Appendix A. Alternatives Development Workshop Presentation

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Interstate 10/ Interstate 17 Corridor Master Plan

Alternatives Brainstorming Workshop

June 22 & 23, 2015

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Corridor Master Plan Process Overview

We are Here

Initiate Project

- Project Management Plan
- Public Involvement Plan
- Controlling Design Criteria and Design Exception/Variance Procedures.

Conduct Corridor Needs Assessment

- Existing Conditions
- PEL Checklist Part 1
- Future Conditions (No-Build)
- Agency and Public Outreach – Round 1
- Purpose and Need

Develop Corridor Alternatives & Screening

- Alternatives Workshop
- Categorize Alternatives
- Tier 1 Qualitative Screening
- Tier 2 Quantitative Screening
- System Bundles
- Tier 3 Quantitative Screening (Bundles)
- Agency and Public Outreach – Round 2
- Select Recommended Alternative

Establish Corridor Master Plan

- Completed PEL
- Priority Resource Impacts Evaluation
- Mitigation Strategy
- Implementation Plan
- Design Exceptions
- Incorporate into MAG Policies
- Purpose and Need guidance for future projects

DECEMBER 2016

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Spine Segment Map

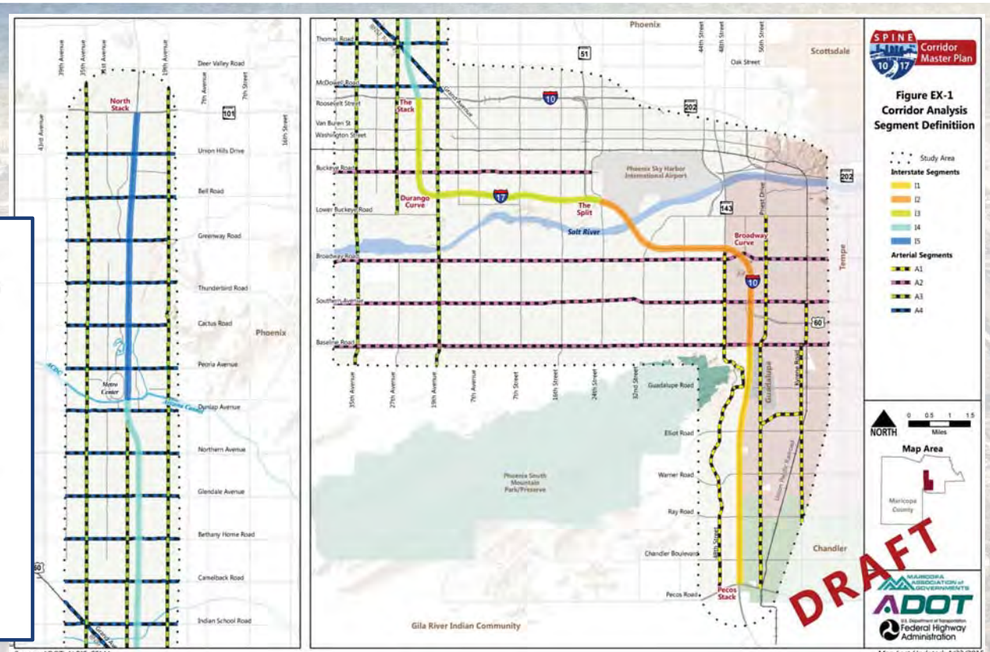
Study Area

Interstate Segments

- I1
- I2
- I3
- I4
- I5

Arterial Segments

- A1
- A2
- A3
- A4



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Workshop Overview

MONDAY, JUNE 22, 2015

8:00 – Study Process and Workshop Overview

8:15 – System-wide Brainstorming

8:45 – Segment I1 Brainstorming

9:45 – Break

10:00 – Segment A1 Brainstorming

10:45 – Segment I2 Brainstorming

12:00 – Lunch (provided)

1:00 – Segment I2 (continued)

1:30 – Segment A2 Brainstorming

3:45 – Break

4:00 – Segment I3 Brainstorming

5:00 - Adjourn

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Workshop Overview

TUESDAY, JUNE 23, 2015

8:00 – Segment I3 (continued)

9:00 – Segment I4 Brainstorming

10:30 – Break

10:45 – Segment I5 Brainstorming

12:00 – Lunch (provided)

1:00 – Segment I5 (continued)

2:00 – Segment A3 Brainstorming

3:30 – Break

3:45 – Segment A4 Brainstorming

5:00 - Adjourn

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Workshop Objective and Ground Rules

- **Brainstorm ideas that address one or more of the corridor segment challenges and get them logged into the alternatives database.**
- **Ground rules:**
  - Focus on generating alternatives that respond to segment needs and capitalize on opportunities.
  - Avoid judging, screening, selling, or evaluating alternatives.
  - No idea is a bad idea.

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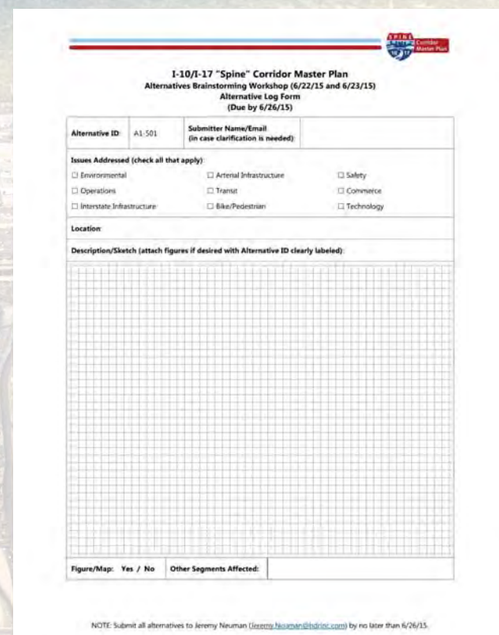
Ways to Log Alternatives

- **Workshop Electronic Database**
  - See Jill Bennett
- **Paper Alternative Forms**
  - Turn in at drop boxes in workshop
  - Email to jeremy.neuman@hdrinc.com by June 26.

*Note: Please indicate what type of issues are addressed with each alternative or idea.



I-10/I-17 "Spine" Corridor Master Plan
Alternatives Brainstorming Workshop (6/22/15 and 6/23/15)
Alternative Log Form
(Due by 6/26/15)

Alternative ID:	A1-501	Submitter Name/Email (in case clarification is needed):	

Issues Addressed (check all that apply):

☐ Environmental	☐ Arterial Infrastructure	☐ Safety
☐ Operations	☐ Transit	☐ Commerce
☐ Interstate Infrastructure	☐ Bike/Pedestrian	☐ Technology

Location:

Description/Sketch (attach figures if desired with Alternative ID clearly labeled):

Figure/Map: Yes / No	Other Segments Affected:

NOTE: Submit all alternatives to Jeremy Neuman (jeremy.neuman@hdrinc.com) by no later than 6/26/15.

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System-wide Alternative Examples

8:15 to 8:45

- HOT Lanes
- 2nd HOV Lane
- Convert HOV to 3+ Occupancy
- +1 General Purpose Lane
- +2 General Purpose Lane
- Freeway Bus Lanes
- Arterial Bus Lanes
- Freeway Truck Lanes
- More Frequent Bus Service

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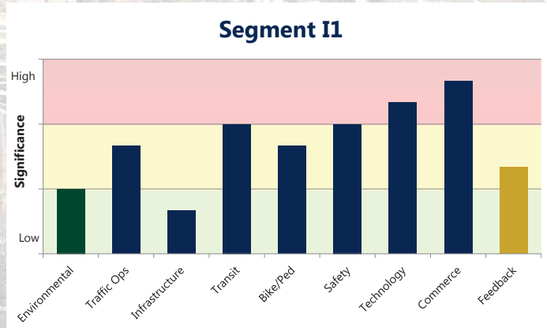
Segment I1 (I-10, SR-202L to Baseline)

8:45 to 9:45

- Adjacent Town of Guadalupe.
- LOS E at 2040, even after NTI.
- Minimal bike and pedestrian crossings.
- High to moderate crash rating.
- High nighttime, DUI, and truck crashes.
- Minimal ITS elements.
- Employment and manufacturing east of I-10 and south of Guadalupe.
- Public seeks TI improvements and improving weave areas.



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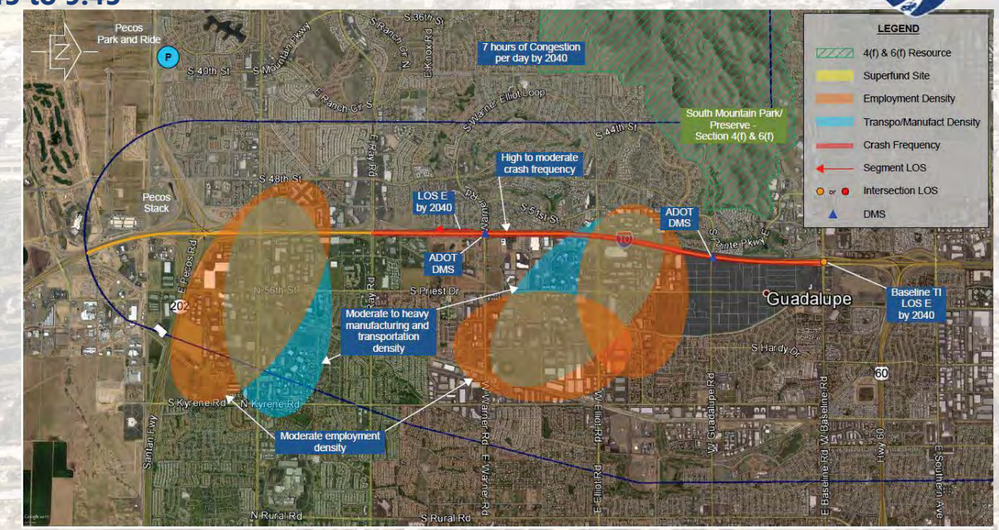
Segment I1 (I-10, SR-202L to Baseline)

8:45 to 9:45



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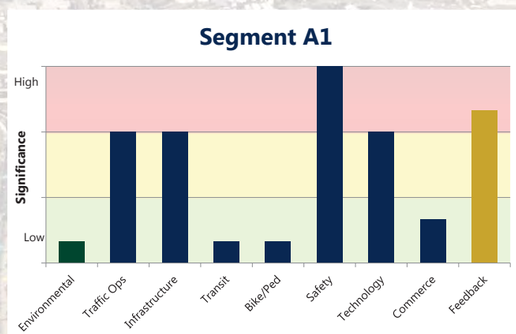
Segment A1 (48th, 56th/Priest, Kyrene)

10:00 to 10:45

- Residential along 48th, Guadalupe along Priest, South Mountain Park 4(f).
- LOS F at 2040 for 48th and Priest.
- Capacity restrictions along 48th and Priest.
- Discontinuous bike lanes.
- High fatal crashes on 48th, Baseline to Elliot.
- Three city agencies using ITS, limited real time information, communication gaps.
- Employment and manufacturing east of I-10 and south of Guadalupe.



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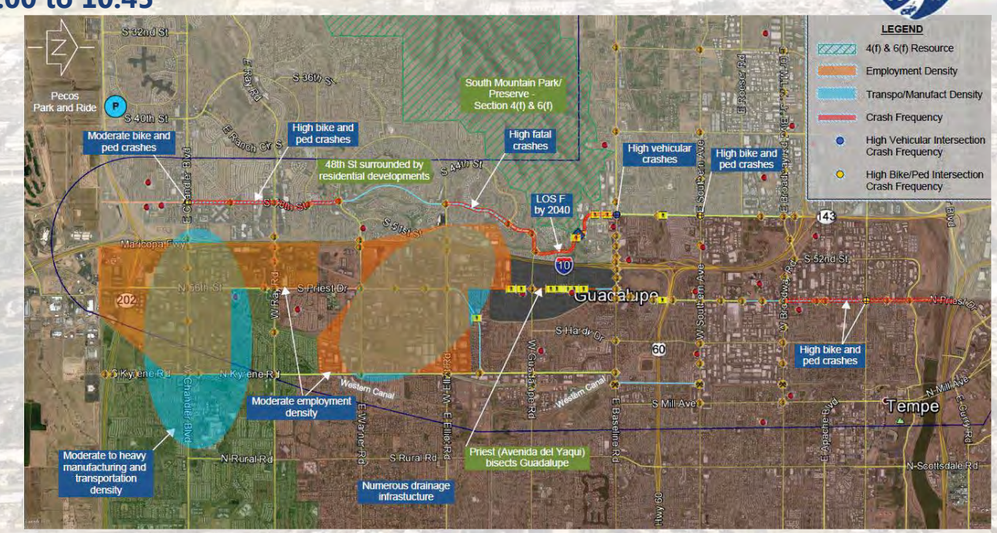
Segment A1 (48th, 56th/Priest, Kyrene)

10:00 to 10:45



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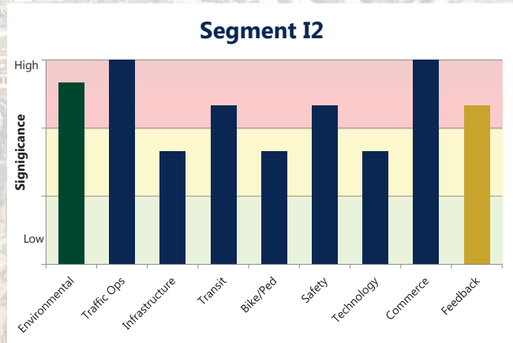
Segment I2 (I-10, Baseline to I-17 Split)

10:45 to 1:30

- Cemeteries, Tempe Drain, Salt River, and PSHIA runway issues.
- LOS E at 2040, and failing TIs.
- Aging PCCP north of the river.
- Highest transit use in corridor. HOV lanes breakdown.
- Fatal, incapacitating, and truck crashes.
- Basic ITS elements currently employed.
- Employment and manufacturing with high truck percentages.
- Public seeks TI improvements and improving weave areas.



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Segment I2 (I-10, Baseline to I-17 Split)

10:45 to 1:30

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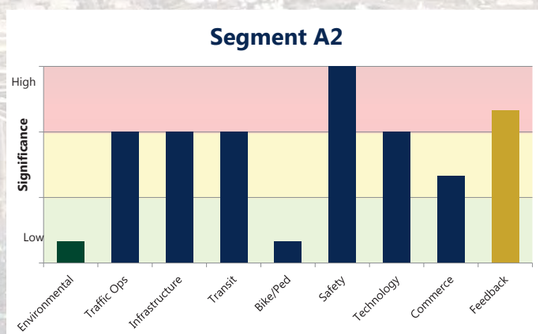
Segment A2 (Broadway, Southern & Baseline)

1:30 to 3:45

- Priority 1 LUST sites, Superfund site, Salt River, potential EJ, prehistoric/historic sites.
- Some 2040 failing segments.
- Arizona Mills Mall, some schools.
- Planned South Central Light Rail.
- Bike lanes discontinuous or non-existent.
- High crashes east of 32nd Street and at some specific intersections.
- Two city agencies using ITS, limited real time information, communication gaps.
- Heavy employment and manufacturing along Broadway Road.



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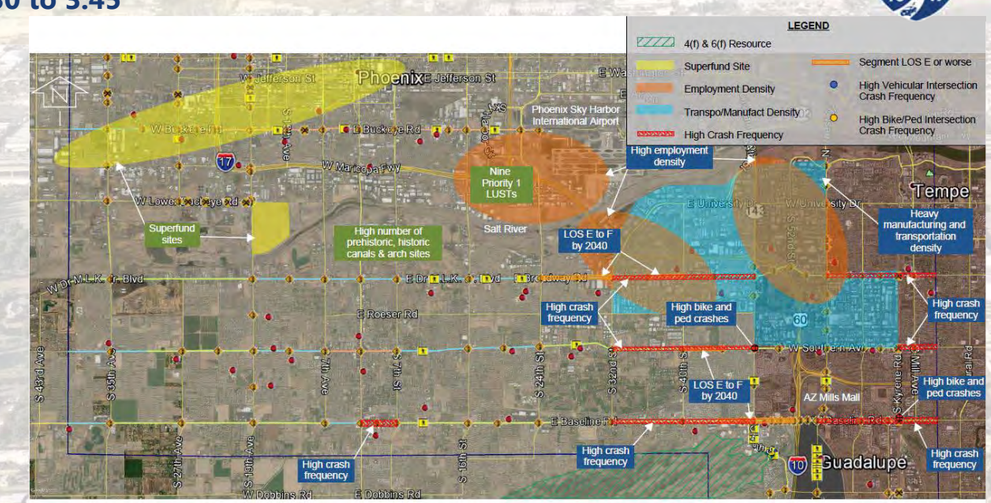
Segment A2 (Broadway, Southern & Baseline)

1:30 to 3:45



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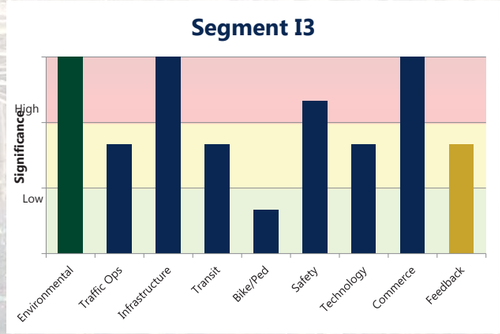
Segment I3 (I-17, I-10 Split to Stack)

4:00 pm to 9:00 am

- 4(f) park, Greenwood Cemetery, Superfund sites, 100-year floodplain, historic neighborhood.
- LOS F at 2040 in certain areas.
- Aging PCCP, bridges, non-standard TIs, narrow ROW, drainage tunnels.
- Minimal transit use. No HOV lanes. Two future light rail crossings.
- Nighttime and truck crashes.
- Basic ITS elements currently employed.
- High employment and manufacturing with highest freeway truck percentages.
- Public seeks TI improvements and improving weave areas.



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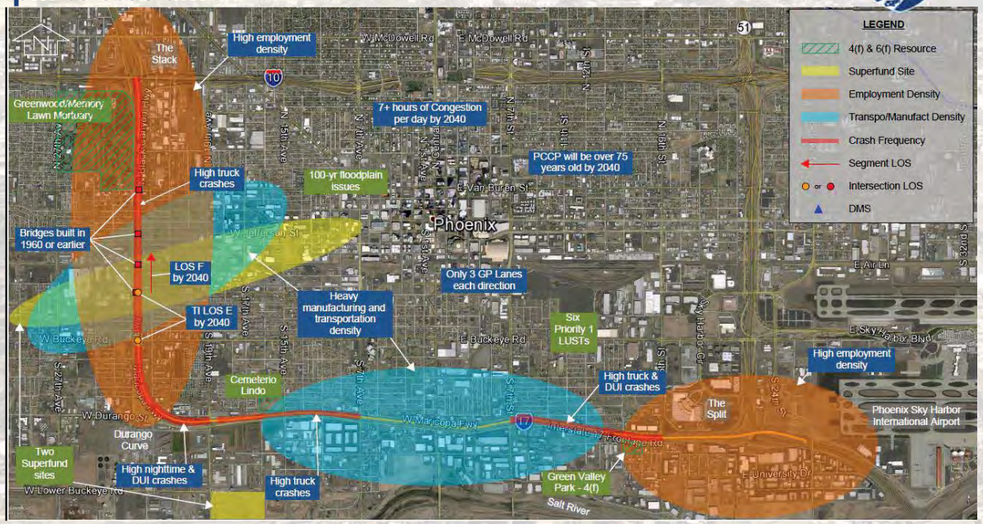
Segment I3 (I-17, I-10 Split to Stack)

4:00 pm to 9:00 am



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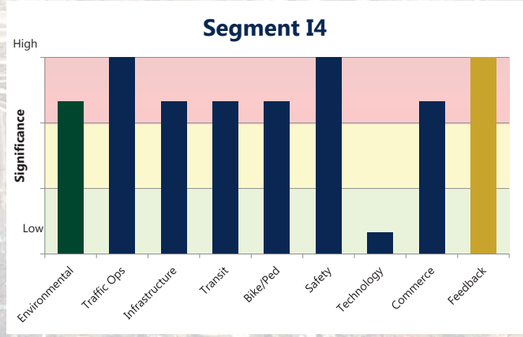
Segment I4 (I-17, Stack to ACDC)

9:00 to 10:30

- Priority 1 LUST sites, potential EJ issues.
- LOS E-F at 2040 and most TIs fail.
- Aging PCCP, bridges, narrow ROW.
- Discontinuity of HOV lanes at south end.
- Limited pedestrian crossings.
- High crash profile with DUI, nighttime, truck and fatal and incapacitating issues.
- High employment and manufacturing near Stack and along Grand Avenue.
- Public seeks TI improvements, improving weave areas, and wider lanes/shoulders.



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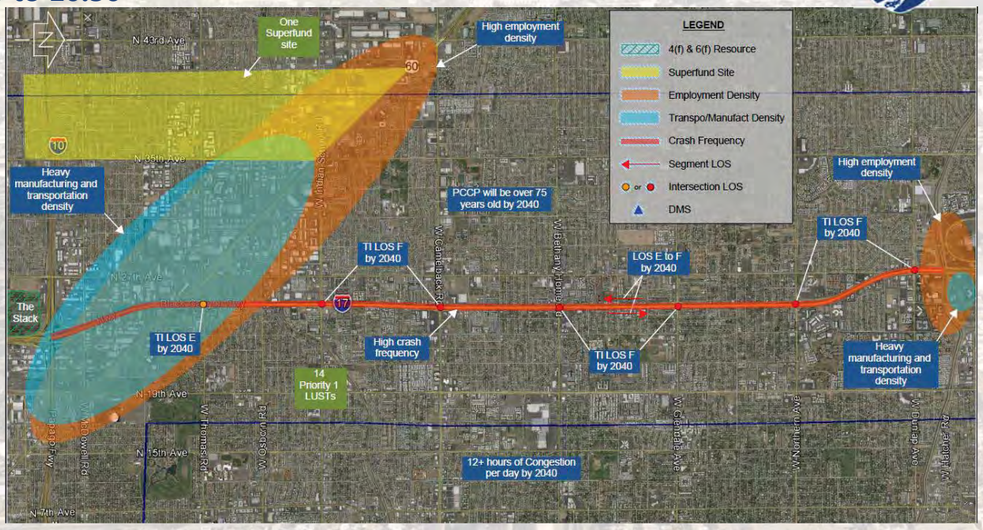
Segment I4 (I-17, Stack to ACDC)

9:00 to 10:30



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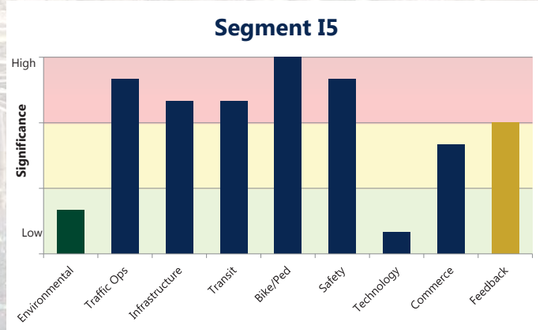
Segment I5 (I-17, ACDC to North Stack)

10:45 to 2:00

- Potential EJ issues, Cave Creek Wash, 3 Canal crossings.
- LOS E-F at 2040 and most TIs fail.
- Aging PCCP, bridges, pump stations. Occasional flooding on some crossroads.
- High transit occupancy loading, park and rides. Future light rail crossing at MetroCenter.
- No pedestrian or bike crossings.
- Moderate crash profile with DUI, nighttime, truck and fatal and incapacitating issues.
- MetroCenter and Deer Valley employment / manufacturing centers.
- Public seeks TI improvements, improving weave areas, and wider lanes/shoulders.



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Segment I5 (I-17, ACDC to North Stack)

10:45 to 2:00

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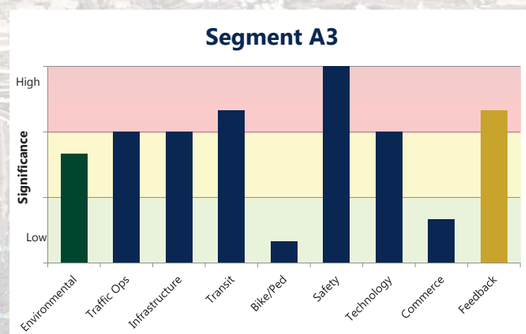
Segment A3 (35th, 27th and 19th Ave.)

2:00 to 3:30

- Priority 1 LUST sites, Superfund site, Salt River, potential EJ, historic districts, and Section 4(f).
- Numerous LOS E-F segments in 2040.
- Light Rail corridor in 19th Avenue, numerous schools, at grade RR crossings.
- Planned Light Rail extension.
- No bike facilities on 27th. High bike crashes along 35th and 19th.
- High crashes on various arterial segments.
- All Phoenix ITS, but with gaps and limitations as noted.
- Heavy employment along 19th Ave south of Stack. Job centers at Metrocenter, colleges, and Deer Valley.



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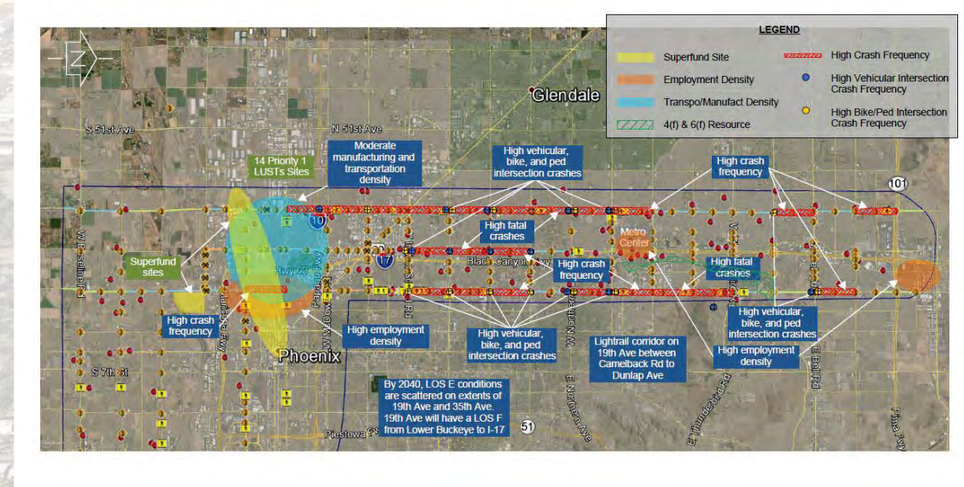
Segment A3 (35th, 27th and 19th Ave.)

2:00 to 3:30



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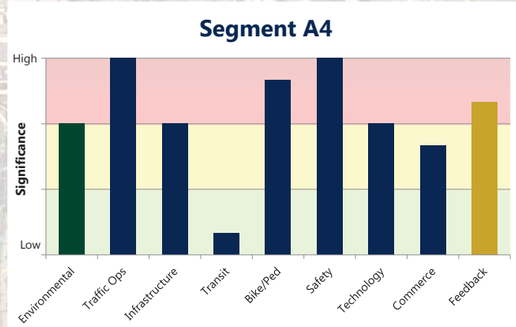
Segment A4 (I-17, East-West Arterials)

3:45 to 5:00

- Priority 1 LUST sites, Superfund site, potential EJ, historic districts, and Section 4(f).
- Numerous LOS E-F segments and TIs in 2040.
- Diagonal Grand Avenue, numerous schools, frequent signals/intersections.
- Planned east-west Light Rail extension, at-grade RR crossings.
- Bike facilities that exist have high crashes, many roads have no bike facilities.
- High crashes at nearly all major intersections.
- All Phoenix ITS, but with gaps and limitations as noted.
- Heavy employment and manufacturing along Grand Avenue.



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Segment A4 (I-17, East-West Arterials)

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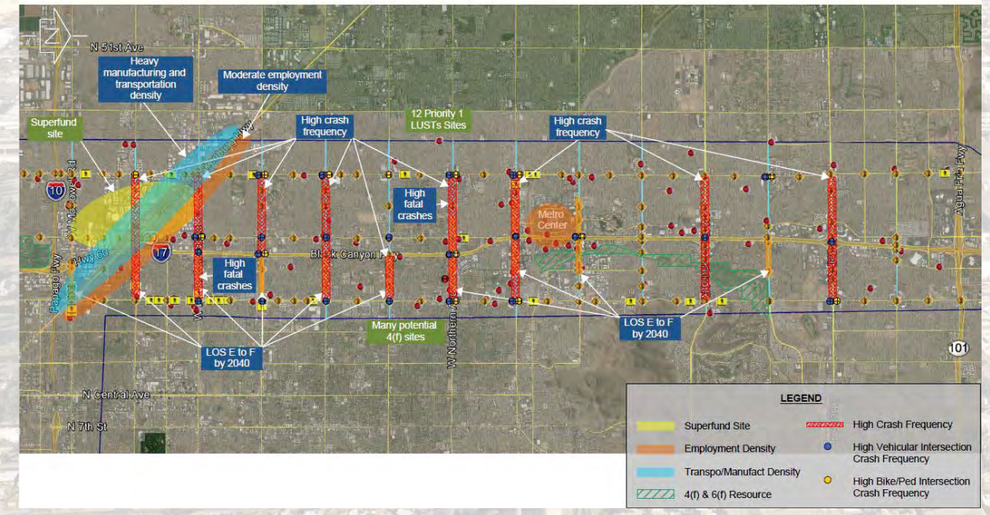

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THANK YOU.

Interstate 10/ Interstate 17 Corridor Master Plan

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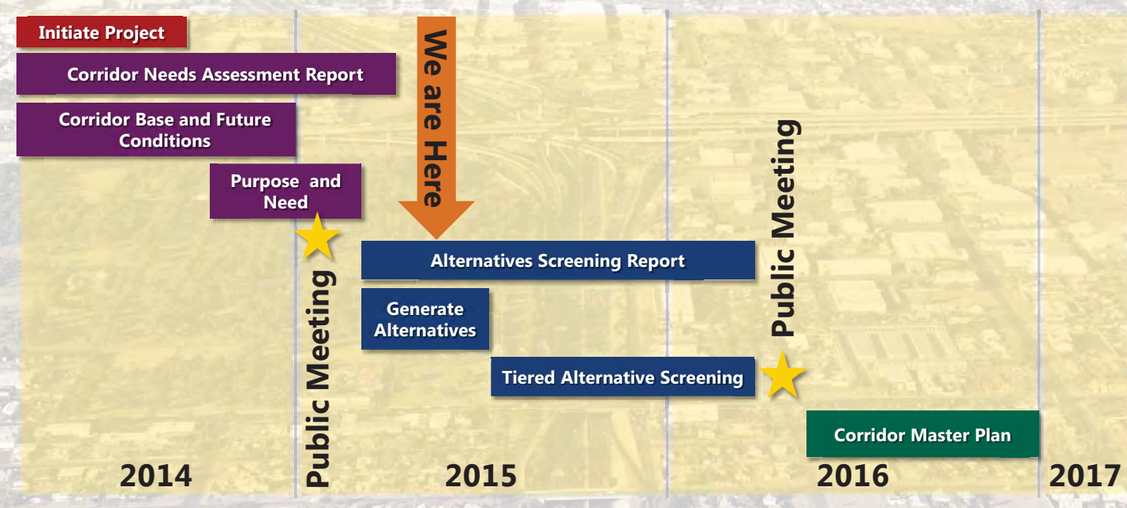
Spine Study Schedule



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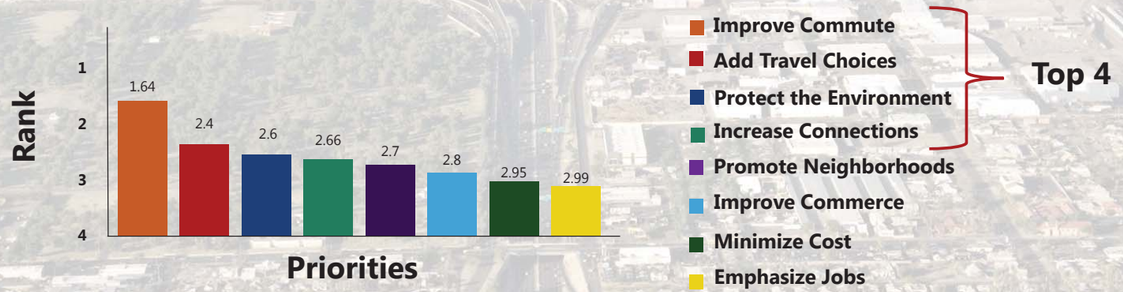
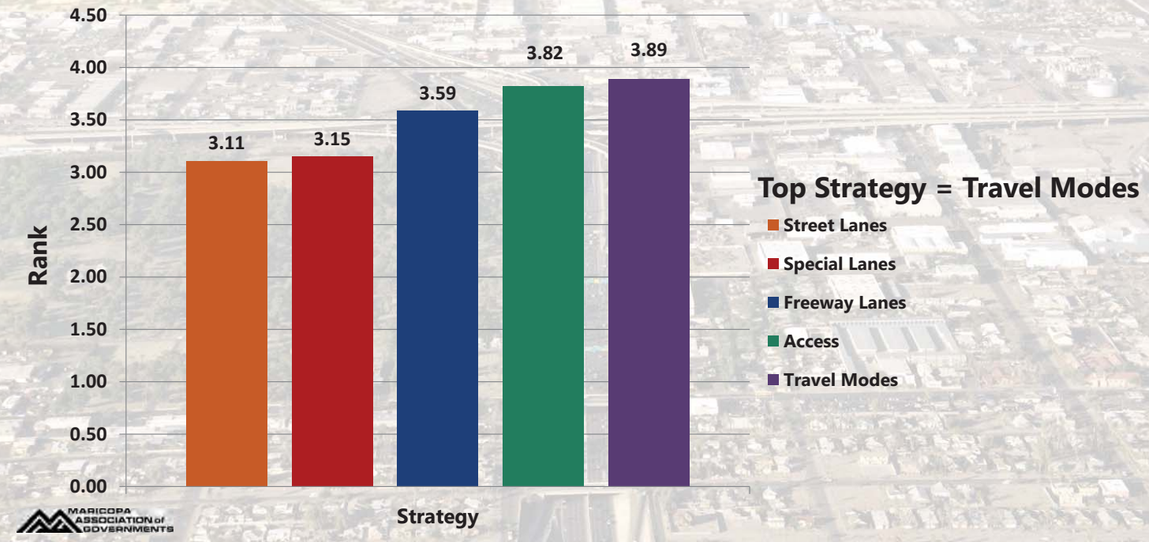
Communications Update
Priority Rankings

- Top 4 Priorities: Improve Commute, Add Travel Choices, Protect the Environment, Increase Connections

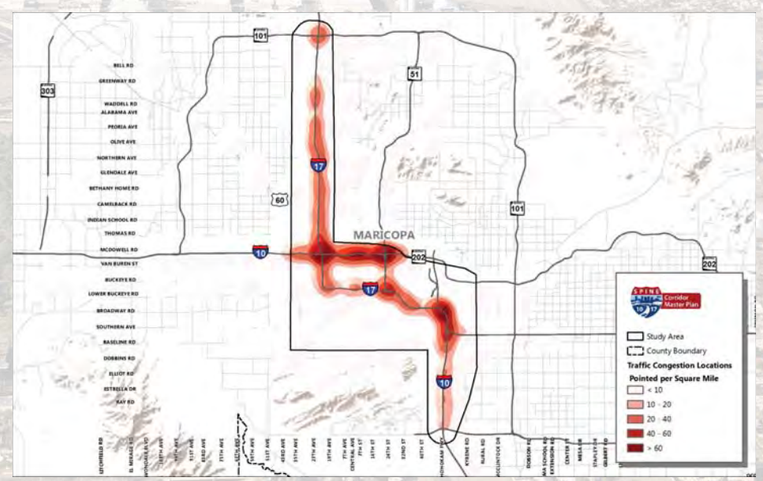


Communications Update
Strategy Rankings



Communications Update
"Traffic Congestion" Issues and Opportunities

- **Hot Spots:**
  - North Stack Interchange
  - Stack Interchange
  - Deck Park Tunnel
  - Mini-Stack Interchange
  - Split Interchange
  - Broadway Curve



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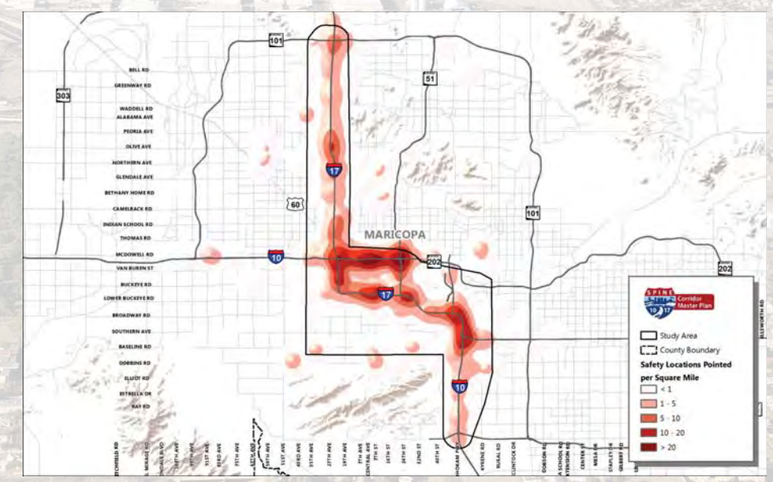
Communications Update
"Safety" Issues and Opportunities

- **Hot Spots:**
  - North Stack Interchange
  - I-17 and Olive
  - Deck Park Tunnel
  - Stack Interchange
  - Durango Curve
  - Mini-Stack Interchange
  - Split Interchange
  - Broadway Curve



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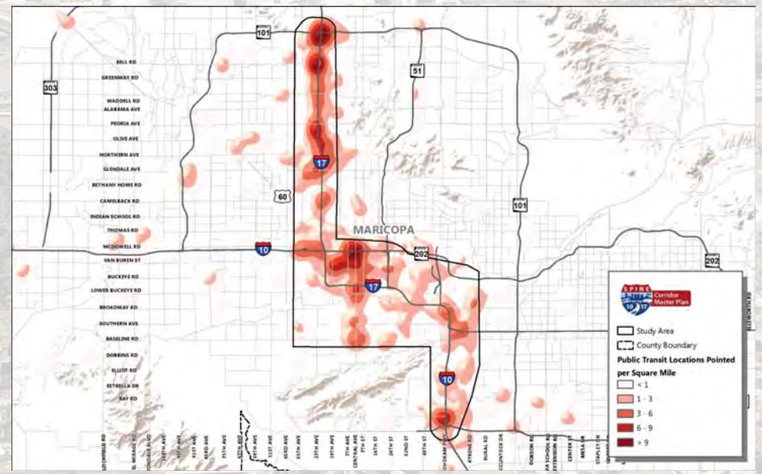
Communications Update
"Public Transit" Issues and Opportunities

- **Hot Spots:**
  - North Stack Interchange
  - I-17 and Bell Road
  - Deck Park Tunnel
  - Downtown Phoenix
  - I-17 and Central Avenue
  - I-10 and Chandler Boulevard



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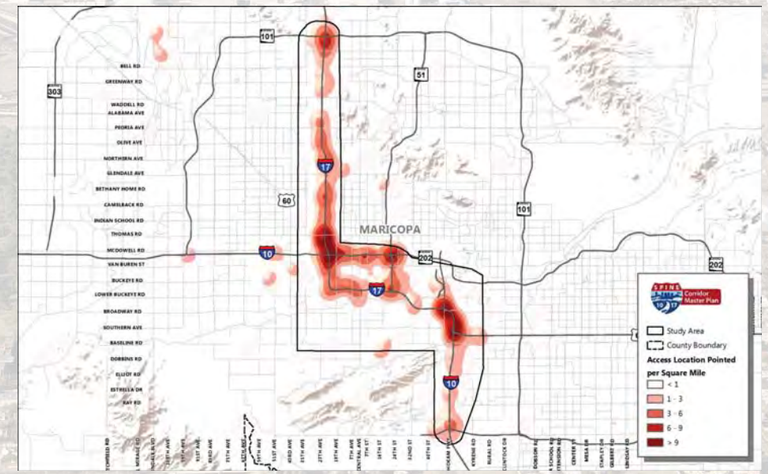
Communications Update
"Access" Issues and Opportunities

- **Hot Spots:**
  - I-17/Loop 101 System Interchange
  - I-17 from Peoria to Glendale
  - Stack and Split Interchange
  - Mini-Stack Interchange
  - Broadway Curve



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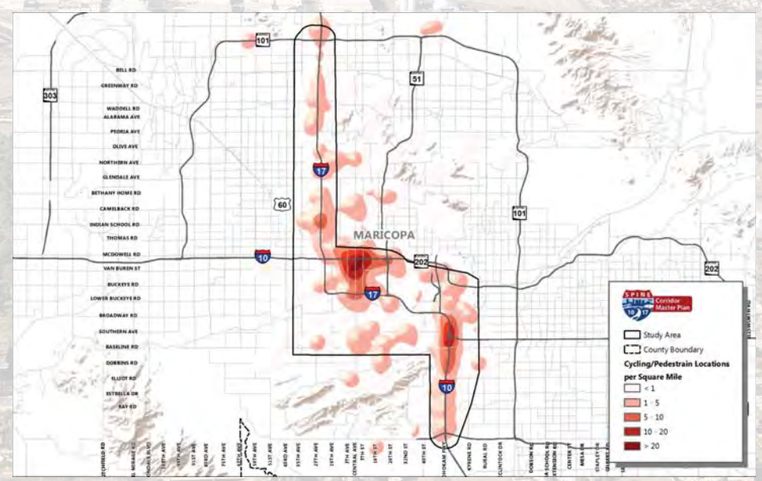
Communications Update
"Cycling/Pedestrian" Issues and Opportunities

- **Hot Spots:**
  - I-17 and Indian School
  - Downtown Phoenix
  - Broadway Curve south to Guadalupe



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Appendix B. Limited Access Dual HOV White Paper

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ISSUES AND FACTORS INFLUENCING THE CHOICE BETWEEN CONTINUOUS- AND LIMITED-ACCESS MANAGED LANE FACILITIES

June 28, 2017

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EXECUTIVE SUMMARY

Recommendations incorporated in the Spine Corridor Master Plan include provision of additional "managed lanes" in three segments of the corridor. The term "managed lane" can refer to any lane that has restrictions or constraints on use; most commonly in the form of high-occupancy vehicle (HOV) and high-occupancy toll (HOT) lanes. HOV lanes restrict use of the lanes to vehicles with a minimum number of occupants, currently two or more in the MAG region. HOT lanes allow single-occupancy vehicles (SOVs) to operate in the HOV lanes or a dedicated, separate facility for a price. When pricing is used in this manner to "manage" entry into the HOV lanes, the SOV operator gains the advantages of an HOV lane by paying a price that usually is adjusted in accordance with the time of day and volume of traffic using the facility.

Introduction of multiple managed lanes in the corridor may require modifications to the current configuration of the existing HOV lanes, which currently provide contiguous, continuous-access, concurrent-flow operation with the general-purpose (GP) freeway lanes. Limitations on access would continue to be asserted through restrictions on HOV lane eligibility – carpools, vanpools, motorcycles, buses, electric/hybrid vehicles – and the charging of a fee or toll to use the HOT lane, if HOT lanes are introduced in the corridor. However, with multiple managed lanes being introduced in the corridor, the future design of such facilities should consider the potential need to include a barrier to separate the managed lanes from the GP freeway lanes. In this case, the current operational characteristic of the HOV lanes – continuous ingress/egress – would be eliminated. Access to the managed lanes facility would be limited to specific locations. This operational scenario essentially creates express lanes for longer commute trips, as points of access (ingress and egress) generally are limited, allowing higher speed of travel and fewer potential conflicts.

Several issues have come to light regarding this potential barrier-separated, limited-access managed lane condition. These issues have been summarized in the following paragraphs.

ENFORCEMENT

Enforcement of managed lanes facilities is a challenging problem, and enforcement is more challenging with respect to painted stripe- and buffer-separated facilities. Active enforcement can be disruptive of the traffic stream in the GP freeway lanes, whereas enforcement within a managed lanes facility can be carried out, if necessary, more safely with provision of an inside, median shoulder sufficiently wide to accommodate stopped vehicles and associated pedestrian movements. The recommended strategies for the I-10/I-17 corridor do include provisions for such shoulders to facilitate enforcement of the managed lanes. In the case of HOT facilities,modern technology, i.e., electronic toll collection (ETC), that supports billing of HOT lane use through transponders and license plate scanning, is an effective and safe form of enforcement and most cost-effective, as the need to have an on-call enforcement official or patrolling official is significantly reduced. ETC is not associated with HOV use; therefore, active enforcement by police officials is required.

PUBLIC OPPOSITION TO MANAGED LANES

HOV facilities are an integral part of the transportation tool box to improve mobility and accessibility, especially in urban areas. According to the Federal Highway Administration (FHWA), HOV facilities "…serve to increase the total number of people moved through a congested corridor by offering two kinds of travel incentives: a substantial savings in travel time, along with a reliable and predictable travel time." The general consensus of the FHWA and many transportation specialists is that managed lanes free up capacity in the GP freeway lanes, and expectations are that this new capacity will allow greater mobility for the community/region overall. By shifting vehicles into the managed lanes congestion in the GP freeway lanes is reduced, which, in turn, results in higher overall average speed, reducing vehicle emissions through the corridor, increasing person throughput, and contributing to regional air quality goals. HOT lanes would allow motorists to opt for an alternative travel experience, per se, at a given price that generally varies throughout the day according to travel demand in the corridor where the facility is located.

Managed lanes generally are not viewed as degrading the overall mobility and safety performance of a freeway system. On the other hand, these facilities permit transportation officials to better manage roadway capacity to create the most efficient travel system possible throughout the day. There are those who present the case that expeditious travel in the managed lanes is critical to motivating use of the lanes. However, should congestion of the GP freeway lanes be relieved, there would be less incentive to use the lanes, let alone pay a fee in the case of HOT lanes. Therefore, ironically, the effectiveness of managed lanes is to a large degree dependent on continuing congestion in the GP freeway lanes. Latent demand has been shown to quickly absorb new freeway capacity. This means that, while person throughput has been increased by multiple persons in a greater number of vehicles in the managed lanes and speed in the managed lanes is higher, general corridor congestion is not necessarily relieved, as drivers using alternative routes, e.g., arterial streets, take advantage of the new capacity.

This dilemma of demand versus supply is precisely the impetus associated with developing and operating managed lanes. Operational adjustments must be made throughout the day to manage access to the managed lanes in such a manner (i.e., by time of day, price, or overall conditions in the corridor) as to optimize vehicle and person throughput while minimizing congestion in the GP freeway lanes. In the case of HOT lanes, the FHWA provides the following guidance respecting the operating strategy associated with managed lanes:

> *The toll should be varied in accordance with travel conditions and should be set at a high enough level that the performance of the HOV lane is not degraded. This optimizes the vehicle throughput of the HOT lane and reduces congestion in the general-purpose lanes by drawing off some of the SOV traffic that would otherwise be forced to use those lanes. So HOVs are no worse off, and vehicles that do not meet the vehicle occupancy requirement, whether they use the HOT lane or the general-purpose lanes, are better off.*[1]

Currently, managed lanes in Arizona are confined to HOV use only, and the option for HOT use of managed lanes facilities has not been introduced, in part due to the uncertainty regarding public opposition to the concept of tolling in general.

SAFETY PERFORMANCE

Specific, quantifiable information regarding the safety experience at access points has not been a focus of the many studies conducted to date. Available studies generally support the notion that limited-access, barrier-separated managed lanes facilities are safer than continuous, concurrent-flow facilities. The safety performance of such facilities primarily is associated with the design of access points and lane configurations. Available studies point to wider facility envelopes, including adequate inside shoulder widths, as a means to reduce crashes and the severity of crashes. Other factors for consideration to mitigate potential hazardous conditions are:

- Direct entry and exit to at-grade slip ramps or Direct HOV (DHOV) ramps from grade-separated arterial roadway via the inside GP freeway lanes, which minimizes immediate weaving and merging;
- Locating ingress and egress points away from freeway on- and off-ramps, which allows time to weave and merge;

1 Chapter V, Strategies to Reduce Congestion and Improve Air Quality in Federal-Aid Highway Program Guidance on High-Occupancy Vehicle (HOV) Lanes, September 2016, at https://ops.fhwa.dot.gov/freewaymgmt/hovguidance/chapter5.htm.

- Provision of adequate instructional/directional signage that informs motorists of advancing conditions; and
- Sufficient lighting to assure changing facility characteristics are easily seen.

FHWA Freeway Management guidance states "the safest HOV lanes are those that are physically separated from the adjacent lanes with a concrete barrier," and separation also creates greater safety for traffic in the GP freeway lanes. The recommendation to have managed lanes begin and terminate at DHOV on/off ramps would minimize the potential hazardous conditions associated with higher speed managed lane traffic merging with slower speed traffic in the GP freeway lanes. Overall, although safety is a real and valid concern, it cannot be the prime determinant for selecting a given highway treatment. The FHWA summarizes this issue in the following manner:

> *Managed lanes can provide safety and operational performance benefits over general-purpose facilities, but the managed lane strategy must be appropriate for the intended user group. Specific benefits in crash reduction seen at one facility do not necessarily translate to another facility, so the selected strategy must account for the conditions unique to a particular facility.*

To that end, the Minnesota Department of Transportation (MnDOT) completed a 2014 study titled "Evaluation of the Effect of MnPASS Lane Design on Mobility and Safety", which investigated and contrasted the closed access conditions on I-384 and the open access conditions on I-35W. The study resulted in the conclusion that both strategies can be effective, depending on the characteristics of the facility. According to a technical summary document of the study "*The research suggests that for most roads, an effective approach is to start with open access but periodically evaluate and limit access in specific areas as appropriate based on traffic density in the HOT lane and the speed differential between HOT and general traffic lanes.*" The study also provided design tools for use in future managed lane construction.

Effect on the Use of HOV lanes

The usual and customary use of the HOV lanes by carpools/vanpools, buses, motorcycles, and electric/hybrid vehicles, as permitted by HOV policies, would not be hampered. HOV lane-eligible users would be allowed access throughout the day. Facility level of service (LOS) would be determined in accordance with real-time observations of traffic and policies established for the facility. Generally, congestion within the freeway corridor during peak travel periods means there would be increased use of the managed lanes facility; therefore, if HOT lanes were introduced, peak periods would have the highest tolls as a discouragement for SOV operators, if congestion forms within the managed lanes facility.

Access to Established Traffic Interchanges Within the Spine Corridor

The inherent operational philosophy associated with development and implementation of managed lanes is to expedite commuter travel over longer distances. Because a good portion of urban freeway usage has become associated with localized movements of a few miles (even one mile or less), separating commuters brings relief to the GP freeway lanes of the burden of what essentially can be considered to be through-traffic movements. Although FHWA notes that access spacing of two to three miles is common for limited-access facilities, ADOT does recognize that barriers limiting entrance and, particularly, exit from a managed lanes facility can be a discouraging aspect for commuters, when exits are not convenient to their desired destination.

Design and location of access points (ingress and egress) not only affects user convenience but, also, safety and operational performance of the facility. Enforcement capabilities also can be affected, as well as facility design, which must support adequate transition zone length and safe positioning of ingress and egress points relative to on/off ramps of the freeway. In the case of the I-10/I-17 Corridor, freeway/arterial interchanges generally are spaced at one-mile intervals. This physical design of the freeway may require (1) DHOV connecting ramps at interchanges or (2) unique designs of at-grade slip ramps for ingress to and egress from the managed lanes in the center of the freeway. Option 1 would only be feasible at dedicated DHOV interchanges, allowing access to the center of the freeway, as is the case at Maryland Avenue on SR 101L in Glendale. Option 2 would require entrance to at-grade ingress slip ramps to be sufficiently far from a freeway on-ramp to assure adequate time for motorists to weave safely to the center lane for access to the slip ramp. The same would be true for motorists exiting the median managed lanes; sufficient distance must be provided to safely merge to the right to access a freeway off-ramp. Thus, the location of intermediate access points will need to be judiciously examined to establish a reliable and safe operational environment for interaction between the GP freeway lanes and the managed lanes.

Summary

In general, limited access managed lanes facilities offer a means to increase the capacity of a highway corridor and expedite through movements in heavily congested corridors. Limiting access, and the friction associated with weaving in and out of the managed lanes, improves the overall travel reliability of the managed lanes. Physical separation of the facilities from the GP freeway lanes creates a critical margin of safety that is especially important due to the speed differential that develops between the facilities and the GP freeway lanes. Therefore, limited access serves a dual function of making travel more efficient and safer. Although the access points tend to be focal points for crashes, due to weaving and merging; by contrast, access along a continuous, contiguous HOV lane represents an essentially infinite string of potential points of conflict as motorists weave into and out of the lane in the same way motorists change lanes in the GP freeway lanes. Nevertheless, there is an argument that this is more consistent with the freeway experience and, therefore, offers some safety due to familiarity of the driving experience. All that being said, there is general agreement that barrier-separated facilities are safer, as the number of potential conflicts characteristic of GP freeway lanes is reduced and direct speed differentials between the managed lanes and GP freeway lanes are minimized.

Limited-access does create limitations on the accessibility to locations within the corridor of travel, and the confining character of the facilities may be unsettling to some users. However, the intent of managed lanes facilities is not to support access within the corridor nor can the anxieties of individual vehicle operators be totally alleviated. More generally, the intent is to support access to destinations requiring longer distance trips in the most expeditious and reliable manner possible and provide a tool for managing traffic flow through the corridor. Therefore, limited access more correctly is seen as a method which allows longer commuter trips by employing a treatment that supports express travel.

Whereas manual enforcement of manged lanes can be an effective means of controlling access, 100% enforcement is virtually impossible. Enforcement is especially critical relative to non-barrier-separated managed lanes, which present to motorists multiple, even infinite, ingress and egress opportunities. In contrast, with regard to HOT lanes, new technologies allowing billing through license plate scanning and transponder contact have created the ability to establish more cost-effective enforcement. The remote sensing aspect of the modern technology is complementary to and supportive of free access by HOV-eligible vehicles, as Dynamic Message Signs (DMSs) and dynamic pricing provide effective tools for transportation officials to control entry and use of the HOT lanes. It should be noted that the need remains for physical enforcement practices (i.e., highway patrol) of the occupancy requirements of the HOV lane in a combined HOV/HOT facility.

Finally, it is clear the decision-making framework relating to adopting a limited-access managed lanes scenario involves numerous complex factors ranging from lane and shoulder widths to facility geometry to access to safety to convenience to cost. The objective of the evaluation must reconcile the goals and objectives of facility development with the multitude of design and operational parameters.

1.0 INTRODUCTION

The I-10/I-17 Corridor Master Plan project includes the proposal to add existing High-Occupancy Vehicle (HOV) lanes along both I-17 and I-10 segments of the Spine Corridor to create limited-access "managed lane" facilities. Managed lanes are defined by the Federal Highway Administration (FHWA) "…as freeway lanes that are set aside and operated using a variety of fixed and/or real-time strategies responding to local goals and objectives that move traffic more efficiently in those lanes."[2] During public outreach efforts several questions were raised regarding the operation, safety, and enforcement of the limited-access managed lane facility. Questions and concerns of respondents regarding this proposed action were determined to require additional information to allow the study team and citizens to make a fully informed decision. This White Paper has been prepared to provide that information.

1.1 BACKGROUND

The objective of this White Paper is to address comments and concerns raised during public outreach efforts associated with the Spine Corridor Study. Specifically, citizens attending outreach meetings were requested to respond to the following question:

> *"Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?"*

In response to the possibility of limiting entrance and exit to HOV facilities, 45% of the respondents either agreed or strongly agreed with the proposed operational concept, 18% were unsure, and 37% either disagreed or strongly disagreed. When asked for their opinion regarding expansion and modification of existing HOV facilities to create managed lanes, 58% agreed or strongly agreed, 16% were unsure, and only 26% disagreed or strongly disagreed. The responses indicate the majority of respondents were favorable to the proposed modification of the existing HOV lanes. However, less than a majority of respondents favored an action that would limit access points to the managed lanes.

Limiting access to the dual managed lanes constitutes a critical operational decision. The questions and concerns raised during the public outreach effort by those disagreeing with the concept of managed lanes and limitations on access specifically relate to enforcement, the presence of HOV lanes in general, and safety. Other issues or concerns that were voiced relate to the ability to enter and exit the limited-access facility, the need to provide greater space for the facility within the Spine Corridor, and the safety performance of the particular type of facility proposed. This White Paper has been designed to address each of the specific comments/concerns voiced as a means of providing a framework for Spine Management Partners to make an informed decision regarding the proposal to develop a two-lane limited-access HOV facility, which, ultimately, could be used to create a combined HOV lane and High-Occupancy Toll (HOT) lane.

1.2 EXISTING HOV SYSTEM

The southbound and northbound HOV lanes of I-17 occupy the median of the highway and originate at Carefree Highway. The 11-foot HOV lanes are separated, or distinguished, from the general purpose (GP) freeway lanes by a wide, solid white stripe. A 9-foot inside shoulder, which can provide refuge for a stalled or disabled vehicle, has been established between the HOV lanes and the concrete median barrier between southbound I-17 and northbound I-17. This design is maintained through the "North Stack" Interchange – I-17/Loop 101 (Pima/Aqua Fria Freeway) – to a point approximately 630 feet north of the Arizona Canal.

Right-of-way constraints at the Arizona Canal have required that the inside shoulder be narrowed (four to five feet). This new design generally is maintained south of the Arizona Canal with minor variations in the width of the inside shoulder, due principally to expanded concrete median widths forming foundations for lighting and signs and bridge structures. The southbound HOV lane ends approximately 235 feet south of Glenrosa Avenue, becoming the inside (or innermost) GP traffic lane of the four-lane freeway. The northbound HOV lane begins approximately 490 feet south of McDowell Road by means of a left merge from the inside lane of a two-lane highway section passing through the "The Stack" Interchange – I-17/I-10 West (Papago Freeway). It extends from this point to the North Stack Interchange, continuing north to Carefree Highway.

Two HOV lanes, one northbound and one southbound, are present along the entire length of I-10 within the Spine Corridor. From the "The Split" Interchange – I-17/I-10 East (Maricopa Freeway) – the southbound HOV lanes are separated from the GP lanes by a buffer delineated as two wide stripes four feet apart with a single chevron located every 30 feet. The southbound HOV lane is 12 feet wide, and the inside shoulder is 13 feet wide. The northbound HOV lane also is 11 feet wide, and the inside shoulder is 11 feet wide. The northbound HOV lane is separated by a single, wide white stripe. This design of the two HOV lanes is maintained to a point approximately 1,300 feet west of 40th Street.

East of 40th Street, the two HOV lanes generally form a symmetrical HOV facility consisting of two 4-foot buffers separating the HOV lanes from the GP freeway lanes, two 12-foot HOV operating lanes, and two 13-foot inside shoulders. This design is maintained to Alameda Drive, where there is a transition to two HOV lanes on each side of the central median barrier; one in each direction supports east- and westbound movements between I-10 and US-60/Superstition Freeway, and one in each direction supports south- and northbound travel on I-10 south of the I-10/US-60 Interchange. The symmetrical two-lane, continuous, contiguous, concurrent HOV lane facility south of the I-10/US-60 Interchange continues to Chandler Boulevard, where a second set of two HOV lanes in each direction has been established to facilitate east- and westbound travel along Loop 202, while maintaining HOV travel on I-10. The southbound I-10 HOV lane ends prior to entering the "Pecos Stack" Interchange – I-10/Loop 202 (Santan/South Mountain Freeway), and the northbound HOV lane begins in the midst of the Pecos Stack Interchange.

1.3 EXISTING HOV LANE OPERATIONS

Within the Spine Corridor, HOV facilities consist of one lane in each direction through most of its length. The HOV lanes operate as continuous, contiguous, concurrent-flow facilities that permit largely limitless entry (ingress) and exit (egress) throughout the length of the HOV lane. At any point along the length of the HOV lanes, motorists can merge directly into or out of the HOV lane from or to the inside left GP freeway lane to transition between the stream of mixed traffic in the GP lanes and the HOV lane. The essentially infinite entry/exit opportunities result in a significant degree of weaving between the HOV and GP freeway lanes, as motorists seek to access the HOV lane for travel from any given entry point (on-ramp) of the freeway to any given exit point (off-ramp). At some points, the entry or exit locations of the HOV lanes have been developed as extensions of the GP freeway lanes, allowing motorists to drive straight into or out of the lanes without an immediate transition or merge associated with the GP traffic stream, effectively creating at-grade "slip" ramps.

1.4 PROPOSED ACTION

Recommendations formulated in the Spine Corridor Master Plan include the addition of a second lane to existing HOV facilities north from The Stack Interchange to Loop 101 and south from The Split Interchange to Loop 202. This second lane is expected to increase the capacity of the corridor by increasing person throughput. In conjunction with this recommendation, limiting ingress and egress to new two-lane "managed lane" facilities to certain locations is being considered. As noted above, the term "managed lane" can refer to any lane that has restrictions or constraints on use; most commonly in the form of high-occupancy vehicle (HOV) and high-occupancy toll (HOT) lanes. HOT lanes allow single-occupancy vehicles (SOVs) and other vehicles with less than the minimum number of persons required for the

[2] Section 8.0, Managed Lanes, Managed Lane Chapter for Freeway Management and Operations Handbook, FHWA, Updated Chapter, January 2011, pg 2.

HOV lane (an LOV) to operate in a dedicated, separate facility for a price. When pricing is used in this manner to "manage" entry into the HOV lanes, the SOV and LOV operators gain the advantages of an HOV lane by paying a price that usually is adjusted in accordance with the time of day and volume of traffic using the facility. This operational scenario essentially creates express lanes for longer commute trips, as points of access (ingress and egress) generally are limited, allowing higher speed of travel and fewer potential conflict with traffic flows. Modern tolling of highway use is controlled or managed by selling use privileges via transponders mounted in the vehicles or through license plate scanning technologies that allow motorists opting to use the limited-access facility to be billed by the facility operator. Therefore, should the designated managed lanes be operated as HOT lanes, free or continuous ingress and egress cannot be permitted as is the case with the existing HOV facilities in the Spine Corridor.

At the present time, only HOV lanes are proposed as part of the recommendations for Spine Corridor improvements; however, implementation of a combination facility including HOV and HOT lanes potentially exists. Creation of a HOT lane requires only the addition of technology to charge for access and the adoption of policies for operation of the lanes. For purposes of this discussion, the term "managed lanes" reflects limited-access HOV lanes, as recommended for implementation in three segments of the Spine Corridor:

Loop 101 to US-60/Grand Avenue – Southbound and northbound dual managed lanes in each direction between the proposed Direct HOV (DHOV) connector ramps at Loop 101 and a proposed DHOV connector ramps in the vicinity of US-60/Grand Avenue and Thomas Road.[3]

US-60/Grand Avenue to I-17/I-10 East Interchange (the "Split") – New southbound and northbound single managed lanes in both directions from the area of US-60/Grand Avenue and Thomas Road to the I-17/I-10 "Split" Interchange to link the managed lanes facility on I-17 with the managed lanes facility on I-10.

I-17/I-10 East Interchange ("Split") to US-60/Superstition Freeway – Southbound and northbound dual managed lanes in each direction between new connector ramps through the I-17/I-10 Split Interchange and the existing dual HOV connector ramps supporting east-west travel on the US-60/Superstition Freeway and north-south travel on I-10/Maricopa Freeway.

