.00

Total for Group 0005:$2,506,000.00

Group 0006: BRIDGE- RCBC 12 x8 KY536 over Tributary to 12-Mile Creek

0087	03000 CONC BOX CULVERT Sta. X+XX	1.00	LS	$468,000.00	$468,000.00

Total for Group 0006:$468,000.00

Group 0007: BRIDGE- KY 536 3 Span Over Jerry Wright Road

0088	30007 BRIDGE- 201 FT - 3 SPAN	1.00	LS	$2,485,000.00	$2,485,000.00

Total for Group 0007:$2,485,000.00

Group 0008: BRIDGE- KY 536 5 Span Over Persimmon Grove Pike

0089	30007 BRIDGE- 508 FT - 5 SPAN	1.00	LS	$6,224,000.00	$6,224,000.00

Total for Group 0008:$6,224,000.00

Group 0009: BRIDGE- KY 536 3 Span Over KY 10-Brush Creek

0090	30007 BRIDGE- 345 FT - 3 SPAN	1.00	LS	$4,239,000.00	$4,239,000.00

Total for Group 0009:$4,239,000.00

Group 0013: SIGNALIZATION

0091	24915ED SIGNAL SYSTEM Reconstruct Signal System (US27)	1.00	LS	$90,000.00	$90,000.00

Total for Group 0013:$90,000.00

Group 0024: DEMOBILIZATION &/OR MOBILIZATION

0092	02568	1.00	LS	$2,332,693.16	$2,332,693.16

Line #	Item Number	Quantity	Units	Unit Price	Extension
	Description ***Supplemental Description***				
	MOBILIZATION				
0093	02569 DEMOBILIZATION	1.00	LS	$699,807.95	$699,807.95

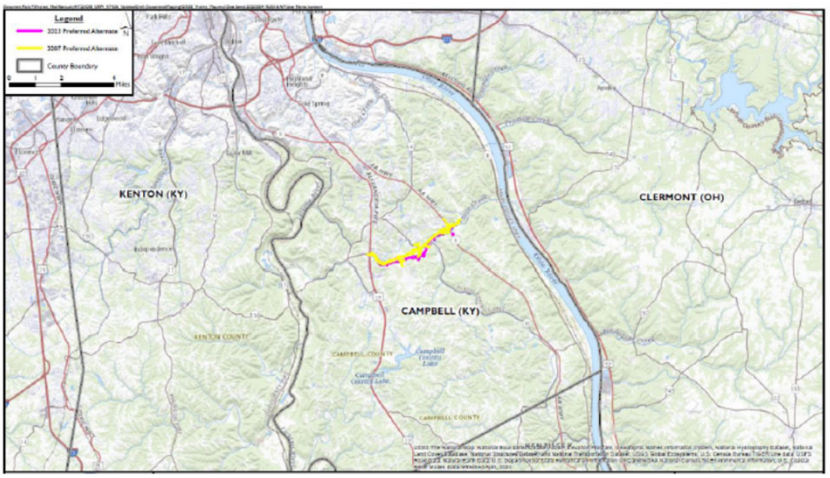
Total for Group 0024:$3,032,501.11

Appendix D. Closing Presentation

VALUE ENGINEERING STUDY

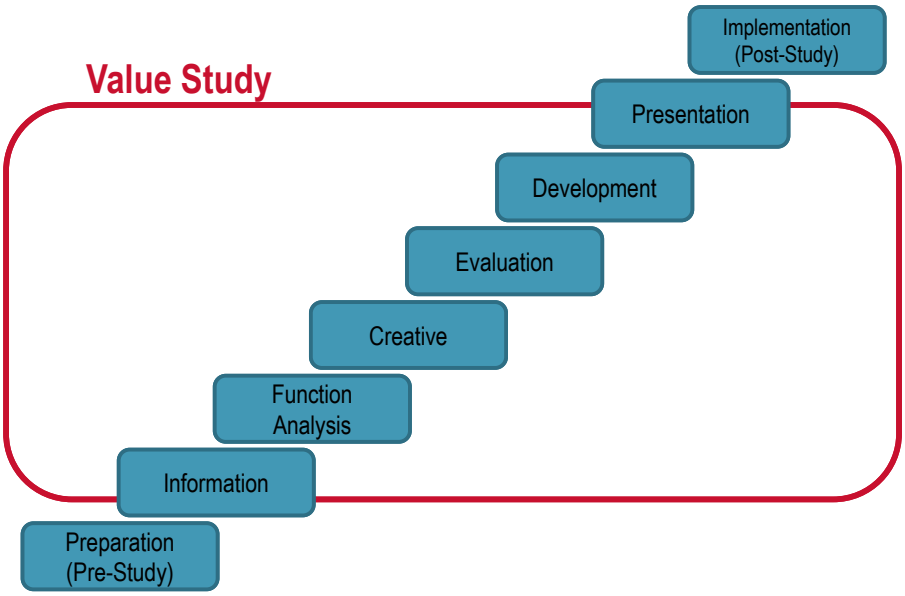
KY-536 Extension

Campbell County, Kentucky



1

VE JOB PLAN



2

VE Study Objectives – Key Functions

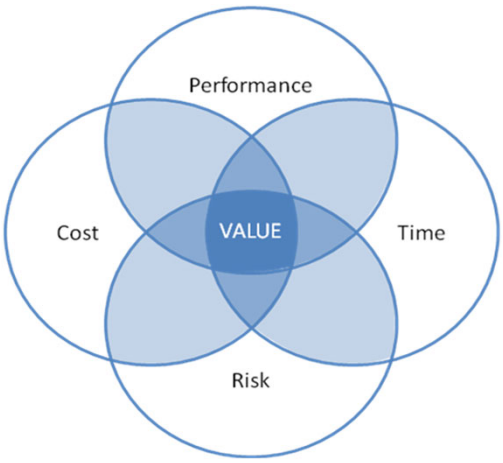
THROUGH APPLICATION OF THE VE JOB PLAN, THE OBJECTIVE OF THE VE STUDY WAS TO ASSESS AND/OR IMPROVE THE PROJECT, FOCUSING ON KEY FUNCTIONS:

IMPROVE TRAVEL TIMES *AND* ***SUPPORT GROWTH*** BY ***CONNECTING ROUTES*** *AND* **ESTABLISHING CONNECTIONS** WHILE ***SEPARATING TRAFFIC*** AND **REDUCING IMPACTS**

