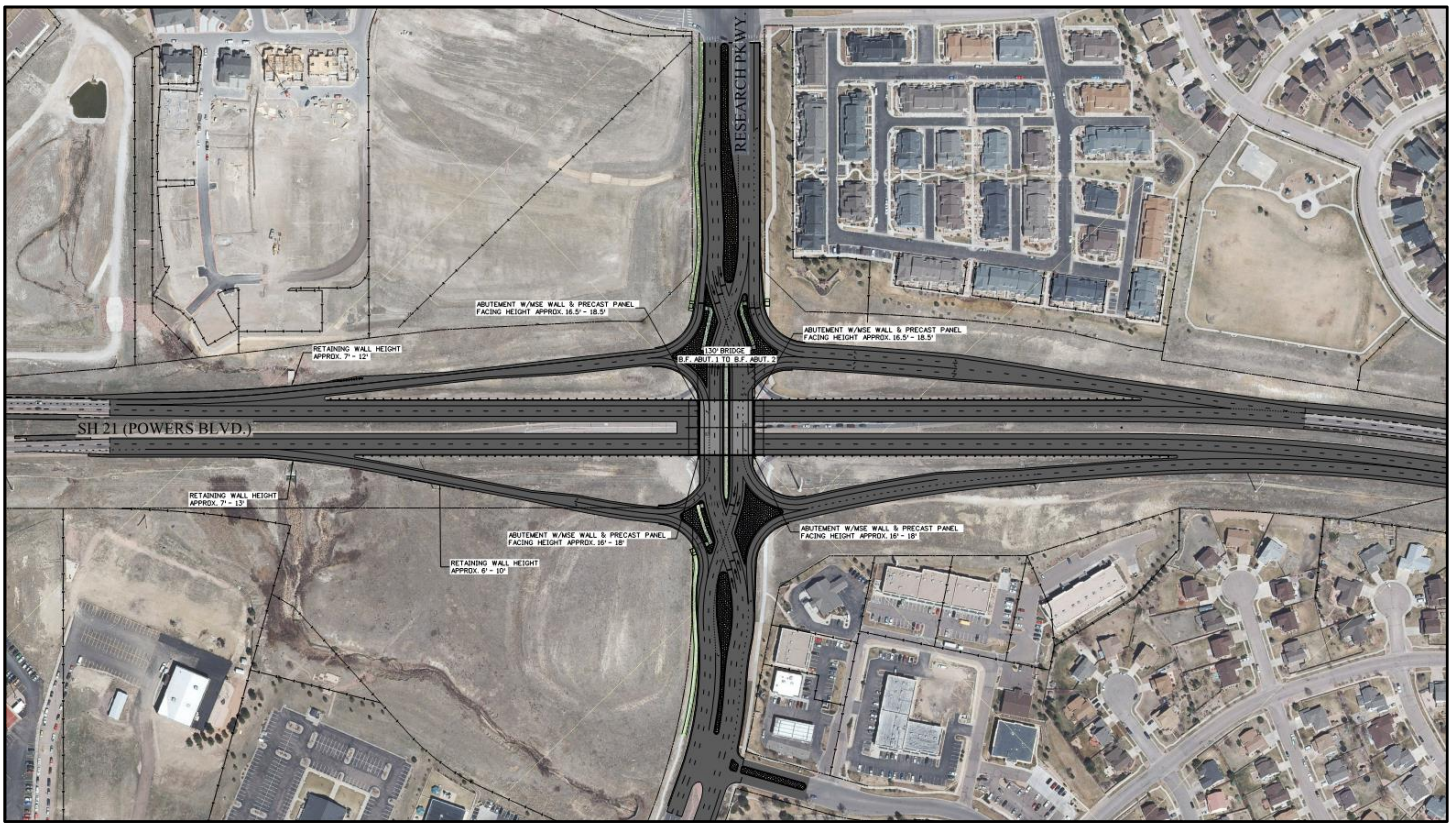
VALUE ENGINEERING WORKSHOP REPORT

for:

Colorado Department of Transportation – Region 2

COLORADO
Department of Transportation

Project: SH21/Powers Boulevard & Research Parkway Interchange
Project No. STU 021A-004 (20913)



Project Designers:

FELSBURG HOLT & ULLEVIG
connecting & enhancing communities

May 11, 2018

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EXECUTIVE SUMMARY

This report presents the results from the value engineering (VE) workshop review of the Colorado Department of Transportation (CDOT), planned improvements to establish a grade separated interchange at the intersection of State Highway 21 (SH21) / Powers Boulevard and Research Parkway (Powers-Research), located in Colorado Springs, Colorado.

Project Purpose

The planned Powers-Research Interchange (IC) project will improve the localized traffic operations by reconfiguration of the existing intersection to meet current and forecast traffic loading. This intersection currently has a level of service (LOS) rating of "F" (LOS-F), the lowest grade, due to congestion that occurs during peak traffic hours.

Figure 1: Powers (SH21) - Research Level of Service

Project Scope

The planned Powers-Research IC project will include improvements along both Powers Boulevard and Research Parkway. The project will separate the existing at-grade intersection, to provide a grade separated interchange. Traffic on Powers Boulevard will continue through after the project has been completed. A diverging diamond intersection (DDI) will be construction on Research Parkway, at the ramp termini from Powers Boulevard. The project Is planned to be constructed in phases.

The planned Powers-Research work includes establishing a northbound (NB) direction auxiliary lane on Powers, between the intersection and the existing bridge over Cottonwood Creek.

Sidewalks will be provided along Research Parkway. These sidewalks will extend from Channel Drive to Grand Cordera Parkway / Cross Creek Drive on the north side, and between Powers and Grand Cordera / Cross Creek on the south side.

A storm water detention pond will be constructed on Fairfax Creek Tributary, in the northwest quadrant of the intersection. This storm water pond also meets City of Colorado Springs requirements to mitigate storm water runoff within the Powers-Research area.

The total length of the Powers-Research IC project is approximately 0.62 miles along Powers, Boulevard / State Highway 21 and 0.35 miles along Research Parkway.

The engineer's opinion of probable cost (EPOC) for the Power-Research IC project is approximately $30.4 million. This amount is inclusive of all anticipated construction work, as well as utilities relocation and roadway lighting work. The EPOC includes 40% construction contingency, based on the planned roadway improvements and SH21/Powers bridge work. Allowances of 30% has been included for utilities relocation, and 10% for roadway lighting.

Project Need

The basic requirements that generate the need for this project are stated above. The project must relieve existing traffic congestion, accommodate the high projected traffic volumes, meet FHWA design standards, and be forward compatible with future improvements. The Powers Boulevard corridor is being rapidly developed.

The project need is based on current and forecast traffic volumes. The planning for this project considered the need to:

- Reduce congestion and improve traffic operations at the Powers-Research intersection.
- Improve safety and reduce accidents rate along Powers Boulevard.
- Accommodate the expected population and commercial growth in the northeast area of Colorado Springs, as well as El Paso County.
- Construct new traffic facilities within the existing right-of-way (ROW) to the greatest extent possible and minimize additional ROW acquisitions.

Project Stakeholders

The Colorado Department of Transportation, Region 2, is the primary project stakeholder. The other key stakeholder is the City of Colorado Springs (COS). Additional project stakeholders and interested parties include the area residents and roadway users, Colorado Springs Utilities (CSU) and other public utilities providers, Academy School District 20 (D20), as well as the retail businesses, medical offices and religious organizations clustered near the intersection.

The Powers-Research project planning and design schematic documents were developed by the design team led by Felsburg, Holt & Ullevig (FHU) of Colorado Springs, Colorado.

Workshop Results

The process used for this VE workshop is the Job Plan as defined within the Value Methodology Standard (2015), published by SAVE International and recognized by the Federal Highways Administration (FHWA), U.S. Department of Transportation (DOT), and other agencies. The VE Job Plan is an organized, multidisciplinary approach designed to find alternative ways to achieve the project's necessary and desired functions at the lowest life cycle cost.

The VE team identified the important project functions and potential alternative means to achieve these functions, then selected the best alternatives using evaluation techniques for development into workable recommendations for project improvement and cost savings.

The VE Team identified 55 alternative ideas during the Creative Phase for consideration as part of the workshop efforts. These alternative ideas were generated under four (4) categories which were project functions as defined by the VE Team:

- Increase Capacity (IC)
- Accommodate Future (AF)
- Connect Neighborhoods (CN)
- Minimize Disruptions (MD)

The complete listing of alternative ideas is within Appendix E, Creative / Alternative Ideas.

Several alternative ideas identified by the VE Team were considered to have lower importance, or limited potential for improved value contribution to the project scope. While these ideas were not developed during the VE Workshop, the VE Team considered these items to have potential merit. These items may be further investigated by CDOT and FHU, the plans, specifications and engineering (PS&E) consultant.

The VE Team designated thirteen (13) items as Design Suggestions, for future consideration by the agency and the design team during the design development. These items represent concepts that could be incorporated during PS&E development, which could improve the overall project or otherwise engage the community and stakeholders.

Nine (9) alternative ideas or concepts were highlighted by the VE Team as being of higher importance than the remaining ideas based on relative scoring. These alternative ideas were investigated by the VE Team and were developed into formal recommendations for incorporation into the overall project work scope.

However, three (3) recommendations were overcome by events due to improvements being implemented, or otherwise considered, by the City of Colorado Springs as work independent of the CDOT Powers-Research interchange project. These recommendations have been designated "Analyzed Not Proposed" which are included within the appendices to this report.

The VE Team identified four (4) significant recommendations that will require further investigation during PS&E development:

1. The existing CSU stanchions for overhead power lines constrain the ramp geometry on the west side of Powers Boulevard. Realignment of the Powers-Research interchange by shifting the mainline to the east will avoid relocation of the existing CSU overhead electrical power lines and any potential schedule delays associated with this work to be performed by CSU. This realignment will require tightening of the planned Research Parkway DDI and use of retaining walls on the mainline overpass. Sound walls may be required as result of realigning Powers Boulevard.
2. The addition of auxiliary / acceleration-deceleration lanes continuous from the Briargate interchange to the Woodmen Road interchange will improve traffic operations along this entire reach of Powers Boulevard, as well as at the Powers-Research interchange.
3. Pedestrian and bicycle movements through the Powers-Research interchange may require further study. The current design routes pedestrians / bicyclists to the DDI center median, which is a counter intuitive movement. Further, the southwest quadrant does not include any pedestrian crossing provisions, thereby requiring individuals who intend to go east along the south side of Research Parkway to go west to Scarborough to cross Research Parkway at a signal.
4. Traffic management during construction will be challenging and may require full closure of through traffic on Research Parkway. Such closure on Research Parkway through traffic would require identification of alternative routes for movements across Powers Boulevard, including provisions for pedestrian and bicyclists.

The VE Team identified the following items as recommended improvements.

Table 1: Summary of Results

Idea No.	Idea Title / Description	Initial Savings[1]	Life Cycle Savings [2]
IC-01	Add Lanes, Both Directions on Powers	-$2,800,000	
CN-03	Provide Sidewalks, Pedestrian Crossing on Southwest Quadrant	-$20,000	
CN-10	Enhanced Pedestrian Crossings	TBD [3]	
MD-01	Shift Interchange East to Avoid Overhead Power Lines	-$3,279,000	
MD-10	Close Research Through Traffic During Construction; Provide Median Turnarounds on Powers	-$509,000	
MD-12	Concrete Pavement for Intersections	-$542,000	$216,000
	Total =	-$7,600,000	$216,000

Each of the recommendations listed above are discussed in greater detail within this document.

These estimated costs in the preceding table represent the order of magnitude cost impact for each individual recommendation. Estimated costs reflect the cost differential between the project schematic design, and the VE Team recommended alternative concept. The VE Team utilized the project schematic design cost estimate, which was based upon recent CDOT actual project unit price cost averages.

1 Cost savings are the difference between the schematic design estimate and the VE Team recommended change. Items with "negative" savings, i.e., ($), are cost additive improvements or project betterments that the VE Team recommend for inclusion. These items should improve project performance or meet an undefined requirement.

2 Total life cycle cost savings is the sum of initial / construction cost savings plus O&M cost savings, if any. O&M costs, calculated as net present worth (NPW) of discounted annual costs over 30-years period, unless otherwise noted within the recommendation.

3 TBD = Cost impacts yet To Be Determined, dependent upon features installed at each location.

Workshop Team

The VE workshop (Workshop) was convened on site in the FHU Colorado Springs offices. The VE workshop team was composed of staff from CDOT Region 2, City of Colorado Springs Public Works Department, and FHU (Centennial office).

Table 2: VE Workshop Team Members

Name	Organization	Role
Wayne Pittman	CDOT Region 2	Professional Engineer I
Shane Ferguson	CDOT Region 2	Professional Engineer II
Jimmy Biren	CDOT Region 2	Traffic
Adam Cooper	City of Colorado Springs, Public Works Department	Senior Engineer
Kurt Kellogg	FHU – Centennial	Roadway Engineer
Wes Boggs	FHU – Salt Lake City	Transportation Engineer [4]
Al Adelgren, PE, CVS-Life	A.K. Adelgren & Associates	VE Team Leader / Facilitator

[4] Part time participant, as a VE Team resource, via Skype.

PROJECT DESCRIPTION

The planned interchange improvements include grade separation of the existing intersection by means of a new Powers mainline overpass bridge, and creation of a diverging diamond intersection (DDI) on Research between the ramps terminal points. The existing Powers Boulevard has posted speed limits up to 65 MPH. The improved roadway will be designed for 70 MPH, with 65 MPH posted speed limit.

The planned improvements will improve traffic operations at the intersection, and alleviate congestion associated with the existing Powers-Research signal.

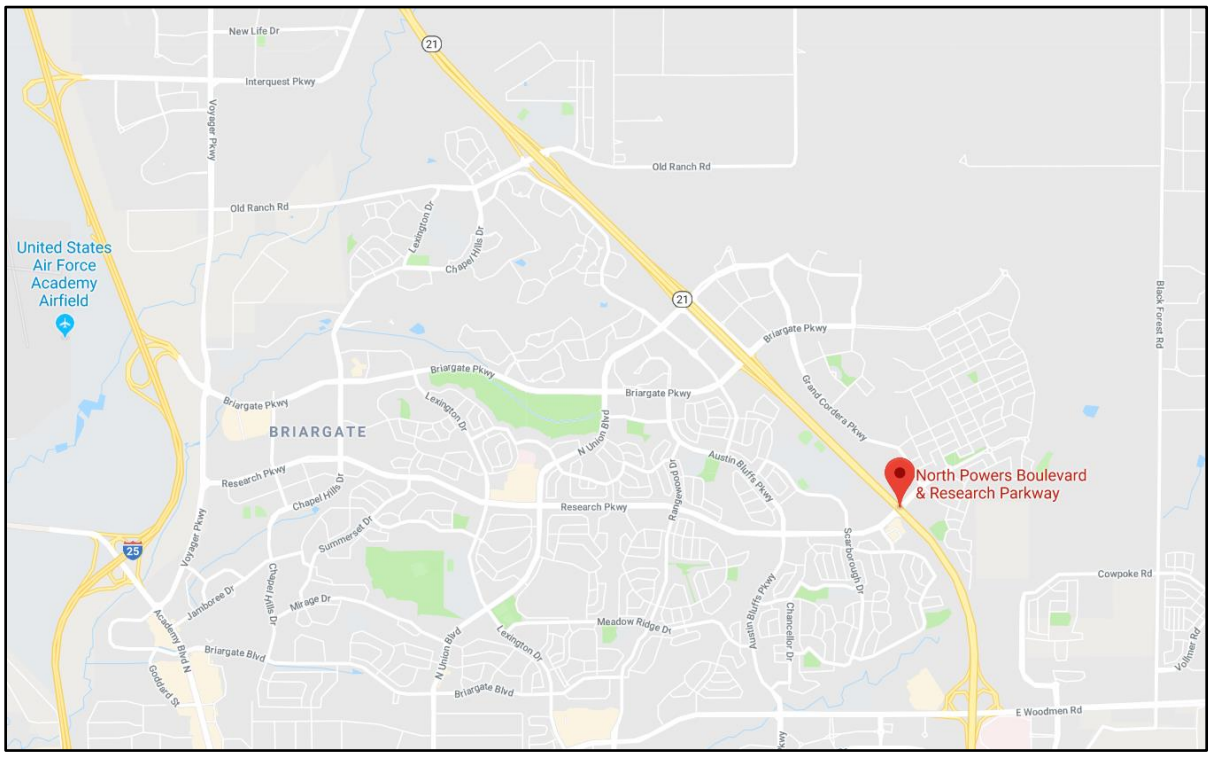
Additional right of way (ROW) acquisitions are not currently anticipated although the schematic design does indicate a minor encroachment on a few properties near the intersection. The schematic design was planned to minimize these required ROW acquisitions. Further design development will determine if ROW acquisition will be required.

There are no known environmental concerns. However, sound walls may be required due to the proximity of the Powers-Research intersection to residential areas.

Location

The planned Powers-Research improvements project extends approximately 0.62 miles along Powers Boulevard, and approximately 0.35 miles along Research Parkway.

Figure 2: Project Location



Project Purpose

The Powers-Research project is part of the overall effort to improve traffic operations and capacity within the northeast area of Colorado Springs. Powers Boulevard serves as an alternative route for traffic within and through the northeast quadrant.

The Powers-Research vicinity area has been steadily growing with new residential and commercial developments since the late 1990s, when these roadways were initially connected. As the area grew, Powers Boulevard (SH21) was extended northward during the mid-2000's to connect with SH83.

The current Powers-Research intersection is a signalized at-grade crossing, typical for suburban areas. The primary traffic movement occurs on Powers Boulevard. Congestion builds during peak travel times due to the Research Parkway signal. Pedestrian movements across Powers require a long signal cycle, which causes additional vehicle queuing on Powers, creating conditions conducive for rear-end collisions. The schematic design utilizes a grade separated interchange to alleviate the current congestion issues on Powers Boulevard.

Project Scope

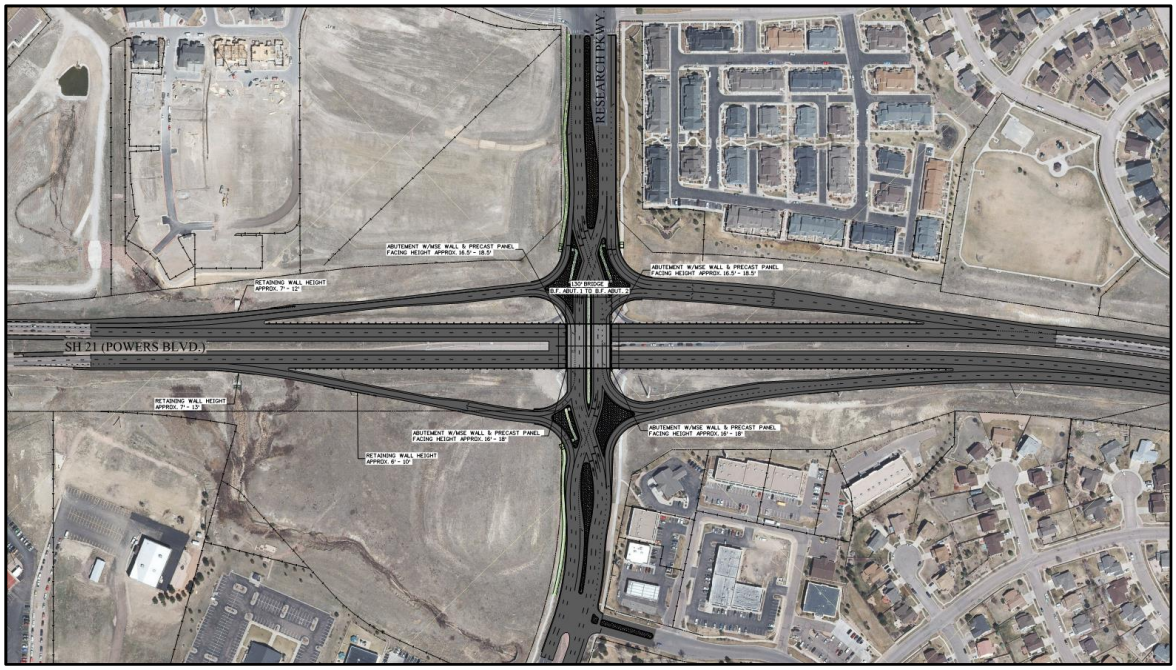
On the first day of the VE workshop project manager and deputy project manager from the schematic design firm, Felsburg, Holt & Ullevig, Inc., of Colorado Springs, provided a thorough presentation of the project including known constraints, design criteria overview, and requested design variances. The design presentation was based upon the FHU prepared schematic design documents, which also included a traffic operations analysis.

