VE# 201904

Value Engineering Study Report - Final

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section)

Item No. 1-314.20

Calloway County

Workshop Dates: November 18-21, 2019

Guiding Teams – Building Success

January 10, 2020

Brent A. Sweger, PE
Manager, Quality Assurance Branch
Division of Highway Design
Kentucky Transportation Cabinet
200 Mero Street
Frankfort, KY 40622
Brent.Sweger@ky.gov

RE: VE# 201904
Value Engineering Study Report – Final
US 641 Reconstruction (southern section)
Item No. 1-314.20
Calloway County

Dear Brent:

Transmitted herewith is an electronic copy (PDF) of the final Value Engineering Study Report for the above referenced project. In addition, attached is an electronic copy (PDF and Word) of the Implementation Form and Instructions for your use.

I appreciate your leadership and cooperation as well as that from Chris Kuntz, Gary Sharpe, Value Engineering study team and all other stakeholders. Should you have any questions, please contact me at (602) 493-1947.

Thank you for the opportunity to work with you and your team!

Sincerely,

RHA, LLC

Patrice Miller

Patrice Miller, CVS
Managing Partner

Value Engineering Study
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section)
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SECTION 1:

INTRODUCTION

Value Engineering Study
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section)
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Section 1: Introduction

Value Methodology

The value methodology (Synonyms: value analysis, value engineering and value management) is a function-oriented, systematic, team approach to add customer value to a program, facility, system, or service. Improvements like performance, quality, initial and life cycle cost are paramount in the value methodology. The workshop is conducted in accordance with the methodology as established by SAVE International, the value society, and is structured using the Job Plan as outlined as follows:

- **Stage 1: Pre-Study**
  - Identify team members
  - Define workshop location
  - Review project documentation
  - Prepare for the Value Study (Workshop)

- **Stage 2: Value Study (Workshop) Job Plan**
  - *Phase 1: Information*
    - Gather, organize and analyze data
    - Define costs and cost models
    - Define the problem/purpose of the study
    - Define study scope, define project goals and workshop goals
  - *Phase 2: Function Analysis*
    - Define and evaluate functions
    - Define needs versus wants
  - *Phase 3: Creative*
    - What else will perform the functions?
    - Is this function required?
  - *Phase 4: Evaluation*
    - Rank and rate the ideas to select
    - Refine the best ideas for further development
  - *Phase 5: Development*
    - Develop the best ideas into VE Alternatives with support and justification
  - *Phase 6: Presentation*
    - VE study team presents results
    - Prepare and issue the report
    - Report implementation ideas

- **Stage 3: Post-Study**
  - Implement approved alternatives
  - Monitor status

Report Contents

The report provides the outcomes associated with this VE workshop and includes the following sections:

Section 1: Introduction – This section outlines the VE process and explains the content of the report.

Section 2: Project Description – This section outlines the project background, project corridor and project purpose and need.

Section 3: Executive Summary – This section is an overview that includes project background, summary of results, a list of the VE study team members and the VE punch list.

Section 4: Summary Information – This section provides an overview in table format of the VE Proposals, Design Suggestions and Design Comments.

Section 5: VE Proposals and Design Suggestions – This section includes alternatives developed as a workbook during the workshop. Each workbook contains the following information:

- Unique Identifying Number (i.e., VE-01, VE-02, etc.)
- Creative Idea Title
- Function Identification
- Baseline Assumption – brief description
- Proposed Alternative – brief description
- Benefits
- Risks/Challenges
- Sketches (Baseline and Proposed), if applicable
- Discussion/Justification
- Implementation Considerations, if applicable
- Initial Cost Detail
- Replacement/Salvage and Annual Cost Detail, if applicable

Section 6: Appendices

Appendix A – Study Participants
Appendix B – Pareto Cost Model and Cost Observations
Appendix C – Function Analysis
Appendix D - Creative Idea List and Evaluation
Appendix E – Supporting Data

i. Risk Identification
ii. Crash Prediction Evaluation Report
iii. Agenda
iv. In-brief Presentation
v. Out-brief Presentation

SECTION 2:

PROJECT DESCRIPTION

Section 2: Project Description

Background

In the 1970s, the Kentucky Transportation Cabinet (KYTC) began its initiative to provide the citizens of the Purchase Area with a safer, more efficient connection to the Interstate Highway System. Construction began on a four-lane improvement on US 641 between Murray and the Purchase Parkway (now I-69) in the 1980s and was opened to traffic before 1990. Following the upgrade of US 641 north of Murray, KY 80 was planned to connect the Purchase Parkway with I-24 east of Cadiz with all but one section being completed by the early 2010s. The western terminus for KY 80 is currently at KY 303 south of Mayfield, with a final section scheduled for construction in 2019 that will connect to the Purchase Parkway/I-69.

Along with the attention to KY 80 in the early 2000s, US 641 has also been a focus of the KYTC and the Tennessee Department of Transportation (TDOT) for improving north-south connectivity in the region. A project to extend the five-lane section of US 641 from Glendale Road in Murray, which transitions to a four-lane divided section before reaching the bridge over the Middle Fork of the Clarks River Bridge (KYTC Item No. 1-314.1). Concurrently, TDOT has been working to provide an improved connection from the state line south to I-40. TDOT is currently planning improvements from the state line south into Paris in Henry County, as well as additional work in Benton County, TN. When completed, these projects will provide regional connectivity between I-69, I-24, and I-40 through the rural western portions of both states.

In December 2018, the US 641 project (KYTC Item Number 1-314.20) was awarded a Better Utilizing Investments to Leverage Development (BUILD) Grant from the US Department of Transportation for $23 million. This grant will be used to partially support the construction of 5.7 miles of the project from south of Murray to EW Miller Road in Hazel, KY, approximately ½ mile north of the Tennessee state line. Funding from the grant will not be used for construction into Tennessee. A Bi-State Agreement for construction of the remainder of the project is being developed. Under the agreement, funds will be committed by both the KYTC and TDOT for immediate construction of the project south of EW Miller Road to its southern limit between Brannon Lane/Crossland Road and Howard Road.

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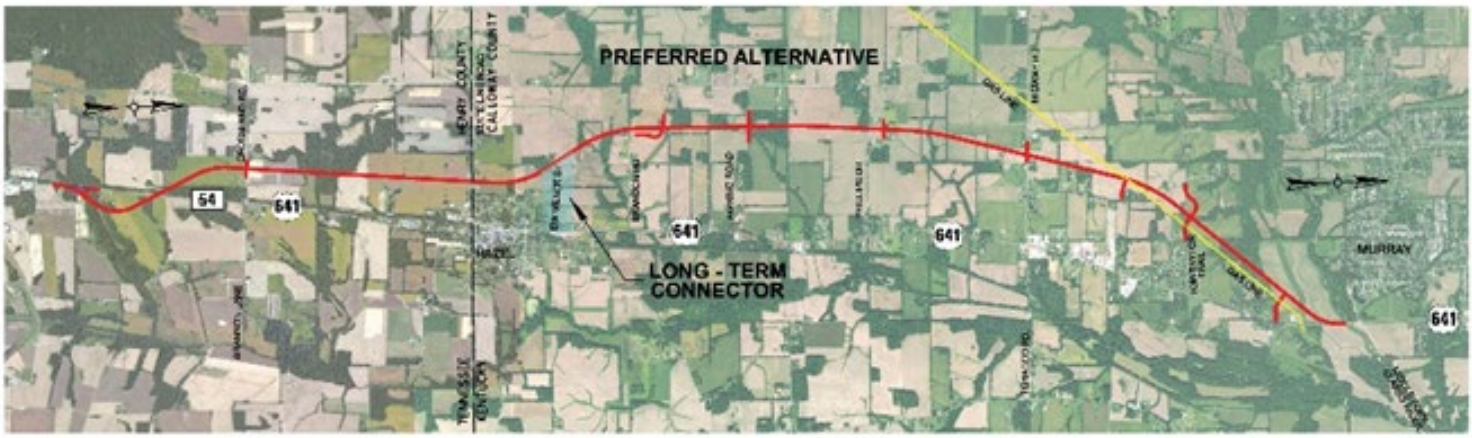
Project Corridor

The US 641 Project in rural western Kentucky and Tennessee will improve an existing two-lane highway to a four-lane divided highway on a parallel alignment in Kentucky and a three-lane section to be constructed on five-lane right of way in Tennessee. The proposed alternatives would construct 6.7 to 8.6 miles of improved roadway, depending on the project beginning point that is selected in Tennessee. Whether the improvement occurs on existing alignment or in a parallel corridor, existing US 641 will continue to operate as it does today by providing local access to existing businesses and residential areas. The project would serve the many agricultural and manufacturing operations in Calloway County and northwestern Tennessee by providing an improved facility meeting current design standards that will result in a significant improvement in safety and traffic operations. An improved US 641 would facilitate safer and more efficient travel and enhance accessibility and connectivity in southern Calloway and northern Henry Counties. US 641 is listed on the National Truck Network as a preferred corridor through Calloway County and western Tennessee to connect with the interstate systems. This project, in combination with planned improvements in Tennessee, will complete the critical connection to I-24, I-69, and I-40. US 641 is the only north-south route through this part of the Kentucky/Tennessee region and, with the implementation of this project, will provide an improved US 641 from I-69 into Tennessee.



Project Purpose

The purpose of this project is to provide a facility for safe and efficient movement of traffic and freight in the region, particularly between I-24, I-40 and I-69. The project corridor is a primary north-south connection between these interstates and its geometric deficiencies inhibit safe mobility in the area and does not afford travelers a modern and safe transportation facility. Narrow driving lanes with narrow shoulders that quickly drop into ditches are consistent

throughout the corridor, making driving conditions dangerous, especially during inclement weather events. Frequent access points and sightlines are also problematic, with many areas having insufficient sight distance for pulling onto or off of US 641. The dominant agricultural economy of the area results in large farming implements frequently using the roadway to access fields, especially during planting and harvesting seasons. These vehicles, coupled with limited safe passing opportunities, slow traffic and present a hazard to travelers in the corridor.

The purpose of the project is to:

- Provide safe and efficient linkage between US 641 in Murray and SR 54 in Henry County, Tennessee; and
- Improve passenger vehicle and freight connectivity with the Interstate system

Project Needs

Based on the project's purpose, three primary needs have been identified for the project:

- Correct geometric deficiencies
- Improve safety
- Improve regional connectivity

SECTION 3:

EXECUTIVE SUMMARY

Section 3: Executive Summary

Background

A Value Engineering (VE) study was conducted on the preliminary design documents for the Kentucky Transportation Cabinet's US 641 Reconstruction (southern section) Project (Item No. 1-314.20, Calloway County) on November 18-21, 2019.

KYTC project manager, Chris Kuntz, and Palmer Engineering project manager, Gary Sharpe, presented the project during the Information Phase kick-off meeting on Monday, November 18, 2019. A copy of this presentation is included in Section 6: Appendices, Appendix E – Supporting Data.

Project/Workshop Constraints

The decisions makers/stakeholders identified the project/workshop constraints for the VE team during the Information Phase kick-off meeting as:

- Schedule – The project funding needs to be obligated by September 30, 2020
- BUILD Grant – Conformance to guidelines and requirements
- Stay within the current right-of-way lines
- Stay within the approved environmental footprint

Workshop Objectives

The workshop objectives were identified at the start of the workshop and are used to focus the VE team's efforts:

- Review Hazel Connector – 5 Options
  - Option 1: Build Final Section and Barricade
  - Option 2: Grade and Drain, Maintain Access to severed properties
  - Option 3: Build Final Section but place surface for one-lane in each direction and Barricade
  - Option 4: Grade and Drain for Final Section, Pave only one lane in each direction
  - Option 5: Build and pave only one direction, grade and drain opposite direction
- Review pavement design

- Evaluate $1.9M Potential Cost Savings – 4 Options
  - Reduce Thickness of Cement Stabilized Roadbed; *Cost Reduction: $309,000 (15% reduction)*
  - Reduce Median Width from 48 feet to 40 feet; Exclude areas between Tom Taylor Trail and Phillips Lane with RCUT (J-Turns); *Cost Reduction: $604,000 (12% Reduction) – (86,000 CY)*
  - Reduce Mainline Driving Lane Widths from 12 feet to 11 feet; *Cost Reduction: $610,000*
  - Reduce Outside Shoulder Width from 10 feet paved to 8 feet paved; *Cost Reduction: $403,000*
- Review Maintenance of Traffic (MOT) plan
- Identify combinations of alternates that bring the project value (i.e., constructability, access, etc.)

Performance Criteria

During the Information Phase, the decision makers helped the VE team understand what defined project success for the US 641 Reconstruction project. These criteria were used later in the workshop by the VE team for both evaluating and developing alternatives.

- **Constructability:** construct the design efficiently
- **Maintenance of traffic:** local access to residents during construction
- **Maintainability:** ability to maintain project at appropriate O&M cost
- **Safety:** achieve an annual reduction of crashes
- **Schedule:** obligate funding by September 30, 2020
- **Conformance to BUILD grant:** what is the deviation from the BUILD grant?

Summary Workshop Results

Summary workshop results are shown in the table below.

Workshop Outcome	Number	Section of Report / Result
Ideas Brainstormed	38	See Creative Idea List (Section 6: Appendices, Appendix D)
Ideas Developed into VE Workbooks	24	See Section 4: Summary Information and Section 5: Value Engineering Proposals and Design Suggestions
Value Engineering Proposals, costed	17	
Design Suggestions, not costed	7	
Design Comments (DC), not developed	5	See Section 4: Summary Information
ALL VE Proposals – Menu of Savings	16	$31,944,000 – Initial Cost and O&M

Workshop Outcome	Number	Section of Report / Result
(potentially reduces initial and/or O&M cost without sacrificing function and/or performance)		Cost, See Section 5: Value Engineering Proposals and Design Suggestions
ALL VE Proposals – Menu of Added Costs (at a cost add to the project, potentially improves function and/or performance)	1	($19,000) – Initial Cost and O&M Cost, See Section 5: Value Engineering Proposals and Design Suggestions

Summary tables of the Value Engineering Proposals, Design Suggestions and Design Comments are included in Section 4: Summary Information. A description and further discussion of Value Engineering Proposals and Design Suggestions are also included in Section 5: Value Engineering Proposals and Design Suggestions. The VE alternatives are categorized in one of five key (high cost and/or high risk) functions—

- Cross Creek (CC)
- Cross Gasline (CG)
- Optimize Geometry (OG)
- Support Load (SL)
- Convey Traffic (CT)

Function Analysis

Function definition and analysis is the heart of Value Engineering. It is the primary activity that separates VE from all other "improvement" programs. The objective of this phase is to ensure the entire team agrees upon the purpose of the project elements. Furthermore, this phase assists with development of the most beneficial areas for continuing the study. The data supporting the function analysis can be found in Section 6: Appendices, Appendix C.

The VE team identified the functions using active verbs and measurable nouns. This process allowed the team to truly understand all of the functions associated with the project. The basic function was defined as *Improve Safety.* A Random Function Identification Worksheet was completed and is included in Appendix C.

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VE Team

- Andy Gilley, PE (Qk4)
- Justin Harrod, VIP (KYTC)
- Jason Littleton, PE (AEI)
- Robert Martin, PE (Qk4)
- Connor Schurman, EIT (KYTC)
- Brent Sweger, PE (KYTC)
- Pat Miller, CVS (RHA) – VE Team Leader

Left to right: Andy, Justin, Rob, Jason, Brent, Connor

Certification

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

Patrice Miller, CVS®
RHA, LLC

VALUE ENGINEERING PUNCH LIST

ITEM NO. **1-314.20** PROJECT COUNTY: **Calloway** DATE OF STUDY: **November 18-21, 2019**

VE Alternative Number	Description	Activity (Y,N,UC-Date)	Implemented Life Cycle Cost Savings	Original Cost	Alternative Cost	Initial Cost Saving	Life Cycle Cost Savings (Total Present Worth)	FHWA Categories	Remarks
VE-01	Cross Bushy Creek more perpendicular in an area outside the wetland			$2,054,000	$1,676,000	$378,000	$0		
VE-02	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph			$2,054,000	$1,376,000	$678,000	$0		
VE-03	Eliminate the Tom Taylor Trail over the gasline (east side)			$1,271,000	$674,000	$597,000	$15,000		
VE-04	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+00 to avoid gaslines			$85,000	$104,000	($19,000)	$0		
VE-05	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines			$525,000	$155,000	$370,000	$10,000		
VE-06	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side			$517,000	$430,000	$87,000	$0		
VE-07	Eliminate the Heron Road tie at Station 6355+00			$128,000	$17,000	$111,000	$0		
VE-08	Eliminate one 3-inch layer of asphalt base			$9,495,000	$7,122,000	$2,373,000	$0		
VE-09	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base			$9,495,000	$7,913,000	$1,582,000	$0		
VE-10	Eliminate two 3-inch layers of asphalt base			$9,495,000	$4,748,000	$4,747,000	$0		
VE-11	Reduce the pavement on the outside shoulders from 10 feet to 4 feet			$1,797,000	$1,269,000	$528,000	$0		
VE-12	Reduce through-lane pavement width from 12 feet to 11 feet			$10,210,000	$9,600,000	$610,000	$74,000		
VE-13	Reduce median width from 48 feet to 40 feet			$4,760,000	$4,156,000	$604,000	$0		
VE-14	Reduce bridge outside shoulder width from 12 feet to 4 feet			$5,059,000	$4,384,000	$675,000	$0		
VE-15	Change from a 4-lane divided typical section to a 2-plus-1 roadway design			$35,758,000	$22,451,000	$13,307,000	$0		
VE-16	Eliminate the Hazel connector and improve the intersection at State Line Road (i.e., roundabout)			$3,580,000	$0	$3,580,000	$20,000		
VE-17	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection			$3,500,000	$1,902,000	$1,598,000	$0		
DESIGN SUGGESTIONS (Not Costed)									
VE-18	Build land bridge over gaslines								
VE-19	Use different superelevation table on the approaches								

VE Alternative Number	Description	Activity (Y,N,UC-Date)	Implemented Life Cycle Cost Savings	Original Cost	Alternative Cost	Initial Cost Saving	Life Cycle Cost Savings (Total Present Worth)	FHWA Categories	Remarks
VE-20	Use the 12-inch Cement Stabilized Roadbed								
VE-21	Set-up quantities for rock roadbed for areas where cement is not feasible (i.e., tying into old road or maintaining access across the new road during construction)								
VE-22	Set-up quantities for granular embankment								
VE-23	Eliminate the shoulder widening for guardrail and specify using 7-foot guardrail posts								
VE-24	Review the Hazel Connector Options 1-5								

SECTION 4:

SUMMARY INFORMATION

Section 4: Summary Information

Introduction

The VE team brainstormed 38 ideas. To shorten the list, the VE team members evaluated the ideas using a two-step process. The first step identified ideas that scored as follows:

- FF Unacceptable Impacts/Fatal Flaw (Has at least one fatal/unacceptable flaw)
- O/S Out of Scope
- ABD Already Being Done
- DC Design Comment (No cost impact, no Workbook)
- DS Design Suggestion (Not costed, Workbook)

This first-step evaluation scored the ideas as appropriate to eliminate them from further evaluation. The second step scored the remaining ideas using the Value Relationship (value=function / resources) along with the idea's alignment with previously identified functions and performance criteria.

PERFORMANCE CRITERIA

- **Constructability:** construct the design efficiently
- **Maintenance of traffic:** local access to residents during construction
- **Maintainability:** ability to maintain project at appropriate O&M cost
- **Safety:** achieve an annual reduction of crashes
- **Schedule:** obligate funding by September 30, 2020
- **Conformance to BUILD grant:** what is the deviation from the BUILD grant?

Of the 38 ideas, 17 ideas were identified for further development into Value Engineering proposals, including cost impacts. The description and further discussion of these are included in the Value Engineering Workbooks section of this report.

Several of the proposals overlap or represent different ways of approaching the same issue. As a result, the savings/cost in the Summary of Alternatives table is not cumulative.

The Summary of Alternatives identifies cost impacts, initial, construction and any potential operations and maintenance (O&M). Cost savings are shown as positive costs while any added costs are noted in parenthesis. Total Life Cycle Costs are the summation of the initial plus O&M costs as estimated by the VE team. Life Cycle Costs are based on a 20-year life.

The VE team also developed seven Design Suggestions (DS), not costed, and identified two Design Comments (DC), not developed/costed.

The following pages list the Value Engineering proposals, Design Suggestions and Design Comments in table format.

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Summary of Value Engineering Proposals & Design Suggestions

IDEA NO.	VE Proposal No.	IDEA TITLE	PERFORMANCE IMPACT					COST IMPACT		
			Construct-ability	Maintenance of Traffic	Safety	Schedule	Conformance to BUILD Grant	Initial Cost Savings / (Add)	O&M	Total Life Cycle Cost
CC		**Cross Creek**								
CC-01	VE-01	Cross Brushy Creek more perpendicular in an area outside the wetland	No impact	No impact	No impact	**Impacted**	No impact	$378,000	$0	$378,000
CC-03	VE-02	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph	No impact	No impact	No impact	**Impacted**	No impact	$678,000	$0	$678,000
CG		**Cross Gasline**								
CG-01	VE-03	Eliminate the Tom Taylor Trail over the gasline (east side)	No impact	No impact	**Improves**	No impact	No impact	$597,000	$15,000	$612,000
CG-02	VE-18	Build land bridge over gaslines	No impact	**Improves**	**Improves**	**Improves**	No impact			
CG-03	VE-04	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+00 to avoid gaslines	**Impacted**	No impact	No impact	**Impacted**	No impact	($19,000)	$0	($19,000)
CG-04	VE-05	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines	**Impacted**	No impact	No impact	No impact	No impact	$370,000	$10,000	$380,000
CG-05	VE-06	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side	No impact	No impact	**Impacted**	**Impacted**	No impact	$87,000	$0	$87,000
CG-06	VE-07	Eliminate the Heron Road tie at Station 6355+00	No impact	No impact	**Improves**	**Improves**	No impact	$111,000	$0	$111,000

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Summary of Value Engineering Proposals & Design Suggestions

IDEA NO.	VE Proposal No.	IDEA TITLE	PERFORMANCE IMPACT					COST IMPACT		
			Construct-ability	Maintenance of Traffic	Safety	Schedule	Conformance to BUILD Grant	Initial Cost Savings / (Add)	O&M	Total Life Cycle Cost
OG		**Optimize Geometry**								
OG-03	VE-19	Use different superelevation table on the approaches	Improves	No impact	No impact	No impact	No impact			
SL		**Support Load**								
SL-01	VE-20	Use the 12-inch Cement Stabilized Roadbed	No impact	No impact	No impact	No impact	No impact			
SL-02	VE-08	Eliminate one 3-inch layer of apshalt base	No impact	No impact	No impact	No impact	No impact	$2,373,000	$0	$2,373,000
SL-03	VE-09	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base	No impact	No impact	No impact	No impact	No impact	$1,582,000	$0	$1,582,000
SL-04	VE-10	Eliminate two 3-inch layers of aphalt base	No impact	No impact	No impact	No impact	No impact	$4,747,000	$0	$4,747,000
SL-05	VE-21	Set-up quantities for rock roadbed for areas where cement is not feasible	No impact	No impact	No impact	No impact	No impact			
SL-06	VE-22	Set-up quantities for granular embankment	Improves	No impact	No impact	No impact	No impact			
CT		**Convey Traffic**								
CT-01	VE-11	Reduce the pavement on the outside shoulders from 10 feet to 4 feet	Impacted	No impact	No impact	No impact	No impact	$528,000	$0	$528,000
CT-03	VE-12	Reduce through-lane pavement width from 12 feet to 11 feet	No impact	No impact	Marginal impact	No impact	No impact	$610,000	$74,000	$684,000
CT-04	VE-13	Reduce median width from 48 feet to 40 feet	No impact	No impact	Marginal impact	No impact	No impact	$604,000	$0	$604,000
CT-06	VE-14	Reduce bridge outside shoulder width from 12 feet to 4 feet	No impact	No impact	Marginal impact	No impact	No impact	$675,000	$0	$675,000
CT-07	VE-23	Eliminate the shoulder widening for guardrail and specify using 7-foot guardrail posts	No impact	No impact	No impact	No impact	No impact			

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Summary of Value Engineering Proposals & Design Suggestions

IDEA NO.	VE Proposal No.	IDEA TITLE	PERFORMANCE IMPACT					COST IMPACT		
			Construct-ability	Maintenance of Traffic	Safety	Schedule	Conformance to BUILD Grant	Initial Cost Savings / (Add)	O&M	Total Life Cycle Cost
CT-08	VE-15	Change from a 4-lane divided typical section to a 2-plus-1 roadway design	No impact	No impact	Marginal impact	Impacted (redesign)	Impacted	$13,307,000	$0	$13,307,000
CT-11	VE-16	Eliminate the Hazel connector and improve the intersection at State Line Road (i.e., roundabout)	Impacted	Impacted	Improves	Impacted (redesign)	No impact	$3,580,000	$20,000	$3,600,000
CT-17	VE-17	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection	No impact	No impact	No impact	No impact	No impact	$1,598,000	$0	$1,598,000
CT-18	VE-24	Review the Hazel Connector Options 1-5	N/A	N/A	N/A	N/A	N/A			

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Design Comments (No Workbook Prepared)

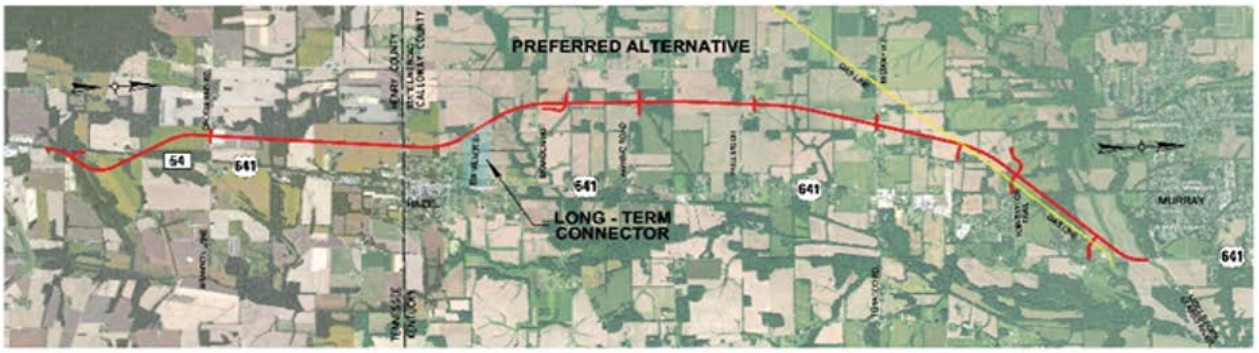
IDEA NO.	Idea Title
CT	**Convey Traffic**
CT-12	Provide a public information/education program on RCUTs, J-hooks and other innovative intersection
CT-19	Review Maintenance of Traffic (MOT) Plan

NOTE: Because CT-19 was a Workshop Objective, it was presented at the out-brief meeting on November 21, 2019; see slide presentation below.

CT-19: Review Maintenance of Traffic (MOT) Plan

14

- Diversions
  - Brandon Road
  - Midway Road
- Access Points



SECTION 5:

VALUE ENGINEERING PROPOSALS & DESIGN SUGGESTIONS

Section 5: Value Engineering Proposals and Design Suggestions

Introduction

The VE team performed a Crash Prediction Evaluation to establish a baseline for comparison of improvement alternatives. This baseline specifies rural, multi-lane divided highway, two 12-foot lanes in each direction with a 4-foot inside paved shoulder, 8-foot outside paved shoulder, 2-foot gravel shoulders beyond the pavement inside and outside and a 48-foot traversable median (inside driving lane to inside driving lane). The results of this evaluation are shown in Appendix E.

The VE team developed 17 Value Engineering proposals, including cost impacts and seven Design Suggestions (DS), not costed.

The following pages detail the Value Engineering Proposals developed as part of the study by the VE study team and include the following information:

- Unique Identifying Number (i.e., VE-01, VE-02, etc.)
- Creative Idea Title
- Function Identification
- Baseline Assumption – brief description
- Proposed Alternative – brief description
- Benefits
- Risks/Challenges
- Cost Summary
- Baseline and Proposed Sketches, if applicable
- Discussion/Justification that includes impact to performance, if applicable
- Implementation Considerations, if applicable
- Initial Cost Detail
- Replacement/Salvage and Annual Cost Detail, if applicable

The costs used are those provided by Palmer Engineering. Where the VE team has offered alternate costs, they are provided for information only, reflective of the short duration of the VE study and should be further evaluated by KYTC. Value Engineering ideas are provided for their evaluation and implementation exclusively by KYTC.

VALUE ENGINEERING PROPOSALS

VALUE ENGINEERING PROPOSAL
VE-01
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland
FUNCTION:	**Cross Creek**

BASELINE ASSUMPTION:

Cross Brushy Creek with approximate 350-foot twin five-span bridges at skew with existing channel across the center of the wetlands.

PROPOSED ALTERNATIVE:

Cross Brushy Creek with 290-foot twin bridges east of the baseline, perpendicular with existing channel, and on east side of wetlands. Maintains the same floodplain opening as the baseline.

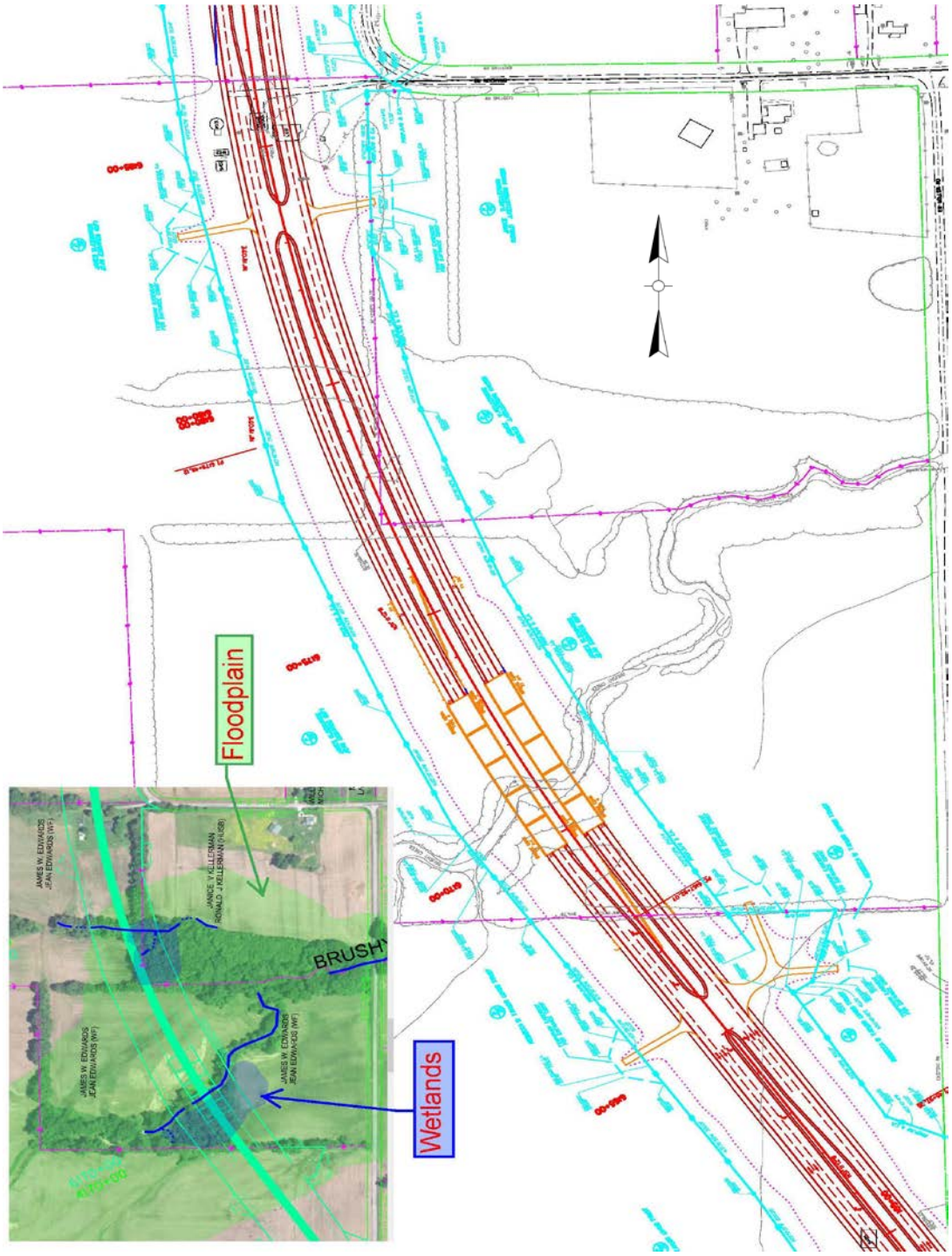
BENEFITS	RISKS/CHALLENGES
• Shortens bridge	• Outside of proposed right-of-way
• Minimizes impacts to wetlands	• Design changes
• Reduces length of project about 70 feet	• Impacts project schedule
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 2,054,000	$ -	$ 2,054,000
PROPOSED ALTERNATIVE:	$ 1,676,000	$ -	$ 1,676,000
TOTAL (Baseline less Proposed)	$ 378,000	$ -	**$ 378,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-01
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland

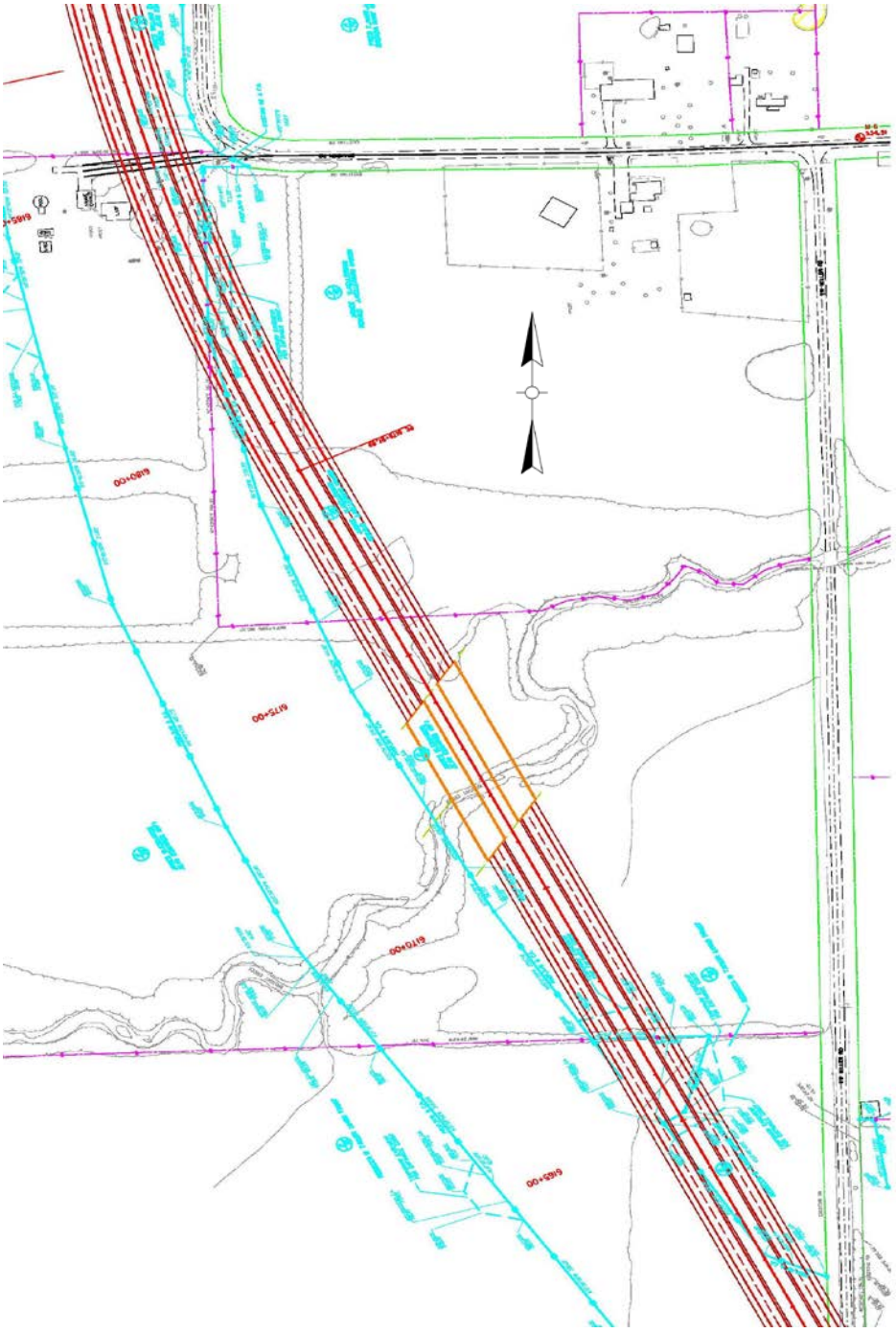
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-01
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-01
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland

DISCUSSION/JUSTIFICATION:

This proposal would modify tangent section of baseline US 641 between two curves nearest to Hazel (approximate Station 6136+00 to Station 6195+00). This realignment allows the bridge over Brushy Creek to cross more perpendicular with the existing channel and minimizes impacts to two wetland locations. With the bridge crossing Brushy Creek in a more perpendicular alignment combined with the skew of the structure more aligned with the flood plain flow limits, it is hoped that the structure length can be reduced and still provide the same hydraulic efficiencies the baseline bridge crossing provides at a reduced cost.

The proposed is outside of existing the right-of-way; however, no new parcels are affected. There is a very minor reduction in the overall length of the project. There could be a risk to the project schedule in terms of possible re-design activities to evaluate a new bridge location. Also, right-of-way acquisition in this area would be delayed while this re-design is taking place.

Please note that the bridge on EW Miller just outside the limits of the current project is part of the Bridging KY program. With this proposed change, it is anticipated that the structure in question could be removed, saving KYTC the costs of replacing or repairing that structure.

The VE Team is concerned the price per square foot used to estimate the bridge costs is very low. The VE team suggests this be examined further moving forward.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-01
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Brushy Creek Bridge	SF	31630	61.17	1,934,888	26100	61.17	1,596,537
Wetland Mitigation	AC	2.4	49,500.00	118,800	1.6	49,500.00	79,200
TOTAL				2,054,000			1,676,000
						CWE (BASELINE LESS PROPOSED)	**378,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-02
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph
FUNCTION:	**Cross Creek**

BASELINE ASSUMPTION:

Cross Brushy Creek with approximate 350-foot twin five-span bridges at skew with existing channel across center of wetlands. Design speed 70 mph.

PROPOSED ALTERNATIVE:

Cross Brushy Creek with 250-foot twin bridges east of baseline, more perpendicular with existing channel, and outside of wetlands. Maintain same floodplain opening as baseline. Design speed 60 mph.

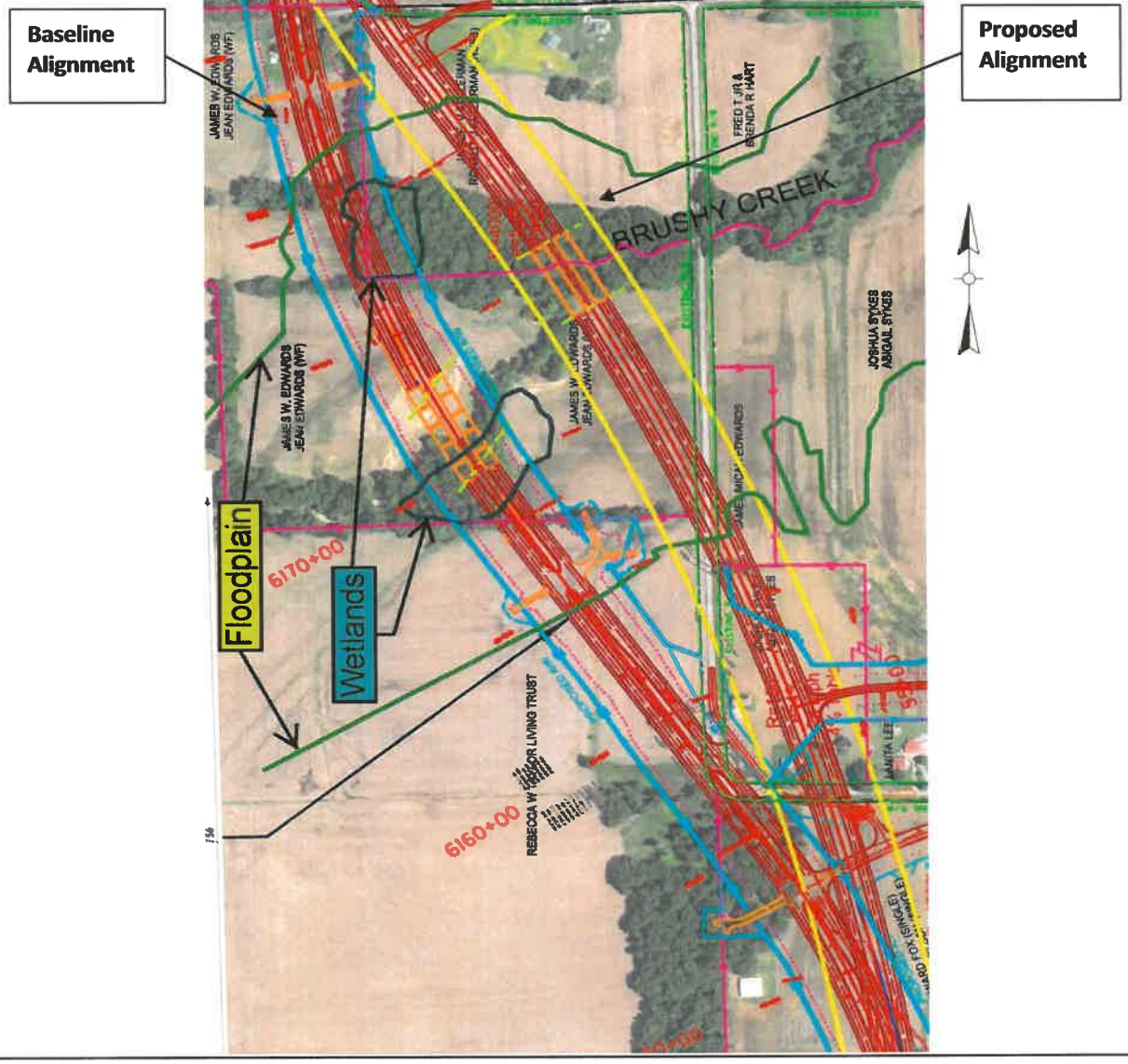
BENEFITS	RISKS/CHALLENGES
● Shortens bridge	● Outside proposed right-of-way
● Eliminates impacts to wetlands	● Design speed changes from 70 mph to 60 mph near Hazel
● Reduces approach alignment for Hazel Connector	● Impacts project schedule
● Eliminates need for connection to EW Miller North	● Major roadway and bridge design changes
● Modifies and reduces approach for Brandon Road; eliminates through movement	●
● Flattens super-elevation in curves	●
●	●

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 2,054,000	$ -	$ 2,054,000
PROPOSED ALTERNATIVE:	$ 1,376,000	$ -	$ 1,376,000
TOTAL (Baseline less Proposed)	$ 678,000	$ -	**$ 678,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-02
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-02
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph

DISCUSSION/JUSTIFICATION:

This proposal would modify 70 mph design baseline US 641 to 60 mph design curves from Stateline Road to North of Brandon Road. This realignment allows the bridge over Brushy Creek to cross approximately 550 feet northeast of baseline alignment and eliminates impacts to two wetland locations. The proposed bridge crosses Brushy Creek in a more perpendicular alignment. This alignment shift allows for a reduction in bridge length while maintaining the same flood plain flow width and hydraulic efficiencies of the baseline bridge crossing at a reduced cost.

The redesigned US 641 alignment also reduces the length of the Hazel Connector and allows for a connection at a reduced upside super elevation along US 641. The proposed 60 mph alignment also allows for a simpler east connection to Brandon road. These possibilities are not factored into the cost savings.