3

VE Study Overview – Value Metrics

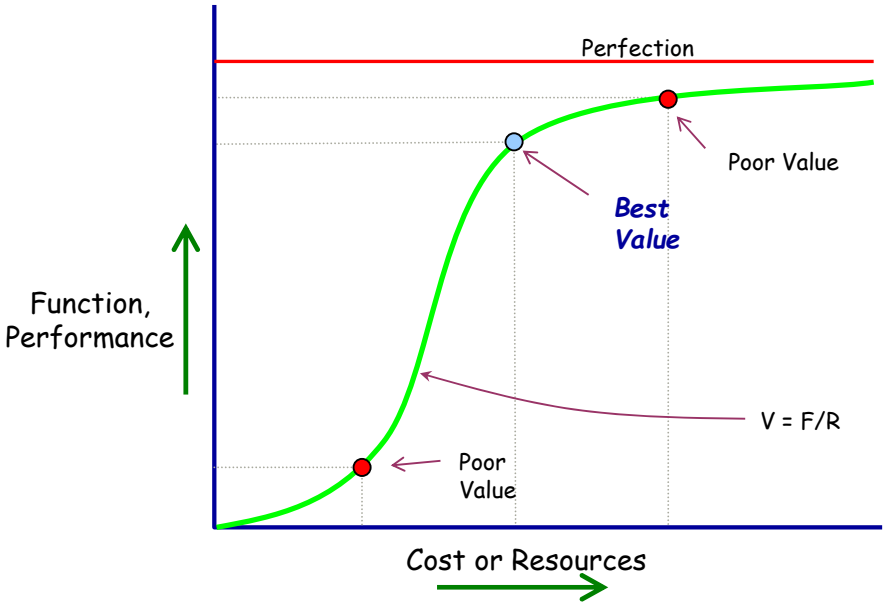
Value Engineering has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that VE can play with regard to improving project performance.



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

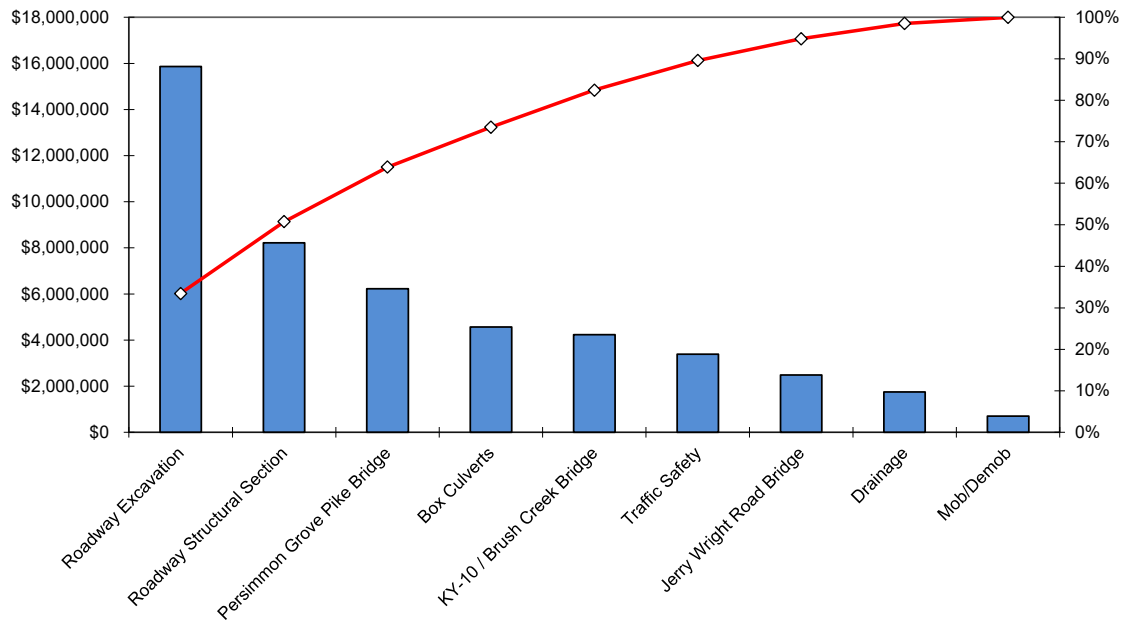
4

The Value Curve



5

Pareto Cost Model



6

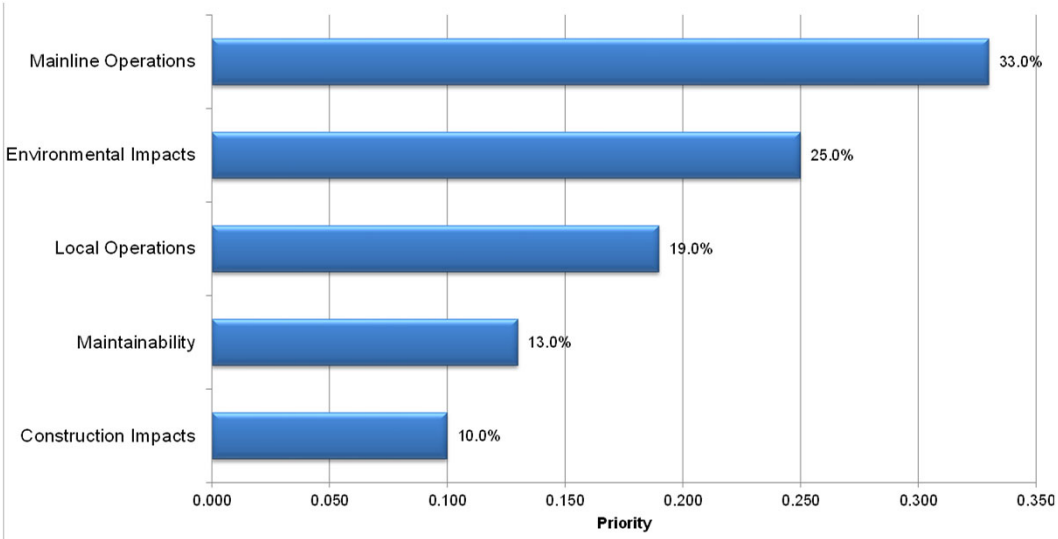
PERFORMANCE REQUIREMENTS

Performance Requirements

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

7

PERFORMANCE ATTRIBUTES AND PRIORITIES



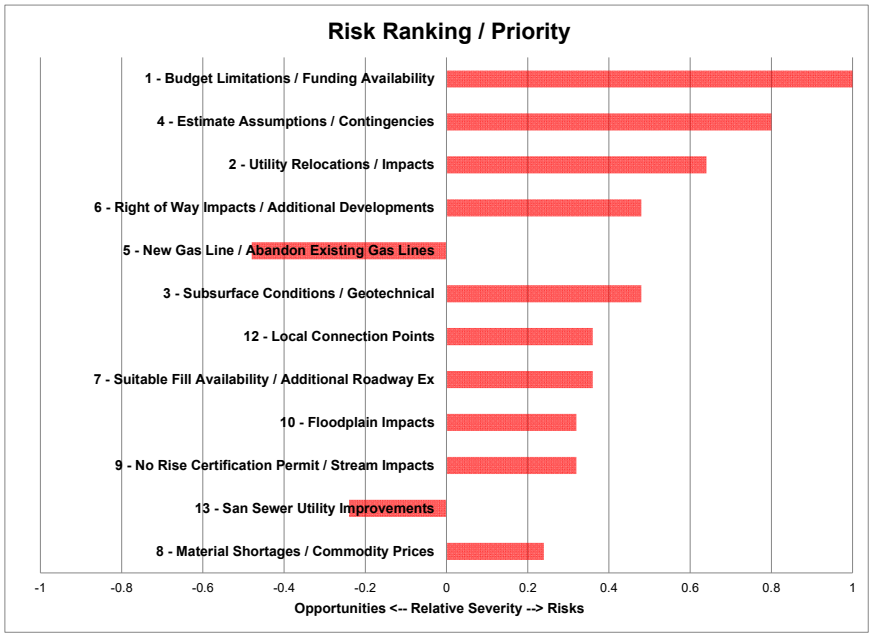
An improvement to which attribute will provide the greatest benefit relative to the project's need and purpose?