A ten-foot wide pedestrian sidewalk will be provided along the full length of Research on the north side, and in the southeast quadrant of the intersection. A protected sidewalk will be provided on the planned DDI center median, connected to three of the four intersection quadrants. Raised median will be provided on Research between Channel Drive and Grand Cordera Parkway / Cross Creek Drive. Powers Boulevard will remain a grass median divided four-lane suburban arterial highway.

The work activities currently planned within this construction project include:

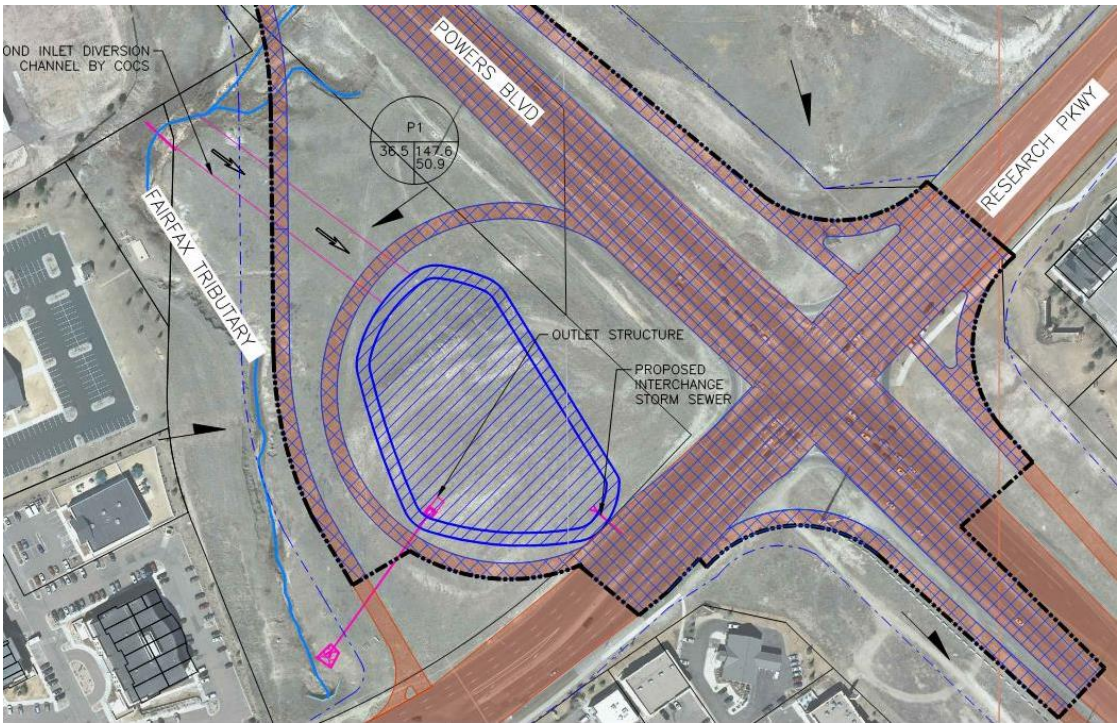
- Grade separated diverging diamond intersection (DDI) on Research Parkway, under Powers Boulevard through traffic mainline.
- Concrete bridge structure, common to both northbound and southbound lanes, for Powers Boulevard mainline traffic.
- Earthwork and embankment work to raise the Powers Boulevard vertical profile.
- Relocation of existing overhead and underground utilities.
- Sidewalks, curbs and gutters along both sides of Research Parkway, on three (3) quadrants of the intersection.
- Minor improvements to Research Parkway.
- Storm water drainage improvements including replacement of the existing box culverts across SH46, east of the US 281 intersection.

Figure 3: Powers-Research Diverging Diamond Intersection



Drainage improvements will include establishing a new detention pond in the northwest quadrant of the Powers-Research intersection, on Fairfax Creek tributary. This detention pond will also support the City of Colorado Springs' stormwater management plans for this area.

Figure 4: Storm Water Detention Pond



Project Cost

The total estimated project cost is $30.4 million. The project cost includes all construction scope elements with contingencies for unforeseen conditions or changes; utility relocations and roadway lighting allowances; temporary environmental protection measures; and construction traffic control.

Cost models based upon the schematic design cost estimate are included within Appendix C.

Project Constraints / Challenges

During the Information Phase on the first day of the VE study, the VE Team identified constraints and known challenges:

- Proximity to existing utilities (i.e., overhead power lines parallel to Powers; underground water / sewer / natural gas along Research).
- Tight existing right of way.
- Concrete box culverts.
- Preserve regional pond opportunities on west side.
- Noise concerns, both sides on south side.
- Out of direction pedestrian and bicycle movements (i.e., must go west to go east).
- Rolling terrain.
- Bridge at Cottonwood Creek.
- Construction phasing and access.

Right of Way

As noted earlier, the Powers-Research project is planned to be constructed within the existing right of way (ROW) limits to the greatest extent possible. Additional ROW may be required to accommodate the widened roadway and related improvements.

PROJECT SPECIFIC WORKSHOP APPROACH

The typical VE workshop would identify individual alternative ideas in contrast to the baseline concept. All alternative ideas are recorded without initial judgement, to foster further creative idea generation, and intent to maximize the potential opportunities.

The cost comparisons would typically reflect a comparable level of detail as depicted within the baseline project estimate. The estimated costs developed for each VE recommendation would be derived from project defined unit pricing and estimated costs.

A life-cycle cost analysis based on net present worth, or discounted cash flow, may also be prepared if appropriate. However, the VE Team did perform life cycle cost analysis calculations with respect to some of the proposed recommendations.

Workshop Timing

The project was at the schematics stage of design development when the VE workshop commenced. The VE workshop was conducted on February 13-15, 2018. The VE Team evaluated the schematic design arrangement plan, roadway sections, and profile drawings dated February 2018; and construction phasing sketches dated September 2017. The VE Team also evaluated the preliminary construction cost estimate dated February 2018.

Presentation of the VE workshop recommendations was conducted on February 20, 2018.

Workshop Objectives

The objective of this VE effort was to identify potential cost reduction recommendations, as well as project betterment opportunities, specific to this project.

The VE Team collectively identify key success factors for both the VE workshop effort and overall Powers-Research project:

- Validate Design Approach.
- Forward Compatibility.
- Efficient use of resources (i.e., cost, right of way, etc.).
- Future maintenance considerations.
- Low impact to existing facilities; compatibility.
- Addressing public needs (i.e., safety, traffic operations, mobility).
- Temporary impacts.
- Satisfy stakeholders.

Several project related issues were discussed which included traffic operations along both Powers Boulevard and Research Parkway, traffic movements in to and out of Channel Drive, pedestrian movements along and across Research Parkway, utilities relocations, as well as storm water drainage considerations.

Function Phase

During the Function Phase, the VE Team utilized a two-word descriptive pairing (active verb plus measurable noun) to define the project elements. These functions were linked together using a "Why" / "How" logic to construct a Function Analysis System Technique (FAST) diagram. The FAST diagram was used to help the VE team understand the interplay between functions within the project under study.

The project specific FAST diagram is provided within Appendix D.

Creative Phase - Alternative Ideas

The VE Team conducted the alternate ideas brainstorming with the following basic rules:

1. All ideas were considered good pending evaluations.
2. All ideas were recorded.
3. Questions to clarify the intent of the idea are allowed.
4. No criticism of ideas was allowed during the creative phase.
5. It is permissible to modify or combine ideas to create new ideas.

The VE Team collectively selected defined functions within the FAST diagram as focal points for the alternative ideas. The VE Team's selected functions were:

- Increase Capacity (IC), which encompassed roadway construction elements that would improve traffic operations at the Powers-Research intersection.
- Accommodate Future (AF), which included considerations for additional improvements at some point in the future.
- Connect Neighborhoods (CN), which included movements between neighborhoods from all four quadrants of the intersection.
- Minimize Disruptions (MD), which included considerations for traffic control and management during construction.

Evaluation Phase

During the evaluation phase, the VE Team considered the identified alternatives individually with respect to the baseline schematic design. The VE Team defined evaluation criteria were:

1. Saves lives, makes lives better.
2. Meets design standards.
3. Constructability.
4. Meets stated or known stakeholder goals:
    a. Water quality
    b. Mobility
    c. Connectivity
5. Best practices, including contracting means and methods.
6. Cost for construction.
7. Best value, long term considerations.

In addition to the above VE Team defined criteria, the VE Team was instructed to consider the following concepts:

8. Design Basis:
   Have any of the identified ideas already been incorporated into the currently available schematic design documents?
9. Commonality:
   Are any of the ideas similar enough to be combined into a common theme? Are any ideas a duplicate to another idea stated in a different manner?
10. Importance:
    Are any of the ideas non-construction (i.e., contract documents), minor construction elements, or concepts that will require further investigation?
11. Timeliness:
    Will any of the ideas require further investigation to determine viability?
12. Relevance:
    Are any of the ideas outside the defined project scope, or requires action by another entity (i.e., stakeholder not financially involved in the project) to implement the suggested change?

The complete creative idea listing with evaluations are provided within Appendix E.

Development Phase

During the Development Phase, the VE Team members were instructed to investigate specific ideas, then prepare the VE recommendation. The VE Team members were also instructed to review each other's work. The intent was to expand the perspective given to each idea, building on individual team member's technical expertise or other related experience.

Available Project Information

The following project documents were provided to the VE Team for their review before, and use during the workshop:

- Schematic design arrangement plans, roadway sections, and profiles.
- Schematic design cost estimate.
- Schematic design basis traffic operations analysis and model, with accident data.

The VE Team also used available cost information from the CDOT statewide average unit cost bid items.

The complete listing of project information that was available to the VE Team during the workshop is included within Appendix G.

Project Issues

The VE workshop commenced with a review of known project issues and past on-site observations and experience. The following summarizes key project issues and site visit observations identified during these sessions.

The following are some of the issues and concerns associated with the project:

- Level of service / maintenance of way during construction; access to businesses and other stakeholders.
- Traffic control during construction, including both worker and public safety concerns.
- Right of way acquisitions, if necessary, may impact construction schedule.
- Utilities that require relocation, both above and below ground.

Site Observations

No formal site visit has been performed as part of the VE Workshop. The VE Team was also able to draw upon personal experience from those Team members who had direct knowledge for the project work area, as well as photographic documentation of the Powers-Research area that is readily available on the internet.

The following were their observations:

VALUE ENGINEERING RECOMMENDATIONS

An alternative idea that survives the evaluation phase may be developed into a value engineering recommendation. Each value engineering recommendation is comprised of several parts, as appropriate to the concept.

- Recommendation summary
- Comparative advantages and disadvantages
- Narrative discussion
- Sketches for baseline and proposed concept
- Representative product or equipment data sheets
- Calculations for baseline and proposed concept
- Estimated quantities and costs for baseline and proposed concept

The VE recommendations were considered with respect to the FHWA defined categories:

- **Safety:** Recommendations that mitigate or reduce hazards on the facility
- **Operations:** Recommendations that improve real-time service and/or local, corridor, or regional levels of service of the facility.
- **Environment:** Recommendations that successfully avoid or mitigate impacts to natural and or cultural resources.
- **Construction:** Recommendations that improve work zone conditions, or expedite the project delivery.
- **Right of Way:** Recommendations that lower the impacts or costs of right of way.

Value Engineering Recommendation

Idea Number: IC-01

Idea Title:

Add Lanes Both Directions on Powers. (IC-01)

Original Concept Description:

The design team is adding a NB Auxiliary Lane between Woodmen and Powers. The original concept design does not incorporate the full TSMO recommendation that will help the safety and mobility along the Powers Corridor.

Proposed Concept Description:

Add a 12' Auxiliary Lanes from Woodmen to Research and then Research to Briargate. NB Powers the existing NB on ramp merges over at the Cottonwood Creek Bridge. The structure is wide enough to accommodate an additional 12' lane

Summary:

Per the TSMO Recommendation, add Auxiliary lanes between interchanges. The cost of incorporating the Auxiliary Lanes will be a minor percentage of the project and the footprint of Powers Blvd can stay within existing ROW.

The addition of these Auxiliary lanes will provide an estimated $13.0 million per mile of user cost benefit or savings, in accordance with the CDOT User Cost model website.

FHWA CATEGORIES	
Safety	☒
Operations	☒
Environment	☐
Construction	☐
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$0	$0	$0
Proposed =	$2,815,000	$0	$2,815,000
Savings =	-$2,815,000	$0	-$2,815,000

Advantages / Disadvantages

Idea Number: IC-01

Advantages

- Alleviates NB weave and lane drop on horizontal curve and at bridge
- Reduces congestion on this corridor
- Improves Safety for traffic

Disadvantages

- Additional cost
- May increase schedule duration
- Project limits will need to be extended to Woodmen to Briargate

Discussions

Idea Number: IC-01

By including the Auxiliary Lanes between interchanges, the construction costs will increase by less than 10% of the current estimate. The Highway Capacity Manual and Roadway Design Guide recommend Auxiliary lanes between interchanges to relieve congestion and increase safety. These interchanges are spaced at approximately 1 mile apart from each other, the minimum recommended distance for urban interchanges in the Roadway Design Guide. This meets CDOT's goal to Save Lives and Makes Lives Better.

The assumption that the existing shoulders are adequate to handle traffic and the costs estimated in this document are to widen the roadway that becomes the new shoulder. The pavement type used is a ROM construction cost and it's understood that the new shoulders would match the pavement type chosen for Powers Blvd.

The estimation material unit costs are based on the 2017 CDOT Cost Data Book, but rounded up to the nearest $5.

It is estimated that only 5% to 10% of the trips on Powers Blvd are through trips from one end to the other. The other 90% to 95% of trips use one or more of the interchanges along Powers Blvd. The Auxiliary lanes would separate slower traffic movements from the freeway, helping smooth traffic flow and reduce the potential for crashes.

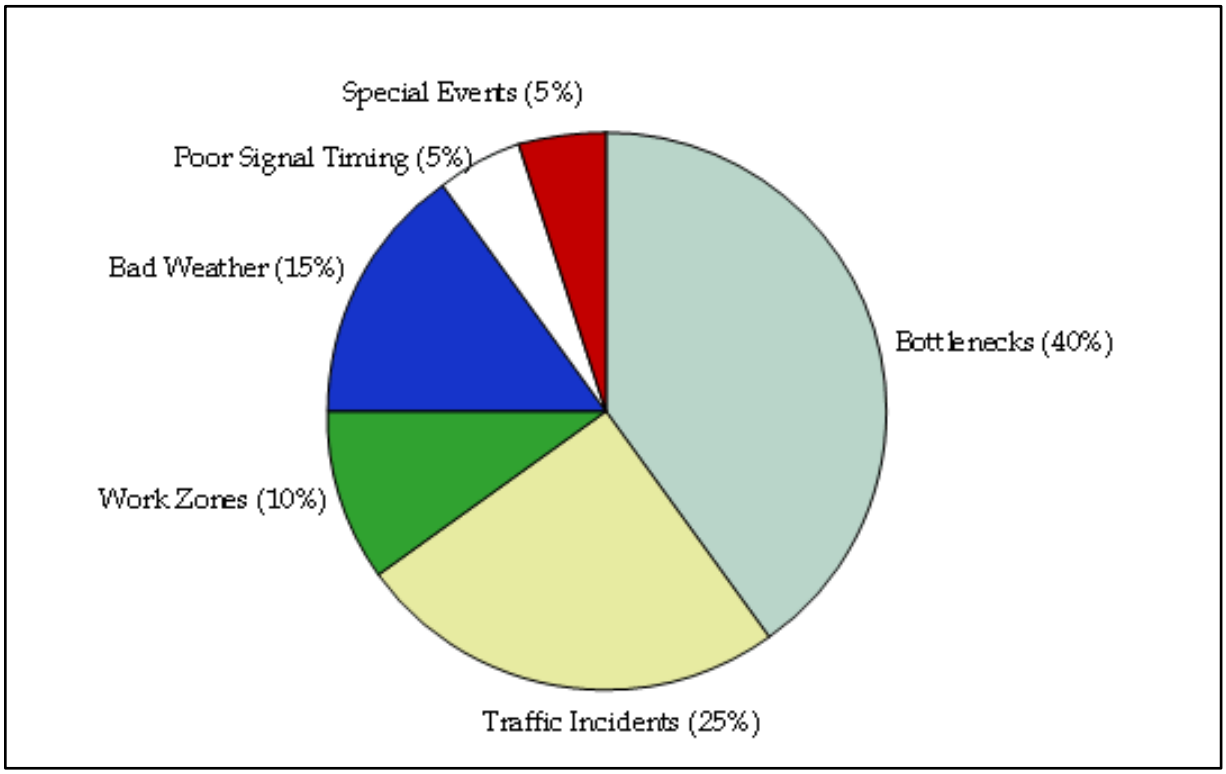
FHWA has illustrated in the figure below that 40% of congestion is due to bottlenecking. An analysis could be done to further define the cost benefit of construction now vs in the future years, but is not included as part of the scope of this report.

Discussions

Idea Number: IC-01

FHWA Office of Transportation Policy Studies
An Initial Assessment of Freight Bottlenecks on Highways

Figure 2.9 Sources of Congestion



Source: "Traffic Congestion and Reliability: Linking Solutions to Problems," prepared by Cambridge Systematics, Inc. for the Federal Highway Administration, Office of Operations, Washington, D.C., July 2004.
https://www.fhwa.dot.gov/policy/otps/bottlenecks/

Cost Estimate Worksheet

Idea Number: IC-01

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
			Total (ORG) =	**$0**

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Earthwork	CY	25	23467	$ 586,666.67
ABC (Cl 6)	CY	35	4693	$ 164,266.67
HMA (64-22)	TN	80	15488	$ 1,239,040.00
SMA	TN	105	3098	$ 325,248.00
Structure Contingency	EA	1	500000	$ 500,000.00
			Total (PRO) =	**$2,815,221.33**
			Difference (PRO – ORG) =	**-$2,815,221.33**

Assumptions:

- Segment 2 miles long 12’ wide 2.5 ‘ earthwork, 6” ABC, 10” HMA, 2” SMA
- The estimation material unit costs are based on the 2017 CDOT Cost Data Book, but rounded up to the nearest $5.

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Additional Information

Idea Number: IC-01

The traffic data for Powers at this intersection was entered into the CDOT Road User Cost Website (https://usercost.cdot.gov). Assuming that is was a 6-lane facility and then reducing it to 4-lanes. The VE Team was curious about the type of values the Road User Cost would be for the opposite application. The Annual Road user cost was $13,005,535.82/mile if a construction project used 2 lanes of traffic for a year. There is a link to the logic that the Road user would gain value in Auxiliary lanes between interchanges, reflected by the estimated construction cost of $2.8M for two miles, would be realized in a short time.

Project Name	Powers & Research
Freeway Name	21
Input Filename	
Project Start Date	1-1-19
Project End Date	1-1-20
Design Speed	65 mph
Speed Limit	55 mph
Workzone Speed Limit	55 mph
Grade	2.0 %
Workzone Length	1.00 miles
Functional Class	Urban Interstate (Weekday)
Total Number of Lanes	6
Number of Open Lanes	4
Number of Temporary Lanes	0
AADT, Directional	38,000
Percentage of Single Unit Trucks	5.0 %
Percentage of Combination Trucks	1.0 %
Work in Both Directions	NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Asphalt (Planing)	$250,851.79	150
403-HMA <= 3.0 Inch	$250,744.16	150
627-Pavement Marking	$108,655.80	65
TOTAL ADDL. USER COST	$610,251.75	365

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 365 DAYS = $13,005,535.82

Value Engineering Recommendation

Idea Number: CN-03

Idea Title:

Provide Sidewalks and Crossing on Southwest Quadrant. (CN-03)

Original Concept Description:

The original concept was to eliminate the sidewalk and crossing on the southwest quadrant. Sidewalk would be removed from Station 214+00 to the east and a crossing would not be provided. Pedestrian traffic would be required to navigate the intersection by crossing Powers either at the east ramp termini intersection, protected by signal or at a protected signal at Scarborough Drive.

Proposed Concept Description:

Maintain the sidewalk on the southwest quadrant and provide a protected crossing across Ramp C approximate station 520+20 and protected crossing of Research to the median sidewalk approximately station 216+00.

Summary:

The concept is to provide neighborhood connectivity on the south side of the interchange. Neighborhoods, shopping center & park are located on the south side as well as on the north side. This eliminates the "back tracking" from Scarborough Drive to the neighborhood on the southwest quadrant as well as Powers Center at Research Shopping Center.