The proposed does come at a risk to the project schedule due to redesign time and impacts outside the baseline Right-of-Way boundary. The project team will need to evaluate status of Right-of-Way negotiations and design risks in detail before pursuing.

Please note that the bridge on EW Miller is just outside the limits of the current project is part of the Bridging KY program. With this proposed change, it is anticipated that the structure in question could be removed, saving KYTC the costs of replacing or repairing that structure.

Also, please note that the costs of the baseline structure over Brushy Creek appear to be low. If the unit price per

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-02
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Brushy Creek Bridge	SF	31630	61.17	1,934,783	22500	61.17	1,376,325
Wetland Mitigation	AC	2.4	49,839.00	119,614			
TOTAL				2,054,000			1,376,000
						CWE (BASELINE LESS PROPOSED)	**678,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-03
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Tom Taylor Trail over the gasline (east side)
FUNCTION:	**Cross Gasline**

BASELINE ASSUMPTION:

Connect Tom Taylor Trail to US 641, crossing the gas transmission lines, providing direct access to US 641 to residents along Tom Taylor east of the new alignment.

PROPOSED ALTERNATIVE:

Remove the east connection to Tom Taylor Trail, eliminating the crossing of the gas transmission lines. Revise mainline grade between approximate Station 6370+00 and Station 6427+00 to reduce embankment need.

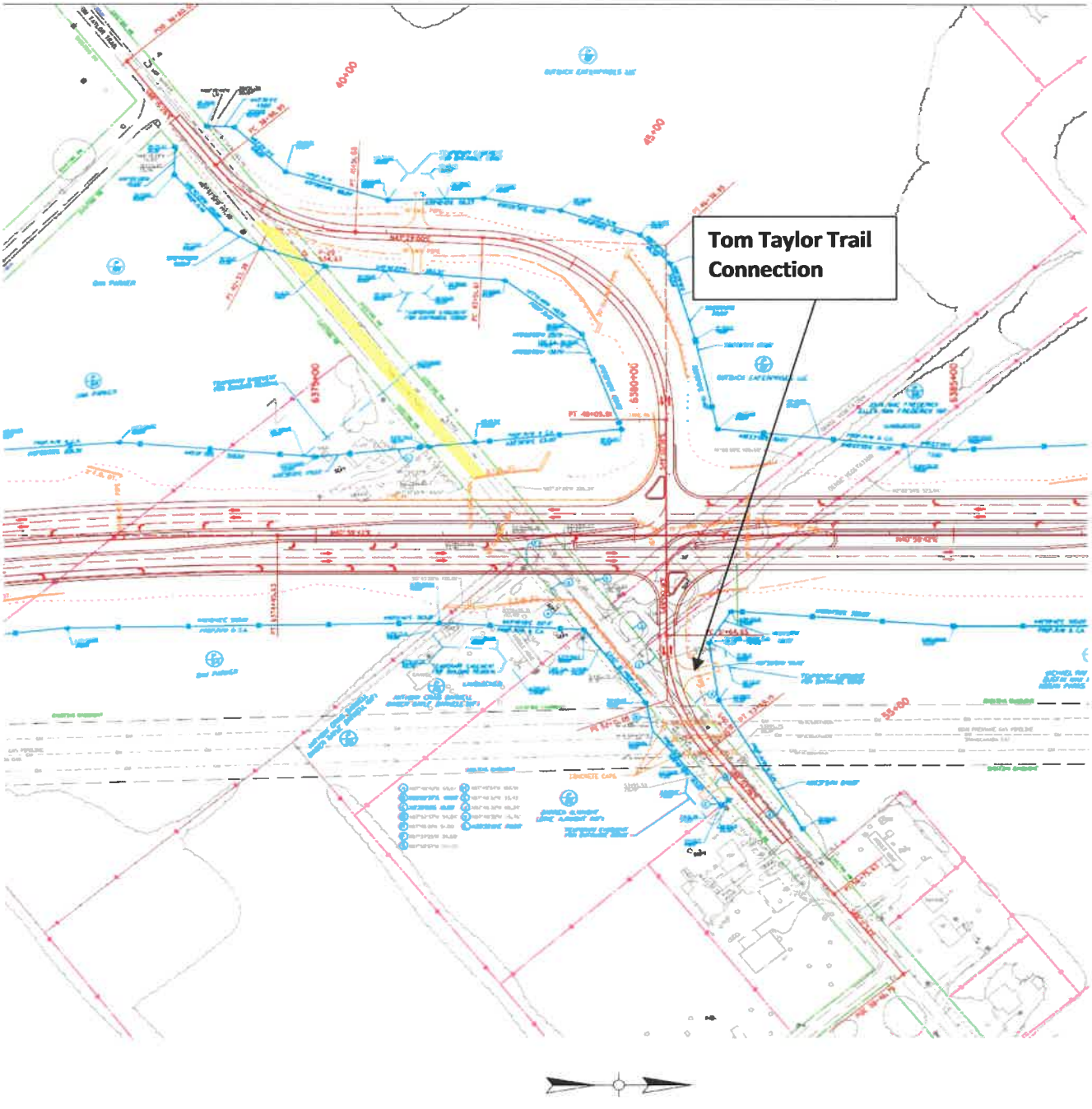
BENEFITS	RISKS/CHALLENGES
• Eliminates gas transmission line crossing	• None apparent
• Reduces earthwork unbalance	•
• Reduces embankment in place need	•
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 1,271,000	$ 15,000	$ 1,286,000
PROPOSED ALTERNATIVE:	$ 674,000	$ -	$ 674,000
TOTAL (Baseline less Proposed)	$ 597,000	$ 15,000	**$ 612,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-03
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Tom Taylor Trail over the gasline (east side)

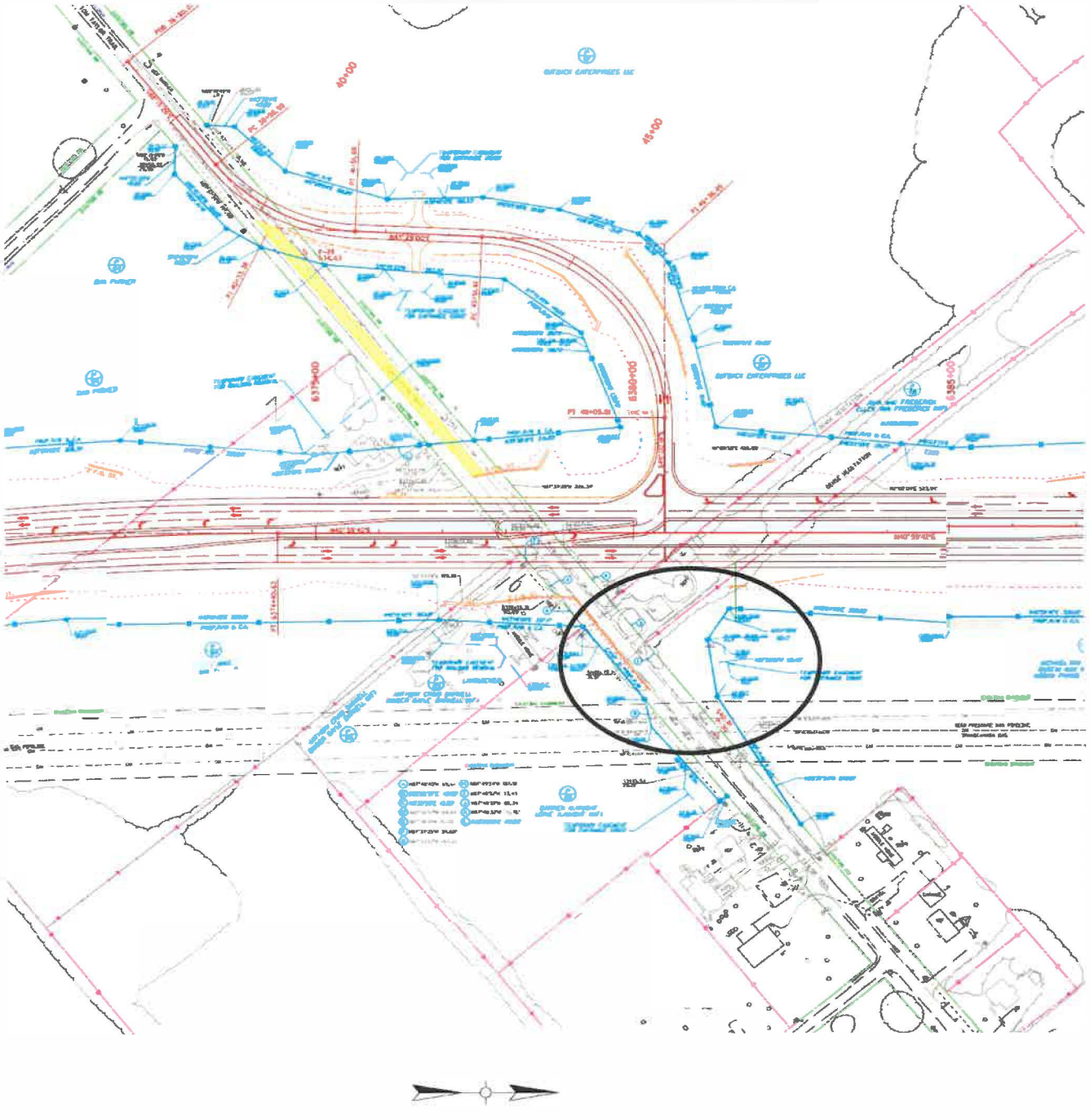
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-03
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Tom Taylor Trail over the gasline (east side)

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-03
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Tom Taylor Trail over the gasline (east side)

DISCUSSION/JUSTIFICATION:

The baseline condition ties US 641 to eastern segment of Tom Taylor Trail. This connection requires an additional crossing of the gas transmission lines. The Tom Taylor Trail intersection is proposed to be an Restricted Crossing U-Turn (RCUT) intersection.

The proposal is to eliminate the eastern connection to Tom Taylor Trail entirely. Coupled with the elimination of the eastern tie to Tom Taylor Trail is a vertical alignment revision on mainline. The assumption was that the mainline grade was high in the area of the intersection to help provide cover over the gas transmission lines. Eliminating the crossing allowed the VE team to lower the mainline grade to reduce embankment need and reduce earthwork imbalance. This also eliminates approximately 1200 feet of right turn lane onto Tom Taylor Trail from mainline US 641.

There is no perceived negative impact to constructability as a result of this proposal. During construction, there is no perceived negative impact to the maintenance of traffic. Although residents along the eastern portion of Tom Taylor Trail will not have a direct connection to the new US 641, they must access via existing US 641 to where it connects to the new alignment.

Long term maintenance for this will be eliminated for this 500 feet of approach; however, it would create a dead-end situation which could be annoying during snow removal.

By eliminating one leg of the intersection, overall safety will be improved. It is expected that the four-leg intersection will experience 12.3 collisions (4.4 fatal & injury, 7.9 PDO) as compared to 9.3 collisions (3.7 fatal & injury, 5.6 PDO) over a 20-year period.

There is no perceived impact to project schedule or conformance to commitments made in the BUILD Grant application as a result of this proposal.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-03
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Tom Taylor Trail over the gasline (east side)						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Embankment-In-Place	CY	1E+05	7.00	855,435	90000	7.00	630,000
CL3 Asph. Surf. 0.38B PG64-22	TON	258	74.06	19,107		74.06	
CL3 Asph. Base 1.00D PG64-22	TON	2060	61.94	127,596		61.94	
Crushed Stone Base	TON	887	17.10	15,168	880	17.10	15,048
CL2 Asph. Base 1.00D PG64-22 (mainline shoulder removing right turn lane)	TON	242	56.55	13,685	505	56.55	28,558
TC Energy Gas Line Excavation (assumed at $1000/LF)	LF	240	1,000.00	240,000		1,000.00	
TOTAL				1,271,000			674,000
						CWE (BASELINE LESS PROPOSED)	**597,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-03
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Tom Taylor Trail over the gasline (east side)

Assumptions			
Interest/Discount Rate(%):	3.0%	Economic Life (yrs):	20

LIFE CYCLE COST ANALYSIS

Salvage & Replacement Costs			Baseline Assumption		Proposed Alternative	
Item	Description	Yr	Est Cost	Pres Worth	Est Cost	Pres Worth
1	Asphalt Resurfacing	10	20,000	14,882		
2						
3						
4						
5						
6						
7						
8						
9						
10						
Total Salvage & Replacement Costs			20,000	14,882		

Annual Costs (pres worth calculated over 20 yrs)		Baseline Assumption		Proposed Alternative	
Item	Description	Est Cost	Pres Worth	Est Cost	Pres Worth
1					
2					
3					
4					
5					
Total Annual Costs					

SUMMARY	Baseline Present Worth	Proposed Present Worth
Total Present Worth (salvage+annual pres worth)	15,000	
RESULTS (Proposed less Baseline)	SAVINGS of -15,000	

Notes: 1) Total Present Worth is rounded to the nearest thousand dollars, 2) Initial costs are covered in the Detail sheet.

VALUE ENGINEERING PROPOSAL
VE-04
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+50 to avoid gaslines
FUNCTION:	**Cross Gasline**

BASELINE ASSUMPTION:

Provides access to Heron Road at Station 6355+00.

PROPOSED ALTERNATIVE:

Relocates access to Heron Road to Station 6343+50.

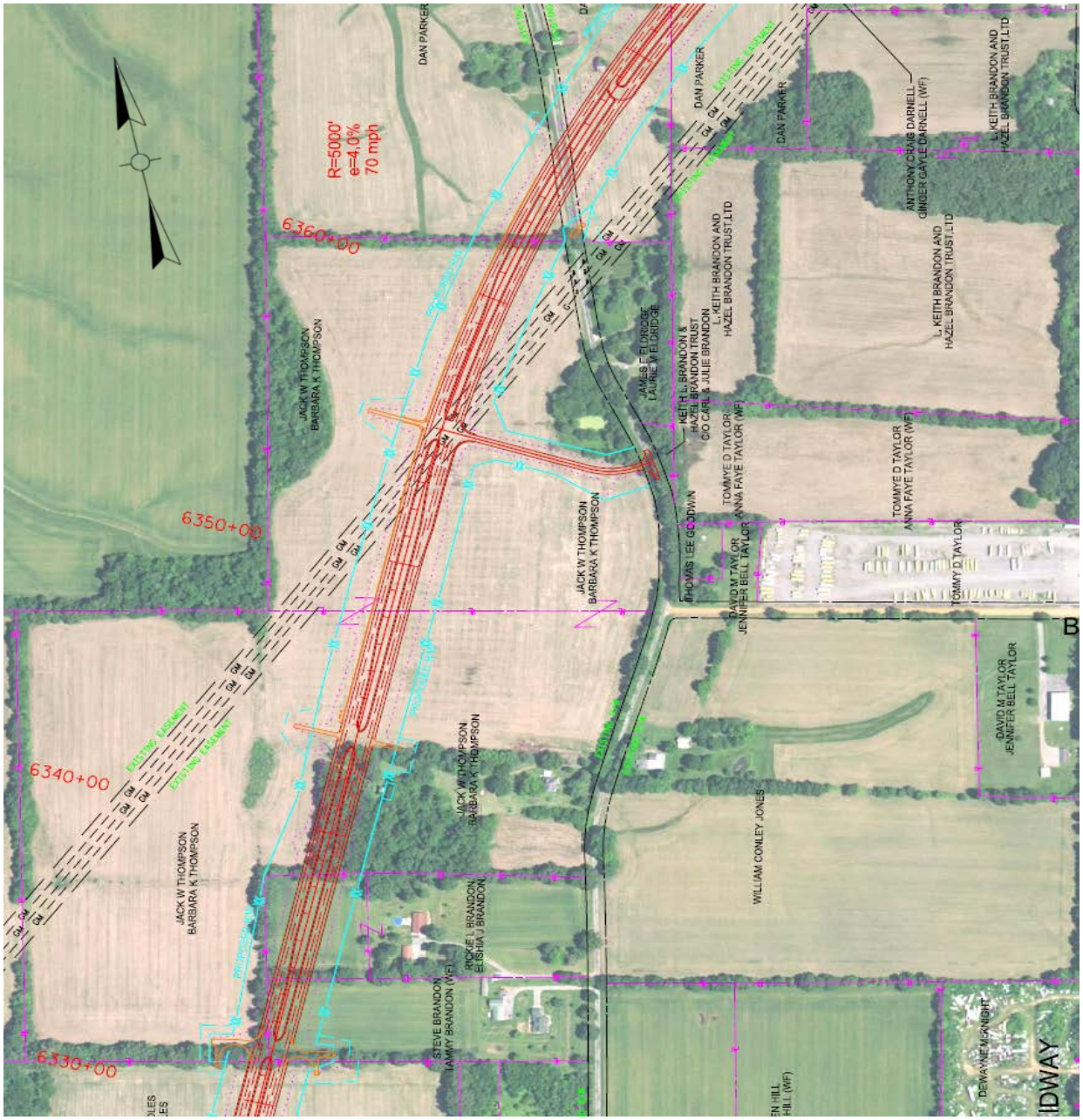
BENEFITS	RISKS/CHALLENGES
• Minimizes construction in proximity of gaslines	• Lengthens approach road by 150 feet
•	• Modified right-of-way impacts which could affect project schedule
•	•
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 85,000	$ -	$ 85,000
PROPOSED ALTERNATIVE:	$ 104,000	$ -	$ 104,000
TOTAL (Baseline less Proposed)	$ (19,000)	$ -	**$ (19,000)**
			COST

VALUE ENGINEERING PROPOSAL
VE-04
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+50 to avoid gaslines

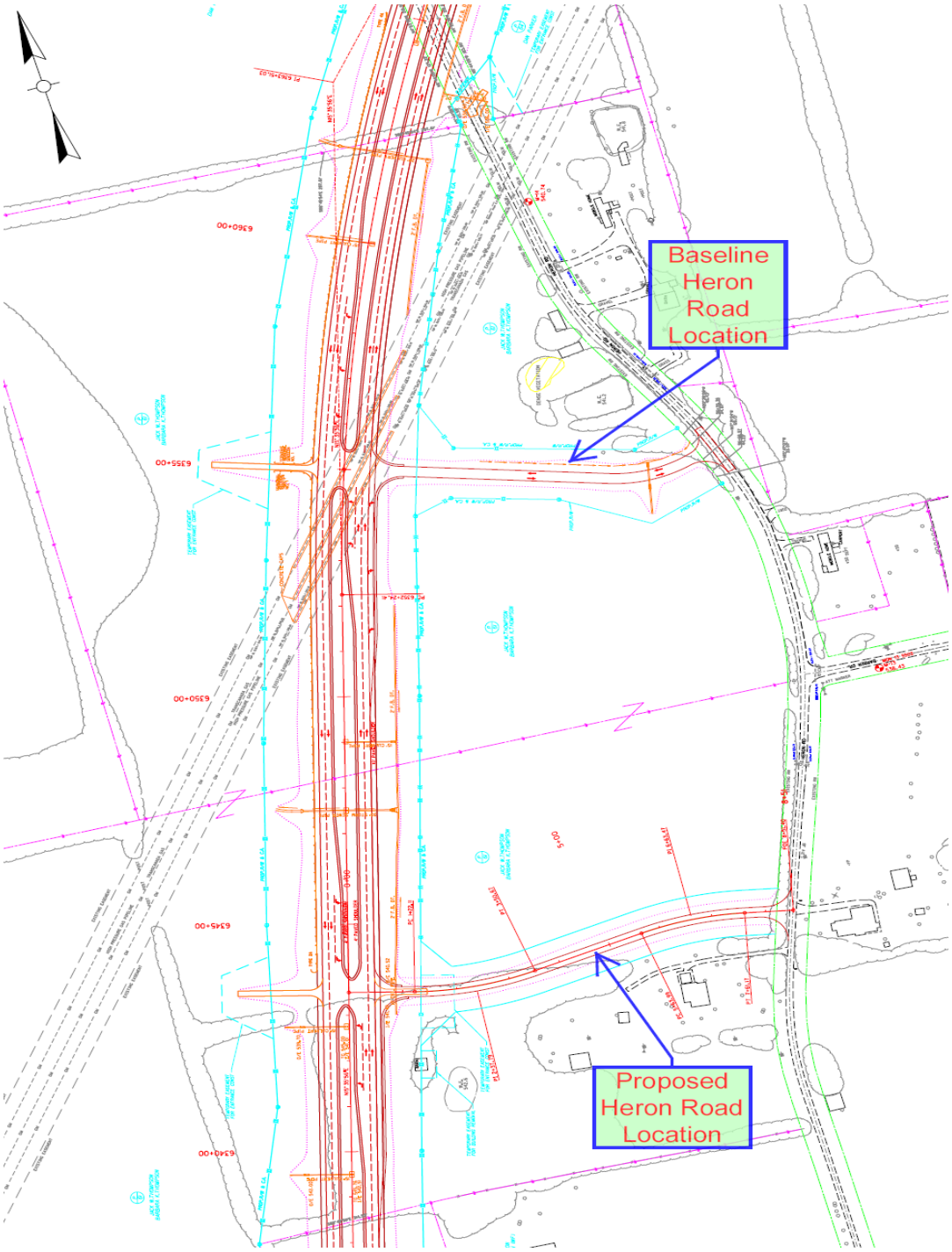
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-04
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+50 to avoid gaslines

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-04
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+50 to avoid gaslines

DISCUSSION/JUSTIFICATION:

Relocating the Heron Road approach reduces the project risk to schedule and constructability associated with working in proximity of the gas lines.

This proposal introduces risk to schedule in the form of changing right-of-way impacts to Parcel 61 depending on where in the process discussions are with this property owner.

No impact to safety, Maintenance of Traffic (MOT), or conformance to BUILD Grant.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-04
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+50 to avoid gaslines						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
CL3 Asph. Surf. 0.38B PG64-22	TON	131	74.06	9,702	161	74.06	11,924
CL3 Asph. Base 1.00D PG64-22	TON	1096	61.94	67,886	1349	61.94	83,557
Crushed Stone Base	TON	406	17.10	6,943	499	17.10	8,533
TOTAL				85,000			104,000
						CWE (BASELINE LESS PROPOSED)	**(19,000)**

Note: Total costs are rounded to the nearest thousand dollars.

COST

VALUE ENGINEERING PROPOSAL
VE-05
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines
FUNCTION:	**Cross Gasline**

BASELINE ASSUMPTION:

Construct US 641 Connector from new alignment to existing alignment tying to the new alignment at Station 6421+30 and crossing the gas transmission lines creating a "T" intersection at existing US 641. Construct typical section of two 12-foot lanes and 4-foot paved shoulders.

PROPOSED ALTERNATIVE:

Relocate US 641 Connector to approximate station 6434+10 using a typical section of two 12-foot lanes and 2-foot paved shoulders.

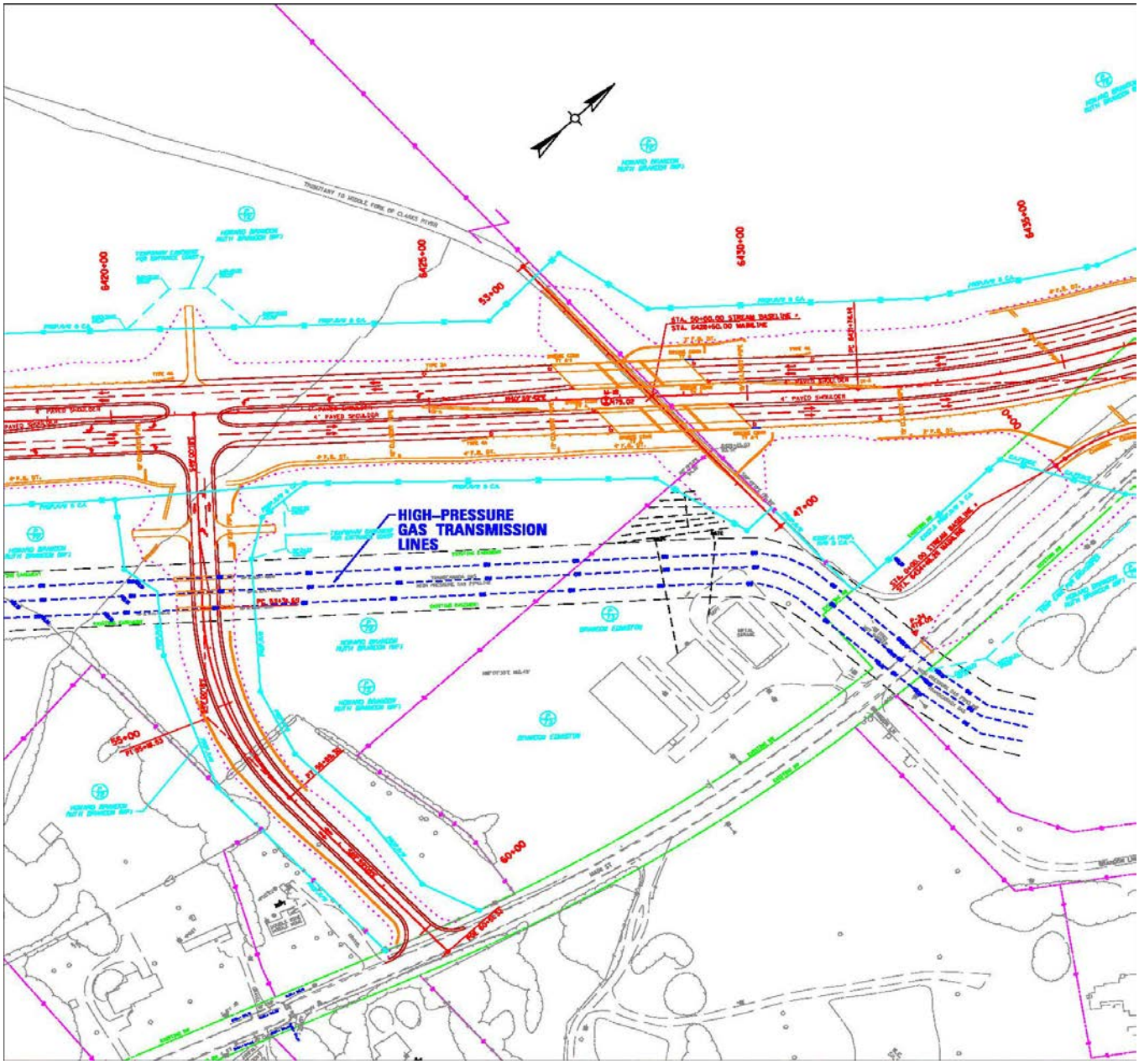
BENEFITS	RISKS/CHALLENGES
• Eliminates gasline crossing at existing US 641 connector	• Crosses unnamed tributary to Middle Fork of Clarks River
• Provides connection to existing US 641 as a free-flow movement	• Shortens turn lane onto US 641
• Constructed within current proposed right-of-way	• Violates access spacing
• Shortens connection to existing US 641	•
• Dead-ends on remnant of existing US 641	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 525,000	$ 17,000	$ 542,000
PROPOSED ALTERNATIVE:	$ 155,000	$ 7,000	$ 162,000
TOTAL (Baseline less Proposed)	$ 370,000	$ 10,000	**$ 380,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-05
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines

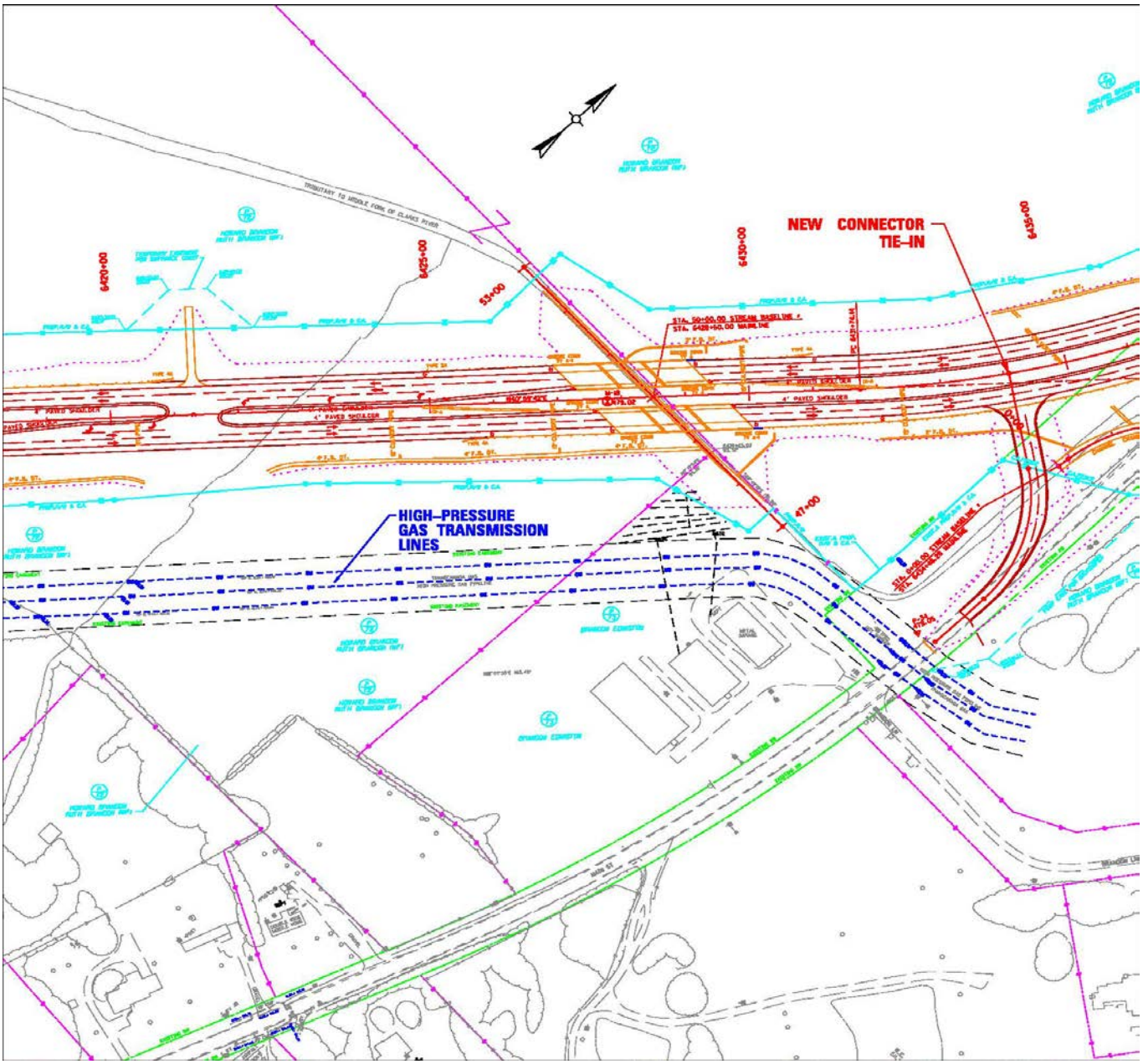
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-05
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-05
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines

DISCUSSION/JUSTIFICATION:

The baseline for the US 641 Connector crosses the TC Energy gas transmission lines and is approximately 980 feet in length. The intersection configuration at the tie to existing US 641 would be a three-leg "T" intersection.

The proposal is to relocate this connection to the new alignment such that it ties to existing US 641 prior to the gas line location and provides a direct connection from the old route to the new. This new alignment will cross the existing location of the unnamed tributary to Middle Fork of Clarks Creek requiring a new bridge structure be built on this tie-in. This bridge structure can be eliminated with the inclusion of VE-06 in the project. There is no bridge in the cost estimate because the proposal assumes that VE-06 is also incorporated. VE-06 can be implemented on its own; however, VE-05 is not economical without the inclusion of VE-06.

Due to the nature of the tie-in to old US 641, the constructability of the proposed alignment will be more difficult than in the baseline as work will need to be done in the existing driving lanes; however, this work would be completed after the new alignment is opened to traffic greatly reducing the impact to the traveling public. Assuming the traffic has been shifted to the new alignment, maintenance of traffic will consist of maintaining access to the Brandon property which is currently served from Brandon Road to the east of the existing alignment.

The proposed alignment would be approximately 400 feet in length, marginally decreasing the long-term maintenance of the facility, however, snow removal will be aided by allowing trucks free-flow onto US 641 as opposed to removing snow from a dead-end street.

There is no perceived impact to project schedule or conformance to commitments made in the BUILD Grant application as a result of this proposal. Safety of the connection is not anticipated to appreciably change. You would be removing an intersection which will improve safety but we do not anticipate and appreciable gains.

The cost savings associated with this proposal are based on the assumption that VE-06 is implemented as well. Without implementing that proposal, another bridge will be required making this proposal uneconomical.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-05
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Embankment-In-Place	CY	5328	7.00	37,296	9715	7.00	68,005
CL2 Asph. Surf. 0.38D PG64-22	TON	69	62.33	4,301	15	62.33	935
CL3 Asph. Surf. 0.38B PG64-22	TON	258	74.06	19,107	125	74.06	9,258
CL2 Asph. Base 1.00D PG64-22	TON	277	56.55	15,664	115	56.55	6,503
CL3 Asph. Base 1.00D PG64-22	TON	2136	61.94	132,304	1000	61.94	61,940
Crushed Stone Base	TON	2131	17.10	36,438	500	17.10	8,550
TC Energy Gas Line Excavation (assumed at $1000/LF)	LF	280	1,000.00	280,000			
TOTAL				525,000			155,000
						CWE (BASELINE LESS PROPOSED)	**370,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-05

Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Shift the northern tie-in to US 641 to connect back to old US 641 without crossing the gaslines

Assumptions			
Interest/Discount Rate(%):	3.0%	**Economic Life (yrs):**	20

LIFE CYCLE COST ANALYSIS

Salvage & Replacement Costs			**Baseline Assumption**		**Proposed Alternative**	
Item	**Description**	**Yr**	**Est Cost**	**Pres Worth**	**Est Cost**	**Pres Worth**
1	Asphalt resurfacing	10	23,500	17,486	10,000.0	7,441
2						
3						
4						
5						
6						
7						
8						
9						
10						
Total Salvage & Replacement Costs			**23,500**	**17,486**	**10,000**	**7,441**

Annual Costs (pres worth calculated over 20 yrs)		**Baseline Assumption**		**Proposed Alternative**	
Item	**Description**	**Est Cost**	**Pres Worth**	**Est Cost**	**Pres Worth**
1					
2					
3					
4					
5					
Total Annual Costs					

SUMMARY	**Baseline Present Worth**	**Proposed Present Worth**
Total Present Worth (salvage+annual pres worth)	17,000	7,000
RESULTS (Proposed less Baseline)	**SAVINGS of -10,000**	

Notes: 1) Total Present Worth is rounded to the nearest thousand dollars, 2) Initial costs are covered in the Detail sheet.

VALUE ENGINEERING PROPOSAL
VE-06
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side
FUNCTION:	**Cross Gasline**

BASELINE ASSUMPTION:

The baseline condition realigns the unnamed tributary to the Middle Fork of Clarks River at the existing US 641 Bridge and then sends the water to an existing 90° bend before being conveyed beneath the new US 641 Bridge and alignment.

PROPOSED ALTERNATIVE:

Relocate the proposed bridge and construct a channel change of the unnamed tributary to the Middle Fork of Clarks River to the west side of the new US 641 alignment.

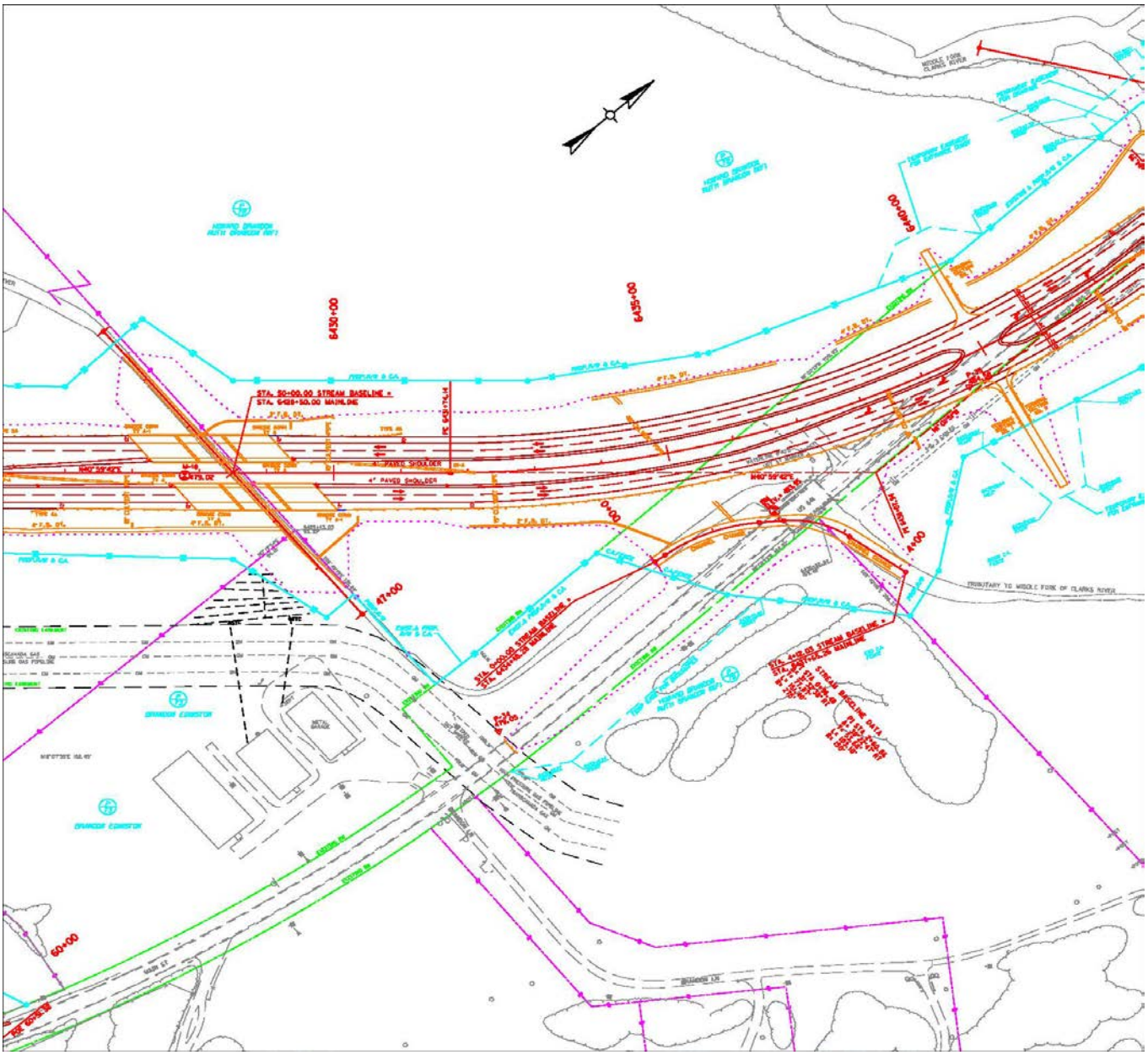
BENEFITS	RISKS/CHALLENGES
• Improves stream stability	• Additional length of channel change
•	• New bridge location requires revised geotechnical investigation
•	• Bridge in 6.8% superelevation - icing concerns
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 517,000	$ -	$ 517,000
PROPOSED ALTERNATIVE:	$ 430,000	$ -	$ 430,000
TOTAL (Baseline less Proposed)	$ 87,000	$ -	**$ 87,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-06
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side

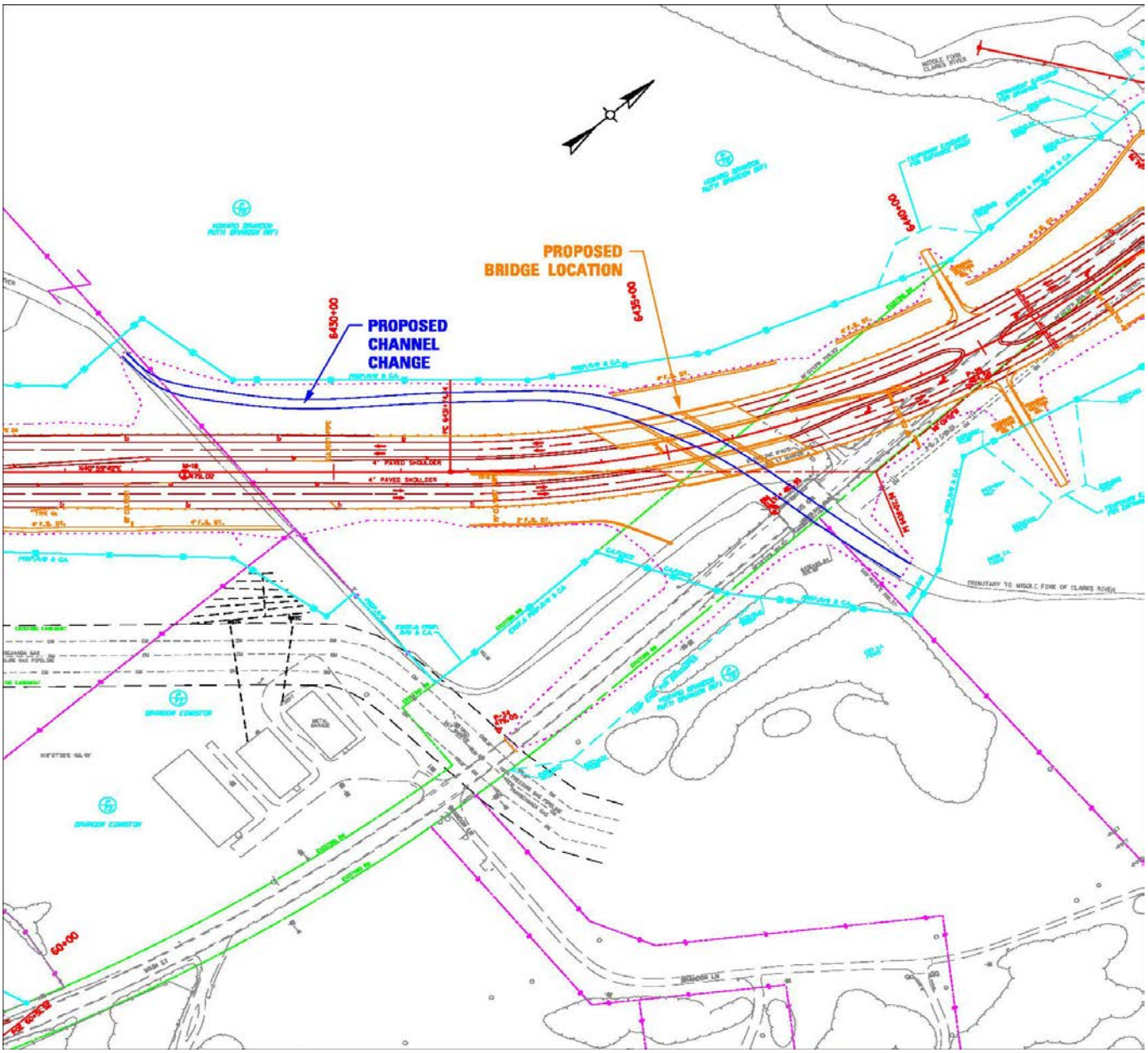
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-06
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-06
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side

DISCUSSION/JUSTIFICATION:

The baseline condition would impact approximately 1520 linear feet of existing channel with about 410 linear feet of channel change. It was assumed that the entire 1520 linear feet of existing channel was included in the in-lieu fees. The baseline bridge is located in a horizontal and vertical tangent.

The proposed condition would require approximately 1265 linear feet of channel change and impact. There is no perceived impacts to constructability, maintenance of traffic or conformance to the BUILD Grant commitments.

The proposed bridge location could pose an increased impact to long-term maintenance. The proposed bridge location is in a curve with 6.8% superelevation and snow and ice removal would be critical for this structure. Coupled with this increase in maintenance, there would be a perceived impact to safety in wet or icy conditions.

There could be an impact to project schedule insofar as it would require new geotechnical investigation as well as design of a new structure. The relocated structure would be located in both horizontal and vertical curves, however, there would not be any superelevation transition across the bridge.