Implementation of managed lane facilities in the Spine Corridor has been recommended with the stipulation that the lanes may have "limited-access" as the operational configuration. Limited access means ingress/egress would be restricted to the DHOV connector ramps in much the same manner as entry of controlled-access freeways is limited through the strategic location of on- and off-ramps. Intermediate access points between the identified DHOV connector ramps have not been specified in the recommendations. Nevertheless, additional access could be incorporated provided sufficient weaving distance is available to support safe entrance to the managed lanes from a freeway on-ramp and save exit from the managed lanes to a freeway off-ramp. The new single HOV lanes recommended between US-60/Grand Avenue and the Split Interchange would operate as contiguous, continuous, concurrent-flow facilities in the same manner as the HOV lanes currently established on I-17 and I-10.

1.5 Methodology Adopted for Developing this White Paper

A quick review of the comments/concerns raised by persons concerned about the proposed action revealed a general focus on the safety of operations, enforcement, and dislike of the potential limited-access, dual managed lanes facility or HOV lanes in general. This led to an Internet search of articles, publications, and other guidance relating to safety performance of a limited-access managed lanes facilities and information relating to the operation of dual managed lanes. The Internet search resulted in identification of 75 items with direct or indirect reference to the noted issues above. Thirty-five of these items specifically focused on safety of operations, enforcement, and general desirability of such facilities have been summarized. These summaries are presented in **Attachment A**. The following two sections attempt to address the various aspects of safety of operations, enforcement, and general desirability associated with managed lanes with particular emphasis on a dual-lane, limited-access, managed lanes facility, as proposed for the Spine Corridor.

In addition, the Internet search revealed a review of Best Practices relating to the separation devised between HOT lanes and GP lanes prepared by the Texas Department of Transportation (TxDOT). This document includes a table comparing the attributes of a concrete barrier, a delineated buffer (i.e., pavement striping), and a buffer with flexible posts or pylons. This table represents a relative comprehensive evaluation of the advantages and disadvantages of these three separation treatments and has been included as **Attachment B** for reference. One additional matrix was recovered that also provides a comparison of separation types; this table is presented as **Attachment C**. In addition, a table developed by the Georgia Department of Transportation addresses emerging issues relating to the different types of barrier- and buffer-separated managed lanes; this table is presented as **Attachment D**.

2.0 Issues Associated with Limited-Access, Managed Lanes Facilities

During the public review and outreach effort conducted in support of development of the Spine Corridor Master Plan, several public comments and concerns were raised relating to limited-access, managed lanes facilities versus the current continuous-access operating conditions of HOV lanes contiguous with existing GP freeway lanes. This section attempts to address the specific comments and concerns raised by those persons relative to the proposed action to develop limited-access, dual managed lanes or the concept HOV lanes as a whole, including the operational characteristics associated with such lanes.

2.1 The Proposed Action cannot be enforced and likely not possible with current HOV enforcement strategy in the Valley – need enhanced enforcement to work (even though the limited-access points could make it easier to enforce)

Enforcement raises numerous issues when considering the type of managed lane facility to develop and implement. Whereas a paved median (i.e., inside shoulder) and enforcement area is the preferred option for new managed lane facilities, physical constraints can stifle efforts to create such areas within existing right-of-way and in place of existing HOV facilities. The literature generally concedes the lack of inside shoulders can have an adverse impact on safety and overall freeway operations. Therefore, enforcement and the degree to which there will be enforcement and the safe implementation of the adopted enforcement level are important considerations in the design and operation of HOV facilities.

The existing HOV lanes in the Spine Corridor have a striped buffer zone separating the HOV lanes from the GP freeway lanes. The buffer consists of a wide white stripe or pair of wide white stripes with periodic chevrons. The buffer is intend to maintain separation of vehicles in the HOV lanes from vehicles in the GP freeway lanes. In effect, the buffer defines an enforcement zone, i.e., motorists operating vehicles in the lanes that are not permitted (e.g., single-occupancy vehicles) can be cited for violating operating rules. Enforcement is based strictly on visual sighting of the offending vehicle/operator by an enforcement official, who then must take action to physically approach, contact (get the attention of), and direct the vehicle/operator out of the HOV lane. The existing inside shoulder of existing HOV lanes north of The Stack Interchange are too narrow to facilitate stopping the offending motorist for purposes of enforcement; therefore, the offending motorist and enforcement officer must weave through the GP freeway lanes to the extreme right shoulder of the roadway from the lane to the edge of the freeway for the issuance of a citation. The wider inside shoulder of HOV lanes south of The Split Interchange could more safely accommodate enforcement within the HOV facility, and are actively used today for this purpose.

[3] DHOV connector ramps are installed at overcrossing arterial roadways to allow direct entry and exit from the HOV lanes in the center of the freeway. DHOV connector ramps necessarily require additional freeway right-of-way to accommodate the ramp structure to and from the arterial roadway.

A study of managed-lane separation treatment options by the Maricopa Association of Governments (MAG) in 2012 concluded that enforcement of painted and buffer-delimited managed lanes generally is more difficult compared to a physically-separated facility.[4] Painted and buffer-delimited facilities allow violators to more easily move between the HOV lane and the GP freeway lanes, e.g., the offending vehicle/operator can easily move from the enforcement zone without consequences, if pending enforcement is noticed sufficiently ahead of contact with the enforcement official. Also, violators can use the HOV lane for short distances to gain advantages with respect to GP freeway lanes or use the HOV lane to pass a vehicles in the GP freeway lanes. Thus, it would be expected that painted and buffer-delimited managed lanes typically would have greater violations of restricted operational criteria than limited-access, barrier-separated managed lane facilities. This latter condition clearly raises the potential for traffic conflicts and is a highly undesirable practice. No information could be located relating to the rate of crashes associated with the different types; however, intuitively one could surmise as the number of merges occurring between the HOV facility and GP freeway lanes increases, the potential for conflicts increases.

On the other hand, barrier-separated managed lane facilities need to provide for safe, efficient, and enforceable operations by users of the facility, maintenance vehicles and personnel, and enforcement officials. As cited in the MAG report, guidance from the AASHTO's *Guide for the Design of High-Occupancy Vehicle Facilities* published by the American Association of Highway and Transportation Officials (AASHTO) states the following:

> *The absence or presence of certain roadway features can adversely affect the enforcement process as well as the safety and operational features of the facility. Physical problems may include lack of safe and easily accessible enforcement areas, absence of vantage points, lack of physical separation, and lack of passing capability for enforcement vehicles.*

Following this guidance would mean additional right-of-way would be necessary to accommodate emergency conditions, such as avoidance of a stalled or disabled vehicle by allowing a bypass path for other motorists using the facility. Ease of ready access by maintenance and enforcement personnel also is desired.

Short of additional right-of-way, the alternative is reduction in the widths of highway shoulders, enforcement areas, and even GP freeway lanes. The Ministry of Transportation of Ontario, Canada, (2017 Web Page) determined that poor safety records of some HOV facilities have resulted from adding an HOV lane where: (1) the existing roadway could not accommodate the desired buffer zone, (2) GP freeway lanes could not be maintained with adequate widths for the all other traffic, and (3) the width of the left (inside) shoulder of the HOV lane, available for emergency and enforcement, was inadequate.[5] These deficiencies resulted in a greater likelihood of collisions and reduced driver maneuverability. As a result, the Ministry adopted a policy of establishing HOV lanes on existing highways only through widening projects, instead of converting existing lanes or shoulders to accommodate the special use of an HOV lane.

The FHWA prepared a compendium of considerations associated with planning relating to the conversion of HOV lanes to HOT lanes.[6] The report highlights six different physical designs to obtain separation from the GP freeway lanes and all included a parallel emergency area (shoulder) for disabled vehicles and enforcement. The report notes that HOV-to-HOT lane conversions, which by definition include pricing from entry to exit, delineated by a painted stripe with no buffer (physical or demarcated hashed area) pose safety and enforcement issues, due to the free flow in and out of the facility of ineligible vehicles. Another design review report prepared by the Washington Department of Transportation (WSDOT) recommends a continuous inside shoulder of 14 feet associated with a HOT lane to accommodate enforcement and serve as a breakdown lane, with a minimum 2-foot opposite-side shoulder recommended to separate the travel lane from any barrier, if the ideal width is not feasible.[7] The WSDOT report also notes that an added feature might be a shoulder area (i.e., bump-out) immediately downstream of the access (entry or ingress) location to permit enforcement officers a station for observing and monitoring use of the HOT lane.

A 2004 study by the Arizona Department of Transportation (ADOT) examined issues relating to enforcement of HOV facilities.[8] It concluded that the lack of adequate enforcement would result in high violation rates. Also, legitimate carpoolers and transit users could express dissatisfaction when violators are noticed operating on the HOV lanes, and there is no enforcement. In effect, the lack of adequate enforcement would invite the HOV lanes to become GP lanes. Guidance developed for the Texas Department of Transportation (TxDOT), also in 2004, identified six characteristics to be evaluated when choosing between a buffer-separated and barrier-separated, concurrent-flow HOV lane. One of the characteristics is the "Opportunity for Enforcement Locations."[9] The report recommends 10-foot shoulders be constructed in conjunction with the HOV lanes for both types of facilities, as well as a clearly apparent painted stripe.

Guidelines developed for the California Department of Transportation (Caltrans) in 2003 sought to clarify the decision process relating to barrier-separated, buffer-separated (pavement striping), and contiguous (painted stripe) HOV facilities.[10] It clearly noted that enforcement raises numerous issues; particularly, limitations on right-of-way can preclude a paved median (inside) shoulder. Lacking an available shoulder contiguous with the HOV lane, the enforcement officer and violator must weave across the GP freeway lanes, across congested, mixed-flow traffic to the right shoulder of the freeway. This not only poses safety risks to the two vehicles and traffic in the mixed-flow GP freeway lanes, but it also is likely to result in congestion, which, in and of itself, creates operational and safety issues. This report concludes "the optimum design is the availability of adequate enforcement areas in the median. Where existing facilities do not have these enforcement areas or new facilities are not designed with them, it can be expected that enforcement on the facility will be challenging."

<u>Conclusion</u>: The literature review clearly indicates that enforcement of managed lane facilities is a challenging problem, and enforcement is more challenging with respect to painted stripe- and buffer-separated (i.e., non-barrier-separated) facilities. Active enforcement of lane violators can be disruptive of the traffic stream in the GP freeway lanes, and there always is the opportunity to avoid enforcement by getting out of the lane. A buffer-separated facility, especially with installed flexible posts or pylons, can stifle that practice to an extent, but the temptation to move into and out of a buffer-separated facility, in and of itself, raises safety issues. Safety issues arise when pylons become dislodged. In addition, pylons have been found to be an expensive traffic control measure, as they can be dislodged or ruined by vehicles traveling through them requiring frequent (90 days), regular maintenance. As a result, may transportation agencies are shying away from posts and pylons as a means of separating traffic flows.

The provision of an inside, median shoulder sufficiently wide to safely accommodate a stalled or disabled vehicle as well as enforcement actions (14 feet is preferred), raises significant issues relating to right-of-way requirements in an area that is constrained and increases development costs. Nonetheless, the recommended action in the I-10/I-17 corridor provides for sufficient shoulder width to support safe enforcement. However, it generally is accepted that a barrier-separated facility can provide a safer environment for both vehicle operations and enforcement and result in less impact on the traffic stream of the GP freeway lanes. Also, although barriers require the highest upfront expenditure, the ongoing maintenance is low compared to pylons, posts, even painted buffers.

All-in-all, with respect to enforcement, the barrier-separated facility offers the safest and most reliable method of enforcement, even precluding the need for physical contact.

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4 "Managed Lane Separation Treatment," *Managed Lanes Network Development Strategy – Phase I*, Maricopa Association of Governments, February 2012.

5 "High-Occupancy Vehicle (HOV) Lanes," Ontario Ministry of Transportation at http://www.mto.gov.on.ca/english/ontario-511/hov-lanes.shtml.

6 *A Compendium of Existing HOV Lane Facilities in the United States*, FHWA HOV Lane Performance (DTFH61-06-D-00006), prepared by Booz-Allen-Hamilton and HNTB, Dec 2008.

7 *HOT Lane Buffer and Mid-Point Access Design Review Report*, Washington State Department of Transportation, Oct 2006.

8 <u>HOV Lanes: Issues and Options for Enforcement</u>, Final Report 552, ADOT, June 2004.

9 *Guidance for Future Design of Freeways with High-Occupancy Vehicle (HOV) Lanes Based on an Analysis of Crash Data from Dallas, Texas*, Texas Transportation Institute for TxDOT and FHWA, FHWA/TX-05/0-4434-P1, May 2004.

10 "High-Occupancy Vehicle Guidelines for Planning, Design, and Operations," Caltrans Department of Transportation Division of Traffic Operations, August 2003.

2.2 Opposed to HOV lanes in general

HOV facilities have become an integral part of the transportation tool box to improve mobility and accessibility, especially in urban areas. According to the FHWA, HOV facilities "…serve to increase the total number of people moved through a congested corridor by offering two kinds of travel incentives: a substantial savings in travel time, along with a reliable and predictable travel time."[11] As the freeway network in Arizona developed over the past several decades, HOV facilities have been an important component of that expansion. Arizona currently ranks fourth in the United States in HOV system lane miles.

Because HOV lanes permit the movement of vehicles with a higher number of occupants, these facilities move significantly more people through the travel corridor during congested periods, even if the number of vehicles that use the lane is lower than on the adjoining GP freeway lanes. For example, facts presented about the HOV system in Los Angeles County indicate an average HOV lane supports the travel of 1,200 vehicles during peak periods carrying 3,100 persons. By comparison, the GP freeway lanes accommodate an average of 1,800 vehicles per lane during the same peak periods, carrying 2,000 persons.[12] The average occupancy in the HOV lane is 2.58 persons per vehicle compared to 1.11 in the GP freeway lanes.

In general, carpoolers, vanpoolers, and bus patrons are the primary beneficiaries of HOV lanes by allowing them to move through congestion; however, the use of managed lanes, in turn, frees up capacity in the GP freeway lanes, and expectations are that this new capacity will allow greater mobility for the community/region overall. Also, managed lanes are oriented to commuter traffic; this allows commuters engaged in longer trips to travel on an express facility to a destinations downstream, bypassing the more congested GP freeway lanes. Obtaining a higher average speed, while operating on the managed lanes, commuter vehicles produce lower emissions and this helps a community/region meet air quality goals. If the presence of the managed lanes also aids in reducing congestion in the GP traffic lanes, then traffic in these lanes will attain a higher overall average speed and reductions in emissions, thereby contributing to regional air quality goals. It is important to note that latent demand, the additional peak period travel occurring as congestion is reduced, ultimately will mean new vehicles will fill up the space vacated by vehicles taking advantage of the managed lanes. "This is not to suggest that increasing road capacity [through the implementation of managed lanes] provides no benefits, but generated traffic affects the nature of these benefits. It means that road capacity expansion benefits consist more of increased peak-period mobility and less of reduced traffic congestion."[13]

In addition to congestion relief and mobility improvements, separation of commuters via express travel facilities, per se, also can provide safety benefits. Reductions in congestion associated with separated lanes (especially barrier-separated lanes) aid in the safety performance of freeways. Conflicts can occur between vehicles operating in the HOV lane and GP freeway lanes, when motorists merge into and out of the HOV lane, and these actions can result in potentially serious crashes and congestion. By comparison, limited-access facilities reduce the occurrence of incidents that disrupt traffic flow in the GP freeway lanes. Generally, any disruptions of the GP freeway lanes result in extended backups and travel time delays for the large number of travelers. Disruptions in the barrier-separated lanes generally do not cause GP freeway lanes to backup (with the exception of the "rubber-necking" phenomenon).

Expeditious movement via managed lanes also provides motorists a choice of travel environments and can be an incentive for forming carpools/vanpools, which, ultimately, increases the capacity of the travel corridor. An important aspect of the modern freeway system is the degree to which roadways, originally developed for longer trips, e.g., interstate travel, now frequently are used for quick, short regional, even local trips. Because commuters often are intent on traveling several miles on their trip, as opposed to local movements between sets of on/off ramps, the managed lanes accommodate this travel more effectively and remove some through traffic from the GP freeway lanes, freeing up capacity for more localized travel and latent demand, which can come from induced travel that would not have been made and travel on alternative local streets.

Conclusion: HOV lanes make travel by HOV (e.g., carpools/vanpools, buses, motorcycles, electric or hybrid vehicles) more efficient, helping to reduce congestion in the GP freeway lanes. As a complementary alternative, HOT lanes allow motorists to opt for a travel experience at a given price. The two methods of expediting movement through corridors can aid in optimizing the transportation system and reducing or delaying the need for costly expansion projects. By increasing the effectiveness of travel through a corridor, efficiencies are attained that aid in reducing motor vehicle emissions and improving travel safety. Managed lanes are not viewed as degrading the overall mobility and safety performance of a freeway system; on the other hand, they permit transportation officials to better manage roadway capacity to create the most efficient travel system possible throughout the day, improving mobility and enhancing safety.

2.3 Dislike the CA/LA Experience

The California experience with HOV/HOT lanes is quite extensive. According to State guidelines for the planning, design, and operation of HOV lanes, the State views these facilities as an effective traffic management strategy that promotes and encourages ridesharing. Ridesharing, in turn, aids in the effort to alleviate congestion and maximizing the throughput of people in a highway corridor. As early implementers of more stringent air quality standards, the goal of managed-lane system has been to reduce congestion and improve air quality. These are the same reasons on which decisions are based in other states, and they are an integral part of Federal air quality improvement programs. Federal funding for HOV/HOT projects has been made available for the express purpose of improving air quality by reducing congestion – vehicles release less pollution when operating at optimum speeds, as opposed to idling and operating in stop-and-go conditions.

Enforcement in California is predicated on achieving optimum adherence to the rules of the HOV system, while attaining cost-effective results within the enforcement establishment. According to the Caltrans Web site, the California Highway Patrol continually monitors HOV/HOT lane use, and the goal is to keep violations below 10 percent of the traffic throughput.[14] If violations exceed 10 percent, heightened enforcement actions are implemented. While this process may seem unfair to the legitimate users of the system, it is a realistic policy decision that attains a reasonable goal while reducing enforcement costs and creating potential safety issues associated with physically contacting and stopping a violator in a stream of traffic.

The design and operation of California HOV/HOT facilities are oriented to achieving reliable travel-time savings, safety goals, and effective enforcement. Significant attention has been given to establishing design guidelines to better accommodate the weaving required to enter and exit HOV/HOT facilities. Detailed analyses are performed with the objective of ensuring facilities meet operational thresholds for the GP freeway lanes, such as merge/diverge requirements, weaving requirements, and other factors. Planning and design is focused on ensuring projects will not create new safety "Hot Spots" or increase the potential for severe or serious collisions. According to a 2012 presentation on California's Managed Lane Design Policy, the HOV facilities are becoming more boldly designated with wider pavement delineations and clarifying signage; plus, the physical enforcement process has been restructured.[15] These changes and other modifications, derived from experience with the operation and enforcement of HOV/HOT facilities in California, throughout the country, and abroad, would be incorporated in the Spine Corridor facilities, as appropriate, considering available right-of-way, costs, safety attributes, and enforcement.

[11] *Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes*, Freeway Management Program, FHWA, November 2012, at https://ops.fhwa.dot.gov/freewaymgmt/hovguidance/, retrieved 3/16/2017.

[12] *HOV Frequently Asked Questions*, Los Angeles County Metropolitan Transportation Authority – "Metro," at http://media.metro.net/projects_studies/hov/faqs.htm.

[13] Generated Traffic and Induced Travel, *Implications for Transport Planning*, Victoria Transport Policy Institute, April 20, 2017.

[14] Caltrans at CA.gov http://www.dot.ca.gov/trafficops/tm/hov.html, Retrieved 03/15/2017.

[15] *California's Managed Lane Design Policy*, PowerPoint Presentation, Joe Rouse, Division of Traffic Operations, Office of System Management Operations, Caltrans, May 2012.

Conclusion: The adaptation of the driving public to HOV/HOT facilities and the use of these facilities is a challenging process. But, there is a large body of information available to assure planners and engineers can create these facilities with the least amount of inconvenience and the highest degree of safety at reasonable cost.

2.4 THE ACCESS POINTS WILL BE A FOCAL POINT OF CRASHES

There has been extensive analyses and evaluations relating to the design and location of access (ingress and egress) points associated with HOV and HOT facilities, since these facilities in the U.S. were first developed in the 1970s. Continuous access associated with contiguous, concurrent-flow HOV facilities, such as those in the Spine Corridor, are the most common and permit a greater, even infinite, number of ingress/egress locations. These facilities provide motorists with the greatest convenience relative to decisions regarding entry to and exit from the freeway. Motorists choosing to use the HOV lane may weave over from a freeway entrance to enter at any point along its length and exit at any point, weaving across the GP lanes to a freeway way exit.

Although this ingress/egress activity can be somewhat difficult, even harrowing for some drivers, generally it occurs with relative success. Information available through the Ontario Ministry of Transportation (2017) indicates that the poor safety records related with buffer-separated HOV facilities, which add a similar degree of separation as provide for the HOV lanes in the center of I-10, primarily resulted from shoehorning facilities into existing corridors and not driver competence.[16] Inadequate buffer zones, narrow GP lanes, and inadequate width of the median (inside) shoulder for emergency and enforcement (not the case on I-10, but particularly relevant for I-17 HOV lanes) were identified as the principal reasons for safety problems. As noted earlier, the Ministry, therefore, adopted a policy of incorporating HOV lanes only through widening projects that permitted attaining the latest highway design standards.

Investigations in Texas (2003) examined a variety of techniques and measures for expediting traffic flow in freeway corridors. Although the Texas study asserts "the characteristics that matter most to the driver are speed of travel, safety, comfort, and convenience," little information is provided regarding the safety of any of the investigated HOV facility types, and no safety information is provided relative to the design criteria for a managed lane facility.[17] Unfortunately, specific, quantifiable information regarding the safety experience at access points has not been a focus of the many studies conducted to date. Nevertheless, the Texas investigations provide some salient points regarding safety that generally are supported by other available studies.

Available studies generally support the notion that limited-access, barrier-separated HOV/HOT facilities are safer than continuous, concurrent-flow facilities. The safety issues of such facilities primarily are associated with the design of access points and lane configurations. While a study for Caltrans in 2009, comparing continuous- and limited-access facilities, concluded "…HOV facilities with limited access offer no safety advantages over those with a continuous access,"[18] the report also notes that inside, median shoulders greater than eight feet in width resulted in "…significantly lower collision rates, regardless of access type." In addition, the study team found collision rates were "markedly higher" for a limited-access HOV facility with a combination of (1) short ingress/egress lengths and (2) close proximity to the nearest on/off ramps.

Thus, the occurrence of crashes appears to be more a function of facility design and integration of access points within the freeway, rather than the facility operation in and of itself. For example, the Texas Manual found that wider facility envelopes are associated with reduced crashes on freeways at all severity levels and all fatal and injury severity levels, and there was an increase in the number of crashes with an increased number of access points.[19] Also, in the 2009 Caltrans study, it was found that, although neither facility provide any safety advantage, "maintaining adequate shoulder and total [facility] width is essential…."[20] Three key conclusions from this study are:

- Maintenance of adequate shoulder width is essential;
- Optimize the length of ingress/egress sections (higher collision rates were found to be associated with the short access sections, i.e., slip ramps);
- Optimize distances between ingress/egress locations and freeway on/off ramps – "…locating access areas in close proximity to on/off ramps should be avoided."

The findings of studies in Texas, California, and Ontario, affirmed, in part, an earlier study by the Washington Department of Transportation (WSDOT) that addressed buffer widths (4-foot buffers preferred, 2-foot minimum), the need for a continuous inside (median) shoulder (14 feet is preferred to accommodate safe enforcement), and minimum lengths for access or slip ramps (500 feet).[21] The later MAG White Paper (2012), prepared to address separation approaches for HOV/HOT lanes, concludes that, assuming all other factors to be equal (e.g., mix and density of traffic, roadway geometrics, access locations, etc.), barrier separation is safer than non-separated treatments.[22] It also notes that safety associated with all treatments, in terms of both crash occurrence and severity, is influenced by the length and location of access locations and the speed and density of traffic streams. A finding similar to that made by the TxDOT and the Ontario Ministry of Transportation.

Conclusion: As late as 2012, a White Paper prepared by MAG found no readily available information in the form of studies or databases to aid in identifying specific causal factors of crashes in relation to the various design treatments. Although only generalized inferences may be drawn from available information, the White Paper concluded a consensus apparently exists that, all things being equal, barrier separation is safer than non-barrier treatments, specifically painted and buffer-delimited treatments. This conclusion is affirmed by the FHWA at its Frequently Asked Questions Web site for Freeway Management, where it is stated that "the safest HOV lanes are those that are physically separated from the adjacent lanes with a concrete barrier," and separation also creates greater safety for traffic in the GP freeway lanes.[23]

Thus, safety at the access points for a limited-access, barrier-separated facility is more a matter of applying the latest knowledge and experience, i.e., best practices, in the design of the facility, specifically the location of access points, the location of these points relative to on/off ramps of the freeway, and the length of access or slip ramps. GP freeway lanes providing direct entry to and exit from the limited-access, barrier-separated facility, along with adequate signage and lighting, are viewed as significantly enhancing the safety performance of the facility and the interaction of facility users with traffic in the GP freeway lanes. The speed differential of vehicle operating in the managed lanes compared to likely congested GP freeway lanes would call for special consideration of signage and facility design to maximize the opportunity for safe transitions. In addition, as noted earlier, wide (14 feet) median (inside) shoulders are considered to be critical to facility performance and enforcement and the number and location of access points would need to reflect access requirement of first responders.

Limited information is available related specifically to dual HOV lane facilities, as these are relatively non-existant in the United States. Therefore, the actual design of the recommended dual managed lane facilities and the number and locations of access points would need to be the subject of modeling and traffic studies to ascertain: traffic volumes in the corridor and demand for the managed lanes; frequency of access and demand along the

[16] "High-Occupancy Vehicle (HOV) Lanes," Ontario Ministry of Transportation at http://www.mto.gov.on.ca/english/ontario-511/hov-lanes.shtml, retrieved 03/09/17.

[17] Interim Manual for Managed Lanes, Texas Transportation Institute for TxDOT, Report 4160-14 (FHWA/TX-04/4160-14), October, 2003.

[18] Safety Performance of High-Occupancy Vehicle (HOV) Facilities: Evaluation of HOV Lane Configurations in California, Safe Transportation Research & Education Center, Kitae Jang, et al, January 2009.

[19] Ibid. Interim Manual for Managed Lanes.

[20] Ibid. Safety Performance of High-Occupancy Vehicle (HOV) Facilities.

[21] Ibid. *HOT Lane Buffer and Mid-Point Access Design Review Report.*

[22] Ibid. Managed Lane Separation Treatment.

[23] *Summary of Key Points RE: HOV Ins*, "Frequently Asked HOV Questions at FHWA Freeway Management Program Web site, https://ops.fhwa.dot.gov/freewaymgmt/faq.htm, retrieved 2017

Spine Corridor; and weaving and queuing dynamics at the ingress and egress points. All this must be considered with the constraints on right-of-way and the degree to which the community agrees with any expansion of right-of-way to accommodate the proposed improvements. As project development proceeds, safety assessments also will be conducted to determine more factually the risks of crashes at key locations within the Spine Corridor, including access points.

3.0 OTHER QUESTIONS/COMMENTS

In addition to the comments and concerns raised by those less favorably disposed to the proposed action, the following additional topics were submitted in various forms. This section seeks to respond to these topics so Spine Management Partners and general public can make a more informed decision regarding the design, configuration, and operation of proposed managed lanes.

3.1 RELATIONSHIP OF RESTRICTED ACCESS POINTS AND TIME OF DAY USE OF HOV?

The provision of a dual managed lane facility may include installation of a barrier to physically separate the HOV lanes (and potential future HOT lanes) from the GP freeway lanes. The purpose of the barrier is to restrict entry and exit to specific locations. This generally is viewed as a more desirable and safer operating configuration, as noted earlier, although the latest guidance from FHWA that Utah and Minnesota have incorporated "…a more continuous access policy…" that increases ingress and egress opportunities.[24] Regardless of the method of separation, access control is critical to the cost, operational, safety, and enforcement trade-offs associated with managed lanes. The usual and customary use of the facility by carpools/vanpools, buses, motorcycles, and electric/hybrid vehicles, as permitted by HOV policies, would not be hampered. HOV lane-eligible users would be allowed unrestricted access throughout the day. Similarly, SOV users are not allowed to use the facility during specified times.

Should a decision be made to incorporate HOT lanes in conjunction with the dual managed lane strategy, tolling operations and policies associated with the HOT lane likely would include dynamically-adjusted toll rates, based on real-time traffic conditions. As the volume of traffic increases in the managed lane facility, the toll would be increased to assure the facility would be able to operate at an acceptable level of service (LOS). Facility LOS would be determined in accordance with real-time observations of traffic and policies established for the facility. Generally, congestion within the freeway corridor during peak travel periods means there would be increased use of the HOV/HOT facility; therefore, peak periods would have the highest toll.

Conclusion: Restricted access points associated with limited-access facilities are managed operations over a 24-hour period. Generally, limited-access facilities associated with tolling are never opened to GP traffic. That is to say, control of limited-access tolling facilities is not relinquished to GP traffic, as is done with HOV lanes currently in the Phoenix area. Recent interest has arisen for continuous access, but issues of pricing, safety, and enforcement become more complex. Signage and driver awareness become more critical with restricted access, as decisions to access a managed lanes facility may be inadvertent resulting in an undesirable maneuver to return to the GP freeway lanes.

GP freeway traffic can make use of the limited-access facility through established ingress and egress points, in accordance with restrictions on use applied throughout the day. Restrictions on use can be modified throughout the day through DMSs, based on the volume of traffic in the corridor. Time-of-day use would only be appropriate with managed lanes that operate much the same as the existing HOV lanes in the Phoenix metropolitan area. These facilities permit access at infinite points and function in restricted operation only during the peak periods and do not impose a charge or toll.

3.2 POTENTIAL FOR ONE MILE ACCESS POINTS GIVEN THE EXISTING ONE-MILE SPACING OF TIS

The inherent operational philosophy associated with development and implementation of managed lanes is to create a reliable facility for trips that (1) expedites commuter travel over longer distances and (2) can be viewed as preferable to the congested GP freeway lanes. Because a good portion of urban freeway usage has become associated with localized movements of a few miles (even one mile or less), separating commuters engaged in longer trips brings relief to the GP freeway lanes of the burden of what essentially can be considered to be through-traffic movements. Because the managed lanes are not established to accommodate shorter distance trips, which do occur (e.g., Glendale Avenue to Camelback Road in the Spine Corridor), access points do not need to be as frequent as the traffic interchanges (TIs). In fact, FHWA notes that "access spacing of two to three miles is common for most restricted access treatments."[25] Nevertheless, ADOT studies have suggested that barriers limiting entrance and, particularly, exit from managed lanes can be a discouraging aspect for commuters, when exits are not convenient to their desired destination.[26]

The design and location of access points (ingress and egress) not only affects user convenience but, also, safety and operational performance of the facility. Enforcement capabilities also can be affected. Another key design consideration for access points (ingress and egress) on a limited-access, barrier-separated managed lane facility is adequate length of the transition or weave zone to support ingress and egress. The weave zone requires an adequate distance between the access point and on/off ramps of the freeway to permit movements into and out of the HOV/HOT facility without impeding movement onto and off of the freeway via on- and off-ramps.

Figure 3.1
Photo of Access Point for Access-Restricted

Source: Section 8.0, Managed Lanes, Managed Lane Chapter for Freeway Management and Operations Handbook, FHWA, Updated Chapter, January 2011.

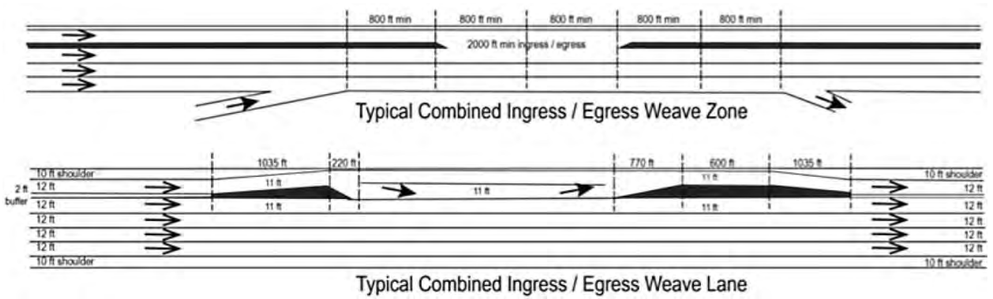
Figure 3.3 shows two plan views for a combined ingress/egress access points. It is clear from **Figure 3.3** that such configurations would occupy much of the space between TIs. The simple ingress/egress weave zone would require 2,400 feet. With modern freeway on- and off-ramps extending 1,200 feet, the weave zone would not be readily accessible from the nearest on- or off-ramps, because there would be insufficient distance to weave through three lanes of traffic. The more complex ingress/egress weave lane would occupy 5,660 feet (assuming a 2,000-foot minimum ingress/egress point, although some sources shows this as little as 1,500 feet).

[24] *Priced Managed Lane Guide*, Chapter 6. Design, Tolling and Pricing Program, Federal Highway Administration at https://ops.fhwa.dot.gov/publications/fhwahop13007/pmlg6_0.htm.

[25] Ibid. Section 8.0, Managed Lanes, pg 38.

[26] HOV Lanes: Issues and Options for Enforcement, Final Report 552, ADOT, June 2004, pg 14.

Figure 3.2 Plan Views of Typical Combined Ingress/Egress Access Points

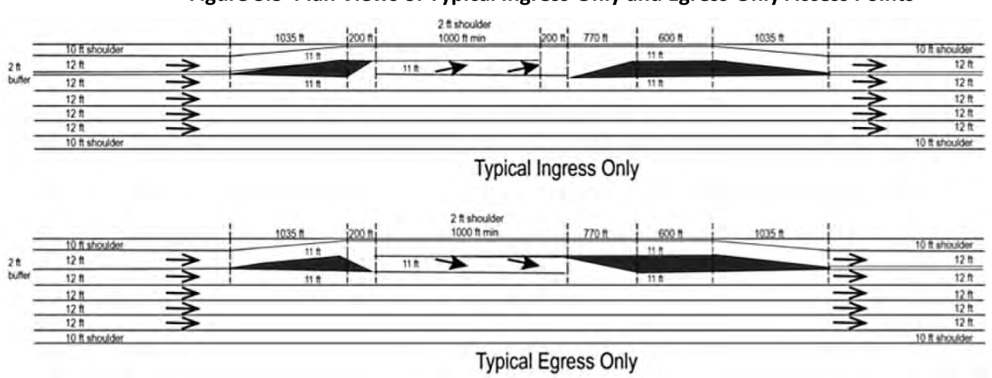


NOTES: The Weave Zone plan does not show an inside shoulder, which would be very desirable.
A 14-foot inside shoulder is preferred for safety of operations, incident response, and enforcement.

Source: Caltrans Traffic Operations Policy Directive, 2011, presented in *Priced Managed Lane Guide*, Chapter 6. Design, Tolling and Pricing Program, Federal Highway Administration at https://ops.fhwa.dot.gov/publications/fhwahop13007/pmlg6_0.htm.

Figure 3.4 shows two plan views of separate ingress and egress access points (refer to **Figure 3.2**). The ingress-only access point accommodates entry to the managed lane by way of a 2,170-foot slip ramp, and the total length of the managed lane bypass is 4,840 feet in length to accommodate the merge. The total length of the egress-only access point is slightly less at 4,640 feet with a 1,970-foot slip ramp.

Figure 3.3 Plan Views of Typical Ingress-Only and Egress-Only Access Points



NOTES: A 14-foot inside shoulder is preferred for safety of operations, incident response, and enforcement.

Source: Caltrans Traffic Operations Policy Directive, 2011, presented in *Priced Managed Lane Guide*, Chapter 6. Design, Tolling and Pricing Program, Federal Highway Administration at https://ops.fhwa.dot.gov/publications/fhwahop13007/pmlg6_0.htm.

Thus, while intermediate access points are doable, there location and design will depend on "…the existing and planned roadway geometrics and the amount of traffic expected to use the opening. In all cases, openings should be located and designed in a way that will not produce adverse impacts to the managed lanes and the parallel highway lanes. The locations of at-grade access openings need to be closely coordinated with highway entrance and exit ramps and allow adequate room for motorists to complete weaving movements when moving between the general-purpose and managed lanes and an entrance or exit ramp."[27] That is to say, the spacing of access points should not be located immediately downstream from a freeway on-ramp or immediately upstream from a freeway off-ramp. The preferred location for access is in a portion of the freeway with the lowest potential for congestion and between on- and off-ramps.[28] This positioning provides motorists ample time and space to complete weaving maneuvers through the GP freeway lanes to access the managed lanes from the on-ramp and exit to an off-ramp. With TIs located every mile, the number of intermediate access points necessarily will be limited to avoid traffic conflicts and tie-ups resulting from dangerous weaving actions. The transition or weave areas would need to be strategically located to coordinate with origins and destinations within the Spine Corridor, while taking into consideration weaving requirements.

Conclusion: As noted earlier, the objective of managed lane facilities is to increase person throughput via a reliable means that is viewed as favorable to congestion. Determining the locations for access points (ingress and egress) necessarily must follow careful examination of corridor travel dynamics as well as major points of origin and major destinations. Longer trips are favored for managed lanes, as limited-access reduces friction, and higher travel speeds reduce travel time. Attempting to identify at this time how many access points should be provided along the Spine Corridor would be an arbitrary action, at best. No specific conclusion regarding access points along the Spine Corridor relative to access points in California is justified based on the information in this White Paper. Determining the number and locations for any intermediate access points (ingress and egress) necessarily must follow careful consideration and examination of: the objectives of the project; travel reliability; travel patterns; traffic volumes; potential disruptions of traffic flow; concentrations of major trip origins and destinations; weaving associated with each access point; geometrics of the freeways, especially the presence of horizontal and vertical curves (horizontal curves being more problematic); as well as connectivity with regional origins, destinations, and other routes of travel.

3.3 PERCEPTION THAT THE RESTRICTED ACCESS POINTS WILL NEED MORE PHYSICAL SPACE.

There is no doubt that managed lanes require space within the travel corridor in addition to the GP freeway lanes and any frontage roads. As noted earlier, the preference for a wide, inside shoulder for emergency and enforcement reasons means adequate space must be allocated to the managed lane facility while maintaining physical capacity of the GP freeway lanes, freeway on- and off-ramps, and frontage roads (if present) as well as an insider shoulder for breakdowns and emergency in the GP freeway lanes. Although limited right-of-way may present challenging design solutions, introduction of a managed lane facility may, on the other hand, allow a community to postpone expansion of an existing freeway facility to add capacity.

Depending on the adopted design and location of access points, there may or may not be a need to expand right-of-way. **Figure 3.2** above shows an access point that is, in effect, a slip-ramp to an HOV lane (refer also to **Figure 3.4**, Ingress-Only). A subsequent slip-ramp of similar design would be provided at an intermediate exit along the length of the managed lanes to facilitate merging into traffic in the GP freeway lanes (refer to **Figure 3.4**, Egress-Only). The locations of intermediate access points (ingress or egress or both) would be determined during detailed planning and operational studies for a managed lane facility. As shown in **Figure 3.3**, both ingress and egress can be at the same location. Both types of access would require widening the freeway in the area of the access point. It should be noted that intermediate access locations are not included in the Spine Corridor Recommendations Key Map; it is not known whether intermediate access points are being contemplated for the managed lanes facility. As noted earlier, DHOV ramps are contemplated, and these ramps likewise would require space within the corridor.

Conclusion: The final design and configuration of the limited-access facility will depend on yet to be accomplished traffic and travel pattern studies, design studies, engineering studies. As proposed in the Spine Corridor Recommendations Key Map, access to the Spine Corridor managed lane facilities would occur at DHOV connector ramps at the ends of three segments. DHOV connector ramps would require additional physical space. Intermediate access points also would require additional physical space. However, it has not yet been determined whether or not the additional physical space would require acquisition of additional right-of-way. Conceptual and preliminary design studies must be accomplished to fully address this issue.

3.4 AAVAILABILITY OF RESEARCH INDICATING THE LIMITED-ACCESS MODEL IS ACTUALLY SAFER

The specific question of the safety associated with access points created for a limited-access managed lane facility has been addressed in a previous section. The most recent guidance relating to development of managed lanes and the overall safety of these facilities is contained in the FHWA Handbook. The FHWA Handbook suggests safety can be a function of HOV/HOT lane operating scheme.[29] The Handbook notes that part-time managed lane operations that revert to GP freeway lanes during non-peak periods need to look and function like the GP freeway lanes. The Handbook states that managed lanes that operate part-time, i.e., eligibility restrictions are in place only during specific periods, should be continuous, as the lane serves the general traffic flow during open periods. This is the case relative to HOV lanes established in the Phoenix metropolitan area.

The part-time operational configuration requires careful and extensive signing and messaging to assure motorists are fully informed of the time-of-day restrictions. Nevertheless, contiguous, continuous-access, concurrent managed lanes can be opposite to driver expectancy and adversely affect safety of traffic operations. That is to say, the presence of such lanes can create confusion for motorists, who may be unfamiliar with the striping and delineation of the specialized lane. This condition provides one argument for barrier-separated, limited-access managed lane facilities and elimination of the time-of-day use scenario.

The Handbook notes that full-time managed lane operations can be either open or entry can be restricted to designated locations in the case of buffer-separated facilities, particularly facilities that employ flexible posts or pylons within the buffer. The reference here is specific to HOV lanes and not HOT lanes. Approximately 60 percent of the HOV lane-miles in the U.S. operate under unrestricted or open access. The remaining facilities incorporate access control with designated or delineated entry zones to accommodate necessary weaving and transition between GP freeway lanes and the HOV lane. The Handbook notes that some access-restricted managed lanes in Southern California are being converted to accommodate continuous-access. At the same time, some HOV lanes elsewhere are being converted to restricted-access to accommodate the charging and enforcement of tolls for use. The Handbook indicates various studies of the safety associated with managed lane operations "suggest" that both unrestricted- and restricted-access facilities "…can be safe and function well."

Nevertheless, the question of crash modification factors (CMFs) certainly is worthy of note. The AASHTO *Highway Safety Manual* (HSM) includes a method for quantitatively gauging the effectiveness of various safety countermeasures (e.g., access management, lighting, and signage). The CMFs are useful in estimating the expected change in the number of crashes (average) at a particular site or locale subsequent to implementation of a safety countermeasure. In a guide prepared for the Pennsylvania Department of Transportation (PennDOT), appropriate CMFs were identified to aid the Department in evaluating safety performance of proposed changes to the highway

[27] Ibid. *Priced Managed Lane Guide*, pg 5.

[28] Ibid. *California's Managed Lane Design Policy*.

[29] Section 8.0, Managed Lanes, Managed Lane Chapter for Freeway Management and Operations Handbook, FHWA, Updated Chapter, January 2011, pg 31.

and street network in the State. In this guide, the authors point out that the CMF is an estimate "obtained from statistical analysis of reported crash data."[30] Further, the true CMF is noted to be "unknown," as there always is some error involved in statistical analysis.

That being said, the importance of having data analysis to support decisions cannot be understated, and the CMF value for converting continuous-access HOV lanes to limited-access facilities was determined by the study team to be 1.74 (less than 1.0 is better). Nevertheless, it must be pointed out that the goal of conversion and the objectives of limited-access facilities, in general, is not safety. The intent of creating a limited-access facility is not to create a safer operating environment, but to create a more efficient roadway or travel corridor by increasing capacity. This is not to say that safety is not a concern, only that safety is not the sole concern. In fact, many elements of the transportation infrastructure must be considered, reviewed, and thoroughly examined within the limits of knowledge and analytical capabilities prior to adopting one particular highway treatment over another. For example, signage, lighting, barrier design, shoulder widths, and other roadway features must be evaluated and integrated to create modern highway facilities. The PennDOT CMF Guide states a single CMF may be applied to a particular site "…to estimate the impact of a single countermeasure" (i.e., safety-oriented improvement) and "…to a particular site to estimate the impact of multiple countermeasures applied simultaneously."[31]

Therefore, the safety aspects of the limited-access managed lanes clearly must be recognized and designs incorporating multiple safety-related improvements, as cited above, must be developed to mitigate potentially hazardous operating conditions. However, safety cannot be the prime determinant for selecting any given treatment. As pointed out in an FHWA publication, *Safety Implications of Managed Lane Cross Sectional Elements*:

> *Managed lanes (ML) can provide safety and operational performance benefits over general-purpose (GP) facilities, but the managed lane strategy must be appropriate for the intended user group. Specific benefits in crash reduction seen at one facility do not necessarily translate to another facility, so the selected strategy must account for the conditions unique to a particular facility.*[32]

Addressing crashes at access points of a managed lane facility, the FHWA publication notes that crashes at freeway access points are similar to crashes common to intersections of surface streets. This similarity derives from comparable operating circumstances, i.e., vehicles re-entering the freeway GP lanes are intersecting with an established stream of traffic. Likewise, vehicle operators at these intersections can be tentative or inappropriately enter the traffic stream, resulting in rear-end crashes. Thus, the issue of safety with regard to access points must be addressed in the same manner as other operational aspects of the vehicle operating environment, which is a normal and customary practice of transportation planners and highway engineers. Hence, it will be important that the following be the primary guide for understanding and mitigating the potential for access point crashes:

> *Traffic volumes, the type of access and separation provided, and proximity of managed lanes access to general-purpose entrance and exit ramps may all have an effect on crashes, and these effects may vary from one facility to another.*[33]

It seems important to reiterate in the discussion of overall facility safety that there two very different operational philosophies associated with unrestricted- and restricted-access with respect to managed lanes:

Unrestricted, or Continuous Access – Allowing open or continuous access is adopted with the intention of (1) providing greater convenience and flexibility of use by motorists throughout the day and (2) allowing drivers to address weaves and merges to the managed lane (normally, a HOV lane) in the same manner as operating within GP freeway lanes.

Restricted or Controlled Access – Controlling entry and exit of the managed lane facility generally has the intent of establishing conditions allowing implementation of a specific policy objective, such as tolling or addressing specific geometric or operational issues associated with the freeway. Restricted access also seeks to reduce unnecessary weaving and/or the frequency of weaving, discourage short distance trips in the managed lanes, and reduce opportunities for queue-jumping under congested conditions.

An important aspect of managed-lane facilities is accommodation of longer distance travel, essentially separating through traffic from more localized traffic that has become a common use of today's urban freeways. Some communities in Texas have, in fact, created separate, grade-separated express facilities parallel with GP freeway lanes with no exits for several miles to encourage commuters to leave the GP freeway lanes, which offer access to intermediate destinations.

The FHWA Handbook notes that the vast majority of managed-lane facilities operating today have been designed for and established within existing freeway corridors, often based on constrained design settings peculiar to the corridors.[34] As such, planning and development of the managed-lane projects have included difficult trade-offs and compromises. Still, it concludes, "since all have operated safely and perform reasonably well in meeting their stated operational objectives, there are few 'best practices' that are nationally transferable."[35] Even so, there is a reasonable body of knowledge upon which to draw in developing managed lanes, especially when managed lanes are proposed as a component of major corridor modifications and widening.

With direct reference to the safety of limited-access managed lanes, the FHWA Handbook suggests the speed differential between managed lanes and GP freeway lanes is the most important aspect to consider.[36] Guidelines for design and development have for many years advocated barrier separation as the safest operating configuration for concurrent traffic streams. Still, all other things being equal, barrier-separated managed lanes have not attained a better over safety record compared with non-separated facilities with lanes designated through pavement markings. Nevertheless, throughput, demand, and cost become factors when considering tolling and the need for barrier-separated facilities.

Continuous-access, concurrent managed lanes cannot safely support the speed differential relative to GP freeway lanes required to justify charging for use. The FHWA Handbook suggests 30 years of experience indicates this type of facility can only provide an average travel speed of 40 miles per hour compared to the typical 20 miles per hour for GP freeway lanes. Therefore, it states "physical separation may be preferable for facilities that incorporate tolling to ensure that violation levels are kept to a minimum and the integrity of the facility is maintained."[37] That is to say, pricing toll lanes needs to assure the purchaser that facility will deliver a high quality of service, i.e., the speed of travel and travel time more than competes with GP freeway lanes and the typical HOV lane.

As noted earlier, limited-access, managed-lane facilities commonly incorporate access spacing of two to three miles. The proposed action would provide considerably less flexibility, incorporating DHOV ramps at select locations, and only the potential for intermediate access points. The defined segments are several miles in length; therefore, there could be one of more access points within the segments. The important point is that the frequency of potential conflict points associated with the existing contiguous, continuous-access, concurrent HOV lanes would be reduced significantly by directing entrance into and exit from the limited-access managed lanes along extended lanes. This

[30] *Pennsylvania CMF Guide*, Gayah, et al, Department of Civil and Environmental Engineering, Pennsylvania State University, for PennDOT, August 2014.

[31] Ibid. pg. 4.

[32] *Safety Implications of Managed Lane Cross Sectional Elements*, Chapter2, Literature Review, Federal Highway Administration, FHWA-HOP-16-076, December 2016, pg 1.

[33] Ibid.

[34] Ibid. Section 8.0, Managed Lanes, pg 34.

[35] Ibid.

[36] Ibid. Section 8.0, Managed Lanes, pg 37.

[37] Section 8.0, Managed Lanes, Managed Lane Chapter for Freeway Management and Operations Handbook, FHWA, Updated Chapter, January 2011, pg 38.

would permit greater time, with adequate signage, for vehicle operators to gain access to the entrance lanes and merge back into the GP traffic lanes upon exiting the facility. In effect, at-grade entrance and exit slip ramps could be created, providing adequate time for transitioning from and reentering the GP freeway lane immediately adjacent the managed lane facility. This would aid in sustaining the speed of the managed lane facility and allow motorists more time to synchronize with the speed of the GP freeway lanes. Clearly, the matter of safety with regard to limited- or restricted-access managed-lane facilities depends largely on the design of the facility. There is now available ample guidance derived from the experience in many communities to aid in developing limited-access, managed-lane facilities that can be as safe or, potentially, safer than contiguous, continuous-access, concurrent managed lanes. Most studies conclude that barrier-separated managed lanes are safer than contiguous, continuous-access, concurrent managed lanes. Guidance from several studies suggest safety performance associated with limited-access, managed-lane facilities is most closely associated with access points. Therefore, entry and exit of the facility as well as adequate signage and lighting is of paramount importance. The speed differential, especially at facility exits, heightens the potential for vehicle conflicts and actions to mitigate the effect of this factor likely would reduce the potential for crashes.

4.0 CONCLUSIONS

The following guidance may be generally deduced from the information provided in this White Paper. The conclusions cited below, however, should not be construed to be recommendations for specific action, as there are many factors that still need to be considered with specific focus on the three segments of the Spine Corridor and the overall functioning of the corridor from Loop 101 to Loop 202.

There are no "overarching" reasons(s) for not adopting the limited-access, managed lanes solution. The objectives of the project are most important, and safety is one aspect of the project – an aspect that has not been definitively found to be better or worse with limited-access managed lanes. The statements below attempt to synthesize matters of apparent concern regarding implementation of a barrier-separated, limited-access, managed lane facility.

Will barrier-separated, limited-access, managed lanes result in greater person throughput, i.e., increase the capacity of the corridor?

The number of persons using the managed lanes and the volume of these vehicles results in greater passenger trips through in the corridor. Managed lanes generally are perceived as providing a faster, safer travel experience, due to the exclusivity of the facility and the reduction of friction caused by congested traffic conditions. Attracting (not diverting) motorists to the managed lanes relieves congestion in the GP freeway lanes, at least in the short-term. Some congestion may reappear in the GP freeway lanes, principally due to latent demand occupying space released by motorists opting for the managed lanes. In the long-term, more person throughput is achieved in the corridor, as motorists operating vehicles with more passengers per vehicle are motivated to use the managed lanes and motorists traveling on other routes (e.g., arterials) are motivated to take trips on the GP freeway lanes being viewed as less congested.

Will safety be enhanced or negatively impacted?

Different safety concerns are associated with the two different types of managed lanes: contiguous, continuous HOV lanes and barrier-separated, limited-access, managed lanes (i.e., HOV/HOT lanes). Limited-access managed lanes largely eliminate direct conflicts with GP freeway lanes; whereas, there are an infinite number of potential collision points associated with contiguous, continuous HOV lanes, as characterized by vehicles frequently transitioning between the HOV lanes and the GP freeway lanes. The managed lane facility generally will be less congested, devoid of lane weaving characteristics of the GP freeway lanes, and provide a safer operating environment. This aids in minimizing the potential for vehicle conflicts. Short of an extremely strong collision that would send a vehicle beyond the barrier, a managed lanes facilities poses no significantly greater safety risks to GP freeway lanes.

The level of safety in the corridor under both types ultimately is determined by the final design and operational configuration of the new combination of managed lanes and GP freeway lanes. That is to say, crashes will occur in the managed lanes, separated or not separated, and in the GP freeway lanes, because, in reality, all lanes are supporting the movement of traffic. Crashes not occurring within the managed lanes facility generally would be associated with the ingress and egress points, where weaving and merging would occur. However, ingress and egress slip ramps formed of the most inside lanes of the freeway would assist in transitions out of and into GP freeway lanes, reducing the potential for and severity of conflicts. Wide inside shoulders would enhance the safety for vehicles operating in both types of managed lanes, as the shoulders will provide a relatively safe location for emergency stopping, enforcement, and clearing of traffic incidents.

Will the managed lanes provide a reliable alternative to travel in the GP freeway lanes?

A primary objective of creating managed lanes is to provide users with a more reliable and expedient travel environment compared to congestion generally characterizing heavily traveled freeway corridors. If reliability and expediency of travel are considered more desirable than using congested GP freeway lanes, officials succeed in relieving pressure on the GP freeway lanes. Generally speaking, based on the large number of communities in the U.S. and outside the U.S., managed lanes are considered to be successful in increasing the carrying capacity of a corridor and a reasonably safe method of enhancing the degree of control over traffic flow in a corridor. Managed lanes which restrict entry and limit opportunities for exit, are considered more reliable than unrestricted HOV lanes, as traffic volume can be controlled and attention to the vagaries of congestion are less a factor for motorists. Contiguous, continuous, concurrent HOV lanes allow almost infinite opportunities for entry and exit through the length of the facilities. However, GP freeway lanes are susceptible to being bogged down easily and quickly in response to the slightest aberration in the flow (e.g., a tapped break, a motorist slowing to merge to another lane, a crash that affects all lanes), and this can directly impact flow in the HOV lanes.

Is time-of-day use of a limited access managed lanes facility an option?

The decision to have an operational managed lane generally would require creation of a limited-access facility. However, there are some recent cases in which greater, even continuous, access has been adopted for managed lane operations in particular. HOV lanes generally have been used to accommodate peak-period travel, and setting the number of persons required in a vehicle to allow use of an HOV lane is a form of traffic management asserted by the community. HOT lanes provide a more nuanced approach to traffic management in that the price for accessing/using HOT lanes can be modified, as necessary, to minimize congestion within the HOT lane facility and optimize operations in the corridor overall. This usually requires full control of the facility throughout the day and assures motorists engaged in longer trips reliable and expedient travel. At times, these lanes will be underutilized, but a primary focus is to assure availability of the facility, minimize the number of access points, and reduce confusion regarding use.

How many access points would be appropriate?

This White Paper cannot purport to establish the frequency or location of access points. This matter must be determined after consideration of numerous physical, operational, and community factors, including, but not limited to:

- Traffic volumes along the Spine Corridor – access points are best located where heavy traffic volumes or hazardous traffic conditions (e.g., curve) are not present;
- Superelevation – Horizontal curvature is particularly critical, due to line-of-sight restrictions (vertical curvature is not as important, but still is a factor to consider);
- Locations of origins and destinations – Mostly oriented to support commutes to Central Business Districts (CBDs) or other employment or activity centers/concentrations;
- Limited access, managed lanes serve to support direct travel between key destinations and providing intermediate access must weigh the level of demand at proposed locations against the potential effects on the operational reliability of the facility;
- Access for response to incidents – Emergency stopping and crashes will occur within a limited-access facility, requiring access by emergency vehicles, which may require additional restricted access points to assure timely response from appropriate entities;
- Pricing decisions – Pricing according to distance traveled typically is associated with tolled facilities, and additional access points will require more complex pricing formulas, more complex ETC equipment and arrangement, alteration of pricing decisions aimed at controlling traffic volume within the facility.

ATTACHMENT A

REVIEW/SUMMARY OF KEY SAFETY POINTS IN SELECTED LITERATURE

REVIEW/SUMMARY OF KEY SAFETY POINTS IN SELECTED LITERATURE

HIGH-OCCUPANCY VEHICLE (HOV) LANES (2017)

["High-Occupancy Vehicle (HOV) Lanes," Ontario Ministry of Transportation at *http://www.mto.gov.on.ca/english/ontario-511/hov-lanes.shtml*, retrieved 03/09/17]

A striped buffer zone is intend to maintain separation of vehicles in HOV lanes from vehicles in the GP freeway lanes. Barrier-separated HOV facilities require additional right-of-way or result in reduction in the widths of highway shoulders, enforcement areas, and travel lanes. A painted buffer is more flexible than a fixed, physical barrier and permits a greater number of ingress/egress locations. The buffered HOV facility is more convenient for motorists in that all freeway exits are accessible. Also, a painted buffer can be more quickly adjusted to respond to changes in traffic patterns and volumes.

Ontario's HOV lanes include a striped buffer to separate the HOV lane from the GP freeway lanes. A left shoulder is included for optimum safety. The Ministry determined that poor safety records of some HOV facilities in other jurisdictions had resulted from adding an HOV lane where: (1) the existing roadway could not accommodate the desired buffer zone, (2) GP freeway lanes could not be maintained with adequate widths for the all other traffic, and (3) the width of the left shoulder of the HOV lane, available for emergency and enforcement, was inadequate. These deficiencies resulted in a greater likelihood of collisions and reduced driver maneuverability. Therefore, HOV lanes have been established on existing highways through widening projects, instead of converting existing lanes or shoulders to accommodate the special use of an HOV lane.

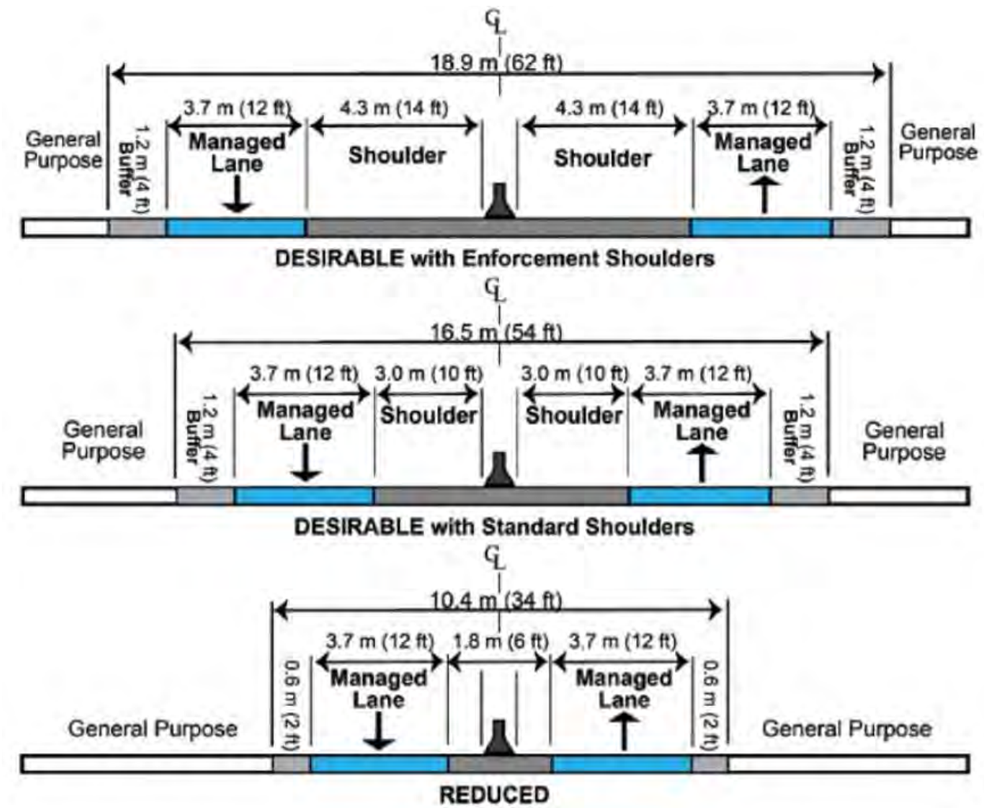
DESIGN OF TOLLED OR PRICED MANAGED LANES (2017)

[*Priced Managed Lane Guide*, Chapter 6. Design, Tolling and Pricing Program, Federal Highway Administration at https://ops.fhwa.dot.gov/publications/fhwahop13007/pmlg6_0.htm.]

The initial statement in this Guide is: "Design considerations for priced managed lanes will inevitably be driven by the corridors in which they are located." The upshot of this statement is that design will differ in accordance with characteristics of the highway corridor, available (and potential future) right-of-way, and previously adopted operational rules and requirements. A key aspect of managed lanes is that they represent a separated roadway system, and a safety analysis may be required to understand the ramifications of design requirements, operational needs, traffic volume levels, and access locations. This Guide identifies basic cross-sections for different configurations of managed lanes facilities, recognizing that adopting "desirable elements" may not work in every case. The Guide attempts to provide attributes of facility design that "bracket" potential desirable and "reduced elements" that may be required under constrained conditions. **Figure 1** depicts how this "bracketing" affects the facility cross-section.

With regard to access, the Guide recognizes this aspect of managed lanes as "a fundamental issue" associated with the design and operation of this type facility. Different levels of access control must be evaluated, especially trade-offs associated with cost, operational goals, safety, and enforcement. The Guide identifies three forms of access to managed lanes: continuous (e.g., current approach of HOV lanes in Phoenix metropolitan area); restricted (or limited), at-grade access; and grade-separated access, such as the Direct HOV (DHOV) connecting ramps being proposed for the Spine Corridor. The Guide also notes that there has been recent interest in providing continuous access to priced managed lanes, but this has implications for the number of tolling points, electronic toll collection (ETC) network, and enforcement. At-grade

Figure 4 | Alternative Managed Lane Cross-Sections for a Dual-Lane, Concurrent-Flow Facility



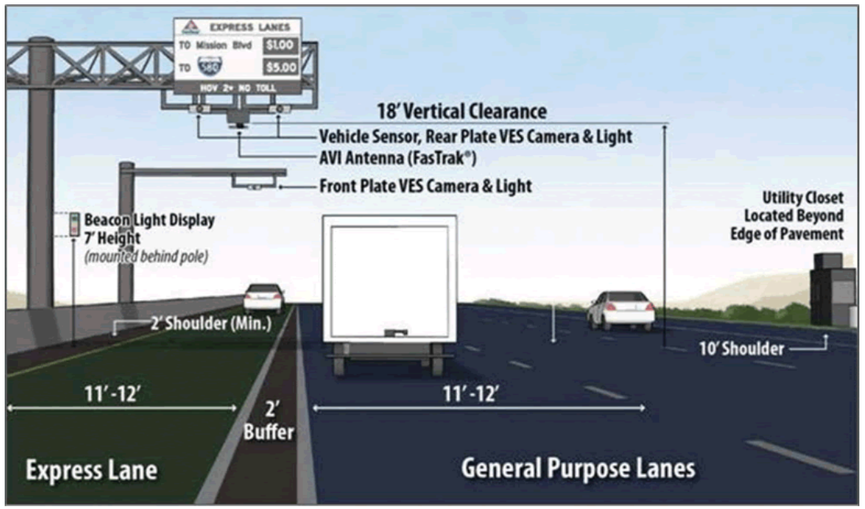
access, continuous and restricted, must consider existing and planned roadway geometrics and expected volumes associated with both the managed lane facility and GP freeway lanes.