FHWA CATEGORIES	
Safety	☐
Operations	☒
Environment	☐
Construction	☐
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$0	$0	$0
Proposed =	$20,000	$0	$20,000
Savings =	-$20,000	$0	-$20,000

Advantages / Disadvantages

Idea Number: CN-03

Advantages

- Maintains continuity & neighborhood connectivity
- Eliminates the potential safety hazard of pedestrians crossing Research unprotected to arrive at the Powers Center at Research Shopping plaza or the neighborhood south.
- Signal timing of the Ramp signal can be timed with the intersection signal
- Provides positive direction to pedestrian movements.

Disadvantages

- Reduces mobility of the eastbound to southbound turning movement.
- Pedestrian conflict point at Ramp C

Discussions

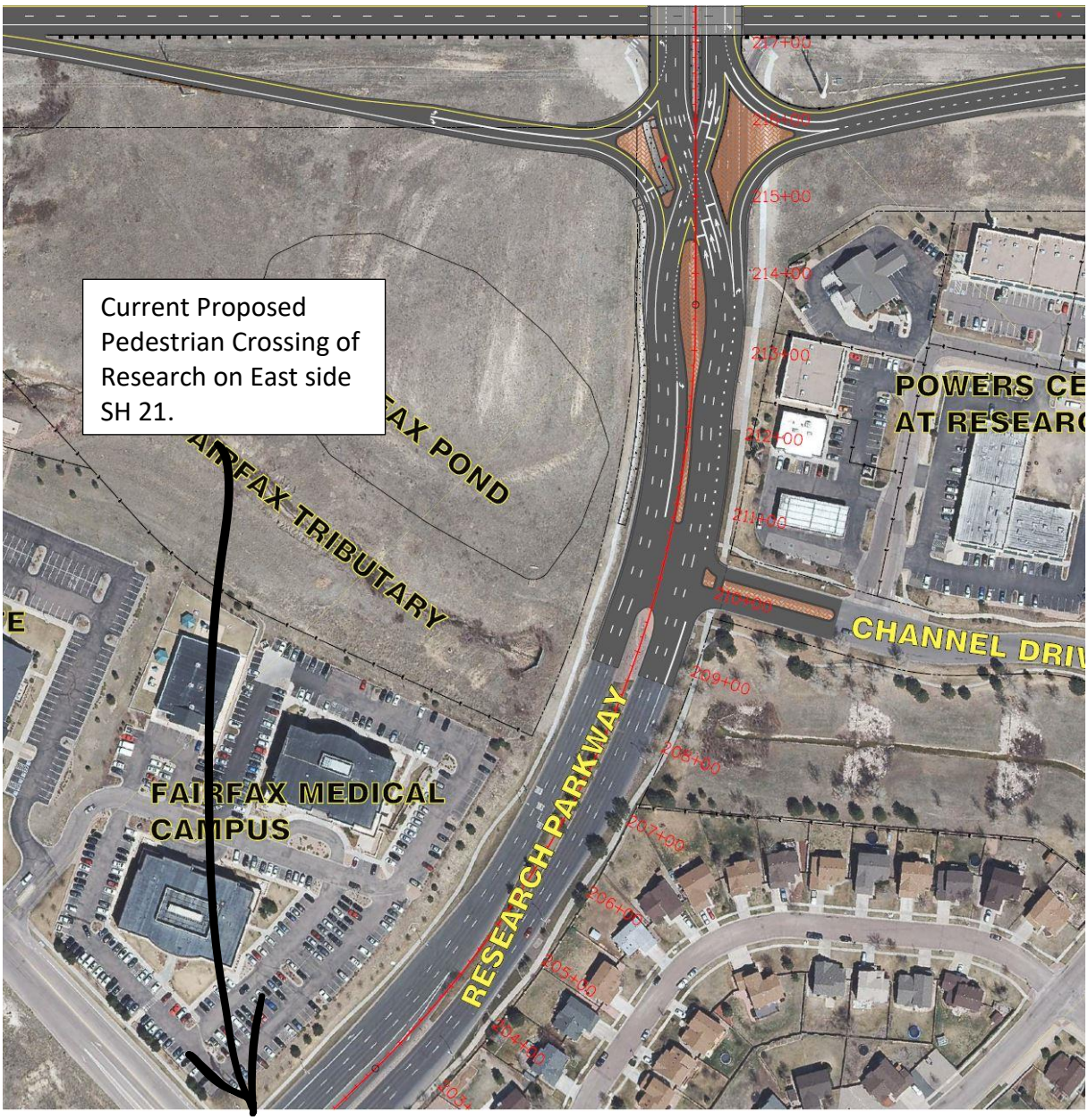
Idea Number: CN-03

The proposed action is to eliminate the crossing on the south side of Research and funnel pedestrian movements to the north side of Research, under SH 21 and along Research to Scarborough. At Scarborough, the signalized intersection will provide protection to allow pedestrian crossing across Research. The concern is pedestrian traffic desiring to access Powers Center at Research Shopping Plaza, Fairfax Ridge neighborhood, Wolf Ranch on the south side of Research and amenities. Providing a signal control at Ramp C timed with the intersection would allow pedestrian crossing to the south side of Research without navigating to Scarborough and backtracking.

Impacts to the current design would include moving the eastbound stop bars back, revising the drainage plan at the island to avoid inlet & manhole conflicts, including signal and pedestrian poles at Ramp C to be timed with the intersection & additional ADA accommodations.

Original Concept - Sketch

Idea Number: CN-03



Proposed Concept – Sketch

Idea Number: CN-03

Original Concept - Cost Estimate

Idea Number: CN-03

Item Description	Units	Unit Cost	Original Concept Quantity	Original Concept Total	Proposed Concept Quantity	Proposed Concept Total
Concrete Sidewalk	SY	51.64		-	60	3,098
Pedestrian Signal Face	EA	600.00		-	3	1,800
Traffic Signal Face	EA	750.00		-	1	750
ADA Ramps	EA	3,000.00		-	4	12,000
Traffic Signal Pedestal Pole Steel	EA	2,200.00		-	1	2,200
				-		-
				-		-
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				-		-
Sub-Totals				-		19,848
Mark-Ups		0%		-		-
Totals w/Markup				-		19,848
Totals (Rounded)				-		**20,000**
					Net Savings =	**(20,000)**

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Value Engineering Recommendation

Idea Number: CN-10

Idea Title:

Provide Enhanced Pedestrian Crossings. (CN-10)

Original Concept Description:

Current design concept does not address enhanced pedestrian crossings

Proposed Concept Description:

Proposed design concept suggests including enhanced pedestrian crossing features.

Summary:

Incorporate enhanced pedestrian crossing elements to provide convenient and comfortable features.

FHWA CATEGORIES	
Safety	☒
Operations	☐
Environment	☐
Construction	☐
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =			
Proposed =	***Cost Dependent Upon Implemented Measures***		
Savings =			

Advantages / Disadvantages

Idea Number: CN-10

Advantages

- Enhancements can help positively direct pedestrian movements
- Enhancements can help with the aesthetics of the corridor
- Enhancements can help reduce pedestrian confusion with the new interchange
- Improves pedestrian safety in the corridor

Disadvantages

- No apparent disadvantages

Discussions

Idea Number: CN-10

The interchange at Research and SH21 separate neighborhoods from east to west as well as shopping, parks and schools. Two schools are located on the west side of SH21 north of Research, Liberty High School and Timberview Middle School. The interchange being considered at this location is a Diverging Diamond Interchange, the second type of interchange in the City. Currently, pedestrians navigate east to west along Research Blvd. for various destinations. Currently the plan for the DDI is to funnel pedestrian movement along the median of the interchange between ramp termini. The proposed median is 14 ft. Access to the medians require crossing ramps through raised islands.

Consider enhancements to allow for safe pedestrian movements in the interchange. Such enhancements can include raised crossings at the ramps, in-pavement LED products, flashing beacons, bollards along median delineating sidewalk, LED lighting in median, advanced signing, concrete barrier along the median and flashing beacons.

Regarding pedestrian counts at the intersection, it should be noted that the pedestrian counts taken and reported in the TSM&O COBRA Program, prepared by Parsons June 2016, were taken on March 17, 2016. According to the District 20 Calendar for 2016, March 17 was Parent / Teacher conference for Elementary and Middle School, and school was not in session for that day, including Timberview Middle School.

Proposed Concept – Sketch

Idea Number: CN-10

Considerations include:

- Depressed sidewalk area within the 14ft wide median. Provide colored / textured concrete to delineate walking path from median structure.
- Potential consideration raised sidewalks at ramp crossings
- Advanced yield or stop pavement markings
- LED lighted Bollards to delineate median under bridge
- In-pavement lighting, flashing beacons
- Barrier protected sidewalk in median

Source

1. El-Urfali, Alan S. "*Guidance and best practices for selectin enhanced pedestrian crossing treatments",* Florida Department of Transportation, 02/14/2018
2. *"Engineering Policy Guide, Section 234.6, Diverging Diamond Interchanges"*, Missouri Department of Transportation, 02/14/2018

Value Engineering Recommendation

Idea Number: MD-01

Idea Title:

Shift Interchange East to Avoid Power Line Disruption. (MD-01)

Original Concept Description:

Original concept moved alignment slightly east to accommodate phasing and reduce impact to overhead power lines.

Proposed Concept Description:

Proposed concept considers additional eastward shift to avoid impact to power lines. This concept would nearly place southbound lanes in the original concept northbound lanes at the interchange. Introduces walls in the median and tightens ramps where possible.

Summary:

Additional eastward shift of the Powers / Research interchange avoids relocation of the overhead power transmission lines, which may impact the construction schedule. However, shifting the interchange will require use of retaining walls, and may require additional right of way not currently within the project scope.

Note: Overhead pole closest to Research (south side) may still be impacted. Consider protection if possible with roadside barrier.

FHWA CATEGORIES	
Safety	☐
Operations	☒
Environment	☐
Construction	☒
ROW	☒

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$0	$0	$0
Proposed =	$3,729,000	$0	$3,729,000
Savings =	-$3,729,000	$0	-$3,729,000

Advantages / Disadvantages

Idea Number: MD-01

Advantages

- Avoids early lead, expensive relocation of overhead power lines.
- Provides additional room for construction phasing (initially).
- Provides greater room on the west side for separation from Channel Drive and proposed regional pond (Fairfax).
- Reduces embankment requirements (through introduction of walls).
- Smaller footprint may help with MS4 requirements.

Disadvantages

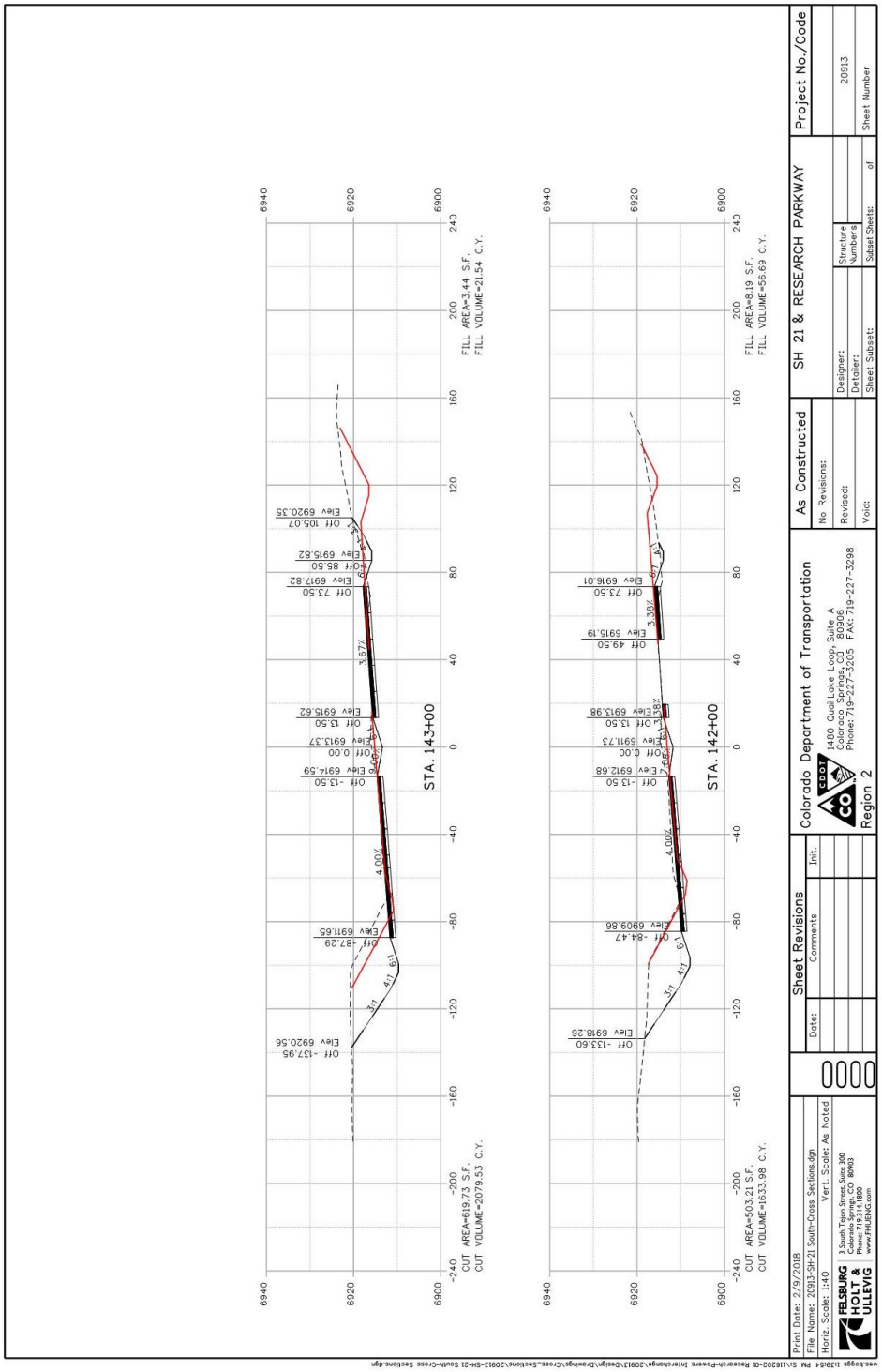
- Additional wall cost will be introduced to the project.
- May introduce additional right-of-way (in lieu of walls).
- Will introduce additional guardrail.
- Surface drainage may be more difficult to deal with in the median of Powers.
- Additional curves would be required from the Cottonwood Bridge to the north tie-in to accommodate shift.

Proposed Concept – Sketch

Idea Number: MD-01

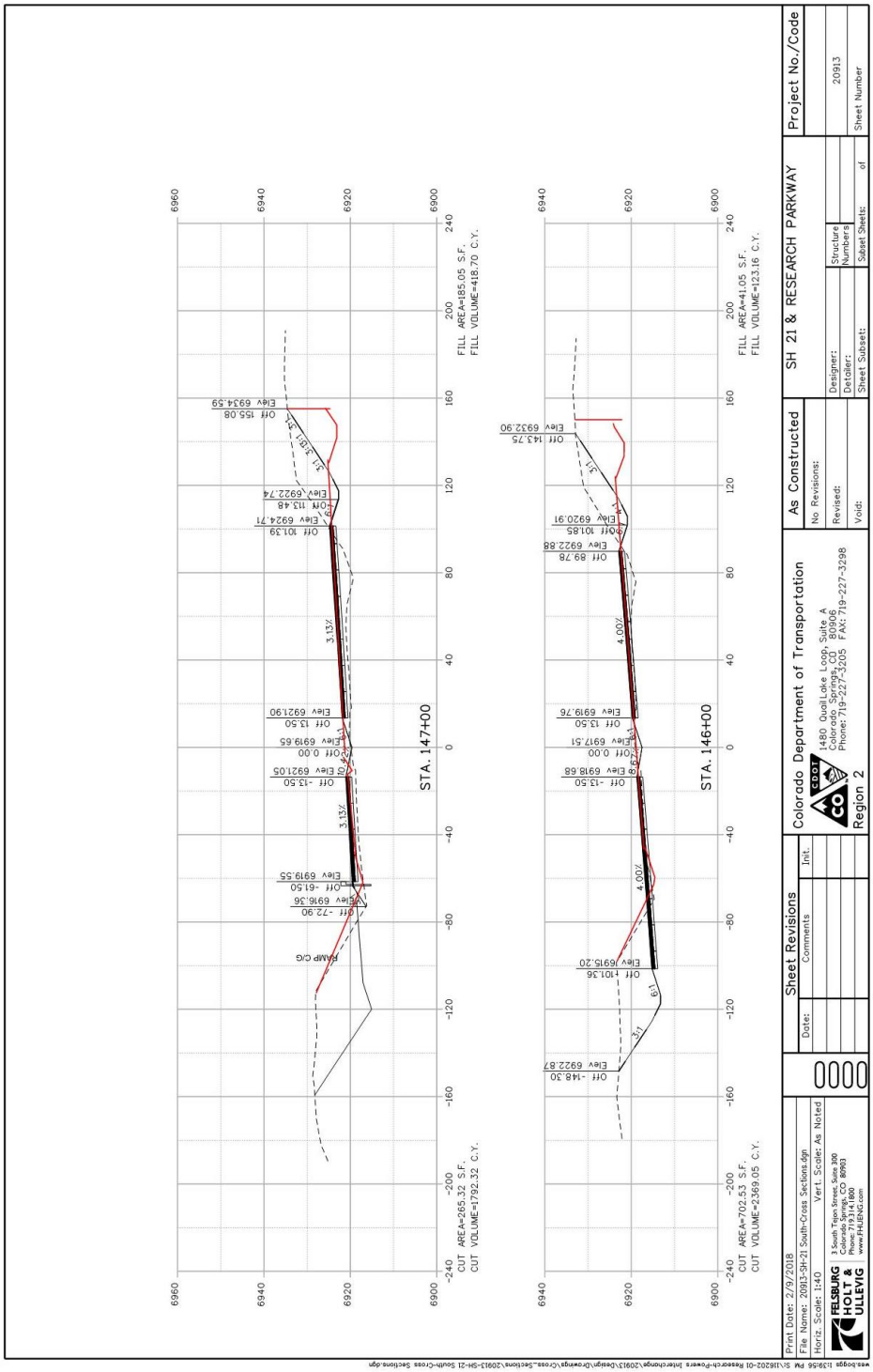
Proposed Concept – Sketch

Idea Number: MD-01



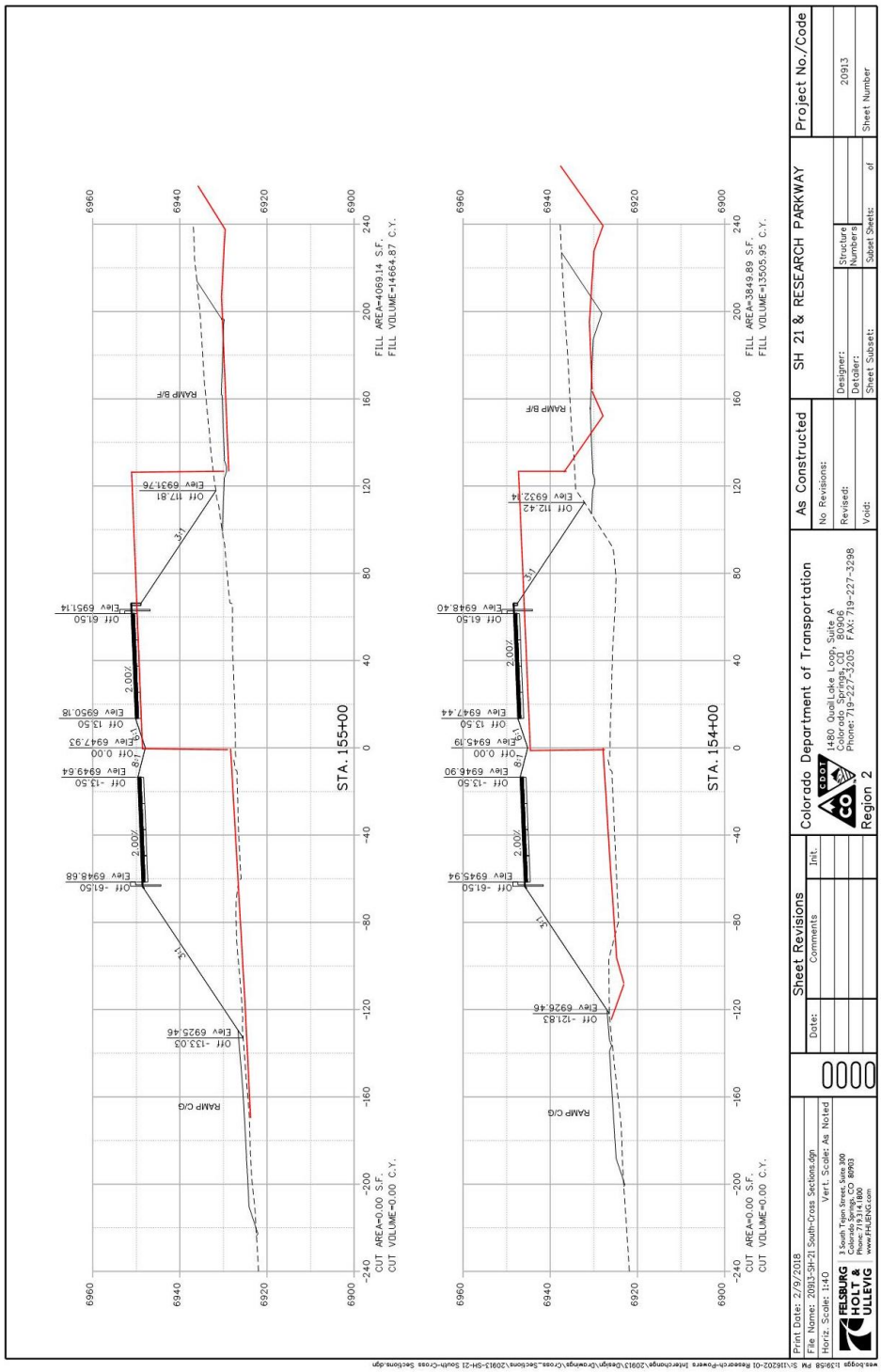
Proposed Concept – Sketch

Idea Number: MD-01



Proposed Concept – Sketch

Idea Number: MD-01



Original Concept – Calculations

Idea Number: MD-01

Estimated Reduction in Earthwork (includes proposed concept earthwork):

South Side

143+00 to 147+00: General reduction in cut, assume approximately 40 feet wide by 10 feet high as an average. 40*10*400 = 160,000 CF or ~6,000 CY (Unclassified Excavation)

147+00 to 156+00: Reduction in fill required for median fill due to shift uphill and introduction of walls. Assume average of 80*10*900 feet reduction and 40*10*900 reintroduced to east as part of shift. 720,000 CF – 360,000 CF = 360,000 CF or ~13,500 CY.