This VE proposal can be coupled with VE-05 (Shift the northern tie to US 641 to the northwest to connect back to old US 641 without crossing the gaslines) to provide further cost savings.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-06
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Stream In-Lieu Fees	LF	1520	340.00	516,800	1265	340.00	430,100
TOTAL				517,000			430,000
						CWE (BASELINE LESS PROPOSED)	**87,000**
Note: Total costs are rounded to the nearest thousand dollars.							**SAVINGS**

VALUE ENGINEERING PROPOSAL
VE-07
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Heron Road tie at Station 6355+00
FUNCTION:	**Cross Gasline**

BASELINE ASSUMPTION:

Provides access to existing Heron Road east of Baseline US 641.

PROPOSED ALTERNATIVE:

Eliminate the Heron Road relocation and connection to new US 641.

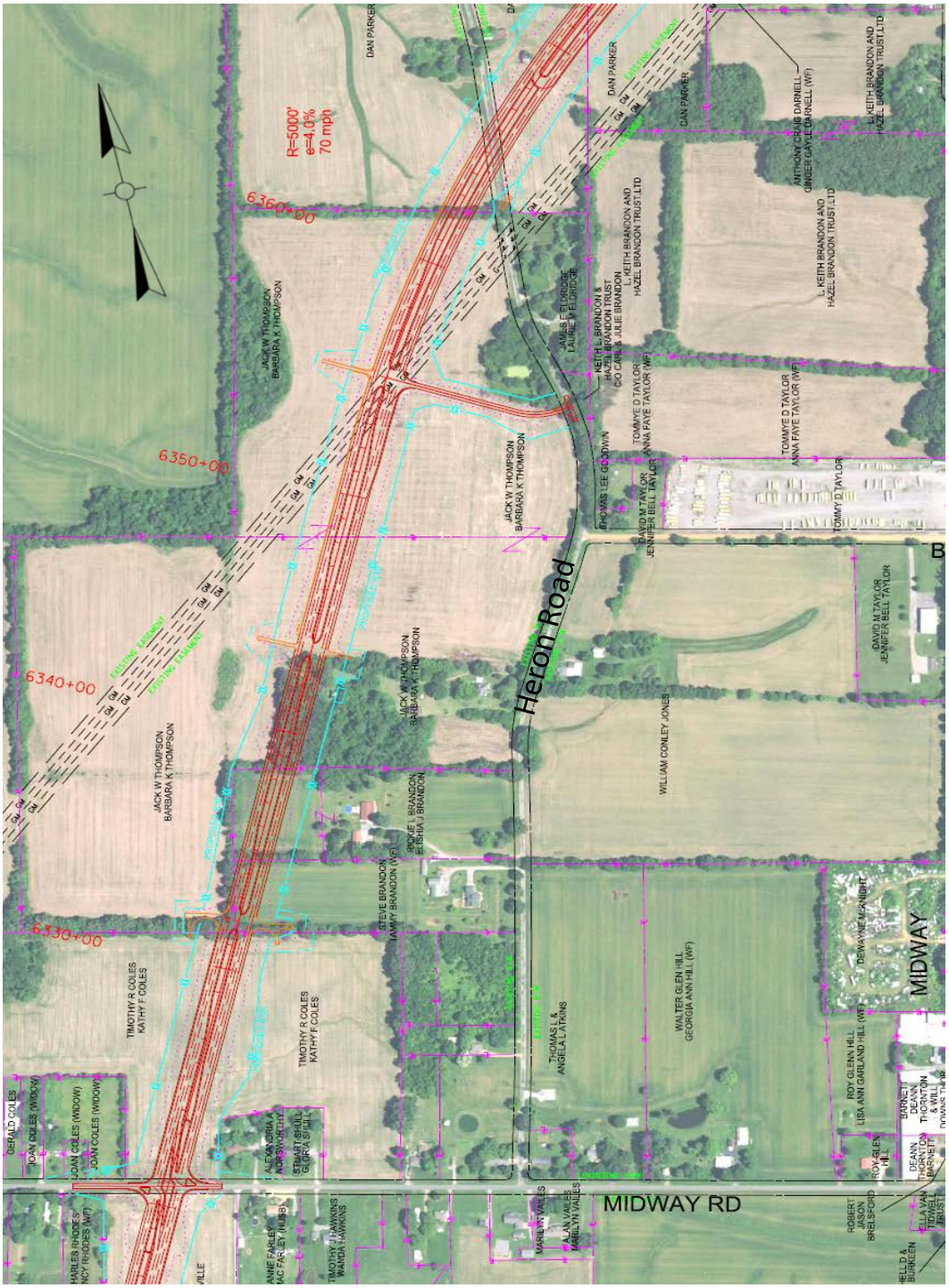
BENEFITS	RISKS/CHALLENGES
• Eliminates 650-foot approach road	• Reduces connectivity
• Eliminates right turn lane from mainline	•
• Reduces right of way impacts (1.7 acres)	•
• Reduces construction in proximity of gas lines	•
• Reduces conflict points - left turns from and onto mainline	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 128,000	$ -	$ 128,000
PROPOSED ALTERNATIVE:	$ 17,000	$ -	$ 17,000
TOTAL (Baseline less Proposed)	$ 111,000	$ -	**$ 111,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-07
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Heron Road tie at Station 6355+00

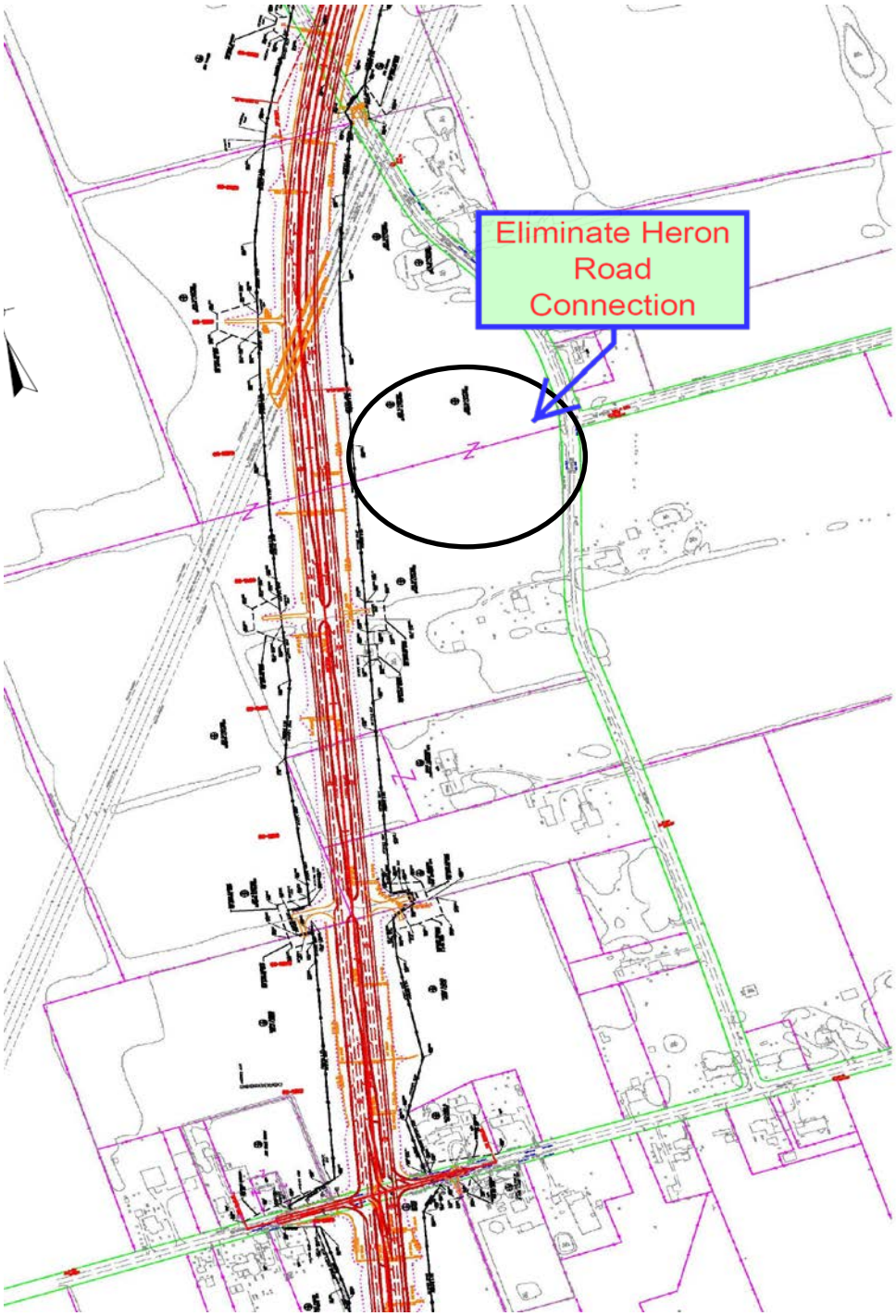
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-07
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Heron Road tie at Station 6355+00

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-07
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Heron Road tie at Station 6355+00

DISCUSSION/JUSTIFICATION:

The VE team felt the Heron Road approach could be eliminated without much loss connectivity for the local community since Midway Road access to US 641 is less than one mile away. Eliminating the Heron Road approach reduces risk associated with construction in the proximity of the gas lines.

Safety - Not constructing the Heron Road access reduces conflicts at a location where left-turns would occur onto and from the mainline.

This proposal additionally helps with project schedule and provides a savings to long term maintenance by reducing pavement resurfacing needs and frequencies.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-07
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Heron Road tie at Station 6355+00						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Approach							
Embankment-In-Place	CY	1510	7.00	10,570			
CL3 Asph. Surf. 0.38B PG64-22	Ton	131	74.06	9,702			
CL3 Asph. Base 1.00D PG64-22	Ton	1096	61.94	67,886			
Crushed Stone Base	Ton	406	17.10	6,943			
Right Turn Lane							
CL3 Asph. Surf. 0.38B PG64-22	Ton	53.74	74.06	3,980	39	74.06	2,888
CL3 Asph. Base 1.00D PG64-22	Ton	429.9	61.94	26,627	156	61.94	9,661
Crushed Stone Base	Ton	149.8	17.10	2,562	271.8	17.10	4,647
TOTAL				128,000			17,000
						CWE (BASELINE LESS PROPOSED)	**111,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-08
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate one 3-inch layer of asphalt base
FUNCTION:	**Support Load**

BASELINE ASSUMPTION:

Four layers of 3-inch asphalt base.

PROPOSED ALTERNATIVE:

Eliminate one 3-inch layer of base.

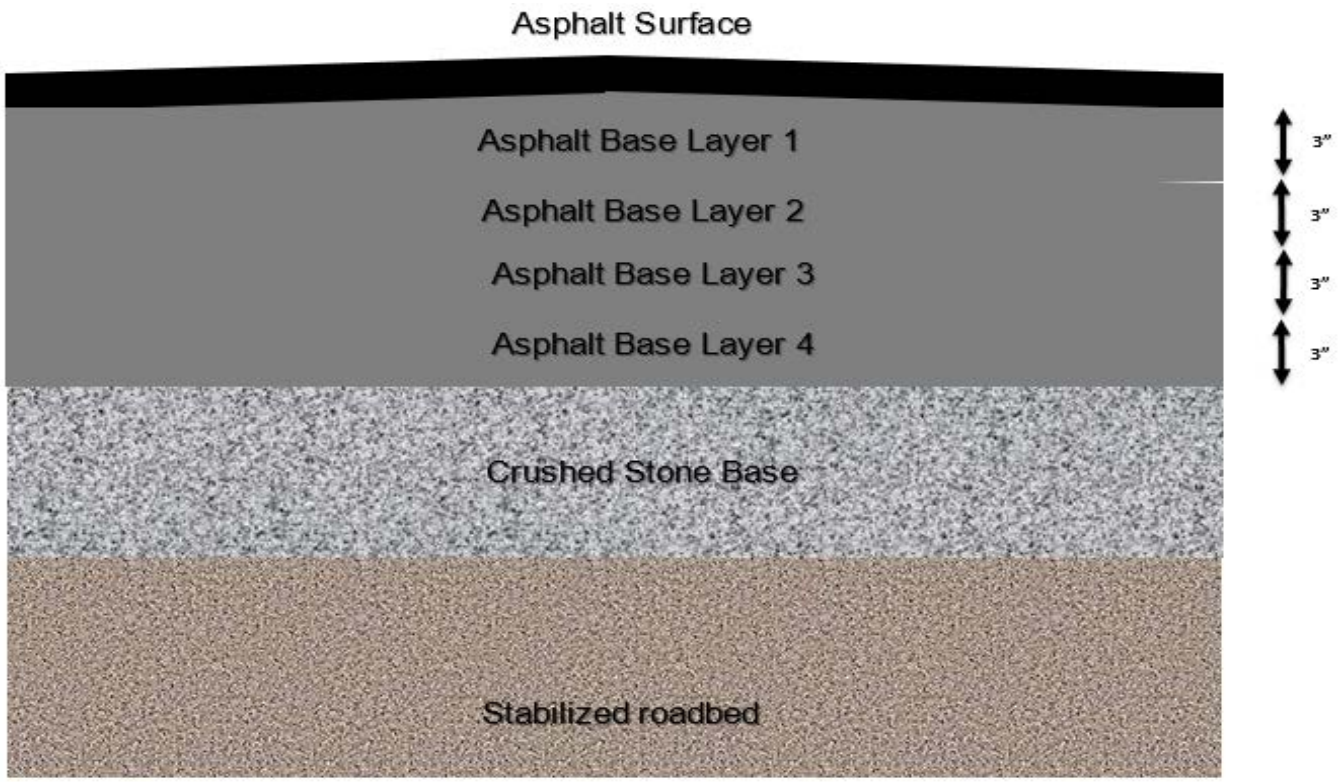
BENEFITS	RISKS/CHALLENGES
• Reduces pavement construction cost	• Possible reduction in pavement life cycle
• No change in fatigue cracking	• Increases total pavement deformation
•	• Large increase in thermal cracking
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 9,495,000	$ -	$ 9,495,000
PROPOSED ALTERNATIVE:	$ 7,122,000	$ -	$ 7,122,000
TOTAL (Baseline less Proposed)	$ 2,373,000	$ -	**$ 2,373,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-08
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate one 3-inch layer of asphalt base

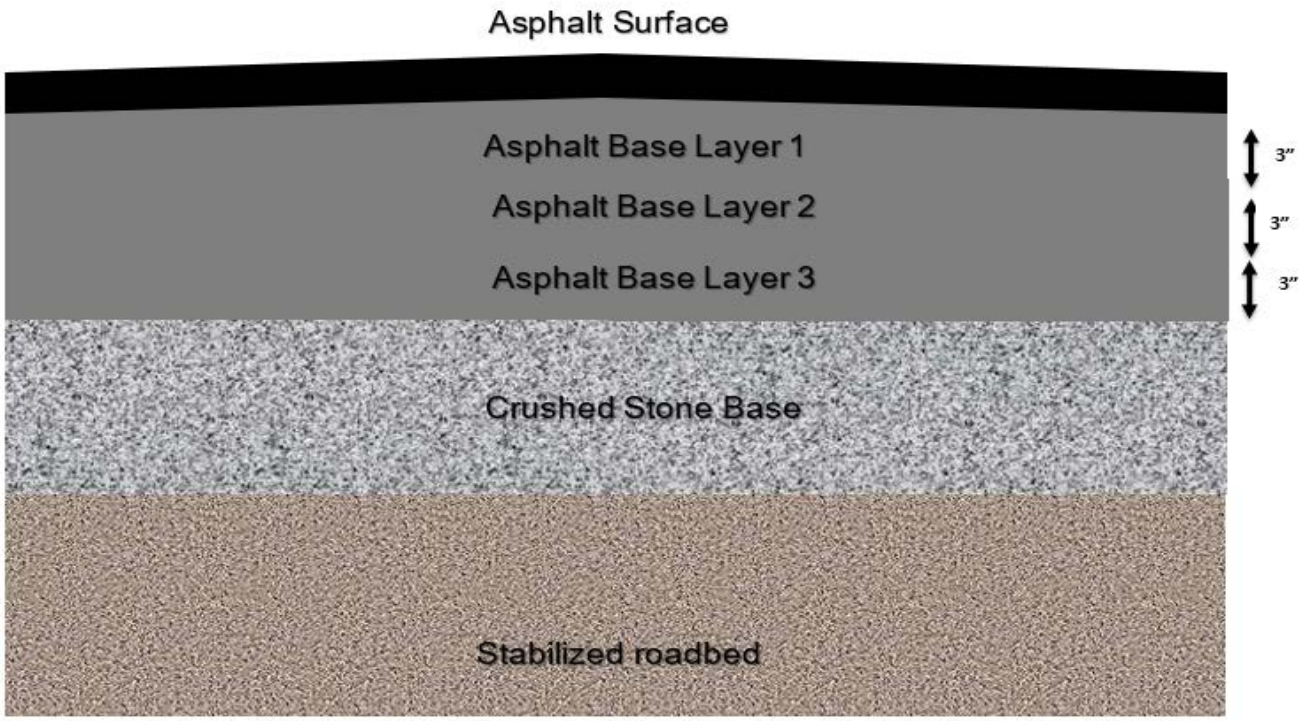
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-08
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate one 3-inch layer of asphalt base

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL

VE-08

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section), Item No. 1-314.20

Calloway County

TITLE:	Eliminate one 3-inch layer of asphalt base

DISCUSSION/JUSTIFICATION:

In terms of constructability, eliminating one 3-inch layer of base will lower the total pavement thickness by 3 inches (the two pavement designs and their respective layer thicknesses are seen below). This would, conceivably, reduce paving time. It would also reduce compaction time. As for maintenance of traffic, no impact would be expected. However, when considering maintainability, many factors arise. As seen in the left graphic below, KYTC has expected pavement performance values. The highlighted yellow column is the current pavement design, which has each performance criteria being met, relatively speaking. As for the graphic on the bottom right, the design without one 3-inch layer of base, the performance parameters do not always meet requirements. For example, the asphalt thermal cracking is over triple what the current pavement design is. However, the asphalt-bottom up fatigue cracking did not change and the asphalt top-down fatigue cracking decreased slightly. In terms of maintainability specifically, the proposed new pavement design could generate higher annual maintenance costs due to the expected increase in cracking. More cracking would result in a need for more maintenance. This anticipated increase in cracking, and perhaps room for other "failures," could also impact safety. When considering safety, cracking, dips, and bumps could negatively affect the vehicle itself or pose as a hazard for drivers. As for schedule, a slight decrease in overall days of construction could be seen. However, this would be minor. Lastly, one positive impact of eliminating one 3-inch layer of base is the reduction in cost. A little over $2.3 million could be saved by using this proposed alternative.

Trial Designs		1
Layer		inches
PG 64-22	1 Asphalt Surface	1.5
PG 64-22	2 Asphalt Base	3.0
PG 64-22	3 Asphalt Base	3.0
PG 64-22	4 Asphalt Base	3.0
PG 64-22	5 Asphalt Base	3.0
	6 Crushed Stone Base	4.0
	7 Cement Stabilized Roadbed	12.0
	Total Pavement Thickness	29.5

KYTC Pavement Performance	KYTC Reliability	
Terminal IRI (160.00)	95%	158.93
Total Pavement Permanent Deformation (0.25 inch)	95%	0.32
Asphalt Bottom-Up Fatigue Cracking (% lane area – 10%)	95%	1.86
Asphalt Thermal Cracking (feet / mile – 1,000 feet)	90%	847.73
Asphalt Top-Down Fatigue Cracking (feet / mile –2,000 feet	90%	280.18
Permanent Deformation – Asphalt Only (0.25 inch)	90%	0.07

Trial Designs	VE #1A	VE #1B	VE #2A
Layer	inches	inches	inches
1 Asphalt Surface	1.5	1.5	1.5
2 Asphalt Base	3.0	3.0	3.0
3 Asphalt Base	3.0	3.0	3.0
4 Asphalt Base	0.0	0.0	3.0
5 Asphalt Base	0.0	0.0	0.0
6 Crushed Stone Base	4.0	6.0	4.0
7 Cement Stabilized Roadbed	12.0	12.0	12.0
Total Pavement Thickness	23.5	25.5	26.5

KYTC Pavement Performance Parameters	KYTC Reliability			
Terminal IRI (160.00)	95%	179.94	179.57	176.55
Total Pavement Permanent Deformation (0.25 inch)	95%	0.49	0.48	0.42
Asphalt Bottom-Up Fatigue Cracking (% lane area – 10%)	95%	1.86	1.86	1.86
Asphalt Thermal Cracking (feet / mile – 1,000 feet)	90%	2452.77	2452.77	2425.19
Asphalt Top-Down Fatigue Cracking (feet / mile –2,000 feet	90%	257.42	257.55	268.07
Permanent Deformation – Asphalt Only (0.25 inch)	90%	0.15	0.16	0.13

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-08
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate one 3-inch layer of asphalt base						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
CL3 ASPH BASE 1.00D PG64-22	TON	153301	61.94	9,495,464	114975	61.94	7,121,552
TOTAL				9,495,000			7,122,000
						CWE (BASELINE LESS PROPOSED)	**2,373,000**
Note: Total costs are rounded to the nearest thousand dollars.							**SAVINGS**

VALUE ENGINEERING PROPOSAL
VE-09
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base
FUNCTION:	**Support Load**

BASELINE ASSUMPTION:

Four layers of 3-inch asphalt base.

PROPOSED ALTERNATIVE:

Eliminate two 3-inch layers of base and replace with one 4.5-inch of base.

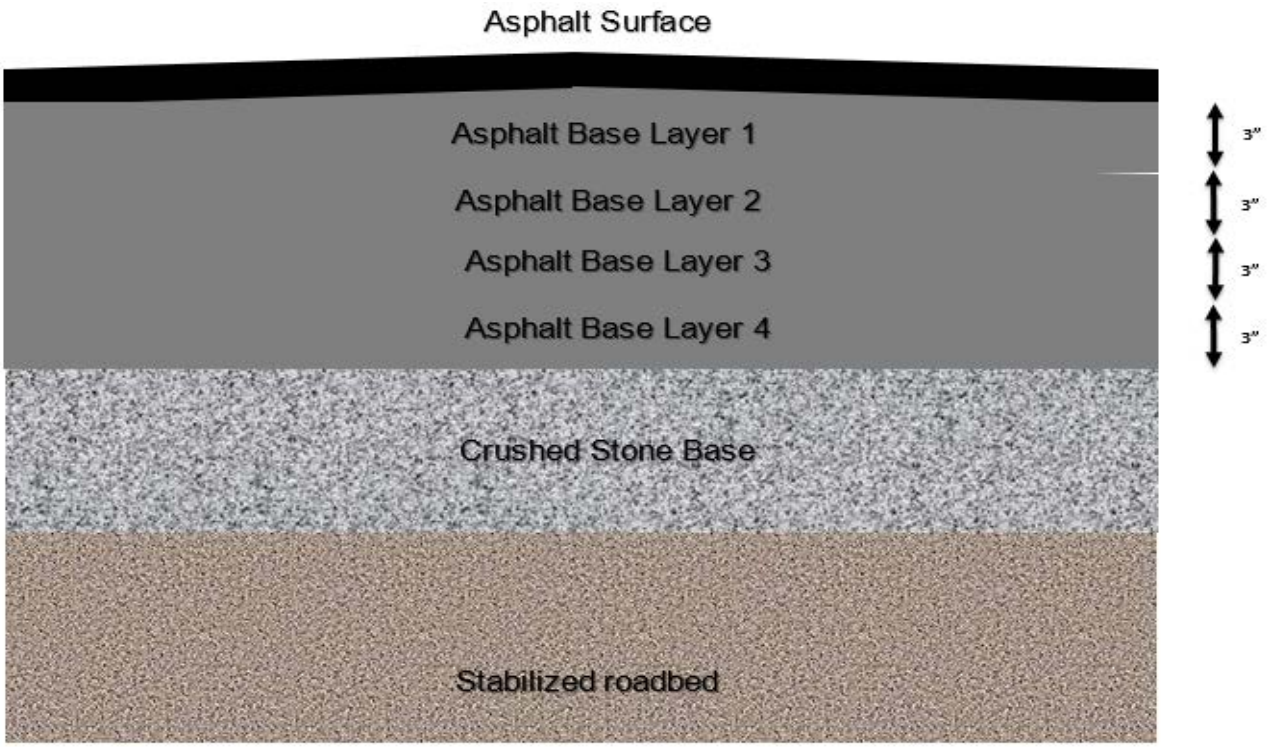
BENEFITS	RISKS/CHALLENGES
• Reduces cost	• Increase in total pavement deformation
• Little to no increase in fatigue cracking	• Large increase in thermal cracking (well above threshold)
•	• Possible reduction in pavement life cycle
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 9,495,000	$ -	$ 9,495,000
PROPOSED ALTERNATIVE:	$ 7,913,000	$ -	$ 7,913,000
TOTAL (Baseline less Proposed)	$ 1,582,000	$ -	**$ 1,582,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-09
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base

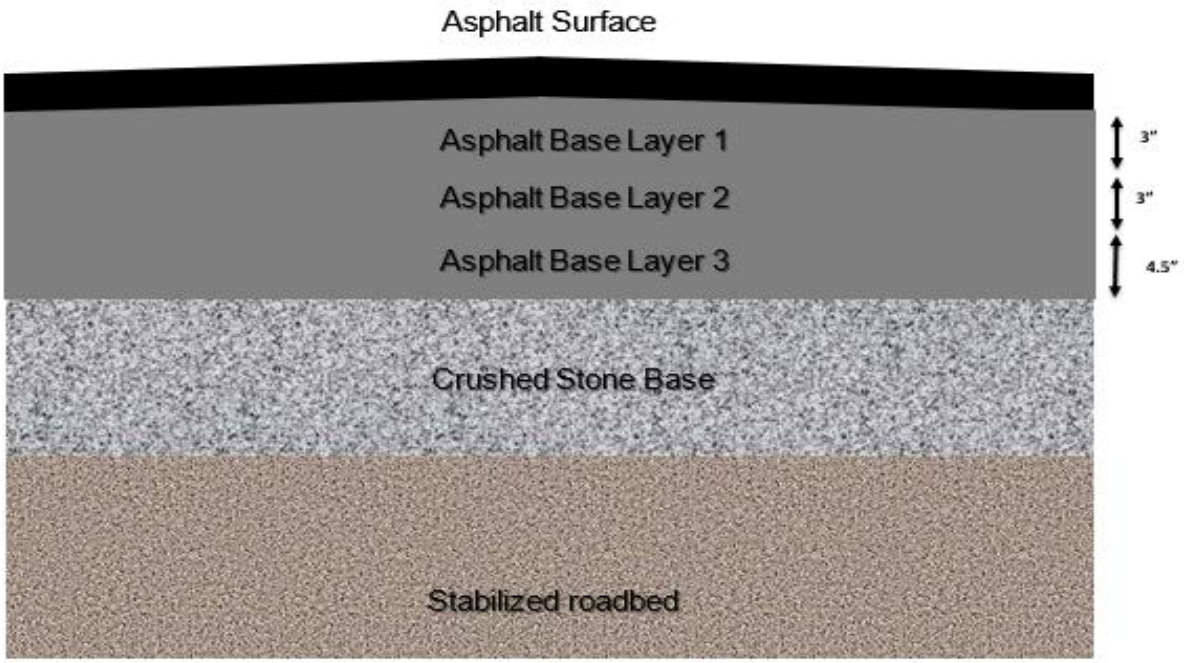
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-09
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL

VE-09

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section), Item No. 1-314.20

Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base

DISCUSSION/JUSTIFICATION:

Many considerations of this proposed alternative are similar to those in the proposed alternative of VE-08. In terms of constructability of VE-09, eliminating two 3-inch layers of base and replacing that with one 4.5-inch of base will lower the total pavement thickness by 1.5 inches (the two pavement designs and their respective layer thicknesses are seen below). This would, conceivably, reduce paving time. It would also reduce compaction time and decrease the amount of time vehicles would not be using the roadway. As for maintenance of traffic, no impact would be expected. However, when considering maintainability, many factors arise. As seen in the left graphic below, KYTC has expected pavement performance values. The highlighted yellow column is the current pavement design, which has each performance criteria being met, relatively speaking. As for the graphic on the right, the design without two 3-inch layers of base and instead one of 4.5-inches, the performance parameters do not always meet requirements. For example, the asphalt thermal cracking is over triple what the current pavement design is. The asphalt top-down fatigue cracking increased slightly, as well. However, the asphalt-bottom up fatigue cracking did not change. In terms of maintainability specifically, the proposed new pavement design could generate higher annual maintenance costs due to the expected increase in cracking. More cracking would result in a need for more maintenance. This anticipated increase in cracking, and perhaps room for other "failures," could also impact safety. When considering safety, cracking, dips, and bumps could negatively affect the vehicle itself or pose as a hazard for drivers. As for schedule, a slight decrease in overall days of construction could be seen. However, this would be minor. Lastly, one positive impact of eliminating two 3-inch layers of base and replacing with one 4.5-inch layer is the reduction in cost. A little over $1.5 million could be saved by using this proposed alternative.

Trial Designs	Layer	1 inches
PG 64-22	1 Asphalt Surface	1.5
PG 64-22	2 Asphalt Base	3.0
PG 64-22	3 Asphalt Base	3.0
PG 64-22	4 Asphalt Base	3.0
PG 64-22	5 Asphalt Base	3.0
	6 Crushed Stone Base	4.0
	7 Cement Stabilized Roadbed	12.0
	Total Pavement Thickness	29.5

KYTC Pavement Performance	KYTC Reliability	
Terminal IRI (160.00)	95%	158.93
Total Pavement Permanent Deformation (0.25 inch)	95%	0.32
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)	95%	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)	90%	847.73
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet	90%	250.18
Permanent Deformation -- Asphalt Only (0.25 inch)	90%	0.07

Trial Designs	Layer	VE #3A inches
	1 Asphalt Surface	1.5
	2 Asphalt Base	3.0
	3 Asphalt Base	3.0
	4 Asphalt Base	4.5
	5 Asphalt Base	0.0
	6 Crushed Stone Base	4.0
	7 Cement Stabilized Roadbed	12.0
	Total Pavement Thickness	28.0

KYTC Pavement Performance Parameters	KYTC Reliability	
Terminal IRI (160.00)	95%	174.61
Total Pavement Permanent Deformation (0.25 inch)	95%	0.37
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)	95%	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)	90%	2411.40
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet	90%	304.03
Permanent Deformation -- Asphalt Only (0.25 inch)	90%	0.11

IMPLEMENTATION CONSIDERATIONS:

KYTC Pavement design branch would need to be consulted to determine the acceptability of thermal cracking estimations outside their recommended thresholds.

VALUE ENGINEERING PROPOSAL
VE-09
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base and replace with one 4.5-inch of asphalt base						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
CL3 ASPH BASE 1.00D PG64-22	TON	153301	61.94	9,495,464	127750	61.94	7,912,835
TOTAL				9,495,000			7,913,000
						CWE (BASELINE LESS PROPOSED)	**1,582,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-10
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base
FUNCTION:	**Support Load**

BASELINE ASSUMPTION:

Four layers of 3-inch asphalt base.

PROPOSED ALTERNATIVE:

Eliminate two 3-inch layers of base.

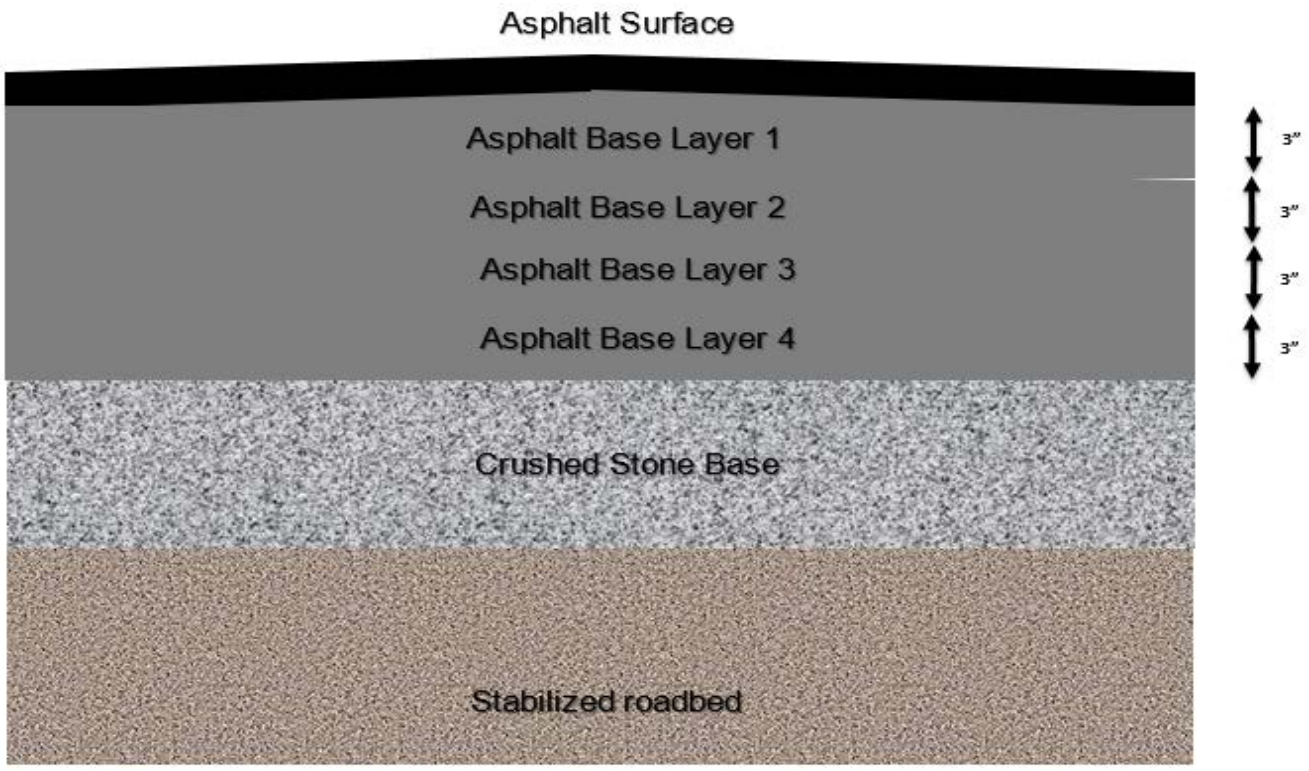
BENEFITS	RISKS/CHALLENGES
• Reduces cost	• Increase in total pavement deformation
• Little to no increase in fatigue cracking	• Large increase in thermal cracking (well above threshold)
•	• Possible reduction in pavement life cycle
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 9,495,000	$ -	$ 9,495,000
PROPOSED ALTERNATIVE:	$ 4,748,000	$ -	$ 4,748,000
TOTAL (Baseline less Proposed)	$ 4,747,000	$ -	**$ 4,747,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-10
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base

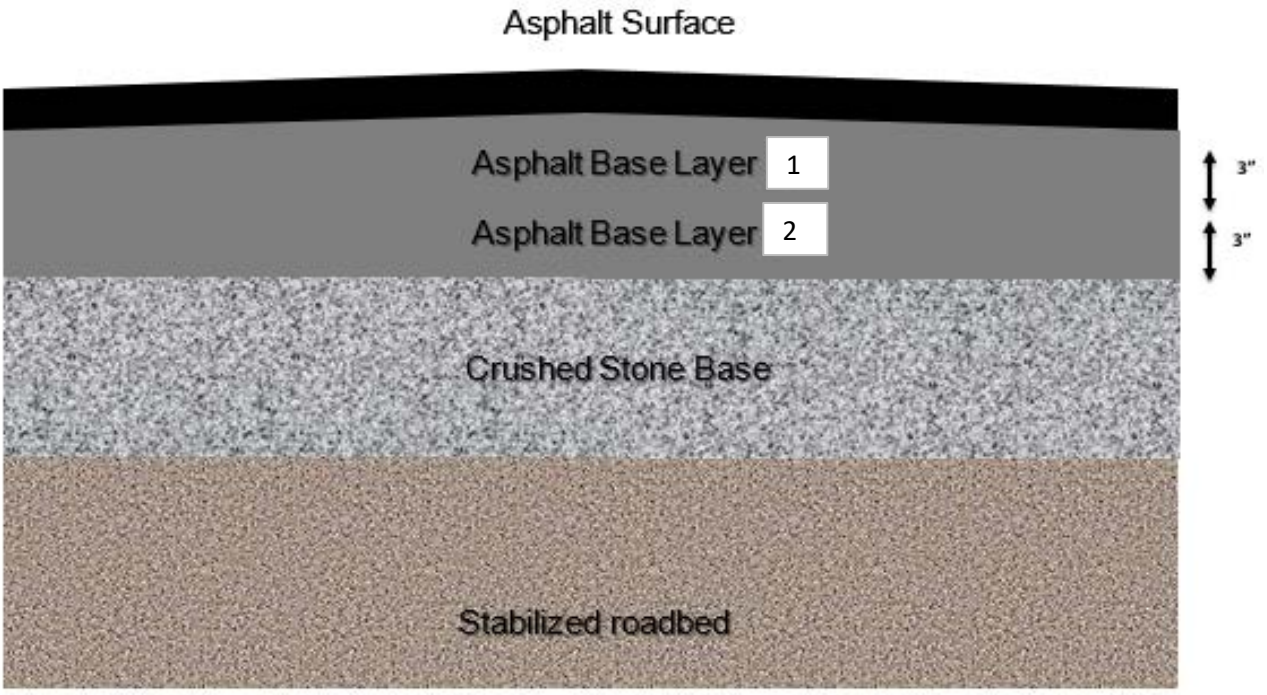
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-10
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL

VE-10

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section), Item No. 1-314.20

Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base

DISCUSSION/JUSTIFICATION:

Many considerations of this proposed alternative are similar to those in the proposed alternative of VE-08. In terms of constructability of VE-10, eliminating two 3-inch layers of base, will lower the total pavement thickness by 6 inches (the two pavement designs and their respective layer thicknesses are seen below). This would, conceivably, reduce paving time. It would also reduce compaction time and decrease the amount of time vehicles would not be using the roadway. As for maintenance of traffic, no impact would be expected. However, when considering maintainability, many factors arise. As seen in the left graphic below, KYTC has expected pavement performance values. The highlighted yellow column is the current pavement design, which has each performance criteria being met, relatively speaking. As for the graphic on the right, the design without two 3-inch layers of base, the performance parameters do not always meet requirements. For example, the asphalt thermal cracking is over triple what the current pavement design is. The asphalt top-down fatigue cracking decreased slightly. The asphalt-bottom up fatigue cracking did not change. In terms of maintainability specifically, the proposed new pavement design could generate higher annual maintenance costs due to the expected increase in cracking. More cracking would result in a need for more maintenance. This anticipated increase in cracking, and perhaps room for other "failures," could also impact safety. When considering safety, cracking, dips, and bumps could negatively affect the vehicle itself or pose as a hazard for drivers. As for schedule, a slight decrease in overall days of construction could be seen. However, this would be minor. Lastly, one positive impact of eliminating two 3-inch layers of base is the reduction in cost. A little over $4.7 million dollars could be saved by using this proposed alternative. This is the largest reduction in cost of VE-08, VE-09 and VE-10.

Trial Designs	Layer	1 inches
PG 64-22	1 Asphalt Surface	1.5
PG 64-22	2 Asphalt Base	3.0
PG 64-22	3 Asphalt Base	3.0
PG 64-22	4 Asphalt Base	3.0
PG 64-22	5 Asphalt Base	3.0
	6 Crushed Stone Base	4.0
	7 Cement Stabilized Roadbed	12.0
	Total Pavement Thickness	29.5

KYTC Pavement Performance	KYTC Reliability	
Terminal IRI (160.00)	95%	158.93
Total Pavement Permanent Deformation (0.25 inch)	95%	0.32
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)	95%	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)	90%	847.73
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet	90%	280.18
Permanent Deformation -- Asphalt Only (0.25 inch)	90%	0.07

Trial Designs	Layer	VE #1A inches
PG 64-22	1 Asphalt Surface	1.5
PG 64-22	2 Asphalt Base	3.0
PG 64-22	3 Asphalt Base	3.0
PG 64-22	4 Asphalt Base	0.0
PG 64-22	5 Asphalt Base	0.0
	6 Crushed Stone Base	4.0
	7 Cement Stabilized Roadbed	12.0
	Total Pavement Thickness	23.5

KYTC Pavement Performance Parameters	KYTC Reliability	
Terminal IRI (160.00)	95%	179.94
Total Pavement Permanent Deformation (0.25 inch)	95%	0.49
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)	95%	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)	90%	2452.77
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet	90%	257.42
Permanent Deformation -- Asphalt Only (0.25 inch)	90%	0.15

IMPLEMENTATION CONSIDERATIONS:

KYTC Pavement design branch would need to be consulted to determine the acceptability of thermal cracking estimations outside their recommended thresholds.

VALUE ENGINEERING PROPOSAL
VE-10
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate two 3-inch layers of asphalt base						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
CL3 ASPH BASE 1.00D PG64-22	TON	153301	61.94	9,495,464	76650.5	61.94	4,747,732
TOTAL				9,495,000			4,748,000
						CWE (BASELINE LESS PROPOSED)	**4,747,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL

VE-11

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section), Item No. 1-314.20

Calloway County

TITLE:	Reduce the pavement on the outside shoulders from 10 feet to 4 feet
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

The outside shoulders are 10 feet wide and fully paved.

PROPOSED ALTERNATIVE:

The outside shoulders will be 10 feet wide, with 4 feet of which will be paved.

BENEFITS	RISKS/CHALLENGES
• Reduces cost significantly	• Some degradation of use as emergency pull off
•	•
•	•
•	•
•	•
•	•
•	•

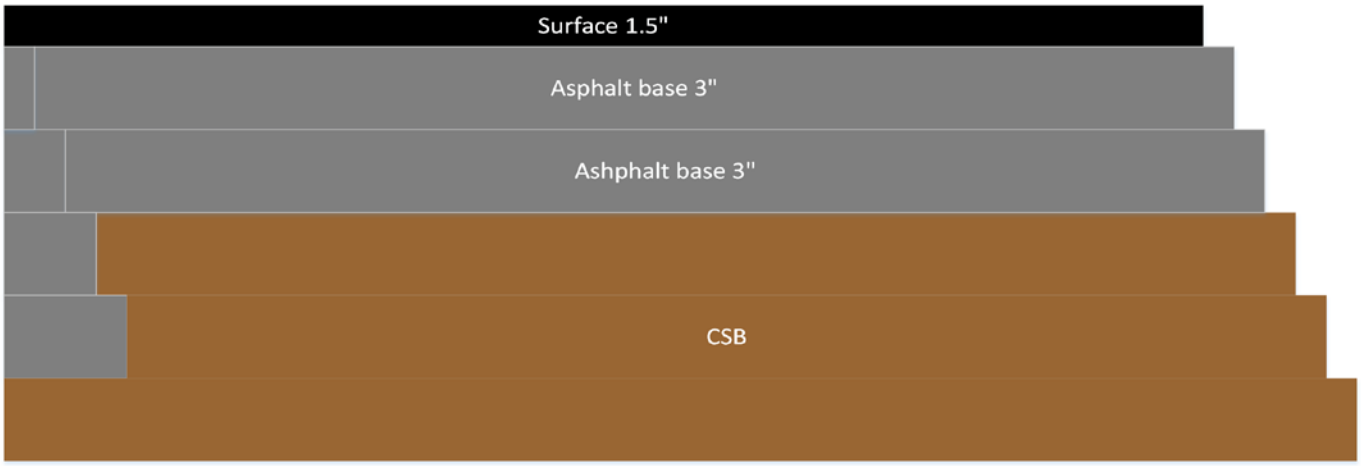
COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 1,797,000	$ -	$ 1,797,000
PROPOSED ALTERNATIVE:	$ 1,269,000	$ -	$ 1,269,000
TOTAL (Baseline less Proposed)	$ 528,000	$ -	**$ 528,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-11
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

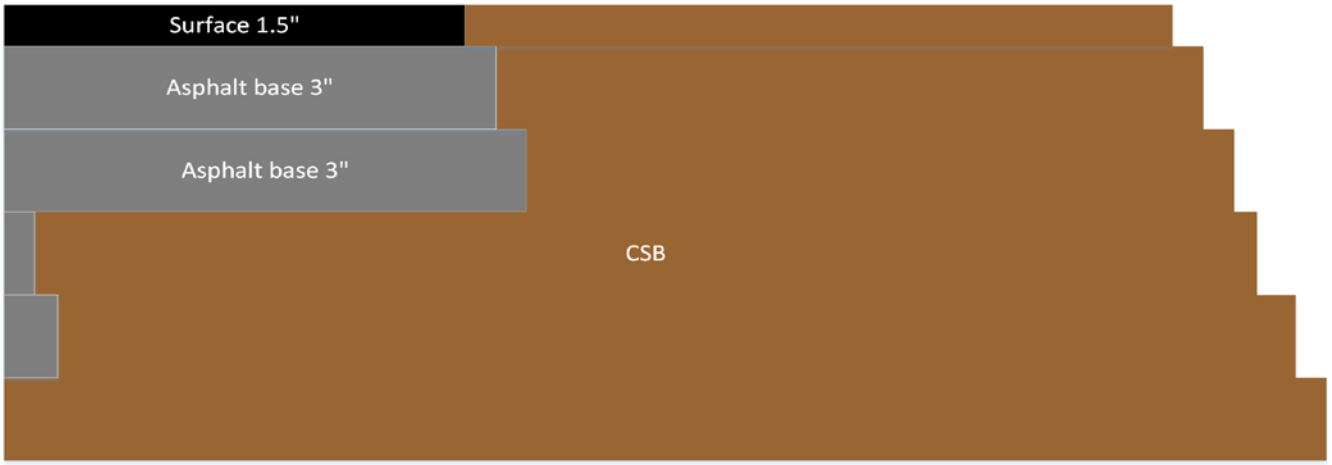
TITLE:	Reduce the pavement on the outside shoulders from 10 feet to 4 feet

SKETCH OF BASELINE ASSUMPTION & PROPOSED ALTERNATIVE

Baseline 10' Paved Shoulder



Proposed 4' Paved + 6' Rock Shoulder



VALUE ENGINEERING PROPOSAL
VE-11
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce the pavement on the outside shoulders from 10 feet to 4 feet

DISCUSSION/JUSTIFICATION:

The primary purpose of the shoulder along this section of highway is to provide a recoverable area for roadway departure and the occasional emergency parking. Additionally, because the entrances are widely spaced from the partial control of access, there are very few locations that service vehicles such as garbage or mail trucks will need to use a shoulder. Therefore, full shoulder pavement width is not necessary for the anticipated functions.