> *In all cases, openings should be located and designed in a way that will not produce adverse impacts to the managed lanes and the parallel highway lanes. The locations of at-grade access openings need to be closely coordinated with highway entrance and exit ramps and allow adequate room for motorists to complete weaving movements when moving between the general-purpose and managed lanes and an entrance or exit ramp.*

The Guide addresses the various separation treatments available to control access; controlling access and separation are, in fact, the dominant considerations relating to managed lanes. Three forms or type of separation are distinguished: concrete barrier, pylons (or flexible posts), and striped buffers. All permit at-grade access. Modern tolling capabilities have allowed some communities to permit open access to priced managed lanes, meaning the separation does not require the fixed concrete barrier to enforce use of the lane(s). The ETC systems allow traffic to flow without stopping at a toll booth, and some facilities incorporate photo-enforcement systems to reduce the chance of missed vehicles. While it is relatively easy to understand how these systems would work in the closed environment of a limited-access managed lanes facility, it is less easy to understand how dynamic tolling occurs with a continuous-access facility. Nevertheless, as complicated as it may seem, the systems can identify vehicles, process toll transactions, identify and photograph license plates of potential violators, and inform enforcement personnel as

to account status through strategically placed beacons. An example of a managed lane toll zone design in provided in **Figure 2**.

Figure 5 | Typical Design of a Continuous-Access, Managed-Lane Toll Zone



Source: *Figure 6-18, Typical Managed Lane Toll Zone Design*, Parsons Brinckerhoff, extracted from *Priced Managed Lane Guide*, Chapter 6. Design, Tolling and Pricing Program, Federal Highway Administration at https://ops.fhwa.dot.gov/publications/fhwahop13007/pmlg6_0.htm.]

Methods for Controlling HOV Lanes (2017)

[*Boston I-93 HOV Lane, A 10-Year "Temporary" Solution for Congestion Management Turns 20*, Road Zipper, Lindsay Transportation Solutions; and Road Zipper In The News, Lindsay Corporation at *http://www.barriersystemsinc.com/in-the-news-1* retrieved 3/14/2017]

As early as the 1970s, Boston began experimenting with design of and access to general-purpose (GP) freeway lanes converted to high-occupancy vehicle (HOV) lanes. Two early attempts were rejected, due to safety and political issues. In need of relieve of severe congestion on I-93 (Southeast Expressway) in the early 1990s, the Massachusetts Department of Transportation (MassDOT) adopted an interim (10-year) solution: a moveable barrier system. More than 25 years later, the interim solution has become a permanent solution. A movable barrier system, termed the Road Zipper, has proven to provide safety between opposing traffic flows and has been demonstrated to be the best alternative. MassDOT recently opted to reinvest in the Road Zipper rather than spend hundreds of millions, even billions, of dollars on a freeway widening project. This same system is operating, among other locations, in San Diego, CA, San Francisco, CA, Indianapolis, IN, Philadelphia, PA, Leicester, GB, Auckland, NZ, as well as Austria and Japan.

Guidance on High Occupancy Vehicles (HOV) Lanes (2016)

[Chapter V. Strategies to Reduce Congestion and Improve Air Quality, Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes, Freeway Management Program, Federal Highway Administration, September 2016, at *https://ops.fhwa.dot.gov/freewaymgmt/hovguidance/chapter5.htm*.]

This publication of the FHWA asserts "congestion pricing dampens demand for roads during peak hours and spreads usage over a longer time period. Differentiating the price of a good by the time of day effectively allocates limited capacity during periods of higher demand." HOV and high-occupancy toll (HOT) lanes are a cost-effective investment that can reduce congestion, but, also, "positively influence the mobility, safety and productivity of multimodal facilities, corridors, and metropolitan transportation systems." This publication makes a case for converting HOV lanes to HOT lanes, allowing motorists to opt for increased trip reliability for a price, i.e., payment of a toll. Because roadway capacity essential is being offered as a commodity for purchase, the quality of travel in the HOT lane must be monitored to assure speed is maintain and congestion within the facility is controlled.

The theory or philosophy of HOT lanes is that these facilities allow transportation officials to optimize vehicle throughput, drawing off some of the traffic in the GP freeway lanes, specifically single-occupancy vehicles (SOVs) that would otherwise be operating in the congested lanes. So, HOVs are no worse off in an HOV/HOT facility, and ineligible vehicles not meeting the minimum vehicle occupancy requirement, are better off paying to use the HOT lane. At the same time, vehicles operating in the GP freeway lanes also are better off, as some traffic has been diverted to the HOV/HOT facility.

This FHWA Guidance encourages development and use of HOV/HOT lane facility provided the performance of the HOV lane continues to meet specified performance standards. Conversion of HOV lanes to HOV/HOT lanes is encouraged where there is underutilization HOV lanes and the GP freeway lanes are experiencing congestion. Operation of a HOT lane requires, by Federal statute – "automatic tolling; dynamic tolls that vary with the level of congestion (i.e., responsive to real-time traffic conditions); adequate enforcement; and ongoing performance monitoring, evaluation, reporting, and modification of operations, when approaching degraded conditions." Changing HOT lanes pricing and vehicle occupancy requirement for HOV lanes is expected to assure facility performance should travel conditions degrade.

Key Points Regarding HOV Lanes (2017)

[*Summary of Key Points RE: HOV lns*, "Frequently Asked HOV Questions at FHWA Freeway Management Program Web site, https://ops.fhwa.dot.gov/freewaymgmt/faq.htm, retrieved 2017]

Regarding the safety record of HOV lanes – "Studies have shown that HOV lanes are frequently as safe as, and in many cases safer than, unrestricted freeway lanes. The safest HOV lanes are those that are physically separated from the adjacent lanes with a concrete barrier, but that would be the case for general purpose lanes too."

Safety and Managed Lanes Cross-Sections (2016)

[*Safety Implications of Managed Lane Cross Sectional Elements*, Battelle and Texas A&M Transportation Institute for USDOT, FHWA-HOP-16-076, December 2016]

This study investigates how crashes are related to the dimensions of buffer-separated, managed-lane facilities. It leads off with a dual premise derived from previous studies that (1) reduced widths (lane and shoulder) are associated with more crashes, and (2) wider facilities envelopes result in fewer freeway crashes in terms of severity of the crash and severity of resulting fatalities and injuries. The analysis only investigated separated, single-lane, managed-lane facilities that did not require weaving maneuvers for ingress or egress and were operational 24 hours per day, seven days a week.

The data employed for this investigation included 128.0 miles of highway in California with flush buffers (no physical object, such as pylons) and 60.4 miles in Texas with 18.7 miles having flush buffers and 40.7 miles having pylon buffers. California data was for years 2007 through 2011 and Texas crash data was for years 2009 to 2014. The conclusions drawn from this study are:

- Wider facility envelopes are associated with reduce crashes on freeways at all severity levels and all fatal and injury severity levels –
  - Texas – wider envelopes result in 2.8 percent fewer total freeway crashes (all severities) for each additional foot of envelope width;

California – wider envelopes result in 2.0 percent fewer total freeway crashes (all severities) for each additional foot of envelope width; and

California – wider envelopes result in 4.4 percent fewer managed lane-related crashes (fatal and injury severity levels) for each additional foot of envelope width.

The width of the left (inside) shoulder of the HOV facility was significant for all severity levels, meaning greater safety benefit is derived from greater width of the shoulder.

Other factors were demonstrated to be significant in explaining the occurrence of managed lane-related crashes:

Decrease in crashes in the managed-lane facility with increasing volume in the GP lanes;

Increase with increasing volume in the managed lane;

Decrease with increasing managed lane width;

Decrease with increasing buffer width; and

Increase with increasing number of entrance ramps or access points.

The overall assessment resulted in the conclusion that lane width is the most influential predictor of safety, i.e., crash occurrence, followed by the width of the buffer. Findings and conclusions are summed thusly:

Results from several previous research studies have demonstrated that reductions in freeway lane width or shoulder width are associated with more crashes. Safety prediction equations are available to evaluate the tradeoffs.

Results from this study, along with other studies, also found that reductions in managed lane envelope widths (shoulder, lane, and buffer width) are associated with more crashes.

This study also found that narrow buffer widths (defined as being equal to and less than 3 ft) appear to be associated with more crashes as compared to 4-ft to 6-ft buffers.

Crash Prediction Methodology (2015)

[*Crash Prediction Method for Freeway Facilities with High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) Lanes*, Final Report, FDOT, Contract BDV32-977-04, August 2015]

This study focused on developing a crash prediction methodology to support evaluation of HOV or HOT lane projects on urban freeway segments. Specifically, safety performance analyses primarily emphasized potential impacts associated with different types of separation between managed lanes and GP lanes. Modeling methods for HOV lanes relied on five years of data available from California, Washington, and Florida, and estimates were developed for the occurrence of fatal and injury (FI) crashes and all crashes. All of the HOV facilities include one HOV lane in each direction.

The model development activity also focused on freeways with HOT lanes, relying on data available for a four-year period. The HOT lane facilities modeling exercise included 48 segment on 27 miles of freeways, also in California, Washington, and Florida. All facilities investigated include two HOT lanes in each direction. Interestingly, safety performance revealed though this effort indicates spatial separation is a key factor with respect to the occurrence of crashes. "Facilities with a 1-foot separation are estimated to have more crashes than those that have a 3-foot separation which in turn have more crashes than facilities with a 20-foot separation" (all other things being equal).

"The effect of separation type on crash rates [was] found to be statistically significant only in the models for ten-lane facilities." The FDOT team developed separate equations to reflect six-, eight-, ten-, and twelve-lane facilities. The modeling effort was undertaken, in part, due to the lack of a methodology for predicting crashes and safety benefits associated with freeway facilities with managed lanes. The focus of the models is the type of separation between managed lanes and GP freeway lanes. FDOT presents models to estimate fatal and injury (FI) crashes and all crashes, including injury severity levels of 'K', 'A', 'B', and 'C'. The "All Crashes" category includes the FI crashes and property damage only. The models are developed in a spreadsheet platform.

Findings Relative to Freeway with HOV Lanes:

Crashes on freeways with HOV lanes increase with increase in traffic volume (AADT) and segment length (measured in miles).

Overall, separation type impacts the number of crashes on ten-lane facilities.

Using a buffer instead of a painted stripe will lead to fewer total crashes on 10-lane freeways; however, increasing the width of the buffer will not reduce total crashes.

A wider buffer (2-3 feet) leads to fewer fatal and injury crashes.

Differences in separation type are not statistically significant in the case of six, eight, and twelve-lane facilities.

Increasing the width of the left shoulder (measured in feet) results in a decrease in the number of crashes for all cross-sections modeled, except the twelve-lane facility.

Findings Relative to Freeway with HOT Lanes:

As noted above, model estimates indicate a 1-foot separation will have more crashes than a 3-foot separation and an especially wide 20-foot separation (the Dallas, TX, facility has both a left shoulder for the general purpose freeway lanes and a right shoulder for the HOT lanes).

Not surprisingly, the occurrence of crashes increases with increases in traffic volume, measured as average annual daily traffic (AADT).

Safety As A Planning Criterion (2015)

[High-Occupancy Vehicle Facilities, Chapter 1410, WSDOT Design Manual, Nov 2015]

Safe, efficient, and enforceable operations are considered one of six planning elements for evaluating appropriate design options for a HOV facility. The Manual recognizes that a separated facility, although the most expensive option, is "normally" more efficient and provides a higher level of safety compared to non-separated facilities.

Managed Lane Separation Treatments (2012)

["Managed Lane Separation Treatment," *Managed Lanes Network Development Strategy – Phase I*, Maricopa Association of Governments, February 2012]

This White Paper looks at three approaches for separating managed lanes from adjacent GP lanes:

Painted line and painted buffer barrier;

Traffic channelizer with physical (flexible post or pylon) or painted barrier; and

Physical barrier.

The assumption for each is "restricted access," meaning the highest level of separation – physical barrier – is the standard for evaluating performance.

The painted line or buffer separation treatments support continuous access (ingress and egress) along the length of the HOV facility. Current guidance in the Manual on Uniform Traffic Control Devices (MUTCD) recognizes "concurrent" operations of an HOV facility without unlimited continuous access. Solid white lines (single or double) are intended to discouraged access movements, and broken or dashed white lines (single or double) are intended to identify locations where access is permitted. This MUTCD guidance is aimed at minimizing the frequency and randomness of access movements to reduce opportunities for conflicts between the HOV facility traffic and traffic operating in the GP freeway lanes.

The channelizer treatment involves installation of brightly colored, 42-inch tall, reflective posts aligned to guide traffic into and out of the HOV facility and establish a more visible barrier between the HOV facility and GP freeway lanes. Channelizers typically are flexible and permanently affixed to the pavement at 12-foot intervals as well as centered within a striped buffer zone. Channelizers are more permanent than pylons, which can be sent flying, if a motorist

opts to exit or enter the HOV facility where the pylons are present. Even so, inadvertent vehicular impacts can damage the post-type channelizers, requiring, according to the White Paper, "roughly 1/3" to be replaced annually.

The White Paper states physical barrier separation is preferred when opposing traffic flows could create direct conflicts. A physical barrier also may be appropriate in concurrent flow cases, where the objective is to maximize the speed differential between the HOV facility and the adjacent GP freeway lanes. Vehicle operators desiring to use the HOV facility are permitted to enter and exit only at certain points; therefore, traffic operating within the HOV facility effectively is contained or restricted within the barrier. Accordingly, there is a need within the HOV facility for a shoulder (typically 10 feet wide) to accommodate emergency breakdowns and permit maneuvering, if necessary, to avoid other vehicles. These requirements impose greater requirements for right-of-way. A dual-lane HOV facility, in effect, offers the second lane as an emergency area, if necessary, which can make the widths and right-of-way requirements of the single-lane with shoulder and dual-lane facilities similar.

The White Paper address four issues determined to influence the lane separation decision: Safety, Traffic and HOT Lane Operations, Enforcement, and Emergency Access. Significantly, the White Paper, prepared as recently as 2012, notes the "no national study has been undertaken, and no database exists, from which specific causal factors associated with separation treatments could be isolated." Some local studies have been conducted and some observations can be noted relative to restricted access studies in California and Texas. The White Paper presents the following observations:

- Safety
  - Assuming all other factors to be equal (e.g., mix and density of traffic, roadway geometrics, access locations, etc.), barrier separation is safer than non-separated treatments.
  - There tends to be a greater number of crashes at entrance locations to concurrent, barrier-separated HOV facilities, where barrier attenuators (i.e., crash cushions) are installed.
  - Channelizers present a readily visible barrier and help reduce the occurrence of deliberate buffer crossing, but do not mitigate the potential impacts of crashes within the HOV facility or crashes that cross over the flexible barrier with from or into the HOV facility.
  - Buffer-separated HOV facilities aid in reducing crashes, if the buffer area is sufficiently wide (4-foot preferred) to allow diversionary vehicle movements, but not wide enough to be perceived as a place of refuge for stalled or disable vehicles.
  - The safety associated with all treatments, in terms of both crash occurrence and severity, is influenced by the length and location of access locations and the speed and density of traffic streams. The White Paper notes that crash data from Dallas experience indicates a higher crash rate and greater severity per incident is associated with the speed differential between the HOV facility and GP freeway lanes and difficulty of entering and exiting the HOV facility.
  - A single-lane HOV facility lacking an inside shoulder limits opportunities for diversionary actions by motorists in the lane and increases the risks of crash occurrence.
  - The use of channelizers, which have a greater requirements for continual maintenance relative to painted lines, painted buffers, and physical barriers, compounds safety issues associated with traffic streams with the presence of maintenance personnel and equipment.
- Traffic and HOT Lane Operations
  - Operational and safety issues associated with ingress/egress locations and tolling sites of HOT Lanes are similar to HOV lanes.
  - The White Paper suggests that "…barrier treatments offer motorists greater confidence that an incident in adjacent lanes [HOV/HOT or GP freeway lanes) will not affect them."
- Enforcement
  - Painted and buffer-delimited managed lanes typically have greater violations of operational criteria than barrier-separated HOV or HOT facilities.
  - Painted and buffer-delimited managed lanes generally are more difficult to enforce, as motorists can more easily move from the dedicated facility and the GP freeway lanes.
  - Automated tolling with transponders and pay-by-mail methods replace physical roadway enforcement with other administrative enforcement methods, reducing exposure of both motorists and enforcement personnel to traffic streams.
- Emergency Access
  - Barrier-separated HOV/HOT managed-lane facilities increase the difficulty of providing quick response to and clearing of travel disruptions, which can be mitigated by the presence of a wide shoulder or a second travel lane.
  - Concurrent, painted and buffer-delimited facilities allow emergency vehicles to access affected lane(s) of a HOV/HOT managed-lane facility, even crossing channelizers, if necessary.
  - Critical questions to be addressed regarding emergency access are: expected frequency of incidents; desired response time; availability of access to the affected lane(s); presence of bypass shoulder or lanes for use by emergency vehicles; and costs associate with providing policy-level access relative to the safety of motorists and emergency personnel.

The White Paper concludes that available information indicates very few concurrent flow HOV/HOT managed-lane facilities are barrier-separated. It notes the degree of safety varies among the separation treatments investigated, and no national study nor does any database exist to provide specific causal factors by treatment. Only generalized inferences may be drawn from available information and published literature. However, a consensus exists that, all things being equal, barrier separation is safer than non-barrier treatments, specifically painted and buffer-delimited treatments. But, the White Paper is quick to point out that both treatments "…are safe, approved, time tested methods of separation for concurrent flow lane applications by FHWA and all of the Departments of Transportation across the United States."

California's Managed Lane Design Policy (2012)

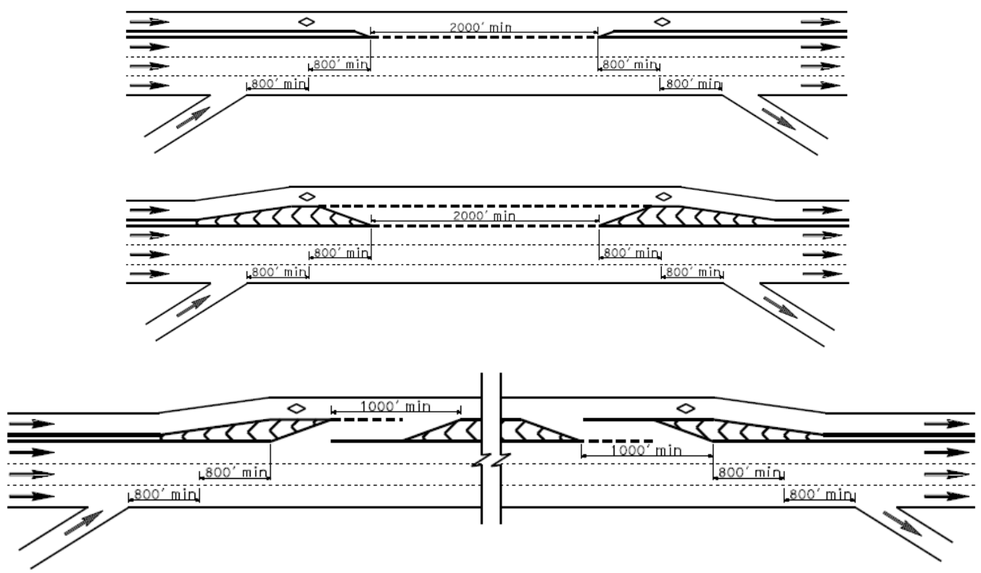
[*California's Managed Lane Design Policy*, Joe Rouse, Caltrans Division of Traffic Operations, Office of System Management Operations; PPT Presentation, July 2010]

This presentation by a Caltrans official discusses a policy directive to guide "Intermediate Access" design of the State's HOV network and conduct of operational analyses. He identifies three types of Intermediate Access:

- Weave Zone – Combined ingress/egress [with no weaving lane]
- Weave Zone – Combined ingress/egress with a weaving lane
- Merge Lane – An ingress or an egress location with a merging lane.

Three cross-sections were presented for each of these conditions, as shown in **Figure 3**. It was noted that operating performance of Intermediate Access "openings" should be level of service (LOS) 'C' or 'D', and should not be co-located with an area of recurrent congestion (existing or expected). Design guidelines for Intermediate Access locations were established at "800 feet per lane change between opening and adjacent ramp" and openings should be 2,000 feet in length. Lighting would be necessary at all Intermediate Access locations and recommended for areas where major weaving would take place.

Figure 6 | California Managed Lane Access Design Policy Cross-Sections



The new policy will be applied to all managed-lane projects during the environmental phase. Analyses will focus on assuring the revised facility configuration will meet operational thresholds and include evaluation of: freeway mainline flow, merge/diverge analysis of drop ramps/direct connectors, and assessment of ingress/egress at access locations. Safety analyses will be performed to ensure design and operation of HOV/HOT managed lane facilities does not create new safety "hot spots" or increase the potential for crashes, particularly crashes resulting in severe or serious injuries. The design under discussion would permit direct ingress/egress at access locations and would supplant the use of solid yellow lines with solid white lines.

FEDERAL HOV GUIDANCE (2012)

[Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes, Freeway Management Program, FHWA, November 2012, at https://ops.fhwa.dot.gov/freewaymgmt/hovguidance/]

This document presents guidance that applies to all federally-funded, HOV facilities, superseding previous versions issued in August, 2008. The document provides information to aid States in the planning, design, operation, and management of HOV and HOT facilities. The Guidance is non-binding and provides examples for States to follow in the process of defining and evaluating proposed changes to HOV lane operations, including proposals to convert an existing HOV lane to a HOT lane. The Guidance specifically states:

> *In locations where existing or anticipated excess HOV lane capacity is available, conversion to a HOT lane facility is encouraged as a way to increase throughput and to provide additional travel options for drivers. As part of an overall approach to respond to increased travel demand and address traffic congestion, HOV and HOT lanes can be a practical alternative to adding more general-purpose travel lanes. The FHWA encourages the implementation of HOV or HOT lanes as an important part of an area-wide approach to help metropolitan areas address their requirements for improved mobility, safety, and productivity, while also being sensitive to environmental and quality of life issues.*

MANAGED LANES HANDBOOK

[8.0 Managed Lanes, Updated Chapter – Managed Lanes Chapter for the Freeway Management and Operations Handbook, Federal Highway Administration, January 2011, at https://ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook/toc.htm]

This FHWA publication states that one commonality among all managed lane facilities is "…active demand and system management." This chapter of the Handbook focuses on the latest practices, strategies, and technologies associated with the implementation and operation of managed lane facilities. Six primary goals are identified for implementing managed lanes: improve traffic operations, facilitate movement of people and goods, enhance performance and efficiency, promote air quality goals, improve safety, and address return on investment. The reason for implementing managed lanes is "…to preserve a reliable trip that is viewed as a preferable alternative over congestion that exists in the general purpose lanes."

Implementation, however, should be intended as a complement to a comprehensive congestion management program that may include, but not be limited to: "…ramp metering, incident management, traffic demand management (TDM) such as rideshare promotion, and associated programs that are both complementary and synergistic to overall regional mobility goals." The Handbook points out that, although managed lanes may be moving more people, the public perception of the lanes may be that there is active capacity that should be used. This phenomenon requires ongoing education and outreach to inform the public of the utility of managed lanes, which can be support by performance monitoring.

Grade-Separated, Direct HOV (DHOV) Access at Maryland Avenue on Loop 101 (Agua Fria Freeway)

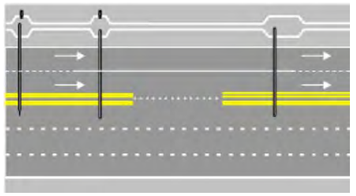
Regarding access, the Handbook notes that limitations on access to managed lanes establishes an operating environment with minimal disruptive impacts facility. It associated with vehicles entering and exiting the also is noted that the facilities reduce side friction multiple associated with concurrent travel of vehicles in or both) lanes. Typically, barrier-separated facilities (HOV, HOT, are accessed via grade-separated ramps referred to as Median Drop Ramps or Direct HOV (DHOV) Ramps. These access treatments generally connect with park-and-ride (P&R) lots, transit centers, and crossing arterial streets. This adds to the safety and expediency of travel associated with the managed lanes and aids in developing a regionally connected system of managed lanes.

The Handbook presents a section specifically addressing access treatments, specifically noting that access treatments "…impact the operation characteristics of a managed lane facility." Most access on restricted (i.e., limited access), concurrent lanes is spaced less frequently than access provided for the GP freeway lanes via on- and off-ramps, and the most common access treatment is at-grade at designated locations or an opening along an inside lane. The Handbook points out that "access spacing of two to three miles is common for most restricted access treatments." It describes five types of access treatments:

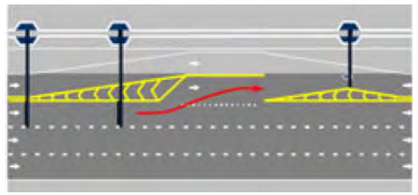
- **Open** – Open or continuous access is the most common treatment, which allows entry into and exit from the managed lane practically anywhere along its length; this treatment is not an effective access protocol for segment-based tolling.
- **Zones** – Access zones (or weave/merge zones) are associated with a large number of concurrent-flow facilities. This treatment establishes specific zones, using signage and pavement markings, to regulate entry into and exit from the facility. Zones must be at least 1,000 feet in length – preferably 2,000 feet – with a minimum of 600 to 800 feet between entry/exit and the on- and off-ramps providing access to the GP freeway lanes to

facilitate weaving/merging. This type of treatment creates a zone of simultaneous ingress and egress movements similar to continuous-access, concurrent managed lanes (e.g., Phoenix metropolitan area HOV lanes), but only at certain predetermined locations.

Designated Access Zone for Ingress and Egress



Designated Ingress Zone with Slip Ramp to Managed Lane



Source: Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes, Freeway Management Program, FHWA, November 2012, at https://ops.fhwa.dot.gov/freewaymgmt/hovguidance/

Slip Ramps – At-grade ramps provide access to the managed lanes when separated from the GP freeway lanes by a barrier, physical structure or painted buffer. The ramps facilitate one-way ingress and egress and reduce friction associated with weave/merge movements directly impacting the left-most GP freeway lane.

Median Drop Ramps – Otherwise reference as DHOV ramps, these establish discrete points of ingress and egress (see DHOV discussion above).

Direct Freeway-to-Freeway Connection – This access treatment is warranted when there is a high volume of traffic anticipated between one facility and another. It is not immediately relevant to the access issues associated with the proposed dual managed lanes in the Spine Corridor.

Determining the best operational scenario for managed lanes requires an assessment of a number of factors. Information in the Handbook indicates the continuous entry/exit HOV lanes, such as are established in the Spine Corridor, are appropriate, as they serve GP freeway traffic. The Handbook points out that, historically, "…about 60 percent of HOV lane-miles in the US have been unrestricted or open access, and the other 40 percent have restricted access to designated weave zones largely through pavement markings." Both types of access can be safe and function well, according to various studies. Transportation officials in southern California are moving toward lifting access restrictions on some managed lanes. Open access is being justified on the benefits of allowing greater flexibility in use of the managed lanes and essentially spreading weaves and merges along the path of the facilities rather than focusing such movements at ingress and egress locations. On the other hand, the addition of tolling of other HOV lanes "…is creating the need to restrict access between toll zones." Tolling is more problematic and complex, if access is not controlled and limited to certain locations. Access restrictions are justified by the desire or need to: control ingress and egress at designated locations; reduce unnecessary or provide better direction to weaving and merging; discouraging short-distance trips from using the lanes; and limiting violations by queue jumpers.

Effective enforcement actions and operating policies are necessary to assure adherence to access, eligibility, and pricing restrictions of managed lanes. Tolling is considered a form of enforcement, but it also allows for the control of volume of travel through the corridor and, therefore, aids transportation officials in optimizing corridor operations. With regard to HOV lane operations, no technology exists that can definitively determine and communicate in real-time the number of occupants in a vehicle that is accepted by police organizations or the courts. Concurrent-flow, continuous HOV facilities are particularly difficult to enforce, because motorists can freely enter and exit at any point to avoid detection. Barrier-separated facilities present more of a deterrent to violators, as they must be willing to travel longer distances in violation of established restrictions. Enforcement activities can be strategically positioned just inside the ingress point or immediately outside the egress point. Ultimately, various strategies to address enforcement roles need to be evaluated to account for the respective business rules, police agency preferences, and facility design that can accommodate the requirements for enforcement.

Current Industry Trends for Separating Express Lanes from General Purpose Lanes

[White Paper, Current Industry Trends for Separating Express Lanes from General Purpose Lanes, AtkinsGlobal.com, September 2011]

This White Paper was prepared to address the advantages, disadvantages, and impacts of lane separation techniques relative to managed lanes. It highlights six key factors to consider when selecting the type of separation to be deployed.

Safety – The White Paper points out that studies show the barrier-separated systems are the safest. Nevertheless, this separation technique presents a concern relating to incident response, due to limited access points. Also, fixed barriers are viewed as potential unforgiving at contact, and designs may not give motorists adequate time to correct or modify an operating error.

Right-of-Way – Space requirements typically are greater where access points to/from are established. Design at access points needs to carefully consider the weave and merge requirements of ingress/egress actions between the express lanes and GP freeway lanes. Constrained rights-of-way may require certain or site-specific types of separation requiring design modifications of the adopted cross-section and waiver of standards.

Cost – Permanent barriers are the most expensive type of separation; pavement markings are the least expensive. However, pavement markings and post/pylons, when adopted as separation techniques, have greater maintenance/replacement requirements that adds to long-term costs. Flexible/tubular delineators, such as post/pylons, require the greatest amount of attention/maintenance tend and represent a greater hazard to traffic, as they can be dislodged by errant vehicles.

Roadway Design Characteristics – Four potential design schemes are identified: reversible lanes, lanes operated to accommodate peak direction traffic always requiring barriers; concurrent flow, lanes operated in the same direction as GP freeway lanes, most common; elevated, lanes are grade-separated eliminating potential conflicts except at access points; and mixed mode, lanes operated as HOV or tolled (HOT) that are open to GP traffic on off-peak hours. The latter HOV/HOT mixed mode scenario is no very common and is viewed at potentially confusing for motorists.

Operational Characteristics – Four potential operational scenarios are identified that impose restrictions or requirements to control traffic: vehicle occupancy, which requires physical/visual enforcement and may affect the type of separation deployed; vehicle type, which affects the ultimate footprint of the facility; dynamic price tolling, which requires constant monitoring to control volume of traffic and can easily be violated without proper separation; and time-of-day tolling, which controls access by time of entry, but lacks control on traffic volume associated with dynamic price tolling.

Access Points - The selected separation technique must consider type of access and the number of access points, i.e., multiple access points, minimal access points, or direct access at crossroads to/from the GP freeway lanes. Access directly affects interaction between vehicles using the managed lanes and vehicles operating in the GP freeway lanes, specifically weaving and merging dynamic. The type of access also affects the design and geometrics of the facility; barriers require crash attenuators at ingress ends, but flexible delineators (e.g., post and pylons) and pavement markings are more forgiving.

Emerging Issues: Barrier versus Buffer Separated Managed Lanes (2010)

[Technical Memorandum 17B: Advantages and Disadvantages of Barrier versus Buffer Separated Managed Lanes, Atlanta Regional Managed Lane System Plan, Georgia Department of Transportation, January 2010]

This White Paper explored the advantages and disadvantages separating managed lanes from GP freeway lanes by means of a barrier or buffer system. Factors identified as contributing to the selection of a barrier or buffer system included: design, cost, access, safety, tolling/congestion pricing operations, enforcement, and public perception. The advantages and disadvantages are discussed in the White Paper, and a two decision matrices prepared addressing: public perceptions of pavement markings used for buffer-separated facilities, concrete barrier, pylons, and grade separation; and the factors noted above relative to buffer-separated facilities and barrier-separated facilities. Some key points made in this White Paper relative to safety, access, and enforcement are excerpted below:

Safety –

- **Buffer System** – The buffer-managed lanes system is either found less safe, due to the potential accidents caused by concurrent speed variations, or equally safe as barrier systems. Accident hot spots along managed lanes corridors are generally a result of congestion and not specifically the design or operation of the facility itself.
- **Barrier-Separated** – A benefit for barrier separated systems is that accidents in the GP freeway lanes do not generally affect operations or safety within their isolated system. Buffer systems, on the other hand, are directly impacted by accidents [and speed variations] in the GP freeway lanes, often reducing flow to a rate similar to the directly affected lanes.

Access –

- **Buffer System** - Both barrier and buffer systems vary in their ability to provide access for travelers. Buffers can be designed with continual access or with painted ingress and egress locations. Buffers with continual access can have the undesirable consequence of reducing capacity in the managed lanes, due to friction between the quick moving managed lane and the slower moving GP freeway lanes. The continued near proximity between the quick and slow moving lanes continues to provide concern for travelers as there is no physical means to prevent a motorist from merging into the managed lanes facility unexpectedly.
- **Barrier-Separated** – The problem of speed differential turbidity is generally alleviated in barrier separated managed lanes systems, where travelers are isolated by a physical barrier preventing access in most locations from the general purpose lanes. Barrier managed lanes trips are targeted more strongly to individuals making longer excursions with foresight into where they will be entering and where they will be exiting the system. In barrier-separated systems, access is best provided by direct ramps and transit centers, keeping the system in less direct interaction with the general purpose lanes, and minimizing multi-lane merging for ingress and egress.

Enforcement –

- **Buffer System** – Buffer-separated managed lanes facilities are harder to enforce and are easier for single occupancy vehicles to abuse. The ease with which travelers can ingress and egress the buffer-separated managed lanes system make it more difficult for law enforcement officials to closely monitor and enforce regulations. Moreover, this phenomenon reduces the incentive to carpool and leads to additional congestion on the general purpose lanes of the highway as a result.
- **Barrier-Separated** – Barrier-separated systems are more difficult to ingress and egress and are, therefore, found to have high levels of compliance. Travelers wishing to cheat the system have to willingly commit to riding a substantially longer distance illegally than in a buffer-separated system. As a result, public confidence in the functionality of barrier-separated systems remains generally high.

HOV to HOT Lane Conversion (2009)

[Technical Memorandum, Final, I-77 Feasibility Study (I-85 to Griffith Street), Task Order No. 1 – I-77 Widening & HOV Facility Extension Sub-task 1.B, Performance Measures Task Order No. 2 – I-77 HOV/HOT Conversion Sub-task 2.B, Performance Measures, TIP Project No. FS-0810B, North Carolina Department of Transportation, June 2009]

This project was undertaken by the North Carolina Department of Transportation (NCDOT) specifically to investigate the feasibility of and ultimately convert standard HOV lanes (i.e., carpool lanes) serving each direction on I-77 to two express, or HOT, lanes in each direction. Information about the project at the I-77 Project Web site (www.i77express.com) notes that NCDOT is following the lead of transportation agencies in California, Colorado, Texas, Virginia, Florida and Georgia by investing in express lanes to alleviate traffic congestion. The express lanes are viewed as being successful at making travel more efficient for all drivers in urban areas. The project plan calls for entry and exit points at several locations along the 26-mile, I-77 project corridor (**Figure 4**). These points will give drivers multiple opportunities to decide whether they want to take advantage of the time-saving benefits the express lanes offer at the specified cost. Ingress/egress flexibility will be facilitated by the fact that each segment in the corridor will be tolled separately. Drivers will see signs prior to the entry point of each segment that indicate the amount of the toll. Under Questions and Answers relating to the project, the sponsors indicate merge lanes are designed with safety in mind, providing plenty of room for drivers to enter and exit the express lanes using at least six designated points. No specific safety information has been made available.

Regional Review of HOV Lanes for Dallas-Fort Worth Metroplex (2009)

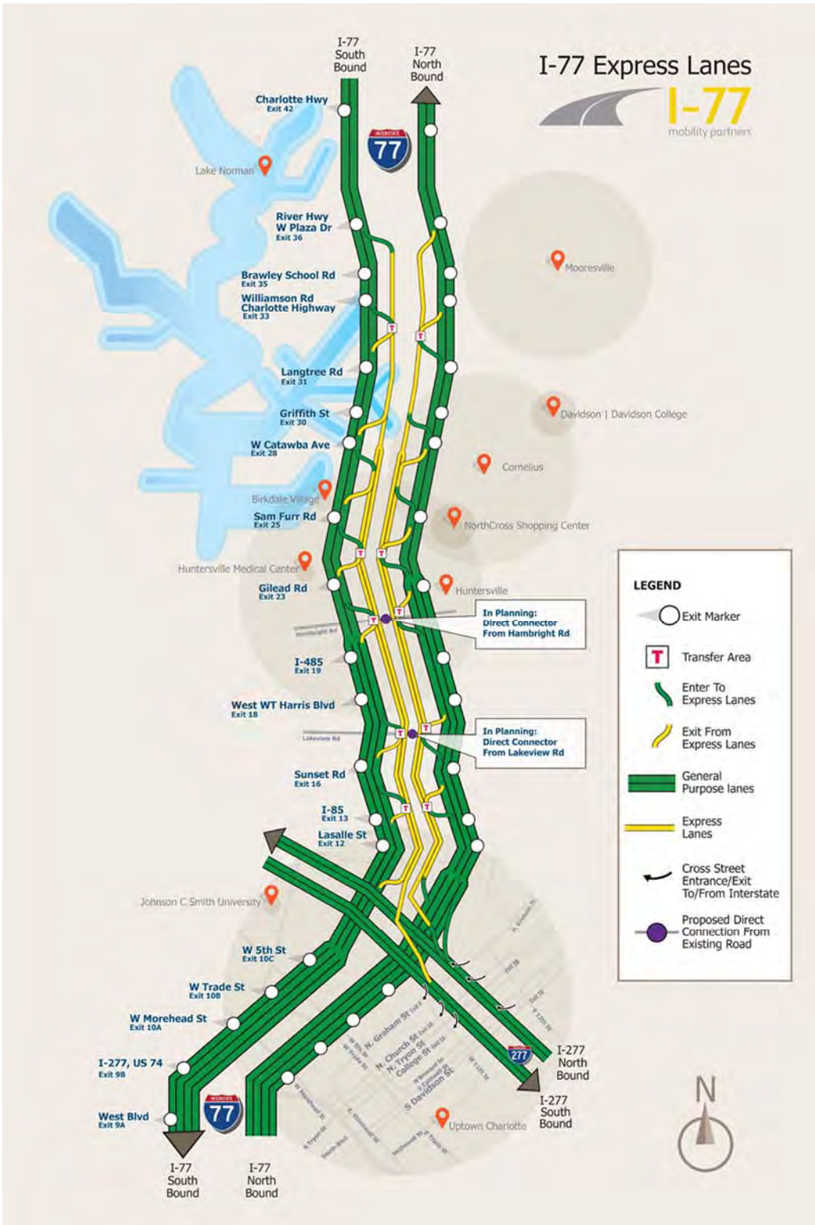
[*HOV Lanes: DFW Regional Review*, Executive Summary, The Metropolitan Transportation Plan – Priced Facilities, Aug 2009]

This review was undertaken following several years of HOV lane operations in the Dallas-Fort Worth (DFW) Metroplex. The overview focuses on:

- Need for these facilities;
- History and changes to these facilities; and
- Answers to questions and concerns related to the design, management, and operation of the facilities.

One section of the White Paper is title "Safety of Design – HOV Facilities and Crash History." The White Paper notes there were 314 HOV facilities in the U.S. at the time. Almost one-half were established as "paint stripe" and buffer-separated facilities: 50 of the HOV lanes were concurrent-flow, buffer-separated, and 102 were concurrent-flow, separated by a paint stripe. Since opening in January, 2006 (a three-year period preceding this report), three fatalities were reported in association with the HOV facility on US-75 – a pylon and curb system – and five fatalities (four incidents) were reported in association with the I-635 HOV facility. A summary of these incidents by corridor is presented in the White Paper:

Figure 7 | I-77 Express Lanes Plan



US-75

- Driver struck a pylon on the left, abruptly swerved right, crossing all freeway lanes prior to flipping and coming to rest in the left lane of the frontage road. Drive died at the scene.
- Motorcyclist crossed the pylon barrier at an illegal location and was struck by a vehicle operating within the HOV lane. Motorcyclist died after being transported to the hospital.
- Driver operating legally in the HOV lane made an improper exit through the barrier, resulting in a second car losing control and crashing. Passenger died after being transported to the hospital.

I-635

- A vehicle, parked perpendicular to the HOV lane with passenger side facing downstream, was struck by a bus, causing the vehicle to spin into the concrete median barrier and ricochet into the left lane of the freeway. Passenger died after being transported to the hospital.
- A vehicle in the left lane of freeway rear-ended another vehicle, which was thrown across the barrier into the HOV lane. A motorcyclist operating legally in the HOV lane, swerved into the freeway's left lane colliding with the vehicle that rear-ended the other vehicle. The motorcycle skidded across the entire width of the freeway, coming to rest in the median between the main lanes and the frontage road. The motorcyclist died after being transported to the hospital. The passenger in the rear-ended vehicle died at the scene.
- A driver, attempting to change lanes from the left lane to the center lane, found the lane to his right occupied by another vehicle. The driver overreacted, abruptly steering back through the left and crossing into the HOV lane. A vehicle traveling legally in the HOV lane was struck, mounted the concrete median barrier, and rolled out into the left lane of the freeway, ultimately killing the driver.
- A driver, wanting to get cell phone photos of an 18-wheeler on fire in the opposing lanes, parked on the shoulder, crossed the freeway on foot, and was struck by a vehicle operating legally in the HOV lane. Drug test results for the pedestrian struck in the HOV lane were positive for cannabis, PCP and depressants.

Following several years of operation subsequent to establishment of the US-75 and I-635 HOV lanes, a TxDOT-contracted review shows "…the crash rate in the first year of operation on I-35E increased 56% and on I-635 increased 41%: speed differential and subsequent access, either exiting or entering, between HOV lanes and GP freeway lanes was most pressing safety concern." The system in place at the time of this White Paper consisted of pylons with 13-foot spacing and limitations on ingress/egress locations. The locations of access points had been selected based on where speed differential concerns were not a critical issue. The evenly spaced pylons created a visible barrier that demanded driver attention, while supporting timely exit of the facility, if necessary, with assistance of freeway patrol officials.

TxDOT originally shied away from too many access locations, due to concerns for traffic operations and traffic conflicts. In the case of US-75, the Department favored terminating HOV lanes in areas where the speed differential was minimized, which excluded an ingress/egress location to serve the City of Richardson, TX. The White Paper notes that discussions were underway to evaluate adding a "wishbone direct ramp" in Richardson to accommodate the many motorists desiring to access the community and use the facility for commuting out of the community. The objective was seen as creating a three-pronged solution that would: satisfy travel demand associated with GP freeway lanes to serve regional mobility, allow local community access, and assure the HOV lanes serve commuter traffic that contributes to the goal of meeting regional air quality goals.

Facility Configurations and Safety (2009)

[*Safety Performance of High-Occupancy Vehicle (HOV) Facilities: Evaluation of HOV Lane Configurations in California*, Safe Transportation Research & Education Center, Kitae Jang, et al, January 2009]

Collision data associated with continuous- and limited-access HOV facilities were reviewed. A key difference between the two types of HOV facilities is that continuous-access lanes generally support special segregated travel opportunities only during peak periods (e.g., 5-9AM and 3-7PM), Monday-Friday. Limited-access HOV facilities, which often require a toll, are operated 24 hours per day, seven days per week. Thus, the comparison focused only on collision incidents occurring in the peak periods.

This study team concluded "…HOV facilities with limited access offer no safety advantages over those with a continuous access." The combined collision rate for limited-access facilities and adjacent GP freeway lanes was found to be higher than the combined collision rate of the continuous-access HOV lane and adjacent GP freeway lanes. However, it was noted that shoulders greater than 8 feet in width result in "…significantly lower collision rates, regardless of access type." The study team also found collision rates were "markedly higher" for a limited-access HOV facility with a combination of (1) short ingress/egress lengths and (2) close proximity to the nearest on/off ramps. Also, the study team determined that "…limited-access HOV facilities with a combination of short ingress/egress length and a close proximity to the nearest on- or off-ramp can result in markedly higher collision rates than other limited-access freeway segments…." It was noted that these factors needed more systematic investigation to determine the degree of effect.

Comparison of Limited v. Continuous HOV Facilities (2009)

[A Comparative Safety Study of Limited versus Continuous Access High Occupancy Vehicle (HOV) Facilities, Institute of Transportation Studies for Caltrans, CA09-0968, March 2009]

This report provides a comparative analysis of the safety performance of limited-access and continuous-access HOV facilities in California during peak travel periods between 1999 and 2003. Findings from the study indicate limited-access facilities offer "…no safety advantages over those with continuous access, whether measured by percentage of collisions, collisions per mile, collisions per VMT, or collision severity." The principal conclusion drawn from these findings is that "maintaining adequate shoulder and total [facility] width is essential…."

Study recommendations include emphasis on general design features that have the potential to maximize safety associated with the limited-access facilities, including: adequate total facility and shoulder width, adequate length of access (ingress and egress) sections of the facility, and establishing an adequate distance between access locations and freeway on/off ramps. These recommendations for design modifications are aimed at addressing two concerns: (1) issues of safety associated with lane-changing concentrated at ingress/egress locations; and (2) the relatively short distance within which lane-changing occurs proximate to freeway ramps and HOV ingress/egress locations.

A key issue associated with limited-access facilities is that ingress and egress maneuvers can be too proximate with freeway on/off ramps. Where this occurs, motorists must immediately weave across consecutive lanes to the facility entrance from a freeway entry point and/or exercise a similar activity to reach a desired freeway off-ramp subsequent to the exit point. Thus, the safety performance of the HOV/HOT managed-lane facility and adjacent free-flow lane of the freeway are likely to be impacted under the limited-access scenario. This study was able to investigate crashes patterns occurring between 1999 and 2003 for four limited-access and four continuous-access facilities.

The investigation revealed that limited-access facilities, when compared to the continuous-access facilities, had a higher percentage of total collisions across all freeway lanes and a higher number of: total collisions per mile per hour; fatal and injury collisions per mile per hour; total collisions per VMT; and fatal and injury collisions per VMT. The investigation found that shoulder width "…was a strong predictor of safety performance…" for both types of facilities, and the limited-access facilities exhibited "…a higher proportion of rear-end collisions…" compared to side-swipe collisions. This is a result that might be expected, given that generally there is only one lane of traffic in the limited-access facility eliminating the possibility of side-swipes.

Regarding the safety performance of the adjacent freeway lane relative to the limited-access and continuous-access facilities, the former exhibited: a higher percentage of total collisions across all freeway lanes; a higher number of: total collisions per mile per hour; a lower number of fatal and injury collisions per mile per hour; a higher number of total collisions per VMT; and a lower number of fatal and injury collisions per VMT. This aspect of the investigation found the freeway lanes adjacent limited-access facilities had lower levels of safety performance for total collisions than those adjacent continuous-access facilities. However, the limited-access facilities performed slightly better relative to fatal and injury collisions. This could indicate reduced severity of crashes, possibly due to slower speeds and greater awareness deriving from clearly defined ingress/egress locations, as opposed to random or uncontrolled ingress/egress associated with the continuous-access facilities.

The investigation also focused on collision records for the facilities and the adjoining lanes combined. The analysis revealed the limited-access facilities reflected the performance of the HOV/HOT manage-lane facilities alone, as cited above, resulting in a lower overall safety performance for the limited-access facilities. Thus, the study conclusion is that establishment of limited-access facilities would not be justified as a project to enhance safety. Still, the study provided the basis for defining three recommendations, i.e., design features, to mitigate the safety issues of limited-access facilities:

- Maintenance of adequate shoulder width is essential;
- Optimize the length of ingress/egress sections (collision rates were found to be higher in the short access sections);
- Optimize distances between ingress/egress locations and freeway on/off ramps – "…locating access areas in close proximity to on/off ramps should be avoided."

Safety of HOV Facilities in California (2008)

[Safety Evaluation of High-Occupancy Vehicle (HOV) Facilities in California, Intellimotion, Volume 14, No. 2, 2008, California Partners for Advanced Transit and Highways (PATH)]

This study focused on evaluation of collision patterns associated with continuous- and limited-access, concurrent-flow HOV lanes with specific attention to safety performance. It is a follow-on study to *A Comparative Safety Study of Limited versus Continuous Access High Occupancy Vehicle (HOV)*, and the study was designed to examine detailed geometric and traffic data, as available. The study focused on four geometric factors: shoulder width, total width (shoulder + HOV lane + buffer), spatial collision patterns, and ingress/egress analysis.

The principal findings of this research "…show that the HOV facility with limited access offers no safety advantages over the one with a continuous access." Nevertheless, the study also notes "the combined collision rates of the HOV and its adjacent lane were higher for the HOV facility with limited access." The conclusions presented follow:

- HOV facilities with shoulder width greater than 8 feet displayed significantly lower collision rates regardless of access type.
- The analysis of total width and crash rates indicates HOV lanes with continuous access may result in lower collision rates, given the same total width of right-of-way.
- Limited-access HOV facilities with a combination of short ingress/egress length and close proximity to the nearest on/off-ramps tends to exhibit markedly higher collision rates than other limited access freeway segments.

HOV Facilities Extant in the U.S. (2008)

[*A Compendium of Existing HOV Lane Facilities in the United States*, FHWA HOV Lane Performance (DTFH61-06-D-00006), prepared by Booz-Allen-Hamilton and HNTB, Dec 2008]

This inventory of HOV facilities in the U.S. conducted in 2008 accounted for a total of 345 HOV facilities. California had the most such facilities, at 88, followed by Minnesota (83), Washington State (41), Texas (35), and Virginia (21). The inventory included the following types of HOV facilities: bus lanes/busways; concurrent (median, right side, second lane on one-way urban arterial); contraflow facilities; dedicated curb lanes; high-standard arterial; high-occupancy toll or HOT lanes (reversible, concurrent); reversible lanes; and separate dedicated roadways. There were a number of separation designs note during the inventory, including: barriers; buffers; cones; dashed line + broken diamond pavement marking; limited-access highway; moveable barrier; none; painted stripe(s); pylons; standard dashed line; traveled lane edge line.

The vast majority of HOV facilities had only one HOV lane in each direction. The longest active HOV facilities were identified in Miami, FL (I-95 between SR 112 and Gateway Blvd – 116.0 lane-miles, 58.0 route miles) and Los Angeles County, CA (I-405 – 105.2 lane-miles, 52.6 route miles). The most common separation technique used for all HOV facilities is the painted stripe; 118 (34 percent) of all such facilities fall into this category. Sixty (17%) of all HOV facilities inventoried were developed with buffers (e.g., linear, diagonally striping on the roadway) used to constrain movements (i.e., limit ingress/egress to pre-determined locations) between the HOV lanes and GP freeway lanes. Buffers do not totally prevent "at will" movements between the HOV lanes and GP freeway lanes.

The inventory identified 45 HOV facilities (13 percent) in the U.S. developed with barriers that constitute "limited-access" HOV facilities (also referred to as "intermediate access"). Barriers effectively restrict ingress/egress to specific locations along the length of the HOV facility, where an opening is provided to permit transitional movements between the HOV facility and GP freeway lanes. Six barrier-type HOV facilities are based on "moveable" barriers used to create an extra lane in the peak direction of travel, which, in effect, is a protected contraflow lane.

The most common type of HOV facility noted during the inventory was the concurrent (median) defined by a painted stripe; 187 facilities (54 percent) fell into this category. Concurrent (median) HOV facilities allow permitted motorists to use the inside lanes of a freeway, i.e., lanes in the center or median, simultaneously and parallel to the GP freeway lanes. Concurrent (median) HOV facilities can be separated simply by a solid white or yellow lane, allowing motorists to move freely between the HOV lanes and GP freeway lanes. This is the principal design of HOV lanes currently established within The Spine Corridor. As noted above, concurrent (median) HOV facilities also can be defined, even separated, by buffers and physical barriers. These features are intended to constrain or "limit" access (ingress/egress) to the lanes at locations, where the buffer or barrier does not exist.

Separation of Toll Lanes and Free Lanes (2007)

[Best Practices: Separation Devices between Toll Lanes and Free Lanes, Center for Transportation Research, The University of Texas at Austin, for TxDOT, FHWA/TX-07/0-5426-1, October 2006, Rvsd November 2007]

This report examines three basic categories of separating or delineating separation of vehicles operating in managed lanes versus mixed traffic operating in GP freeway lanes. Managed lanes, the report indicates, provide a means of expanding the potential of current highway infrastructure to accommodate greater travel. HOV and HOT lanes allow transportation engineers to manipulate roadway operations and achieve varying LOS. To manage traffic in special lanes, the lanes must be separated from the GP freeway lanes. HOV lanes have been used widely with considerable success in terms of operational advantages and safe travel, and this report seeks to determine whether safety and cost factors of HOV lanes can be applied to managed lanes, here specifically referring to HOT lanes.

The project included convening an "expert panel" to discuss conceivable factors that may influence the choice of treatment for delineating managed lanes. The discussion first focused on the implications of differing roadway conditions and how those conditions would affect the choice of a delineation treatment. The final list of roadway variables is shown below:

Lane and Shoulder Widths,
Traffic Volume on the Highway,
Truck Volume on the Managed Lanes,
Bus Volume on the Managed Lanes,
Centerline Geometry, and
Main Lane Entry/Exit Frequency.

Secondly, the panel examined and considered the various inherent characteristics of each type of treatment – characteristics that would not change from site to site. The final list of common characteristics is show below:

Entry/Exit Considerations,
Enforceability/Compliance,
Cost,
Safety,
Aesthetics, and
Constructability.

The three basic categories adopted for consideration during these analyses were: concrete barrier, pylon posts, and painted buffers. The result of the expert panel's exercise is a table of comments and responses regarding each of the conditions and characteristics cited above. This table is included as **Attachment B**.

Under the subject of Safety, presented here as **Table 1**, the panel addressed "Safety for Managed Lane Users," and "Safety for Users of Non-Managed Lanes." It is readily apparent from the '+s' and '-s' that the Concrete Barrier was most favored as a design treatment. However, there are two "ifs" that deserve attention. These "ifs" relate directly to the means of access, indicating that entry into the barrier-separated managed lanes was considered a significant challenge and needed serious, careful consideration. The primary issues associated with the painter buffer and pylon (or post) relate to the weaving activity essential to the ingress and egress of these types of lanes. This apparently was seen almost as a fatal flaw, when addressing the question of safety of operations.

Table 1 | Expert Panel Safety Analysis

	Concrete Barrier	Buffer	Post
VIII. Safety			
1. Safety for managed lane users	**Yes** + Provides protection from swerving vehicles from adjacent general-purpose lane. + Provides protection from high-speed differentials with adjacent general-purpose lane. + If access to facility is provided via t-ramps, no weaving is necessary. – If direct connections are not provided, drivers face the potential of striking the edge of the barrier when entering the facility.	**No** – No protection from swerving/wayward vehicles – Drivers must weave across main lanes to access managed facility.	**No** – No substantial protection from swerving/wayward vehicles. – Drivers must weave across main lanes to access managed facility.
2. Safety for users of non-managed lanes	**Yes** + Provides protection from swerving vehicles from managed lanes. + Provides protection from speed differentials with managed lane. + If access to facility is provided via t-ramps, no weaving is necessary.	**No** – No protection from swerving/wayward vehicles – Main lane motorists will have to deal with managed-lane users weaving across the main lanes.	**No** – No substantial protection from swerving/wayward vehicles – Main lane motorists will have to deal with managed-lane users weaving across the main lanes.

Weaving was seen as a problem for the barrier-separated lanes, if the entrances and exits are accessible to the GP freeway lanes. This treatment was seen as most safe with provisions for direct access via a ramp. The T-ramp, or direct HOV (DHOV) ramp, was seen as an example of safe ingress/egress, as it permitted motorists to enter and exit without the "tricky maneuvering involved with weaving." The panel concluded that concrete barriers, providing a barrier-separated operating environment, is generally accepted as the safest treatment; "neither [the] post nor buffer styles of delineation is as safe as concrete barriers." Nevertheless, a safety concern was raised relative to the accommodation of disabled vehicles, especially in sections where the stopping sight distance is limited. Because of the possibility of crashes occurring within the concrete barriers, the panel "…strongly recommended using a cross section of no less than 18 feet [5.5m]."

The panel found no significant distinctions between buffers and posts as methods of delineating managed lanes relative to safety concerns. The posts were viewed as slightly more effective, as motorists may perceive them to be potential damaging to the vehicle. Also, the use of post, or pylons, generally includes greater control of ingress and egress locations, resulting in a reduction in the amount of vehicles weaving through mixed traffic of the GP freeway lanes to enter and exit the dedicated travel lane. The post treatment also may make it more likely for a motorist to not attempt to avoid a crash, due to reluctance to cross through the line of posts. Although this issue is not associated with a painted buffer, weaving maneuvers for entrance or exit purposes, especially if a high speed differential is present, can result in crashes impacting both the managed lanes and GP freeway lanes. Nevertheless, the buffer-separated facility offers the opportunity to avoid a collision or object, if the adjacent GP freeway lane is clear

This report also includes a comparison of the findings, conclusions, and recommendations of the "expert panel" with information available through published sources. The literature review conducted for this report generally supports the conclusion of the panel that concrete barrier-separated managed lanes would be safer. This is particularly true when the speed differential between the managed lanes and GP freeway lanes is high. The literature also agrees that a physical barrier precludes violators and random ingress/egress activity. However, a continuous barrier is seen as a potential disadvantage relative to response times and operations of emergency vehicles.

Although one source noted that at-grade access to managed lanes from the GP freeway lanes was acceptable "…when cost or right-of-way limitations preclude the use of direct-access designs [ramps]," the report states "…no source recommends the use of at-grade access…" if grade-separated, direct access is feasible. Direct connections largely eliminate complicated weaving maneuvers in congested traffic that potentially can degrade traffic flow and impact safety. The literature review largely agrees with the expert panel regarding the issue of weaving associated with painted buffer- and post-separated managed lanes. Neither treatment is compatible with the speed differentials between the managed lanes and GP freeway lanes, which poses a challenge for motorists operating in both environments. Even so, these "barrier-lite" type of treatments do have the advantage of being more accessible for use by emergency and maintenance vehicles. The comparison of the expert panel with the literature resulted in the following conclusions regarding operational safety of managed lanes:

- In cases of restricted right-of-way, buffers and posts are preferable to barriers.
- Concrete barriers should not be considered for single-lane facilities unless a barrier-to-barrier clear width of at least 18 ft [5.5m] can be provided.
- The expert panel strongly discouraged the use of concrete barriers without grade-separated, fly-over connections; weaving sections introduce the possibility of drivers striking the end of the barrier at high speeds.
- The Panel generally found posts to be the least favorable type of delineation, but could be useful as a transition to barrier-separated facility.

HOV Lane Safety: Before and After (2007)

[Contiguous HOV Lane Safety: A Before and After Comparison of Accident Rates, Conference Paper, Carol Pearce and David Stanek, July 2007]

This paper points out that research studies associated with buffer- and barrier-separated HOV lanes found crashes to be concentrated at the ingress/egress locations. The paper focused on safety and crash rates associated with concurrent, contiguous operations before and after installation. Two freeway corridors, HOV lanes present and operational were evaluated. The evaluation looked at: the location of collisions (e.g., shoulder, left lane of freeway, etc.); collision type (e.g., sideswipe, rear end, etc.); maneuver immediately preceding the collisions (straight, weaving/changing lanes, etc.); and variations in traffic levels and congestion before and after construction of the facilities.

Findings and conclusions drawn from the study indicate there was no relationship between the rate of crashes in the corridor, where the facilities are located, and the addition of the contiguous, concurrent-flow HOV lanes. A further conclusion was that notable increases in the overall crash rate for the facilities evaluated was related to the level of congestion, rather than the evaluation factors cited above. On the other hand, although the increase in crash rates after establishment of the HOV facilities was not closely related to lane operations, the analysis indicated the limits of the HOV lane seemed to affect the level of congestion, which indirectly did affect crash rates. This study concludes that crash rates are influenced more by congestion than the presence or non-presence of HOV facilities. The crash data examined showed no definitive changes in collision type, movement preceding collisions, or other operating factors "…that would support the contention that contiguous HOV lanes affect traffic safety."

HOV Lane Safety without Physical Separation (2007)

[Safety of High-Occupancy Vehicle Lanes without Physical Separation, Thomas F. Golob, et al, for Caltrans, October 2007]

This study compared 14 months of crash data for an HOV operation in greater Los Angeles area with similar data for six years prior to opening of the HOV lane. The period covered by the examined data was January 1, 1979, through August 31, 1986. The lane is not separated from the GP freeway lanes by a physical barrier. The results of this case study revealed no adverse effect on safety conditions could logically be attributed to the introduction of HOV operations. The study team found the location and timing of traffic congestion was the best explainer of changes the number of crashes and the pattern of crashes. The case study, however, demonstrated that the locations of crashes migrated along the corridor as a response to changes in the location congested areas and the creation of bottlenecks downstream from the HOV project. This suggests that planning and design of HOV/HOT managed-lane facilities need to take into account potential changes in the travel dynamics of the corridor wherein such facilities are established. This particular case study notes that the HOV lane did not degrade safety performance in the corridor, but neither did it improve safety performance.

Considerations for Creating a Managed Lane (2007)

[*Considerations for High-Occupancy Vehicle (HOV) to High-Occupancy Toll (HOT) Lane Conversions Guidebook*, FHWA, Office of Operations, June 2007]

This report notes that differences in right-of-way availability may affect the adopted design standards for a HOT Lane (i.e., managed lane) and the method of separating HOT Lane operations from vehicles operating in GP freeway lanes. It addresses multiple aspects of the physical design of HOT Lanes and summarizes the various benefits and issues associated with each type: barrier separated, buffer separated, contiguous (i.e., concurrent), and grade separated. This report cites three safety considerations when developing the cross-section for a managed lane:

Crash attenuation for the exposed barrier ends at the entrance to the facility,
Transition treatments associated with HOV and GP freeway lanes, and
Adequate access (ingress/egress) opening lengths.

The safety concerns highlighted in this report are summarized in **Table 2**, according to six physical design options to obtain separation. All, except the Non-Separated Shoulder, include a parallel emergency area for disabled vehicles and enforcement.

Ultimately, managing vehicle movements between HOV/HOT managed lanes facilities and GP freeway lanes will determine the effectiveness and safety of managed lanes. The facilities must be well-designed to accommodate ingress and egress, while avoiding unnecessary bottlenecking, violations, and unsafe weaving movements in the GP freeway lanes. The cross-section design (lane and facility geometry) is a critical prerequisite to attaining safety goals, while achieving the desire LOS.

Table 2 | Comparison of Benefits and issues by HOT Lane Separation Type

HOT Lane Separation Type	Benefits	Issues
Concrete Barrier	Safety for General Purpose Lanes	▪ Users feel confined ▪ Limitations on access critical with occurrence of an incident disrupting traffic flow
Flexible Delineators (Pylons)	Unlimited ingress/egress	▪ Motorists able to drive through delineators ▪ Possible hazard for other vehicles from flying delineator
Buffer	Motorists have a way out	▪ Motorists cutting in and out of the buffer-defined facility
Non-Buffer (Painted Stripe)	Motorists have a way out	▪ Safety and enforcement issues associated with free flow in and out of the facility
Non-Separated Shoulder	Provides improved capacity without an dedicated new lane	▪ Confusion of lane use can occur ▪ Lack of emergency pull-outs for disabled vehicles
Grade Separation	Safest, due to exclusive use and limited access	▪ Users feel confined ▪ Expensive

Signage is cited as "a major element in HOT [lane] operations and management." Inadequate signage and the location of such signage, both upstream and downstream of the access locations, is critical to motorists making a timely, informed travel decision. Inadequate signage can compromise facility and vehicle safety; therefore, signage must be such that motorists in the managed lanes and general purpose lanes understand which message should be followed. That is to say, motorists must be able to understand the message intended for their lane, but, also, they need to understand the message for the other lanes. This means signage must be located sufficiently in advance of the need to maneuver to permit motorists adequate opportunity to process and execute the directions obtained from the sign.