8

Risk Review

Risk Assessment

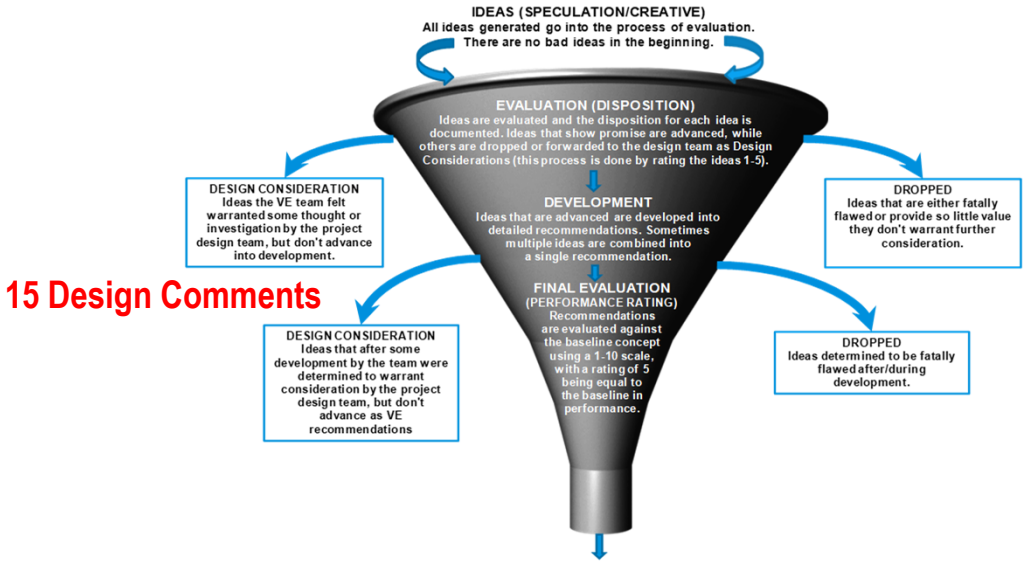
- Identified uncertainties that may impact cost and/or schedule
- Qualitative analysis / Priorities
- VE Alternatives and specific Risk Mitigations



9

Evaluation Process – Tiered Approach

55 Brainstormed Ideas



15 Design Comments

14 Developed VE Alternatives

10

VALUE OPPORTUNITIES / VE FOCUS POINTS

- **Load Road Crossings and ML Connection Access**
  - Grade Separations vs. Intersections/Alternate Routing
  - Local movements / Connection accommodations
- **KY 536 Horizontal Alignment**
  - Right of Way Impacts
  - Stream Impacts / Culverts
  - Terrain / Topography vs. Earthwork
- **Roadway Profile and Cross Section**
  - Roadway Character / Purpose and Need
  - Right of Way and Earthwork impacts
- **Truck Climbing Lane**
  - Benefit vs. Cost Analysis
- **Stream Crossings and Culverts**
  - Stream Impacts / Mitigations vs. Structure Costs & Maintenance
- **Pavement Design**

11

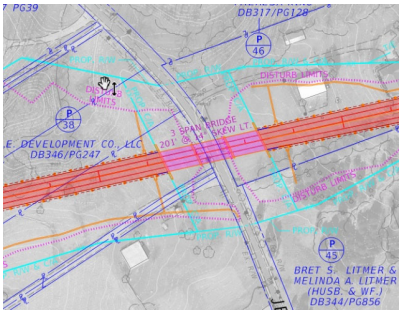
DEVELOPMENT PHASE

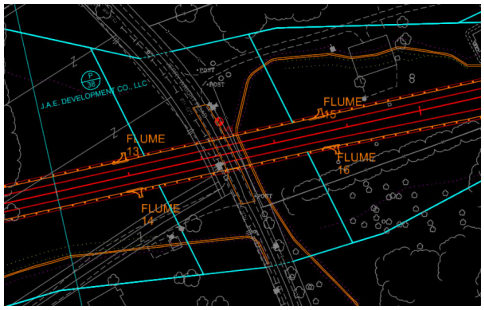
VE Alternative Development Content

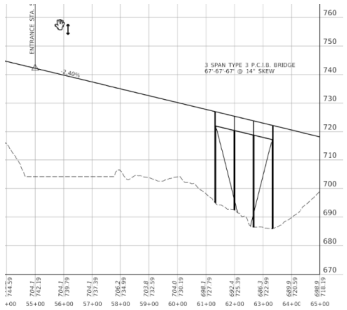
- Baseline and Alternative Concept Narratives
- Advantages/Disadvantages
- Discussion/Justification
- Schedule and Risk Impacts
- Performance Attribute Comparison
- Sketches & Calculations
- Cost Estimates