The proposal is to provide a 10-foot wide shoulder that will include 4 feet of pavement and with the remaining 6 feet built from crushed stone base (CSB.) The area with pavement will help both with long term stability of the travel lane structure, limit the raveling on the edge of pavement (if it were narrower), provide adequate space for a rumble strip and give a recoverable area on pavement should a driver drift out the travel lane.

This alternative will have little impact on project safety performance compared to the proposed design. Comparing the proposed alternative to the baseline proposed design, below are the projected crashes over a twenty period analysis timeframe:
Total Crashes: 152 (140 baseline) +8.6%
Fatal + Injury: 83 (76 baseline) +9.2%
Fatal + Serious Injury: 55 (51 baseline) +7.8%
PDO: 70 (64 baseline) +9.4%

From the Highway Safety Manual (HSM), Crash Modification Factors (CMFs) for right (outside) shoulder width on divided highways only apply to the paved shoulder width. The HSM states in Section 11.7.2 that “The effects of unpaved right shoulders on divided roadway segments and of left (median) shoulders of any width or material are unknown.” From this statement, the VE team can determine that the paved shoulder portion of the outside shoulder is all that is considered in the safety analysis. However, it stands to reason that providing a graded shoulder (of any type) would have a beneficial impact on roadway safety over the absence of a graded shoulder. While this proposal does decrease the paved shoulder portion, it does not reduce the total graded shoulder. Seeing this, the VE team reasoned that there will be a marginal impact on roadway safety as a result of changing paved shoulder width for gravel or earth shoulder width. In addition, there is no supporting evidence to show that a 10-foot paved shoulder (as proposed) is any safer than an 8’ paved shoulder; running analysis on both configurations would produce the same expected collisions as the CMF for a 10-foot shoulder as in relation to an 8’ shoulder is recommended to be 1.0.

The lesser paved shoulder width may be viewed as a “constructability” concern at the tie-ins because the extra width can be used during part width construction to keep traffic moving. For the rest of the project, since it is cross country, that should not be an issue.

VALUE ENGINEERING PROPOSAL

VE-11

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section), Item No. 1-314.20

Calloway County

TITLE:	Reduce the pavement on the outside shoulders from 10 feet to 4 feet

DISCUSSION/JUSTIFICATION:

Calculations and Assumptions:

Total Length of project is 5.666 miles (29,916.48 feet). Combine Cardinal and Non-Cardinal sides for a total 59,832.96 feet. From looking at drawing plans, about 11,700 feet have been observed to not include 10 foot paved shoulders.

Total length with 10' shoulders = 48,124

Unit prices: 1" Asphalt Surface = $3.43/SY, 1" Asphalt Base= $3.11/SY, and 1" CSB= $0.98/SY.

For 10-foot paved shoulders, ((48,132.96*10)/9)= 53,481 SY.

For 4-foot paved shoulders, ((48,132.96*4)/9)= 21,392.4 SY.

For 6 foot unpaved shoulders, ((48,132.96*6)/9)= 32,088.6 SY.

For 10-foot paved and 4-foot paved shoulders, the depth looks like: 1.5" Surface Layer, 2x 3" Asphalt Base Layers, and a 10" CSB Layer.

For 6-foot unpaved shoulders, the depth looks like: a 17.5" CSB Layer.

See Cost Sheet for continuation.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-11
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce the pavement on the outside shoulders from 10 feet to 4 feet						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Surface Layer @ 1.5"	SY	53481	5.14	274,892	21392.4	5.14	109,957
Asphalt Base @ 6"	SY	53481	18.66	997,955	21392.4	18.66	399,182
CSB @ 10"	SY	53481	9.80	524,114	21392.4	9.80	209,646
CSB @ 17.5" for the 6 feet of unpaved shoulder					32088.6	17.15	550,319
TOTAL				1,797,000			1,269,000
						CWE (BASELINE LESS PROPOSED)	**528,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-12
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce through-lane pavement width from 12 feet to 11 feet
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

Construct 12-foot through lanes.

PROPOSED ALTERNATIVE:

Construct 11-foot through lanes.

The *Option 3, Potential Cost Savings* was put forth by the design team for the Value Engineering team to evaluate. This alternate is the evaluation of the option.

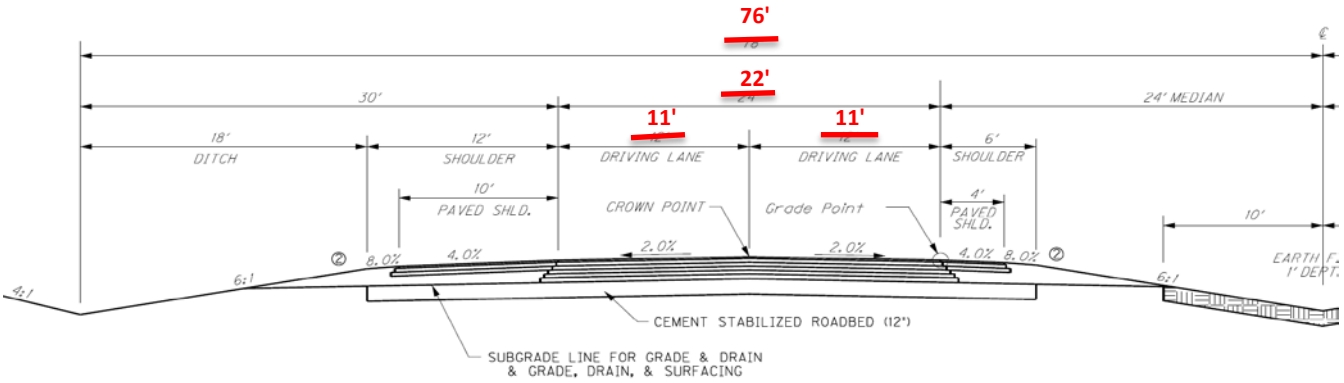
BENEFITS	RISKS/CHALLENGES
• Reduces pavement need	• Marginal increases in collision frequency
• Reduces earthwork	•
•	•
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 10,210,000	$ 893,000	$ 11,103,000
PROPOSED ALTERNATIVE:	$ 9,600,000	$ 819,000	$ 10,419,000
TOTAL (Baseline less Proposed)	$ 610,000	$ 74,000	**$ 684,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-12
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce through-lane pavement width from 12 feet to 11 feet

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-12
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce through-lane pavement width from 12 feet to 11 feet

DISCUSSION/JUSTIFICATION:

The baseline condition proposes to construct four 12-foot lanes throughout the entirety of the project.

The proposed condition is to decrease the lane width from 12 feet to 11 feet for the entirety of the project.

There are no perceived impacts to constructability, maintenance of traffic or project schedule.

The BUILD Grant application did propose to construct 12-foot lanes, and this may be an issue with the grant administrators. It is the VE team's opinion that the change in lane width does not alter the scope of the project.

There is a minor savings to long term maintenance due to decreased asphalt resurfacing needs.

IHSDM Analysis

This is a marginal detriment to expected collisions. The baseline analysis predicted 139.8 (75.8 fatal & injury, 64.0 PDO) collisions over 20 years. The analysis using 11-foot lanes instead of 12-foot predicted 141.9 (77.0 fatal and injury, 64.9 PDO) collisions over the same 20-year time period.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-12
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce through-lane pavement width from 12 feet to 11 feet						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
CL3 Asph. Surf. 0.38B PG64-22	Ton	16068	74.06	1,189,996	15079	74.06	1,116,751
CL3 Asph. Base 1.00D PG64-22	Ton	1E+05	61.94	8,211,014	1E+05	61.94	7,721,193
Crushed Stone Base	Ton	47320	17.10	809,172	44564	17.10	762,044
TOTAL				10,210,000			9,600,000
						CWE (BASELINE LESS PROPOSED)	**610,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-12

Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce through-lane pavement width from 12 feet to 11 feet

Assumptions			
Interest/Discount Rate(%):	3.0%	Economic Life (yrs):	20

LIFE CYCLE COST ANALYSIS

Salvage & Replacement Costs			Baseline Assumption		Proposed Alternative	
Item	Description	Yr	Est Cost	Pres Worth	Est Cost	Pres Worth
1	Asphalt Resurfacing	10	1,200,000	892,913	1,100,000.0	818,503
2						
3						
4						
5						
6						
7						
8						
9						
10						
Total Salvage & Replacement Costs			**1,200,000**	**892,913**	**1,100,000**	**818,503**

Annual Costs (pres worth calculated over 20 yrs)		Baseline Assumption		Proposed Alternative	
Item	Description	Est Cost	Pres Worth	Est Cost	Pres Worth
1					
2					
3					
4					
5					
Total Annual Costs					

SUMMARY	Baseline Present Worth	Proposed Present Worth
Total Present Worth (salvage+annual pres worth)	893,000	819,000
RESULTS (Proposed less Baseline)	**SAVINGS of -74,000**	

Notes: 1) Total Present Worth is rounded to the nearest thousand dollars, 2) Initial costs are covered in the Detail sheet.

VALUE ENGINEERING PROPOSAL
VE-13
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce median width from 48 feet to 40 feet
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

Construct 48-foot median (inside driving lane to inside driving lane).

PROPOSED ALTERNATIVE:

Construct 40-foot median (inside driving lane to inside driving lane). **costed alternate

As an alternative, construct 30-foot median (inside driving lane to inside driving lane).

The *Option 2, Potential Cost Savings* was put forth by the design team for the Value Engineering team to evaluate. This alternative is the evaluation of the option.

BENEFITS	**RISKS/CHALLENGES**
● Reduces earthwork	● Marginal increases in collision frequency
●	● Additional pavement width needed at U-turn locations
●	●
●	●
●	●
●	●
●	●

COST SUMMARY	**Initial Costs**	**O&M Costs**	**Total Life Cycle Cost**
BASELINE ASSUMPTION:	$ 4,760,000	$ -	$ 4,760,000
PROPOSED ALTERNATIVE:	$ 4,156,000	$ -	$ 4,156,000
TOTAL (Baseline less Proposed)	$ 604,000	$ -	**$ 604,000**
			SAVINGS

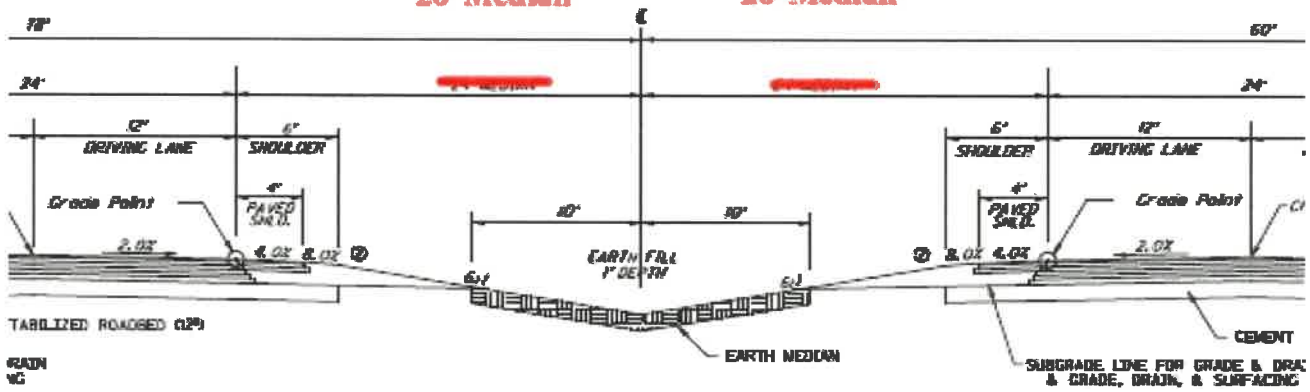
VALUE ENGINEERING PROPOSAL
VE-13
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce median width from 48 feet to 40 feet

SKETCH OF PROPOSED ALTERNATIVE

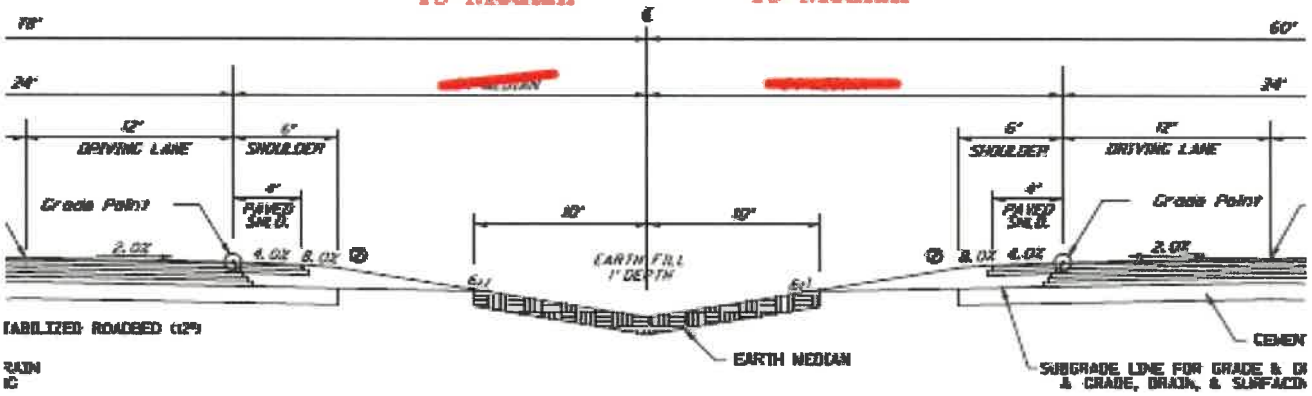
40" Median

20' Median 20' Median



30' Median

15' Median 15' Median



VALUE ENGINEERING PROPOSAL
VE-13
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce median width from 48 feet to 40 feet

DISCUSSION/JUSTIFICATION:

The baseline condition proposes to construct a 48-foot median throughout the entirety of the project.

The proposed condition is to decrease the median width from 48 feet to 40 feet (or 30 feet) for the entirety of the project.

There are no perceived impacts to constructability, maintenance of traffic or project schedule.

The BUILD Grant application did propose to construct a 48 feet median, and this may be an issue with the grant administrators. It is our opinion that the change in median width does not alter the scope of the project.

There is a minor savings to long-term maintenance due to decreased maintenance footprint.

This is a marginal detriment expected collisions. The baseline analysis predicted 139.8 (75.8 fatal & injury, 64.0 PDO) collisions. The analysis using 40-foot median instead of 48-foot predicted 142.1 (77.1 fatal and injury, 65.0 PDO) collisions over the same 20-year time period.

<u>IHSDM Analysis</u>
The analysis using 30-foot median instead of 48-foot predicted 143.5 (77.9 fatal and injury, 65.6 PDO) collisions over the same 20-year time period.

It should be noted that in the collision analysis, intersections were not considered. One would not expect much increase in intersection-related collisions associated with decreasing the median width to 40 feet; however more substantial increases may be possible when decreasing to 30-foot median.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-13
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce median width from 48 feet to 40 feet						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Embankment-In-Place	CY	680062	7.00	4,760,434	593688	7.00	4,155,816
TOTAL				4,760,000			4,156,000
						CWE (BASELINE LESS PROPOSED)	**604,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-14
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce bridge outside shoulder width from 12 feet to 4 feet
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

Bushy Creek Bridge and Tributary to Clarks River Bridge have an outside shoulder width of 12 feet.

PROPOSED ALTERNATIVE:

The width of the outside shoulder of the bridges will be reduced to 4 feet.

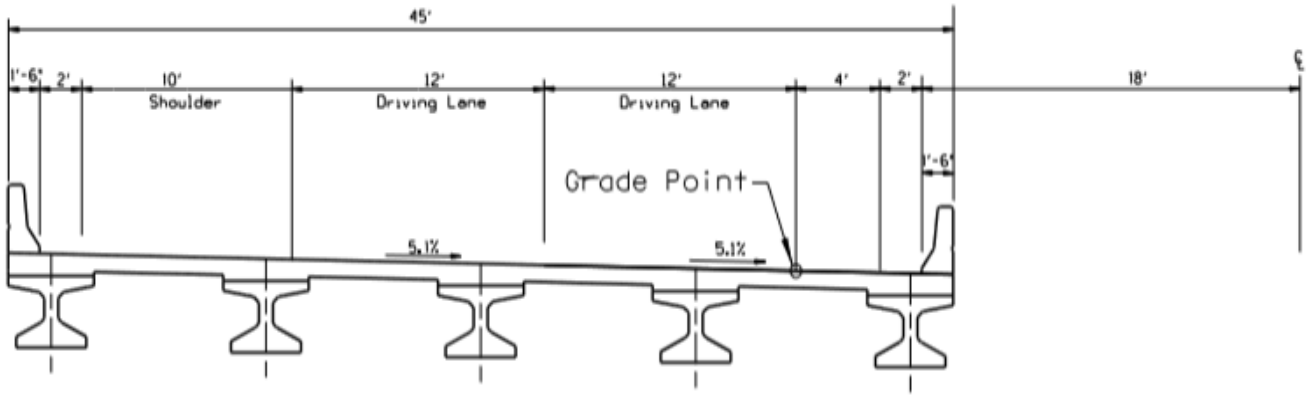
BENEFITS	RISKS/CHALLENGES
• Reduces structures cost	• Design exception would be needed
• Reduces maintenance cost over time	• Reduces safety
• Possible reduction in number of beams needed (5 to 4)	•
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 5,059,000	$ -	$ 5,059,000
PROPOSED ALTERNATIVE:	$ 4,384,000	$ -	$ 4,384,000
TOTAL (Baseline less Proposed)	$ 675,000	$ -	**$ 675,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-14
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce bridge outside shoulder width from 12 feet to 4 feet

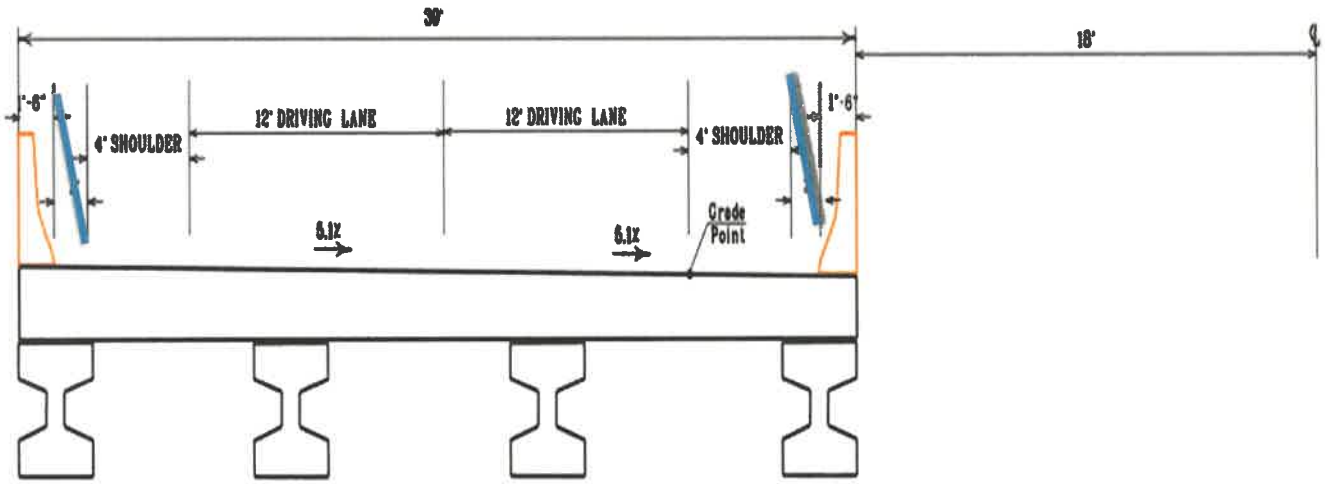
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-14
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce bridge outside shoulder width from 12 feet to 4 feet

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-14
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce bridge outside shoulder width from 12 feet to 4 feet

DISCUSSION/JUSTIFICATION:

The design typical bridge section shows an additional 2-foot outside the “shoulder” width. The total shoulder width on the bridge is 12' and the total inside shoulder width on the bridge is 6' as currently designed. As an alternative, change both the inside and outside shoulder widths to 4' total width resulting in a 10' bridge width reduction. The proposed sketch shows the additional 2 feet still included but have been marked out. Also, if 11-foot lanes were constructed, that would eliminate and additional 2 feet from each bridge (one-foot from each of the 2 lanes on each bridge).

When considering constructability of the newly design bridge with smaller outside shoulders, a "Design Exception" would need to be implemented, which is further explained below. The reduction in shoulder width would also, in terms of constructability, reduce cost. A savings of $675,000 was estimated for this 8-foot reduction. With the reduction of outside shoulder width comes a potential for a reduction in number of bridge beams (from 5 to 4 due to the reduced overall width of the bridge was 45 feet to 35 feet). In terms of maintenance of traffic, smaller shoulders would make MOT potentially more difficult. Shoulders can, temporarily, act as travel lanes for vehicles during construction. If the shoulders were only 4 feet, this would not be as feasible. 12-foot lanes can be satisfactory for a traveled lane. A diversion or detour may need to be implemented instead. As for maintainability, a smaller shoulder could potentially mean a reduction in cracks, dumps, dips, etc. simply because of probability; less pavement means less probability for "failure." A 4-foot shoulder is also not as "welcoming" for a vehicle to stop on as a 12-foot shoulder; this could mean less vehicles using the shoulder. Maintainability, however, would still be similar for both 12-foot and 4-foot shoulders. In terms of safety, a reduction in safety is possible with a smaller shoulder. Smaller shoulders can yield less room for vehicles to make emergency stops or maneuvers. Drivers also expect wider traveled lanes and more clear zone. Also, drivers thrive on consistency and if the shoulders before the bridges were 12 feet, then a reduction in shoulders on the bridges would be a change in driver expectation. Lastly, in terms of schedule, no major impact is expected. A potential in overall time (days) spent constructing the shoulders may be expected to increase.

IMPLEMENTATION CONSIDERATIONS:

Transportation agencies face an ever-increasing complex challenge of balancing available resources with priorities and needs. "Performance-Based Practical Design" challenges agencies to think beyond cost-based choices by identifying measurable or predicted performance information used to establish a relative performance value of the options, and ultimately better understand the investment value of their choices. This typically will go hand-in-hand with "Design Exceptions." A "Design Exception" is a documented decision to design a highway element or a segment of highway to design criteria that do not meet minimum values or ranges established for that highway or project. Reducing the outside shoulder width from 12 feet to 4 feet would become a "Design Exception."

VALUE ENGINEERING PROPOSAL
VE-14
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Reduce bridge outside shoulder width from 12 feet to 4 feet						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Brushy Creek Bridge	LS	1	1,934,888.00	1,934,888	1	$ 1,676,902.93	1,676,903
Trib To Clarks River Bridge	LS	1	1,786,050.00	1,786,050	1	1,547,910.00	1,547,910
Clarks River Bridge	LS	1	1,337,962.17	1,337,962	1	1,159,567.21	1,159,567
TOTAL				5,059,000			4,384,000
						CWE (BASELINE LESS PROPOSED)	**675,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-15
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Change from a 4-lane divided typical section to a 2-plus-1 roadway design
FUNCTION:	

BASELINE ASSUMPTION:

The existing design includes four travel lanes, wide shoulders, and a 48-foot depressed median.

PROPOSED ALTERNATIVE:

Use a 2+1 design approach where there is a single travel lane in each direction and a passing lane that alternates between each direction.

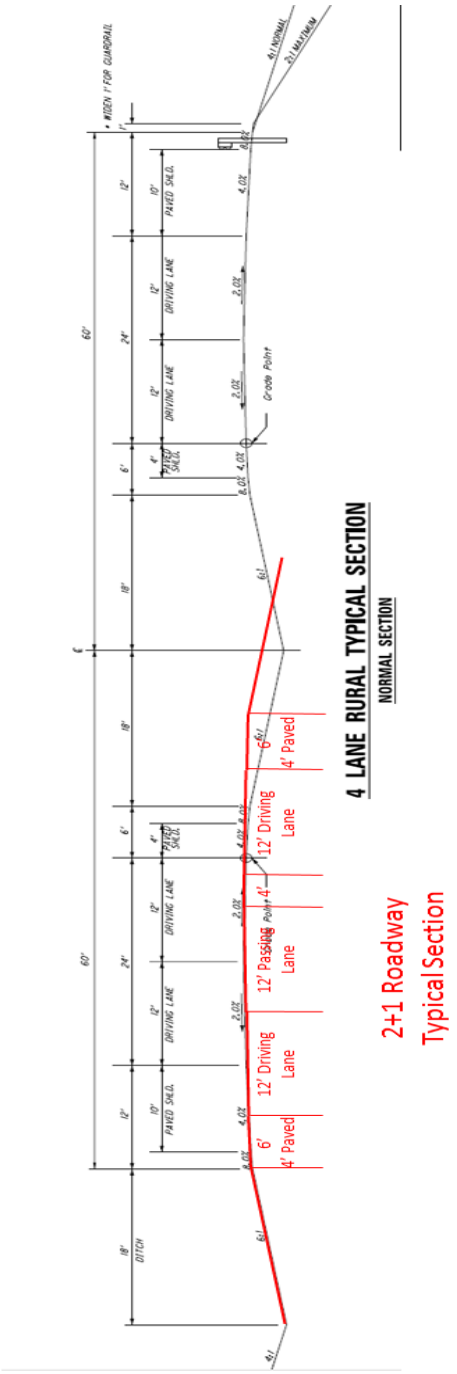
BENEFITS	RISKS/CHALLENGES
• Significantly reduces cost	• Differs from the current description in the BUILD grant agreement
• Provides adequate level of service	• Will take extra time in design to modify
• Reduces long term pavement and right-of-way maintenance costs	• Local leaders may not buy into the concept
• Ties neatly into Tennessee DOT plans to the south	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 35,758,000	$ -	$ 35,758,000
PROPOSED ALTERNATIVE:	$ 22,451,000	$ -	$ 22,451,000
TOTAL (Baseline less Proposed)	$ 13,307,000	$ -	**$ 13,307,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-15
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Change from a 4-lane divided typical section to a 2-plus-1 roadway design

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-15
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Change from a 4-lane divided typical section to a 2-plus-1 roadway design

SKETCH OF PROPOSED ALTERNATIVE

VALUE ENGINEERING PROPOSAL
VE-15
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Change from a 4-lane divided typical section to a 2-plus-1 roadway design

DISCUSSION/JUSTIFICATION:

A two lane roadway has adequate capacity to handle the current levels of traffic - just over 7000 vehicles per day. However, for Class 1 highways, LOS is determined by two measures of effectiveness:

1. Average travel speed (ATS)
2. Percent time spent following (PTSF)

By using a 2+1 roadway design, the LOS can be improved compared to a standard two-lane highway and meet the traffic needs for this project. It can also be built in a manner that would allow a future four-lane divided highway within the purchased right-of-way should traffic volumes increase to deem it necessary.

The design would include two 12-foot travel lanes, 12-foot passing lane, 4-foot flush median. One shoulder would be 10 feet (4 feet of pavement and 6 feet of CSB) and the other 4-foot paved only. This design will provide construction cost savings.

With approximately 6 miles of project length, four to five transitions can be designed. Because there are not many cross roads or entrances with significant volumes, there is flexibility in the configuration of the transitions. Additionally, with such flat terrain, slopes will not need to be a major deciding factor on the configuration. At this time, it may make sense to taper out to two lanes heading northbound from the southern end and two lanes heading southbound from the northern end.

This proposal will also tie in nicely with a three-lane section that will be the initial build typical section in Tennessee.

The VE team recognizes that this design concept deviates significantly from the original proposal and agreement for the BUILD grant. It would require FHWA headquarters approval to modify this design. With such a tight timeframe on design, it may not be possible to make this change and meet the schedule requirements. One opportunity to overcome this time constraint would be to use a Design Build procurement method.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-15
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Change from a 4-lane divided typical section to a 2-plus-1 roadway design						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Pavement (65% of original design)	LS	1	18,195,694.00	18,195,694	0.65	18,195,694.00	11,827,201
Earthwork (~70% of original design)	LS	1	680,062.00	680,062	0.7	680,062.00	476,043
CSB	LS	1	2,514,161.00	2,514,161	0.7	2,514,161.00	1,759,913
Subbase Stabilization (65% of original design)	LS	1	1,679,142	1,679,142	0.65	1,679,142	1,091,442
Drainage (not included in this calculation)							
Strucutres (3 bridges)	LS	1	5,058,900.00	5,058,900	0.5	5,058,900.00	2,529,450
Strucuture Rip Rap	LS	1	374,655.00	374,655	0.5	374,655.00	187,328
Fuel Adjustment & Asphalt Adjustment ((65% of est)	LS	1	944,277.00	944,277	0.7	944,277.00	660,994
Contingency	LS	1	3,919,222.00	3,919,222	0.7	3,919,222.00	2,743,455
Mobilization & demobilization	LS	1	2,392,013	2,392,013	0.7	1,679,142	1,175,399
TOTAL				35,758,000			22,451,000
						CWE (BASELINE LESS PROPOSED)	**13,307,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL

VE-16

Kentucky Transportation Cabinet

US 641 Reconstruction (southern section), Item No. 1-314.20

Calloway County

TITLE:	Eliminate the Hazel Connector and improve the intersection at State Line Road (i.e., roundabout)
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

To connect the new alignment to existing US 641, the proposed design includes a connector road on new alignment.

PROPOSED ALTERNATIVE:

Connect the new alignment along State Line Road. Eliminate the new connector road.

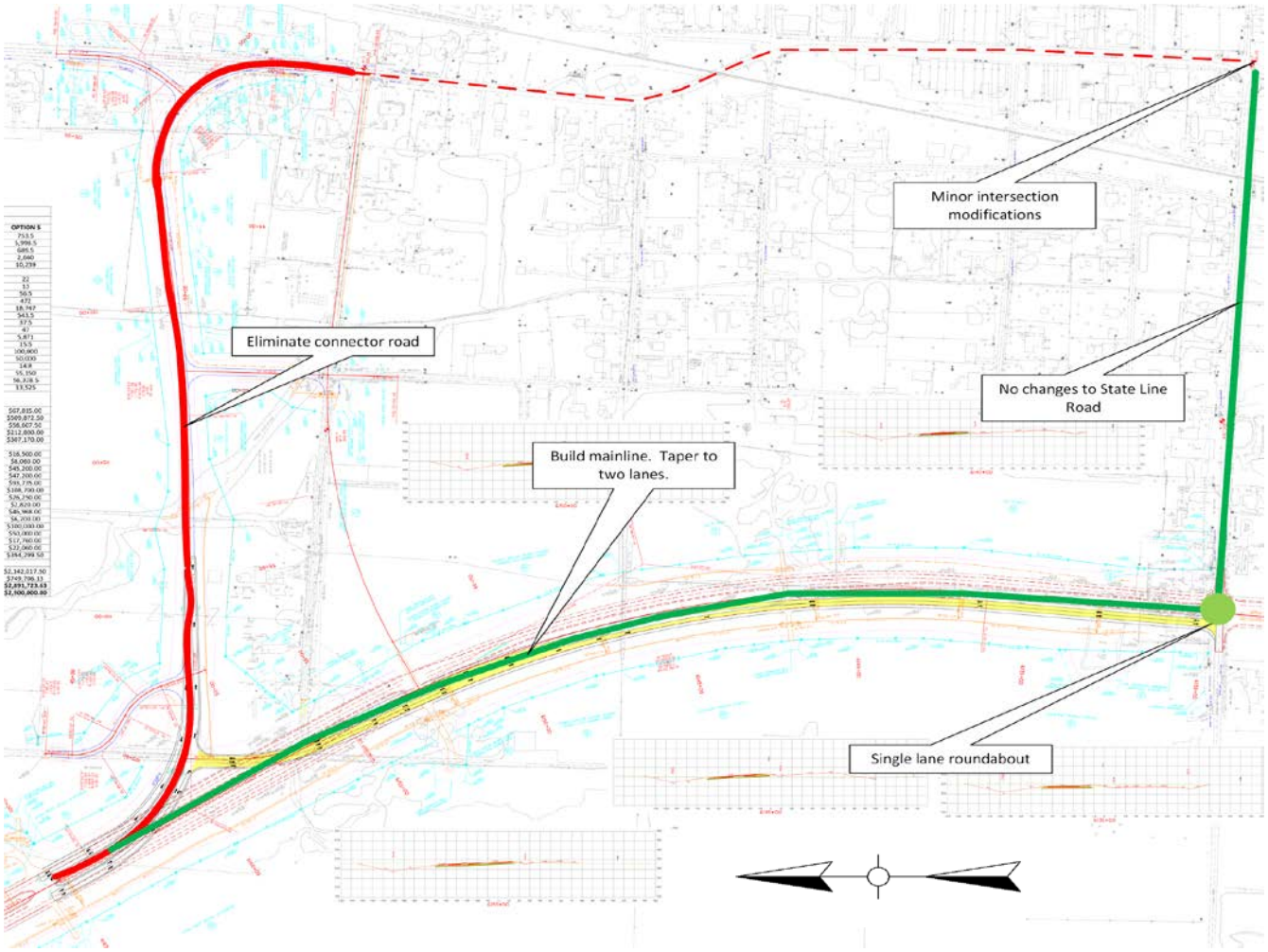
BENEFITS	RISKS/CHALLENGES
• Significant cost savings	• Challenge of high speed approach and traffic control at intersection of new route and State Line Road
• Reduces long-term maintenance	•
• Eliminates unused or underutilized right-of-way	•
•	•
•	•
•	•
•	•

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 3,580,000	$ 20,000	$ 3,600,000
PROPOSED ALTERNATIVE:	$ -	$ -	$ -
TOTAL (Baseline less Proposed)	$ 3,580,000	$ 20,000	**$ 3,600,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-16
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve the intersection at State Line Road (i.e., roundabout)

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-16
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve the intersection at State Line Road (i.e., roundabout)

DISCUSSION/JUSTIFICATION:

This recommendation would eliminate the construction of the connector that is proposed between the new alignment and existing US 641. The proposed connector primarily would serve a temporary condition until Tennessee DOT builds the portion of the new road to State Line Road from the south. This is estimated to be 10 years from now.

The primary benefit of this alternative is to provide significant cost savings. It also justifies the construction of this section of the new alignment because traffic will use it.

To accommodate traffic flow, the planned alignment would be built from approximately Station 6160+00 to Station 6130+00. The four travel lanes would be tapered to two as it approached the southern termini at State Line Road. A single lane compact roundabout could be installed to facilitate free flow movement to and from State Line Road while not impeding the through movement on the existing road. It would be expected that the roundabout would be removed and the intersection converted to an R-CUT or J-turn design once Tennessee ties into this location.

The section of State Line Road that would be used is approximately 1/4 mile long and would have a 35 mph speed limit. This roadway environment is comparable to the existing US 641 in and south of Hazel.

Modifications to the intersection at State Line Road and existing US 641 will need to be made. A four-way stop or compact roundabout are two options that will better facilitate the moderately heavy northbound left-turn movement that traffic would follow. Either of these options would also allow for easy change for local traffic flow once the mainline US 641 traffic in Tennessee is shifted to the new alignment.

The travel time between the proposed design and this VE alternative will be negligible. The total distance from station 6160+00 to the intersection of US 641/State Line Road is just under a mile for both options.

The cost estimate for the Connector Road was provided by Palmer Engineering. It includes construction, right-of-way, and utility location. Although this option would reduce the initial cost of pavement construction due to less lanes and some additional cost for a roundabout, they would be relatively small and were not included in this write-up.

IMPLEMENTATION CONSIDERATIONS:

The increase in traffic on State Line Road will be a change for the few residents whose homes access the road. However, introduction of the roundabout may introduce lower running speeds in front of their homes.

This alternative will also decrease the traffic volume through the business area of Hazel compared to the proposed design during this interim period.

Heavy truck turning movements will need to be accommodated at both intersections. Some minor right-of-way may need to be acquired to facilitate these turns.

No improvements to State Line Road appear to be warranted at this time.

VALUE ENGINEERING PROPOSAL
VE-16
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve the intersection at State Line Road (i.e., roundabout)						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Connector Road	LS	1	3,580,000.00	3,580,000		$ -	$ -
TOTAL				3,580,000			
						CWE (BASELINE LESS PROPOSED)	**3,580,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

VALUE ENGINEERING PROPOSAL
VE-16
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve the intersection at State Line Road (i.e., roundabout)

Assumptions			
Interest/Discount Rate(%):	3.0%	Economic Life (yrs):	20

LIFE CYCLE COST ANALYSIS

Salvage & Replacement Costs			Baseline Assumption		Proposed Alternative	
Item	Description	Yr	Est Cost	Pres Worth	Est Cost	Pres Worth
1	Resurfacing: 1" (2800'x32'/9)x ($3.11/SYx2/3 + $1.02)	15	30,900	19,834		
2						
3						
4						
5						
6						
7						
8						
9						
10						
Total Salvage & Replacement Costs			30,900	19,834		

Annual Costs (pres worth calculated over 20 yrs)		Baseline Assumption		Proposed Alternative	
Item	Description	Est Cost	Pres Worth	Est Cost	Pres Worth
1					
2					
3					
4					
5					
Total Annual Costs					

SUMMARY	Baseline Present Worth	Proposed Present Worth
Total Present Worth (salvage+annual pres worth)	20,000	
RESULTS (Proposed less Baseline)	SAVINGS of -20,000	

Notes: 1) Total Present Worth is rounded to the nearest thousand dollars, 2) Initial costs are covered in the Detail sheet.

VALUE ENGINEERING PROPOSAL
VE-17
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

Provide free flow access to the north side of Hazel by building a new connector road to relocated US 641 north of Hazel.

PROPOSED ALTERNATIVE:

Provide access to north side of Hazel using the existing Brandon Road corridor. Improve Brandon Road to accommodate the increase in traffic.