The report notes that inadequacy of enforcement signage can contribute to hazardous operation conditions, especially associated with the practice of "lane diving" or lane shifting/weaving, whereby motorists move freely between lanes of a non-barrier separated facility and GP freeway lanes. In fact, it states "One of the biggest challenges facing HOT lane planning and operations is and will continue to be enforcement." A major lesson gleaned during this study is that manual enforcement can be an effective means of controlling access to HOT lanes; even so, it is virtually impossible to assure 100% enforcement. Enforcement is especially critical relative to non-barrier-separated managed lanes, which would have multiple, even infinite, access locations. The report notes that expansion from a HOT lane to a HOT lanes network will stretch manual enforcement capabilities even further and diminish its effectiveness as a deterrent to violations, which creates the potential for a less safe operating environment.

HOT Lane Buffer and Mid-Point Access (2006)

[*HOT Lane Buffer and Mid-Point Access Design Review Report*, Washington State Department of Transportation, Oct 2006]

This Washington Department of Transportation (WSDOT) report provides an overview of buffer and mid-point access designs for HOT lanes operating concurrently with GP freeway lanes. Three design recommendations (cited below) emerged from the literature review and studies supporting this report:

A preferred buffer width between a HOT lane and an adjacent GP freeway lane of 4 feet, with a minimum recommended width of 2 feet, if it is not feasible to provide a 4-foot buffer.

A continuous inside shoulder of 14 feet for enforcement and to serve as a breakdown lane, with a minimum 2-foot inside shoulder width recommended to separate the travel lane from any barrier, if the ideal width is not feasible.

Mid-point access location openings of 1,000 feet per lane change; with a minimum length of 500 feet. For a combined access (allowing both ingress and egress), the length of the access point should be at least 1,000 feet (twice the minimum acceptable lane change distance of 500 feet).

The report addresses safety issues and concerns associated with HOT lanes. The first notable conclusion presented states little research or experience is available to permit conclusive statements regarding safety and the buffer width between the HOT lane and GP freeway lanes. It does note that evidence suggests buffers greater than four feet tend to collect debris. Also, the literature review indicates a concern that some drivers may try to use wider buffers as a breakdown lane, which would present particularly hazardous conditions with high speed traffic operating on both sides of the buffer. A buffer width minimum of two feet is cited from the *FHWA Guide for HOT Lane Development*.

The report notes that a recent report produced by the Texas Transportation Institute (TTI) indicates no definitive conclusions can be reached relative to the safety of concurrent flow, buffer-separated HOT lane facilities.[38] The TTI review of previous studies revealed there is conflicting evidence regarding the safety of buffer-separated HOV lanes. However, TTI notes there seems to be anecdotal evidence that injury crash rates have increased, where such facilities have been installed in Dallas, TX. Nevertheless, the TTI report indicates this increase likely resulted from the speed differential between the HOV lanes and GP freeway lanes.

The report cites a study in Orange County, CA, addressing the advantages and disadvantages of a continuous, concurrent facilities and buffer-separated, concurrent facilities with controls on access. **Table 3** cites the safety-related issues and concerns raised as a result of this study.[39]

The ideal access design would separate ingress and egress locations; this would eliminate potential conflicts between vehicle entering the facility and vehicles exiting the facility. In addition, an auxiliary lane would be provided between HOV/HOT managed-lane facilities and GP freeway lanes to permit motorists to accelerate or decelerate, as appropriate. An added feature might be a shoulder area immediately downstream of the access location to permit enforcement officers a station for observing and monitoring use of the HOV/HOT managed lanes. In the case of right-of-way constraints, the ingress/egress location may be combined and the auxiliary lane excluded. This, however, would require sufficient length to accommodate safe weaving of vehicles entering and departing the facility. If no barrier is installed, the minimum restriction on vehicle transitions between the HOV/HOT managed lane facilities would be a double white stripe, which would change to a permissive dashed white stripe. That being said, this report notes:

Table 3 | Issues and Concerns Associated with Unlimited- and Limited-Access Facilities

Issue/Concern	Unlimited Access	Buffer-Separated Limited Access
Safety	▪ No systematic impact on crash rate ▪ Traffic queued in general-purpose lane can maneuver into HOV lane unexpectedly ▪ Potential for unexpected access of HOV lane creates perception of hazardous operating condition	▪ No systematic impact on crash rate ▪ Concentrates merging and weaving at designated access (ingress/egress) locations ▪ Reduces merging between access locations ▪ Impacts are location-specific
Isolation form Congestion and Incidents in General Purpose Lanes	▪ HOV volumes can spike at congestion hot spots due to HOV traffic shifts into HOV lanes	▪ Minimizes impact to HOV lane operations resulting from traffic disrupting incidents and congestion in general-purpose lanes ▪ HOV lane traffic can be enhanced and operating environment can be increased with addition of left-side shoulder and direct access ramps
Impact on General Purpose Traffic	▪ Weaving (ingress/egress) actions are distributed over the length of the facility/corridor ▪ Concentration of weaving at inappropriate locations or inadequate weave distance exacerbates bottlenecks	▪ Weaving can be concentrated where adequate capacity exists ▪ Limited direct access locations reduces weaving associated with access (ingress/egress) of HOV lane
Driver Expectancy (Regional Consistency)	▪ HOV facility operation is similar to general purpose lanes	▪ Isolated buffer and access treatments may be appropriate when a facility does not connect with other HOV facilities ▪ Buffer and access treatments should be consistent with adjacent facilities
Compatibility with HOV and Potential Transit Operations	▪ Most appropriate when HOV lane is used for general purpose travel in non-peak periods	▪ Buffer treatment may be desired in anticipation of future HOT Lane or Bus Rapid Transit (BRT) operations ▪ Direct access can be provided to further reduce vehicle weaving

> *Extensive research designed to definitively identify the impacts of the different designs does not exist, particularly regarding access design where physical constraints often determine the type of access (combined, vs. separate, whether a weave lane is provided, etc.). In existing facilities, every effort is made to adequately balance the desire for high levels of service in the managed lanes with providing safe and efficient access and separation options.*

This report brings out another important aspect of HOV/HOT managed lane operations: mid-point or intermediate access. It should be noted that this concept is not being contemplated for the HOV/HOT managed lanes facility in the Spine Corridor. A common design of an intermediate access location allows ingress and egress by changing the buffer striping only, in the case of a buffer-separated facility. Prohibitive, solid striping changes to permitted, dashed striping to allow a lane change. Vehicles then may enter or leave within this zone, merging essentially within an auxiliary lane.

[38] *Crash Data Identify Safety Issues for High-Occupancy Vehicle Lanes in Selected Texas Corridors*, Texas Transportation Institute, 2004. Project Summary Report 04434S.

[39] Orange County HOV Lane Operations Policy Study, Orange County Transportation Authority, 2002, Page 40.

A barrier-separated HOV/HOT managed-lane facility also can have an intermediate access location(s) with breaks in the barrier to permit the transit of vehicles into and out of the HOV/HOT facility.

MANAGED-LANE FACILITY PERFORMANCE (2005)

[*Monitoring and Evaluating Managed Lane Facility Performance*, Technical Report, Texas Transportation Institute, for TxDOT, FHWA/TX-06/0-4160-23, November 2005]

This Technical Report was prepared to provide information relating to the best performance monitoring and evaluation practices and principles explicitly employed with regard to managed-lane facilities, specifically, in the context of this report, value-priced and HOT. Although the focus of this report is on performance, some information is provided about safety and evaluating the safety of various managed-lane treatments. Ultimately, the report concludes that, in general, the creation of passenger-focused, managed-lane facilities has the primary intent of increasing person throughput. Safety is addressed as a secondary interest and then primarily to "confirm no adverse impacts from implementation of the managed-lane facility." It is noted that crashes associated with managed lanes occur infrequently; therefore, a lengthy evaluation period is necessary to acquire a reasonable dataset for analysis. The implication here being that the facilities have not been the objects of adequate attention nor time commitments required to compile a useful body of knowledge to evaluate safety effects.

Similarly, although, HOV facilities have a more extensive history of performance monitoring and evaluation, these facilities also are implemented with the primary purpose of increasing person throughput. Safety and environmental concerns (e.g., air quality) typically are secondary interests, although some HOV projects have been implemented to achieve safety goals and objectives. In contrast, the report notes that freight-focused managed-lane facilities often are undertaken with a primary interest in improving safety and achieving benefits with respect to preserving pavement infrastructure. Thus, while this is an extensive dissertation that presents lengthy discussion of evaluation methods, such as goals, objectives, and performance measures, relating to managed lanes, it does not represent a significant contribution to the subject of safety.

MANAGED LANES PRIMER (2005)

[Managed Lanes, A Primer, Federal Highway Administration, FHWA-HOP-05-031]

This Primer was prepared to provide local transportation officials with information about managed lanes as a mobility strategy. It provides a definition of managed lanes, presents managed lanes success stories, identifies issues and challenges unique to this type of project, and examines the future of managed lanes as a transportation mobility solution. First off, the Primer couches the issues of transportation capacity by pointing out the vehicle miles traveled nationally increased 70 percent from 1985 t0 2005, but highway capacity grew by only 0.3 percent. In addition to various constraining factors, like increased costs, right-of-way constraints, environmental concerns, and societal impacts, the Primer notes that many transportation agencies "…are grappling with a serious transportation funding crisis."

Managed lanes are defined as a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions.

Managed lanes is one approach to make more effective and efficient use of existing highway capacity. This is accomplished by engaging in three primary actions: pricing (i.e., tolling and value pricing), vehicle eligibility (e.g., minimum occupancy), and access control (i.e., limitations on entry to manage congestion and operational conditions). These actions are implemented to regulate traffic flow in essentially a "freeway within a freeway." Travel activity on the managed lanes is managed to respond to growth of traffic in the corridor and changing demand; this is a continuously active practice to optimize operational conditions to achieve and maintain "free-flow" speeds. This requires careful considerations of project goals and evaluation of the unique characteristics of the corridors where facilities are planned.

Developing, implementing, and operating managed lanes has proven effective for mobility improvement in many communities in the U.S. and around the world. Nevertheless, there a number of critical issues that have come to light, including:

- access design [an safety],
- driver information and signing,
- enforcement,
- revenue generation and equity,
- legislative authority,
- new institutional arrangements,
- analysis techniques and demand forecasting models,
- design flexibility,
- integrated transportation opportunities, and
- technology.

Significant for the issues and concerns voiced relative to the Spine Corridor:

- Access design impacts operational conditions and affects the ability to manage lanes through modifications to operating strategies.
- The number and spacing of access points increases the complexity of operations and makes enforcement more challenging.
- Spacing of access points, particularly relative to freeway on- and off-ramps, affects the length of weave/merge sections with the potential to impact the safety and operating conditions of the managed lanes and the GP freeway lanes.
- Combinations of pricing, vehicle eligibility, and/or access location, such as would be associated with a HOV/HOT lanes facility, requires information be communicated to motorists in a clear, concise manner, while avoiding information overload. Motorists must process standard and special (i.e., managed lane-specific) directional and informational signs quickly and efficiently to be able to operate vehicles in a safe manner. Motorists unfamiliar with the corridor may need to make quick decision on whether or
- Not to use the facility, which can be particularly challenging and impact safe operations of the managed lanes and the GP freeway lanes.
- Complex operating strategies involving vehicle eligibility, vehicle occupancy, and pricing makes enforcement more challenging.

OPERATIONS CONCERNS AND MITIGATION MEASURES (2005)

[12th International HOV Systems Conference: Conference Proceedings, Breakout Session – Operation Updates, FHWA, April 2005]

A study presented relating to HOV facility use during an Operation Pilot Project sponsored by WSDOT indicated there was considerable excess capacity in the HOV lanes in evening periods. The question of allowing SOVs to operate in the lanes during these periods revealed potential safety concerns, but also revealed a key advantage of non-barrier HOV facilities that allow easy and convenient access by all vehicles in the travel corridor. Specific roadway improvements, such as ground-in, rumble-strips and profiled edge striping, were implemented.

A study presented regarding Houston HOV facilities documented crashes on HOV lanes and the characteristics of those crashes. The study also included an attempt to compare the safety of HOV land with non-HOV GP freeway lanes. It was found that crashes in the HOV lanes typically peaked during the congested periods and peaked more than the GP freeway lanes. Not too surprising, single vehicle crashes accounted for 30 percent of crashes in HOV lanes, but only 24 percent on GP freeway lanes. This likely could be due to the fact that HOV lanes support a single lane of traffic, minimizing the opportunities for multi-vehicle crashes. Also, not surprising, speeding

accounted for over 50 percent of crashes on both the HOV (53%) and GP freeway lanes (56%). The slightly higher percentage for the GP freeway lanes likely is related to more opportunities to collide with other vehicles in a congested stream of mixed traffic. Another finding likely to be associated with the single line of traffic in the HOV lanes, following too close accounted for a greater percentage of crashes on HOV lanes (5%) compared to the GP freeway lanes (3%).

Findings presented from the Houston study included the tentative conclusion that HOV lanes are safe relative to GP freeway lanes. But, the presenter also notes that there "…appears to be a safety trade-off between barrier facilities and concurrent flow lanes." Future research was necessary to determine the characteristics of this trade-off and how the two types of facilities affect different groups of drivers.

Crash Occurrence in Barrier-Separated HOV/HOT Facilities (2005)

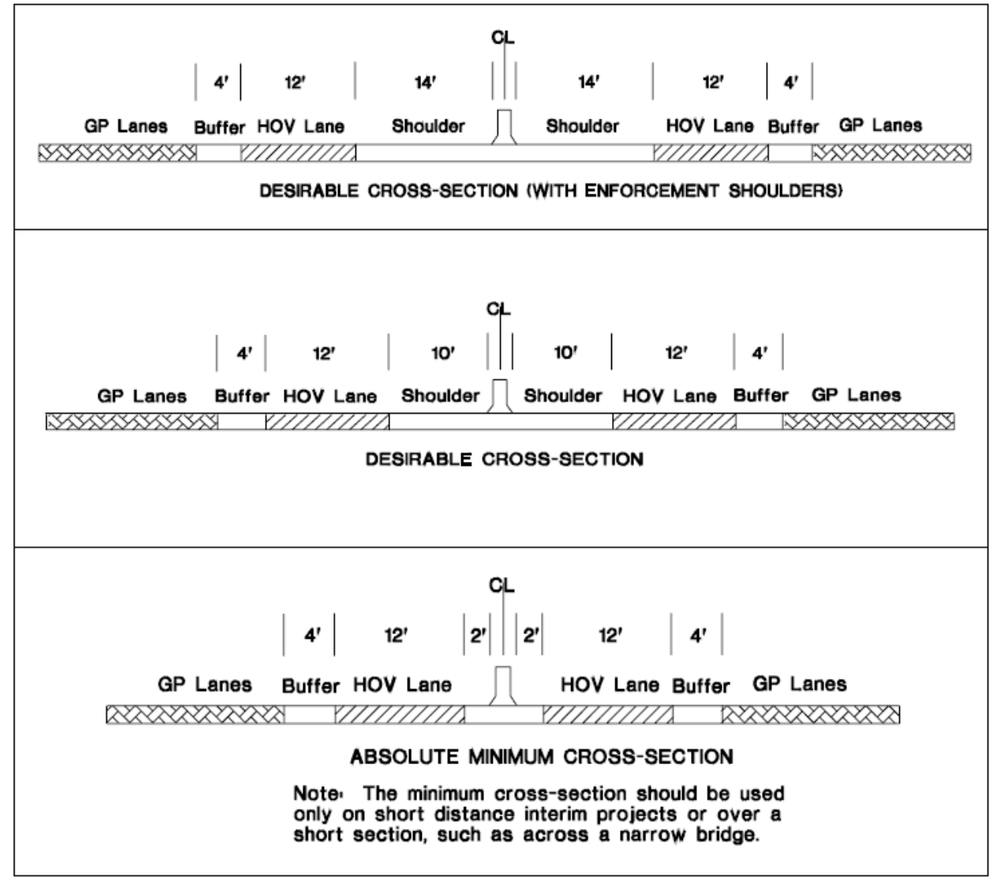
[*Crash Data Identify Safety Issues for High-Occupancy Vehicle Lanes in Selected Texas Corridors*, Project 0-4434: Safety Evaluation of HOV Lane Design Elements, Texas Transportation Institute (TTI), March 2005]

The objective of this study was to gain greater understanding of "…safety issues associated with HOV lanes, particularly buffer-separated concurrent flow HOV lanes." Although the study principally was looking at options associated with moveable barriers, the conclusions shed some light on the safety performance of fixed-barrier facilities. The report states available studies indicate safety performance of buffer- and barrier-separated, concurrent-flow facilities is similar to other types of HOV lane facilities (e.g., concurrent, contiguous, concurrent-flow projects). It generally is recognized that crashes in separated facilities do not disrupt operations of the GP freeway lanes (discounting "rubber necking," of course) and vice versa. Preparers of this report note there are two primary concerns often raised relative to separated HOV/HOT facilities: (1) the speed differential created between the separated facilities and GP freeway lanes, and (2) the inability of vehicles operating within the facility to maneuver around or avoid traffic interrupting incident.

This study relied on a before-and-after focus to identify the change in crash rates subsequent to establishment of buffer-separated HOV lanes in the IH-35E North and IH-635 corridors in Dallas, TX. The study team found the crash rate increased 56 percent in the IH-35E North corridor and 41 percent in the IH-635 corridor. Three key findings were identified: (1) the injury crash rate increased; (2) crashes primarily occurred within the HOV facility and the immediately adjacent GP freeway lanes; and (3) the increase in crashes likely resulted from the speed differential between the HOV lane and GP freeway lane. The speed differential results from congestion in the GP freeway lanes slowing the operating speed compared to faster traffic in the HOV lane.

The speed differential creates problems for motorists exiting the HOV lane, as there few gaps available in the adjacent, congested GP freeway lane and other lanes. The study team also found that most of the crashes associated with the buffer-separated HOV facility with intermediate access locations occurred at or near the ingress and egress locations. The team also indicated that, due to the speed differential, it would be advisable to identify and implement actions that would reduce speeds at the ingress and egress locations, specifically on the HOV lane. The report provides recommend cross-sections for future HOV projects that were developed in a prior study, *Guidance for Future Design of Freeways with High-Occupancy Vehicle (HOV) Lanes Based on an Analysis of Crash Data from Dallas*, which is summarized below (**Figure 5**).

Figure 8 | Buffer-Separated, Concurrent Flow HOV Lanes Desirable/Minimum)



The study team believes the recommended cross-sections will aid in preventing the type of crashes noted during the analysis. A specific recommendation addresses the need for space to bypass a slowing, stalled, or disabled vehicle in the HOV lane:

> *The minimum cross-section provides enough room for two 8-foot-wide vehicles to be in the HOV lane area (inside shoulder, HOV lane, and painted buffer) of the freeway without encroaching on the general-purpose lanes.*

ISSUES AND OPTIONS FOR ENFORCEMENT (2004)

[HOV Lanes: Issues and Options for Enforcement, Final Report 552, ADOT, June 2004]

This report, citing a Minnesota Department of Transportation (MinnDOT) study, indicates the rate of traffic incidents (i.e., crashes) associated with buffer-separated HOV lanes is roughly twice that of barrier-separated HOV lanes. The cited study indicates two to three incidents per million miles of travel for the buffer-separated facility versus ≈1.4 incidents for the barrier-separated facility.[40] That being said, the report also notes that barrier-separated facilities "…are used less often, and for shorter distances." Also, barriers limit entrance, particularly exit, which is a discouraging aspect for commuters when exits are not convenient to their desired destination. The remainder of this study focuses on enforcement conditions and designs and procedures for enforcement.

Key Findings

- No technology exists that can fully automate HOV occupancy enforcement, because no technology exists that can see through metal vehicles and pick out the people inside.
- Of the factors that limit the ability to see inside a vehicle, the most pernicious is window tinting, because of the threat it poses to law enforcement. Opaque auto glass tinting can hide not only a weapon, but also the person reaching for it.
- Adequate enforcement requires extensive space in the median. In many instances it is not feasible to provide this space.
- Current statutes that require officers to have vehicles pull over to the right are inappropriate for HOV enforcement.

GUIDANCE FOR FUTURE HOV FACILITY DESIGN (2004)

[Guidance for Future Design of Freeways with High-Occupancy Vehicle (HOV) Lanes Based on an Analysis of Crash Data from Dallas, Texas, Texas Transportation Institute for TxDOT and FHWA, FHWA/TX-05/0-4434-P1, May 2004]

This report, based on crash data, has been created to provide guidance for future design of HOV facilities on freeways. The IH-635 facility in Dallas is highly congested and used frequently for short trips within the urban area. This travel characteristic results in excessive weaving associated with entry and exit of the HOV facility, and the presence of numerous freeway on/off ramps contributes to the weaving activity. The heavily congested conditions makes it difficult for motorists to find gaps in the GP freeway lane adjacent the HOV lane to exit the facility. Also, the continuous, contiguous, concurrent-flow, barrier-free HOV lane is difficult to enter, as motorists must weave to the lane then quickly accelerate up to the higher speed of the less congested facility. In both situations, the speed differential appears to be a primary factor affecting crash occurrence.

This report suggests six specific corridor characteristics to be utilized as guidance for choosing to implement a buffer- or barrier-separated, concurrent-flow HOV lane, specifically:

- Radial corridor,
- Long distance trips,
- Minimum cross-section can be used for interim installations,
- Minimum cross-section can be used across a narrow bridge structure or around columns,
- Good freeway ramp spacing that meets or exceeds current AASHTO guidelines, and
- Opportunity for enforcement locations.

The cross-sections developed as a result of this TTI study for TxDOT were incorporated into a subsequent TTI study, *Crash Data Identify Safety Issues for High-Occupancy Vehicle Lanes in Selected Texas Corridors*, as summarized earlier (refer to **Figure 3)**. The study team explains the functioning/operation of the recommended cross-sections in the following manner. The desirable cross-section with inside 10-foot shoulder, HOV lane, and painted buffer enables two 8-foot-wide vehicles to operate safely within the HOV facility, as may be required, without encroaching on the GP freeway lanes. This cross-section provides sufficient space for an entering vehicles to accelerate, while allow any upstream, oncoming vehicles to bypass on the inside shoulder, if necessary. The wide shoulder of the desirable cross-section would enable motorists to better accommodate the speed differential between the HOV lane and the GP freeway lanes. Exiting vehicles could slow or even stop, if necessary, to take advantage of gaps in the GP freeway lanes; the shoulder, in this case, would provide sufficient space for another HOV vehicle to pass. The cross-sections, in effect, support the need for acceleration and deceleration, as required, to accommodate ingress and egress, respectively.

The report notes there are two additional design/operational treatments to consider in addition to the overall cross-section.

- Endpoint/Terminus of HOV Facility
  - Terminating the HOV/HOT facility in an area of congestion is not recommended.
  - Provide, as may be possible or feasible, a dedicated travel lane at the facility terminus and any intermediate egress location to assure ample time for vehicles exiting the facility to transition into the mixed flow of the GP freeway lanes.
- Ingress/Egress Functions
  - Direct connector ramps are desirable for entering or exiting the HOV/HOT facility rather than weaving through the GP freeway lanes.
  - Allow at least 800 feet for any weaving maneuvers to enter and exit the HOV/HOT facility.
  - Maximize the distance between ingress/egress locations and the nearest on/off ramps of the freeway to accommodate weaving vehicles.
  - Merge areas for ingress/egress locations should be 1,300 to 1,500 feet in length.
  - Traffic volumes should be used as the guide for merge area lengths.
  - Refrain from locating ingress/egress points on horizontal or vertical curve, but, if necessary, account for speed differentials when evaluating needed sight distance.
  - The preferred location for facility ingress is after an exit ramp to preclude motorists diving toward the HOV lane soon after entering the freeway stream; similarly, egress locations should not immediately precede a freeway exit.

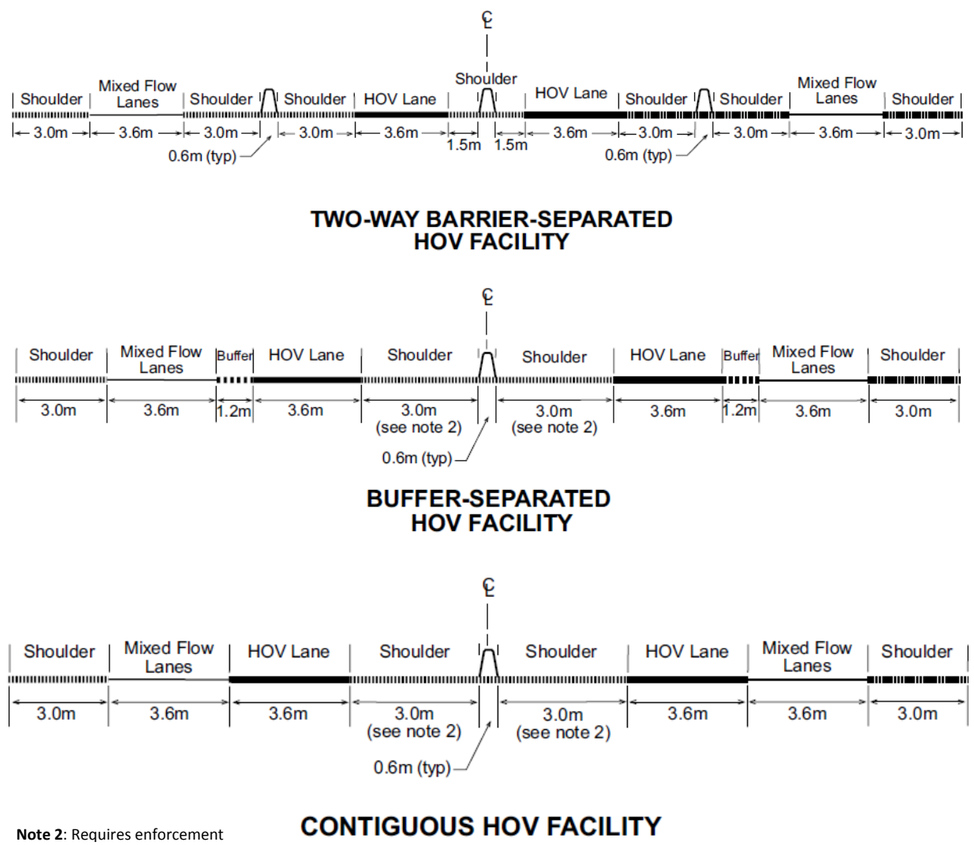
HOV PLANNING, DESIGN, AND OPERATIONS GUIDELINES (2003)

[High-Occupancy Vehicle Guidelines for Planning, Design, and Operations, Caltrans Department of Transportation Division of Traffic Operations, August 2003]

This document addresses barrier-separated, buffer-separated, and contiguous HOV facilities, all based on a concurrent-flow operation. Barrier-separated facilities are divided into two-way, barrier-separated HOV facilities and one-way, reversible barrier-separated HOV Facilities (the latter has not been identified as an option under consideration for The Spine Corridor). The report describes barrier-separated HOV facilities as having the following advantages: easy to enforce, easy to manage incidents, no interference from mixed-flow GP freeway lanes, low violation rate, and high level of driver comfort. The three cross-sections are shown in **Figure 6**.

[40] Cambridge Systematics with URS, Inc. *Twin Cities HOV Study Final Report.* (Minnesota Dept. of Transportation; February 2002), 5-4.

Figure 9 | Alternative Cross-Sections for HOV Facilities



Note 2: Requires enforcement

Traffic operating on a buffer-separated HOV facility is segregated from GP freeway lanes by a buffer generally 1.2m wide or less (nominal 4 feet). Wider buffers are not desirable, as they may be perceived by motorists as refuge areas, which can result in hazardous driving conditions for traffic in both the HOV and GP freeway lanes. The typical section shown in **Figure 4** includes a 3m-wide shoulder (nominal 10 feet) to the left (median side) of the HOV lane. The Caltrans report notes that buffer-separated HOV facilities generally provide motorists with better LOS compared to contiguous HOV facilities. The separation provides higher driver comfort and extra margin of safety by providing additional area for maneuvering, and it lessens potential impacts deriving from incidents occurring on the adjacent GP freeway lanes.

Caltrans notes that contiguous HOV facilities normally are associated with short duration, high-volume, peak commute travel demand. These facilities do not offer any separation, aside from a delineating pavement striping, from traffic on contiguous GP freeway lanes, primarily due to limited right-of-way. Users of the HOV lane are free to enter and exit the lane throughout the length of the facility. No design details or special accommodations are required to facilitate ingress/egress, except for pavement striping and signage at the beginning and end of the HOV facilities. A typical cross-section for a contiguous HOV facility operating concurrently with GP freeway lanes is shown in **Figure 4**.

The Caltrans report indicates that direct connector ramps are appropriate to facilitate seamless freeway-to-freeway movements. A decision to pursue this operational solution would depend on:

- Peak-hour volumes on the HOV lanes,
- Available right-of-way along the freeway and within the interchange area,
- Need to alleviate congestion bottlenecks resulting from HOV lane egress and weaving movements across mixed-flow traffic,
- Various issues associated with LOS and travel-time savings, and
- Safety compared to merging requirements, as vehicles exit the HOV lanes into mixed traffic of the GP freeway lanes.

Emphasis appears to be on operational issues and funding, as there is little information available regarding the safety benefits of direct connectors versus at-grade transitions.

General guidance regarding signage and markings associated with HOV facilities states “much of HOV signs and markings relate to enhancing safety for the motorists.” Specific guidance is provide regarding signage associated with HOV facilities:

- Signage is necessary to alert drivers of differential speeds between the HOV lanes and adjacent GP freeway lanes.
- Signage needs to make clear that passing opportunities are constrained and discourage frequent weaving and merging across the delineating striping or buffer zone to pass slower vehicles.
- Signage and markings must be carefully considered to assure not only the typical commuter but also the occasional user can effectively operate on the HOV facility.

Extensive guidance is provided regarding the information, positioning, and maintenance of signage and markings for various type of HOV facilities.

Enforcement raises numerous issues when considering the type of HOV facility. While a paved median and enforcement area is the preferred option of new HOV facilities, right-of-way limitations can stifle efforts to create such areas to support operations of existing HOV facilities. The lack of inside shoulders can have an adverse impact on safety and overall freeway operations. Enforcement, the degree to which there will be enforcement, and safe implementation of the adopted enforcement level also must be a consideration in the design and operation of HOV facilities. The single-stripe barrier creates separation, but this type of treatment may limit enforcement capabilities, due to a requirement for the violator to exit the HOV lane into mixed traffic of the GP freeway lanes. The wider, painted buffer presents a similar challenge, and it is crucial that the buffer be no wider than 1.2m (nominal 4-feet) to prevent the illusion it is a safe place to stop.

A physical enforcement action requires the violator and enforcement official to exit a single-stripe or buffered HOV lane, the two vehicles must weave across the GP freeway lanes, across congested, mixed-flow traffic to the right shoulder of the freeway. This not only poses safety risks to the two vehicles and traffic in the mixed-flow GP freeway lanes, but it is likely to result in congestion. The potential for congestion, in and of itself, creates safety issues for missed-flow traffic traveling at high speeds. Therefore, the potential impacts of enforcement must be weighed against the benefits to be attained in the operations of the HOV facility. Physically-separated HOV lanes with a fixed, permanent barrier requires additional areas to assure safe operation of the HOV facility, safe enforcement activities, and accommodations for emergency vehicles, as necessary. The cross-sections shown in **Figure 4** incorporate nominal

10-foot shoulders complementing the HOV lane, which can minimally support enforcement needs. The Caltrans report states "The optimum design is the availability of adequate enforcement areas in the median. Where existing facilities do not have these enforcement areas or new facilities are not designed with them, it can be expected that enforcement on the facility will be challenging."

INTERIM MANUAL FOR MANAGED LANES (2003)

[Interim Manual for Managed Lanes, Texas Transportation Institute for TxDOT, Report 4160-14 (FHWA/TX-04/4160-14), October, 2003]

This research project was undertaken to (1) investigate the complex and interrelated issues associated with the operation of managed lanes using various operating strategies and (2) develop a Managed Lanes Manual for the Texas Department of Transportation (TxDOT). The project represents three years of research to aid TxDOT in making informed planning, design, and operational decisions regarding managed lanes. The research examined a variety of techniques and measures for expediting traffic flow, including:

Separated Two-Way HOV Lanes,
Concurrent Flow HOV Lanes,
Contraflow HOV Lanes,
Value-Priced Lanes and High-Occupancy Toll (HOT) Lanes,
Exclusive Busways,
Exclusive Truck Lanes,
Separation/Bypass Lanes,
Lane Restrictions, and
Dual Facilities (Inner roadway for light trucks/cars; Outer roadway for all vehicles – for trucks/buses/cars).

The report notes that "the characteristics that matter most to the driver are speed of travel, safety, comfort, and convenience." Although, little information is provided regarding the safety of any of the investigated facility types, and no safety information is provided relative to the design criteria for a managed lane facility. Nevertheless, recommendations are sometimes supported with comments that the specified criteria are needed "…to assure safety…" without supporting evidence or data analysis.

The two configurations of interest for the purposes of this research are Concurrent-Flow HOV lanes and Value-Priced Lanes and High-Occupancy Toll (HOT) Lanes.

Concurrent-Flow, Managed-Lane Facilities

This type of facility generally is not physically separated from the GP freeway lanes. Concurrent-flow HOV lanes generally are located in the median area of highways. Pavement markings commonly are used to delineate these lanes from the GP freeway lanes. Restrictions on use during peak periods commonly promotes more expeditious travel by eligible vehicles. Unlimited ingress and egress to the HOV lanes is a common operational mode, although limited-access is preferred for these types of facilities from the stand point of enforcement. Restrictions on entry/use often are lifted during off-peak periods to expanding the capacity of GP freeway lanes. Key design components of concurrent-flow, managed-lane facilities are outlined below:

Desirable inside shoulder widths contiguous with the median barrier is 10 to 14 ft (3.0 to 4.2 m) for enforcement purposes, but can be less depending on other project constraints (e.g., right-of-way, electronic enforcement).

A concurrent-flow, managed-lane should adhere to the design standards of the GP freeway lanes, which generally are 12-foot (3.6 m) travel lanes.

The desirable buffer width is 4-ft (1.2m); buffers between 4 ft (1.2 m) and 8 ft (2.4 m) should be avoided between the concurrent-flow, managed-lane and adjacent GP freeway lane, as this range may encourage unsafe use of the shoulder as a breakdown or emergency stopping area.

The desirable cross-section for a two-way, concurrent-flow, managed lane includes median barrier, a shoulder (or lateral clearance), managed lanes, and painted stripe or painted buffer to separate the managed lane from the GP freeway lane creating a general design envelope of 54- to 62-ft (16.3 to 18.8 m). Reducing the design envelope to as narrow as 34-ft (10.3 m) may be justified under special circumstances, such a reduction could adversely impact the safe and efficient operation of a facility.

Three different design scheme for concurrent-flow, managed-lanes are shown in **Figure 7**.

Exclusive Two-Way Managed Lane Facilities

Exclusive two-way, managed-lane facilities, or limited-access facilities, are physically separated from the GP freeway lanes, usually by concrete barriers.[41] As this type of facility generally is developed to permit the imposition of value-pricing or tolls, exclusive two-way managed-lane facilities generally remain exclusive throughout most of the day. This type of facility is controlled by limiting access to the beginning and ending of the lanes, although, sometimes, intermediate access points. Intermediate access points permit value-pricing for individual segments and allows access to locations along the route of the facility. The facilities may include direct ramps to overcrossing arterial roadway and other exclusive ingress and egress treatments, e.g., connector ramps from intersecting highways. Key design components of two-way, limited-access, managed-lane facilities are outlined below:

A 2- to 4-ft (0.6 to 1.2 m) lateral clearance should be provided adjacent to the median barrier. As a minimum, a shared median shoulder 10-ft (3.0M) wide would be necessary; however, this treatment would only be applicable for two-way ramps, short sections of roadway, low-volume segments of the facility, or other lower speed conditions.

Operating lanes should be adhere to the design standards of the 12-foot GP freeway lanes.

A 2- to 4-ft (0.6 to 1.2 m) lateral clearance should be provided adjacent to the barrier separating the managed lane(s) from the adjacent GP freeway lane, and a similar lateral clearance should be provided on the GP freeway land side of the barrier.

The cross-section for a two-way, concurrent-flow, managed lane includes median barrier, an inside shoulder (or lateral clearance), managed lanes, an outside shoulder, concrete barrier, and lateral clearance for the adjacent GP freeway lane, creating a general design envelope of 38 to 54-ft (16.3 to 18.8 m). Reducing the design envelope may be justified under special circumstances (e.g., right-of-way constraints, bridge crossing); however, such a reduction could adversely impact the safe and efficient operation of a facility.

Three different design scheme for concurrent-flow, managed-lanes are shown in **Figure 8**.

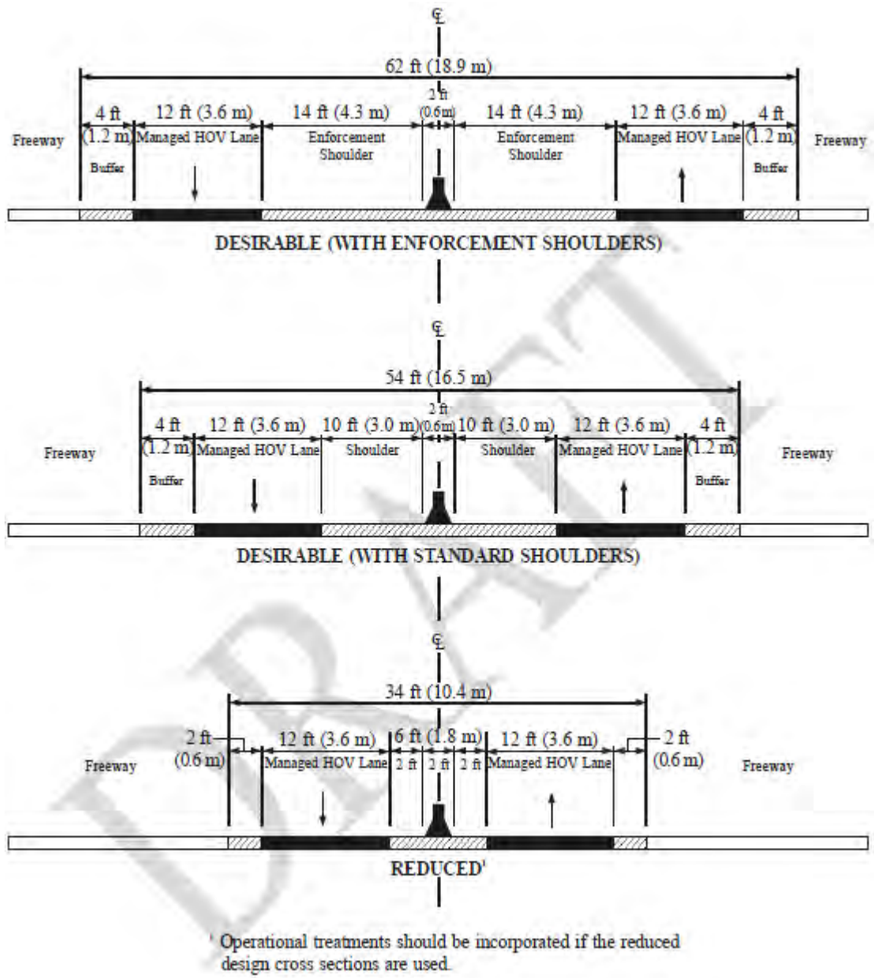
THOUGHTS FROM THE 2002 CALIFORNIA HOV SUMMIT (2002)

[Respectively: Jeff Lindley, Director, Office of Travel Management, FHWA; Tony Harris, Chief Deputy, Caltrans; Chuck Fuhs, Senior Project Manager, Parsons Brinckerhoff, Quade & Douglas, October 2002]

FHWA's position and policies require that, when communities desire to change HOV facilities, it is necessary that all techniques are employed to make the modified facilities a success. At the point a community decides to change HOV facilities, there is a federal process to be followed to permit review of any significant changes to the hours of operation and occupancy requirements.

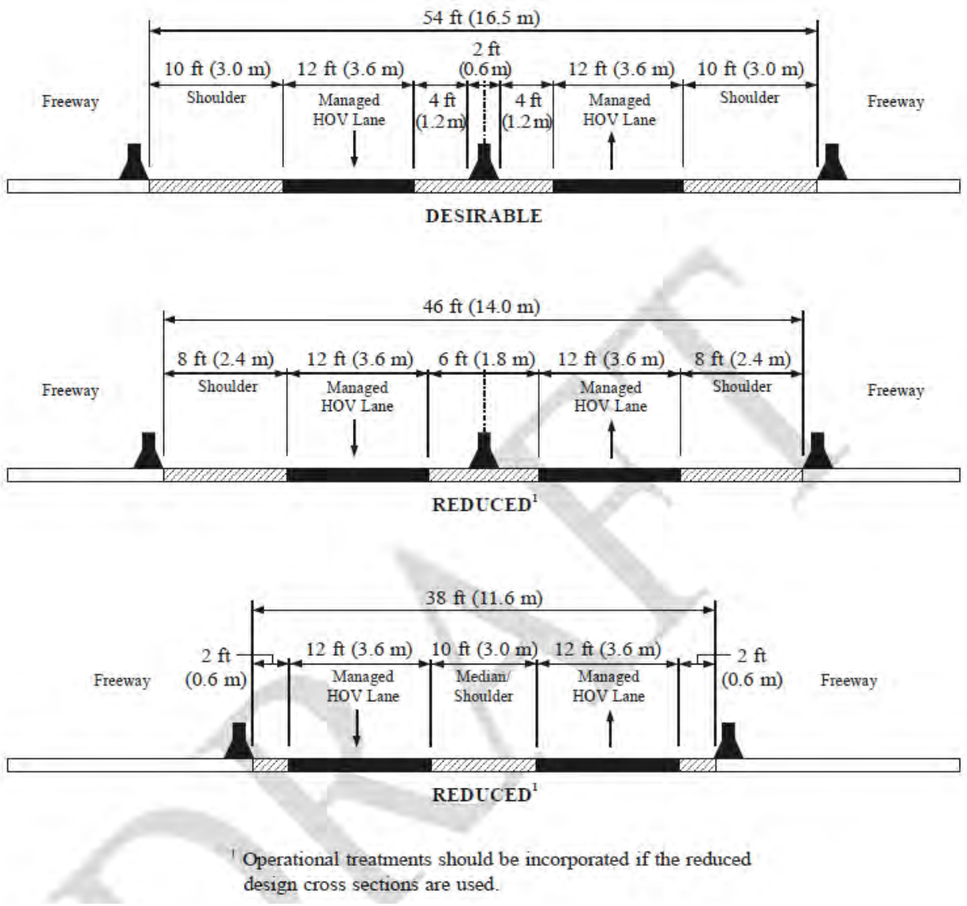
[41] It should be noted that hybrid versions of buffer-separated facilities, as described above, have been developed using flexible, reflective posts attached to the pavement or less permanent pylons; however, this type of treatment does not ensure exclusivity of the facility.

Figure 10 | Typical Cross-Sections Options for Concurrent-Flow, Managed-Lane Facilities



Source: Interim Manual for Managed Lanes, TxDOT; Adapted from Texas Transportation Institute, Parsons, Brinckerhoff, Quade, and Douglas, and Pacific Rim Resources. NCHRP Report 414: HOV Systems Manual. TRB, National Research Council, Washington, D.C., 1998.

Figure 11 | Typical Cross-Sections Options for Limited-Access, Managed-Lane Facilities



Source: Interim Manual for Managed Lanes, TxDOT; Adapted from Texas Transportation Institute, Parsons, Brinckerhoff, Quade, and Douglas, and Pacific Rim Resources. NCHRP Report 414: HOV Systems Manual. TRB, National Research Council, Washington, D.C., 1998.

The Caltrans representative pointed out that the safe operation of HOV facilities is important, as users need to count on reliability for trips. Maintenance of system reliability for users is the best motivator for travelers to use the HOV facilities.

Persons representing the Los Angeles Metropolitan Transit Authority (MTA) presented the findings of research performed to determine and understand HOV facilities use in Los Angeles County. An MTA consultant outlined nine concerns, one of which addressed safety. He noted that research was inconclusive, due to the fact that crashes occurring in the HOV lanes are not always identified as such, resulting in HOV lane crashes being comingled with the GP freeway lanes, or free-flow, lanes. The research team "…found no strong correlation to indicate that carpool lanes are unsafe."

Mobility Measures (2001)

[Chapter 24 – Mobility Measures, NYDOT Highway Design Manual, Revision 32, May 2001]

This Manual makes note of the following guidance provided in AASHTO's *Guide for the Design of High-occupancy Vehicle Facilities*. The HOV facility design that can be provided should allow for safe, efficient, and enforceable operation. With respect to enforcement, the Manual states:

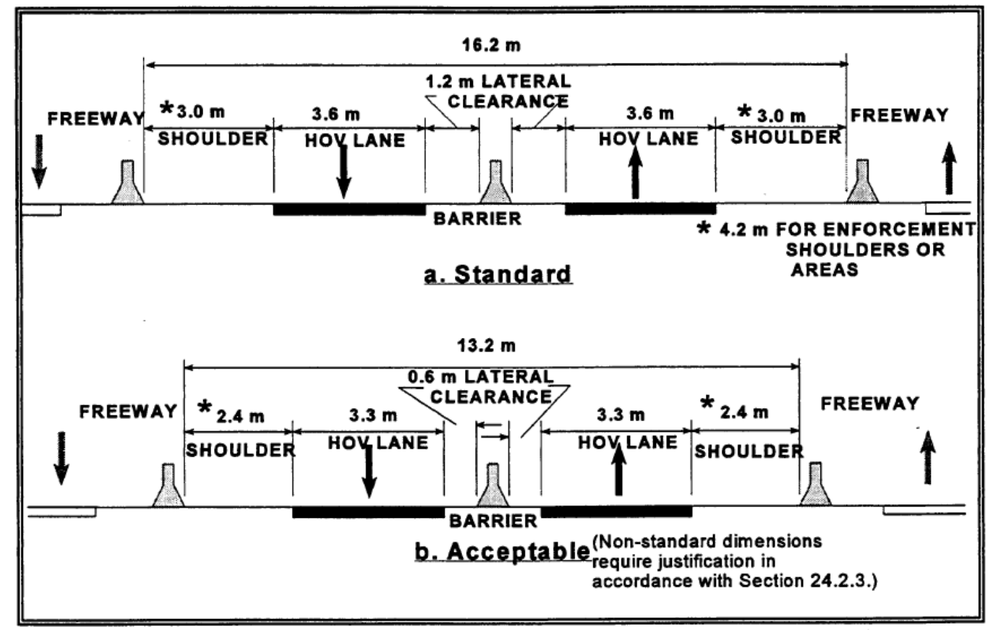
> *The absence or presence of certain roadway features can adversely affect the enforcement process as well as the safety and operational features of the facility. Physical problems may include lack of safe and easily accessible enforcement areas, absence of vantage points, lack of physical separation, and lack of passing capability for enforcement vehicles.*

Also, the Manual discusses the admission of commercial vehicles to HOV facilities. Although the potential for improving safety on the GP freeway lanes during peak periods is noted, the Manual also states the geometrics of HOV facilities may not be compatible with commercial truck movements. In addition, the weaving of large commercial trucks in the mixed-traffic of GP freeway lanes may be problematic. In any case, as noted above the intent of HOV facilities is to increase person throughput, and trucks do not contribute to this goal.

Regarding buffer-delimitation or buffer strips on the pavement to define a restricted area, i.e., HOV lane v. GP freeway lane, the width of a narrow buffer should be no greater than 1.2m (nominal 4 feet) or less than 0.3m (nominal 1 foot). A wide buffer should not be greater than 4.2m (nominal 14 feet) or less than 3.0m (nominal 10 feet). A narrow buffer should not exceed 1.2m and a wide buffer should not be less than 3.0m. Buffer widths within the 1.2m to 3.0m range are considered unsafe for drivers to use as a refuge.

The Manual notes that two-way, symmetrical, barrier-separated facilities provide safe operations, as they prevent traffic conflicts of HOV lane travel with the GP freeway traffic. It states that, "when dedicated access connections are provided, exclusive two-way flow lanes function as fully controlled lanes within a freeway and are considered the most desirable type of HOV treatment, albeit the most costly treatment." It is important to point out, the Manual emphasizes openings for access by emergency vehicles must be provided in the median barrier at reasonable intervals. Typical cross-sections for two-way, symmetrical, barrier-separated facilities are shown in **Figure 9**.

Figure 12 | Typical Cross-Sections for Barrier Separated Two-Way Flow HOV Lanes



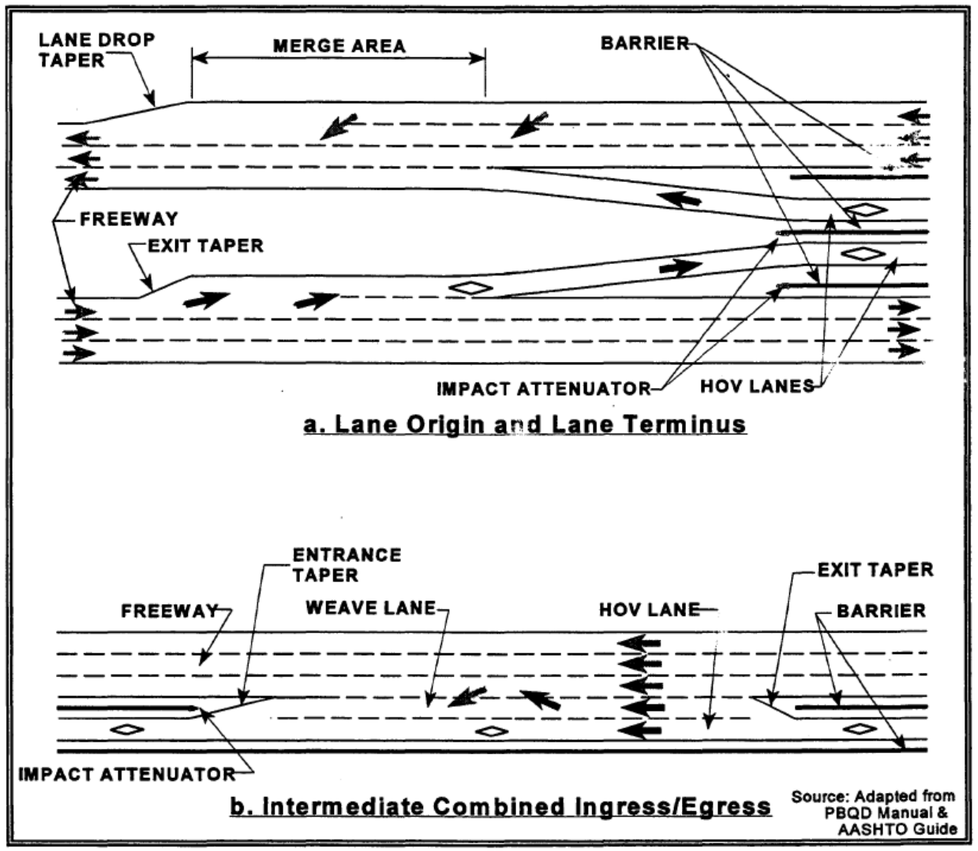
Ingress and egress is a critical challenge in the efficiency and safety of two-way, symmetrical, barrier-separated facilities. The Manual provides the following guidance for accommodating ingress and egress at the facility terminal points and at intermediate locations, in included. This guidance is cited below:

> *When conditions permit, intermediate ingress and egress should be provided at separate barrier opening locations to prevent conflicts between the associated weaves. Egress from the HOV lane should always precede ingress to the HOV lane to avoid congestion on the HOV lane. In addition, HOV egress should not be considered at the first access point downstream from the origin, and HOV ingress should not be considered at the last barrier opening upstream from the HOV lane termination. Each barrier opening should provide adequate distance for HOVs to weave into or out of the HOV lane. Special consideration should be given to the acceleration and deceleration characteristics of loaded buses, particularly if access ramps have significant grades. The weave distance should be calculated in accordance with TRB's Special Report 209 Highway Capacity Manual.*

When constraints prevent the installation of separate ingress and egress, they may be provided at the same location. If there is enough space available, a weave lane should be provided to allow the entering and leaving vehicles to make an orderly transition from one facility to the other. The opening length should generally range between 300 m and 450 m, as determined by a weave analysis in accordance with TRB Special Report 209, Highway Capacity Manual. Shorter distances may create a safety hazard by not providing adequate weave distance. Longer distances provide so much distance that the weave lane could be used as a passing lane by HOVs.

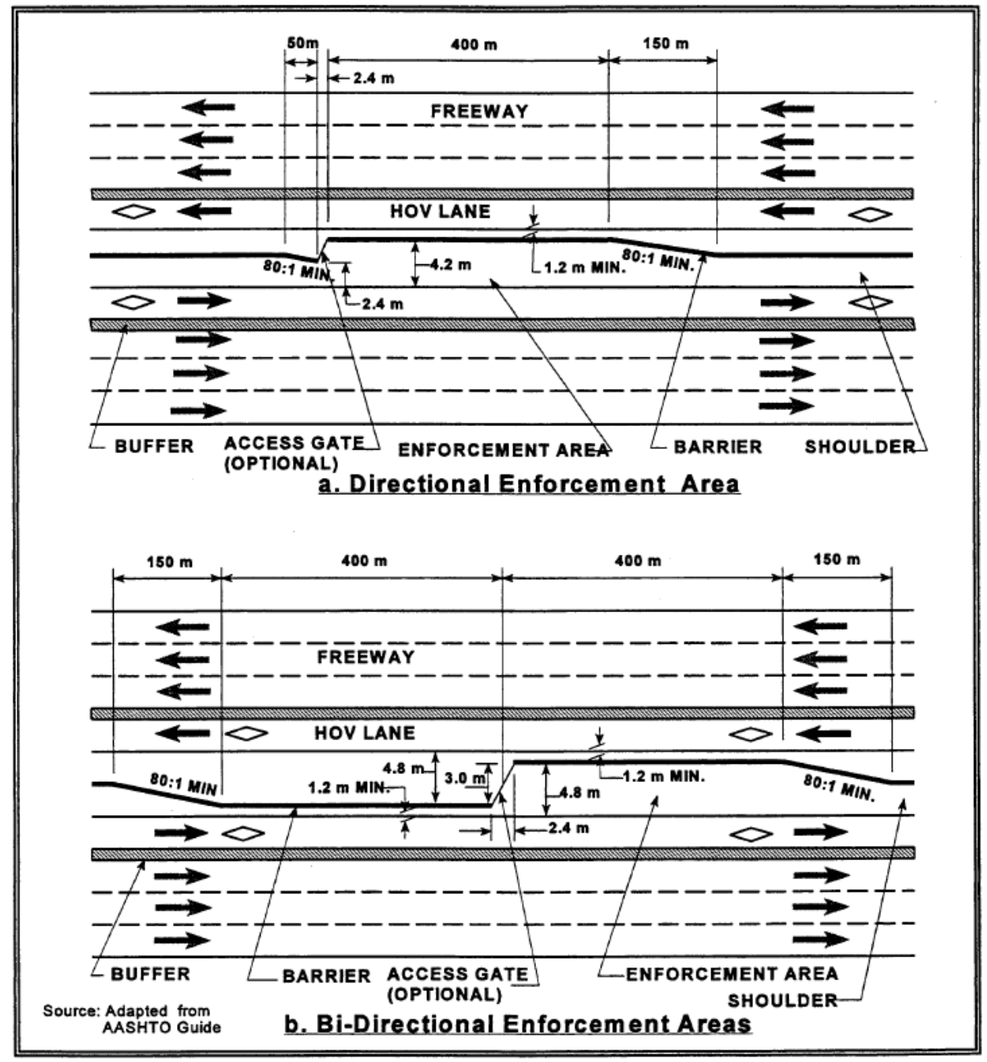
Figure 10 shows this graphically depicts the essence of this guidance.

Figure 13 | At-Grade Slip Ramps for Barrier-Separated Two-Way Flow HOV Lanes



Safety of operations associated with HOV/HOT managed-lane facilities generally includes accommodations for enforcement. Enforcement opportunities differ, depending on the width of the facility. For two-way, symmetrical, barrier-separated facilities with an inside shoulder, an enforcement area can be created by widening one shoulder into the other. Sufficient distance must be allocated to allow deceleration/acceleration of vehicles entering and existing the enforcement area. Two enforcement areas also can be paired. **Figure 11** shows two examples of enforcement areas for a two-way, symmetrical, barrier-separated facility. Buffer-separated, limited-access/intermediate-access lanes also may need to accommodate enforcement areas, as ingress and egress are facilitated at specified locations. Although it is possible, though not permissible to cross the buffer, these types of facilities effectively are barrier-separated with respect to vehicle operations.

Figure 14 | Median Enforcement Area for Medians 6.0 to 9.0 Wide



Non-separated, continuous, contiguous, concurrent-flow HOV/HOT managed-lane facilities provide greater ease of ingress/egress from/to the GP freeway lanes. However, enforcement is complicated by the lack of an enforcement area, unless an inside shoulder is sufficiently wide to accommodate stopped vehicles and pedestrian (primarily enforcement officers) movements. The principal safety issue associated with non-separated, continuous, contiguous, concurrent-flow HOV/HOT managed-lane facilities traffic is the risk of legal or illegal entry of low-speed vehicles from the GP freeway lanes, which may be congested, into the HOV lanes with greater free flow and, therefore, higher speed. Although contiguous lanes are separated by pavement striping, the minimal standard HOV facility with a 3.6m (nominal 12-f) lane and 3.0m (nominal 10-foot) inside (left shoulder) does not accommodate safe enforcement. If continuous enforcement or intermediate enforcement is too be maintained, then the inside shoulder needs to 4.2m (nominal 14 feet) wide.

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HOV and HOT Managed Lanes Pricing and Operations

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ATTACHMENT B

SITE CHARACTERISTICS CONSIDERATIONS FOR SEPARATION OF MANAGED LANES FROM GENERAL PURPOSE LANES

ATTACHMENT B

SITE CHARACTERISTICS CONSIDERATIONS FOR SEPARATION OF MANAGED LANES FROM GENERAL PURPOSE LANES

	Concrete Barrier	Buffer	Post
I. Lane & Shoulder Width			
1. Ideal lane and shoulder widths	Yes	Yes	Yes
2. Lane and shoulder widths less than ideal	Maybe – Must have room for the barrier itself. – Must have sufficient room in a managed lane delineated by barriers to allow incident bypass and clearing. – *Tunnel effect*: Users of managed lane may feel they have less room than they actually do; Level of Service may drop.	Maybe – Drivers will be less likely to maintain a high speed differential on a narrow lane; Level of Service may drop. – Unlawfully crossing boundary will be easier.	Maybe – Posts require a buffer of at least 2 ft. – Drivers will be less likely to maintain a high speed differential on a narrow lane; Level of Service may drop. – Unlawfully crossing boundary will be easier. – Posts may make users of managed lane feel like they have less room than they actually do; Level of Service may drop.
3. Shoulders available in managed lane	Yes	Yes	Yes
4. No or minimal shoulder available in managed lane	No – Motorists can be trapped behind an incident. – No room to safely avoid a disabled vehicle. – Emergency vehicles may not be able to reach an accident.	Maybe – No refuge for disabled vehicles.	Maybe – No refuge for disabled vehicles.
II. Traffic Considerations			
1. Uncongested main lanes	Yes	Yes	Yes
2. Congested main lanes	Yes + Physical barrier separates managed lane and main lanes, making higher speed differentials possible.	Maybe – Drivers may be uncomfortable with high speed differentials without physical separation. – Risk of drivers illegally swerving into managed lanes to pass slower traffic. ! A wide buffer may negate these effects.	Maybe – Drivers may be uncomfortable with high speed differentials without a more rigid separation ! A wide buffer may negate these effects.
3. Trucks allowed in managed lane	Yes + General-purpose lanes are protected from trucks using the faster managed facility. – If managed lane consists of only one lane, drivers may get stuck behind trucks, especially on inclines.	No – Having trucks in the fast-moving managed lanes without any physical separation from slower main lanes is unadvisable.	No – Having trucks in the fast-moving managed lanes without more substantial physical separation from slower main lanes is unadvisable. – Trucks often mow down posts, especially in restricted-width conditions.
4. Trucks in adjacent general-purpose lane	Yes + Provides protection for managed lane from adjacent, slow-moving trucks.	Maybe – No protection for managed lane from adjacent, slow-moving trucks.	Maybe – No protection for managed lane from adjacent, slow-moving trucks.
5. Buses/transit use managed lane	Yes ! Slow-moving buses may lower the Level of Service for the facility if a single-lane configuration is used.	Yes ! Slow moving buses may encourage people to weave in and out of managed lanes to overtake them.	Yes ! Slow-moving buses may lower the Level of Service for the facility if a single-lane configuration is used.
6. No buses on managed lane	Yes	Yes	Yes
III. Centerline Geometry			
1. Less than ideal horizontal curve radii	Maybe – If sight distance is less than ideal, barriers may further reduce it. ! Adequate shoulders are essential: if not provided, vehicles will be forced to drive close to the barrier; level of service may suffer, especially on turns. ! Adequate shoulders will allow drivers to swerve to avoid incidents that they were blocked from seeing.	Maybe – Drivers may feel uncomfortable making a sharp turn coupled with a high-speed differential.	Maybe – Drivers may feel uncomfortable making a sharp turn with a high-speed differential. – Posts may provide a distraction, which may increase stopping sight distance.
2. Ideal horizontal curve radii	Yes	Yes	Maybe – Use of posts on curves can be expected to increase maintenance costs due to vehicle impacts

Source: Table 2.1: Expert Panel Results, Site Characteristic Considerations, *Best Practices: Separation Devices between Toll Lanes and Free Lanes*, Texas Department of Transportation (TxDOT), FHWA/TX-07/0-5426-1, October 2006, Revised February 2007.