12

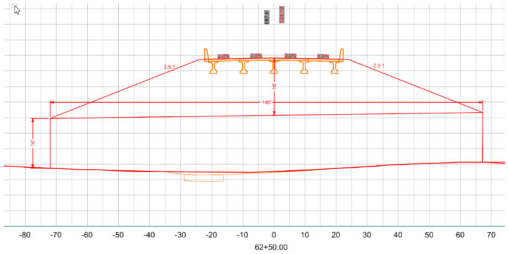
USE ARCH CULVERT AT JERRY WRIGHT







Baseline

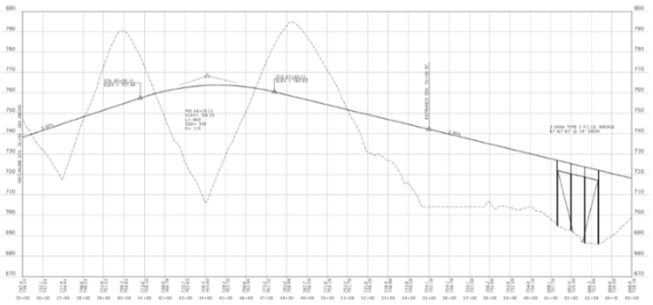


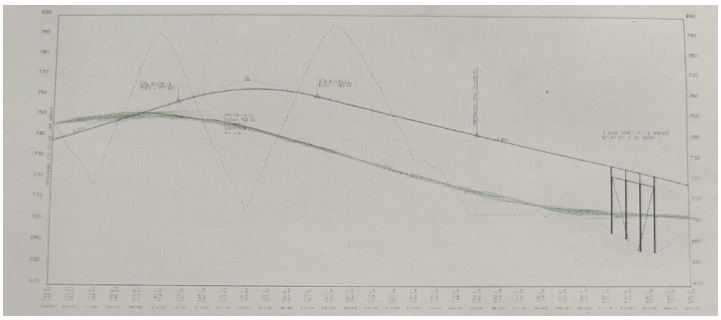
VE Alternative

13

AT-GRADE INTERSECTION AT JERRY WRIGHT

Baseline

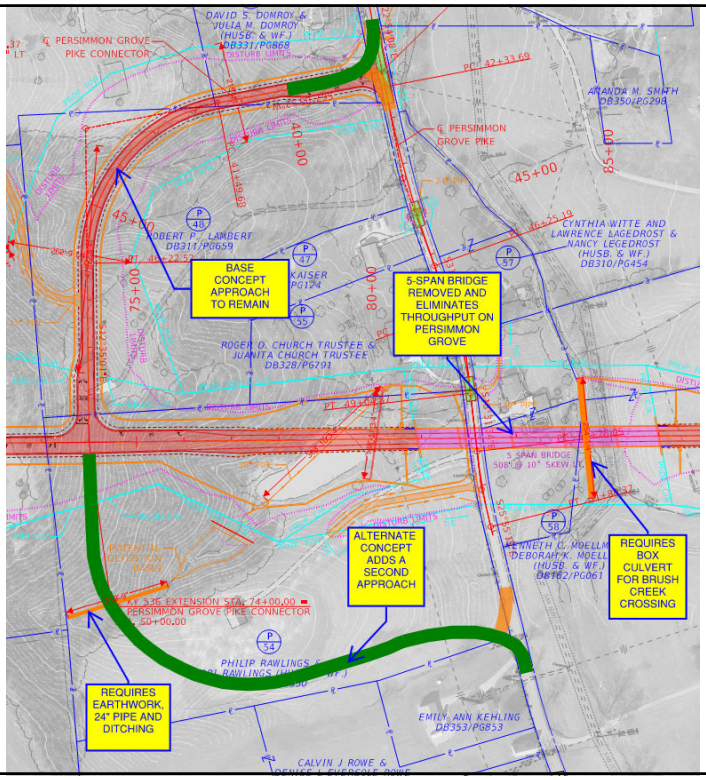




VE Alternative

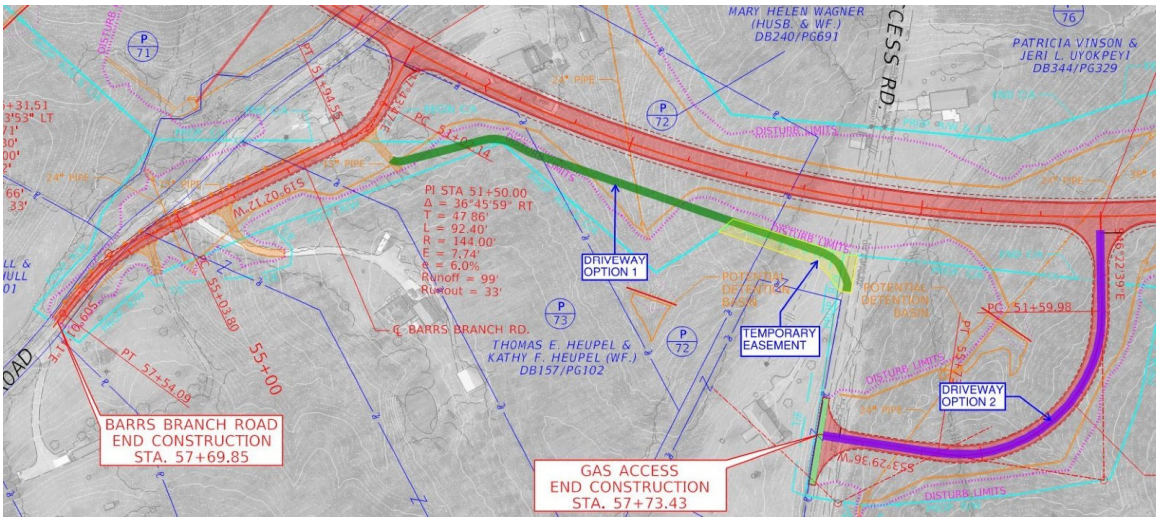
14

PROVIDE LOCAL CONNECTORS AT PERSIMMON GROVE IN LIEU OF BRIDGE



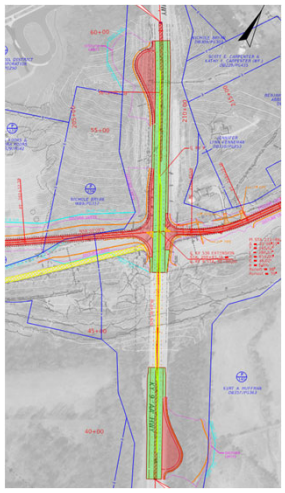
15

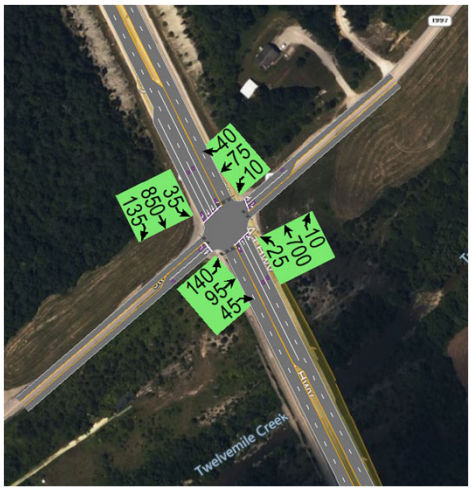
USE FRONTAGE ROAD OR LOCAL DRIVEWAY FOR GAS ACCESS ROAD



16

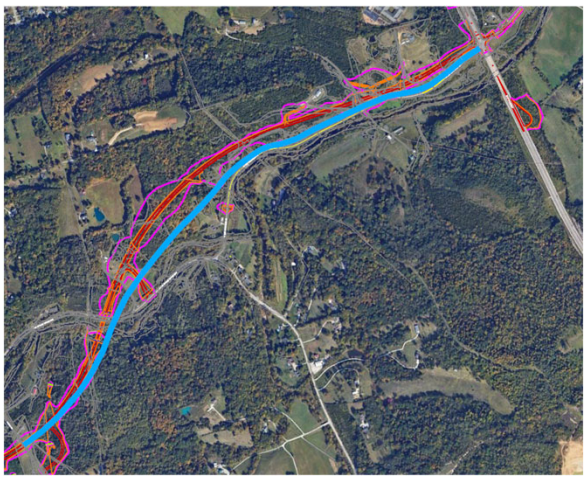
USE SIGNALIZED INTERSECTION AT KY-9 IN LIEU OF MUTS