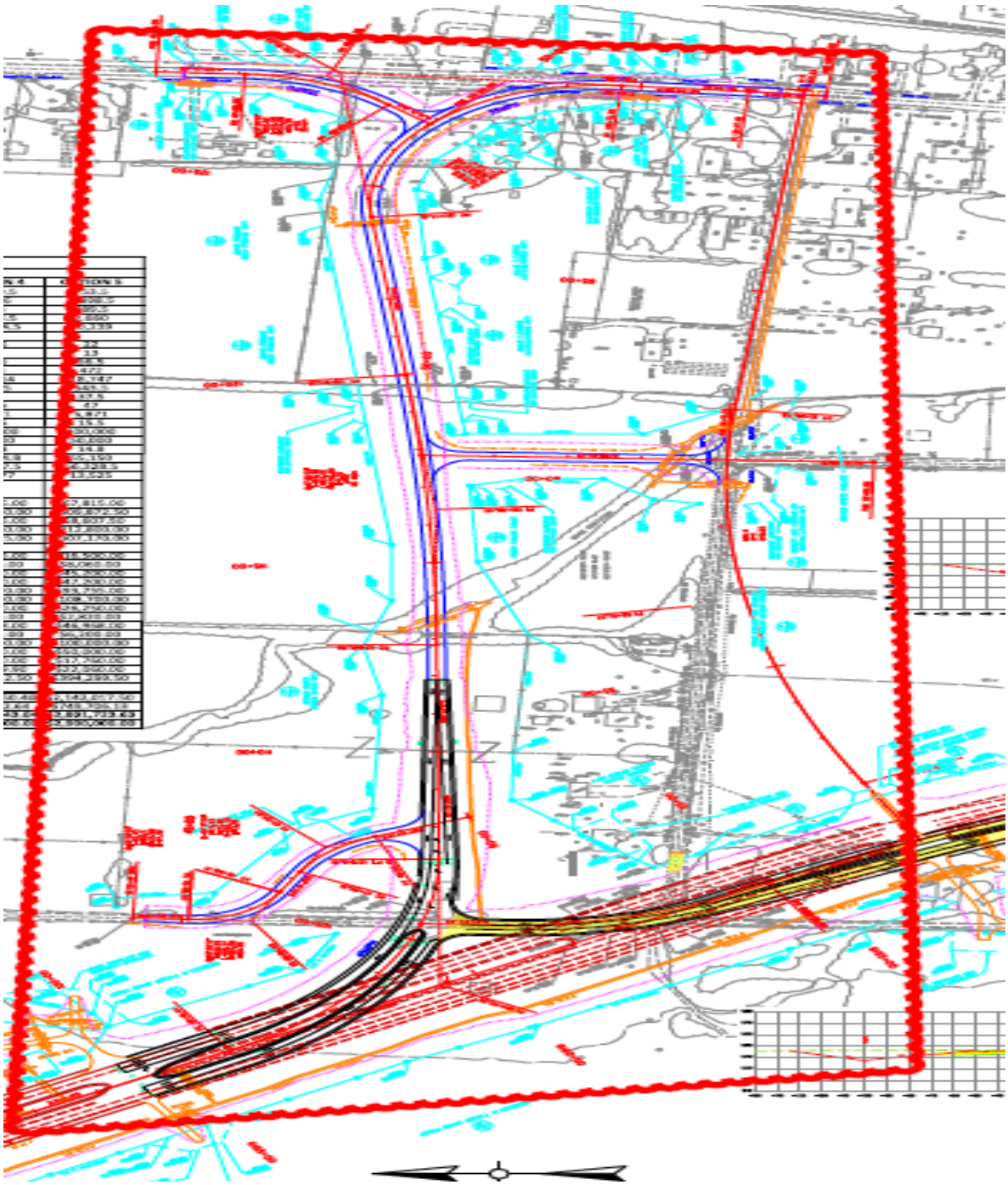
BENEFITS	RISKS/CHALLENGES
● Utilizes existing right-of-way of Brandon Road to make roadway connection north of Hazel; eliminates purchasing new right-of-way for the new connector	● Does not provide a free flow access to the north side of Hazel
● Reduces construction costs for building the northern access to Hazel; widen and provide structural overlay to Brandon Road to accommodate increase in traffic	● Potential increase in utility relocations along Brandon Road to accommodate widening
● Ultimately reduces length of roadway to be maintained by improving an existing facility rather than constructing a new one, when an improved Brandon Road serves the same purpose	● Requires bridge/drainage structures to be widened
●	●
●	●
●	●

COST SUMMARY	Initial Costs	O&M Costs	Total Life Cycle Cost
BASELINE ASSUMPTION:	$ 3,500,000	$ -	$ 3,500,000
PROPOSED ALTERNATIVE:	$ 1,902,000	$ -	$ 1,902,000
TOTAL (Baseline less Proposed)	$ 1,598,000	$ -	**$ 1,598,000**
			SAVINGS

VALUE ENGINEERING PROPOSAL
VE-17
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection

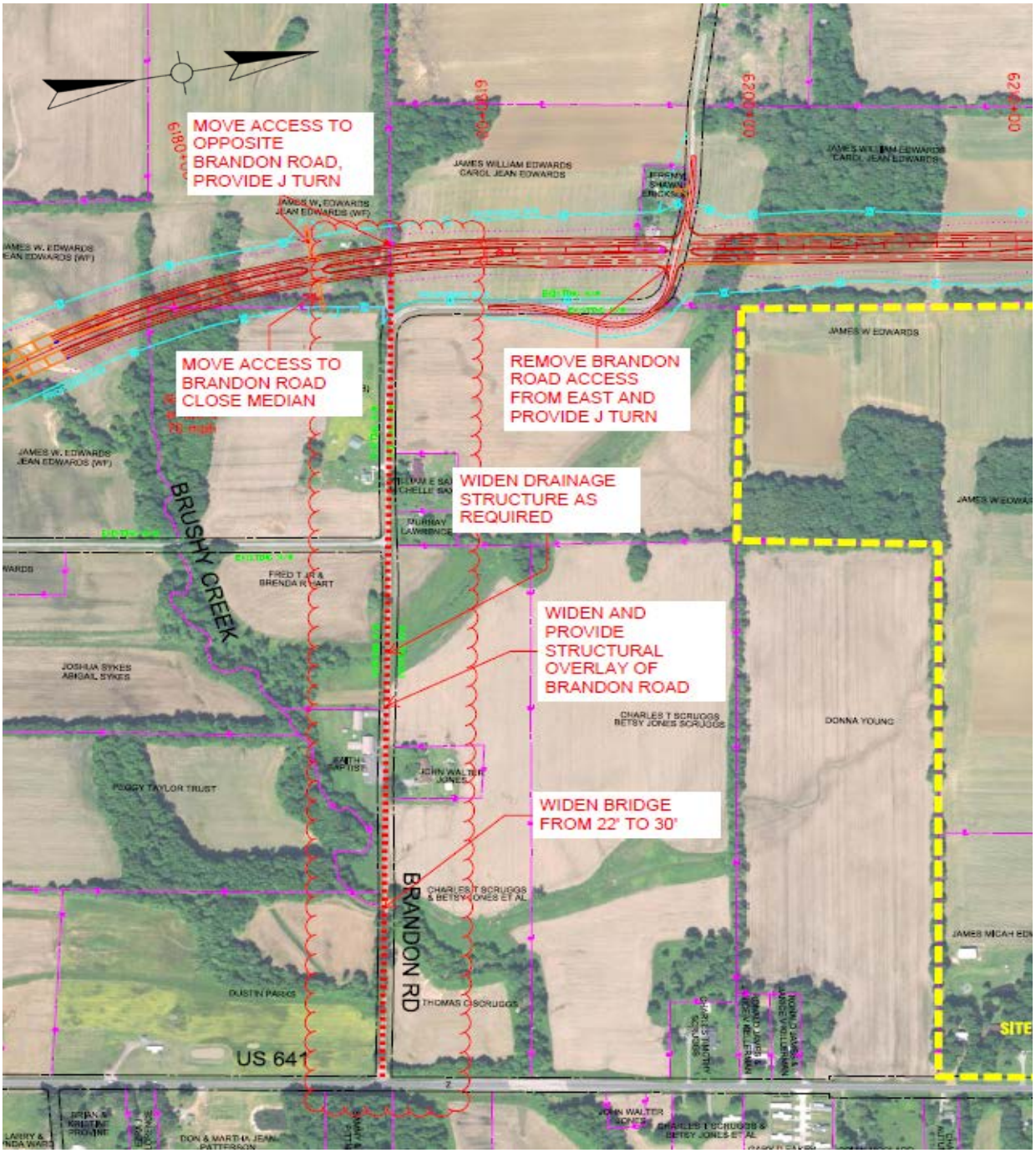
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-17
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-17
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection

DISCUSSION/JUSTIFICATION:

The purpose of the Hazel Connector in part appears to provide better access to the north side of Hazel for both the temporary and ultimate construction build out of the relocation of US 641. This proposed new roadway would have tangible benefits in terms of enhanced access, but an improvement to existing Brandon Road will also provide many of the same benefits and opportunities for northern access to Hazel at a significantly less cost. Granted, the northern access via Brandon Road would not be free flow. However, the cost of the new connector is over $3.5 million, including right-of-way.

The estimated improvements to Brandon Road can be done for $2,000,000 (including a contingency for utility relocations and minimal right-of-way). Also, with this proposal, one side of the Brandon Connector (approximately 800 feet) can be eliminated. It is anticipated that the value of this work would easily cover the costs for constructing the J-hooks proposed for mainline to address the proposed modifications for access.

The eastern portion of Brandon Road at the US 641 intersection (along with existing US 641) is currently in the flood plain. However, with construction of the new US 641, access to Hazel during flood events will be maintained, even if Brandon Road floods.

In regards to future maintenance commitments, if the new connector is built, KYTC or Calloway County will be responsible for maintenance of this roadway as well as Calloway County will still own Brandon Road. Ultimately, best case scenario from maintenance perspective for both KYTC and Calloway County is only an improved Brandon Road is in the roadway system.

IMPLEMENTATION CONSIDERATIONS:

Right-of-way for the project is currently being purchased. If right-of-way for the Hazel Connector has already been purchased, this option is less attractive from an overall budgetary perspective.

VALUE ENGINEERING PROPOSAL
VE-17
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection						
DESIGN ELEMENT	**BASELINE ASSUMPTION**				**PROPOSED ALTERNATIVE**		
Description	Unit	Qty	Unit Cost $	TOTAL $	Qty	Unit Cost $	TOTAL $
Hazel Connector (including ROW)	LS	1	3,500,000.00	3,500,000			
Brandon Road Improvement - Structure Replacement & Widening (USING BRIDGING KY COST ESTIMATES)	SF				900	400.00	360,000
Brandon Road Improvement - Drainage Structure Widening (assume 72" pipe)	LF				24	278.00	6,672
Brandon Road Improvement - 3400 feet Pavement, 22 Feet wide with 2 feet shoulders	TON				3430	60.00	205,800
Brandon Road Improvement - 3400 feet CSB, 22 Feet wide with 2 feet shoulders (12 feet widening)	TON				1200	17.00	20,400
Brandon Road Improvement - 3400 feet Cement Stabilize, 22 Feet wide with 2 feet shoulders (12 feet widening)	SY				4800	2.34	11,232
Brandon Road Improvement - 3400 feet Cement Stabilize, 22 Feet wide with 2 feet shoulders (12 feet widening)	TON				140	101.20	14,168
Earthwork	CY				4800	7.00	33,600
Utilities	LS				1	500,000.00	500,000
ROW	LS				1	300,000.00	300,000
30% contingency	LS				1	450,000.00	450,000
TOTAL				3,500,000			1,902,000
						CWE (BASELINE LESS PROPOSED)	**1,598,000**

Note: Total costs are rounded to the nearest thousand dollars.

SAVINGS

DESIGN SUGGESTIONS

VALUE ENGINEERING PROPOSAL
VE-18
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Build land bridge over gaslines
FUNCTION:	**Cross Gasline**

BASELINE ASSUMPTION:

Cross gaslines with seven feet minimum cover over top of lines under pavement and five feet minimum cover in the ditch lines. Protection for crossing gaslines must be maintained at all times during construction, including the use of temporary crossing protection.

PROPOSED ALTERNATIVE:

Consider use of land bridge for short, perpendicular gasline crossings at Tom Taylor Trail and the northern approach at approximately Station 6420+00 in lieu of raising the profile grade of mainline.

BENEFITS	RISKS/CHALLENGES
• Reduces embankment in place required for mainline roadway construction	• Need concurrence from TC Energy this is acceptable
• Installation of land bridge would eliminate most of the cost (and safety concerns) for the equipment crossing the gas lines during construction	•
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DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-18
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Build land bridge over gaslines

DISCUSSION/JUSTIFICATION:

The VE team suggests consideration be given to constructing a land bridge over the perpendicular gas line crossings at Tom Taylor Trail and the northern approach road at approximately Station 6420+00. As detailed in the VE proposal VE-03, if the profile did not have to be raised in the area of the Tom Taylor approach, the embankment in place could be reduced approximately 30,000 cubic yards, with a value of at least $210,000 using a unit price of $7 per cubic yard. Based on recent bids for earthwork in the area of the project ($14 per cubic yard), the VE team believes that finding ways to minimize the earthwork will be extremely cost effective. The use of the land bridge, if agreed to by TC Energy, is worth considering. The land bridge, if installed early, would eliminate the need for temporary crossing preparation work during construction (the contractor would drive over the bridge once installed) and would greatly decrease the likelihood of an accident involving the line once it is protected. The VE team recommends the Design Team explore this option further with TC Energy.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-19
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Use different superelevation table on the approaches
FUNCTION:	**Optimize Geometry**

BASELINE ASSUMPTION:

The approach road design speed varies, appear to use the 8% superelevation tables throughout.

PROPOSED ALTERNATIVE:

Consider use of the 4% or 6% superelevation tables for the approaches with stop conditions prevalent.

BENEFITS	RISKS/CHALLENGES
• Use of 4% or 6% superelevation tables as part of the design allows more flexibility with the superelevations for the horizontal curves	• None apparent
• Allows smoother grading transitions at approach road intersections, especially with stop conditions prevalent	•
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DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-19
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Use different superelevation table on the approaches

DISCUSSION/JUSTIFICATION:

The VE team suggests consideration be given to a reduced design speed for the approach roads, primarily in regards to the superelevations being used for the horizontal curves. It appears the 8% super tables are being used when the curves for the approach roads end with stop conditions. The 4% and 6% super elevations will allow for smoother transitions with no compromises in safety.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-20
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Use the 12-inch Cement Stabilized Roadbed
FUNCTION:	**Support Load**

BASELINE ASSUMPTION:

In their 11/18/2019 presentation, Palmer Engineering included a Pavement Design spreadsheet that laid out some potential pavement designs. The recommended design reduced the Cement Stabilized Roadbed (CSR) from 12 inches (recommended in Geotechnical report) to 8 inches.

PROPOSED ALTERNATIVE:

The VE team recommends keeping the CSR as 12 inches and not to change to an 8-inch CSR.

The *Option 1, Potential Cost Savings* was put forth by the design team for the Value Engineering team to evaluate. It was decided not to consider this option.

BENEFITS	RISKS/CHALLENGES
• Long term stability of the subbase	• Additional material (cement) cost
• Additional stability to prevent pavement cracking or failure	•
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DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-20
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Use the 12-inch Cement Stabilized Roadbed

DISCUSSION/JUSTIFICATION:

It is the VE team's suggestion to keep the 12 inches CSR due to the area in which the project is being built in. This area is mainly farmland, and due to that, the soil strength might not be as high. Cutting the CSR from 12 inches to 8 inches might cause issues such as subbase failure that could be avoided if keeping CSR at 12 inches.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-21
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Set-up quantities for rock roadbed for areas where cement is not feasible
FUNCTION:	**Support Load**

BASELINE ASSUMPTION:

Specify 12 inches of cement stabilization specified for entire alignment.

PROPOSED ALTERNATIVE:

Specify 18 inches of rock roadbed in areas where uneconomical or infeasible for construction of cement stabilized roadbed.

BENEFITS	RISKS/CHALLENGES
• Sets unit price for bid items at letting rather than negotiating in construction	• None apparent
• Allows flexibility to use different roadbed stabilization where necessary	•
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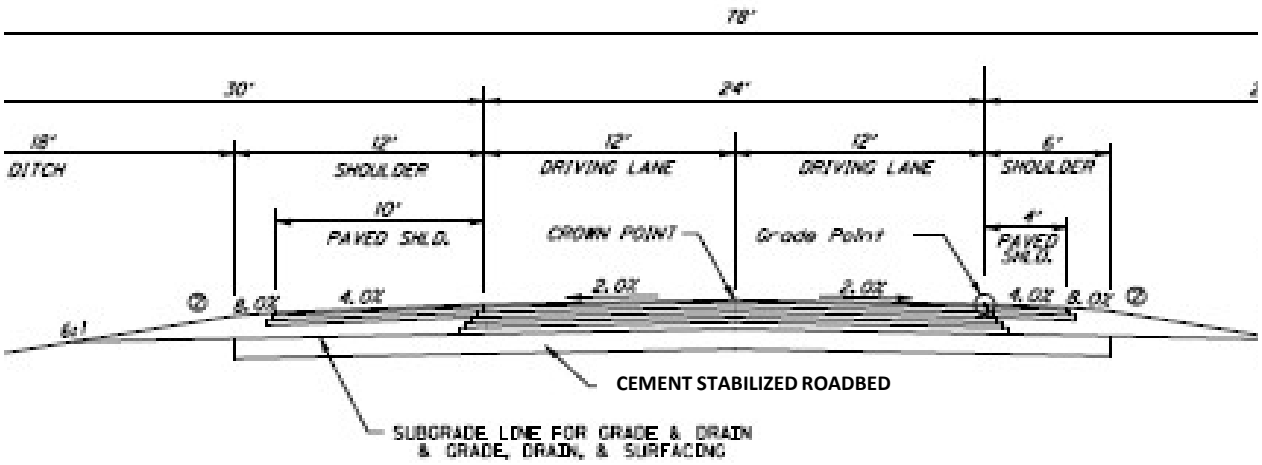
DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-21
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Set-up quantities for rock roadbed for areas where cement is not feasible

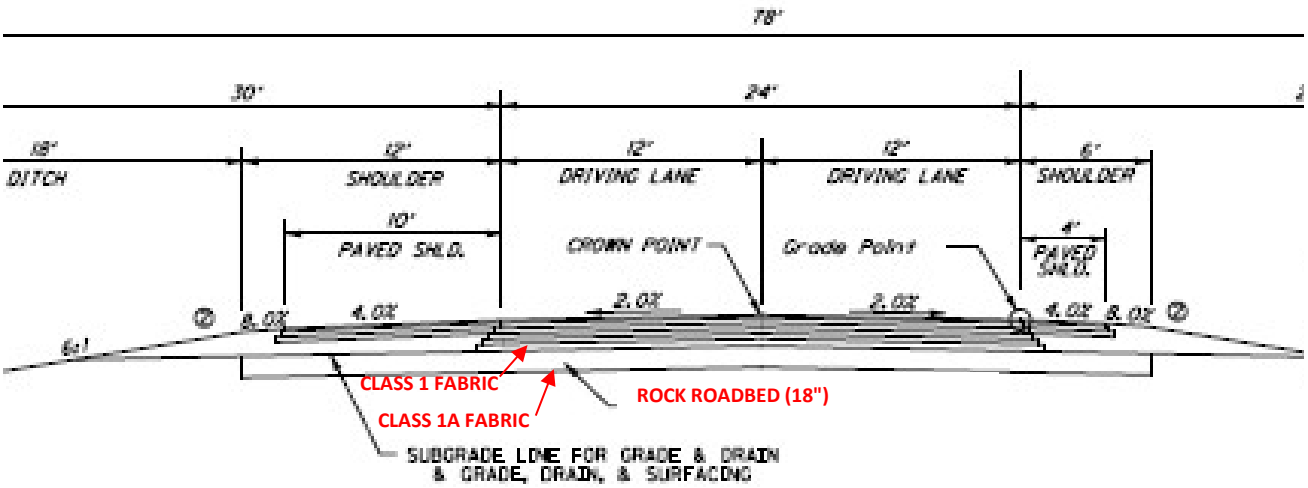
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-21
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Set-up quantities for rock roadbed for areas where cement is not feasible

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-21
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Set-up quantities for rock roadbed for areas where cement is not feasible

DISCUSSION/JUSTIFICATION:

The baseline situation specifies constructing a cement stabilized roadbed for the entire US 641 alignment.

The proposal is to establish quantities for an equivalent rock roadbed thickness to be used where cement stabilization equipment is uneconomical to use or where it is necessary to maintain traffic across the new alignment. This may include locations where tying into the old road or maintain access across the new road during construction.

There are no perceived impacts to constructability, long-term maintenance, vehicular safety, overall project schedule or conformance with the BUILD Grant application.

There are benefits to the construction maintenance of traffic in that the rock roadbed allows the contractor to maintain traffic across the new alignment whereas the cement must cure for a time period before allowing traffic on it.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-22
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Set-up quantities for granular embankment
FUNCTION:	**Support Load**

BASELINE ASSUMPTION:

No quantities have yet been set up for gravel embankment.

PROPOSED ALTERNATIVE:

Provide quantities for geotextile fabric and granular embankment.

BENEFITS	RISKS/CHALLENGES
• Provides means to remediate areas anticipated to be unsuitable for embankment construction	• None apparent
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•	•
•	•
•	•
•	•
•	•

DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-22
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Set-up quantities for granular embankment

DISCUSSION/JUSTIFICATION:

The VE team suggests to establish quantities for geotextile fabric and granular embankment to be used to provide a working platform for construction of the roadway embankments in areas anticipated to need remediation, such as the wetlands near the new bridges over Brushy Creek.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-23
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the shoulder widening for guardrail and specify using 7-foot guardrail posts
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

Guardrail with 6-foot posts to be installed at locations to reduce severity of crashes. The use of 6-foot posts requires the shoulders to be widened an additional 1-foot to support the post.

PROPOSED ALTERNATIVE:

Use guardrail with 7-foot posts at locations to reduce severity of crashes. The use of 7-foot posts eliminates the need to widen the shoulders an additional one-foot.

BENEFITS	RISKS/CHALLENGES
• Equal performance to guardrail with 6-foot posts	• None apparent
• Eliminates shoulder widening and thus reduces costs for earthwork and crushed stone base shoulder material	•
•	•
•	•
•	•
•	•
•	•

DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-23
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Eliminate the shoulder widening for guardrail and specify using 7-foot guardrail posts

DISCUSSION/JUSTIFICATION:

The use of 7-foot guardrail posts in lieu of 6-foot guardrail posts is allowed by KYTC standards. For this project, which is an embankment in place earthwork job, minimizing the embankment in place needed to widen the typical section for one foot extra to install guardrail with 6-foot posts, plus the additional crushed stone base needed to construct the graded shoulder, would reduce the costs of the project with no impacts to performance of the guardrail system.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

VALUE ENGINEERING PROPOSAL
VE-24
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Review the Hazel Connector Options 1-5
FUNCTION:	**Convey Traffic**

BASELINE ASSUMPTION:

Preferred option under review.

PROPOSED ALTERNATIVE:

Option 5 with modifications to only place pavement for 2 lanes. Grade work to be done for future template to serve as a source of borrow material for construction of main project corridor. (Also see VE-16 and VE-17 for suggestions on the Hazel Connection.)

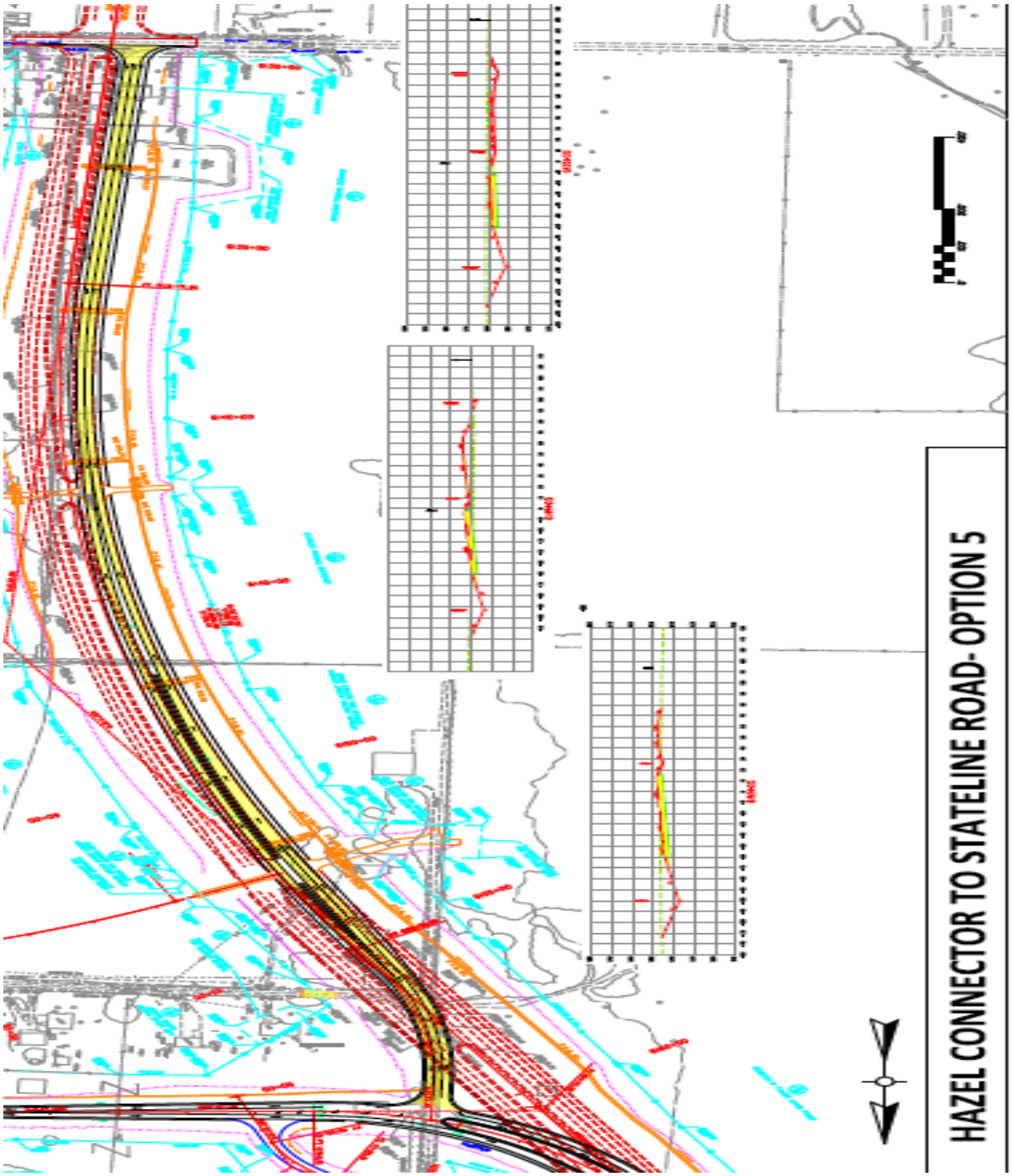
BENEFITS	RISKS/CHALLENGES
• Provides desired temporary connectivity at minimal cost	• Potential increase of maintenance of graded area
• Provides for more flexibility with future alignment extending south to Tennessee	•
• Generates additional borrow material for use in construction of the overall project, reducing costs and environmental impacts	•
•	•
•	•
•	•
•	•

DESIGN SUGGESTION

VALUE ENGINEERING PROPOSAL
VE-24
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Review the Hazel Connector Options 1-5

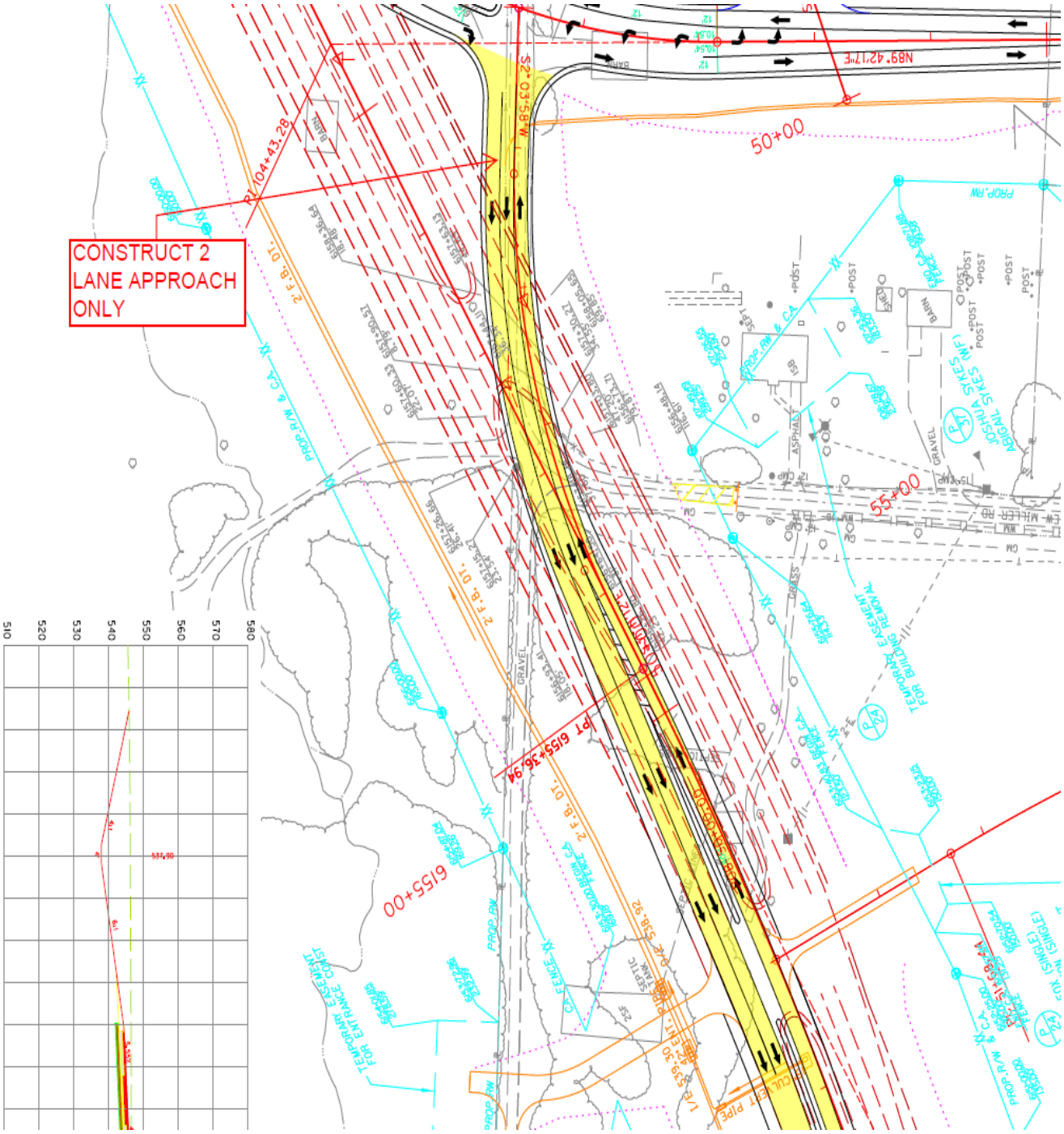
SKETCH OF BASELINE ASSUMPTION



VALUE ENGINEERING PROPOSAL
VE-24
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Review the Hazel Connector Options 1-5

SKETCH OF PROPOSED ALTERNATIVE



VALUE ENGINEERING PROPOSAL
VE-24
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

TITLE:	Review the Hazel Connector Options 1-5

DISCUSSION/JUSTIFICATION:

The VE team reviewed the Hazel Connector Options 1-5 and the results of review are shown below.

Creative Idea No. CT-13: The VE team does not recommend Hazel Connector to Stateline Road Options 1, 3 and 4

Hazel Connector to State Line Road, Option 1 - Significant cost with less flexibility for future project

Hazel Connector to State Line Road, Option 3 - Significant cost with less flexibility for future project

Hazel Connector to State Line Road, Option 4 - Significant cost with less flexibility for future project

Hazel Connector to Stateline Road Option 2 - This is option with lowest initial cost and most flexibility. However, if project is delayed a substantial amount of time, some level of access to State Line Road beyond the free flow connector could be warranted. Also, the VE team expressed a concern that the right-of-way purchased for this piece could be eligible to revert back to the original property owner, placing the extension of the overall project in jeopardy.

Creative Idea No. CT-14: Hazel Connector to Stateline Road - Option 2: Flatten backslope 6:1 (left side) to provide a borrow source: Based on review of the cross sections, there appears to be sufficient room on the proposed ROW to flatten the backslopes from 4:1 as shown to 6:1. This would provide additional material to construct the remainder of the roadway and make maintenance (mowing) easier as well as improve slope stability.

Creative Idea No. CT-15: Hazel Connector to Stateline Road - Option 5: Pave two lanes only: With the current plans to construct a separate free flow connector to the north side of Hazel, only a two lane temporary approach to State Line Road at the intersection with the free flow connector would be necessary. Cost savings on temporary pavement and medians could be realized with this approach.

IMPLEMENTATION CONSIDERATIONS:

None apparent.

SECTION 6:

APPENDICES

Section 6: Appendices

Appendix A – Study Participants

VALUE ENGINEERING STUDY ATTENDEES

Kentucky Transportation Cabinet (KYTC)
US 641 Reconstruction (southern section) Project, Item No. 1-314.20
Calloway County

November				Name	Organization	Position	Office Phone Mobile Phone	Email
18	19	20	21					
✓	✓	✓	✓	Brent Sweger	KYTC	Manager, Quality Assurance Branch	502-782-4912 410 693 5822	Brent.Sweger@ky.gov
✓			✓	Chris Kuntz	KYTC	Project Manager		Chris.Kuntz@ky.gov
✓	✓	✓	✓	Jason Harrod	KYTC	Transportation Engineering Technologist III	502-782-5059 502-564-3280	Justin.Harrod@ky.gov
✓			✓	Gary Sharpe	Palmer Engineering	Consultant Project Manager	859-744-1218 859-221-6912	GSharpe@palmernet.com
✓	✓	✓	✓	Jason Littleton	American Engineers	VE Team SME	502-245-3813 859-576-4192	jlittleton@aei.cc
✓	✓	✓	✓	Robert Martin	Qk4	VE Team SME	502-435-2140	rmartin@qk4.com
✓	✓	✓	✓	Andy Gilley	Qk4	VE Team SME	270-801-0091 ext. 6301	agilley@qk4.com
✓	✓	✓		Pat Miller	RHA, LLC	VE Team Leader (CVS)	602-493-1947 480-773-8533	patrice@teamrha.com
✓			✓	Tim Layson	KYTC	CO Design	502-564-3280	Tim.Layson@ky.gov

T=via Telephone

VALUE ENGINEERING STUDY ATTENDEES

Kentucky Transportation Cabinet (KYTC)
US 641 Reconstruction (southern section) Project, Item No. 1-314.20
Calloway County

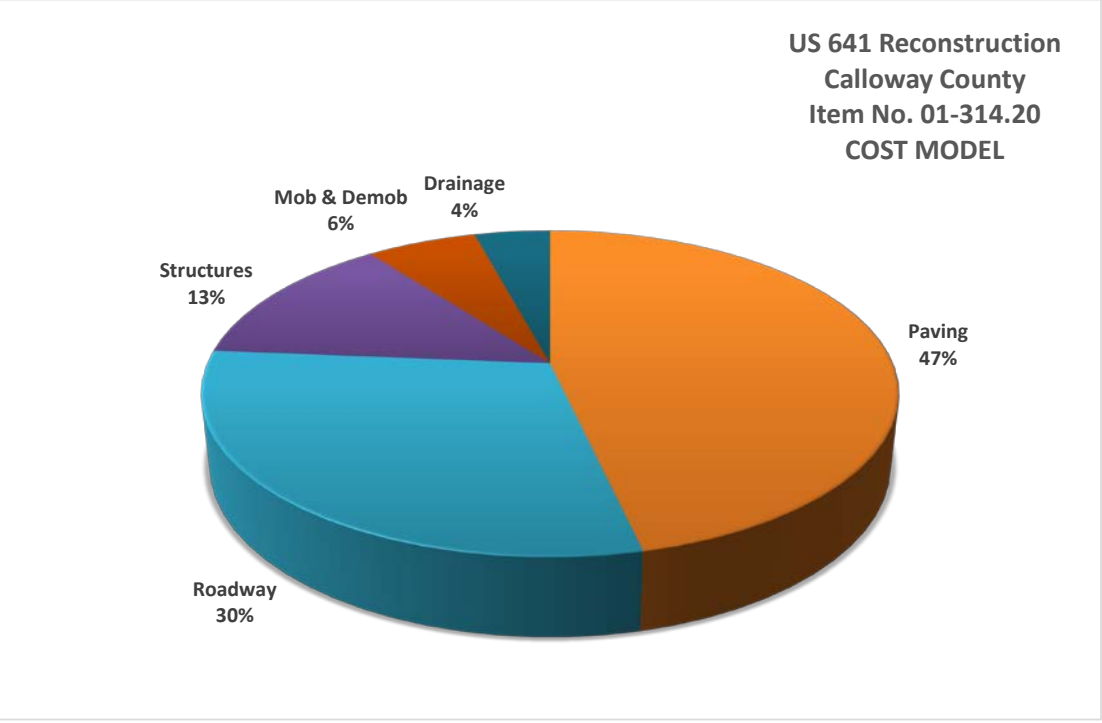
November				Name	Organization	Position	Office Phone Mobile Phone	Email
18	19	20	21					
✓			✓	Kyle Peat	KYTC	District Engr.		
✓			✓	Susan Oatman	KYTC	Prog Management		Susan.Oatman@ky.gov
✓	✓		✓	J. Moore	"		502-227-5288	
	✓	✓		Connor Schuyrm	"			Connm.Schuyrm@ky.gov
			✓	DAVID LINDEMAN	PALMER		859-744-1218	dlindeman@palmernets.com
			✓	Eileen Vaughan	FHWA	Engineer	502-223-6740	eileen.Vaughan@dot.gov
			✓	DAVID WHITWORTH	FHWA	TEAM LEADER	502-223-6741	david.whitworth@dot.gov
			✓	MICHAEL LOYOLA	FHWA	Major Proj Eng	502 223 6788	michael.loyola@dot.gov

T=via Telephone

Appendix B – Pareto Cost Model

Cost model (following page) was prepared from the cost estimate data provided by Palmer Engineering. The model is organized to identify major tasks and KYTC's estimated costs of total project cost for the significant cost items. The cost models clearly illustrated the cost drivers for the project and were used to guide the VE study team during the workshop.

Item Code	Description	Estimated Cost	% Total	% Cumm	# Line Items	
0001	Paving	$ 18,195,694	46.4%	46.4%	13	9%
0002	Roadway	$ 11,704,963	29.9%	76.3%	73	49%
0004	Structures	$ 5,258,100	13.4%	89.7%	6	4%
0005	Mob & Demob	$ 2,392,014	6.1%	95.8%	2	1%
0003	Drainage	$ 1,641,450	4.2%	100.0%	54	36%
	TOTAL	**$ 39,192,222**			**148**	**100%**



Cost Observations

During the workshop, the VE team made the following observations of the cost estimate dated 10/22/2019:

- Earthwork cost seems low @ $7.00/CY; should be more like $18.00/CY
  - Project cost delta of $7.5M higher (adds $7.5M to project cost)
- Crushed stone cost seems low @ $17.00/ton; should be more like $25.00/ton
  - Project cost delta of $1.1M higher (adds $1.1M to project cost)
- Cement cost seems low @ $101.20/ton; should be more like $180.00/ton (per average unit prices from 2018)
  - Project cost delta of $730,000 higher (adds $730,000 to project cost)
- Brushy Creek bridge cost seems low at $1.9M
- 10,000 LF of guardrail seems like a high quantity, especially for flat land
- $750,000 of clearing and grubbing seems high for project that is characterized by an open field

Appendix C – Function Analysis

Function definition and analysis is the heart of Value Engineering. It is the primary activity that separates VE from all other "improvement" programs. The objective of this phase is to ensure the entire team agrees upon the purposes for the project elements. Furthermore, this phase assists with development of the most beneficial areas for continuing study.

The VE study team identified the functions of the **US 641 Reconstruction Project** using active verbs and measurable nouns. This process allowed the team to truly understand the functions associated with the project. A Random Function Identification Worksheet is provided below.

FUNCTION IDENTIFICATION		FUNCTION CLASSIFICATION	HIGH COST?	HIGH RISK?
ACTIVE VERB	MEASUREABLE NOUN			
Reduce	*Crashes*	*Higher Order*		
Improve	**Safety**	**Basic**		
Cross	Creek	Secondary	YES	YES
Cross	Gas-line	Secondary	YES	YES
Meet	Schedule	Secondary		YES
Meet	Commitments	Secondary		YES
Stay-in	Footprint	Secondary		
Convey	Traffic	Secondary		
Connect	Roadway	Secondary		
Support	Load	Secondary	YES	
Support	Subgrade	Secondary	YES	
Create	Access	Secondary		
Maintain	Access	Secondary		
Control	Access	Secondary		
Minimize	Environmental-impacts*	Secondary	YES	YES
Optimize	Geometry	Secondary		
Maintain	Driver-expectations	Secondary		
Obligate	*Funds*	*Lower Order (Assumed)*		
Complete	*Design*	*Lower Order (Assumed)*		

*(includes wetlands, historic properties, channel changes)

High cost and/or high risk functions were identified using cost data and the VE study team expertise. The VE study team identified **Improve Safety** as the basic function of the project.

The definitions of the classifications are:

- **Higher Order Function** defines the specific goal or need for which the basic function exists and is outside the scope of the project under study.
- **Basic Function** defines the specific purpose(s) for which a project exists; it answers the question, "What must it do?"
- **Secondary Function** supports the basic function or required secondary function(s) and results for the specific design approach to achieve the basic function; answers the question, "What else do we want or does it do?"
- **Lower Order Function** is a function that is selected to initiate the project and is outside the scope of the subject under study.

Appendix D – Creative Idea List and Evaluation

Creative Idea List

The list of ideas from the study is shown on successive pages. Some of the ideas were selected for further development as represented in the previous alternatives.

Creative Idea List

IDEA NO.	Idea Title	Score
CC	**Cross Creek**	
CC-01	Cross Brushy Creek more perpendicular in an area outside the wetland	5
CC-02	Eliminate existing Brushy Creek bridge	w/CC-01
CC-03	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph	5
CG	**Cross Gasline**	
CG-01	Eliminate the Tom Taylor Trail over the gasline (east side)	4
CG-02	Build land bridge over gaslines	DS
CG-03	At Station 6355+00 (Heron Road), relocate the approach tie to Station 6343+00 to avoid gaslines	4
CG-04	Shift the northern tie to US 641 to the northwest to connect back to old US 641 without crossing the gaslines	4
CG-05	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side	5
CG-06	Eliminate the Heron Road tie at Station 6355+00	5
OG	**Optimize Geometry**	
OG-01	Lower the design speed to 60 mph throughout the entire length of the project	3
OG-02	Lower the design speed to 60 mph to the Hazel approach	w/OG-01
OG-03	Use different superelevation table on the approaches	DS
SL	**Support Load**	
SL-01	Use the 12-inch Cement Stabilized Roadbed (do not consider *Option 1, Potential Cost Savings*)	DS
SL-02	Eliminate one 3-inch layer of base	5
SL-03	Eliminate two 3-inch layers of base and replace with one 4.5-inch of base	5
SL-04	Eliminate two 3-inch layers of base	5

Creative Idea List

IDEA NO.	Idea Title	Score
SL-05	Set-up quantities for rock roadbed for areas where cement is not feasible (i.e., tying into old road or maintaining access across the new road during construction)	DS
SL-06	Set-up quantities for granular embankment	DS
CT	**Convey Traffic**	
CT-01	Reduce the pavement on the outside shoulders from 10 feet to 4 feet	5
CT-02	Reduce the pavement on the outside shoulders from 10 feet to 8 feet *(Option 4, Potential Cost Savings)*	w/CT-01
CT-03	Reduce through-lane pavement width from 12 feet to 11 feet *(Option 3, Potential Cost Savings)*	5
CT-04	Reduce median width from 48 feet to 40 feet *(Option 2, Potential Cost Savings)*	4
CT-05	Reduce median width from 48 feet to 30 feet	w/CT-05
CT-06	Reduce bridge outside shoulder width from 12 feet to 4 feet	5
CT-07	Eliminate the shoulder widening for guardrail and specify using 7-foot guardrail posts	DS
CT-08	Change from a 4-lane divided typical section to a 2-plus-1 roadway design	5
CT-09	Provide more U-turn opportunities to minimize crossing conflict points	3
CT-10	Use RCUT at Midway only; use J-turns at the remaining locations	3
CT-11	Eliminate the Hazel connector and improve the intersection at State Line Road (i.e., roundabout)	4
CT-12	Provide a public information/education program on RCUTs, J-hooks and other innovative intersection	DC
CT-13	VE team does not recommend Hazel Connector to Stateline Road Options 1, 3 and 4	w/CT-18
CT-14	Hazel Connector to Stateline Road - Option 2: Flatten backslope 6:1 (left side) to provide a borrow source	w/CT-18
CT-15	Hazel Connector to Stateline Road - Option 5: Pave two lanes only	w/CT-18
CT-16	Reduce the outside shoulder width across bridges	w/CT-06

Value Engineering Study
Kentucky Transportation Cabinet
US 641 Reconstruction (southern section), Item No. 1-314.20
Calloway County

Creative Idea List

IDEA NO.	Idea Title	Score
CT-17	Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection	4
CT-18	Review the Hazel Connector Options 1-5	DS
CT-19	Review Maintenance of Traffic (MOT) Plan	DC
ME	**Minimize Environmental-impacts**	
ME-01	Avoid floodplain areas	w/CC-01

O/S=Out of Scope
FF=Fatal Flaw
ABD=Already Being Done

DS=Design Suggestion (Workbook)
DC=Design Comment (No Workbook)

5=Great Opportunity
4=Good Opportunity
3=Moderate Opportunity
2=Poor Opportunity

Evaluation Process

The VE study team members evaluated the ideas using a two-step process. The first step, to shorten the list, identified ideas that scored as follows:

- FF Unacceptable Impacts/Fatal Flaw (Has at least one fatal/unacceptable flaw)
- O/S Out of Scope
- ABD Already Being Done
- DC Design Comment (No cost impact, no Workbook)
- DS Design Suggestions (Not costed, Workbook)

This first-step evaluation scored the ideas as appropriate to eliminate them from further evaluation.

The second step scored the remaining ideas using the **Value Relationship Key shown on the following page** along with the idea's alignment with previously identified functions and performance criteria. The prioritization for further development and documentation is as follows:

Score =

- 5 – Great Value meeting the criteria (Workbook)
- 4 – Good Value meeting the criteria (Workbook)
- 3 – Moderate Value meeting the criteria (No Workbook)
- 2 – Poor Value (No Workbook)

Value Engineering Study
Kentucky Transportation Cabinet
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Item No. 1-314.20
Calloway County

Value Relationship Key		**Value = Function / Cost**					
Rating							
5.	Great Opportunity	F C--	F+ C--	F++ C	F++ C-	F++ C--	F++ C+
4.	Good Opportunity	F- C--	F C-	F+ C	F+ C-	F+ C+	F++(*) C++
3.	Moderate Value	F-- C-	F- C-	F++(*) C++			
2.	Poor Value	F-- C	F-- C--	F C+	F C++	F++(*) C++	

*Is the Function improved to the point that it overcomes the high cost?