147+00 to 156+00: Increase in cut required on east side is approximately 50*10*900 = 450,000 CF or ~16,500 CY.

NOTE: Net increase in cut (16,500-6,000 = 10,500 CY) increases material required for the job from onsite. Although the project is being paid for using the Embankment bid item, this may reduce contractor costs.

North Side

Assume same values as south side.

Totals:

Add ~21,000 CY unclassified excavation

Deduct ~27,000 CY embankment

Proposed Concept – Calculations

Idea Number: MD-01

For the proposed concept, walls are being introduced on either side of Powers approaching the bridge over Research Parkway.

Use – 0 to 23 feet high exposed (2 to 25 feet high face) wall on either side of Powers (SH 21) from Sta. 147+00 to 156+00.

Avg. 13.5*900 LF * 2 sides = 24,300 (say 24,500 SF).

For the proposed concept, walls are being introduced on east side of NB ramps approaching the bridge over Research Parkway.

Use – estimated 2 to 10 feet height from Sta. 130+00 to 147+00.

Avg. 6*1700 LF = 10,200 (say 10,250 SF).

Add guardrail along Powers for bridge approaches ~ 900 LF x 2 sides = 1,800 LF.

Assume same for north side, all quantities.

Proposed Concept - Cost Estimate

Idea Number: MD-01

Change in quantities:

Deduct in Embankment Material (Complete in Place) = 27,000 CY.

Increase in Powers walls = 49,000 SF
Increase in Ramp Walls = 20,500 SF

Total Increase = 69,500 SF

Increase in guardrail – 3,600 LF.

Use Original Concept Costs.

Decrease in utilities assumed at 30% of total.

5,327,800

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.
- Contractor overhead / markups, not included.

Cost Estimate Worksheet

Idea Number: MD-01

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Not used				
			Total (ORG) =	

Proposed (PRO) Concept (DELTA from ORG)

Description	Units	Unit Cost	Quantity	Totals
Deduct Embankment Material (CIP)	CY	$17.40	(27,000)	($469,800)
Add Guardrail Type 7	LF	$66.00	3,600	$237,600
Add Wall*	SF	$80.00	69,500	$5,560,000
Deduct utilities	30% of	above		($1,598,340)
			Total (PRO) =	**$3,729,460**
			****Difference (PRO – ORG) =**	**-$3,729,460**

Assumptions:

- *Retaining wall costs could be lessened on the outside of NB ramps by purchasing right-of-way.
- **40% contingency ~ $1.5 million dollars (excessive given traffic control opportunities? Design team to confirm. Also should include items such as added end impact attenuators, reduced landscape, etc.)

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: MD-10

Idea Title:

Close Research Through Traffic During Construction and Provide Median Turnarounds on Powers. (MD-10)

Original Concept Description:

Several different options for construction phasing was proposed in the "Initial Construction Phasing Evaluation" Memo. No final recommendation was given in the report, but recommends the concepts be advanced during design.

Proposed Concept Description:

Evaluate Option D "U-turn" as the preferred alternative.

Summary:

The original option does not make a recommendation, but rather offers options. Option D for a U-turn north and south of Research will allow complete construction of mainline Powers without Research open across powers is the recommended option.

FHWA CATEGORIES	
Safety	☐
Operations	☐
Environment	☐
Construction	☒
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$0	$0	$0
Proposed =	$509,000	$0	$509,000
Savings =	-$509,000	$0	-$509,000

Advantages / Disadvantages

Idea Number: MD-10

Advantages

- 4-5 month savings in construction schedule
- The bridge construction and embankment is estimated at 12 months being the longest section of the project that could be constructed without additional traffic shifts.
- Research would not need to be closed to place the bridge section over the Research lanes because they are already re-directed onto Powers for a U-turn.
- Give the Contractor a large work area to stage and construct the project in Powers.
- Can construct final ramp grade/configuration and then use as detour to reduce temporary work.
- U-turn could be left in Powers median for emergency access.

Disadvantages

- Power pole relocation would hold up the start of the project. Poles would need to be relocated before construction of the interchange could start, slowing the initial start time of the project. This would need to be worked into the timeline and bid package for the potential delay.
- Haul trucks delivering fill material from the pond site would have to cross traffic to the center of Powers to place the material.
- A temporary configuration would be required on the ramps at Research because the DDI medians on Research would block through traffic on the ramps.
- Traffic on Research would have to detour onto Powers and make a U-turn to continue along Research.
- The existing roadway width on Powers is not wide enough for a U-turn that can accommodate truck traffic, so truck traffic would have to go to the next interchange to turn around.
- U-turn south of interchange would probably need a small amount of temporary asphalt widening to allow for 2 through lanes and 2 turn lanes.

Discussions

Idea Number: MD-10

Minimizing disruption to the traveling public during construction is going to be difficult at this location. Closing through traffic on Research over Powers during construction will allow the contractor to construct the largest element of the project without continually shifting traffic.

A temporary pedestrian path could be constructed through the work zone to keep access across powers open. Or, the contractor could hire a shuttle service to drive pedestrians around the work zone.

The Contractor could potentially set up a temporary light at Channel Drive to allow construction traffic out of the pond site to haul material east on Research to place fill on Powers.

The U-turn idea was previously implemented recently on Powers at the Old Ranch Road interchange, so it would not be totally new to the traveling public along this corridor.

Original Concept - Sketch

Idea Number: MD-10

Option D, Phase 3:

Traffic Routing:

1. Mainline Powers with overpass fully open.
2. Research closed to through traffic.
3. All Research traffic routed to turn lanes onto Powers and off of Powers (4 right turn ramps).
4. U-Turn intersections for NB and SB traffic constructed on Powers.
5. Pedestrian traffic posted to N or S of Research during work.

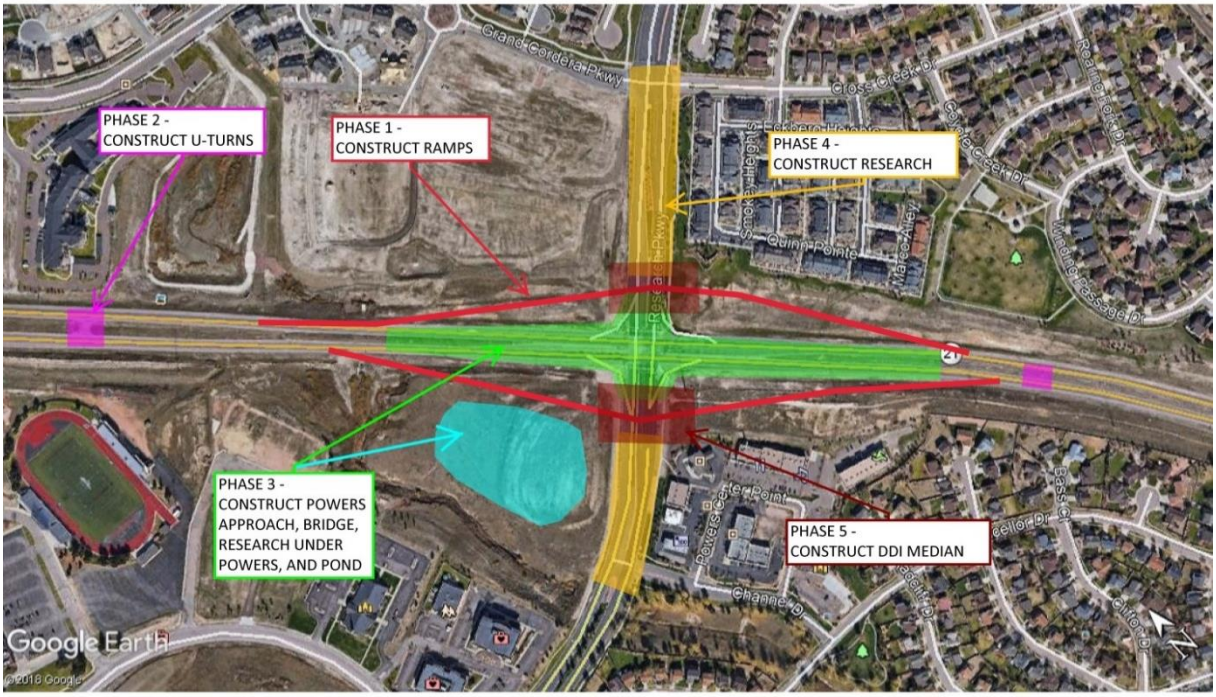
Major Construction Efforts:

1. Paving operations for Research between and including future DDDI intersections.
2. Construction paving of all Research medians.
3. Final DDI configuration setup with stripe work and signaling.
4. Deconstruction of Powers detours.

Proposed Concept – Sketch

Idea Number: MD-10

Example phasing for Research and Powers with U-turn on Powers and Research closed over Powers.



Proposed Concept – Sketch

Idea Number: MD-10

Example phasing of Old Ranch road and Powers using the U-turn technique a few years ago.

Proposed Concept – Calculations

Idea Number: MD-10

Items required:

1. Temporary traffic signals
2. Temporary asphalt in median on Powers
3. R&R C&G for south turn around on Powers
4. Possible temporary asphalt for Powers widening at U-turn for south turn around
5. Temporary asphalt on ramps at Research where DDI median will go
6. Temporary signage
7. Temporary striping
8. Temporary pedestrian access

Cost Estimate Worksheet

Idea Number: MD-10

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
			Total (ORG) =	

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Temp Traffic Signal (1 year)	EA	40,000	8	$320,000
Temp Asphalt for U-turn	SY	50	30	$1,500
Temp Asphalt for DDI	SY	40	2,300	$92,000
Temp Ped Access	LS	60,000	1	$60,000
Temp Signage/Striping	LS	35,000	1	$35,000
			Total (PRO) =	**$509,000**
			Difference (PRO – ORG) =	**-$509,000**

Assumptions:

- Temp Ped Access would be with a shuttle
- Temp Traffic Signal would be 2x each turn around and 4x at Research and Powers

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: MD-12

Idea Title:

Concrete Pavement for Intersections. (MD-12)

Original Concept Description:

Original concept assumes HMA paving for the project.

Proposed Concept Description:

Proposed concept suggests concrete surfacing for the ramp intersections and between ramps (through the diverging portion of Research Parkway).

Summary:

Replace HMA surfacing with concrete through the interchange on Research Parkway.

FHWA CATEGORIES	
Safety	☒
Operations	☒
Environment	☐
Construction	☒
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$973,000	$218,000	$1,191,000
Proposed =	$1,515,000	$0	$1,515,000
Savings =	-$542,000	$218,000	-$324,000

Advantages / Disadvantages

Idea Number: MD-12

Advantages

- Accommodates traffic through the intersections as needed (for Powers) during construction.
- Use of pinned curb (CDOT Type 4) for raised islands eliminates need for removals during later phases. This may also reduce work zone and speed up construction for median curb and gutter.)
- Longer life for the surfacing.
- Reduces amount of base material and reduces overall pavement section. (Thickness)

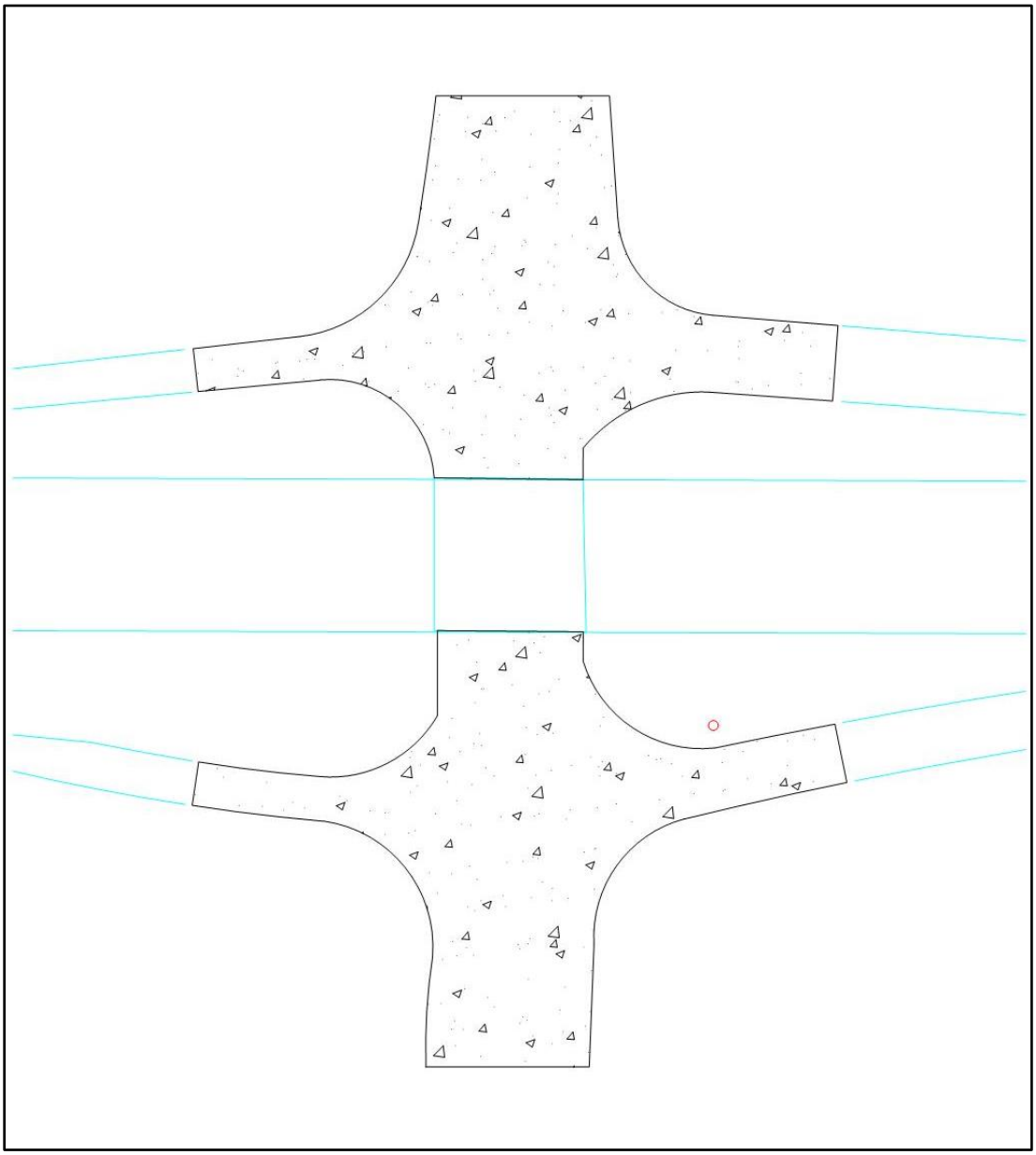
Disadvantages

- Introduces a seam between HMA and concrete pavement on entrance/exit to intersections (differential settlement and jointing of medians).
- Less flexibility in time and traffic control for initial construction.
- Jointing to follow lane lines becomes ‘interesting’.

Proposed Concept – Sketch

Idea Number: MD-12

Proposed Concrete Intersection Pavement



Proposed Concept – Calculations

Idea Number: MD-12

Proposed concrete pavement assumes full intersections (no breaks for medians – see assumptions on Cost Estimate.)

From CAD, approximate areas of intersections are as follow:

West of Powers, 71,000 SF.
East of Powers, 70,500 SF.

Say total = 142,000 SF.

For removal of Original Concept HMA, use 90% of concrete areas to account for medians.

Proposed Concept - Cost Estimate

Idea Number: MD-12

Change in quantities:

REMOVAL OF HMA

90% of concrete pavement area = .9*142,000 SF = 127,800 SF.

110*127,800*10 in./18,000 = 7,810 Tons (Use 7,800)

REDUCTION OF BASE

Total area = 142,000 SF, base = 12 inches for HMA – 4 inches for concrete.

136 lbs./cf*142,000 SF * 0.67 ft/2,000 lbs./Ton ~ 6,500 Tons. (Deduct)

CONCRETE PAVEMENT

142,000 SF (12-inch thickness) = 15,778 SY (Use 15,800)

			Original Concept		Proposed Concept	
Item Description	Units	Unit Cost	Quantity	Total	Quantity	Total
				-		-
Asphalt Pavement				-		-
10" HMA (Grading SX)	TONS	82.60	8,678	716,784		-
12" ABC (Class 6)	TONS	26.50	9,656	255,884		-
				-		-
Concrete Pavement				-		-
12" Depth	SY	90.50		-	15800	1,429,900
12" ABC (Class 6)	TONS	26.50		-	3219	85,295
				-		-
				-		-
Sub-Totals				972,668		1,515,195
Mark-Ups		0%		-		-
Totals w/Markup				972,668		1,515,195
Totals (Rounded)				**973,000**		**1,515,000**
					Net Savings =	**(542,000)**

Life Cycle Cost Analysis

Idea Number: MD-12

										ORIGINAL	PROPOSED
LIFE CYCLE PERIOD:				30	**years**					**ORIGINAL**	**PROPOSED**
INTEREST RATE:				3.00%	**ESCALATION:**		0.00%			**Asphalt**	**Concrete**
A.	**FIRST / INITIAL COST**				(Note - Use 0.00% escalation for				Amount =	$ 973,000	$ 1,515,000
	Useful Life (Years)				constant dollar LCC analysis)				Years =	30	30
								INITIAL COST SAVINGS			(542,000)
B.	**RECURRING COSTS (Annual Expenditures)**										
Maintenance:				Simple, estimated percentage of install cost					0.0%	-	
									0.0%		-
				Detailed (carried over from Recurring Costs sheet)					Original	-	
									Alternate		-
Operations:				Detailed (carried over from Recurring Costs sheet)					Original	-	
									Alternate		-
								Total Annual Costs		-	-
								Present Worth Factor		19.6004	19.6004
								Present Worth of RECURRENT COSTS		-	-
C.	**SINGLE EXPENDITURES (Future)**							**Year**	**Amount**	**PW factor**	**ORIGINAL**	**PROPOSED**
ORG	PRO	**< Put "x" in appropriate box (original design or proposed alternate)**										
X		Plane / mill, 2-in depth						10	21,300	0.744	15,849	-
		14200 SY @ $1.50/SY								1.000	-	-
X		Resurface wearing layer, 2-in HMA (SX)						10	127,800	0.744	95,095	-
		14200 SY @ $9.00/SY								1.000	-	-
X		Traffic Markings						10	12,000	0.744	8,929	-
		SAY 6,000 LF @ $2.00/LF								1.000	-	-
X		Traffic Control (8% of construction)						10	12,888	0.744	9,590	-
X		Plane / mill, 2-in depth						20	21,300	0.554	11,793	-
		14200 SY @ $1.50/SY								1.000	-	-
X		Resurface wearing layer, 2-in HMA (SX)						20	127,800	0.554	70,760	-
		14200 SY @ $9.00/SY								1.000	-	-
X		Traffic Markings						20	12,000	0.554	6,644	-
		SAY 6,000 LF @ $2.00/LF								1.000	-	-
X		Traffic Control (8% of construction)						20	12,888	0.554	7,136	-
									SINGLE EXPENDITURES sub-total		225,796	-
D.	**SALVAGE VALUE (income)**							**Year**	**Amount**	**PW factor**	**ORIGINAL**	**PROPOSED**
X		Reclaim Millings				(assume 5% install)		10	6,390	0.744	(4,755)	-
X		Reclaim Millings						20	6,390	0.554	(3,538)	-
									SALVAGE VALUE sub-total		(8,293)	-
								Present Worth of SINGLE EXPENDITURES (C + D)			217,503	-
E.	**Total Recurrent Costs (B) & Single (C + D) Expenditures**										217,503	-
									(ROUNDED)		218,000	-
								RECURRING COSTS & SINGLE EXPENDITURES SAVINGS				218,000
								PRESENT WORTH TOTAL COST (A + E) (ROUNDED)			1,191,000	1,515,000
								TOTAL LIFE CYCLE SAVINGS (ROUNDED)				**(324,000)**

General Notes:

- Annual costs are current values, without escalation.
- Discounted net present worth calculation of annual / recurring costs.