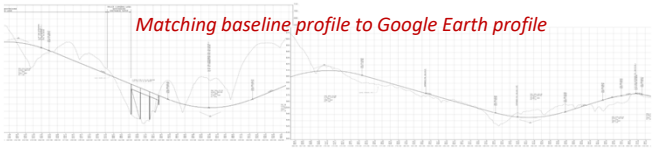
17

REALIGN 536 CLOSER TO STONEHOUSE ROAD

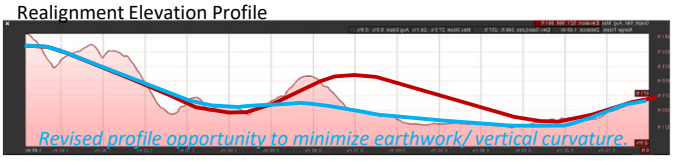


Baseline Elevation Profile

Matching baseline profile to Google Earth profile



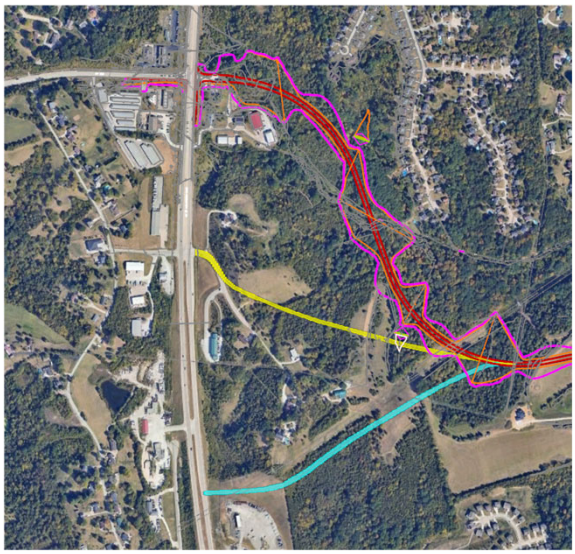
Realignment Elevation Profile



Revised profile opportunity to minimize earthwork/ vertical curvature.

18

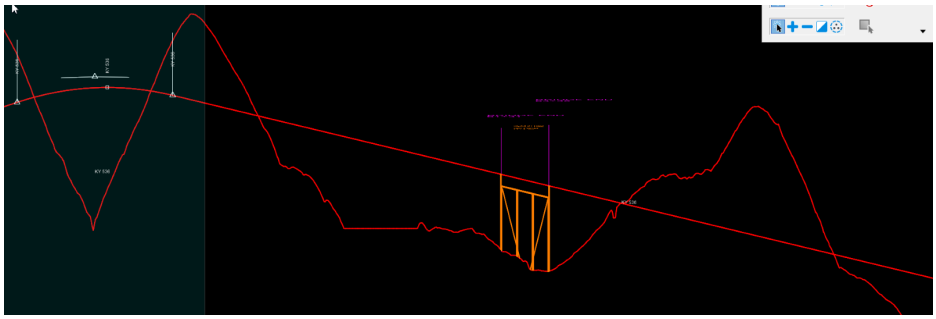
REALIGN WEST CONNECTION AND CONNECT TO US-27 TO THE SOUTH

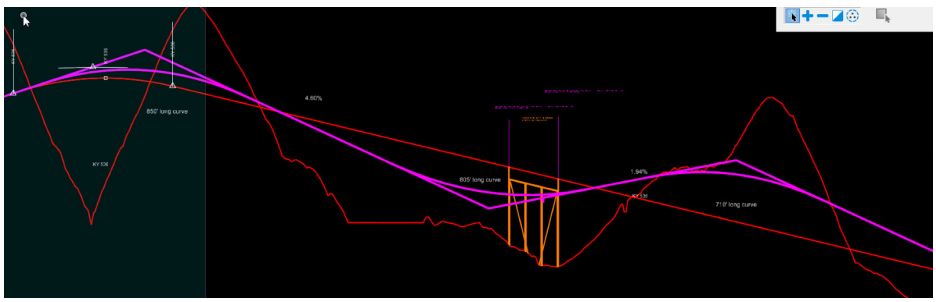


19

REDUCE PROFILES THROUGHOUT AND INCREASE ROADWAY GRADES

Baseline

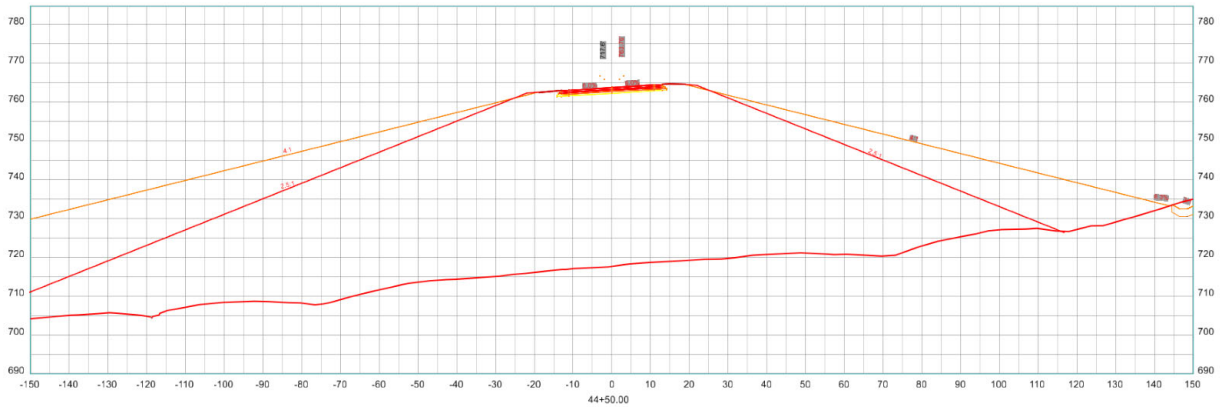




VE Alternative

20

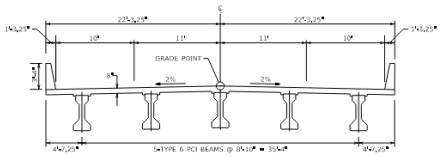
REDUCE FOOTPRINT WITH STEEPER SIDE SLOPES