ATTACHMENT C

COMPARISON OF SEPARATION TREATMENTS

COMPARISON OF SEPARATION TREATMENTS

Separation Type		Rigid Barriers	Delineators	Pavement Markings
Safety	Pros	• Reduces General Purpose Lane and Express Lane side swipes • Express Lane traffic is separated from incidents in General Purpose Lanes	• Easier access for emergency vehicles since delineators can be driven over	• Easy access for emergency vehicles since there is no physical separation • Easy for Express Lanes traffic to vacate the lanes in case of an emergency or incident in the lanes
	Cons	• Access to lanes is restricted, therefore Incident Management response may take longer • With an incident in the Express Lanes, the impact to Express Lane traffic is high because of lane blockage • More difficult to vacate lanes in case of an emergency or incident	• Impacts to delineators can create roadway debris • Vehicles in the General Purpose Lanes are not physically separated from Express Lanes if an incident does occur	• More opportunity for General Purpose Lane and Express Lane side swipes • Vehicles in the General Purpose lanes are not physically separated from Express Lanes if an incident does occur
Right-of-Way	Pros	*None*	• No right of way typically needed for installation	• No right of way typically needed for installation
	Cons	• Right of way typically needed for access points installation	*None*	*None*
Cost	Pros	• Low maintenance • Allows for overhead sign structure uprights to be placed within barrier, which reduces sign structure spans	• Easy installation • Low installation cost	• Easy installation • Low installation cost
	Cons	• Higher cost for installation than other methods	• High maintenance costs due to frequent replacement of delineators that are hit by vehicles • No location for overhead sign structure uprights within area separating General Purpose Lane & Express Lane, which results in longer sign structure spans	• No location for overhead sign structure uprights within area separating General Purpose Lane & Express Lane, which results in longer sign structure spans
Express Lane Roadway Features and Operational Characteristics	Pros	• Allows for higher operating speeds in Concurrent Flow operations • Reduces toll avoidance • Better enforcement areas due to limited access points	• Provides some physical separation which can help reduce toll avoidance • Reduces illegal lane changes	• Easy to operate in mixed mode during non-peak times
	Cons	• When installed within existing roadway cross sections, design constraints may be involved • Mixed mode operations in non-peak times are not applicable • Special openings or devices may be needed for emergency vehicles during incident responses	• Hard to operate in mixed mode during non-peak times • Easily traversed • Hard to establish enforcement areas • Operating speeds may be lower than posted because of limited physical separation • Frequent maintenance on delineator replacements	• Illegal lane changes are not deterred • Hard to enforce illegal maneuvers and other infractions because enforcement areas are hard to establish • Operating speeds within the Express Lanes are typically lower than posted during congested times because no physical separation is present
Access Points	Pros	• Access points are controlled by physical separation making them easier to enforce and limits violators	• Easy adjustment of access points after initial installation • Access points are controlled by visual/soft separation limiting violators	• Easy adjustment of access points after initial installation
	Cons	• Possible flyovers or extra ramps required for General Purpose Lane left exits	• General Purpose Lane traffic may have to merge with Express Lane traffic for left exits	• General Purpose Lane traffic may have to merge with Express Lane traffic for left exits

ATTACHMENT D

PUBLIC PERCEPTION OF DIFFERENT BARRIER AND BUFFER SCHEMES

PUBLIC PERCEPTION OF DIFFERENT BARRIER AND BUFFER SCHEMES

System Separation Alternative	Perceived Pros	Perceived Cons
Pavement Markings (Buffer-separated)	▪ Inexpensive ▪ Familiarity to Atlanta residents ▪ Faster implementation possible ▪ Easy to remove if managed lanes system is unsuccessful ▪ Can vacate lane if necessary	▪ Easier to cheat this system ▪ Drivers can cut in and out of managed lanes
Concrete Barrier	▪ Reversible lanes concept is possible with this arrangement ▪ Feeling of safety when physically separated from the slower moving traffic in the general purpose lanes	▪ Some respondents feel this arrangement would exasperate their claustrophobia ▪ Fear of hitting the concrete barrier and damaging their vehicles induces some travelers to drive more slowly ▪ Trapped within the concrete barrier system in the event of an emergency
System Separation Alternative	Perceived Pros	Perceived Cons
Pylons	▪ Relatively inexpensive ▪ Provides a clear demarcation between lanes ▪ Travelers can drive over a pylon in an extreme emergency if necessary ▪ Easy to remove if managed lanes system is unsuccessful	▪ Frequent maintenance would be required for destroyed pylons
Grade Separation	▪ Perceived as efficient, especially for long trips ▪ The time and investment necessary elicited the response that this type of facility would best be suited as a HOT or toll system ▪ Feeling of safety when separated from slower moving traffic in the general purpose lanes	▪ Some respondents feel this arrangement would exasperate their claustrophobia and/or acrophobia ▪ Trapped within the system without a means to vacate in the event of an emergency ▪ Long construction times ▪ General disbelief that such a complex and expensive system would ever be implemented

Source: Table 1, Public Perception of Different Barrier and Buffer Schemes, in *Technical Memorandum 17B: Advantages and Disadvantages of Barrier versus Buffer Separated Managed Lanes,* Emerging Issues: Barrier versus Buffer Separated Managed Lanes, Atlanta Regional Manage Lane System Plan, Georgia Department of Transportation (GDOT), January 2010.

Appendix C. Agency and Public Involvement

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Agency Letter

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50th Anniversary 1967–2017

January 4, 2017

RE: Interstate 10/Interstate 17 Spine Corridor Master Plan Public Meetings

Dear Agency Representative:

In early 2014, the Maricopa Association of Governments (MAG), in association with the Arizona Department of Transportation (ADOT) and Federal Highway Administration (FHWA), entered into a partnership establishing a Corridor Master Plan to determine, plan, and implement Regional Transportation Plan (RTP) improvements to Interstates 10 (I-10) and 17 (I-17) and parallel arterial corridors in the Phoenix Metropolitan area. The study corridor has been named the "Spine" because it serves as the backbone for transportation in the metropolitan Phoenix area. MAG, along with its study partners, are planning public open houses to share the results of the technical analysis and receive feedback on the recommended improvements.

The purpose of this study was to investigate long-term options to improve travel mobility and address projected travel demand on I-10 and I-17. The Spine Corridor Master Plan will provide guidance in establishing a group of projects contributing to and meeting a regional vision for I-10 and I-17. As part of this study, a Planning and Environmental Linkages (PEL) process is underway to integrate environmental, community, and economic goals into the transportation planning process.

This letter serves as MAG's invitation to participate in any of the four upcoming public open houses to learn more about the study and recommended improvements:

Tuesday, January 24, 2017
❶11:30 a.m. to 1:00 p.m. and ❷6:00 to 7:30 p.m.
Maricopa Association of Governments, Saguaro Room, 2nd Floor
302 N. 1st Ave., Phoenix, 85003

Wednesday, January 25, 2017
❸6:00 to 7:30 p.m.
Town of Guadalupe El Tianguis Mercado, Multipurpose Room
9201 S. Avendia del Yaqui, Guadalupe, 85283

Tuesday, January 31, 2017
❹6:00 to 7:30 p.m.
Washington Activity Center, Multipurpose Room
2240 W. Citrus Way, Phoenix, 85015

Meeting materials will be posted on the project website in mid-January; I encourage you to visit http://spine.azmag.gov to learn more about the project. Comments may be mailed to Maricopa Association of Governments, c/o Bob Hazlett, 302 N. 1st Ave., Suite 200, Phoenix, AZ 85003 or e-mailed to spine@azmag.gov. **We would appreciate receipt of your comments by Friday, February 17, 2017**.

Sincerely,

Robert C. Hazlett, P.E.
Senior Engineering Manager

50 Years of Serving the Region

City of Apache Junction ▲ Arizona Department of Transportation ▲ City of Avondale ▲ City of Buckeye ▲ Town of Carefree ▲ Town of Cave Creek ▲ City of Chandler ▲ Citizens Transportation Oversight Committee
City of El Mirage ▲ Town of Florence ▲ Fort McDowell Yavapai Nation ▲ Town of Fountain Hills ▲ Town of Gila Bend ▲ Gila River Indian Community ▲ Town of Gilbert ▲ City of Glendale ▲ City of Goodyear
Town of Guadalupe ▲ City of Litchfield Park ▲ City of Maricopa ▲ Maricopa County ▲ City of Mesa ▲ Town of Paradise Valley ▲ City of Peoria ▲ City of Phoenix ▲ Pinal County ▲ Town of Queen Creek
Salt River Pima-Maricopa Indian Community ▲ City of Scottsdale ▲ City of Surprise ▲ City of Tempe ▲ City of Tolleson ▲ Town of Wickenburg ▲ Town of Youngtown

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	Sir or Madame	Salt River Pima-Maricopa Indian Community	christopher.horan@srpmic-nsn.gov
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Press Release

MARICOPA ASSOCIATION of GOVERNMENTS

NEWS RELEASE

www.azmag.gov

50th Anniversary 1967-2017

FOR IMMEDIATE RELEASE
CONTACT: Kelly Taft, MAG Communications Manager, (602) 452-5020

I-10, I-17 Travelers Urged to Provide Final Input in "Spine" Study

PHOENIX (January 11, 2017)—Transportation planners have finished a two-year study and are preparing final recommendations to improve traffic along the Interstate 10/Interstate 17 corridor, known as the "Spine" because it serves as the backbone of the freeway system in the metropolitan area. They hope members of the public will share their final thoughts on the plan during four upcoming public meetings. The study team received more than 4,000 comments on necessary improvements to the corridor during earlier outreach efforts.

More than 40 percent of all daily freeway traffic uses the Spine. The Maricopa Association of Governments (MAG), in partnership with the Federal Highway Administration and the Arizona Department of Transportation, embarked on the study in 2014 to develop a master plan for the I-10/I-17 corridor. The 31-mile Spine corridor begins at the I-17/Loop 101 North Stack interchange in the north Valley and travels south and east to the interchange with I-10/Loop 202 Pecos Stack.

"Our goal is to make our most heavily traveled freeway corridor safer and more efficient for commuters, residents and pedestrians, so community feedback is vital," said MAG Chair and Phoenix Mayor Greg Stanton. "One of the big 'aha' moments of the study that has emerged so far came when we realized that more than twice the amount of traffic crosses over I-17 than uses it. I-17 should not be a wall that separates neighborhoods. The recommendations will include solutions to improve connections from one side of the freeway to the other."

In fact, the recommendations include upgrades to 24 of 31 traffic interchanges. These include widening or adding structures to improve cross-freeway traffic. Other key recommendations include:

- Improving safety by modernizing interstates to current design standards.
- Modernizing interchanges to improve accessibility and safety for truck traffic.
- Expanding managed capacity, such as HOV lanes, to enhance reliability.
- Improving availability and reliability for transit and carpooling, including addition of five direct HOV (DHOV) ramps.
- Providing safer bicycle/pedestrian crossings at 20 locations, including nine separate structures.
- Protecting the environment by minimizing interstate expansion and addressing flooding issues.
- Providing better technology to help communicate travel information to drivers.
- Minimizing cost by including technology and tactics that consider future autonomous or 'self-driving' vehicles.
- Protecting private property investments.

The public is urged to attend of the following meetings, or provide input online at spine.azmag.gov.

Tuesday, January 24, 2017
❶ 11:30 a.m. to 1:00 p.m. and ❷ 6:00 to 7:30 p.m.
Maricopa Association of Governments, Saguaro Room, 2nd Floor
302 N. 1st Ave., Phoenix, 85003

Wednesday, January 25, 2017
❸ 6:00 to 7:30 p.m.
Town of Guadalupe El Tianguis Mercado, Multipurpose Room
9201 S. Avenida del Yaqui, Guadalupe, 85283

Tuesday, January 31, 2017
❹ 6:00 to 7:30 p.m.
Washington Activity Center, Multipurpose Room
2240 W. Citrus Way, Phoenix, 85015

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Email Invitation

From: Maricopa Association of Governments <mag@service.govdelivery.com>
Sent: Monday, January 09, 2017 4:30 PM
To:
Subject: Mark Your Calendar! I-10 and I-17 Spine Corridor Master Plan Public Meetings

SAVE THE DATE

SPINE Corridor Master Plan 10 17

We want to hear from you!

The Interstate 10/Interstate 17 Corridor Master Plan Study is a proactive effort to respond to future traffic needs along the I-10 and I-17 corridor. This corridor has been named the "Spine" because it serves as the backbone for transportation in the metropolitan Phoenix area.

Recommendations have been developed for the "Spine" Corridor and include a collection of improvements focused on operations and safety for the traveling public. You are invited to attend public meetings to learn about the study and to share your thoughts on the recommended improvements. Meetings are held in an open house format with no formal presentation.

Tuesday, January 24, 2017
Afternoon meeting: 11:30 a.m. to 1:00 p.m.
Evening meeting: 6:00 to 7:30 p.m.
Maricopa Association of Governments
Saguaro Room, 2nd Floor
302 N. 1st Ave., Phoenix, 85003

Wednesday, January 25, 2017
6:00 to 7:30 p.m.
Town of Guadalupe El Tianguis Mercado
Multipurpose Room
9201 S. Avenida del Yaqui, Guadalupe, 85283

Tuesday, January 31, 2017
6:00 to 7:30 p.m.
Washington Activity Center, Multipurpose Room
2240 W. Citrus Way, Phoenix, 85015

To learn more, visit the study website at spine.azmag.gov.

The study is being conducted by the Maricopa Association of Governments (MAG), in partnership with the Federal Highway Administration (FHWA) and the Arizona Department of Transportation (ADOT).

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***Ahwatukee Foothills News* Newspaper Advertisement**

SPINE Corridor Master Plan

Interstate10/Interstate17CorridorMasterPlan"SpineStudy"

Imagine a safer drive by helping us shape your future commute.

More than 40% of all daily freeway traffic in Maricopa County travels the I-10/I-17 freeway corridor–the *"Spine"* of the Valley's transportation system–each day!

The Maricopa Association of Governments, the Arizona Department of Transportation, and the Federal Highway Administration are studying the Spine corridor to find solutions to current and future needs. Your input is critical to this process! The outcome of the Spine Study will be a detailed strategy to manage future traffic along the I-10 and I-17 corridor.

Meetings will be held in an open house format with no formal presentation.

YOU'RE INVITED TO PARTICIPATE:

Tuesday, January 24, 2017,

1. **11:30 a.m. to 1:00 p.m. and**
2. **6:00 p.m. to 7:30 p.m.**
   Maricopa Association of Governments,
   302 N. 1st Ave., Phoenix, 85003
   Saguaro Room, 2nd Floor
3. **Wednesday, January 25, 2017, 6:00 to 7:30 p.m.**
   Town of Guadalupe El Tianguis Mercado, Multipurpose Room,
   9201 S. Avenida del Yaqui, Guadalupe, 85283
4. **Tuesday, January 31, 2017, 6:00 to 7:30 p.m.**
   Washington Activity Center, Multipurpose Room,
   2240 W. Citrus Way, Phoenix, 85015

Can't make a meeting?

Take our online survey:
spine.azmag.gov

Call the study team:
602-759-1916

Email: spine@azmag.gov

Mail comments:
Spine Study Team
302 N. 1st Avenue, Suite 200,
Phoenix, AZ 85003

Survey responses and comments received by 02/17/2017 will be included in the project record.

Persons requiring reasonable accommodations such as a sign language interpreter should request as early as possible. Call 602-254-6300 for information. Para información en español llame al **602-254-6300**.

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SPINE Corridor Master Plan 10 17

Interstate 10 / Interstate 17 Corridor Master Plan "Spine Study"

Help us develop a safer commute for you across the Valley!

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Maricopa Association of Governments, 2nd Floor, Saguaro Rm.,
302 N. 1st Ave., Phoenix, 85003
Saguaro Room, 2nd Floor

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spine.azmag.gov

Call the study team: (602) 759-1916

Email: spine@azmag.gov

Mail comments:
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Phoenix, AZ 85003

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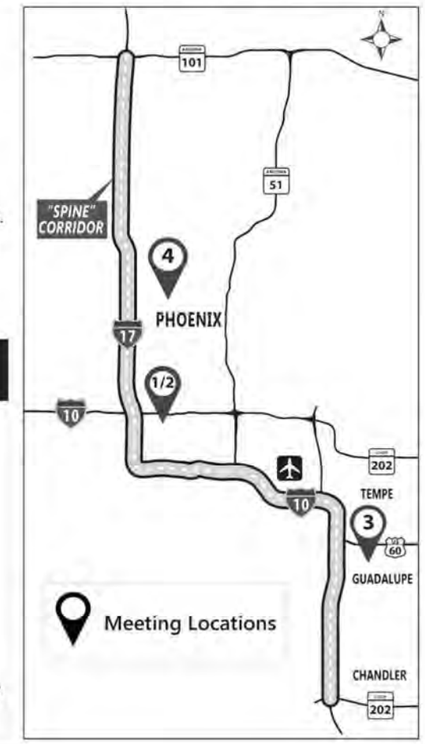

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***Arizona Republic* Newspaper Advertisement**

SPINE Corridor Master Plan 10 17

Interstate 10/Interstate 17 Corridor Master Plan "Spine Study"

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Maricopa Association of Governments, 2nd Fl.
302 N. 1st Ave., Phoenix, 85003

Wednesday, January 25, 2017,

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Tuesday, January 31, 2017,

4 6:00 p.m. to 7:30 p.m.
Washington Activity Center, Multipurpose Room, 2240 W. Citrus Way, Phoenix, 85015

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Take our online survey: spine.azmag.gov

Call the study team: (602) 759-1916

Email: spine@azmag.gov

Mail comments:
Spine Study Team
302 N. 1st Avenue, Suite 200, Phoenix, AZ 85003

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***East Valley Tribune* Newspaper Advertisement**

SPINE Corridor Master Plan 10/17

Interstate10/Interstate17CorridorMasterPlan"SpineStudy"

Help us develop a safer commute for you across the Valley!

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The Maricopa Association of Governments, the Arizona Department of Transportation, and the Federal Highway Administration are studying the Spine corridor to find solutions to current and future traffic needs. Your input is critical to this process! The outcome of the Spine Study will be a detailed strategy to manage future traffic along the I-10 and I-17 corridor.

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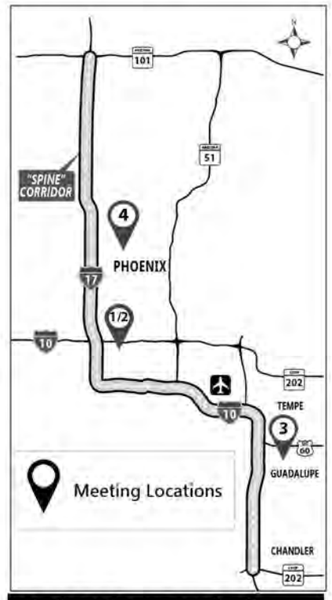

YOU'RE INVITED TO PARTICIPATE:

Tuesday, January 24, 2017,

1 11:30 a.m. to 1:00 p.m. and 2 6:00 p.m. to 7:30 p.m.
Maricopa Association of Governments, 2nd Floor, Saguaro Room
302 N. 1st Ave., Phoenix, 85003

Wednesday, January 25, 2017,

3 6:00 p.m. to 7:30 p.m.
Town of Guadalupe El Tianguis Mercado, Multipurpose Room, 9201 S. Avenida del Yaqui, Guadalupe, 85283

Tuesday, January 31, 2017,

4 6:00 p.m. to 7:30 p.m.
Washington Activity Center, Multipurpose Room,
2240 W. Citrus Way, Phoenix, 85015

Can't make a meeting?

Take our online survey:
spine.azmag.gov

Call the study team:
602-759-1916

Email: spine@azmag.gov

Mail comments:
Spine Study Team
302 N. 1st Avenue, Suite 200,
Phoenix, AZ 85003

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MARICOPA ASSOCIATION of GOVERNMENTS ADOT U.S. Department of Transportation Federal Highway Administration

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Prensa Hispana Newspaper Advertisement

SPINE Corridor Master Plan | Plan Maestro del Corredor I-10/I-17 – Estudio "La Espina"

Ayudenos a desarrolar un sistema de manejo mas seguro atraves del Valley.

Mas de 40% de todo viaje cotidiano en las autopistas del Valle usan el corredor conocido como "La Espina" de I-10/I-17.

La Asociación de Gobiernos de Maricopa, en asociación con la Administración Federal de Carreteras (FHWA) y el Departamento de Transporte de Arizona (ADOT) estan estudiando el corredor "La Espina" con el fin de identificar estrategias para administrar el tráfico actual y del futuro atraves de las autopistas 10 y 17. ¡Su aportación en este proceso es solicitada!

Por favor asista a una reunión de información pública, estilo casa abierta sin presentación formal, para aprender más y para compartir su opinión sobre las estrategias identificadas para administrar el trafico actual y futuro.

LE INVITAMOS A PARTICIPAR:

Martes 24 de enero del 2017,

1 11:30 a.m.- 1:00 p.m. y **2** 6:00 p.m. - 7:30 p.m.
Asociacion de Gobernos de Maricopa, 302 N. 1st Ave, Segundo Piso, Salon Saguaro, Phoenix, 85003

Miércoles 25 de enero del 2017, 6:00 p.m. - 7:30 p.m.
3 9201 S. Avenida del Yaqui, Salon Multiuso, Guadalupe, 85283

Martes 31 de enero del 2017, 6:00 p.m.- 7:30 p.m.
4 Centro de actividades Washington, 2240 W. Citrus Way, Salon Multiuso, Phoenix, 85015

Las encuestas en línea y los comentarios sometidos antes del 17 de febrero del 2017 serán incluidos en el registro del proyecto.

¿No puede asistir a una reunión?

Tomé nuestra encuesta en línea:
spine.azmag.gov

Llame al equipo del estudio:
602-759-1916
Por favor proporcione su comentarios antes del 17 de marzo del 2017.

Envíe un correo electronico:
spine@azmag.gov

Envíe sus comentarios por correo a:
Spine Study Team
302 N. 1st Avenue, Suite 200,
Phoenix, AZ 85003

Las personas que necesiten ayuda o adaptaciones razonables, como interpretación en lenguaje a señas, pueden solicitarla llamando lo antes posible al 602-254-6300. Para información en español llame al 602-254-6300.

MARICOPA ASSOCIATION of GOVERNMENTS | ADOT | U.S. Department of Transportation Federal Highway Administration

Fact Sheet – English

FACT SHEET

SPINE Corridor Master Plan

What is the Spine Study?

The Interstate 10/Interstate 17 Corridor Master Plan Study is a proactive effort to respond to future traffic needs along the I-10 and I-17 corridor. This corridor has been named the "Spine" because it serves as the backbone for transportation in the metropolitan Phoenix area.

The Spine Study seeks long-term options to improve travel. Solutions being studied include a combination of traditional methods, new technology and increased use of transit (such as buses). The outcome of the Spine Study will be a detailed strategy to improve traffic flow along the I-10 and I-17 corridors through 2040.

The study is being conducted by the Maricopa Association of Governments (MAG), in partnership with the Federal Highway Administration (FHWA) and the Arizona Department of Transportation (ADOT).

DID YOU KNOW?
Over **40%** of ALL daily freeway traffic uses the Spine Corridor.

DID YOU KNOW?
2x more traffic CROSSES OVER I-17 than uses it.

HOW DID WE EVALUATE OPTIONS?

The study team started the evaluation process by identifying a wide range of ideas and possible solutions to meet the needs of the corridor. Those ideas were filtered through several levels of technical screening and analysis. Ideas that met the evaluation criteria moved forward in the analysis, while ideas that did not were eliminated from further consideration. This process, depicted below, is similar to a funnel where ideas are evaluated or "filtered." The Corridor Master Plan Recommendations reflect the best performing strategies and alternatives evaluated.

349 IDEAS

EVALUATION CRITERIA

Enhances Existing System Use
Improves Travel Time Reliability
Practicality
Enhances Safety
Reduces Congestion Duration
Improves Travel Time
Disproportionate Impacts on Disadvantaged Communities
Replaces Deficient Infrastructure
Agency Support
Alternative Adaptability
Programming Flexibility

ALTERNATIVES

What if we only maintain existing infrastructure?
What if we focus on necessary spot improvements?
What if we focus on reconstructing old infrastructure?
What if we focus on adding lanes?
General Purpose Lanes
High Occupancy Vehicle (HOV) Lanes
Express Lanes
HOV/Toll Lanes

EVALUATION CRITERIA

Environmental
Hazardous Materials
Historical & Cultural Resources
Water Resources
Land Use & Jurisdiction
Socioeconomic
Non-discrimination & Equity

Engineering
Footprint
Design
Right of Way Impacts
Cost
Replacement of Infrastructure

Operations
Duration of Congestion
Travel Times
Volume/Capacity
Person Trips
Vehicle Miles Traveled
Vehicle Hours Traveled
Average Speed

Consistency with Public Feedback

Safety

CORRIDOR MASTER PLAN RECOMMENDATIONS

STUDY PARTNERS

U.S. Department of Transportation
Federal Highway Administration
ADOT
MARICOPA ASSOCIATION of GOVERNMENTS
Chandler · Arizona
CITY OF TEMPE ARIZONA
VALLEY METRO

HOW TO PARTICIPATE

You are invited to attend public meetings to learn about the study and share your thoughts on necessary improvements. Meetings are held in an open house format with no formal presentation. You may also contact the study team online, by phone, or mail.

VISIT THE STUDY WEBSITE TO REVIEW AN INTERACTIVE MAP OF THE CORRIDOR MASTER PLAN RECOMMENDATIONS AND TO COMPLETE THE FEEDBACK FORM ONLINE AT SPINE.AZMAG.GOV

Phone: (602) 759-1916

Email: spine@azmag.gov

Mail: Spine Study Team
302 N. 1st Ave., Ste. 200
Phoenix, AZ 85003

Tuesday, January 24, 2017
11:30 a.m. to 1:00 p.m. and **6:00 to 7:30 p.m.**
Maricopa Association of Governments
Saguaro Room, 2nd Floor
302 N. 1st Ave., Phoenix, 85003

Wednesday, January 25, 2017
6:00 to 7:30 p.m.
Town of Guadalupe El Tianguis Mercado
Multipurpose Room
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Tuesday, January 31, 2017
6:00 to 7:30 p.m.
Washington Activity Center, Multipurpose Room
2240 W. Citrus Way, Phoenix, 85015

Comments received by February 17, 2017, will be included in the project record.

spine.azmag.gov

EARLY 2017

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CORRIDOR MASTER PLAN RECOMMENDATIONS

SPINE

The recommendations for the 31-mile portion of Interstates I-10 and I-17 "Spine" Corridor are a collection of improvements focused on operations and safety for the traveling public. Below are some of the ways the recommended improvements respond to priorities conveyed by the public at the beginning of the study (early 2015).

IMPROVE COMMUTE

Improves safety by modernizing interstates to current design standards.

Expands managed capacity, such as high occupancy vehicle (HOV) lanes, to enhance reliability.

ADD TRAVEL CHOICES

Improves availability and reliability for transit, shared rides.

Improves roadway design to shorten travel times and improve safety.

Adds 20 bicycle/pedestrian crossings, including 9 new structures.

PROTECT THE ENVIRONMENT

Constrains right of way impacts by minimizing significant interstate expansion.

Remedies long-standing flooding issues along I-17.

Improves air quality with congestion management and technology that improves traffic flow.

INCREASE CONNECTIONS

Allows enhanced ramp metering to protect freeway traffic flow.

Upgrades 24 of the 31 traffic interchanges.

Adds 5 new direct high occupancy vehicle (DHOV) ramps.

PROMOTE NEIGHBORHOODS

Includes bicycle/pedestrian enhancements at interchanges.

Improves neighborhood connections by adding 9 dedicated bicycle/pedestrian structures across interstates.

Minimizes impacts to neighborhoods in the corridor.

IMPROVE COMMERCE

Modernizes traffic interchanges and improves accessibility and safety for truck traffic.

Includes technology to better communicate travel conditions and information to drivers and businesses.

MINIMIZE COST

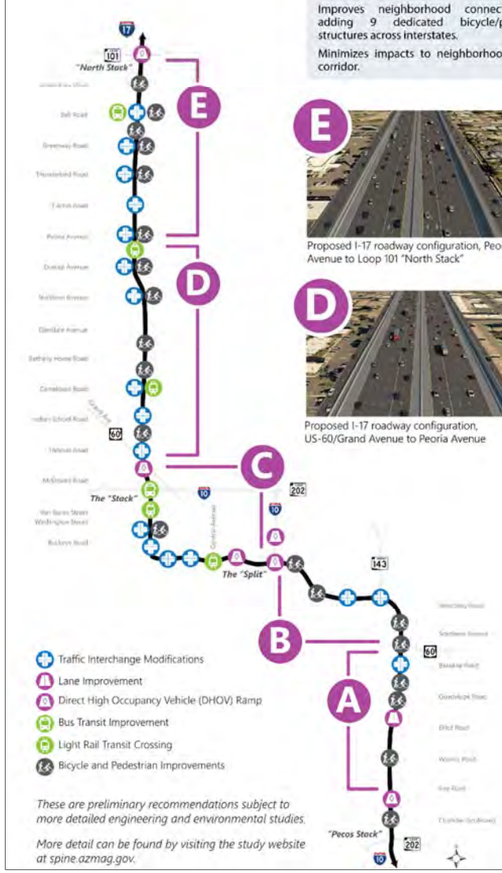
Includes strategies to respond to advancements in technology, such as active traffic management and tactics related to connected and self-driving vehicles.

Invests in modernizing and preserving corridor infrastructure.

EMPHASIZE JOBS

Improves system reliability and efficient movement of people and commercial goods.

Prioritizes protecting private property investments.



These are preliminary recommendations subject to more detailed engineering and environmental studies.

More detail can be found by visiting the study website at spine.azmag.gov.

Proposed I-17 roadway configuration, Peoria Avenue to Loop 101 "North Stack"

Proposed I-17 roadway configuration, US-60/Grand Avenue to Peoria Avenue

Proposed I-17 roadway configuration, I-10/I-17 "Split" to US-60/Grand Avenue

Proposed I-10 roadway configuration, US-60 to I-10/I-17 "Split"

Proposed I-10 roadway configuration, Ray to Baseline roads

Fact Sheet – Spanish

HOJA DE DATOS

SPINE Corridor Master Plan

¿Qué es el estudio "La Espina"?

El Plan Maestro del Corredor I-10/I-17 es un esfuerzo proactivo para anticipar las necesidades del tráfico del futuro. Este corredor se ha llamado "La Espina" porque cumple la función de "espina principal" del sistema de transporte en el área metropolitana de Phoenix.

El estudio "La Espina" investigó opciones de largo plazo para mejorar la movilidad del tránsito, usando una combinación de métodos tradicionales, nuevas tecnologías y el uso incremental del transporte público (por ejemplo autobuses). El resultado del estudio "La Espina" será una estrategia detallada para gestionar el tráfico a lo largo de los corredores de las autopistas 10 y 17 hasta el año 2040.

El estudio está siendo realizado por la Asociación de Gobiernos de Maricopa, en asociación con la Administración Federal de Carreteras (FHWA) y el Departamento de Transporte de Arizona (ADOT).

¿SABIA USTED?

Que más de **40%** de todo viaje cotidiano en las autopistas del Valle usan el corredor de las autopistas 10 y 17 conocido como "La Espina".

¿SABIA USTED?

Que en la autopista 17 **2x** más tráfico CRUZA SOBRE la autopista de lo que viaja en ella.

¿Como se evaluaron las opciones?

El equipo de estudio inició el proceso de evaluación identificando una amplia variedad de ideas y posibles soluciones para satisfacer las necesidades del corredor. Esas ideas fueron filtradas a través de varios niveles de análisis técnicos. Las soluciones que cumplían con los criterios de evaluación, avanzaron en el análisis. Este proceso, que se muestra a continuación, es similar a un embudo donde las ideas son evaluadas o "filtradas". Las recomendaciones del Plan Maestro del Corredor "La Espina" reflejan las estrategias evaluadas y las alternativas más eficaces.

349 IDEAS

CRITERIOS DE EVALUACIÓN

Mejora el uso del sistema existente
Mejora la fiabilidad del tiempo de viaje
Factibilidad
Aumentar la seguridad
Reducir el congestionamiento
Mejora el ahorro en viaje
Disminuir impactos desproporcionados para comunidades de bajos ingresos
Satisfacer infraestructura deficiente
Apoyo de agencia
Adaptabilidad innovativa
Flexibilidad en la programación de cambios al futuro

ALTERNATIVAS

¿Qué pasa si sólo mantenemos la infraestructura existente?
¿Qué pasa si sólo nos concentramos en las mejoras necesarias?
¿Qué pasa si nos centramos en reconstruir la infraestructura antigua?
¿Qué pasa si nos centramos en agregar carriles?
Carriles de propósito general
Carril para vehículos de alta ocupación (HOV)
Carril-rápido
Peajede para carril de de alta ocupación

CRITERIOS DE EVALUACIÓN

Ambiental
Materiales peligrosos
Recursos históricos y culturales
Recursos hídricos
Uso de suelo y jurisdicción
Socioeconómico
Equidad sin discriminación

Ingeniería
Huella
Diseño
Impacto al derecho de paso
Costo
Reemplazo de infraestructura

Operaciones
Duración de la congestión
Tiempo de viaje
Volumen/Capacidad
Viajes de persona
Millas viajades por vehículo
Horas viajades por vehículo
Promedio de velocidad

Consistencia con las opiniones del público

Seguridad

Recomendaciones del Plan Maestro del Corredor

SOCIOS DEL ESTUDIO

U.S. Department of Transportation
Federal Highway Administration
ADOT
MARICOPA ASSOCIATION of GOVERNMENTS
Chandler - Arizona
CITY OF TEMPE ARIZONA
VALLEY METRO

COMO PUEDE PARTICIPAR

Le invitamos a asistir a las reuniones públicas para aprender sobre el estudio y para compartir sus pensamientos sobre las recomendaciones. Las reuniones serán en formato de apertura pública sin presentación formal. También puede comunicarse con el equipo del estudio en línea, por teléfono o por correo postal.

VISITE EL SITIO WEB, WWW.SPINE.AZMAG.GOV, DEL ESTUDIO PARA REVISAR UN MAPA INTERACTIVO DE LAS RECOMENDACIONES DEL PLAN MAESTRO DEL CORREDOR Y PARA COMPLETAR EL FORMULARIO DE COMENTARIO EN LÍNEA.

Teléfono: (602) 759-1916

Correo electrónico:
spine@azmag.gov

Correo postal:
Spine Study Team
302 N. 1st Ave., Ste. 200
Phoenix, AZ 85003

Martes 24 de enero del 2017
11:30 a.m. a 1:00 p.m. y **6:00 a 7:30 p.m.**
Asociación de Gobiernos de Maricopa
Segundo Piso, Salon Saguaro
302 N. 1st Ave., Phoenix, 85003

Miércoles 25 de enero del 2017
6:00 a 7:30 p.m.
Pueblo de Guadalupe, El Tianguis Mercado,
Salon Multiuso
9201 S. Avenida del Yaqui, Guadalupe, 85283

Martes 31 de enero del 2017
6:00 a 7:30 p.m.
Centro de actividades Washington, Salon Multiuso
2240 W. Citrus Way, Phoenix, 85015

Los comentarios recibidos antes del 17 de febrero del 2017 serán incluidos en el registro del proyecto.

spine.azmag.gov

Principios del 2017

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Recomendaciones del Plan Maestro del Corredor "La Espina"

SPINE

Las recomendaciones para la porción de 31 millas de las autopistas 10 y 17 conocidas como el corredor "La Espina" son un grupo de recomendaciones enfocadas en la operación del sistema y la seguridad del público viajero. A continuación se presentan algunas de las maneras en que las recomendaciones responden a las prioridades declaradas por el público al comienzo de este estudio (a principios del 2015).

MEJORAR VIAJES

La modernizacion de las autopistas a diseños modernos mejora la seguridad.

Los carriles de vehículos de alta ocupación (HOV) amplían la administración de capacidad para mejorar la fiabilidad del sistema.

AÑADIR OPCIONES DE VIAJE

Mejora la disponibilidad y la confiabilidad para el transporte público y viajes compartidos.

Mejora el diseño de la carretera para acortar el tiempo de viaje e incrementa la seguridad.

Agrega 20 pasos desnivel para bicicletas y peatones e incluyen 9 nuevas estructuras.

PROTEGER EL MEDIO AMBIENTE

Restringe los impactos de derechos de paso reduciendo significativamente la expansión interestatal.

Remedia problemas de inundaciones a lo largo de la autopista 17.

Usando tecnología para gestionar la congestión mejoramos el flujo de tráfico y eso mejora la calidad del aire.

INCREMENTAR CONEXIONES

Permite mejorar la medición de rampas para preservar el flujo de tráfico de la autopista.

Actualiza 24 de los 31 intercambios de tráfico.

Añade 5 nuevas rampas directas de vehículos de alta ocupación (DHOV).

PROMOVER VECINDARIOS

Incluye mejoras para bicicletas y peatones en los intercambios.

Mejora las conexiones de vecindario añadiendo 9 estructuras dedicadas a bicicleta y/o peatones a través de las autopistas.

Reduce los impactos a los vecindarios a lo largo del corredor.

MEJORAR EL COMERCIO

Moderniza los intercambios de tráfico y mejora la accesibilidad y seguridad para los camiones.

Incluye tecnología para mejorar la comunicación de las condiciones de tráfico e información a los conductores y empresas.

REDUCIR EL COSTO

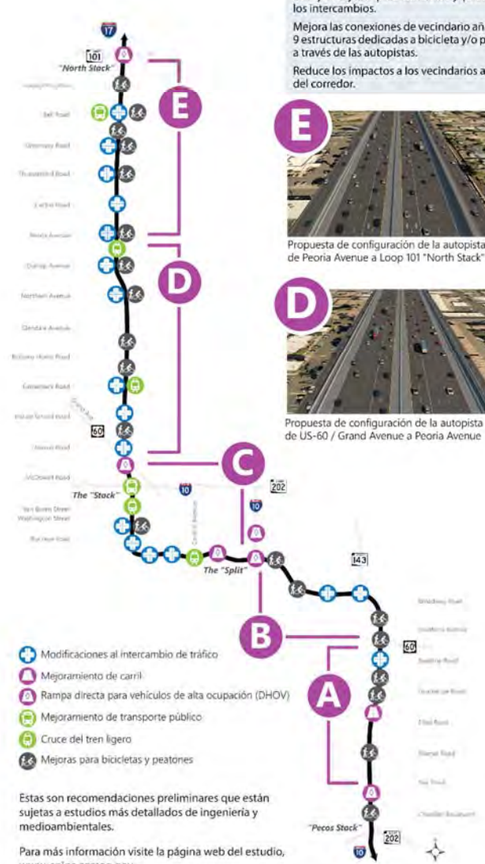
Incluye estrategias para responder a los avances tecnológicos, como la gestión activa del tráfico y tácticas relacionadas a los vehículos conectados y auto dirigidos.

Invierte en modernizar y preservar la infraestructura del corredor.

ENFATIZAR EMPLEOS

Mejora la fiabilidad del sistema y el movimiento eficiente de personas y bienes comerciales.

Prevalece la protección a las inversiones de propiedad privada.



Propuesta de configuración de la autopista 17 de Peoria Avenue a Loop 101 "North Stack"

Propuesta de configuración de la autopista 17 de US-60 / Grand Avenue a Peoria Avenue

Propuesta de configuración de la autopista 17 del "Split" (autopistas 10 y 17) a US-60 / Grand Avenue

Propuesta de configuración de la autopista 10 de US-60 al "Split" autopistas 10 y 17

Propuesta de configuración de la autopista 10 de Ray Road a Baseline

Estas son recomendaciones preliminares que están sujetas a estudios más detallados de ingeniería y medioambientales.

Para más información visite la página web del estudio, www. spine.azmag.gov.

Comment Form – English

SPINE Corridor Master Plan 10 17

Comment Form

Welcome and thank you for attending. The purpose of this public open house is to present the recommendations for the 31-mile portion of Interstates I-10 and I-17 "Spine" Corridor. Members of the study team are available throughout the room to answer your questions. This comment form is also available as an online survey at spine.azmag.gov. **Comments received by Friday, February 17, 2017, will be included in the study record.** Thank you!

1. The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?

☐ Strongly agree ☐ Agree ☐ Neutral / Don't know ☐ Disagree ☐ Strongly disagree

Comments:

Example of double managed lanes, illustrated above as two HOV lanes (Source: MAG)

*A managed lane is one where strategies are proactively implemented in response to conditions.

2. Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?

☐ Strongly agree ☐ Agree ☐ Neutral / Don't know ☐ Disagree ☐ Strongly disagree

Comments:

Example of limited access managed lane. (Source: FHWA)

3. The Corridor Master Plan Recommendations would likely require acquisition (purchasing) of some right of way (properties) along the corridor. Do you support taking some properties along the corridor in order to improve traffic operations and safety?

☐ Strongly agree ☐ Agree ☐ Neutral / Don't know ☐ Disagree ☐ Strongly disagree

Comments:

over →

4. The Corridor Master Plan Recommendations include a variety of other strategies, including bicycle and pedestrian crossings and traffic interchange modifications. What feedback do you have regarding these other improvements recommended as part of this strategy?

5. Do you have any other feedback regarding the Corridor Master Plan Recommendations?

Thank you for sharing your views on the future of transportation in the Valley. Please tell us about yourself by answering these simple questions. Your input is greatly appreciated.

6. What is the zip code of your home address?

☐☐☐☐☐

7. How often do you use the Spine Corridor?

☐ 10 or more times per week ☐ 1-4 times a week ☐ A couple times a year
☐ 5-9 times a week ☐ A couple times a month ☐ Almost Never

8. How do you typically travel in the Spine Corridor?

☐ Personal vehicle ☐ Bicycle/Walk ☐ Carpool/Vanpool
☐ Transit ☐ Commercial vehicle or truck for business ☐ Other

9. What is your interest in the Spine Corridor?

☐ Commuter ☐ Property owner ☐ Business customer
☐ Business owner ☐ Nearby resident ☐ Other

Comment Form – Spanish

Formulario para comentarios

¡Bienvenido y gracias por asistir! El propósito de esta apertura pública es de presentar las recomendaciones para el corredor "La Espina" que incluyen 31 millas de las autopistas 10 y 17 . Miembros del equipo de estudio están disponibles para contestar sus preguntas. Este formulario también está disponible como una encuesta online y lo puede completar visitando la página www.spine.azmag.gov. **Los comentarios recibidos antes del 17 de febrero del 2017 serán incluidos en el registro del proyecto.** ¡Gracias!

1. Las recomendaciones del Plan Maestro del Corredor "La Espina" incluyen la adición de un carril gestionado* a través del corredor. La estrategia inicial contempla un segundo carril de vehículos de alta ocupación (HOV). Esta estrategia ayudaría al transporte público, reduciría la congestión y mejoraría la confiabilidad del tiempo de viaje. ¿Cuáles son sus pensamientos sobre esta estrategia?

☐ Muy de acuerdo ☐ De acuerdo ☐ Neutral ☐ Desacuerdo ☐ Muy desacuerdo

Comentario:

Ejemplo ilustrado de dos carriles HOV gestionados. (Fuente: MAG)

*Un carril gestionado es aquel en el que estrategias se implementan de manera proactiva en respuesta a las condiciones de tráfico.

2. Actualmente, los conductores pueden entrar y salir del carril HOV a voluntad. Por seguridad, al tener dos carriles gestionados en cada dirección habría que limitar la entrada y la salida a esos carriles a puntos específicos. ¿Cuáles son sus pensamientos sobre esta estrategia?

☐ Muy de acuerdo ☐ De acuerdo ☐ Neutral ☐ Desacuerdo ☐ Muy desacuerdo

Comentario:

Ejemplo ilustrado de acceso limitado de carriles gestionados HOV. (Fuente: FHWA)

3. Las recomendaciones del Plan Maestro del Corredor "La Espina" probablemente requerirían la adquisición de propiedad privada para el derecho de paso a lo largo del corredor. ¿Apoya usted tomar algunas propiedades a lo largo del corredor para mejorar las operaciones de tráfico y seguridad?

☐ Muy de acuerdo ☐ De acuerdo ☐ Neutral ☐ Desacuerdo ☐ Muy desacuerdo

Comentario:

Mas →

4. Las recomendaciones del Plan Maestro del Corredor "La Espina" incluyen varias estrategias, que incluyen pasos para ciclistas y peatones y modificaciones al intercambio del tráfico. ¿Qué comentarios tiene respecto a la recopilación de otras mejoras recomendadas como parte de esta estrategia?

5. ¿Tiene comentarios adicionales acerca de las recomendaciones del Plan Maestro del Corredor "La Espina"?

Muchas gracias por compartir su punto de vista sobre el futuro del transporte en el Valle. Por favor proporciónenos información contestando estas sencillas preguntas. Sus respuestas son apreciadas.

6. ¿Cuál es el código postal de su domicilio?

☐ ☐ ☐ ☐ ☐

7. ¿Qué tan frecuentemente viaja por el corredor "La Espina"?

☐ 10 o más veces por semana ☐ 1-4 veces por semana ☐ Un par de veces al año
☐ 5-9 veces por semana ☐ Un par de veces al mes ☐ Casi nunca

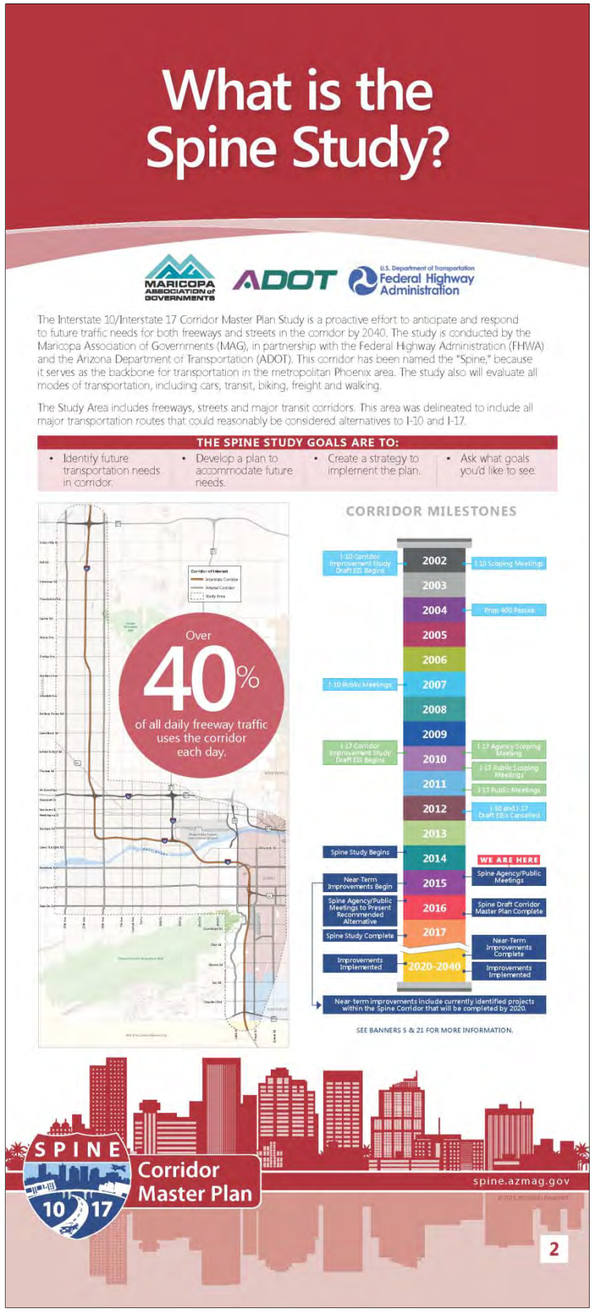
8. ¿Cómo viaja típicamente por el corredor?

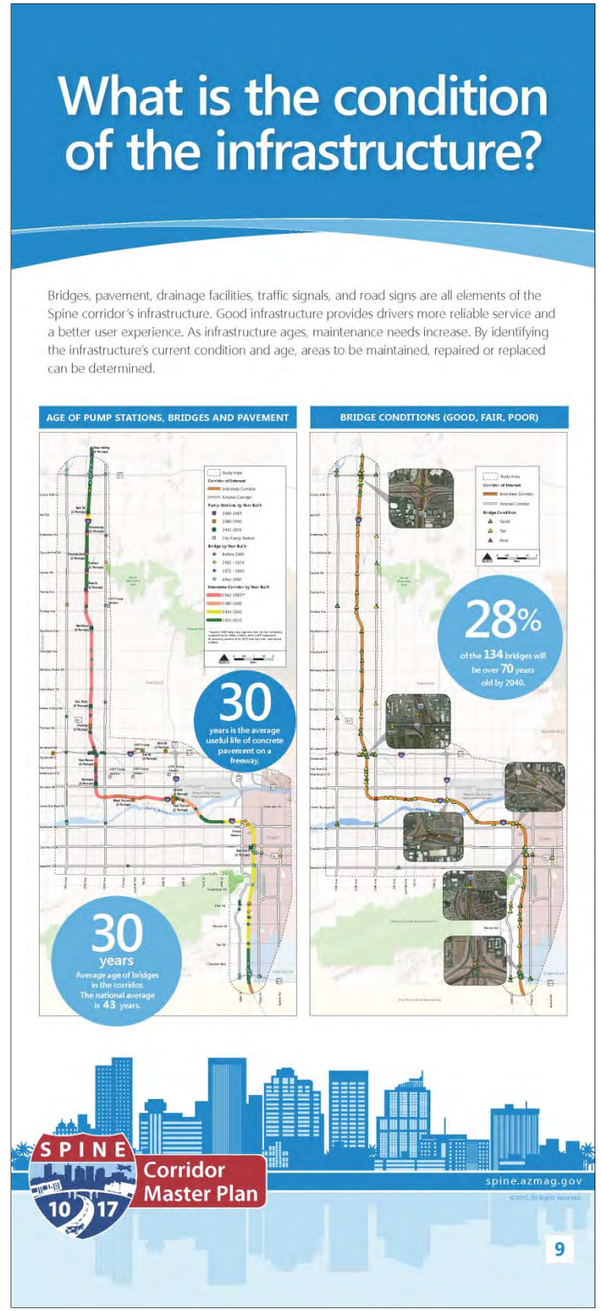
☐ Vehículo personal ☐ Bicicleta/Caminando ☐ Comparto el viaje en auto/camioneta
☐ Transporte público ☐ Vehículo o camión comercial ☐ Otra manera

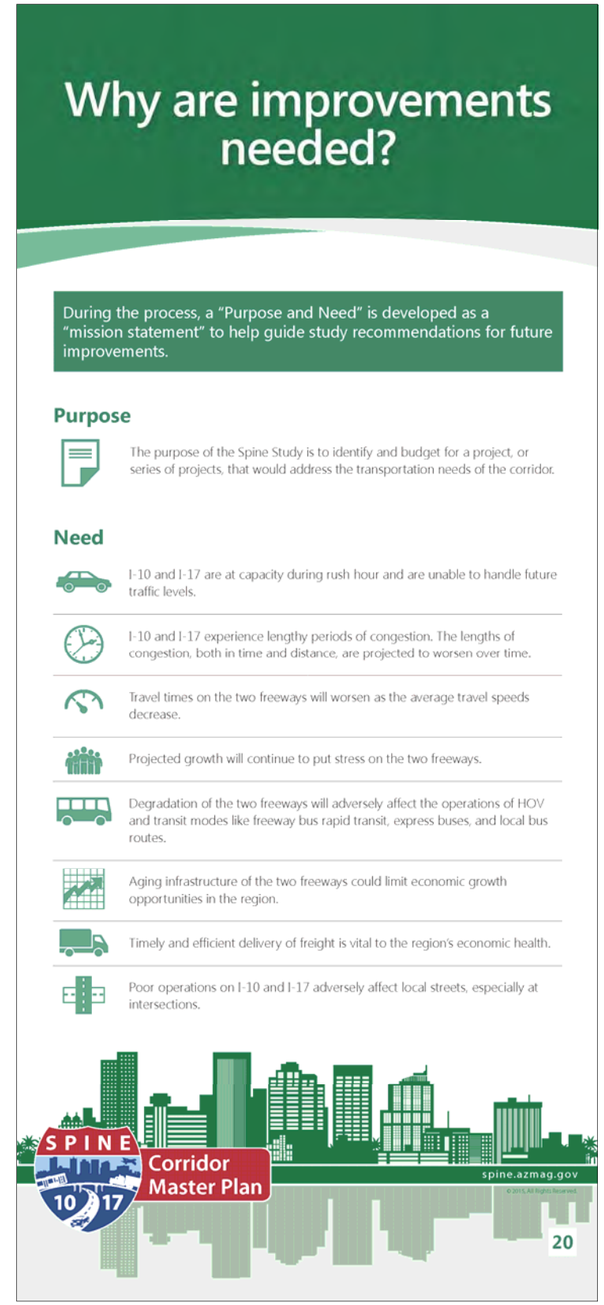
9. ¿Cuál es su interés en el corredor "La Espina"?

☐ Viaje cotidiano ☐ Dueño/a de propiedad ☐ Cliente de negocio
☐ Dueño/a de negocio ☐ Residente cercano ☐ Otra razón

Public Meeting Banners







How will technology shape the future transportation network?

By 2040, nearly all vehicles will be able to "talk" to traffic signals and other cars on the road.

By 2040, it will be common to see self-driving vehicles on the road.

Mobile technology makes information easily accessible for travelers, and travelers can contribute to real-time information.

Systems are being developed that can "predict" what traffic conditions will be so travelers can better plan their trips.

looking ahead...

Using technology to actively manage freeway, street and transit networks can:

- Improve freeway capacity by up to 23%.
- Reduce primary crashes by 30%.
- Reduce secondary crashes by 40-50%.
- Reduce delay on arterials by 10-30%.
- Improve transit on-time performance.

POTENTIAL FUTURE SYSTEMS

Temporary shoulder use and variable speeds.

Next generation in-vehicle and mobile technologies.

Integrated and seamless transit and traffic management.

Did You Know?

Over the last 10 years, enormous innovations in transportation technology and advanced traffic management techniques have occurred. Numerous cities and regions around the world have adopted these strategies as a means of enhancing the capacity and efficiency of the existing transportation system without adding new expensive infrastructure. Depending on the strategies and technology used, it has been estimated that the capacity of an existing roadway can improve by 5% to 25%. This means that on an existing four-lane freeway, these strategies can have the same effect as adding a new lane.

SPINE 10 17 Corridor Master Plan

spine.azmag.gov

25

What You Told Us About Spine in 2015.

In February and March 2015, the Spine Study team held three public meetings throughout the study area and conducted a two-month online survey with remarkable results. **More than 1,800 people participated** in the process and shared **more than 4,390 comments**. Here's what you shared:

We asked...

What strategies would you prefer?

You said...

Providing alternative travel modes, improving freeway access, and adding new freeway lanes are your top three preferred strategies.

93% of you said to **build something** rather than do nothing.

We asked...

What challenges do you experience in the Corridor and where are they?

You showed us...

... by placing **3,538** pins on a virtual map.

SPINE 10 17 Corridor Master Plan

spine.azmag.gov

How Did We Evaluate the Options?

The study team started the evaluation process by identifying a wide range of ideas and possible solutions to meet the needs of the corridor. Those ideas were filtered through several levels of technical screening and analysis. Ideas that met the evaluation criteria moved forward in the analysis, while ideas that did not were eliminated from further consideration. This process, depicted below, is similar to a funnel where ideas are evaluated or "filtered." The Corridor Master Plan Recommendations reflect the best performing strategies and alternatives evaluated.

349 IDEAS

EVALUATION CRITERIA

Enhances Existing System Use
Improves Travel Time Reliability
Practicability
Enhances Safety
Reduces Congestion Duration
Improves Travel Time
Disproportionate Impacts to Disadvantaged Communities
Replaces Deficient Infrastructure
Agency Support
Alternative Adaptability
Programming Flexibility

ALTERNATIVES

What if we only maintain existing infrastructure?

What if we focus on necessary spot improvements?

What if we focus on reconstructing old infrastructure?

What if we focus on adding lanes?

General Purpose Lanes
High Occupancy Vehicle (HOV) Lanes
Express Lanes
HOT/Toll Lanes

EVALUATION CRITERIA

Environmental
Hazardous Materials
Historical & Cultural Resources
Water Resources
Land Use & Jurisdiction
Socioeconomic
Non-discrimination & Equity

Operations
Duration of Congestion
Travel Times
Volume/Capacity
Person Trips
Vehicle Miles Traveled
Vehicle Hours Traveled
Average Speed

Engineering
Footprint
Design
Right of Way Impacts
Cost
Replacement of Infrastructure

Consistency with Public Feedback

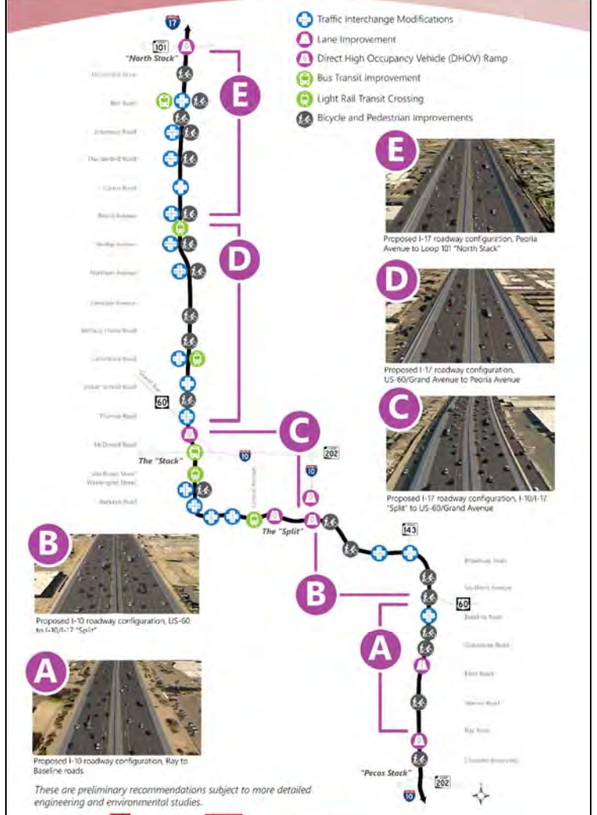
Safety

CORRIDOR MASTER PLAN RECOMMENDATIONS

SPINE 10 17 Corridor Master Plan

spine.azmag.gov

Corridor Master Plan Recommendations.



SPINE Corridor Master Plan 10 17 spine.azmag.gov

How Do the Improvements Respond to Your Priorities?

Below are some of the ways the improvements included in the Corridor Master Plan Recommendations respond to priorities conveyed by the public at the beginning of the study (early 2015).

IMPROVE COMMUTE

Improves safety by modernizing interstates to current design standards.

Expands managed capacity, such as high occupancy vehicle (HOV) lanes, to enhance reliability.

ADD TRAVEL CHOICES

Improves availability and reliability for transit, shared rides.

Improves roadway design to shorten travel times and improve safety.

Adds 20 bicycle/pedestrian crossings, including 9 new structures.

PROTECT THE ENVIRONMENT

Constrains right of way impacts by minimizing significant interstate expansion.

Remedies long-standing flooding issues along I-17.

Improves air quality with congestion management and technology that improves traffic flow.

INCREASE CONNECTIONS

Allows enhanced ramp metering to protect freeway traffic flow.

Upgrades 24 of the 31 traffic interchanges.

Adds 5 new direct high occupancy vehicle (DHOV) ramps.

PROMOTE NEIGHBORHOODS

Includes bicycle/pedestrian enhancements at interchanges.

Improves neighborhood connections by adding 9 dedicated bicycle/pedestrian structures across interstates.

Minimizes impacts to neighborhoods in the corridor.

IMPROVE COMMERCE

Modernizes traffic interchanges and improves accessibility and safety for truck traffic.

Includes technology to better communicate travel conditions and information to drivers and businesses.

MINIMIZE COST

Includes strategies to respond to advancements in technology, such as active traffic management and tactics related to connected and self-driving vehicles.

Invests in modernizing and preserving corridor infrastructure.

EMPHASIZE JOBS

Improves system reliability and efficient movement of people and commercial goods.

Prioritizes protecting private property investments.

SPINE Corridor Master Plan 10 17 spine.azmag.gov

Agency Consultation Letter – City of Tempe

City of Tempe
P.O. Box 5002
31 East Fifth Street
Tempe, AZ 85280
480-350-8575

Andrew B. Ching

March 24, 2017

Mr. Eric Anderson
302 N. 1st Avenue, #300
Phoenix, AZ 85003

Dear Mr. Anderson:

Over the past two years, the City of Tempe has been highly engaged with the Maricopa Association of Government (MAG) and its member agencies in the planning efforts for the Interstate 10/Interstate 17 Corridor Master Plan project. The City of Tempe's involvement to date has included numerous brainstorming sessions, alternatives analysis, and input on recommendations. MAG staff also presented twice to the City of Tempe Transportation Commission to update them on specifics of the process and recommendations.

The City of Tempe is in full support of the Interstate 10/Interstate 17 Corridor Master Plan planning process and the associated recommendations that were presented to the public in January 2017. The recommendations are in line with the City's goal of providing a balanced multimodal transportation system that serves motorists, transit, freight, pedestrians and bicyclists.

Specific projects that will directly benefit the City of Tempe include additional lanes on Interstate 10, traffic interchange modifications on Interstate 10 at State Route 143 and at Baseline Road, and construction of bicycle/pedestrian improvements at Alameda Drive, the Western Canal Shared Use Path, the Highline Canal Shared Use Path, Guadalupe Road, and Warner Road. The freeway and interchange improvements will better accommodate the region's steadily increasing vehicular traffic while the bicycle/pedestrian improvements will reconnect neighborhoods. These projects are all reflective of the goals set out in the City of Tempe's General Plan 2040 and Transportation Master Plan.

Although not included in the recommendations that were presented to the public in January 2017, the City of Tempe would like to provide concurrence with MAG and the City of Phoenix that the plan could be improved by the addition of a bicycle/pedestrian connection at Interstate 10 and the Knox Road alignment. This has been identified as an important connection by both the City of Phoenix and the City of Tempe, as it would potentially connect an existing recreational park area to a future recreational park area. Similar to the other recommended bicycle/pedestrian connections, this project is reflective of the goals in the City of Tempe's General Plan 2040 and Transportation Master Plan. It also reflects the goals in the City of Phoenix's Comprehensive Bicycle Master Plan.

Thank you for engaging City of Tempe staff and residents in the planning process. These recommended improvements are forward thinking and will allow the City of Tempe, and the Phoenix Region, to accommodate current traffic, address future growth, and reconnect neighborhoods. For this reason, the City of Tempe fully supports the recommendations of the Interstate 10/Interstate 17 Corridor Master Plan with the addition of the bicycle/pedestrian crossing at the Knox Road alignment.

Sincerely,

Andrew B. Ching

Andrew B. Ching

Agency Consultation Letter – City of Chandler

Chandler · Arizona
Where Values Make The Difference

Maricopa Association of Governments
Received
APR 3 2017

March 29, 2017

Mr. Dennis Smith
Executive Director
Maricopa Association of Governments
302 North 1st Avenue
Suite 300
Phoenix, Arizona 85003

RE: Interstate 10/ Interstate 17 Corridor Master Plan
Planning and Environmental Linkages Consultation

Dear Dennis:

The City of Chandler appreciates being involved in the Interstate 10/Interstate 17 Corridor Master Plan which is nearing completion. Your agency's leadership on this project will result in an overall benefit to Chandler, Guadalupe, Tempe, Phoenix, and the rest of the region.

We are in support of the proposed Master Plan as it affects Chandler. The proposed bike/pedestrian bridge over I-10 near Chandler Boulevard will provide a safer means of crossing I-10 for bicyclist and pedestrians. The proposed direct high occupancy vehicle ramp to I-10 at Galveston Road will improve the commute for Chandler and Phoenix residents with its direct access to and from the HOV lanes.

A presentation of the final proposed plan to Chandler management staff and the Chandler Transportation Commission would be very beneficial in allowing us to better understand the main features of this project, as they affect Chandler and our partner cities.

Please let me know of a convenient time for these presentations. Ryan Peters can assist in getting them arranged for Chandler.

Thank you again for your leadership on this project.