VALUE ENGINEERING PROCESS

A systematic approach is used in the VE workshop. The key procedures followed were organized into three distinct parts:
(1) Pre-Workshop Preparation,
(2) VE Workshop, and
(3) Post-Workshop.

Pre-Workshop Preparation

In preparation for the VE workshop, the team leader reviewed critical aspects of the project and areas for improvement. In the week prior to the start of the VE workshop, the VE team members reviewed the documents provided by the designer to become better prepared for the workshop. In addition, performance attributes and requirements were initially identified that are relevant to the project.

VE Job Plan

The SAVE International recognized six-phase VE Job Plan was utilized to guide the team members in the consideration of project functionality and performance, potential schedule issues, high cost areas, and risk factors in the design. These considerations were considered in developing alternative solutions for the optimization of project value. The prescribed VE Job Plan phases are:

- Information Phase
- Function Phase
- Creative Phase
- Evaluation Phase
- Development Phase
- Presentation Phase

Information Phase

During the traditional VE workshop, the design team presented a more detailed review of the design concept and the various component systems. This presentation included an overview of the project as well as its various requirements and user constraints, with the intent to further enhance the VE team's knowledge and understanding of the project. The project design team responded to questions posed by the VE team during the presentation.

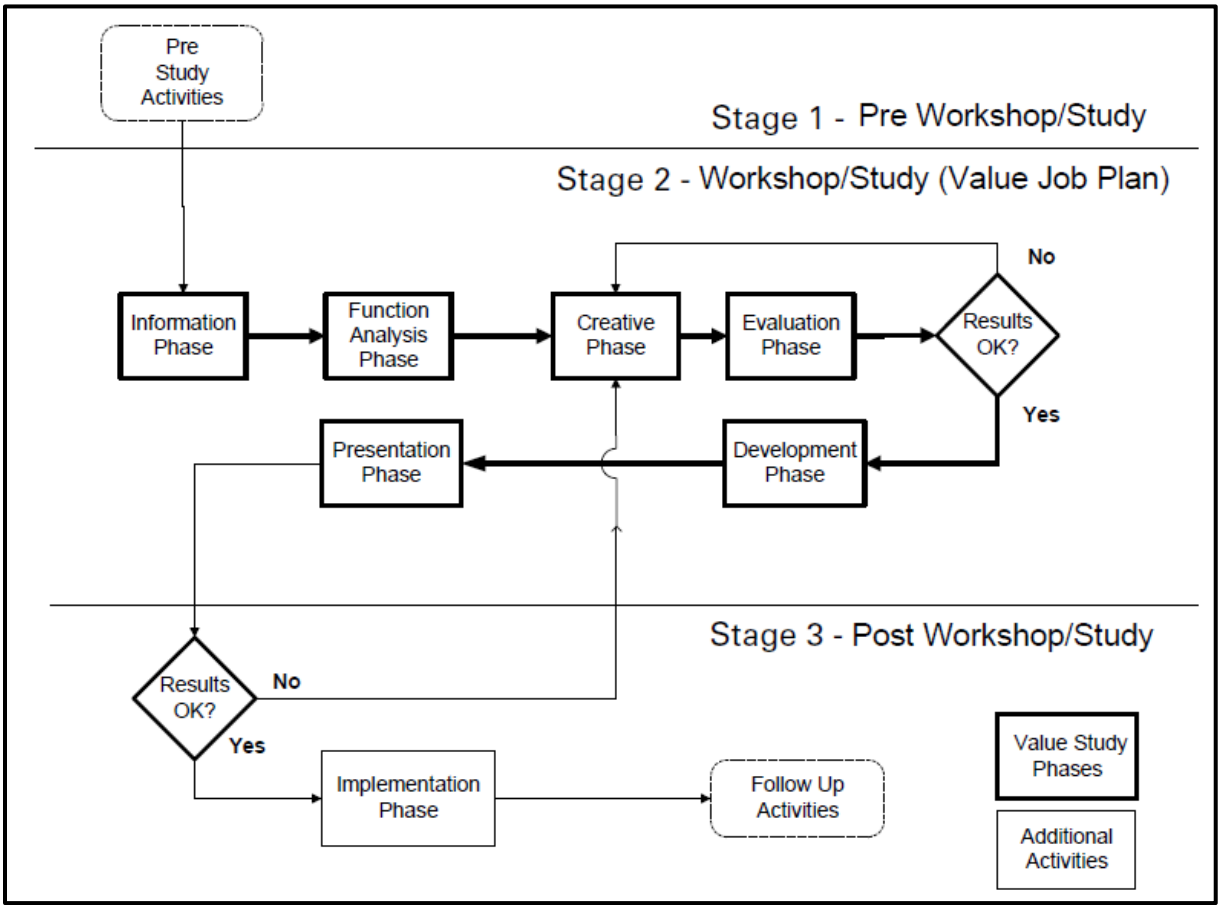
After the briefing, the VE Team further reviewed the project schematic design documents, reports, and cost estimates. The VE Team also reviewed the project in the context of access for existing property owners, and anticipated traffic related to future real estate development.

The VE Team reviewed a Pareto format cost model which was based on the schematic design cost estimate. The Pareto cost model was used to focus the VE Team on the higher cost elements of the project.

The VE Team discussed the Pareto cost models relative to project risk. The VE Team was instructed to consider each defined major cost element based upon low, medium and high potential to deviate from the estimated costs.

The Pareto cost model can be found in Appendix C.

Figure 5: Value Methodology Job Plan Process Diagram



Function Phase

The purpose of Function Analysis is to understand the project from a functional perspective; what must the project do, rather than how the project is defined in the scoping documents. The fundamental question is: ***What are the functions and how are they related?***

During this phase, the VE Team was challenged to define the project functions using a simple two-word, active verb / measurable noun sentence construct. The VE Team defined the project attributes by considering two questions:

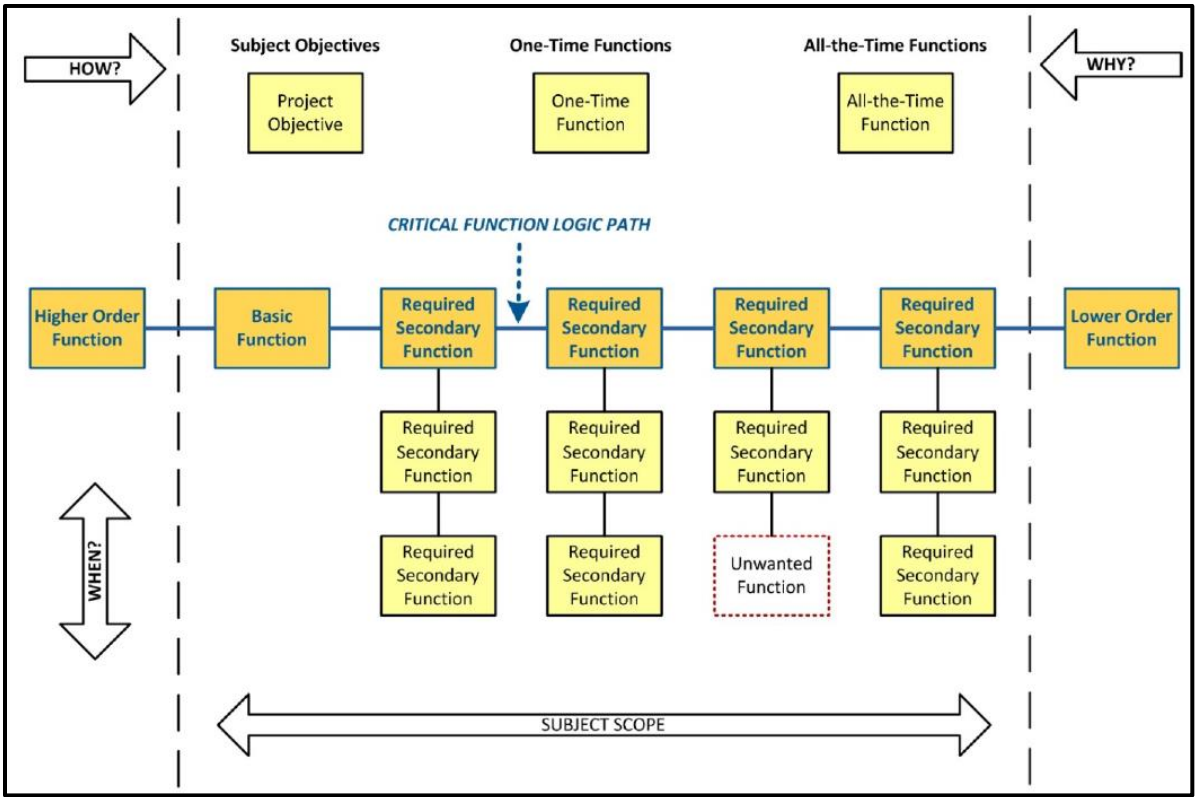
- "What must it do?" [Active Verb]
- "What must it do it to?" [Measurable Noun]

This function definition process is beneficial to the VE Team, as it requires the participants to think in terms of concise functions and their relative importance towards achieving the project's need and purpose. This facilitates a deeper understanding of the project.

The functions are related by a "How-Why" logic, or questioning technique.

- "Why is this function (to the right) performed?" determines higher order function.
- "How is this function (to the left) performed?" determines secondary function.

Figure 6: Function Analysis System Technique (FAST)



The VE Team was then asked to review and analyze these functions to determine which need improvement, elimination, or creation to meet the project's goals.

The VE Team considered the defined functions using the same risk perspectives discussed in relation to the Pareto cost models. Different colored dots were used to annotate the draft FAST diagram to highlight which functions would be influenced by risk associated with the primary cost estimate elements.

Creative Phase

The Creative Phase involves identifying and listing alternative ideas. During this phase, the VE team participates in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas is not permitted to preserve a positive environment and thereby foster the generation a large quantity and broad range of ideas.

The idea list includes all alternative ideas suggested during the workshop. These ideas should be reviewed further by the project team, since they may contain ideas that are worthy of further evaluation and may be used as the design develops.

Evaluation Phase

In this workshop phase, the VE Team selected the ideas with the most merit for further development. The basic criteria used for selection were:

1. Inherent value, benefit and technical appropriateness of the idea.
2. Expected magnitude of the potential capital construction and life cycle cost savings.
3. Potential for owner-user agency acceptance of the idea.

There are a wide variety of evaluation tools that are available to VE Teams to review and cull the amassed alternative ideas. These tools are typically selected based on the scope of the VE workshop, as well as the quantity of the alternative ideas generated.

Team members were encouraged to identify any duplicate alternative ideas, or ideas that could easily be consolidated based on common theme. The Team consolidated several ideas into common concepts.

For this VE workshop, the alternative ideas were evaluated using a modified version of the Nominal Group Technique (NGT). The VE team members were given adhesive backed colored dots for use to "vote" on the creative ideas. The number of votes given to each VE Team Member was directly proportional to the total number of ideas, inclusive of all function groups.

Each of the team members were issued several "votes" to cast, nominally 15% of the total number of creative ideas generated. Ideas evaluation using the NGT method directly applies the Pareto principle; Team Members select the top ideas based on their individual perspective.

Different colored dots may be used in some circumstances (i.e., separate colors for design, construction, operational and maintenance perspectives). However, all team members used the same color dots as votes for this VE workshop.

VE team members were instructed to initial or otherwise uniquely mark each of their dots prior to voting. Each person then could cast "votes" for the alternative ideas that they felt held the best potential to enhance the project. However, each person could vote only once for an idea and cannot move or disturb the votes of another team member.

Votes were tallied with the team selecting the alternative ideas that scored highest. These ideas became the focal point for further development by the team during the limited time allowed within working sessions.

Team members were encouraged to identify any duplicate alternative ideas, or ideas that could easily be consolidated based on common theme. The Team consolidated several ideas into common concepts.

The VE Team again reviewed the list to determine if any key points were missed, or not clearly understood during the initial evaluation sweep. Some additional ideas were promoted upward as the result of the post vote review and discussions.

Development Phase

Idea development typically includes summarization of the advantages / disadvantages for the alternative, a narrative description of the alternative idea intent and expected performance, preparation of comparative capital construction and life cycle cost comparisons, concept proof calculations, and sketches.

Life cycle cost analysis is typically performed on a discounted cash flow net present worth basis and will typically include maintenance, repairs, energy consumption, replacement, salvage and other recurring costs. The analysis period will vary based on the construction feature, ranging from 30 to 50 years, and up to 100 years in some instances.

Presentation Phase

On the final day of the VE workshop, the VE Team presented their findings and collective recommendations to the senior representatives from Agency and the project schematic design team. The objective of this presentation was to provide a succinct overview of each recommendation, as well as an overall summary of results. Each item was discussed with an explanation of the VE Team's logic for the recommendation.

Implementation Phase

Implementation of the Agency accepted, or approved recommendations will occur during the design development efforts, and part of the Post-Workshop activities. Each recommendation will be further investigated for respective benefit to the project, as applicable.

APPENDICES

A. VE Team Roster / Contact Data
B. Workshop Agenda
C. Project Cost Estimate / Pareto Model
D. Function Analysis
E. Creative / Alternative Ideas
F. Design Suggestions
G. Analyzed Not Proposed
H. Available Project Information
I. Project Briefing Presentation
J. VE Results Presentation

Appendix A: VE Team Roster & Contact Data

Table 3: Team Roster with Contact Data

Firm / Location			
Team Member	**Role / Discipline**	**Email**	**Phone**
Colorado Department of Transportation – Region 2, Colorado Springs, CO			
Wayne Pittman	Professional Engineer I	patrick.pittman@state.co.us	719-659-7705
Shane Ferguson	Professional Engineer II	shane.ferguson@state.co.us	719-227-3244
Jimmy Biren	Traffic	james.biren@state.co.us	719-546-5404
City of Colorado Springs			
Adam Copper	Senior Engineer	acoooper@springs.gov.com	719-385-5436
Felsburg, Holt & Ullevig, Colorado Springs, CO			
Steve Murray	Design PM	steve.murray@fhueng.com	719-287-7447
Todd Frisbie	Deputy Design PM	todd.frisbie@fhueng.com	719-201-1804
Wes Boggs	Transportation Engineer	(via skype)	
Felsburg, Holt & Ullevig, Centennial, CO			
Kurt Kellogg	Roadway Engineer	kurt.kellogg@fhueng.com	303-771-1440
A. K. Adelgren & Associates / Grand Junction, Colorado			
Al Adelgren, PE, CVS-Life, LEED AP, CPP	VE Facilitator	akadelgren@outlook.com	970-260-0124

Table 4: VE Presentation Roster with Contact Data

Firm / Location			
Team Member	**Role / Discipline**	**Email**	**Phone**
Colorado Department of Transportation – Region 2, Colorado Springs, CO			
Wayne Pittman	Professional Engineer I	patrick.pittman@state.co.us	719-659-7705
Shane Ferguson	Professional Engineer II	shane.ferguson@state.co.us	719-227-3244
Jimmy Biren	Traffic	james.biren@state.co.us	719-546-5404
Andy Stecklein	Project Manager	andrew.stecklein@state.co.us	719-227-3264
City of Colorado Springs			
Adam Copper	Senior Engineer	acoooper@springs.gov.com	719-385-5436
Kathleen Krager	Transportation Planning Manager	kkrager@springs.gov.com	303-759-3209
Felsburg, Holt & Ullevig, Colorado Springs, CO			
Steve Murray	Design PM	steve.murray@fhueng.com	719-287-7447
Todd Frisbie	Deputy Design PM	todd.frisbie@fhueng.com	719-201-1804
Wes Boggs	Transportation Engineer	(via skype)	
Nick Glenn	Construction Engineer	nick.glenn@fhueng.com	540-538-8676
Federal Highways Administration, Denver, CO			
Melinda Urban, PE	Sr. Area Engineer	melinda.urban@dot.gov	720-963-3015
Bachman Public Relations			
Monica Ramey	Public Information	monica@bachmanpr.com	719-339-4109
A. K. Adelgren & Associates / Grand Junction, Colorado			
Al Adelgren, PE, CVS-Life, LEED AP, CPP	VE Facilitator	akadelgren@outlook.com	970-260-0124

Appendix B: Workshop Agenda

The VE Team used the following agenda to plan and perform the Workshop efforts. This agenda conforms with the six-phase Value Methodology Job Plan, as recognized by FHWA and other agencies. The agenda was adjusted during the Workshop based on actual progress.

Figure 7: VE Workshop Agenda

Value Engineering Workshop Agenda

CDOT Region 2

Project: SH 21 / Powers Boulevard & Research Parkway Interchange

Project Number: STU 021A-004

City of Colorado Springs, Colorado

Day 1: Tuesday, 13 February [1]

8:30 am – 9:00 am	VE Team Assembles
9:00 am – 9:15 am	Introductions • Workshop Agenda • Value Methodology – SAVE International
9:15 am – 10:00 am	Information Phase - Project Delivery Team • Project Presentation / Design Overview
10:00am – 11:30 Noon	Information Phase – VE Team • Site visit (***proper PPE required***)
11:30 Noon – 12:30 pm	Lunch Break (typical; times may vary daily)
12:30 pm – 2:00 pm	Information Phase [2] • Documents Review / Project Data Familiarization • Cost Models / Risk Analysis
2:00 pm – 3:00 pm	Function Analysis Phase
3:00 pm – 4:45 pm	Creative Phase
4:45pm – 5:00pm	Review the Day's Work / Prepare for next day

Day 2: Wednesday, 14 February

8:00 am – 8:30 am	Creative Phase - Recap
8:30 am – 9:30 am	Evaluation/Judgment Phase
9:30 am – 10:00 am	Development of Recommendations • Team Discussion – Forms • Recommendations Selection • Assignment
10-00 am - 11:30 am	Development of Recommendations
11:30 am – 12:30 pm	Lunch (working)
1:00 pm – 4:30 pm	Development of Recommendations - Continued
4:45 pm – 5:00 pm	Review the Day's Work / Prepare for next day

Day 3: Thursday, 15 February

8:00 am – 11:30 am	Development of Recommendations - Continued
11:30 am – 12:30 pm	Lunch (working)
12:30 pm – 4:00 pm	Development of Recommendations - Continued
4:00 pm – 5:00 pm	Finalize Recommendations / VE Team QC Review

Day 4: Tuesday, 19 February

8:00 am – 10:00am	Preparation for Presentation
10:00am– 12:00 pm	VE Team Presentation to Stakeholders

Note: The VE Team determined that a site visit was not necessary based upon their understanding of the project.

Appendix C: Project Cost Estimate / Pareto Model

Construction Cost Estimates

The *Engineer's Opinion of Probable Cost* (EPOC), or project construction cost estimate, was prepared immediately prior to the VE Workshop effort. The EPOC was based upon the schematic design documents. The cost estimates reflect the schematic design.