21

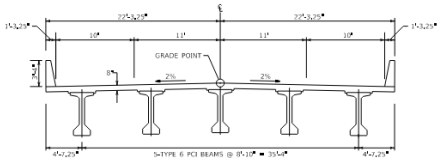
PROVIDE 8’ SHOULDERS ON ALL BRIDGES

KY 536 OVER JERRY WRIGHT ROAD
STA. 61+31 - 63+35



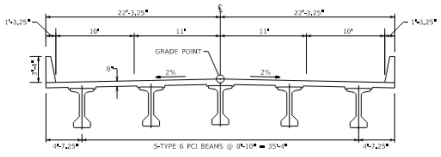
BRIDGE SECTION

KY 536 OVER KY 10
STA. 145+26 - 148+74



BRIDGE SECTION

KY 536 OVER PERSIMMON GROVE PIKE
STA. 80+82 - 85+85

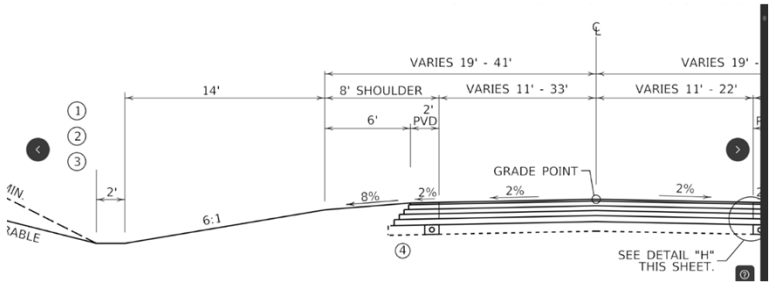


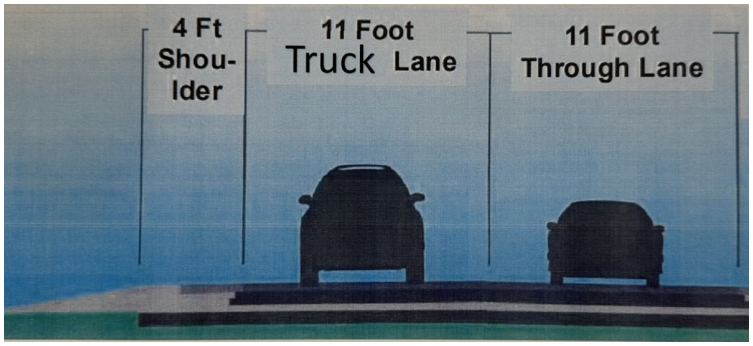
BRIDGE SECTION

22

REDUCE SHOULDERS AT TRUCK CLIMBING LANE

Baseline

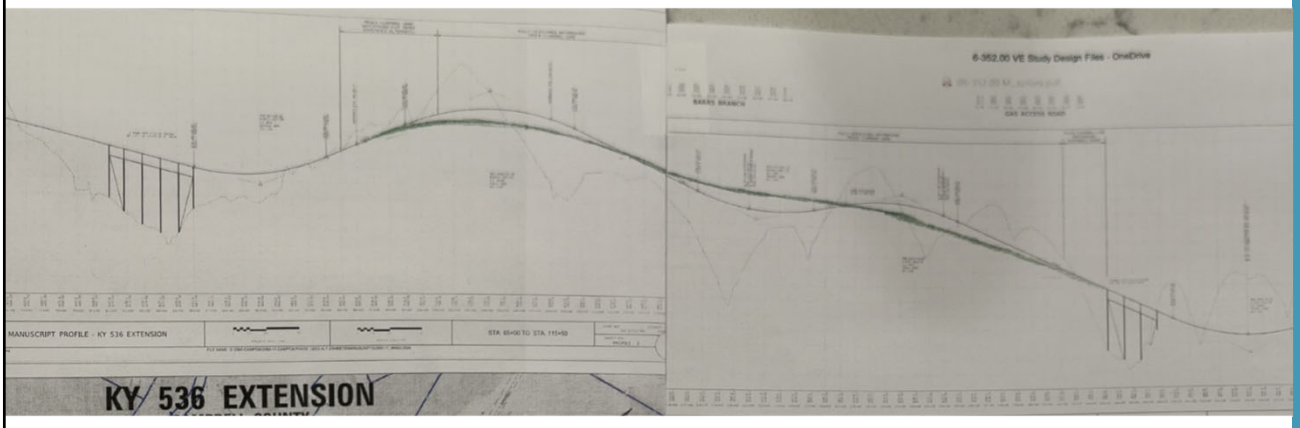




VE Alternative

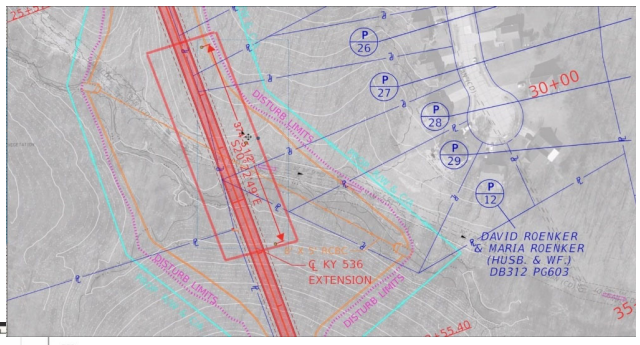
23

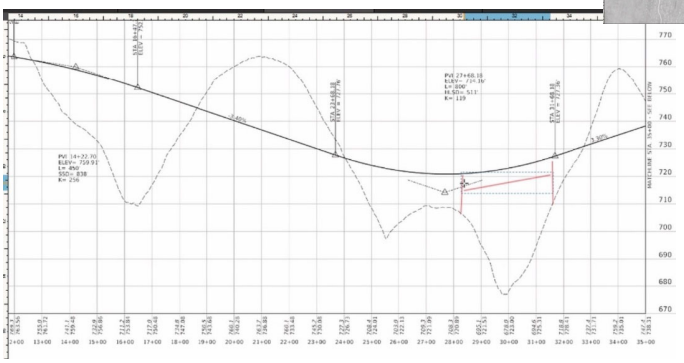
ADJUST PROFILE AND ELIMINATE TRUCK CLIMBING LANE



24

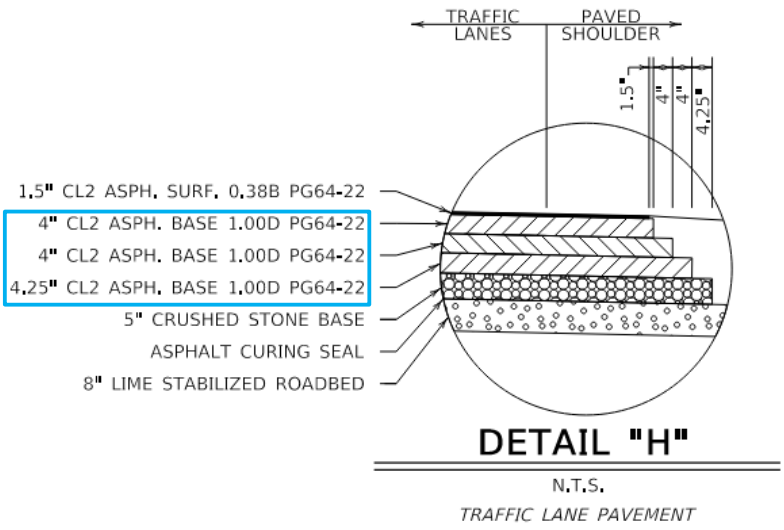
REALIGN CULVERTS AND SHORTEN STRUCTURE LENGTHS/SIZE