Sincerely,

Marsha Reed

Marsha Reed, P.E.
City Manager

Cc: Derek Horn, Acting Transportation & Development Director
Dan Cook, City Engineer
Ryan Peters, Intergovernmental Affairs Coordinator

Chandler All-America City 2010

Mailing Address
Mail Stop 605
PO Box 4008
Chandler, Arizona 85244-4008

Office of the City Manager
Telephone (480) 782-2210
Fax (480) 782-2209
Web www.chandleraz.gov

Location
Fifth Floor
175 South Arizona Avenue
Chandler, Arizona 85225

Printed on recycled paper

Agency Consultation Letter – City of Phoenix

City of Phoenix
OFFICE OF THE CITY MANAGER

Maricopa Association of Governments
Received
APR 17 2017

April 12, 2017

Mr. Dennis Smith
Executive Director
Maricopa Association of Governments
302 North First Avenue, Suite 300
Phoenix, AZ 85003

Re: Interstate 10/Interstate 17 Corridor Master Plan Consultation Letter

Dear Mr. Smith:

This letter is to acknowledge the City of Phoenix's involvement and support of the Interstate 10/Interstate 17 Corridor Master Plan process presented to the public in January 2017. Over the past two years, the Maricopa Association of Governments (MAG) provided two presentations to the Phoenix City Council Transportation and Infrastructure Subcommittee, as well as held meetings with representatives of various City departments including Street Transportation, Public Transit, Community and Economic Development, Neighborhood Services, Planning and Development, Aviation, and the City Manager's Office to receive input on recommendations. Additionally, three of the four public meetings were held in Phoenix.

The Interstate 10/Interstate 17 Corridor Master Plan ("Spine") study makes several recommendations that are beneficial to the City of Phoenix including modernizing the freeway to current design standards, adding additional lanes in each direction, adding direct high occupancy vehicle (HOV) ramps to prevent traffic from having to cross general purpose lanes to enter or exit the freeway, upgrades to 24 of 31 traffic interchanges, as well as bicycle and pedestrian structures.

The Spine study revealed that two times more traffic crosses over Interstate 17 (I-17) than travels on it. This is an important realization for Phoenix, as residents traveling east and west over I-17 feel the impact in their daily commute and access to nearby businesses are impacted. The study identified the need for five high capacity traffic interchanges with enhanced east-west traffic capacity along I-17 (Indian School Road, Camelback Road, Northern Avenue, Thunderbird Road and Bell Road). Phoenix staff would recommend that the study also look to reconfigure the I-17 and Glendale Avenue traffic interchange to better accommodate large east-west arterial improvements on Glendale Avenue, as well as other operational improvements to increase safety, capacity, and incorporate bicycle and pedestrian movements.

As MAG and the Arizona Department of Transportation (ADOT) look to design the new high capacity interchanges, it is the City's expectation that there will be expansive outreach to residents and businesses to ensure the final design enhances connectivity and does not negatively impact the community and neighboring businesses. The City has heard concerns

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from businesses along the Camelback corridor regarding the right-of-way implications of a high capacity traffic interchange. It is critical that MAG, ADOT, and the City of Phoenix work closely with the business community to develop a transparent public process ensuring the continued economic success of the I-17 and Camelback Road area.

The City of Phoenix appreciates that the study recommendations embrace the 2014 Comprehensive Bicycle Master Plan and that the recommendations will make it easier for bicyclists and pedestrians to cross the freeway. Additionally, several of the recommendations will make a more reliable ride time for transit users. Thank you for including City of Phoenix staff and residents in the planning process. These improvements will allow Phoenix and the region to grow and thrive into the future.

In conclusion, the City of Phoenix supports the recommendations of the Interstate 10/Interstate 17 Corridor Master Plan with the additional study of a high capacity traffic interchange at I-17 and Glendale Road. Additionally, the design of all high capacity traffic interchanges need to be thoroughly reviewed with community input.

Sincerely,

Ed Zuercher
City Manager

cc: Mario Paniagua, Deputy City Manager
Ray Dovalina, Street Transportation Direction
Tom Remes, Freeway Coordination Manager

Feedback on Managed Lanes

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?	Managed Lanes Strategy – Comments
Meeting	Strongly agree	No general-purpose lanes should be added and HOV should be mandated for 3+ passengers.
Meeting	Strongly agree	If the new HOV lanes are not newly buildt, but instead newly delineated this is excellent. If you are merely adding more lanes, that is unacceptable, HOV or otherwise. Additional lanes is an old way of thinking and lacks innovation 2 HOV lanes, taking a lane aways is worthy of applause.
Mailed	Strongly agree	I-17 definitely needs improvement. Dual lanes are needed for safety. Reduce rear end accidents also reduce congestion and pollution.
Meeting	Strongly agree	The traffic is horrible from Ray to 60 - it needs improvement.
Delivered by Neighborhood	Strongly agree	Phoenix needs a "corridor" or vein for traffic to move smoothly and efficiently. I agree with expansion for the sake of the valley and metro area. Suggest keeping priority on motorcycle, electric & hybrid vehicles for use in these lanes.
Online English	Strongly agree	Since buses use I-10 from Chandler Blvd north, I recommend a second a second diamond lane going north and south assuming that the 202/I-10 interchange will allow transition via diamond lane to go west as it currently goes east. There is a bottleneck created south of the interchange that will continue block traffic until the I-10 is widened south beyond Queen Creek Road. Section B, D, and E should have the double diamond lanes, but I wonder about the transition from the I-10 to the I-17 @ the Stack as we widen the I-17 between the Stack and the Split. Many drivers will be driving the I-10 west through the city to access the I-17 going north and could be a problem.
Online English	Strongly agree	When are tolling options going to made available?
Online English	Strongly agree	Lane striping should comply with the MUTCD - 2 solid white lines to delineate the managed lanes from general purpose lanes.
Online English	Strongly agree	But enforcement is lacking. These lanes are full of violators and makes the HOV lanes a joke during rush hour. It's insulting to folks who actually carpool. Electronic enforcement is necessary.
Online English	Strongly agree	Assign one of them for public transportation so buses are not in traffic and can be a more reliable transportation. That would motivate people to change onto public transportation.
Online English	Strongly agree	This is a good strategy, more people would likely carpool as a result.
Online English	Strongly agree	In favor of a strategy that supports transit and improves travel time reliability.
Online English	Strongly agree	This would be most helpful from the split to 60 and vice versa as the HOV lane in the afternoons on the stretch is no faster than other lanes.
Online English	Strongly agree	Well needed as our population continues to grow. It seems like the expressways are crowded for a large part of the day. Not just a few hours in the morning and in the evening. I have gone out at 10, 12, 1, 8. It is like rush hour all the time. The congestion is becoming impossible.
Online English	Strongly agree	My Name Is [redacted] I live in the subdivision of Siesta Terrace, and I LOVE my neighborhood. I would not be opposed to the expansion of the I-17 corridor in your current plans WITH ONE EXCEPTION. I WOULD, and I AM COMPLETELY AGAINST ANY pedestrian bridge of ANY typed whatsoever at the Osborn & I-17 intersection and so are almost all, if Not All of my neighbors. Our neighborhood is experiencing a Surge in crime already, and that Foot/Bicycle Bridge would do Nothing but encourage More! The Foot/Bicycle cross overs at the Main Intersections of Thomas Road and Indian School Road are PLENTY as they exist now, OR if you care to improve those, but NOT at Osborn, & I-17. We in Siesta Terrace, AND Westwood Village/Estates are Extremely Opposed to this idea, and are happy to discuss it with anyone at your office. Respectfully, [redacted]
Online English	Strongly agree	This is a must. Slower HOV traffic causes the faster HOV traffic to pass unsafely on the right slowing down the main traffic lanes.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?	Managed Lanes Strategy – Comments
Online English	Strongly agree	As long as it is actually managed well. It could just entice more people to use a lane they dont belong in and therefore be just as good/bad as an additional standard lane.
Online English	Strongly agree	the single HOV lane gives very little benefit right now
Online English	Strongly agree	I like this approach.
Online English	Strongly agree	I like the idea of the managed lane. HOV lanes are good, but without proper enforcement they quickly become a negative. People constantly ride in the lines with no passengers and jump in out of the lane to try to avoid detection. This slows both the HOV lane and lane next to it with erratic drivers jumping back and forth.
Online English	Strongly agree	I like the idea of this. I feel like if you are carpooling (regardless if you are transporting your own children, spouse, etc.) you should be allowed access to faster transit. I think 2 HOV lanes will come with issues as people get use to it, but hopefully everyone will use common sense to navigate the additional lane.
Online English	Strongly agree	This is an excellent idea. Where ever its feasible, this would be beneficial to HOV vehicles for smoother HOV traffic flow and volume. Even if it means elevated stretches above existing 1-17 through dense midtown Phoenix areas.
Online English	Strongly agree	my only concern, as is with the current HOV lane, is surveillance. there are bullies that are seemingly angered when they person you going to slow; they ride your back. having a second HOV will help alleviate that, but if no surveillance of proper usage of HOV lanes, it will simply mean an increase in HOV lane bullies and abusers. these concerns matter to me, especially since i am a senior and i FOLLOW the rules.
Online English	Strongly agree	great idea, encourage more HOV travel.
Online English	Strongly agree	As a former member for 4 years of the 202 Freeway Committee I remember a presentation given us showing that the connection of the 202 to I-10 at 53-55 avenue would create a slow down if not a bottle neck at the I-10 & I-17 interchanges. Is anything being planned for this situation?
Online English	Strongly agree	get going! this will take a long time to implement and it is needed years ago. thanks
Online English	Strongly agree	HOV lanes are needed, and (hopefully) the additional required widening cost would be less than "stacked" alternatives
Online English	Strongly agree	currently the car pool lane is just as slow as a regular lane. Really do not see a reason why the traffic on these lanes should not just move.
Meeting	Agree	However - sende vista side of Town has NO WALL we have lots of noise from freeway traffic. Wall must be installed as well NOISE WALL Needed in Sende Vista
Meeting	Agree	Against tolls for managed lane; would reduce efficiency
Meeting	Agree	HOV lanes will help but the majority of backed up traffic is in "non-HOV" lanes
Meeting	Agree	Managed lines are good idea Re reducing volumn
Delivered by Neighborhood	Agree	As long as it is NOT a toll lane.
Meeting	Agree	As long as homeowners that are located on the border of the freeway are informed and they give their individual input
Meeting	Agree	Drivers "hopping" in and out of the existing HOV does create a lot of back-ups and congestion. Adding an additional HOV lane will help encourage carpooling. Any additional lanes of traffic will help with congestion.
Meeting	Agree	I believe this would reduce traffic as long as is improved using government property that is available.
Meeting	Agree	Good, as long that this project doesn't affect Guadalupe.
Online English	Agree	I agree that we need to expand I-17 and I understand having two HOV lanes. The question is about safety - getting in and out of the HOV lanes in emergencies.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?	Managed Lanes Strategy – Comments
Online English	Agree	As long as ADOT does not take out significant property on either side of the freeway to accomplish this goal. I am concerned about the next phase of light rail along the I-10 extending West. This will be a massive construction project that will take some time to complete. Will there be conflicts with these two projects.
Online English	Agree	What is the projected time frame for the second lane to achieve the desired use? I understand this will encourage more people to use the addition lane but unless the current lane is congested I don't see how making travel easier for the HOV crowd would benifit the other drivers? I feel like more people will just use it as an additional lane even during operational hours.
Online English	Agree	Building for capacity is not sustainable. Need to find ways to really encourage ride share, carpooling, transit, etc.
Online English	Agree	My only concern with a barrier to these lanes would be the inability to use these lanes as a pass-through to maneuver large amounts of traffic around accidents. If an accident occurs in one of these lanes, how does traffic in those restricted lanes maneuver out?
Online English	Agree	I like the idea of less traffic and managed lanes. But NO to the foot bridge !! I do not want people to be able to just walk across the 17 into my neighborhood at Osborn. This will bring more traffic and crime. NO!!
Online English	Agree	If they add a non managed lane to increase traffic that is the problem- single occupancy vehicles.
Online English	Agree	HOV lanes should be reconfigured for managed access (median or other barrier) to prevent unnecessary lane changes. Most other cities do this with their managed lanes.
Online English	Agree	Seems like HOV lanes are underutilized right now. Double lane would only work there is a very heavy congestion flow.
Online English	Agree	I have the reverse commute - I live downtown and work in the west suburbs. Is the HOV lane necessary for the reverse commute? Can the hours switch? People just don't seem to understand the HOV lane and people drive slow in the left lanes.
Online English	Agree	As long as it's an additional lane, not converting an existing lane to hov
Online English	Agree	I am all for anything that encourages carpooling and hybrid/electric vehicles. ALL hybrid/electric vehicles should be able to use these HOV lanes regardless of their license plates.
Online English	Agree	I agree with the addition of managed lanes but NOT at the expense of existing non-managed lanes. In other words, I do not support the conversion of existing lanes to managed without associated road widening to support those additional lanes.
Online English	Agree	This is great when the lanes are full, but usually they're quite empty.
Online English	Agree	I agree with this strategy provided that a "slower traffic, keep right" law is also enforced for the non-managed lanes. Traffic flow is impeded more by slower drivers "wolf packing" across multiple lanes than from any lack of managed lane access.
Online English	Agree	It would probably help since sometimes the HOV lane is moving slower than the rest..
Online English	Agree	HOV Lane challenges occur when drivers enter the lane outside of carpool times/days and then drive the exact same speed as other drivers, impeding the ability to use the HOV lane to maneuver through stagnant traffic. I will continue to say this.....a critical component of the highway mess is the fact that drivers do not obey/follow basic traffic laws (ie: slow traffic to right, passing to left) Also, phone use on these roads is a problem.
Online English	Agree	This could be beneficial but frustrating to those that don't use the HOV lanes.
Online English	Agree	People other than multiple passenger "carpool" & "green" individual should be able to use the HOV if they buy in. Have a permit that costs $X that commuters can buy and add a plate sticker or window sticker and have unfettered access to HOV lane. Essentially, a quasi toll road (lane).
Online English	Agree	A carpool transition lane between I-17 and loop 101 (all directions) would also be extremely helpful.

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Online English	Agree	I agree that HOV lanes should exist across the Phoenix area. Not sure we need two lanes everywhere one exists today. I'm sure there are some stretches of highway this is the case, but the wording above implies everywhere "HOV lanes currently exist".
Online English	Agree	As long as it doesn't take away a lane of non-HOV.....
Online English	Agree	A dedicated bus & long haul freight lane should be an option.
Online English	Agree	I do believe this is a necessary option at some points during the day - say for example, during peak traffic rush hours.
Online English	Agree	The I-10 traffic, particularly west of I-17, is worse. This corridor needs to be improved.
Online English	Agree	The addition of a meaningful amount of HOV flyout exit/entry ramps would improve use.
Online English	Agree	It appears you have two choices; expand the existing freeways by constructing more lanes (very expensive, and disruptive) or institute "managed lanes"; taking from the existing lanes, the least expensive solution; but has the maximum inconvenience. Of course, few will want to have their travel inconvenienced with fewer lanes. Therefore, the project will have to sell the idea of "managed lanes"; clearly it will be a tough sell. What the driving public really wants is more lanes and fewer restrictions; either of which are not likely to happen. It's a Hobb's choice for us.
Online English	Agree	Hire more DPS officers to ticket people in HOV lane that don't qualify.
Online English	Agree	Extra HOV lane could help but is not the main source of traffic. Often times the HOV is empty and those abiding by traffic laws are stuck in grid lock. What about a pay to ride program like California? I would pay 20 bucks a month if it meant I reduce my trip time by half. I live north of 1-17 and Greenway and travel to Tempe for work 4 times a week.
Online English	Agree	We should give more lane space to people reducing emissions the smog over Phoenix is disgusting. I was hiking Shaw Butte and North Mountain a few afternoons ago and my view of the valley was hindered by this gross smog over the entire valley. Also, why is there no research into adding a Metro System or higher capacity rail corridor along I-17, with the frontage roads and all the space available on I-17, why are we not looking into more innovative ideas than just improving asphalt!?
Online Spanish	Agree	It is a good idea. However, as long as the problem of freight and commercial vehicles that occupy all lanes of traffic is not addressed, it will be very difficult to alleviate traffic congestion. My recommendation would be to limit the movement of these cargo units and passage to the far right lane, so that they leave the other lanes clear. This can be applied at least in the urban area.
Mailed	Neutral/Don't know	I think this will only add accidents. An additional travel lane before two HOV lanes.
Meeting	Neutral/Don't know	I suggest a trail segment first to conduct a "shakedown. Cruise" of the proposal. If it works it can then be expanded
Meeting	Neutral/Don't know	Depends on how many commuters actually use the HOV lanes.
Online English	Neutral/Don't know	I think hov lanes should be available to all drivers all 24/7
Online English	Neutral/Don't know	More lanes just mean more traffic, studies have been done showing that increased lanes on highways means increased traffic. I'd really hate to see more traffic in this already congested area.
Online English	Neutral/Don't know	What about a designated Truck Lane. I find them to really cause problems as far being very dangerous in this area they are constantly changing lanes. I have witnessed several accidents caused by them.
Online English	Neutral/Don't know	This is a very vague explanation of this component of the proposal. It's difficult to have an opinion without knowing more details. For example, "a large part of the I-10/I-17 Spine Corridor" does not specifically identify the areas that will be affected. Also, does this involve widening the interstates, and if so, how will surrounding land be affected?

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Online English	Neutral/Don't know	The extra HOV lanes may help. However there is still a risk of unsafe driving. Right now folks feel that when they get on the freeway, they need to head as far over to the left as fast as possible with little regard to the rest of traffic. During high volume times, those main lanes are not evenly spaced as your graphic, its bumper to bumper, so merging across lanes is a challenge.
Online English	Neutral/Don't know	It depends on whether these lanes are created by narrowing existing lanes or widening the road. If the former, the impact would be positive. If the latter, the negatives might outweigh the positives.
Online English	Neutral/Don't know	DHOV lanes are identified in the primary corridor I use every morning. Only if HOV fly over is provided to Split and Stack is this a great option. The bottleneck begins at Indian School - as much of the local traffic has jumped south to skip Camelback. Getting on the freeway here daily I face too many vehicles getting off or positioning to get onto I-10 at the Stack.
Online English	Neutral/Don't know	I use the 51 N/S (Exit Bethany Home) and 10 E/W (Exit 7th St) daily. I do not use this corridor. My observations are the 202/51/10 exchange is the worst bottleneck and needs immediate attention. The connection provided by the 202 between the 101 and the 10 and continuing west on the 10 is an important component of your plans that should not be ignored.
Online English	Neutral/Don't know	Unless greater mass transit initiatives are added in conjunction with these additional HOV lanes, I do not see how this will have much impact.
Online English	Neutral/Don't know	Exiting from HOV lanes across six lanes of traffic may be difficult and dangerous. There should be exits available on the left side of the freeway.
Online English	Neutral/Don't know	the placement of these would be highly dependent on interrelated projects - one of the biggest problems i consistently see on Phoenix roads is cross-weave going in and out of HOV lanes. adding more lanes in any capacity without addressing cross-weave and HOV access will only make things worse.
Online English	Neutral/Don't know	Although the hov lanes are great, it is hard to cross 3 lanes on the 17 to exit the freeway. I can't imagine trying to exit with additional lanes.
Online Spanish	Neutral/Don't Know	You should make a lane just for commercial vehicles because these vehicles are spread out through all the lanes and they impede the movement of smaller vehicles.
Meeting	Disagree	Focus on I-17 corridor more because those commutes from Central Phoenix, north are horrendous.
Delivered by Neighborhood	Disagree	Increased Pollution Increase in Accidents Increase in Heat/Noise
Meeting	Disagree	I like the idea of extra lane but I do not feel a second HOV is the answer. Congestion lies with the other lanes, while the HOV is typically clear.
Meeting	Disagree	This will not help during rush hour traffic People do not use HOV lane - very difficult to get into the lane
Online English	Disagree	We don't need another HoV lane.
Online English	Disagree	I disagree. Most drivers here in Phx don't know how to drive, or have forgotten how to drive. A 2nd carpool lane where one already exists would, in my opinion, create a hazardous condition. Also, during rush hour traffic, all lanes slow down to a crawl, even the HOV lane. The only way something like this would work, would be to create enter/exit carpool lanes every 4 miles or so, similar to the ones located at I-10 @ 79th Ave, I-10 @ 5th Ave, and I-10 @ 3rd St. More of these types of enter/exit lanes should be constructed for the carpoolers. How about adding more of these at the I-10 @111th Ave, @47th Ave, and other locations between US60/I-10 and Chandler Blvd?
Online English	Disagree	The HOV lanes are not backed up as much as other lanes so only 1 HOV is needed since limited spacing, more general lanes is better
Online English	Disagree	I drive in the HOV land T-Bird to Central Ave and Roosevelt everyday. One HOV lane is good. Two would hinder traffic as many people try to jump in the lane when traffic slows and causing dangerous conditions. I would rather see it added to the regular traffic.

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Online English	Disagree	Within 10 years 90% of traffic will be self-driving and congestion will no longer be a major concern.
Online English	Disagree	Add another regular lane, I've seen people use the HOV lane without a passenger, adding another regular lane will help more than another HOV lane
Online English	Disagree	I agree that adding a HOV lane where one doesn't already exist might alleviate congestion, but adding a second HOV land to an already existing one, would only take away from more readily available space that might be utilized by all commuters already. This would mean that more cars would be left with less lanes, while the "carpool" lane commuters would be given even more space. Carpool lane commuters do not encounter nearly the same congestion and in fact, many, many people violate the carpool lane already. Do you want more people to break the law because two lanes are accessible with less congestion? This would only increase road rage, and increase congestion by not allowing four or five lanes to be open to all commuters because two lanes have been given priority to law breaking commuters and carpoolers.
Online English	Disagree	when traffic is pretty packed the HOV lanes are still pretty open. I dont see adding a second HOV lane being very beneficial
Online English	Disagree	more lanes of traffic encourage driving; route resources to increaseing safety, frequency, and materials on public transit
Online English	Disagree	You need to start ticketing and revoking licenses of drivers who are repeat the offenders amd make the punishments harsher. Also you need to implement a minimum speed law so that trashy junk vehicles doing 41 in a 55 don't clog up lanes of traffic. Start ticketing drivers who are going slower than speed of traffic in the left lane as well as those that refuse to stay right except to pass.
Online English	Disagree	HOV lanes do not relieve traffic congestion. Instead they increase congestion in the following ways: 1) HOV lane users aren't "with the program" and do not maintain speed limit speeds, causing followers to cut into other lanes to pass; 2) HOV lane users have to cut across 2 - 4 lanes of traffic to exit, thereby slowing down and stopping each lane as they maneuver to the exit.
Online English	Disagree	Adding an additional HOV lane where there is one already there doesn't help with anything. That lane is almost always sparce with cars.
Online English	Disagree	Instead of additional HOV lane, covert HOV lane(s) to Toll Fares
Online English	Disagree	People in this state don't carpool, just add an extra lane for single users or find someone to set up car pools ... I would be happy to car pool, I don't know how to make contact with someone that works in the same area, that lives in the same area with the same hours that I have.
Online English	Disagree	The HOV lanes have always been ineffective. They are abused constantly with no visible enforcement and at peak times do nothing to alleviate congestion. Eliminate them and make the lanes general use at all times.
Online English	Disagree	Concern is traffic exiting the managed lanes, especially the most left lane, for a freeway exit. Maybe if the inner lanes were for through the valley only traffic.
Online English	Disagree	Wasting tax payer $s again. over complicated documents that cost big $s.....only supported by data collected by those that want the plan.
Online English	Disagree	It has been my experience that when crowded and slow, the HOV lanes are used by one occupant vehicles because there is no enforcement of the current HOV law. Only the law abiding citizens stay stuck in traffic. Adding more regular lanes is a better idea if there is no enforcement.
Online English	Disagree	The HOV lane we have is poorly enforced. My (admittedly unscientific) daily sample is that the number of vehicles using it that actually have more than one person is almost always <50% during peak traffic hours. This makes me skeptical that adding a 2nd lane will have any impact on total # of cars on the road. Instead, ADOT should increase the number of unrestricted lanes.
Online English	Disagree	People don't hardly use the car pool lane legally now. Maybe in the future when people actually carpool
Online English	Disagree	I witness daily a very high non-compliance in the current HOV lanes. An additional lane will just further encourage abuse and non-compliance. Enforcement appears minimal currently, even harder as traffic grows

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Online English	Disagree	IN most areas I travel, the HOV lane is just fine. I would carpool if I could, but it just doesn't work with my travel requirements. It is the OTHER lanes that are overly congested.
Online English	Disagree	The additional lanes/capacity should be general purpose. One HOV lane is plenty (and, for example, on the I-17 portion, the 1 HOV lane is enough that typically any vehicles in the HOV lane are free-flowing during peak periods). If two HOV lanes are the direction the project is going, then the state needs to be flexible to allow them to be re-striped in the near future after project completion to a general purpose lane if HOV usage is low and a GP lane would be more beneficial. HOV lanes have been around long enough in the Valley that many new people aren't going to try carpooling to take advantage of the added benefit of an HOV lane if they haven't already, so even more HOV lanes (2 instead of 1) might be a waste.
Online English	Disagree	HOV lanes are counter-productive during rush hour. The majority of drivers are single commuters and the HOV lanes are not utilized efficiently to help the flow of traffic. More lanes that ALL drivers can use are needed; not more HOV lanes that a small percentage of drivers can use
Online English	Disagree	Inefficient. I believe there is federal funding associated with the HOV lanes but I think the best option will be make all additional lanes general purpose at this point. Tolling could be an option. Pedestrian and bicycle options should be secondary to vehicles and then transit in my mind.
Online English	Disagree	Too many commuters in the Phoenix metropolitan area are driving alone --- that makes the HOV lane unavailable to them. More HOV lanes will not help.
Online English	Disagree	The HOV lanes aren't crowded enough to require a 2nd lane. Maybe if the new lane were just for semi's and other large vehicles, that would make a difference.
Mailed	Strongly disagree	I live in a housing cooperative. There are 99 units in this corporation. Each of us owns a share of stock. You can't take one unit without buying out the entire property. Many are on fixed incomes. The stock share is NOT a deed. These units have on driveway & one master waterline that would be destroyed if lanes are added...because the property is just across a brick wall from the frontage road. Contact attorney for the cooperative called "Bethany Crest" 6 Cooperative". [redacted]
Meeting	Strongly disagree	I don't see the need for the HOV lane change in the area. Money would be better spent less where.
Delivered by Neighborhood	Strongly disagree	Need another regular lane since there are more single people in the car.
Delivered by Neighborhood	Strongly disagree	The amount of HOV drivers does not warrant another HOV lane.
Delivered by Neighborhood	Strongly disagree	extra HOV lanes are unwarranted. Since not many cars use the existing one
Meeting	Strongly disagree	HOV lanes not utelized 60% of the time
Meeting	Strongly disagree	The HOV lane is under-utilized adding a second won't help.
Meeting	Strongly disagree	I believe the HOV lanes are not the proble. They are already underutilized and during the busy commute times I believe the other lanes would benefit more with an extra lane.
Meeting	Strongly disagree	Having a second HOV lane only helps the Rapid the bus to the S.E. Valley cities and you can't force people to carpool or vanpool. You might as well put the light rail down the middle of the road with stations like Chicago, [redacted]
Delivered by Neighborhood	Strongly disagree	This expansion would take my home.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?	Managed Lanes Strategy – Comments
Online English	Strongly disagree	Wow I agree with the I 17 road expansion, I am not in agreement with having a pedestrian bridge on Osborne, we do not need to have a high crime rate area having access into our neighborhood
Online English	Strongly disagree	Most drivers still drive alone. Reducing the number of lanes for non HOV drivers, will make traffic congestion even worse.
Online English	Strongly disagree	You don't tell me if this will take away from a no HOV Lane or if it's a new HOV one ?
Online English	Strongly disagree	I live in the Westwood division on Osborn Rd I have many reservationstudents on pedestrian bridges over the I-17 freeway it will just make it easier for the criminalsame to come in and out of this neighborhood the traffic projects I don't have a problem with
Online English	Strongly disagree	There is no policing of these lanes as they stand. what makes anyone thing that people will abide by the law if new lanes are put in.
Online English	Strongly disagree	dont build more roads. waste of resources. there is tons of academic literature which supports the notion that more roads do not solve congestion problems, but ironically, can lead to further congestion. phoenix needs to quit investing in these outdated transportation frameworks.
Online English	Strongly disagree	You are missing the mini stack and the tunnel for I-10 and 202/51
Online English	Strongly disagree	-need to add an extra GP lane to the I-17 between the split and the 101 -why arent the intersections from 19th ave and the stack being reconfigured? -what do you mean when you say that the managed lanes are initally going to be hov lanes? Are they going to eventually going to be turned into GP lanes? I dont like the idea of my tax money going to build a lane that i cant use. if your going to be adding an extra hov lane there needs to be GP lane built also -encanto lane should cross over the I-17 -Texas U turns should have been considered especially on the southern half of the I-17 and thomas interchange where literally hundreds of shamrock trucks and UPS trucks do a u turn in order to get to encanto -Texas Uturn would also be good for the northern half of mcdowell and I-17 alleviating shamrock and ups traffic who need to go north and clog up the thomas and I-17 intersection during rush hour
Online English	Strongly disagree	Adding another lane to HOV adds confusion and opportunity for reckless driving...SAFETY FIRST!
Online English	Strongly disagree	I strongly agree with the idea of additional HOV lanes, however managed lanes segregate traffic based upon the ability to pay. Managed lanes should not be implemented in the Phoenix area where the system has been supported by tax payer funds. You want a toll road, go build one, but do not toll facilities that were previously free to drive on for everyone.
Online English	Strongly disagree	This will bring in more drug and prostitution traffic. Tweekers and the sorts will be happy to have a secret passage to rob with a quick getaway!! Oppose, oppose oppose!!!!!!
Online English	Strongly disagree	It will only bring in more crime. I oppose to this bridge as this area has slowly cleaned up and across Indian School is already a bad area for us to deal with. We will then have that area, the canal traffic (with that bridge), and the traffic from across the freeway.
Online English	Strongly disagree	This would increase foot traffic of the homeless into our neighborhood.... crime will skyrocket.. of our roundabout at 23rd avenue and Osborn cannot improve for safety of our residents, why would we approve this??
Online English	Strongly disagree	Was there any visual observations that went along with the study? An additional HOV lane?????? As a person whose life is being destroyed by the Phoenix freeway system (1.5 to 2 drives each direction) I see many people who not belong in the HOV lane driving along with no worries... these people would include off duty policeman, ADOT employees in company trucks, young women, prius drivers, none of them do not have the "Cloud" license plate. Do they have some kind of immunity???? The HOV lane is hardly used and is the only option to get anywhere at times. The state of Texas does no utilize HOV lanes. Those lanes are a joke.... Think outside the box and don't waste taxpayer money. This is a really silly solution to the traffic problems.
Online English	Strongly disagree	Only traffic this would open up is transients and those coming over to colaberate theft

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?	Managed Lanes Strategy – Comments
Online English	Strongly disagree	On the Interstate 17 portion from 101 down to Indian School where an existing HOV lanes is already present I think this idea is ridiculous. I have driven in the HOV lane during rush hour for over 8 years and thousands of times, unless there is an accident the HOV rarely gets slowed down that much meaning it is not even near capacity. Why would you build a second HOV lane when the three general purpose lanes are in stop and go mode? Yes, if you build a forth general purpose lane it too will eventually get to capacity but I thought the goal was to move the most amount of traffic the most efficiently. Adding a second HOV lane will only allow the legal and illegal users of the lanes to go at and above the speed limit while passing three lanes of traffic at a stand still. Not a very smart usage of taxpayers money in my opinion unless you are trying to discourage driving on Interstate 17 during rush hour.
Online English	Strongly disagree	All you need to do is establish enough separation between cars, the more traffic, the more space needed between cars and problem solved. Why does every driver have to follow the other so close and cause a jam? Idiots. Adding more lanes is not the answer. Double Managed Lanes, where do you come up with this nonsense?
Online English	Strongly disagree	It doesn't seem like the one how lane is ever busy so why a second? And I travel during traffic hours.
Online English	Strongly disagree	This in no way would alleviate the traffic issues of the so-called "spine". The canyon portion of I-17 below Dunlap- Durango curve, would have to receive a major overhaul (eliminating the sloped shotcrete tapered sides) should be first on that agenda. What to do with all entrance and exit ramps in the process. Not sure even then if the Black canyon freeway would be able to add much more than one lane in either direction.
Online English	Strongly disagree	The HOV lanes are not used enough as it is. Forcing people to commute together is not going to work.
Online English	Strongly disagree	HOV will not solve any traffic problems. Current HOV lane should enough. The main issues are the left lane merges, get rid of those lane merge will greatly improve the traffic. For example, get rid of 101 south bound Guadalupe merge, Broadway merge; and north bound broadway merge. These merges kills all 101 traffic. For I-10 and 60 interchange, get rid of Broadway exit. For I-10 and I-17 split, close 7th Ave entrance. All these are traffic blockers. I am surprised that non of AOT can figure these out.
Online English	Strongly disagree	Az drivers, do not support HOV, so you will waste another usable lane of traffic that will be empty.
Online English	Strongly disagree	I was going to recommend the exact opposite; either reduce the time restrictions for HOV or remove the HOV lanes all together. The additional lanes for all traffic would likely prove more beneficial than enabling two HOV lanes.
Online English	Strongly disagree	Get rid of the HOV or otherwise restricted lanes and let them be open to everyone during rush hour. It makes no sense to close off a fourth of the space to three fourths or more of drivers.
Online English	Strongly disagree	The existing HOV lanes on I-17 are already under utilized. Adding a second lane would accomplish nothing except encourage more illegal usage of the lane. I personally use the HOV lanes on a regular basis, and there is minimal to no congestion there along I-17 even during the most congested periods of rush hour. Also, I see cars with a single occupant playing leapfrog with the lane, hopping in and out to save time in the hopes they don't get caught. If you add a second HOV lane, you are only going to make this worse, and the lanes will sit there mostly empty while other traffic lanes crawl along at 5MPH. We do not need more HOV lanes. I can't speak for I-10, as I refuse to drive on I-10 because it is a bloody parking lot and I have found it is faster to take surface streets than to attempt to drive on I-10.
Online English	Strongly disagree	Existing HOV lanes are seldom at capacity. Use funding elsewhere!
Online English	Strongly disagree	I think HOV lanes are running just fine. They are never backed up. Adding another HOV lane will just cause more back up of the regular lanes, which are ALWAYS backed up! We need a solution for those.
Online English	Strongly disagree	You also need additional lanes for cars with single drivers. The phoenix population is scattered across hundreds of square miles. Increasing number of HOV lanes will not guarantee that these double lanes will be filled with autos.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations include the addition of a managed lane* through a large part of the I-10/I-17 Spine Corridor. The initial strategy envisions a second high occupancy vehicle (HOV) lane where HOV lanes currently exist, and a new single HOV lane where HOV lanes do not currently exist. This strategy would support transit, reduce congestion, and improve travel time reliability. What are your thoughts on this strategy?	Managed Lanes Strategy – Comments
Online English	Strongly disagree	already too few lanes during heavy traffic times . Reducing this to two or three lanes will clog things up further unless the freeway is widened
Online English	Strongly disagree	These lanes are underused and contribute to additional congestion in the remaining lanes. I have counted cars in the current HOV lane on I-17, during peak hours, and 50% of the cars I counted contained 1 person in the car. Those who follow the rules are forced to sit in the remaining lanes and watch 2-3% of the total traffic pass by in the HOV lane.
Online English	Strongly disagree	If you do not encourage people to use mass transit they will not use mass transit. If there's no reason for people to live closer to where they work they will not live closer to where they work they will use more freeways and pollute more air.
Online English	Strongly disagree	Add another normal lane. In fact, add 3 more normal lanes if you truly want to minimize turbulence in the traffic flow.
Online English	Strongly disagree	Instead of causing traffic jams for years of lane expansion construction, why not do the right thing and make another new freeway north & south between the Phoenix area to the Flagstaff area. It's already a nightmare going north with only 2 lanes and being stuck behind trucks going up mountains. When there is an accident, hundreds of cars have to sit there for hours while the freeway is cleared. Somebody should have thought of this years ago before traffic in Phoenix got as bad as it is in Los Angeles. We DO NOT need a new freeway to Las Vegas, we need a new freeway to Prescott & Flagstaff. Millions of tourists travel to the Grand Canyon from the Phoenix area and the ONLY way to get there is the clogged 17. It's totally rediculous.
Online English	Strongly disagree	High-capacity rail transit is needed here, not additional vehicle travel lanes
Online English	Strongly disagree	No more lanes. Execute this by simply converting an existing regular lane into a managed lane.
Online English	Strongly disagree	Carpooling is great in theory, but it is not practical. We are all incentivized to carpool, and I loved it when I was able. However, it is often too difficult to coordinate with everyone's busy schedules. These lanes would not reduce congestion. In fact, it seemed as though congestion improved when the SB HOV lane was changed to an all-purpose lane further north, beginning at Indian School. Making room for additional HOV lanes would be wasted on the few that can actually make carpooling work for their schedules. Meanwhile, the vast majority of travelers would continue to be stuck in the same lanes that are congested now. Currently it's not the HOV lanes that are congested, and I and others would take them if we could!
Online English	Strongly disagree	First off, the picture above of is not accurate. It should show the regular lanes jammed while the HOV lane is marginally utilized. As far as your question, adding a second marginally used lane is not the answer. If you really want to add a "special" lane, do what they do in other big cities and add an express lane. I am 100% totally opposed to adding another HOV lane.
Online English	Strongly disagree	ever seen the Katy freeway? Look into it.

Note: Comments are presented as submitted and are not edited or corrected for grammar.

Feedback on Designated Entry Points to Managed Lanes

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Meeting	Strongly agree	Many people use the HOV lane without meeting the requirements. This would reduce that. The problem I see with this is not peak travel time is it's lack of utilization. Not a major problem, but something to consider. I would prefer a physical barrier than a few feet of space to reduce space/built environment impacts.
Mailed	Strongly agree	Dual lanes would aid people in entering and exiting and easing congestion.
Meeting	Strongly agree	Unmanaged lanes allow use of lanes for passing by non-HOV drivers, a common practice at all times of day. DPS is severly understaffed and unable to effectively enforce speed limits and weaving - this will not change.
Delivered by Neighborhood	Strongly agree	seems safer
Delivered by Neighborhood	Strongly agree	Safe entry/exit on HOV lanes is a serious problem. Needs to be resolved with specific entry/exit spots. Great suggestion!
Mailed	Strongly agree	Ohio DOT has put in express lanes (not HOV, but same idea) along I271 East of Cleveland. Entry points are 3 to 4 miles apart. This works VERY well and could easily used as a HOV lane. Please contact ODOT about this.
Online English	Strongly agree	Get on with it!
Online English	Strongly agree	Striping should conform to the MUTCD
Online English	Strongly agree	This is a necessary change to help with enforcement!!!!
Online English	Strongly agree	It's very dangerous when cars come in and out of HOV wherever.
Online English	Strongly agree	I strongly support this - we have had far too many accidents from wrong-way traffic at the on/off ramp that has two way traffic.
Online English	Strongly agree	Too many vehicles zip in and out of this lane to pass traffic
Online English	Strongly agree	My Name Is [redacted], [redacted] I live in the subdivision of Siesta Terrace, and I LOVE my neighborhood. I would not be opposed to the expansion of the I-17 corridor in your current plans WITH ONE EXCEPTION. I WOULD, and I AM COMPLETELY AGAINST ANY pedestrian bridge of ANY typed whatsoever at the Osborn & I-17 intersection and so are almost all, if Not All of my neighbors. Our neighborhood is experiencing a Surge in crime already, and that Foot/Bicycle Bridge would do Nothing but encourage More! The Foot/Bicycle cross overs at the Main Intersections of Thomas Road and Indian School Road are PLENTY as they exist now, OR if you care to improve those, but NOT at Osborn, & I-17. We in Siesta Terrace, AND Westwood Village/Estates are Extremely Opposed to this idea, and are happy to discuss it with anyone at your office. Respectfully, [redacted]
Online English	Strongly agree	California utilizes something similar and it works great.
Online English	Strongly agree	Many drivers currently misuse HOV lanes as ultra-high-speed passing lanes. Controlling access would help manage this behavior.
Online English	Strongly agree	I agree with this strategy. As with my previous comment, enforcement would be key.
Online English	Strongly agree	YES!!!! The Express Lanes in Chicago seem to help traffic flow. If you know that you'll be taking highway for the next 12 miles, get in the far lane, get out of the way, and keep it moving! I feel like this would be a nice option for non-HOV lanes as well. I love the cone-type barriers that have been erected for the 60-West/10-East interchange. It keeps people from cutting in, slowing down traffic, and making last minute bad decisions to jump out of that lane.
Online English	Strongly agree	I commuted in MInneapolis/St. Paul for a number of years. They built a similar system and it works great. For my commute here in Phoenix, I get on the I17 from the I10 and I don't exit until Yorkshire. I utilize the HOV with a passenger and would love to worry less about traffic jumping in front of me from a dead stop along the way.
Online English	Strongly agree	This is used in CA and I believe it improves HOV flow.
Online English	Strongly agree	excellent idea as long as the "rushed" bullies are monitored so they DO NOT harass other drivers.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Strongly agree	We were shown this concept at the 202 Freeway committee meetings and it seemed a very good way to go.
Online English	Strongly agree	Greatly increases proper usage as DPS can monitor specific areas for violations, with drivers unable to get out at will
Online English	Strongly agree	I like it. main reason for broadway curve back up is all the lane changing going on. make people commit sooner.
Online English	Strongly agree	This would help decrease all the merging that slows down traffic and also causes accidents. Great idea!
Meeting	Agree	Flow of traffic is what matters & that's near the split, so that is actually a good thing
Meeting	Agree	Probably will need traffic lights where HOV lanes merge
Meeting	Agree	This would segment HOV lanes and further eliminate random in and out access by non-HOV vehicles
Meeting	Agree	I think having manage entry/exit point for HOV traffic will help manage traffic flows. However, additional care needs to make sure that the managed points meet future and current needs for travelers (not allowing people to get out where needed, etc.)
Meeting	Agree	Very difficult to get into HOV lanes during heavy traffic
Meeting	Agree	Depends on how many HOV commuters could stay in managed lanes. Education would be a key.
Meeting	Agree	Good, as long as there are signs or something better for wrong way drivers!
Online English	Agree	As long as the restrictions are not causing more confusion at times of emergencies. That it will be understood how to handle the HOV lanes and be able to see the signs clearly especially at night.
Online English	Agree	Unlike California, our major intersections are roughly one mile apart leaving little time transitioning at freeway speeds. The two lanes help relieve the traffic on the other lanes as long as the state does not change the times for exclusive use by vehicles with 2 or more passengers.
Online English	Agree	Seems efficient, but again, what is done to manage traffic when accidents occur?
Online English	Agree	I like the idea of less traffic and managed lanes. But NO to the foot bridge !! I do not want people to be able to just walk across the 17 into my neighborhood at Osborn. This will bring more traffic and crime. NO!!
Online English	Agree	How would violators of this be handled? That is, if a driver entered/ exited this proposed area, would there be more patrol officers watching this, or perhaps, cameras, recording and sending a ticket in the mail along with a picture of the violation occurring? I follow the rules of the road, and it bothers me to see someone "doing whatever the driver wants, whenever they want", and no one to cite them for the violation. Other than this, I think this is a good idea to implement with the HOV lanes we currently have.
Online English	Agree	Have seen them in operation in California - Arizona drivers would have to be educated!!
Online English	Agree	I only agree if this option does not take away space. I'd rather have two HOV lanes that are unmanaged than one that is managed.
Online English	Agree	The double lanes are used in a few places in Southern California. We will need to adjust.
Online English	Agree	Can be helpful, though driving in LA it did not help there. Just made more of traffic headache, as many driver do not plan out there routes or think ahead. Many drivers place their mind in auto pilot, and any deviation in what they see daily, makes them indecisive and un-adaptable to variations in traffic. This I believe will create a new level of confusion where roughly 65-75% of the drivers will not be able to handle with the efficiency needed.
Online English	Agree	As long as people are paying attention and not on their phones, I can see this working. Just have it well marked with signs, etc.
Online English	Agree	It depends on where those entrances and exits are. Will they be at main cross roads or every 5 or 10 miles apart. How about one managed limited access lane can be used only for passage through the city, long distances travel. This would not an HOV lane and can be used by anyone with enter and exit every 5 or 10 miles apart. The other lane is to be a HOV lane that can be entered or exited at will.
Online English	Agree	I see the benefits, but again, my concern is how eliminating the use of HOV lanes to maneuver around three lanes of drivers who are going the SAME speed and clogging traffic flow due to drivers not following the rules of the road, including moving over to the left when you are going the same speed.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Agree	First thought that comes to mind: waste of space. Although I like the idea of a "safe" HOV where cars cannot cut you off (making you hard brake because they are coming into your smooth flow of speed from a dead stop in rush hour traffic)
Online English	Agree	This approach is intelligent for preventing vehicles pulling into the HOV anywhere now during congested periods and the danger it poses to riders in the lane already.
Online English	Agree	I know this is commonly used in Los Angeles. My concern would be that drivers who aren't familiar with it in Phoenix won't know how long they'll be "trapped." I'd recommend a sign at the entrance that says where the next exit will be so drivers know they won't miss their exit and be tempted to exit the HOV lane illegally.
Online English	Agree	Like the idea, however, with a lot of people being distracted, they may not realize they cannot exit when they want too and instead cause accidents. Large easy to understand signage would be necessary if this idea moves forward.
Online English	Agree	Particularly for bus and freight traffic.
Online English	Agree	Works pretty well in California
Online English	Agree	If you don't know where you're going it might cause accidents for drivers to cut across that area
Online English	Agree	The speed differential between the HOV lane and the adjacent lane is huge during peak hours (75 mph vs 30 mph) and it is dangerous to navigate in and out.
Online English	Agree	The exits from the managed lanes needs to be at points where vehicles can navigate to freeways exits easily.
Online English	Agree	The Broadway curve has too many entrance points. Several should be eliminated.
Online English	Agree	if you're going to do it, put a wall up like TX does.
Online English	Agree	Again we should reward commuter that are not contributing to the smog and congestion, but why are we not seeing more proposals that involve public transit options. Owning a personal vehicle is expensive. We should explore options that can benefit the entire community as well.
Meeting	Neutral/Don’t know	Adopt what California uses in regards to HOV lane policy. No moving at will.
Meeting	Neutral/Don’t know	I am not sure that this will improve it. I think that it might cause problems with drivers already in this area.
Online English	Neutral/Don’t know	I've seen this in LA where traffic is much worse. Not sure if an actual issue here, at least yet. Can be a big difference in speeds between HOV and others, but not sure if separation is needed. Limited options in avoiding accidents.
Online English	Neutral/Don’t know	I feel neutral towards this strategy, with my concern being that some drivers might worry about not knowing where the limited entrance and exits will be at, and miss an exit. I would feel confident about this approach if it is paired with more hov ramps and good signage.
Online English	Neutral/Don’t know	The use of collector lanes could allow normal and limited access HOV lanes to coexist, otherwise people may not use the lanes if they can not easily get in or out.
Online English	Neutral/Don’t know	how about changing these managed lanes over to express lanes with limited exits? Like on the I-15 near the strip in vegas im strongly against adding these managed lanes since i cannot use them but am ultimately going to be stuck with paying for them
Online English	Neutral/Don’t know	This idea is fine as long as entry/exit lanes are available no less than every 3-4 miles.
Online English	Neutral/Don’t know	I've never been on a road like this and it seems like the designated entry and exit areas could get very crowded
Online English	Neutral/Don’t know	This would help discourage illegal usage of the lane, but if you don't have enough access points, it will also discourage legitimate usage of the lane. The lanes along I-17 are already under utilized, and this might make the problem worse. Think carefully before you do this.
Online English	Neutral/Don’t know	I have concerns that this'll cause bunching up of vehicles & a greater amt of last-minute weaving of HOV vehicles when they're permitted to exit the HOV lane at a certain point, & then must exit only a short distance away- they will then have to move VERY quickly over several lanes of traffic to exit.
Online English	Neutral/Don’t know	I've used them in Utah, and found them to be more trouble than their worth. As with our current HOV lanes, no enforcement and abuse there as well.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Neutral/Don't know	This seems like a great idea, however, if the designated points are not positioned right, it may cause more anxiety for all drivers. Right now, drivers will speed to get over in order to get off an exit from the HOV lane although they have only a few feet to do so. I have seen them speed over 4 lanes to get off almost causing major accidents.
Online English	Neutral/Don't know	I can't determine from the rendering nor the question the safety impact of your suggestion so I don't know how to answer this question.
Online English	Neutral/Don't know	It's OK the way it is, but would be less traffic if EVERYBODY could use the HOV lanes, not just cars with 2 + passengers.
Online English	Neutral/Don't know	I am not sure limited HOV access will work in urban Phx with exiting/merging every mile.
Online English	Neutral/Don't know	Not sure how this will translate to keeping the flow moving.
Online Spanish	Neutral/Don't Know	It will be necessary to see if these strategic points of exit are adjusted to the needs of the drivers. Also, having two exclusive HOV lanes would imply the need to better monitor their use with existing technology. To date, there are many violations of this rule, because those who should not be in those lanes currently circulate in them. In addition, the message that the lanes are not HIGH SPEED, but HIGH OCCUPANCY, should be emphasized, since many use them to simply pass at very high speeds.
Meeting	Disagree	Drivers will enter & exit at will
Meeting	Disagree	During rush hour, the HOV lane stays flowing 2 would be pointless.
Meeting	Disagree	Not good for tourists who are not familiar with system
Delivered by Neighborhood	Disagree	I am a board member at Bethany Crest #6 and represent 99 corporate share holders Sorry for the wrighting and spelling
Mailed	Disagree	This will only add confusion. A round A Bout in my neighborhood has caused so many problems and accidents. Lets keep it simple. An additional travel lane would be better than an HOV lane.
Meeting	Disagree	People don't follow the rules now!
Online English	Disagree	I like the freedom and simplicity of entering or leaving carpool lanes at any location. I think it's less stressful and less confusing for folks, esp. visitors.
Online English	Disagree	This creates a congestion point in traffic with folks juggling to get over to get into/out of the HOV lanes. Additionally if there is an accident in the HOV lanes this restricted area could cause even greater risks to the flow of traffic and driver safety.
Online English	Disagree	We have too many out of state seasonal visitors to limit the lane entry/exit and think it would cause more accidents, also if limited entry then less people inclined to use it since not know if can get out when need to
Online English	Disagree	They should be treated like the HOV lanes now. Enter and exit at will.
Online English	Disagree	Personally I feel designated entrance and exit points cause more confusion which lead to rash decision making while driving. When in California when driving on these designated entrance and exit roads, I often find myself rushing to get from the left side of the road to the right side of the road to exit when I know I only have so much time to exit. This causes me to have more stress and sometimes cut people off because I don't want to have to be stuck in the managed lanes and then miss my exit
Online English	Disagree	One HOV lane is enough and allows for safer exit and entry.
Online English	Disagree	Depending on where the access points are, may limit use by local residents.
Online English	Disagree	I've been trapped by this in California before. Driver's who may have inadvertently entered the HOV lanes, have no way to immediately correct their mistake. This puts them at risk of being ticketed, or of missing an exit (depending on design).
Online English	Disagree	I would need to see some sort of research that supports this format being safer; I highly doubt that it is.
Online English	Disagree	I have driven these types of lanes in Los Angeles County and either the drivers don't respect the lane laws or make a mad dash to get across to the exit

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Disagree	This has already been used in salt lake city, and currently commuters break the solid white line at will. Commuters will not only be confused and irritated at missing exits and entrances, but violaters will still cross at will. This will only increase road rage and congestion.
Online English	Disagree	This has been tried in other states with disastrous results and popular opinion
Online English	Disagree	driving in areas where this is an practice (CA) does not seem to limit lane changes; only when HOV traffic is specifically forced to stay in HOV, such as with cement barriers partitioning them from other traffic (East Coast 1-95 Hot Lanes), does this seem to work
Online English	Disagree	I disagree on adding a second HOV lane. If you control access the only benefit that will be provided is to keep drivers doing 30-40 mph less than the HOV lane drivers from entering the HOV lane and causing HOV drivers to slam on their brakes.
Online English	Disagree	put the hov lanes on the far right and make it an exit only lane for those that would otherwise not be allowed. This would encourage more HOV usage because then you wont have to fight so hard to get to and into the HOV lane and not have to fight to get out of it to exit.
Online English	Disagree	When there is an accident in those lanes due to people not following the laws and driving slowly causing congestio then it will back up the main line as well.
Online English	Disagree	Covert HOV lanes to Paid Toll Lanes----I drive I-10 daily from Litchfield Park to Tempe. Hov Lane is not busy and many people use the lane with only 1 passenger
Online English	Disagree	Change is good, but this is confusing. Must install raised markings - like at US60 WBND to I-10 WBND.
Online English	Disagree	We already have enough California strategies, this just causes people to whip in and out and take their chances...they see their exit and they sneak in...causing the people behind to slam on their brakes.
Online English	Disagree	This would mean that there would be backups around those access points.
Online English	Disagree	I've seen this in California and it makes it more difficult for carpoolers to use the HOV because the entrance and exit points aren't necessarily coordinating with where you need to enter / exit the freeway.
Online English	Disagree	Seems like it would take too much space. I would rather see an extra lane go in than have that barrier space to seperate the HOV from regular lanes.
Online English	Disagree	This does not work in California... Those lanes are essentially empty, and the regular lanes are congested. What would work is having designated minimum speeds for the individual regular lanes (PAINTED ON THE LANES). Min. 65 in far right lane. Min. 70 in center lane. Min. 75 in far right lane. The problem of backup begins when there is a "slow" moving vehicle in the left lane(s). Furthermore, vehicles that are not freeway worthy, and drivers whom are not skilled enough to nor follow proper freeway etiquette are causing the congestion.
Online English	Disagree	This concept is not rooted in common sense. Why would you ever limit access to an hov lane, should you decide to keep them? There would be significant bottle necks where drivers attempted to exit the hov lane.
Online English	Disagree	Limited access managed lanes are only known to be useful where there are a high correlation of origin and destination locations in specific places. This is not supported by provided information and past data from MAG and regional studies.
Online English	Disagree	Big government trying to regulate and where you can and can't do anything. There is no reason to restrict entrance to HOV lanes, as is done in many states, which cause many problems at those entrance and exit points and ignored by those doing the surveys. Travel them sometimes, at peak traffic times, and you'll get my point.
Online English	Disagree	In California for tourists, it makes for more danger because they are not necessarily familiar with the area. this would be horrible because of the amount of tourism we see during winter and spring months.
Online English	Disagree	makes it hard to cut across lots of lanes of traffic in a short amount of time to reach desired exit, especially for those not familiar with where the HOV lane access point is
Online English	Disagree	Safe but inefficient use of roadway. Vehicles will also likely cut across pavement markings.
Online English	Disagree	Take a look at California --- they have limited access and it doesn't help traffic congestion. In my open it helps create congestion.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Disagree	I only suggest this in the areas where traffic is known to slow due to merging issues. One example would be the small polls recently installed on the 60 west/10 south hov off ramp. People were known to skip the line and merge last minute often causing accidents. That is where I would suggest this measure. The other one would be were the 10 west split off to the 17 right before 24th st
Online English	Disagree	Limited ingress and egress seems to cause more problems, especially during stop and go traffic.
Mailed	Strongly disagree	I hate driving in California for this Very reason. Causes problems when you are forced to slow to a stop just to exit when allowed - especially if traffic to the right will not yield to let someone exit. No. No. No. Please.
Meeting	Strongly disagree	I don't see the need to the extra HOV lane.
Meeting	Strongly disagree	I understand why, but I feel this will cause more issues than it will solve.
Meeting	Strongly disagree	I am against two lanes. One HOV lane is working fine now. No need to spend the money
Meeting	Strongly disagree	Some of our entrance ramps are currently 2 lane and merge into 1. I think the extra space should be used in additional lanes on Hwy.
Meeting	Strongly disagree	Too many wrong way crashes this will only increase the # of wrong way crashes
Online English	Strongly disagree	I think the idea is kind of cool but I'm sorry people are stupid and selfish and I only see this as creating designated points of congestion or accidents along the freeways. Forcing the entry and exit and ultimately the mixing of two free flowing bodies of traffic just seems like you're asking for more accidents.
Online English	Strongly disagree	I like being able to enter and exit at will. Creating the limited access managed lanes will create confusion and trap cars in these lanes until they reach the next marked exit/enter section. Drivers will ignore this anyway, as they do on surface streets where solid white lines exist.
Online English	Strongly disagree	I like having control of my safety, the government has more than they can handle now ?
Online English	Strongly disagree	I think this would just add more confusion to the use of the HOV lanes.
Online English	Strongly disagree	During off hours you lose the ability to use the lane as a passing lane.
Online English	Strongly disagree	Limited access HOV provides opportunity for more reckless driving...SAFETY FIRST!
Online English	Strongly disagree	Drivers will be totally confused. Do the people who start these ideas ever drive the freeway? Drivers need to be educated about excessive speed, we need more police on the freeway, and texting while driving should be outlawed.
Online English	Strongly disagree	HOV lanes are great but I don't think limiting access would be equitable because it would not optimize their usage. Managed lanes give the connotation that they could someday become toll lanes.
Online English	Strongly disagree	It would be better to extend the light rail and encourage responsible commuting than enable people to drive to the central corridor
Online English	Strongly disagree	Was there any visual observations that went along with the study? An additional HOV lane?????? As a person whose life is being destroyed by the Phoenix freeway system (1.5 to 2 drives each direction) I see many people who not belong in the HOV lane driving along with no worries... these people would include off duty policeman, ADOT employees in company trucks, young women, prius drivers, none of them do not have the "Cloud" license plate. Do they have some kind of immunity???? The HOV lane is hardly used and is the only option to get anywhere at times. The state of Texas does no utilize HOV lanes. Those lanes are a joke.... Think outside the box and don't waste taxpayer money. This is a really silly solution to the traffic problems.
Online English	Strongly disagree	there are no issues on I-17 enter exit at will!
Online English	Strongly disagree	Nonsense. pure nonsense.
Online English	Strongly disagree	Don't need 2 hot lanes.
Online English	Strongly disagree	For safety? Seriously? How safe would it be to have all traffic wanting to exit at designated points, and was unable to because of one reason or another? I can only imagine the nightmare this would generate. I -17 would be incapable at this point ... to even add another lane for HOV traffic. Having a huge portion of I-17 below grade ... would be a nightmare to improve without double decking. Which seems to be the only realistic idea.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Strongly disagree	This can cause more backup in the HOV lane if both lanes are occupied by slower drivers and backup the main traffic lanes from people missing the entrance or hesitating and jumping off of the on ramp creating unsafe conditions.
Online English	Strongly disagree	As last comment, it will not solve any problem and will create more confusion.
Online English	Strongly disagree	Californa does this and cars move in and out at will. Why cause an expence like this for very little return.
Online English	Strongly disagree	Nope, waste of time and money, one single lane of HOV and current, cross the line when ever you want. This appears to be hazardous to me as it will force late decisions to cross many lanes to hit the entrance, since the entrances are not constant as it is today. Our elderly drivers will struggle with this change. Wasteful idea, lots of work for no tangible value.
Online English	Strongly disagree	At will is different from other states and causes confusion for that reason. Further, at will allows for weaving in and out of traffic and many times the HOV is moving at considerably higher rates of speed than regular lanes.
Online English	Strongly disagree	Confusing, especially to visitors which Phoenix has a lot of. Instead eliminate "specialty" lanes and let all be open to everyone.
Online English	Strongly disagree	I don't really see why we need this! Keep the HOV lanes as they are. Just one lane. Save some money. The regular lanes are congested and will just become more congested with this strategy. No.
Online English	Strongly disagree	better off to expand light rail or have freeway busses
Online English	Strongly disagree	This takes up as much room as a couple of additional lanes that anyone could use - which would immediately reduce congestion.
Online English	Strongly disagree	I've used these in other states and they are terrible.
Online English	Strongly disagree	Such restrictions will make HOV lanes harder to use, reduce flexibility, use valuable lane real estate that could be used for unrestricted lanes, and have the unintended consequence of making drivers less safe by incentivizing them to make hasty lane changes to enter the lanes. This is a terrible idea.
Online English	Strongly disagree	I think this will make it more difficult - it's a quasi-express lane and HOV lane - to maneuver. Confusing for drivers and quite likely to cause more non-compliance as well as accidents.
Online English	Strongly disagree	Wasted space. An additional lane would be better.
Online English	Strongly disagree	Limited access to/from HOV lanes is a poor idea. In California, residents only see it as over-regulation of the roadway and a way for DPS/the State to give people more traffic violations and money-grab. Additionally, many people will not follow the rules and will enter and exit as they need at any location. This might actually decrease safety as drivers in the left-most GP lane won't expect anyone changing lanes from the HOV lane at non-designated locations. It will also need more DPS patrol to enforce the HOV limited access rules, which will cost more money. And if DPS's man-power isn't increased and they can't keep up to enforce the rules, drivers will be discouraged and tend to violate more. Finally, Phoenix's grid lends to all mile-arterials to be heavily used, choosing which crossroads have HOV access seems too random. Limiting access to/from the HOV lanes will likely have a detrimental impact by forcing people that just entered the freeway that want to enter the HOV lane to stay in the GP lanes longer than they normally would which can increase congestion in the GP lanes. Plus, the locations where a driver can exit the HOV lane will likely be a magnet for crashes (extra weaving vehicles) and the crossroad off-ramp/exit at an HOV access location will be even more congested since more drivers than normal will be forced to use those off-ramps. Overall, I don't think this is a more safe option.
Online English	Strongly disagree	Again, we need normal lanes not more HOV lanes. Restricting where people can get in and out of lanes will only further confuse the drivers and create anxiety rather calm.
Online English	Strongly disagree	im going to be blunt: Phoenix drivers are far too stupid to manage this kind of thing safely, and unless there is a physical barrier, nobody will pay attention to the rules. and as evidenced by the breakway separators on the WB 60 HOV ramp going into I-10, even a physical barrier will not be enough to stop some of these people.
Online English	Strongly disagree	This would create less entry/exit points on the HOV lanes therefore fewer commuters would use. This would then impact the regular lanes
Online English	Strongly disagree	This is a horrible idea. Have driven in California and people do not follow this. It also makes it more difficult for out of town drivers to navigate our highways.
Online English	Strongly disagree	This approach does not work in other major cities

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	Currently, drivers can enter and exit the HOV lane at will. Having two managed lanes in each direction would result in limiting entrance and exit to those lanes at specific, designated points for safety. What are your thoughts on this strategy?	Designated Entry Points – Comments
Online English	Strongly disagree	I have experienced this in California. I find entering a fast moving HOV lane with limited access options difficult when merging from slow congested lanes. It disrupts the flow of the HOV lane when lane changes are focused in a short space.
Online English	Strongly disagree	Again, adding more under utilized HOV lanes makes no sense. If the HOV lanes were jammed, then they would make sense but they are not. I take my child to daycare down the 51 freeway every day and we can drive as fast as we want BECAUSE NO ONE IS USING THE HOV LANE BUT US. Adding more HOV lanes makes no sense. Have you done any traffic simulations on this? Add 20% more traffic to the normal existing freeway lanes and a corresponding 20% addition to the HOV lanes and what do you have? JAMMED NORMAL LANES AND EMPTY HOV LANES. I am 100% opposed to this. This is not the answer.

Note: Comments are presented as submitted and are not edited or corrected for grammar.