The summary cost estimate consolidates the individual estimates for each listed work area, which are provided on the following pages. The summary estimate also includes appropriate levels of contingency (40%), as well as allowances for utilities relocations (30%) and roadway lighting (10%) which have not yet been designed. However, the summary estimate allowance percentages are Utilities and Lighting were apparently switched and considered to be a minor typographical error.

Figure 8: Construction Cost Estimate – Summary

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OPINION OF PROBABLE COST

In providing opinions of probable construction cost, the Client understands that Felsburg Holt & Ullevig has no control over costs or the price of labor, equipment or materials, or over the Contractor's method of pricing, and that the opinions of probable construction costs provided herein are to be made on the basis of our qualifications and experience. FHU as to the accuracy of such opinions as compared to bid or actual costs.

Research-Powers Interchange

Prepared By: Steve Murry, PE
Date: 2/6/18
Conceptual Level
FHU Reference No: 116202 - 20913

CONSTRUCTION ITEM COSTS			
SH-21 - Powers Blvd			$10,036,326
Research Parkway			$2,210,929
Ramp A-E			$642,401
Ramp B-F			$258,889
Ramp C-G			$236,220
Ramp D-H			$547,654
ITEM COST SUBTOTAL			$13,932,418
ITEM COST CONTINGENCY			40%
ITEM COST TOTAL			**$19,505,386**
	Cost based on percentage of Item Costs:		
UTILITY COSTS	10%	x a	$1,393,242
LIGHTING	30%	x a	$4,179,726
RIGHT OF WAY COSTS	3%	x a	$417,973
DESIGN FEE + CONSTRUCTION FEE + MOBILIZATION + F/A	35%	x a	$4,876,346
TOTAL PROJECT COST			***$30,372,672***

Figure 9: Construction Cost Estimate – SH21

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Engineers Opinion of Probable Cost

Project: Description	Research-Powers Interchange
Project Number	20913
Name of Preparer	Steve Murray, PE

Item No.	Item Description	Unit	*2016*	Unit Cost	Quantity	Cost
203-00060	Embankment Material (Complete In Place)	CY	*$17.40*	$17.40	203,724	$3,544,802
304-06000	Aggregate Base Course (Class 6)	TON	*$26.47*	$26.50	25,481	$675,234
403-34741	Hot Mix Asphalt (Grading SX) (75) (PG 64-22)	TON	*$82.64*	$82.60	16,859	$1,392,578
403-34841	Hot Mix Asphalt (Grading SX) (100) (PG 64-22)	TON	*$72.83*	$72.80	5,620	$409,119
606-00301	Guardrail Type 3 (6-3 Post Spacing)	LF	*$28.30*	$28.30	3,288	$93,036
606-00750	Guardrail Type 7 (Style CL)	LF		$145.00	571	$82,795
606-01340	End Anchorage Type 3D	EACH	*$1,457.22*	$1,457.20	2	$2,914
606-01370	Transition Type 3G	EACH	*$2,282.49*	$2,282.50	2	$4,565
606-01380	Transition Type 3H	EACH	*$1,735.72*	$1,735.70	2	$3,471
606-10700	Bridge Rail Type 7	LF	*$105.95*	$106.00	418	$44,308
606-02003	End Anchorage (Nonflared)	EACH	*$2,617.76*	$2,617.80	2	$5,236
614-85130	Impact Attenuator (Quadguard II)	EACH	*$24,236.79*	$24,236.80	4	$96,947
900-	Bridge	SF		$185.00	15,624	$2,890,440
900-	Wall	SF		$80.00	9,886	$790,880

ITEM COST SUBTOTAL:	$10,036,326

Figure 10: Construction Cost Estimate – Research Parkway

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Engineers Opinion of Probable Cost

Project: Description	Research-Powers Interchange
Project Number	20913
Name of Preparer	Steve Murray, PE

Item No.	Item Description	Unit	*2016*	Unit Cost	Quantity	Cost
203-00060	Embankment Material (Complete In Place)	CY	*$17.40*	$17.40	533	$9,275
304-06000	Aggregate Base Course (Class 6)	TON	*$26.47*	$26.50	13,973	$370,279
403-34741	Hot Mix Asphalt (Grading SX) (75) (PG 64-22)	TON	*$82.64*	$82.60	12,840	$1,060,624
606-00710	Guardrail Type 7 (Style CA)	LF	*$65.96*	$66.00	409	$26,994
606-00730	Guardrail Type 7 (Style CD)	LF	*$63.85*	$63.90	266	$16,997
608-00006	Concrete Sidewalk (6 Inch)	SY	*$51.64*	$38.70	694	$26,858
610-00024	Median Cover Material (4 Inch Patterned Concrete)	SF	*$5.20*	$5.20	39,088	$203,258
613-10000	Wiring	L S	*$26,500.30*	$26,500.30	2	$53,001
613-70250	Luminaire High Pressure Sodium (250 Watt)	EACH	*$444.85*	$444.90	8	$3,559
614-70117	Pedestrian Signal Face (16)	EACH	*$600.00*	$600.00	16	$9,600
614-70336	Traffic Signal Face (12-12-12)	EACH	*$809.49*	$809.50	30	$24,285
614-70560	Traffic Signal Face (12-12-12-12-12)	EACH	*$1,190.44*	$1,190.40	10	$11,904
614-72860	Pedestrian Push Button	EACH	*$663.69*	$663.70	16	$10,619
614-72886	Intersection Detection System (Camera)	EACH	*$8,653.25*	$8,653.30	8	$69,226
614-81150	Traffic Signal-Light Pole Steel (1-50 Foot Mast Arm)	EACH	*$15,994.83*	$15,994.80	8	$127,958
614-84000	Traffic Signal Pedestal Pole Steel	EACH	*$2,322.95*	$2,323.00	16	$37,168
614-86245	Controller (Type 170E)	EACH	*$400.00*	$400.00	2	$800
900-00001	City Curb and Gutter Type 1	LF	*$25.00*	$25.00	5,103	$127,575
900-00002	City Curb and Gutter Type 7	LF	*$16.58*	$16.60	1,262	$20,949

ITEM COST SUBTOTAL:	$2,210,929

Figure 11: Construction Cost Estimate – Ramp A-E

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Engineers Opinion of Probable Cost

Project: Description	Research-Powers Interchange
Project Number	20913
Name of Preparer	Steve Murray, PE

Item No.	Item Description	Unit	*2016*	Unit Cost	Quantity	Cost
203-00060	Embankment Material (Complete In Place)	CY	*$17.40*	$17.40	6,607	$114,967
304-06000	Aggregate Base Course (Class 6)	TON	*$26.47*	$26.50	1,325	$35,107
403-34741	Hot Mix Asphalt (Grading SX) (75) (PG 64-22)	TON	*$82.64*	$82.60	877	$72,403
403-34841	Hot Mix Asphalt (Grading SX) (100) (PG 64-22)	TON	*$72.83*	$72.80	292	$21,271
606-00710	Guardrail Type 7 (Style CA)	LF	*$65.96*	$66.00	412	$27,192
606-01370	Transition Type 3G	EACH	*$2,282.49*	$2,282.50	1	$2,283
606-02003	End Anchorage (Nonflared)	EACH	*$2,617.76*	$2,617.80	1	$2,618
900-	Wall	SF		$80.00	4,582	$366,560

ITEM COST SUBTOTAL:	$642,401

Figure 12: Construction Cost Estimate – Ramp B-F

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Engineers Opinion of Probable Cost

Project: Description	Research-Powers Interchange
Project Number	20913
Name of Preparer	Steve Murray, PE

Item No.	Item Description	Unit	*2016*	Unit Cost	Quantity	Cost
203-00060	Embankment Material (Complete In Place)	CY	*$17.40*	$17.40	2,528	$43,992
304-06000	Aggregate Base Course (Class 6)	TON	*$26.47*	$26.50	2,211	$58,583
403-34741	Hot Mix Asphalt (Grading SX) (75) (PG 64-22)	TON	*$82.64*	$82.60	1,463	$120,820
403-34841	Hot Mix Asphalt (Grading SX) (100) (PG 64-22)	TON	*$72.83*	$72.80	488	$35,495

ITEM COST SUBTOTAL:	$258,889

Figure 13: Construction Cost Estimate – Ramp C-G

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Engineers Opinion of Probable Cost

Project: Description	Research-Powers Interchange
Project Number	20913
Name of Preparer	Steve Murray, PE

Item No.	Item Description	Unit	*2016*	Unit Cost	Quantity	Cost
203-00060	Embankment Material (Complete In Place)	CY	*$17.40*	$17.40	2,034	$35,398
304-06000	Aggregate Base Course (Class 6)	TON	*$26.47*	$26.50	1,955	$51,809
403-34741	Hot Mix Asphalt (Grading SX) (75) (PG 64-22)	TON	*$82.64*	$82.60	1,294	$106,848
403-34841	Hot Mix Asphalt (Grading SX) (100) (PG 64-22)	TON	*$72.83*	$72.80	431	$31,390
606-00710	Guardrail Type 7 (Style CA)	LF	*$65.96*	$66.00	89	$5,874
606-01370	Transition Type 3G	EACH	*$2,282.49*	$2,282.50	1	$2,283
606-02003	End Anchorage (Nonflared)	EACH	*$2,617.76*	$2,617.80	1	$2,618

ITEM COST SUBTOTAL:	$236,220

Figure 14: Construction Cost Estimate – Ramp D-H

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Engineers Opinion of Probable Cost

Project: Description	Research-Powers Interchange
Project Number	20913
Name of Preparer	Steve Murray, PE

Item No.	Item Description	Unit	*2016*	Unit Cost	Quantity	Cost
203-00060	Embankment Material (Complete In Place)	CY	*$17.40*	$17.40	10,355	$180,184
304-06000	Aggregate Base Course (Class 6)	TON	*$26.47*	$26.50	1,139	$30,177
403-34741	Hot Mix Asphalt (Grading SX) (75) (PG 64-22)	TON	*$82.64*	$82.60	753	$62,236
403-34841	Hot Mix Asphalt (Grading SX) (100) (PG 64-22)	TON	*$72.83*	$72.80	251	$18,284
606-00710	Guardrail Type 7 (Style CA)	LF	*$65.96*	$66.00	302	$19,932
606-01370	Transition Type 3G	EACH	*$2,282.49*	$2,282.50	2	$4,565
606-02003	End Anchorage (Nonflared)	EACH	*$2,617.76*	$2,617.80	2	$5,236
900-	Wall	SF		$80.00	2,838	$227,040

ITEM COST SUBTOTAL:	$547,654

Pareto Cost Models

A Pareto Cost Model can be used to identify key focal points for evaluation during a VE Workshop effort. The intent for using of Pareto analysis is to both define focal points for review and determine if the project costs are disproportionally dominated by any construction activity.

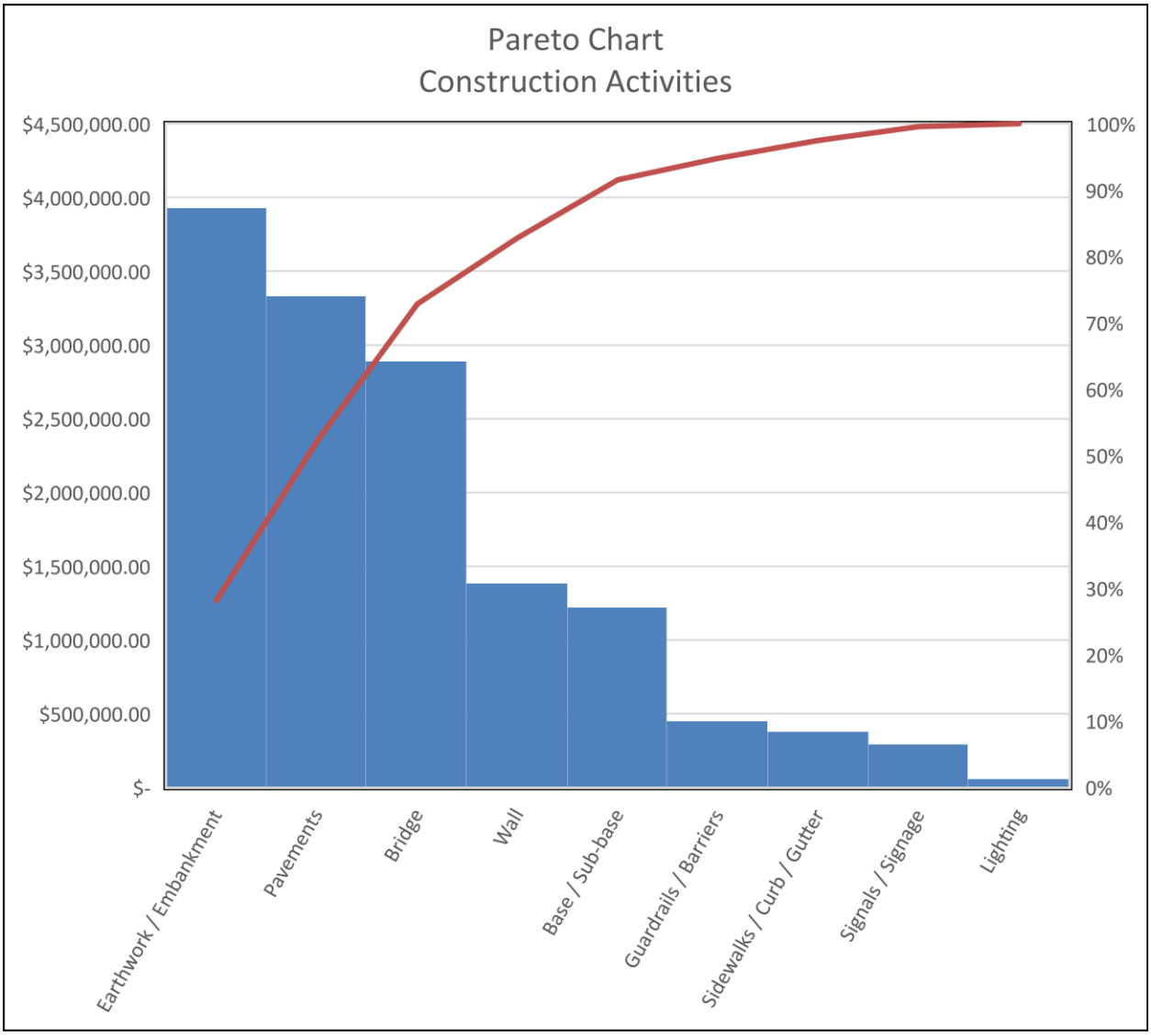
The format of the EPOC construction cost estimate was suitable for creation of the Pareto Model. The cost elements were sorted However, the summary EPOC estimate included contingency (40%), as well as allowances for utilities relocations (30%) and roadway lighting (10%). Therefore, these allowances were excluded from the Pareto analysis since these were not based upon the schematic design.

The three (3) highlighted line items representing the principal construction cost elements for the project, which total 73% of the project cost (without noted allowances). Each of these line items were addressed during Function Analysis, as well as during the Creative Phase when alternative ideas were generated.

Figure 15: Pareto Cost Model (Tabular)

Element	Cost	Share
Earthwork / Embankment	$ 3,928,617.59	28%
Base / Sub-base	$ 1,221,188.44	9%
Pavements	$ 3,331,068.60	24%
Guardrails / Barriers	$ 449,863.45	3%
Sidewalks / Curb / Gutter	$ 378,639.60	3%
Lighting	$ 56,559.80	0%
Signals / Signage	$ 291,561.00	2%
Bridge	$ 2,890,440.00	21%
Wall	$ 1,384,480.00	10%
Total =	$ 13,932,418.47	
Top 3 Items =	$ 10,150,126.18	73%

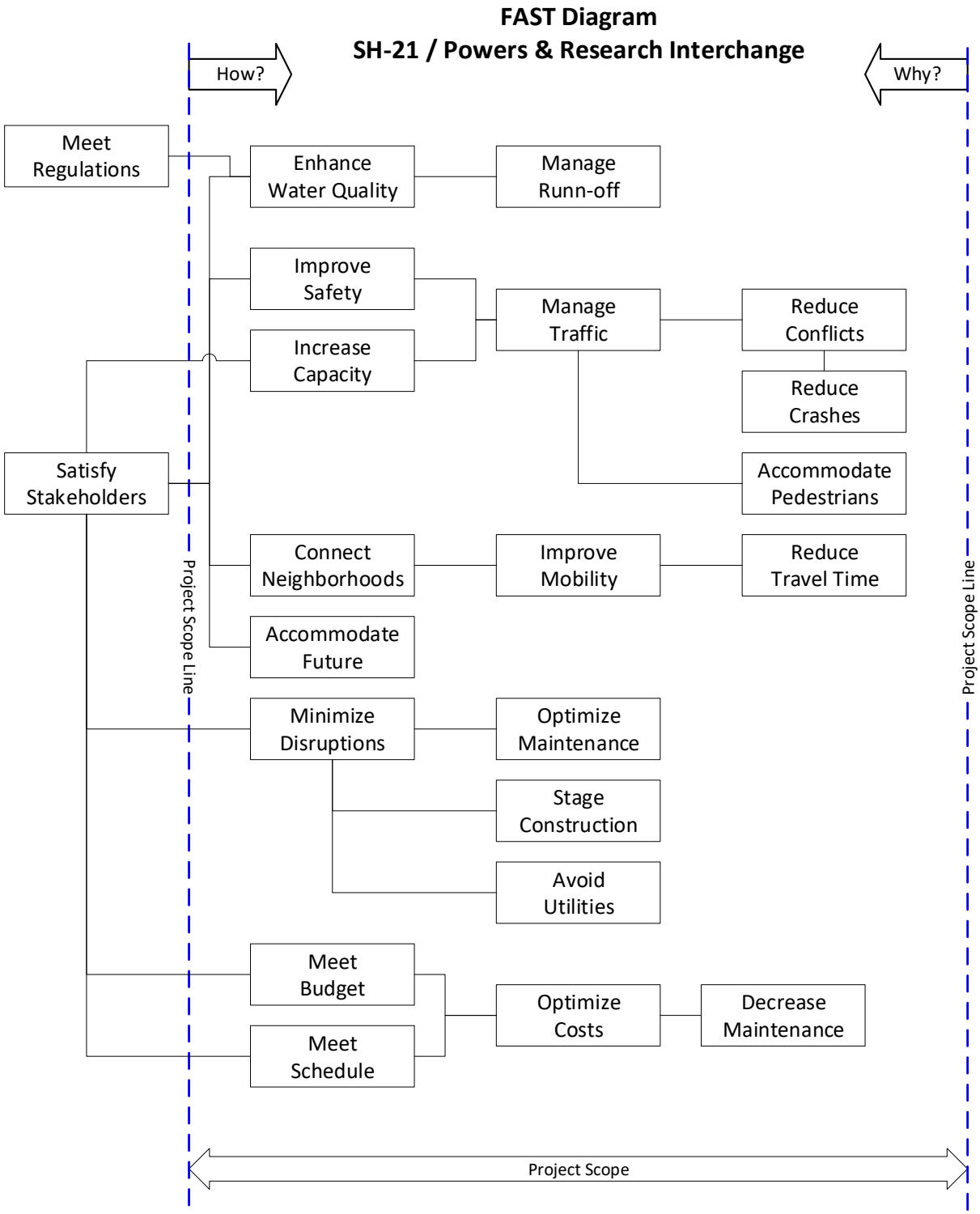
Figure 16: Pareto Cost Model (Graphical)



Appendix D: Function Analysis

The project Function Analysis System Technique (FAST) diagram.

Figure 17: FAST Diagram



Appendix E: Creative / Alternative Ideas Listing

The following tables contain the creative ideas, with Nominal Group Technique (NGT) scores and evaluations.

Table 5: Increase Capacity (IC)

Increase Capacity (IC)		
Idea No.	**Description**	**Action [5]**
IC-01	Add lanes, either direction on Powers	3
IC-02	Grade separate Research from Powers	AD
IC-03	Grade separate pedestrians.	1
IC-04	Restrict movements	C w/ IC-10
IC-05	Combine signal phasing.	DS
IC-06	Auxiliary lanes.	C w/ IC-01
IC-07	Increase speeds.	
IC-08	Decrease speeds.	
IC-09	Close access points.	D w/ AF-07
IC-10	Restrict truck traffic.	
IC-11	Provide transit bus turnouts.	
IC-12	Eliminate interchange; use collector-distributor roads to access Powers.	
IC-13	Direct connectors in lieu of ramps.	

Note: Alternative ideas without a score value were not considered for further investigation by the VE Team. However, CDOT or the Design Team may have interest in these alternative ideas as part of other, future projects.