VALUE CUE KEY –
MAGNITUDE OF CHANGE

F	=	No impact to function
F-	=	Small negative impact to function
F--	=	Large negative impact to function
F+	=	Small increase in function
F++	=	Large increase in function
C	=	No impact to cost
C-	=	Small decrease in cost
C--	=	Large decrease in cost
C+	=	Small increase in cost
C++	=	Large increase in cost

Appendix E – Supporting Data

Risk Identification

When brainstorming alternatives during the creative phase, the VE team considered the following risks that were identified during the Information Phase kick-off meeting:

- Gas line – expose entire pipe will increase cost and schedule
- Right-of-way change will impact schedule, cost and environmental document
- Commitments to City, County, federal government, public, KYTC will impact both cost and schedule
- Public acceptance of innovative intersection

CRASH PREDICTION REPORT

Interactive Highway Safety Design Model

Crash Prediction Evaluation Report

November 20, 2019

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Report Overview

Report Generated: Nov 20, 2019 2:46 PM
Report Template: System: Multi-Page [System] (mlcpm2, Nov 11, 2019 7:50 AM)

Evaluation Date: Wed Nov 20 14:46:07 EST 2019
IHSDM Version: v15.0.0 (Oct 31, 2019)
Crash Prediction Module: v10.0.0 (Oct 31, 2019)

User Name: jlittleton
Organization Name: American Engineers, Inc
Phone: 502-245-3813
E-Mail: jlittleton@aei.cc

Project Title: US 641 VE Study
Project Comment: Created Mon Nov 18 07:49:44 EST 2019
Project Unit System: U.S. Customary

Highway Title: Palmer-US641
Highway Comment: Created Mon Nov 18 07:55:47 EST 2019
Highway Version: 1

Evaluation Title: 1-314.20 Baseline Evaluation
Evaluation Comment: This evaluation is intended to establish a baseline for comparision of improvement alternatives. This baseline specifies rural, multi-lane divided highway, 2 12ft lanes in each direction with a 4ft inside paved shoulder, 8ft outside paved shoulder, 2ft gravel shoulders beyond the pavement inside and outside and a 48 ft traversable median (inside driving lane to inside driving lane).

Minimum Location: 6129+50.000
Maximum Location: 6444+00.000
Policy for Superelevation: AASHTO 2011 U.S. Customary
Calibration: HSM Configuration
Crash Distribution: HSM Configuration
Model/CMF: HSM Configuration
First Year of Analysis: 2021
Last Year of Analysis: 2040
Empirical-Bayes Analysis: None
First Year of Observed Crashes:
Last Year of Observed Crashes:

Disclaimer Regarding Crash Prediction Method

IMPORTANT NOTICE ABOUT COMPARING RESULTS FROM HIGHWAY SAFETY MANUAL FIRST EDITION (2010) MODELS TO RESULTS FROM NEW MODELS DEVELOPED UNDER NCHRP PROJECTS 17-70 AND 17-58

Since the publication of the Highway Safety Manual - First Edition (HSM-1), in 2010 by the American Association of State Highway and Transportation Officials (AASHTO), multiple research efforts have been undertaken through the National Cooperative Highway Research Program (NCHRP) to develop safety performance models for road segment and intersection facility types that were not initially reflected in the HSM-1, in order to expand the breadth and depth of the HSM in the future.

The IHSDM Crash Prediction Module (CPM) is intended as a faithful implementation of HSM Part C predictive methods. As NCHRP projects to develop new predictive methods for the HSM are completed, FHWA works to incorporate the new methods into IHSDM, sometimes in advance of publication in the HSM. The following new crash predictive methods have been accepted by NCHRP project panels and incorporated into IHSDM, while pending AASHTO's approval for incorporation into a future edition of the HSM:

- Roundabouts: completed in 2018 under NCHRP Project 17-70, the new methods will provide improved outcomes for the safety analysis of roundabouts.
- 6+ lane and one-way urban/suburban arterials (including models for segments and intersections): completed under NCHRP Project 17-58.

However, in the absence of local calibration factors (see HSM-1 Part C, Appendix A for guidance on calibration of the predictive models), it is neither appropriate nor advisable to directly compare the results from new models (from NCHRP Projects 17-58 and 17-70) to results from HSM-1 models, as the models were not calibrated to the same base state data sets, and consequently can produce unexpected results. If local calibration factors are available and applied to both new models and HSM-1 models, then it may be appropriate to directly compare the results.*[Note: Work being performed under NCHRP Project 17-72 (Update of Crash Modification Factors for the Highway Safety Manual) is expected to re-calibrate many of the old (HSM-1) and new (e.g., NCHRP 17-70) models to data from a single (or small number of) states, that would allow results from all models to be directly compared.]*

The models produced for NCHRP Project 17-70 have independent value in terms of informing the design of a roundabout and assessing the effects of different design characteristics on the expected safety performance of a roundabout.

The HSM-1 interim method previously included in IHSDM for evaluating roundabouts on urban/suburban arterials (i.e., evaluating an existing intersection and then applying a Crash Modification Factor for replacing the existing intersection with a roundabout) has been deactivated in IHSDM, to minimize any confusion with the new roundabout methodology.

Section Types

Section 1 Evaluation

Section: Section 1
Evaluation Start Location: 6129+50.000
Evaluation End Location: 6444+00.000
Area Type: Rural
Functional Class: Arterial
Type of Alignment: Undivided/Divided Multilane
Model Category: Rural, Multilane
Calibration Factor: 4D=1.0;

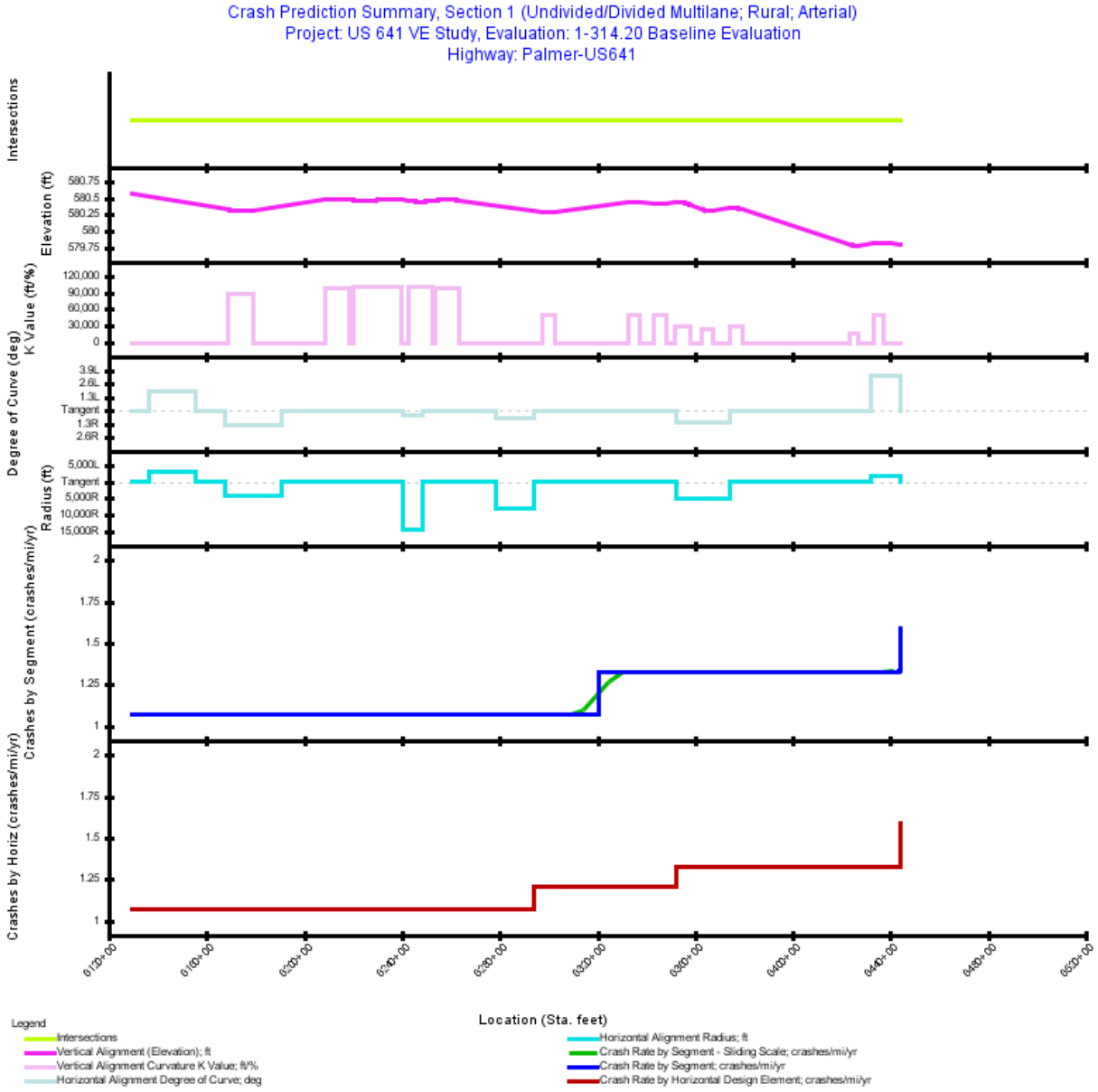


Figure 1. Crash Prediction Summary (Section 1)

Table 1. Evaluation Highway - Homogeneous Segments (Section 1)

Seg. No.	Type	Start Location (Sta. ft)	End Location (Sta. ft)	Length (ft)	Length(mi)	AADT	Left Lane Width (ft)	Right Lane Width (ft)	Left Shoulder Width (ft)	Right Shoulder Width (ft)	Median Width (ft)	Median Type	Effective Median Width (ft)	Lighting	Automated Speed Enforcement	Left Side Slope	Right Side Slope
1	4D	6129+50.000	6133+46.660	396.66	0.0751	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
2	4D	6133+46.660	6135+26.660	180.00	0.0341	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
3	4D	6135+26.660	6136+22.663	96.00	0.0182	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
4	4D	6136+22.663	6137+15.660	93.00	0.0176	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
5	4D	6137+15.660	6140+50.000	334.34	0.0633	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
6	4D	6140+50.000	6141+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
7	4D	6141+50.000	6154+43.940	1,293.94	0.2451	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
8	4D	6154+43.940	6154+50.000	6.06	0.0011	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
9	4D	6154+50.000	6155+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
10	4D	6155+00.000	6155+36.936	36.94	0.0070	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
11	4D	6155+36.936	6156+32.940	96.00	0.0182	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
12	4D	6156+32.940	6158+12.940	180.00	0.0341	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
13	4D	6158+12.940	6159+50.000	137.06	0.0260	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
14	4D	6159+50.000	6160+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
15	4D	6160+00.000	6160+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
16	4D	6160+50.000	6165+42.070	492.07	0.0932	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
17	4D	6165+42.070	6167+22.070	180.00	0.0341	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
18	4D	6167+22.070	6167+82.071	60.00	0.0114	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
19	4D	6167+82.071	6168+00.000	17.93	0.0034	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
20	4D	6168+00.000	6168+57.070	57.07	0.0108	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
21	4D	6168+57.070	6169+00.000	42.93	0.0081	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	50.00	false	false		
22	4D	6169+00.000	6169+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
23	4D	6169+50.000	6173+50.000	400.00	0.0758	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
24	4D	6173+50.000	6174+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
25	4D	6174+50.000	6189+76.290	1,526.29	0.2891	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
26	4D	6189+76.290	6190+00.000	23.71	0.0045	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
27	4D	6190+00.000	6190+51.290	51.29	0.0097	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
28	4D	6190+51.290	6191+11.290	60.00	0.0114	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
29	4D	6191+11.290	6192+91.290	180.00	0.0341	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
30	4D	6192+91.290	6193+00.000	8.71	0.0016	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
31	4D	6193+00.000	6193+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
32	4D	6193+50.000	6195+50.000	200.00	0.0379	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
33	4D	6195+50.000	6196+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		

Seg. No.	Type	Start Location (Sta. ft)	End Location (Sta. ft)	Length (ft)	Length(mi)	AADT	Left Lane Width (ft)	Right Lane Width (ft)	Left Shoulder Width (ft)	Right Shoulder Width (ft)	Median Width (ft)	Median Type	Effective Median Width (ft)	Lighting	Automated Speed Enforcement	Left Side Slope	Right Side Slope
34	4D	6196+00.000	6196+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
35	4D	6196+50.000	6197+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
36	4D	6197+50.000	6198+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
37	4D	6198+00.000	6199+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
38	4D	6199+00.000	6200+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
39	4D	6200+00.000	6201+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
40	4D	6201+00.000	6201+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
41	4D	6201+50.000	6202+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
42	4D	6202+50.000	6203+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
43	4D	6203+50.000	6204+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
44	4D	6204+50.000	6205+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
45	4D	6205+50.000	6206+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
46	4D	6206+00.000	6206+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
47	4D	6206+50.000	6217+50.000	1,100.00	0.2083	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
48	4D	6217+50.000	6218+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
49	4D	6218+00.000	6220+00.000	200.00	0.0379	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
50	4D	6220+00.000	6220+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
51	4D	6220+50.000	6223+50.000	300.00	0.0568	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
52	4D	6223+50.000	6224+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
53	4D	6224+00.000	6225+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
54	4D	6225+00.000	6225+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
55	4D	6225+50.000	6226+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
56	4D	6226+00.000	6227+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
57	4D	6227+00.000	6240+47.779	1,347.78	0.2553	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
58	4D	6240+47.779	6242+50.000	202.22	0.0383	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
59	4D	6242+50.000	6243+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
60	4D	6243+00.000	6247+50.000	450.00	0.0852	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
61	4D	6247+50.000	6248+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
62	4D	6248+00.000	6248+67.923	67.92	0.0129	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
63	4D	6248+67.923	6251+50.000	282.08	0.0534	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
64	4D	6251+50.000	6252+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
65	4D	6252+00.000	6253+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
66	4D	6253+00.000	6253+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
67	4D	6253+50.000	6259+50.000	600.00	0.1136	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
68	4D	6259+50.000	6260+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		

Seg. No.	Type	Start Location (Sta. ft)	End Location (Sta. ft)	Length (ft)	Length(mi)	AADT	Left Lane Width (ft)	Right Lane Width (ft)	Left Shoulder Width (ft)	Right Shoulder Width (ft)	Median Width (ft)	Median Type	Effective Median Width (ft)	Lighting	Automated Speed Enforcement	Left Side Slope	Right Side Slope
69	4D	6260+00.000	6265+00.000	500.00	0.0947	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
70	4D	6265+00.000	6265+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
71	4D	6265+50.000	6267+50.000	200.00	0.0379	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
72	4D	6267+50.000	6268+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
73	4D	6268+00.000	6269+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
74	4D	6269+00.000	6269+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
75	4D	6269+50.000	6270+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
76	4D	6270+00.000	6270+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
77	4D	6270+50.000	6271+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
78	4D	6271+00.000	6273+50.000	250.00	0.0474	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
79	4D	6273+50.000	6275+50.000	200.00	0.0379	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
80	4D	6275+50.000	6276+50.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
81	4D	6276+50.000	6276+89.990	39.99	0.0076	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
82	4D	6276+89.990	6277+00.000	10.01	0.0019	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
83	4D	6277+00.000	6278+50.000	150.00	0.0284	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
84	4D	6278+50.000	6278+57.990	7.99	0.0015	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
85	4D	6278+57.990	6279+00.000	42.01	0.0080	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
86	4D	6279+00.000	6281+50.000	250.00	0.0474	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
87	4D	6281+50.000	6282+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
88	4D	6282+00.000	6283+00.000	100.00	0.0189	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
89	4D	6283+00.000	6285+00.000	200.00	0.0379	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
90	4D	6285+00.000	6285+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
91	4D	6285+50.000	6286+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
92	4D	6286+00.000	6288+00.000	200.00	0.0379	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
93	4D	6288+00.000	6288+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
94	4D	6288+50.000	6289+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
95	4D	6289+00.000	6289+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
96	4D	6289+50.000	6293+60.530	410.53	0.0777	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
97	4D	6293+60.530	6293+99.531	39.00	0.0074	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
98	4D	6293+99.531	6295+67.530	168.00	0.0318	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
99	4D	6295+67.530	6301+00.000	532.47	0.1008	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
100	4D	6301+00.000	6301+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
101	4D	6301+50.000	6302+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
102	4D	6302+00.000	6305+50.000	350.00	0.0663	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
103	4D	6305+50.000	6306+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		

Seg. No.	Type	Start Location (Sta. ft)	End Location (Sta. ft)	Length (ft)	Length(mi)	AADT	Left Lane Width (ft)	Right Lane Width (ft)	Left Shoulder Width (ft)	Right Shoulder Width (ft)	Median Width (ft)	Median Type	Effective Median Width (ft)	Lighting	Automated Speed Enforcement	Left Side Slope	Right Side Slope
104	4D	6306+00.000	6306+50.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
105	4D	6306+50.000	6312+50.000	600.00	0.1136	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
106	4D	6312+50.000	6313+00.000	50.00	0.0095	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
107	4D	6313+00.000	6320+82.000	782.00	0.1481	2021-2040: 5,984	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
108	4D	6320+82.000	6321+00.000	18.00	0.0034	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
109	4D	6321+00.000	6321+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
110	4D	6321+50.000	6323+50.000	200.00	0.0379	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
111	4D	6323+50.000	6324+00.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
112	4D	6324+00.000	6324+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
113	4D	6324+50.000	6325+00.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
114	4D	6325+00.000	6344+50.000	1,950.00	0.3693	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
115	4D	6344+50.000	6346+50.000	200.00	0.0379	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
116	4D	6346+50.000	6350+14.410	364.41	0.0690	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
117	4D	6350+14.410	6352+24.408	210.00	0.0398	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
118	4D	6352+24.408	6352+84.410	60.00	0.0114	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
119	4D	6352+84.410	6362+00.000	915.59	0.1734	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
120	4D	6362+00.000	6362+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
121	4D	6362+50.000	6364+50.000	200.00	0.0379	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
122	4D	6364+50.000	6373+80.630	930.63	0.1763	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
123	4D	6373+80.630	6374+40.635	60.00	0.0114	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
124	4D	6374+40.635	6374+50.000	9.37	0.0018	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
125	4D	6374+50.000	6375+50.000	100.00	0.0189	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
126	4D	6375+50.000	6376+50.630	100.63	0.0191	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
127	4D	6376+50.630	6377+00.000	49.37	0.0094	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
128	4D	6377+00.000	6379+00.000	200.00	0.0379	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
129	4D	6379+00.000	6379+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
130	4D	6379+50.000	6381+00.000	150.00	0.0284	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
131	4D	6381+00.000	6381+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
132	4D	6381+50.000	6384+00.000	250.00	0.0474	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
133	4D	6384+00.000	6384+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
134	4D	6384+50.000	6397+00.000	1,250.00	0.2367	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
135	4D	6397+00.000	6399+00.000	200.00	0.0379	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
136	4D	6399+00.000	6400+00.000	100.00	0.0189	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
137	4D	6400+00.000	6400+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
138	4D	6400+50.000	6401+50.000	100.00	0.0189	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		

Seg. No.	Type	Start Location (Sta. ft)	End Location (Sta. ft)	Length (ft)	Length(mi)	AADT	Left Lane Width (ft)	Right Lane Width (ft)	Left Shoulder Width (ft)	Right Shoulder Width (ft)	Median Width (ft)	Median Type	Effective Median Width (ft)	Lighting	Automated Speed Enforcement	Left Side Slope	Right Side Slope
139	4D	6401+50.000	6402+50.000	100.00	0.0189	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
140	4D	6402+50.000	6404+00.000	150.00	0.0284	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
141	4D	6404+00.000	6407+00.000	300.00	0.0568	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
142	4D	6407+00.000	6408+50.000	150.00	0.0284	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
143	4D	6408+50.000	6409+00.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
144	4D	6409+00.000	6411+50.000	250.00	0.0474	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
145	4D	6411+50.000	6412+00.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
146	4D	6412+00.000	6412+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
147	4D	6412+50.000	6418+00.000	550.00	0.1042	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
148	4D	6418+00.000	6419+50.000	150.00	0.0284	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
149	4D	6419+50.000	6426+00.000	650.00	0.1231	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
150	4D	6426+00.000	6426+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
151	4D	6426+50.000	6427+50.000	100.00	0.0189	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
152	4D	6427+50.000	6429+50.000	200.00	0.0379	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
153	4D	6429+50.000	6430+00.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
154	4D	6430+00.000	6430+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
155	4D	6430+50.000	6431+52.940	102.94	0.0195	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
156	4D	6431+52.940	6431+74.135	21.20	0.0040	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
157	4D	6431+74.135	6433+36.470	162.34	0.0307	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
158	4D	6433+36.470	6440+00.000	663.53	0.1257	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
159	4D	6440+00.000	6440+50.000	50.00	0.0095	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
160	4D	6440+50.000	6442+31.440	181.44	0.0344	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
161	4D	6442+31.440	6443+50.000	118.56	0.0225	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	48.00	false	false		
162	4D	6443+50.000	6443+84.391	34.39	0.0065	2021-2040: 7,320	12.00	12.00	12.00	12.00	36.00	Traversable Median	44.00	false	false		
163	4D	6443+84.391	6444+00.000	15.61	0.0030	2021-2040: 7,320	12.00	12.00	2.00	2.00	36.00	Traversable Median	40.00	false	false		

Table 2. Predicted Highway Crash Rates and Frequencies Summary (Section 1)

First Year of Analysis	**2021**
Last Year of Analysis	**2040**
Evaluated Length (mi)	**5.9564**
Average Future Road AADT (vpd)	**6,507**
Predicted Crashes	
Total Crashes	**139.79**
Fatal and Injury Crashes	**75.84**
Fatal and Serious Injury Crashes	**50.54**
Property-Damage-Only Crashes	**63.95**
Percent of Total Predicted Crashes	
Percent Fatal and Injury Crashes (%)	**54**
Percent Fatal and Serious Injury Crashes (%)	**36**
Percent Property-Damage-Only Crashes (%)	**46**
Predicted Crash Rate	
Crash Rate (crashes/mi/yr)	**1.1735**
FI Crash Rate (crashes/mi/yr)	**0.6366**
FI no/C Crash Rate (crashes/mi/yr)	**0.4242**
PDO Crash Rate (crashes/mi/yr)	**0.5368**
Predicted Travel Crash Rate	
Total Travel (million veh-mi)	**282.95**
Travel Crash Rate (crashes/million veh-mi)	**0.49**
Travel FI Crash Rate (crashes/million veh-mi)	**0.27**
Travel FI no/C Crash Rate (crashes/million veh-mi)	**0.18**
Travel PDO Crash Rate (crashes/million veh-mi)	**0.23**

Table 3. Predicted Crash Frequencies and Rates by Highway Segment/Intersection (Section 1)

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
1	6129+50.000	6133+46.660	0.0751	1.614	0.0807	0.0441	0.0296	0.0366	1.0743	0.49
2	6133+46.660	6135+26.660	0.0341	0.733	0.0366	0.0200	0.0134	0.0166	1.0743	0.49
3	6135+26.660	6136+22.663	0.0182	0.391	0.0195	0.0107	0.0072	0.0088	1.0743	0.49
4	6136+22.663	6137+15.660	0.0176	0.378	0.0189	0.0103	0.0069	0.0086	1.0743	0.49
5	6137+15.660	6140+50.000	0.0633	1.361	0.0680	0.0372	0.0250	0.0308	1.0743	0.49
6	6140+50.000	6141+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
7	6141+50.000	6154+43.940	0.2451	5.265	0.2633	0.1440	0.0967	0.1193	1.0743	0.49
8	6154+43.940	6154+50.000	0.0011	0.025	0.0012	0.0007	0.0005	0.0006	1.0743	0.49
9	6154+50.000	6155+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
10	6155+00.000	6155+36.936	0.0070	0.150	0.0075	0.0041	0.0028	0.0034	1.0743	0.49
11	6155+36.936	6156+32.940	0.0182	0.391	0.0195	0.0107	0.0072	0.0088	1.0743	0.49
12	6156+32.940	6158+12.940	0.0341	0.733	0.0366	0.0200	0.0134	0.0166	1.0743	0.49
13	6158+12.940	6159+50.000	0.0260	0.558	0.0279	0.0153	0.0102	0.0126	1.0743	0.49
14	6159+50.000	6160+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
15	6160+00.000	6160+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
16	6160+50.000	6165+42.070	0.0932	2.002	0.1001	0.0548	0.0368	0.0454	1.0743	0.49
17	6165+42.070	6167+22.070	0.0341	0.733	0.0366	0.0200	0.0134	0.0166	1.0743	0.49
18	6167+22.070	6167+82.071	0.0114	0.244	0.0122	0.0067	0.0045	0.0055	1.0743	0.49
19	6167+82.071	6168+00.000	0.0034	0.073	0.0036	0.0020	0.0013	0.0017	1.0743	0.49
20	6168+00.000	6168+57.070	0.0108	0.232	0.0116	0.0064	0.0043	0.0053	1.0743	0.49
21	6168+57.070	6169+00.000	0.0081	0.174	0.0087	0.0048	0.0032	0.0039	1.0699	0.49
22	6169+00.000	6169+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
23	6169+50.000	6173+50.000	0.0758	1.628	0.0814	0.0445	0.0299	0.0369	1.0743	0.49

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
24	6173+50.000	6174+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
25	6174+50.000	6189+76.290	0.2891	6.211	0.3105	0.1698	0.1140	0.1407	1.0743	0.49
26	6189+76.290	6190+00.000	0.0045	0.097	0.0048	0.0026	0.0018	0.0022	1.0743	0.49
27	6190+00.000	6190+51.290	0.0097	0.209	0.0104	0.0057	0.0038	0.0047	1.0743	0.49
28	6190+51.290	6191+11.290	0.0114	0.244	0.0122	0.0067	0.0045	0.0055	1.0743	0.49
29	6191+11.290	6192+91.290	0.0341	0.733	0.0366	0.0200	0.0134	0.0166	1.0743	0.49
30	6192+91.290	6193+00.000	0.0016	0.035	0.0018	0.0010	0.0007	0.0008	1.0743	0.49
31	6193+00.000	6193+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
32	6193+50.000	6195+50.000	0.0379	0.814	0.0407	0.0223	0.0149	0.0184	1.0743	0.49
33	6195+50.000	6196+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
34	6196+00.000	6196+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
35	6196+50.000	6197+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
36	6197+50.000	6198+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
37	6198+00.000	6199+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
38	6199+00.000	6200+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
39	6200+00.000	6201+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
40	6201+00.000	6201+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
41	6201+50.000	6202+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
42	6202+50.000	6203+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
43	6203+50.000	6204+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
44	6204+50.000	6205+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
45	6205+50.000	6206+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
46	6206+00.000	6206+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
47	6206+50.000	6217+50.000	0.2083	4.476	0.2238	0.1224	0.0822	0.1014	1.0743	0.49
48	6217+50.000	6218+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
49	6218+00.000	6220+00.000	0.0379	0.814	0.0407	0.0223	0.0149	0.0184	1.0743	0.49
50	6220+00.000	6220+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
51	6220+50.000	6223+50.000	0.0568	1.221	0.0610	0.0334	0.0224	0.0277	1.0743	0.49
52	6223+50.000	6224+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
53	6224+00.000	6225+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
54	6225+00.000	6225+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
55	6225+50.000	6226+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
56	6226+00.000	6227+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
57	6227+00.000	6240+47.779	0.2553	5.484	0.2742	0.1500	0.1007	0.1242	1.0743	0.49
58	6240+47.779	6242+50.000	0.0383	0.823	0.0411	0.0225	0.0151	0.0186	1.0743	0.49
59	6242+50.000	6243+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
60	6243+00.000	6247+50.000	0.0852	1.831	0.0916	0.0501	0.0336	0.0415	1.0743	0.49
61	6247+50.000	6248+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
62	6248+00.000	6248+67.923	0.0129	0.276	0.0138	0.0076	0.0051	0.0063	1.0743	0.49
63	6248+67.923	6251+50.000	0.0534	1.148	0.0574	0.0314	0.0211	0.0260	1.0743	0.49
64	6251+50.000	6252+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
65	6252+00.000	6253+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
66	6253+00.000	6253+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
67	6253+50.000	6259+50.000	0.1136	2.442	0.1221	0.0668	0.0448	0.0553	1.0743	0.49
68	6259+50.000	6260+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
69	6260+00.000	6265+00.000	0.0947	2.035	0.1017	0.0556	0.0374	0.0461	1.0743	0.49
70	6265+00.000	6265+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
71	6265+50.000	6267+50.000	0.0379	0.814	0.0407	0.0223	0.0149	0.0184	1.0743	0.49
72	6267+50.000	6268+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
73	6268+00.000	6269+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
74	6269+00.000	6269+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
75	6269+50.000	6270+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
76	6270+00.000	6270+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
77	6270+50.000	6271+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
78	6271+00.000	6273+50.000	0.0473	1.017	0.0509	0.0278	0.0187	0.0230	1.0743	0.49
79	6273+50.000	6275+50.000	0.0379	0.814	0.0407	0.0223	0.0149	0.0184	1.0743	0.49
80	6275+50.000	6276+50.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
81	6276+50.000	6276+89.990	0.0076	0.163	0.0081	0.0045	0.0030	0.0037	1.0743	0.49
82	6276+89.990	6277+00.000	0.0019	0.041	0.0020	0.0011	0.0007	0.0009	1.0743	0.49
83	6277+00.000	6278+50.000	0.0284	0.610	0.0305	0.0167	0.0112	0.0138	1.0743	0.49
84	6278+50.000	6278+57.990	0.0015	0.033	0.0016	0.0009	0.0006	0.0007	1.0743	0.49
85	6278+57.990	6279+00.000	0.0080	0.171	0.0085	0.0047	0.0031	0.0039	1.0743	0.49
86	6279+00.000	6281+50.000	0.0473	1.017	0.0509	0.0278	0.0187	0.0230	1.0743	0.49
87	6281+50.000	6282+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
88	6282+00.000	6283+00.000	0.0189	0.407	0.0203	0.0111	0.0075	0.0092	1.0743	0.49
89	6283+00.000	6285+00.000	0.0379	0.814	0.0407	0.0223	0.0149	0.0184	1.0743	0.49
90	6285+00.000	6285+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
91	6285+50.000	6286+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
92	6286+00.000	6288+00.000	0.0379	0.814	0.0407	0.0223	0.0149	0.0184	1.0743	0.49
93	6288+00.000	6288+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
94	6288+50.000	6289+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
95	6289+00.000	6289+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
96	6289+50.000	6293+60.530	0.0778	1.671	0.0835	0.0457	0.0307	0.0378	1.0743	0.49
97	6293+60.530	6293+99.531	0.0074	0.159	0.0079	0.0043	0.0029	0.0036	1.0743	0.49
98	6293+99.531	6295+67.530	0.0318	0.684	0.0342	0.0187	0.0126	0.0155	1.0743	0.49

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
99	6295+67.530	6301+00.000	0.1008	2.167	0.1083	0.0593	0.0398	0.0491	1.0743	0.49
100	6301+00.000	6301+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
101	6301+50.000	6302+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
102	6302+00.000	6305+50.000	0.0663	1.424	0.0712	0.0389	0.0261	0.0323	1.0743	0.49
103	6305+50.000	6306+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
104	6306+00.000	6306+50.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
105	6306+50.000	6312+50.000	0.1136	2.442	0.1221	0.0668	0.0448	0.0553	1.0743	0.49
106	6312+50.000	6313+00.000	0.0095	0.203	0.0102	0.0056	0.0037	0.0046	1.0743	0.49
107	6313+00.000	6320+82.000	0.1481	3.182	0.1591	0.0870	0.0584	0.0721	1.0743	0.49
108	6320+82.000	6321+00.000	0.0034	0.090	0.0045	0.0024	0.0016	0.0021	1.3272	0.50
109	6321+00.000	6321+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
110	6321+50.000	6323+50.000	0.0379	1.005	0.0503	0.0270	0.0178	0.0233	1.3272	0.50
111	6323+50.000	6324+00.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
112	6324+00.000	6324+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
113	6324+50.000	6325+00.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
114	6325+00.000	6344+50.000	0.3693	9.803	0.4901	0.2632	0.1737	0.2269	1.3272	0.50
115	6344+50.000	6346+50.000	0.0379	1.005	0.0503	0.0270	0.0178	0.0233	1.3272	0.50
116	6346+50.000	6350+14.410	0.0690	1.832	0.0916	0.0492	0.0325	0.0424	1.3272	0.50
117	6350+14.410	6352+24.408	0.0398	1.056	0.0528	0.0283	0.0187	0.0244	1.3272	0.50
118	6352+24.408	6352+84.410	0.0114	0.302	0.0151	0.0081	0.0053	0.0070	1.3272	0.50
119	6352+84.410	6362+00.000	0.1734	4.603	0.2301	0.1236	0.0816	0.1066	1.3272	0.50
120	6362+00.000	6362+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
121	6362+50.000	6364+50.000	0.0379	1.005	0.0503	0.0270	0.0178	0.0233	1.3272	0.50
122	6364+50.000	6373+80.630	0.1763	4.678	0.2339	0.1256	0.0829	0.1083	1.3272	0.50
123	6373+80.630	6374+40.635	0.0114	0.302	0.0151	0.0081	0.0053	0.0070	1.3272	0.50

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
124	6374+40.635	6374+50.000	0.0018	0.047	0.0024	0.0013	0.0008	0.0011	1.3272	0.50
125	6374+50.000	6375+50.000	0.0189	0.503	0.0251	0.0135	0.0089	0.0116	1.3272	0.50
126	6375+50.000	6376+50.630	0.0191	0.506	0.0253	0.0136	0.0090	0.0117	1.3272	0.50
127	6376+50.630	6377+00.000	0.0094	0.248	0.0124	0.0067	0.0044	0.0057	1.3272	0.50
128	6377+00.000	6379+00.000	0.0379	1.005	0.0503	0.0270	0.0178	0.0233	1.3272	0.50
129	6379+00.000	6379+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
130	6379+50.000	6381+00.000	0.0284	0.754	0.0377	0.0202	0.0134	0.0175	1.3272	0.50
131	6381+00.000	6381+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
132	6381+50.000	6384+00.000	0.0473	1.257	0.0628	0.0337	0.0223	0.0291	1.3272	0.50
133	6384+00.000	6384+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
134	6384+50.000	6397+00.000	0.2367	6.284	0.3142	0.1687	0.1114	0.1455	1.3272	0.50
135	6397+00.000	6399+00.000	0.0379	1.005	0.0503	0.0270	0.0178	0.0233	1.3272	0.50
136	6399+00.000	6400+00.000	0.0189	0.503	0.0251	0.0135	0.0089	0.0116	1.3272	0.50
137	6400+00.000	6400+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
138	6400+50.000	6401+50.000	0.0189	0.503	0.0251	0.0135	0.0089	0.0116	1.3272	0.50
139	6401+50.000	6402+50.000	0.0189	0.503	0.0251	0.0135	0.0089	0.0116	1.3272	0.50
140	6402+50.000	6404+00.000	0.0284	0.754	0.0377	0.0202	0.0134	0.0175	1.3272	0.50
141	6404+00.000	6407+00.000	0.0568	1.508	0.0754	0.0405	0.0267	0.0349	1.3272	0.50
142	6407+00.000	6408+50.000	0.0284	0.754	0.0377	0.0202	0.0134	0.0175	1.3272	0.50
143	6408+50.000	6409+00.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
144	6409+00.000	6411+50.000	0.0473	1.257	0.0628	0.0337	0.0223	0.0291	1.3272	0.50
145	6411+50.000	6412+00.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
146	6412+00.000	6412+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
147	6412+50.000	6418+00.000	0.1042	2.765	0.1382	0.0742	0.0490	0.0640	1.3272	0.50
148	6418+00.000	6419+50.000	0.0284	0.754	0.0377	0.0202	0.0134	0.0175	1.3272	0.50

Segment Number/Intersection Name/Cross Road	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
149	6419+50.000	6426+00.000	0.1231	3.268	0.1634	0.0877	0.0579	0.0756	1.3272	0.50
150	6426+00.000	6426+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
151	6426+50.000	6427+50.000	0.0189	0.503	0.0251	0.0135	0.0089	0.0116	1.3272	0.50
152	6427+50.000	6429+50.000	0.0379	1.005	0.0503	0.0270	0.0178	0.0233	1.3272	0.50
153	6429+50.000	6430+00.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
154	6430+00.000	6430+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
155	6430+50.000	6431+52.940	0.0195	0.517	0.0259	0.0139	0.0092	0.0120	1.3272	0.50
156	6431+52.940	6431+74.135	0.0040	0.106	0.0053	0.0029	0.0019	0.0025	1.3272	0.50
157	6431+74.135	6433+36.470	0.0307	0.816	0.0408	0.0219	0.0145	0.0189	1.3272	0.50
158	6433+36.470	6440+00.000	0.1257	3.336	0.1668	0.0896	0.0591	0.0772	1.3272	0.50
159	6440+00.000	6440+50.000	0.0095	0.251	0.0126	0.0067	0.0045	0.0058	1.3272	0.50
160	6440+50.000	6442+31.440	0.0344	0.912	0.0456	0.0245	0.0162	0.0211	1.3272	0.50
161	6442+31.440	6443+50.000	0.0225	0.596	0.0298	0.0160	0.0106	0.0138	1.3272	0.50
162	6443+50.000	6443+84.391	0.0065	0.174	0.0087	0.0047	0.0031	0.0040	1.3381	0.50
163	6443+84.391	6444+00.000	0.0030	0.094	0.0047	0.0025	0.0017	0.0022	1.5918	0.60
Total			5.9564	139.793	6.9896	3.7921	2.5269	3.1975	1.1735	

Table 4. Predicted Crash Frequencies and Rates by Horizontal Design Element (Section 1)

Title	Start Location (Sta. ft)	End Location (Sta. ft)	Length (mi)	Total Predicted Crashes for Evaluation Period	Predicted Total Crash Frequency (crashes/yr)	Predicted FI Crash Frequency (crashes/yr)	Predicted FI no/C Crash Frequency (crashes/yr)	Predicted PDO Crash Frequency (crashes/yr)	Predicted Crash Rate (crashes/mi/yr)	Predicted Travel Crash Rate (crashes/million veh-mi)
Tangent	6129+50.000	6136+22.663	0.1274	2.737	0.1369	0.0749	0.0503	0.0620	1.0743	0.49
Simple Curve 1	6136+22.663	6155+36.936	0.3626	7.790	0.3895	0.2130	0.1430	0.1765	1.0743	0.49
Tangent	6155+36.936	6167+82.071	0.2358	5.067	0.2533	0.1386	0.0930	0.1148	1.0743	0.49
Simple Curve 2	6167+82.071	6190+51.290	0.4298	9.233	0.4617	0.2525	0.1695	0.2092	1.0742	0.49
Tangent	6190+51.290	6240+47.779	0.9463	20.332	1.0166	0.5560	0.3733	0.4606	1.0743	0.49
Simple Curve 3	6240+47.779	6248+67.923	0.1553	3.337	0.1669	0.0913	0.0613	0.0756	1.0743	0.49
Tangent	6248+67.923	6278+57.990	0.5663	12.167	0.6084	0.3327	0.2234	0.2756	1.0743	0.49
Simple Curve 4	6278+57.990	6293+99.531	0.2920	6.273	0.3136	0.1715	0.1152	0.1421	1.0743	0.49
Tangent	6293+99.531	6352+24.408	1.1032	26.713	1.3356	0.7227	0.4803	0.6130	1.2107	0.49
Simple Curve 5	6352+24.408	6374+40.635	0.4197	11.141	0.5571	0.2991	0.1974	0.2579	1.3272	0.50
Tangent	6374+40.635	6431+74.135	1.0859	28.823	1.4412	0.7739	0.5108	0.6672	1.3272	0.50
Simple Curve 6	6431+74.135	6443+84.391	0.2292	6.085	0.3043	0.1634	0.1078	0.1409	1.3275	0.50
Tangent	6443+84.391	6444+00.000	0.0030	0.094	0.0047	0.0025	0.0017	0.0022	1.5918	0.60

Table 5. Predicted Crash Frequencies by Year (Section 1)

Year	Total Crashes	FI Crashes	Percent FI (%)	FI/no C Crashes	Percent FI/no C (%)	PDO Crashes	Percent PDO (%)
2021	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2022	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2023	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2024	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2025	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2026	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2027	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2028	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2029	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2030	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2031	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2032	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2033	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2034	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2035	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2036	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2037	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2038	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2039	6.99	3.79	54.254	2.53	36.153	3.20	45.746
2040	6.99	3.79	54.254	2.53	36.153	3.20	45.746
Total	139.79	75.84	54.254	50.54	36.153	63.95	45.746
Average	6.99	3.79	54.254	2.53	36.153	3.20	45.746

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

Table 6. Predicted Crash Type Distribution (Section 1)

Element Type	Crash Type	Fatal and Injury		Fatal and Serious Injury		Property Damage Only		Total	
		Crashes	Crashes (%)	Crashes	Crashes (%)	Crashes	Crashes (%)	Crashes	Crashes (%)
Highway Segment	Right-Angle Collision	3.64	2.6	2.27	1.6	2.62	1.9	6.01	4.3
Highway Segment	Head-on Collision	0.99	0.7	0.91	0.7	0.13	0.1	0.84	0.6
Highway Segment	Rear-end Collision	12.36	8.8	5.76	4.1	5.63	4.0	16.22	11.6
Highway Segment	Total Multiple Vehicle Crashes	16.99	12.2	8.95	6.4	8.38	6.0	23.07	16.5
Highway Segment	Total Highway Segment Crashes	75.84	54.3	50.54	36.2	63.95	45.7	139.79	100.0
Highway Segment	Other Collision	1.67	1.2	1.16	0.8	1.53	1.1	3.35	2.4
Highway Segment	Sideswipe	2.05	1.5	1.11	0.8	3.39	2.4	6.01	4.3
Highway Segment	Single	55.14	39.4	39.32	28.1	50.65	36.2	107.36	76.8
	Total Crashes	75.84	54.3	50.54	36.2	63.95	45.7	139.79	100.0

Note: *Fatal and Injury Crashes* and *Property Damage Only Crashes* do not necessarily sum up to *Total Crashes* because the distribution of these three crashes had been derived independently.