Feedback on Property Acquisition

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations would likely require acquisition (purchasing) of some right of way (properties) along the corridor. Do you support taking some properties along the corridor in order to improve traffic operations and safety? What are your thoughts on this strategy?	Property Acquisition – Comments
Online Spanish	Strongly agree	I support the measure because I consider that the common good is above the good of individuals who, in the future, will also be able to benefit from these improvements.
Mailed	Strongly agree	All the improvements are needed and would require purchasing properties which is understandable by most people and accetable.
Meeting	Strongly agree	Many old and poor condition buildings that need to go away.
Meeting	Strongly agree	You also need to consider potential noise and health impacts to residents near the expanded freeway.
Meeting	Strongly agree	Please contact us [redacted]; see comments àPlease consider rubberizing
Meeting	Strongly agree	Unfortunate, but needed.
Mailed	Strongly agree	Especially if you expand to the West.
Delivered by Neighborhood	Strongly agree	I live along this corridor in a 99 unit cooperative. Despite being a senior citizen & "comfortable" where I live, I think it necessary to be for corridor expansion despite possible personal displacement in the process. I have talked to other persons in similar situations, so long as fair reimbursement is possible I support expansion
Meeting	Strongly agree	Especially along I-17 between Thomas Rd. and Bell Rd. very high crime area.
Meeting	Strongly agree	Yes we need more roadway
Online English	Strongly agree	Especially any property west of I-17 up to 27th Avenue. On the east side of I-17 nothing past 24th Avenue.
Online English	Strongly agree	As I see the plan, this should be the last major reconstruction of our freeway system. We should do it right to provide adequate space for the construction. As noted by Bob Hazlett, we do not know the future need for transportation corridores nor do we know the effect of technology to more efficiently transport people. At this point, we need to factor in all transportation modes as they interact with our modern update of the freeway system. This will prevent the need to do major reconstruction in the future.
Online English	Strongly agree	I also believe you should take RESIDENTIAL properties within 50 yards of major intersections such as the crossroads of Bethany Home and I-17. The increased traffic, noise, pollution, drainage issues will greatly impact these homes both during and after construction. After the completion of construction have these properties re-zoned commercial and sell them to developers for local businesses. This would: (1) mitigate any residential issues during construction (a) Noise (b) Construction traffic (c) Structural damage to nearby homes that (remember the structural damage that resulted during the rebuilding of the bridges over I-17 at major intersections.) Foundation cracks in older construction. (2) After construction (a) Neighborhood cut through traffic (b) Impact on the residents from the noise levels due to traffic (c) Environmental impact on health of those closest to the intersections with increased vehicles idling (d) Mitigate the impact of draining issues. Remember water flows downstream and as you build these roadways higher, the water from these intersections flows into neighborhoods. (3) Increase economic development by allowing for new business opportunities in the neighborhoods. (4) Will show your concern for the residents that are impacted the greatest due to the proximity of the major intersections which are growing larger to accommodate the increased traffic flow. (a) Remember, areas this close to the intersections and which are beyond the freeway exit ramps do not have the advantage of the sound walls for noise mitigation. (b) Based on the "new design" these properties are also at greatest risk for a major accident impacting their residential property due to their proximity.
Online English	Strongly agree	The freeway needs to removed the lanes that appear and then disappear. The poor ability of people to merge results in traffic slowing when it does not need to
Online English	Strongly agree	There are many run-down and crime-infested old apartment buildings along I-17. Seeing these gone would be a welcome improvement to nearby home ownerships. Businesses can relocate - lots of open retail spaces around the phoenix corridor.
Online English	Strongly agree	This needs to be done. Most properties in question are dilapidated and an eye sore.
Online English	Strongly agree	If this can be done expeditiously than do it. If it takes too long the need will likely no longer be there.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations would likely require acquisition (purchasing) of some right of way (properties) along the corridor. Do you support taking some properties along the corridor in order to improve traffic operations and safety? What are your thoughts on this strategy?	Property Acquisition – Comments
Online English	Strongly agree	If the added land is needed to properly construct a safe and usable highway, YES.
Online English	Strongly agree	For the safety of everyone, it is a must that safety be maintained for all
Online English	Strongly agree	Definitely, if it is to improve traffic and SAFETY, then yes. Those properties along the corridor wouldn't be in a safe area if they stayed. The cost of someone's life is never comparable to how much income a property makes
Online English	Strongly agree	Absolutely. A good transportation system is in the public's interest.
Online English	Strongly agree	Would support taking property if owners are fairly compensated and road expansion would result in better traffic flow.
Online English	Strongly agree	Please add sound walls between Ray and Warner on the West side.
Online English	Strongly agree	Yes why has this not happen before. Many buildings/homes right along I-17 are vacant, in disrepair, or left to rot. Further more, why is 2 dimensions only ever considered in out state? Major Earth events are unlikely to happen here. A second level for rail(monorails, skytran or lightrail) and vehicles passing through town should be able to be built over portions of the existing roadways. On Top of that, Solar power infrastructure should be created or leased to companies to build over to generate income of our state and powers those around us.
Online English	Strongly agree	The I-17 corridor is especially deficient in width and would benefit greatly by widening the corridor.
Online English	Strongly agree	Do what is necessary to increase the width of the corridor. Make it fair to all law abiding citizens who do NOT drive in the HOV lane. DO NOT add an additional lane.... drive around and make some visual observations...
Online English	Strongly agree	My Name Is [redacted] I live in the subdivision of Siesta Terrace, and I LOVE my neighborhood. I would not be opposed to the expansion of the I-17 corridor in your current plans WITH ONE EXCEPTION. I WOULD, and I AM COMPLETELY AGAINST ANY pedestrian bridge of ANY typed whatsoever at the Osborn & I-17 intersection and so are almost all, if Not All of my neighbors. Our neighborhood is experiencing a Surge in crime already, and that Foot/Bicycle Bridge would do Nothing but encourage More! The Foot/Bicycle cross overs at the Main Intersections of Thomas Road and Indian School Road are PLENTY as they exist now, OR if you care to improve those, but NOT at Osborn, & I-17. We in Siesta Terrace, AND Westwood Village/Estates are Extremely Opposed to this idea, and are happy to discuss it with anyone at your office. Respectfully, [redacted]
Online English	Strongly agree	Yes. Yes. Yes. I have studied the I-17 for years now and the only way to maximize the traffic flow is to incorporate existing frontage roads into the the interstate itself. If you pay attention to traffic flow, you will see that commuters already utilize frontage roads to circumvent traffic congestion during rush hour. Why would you not want to utilize that valuable space into the freeway already? Better yet, follow the traffic conditions set upon in Houston, whereas the frontage roads are not tolled, and the freeway is completely paid for by toll. If you want to make the frontage roads a multi-divided highway and have commuters use the I-17 interstate corridor if they pay a toll, then you might be able to afford to build the kind of interstates already in existence in Houston. Then you could build a free standing freeway from the stack to the 101 and have existing frontage roads act as one way freeways on each side.
Online English	Strongly agree	This is an unfortunate evil when it comes to increasing and rebuilding the infrastructure.
Online English	Strongly agree	With proper compensation for the properties I am for this.
Online English	Strongly agree	Agree if purchase offered at fair market value with reasonable time for property owner to relocate.
Online English	Strongly agree	Though not for the purpose of creating additional managed lanes, I agree expansion of the corridor is necessary and acquisition of additional property would be necessary to effectuate that expansion.
Online English	Strongly agree	Yes. Absolutely. Most properties immediately adjacent to the existing highways need to be bulldozed anyway, and doing so would be doing a favor to the community. Take what you need and fix the d**mn roads!
Online English	Strongly agree	A no brainer

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Online English	Strongly agree	Great idea, however many miles of traffic in metro phoenix are land locked with concrete, e.g. Interstate 17 and Interstate 10 thru downtown phoenix. Why not create double decker highways?
Online English	Strongly agree	Absolutely. Unfortunately, purchasing private/commercial properties is just going to happen. As Phoenix continues to grow, the roads will need to grow to accommodate the increase in traffic. I think people should be compensated for this unexpected upheaval, but, ultimately, it's for the good of the general public.
Online English	Strongly agree	do it now, before it's too expensive, plan for the future now
Online English	Strongly agree	Yes, it is necessary to improve traffic flow though dense areas like midtown Phoenix where I-17 needs to be widened desperately. The current width is impossible to work around unless neighbors want portions of the freeway elevated to accommodate expansion?
Online English	Strongly agree	sacrifice of a few for the betterment of the masses; price we pay for living in community. any "reasonable" person understands that at times a price must be paid. kewl.....
Online English	Strongly agree	Absolutely. Most of the properties along the corridor need to be torn down anyway.
Online English	Strongly agree	in the areas where you would be widening, would be along I-17 where improving the freeways would be improving the neighborhoods.
Online English	Strongly agree	Traffic control is the life blood of a major city.
Online English	Strongly agree	We need more lanes on the spine and that requires more real estate. Our protections and processes for acquisition have been consistently fair and reasonable to property owners. I support this idea.
Online English	Strongly agree	This is inevitable. As long as the private property owners are compensated at a fair market value - as determined by (2) independent certified appraisers - I don't have a problem with it. Shame that city and traffic planners didn't provide for the necessary ROW in the very beginning.
Online English	Strongly agree	Yes. I know it is a little unpopular for the "government" to acquire these properties, but it's what has got to happen!
Online English	Strongly agree	Definitely need more room for trffic safety. Also, any freeway improvements need to take into account future driverless vehicles.
Online English	Strongly agree	Get out the way!
Online English	Strongly agree	if you buy a house next to a freeway you should be prepared to accept that traffic needs may necessitate destruction of the home. i think a lot of people buy these houses trying to save a buck then drag their heels claiming "they didnt know" and various other excuses.
Online English	Strongly agree	I hate property takings, but freeways, and particularly incremental freeway expansions like this are the best example of when it should be done. I wouldn't say the same if this were for a private company to make a toll road, but this public freeway is the best reason for takings.
Online English	Strongly agree	ANYTHING that improves the lousy traffic flow should be done.
Online English	Strongly agree	Sometimes it is necessary for progress. I doubt the people planning the I-17/I-10 corridor ever thought the valley would grow like it has over the years. What's the other option, a double decked freeway.
Online English	Strongly agree	As much as I hate eminent domain, the ROW needs are higher for this corridor and we may need to stimulate more investment any.
Online English	Strongly agree	Landowner needs to be compensated for loss of land use and if needed including re-location costs, structure acquistion.
Online English	Strongly agree	take three times what you think you need now and pave it all. you want to grow the economy, improve the flow of traffic beyond any goals you have today.
Online English	Strongly agree	Yes we should be taking right of way in order to build transportation systems that are beneficial to the community as whole. There should be more high capacity public transit in the nation's sixth largest city.
Online English	Strongly agree	Our highway system is way to bogged down currently and we need to make sure we plan for further growth.
Meeting	Agree	Take properties where project limits access to the properties; provide access program for properties retained.
Meeting	Agree	Give people a proper payment for their home.

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Mailed	Agree	This property is one corporation - You can't take one without affecting all of the units. The membership carrying charges would be shared over fewer people and likely will cost more than the elderly membership can afford. All units are owner occupied. We are across the freeway from Grand Canyon University & fear we will be overshadowed by a BIG company. The land there is not occupied by residents. We strongly hope the little guy gets a
Delivered by Neighborhood	Agree	only if the acquisitions are done fairly and at the cheepest cost possible - you own properity north of Camelback on the west side of freeway now - use that and leave us alone.
Meeting	Agree	Acquisition cost will be astronomical.
Meeting	Agree	R/W acquisitions should be balanced with needs for improvements (i.e. linking critical improvement components to vital r/w acquisitions.)
Mailed	Agree	Please take industrial properties over residential.
Meeting	Agree	I seen where property is being bought as long as it does not affect the Town of Guadalupe City limity as well as Awatukee. For a lot of people & businesses will be affected.
Online English	Agree	If this happens, I hope the property owners will receive a fair and just compensation as a result of the acquisition. I don't mind paying a little extra sales tax to support this. After all, if it was you or me losing our property in the name of progress, wouldn't we want to be compensated fairly?
Online English	Agree	At a fair price to the property owner and will relocation assistance.
Online English	Agree	It would be beneficial to sacrifice a general purpose lane for a managed lane in order to maintain travel time reliability for the managed lanes. Currently HOV lanes on I-10 do not function during peak periods, and at times perform worse than general purpose lanes.
Online English	Agree	I agree if people are reimbursed fairly.
Online English	Agree	It must be on a very limited basis and as small as possible.
Online English	Agree	This is a very tentative agreement towards takings. I understand the occasional need, but believe it should be done as rarely as possible.
Online English	Agree	Managed, maintained roads are better than bigger roads
Online English	Agree	As long as it is only the area next to the freeway (access road) and only the building on that access road. Our neighborhood is in the process of going historic and our boundaries from east to west are 19th Ave to 24th Ave south of Osborn and 23rd Ave north of Osborn, from Thomas Road north to Fairmount.
Online English	Agree	Yes some of the areas are pretty run down and need to be revamped anyway
Online English	Agree	Provided that the taking of properties does not affect older home areas which are attempting to be designated historic. I do have a worry that this will reduce my home value.
Online English	Agree	Get rid of some of the shit hole apartment and neighborhoods that are lost causes and put the freeway up.
Online English	Agree	As long as the home owners are compensated enough to purchase a bigger/better home. If commercial business, they need to be compensated as well.
Online English	Agree	I agree, but only if the situation is handled with respect and fairness to any businesses that are effected.
Online English	Agree	We need more lanes for traffic. I support property acquisition for this effort.
Online English	Agree	As long as those property owners are sufficiently and fairly compensated.
Online English	Agree	most likely necessary - but taking homes is a problem. How do you plan to minimize the increased devisivness of the monster road?
Online English	Agree	As long as it doesn't disproportionately affect low income areas, and that those residents are given fair compensation so as not to create a situation in which being forced to move puts them deeper into poverty or results in some homeless situations.
Online English	Agree	I like expanding what we have versus making new routes.
Online English	Agree	The freeways comprising the spine have been in place for decades. Adjacent landowners should not be surprised by use of eminent domain

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Online English	Agree	If they get it for a good price.
Online English	Agree	Yes, for fair pricing and rates.
Online English	Agree	Agree if and only if land acquisition is made to support transit, not private vehicle movements
Online English	Agree	Property owners should be compensated with a fair price for land taken.
Meeting	Neutral/Don't know	There should be NO widening, NO expansion, ONLY reallocation. Only for existing HOV lanes, or newly designated HOV lanes on and off ramps seem worthy of this.
Delivered by Neighborhood	Neutral/Don't know	No drastic loss of housing.
Delivered by Neighborhood	Neutral/Don't know	I do know it will take my home, eventually.
Meeting	Neutral/Don't know	Not in Guadalupe.
Mailed	Neutral/Don't know	Would like to see acquisitions to be on industrial side rather than homes that are about to go historic. i.e. West side of I-17 North of Thomas
Meeting	Neutral/Don't know	As long as businesses/neighborhoods that remain are "protected" from noise/traffic.
Online English	Neutral/Don't know	use existing access roads
Online English	Neutral/Don't know	Again concerns on what property is being taken and who benefits from that acquisition. Will the property owners be compensated
Online English	Neutral/Don't know	I don't know from your information how many businesses or residences this would effect.
Online English	Neutral/Don't know	I only agree with this if the people in these areas knew it might someday happen like with the 202 in the east valley. And if the people displaced are given the amount of money required to purchase the equivalent home or property they are already in. Not a present day value on their home or property. Forcing someone to downgrade their living situation even if it's for the sake of the "greater good" is wrong.
Online English	Neutral/Don't know	I would prefer that these didn't cut into the bikability and walkability of the area.
Online English	Neutral/Don't know	If property owners are properly compensated for the their inconvenience, then I could accept some stealing of property. Proper compensation in my opinion includes all of the disruption as well as non-monetary considerations such as transactions costs. The proper compensation should also consider the benefits to society as a monetary value. Roughly 8 times the current value seems fair. Anything less is abhorrent.
Online English	Neutral/Don't know	Not sure...Would this affect homes / apartment buildings along 17?
Online English	Neutral/Don't know	I'm currently a resident of 23rd ave and Thomas, if this would mean expanding west where there are less residential structures then I would support this project.
Online English	Neutral/Don't know	I would like more details in the acquisition process.
Online English	Neutral/Don't know	don't want to take anybody out of there homes or businesses unwillingly
Online English	Neutral/Don't know	In order for the plan to work ... something would have to give. Decking the freeway ... would be the only way to improve traffic flow, and minimize property owners being uprooted.
Online English	Neutral/Don't know	It depends on the properties acquired and what the land is used for. Freeway widening is almost never effective due to the treadmill effect of induced demand. If the land is used for another purpose, it might be worthwhile.
Online English	Neutral/Don't know	It depends...I think there are better ways to decrease this traffic, such as have the government offices switch office hours. Days that government entities have the day off, such as President's day I can get to work in half the time, so if Government offices changed from 8 - 5 to 9:30 to 6:30 it would take a huge amount of congestion off the streets.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations would likely require acquisition (purchasing) of some right of way (properties) along the corridor. Do you support taking some properties along the corridor in order to improve traffic operations and safety? What are your thoughts on this strategy?	Property Acquisition – Comments
Online English	Neutral/Don't know	Not if eminent domain is required... If land owners are willing to sell, then yes.
Online English	Neutral/Don't know	This is a difficult one. I think what gets me is the word, "taking". Ouch! Just imagine the many businesses and apartments along the Black Canyon Freeway that would need to be relocated. How many of those would go willingly? Where would they be sent to? But I understand the space is required. Can't we build UP? Maybe add a top level to the freeway (we don't have strong earthquakes here). Have the top going one way and the lower level go the opposite direction.
Online English	Neutral/Don't know	Great emphasis should be placed on working with residents to ensure they are cared for and relocated, not simply displaced with financial compensation.
Online English	Neutral/Don't know	This happened along the light rail corridor - too soon to see what the impact is
Delivered by Neighborhood	Disagree	sounds expensive
Mailed	Disagree	No families should be fooled to sell their homes. If the city/developer wants these homes, they must offer MORE than fair market value, guarantee loans for purchase of a new home regardless of credit and must pay for all relocation services!
Online English	Disagree	Disagree if it means taking homes and disturbing neighborhoods.
Online English	Disagree	I don't agree with forcing families from their homes for the purpose of increasing freeway width. The only way I see this being positive is if the families all agree to sell and are paid more than fair market value for their properties as their properties are not being considered for their market value but as necessary space for widening the freeway. Additionally, efforts should be made to aid displaced families with guaranteed loan backing for relocation if forced to move.
Online English	Disagree	disagree under the assumption that purchased properties will be turned into additional lanes. if used to install bus lanes/light rail, ect ect...this would be okay with me.
Online English	Disagree	As long as those properties in the corridors are compensated appropriately do I approve.
Online English	Disagree	Only if you are building light rail
Online English	Disagree	I believe spending money on improving traffic operations is fruitless, since we are transitioning to a driverless economy where the software guiding vehicles will auto-correct and the 'human error' element will be completely removed.
Online English	Disagree	"Taking" is an ugly word. No one should be required to sell their property.
Online English	Disagree	I dont live near the highways, but as a property owner, I would be irate to lose my home, property at a discounted rate .
Online English	Disagree	Just depends....I disagree if it is to increase the HOV lanes. Add more regular lanes!
Meeting	Strongly disagree	Noway! Not Homes, business' at Baseline - fine. But ABOSOLUTELY NO Homes
Meeting	Strongly disagree	It would take away from businesses.
Meeting	Strongly disagree	Properties should not be considered for acquisition, what so ever.
Mailed	Strongly disagree	I disagree with residential houses being used. I wouldn't mind seeing industrial and hotels go. No Houses!
Meeting	Strongly disagree	I don't believe we should hurt our local businesses; especially businesses who have been operating for 90 years.
Delivered by Neighborhood	Strongly disagree	disrupting people's homes for a minimal use HOV lane is not supported
Delivered by Neighborhood	Strongly disagree	too costly & interferes with numerous people's homes for minimal use
Meeting	Strongly disagree	You would be affecting buisnesses that are supose to pay for it

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations would likely require acquisition (purchasing) of some right of way (properties) along the corridor. Do you support taking some properties along the corridor in order to improve traffic operations and safety? What are your thoughts on this strategy?	Property Acquisition – Comments
Meeting	Strongly disagree	I do not agree with pulling property away from businesses who are contributing to our economy. This will hurt business, which will in turn hurt our local community & economy.
Meeting	Strongly disagree	Big waste of money!
Meeting	Strongly disagree	I don't believe the proposed plans would impact the flow of traffic enough to warrant the acquisition of any properties that would impact local business!
Delivered by Neighborhood	Strongly disagree	This expansion would take my home.
Online English	Strongly disagree	I think the improvements should be made within the pre-existing confines. Seems to be plenty of right-of-way to work with. Acquiring improved properties will have negative impacts on the cities and neighborhoods along those routes - it will create orphan properties and parcels and create areas that will be difficult or impossible to rebuild or prosper. The highway path will be way too wide. it is not good urban planning.
Online English	Strongly disagree	I'd like to know what alternatives were considered before considering this.
Online English	Strongly disagree	I do not support the taking of private property
Online English	Strongly disagree	No!! Please don't destroy our neighborhood and surrounding businesses to make a bigger freeway. I'd rather have it be a bit more congested than take away from our gorgeous neighborhood
Online English	Strongly disagree	I do not support this at all. Although the word "purchase" is used, historically this means forced out at a below market price.
Online English	Strongly disagree	These areas become crime ridden
Online English	Strongly disagree	Those property owners never get market value of their properties
Online English	Strongly disagree	No. I don't support taking of private land for unnecessary improvements which won't help solve the problem anyway.
Online English	Strongly disagree	Do not need to do it.
Online English	Strongly disagree	Build up, not out. Stack the freeway. Consider local traffic use and through traffic. Mark the pavement, not erected eye-level signs. Too many signs. Minimizing footprint and encouraging use of transit, light rail, buses, carpooling. Giving more lanes to people increases independence, less carpooling, more pollution.
Online English	Strongly disagree	Maybe if other means suggested do not work. Phoenix taxes are absurdly high already. Residents do not want this additional burden.
Online English	Strongly disagree	Interstates have already had a massively negative impact on neighborhoods and communities. The efforts to expand these pieces of infrastructure disproportionately impact low income and ethnic communities. Any effort to further expand these expansive and invasive pieces of infrastructure will undoubtedly further this damage. Again, mass transit initiatives work to alleviate this problem. Why not look into a city-wide express mass transit system, such as Bus Rapid Transit or Express bus service similar to what is ran in Seattle instead of only catering to suburban residents that work 9-5 jobs in the downtown phoenix areas? Building more is not equivalent to building smart.
Online English	Strongly disagree	just get rid of frontage roads
Online English	Strongly disagree	Big government encroaching upon surrounding neighborhoods bringing crime and devastated neighborhoods. Look at I17 from Thomas Rd North....use to nice neighborhoods. only to fall to crime and the crap brought on by big city decisions on local communities to solve the problems they over exaggerate. Get someone to do the studies that understands neighborhoods and the traffic flows of these neighborhoods and the impact on the affected neighborhoods.
Online English	Strongly disagree	If the acquisition is to create additional lanes for HOV, rather than for all to use, I do not support this.

Comment Form – Online or Hard Copy (meeting, mailed, etc.)	The Corridor Master Plan Recommendations would likely require acquisition (purchasing) of some right of way (properties) along the corridor. Do you support taking some properties along the corridor in order to improve traffic operations and safety? What are your thoughts on this strategy?	Property Acquisition – Comments
Online English	Strongly disagree	The reason I strongly disagree it is my experience that MAG does not take into consideration neighborhoods they impact when they begin to build roadways in this fashion. When Three and Five Avenue were proposed to be converted to one ways the neighborhood that action would directly impact was not included in massive public information meetings. If this is going to happen without involvement from the neighborhood Action Associations and membership (Not just leadership) these changes will impact I cannot support them. MAG has ignored downtown Neighborhood's for a long time. Prior to the completion of interstate 10 and the tunnel and the deck park and now decades after that engineering feat. The Moreland Corredor was destroyed, for the last leg of the I 10. Is MAG or the city of Phoenix or the state of Arizona proposing transportation destroy yet one more historic neighborhood in downtown Phoenix? Neighborhoods matter in these changes. Why doesn't MAG tell their survey takers what right-of-way they would like to take? Your survey covers a large stretch and right-of-way is a pretty broad statement. What specifically is MAG talking about and how can anyone answer the survey not knowing?
Online English	Strongly disagree	The way Arizona/Phoenix works, this will be a major waste of money. Remove frontage roads if necessary. This will likely end up being such an incredible waste of space. We should fit it in as much as we can in the space we have.
Online English	Strongly disagree	I do not believe in eminent domain. I feel like those areas will be pushed out further into neighborhoods that were not previously built with the highway in mind. Often times those are poorer areas with sleezy hotels and those will get demolished and pushed into the neighboring communities that try to keep their streets clean
Online English	Strongly disagree	We have to protect our historic neighborhoods and the environment.
Meeting		Expansion by force is wrong! Design the roadways as not to encroach on exsisting businesses.
Meeting		If it doesn't affect then ok

Note: Comments are presented as submitted and are not edited or corrected for grammar.

Appendix D. Cost Risk and Value Planning Workshops

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Appendix Contents

I-10, Near Term Improvements CRA Workshop Results, Design-Bid-Build Assumption, January 12–14, 2015

I-10, Near Term Improvements CRA Workshop Results, Design-Build Assumption, May 29, 2015

I-17, 19th Avenue to the I-10 Split CRA & Value Planning Workshop Results, January 25–26, 2016, February 8–10, 2016

I-17/Camelback TI CRA & Value Planning Workshop Results (in coordination with Valley Metro Phoenix West/Glendale Extension LRT), June 27–30, 2016

I-10/West Sky Harbor Access Value Planning Workshop Results, February 13–17, 2017

I-17/Central Avenue Bridge Replacement CRA Workshop Results (in coordination with Valley Metro South Central LRT), May 2, 2017

I-17/Mountain View CRA Workshop Results (in coordination with Valley Metro Northwest Extension LRT), May 3, 2017

I-17/Indian School TI, I-17/Northern TI, I-17/Glendale TI, I-17/Thunderbird TI, and I-17/Bell TI CRA Workshop Results, May 16 & 18, 2017

I-17 Drainage Improvements; ACDC Canal to Greenway Road CRA Workshop Results, May 17, 2017

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I-10, Near Term Improvements CRA Workshop Results

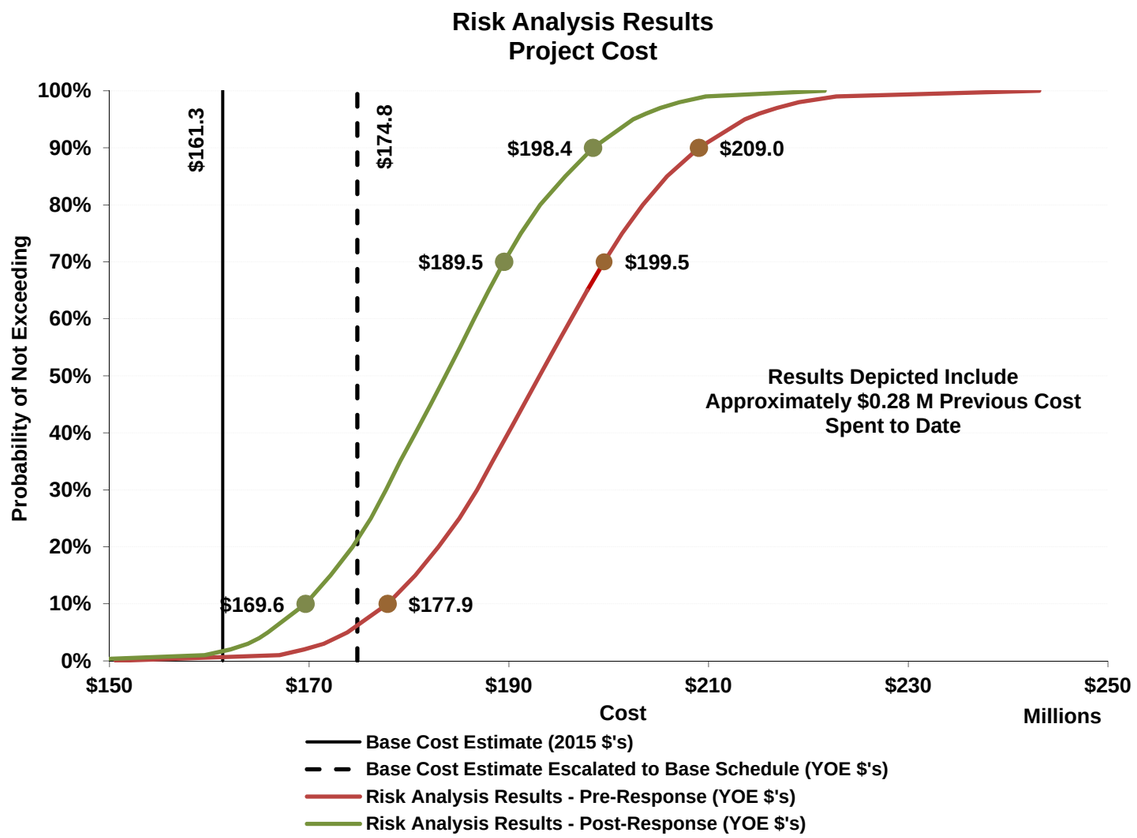
Design-Bid-Build Assumption

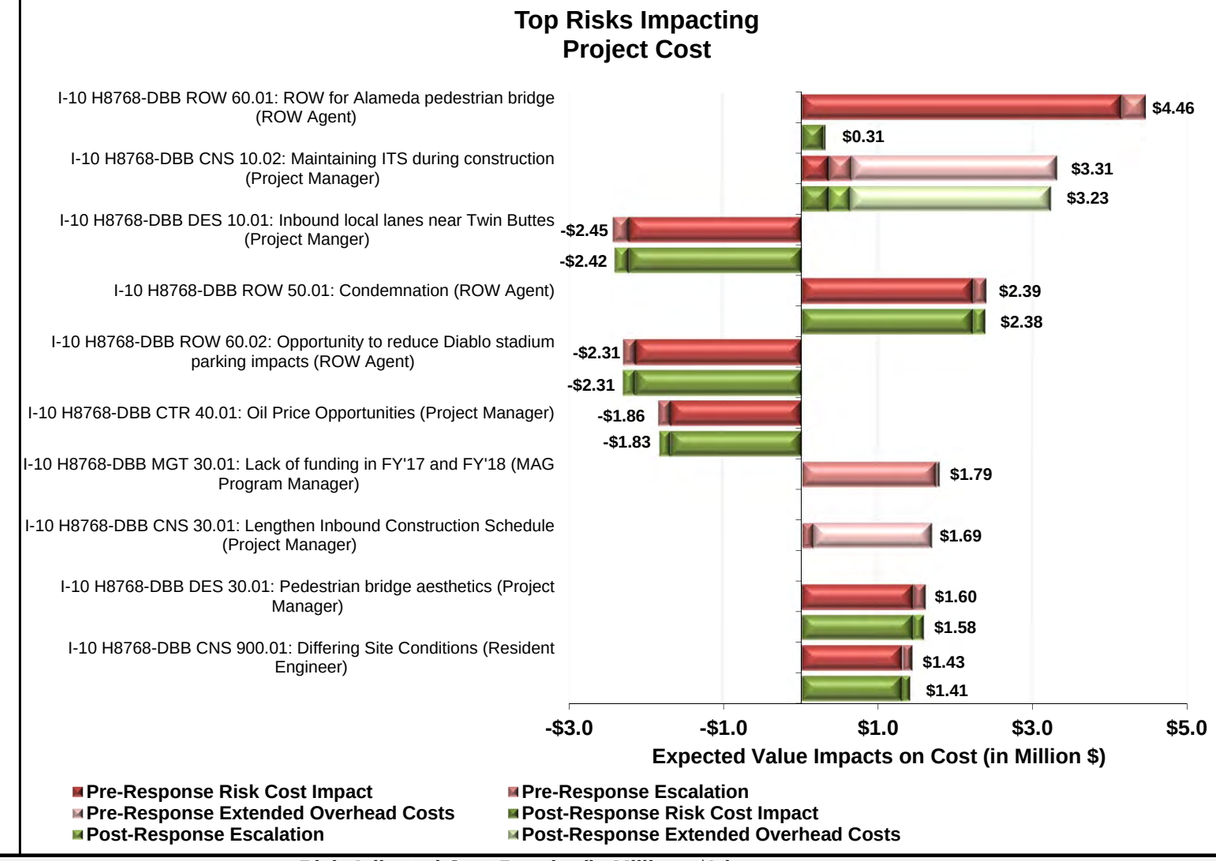
January 12-14, 2015

CRA Workshop Cost Summary Sheet	I-10, Maricopa (SR-143 – SR-202L, Santan) Near-Term Improvements Design-Bid-Build Scenario / TRACS# H8768-DBB Last Updated January 2015	Level of Project Design	Low Medium High	CRA Workshop Cost Summary Sheet

Project Description

A modified collector-distributor roadway system will be developed to eliminate the existing weaving conditions between SR-143, Broadway Road and US 60 that is causing significant congestion on I-10 during the morning and evening peak travel periods. All existing system and service interchange freeway access will be retained with the Recommended Alternative. South of Baseline Road, I-10 will be widened to provide additional freeway capacity within that segment of the project.





Cost Results

The S-curves reveal that, prior to risk response, there was a **70 percent** chance of the total project costs being less than **$199.5 million** in year-of-expenditure (YOE).

With the risk response strategies included, project costs now have a **70 percent** chance of being less than **$189.5 million** YOE.

These results indicate that by implementing the risk response strategies developed at the CRA workshop, project costs are expected to be reduced by **$10.0 million**.

Risk-Adjusted Cost Results (in Millions $'s)					
Category	Base Cost 2015 $'s	Base Cost YOE $'s	Cost Range YOE $'s		
			10th Percentile	70th Percentile	90th Percentile
Pre-Response Results Total Project	$161.3	$174.8	$177.9	$199.5	$209.0
Post-Response Results Total Project			$169.6	$189.5	$198.4
Post-Response Preliminary Engineering	$13.9	$14.9	$14.5	$15.1	$15.3
Post-Response Right-of-Way	$12.0	$12.8	$10.4	$15.1	$17.2
Post-Response Construction	$135.4	$147.1	$141.8	$160.6	$168.9
Category	Base Cost 2015 $'s		Cost Range 2015 $'s		
			10th Percentile	70th Percentile	90th Percentile
Post-Response Results Total Project	$161.3		$155.8	$173.8	$181.6

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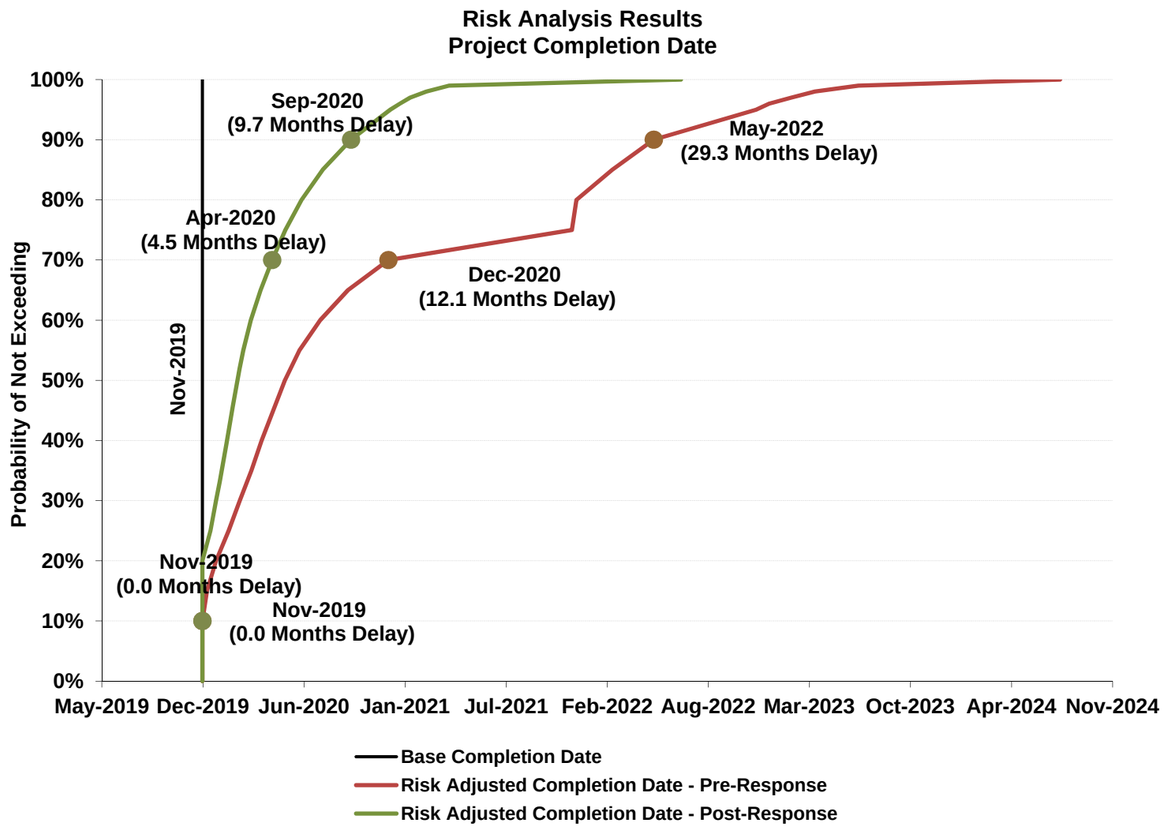
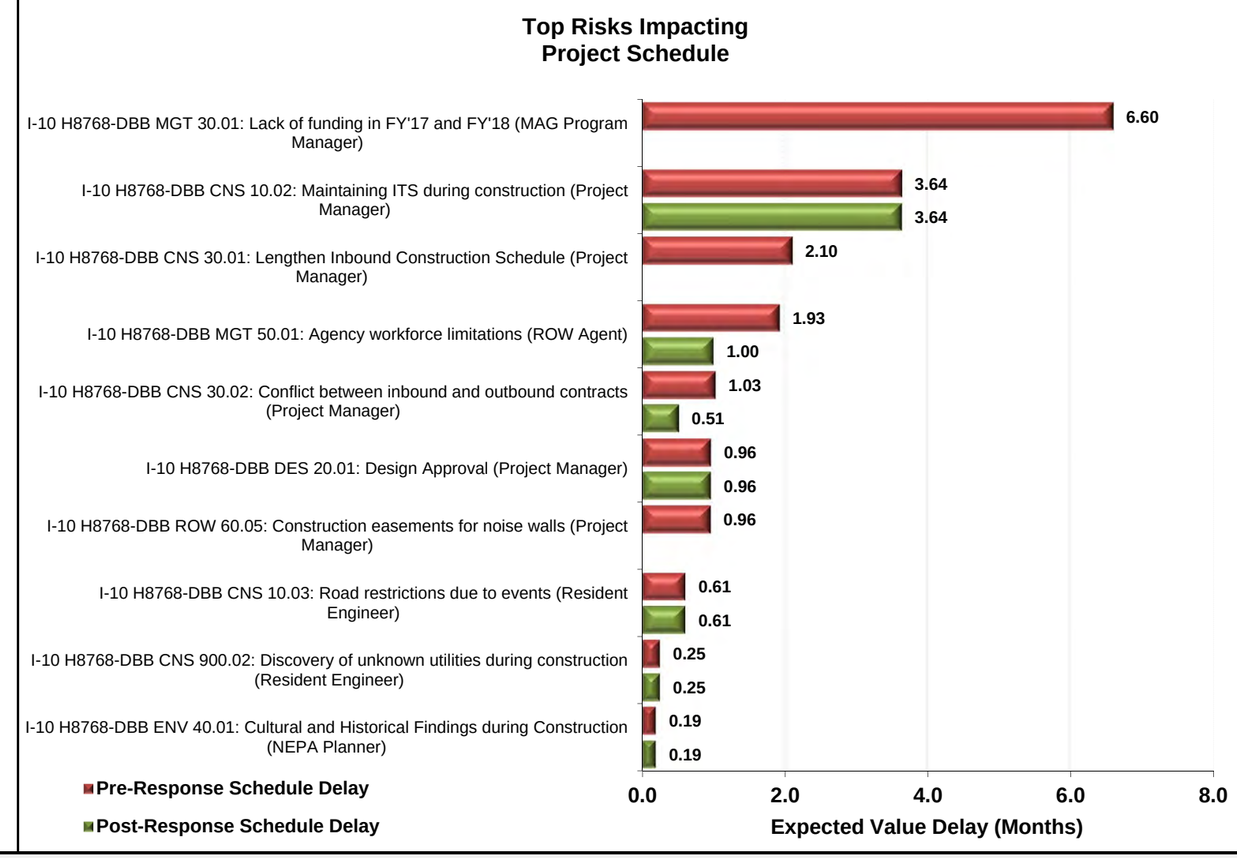
CRA Workshop Schedule Summary Sheet	I-10, Maricopa (SR-143 – SR-202L, Santan) Near-Term Improvements Design-Bid-Build Scenario / TRACS# H8768-DBB Last Updated January 2015	Level of Project Design	Low Medium High	CRA Workshop Schedule Summary Sheet





Schedule Results

Under the base schedule, the project is expected to be completed in **November, 2019**. The S-curves reveal that, prior to risk response, there is a **70 percent** chance that the project will be completed by **December, 2020** indicating a risk of potential delay to project completion of approximately **12.1 months**.

After including the risk response strategies developed at the CRA workshop, the project completion delay is reduced to approximately **4.5 months** with the project being completed in **April, 2020**.

By employing the risk response strategies developed within the CRA, project completion can be achieved **7.6 months** earlier.

Risk-Adjusted Schedule Results

Category	Base Date	Project Completion Date Range		
		10th Percentile	70th Percentile	90th Percentile
Pre-Response Results	Nov-2019	Nov-2019	Dec-2020	May-2022
Post-Response Results		Nov-2019	Apr-2020	Sep-2020
Post-Response Advertisement Date (Inbound)	Jun-2017	Jun-2017	Jun-2017	Oct-2017
Post-Response Construction Duration (Inbound)	18.0 Months	18.0 Months	20.3 Months	27.3 Months
Post-Response Advertisement Date (Outbound)	Jun-2018	Jun-2018	Jun-2018	Oct-2018
Post-Response Construction Duration (Outbound)	14.0 Months	14.0 Months	16.4 Months	22.5 Months

Key Risk Response Strategies

ROW 60.01 - ROW for Alameda pedestrian bridge Move the Alameda pedestrian bridge switchback ramps on the east side into the existing ROW that is owned. Would eliminate impacts on the east side. Move the Alameda pedestrian bridge switchback ramps on the west side closer to I-10 would minimize impacts to parking for Diablo stadium and the billboard that is in the stadium parking lot. There may be a requirement for an easement on the east side. Negotiations with city of Tempe about impacts to Diablo stadium parking impacts.

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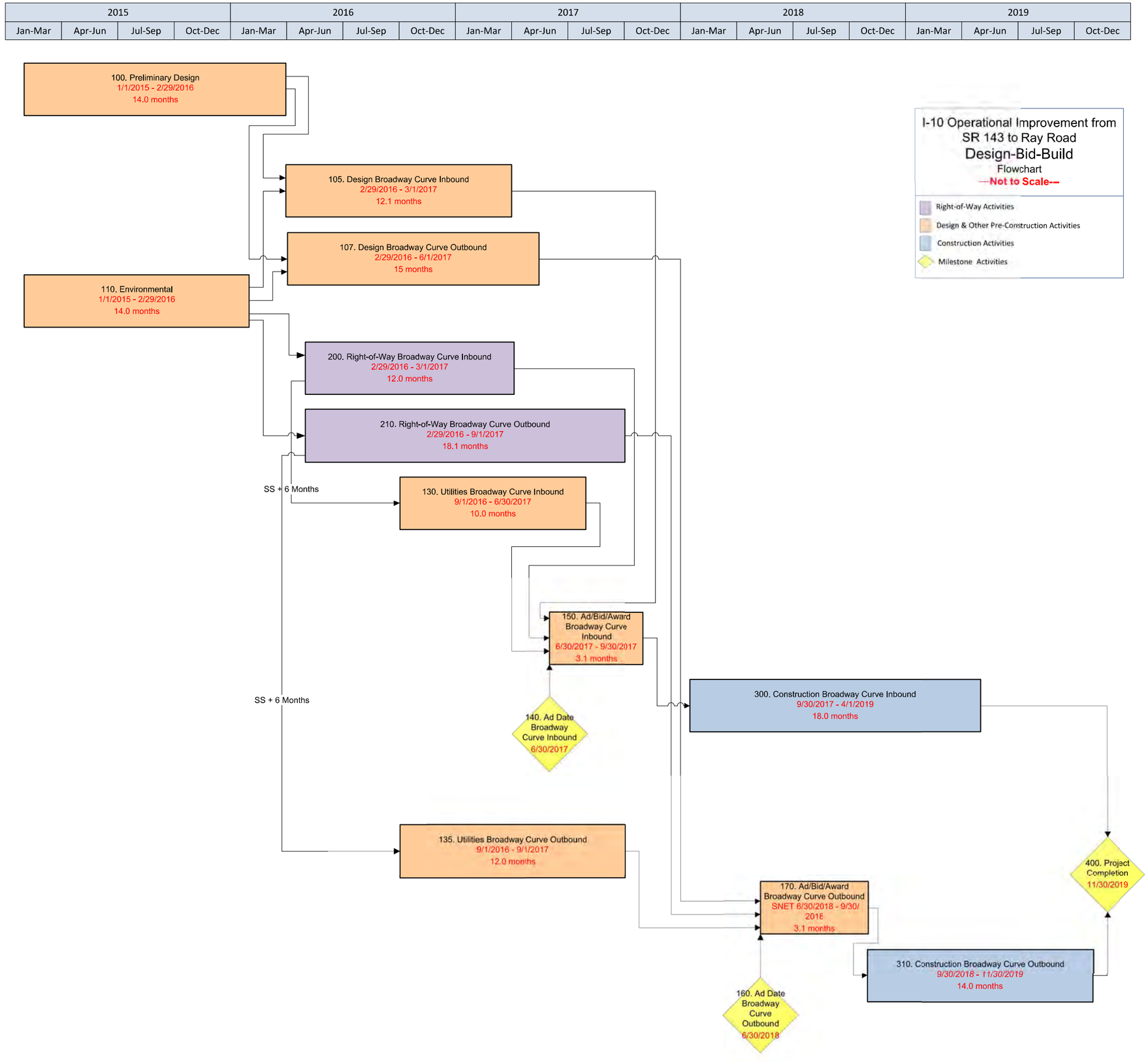

2015
2016
2017
2018
2019
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
I-10 Operational Improvement from SR 143 to Ray Road
Design-Bid-Build
Flowchart
--Not to Scale--
Right-of-Way Activities
Design & Other Pre-Construction Activities
Construction Activities
Milestone Activities
100. Preliminary Design
1/1/2015 - 2/29/2016
14.0 months
105. Design Broadway Curve Inbound
2/29/2016 - 3/1/2017
12.1 months
107. Design Broadway Curve Outbound
2/29/2016 - 6/1/2017
15 months
110. Environmental
1/1/2015 - 2/29/2016
14.0 months
200. Right-of-Way Broadway Curve Inbound
2/29/2016 - 3/1/2017
12.0 months
210. Right-of-Way Broadway Curve Outbound
2/29/2016 - 9/1/2017
18.1 months
SS + 6 Months
130. Utilities Broadway Curve Inbound
9/1/2016 - 6/30/2017
10.0 months
150. Ad/Bid/Award Broadway Curve Inbound
6/30/2017 - 9/30/2017
3.1 months
SS + 6 Months
140. Ad Date Broadway Curve Inbound
6/30/2017
300. Construction Broadway Curve Inbound
9/30/2017 - 4/1/2019
18.0 months
135. Utilities Broadway Curve Outbound
9/1/2016 - 9/1/2017
12.0 months
400. Project Completion
11/30/2019
170. Ad/Bid/Award Broadway Curve Outbound
SNET 6/30/2018 - 9/30/2018
3.1 months
310. Construction Broadway Curve Outbound
9/30/2018 - 11/30/2019
14.0 months
160. Ad Date Broadway Curve Outbound
6/30/2018

I-10, Near Term Improvements CRA Workshop Results

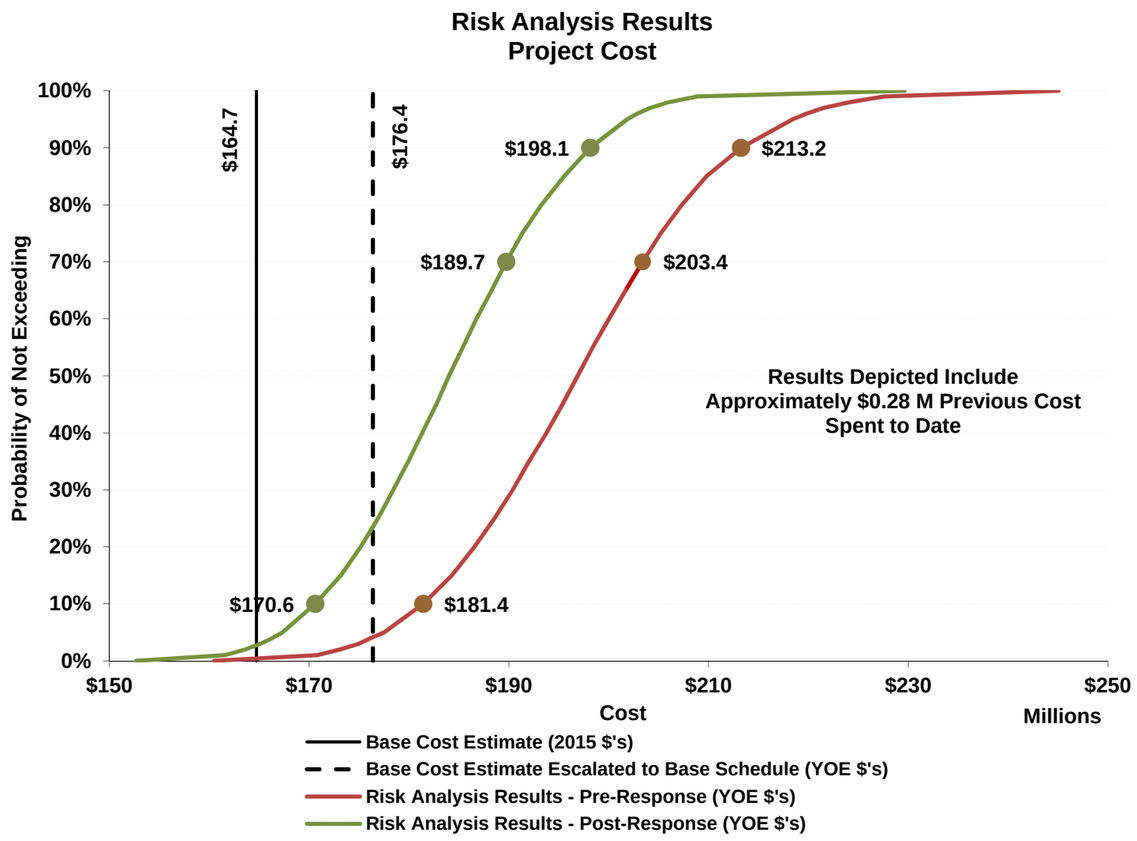
Design-Build Assumption

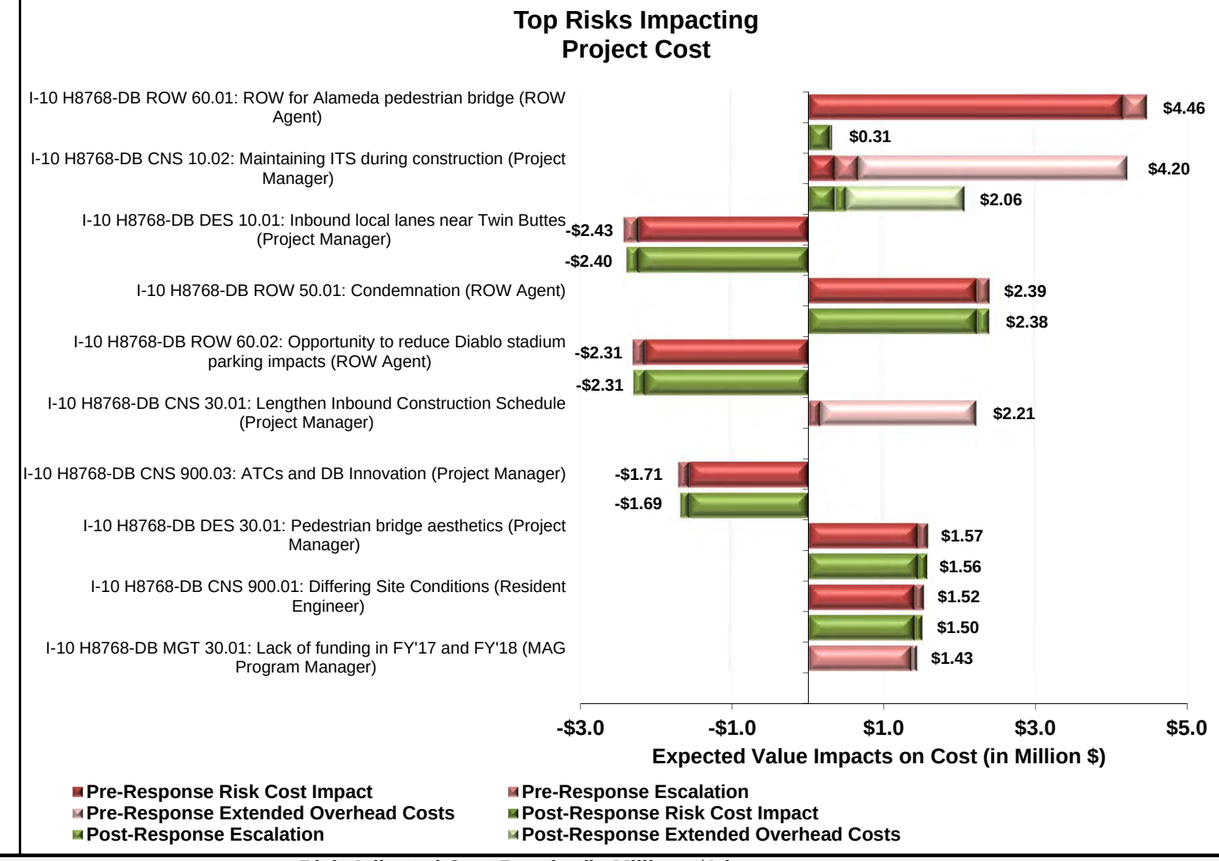
May 29, 2015

CRA Workshop Cost Summary Sheet	I-10, Maricopa (SR-143 – SR-202L, Santan) Near-Term Improvements Design-Build Scenario / TRACS# H8768-DB Last Updated June 2015	Level of Project Design	Low Medium High	CRA Workshop Cost Summary Sheet

Project Description

A modified collector-distributor roadway system will be developed to eliminate the existing weaving conditions between SR-143, Broadway Road and US 60 that is causing significant congestion on I-10 during the morning and evening peak travel periods. All existing system and service interchange freeway access will be retained with the Recommended Alternative. South of Baseline Road, I-10 will be widened to provide additional freeway capacity within that segment of the project.





Cost Results

The S-curves reveal that, prior to risk response, there was a **70 percent** chance of the total project costs being less than **$203.4 million** in year-of-expenditure (YOE).

With the risk response strategies included, project costs now have a **70 percent** chance of being less than **$189.7 million** YOE.

These results indicate that by implementing the risk response strategies developed at the CRA workshop, project costs are expected to be reduced by **$13.7 million**.

Risk-Adjusted Cost Results (in Millions $'s)

Category	Base Cost 2015 $'s	Base Cost YOE $'s	Cost Range YOE $'s		
			10th Percentile	70th Percentile	90th Percentile
Pre-Response Results Total Project	$164.7	$176.4	$181.4	$203.4	$213.2
Post-Response Results Total Project			$170.6	$189.7	$198.1
Post-Response Preliminary Engineering	$7.1	$7.4	$6.9	$7.7	$8.0
Post-Response Right-of-Way	$12.0	$12.8	$10.4	$15.1	$17.1
Post-Response Construction	$145.6	$156.1	$150.6	$168.0	$175.9

Category	Base Cost 2015 $'s	Cost Range 2015 $'s		
		10th Percentile	70th Percentile	90th Percentile
Post-Response Results Total Project	$164.7	$158.4	$176.0	$183.7

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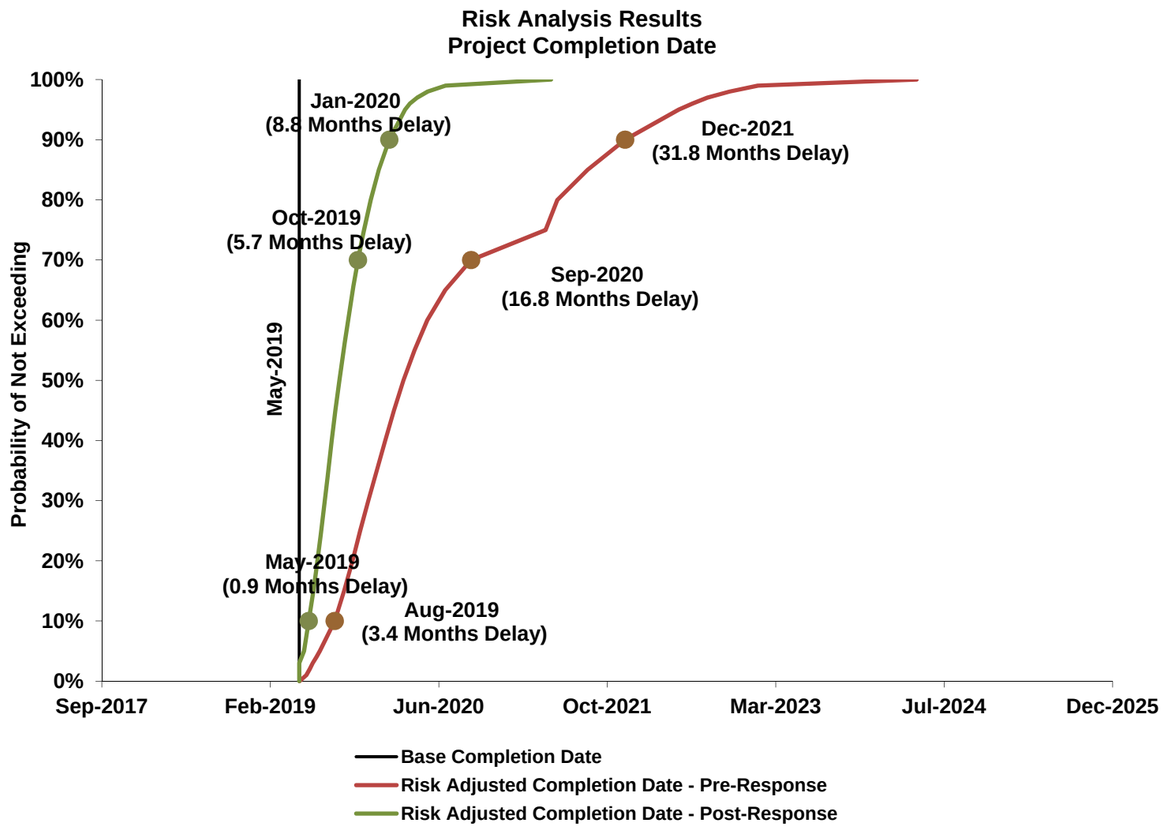
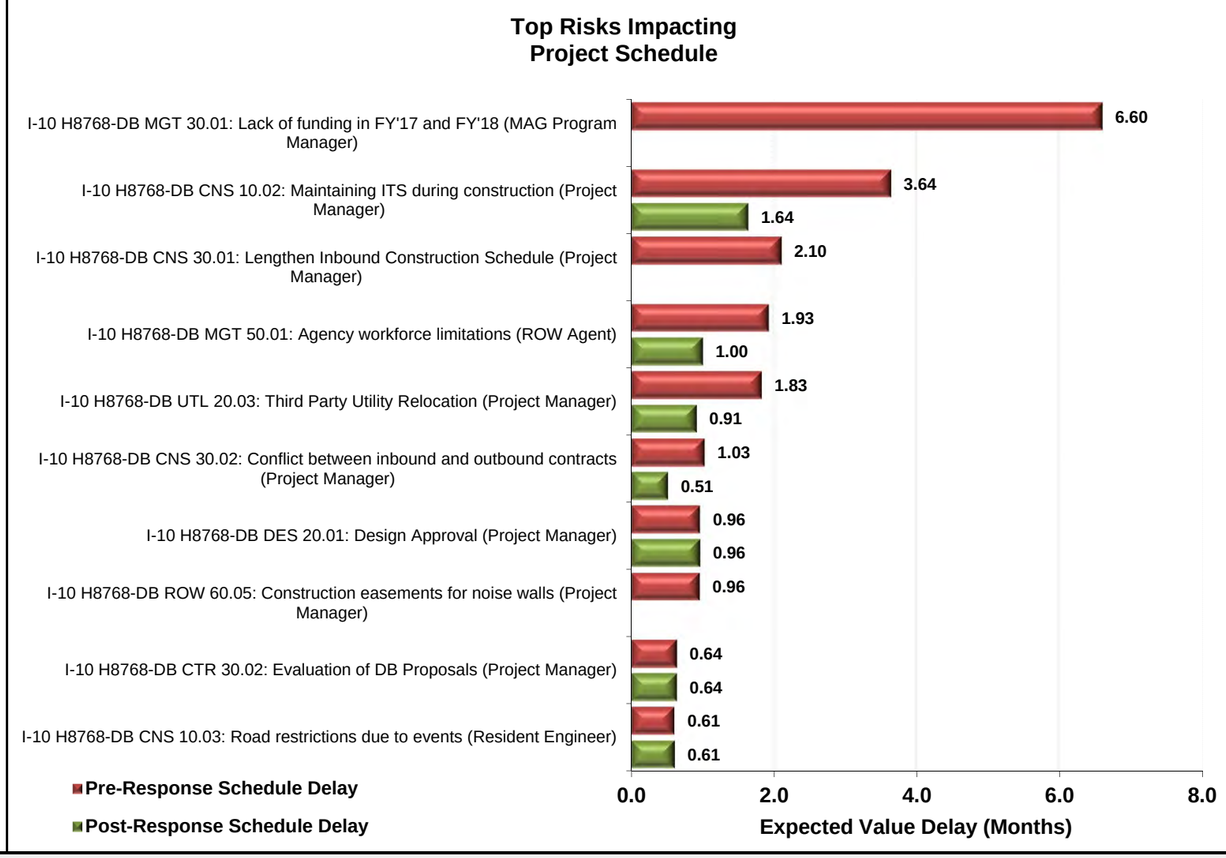
CRA Workshop Schedule Summary Sheet	I-10, Maricopa (SR-143 – SR-202L, Santan) Near-Term Improvements Design-Build Scenario / TRACS# H8768-DB Last Updated June 2015	Level of Project Design	Low Medium High	CRA Workshop Schedule Summary Sheet





Schedule Results

Under the base schedule, the project is expected to be completed in **May, 2019**. The S-curves reveal that, prior to risk response, there is a **70 percent** chance that the project will be completed by **September, 2020** indicating a risk of potential delay to project completion of approximately **16.8 months**.

After including the risk response strategies developed at the CRA workshop, the project completion delay is reduced to approximately **5.7 months** with the project being completed in **October, 2019**.

By employing the risk response strategies developed within the CRA, project completion can be achieved **11.0 months** earlier.