25

REDUCE THICKNESS OF AC PAVEMENT IN TYPICAL STRUCTURAL SECTION

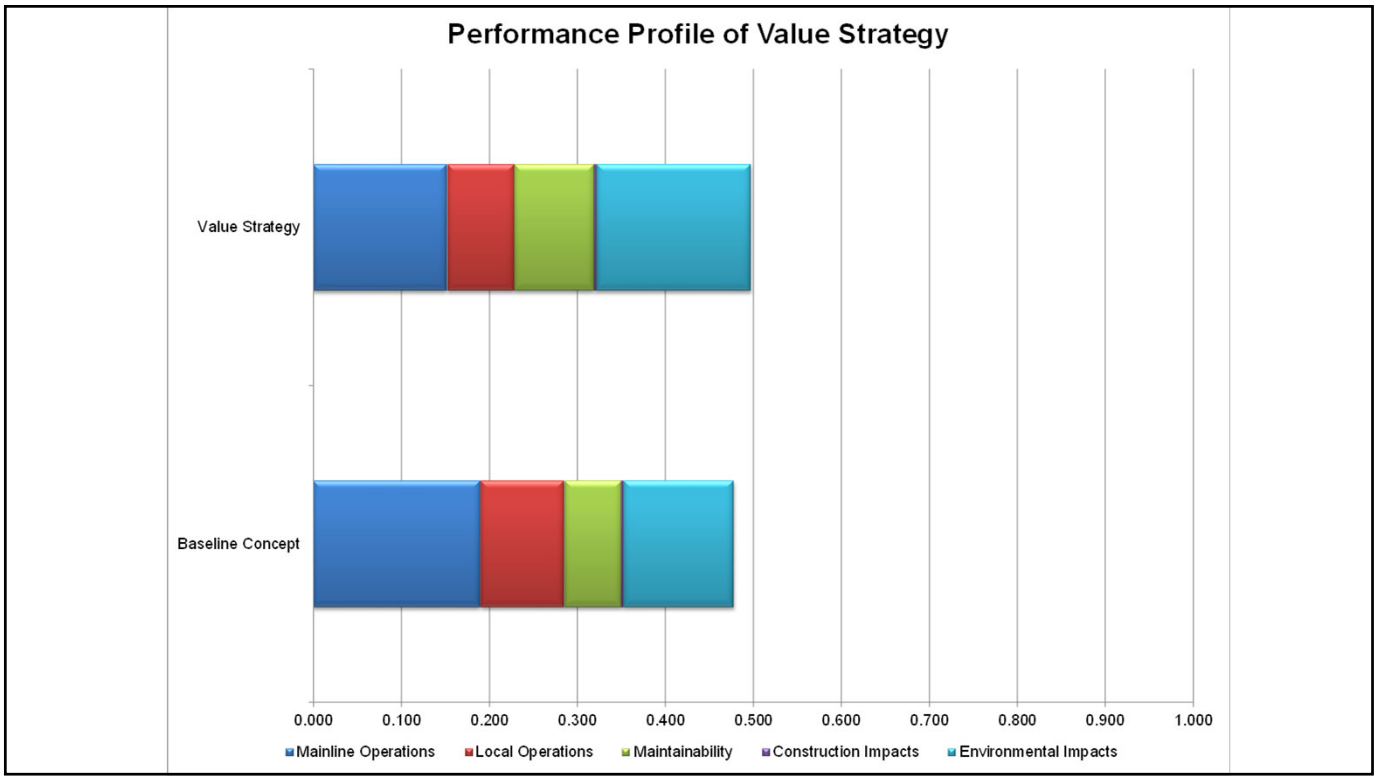


26

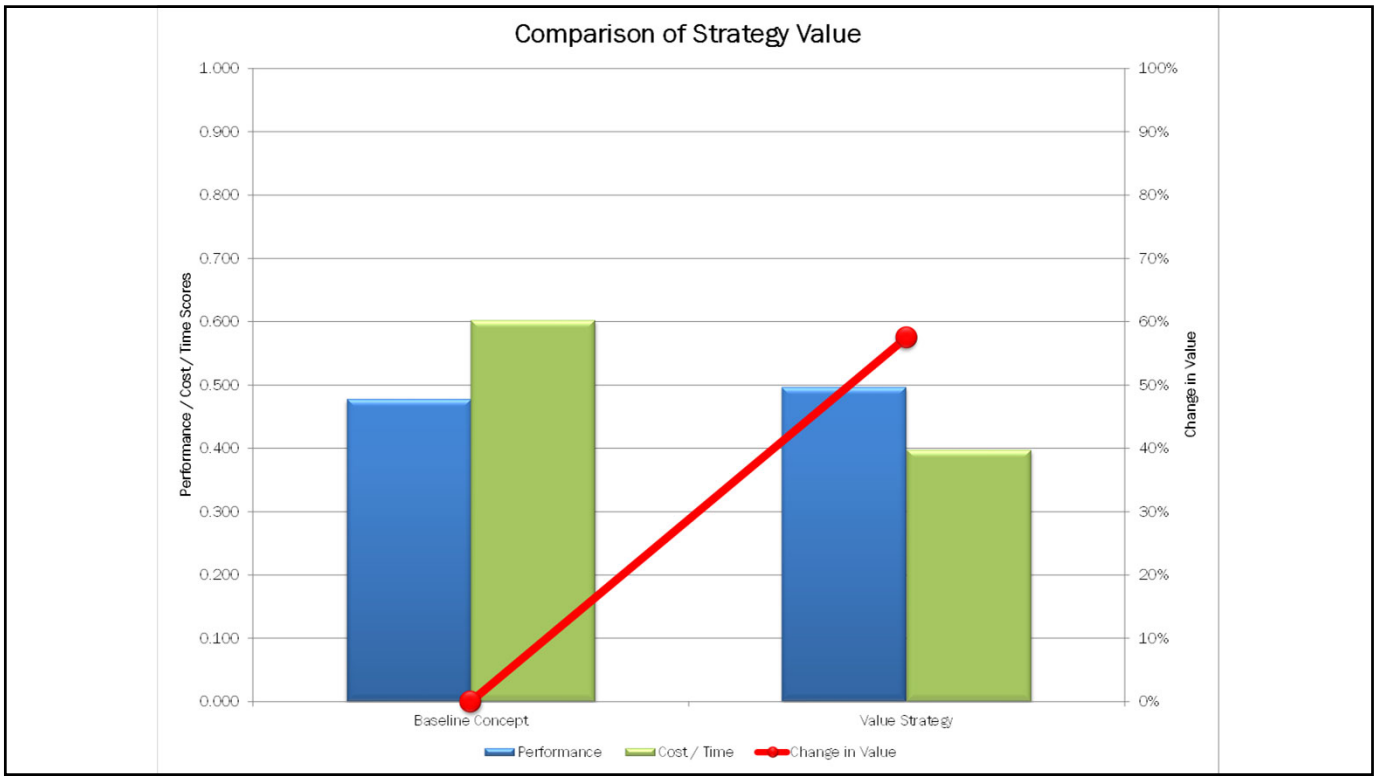
TAKE AWAYS / VE STRATEGY

- 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 LR-1, LR-3, LR-4, A-1, A-2, PX-3, TC-1, SC-1, S-1
- Total Cumulative Cost Savings Potential: ~$17M