US 641 CORRIDOR
CALLOWAY COUNTY

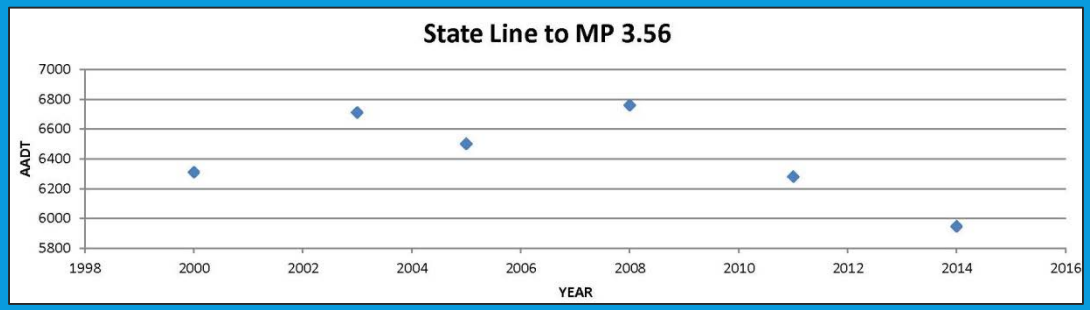
Improving Safety and Mobility

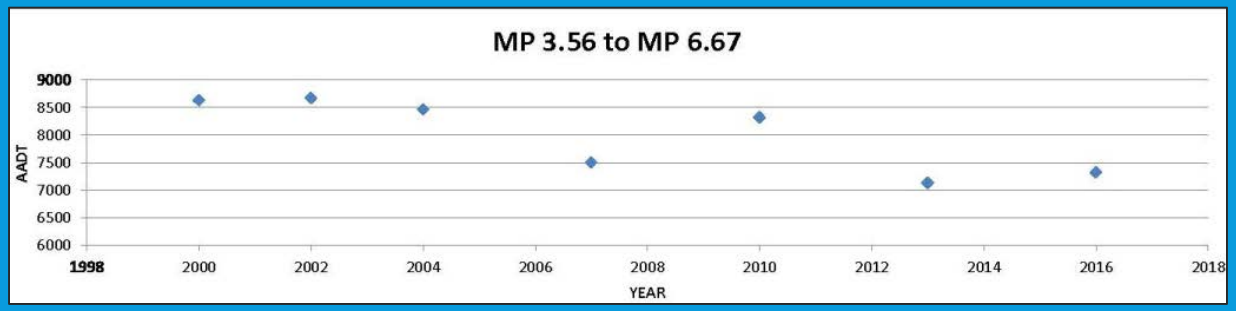
Palmer ENGINEERING

KENTUCKY TRANSPORTATION CABINET

EXISTING CONDITIONS -- TRAFFIC

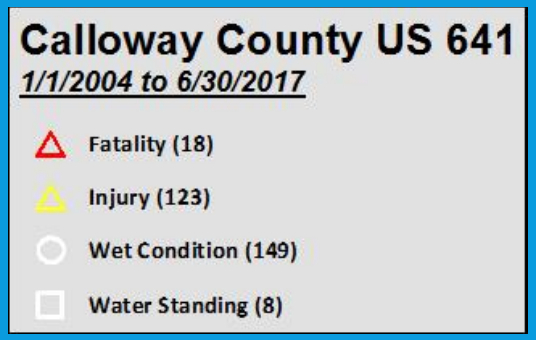
- Average Daily Traffic
  - State Line to MP 3.56 (Midway): 5,900 Vehicles per day
  - MP 3.56 to MP 6.67 (Murray): 7,300 Vehicles per Day
- Traffic is Not Growing
- Truck Percentages:
  - 9% (2016)
  - 12% (2007



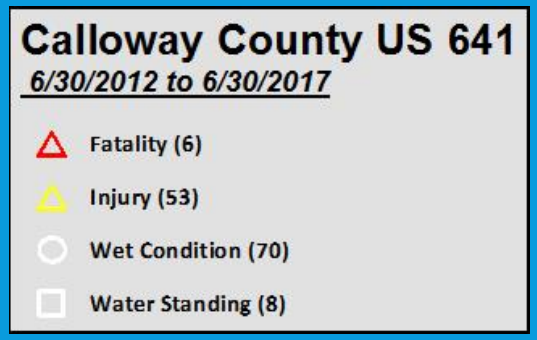


EXISTING CONDITIONS -- CRASH HISTORY

January 1, 2004 - June 30, 2017



June 30, 2016 - June 30, 2017



PROJECT EVOLUTION
PREVIOUS STUDIES AND PROJECTS

- 2002 Alternatives Study
- 2011 Preliminary Engineering
- 2012 Value Engineering Study – RHA
- 2017 HSIP (Highway Safety Improvement Program)
  - Roadway Departure Corridor Analysis
  - Limited Funding for Spot Improvements

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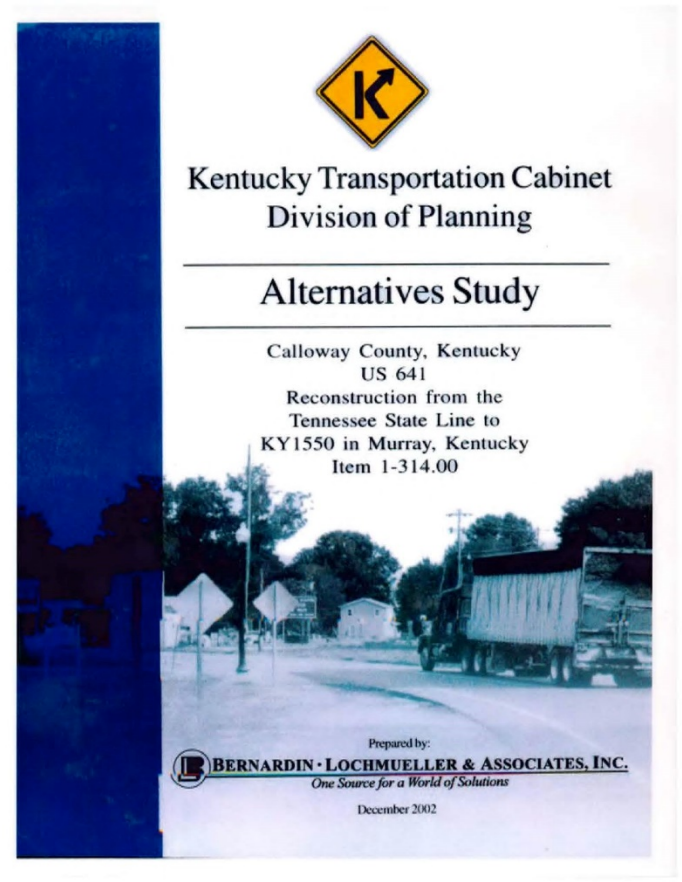
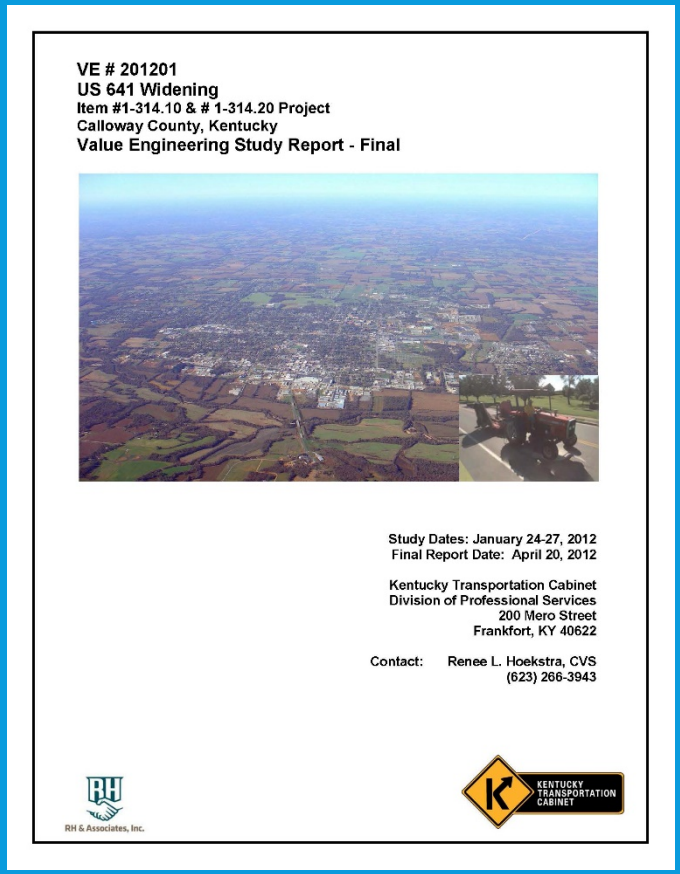
KENTUCKY TRANSPORTATION CABINET

EARLY STUDIES

2002 ALTERNATIVES STUDY

2012 VALUE ENGINEERING STUDY – RHA





ALTERNATIVES STUDY DECEMBER 2002

- Issues and Concerns Identified
  - Existing Narrow Lanes and Shoulders
  - Anticipated Traffic Growth (2%)
  - Heavy Truck Traffic
  - Future Capacity Deficiencies
  - Adverse Community Impacts

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KENTUCKY TRANSPORTATION CABINET

ALTERNATIVES STUDY DECEMBER 2002

- Alternatives Considered – *4 Lanes*
  - Reconstruction West (State Line to Midway) and East (Midway to Middle Fork of Clarks River)
  - Reconstruction West of Existing Alignment
  - Reconstruction Along Existing Alignment (North of Hazel to KY 1550)
  - Reconstruction Along Existing Alignment (From Midway to KY 1550)

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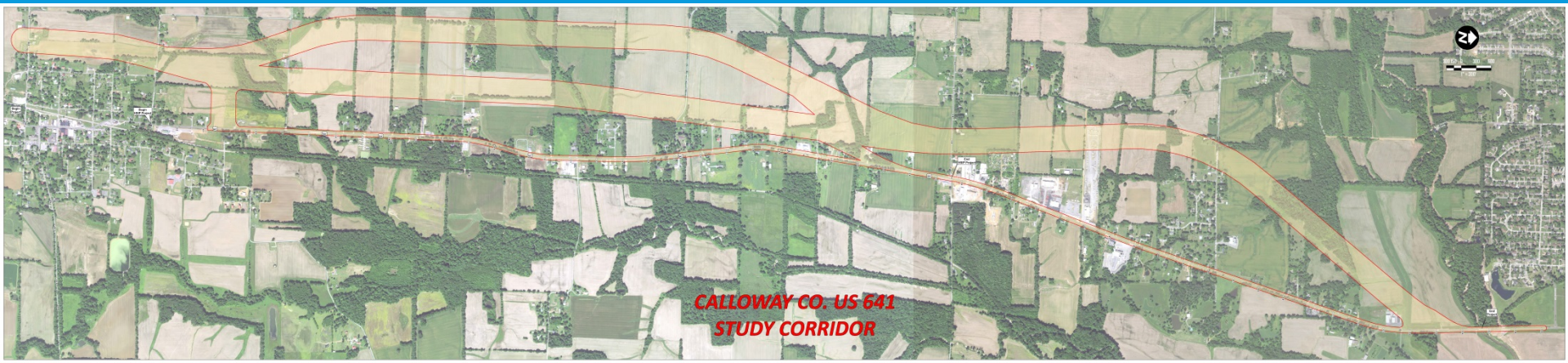
KENTUCKY TRANSPORTATION CABINET

2011 PRELIMINARY ENGINEERING STUDY
2012 VALUE ENGINEERING STUDY

- Refined Study Corridors
  - Along Existing US 641 Corridor
    - Improved 2-lanes
    - 3-lanes
  - West of Existing US 641 Corridor – 4 Lanes



Palmer ENGINEERING

KENTUCKY TRANSPORTATION CABINET

VALUE ENGINEERING STUDY APRIL 2012

- Key Recommendations
  - Reduce median width to 30 feet
  - Partially use US 641 as Alternative 3
  - Use 2+1 Typical Section or 2-Lane with Auxiliary Lane
  - Revise alignment to lessen impacts to gas line
    - Avoid gas line by using existing US 641 from Clarks River to KY 1828
  - Reduce typical section –lane width, ditch width, etc.
  - Provide an eastern alignment

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KENTUCKY TRANSPORTATION CABINET

2017 HSIP ROADWAY DEPARTURE PROJECT CALLOWAY COUNTY US 641 – MP 0.498 TO MP 3.556

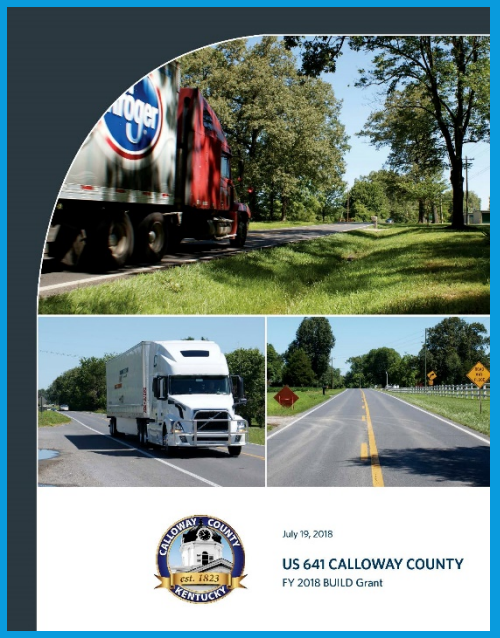
- Approximately $1,400,000 Planned Improvements
- Constructed 2017-2018
  - Addressed Critical Crash Locations

Palmer ENGINEERING

KENTUCKY TRANSPORTATION CABINET

MOVING FORWARD

- No Project Activity – 2012 until 2017
  - 2017 -- HSIP – Roadway Departure Project
- 2018 -- Re-Start Project
  - Project was changed from State Funded to Federal Funding – Environmental Documentation (NEPA) now required
- 2018 -- BUILD Grant -- *Better Utilizing Investments to Leverage Development*
  - $23,000,000 BUILD Grant
  - $32,500,000 KYTC Contribution (Federal and State)
  - $1,000,000 Local Contributions
  - $56,500,000 Total Project Funding
    - Design, Right of Way, Utilities, Construction
    - **Must be under construction – October 2020**
    - **Must be completed by September 2025**



PRELIMINARY ENGINEERING

- Environmental Studies – August 2018
- Initial Historic Eligibility Report submitted February 2019
  - Preliminary Information Provided in October 2018
  - Identified Adverse Effects to Historic Properties for Alternatives 1 and 2
- Alternatives 4, 4A, and Alternatives 5 developed
  - Alternatives 4 and 4A were west of existing US 641
  - Alternative 5 was east of existing US 641
- Alternative 3 (along existing US 641) was refined
  - 5-lane option ultimately eliminated from consideration
  - 3-lane option carried forward

PRELIMINARY ENGINEERING

- Preliminary Line and Grade Meeting – February 8, 2019
  - Alternative 4A was identified as *Preliminarily Preferred*
- Public Meeting Planned for March 12, 2019
- TDOT Coordination
  - Bi-State Agreement Drafted
- Public Meeting – March 12, 2019
  - Public Preferences
    - Alternative 3 – 20%
    - Alternative 4 – 19%
    - Alternative 4A – 47%
    - Alternative 5 – 10%
    - Do Nothing – 4%

PRELIMINARY ENGINEERING

- Plans and Cross-Sections submitted to Geotechnical Branch -- February 22, 2019
-
- Preliminary Right of Way Plans – submitted March 1, 2019
  - Jump-Start Title Research and Appraisals
- PRESS RELEASE – KYTC *Preferred Alternative 4A* – April 8, 2019
- TDOT identified *Preferred Alternative 4I* – April 30, 2019

PRELIMINARY ENGINEERING 50% PLANS

- 50% Review Meeting – June 5, 2019
  - RCUTs (J-Turns) at Tom Taylor Trail, Midway Road, Phillips Lane
  - Maintenance of Traffic -- closures allowed for up to two weeks
    - Lawring Drive, Phillips Lane, Tom Taylor Trail
    - Diversions will be used at State Line Road, Midway Road, and Brandon Road
  - Connectivity to Hazel
    - Improve E.W. Miller Street/ Road– "T" intersections, Free Flowing
    - New Alignment – Free Flowing
  - Gas Line Coordination – TransCanada Gas (TC Energy)

    3 Lines (Two 30-inch lines, one 36-in line)

    Minimum 7 feet cover under driving lanes

    Concrete Cap 3-feet over gas lines

  Drainage

    2 Dimensional HECRAS Analysis suggested

    Ponding Easements will not be required

PRELIMINARY ENGINEERING RIGHT OF WAY

- Preliminary Right of Way Plans – submitted March 1, 2019
  - Jump-Start Title Research and Appraisals
- Stage I Final Right of Way Plans – June 24, 2019
- Stage II Right of Way Plans – Hazel Connector – September 27, 2019
  - *To be determined after Public Hearing*
  - *Three Options for Hazel Connector*
    - *E.W. Miller Street / Road – "T" Intersection*
    - *E.W. Miller Street / Road – Free Flow*
    - *New Alignment – Free Flow* – Selected
  - **We are buying Right of Way**

PUBLIC HEARING AUGUST 22, 2019

- Not as Well Attended
- Some Opposition to the Identified Preferred Alternative 4A
- Preference for Free-Flowing Intersections for Hazel Connector
  - KYTC Preference – New Alignment north of E. W. Miller Street / Road

STATE LINE ROAD TO HAZEL CONNECTOR

WE NEED YOUR INPUT!

- Tie-Down in Tennessee will not be constructed for 8 to 10 years.
- How can we best address the section between State Line Road and the Hazel Connector?
- **Right of Way will be Purchased.**
- Five Options Under Consideration
  - *Option 1: Build Final Section and Barricade*
  - *Option 2: Grade and Drain, Maintain Access to severed properties*
  - *Option 3: Build Final Section but place surface for one-lane in each direction and Barricade*
  - *Option 4: Grade and Drain for Final Section, Pave only one lane in each direction.*
  - *Option 5: Build and pave only one direction, grade and drain opposite direction*

CURRENT ESTIMATE

- Current Estimate: $43,111,444
  - Pavement: 46%
  - Roadway: 30%
  - Drainage: 4%
  - Structures: 13%
  - Mobilization / Demobilization: 6%

COST SAVING MEASURES WE HAVE CONSIDERED

WE NEED YOUR

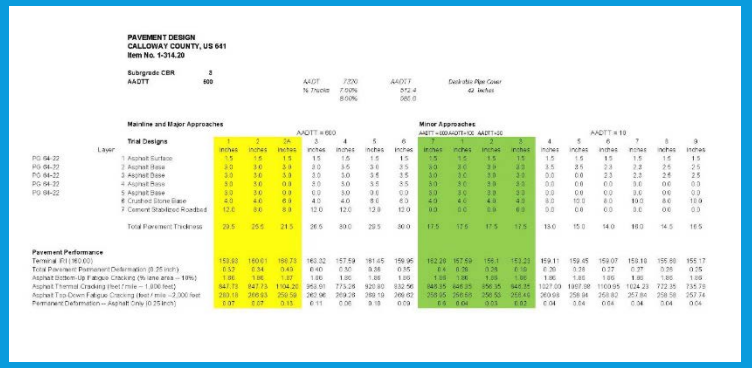
- Reduce Thickness of Cement Stabilized Roadbed
  - Cost Reduction: $309,000 (15% reduction)
- Reduce Median Width from 48 feet to 40 feet
  - Exclude areas between Tom Taylor Trail and Phillips Lane with RCUT (J-Turns)
  - Cost Reduction: $604,000 (12% Reduction) – (86,000 cu. yd.)
- Reduce Mainline Driving Lane Widths from12 feet to 11 feet
  - Cost Reduction: $610,000
- Reduce Outside Shoulder Width from 10 feet paved to 8 feet paved
  - Cost Reduction: $403,000
- Total Cost Reduction Opportunities: $1,900,000

PAVEMENT DESIGN

- Design Methodology
  - *AASHTOWare Pavement ME*
  - *KYTC Web-based Pavement Design Catalog (developed from AASHTOWare Pavement ME*
- Input Parameters
  - Mainline
    - Subgrade CBR 3
    - Average Annual Daily Truck Traffic (AADTT): 600
    - Average Annual Daily Traffic (AADT): 7320
    - 8% Trucks

MAINLINE PAVEMENT DESIGN

- AASHTOWare Pavement ME
  - 1.5 inches CL3 ASPH Surf 0.5B PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 4.0 inches Crushed Stone Base
  - 12 inches Cement Stabilized Roadbed



PAVEMENT DESIGN
CALLOWAY COUNTY, US 641
Item No. 1-314.20

Subgrade CBR 8
AADTT 600

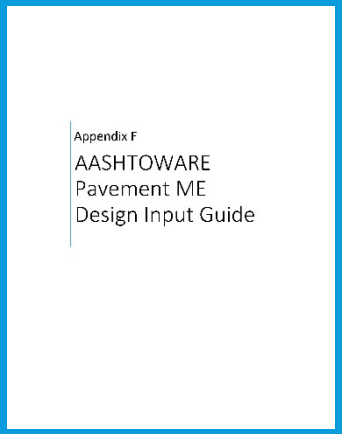
AADT 7320
% Trucks 7.00% 8.00%
AADT 512.4 585.6

Backslope Pipe Cover 42 Inches

Mainline and Major Approaches — AADTT = 600
Minor Approaches — AADTT = 600 AADTT=100 AADTT=100 — AADTT = 10

Trial Designs	1	2	2A	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Layer	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
PG 64-22 1 Asphalt Surface	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
PG 64-22 2 Asphalt Base	3.0	3.0	3.0	3.0	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.5	2.5	2.5	2.5	2.5
PG 64-22 3 Asphalt Base	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	2.5	2.5	2.5	2.5
PG 64-22 4 Asphalt Base	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	0.0	0.0
PG 64-22 5 Asphalt Base	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	0.0	0.0
6 Crushed Stone Base	4.0	4.0	6.0	4.0	4.0	6.0	6.0	4.0	4.0	4.0	4.0	4.0	4.0	8.0	10.0	8.0	10.0	8.0	10.0
7 Cement Stabilized Roadbed	12.0	8.0	8.0	12.0	12.0	12.0	12.0	8.0	8.0	8.0	8.0	8.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Pavement Thickness	29.5	25.5	27.5	26.5	30.0	29.5	30.0	23.5	23.5	23.5	23.5	23.5	23.5	13.0	15.0	14.0	19.0	14.5	16.5
Pavement Performance																			
Terminal IRI (160.00)	153.92	160.61	160.73	162.32	157.59	161.45	159.96	162.29	157.59	159.1	163.23	159.11	159.45	159.07	159.19	155.88	155.17		
Total Pavement Permanent Deformation (0.25 inch)	0.32	0.34	0.40	0.40	0.30	0.28	0.35	0.4	0.28	0.28	0.19	0.26	0.26	0.27	0.27	0.28	0.25		
Asphalt Bottom-Up Fatigue Cracking (% lane area – 10%)	1.06	1.06	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
Asphalt Thermal Cracking (feet/mile – 1,000 feet)	947.73	947.73	1104.26	958.91	775.26	920.80	832.56	949.35	846.25	856.35	948.35	1027.00	1057.98	1109.95	1024.23	772.35	735.78		
Asphalt Top-Down Fatigue Cracking (feet/mile – 2,000 feet	263.10	269.63	259.59	262.96	269.24	269.19	269.92	259.95	258.68	258.53	258.46	269.68	258.94	258.82	257.84	258.58	257.74		
Permanent Deformation – Asphalt Only (0.25 inch)	0.07	0.07	0.13	0.11	0.06	0.13	0.09	0.6	0.04	0.03	0.02	0.04	0.04	0.04	0.04	0.04	0.04		

- KYTC Web-based Catalog
  - 1.5 inches CL3 ASPH Surf 0.5B PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 6.0 inches Crushed Stone Base
  - 8.0 inches Cement Stabilized Roadbed



Appendix F
AASHTOWARE
Pavement ME
Design Input Guide

SUMMARY OF RESULTS PAVEMENT DESIGN ANALYSES AASHTO PAVEMENT ME

PAVEMENT DESIGN
CALLOWAY COUNTY, US 641
Item No. 1-314.20

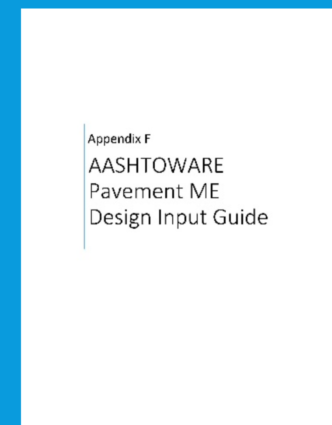
Subgrade CBR 3
AADTT 600

AADT *7320* *AADTT* *Desirable Pipe Cover*
% Trucks *7.00%* *512.4* *42 inches*
8.00% *585.6*

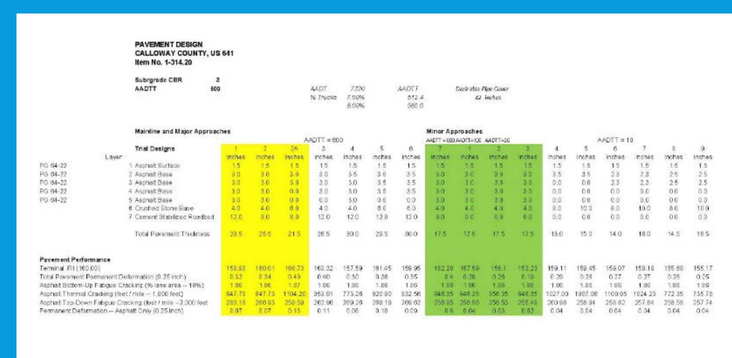
		Mainline and Major Approaches							**Minor Approaches**									
			AADTT = 600							AADTT = 600	AADTT=100	AADTT=50		AADTT = 10				
		Trial Designs	1	2	2A	3	4	5	6	7	1	2	3	4	5	6	7	8	9
	Layer		inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
PG 64-22	1	Asphalt Surface	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
PG 64-22	2	Asphalt Base	3.0	3.0	3.0	3.0	3.5	3.0	3.5	3.0	3.0	3.0	3.0	3.5	3.5	2.3	2.3	2.5	2.5
PG 64-22	3	Asphalt Base	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	0.0	0.0	2.3	2.3	2.5	2.5
PG 64-22	4	Asphalt Base	3.0	3.0	0.0	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
PG 64-22	5	Asphalt Base	3.0	3.0	0.0	0.0	3.0	0.0	0.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
	6	Crushed Stone Base	4.0	4.0	6.0	4.0	4.0	6.0	6.0	4.0	4.0	4.0	4.0	8.0	10.0	8.0	10.0	8.0	10.0
	7	Cement Stabilized Roadbed	12.0	8.0	8.0	12.0	12.0	12.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Total Pavement Thickness	29.5	25.5	21.5	26.5	30.0	29.5	30.0	17.5	17.5	17.5	17.5	13.0	15.0	14.0	16.0	14.5	16.5
Pavement Performance																			
Terminal IRI (160.00)			158.93	160.01	168.73	163.32	157.59	161.45	159.95	162.28	157.59	156.1	153.23	159.11	159.45	159.07	158.18	155.68	155.17
Total Pavement Permanent Deformation (0.25 inch)			0.32	0.34	0.49	0.40	0.30	0.36	0.35	0.4	0.29	0.26	0.19	0.29	0.28	0.27	0.27	0.26	0.25
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)			1.86	1.86	1.87	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)			847.73	847.73	1104.20	953.91	773.26	920.80	832.56	846.35	846.35	856.35	846.35	1027.00	1097.98	1100.95	1024.23	772.35	735.79
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet			280.18	266.93	259.59	262.96	269.26	269.19	269.62	256.95	256.56	256.53	256.49	260.98	258.94	258.82	257.84	258.58	257.74
Permanent Deformation -- Asphalt Only (0.25 inch)			0.07	0.07	0.13	0.11	0.06	0.10	0.09	0.6	0.04	0.03	0.02	0.04	0.04	0.04	0.04	0.04	0.04

MINOR APPROACHES PAVEMENT DESIGN

- Input Parameters
  - Minor Approaches
    - Subgrade CBR 3
    - Average Annual Daily Truck Traffic (AADTT): 100
    - Variations from AADTT--10 to 100



- AASHTOWare Pavement ME
  - 1.5 inches CL3 ASPH Surf 0.5D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 3.0 inches CL3 ASPH Base 1.00D PG64-22
  - 4.0 inches Crushed Stone Base



QUESTIONS / COMMENTS

PLEASE NOTE THAT THE FOLLOWING OUT-BRIEF PRESENTATION WAS GIVEN ON NOVEMBER 21, 2019. INFORMATION CONTAINED THEREIN MAY DIFFER FROM WHAT IS PRESENTED IN EARLIER SECTIONS OF THIS REPORT THAT HAVE BEEN MORE FULLY VETTED POST-WORKSHOP.

KENTUCKY TRANSPORTATION CABINET

US 641 RECONSTRUCTION (CALLOWAY COUNTY) ITEM NO. 1-314.20

VALUE ENGINEERING STUDY OUT-BRIEF PRESENTATION

NOVEMBER 21, 2019

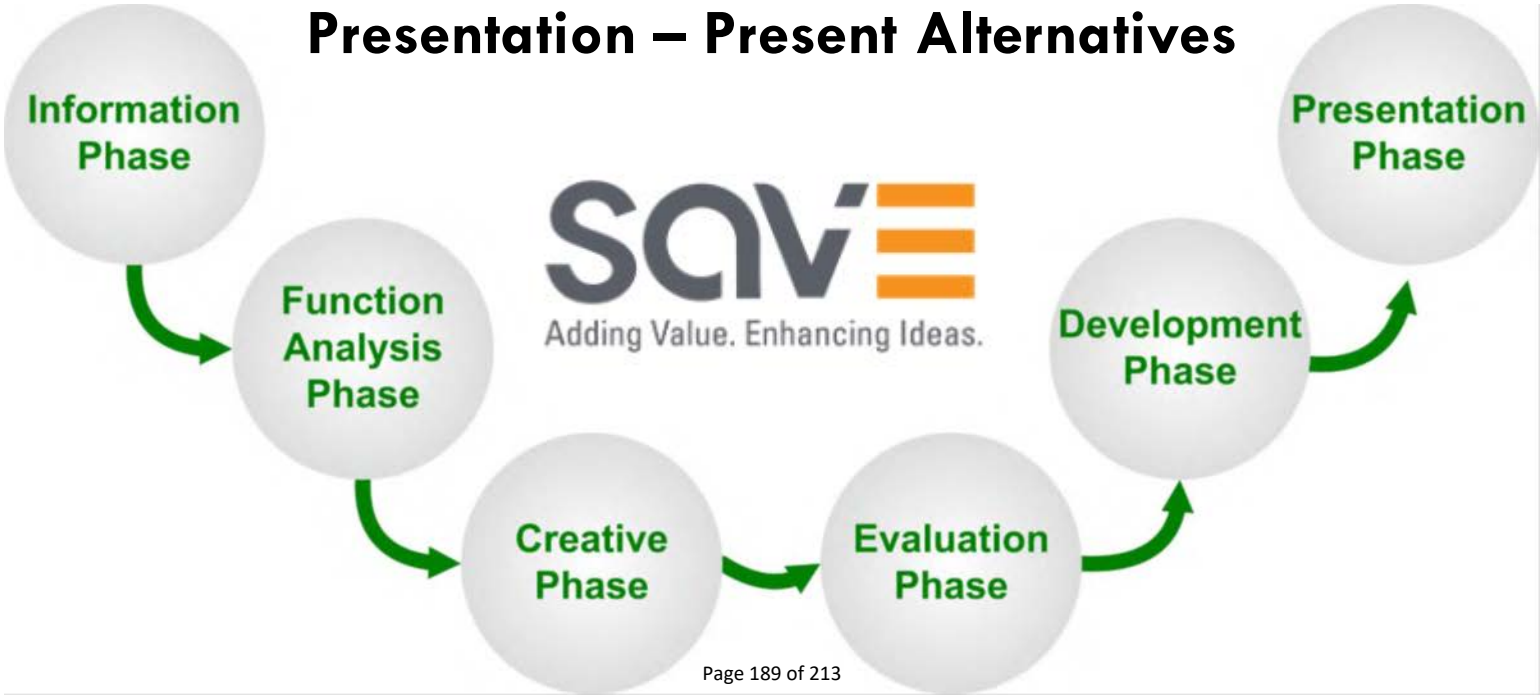
VE Study Team

- Andy Gilley, PE (Qk4)
- Justin Harrod, VIP (KYTC)
- Jason Littleton, PE (AEI)
- Robert Martin, PE (Qk4)
- Connor Schurman, EIT (KYTC)
- Brent Sweger, PE (KYTC)
- Pat Miller, CVS (RHA) – VE Team Leader

Left to right: Andy, Justin, Rob, Jason, Brent, Connor

VE Job Plan

Information – Analyze Information
Function Analysis – Define Functions
Creative – Generate Ideas
Evaluation – Select Ideas
Development – Develop Ideas
Presentation – Present Alternatives



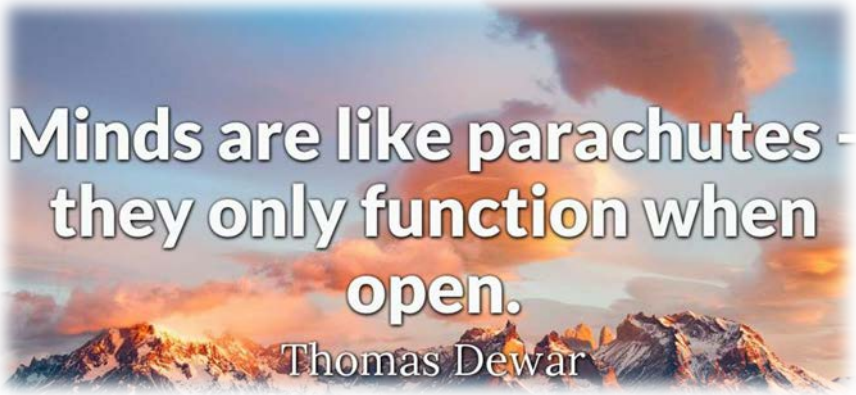
Baseline Design

Workshop Objectives

- Review Hazel Connector – 5 Options
- Review pavement design
- Evaluate $1.9M Potential Cost Savings – 4 Options
- Review MOT plan
- Identify combinations of alternates that bring the project value (i.e., constructability, access)

Project Functions

- Basic Function (What must this project do?)
  - Improve Safety (Build safer route between Murray and Paris)
- Higher Order Function
  - Reduce Crashes
- Brainstormed alternatives using key functions
  - Cross Creek (CC)
  - Cross Gasline (CG)
  - Optimize Geometry (OG)
  - Support Load (SL)
  - Convey Traffic (CT)
  - Minimize Environmental-impacts (ME)

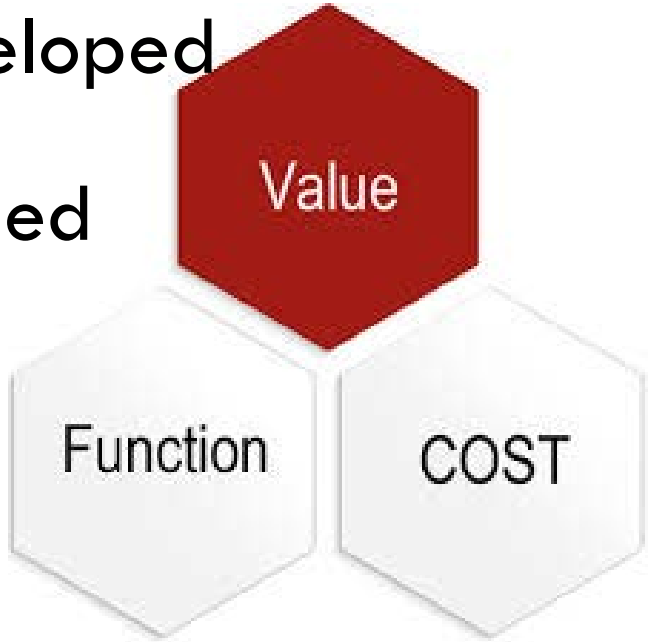


Performance Attributes

- **Constructability:** construct the design efficiently
- **Maintenance of traffic:** local access to residents during construction
- **Maintainability:** ability to maintain project at appropriate O&M cost
- **Safety:** achieve an annual reduction of crashes
- **Schedule:** obligate funding by September 30, 2020
- **Conformance to BUILD grant:** what is the deviation from the BUILD grant?

Creative Ideas

- **38** Ideas brainstormed
  - **18** Alternatives developed
  - **8** Design Suggestions developed
  - **1** Design Comment identified



VE Proposal Summary

Summary of Value Engineering Proposals

IDEA NO.	IDEA TITLE	PERFORMANCE IMPACT					COST IMPACT		
		Construct-ability	Maintenance of Traffic	Safety	Schedule	Conformance to BUILD Grant	Initial Cost Savings / (Add)	O&M	Total Life Cycle Cost
CC	**Cross Creek**								
CC-01	Cross Brushy Creek more perpendicular in an area outside the wetland	No impact	No impact	No impact	**Impacted**	No impact	$378,000	$0	$378,000
CC-03	Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph	No impact	No impact	No impact	**Impacted**	No impact	$679,000	$0	$679,000
CG	**Cross Gasline**								
CG-01	Eliminate the Tom Taylor Trail over the gasline (east side)	No impact	No impact	**Improves**	No impact	No impact	$597,000	$26,000	$623,000
CG-02	Build land bridge over gaslines	No impact	**Improves**	**Improves**	**Improves**	No impact			
CG-03	At 6355+00 (Heron Road), relocate the approach tie to 6343+00 to avoid gaslines	**Impacted**	No impact	No impact	**Impacted**	No impact	($19,000)	$0	($19,000)
CG-04	Shift the northern tie to US 641 to the northwest to connect back to old US 641 without crossing the gaslines	**Impacted**	No impact	No impact	No impact	No impact	$370,000	$17,000	$387,000
CG-05	Relocate the bridge over the tributary to Middle Fork of Clarks River to the same approximate location of the existing bridge, take the channel under the road at the new location, and run the channel change parallel to the roadway on the west side	No impact	No impact	**Impacted**	**Impacted**	No impact	$87,000	$0	$87,000
CG-06	Eliminate the Heron Road tie at 6355+00	No impact	No impact	**Improves**	**Improves**	No impact	$111,000	$0	$111,000

PAVEMENT DESIGN (SL-01, SL-02, SL-03, SL-04)

PAVEMENT DESIGN
CALLOWAY COUNTY, US 641
Item No. 1-314.20

Subgrade CBR 3
AADTT 600

AADT 7320 *AADTT* 512.4
% Trucks 7.00% 8.00% 585.6

Desirable Pipe Cover 42 *inches*

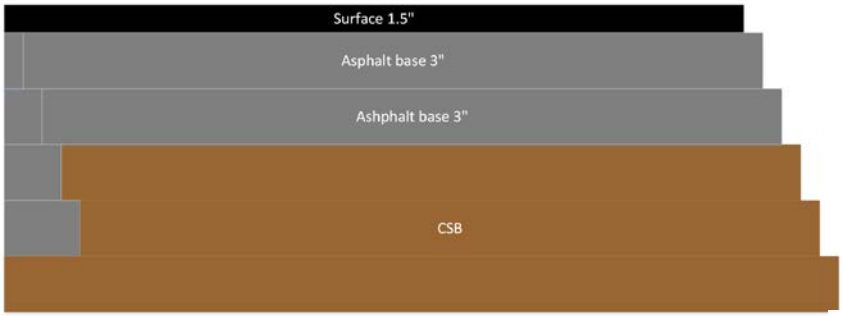
			Mainline and Major Approaches							Minor Approaches								
			AADTT = 600							AADTT = 600	AADTT=100	AADTT=50		AADTT = 10				
	Trial Designs		1	2	2A	3	4	5	6	7	1	2	3	4	5	6	7	8	9
	Layer		inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
PG 64-22	1 Asphalt Surface		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
PG 64-22	2 Asphalt Base		3.0	3.0	3.0	3.0	3.5	3.0	3.5	3.0	3.0	3.0	3.0	3.5	3.5	2.3	2.3	2.5	2.5
PG 64-22	3 Asphalt Base		3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	0.0	0.0	2.3	2.3	2.5	2.5
PG 64-22	4 Asphalt Base		3.0	3.0	0.0	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
PG 64-22	5 Asphalt Base		3.0	3.0	0.0	0.0	3.0	0.0	0.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
	6 Crushed Stone Base		4.0	4.0	6.0	4.0	4.0	6.0	6.0	4.0	4.0	4.0	4.0	8.0	10.0	8.0	10.0	8.0	10.0
	7 Cement Stabilized Roadbed		12.0	8.0	8.0	12.0	12.0	12.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total Pavement Thickness		29.5	25.5	21.5	26.5	30.0	29.5	30.0	17.5	17.5	17.5	17.5	13.0	15.0	14.0	16.0	14.5	16.5
KYTC Pavement Performance		**KYTC Reliability**																	
Terminal IRI (160.00)		95%	158.93	159.85	168.68	176.55	157.59	161.45	159.95	162.11	157.49	156.18	153.17	159.11	159.45	159.07	158.18	155.68	155.17
Total Pavement Permanent Deformation (0.25 inch)		95%	0.32	0.34	0.48	0.42	0.30	0.36	0.35	0.39	0.29	0.25	0.19	0.29	0.28	0.27	0.27	0.26	0.25
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)		95%	1.86	1.86	1.87	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)		90%	847.73	847.73	1130.41	2425.19	773.26	920.80	832.56	847.73	847.73	867.03	847.73	1027.00	1097.98	1100.95	1024.23	772.35	735.79
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet		90%	280.18	262.21	259.07	268.07	269.26	269.19	269.62	256.84	256.55	256.52	256.49	260.98	258.94	258.82	257.84	258.58	257.74
Permanent Deformation -- Asphalt Only (0.25 inch)		90%	0.07	0.07	0.12	0.13	0.06	0.10	0.09	0.06	0.04	0.03	0.02	0.04	0.04	0.04	0.04	0.04	0.04

			AADTT = 600							
	Trial Designs		VE #1A	VE #1B	VE #2A	VE #2B	VE #3A	VE #3B	GWS #1A	GWS #1B
	Layer		inches	inches	inches	inches	inches	inches	inches	inches
PG 64-22	1 Asphalt Surface		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
PG 64-22	2 Asphalt Base		3.0	3.0	3.0	3.0	3.0	3.0	4.5	4.5
PG 64-22	3 Asphalt Base		3.0	3.0	3.0	3.0	3.0	3.0	4.5	4.5
PG 64-22	4 Asphalt Base		0.0	0.0	3.0	3.0	4.5	4.5	0.0	0.0
PG 64-22	5 Asphalt Base		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6 Crushed Stone Base		4.0	6.0	4.0	6.0	4.0	6.0	4.0	6.0
	7 Cement Stabilized Roadbed		12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
	Total Pavement Thickness		23.5	25.5	26.5	28.5	28.0	30.0	26.5	28.5
KYTC Pavement Performance Parameters		**KYTC Reliability**								
Terminal IRI (160.00)		95%	179.94	179.57	176.55	176.24	174.61	174.33	161.73	161.49
Total Pavement Permanent Deformation (0.25 inch)		95%	0.49	0.48	0.42	0.41	0.37	0.37	0.38	0.37
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 10%)		95%	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)		90%	2452.77	2452.77	2425.19	2425.19	2411.40	2411.40	854.63	864.28
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet		90%	257.42	257.55	268.07	273.09	304.03	317.58	258.22	259.23
Permanent Deformation -- Asphalt Only (0.25 inch)		90%	0.15	0.16	0.13	0.13	0.11	0.11	0.10	0.10
AASHTO Pavement Performance Parameters		**AASHTO Reliability**								
Terminal IRI (172.00)		90%	167.60	167.25	164.39	164.10	162.55	162.29	150.49	150.27
Total Pavement Permanent Deformation (0.75 inch)		90%	0.46	0.45	0.39	0.38	0.35	0.34	0.36	0.35
Asphalt Bottom-Up Fatigue Cracking (% lane area -- 25%)		90%	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Asphalt Thermal Cracking (feet / mile -- 1,000 feet)		90%	2452.77	2452.77	2425.19	2425.19	2411.40	2411.40	854.63	864.28
Asphalt Top-Down Fatigue Cracking (feet / mile --2,000 feet		90%	257.42	257.55	268.07	273.09	304.03	317.58	258.22	259.23
Permanent Deformation -- Asphalt Only (0.25 inch)		90%	0.15	0.16	0.13	0.13	0.11	0.11	0.10	0.10

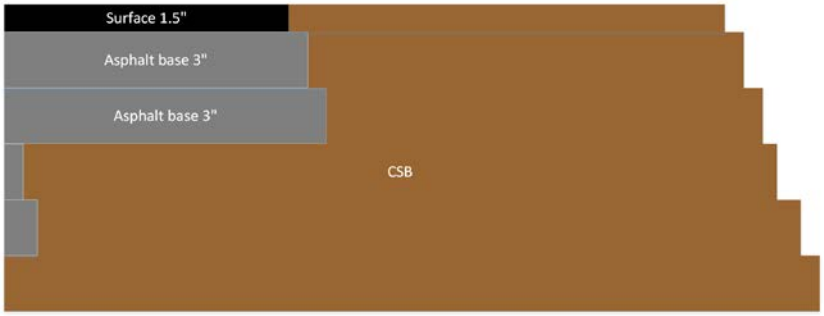
REDUCE PAVEMENT WIDTH (CT-01, CT-03)

CT-01: Reduce the pavement on the outside shoulders from 10 feet to 4 feet
Cost Avoid - $528,000