[5] Action codes:
(value) = Number of VE Team Member votes received during Nominal Group Technique evaluation.
AD = As Designed / Already Being Done
C = Combine with idea number (XX-##)
D = Duplicate of idea number (XX-##)
DS = Design Suggestion
ANP = Analyzed Not Proposed
OBE = Overcome by Events

Table 6: Accommodate Future (AF)

Accommodate Future (AF)		
AF-01	Build out to ultimate condition (8-lanes), on Powers	1
AF-02	Perform detailed future planning study.	DS
AF-03	Pedestrian bridges.	D w/ IC-03
AF-04	Provide ITS fiber.	DS
AF-05	Dedicated access point, ramp for pond inspection and maintenance.	DS
AF-06	Roundabout at Channel Drive	
AF-07	Sever Channel Drive connection to Research	
AF-08	Roundabout at Cross Creek	ANP (OBE)
AF-09	Intersection control at Cross Creek, signalization	ANP (OBE)
AF-10	Complete right-of-way acquisition as soon as possible.	DS
AF-11	Add sidewalk on north side of Research.	AD
AF-12	Add bike lanes	D w/ CN-04

Table 7: Connect Neighborhoods (CN)

Connect Neighborhoods (CN)		
CN-01	Eliminate ramps, over pass only.	C w/ IC-12
CN-02	Pedestrian tunnels under Powers	
CN-03	Provide sidewalks southwest quadrant; provide pedestrian crossing	3
CN-04	Provide bike lanes, both sides.	DS
CN-05	Extend Cottonwood Creek trail	
CN-06	Pedestrian tunnel at Fairfax	
CN-07	Visual buffering (i.e., walls, landscaping, etc.) for identity connection	DS
CN-08	Provide gateway / neighborhood monuments.	DS
CN-09	Incorporate pond as amenity, park.	DS
CN-10	Enhanced pedestrian crossings.	4
CN-11	Use school buses to shuttle pedestrians through work zone when not in school use	C w/ MD-07
CN-12	Continuous green tee / intersection at Channel Drive	ANP (OBE)

Table 8: Control Access (CA)

Minimize Disruptions (MD)		
MD-01	Shift interchange east to avoid overhead power lines disruption	3 (see also MD-11)
MD-02	Move ramps to east side (i.e., folded diamond interchange)	1
MD-03	Innovative contracting (A+B) model	DS
MD-04	Accelerated bridge construction (ABC) techniques.	DS
MD-05	Pre-order long lead items.	
MD-06	Temporary pedestrian bridge / scaffold during construction.	
MD-07	Contractor operated shuttle for pedestrians and bikes during construction.	DS (see also CN-11)
MD-08	Develop and define alternate routes.	DS
MD-09	Total intersection closure with detours to minimize construction duration.	2
MD-10	Close Research through traffic during construction, provide median turnarounds on Powers	3
MD-11	Build Powers on MSE walls, tighten ramps to avoid overhead power lines	C w/ MD-01
MD-12	Concrete pavement for intersections.	3
MD-13	Concrete pavement for roadways.	
MD-14	Extend concrete bridge approach aprons.	
MD-15	Use twin roundabouts (i.e., dumbbell) on Research at interchange.	1
MD-16	Provide pedestrian crossing near Channel Drive / Fairfax Creek.	1
MD-17	Pedestrian underpass on west side	
MD-18	Pedestrian underpass at Fairfax Creek, tie in urban trail.	D w/ CN-06

Appendix F: Design Suggestions

The following alternative idea was initially deemed worthy of further analysis and development by the VE Team. These ideas were determined to have the potential to positively influence the overall project.

Each of the ideas listed below are further explained within the following pages.

Table 9: Design Suggestions

Idea No.	Description
IC-05	Right Turn Signal Phasing
AF-02	Detailed Future Planning Study
AF-04	Provide ITS Fiber
AF-05	Dedicated Access Point / Ramp for Pond Maintenance
AF-10	Right-of-Way Acquisition As Soon As Possible
CN-04	Provide Bike Lanes, Both Sides
CN-07	Visual Buffering – Walls, Landscaping for Community Identity Connection
CN-08	Provide Gateway / Neighborhood Monuments
CN-09	Incorporate Pond as Amenity / Park
MD-03	Innovative Contracting Model (A + B)
MD-04	Accelerated Bridge Construction Techniques
MD-07	Contractor Operate Shuttle for Pedestrians / Bikes During Construction
MD-08	Develop and Define Alternative Routes

Design Suggestion

Idea Number: IC-05

Idea Title:

Right Turn Signal Phasing (IC-05)

Consider separate right turn phasing to control the right turn movements entering Powers to reduce conflict with pedestrians. This can be accomplished by creating a pedestrian phase on the second ring and utilizing the un-used conflicting left turn to control the vehicle movement. An overlap can be created with parent phase on the other side of barrier.

In the below example ring/barrier design, phase 5 would be driven by a phase 4/5 overlap:

Ph2 | Ph 4
Ph5 / Ph6-ped |

Also, consider controlling both off ramp right-turns to reduce weaving conflicts between DDI and adjacent intersections.

FHWA CATEGORIES

Safety	☒	Operations	☒	Environment	☐	Construction	☐	ROW	☐

Design Suggestion

Idea Number: **AF-02**

Idea Title: **Detailed Future Planning Study (AF-02)**

The VE Team feels that this project would lend itself to have a meeting with City of Colorado Springs for multiple aspects of the Master Plan in the area.

Colorado Springs Parks and Rec has plans of a trail extension under Cottonwood Creek Bridge to the east. Design Team should coordinate the scope of the midrange planned trail system through the Fairfax Drainage system; you could potentially tie the Wolf Ranch Neighborhood and Fairfax Ridge into a trail system that would allow access to Liberty High School and the Radiant Church through the CBC under Powers at Fairfax Creek. Furthermore, a sidewalk connection under Research at the Fairfax Channel would allow a connection to the north side of Research and then to the sidewalk route shown across Powers. The pedestrian access across Powers on Research seems to be a potential flaw with pedestrian and bike routes from the east side neighborhoods traveling to safely reach the attractors on the west side of Powers, and not being well planned to be a good accommodation of pedestrian and bikes.

Ensure that the traffic on Research will accommodate the planned buildout of houses on the east side of Powers Blvd.

FHWA CATEGORIES

Safety	☐	Operations	☒	Environment	☐	Construction	☒	ROW	☐

Design Suggestion

Idea Number: AF-04

Idea Title:

ITS - Fiber (AF-04)

Provide infrastructure for future CDOT fiber connection between Platte Ave and I-25. This will reduce construction effort when funding becomes available to connect this highway to the CDOT fiber network.

FHWA CATEGORIES

Safety	☐	Operations	☒	Environment	☐	Construction	☐	ROW	☐

Design Suggestion

Idea Number: AF-05

Idea Title:

Dedicated Access Point/Ramp for Pond Maintenance. (AF-05)

The proposed pond will provide both flood control and water quality. The intended function of a water quality pond is to remove sediment and pollutants by having them settle to the bottom of the pond. This requires routine maintenance to keep the pond functioning as designed.

Access to the pond and critical features should be taken into account during design. A dedicated access point should be provided to the pond that can accommodate large maintenance vehicles including vacuum trucks, dump trucks, and lowboy trailers. Access should also be considered and provided into the pond to critical components like forebays, trickle channels and outlet structures.

Refer to the City of Colorado Springs Drainage Criteria Manual for required maintenance considerations during design.

FHWA CATEGORIES

Safety	☐	Operations	☒	Environment	☒	Construction	☐	ROW	☐

Design Suggestion

Idea Number: AF-10

Idea Title:

ROW Acquisition ASAP (AF-10)

To accommodate early advertisement of construction, it is suggested that right-of-way acquisition be started as soon as possible. This may also represent a long-term cost savings.

(The VE Team recognizes that much of the right-of-way has either already been obtained or may be in process.)

For early acquisition, several design decisions need to be made:

1. Determination of final geometrics (including utility needs)
2. IAR process 1601 must be complete (or possibly under review).
3. Front page Form 128 must be cleared through CDOT Environmental.
4. Determination of use of walls, in lieu of slopes, should be set.

FHWA CATEGORIES

Safety	☐	Operations	☐	Environment	☐	Construction	☒	ROW	☒

Design Suggestion

Idea Number: CN-04

Idea Title:

Provide Bike Lanes, Both Sides

In compliance of Procedural Directive 1602.1, consider accommodating and including a bike way in the geometric configuration. The typical section under the bridge has enough room on the shoulders to accommodate bike lanes in both direction. Consider including within the project limits lanes east and west of the bridge. Currently, the typical sections before and after the bridge does not identify a "bike way" as defined in PD 1602.1. With a large neighborhood on the east side of SH21 (Wolf Ranch) and Liberty High School and Timberview Middle School on the west side, accommodating a safe bike way for current and future bike use should be considered.

A bike way can include bike lanes, bike paths, shoulders and multi-purpose paths. Currently within the typical a 10ft sidewalk is attached behind curb & gutter. A multi-purpose path is defined as being physically separated by vehicular traffic by an open space or barrier and specifically designated as being open to non-motorized users.

If a bike way as defined in PD 1602.1 cannot be accommodated, document the decision in Exemption Form 464 BP. The form shall be reviewed and accepted / rejected by the Region Transportation Director.

FHWA CATEGORIES

Safety	☒	Operations	☐	Environment	☐	Construction	☐	ROW	☐

Design Suggestion

Idea Number: CN-07

Idea Title:

Visual Buffering – Walls, Landscaping for Community Identity Connection

Considering the location of the interchange in proximity of growing and established neighborhoods, schools and shopping, include visual buffering and aesthetic treatments within the project limits. This can include sustainable landscaping, colored & textured concrete, community related themes (Timberview Middle School and Liberty High School), etc. Enlist community ideas and input in developing the architectural and aesthetic treatments.

FHWA CATEGORIES

Safety	☐	Operations	☐	Environment	☒	Construction	☐	ROW	☐

Design Suggestion

Idea Number: CN-08

Idea Title:

Provide Gateway/Neighborhood Monuments (CN-08)

Neighborhoods can feel more connected and identify with an area when neighborhood signs are present that identify the area. This can lead to community pride and ownership of the neighborhood.

Research serves large residential developments to the east with the largest appearing to be the Wolf Ranch subdivision. There is already an existing monument sign for Wolf Ranch on the south east corner of Powers and Research and additional branding at most intersections along Research to the east of Powers. There does not appear to be any existing monuments on Research west of Powers.

Sometimes road names are incorporated into the casting of the bridge elements to identify streets or neighborhoods. This could be an opportunity to add gateway signage at a low cost to the project.

FHWA CATEGORIES

Safety	☐	Operations	☐	Environment	☐	Construction	☐	ROW	☐

Design Suggestion

Idea Number: CN-09

Idea Title:

Incorporate Pond as Amenity/Park (CN-09)

The proposed pond will take up a large section of the "open space" currently around the intersection. The pond and Fairfax Tributary creek can offer an opportunity to engage the public with stormwater and the City's "complete creek" concept.

The City is developing a complete creek concept and initial discussion can be found at the following link:

https://coloradosprings.gov/planning/page/plancos-explores-complete-creeks

As the pond design is developed with the intersection project, the possibility to utilize the pond location for more than stormwater detention should be kept in mind. Check with the City Parks department to see if they would have any interest in a shared facility or partnering on the project. If the pond area does become a public used area, fencing may be needed along Powers to control unwanted pedestrian access onto Powers. Access would need to be considered off of Research Parkway.

FHWA CATEGORIES

Safety	☐	Operations	☐	Environment	☒	Construction	☐	ROW	☐

Design Suggestion

Idea Number: **MD-03**

Idea Title:

Innovative Contracting Model A + B. (MD-03)

The VE Team feels that this project would lend itself to an Innovative Contracting Method commonly referred to as A + B if the Decision matrix has determined that DBB is the appropriate contracting method for this project.

See section below from the CDOT Innovative Contracting Guidelines (Rev 1-8-2015)

4.5 Cost-Plus-Time or (A + B) Contracts

Definition: Cost-plus-time, or A+B contracts involve time with an associated cost for the determination of Award based on low-bid. Under the A + B method, each bid submitted consists of two components:

- The "A" component is the traditional bid for the contract items and is the dollar amount for all work to be performed under the contract.
- The "B" component is a "bid" of the total number of calendar days required to complete the project as estimated by the bidder.

The number of calendar days, "B" is multiplied by the road user cost furnished by the Department and added to the "A" component to obtain the total bid. *This formula is only used to determine the lowest bid for award and is not used to determine payment to the contractor.*

(A) + (B x Daily Cost)

The Daily Cost is based on the failure to complete the entire project by the specified date, and is determined using the C.D.O.T. Work Zone – User Cost Program – Road User Cost Calculator. The Daily Cost utilized shall be documented in the project file. Note: The Work Zone User Cost Program may be used to calculate full closures, individual lane closures, multiple lane closures, and the operational impacts of cuing which result from individual or multiple lane closures.

FHWA CATEGORIES

Safety	☐	Operations	☐	Environment	☐	Construction	☒	ROW	☐

Design Suggestion

Idea Number: **MD-04**

Idea Title:

Accelerated Bridge Construction Techniques (MD-04)

The VE Team feels that this project would lend itself to Accelerated Bridge Construction Techniques, please consider incorporating these in the Plans and Specifications.

See section below from the FHWA

https://www.fhwa.dot.gov/bridge/abc/docs/abcmanual.pdf

Accelerated Bridge Construction (ABC): ABC is bridge construction that uses innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges.

ABC improves:

- Site Constructability
- Total project delivery time
- Material quality and product durability
- Work-zone safety for the traveling public and contractor personnel

ABC reduces:

- Traffic Impacts
- Onsite construction time
- Weather-related time delays

ABC can minimize:

- Environmental impacts
- Impacts to existing roadway alignment
- Utility relocations and right-of-way take

FHWA CATEGORIES

Safety	☐	Operations	☐	Environment	☐	Construction	☒	ROW	☐

Design Suggestion

Idea Number: MD-07

Idea Title:

Contractor Operate Shuttle for Pedestrians / Bikes During Construction. (MD-07)

Maintaining pedestrian and bicycle connection over Powers on Research will be very difficult during construction. It is about a mile to the north or a mile to the south until you reach the next pedestrian crossing over Powers. These locations do not all have good connectivity for pedestrians back to Research. The contractor may consider providing a shuttle service for pedestrian access from the west side of the Research to the east side across Powers and vice versa. This would eliminate trying to maintain a safe access through the construction zone and across powers.

FHWA CATEGORIES

Safety	☒	Operations	☐	Environment	☐	Construction	☒	ROW	☐

Design Suggestion

Idea Number: MD-08

Idea Title:

Develop and Define Alternative Routes

During the construction phasing development, consider defining and developing alternative routes for the neighborhoods. Mobility east-west will be constrained during construction. A large neighborhood is located on the east side of State Highway 21 (Wolf Ranch).

Developing an alternative route to the High School and Middle School should be clearly identified and communicated to the public. Coordinate with District 20 regarding bus routes and schedules. Identify pedestrian / bike routes during construction or develop the contract to require the contractor to clearly maintain and accommodate pedestrian and bike routes.

FHWA CATEGORIES

Safety	☐	Operations	☒	Environment	☐	Construction	☐	ROW	☐

Appendix G: Analyzed Not Proposed

The following alternative idea was initially deemed worthy of further analysis and development by the VE Team. However, during the VE Results Presentation these ideas were determined to be overcome by events that were unknown to the VE Team, or work that will be incorporated by the City of Colorado Springs as an improvement that will be outside the scope of the Powers-Research Interchange project.

Table 10: Analyzed Not Proposed

Idea No.	Description	Action
AF-08	Consider Roundabout Intersection Control / Type Improvements at Research and Grand Cordera Parkway / Cross Creek Drive	Mutually exclusive to idea AF-08; see below.
AF-09	Consider Signalized Intersection Control / Type Improvements at Research and Grand Cordera Parkway / Cross Creek Drive	City advised that this item will be constructed by a developer; no CDOT action required.
CN-12	Continuous Green Tee (Florida Tee) Intersection at Channel Drive	City advised that this item will be implemented as a Public Works intersection improvement project within the near future; no CDOT action required.

Value Engineering Recommendation

Idea Number: AF-08

Idea Title:

Consider Roundabout Intersection Control / Type Improvements at Research and Grand Cordera Parkway / Cross Creek Drive. (AF-08)

Original Concept Description:

The intersection is shown to remain as-is with the assumption that the intersection would be signalized by 2040.

Proposed Concept Description:

Provide improvements to intersection as a roundabout as part of project.

Summary:

The original concept provides 3 thru lanes, 1 left turn lane and 1 continuous right lane for eastbound traffic entering the intersection; westbound traffic is provided 3 receiving lanes. The proposed concept would reduce roadway width between the interchange and the Grand Cordera Pkwy/Cross Creek Dr intersection. A roundabout would likely only need two receiving lanes and two incoming lanes.

FHWA CATEGORIES	
Safety	☒
Operations	☒
Environment	☐
Construction	☐
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$98,000	$0	$98,000
Proposed =	$429,000	$0	$429,000
Savings =	-$331,000	$0	-$331,000

Advantages / Disadvantages

Idea Number: AF-08

Advantages

- Reduces pavement width
- Shortens pedestrian crossing
- Reduces side street delay
- Fits well with adjacent roundabouts
- Traffic signal warrant not needed to be met
- Reduces weaving issues between interchange and intersection
- Reduces crash potential
- Efficient distribution of traffic among intersection legs.
- Provides easy turn around for CDOT snowplow plowing interchange movements.

Disadvantages

- Increases delay on major road
- Could add to construction schedule
- Right-of-way corners may be needed

Discussions

Idea Number: AF-08

This project exemplifies an opportunity to provide continuity along Research Pkwy between Powers Blvd and Tutt Blvd. Leaving the intersection of Research Pkwy with Grand Cordera Pkwy/Cross Creek Dr as-is today would leave the intersection out of context with the DDI and Research Pkwy to the east. The intersection has excess lanes that are not necessary for exceptional operation in the long-term. The current configuration is driving the need for the seven-lane cross-section between Powers Blvd and Grand Cordera Pkwy/Cross Creek Dr.

Eastbound Research Pkwy leaving the proposed DDI is composed of two thru lanes and two parallel, signalized right-turn added lanes. In order for right turn traffic to reach Grand Cordera Dr, three lane changes are made. In order for thru turn traffic to reach Cross Creek Dr, two lane changes are made. This appears to be problematic in the short 400-500 feet.

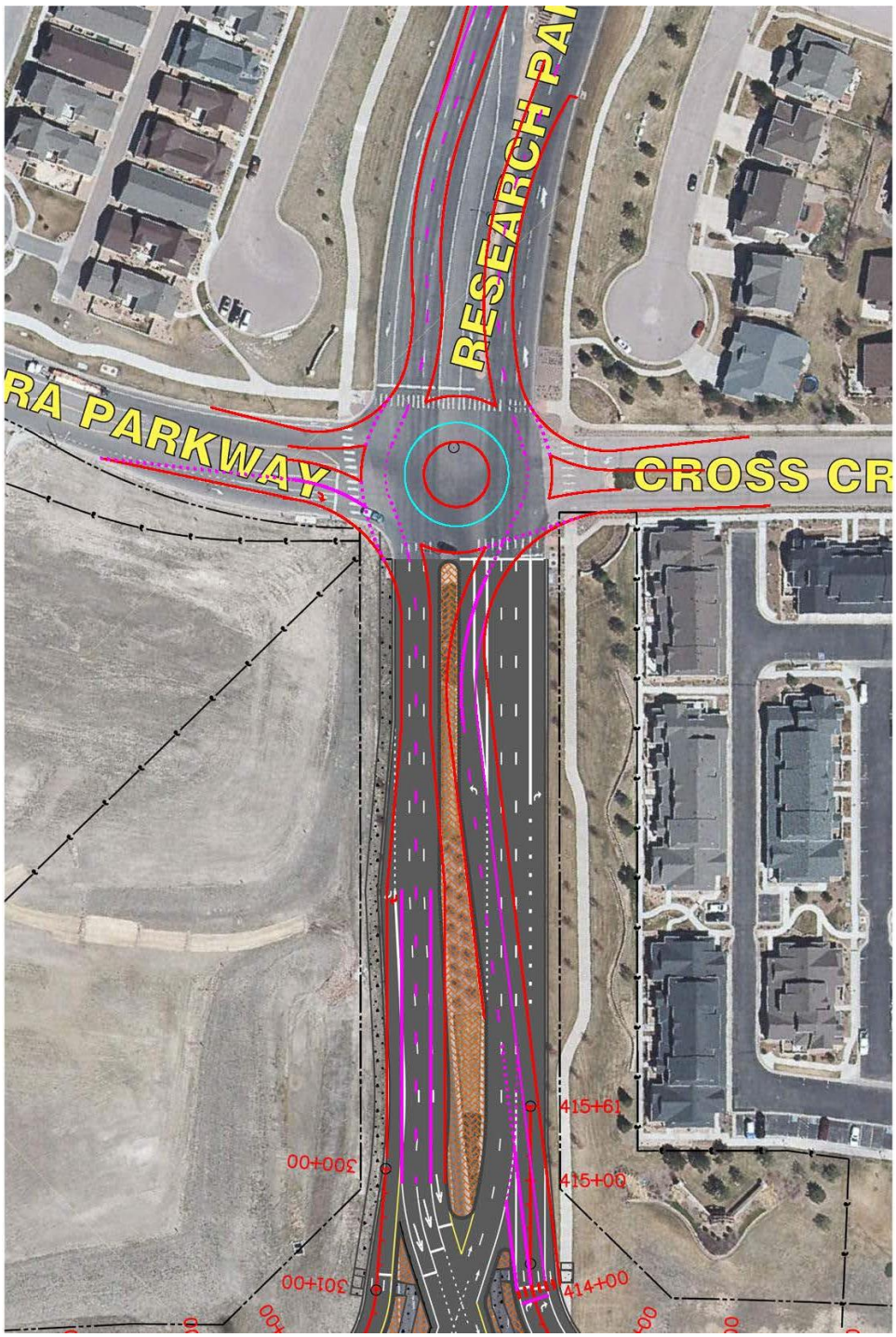
Westbound Research Pkwy entering the DDI is composed of three thru lanes with the left lane dropping for southbound Powers, (the #3 lane is developed west of Tutt Blvd). This configuration would require thru traffic to shift a lane to the right to stay balanced.