27



28



29

Next Steps

- Draft VE Report Submitted (January 31)
- Draft Report Review
  - Includes Implementation Action & Decisions
- Final VE Study Report

30

31

Appendix E. VE Implementation Approval Form

		FHWA Functional								Project Team Response
	VE Alternative	Safety	Operations	Environment	Construction	Right of Way	Estimated Savings (in millions)	Added Cost (in millions)	Project Team Recommendation	Comments or Reason for Rejection
LR-1	Use arch culvert in lieu of bridge at Jerry Wright				1		$ 1.63		A	Redesign required. Historical Note: In 2001, reconstruction of Jerry Wright Rd to provide an at-grade intersection was considered but ultimately not advanced due to its negative effect on the residents along the existing road.
LR-2	Provide intersection at Jerry Wright in lieu of grade separation				1		$ 2.30		R	Does not provide any savings over recommendation LR-1 when the additional 30,000 cubic yards of exavation is taken into consideration
LR-3	Use connectors to KY-536 at Persimmon Grove in lieu of bridge for grade separation		1	1			$ 3.54		A	An acceptable design should be achievable, but undesirable features may be unavoidable. Additional design and survey is required for the south side connection and new drainage structure. The mainline grade change will require redesign of the north connector. Preliminary calculations show a larger culvert opening will be required than was shown in the VE Draft Report. Historical Notes: During Phase 1 design it was found that a south side connection produces more cut and takes more length to tie in than the north side connector. This option also increased stream impacts. In 2005 the project team had a shorter 3-span bridge here with a 25X8 box culvert. In 2013 the project team decided that a longer 5 span bridge was preferred to a bridge and culvert combination because the cost of the 320' RCBC did not provide any savings over shortening the bridge and also increased the stream impact. Later in 2023 the team decided that the 5 span bridge would continue to be advanced and access provided from the mainline to Persimmon Grove Pike with a connector road to the north.
LR-4	Use frontage road or local driveway for Gas Access Road		1	1			$ 0.14		R	With the additional right of way cost and the future maintenance this recommendation does not provide any savings and is therefore rejected.
LR-5	Use signalized intersection at KY-9 in lieu of MUTs		1	1			$ 0.33		A	Development of a functional access management design required additional survey and roadwork on KY 9 between the MUTs including milling and resurfacing of traffic lanes, removal of the existing median and replacing with full depth pavement, and drainage accommodations. A potential additional savings of at least $100K could be realized with this alternate. It should also be noted that the existing KY 9 median is more narrow than desirable to convert them into MUT left turn lanes. During the design process a new signal was added on KY 9 just north of the proposed KY 536 intersection which eliminated the project team's desire to avoid a signal at this location. Historical Note: The project team agreed to change intersection from signalized to RI/RO with MUTs on KY 9 at PLG held 5/19/23.
A-1	Realign 536 closer to Stonehouse Road			1		1	$ 3.72		R	Moving the route closer to Twelve mile creek has major impacts to the flood plain, therefore this recommendation is rejected.
A-2	Realign west connection and connect to US-27 to the south			1		1	$ 3.71		R	Moving the intersection at US 27 to the south destroys the corridor that goes from US 42 in Boone County all the way to AA Highway in Campbell County. Since this is considered a three county corridor, it is very important to consider the impacts for the entire corridor, therefor this recommendation is rejected.

VE Alternative		FHWA Functional					Estimated Savings (in millions)	Added Cost (in millions)	Project Team Recommendation	Project Team Response
		Safety	Operations	Environment	Construction	Right of Way				Comments or Reason for Rejection
PX-1	Reduce profiles throughout and increase roadway grades			1	1	1			A	Redesign required. Please note that these vertical changes to minimize earthwork will result in additional segments of the corridor that will show significant truck speed reduction and/or have steep grades on both sides of proposed intersections. And will also require additional work at the intersections.
PX-2	Reduce footprint with steeper side slopes			1		1			FS	Further Study. Redesign required. It may be worth considering the use of 2.5:1 fill with GR or a 4:1 to 2.5:1 "barn-roof" typical at large structures such as RCBC's and the arch at Jerry Wright Road to reduce structure length. Historical Note: At the more recent design team meetings (2023 and later), 4:1 slopes were to be used throughout the corridor except at the bridge approaches. Note: Since this project is an excess material project, steepening the slopes may require the purchase of additional waste sites which could minimize the savings and increase the undesirable use of guardrail.
PX-3	Provide 8’ shoulders on all bridges						$ 1.48		A	Redesign required. Please note that the cost savings would likely apply to the bridge deck only and the savings realized would be less than shown here. Historically, the structure division has not wanted a reduced shoulder width used unless the bridge length is longer to justify the width reduction and subsequent safety reduction. Historical Note: The project team discussed the bridge shoulder width after the 2023 PL&G Inspection when the mainline shoulders were reduced from 10' paved to 8' (2' paved). The team had decided that 10' shoulders were still desirable on the bridges instead of matching the rest of the mainline shoulder width.
TC-1	Adjust profile and eliminate truck climbing lane			1	1	1	$ 1.14		FS	Further Study. This option should be considered and balanced with implementation of VE Alternative PX-1, which will result in other parts of the corridor where TCLs are warranted. It was suggested that the project team make note of locations that TCL warrants are met. Where viable, the project team will consider including adequate Right of Way to account for future TCL's. The team will also examine whether building the shoulder out wide enough to accommodate a future TCL in these areas will help with the overall project earthwork balance. Historical Note: Design team was asked to study warrants for and add TCL if met in 2023. Results showed a 18 mph reduction.
TC-2	Reduce shoulders at truck climbing lane			1		1	$ 0.09		FS	Further Study. Redesign required. Any locations selected for future TCL development will account for a 11 ft TCL and a 4 ft shoulder (2 ft paved).
SC-1	Realign culverts and shorten structure lengths/size			1		1	$ 0.36		FS	Further Study. Depending on location, some suggestions are not feasible.
S-1	Reduce thickness of AC pavement in typical structural section						$ 2.01		A	Redesign required. Previous pavement design was advanced by the project team and the pavement design was approved in August 2024. A new design will require resubmission, review and approval.