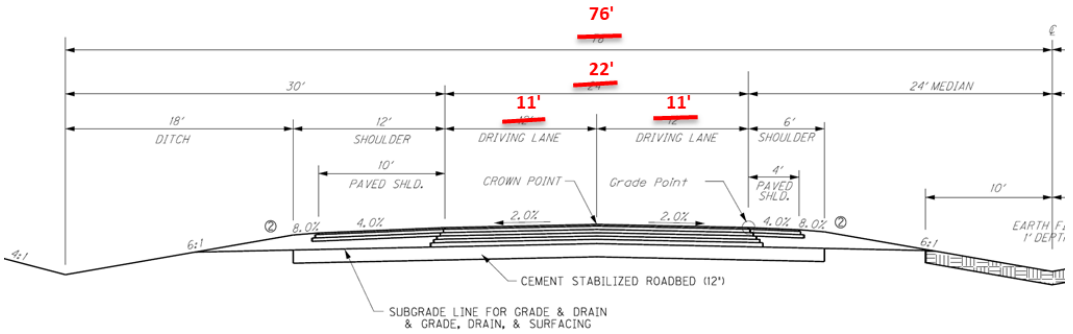
Baseline 10' Paved Shoulder



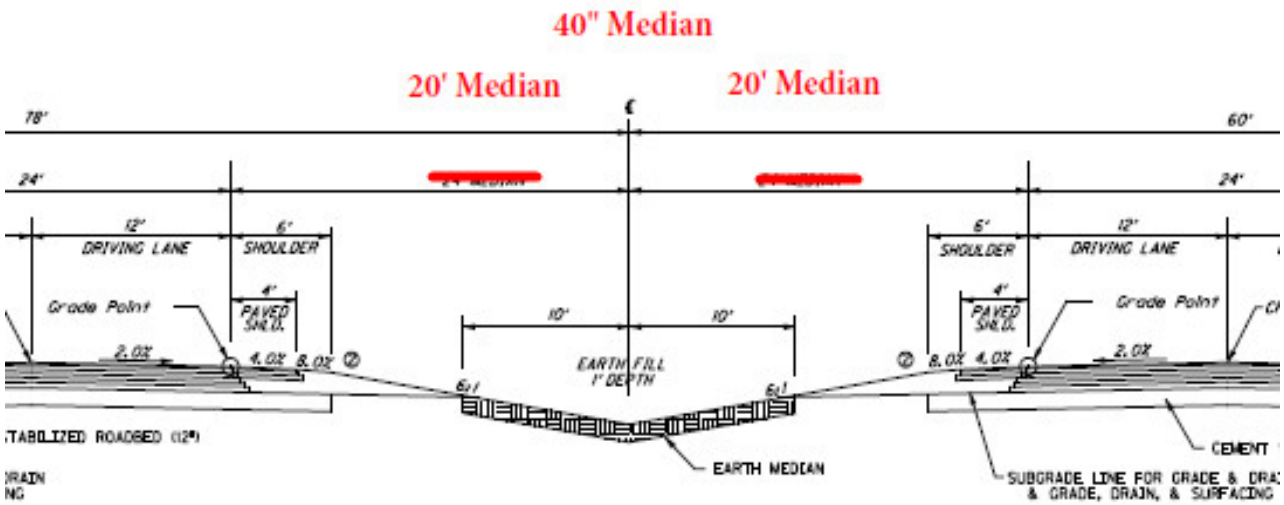
Proposed 4' Paved + 6' Rock Shoulder

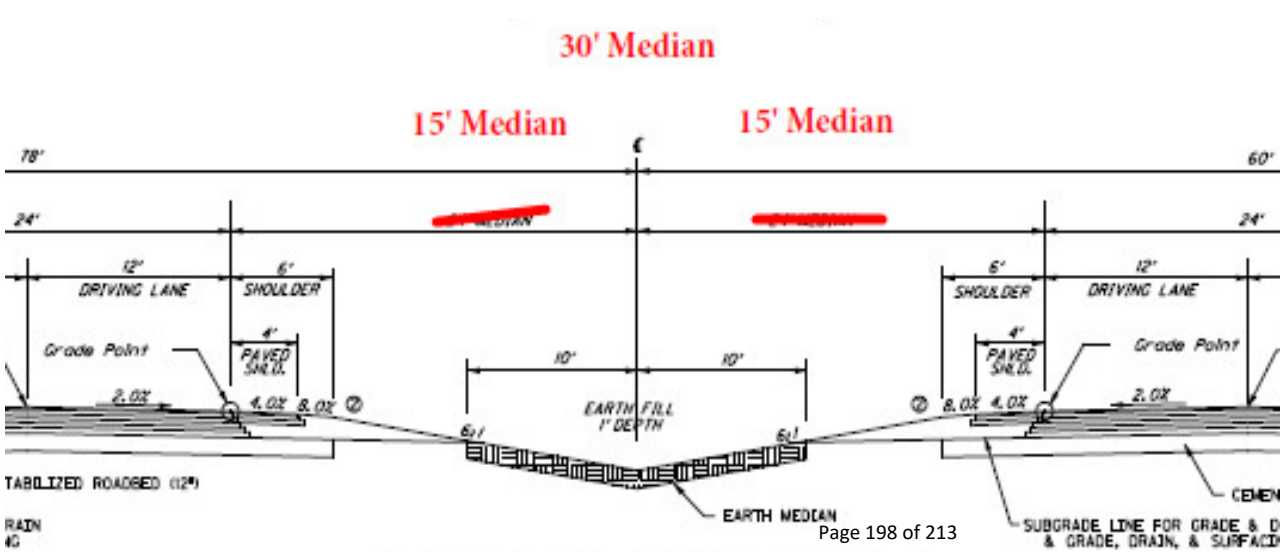


CT-03: Reduce through-lane pavement width from 12 feet to 11 feet *(Option 3, Potential Cost Savings)*
Cost Avoid - $610,000+129,000=$739,000



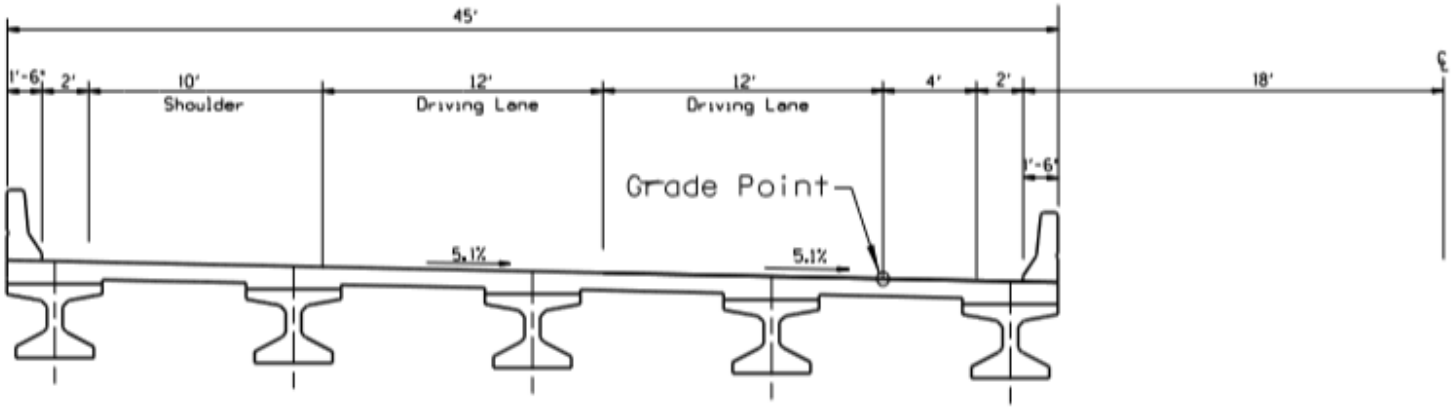
CT-04: Reduce median width from 48 feet to 40 feet *(Option 2, Potential Cost Savings)*

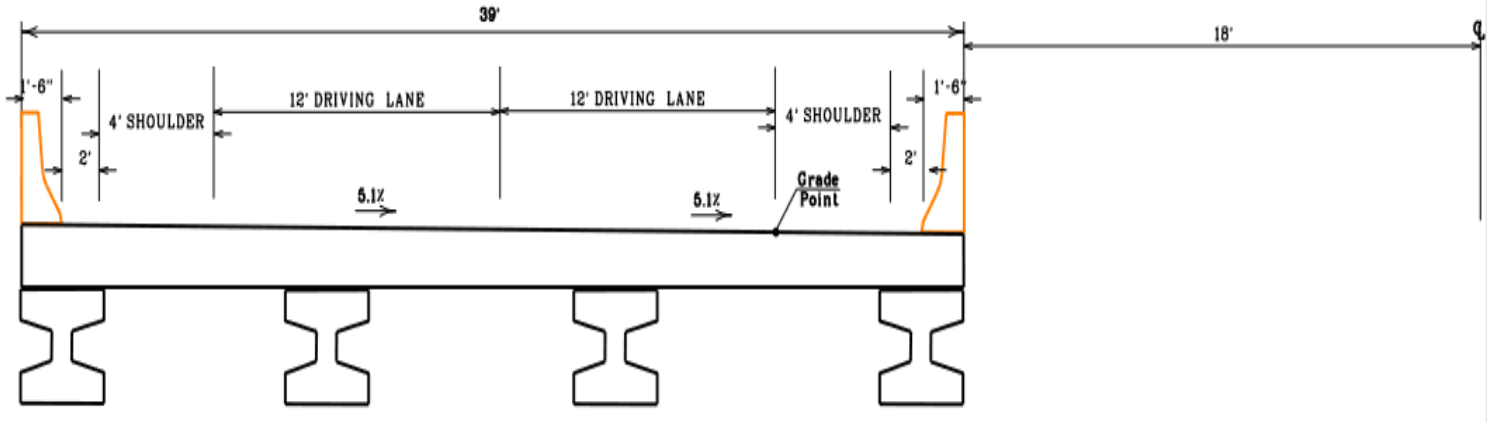




Cost Avoid - $604,000

CT-06: Reduce bridge outside shoulder width from 12 feet to 4 feet





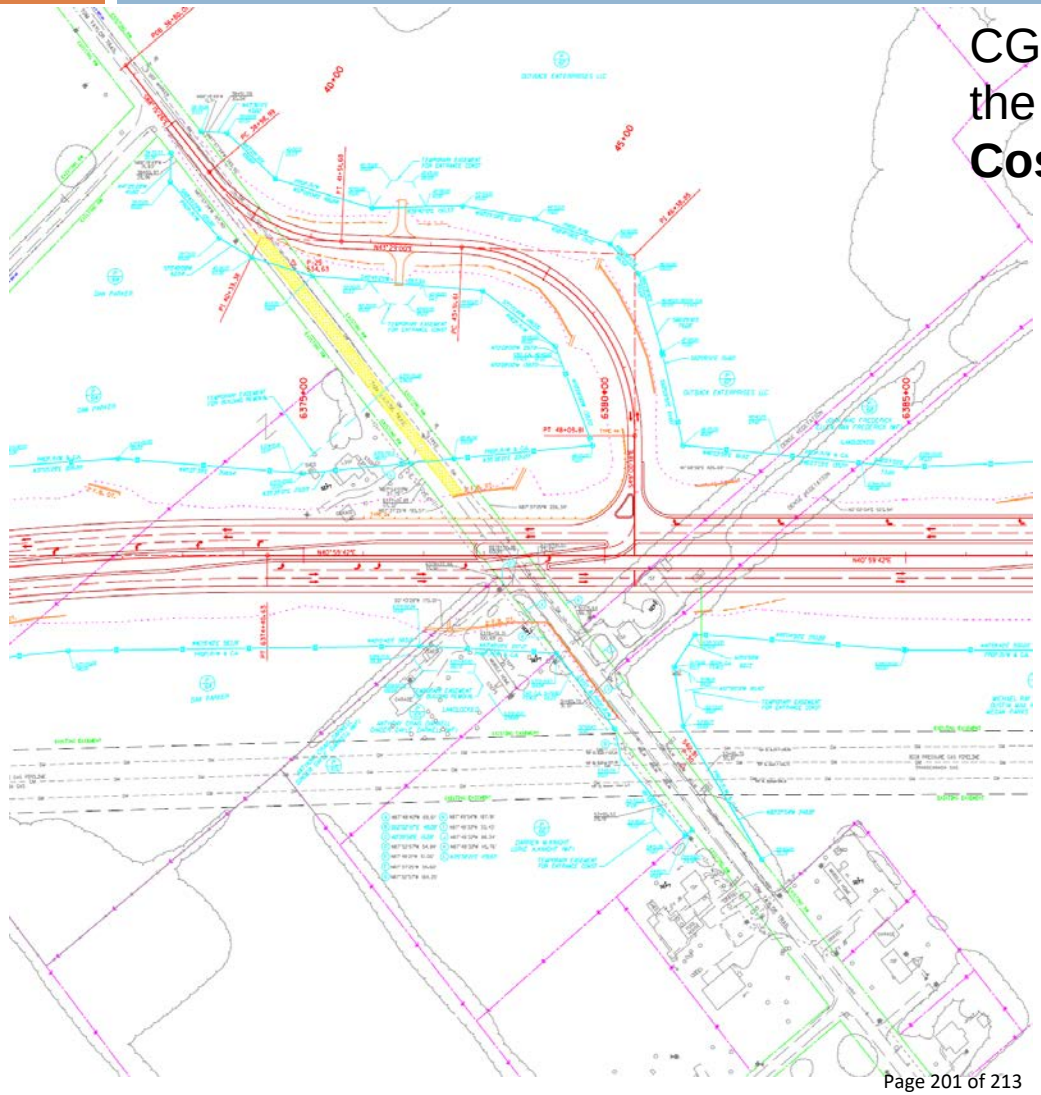
Cost Avoid - $675,000

CT-19: Review Maintenance of Traffic (MOT) Plan

- Diversions
  - Brandon Road
  - Midway Road
- Access Points

Design Suggestion

GASLINES (CG-01, CG-02)



CG-01: Eliminate the Tom Taylor Trail over the gasline (east side)

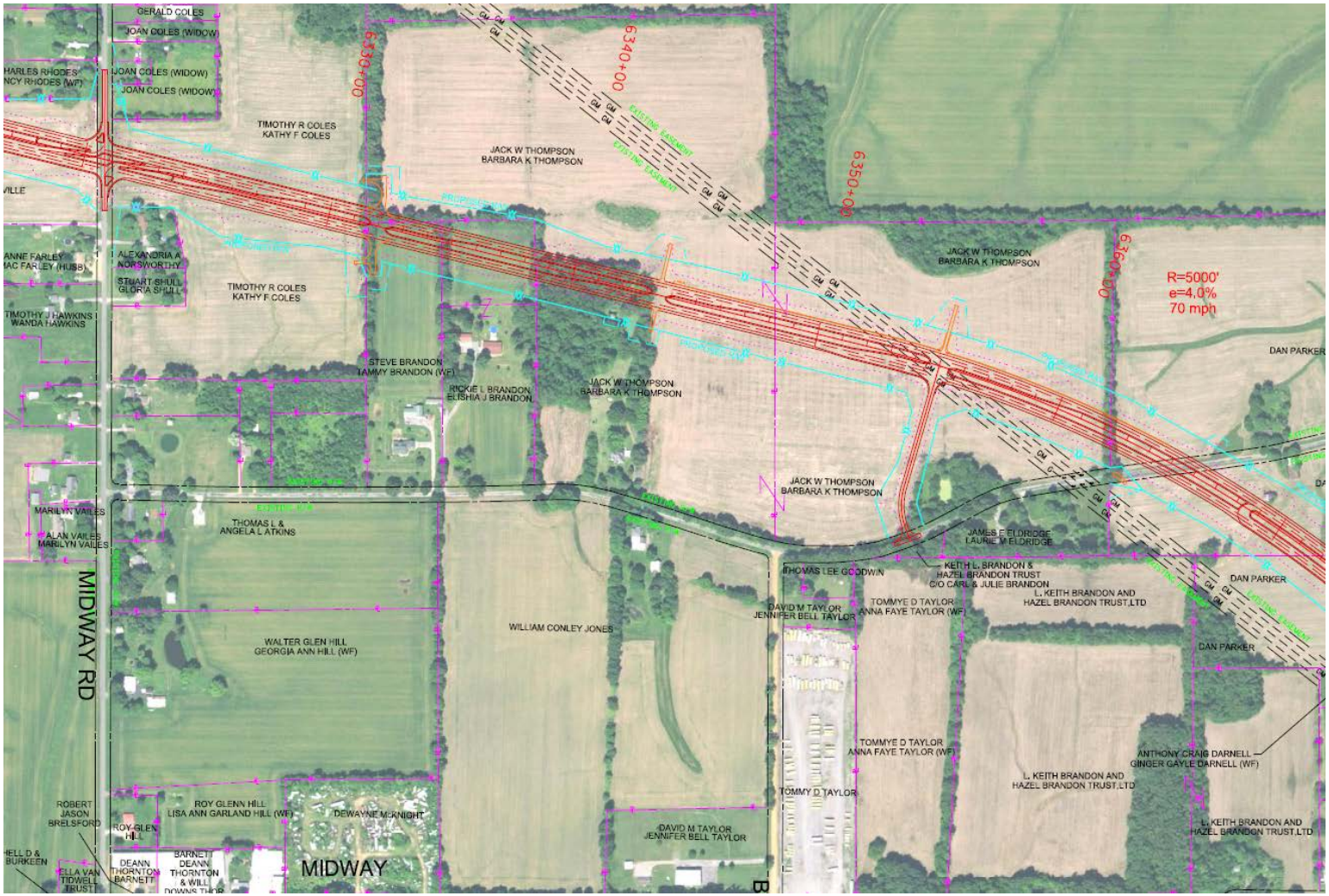
Cost Avoid - $597,000+$26,000=$623,000

CG-02: Build land bridge over the gaslines

Design Suggestion

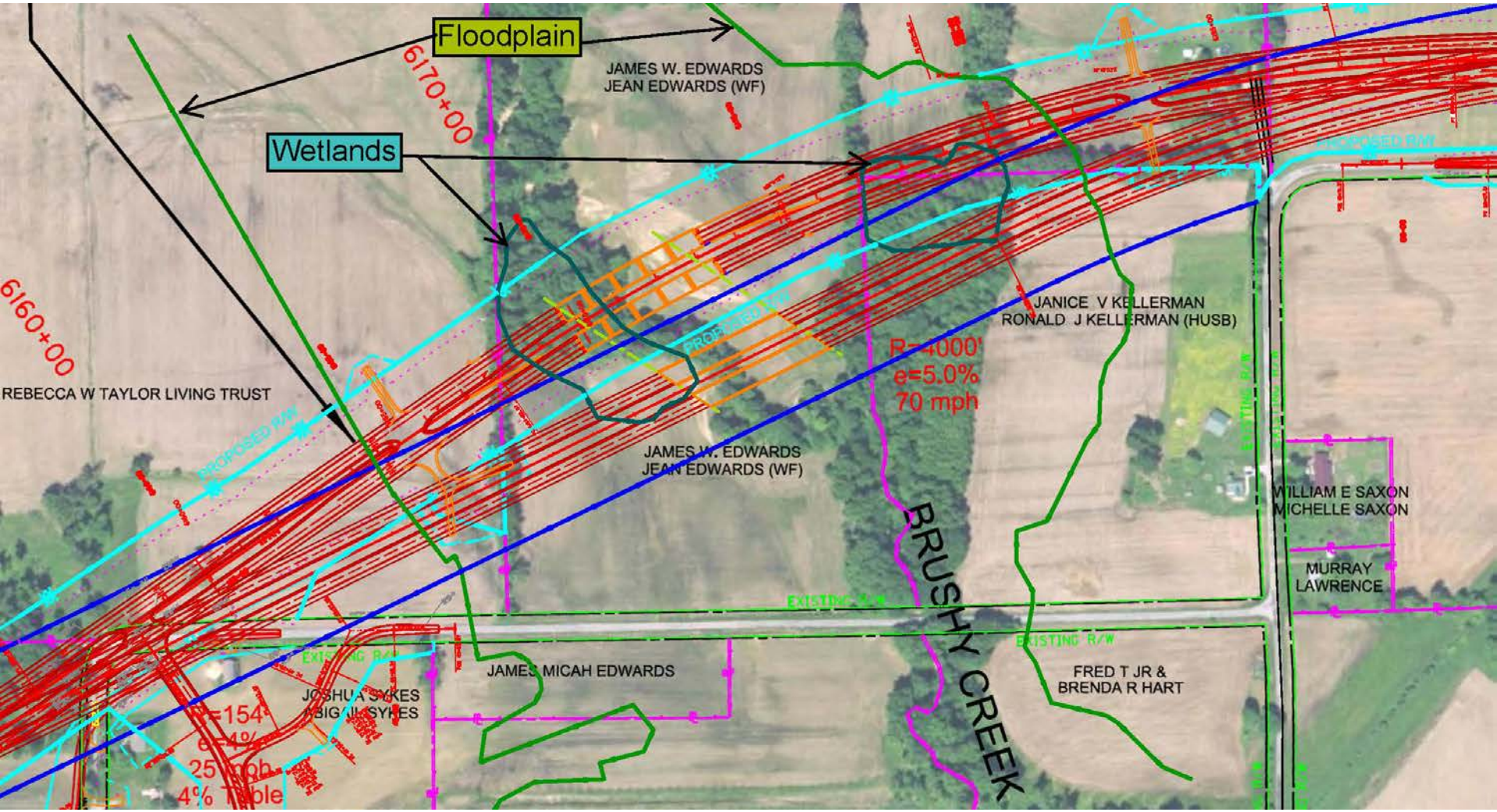
CG-06: Eliminate the Heron Road tie at 6355+00

16



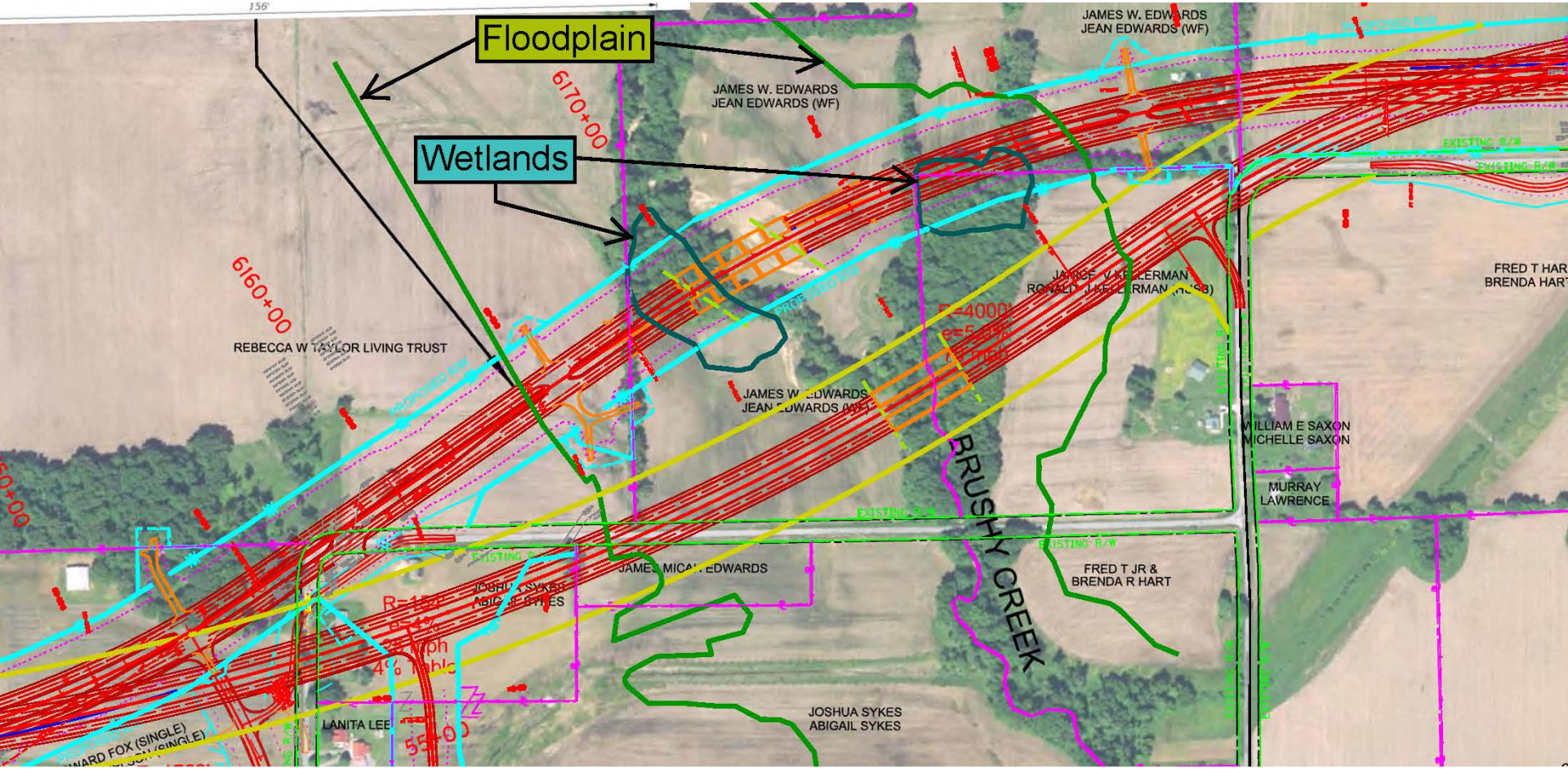
Cost Avoid - $111,000

CC-01: Cross Brushy Creek more perpendicular in an area outside the wetland



Cost Avoid - $398,000

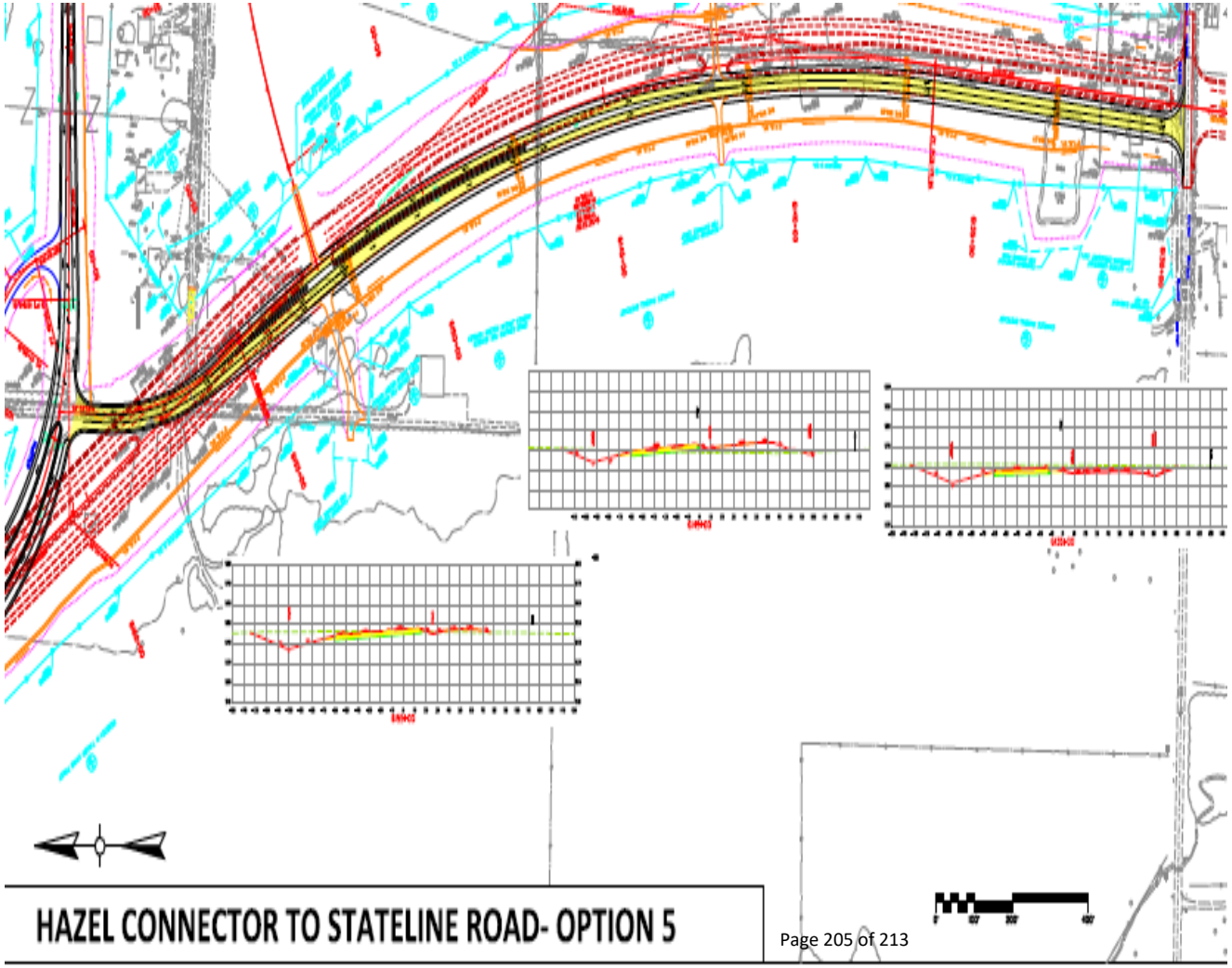
CC-03: Cross Brushy Creek more perpendicular in an area outside the wetland at 60 mph



Cost Avoid - $679,000

CT-18: Review the Hazel Connector Options 1-5

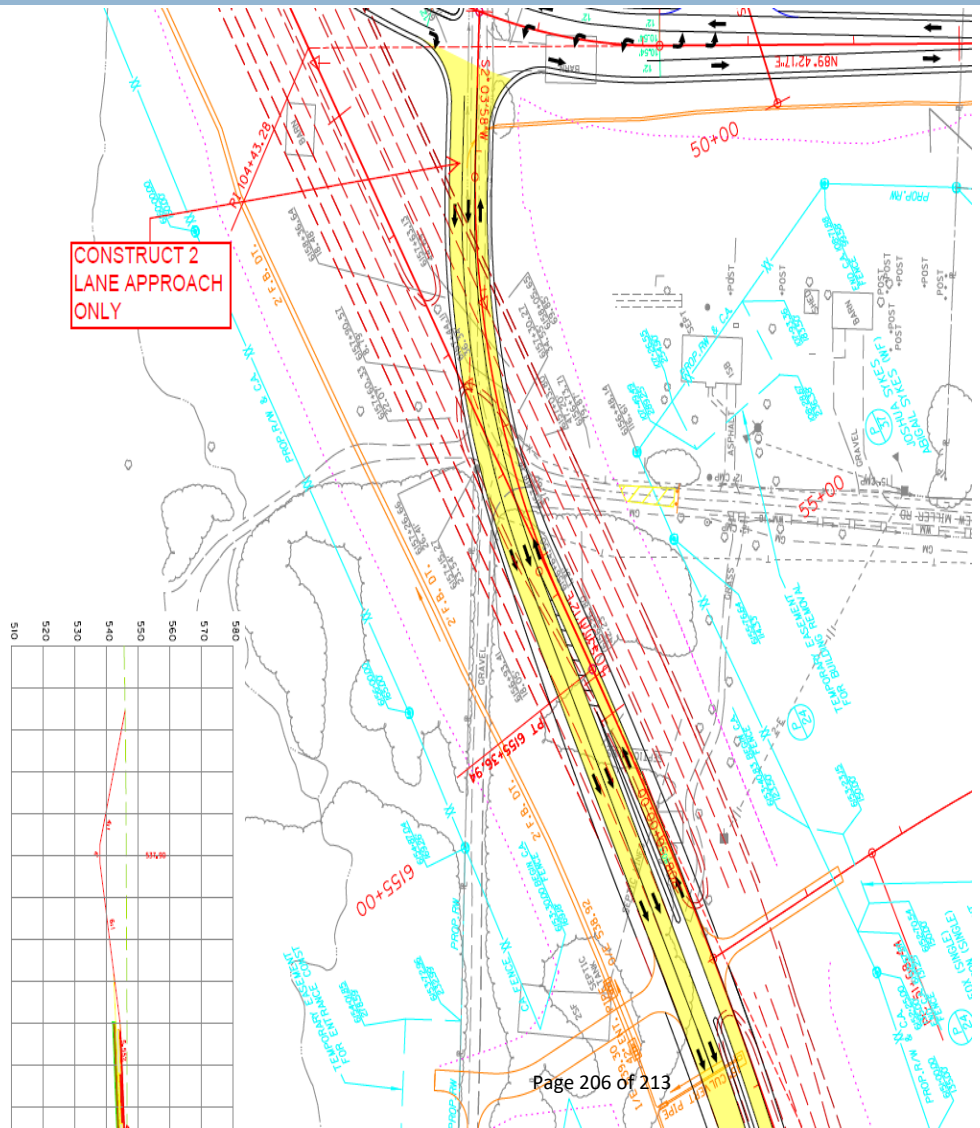
Baseline



Design Suggestion

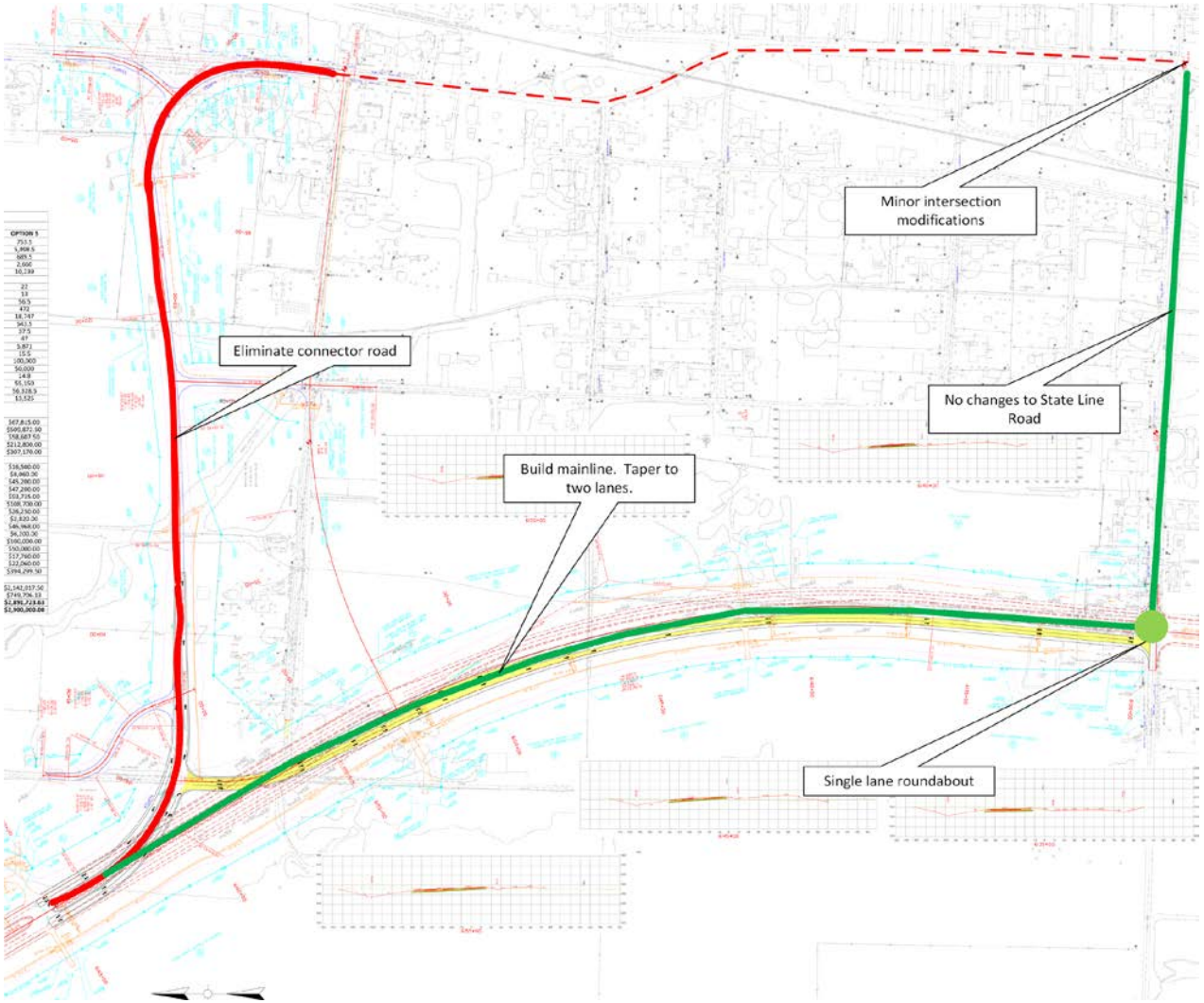
CT-18: Review the Hazel Connector Options 1-5

Proposed



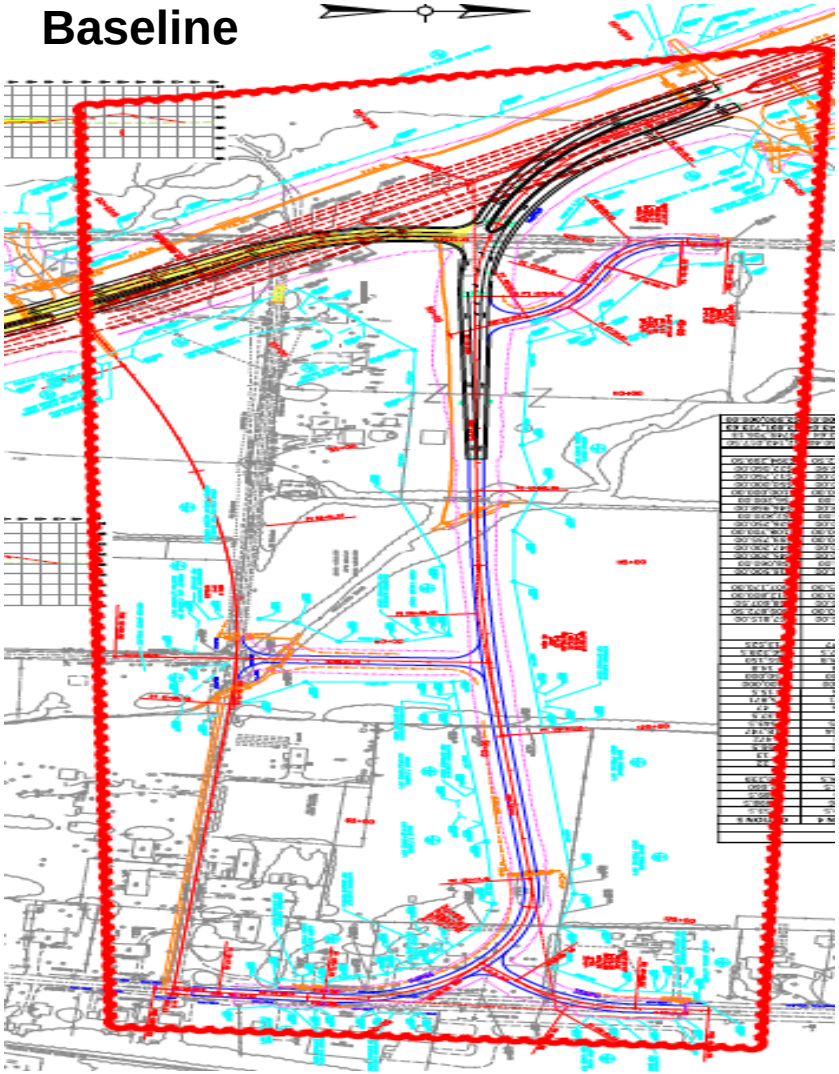
Design Suggestion

CT-11: Eliminate the Hazel connector and improve the intersection at State Line Road (i.e., roundabout)

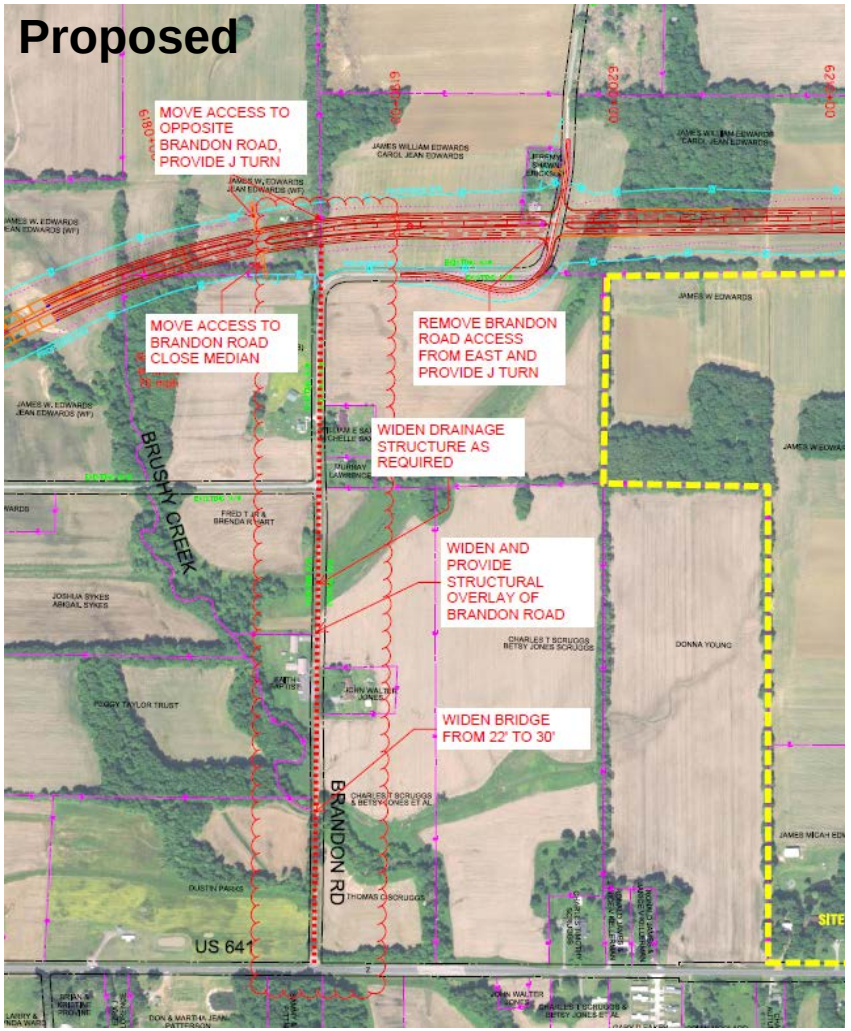


CT-17: Eliminate the Hazel Connector and improve Brandon Road as an alternate northern connection

Baseline



Proposed



Cost Avoid - $1,598,128

CT-08: Change from a 4-lane divided typical section to a 2-plus-1 roadway design

Cost Avoid – $13,307,000

Questions

Next Steps

- Draft Report due Thursday, December 5, 2019

Value Engineering Study – Agenda

Kentucky Transportation Cabinet

Agenda November 18-21, 2019

Study Location

KYTC Office, 200 Mero Street, Frankfort, KY – Conference Center C117

Day 1: Monday, November 18, 2019

INFORMATION PHASE

9:00-9:15	Introductions (All) & Brief Overview of the VE Process *(Team Leader-Pat Miller)*
9:15-10:30	Project Overview, Presentation *(KYTC Project Manager Chris Kuntz, Palmer Engineering Gary Sharpe)*
10:30-10:45	Break
10:45-12:00	Project Goals & Constraints, Workshop Objectives, Identify Key Performance Attributes Identify Project Risks
12:00-1:00	Lunch
1:00-1:15	Review Cost Estimate / Cost Model
1:15-1:45	VE Team Observations

FUNCTION ANALYSIS PHASE

1:45-2:15	Function Identification of Project Elements
2:15-2:30	Break

CREATIVE PHASE

2:30-5:00	Brainstorm Ideas / Alternatives
5:00	Adjourn

Day 2: Tuesday, November 19, 2019

8:00-8:05	Check-in with VE Team

CREATIVE PHASE (continued)

8:05-10:00	Brainstorm Ideas / Alternatives
10:00-10:15	Break
10:15-12:00	Brainstorm Ideas / Alternatives
12:00-1:00	Lunch

EVALUATION PHASE

1:00-2:30	Evaluation of Ideas – Team Assignments for Development

DEVELOPMENT PHASE

2:30-2:45	Break
2:45-5:00	Develop / Cost Alternatives
5:00	Adjourn

Day 3: Wednesday, November 20, 2019

8:00-8:05 Check-in with VE Team

DEVELOPMENT PHASE

8:05-12:00 Develop / Cost Alternatives
12:00-1:00 Lunch
1:00-5:00 Develop / Cost Alternatives
Group Review of VE Alternatives / Prepare Presentation
5:00 Adjourn

Day 4: Thursday, November 21, 2019

8:00-8:05 Check-in with VE Team

DEVELOPMENT PHASE/PRESENTATION PHASE

8:05-10:00 Group Review of VE Alternatives
Presentation Run-through
10:00-11:30 Presentation of VE Alternatives / Out-brief Meeting *(Management, Stakeholders)*
11:30-12:00 Wrap-up with VE Team
12:00 Adjourn