The roundabout option at Grand Cordera Pkwy/Cross Creek Dr would provide a 2040 solution to the intersection as well as limit weaving between intersections to one lane change.

Proposed Concept – Sketch

Idea Number: AF-08

Roundabout at Research Parkway - Grand Cordera Parkway / Cross Creek Drive



Cost Estimate Worksheet

Idea Number: AF-08

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Aggregate Base Course (Class 6)	TON	26.47	950	25,157
HMA (SX)(75)(PG 64-22)	TON	82.64	880	72,723
		Total (ORG) =		97,880

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Aggregate Base Course (Class 6)	TON	26.47	2,730	72,263
HMA (SX)(75)(PG 64-22)	TON	82.64	2,530	209,079
Concrete Sidewalk (6 Inch)	SY	51.64	600	30,984
Median Cover Material (4" Patterned Concrete)	SF	5.20	6,000	31,200
Inlet Type R (15 Ft)	EA	25,000.00	1	25,000
Curb and Gutter	CY	20.00	3,000	60,000
			Total (PRO) =	428,526
			Difference (PRO – ORG) =	**330,646**

Assumptions:

- Assumed 2 less 12’ lanes for 600 feet between DDI and intersection
- Assumed HMA road design in Pavement Summary Memo
- Roundabout Areas and perimeters measured from MicroStation

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Alternative

Idea Number: AF-09

Idea Title:

Consider Signalized Intersection Control / Type Improvements at Research and Grand Cordera Parkway / Cross Creek Drive. (AF-09)

Original Concept Description:

The intersection is shown to remain as-is with the assumption that the intersection would be signalized by 2040.

Proposed Concept Description:

Provide improvements to intersection as a signalized intersection as part of project.

Summary:

The original concept provides 3 thru lanes, 1 left turn lane and 1 continuous right lane for eastbound traffic entering the intersection; westbound traffic is provided 3 receiving lanes. The proposed concept would reduce roadway width between the interchange and the Grand Cordera Pkwy/Cross Creek Dr intersection. The intersection likely only needs two receiving lanes and two incoming lanes.

FHWA CATEGORIES	
Safety	☒
Operations	☒
Environment	☐
Construction	☐
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$61,000	$0	$61,000
Proposed =	$290,000	$0	$290,000
Savings =	-$229,000	$0	-$229,000

Advantages / Disadvantages

Idea Number: AF-09

Advantages

- Provide signalized pedestrian crossing
- Reduces pavement width
- Shortens pedestrian crossing
- Reduces side street delay
- Reduces weaving issues between interchange and intersection

Disadvantages

- The signal currently does not meet signal warrants
- By 2040, the intersection still may barely meet a warrant
- Likely increase in rear-end crashes until warrant is met
- Likely need left-turn phases increasing delay

Discussions

Idea Number: AF-09

This project exemplifies an opportunity to provide continuity along Research Pkwy between Powers Blvd and Tutt Blvd. Leaving the intersection of Research Pkwy with Grand Cordera Pkwy/Cross Creek Dr as-is today would leave the intersection out of context with the DDI and Research Pkwy to the east. The intersection has excess lanes that are not necessary for exceptional operation in the long-term. The current configuration is driving the need for the seven-lane cross-section between Powers Blvd and Grand Cordera Pkwy/Cross Creek Dr.

Eastbound Research Pkwy leaving the proposed DDI is composed of two thru lanes and two parallel, signalized right-turn added lanes. In order for right turn traffic to reach Grand Cordera Dr, three lane changes are made. In order for thru turn traffic to reach Cross Creek Dr, two lane changes are made. This appears to be problematic in the short 400-500 feet.

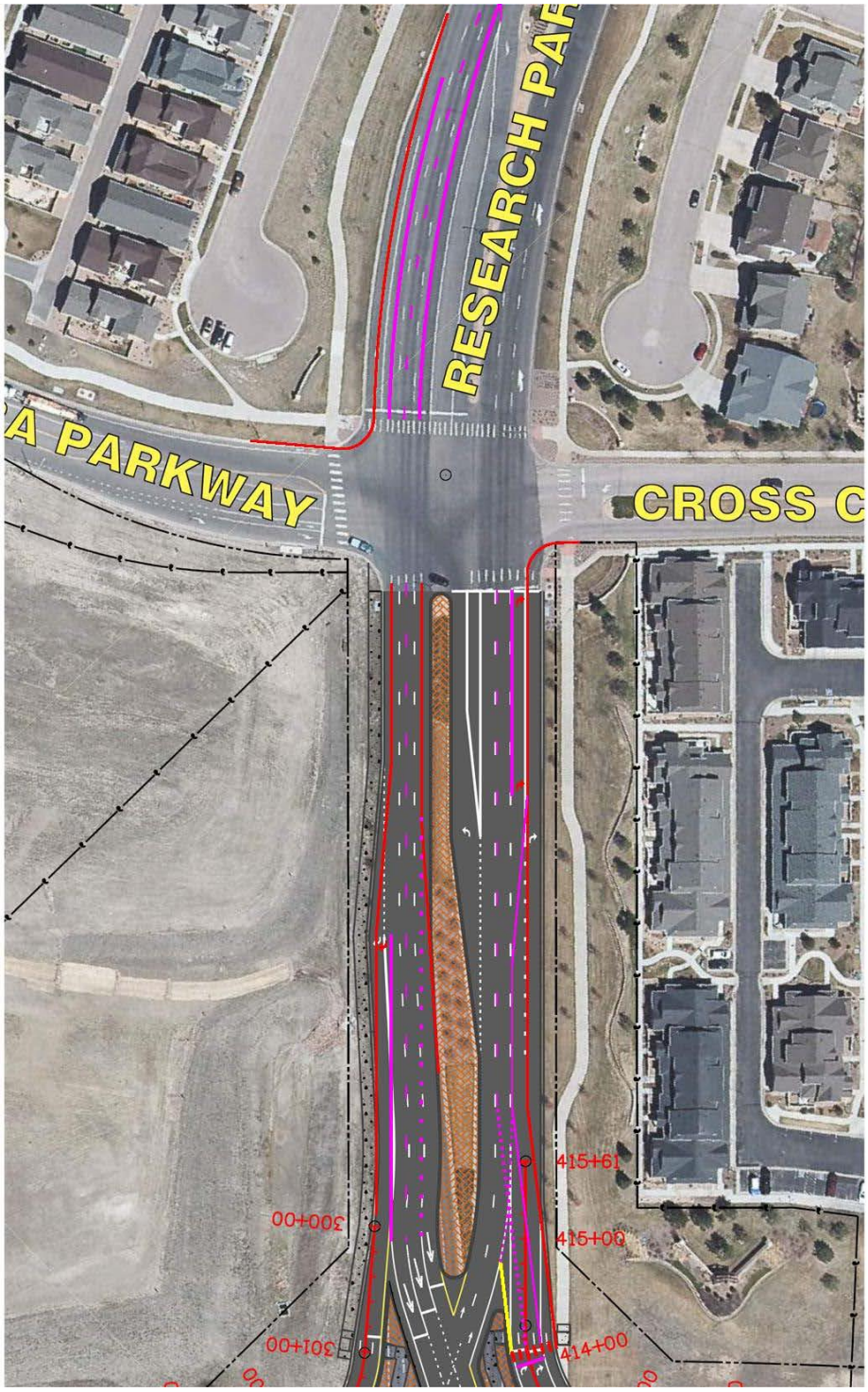
Westbound Research Pkwy entering the DDI is composed of three thru lanes with the left lane dropping for southbound Powers, (the #3 lane is developed west of Tutt Blvd). This configuration would require thru traffic to shift a lane to the right to stay balanced.

The signalized option at Grand Cordera Pkwy/Cross Creek Dr would provide a 2040 solution to the intersection. The narrowing of the intersection will limit weaving between intersections to one or two lane changes.

Proposed Concept – Sketch

Idea Number: AF-09

Signalized Intersection at Research Parkway - Grand Cordera Parkway / Cross Creek Drive



Cost Estimate Worksheet

Idea Number: AF-09

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
Aggregate Base Course (Class 6)	TON	26.47	594	15,723
HMA (SX)(75)(PG 64-22)	TON	82.64	550	45,452
		Total (ORG) =		61,175

Proposed (PRO) Concept

Description	Units	Unit Cost	Quantity	Totals
Embankment Material (CIP)	CY	17.40	370	7,400
Curb and Gutter	CY	20.00	1	25,000
Traffic Signal Controller Cabinet	EA	25,000.00	1	8,000
Wiring	LS	8,000.00	2,000	48,000
3" Conduit Bored	LF	24.00	80	40,000
36" Drilled Caisson	LF	500.00	4	64,000
Traffic Signal-Light Pole Steel (50 Ft Mast Arm)	EA	16,000.00	8	8,000
Pedestrian Push Button	EA	1,000.00	4	34,613
Intersection Detection System (Camera)	EA	8,653.25	24	24,000
Signal Faces	EA	1,000.00	370	7,400
			Total (PRO) =	290,333
			Difference (PRO – ORG) =	**229,158**

Assumptions:

- Assumed 1.2 less 12’ lanes for 600 feet between DDI and intersection
- Assumed HMA road design in Pavement Summary Memo

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Value Engineering Recommendation

Idea Number: CN-12

Idea Title:

Continuous Green Tee Intersection at Channel Drive (CN-12)

Original Concept Description:

Original Concept eliminates left turns from Channel Drive westbound (restricted to right-out only).

Proposed Concept Description:

Proposed concept allows left turns out by making use of the median width to provide a channelized lane that can merge west of Channel Drive (continuous flow in through lanes eastbound on Research Parkway through intersection with Channel Drive).

Summary:

Accommodates an additional movement from Channel Drive (as well as Powers Center at Research and Fairfax Neighborhood).

FHWA CATEGORIES	
Safety	☒
Operations	☒
Environment	☐
Construction	☒
ROW	☐

ESTIMATED COST IMPACT			
	Construction Cost	Present Worth O&M Cost	Present Worth Total Cost
Original =	$0	$0	$0
Proposed =	$9,000	$0	$9,000
Savings =	-$9,000	$0	-$9,000

Advantages / Disadvantages

Idea Number: CN-12

Advantages

- Accommodates an additional movement at Channel Drive intersection with Research Parkway.
- May provide additional pedestrian refuge on Research Parkway should a crossing be provided at this intersection.
- Reduces median area/cost on Channel Drive.
- May reduce median area/cost on Research Parkway (TBD).
- Does not require additional right-of-way along Research Parkway.

Disadvantages

- Reduces pedestrian refuge area in median on Channel Drive.
- Requires additional surfacing on Research Parkway and Channel Drive to accommodate the left turn lane.
- May increase median area/cost on Research Parkway (TBD).
- May incur an additional traffic weave in westbound direction prior to intersection with Scarborough Drive.
- Eliminates median plantings.

Original Concept - Sketch

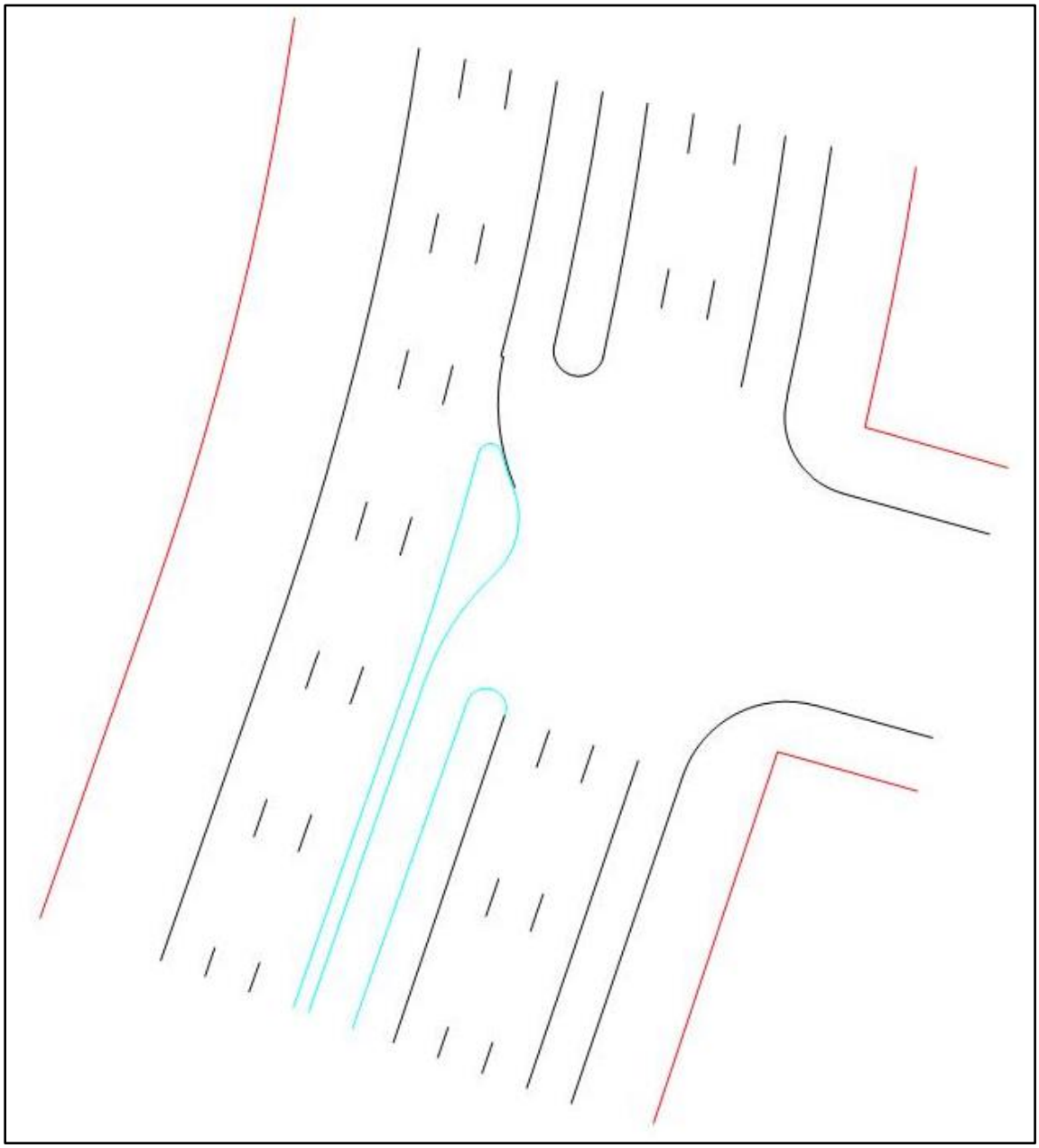
Idea Number: CN-12

Current Intersection at Research Parkway – Channel Drive

Proposed Concept – Sketch

Idea Number: CN-12

Continuous Through Tee Intersection at Research Parkway – Channel Drive



Original Concept – Calculations

Idea Number: CN-12

RESEARCH PARKWAY

300 LF x 26 feet wide = 7,800 SF (~600 LF of curb and gutter)

300 LF x 17 feet wide = 5,100 SF (tapers from 8 to 26 ±) (600 LF of curb and gutter)

Total = 13,900 SF Median (1200 LF curb and gutter)

CHANNEL DRIVE

180 LF x 14 feet wide = 2,520 SF (curb and gutter remain same)

Proposed Concept – Calculations

Idea Number: CN-12

Proposed concept calculations include increase/reduction to paved and median areas.

(For calculation purposes, the added lane width is assumed at 12 feet but will likely need to be wider if implemented.)

Added median area at intersection ~ 600 SF (measured in cad) = reduced pavement area. (approximately 130 LF of curb and gutter)

Total median area along Research (west of Channel) approximated as follows:

RESEARCH PARKWAY

300 LF x 14 feet wide = 4,200 SF (~1,200 LF of curb and gutter)

300 LF x 11 feet wide = 3,300 SF (tapers from 8 to 14 ±) (No change to curb and gutter)

Total = 7,500 SF Median (1800 LF of curb and gutter), 6,400 SF HMA paving

CHANNEL DRIVE

180 LF x 4 feet wide (current NB lane is wider than 12 feet) = 720 SF, 1,800 SF HMA paving

Proposed Concept - Cost Estimate

Idea Number: CN-12

Change in quantities:

RESEARCH PARKWAY

Deduct 6,400 SF Median Cover Material

Add 600 LF Curb and Gutter (Type 2 Sec IB = City Curb and Gutter Type 7)

Add 6,400 SF HMA Paving (10 inch), Assume base to be full width of roadway currently.

[392 Tons]

CHANNEL DRIVE

Deduct 1,800 SF Median Cover Material

Add 1,800 SF HMA Paving (10 Inch), Assume base to be full width of roadway currently.

[110 Tons]

Cost Estimate Worksheet

Idea Number: CN-12

Original (ORG) Concept

Description	Units	Unit Cost	Quantity	Totals
			Total (ORG) =	

Proposed (PRO) Concept (DELTA from ORG)

Description	Units	Unit Cost	Quantity	Totals
(Deduct) Median Cover Material	SF	$5.20	(8,200)	($42,640)
Add Curb and Gutter, Type 2 Sec IB	LF	$16.60	600	$9,960
Add Hot Mix Asphalt (Grading SX)	TN	$82.60	502	$41,465
			Total (PRO) =	**8,785**
			***Difference (PRO – ORG) =**	**- 8,785**

Assumptions:

- *Adds $8,785 in construction bid cost estimate. With 40% contingency, the total increases to ~**$12,300.**

General Notes:

- Estimated costs are order of magnitude, not considered actual cost of construction.

Appendix H: Available Project Information

The following project documents were provided to the VE Team:

- Research-Powers Interchange Design
  - Design Criteria
  - Project Design Variances Summary
  - Geometry Mainline and Ramps
  - Typical Sections
- Engineers Opinion of Probable Cost (dated Feb. 6. 2018)
- Construction Phasing Concept
  - Construction Phasing Memorandum (dated Feb. 8, 2018)
  - Construction Phasing Drawings
    - Powers Work, Phases 1 / 2
    - Research Work, Phases 3 / 4 / 5
- Cross sections (dated Feb. 12, 2018)
  - SH-21 North
  - Research Parkway
  - Ramp A-E
  - Ramp B-F
  - Ramp C-G
  - Ramp D-H
- Interchange Drainage Concept Plan
- Fairfax Pod Grant Submittal
  - Fairfax Grant Application (Oct. 14, 2016)
  - Cost Estimate
  - Pond Exhibit
  - PWQ Cost Estimate Tables
  - PWQ Treatment Area and Cost Estimate Tables
- Noise Analysis Memorandum (dated Sept. 28, 2017)
- Pavement Summary Memorandum (dated Feb. 9,2018)
  - Site Plans
- Profile Drawings
  - SH-21 PGL Plot
  - Research Parkway PGL Plot
  - Ramps A-E and B-F
  - Ramps C-G and D-H

Appendix I: Project Breifing Presentation

Appendix J: VE Results Presentation