Risk-Adjusted Schedule Results

Category	Base Date	Project Completion Date Range		
		10th Percentile	70th Percentile	90th Percentile
Pre-Response Results	May-2019	Aug-2019	Sep-2020	Dec-2021
Post-Response Results		May-2019	Oct-2019	Jan-2020
Post-Response RFP Date (Inbound)	Mar-2017	Mar-2017	Mar-2017	Jul-2017
Post-Response Construction Duration (Inbound)	20.1 Months	20.1 Months	21.5 Months	24.2 Months
Post-Response RFP Date (Outbound)	Jul-2017	Jul-2017	Jul-2017	Jul-2017
Post-Response Construction Duration (Outbound)	20.0 Months	20.0 Months	22.3 Months	24.8 Months

Key Risk Response Strategies

ROW 60.01 - ROW for Alameda pedestrian bridge Move the Alameda pedestrian bridge switchback ramps on the east side into the existing ROW that is owned. Would eliminate impacts on the east side. Move the Alameda pedestrian bridge switchback ramps on the west side closer to I-10 would minimize impacts to parking for Diablo stadium and the billboard that is in the stadium parking lot. There may be a requirement for an easement on the east side. Negotiations with city of Tempe about impacts to Diablo stadium parking impacts.

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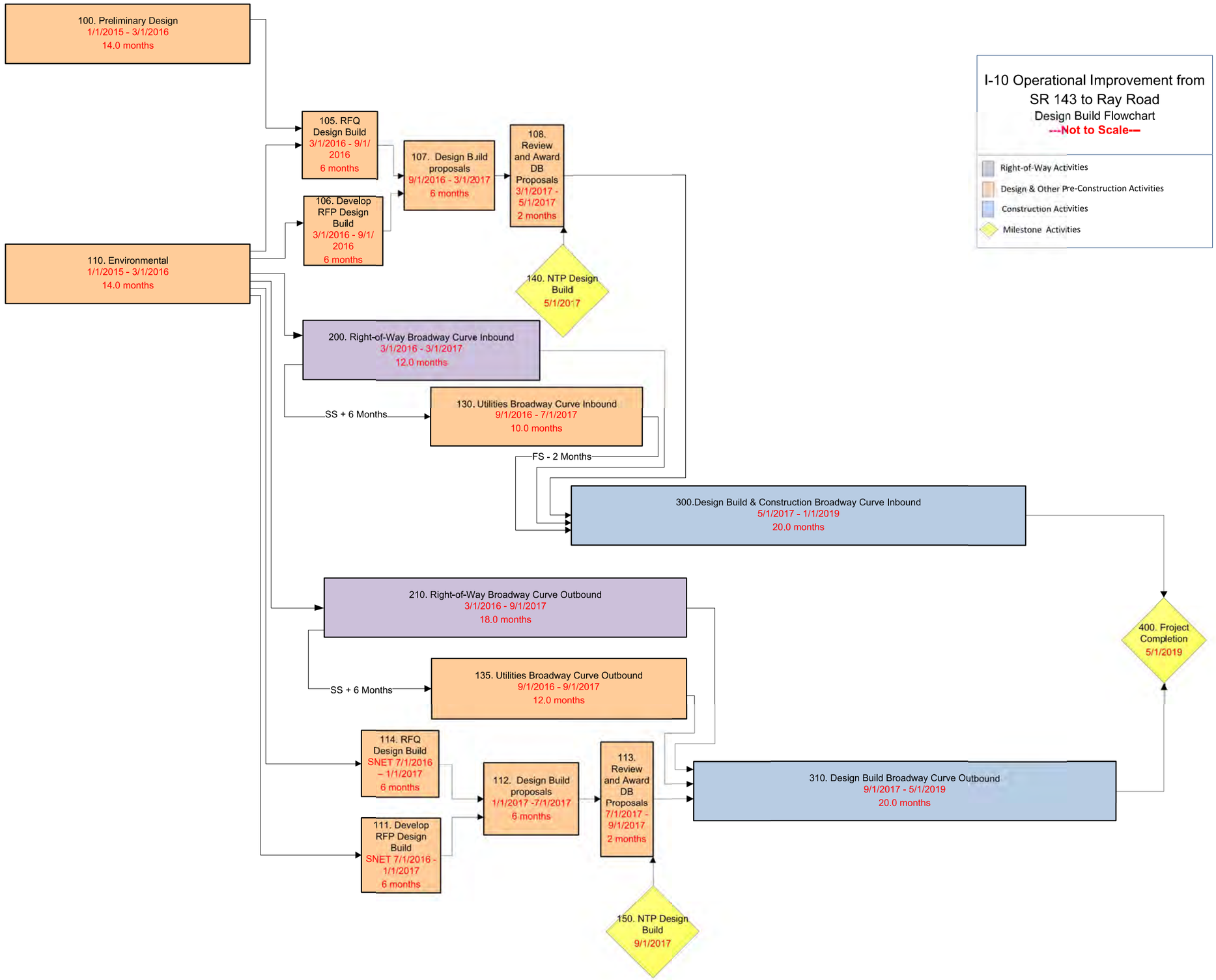
2015				2016				2017				2018				2019			
Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec



I-17, 19th Avenue to the I-10 Split CRA & Value Planning Workshop Results

January 25-26, 2016

February 8-10, 2016

I-17: I-10 Split to 19th Avenue
Cost Risk Assessment & Value Planning Study

Final Report

Prepared for:
Maricopa Association of Governments

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Trent Eakin

Prepared By:
HDR Engineering, Inc.

Date:
CRA Workshop: January 26-27, 2016
Value Planning Study: February 8-10, 2016
Presentation: February 11, 2016

Disclaimer:

The information contained in this report is the professional opinions of the team members during the Cost Risk Assessment Workshop and Value Planning Study. These opinions were based on the information provided to the team at the time of these workshops. As the project continues to develop, new information will become available, and this information will need to be evaluated on how it may affect the recommendations and findings in this report. All costs displayed in the report are based on best available information at the time of the study and unless otherwise noted are in 2016 dollars.

This report was prepared by:

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Phoenix, AZ 85018

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Executive Summary

Introduction

This cost risk assessment (CRA) and value planning report summarizes the events of the workshops conducted for the Maricopa Association of Governments, facilitated by HDR, Inc. Value planning is a process of developing the appropriate scope of work using the Value Engineering process and tools.

Value Planning Summary

Near Term Project Cost: $70M (YOE)

Number of Planning Recommendations: 7

Total Number of Team Members: 14

MAG Employees: 6

ADOT Employees: 3

Consultant: 5

Facilitator: HDR Engineering, Inc.

The project under review was the I-17: I-10 Split to 19th Avenue Corridor. The CRA workshop was conducted January 25-26, 2016 while the Value Planning Study was held February 8-10, 2016. The risk register, initially developed during the CRA workshop, was again updated at the end of the Value Planning workshop. The presentation of both the preliminary CRA model results and Value Planning Recommendations was held February 11, 2016.

The primary objectives of the team through application of the Value Engineering Job Plan (see Appendix) were to:

- Conduct a thorough review and analysis of the key project issues using a multidiscipline, cross-functional team (i.e. review the Near Term project and design)
- Verify or improve upon the various concepts proposed for the corridor
- Improve the value of the project through innovative measures aimed at improving the performance while reducing costs of the project
- Identify high-risk areas in delivering this project
- Perform a cost risk assessment on both the baseline design and the Value Planning-recommended design (risk register adjusted with team at the end of the Value Planning Study)

Project Overview

Near Term Improvements

The purpose of this project is to improve the operation and safety of I-17. The proposed near-term improvements would add auxiliary lanes between the entrance and exit ramps in both the northbound and southbound directions of travel between 16th Street and 19th Avenue and would extend the I-10/I-17 Traffic Interchange (TI) East-to-North (EN) Ramp auxiliary lane to the Seventh Street Northbound Exit Ramp. The corridor is under evaluation to address a number of other deficiencies identified throughout the project. These include:

1. Narrow shoulder widths that do not meet current highway standards
2. Low overhead clearances for I-17 structures over city streets

3. Short merge distances between on/off ramps and the general purpose lanes

The Near Term Improvement 15% design plans include the addition of auxiliary lanes (merge lanes) between the I-10 Split Interchange and 19th Avenue. It also includes widening of existing structures to accommodate the additional roadway width. Walls would be constructed near the limits, at or near the shoulder of the Near Term roadway design widths to support the elevated freeway section throughout the majority of the corridor. The estimated cost of the Near Term project after factoring identified risks, at 70% certainty in 2016 dollars is just over $68 million. A direct cost comparison was then developed to compare the Near Term project costs with the Ultimate costs.

Ultimate Improvements

The proposed Ultimate Improvements, if the Near Term project is omitted, would also add auxiliary lanes between the entrance and exit ramps in both the northbound and southbound directions between 16th Street and 19th Avenue and extend the I-10/I-17 Traffic Interchange (TI) East-to-North (EN) Ramp auxiliary lane to the Seventh Street Northbound Exit Ramp. The project will replace all structures and pavement and bring the roadway up to meet current clearance standards. The Ultimate plans for the corridor include:

1. Raising of mainline profile to accommodate new structures at overcrossings to meet clearance requirements and geometric standards

Other Ultimate developments include the addition of HOV lanes, one in each direction, throughout the length of the corridor. For the purposes of this study, the team assumed the HOV lane construction would occur in the future, therefore the costs for including HOV lanes are not considered in the analysis.

Cost Risk Assessment

In performing the cost risk analysis, a risk-based modeling tool was incorporated to model the overall risk of the project, both schedule and cost. Pre-response results are based on the likelihood of an event prior to implementation of mitigation strategies, the backbone of a risk management plan. Post-response results are based on the likelihood that this risk may be reduced or even eliminated based on the risk mitigation strategies currently identified. During these workshops, the team identified 31 independent risks that may have both schedule and cost impacts, some of which were recognized as opportunities. In the workshop, a likely range of impact and probability of occurrence was identified for each risk (or opportunity). Due to the current level of design and based on the limited mitigation strategies identified at this stage, pre-response and post-response results are within a relatively close range. As the project (or potential projects) in the program advance, there will be additional opportunities to identify additional risk mitigation strategies as the risk profile evolves. The risks, their probability of occurrence, cost and schedule impacts, and the mitigation strategies currently in place are provided in the risk data sheets listed in the Appendix.

The results after considering the risk, cost and schedule impacts, and their probability of occurrence was incorporated into a model to consider 10,000 iterations, or the possibilities of

the risk occurring and the associated impacts. The results of the analysis for the Ultimate Project configuration are provided in Table 1. Base costs for the Ultimate project, excluding risk impacts, is estimated to be $195.8 million (2016 $) or $213 million at year of expenditure (YOE). Based on current risk, cost and schedule inputs, the project will be at or below **$210.5 million (2016 $) or $231.1 million (YOE)** at a 70% confidence level**.**

Table 1: Ultimate Project Risk-Adjusted Cost Results (in Millions $s)

Category	Base Cost 2016 $s	Base Cost YOE $s	70th Percentile 2016 $s	70th Percentile YOE $s
Total Project Pre-Response Results	$195.8	$213.0	$210.5	**$231.1**
Total Project Post-Response Results			$210.4	**$231.1**
Post-Response Preliminary Engineering	$16.4	$17.3	$19.2	$20.6
Post-Response Right-of-Way	$0.0	$0.0	$0.0	$0.0
Post-Response Construction	$179.4	$195.8	$191.2	$210.5

The schedule was evaluated by the team while considering both negative impacts and opportunities. Compared to the baseline schedule, while also considering the recommendations identified by the team, the project will be complete by December 2021 at the 70% confidence level. This is over four months beyond the baseline completion date of August 2021. A recommendation for a schedule opportunity was captured by the project team. Although the probability is not considered high, the recommendation focuses on preliminary traffic control scenario's that may reduce the overall schedule by six months. Please see Table 2 below and the 'Analysis of Results' section of this report for a more detailed analysis of the cost and schedule model output results.

Table 2: Ultimate Project Risk-Adjusted Schedule Results

Category	Base Schedule Completion Date	Project Completion Date Range		
		10th Percentile	70th Percentile	90th Percentile
Pre-Response Results	Aug-2021	Feb-2021	Dec-2021	Jun-2022
Post-Response Results		Feb-2021	**Dec-2021**	Jun-2022
Post-Response Advertisement Date	Apr-2018	Apr-2018	Nov-2018	May-2019
Post-Response Construction Duration	36.0 Months	30.0 Months	36.0 Months	36.0 Months

These tables illustrate the results of the model and show, based on a comparison to the baseline estimate and schedule, what costs and schedule risk reserve may be expected for the

ultimate project at this stage. Based on workshop discussion and preliminary analysis results, the team recommends that the Ultimate project provides the best overall value versus Near Term improvements proposed for the corridor.

Value Planning Study Summary

The Value Planning study evolved into an assessment of whether the Near Term project would benefit the Ultimate needs of the corridor and if an alternative approach with a longer term solution would be more beneficial. As discussions over the Ultimate plans progressed, it was understood other immediate needs include potential bridge replacements to alleviate current height restrictions on city streets and additional plans to accommodate both auxiliary lanes and general purpose lanes for future expansion projects. Other plans include construction of HOV lanes through the project, one lane in each direction.

The team discussed the time frame between when the Near Term project and when the Ultimate projects were scheduled. It was understood that the time frame between projects was within just a few years. A high level cost estimate was developed for the Ultimate option to provide a direct comparison between the Near Term and Ultimate project alternatives under consideration. Following development of the risk register for the Near Term project during the CRA workshop, a supplemental risk register was developed for the Ultimate project. A direct comparison between the Near Term, risk loaded cost results and the Ultimate risk loaded costs, both in current dollars and at year-of-expenditure, is provided in Table 3.

Table 3: Near Term & Ultimate Project Cost Comparison

	Near Term Project Cost Results			Ultimate Project CRA Results		
Category	Base Cost 2016 $s	70th Percentile 2016 $s	70th Percentile YOE $s	Base Cost 2016 $s	70th Percentile 2016 $s	70th Percentile YOE $s
Total Project Pre-Response Results	**$45.9**	**$68.2**	**$72.9**	**$195.8**	**$210.5**	**$231.1**
Post-Response Preliminary Engineering	$3.1	$4.3	$4.5	$16.4	$19.2	$20.6
Post-Response Right-of-Way	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Post-Response Construction	$42.8	$61.9	**$66.2**	$179.4	$191.2	**$210.5**
Total Project Post-Response Results	**$45.9**	**$66.2**	**$70.7**	**$195.8**	**$210.4**	**$231.1**

The majority of the Near Term construction improvements would essentially be replaced by the Ultimate project configuration. Based on the cost estimate results and short time frame between Near Term and Ultimate projects, the team assumed that the Ultimate project would be the baseline project, with the construction of the HOV lanes to be performed at a later time. The

remainder of the workshop focused directly on planning and identifying risks for the Ultimate corridor plan, where the remainder of this report will focus. Alternatives will be compared to the Ultimate plan and recommendations will be relevant to the Ultimate corridor plan, also referred to as the 'Ultimate' project alternative. Accommodations were also considered for the future HOV lane project. Additional information regarding the complete cost and schedule details is found in the 'Analysis of Results' section of this report. Near term project cost and risk analysis data is provided in the Appendix. The remainder of this report will focus on the Ultimate project configuration with HOV lane construction anticipated in the future.

Value Planning Recommendations

The Team generated seven recommendations for the Ultimate Project configuration. These ideas were evaluated against the baseline concept as developed by the project team, or the Ultimate improvement plan. Please keep in mind that based on project status, these design suggestions are iterative in nature and may likely cause project costs to rise, but at the same time will help improve the overall project value.

The recommendations developed by the Value Planning Team are shown in Table 4 and are detailed in the Development Phase section of this report. A cost impact for each recommendation and the probability of implementation of these recommendations is also provided. These recommendations show what the team developed over the course of the workshop and will allow project manager's a preliminary risk management plan to help improve the project, limit the impacts to mobility, and save cost. These recommendations are a starting point of incorporation of a Value Engineering and Risk Management Plan. These recommendations may or may not advance based on project circumstances but will provide the cornerstone to ensuring the project advances successfully.

Table 4: List of Recommendations

#	Description	Value ($M)	Probability of Implementation
1	Bridge Lengths	-7.4	90%
2	Remove 3rd Street Bridge	-0.7	75%
3	Accelerated Bridge Const. (ABC)	NQ	
4	Reverse Ramps	5.3	75%
5	Walls at Frontage Roads	12.8	
6	Roadway Width	8.1	
7	Maintenance of Traffic (MOT)	-12.5	60%

To facilitate implementation, a Value Engineering Recommendation Approval Form is included as Appendix. If the Agency elects to reject or modify a recommendation, please include a brief explanation of why.

Decision Support

The team has developed the following list of current alternatives proposed for the corridor. Again, the team analyzed both the Near Term improvements versus the Ultimate improvements and made recommendations based on accommodations for the Ultimate Configuration. The alternatives analyzed at the time of the workshop include:

1. **Near Term - Auxiliary Lanes with shoulder widening and existing structure widening)**
    a. Construction Duration: 18 to 20 months scheduled for completion in 2019
    b. Status – 15% design
    c. Base Cost Estimate: $45.9 million (2016 $) and $48.2 million (YOE)
    d. Risk Adjusted Cost Estimate (post-response): $66.2 million (2016 $) and $70.7 million (YOE)

Keep in mind that the majority of the project improvements proposed for the corridor in the Near Term plan will be replaced with the improvements proposed for the Ultimate plan (walls, existing structure widening, drainage improvements, etc.). The team believes that eliminating the Near Term project and replacing it with the Ultimate improvement project, with or without HOV lanes, will utilize funding more appropriately and better meet the Ultimate needs of the corridor.

2. **Ultimate Configuration – Value Planning**
    a. Construction Duration: 24 to 36 months scheduled for completion in 2022
    b. Status: 0% design
    c. Base Cost Estimate: $195.8 million (2016 $) and $213 million (YOE)
    d. Risk Adjusted Cost Estimate (post-response): $210.4 million (2016 $) and $231.1 million (YOE).

As the workshop progressed, the team also evaluated the addition of the HOV lanes through the project corridor. While the ultimate configuration described above does provide the accommodations for the HOV lanes in the future, it does not include the costs associated with HOV lane construction. This alternative is described below.

3. **Ultimate Configuration (with HOV lanes) – Value Planning**
    a. Construction Duration: 36 months scheduled for completion in 2022
    b. Current Status: 0% design
    c. Risk Adjusted Cost Estimate: $232 million @ the 70th percentile confidence level (2016 $)

The Team wishes to express its appreciation to the project design team and management for the excellent support they provided during the study. These value planning recommendations and other design considerations provided will assist in the management decisions necessary to move the project forward.

Ken L. Smith, PE, CVS®
Risk Lead and Value Planning Team Lead

Introduction

This report summarizes the events of the Cost Risk Assessment (CRA) Workshop and Value Planning Study conducted for the Maricopa Association of Governments (MAG), facilitated by HDR Engineering, Inc. The subject of the study was the I-17: I-10 Split to 19th Avenue Project.

Project Description

The primary need for the project is to provide auxiliary lanes, add capacity, develop standard shoulder widths, and meet overcrossing geometric standards and clearance requirements along the I-17 corridor between the I-10 Split and 19th Avenue. The Near Term project adds the auxiliary lanes and widens the existing roadway with the construction of new walls and modifications to the existing bridge structures. Ultimate plans are to raise the profile at the overcrossing locations, build new overcrossing structures, and widen the freeway to accommodate standard shoulder widths and add additional lane capacity. It was identified during the value planning study that HOV lanes are anticipated to be added to the corridor in the future as well.

Near Term Improvements

The proposed near-term improvements would add auxiliary lanes between the entrance and exit ramps in both the northbound and southbound directions of travel between 16th Street and 19th Avenue and would extend the I-10/I-17 Traffic Interchange (TI) East-to-North (EN) Ramp auxiliary lane to the Seventh Street Northbound Exit Ramp. The Near Term project addresses a number of roadway deficiencies that include:

1. Narrow shoulder widths that do not meet current highway standards.
2. Short merge distances between on/off ramps and the general purpose lanes :

The Near Term project, or Near Term improvement plans, includes the addition of auxiliary lanes (merge lanes) between the I-10 Split Interchange and 19th Avenue. It also includes widening of existing structures to accommodate additional roadway width. Walls would be constructed near the limits, at or near the shoulder of the Near Term roadway design widths to support the elevated freeway section throughout the majority of the corridor. The estimated cost of this project at 15% design is $45 million. A direct cost comparison was developed to compare the Near Term project costs with the Ultimate costs. The cost data and risk analysis results for the Near Term project are provided in the Appendices.

Ultimate Improvements

The proposed Ultimate improvements, if the Near Term project was forgone, would also add auxiliary lanes between the entrance and exit ramps in both the northbound and southbound directions of travel between 16th Street and 19th Avenue and extend the I-10/I-17 Traffic Interchange (TI) East-to-North (EN) Ramp auxiliary lane to the Seventh Street Northbound Exit Ramp. The project will replace all structures and pavement and bring the roadway profile up at

overcrossing locations to meet current clearance standards. The Ultimate plans for the corridor include:

1. Raising of mainline profile to accommodate new structures at overcrossings to meet clearance requirements and geometric standards
2. Replace existing roadway, the majority of which is concrete placed along the mainline
3. Construct walls at frontage roads to accommodate additional mainline width

Other Ultimate developments include the addition of HOV lanes, one in each direction, throughout the length of the corridor.

Value Engineering Approach

Value Engineering has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that value analysis can play to improve project performance. To address this issue, a performance-based VE approach was used.

The primary objective of any VE study is to improve the value of the project. A simple way to think of value in terms of an equation is shown at right. While project costs are fairly easy to quantify and compare through traditional estimating techniques, performance is not so easily quantifiable.

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

The use of performance measures provides the cornerstone of the performance-based VE process by giving a systematic and structured way of considering the relationship of a project's performance and cost as it relates to value. Project performance must be properly defined and agreed on by the stakeholders at the beginning of the VE study. The performance attributes and requirements that are developed are then used throughout the study to identify, evaluate, and document alternatives.

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

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

The following are the key project performance attributes that were used in this VE study:

- Mainline Operations
- Local Operations
- Maintainability

- Construction Impacts
- Environmental Impacts
- Project Schedule

A detailed definition of the performance attributes can be found in the 'Performance Attribute' section of this report.

Scope of the CRA and Value Planning Study

The scope of the workshops was to verify or improve upon the concepts being proposed for I-17: I-10 Split to 19th Avenue Corridor.

To accomplish this, the CRA & Value Planning Teams:

- Applied the principles and practices of the VE Job Plan (see Appendix)
- Conducted a thorough review and analysis of the key project issues using a multidiscipline, cross-functional team (i.e. review the baseline design)
- Verified or improved upon the various concepts for the project
- Improved the value of the project through innovative measures aimed at improving the performance while reducing costs
- Identified high risk areas in delivering the project
- Performed a cost risk assessment on both the baseline design and the Value Planning recommended design

CRA and Value Planning Study Timing

The timing of the study was based on a 15% design for the Near Term improvement plan proposed for the project. The cost risk assessment workshop was held at the MAG building downtown Phoenix from January 25-26, 2016. The Value Planning portion of the study was held February 8-10, 2016. The presentation of findings for both workshops was held February 11, 2016.

CRA and Value Planning Team Members

The list of team members who participated in the study, either the CRA or Value Planning session, is provided in Table 5. Other attendees and their documented participation during the study are listed on the sign-in sheets provided in the Appendix.

Table 5: CRA & Value Planning Team Members

Name	Organization	Position/Discipline
Ken Smith	HDR	Risk/Value Planning Lead
Suresh Raghavendra	HDR	Workshop Assistant
Chaun Hill	MAG	Senior Transportation Engineer
Quinn Castro	MAG	Transportation
Trent Eakin	HDR	SME/Modeler
John Misik	HDR	Structures
Brian Bombardier	HDR	Interchange Design

Table 5: CRA & Value Planning Team Members

Name	Organization	Position/Discipline
Dave Moody	MAG	Associate
Madhu Reddy	ADOT	District Engineer – Central District
Kole Dea	ADOT	Resident Engineer – Central District
Bob Hazlett	MAG	Senior Engineering Manager
Trent Kelso	ADOT	Engineering Manager
Dale Drost	ADOT CD	Maintenance
Mustafa Muradvich	ADOT EP	Environmental Planner
John Louis	PB	Senior Engineer
Matt Tolman	ADOT	ROW/CPA Liaison
Dave Edwards	ADOT	R/W
Thomas O'Reilly	PB	Project Manager
Eric Prosnier	ADOT	Project Manager
Don Smith	PB	Environmental Manager
Abhishek Dayal	Valley Metro	Manager of Capital Development
Glenn Gaelick	ADOT	Roadway
Gary Sun	PB	Drainage
Maurice Goyette	COP	Light Rail Coordinator
Scott Gehrke	Valley Metro	Transit Engineer
Scott Miller	Valley Metro	Transit Planner
William Downes	ADOT	Bridge Group
Aryan Lirange	FHWA	
Rados Gluscevic	ADOT	Traffic Group
David Benton	ADOT	Bridge Engineer

Figure 1: CRA Team

Figure 2: Value Planning Team

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Information Phase

Summary of Analysis

The following analysis tools were used to study the project:

- Information provided to the CRA and Value Planning Team
- Constraints and Controlling Decisions
- Investigation Observations
- Base Cost Review
- Cost Model
- Uncertainty
- Project Schedule Review
- Project Escalation Assumptions
- Performance Attributes
- Performance Attribute Matrix
- Function Analysis
- FAST Diagram

Constraints and Controlling Decisions

As part of the project briefing, the CRA and Value Planning Teams were given the following project constraints and controlling factors when considering alternatives:

- Limit ROW impacts
- Utilize value planning with a Value Engineering Approach to develop best overall project concept strategies
- Develop preliminary planning and design concepts to guide the planning team as the project advances.

Investigation Observations

The first day of the CRA workshop study included a presentation from the Project Team. The following summarizes key project issues, project drivers and observations identified during the session.

- Project needs:
  - Maintenance of traffic
  - Future capacity for I-17 corridor
  - Address geometric deficiencies
  - Alternatives consistent with local development
  - Meet regulatory requirements for the corridor
- R/W requirements:
  - Limit ROW impacts as much as possible
- Funding:
  - This project currently has funding available, both for the Near Term and for the ultimate configurations

Base Cost Review

One of the objectives of a cost risk assessment is to review the base cost estimate in a collaborative setting with independent expert opinion and Project Team members. The base cost estimate represents the project cost that can reasonably be expected if the project materializes as planned, and there is no occurrence of significant risk.

A base cost estimate is unbiased and neutral - it is neither optimistic nor conservative. The base cost includes the known and quantified items and the known but not yet quantified items or miscellaneous item allowances. The base cost estimate does not include any risks (either threats or opportunities), unknown/unknowns, or contingencies. Table 6 provides a list of major items for the Ultimate Project configuration base costs. Table 7 shows the 'other items' or below the line items used for base costs.

Table 6: Ultimate Cost Estimate

Major Items	Cost	% of Project[1]
CONTRACTOR QUALITY CONTROL	$2,020,600	1.1%
CONTRACTOR SURVEYING	$2,020,600	1.1%
ROADSIDE DEVELOPMENT	$2,940,100	1.6%
ROADWAY APPURTENANCES ($1M/MILE)	$3,570,000	1.9%
DRAINAGE	$4,869,375	2.6%
OTHER ITEMS	$5,842,000	3.2%
CONSTRUCTION CONTINGENCIES	$7,092,300	3.8%
MOBILIZATION	$8,405,600	4.6%
EARTHWORK	$9,176,000	5.0%
CONSTRUCTION ENGINEERING	$12,766,000	6.9%
BASE AND SURFACE TREATMENT	$13,912,500	7.5%
PRELIM/FINAL DESIGN	$16,754,500	9.1%
STRUCTURES	$18,474,000	10.0%
MOT & TRAFFIC	$22,193,100	12.0%
WALLS - NOISE AND RETAINING	$25,893,400	14.0%

[1]Percentage based on total raw construction cost, excluding miscellaneous item allowance and below the line items.

Table 7: Ultimate Cost Estimate – Other Items	
MISCELLANEOUS ITEM ALLOWANCE	$27,908,852
PRELIM/FINAL DESIGN (10% of total)	$14,847,509
CONSTRUCTION ENGINEERING (9% of total)	$10,047,187
PRIOR RIGHT UTILITY RELOCATION & SERVICE AGREEMENTS ($1M/Mile)	$3,570,000
ICAP (10.35%)	$18,365,018

During the workshop, adjustments were made to the base cost estimate as additional information was acquired and more knowledge of the project was obtained. The base cost review results for this project are located within the Appendix of this report. All construction contingency estimate amounts were removed in the base costs and added in as risk items.

Cost Model

The CRA and Value Planning Team Leader prepared a cost model from the cost estimate developed by the team. The cost model is organized to identify major construction elements or trade categories (risk and miscellaneous categories are omitted in the chart), and the percent of total project cost for the significant cost items.

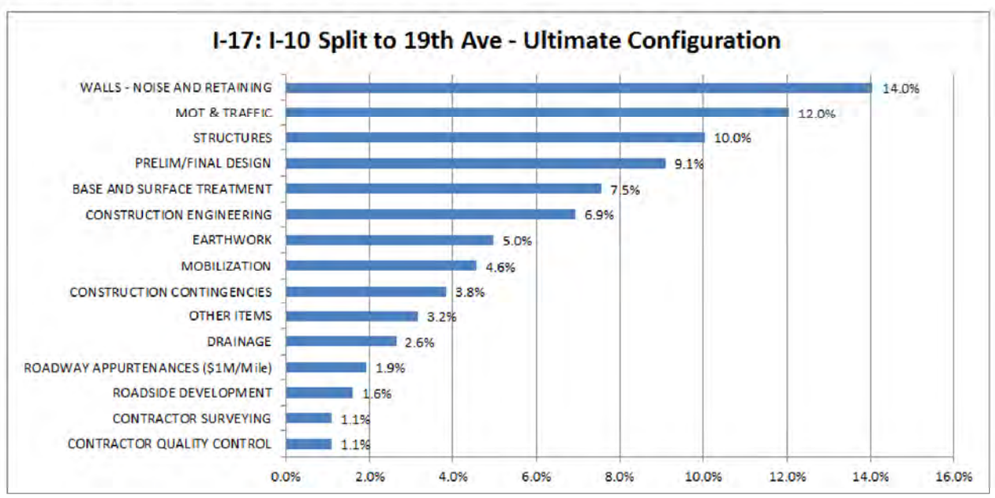

Figure 3: Ultimate Project Cost Model

The most significant cost for the project is attributed to wall construction to accommodate mainline widening followed by costs for maintenance of traffic. Structures, excluding walls, come in as the third highest cost. This chart omits the miscellaneous item category to provide more clarity as miscellaneous items are a 'group' of costs not related to one individual cost

category. This breakdown appears legitimate based on the type of project and the high level of impacts to mobility expected from construction.

Uncertainty

Estimating is not an exact science; a cost estimate is an approximation of the costs comprised of many elements that may not be completely or equally defined at the time the estimate is prepared. As a result, there is variability or uncertainty associated with any estimate. When applied to the project estimate, this uncertainty establishes the range that the base cost could fall within. A numerical value of uncertainty is, in essence, an estimate of the error or tolerance within the quantity and/or unit price of each item within the estimate.

For any given project, the level of uncertainty is directly related to its position in the project life cycle (i.e., the earlier in the project development process, the greater the uncertainty; conversely, the closer to completion, the less uncertainty).

In establishing the uncertainty ranges for each item, consideration was given to factors that might affect quantities or bid prices, such as project location (rural vs. urban), quantities (large or small), items that are difficult to construct or site constraints, methods of payments, timing of advertisement, specialty work, geotechnical and project delivery methods.

Uncertainty was established for the base cost estimate based upon all the available information at the time of the workshop. Doing this established an uncertainty or variability in the overall base cost estimate with a range of -15.4% of the base cost on the low side, or 17.5% above the base cost on the high side. This range was used in the model to simulate a range of typical costs seen on a bid. Table 8 illustrates the low, most likely, and high base estimate range values and the percentage below or above the most likely estimate value.

Table 8: Ultimate Baseline Estimate Uncertainty Range		
Low	Most Likely	High
$165,747,591	**$195,804,804**	**$230,151,067**
-15.4%		17.5%

Project Schedule Review

A preliminary schedule was developed to provide a date range for known project activities and milestones including environmental, design, utility and construction activities. These activities, provided in the below, are then cost loaded to allow the risks to impact a specific activity that will either lengthen or reduce the baseline schedule. This provides a more reasonable cost outcome based on risk impacts that carry schedule impacts. The activities and the amounts cost loaded into each are provided in the tables below. The preliminary schedule was reviewed by the entire team and updated as necessary throughout the workshop. Table 9 shows the activities and their estimated start and end dates. Table 10 portrays the amount allocated to each individual schedule activity, or the 'Cost Loaded' activity. Please see the Appendix for the flowchart activity diagram for an illustration of the project schedule.

Table 9: Project Activity Ultimate Baseline Schedule			
Activity ID	**Activity Name**	**Start Date**	**End Date**
300	Environmental	4/1/16	4/1/17
310	Preliminary Design	4/1/16	4/1/17
320	Final Design	4/1/17	4/1/18
400	Right-of-Way	4/1/17	4/1/18
500	Utilities	4/1/17	4/1/18
330	Procurement	4/1/18	8/1/18
510	Construction	8/1/18	8/1/21
520	Project Completion	8/1/21	8/1/21

Table 10: Cost Loaded Ultimate Schedule Activities				
Activity ID	**Activity Name**	**Cost**		
		Low	**Base**	**High**
001	Costs Spent to Date[1]	----	----	----
300	Environmental (Ultimate)	$693,137	$819,211	$960,547
310	Preliminary Design (Ultimate)	$2,633,921	$3,113,003	$3,650,078
320	Final Design (Ultimate)	$10,397,058	$12,288,170	$14,408,202
330	Procurement (Ultimate)	$138,627	$163,842	$ 192,109
400	Right of Way (Ultimate)	$0	$0	$0
500	Utilities (Ultimate)	$3,545,546	$3,939,495	$4,727,394
510	Construction	$148,339,301	$175,481,083	$206,212,738
	TOTAL	**$165,747,591**	**$195,804,804**	**$230,151,067**

[1]No assumed costs spent to date based on current level of design for the ultimate project

The baseline completion date for the Ultimate configuration is August 2021. The cost range, based on bid item uncertainty is between $165 million and $230 million in 2016 dollars, with a base cost of $195.8 million. Cost and risk loaded activity schedule model results are provide in the 'Analysis of Results' section of this report.

Project Escalation Assumptions

To account for increases in prices between the date the base cost estimate was created and when the actual work will be performed, the model for this project includes escalation rates

forecast for construction, preliminary engineering and right-of-way costs. Table 11 lists the annual escalation rates for construction, pre-construction, and right-of-way.

Table 11: Escalation Rates			
Year	**Construction Escalation Rate**	**Pre-Construction Escalation Rate**	**Right of Way Escalation Rate**
2015	1.83%	3.06%	3.54%
2016	2.04%	3.61%	3.69%
2017	2.27%	3.81%	3.50%
2018	2.30%	4.36%	3.33%
2019	2.27%	4.41%	3.50%
2020	2.27%	3.54%	2.89%
2021	2.27%	4.27%	3.25%
2022	2.27%	3.31%	3.03%
2023	2.44%	2.36%	2.80%
2024	2.61%	2.36%	2.80%
2025	2.61%	2.36%	2.80%
2026	2.61%	2.36%	2.80%
2027	2.61%	2.36%	2.80%
2028	2.59%	2.36%	2.80%
2029	2.56%	2.36%	2.80%
2030	2.56%	2.36%	2.80%
2031	2.56%	2.36%	2.80%

Performance Attributes

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

Performance attributes can generally be divided between project scope components (mainline operations, environmental impacts, maintainability, etc.) and project delivery components. It is important to make a distinction between performance attributes and performance requirements. Performance requirements are mandatory and binary in nature. All performance requirements MUST be met by any VE recommendation being considered.

Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and construction of a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives could be acceptable that had different durations.

The Value Planning Team, along with the Project Team, identified and defined the performance attributes for this project and then defined the baseline concept as it pertains to these attributes. The following performance attributes shown in Table 12 were used throughout the study to identify, evaluate, and document ideas and recommendations.

Table 12: Performance Attributes

Performance Attribute	Definition	Baseline
Mainline Operations	An assessment of traffic operations and safety on I-17 within the project limits. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance and lane and shoulder widths.	3-12' through lanes, 12' inside shoulder, 12' aux lane, 12 outside shoulder each direction, X ramps for 7th St, 7th Ave, half at 16th St and half at 19th Ave. Two lane one way frontage roads dropping to one lane in vicinity of ramps
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure (cross streets). Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane and shoulder widths; bicycle and pedestrian operations and access.	Cross streets at 19th Ave, 15th Ave, 11th Ave, 7th Ave, Central Ave, 7th St, and 16th St. Structures 60' longer than current bridges.
Maintainability	An assessment of the long-term maintainability of the facility. Maintenance considerations include the overall durability, longevity, and maintainability of structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel, including sediment and debris removal.	Concrete pavement, with ACFC on I-17 concrete ramps and no repaving of exiting frontage roads. All bridges re-constructed with AASHTO girders
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to existing utilities; impacts to businesses and residents relative to access, visual effects, noise, vibration, dust, and construction traffic; environmental impacts.	Staged construction maintaining two lanes in each direction
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts; impacts to cultural, recreational and historic resources.	Minimal or no Environmental impacts
Project Schedule	An assessment of activities to determine if construction can be completed within the baseline schedule duration.	36 months of construction

Function Analysis

Function analysis results in a unique view of the project. It transforms project elements into functions, which moves the CRA and Value Planning Team mentally away from the original design and takes it toward a function view of the project.

Functions are defined in verb-noun statements to reduce the needs of the project to their most elemental level. Identifying the functions of the major design elements of the project allows a broader consideration of alternative ways to accomplish the functions. The major functions identified by the team are shown in Table 13.

Table 13: Functions

Component	Verb	Noun
Roadway	Span	Roadway
Roadway	Widen	Roadway
MOT	Maintain	Traffic
Stakeholders	Reduce	Risk
MOT	Reduce	Conflict

FAST Diagram

The Function Analysis System Technique or FAST diagram arranges the functions in logical order so that when read from left to right; the functions answer the question “How?” If the diagram is read from right to left, the functions answer the question “Why?” Functions connected with a vertical line are those that happen at the same time as, or are caused by, the function at the top of the column.

The FAST Diagram for this project shows “Reduce Conflicts” and “Improve Mobility” as the basic functions of this project. Key secondary functions included Widen Roadway and Span Roadway. This provided the Value Planning Team with an understanding of the project design rationale and which functions offer the best opportunity for cost or performance improvement.

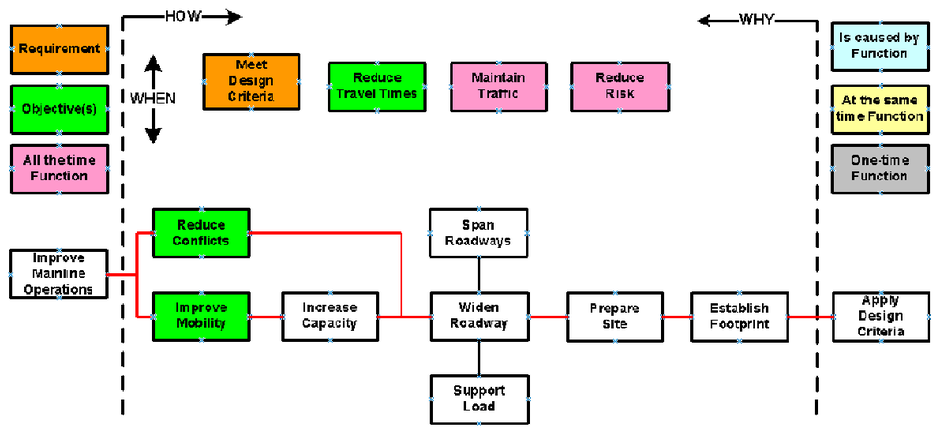

Figure 4: FAST Diagram

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Creative Phase

During the Creative Phase of the VE Job Plan, the Value Planning Team brainstormed ideas on how to achieve the various functions. These ideas were based on the available information given to them at the time of the study, taking into consideration the constraints and controlling decisions that were also defined for them. The ideas listed below coincide with each function being considered:

Creative Idea List

Function: Span Roadway

- Precast panels for the bridge deck
- Precast box beams
- 3-span structures with sidewalks on the end spans
- Use ABC construction
- Maintain/reduce 16th St bridge length
- Single span 16th St bridge for constructability
- Adjust HT power lane over I-17 in the vicinity of the 16th St bridge
- Eliminate the pedestrian crossing at 12th st
- Replace the pedestrian crossing at 12th st
- Single span 7th St bridge for constructability
- Remove 3rd St bridge
- Lower the mainline profile at 3rd St
- Convert Central Avenue to 2-span
- Maintain/reduce 7th Avenue bridge length
- Single span 7th Avenue bridge for constructability
- Do not replace 11th Avenue bridge
- Maintain/reduce 11th Avenue bridge length
- Replace only the bridge superstructure and widen as needed
- Lengthen 7th Avenue ramps (west side) and widen 11th Avenue bridge
- Single span 15th Avenue bridge for constructability
- Maintain/reduce 15th Avenue bridge length
- Adjust HT power lane over I-17 in the vicinity of the 19th Avenue bridge
- Close 7th Avenue west side ramps and add west side ramps at 19th Avenue
- Reverse the ramps between 7th Avenue and 19th Avenue

Function: Widen Roadway

- Maintain substandard shoulders (existing 7 feet and 10 feet)
- Use 10-foot inside and outside shoulders
- Use 14-foot inside and outside shoulders
- Do not use ARFC
- Use full depth asphalt on the mainline
- One-lane frontage roads in each direction

Function: Maintain Traffic

- Close entire section of the I-17 mainline (after opening of South Mountain)
- Add ramps east of 16th St and northbound on-ramp west of 19th Avenue and utilize frontage roads as detours; restripe frontage roads to 2 lanes
- Reversible mainline lanes; build half the freeway in one stage
- Median crossover with temporary widening; move traffic to one side and build half the freeway in one stage; this may require closing of existing ramps and adding temporary ramps
- Eliminate all on and off ramps during construction
- Eliminate every other on and off ramp during construction
- Permanently shift the alignment and build half the freeway at a time
- Hazardous material detour on frontage roads; corridor closed to all other traffic
- Close one direction of the mainline at a time
- Maintain major crossroads open at all time
- Execute Central Avenue as a standalone project
- Phase the wall construction prior to impacts to I-17

Function: Reduce Risk

- Drainage
  - Peak discharge mitigation basins; water quality BMP's
  - Obtain permits for discharge to the river
- Walls
  - Build the footing for the ultimate wall height
  - Build the walls full height at the inside edge of the frontage roads
- ITS/FMS

Evaluation Phase

Although each project is different, the evaluation process for each value engineering effort can be thought of in its simplest form as a way of combining, evaluating, and narrowing ideas until the Value Engineering team agrees on the proposals to be forwarded.

Taking into consideration the constraints and controlling decisions, the team discussed each idea and documented the advantages and disadvantages. Each idea was then carefully evaluated with the Value Engineering Team reaching consensus on the overall rating of the idea (zero through five). High-rated ideas (four or higher) were developed further; those that were considered to be equivalent to the baseline (rated three) were documented as design considerations; and low-rated ones (two or lower) were dropped from further consideration; however, the team provided a short description and justification to support the low rating. The rating values are shown below:

5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor Value Degradation
1 = Major Value Degradation
0 = Fatal Flaw (unacceptable impact or doesn't meet the project purpose and need)

= Advanced as recommendation

= Forwarded as design consideration

= Dropped from future consideration

Function: Span Roadway

#	Description	Advantages	Disadvantages
SR-1	Precast panels for the bridge deck	▪ Reduces construction duration ▪ Eliminates deck forming ▪ May avoid closure during deck placement	▪ Still requires an overlay ▪ Could cost more ▪ Could have long term maintenance issues

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
		👎	👍		👍

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

#	Description	Advantages	Disadvantages
SR-2	Precast box beams	▪ Lower profile ▪ Less Earthwork required for mainline ▪ Reduces construction duration ▪ Eliminates deck forming ▪ May avoid closure during deck placement	▪ Could cost more ▪ Limited span length ▪ Maybe limited suppliers ▪ Utilities across the bridge may be hard to accommodate

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
			👍		👍

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4.5	

#	Description	Advantages	Disadvantages
SR-3	3-span structures with sidewalks on the end spans	▪ Eliminates piers from local street ▪ Eliminates fixed objects from centerline ▪ May reduce girder depth ▪ May help with construction staging (built outside existing infrastructure)	▪ Adds more substructure cost ▪ Limits the crossroad section for future expansion ▪ Increases construction schedule

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👍		👍👎		👍👎

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-4	Use ABC construction	▪ Could reduce construction time	▪ Needs a site for offsite construction ▪ Complicated for design-bid-build ▪ Could cost more

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
			👍		👍

Cost:	*Justification/Comments: Depends on delivery method and site specific opportunity. Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-5	Maintain/reduce 16th St bridge length	▪ Current roadway is at its ultimate configuration ▪ Reduce cost for 60-foot of length ▪ Reduction in maintenance	▪ Constrain future widening of 16th St ▪ May conflict with existing abutments

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👍	👎		👍

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

#	Description	Advantages	Disadvantages
SR-6	Single span 16th St bridge for constructability	▪ Removes centerline pier	▪ May increase girder depth

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👍	👍	👍		👍

Cost:	*Justification/Comments: This idea was moved forward for further development and combine with SR-5*
Rating: 4	

#	Description	Advantages	Disadvantages
SR-7	Adjust HT power line over I-17 in the vicinity of the 16th St bridge	▪ Provides vertical clearance	▪ None noted

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Assumes in base cost*
Rating:	

#	Description	Advantages	Disadvantages
SR-8	Eliminate the pedestrian crossing at 12th St	▪ Could reduce cost ▪ Land use compatible ▪ Reduces maintenance	▪ Added cost for removal

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👍	👎		👎

Cost:	*Justification/Comments: Not in the base cost for removal. Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-9	Replace the pedestrian crossing at 12th St.	▪	▪ Costs more ▪ May not be warranted

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
		👎	👎		👎

Cost:	*Justification/Comments: Dropped for further consideration.*
Rating: 1	

#	Description	Advantages	Disadvantages
SR-10	Single span 7th St bridge for constructability	▪ Removes centerline pier	▪ May increase girder depth ▪ May require steel girders ▪ May increase costs

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
		👎	👍		👍

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-11	Remove 3rd St bridge	▪ Reduces cost ▪ Reduces construction duration ▪ May help lower the I-17 profile and flatten the ramp grade	▪ Could lead to pedestrian crossing concerns

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👍	👍		👍

Cost:	*Justification/Comments: Base assumes box culvert for pedestrian crossing. This idea was moved forward for further development.*
Rating: 4.5	

#	Description	Advantages	Disadvantages
SR-12	Lower the mainline profile at 3rd St	▪	▪

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Assumes part of the base*
Rating:	

#	Description	Advantages	Disadvantages
SR-13	Convert Central Avenue to 2-span	▪	▪

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This is the baseline*
Rating:	

#	Description	Advantages	Disadvantages
SR-14	Maintain/reduce 7th Avenue bridge length	▪ Reduce cost for 40-foot of length ▪ Reduction in maintenance	▪ May constrain future widening of 7th Avenue

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👍			

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 1.5	

#	Description	Advantages	Disadvantages
SR-15	Single span 7th Avenue bridge for constructability	▪ Removes centerline pier	▪ May increase girder depth ▪ May require steel girders ▪ May increase costs

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👍	👍	👍👎		

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

#	Description	Advantages	Disadvantages
SR-16	Do not replace 11th Avenue bridge (Widen only)	▪ Reduces cost	▪ Vertical clearance issues with railroad ▪ May decrease sight distance

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👎	👍		👍

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 2	

#	Description	Advantages	Disadvantages
SR-17	Maintain/reduce 11th Avenue bridge length	▪ Reduction in maintenance	▪ May constrain future widening of 11th Avenue ▪ Decreases sight distance

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👍	👍		

Cost:	*Justification/Comments: Considered skewed abutments to improve sight distance. Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-18	Replace only the bridge superstructure and widen as needed at 11th Avenue.	▪ Reduces cost	▪ Decreased sight distance ▪ May constrain future widening of 11th Avenue

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎	👎			

Cost:	*Justification/Comments: Raise the superstructure on the existing substructure. This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
SR-19	Lengthen 7th Avenue ramps (west side) and widen 11th Avenue bridge	▪ Flattens the 7th Avenue west side ramps	▪ Will result in a wider 11th Avenue bridge ▪ Will add cost

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
👍		👍👎		👍	

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4.5	

#	Description	Advantages	Disadvantages
SR-20	Single span 15th Avenue bridge for constructability	▪ Removes centerline pier	▪ May increase girder depth ▪ May increase costs ▪ May not improve sight distance issues

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👍	👍	👍		

Cost:	*Justification/Comments: Might reduce span length. This idea was moved forward for further development.*
Rating: 4	

#	Description	Advantages	Disadvantages
SR-21	Maintain/reduce 15th Avenue bridge length	▪ Reduction in maintenance ▪ May reduce cost ▪ May reduce structure depth	▪ May constrain future widening of 15th Avenue ▪ Decreases sight distance

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
		👍			

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-22	Adjust HT power line over I-17 in the vicinity of the 19th Avenue bridge	▪ Constructability of the structure	▪

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
SR-23	Close 7th Avenue west side ramps and add west side ramps at 19th Avenue	▪ Eliminates substandard profiles of the 7th Avenue west side ramps ▪ May eliminate the NB aux lane requirement between 7th Avenue and 19th Avenue ▪ May provide the ability to shift the 19th Avenue east side ramps further east	▪ Requires a change of access report ▪ Adds through traffic through 15th and 19th Avenues ▪ May have ROW impacts ▪ May require signal at 15th Avenue

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👍👎	👍	👍	👎	

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
SR-24	Reverse the ramps between 7th Avenue and 19th Avenue.	▪ Eliminates substandard profiles of the 7th Avenue west side ramps ▪ May eliminate aux lanes requirement between 7th Avenue and 19th Avenue	▪ Requires a change of access report ▪ Adds through traffic through 15th and 11th Avenues ▪ May have ROW impacts ▪ May require signal at 15th Avenue and possibly 11th Avenue

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
👍	👍👎	👍	👍	👎	

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

Function: Widen Roadway

#	Description	Advantages	Disadvantages
WR-1	Maintain substandard shoulders (existing 7 feet and 10 feet)	▪ Reduces cost	▪ Will result in walls in the wrong location ▪ Non-standard shoulder widths ▪ FHWA might not support

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
👎					

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 1	

#	Description	Advantages	Disadvantages
WR-2	Use 10-foot inside and outside shoulders	▪ Reduces 4 feet of width ▪ Lower cost	▪ Requires ADOT design exception ▪ May have an impact on incident management

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
👎					

Cost:	*Justification/Comments: Meets AASHTO minimum but not ADOT standards. This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
WR-3	Use 14-foot inside and outside shoulders	▪ Could allow for future restriping to accommodate an extra lane ▪ Extra width for maintenance	▪ Extra width to maintain ▪ Added cost ▪ Wider shoulders could be perceived as a travel lane ▪ May have ROW impacts

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
👍		👍👎		👎	

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

#	Description	Advantages	Disadvantages
WR-4	Do not use ARFC	▪ Reduced cost ▪ Reduces repaving requirement (frequency) ▪ May shorten construction schedule	▪ Road noise

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
		👍👎		👎	👍

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 2	

#	Description	Advantages	Disadvantages
WR-5	Use full depth asphalt on the mainline	▪ May have additional flexibility on construction staging	▪ High truck percentage ▪ Increased paving cycles

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
		👎	👍		👍

Cost:	*Justification/Comments: Dropped from further consideration*
Rating: 1	

#	Description	Advantages	Disadvantages
WR-6	One-lane frontage roads in each direction	▪ Provides more width for mainline widening	▪ Extra width may not be required ▪ May impact incident management

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
👎					

Cost:	*Justification/Comments: Dropped from further consideration*
Rating: 2	

Function: Maintain Traffic

#	Description	Advantages	Disadvantages
MT-1	Close the entire section of I-17 mainline (after opening of South Mountain)	▪ May reduce 12 months of construction time	▪ No viable HAZMAT detour route for the I-10 tunnel ▪ May require temporary ramps to access frontage roads ▪ Requires an extensive public outreach campaign

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
	👎		👎	👎	👍

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
MT-2	Add ramps east of 16th St and northbound on-ramp west of 19th Avenue and utilize frontage roads as detours; restripe frontage roads to 2 lanes	▪ Opens the freeway up for construction ▪ May reduce construction time	▪ May require temporary easements and paving ▪ May require temporary signals and revised signal timing at the crossroads

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule
			👎	👎	👍

Cost:	*Justification/Comments: Coordination with Valley Metro's South Central Extension project. This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
MT-3	Reversible mainline lanes; build half the freeway in one stage	▪ None noted	▪ Will result in left hand access ramps ▪ Will require resigning and re-signaling ▪ No directional traffic split

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Dropped from further consideration*
Rating: 1	

#	Description	Advantages	Disadvantages
MT-4	Median crossover with temporary widening; move traffic to one side and build half the freeway in one stage; this may require closing of existing ramps and adding temporary ramps	▪ Opens up half of the freeway for construction ▪ Maintains traffic on the freeway and the frontage roads ▪ May reduce construction time	▪ May require temporary bridge widening ▪ May impact existing signal systems

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Temporary widening of the bridges can be done as a separate 2-lane wide structure. This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
MT-5	Eliminate all on and off ramps during construction	▪ Less temporary ramps required ▪ Less conflict points during construction	▪ May add a lot of traffic on the frontage roads and the arterial grid

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Combine with other ideas. This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
MT-6	Eliminate every other on and off ramp during construction	▪ This is currently allowed	▪

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
MT-7	Permanently shift the alignment and build half the freeway at a time	▪ Opens up half the freeway for construction	▪ Eliminate a frontage road ▪ ROW impacts ▪ May add cost

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Dropped from further consideration*
Rating: 2	

#	Description	Advantages	Disadvantages
MT-8	Hazardous material detour on frontage roads; corridor closed to all other traffic	▪ Allows a viable detour for hazardous material	▪ Hard to enforce ▪ Public relations issues/concerns

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Similar to MT-1. Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
MT-9	Maintain major crossroads open at all time	▪	▪

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This is the baseline*
Rating:	

#	Description	Advantages	Disadvantages
MT-10	Execute Central Avenue as a standalone project	▪ Accommodates Valley Metro schedule	▪ Might extend the construction staging of the I-17 corridor

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: Only consider if this project doesn't move forward as planned. Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
MT-11	Phase the wall construction prior to impacts to I-17	▪ Minimizes impacts to I-17	▪ Could have major impacts on the Frontage Roads

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 3.5	

Function: Reduce Risk

#	Description	Advantages	Disadvantages
RR-1	Drainage 1: Peak discharge mitigation basins; water quality BMP's	▪	▪ May require ROW

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This is the baseline condition*
Rating:	

#	Description	Advantages	Disadvantages
RR-2	Obtain permits for discharge to the river	▪	▪

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This is the baseline condition*
Rating:	

#	Description	Advantages	Disadvantages
RR-3	Build the footing for the ultimate wall height	▪ Reduce throw away ▪ Allows future flexibility for expansion	▪ Wall might still not be in the right place, horizontally ▪ Still needs an assumption for ultimate wall height ▪ May increase cost

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

#	Description	Advantages	Disadvantages
RR-4	Build the walls full height at the inside edge of the frontage roads	▪ Provides flexibility for future widening	▪ May increase cost ▪ May have ROW impacts with frontage road realignment ▪ Construction impacts to the frontage roads

Mainline Operations	Local Operations	Maintainability	Construction Impacts	Environmental Impacts	Project Schedule

Cost:	*Justification/Comments: This idea was moved forward for further development.*
Rating: 4	

Development Phase

The VE recommendations are presented as written by the team during the Value Planning Study. While they have been edited from the CRA & Value Planning Report to correct errors or better clarify the recommendation, they represent the Value Planning Team's findings during the study. Table 14 provides a summary of all recommendations generated and their potential cost impact to the project.

Table 14: Summary of Recommendations

#	Description	Value ($M)	Probability of Implementation
1	Bridge Lengths	-7.4	90%
2	Remove 3rd Street Bridge	-0.7	75%
3	Accelerated Bridge Const. (ABC)	NQ	
4	Reverse Ramps	5.3	75%
5	Walls at Frontage Roads	12.8	
6	Roadway Width	8.1	
7	Maintenance of Traffic (MOT)	-12.5	60%

The cost comparisons reflect a difference or delta between the baseline idea and the VE recommendation. As the project progresses, these values can be updated to reflect actual implemented results.

FHWA Function Benefit Criteria

Each year, State Department of Transportation (DOT) offices are required to report on VE Recommendations to the Federal Highway Administration (FHWA). In addition to cost implications, FHWA requires the DOTs to evaluate each approved recommendation in terms of the project feature or features that recommendation benefits. If a specific recommendation can be shown to provide benefit to more than one feature described below, count the recommendation in *each category that is applicable*. These same criteria can be found on each of the individual recommendations that follow.

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

Value Engineering Recommendation Approval

The VE Recommendation form is to aid in annual reporting of VE activities to FHWA. It is the intent that the project manager review and evaluate the report. The Project Manager would then complete the Recommendation Approval form shown in the Appendix.

Each recommendation that is not approved or is modified by the Project Manager should include a justification (a summary statement containing the Project Manager's decision not to use the recommendation in the project).

The completed Value Engineering Recommendation Approval form, including justification for any recommendations not approved or modified, shall be sent to the Program Manager so the results can be included in the annual VE Report to FHWA.

Recommendations

Based on the evaluation process, individual recommendations were developed. Each recommendation consists of a summary of the original concept, a description of the suggested change, a listing of its advantages and disadvantages, and a brief narrative that includes justification, sketches, photos, assumptions and calculations (where applicable) as developed by the Team.

VP RECOMMENDATION No. 01
BRIDGE LENGTH

Function: Span Roadway	**IDEA NO(s).SR-5, SR-6, SR-10, SR-14, SR-15, SR-20, SR-21**

Baseline:

- The baseline design assumes adding 30 feet of span length (total span length of 60 feet) to each side of the cross street to accommodate future needs of the existing street facility.
- The baseline design assumes the new bridges have the same number of spans as the existing bridges.

Recommendation:

- Maintain / reduce bridge length based on specific needs of each cross street.
- Look at a single span option at 16th Street, 7th Street, 7th Avenue and 15th Avenue.
- Look at 2-span option for Central Avenue Bridge to accommodate Valley Metro and reduce structure depth.

Advantages:

- Current roadway is at its ultimate configuration
- Reduce cost from 60-foot base line cost
- Reduction in maintenance
- Remove pier where currently exists

Disadvantages

- Constrain future widening of cross street
- May conflict with existing abutments
- Increases structure depth

COST SUMMARY	COST
Baseline	**$17.7 M**
Recommendation	**$12.5 M**
Cost Savings	**$5.2 M + 42.4% markup = $7.4 M**

FHWA Functional Benefits

Safety	Operations	Environment	Construction	ROW
			✓	

VP RECOMMENDATION No. 01
BRIDGE LENGTH

Discussion/Justification/Sketches/Photos:

The following cross street classification (based on City of Phoenix Street Classification Map dated March 19, 2014) are assumed for this recommendation:

- 16th Street – Arterial
- 7th Street – Major Arterial
- Central Avenue – Arterial
- 7th Avenue – Arterial (assume a Major Arterial for this study)
- 15th Avenue – Minor Collector
- 19th Avenue - Major Arterial

The following cross street typical sections(based on City of Phoenix Street Classification Map (dated March 19, 2014) are assumed for this recommendation:

- Major Arterial - 3 through lanes, 2 left turn lanes, bike lane and sidewalk area in each direction for a total length of 130 feet.
- Arterial - 3 through lanes, 1 left turn lane, bike lane and sidewalk area in each direction for a total length of 110 feet.
- Minor Collector - 1 through lane, 1 left turn lane, bike lane and sidewalk area in each direction for a total length of 80 feet.

VP RECOMMENDATION No. 01
BRIDGE LENGTH

Assumptions and Calculations:

The following reduction in bridge length from the base estimate is assumed for this recommendation:

- 16th Street – Arterial 162' – 110' = 52', Assumed bridge width = 135'
  - Savings = 52' x 135' x 120/sq ft = $840,000
- 7th Street – Major Arterial 164' – 130' = 34', Assumed bridge width = 130'
  - Savings = 34' x 130' x 120/sq ft = $530,000
- Central Avenue – Arterial 185' – 110' = 75', Assumed bridge width = 152'
  - Savings = 75' x 152' x 120/sq ft = $1,360,000 (assume 2 span)
- 7th Avenue – Arterial (assume a Major Arterial for this study) 162 – 130' = 32', Assumed bridge width = 128'
  - Savings = 32' x 128' x 120/sq ft = $490,000
- 15th Avenue – Minor Collector 160' – 80' = 80', Assumed bridge width = 152'
  - Savings = 80' x 152' x 120/sq ft = $1,460,000
- 19th Avenue - Major Arterial 164' – 130' = 34', Assumed bridge width = 135'
  - Savings = 34' x 135' x 120/sq ft = $550,000

Total Savings = $5,230,000

VP RECOMMENDATION No. 02
Remove 3rd Street Bridge

Function: Span Roadway	**IDEA NO(s).** SR-11, SR-12

Baseline:

- The existing bridge at 3rd Street was originally spanning a railroad spur line. The spur line as since been abandoned and removed. The baseline design assumes the bridge is replaced with a reinforced box culvert to accommodate pedestrians.

Recommendation:

- Remove the pedestrian crossing and replace it with roadway embankment.
- The I-17 mainline profile grade was set to allow clearance over the railroad spur line. The revised use of the 3rd Street crossing allows lowering of the I-17 main line which improves the profile grade of the 7th Street ramps.

Advantages:

- Reduces cost
- Reduces construction duration
- May help lower the I-17 profile and flatten the ramp grade

Disadvantages

- Could lead to pedestrian crossing concerns

COST SUMMARY	COST
Baseline	**Not Quantified**
Recommendation	**Not Quantified**
Cost Savings	**$0.5 M + 42.4% markup = $0.7 M**

FHWA Functional Benefits

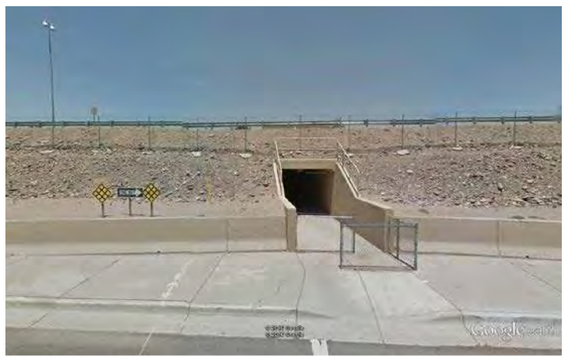
Safety	Operations	Environment	Construction	ROW
			✓	

VP RECOMMENDATION No. 02
Remove 3rd Street Bridge

Discussion/Justification/Sketches/Photos:

The existing crossing is a bridge over an abandoned rail line

The proposed pedestrian crossing is assumed to be a 10’ x 10’ reinforced box culvert with a length of 170 feet. Similar to what is shown below.



VP RECOMMENDATION No. 02
Remove 3rd Street Bridge

Assumptions and Calculations:

The unit cost of the box culvert is $60 / sq. ft.

- Remove 3rd Street pedestrian structure:
  - 10’ x 170’ x $60 / sq. ft. = $102,000
- Add roadway fill in place of box culvert:
  - (10’ x 10’ x 170’)/27 x $7/CY = $5000
- Estimated savings of earthwork and walls from lowering profile grade of I-17 = $400,000

Total savings = $102,000 - $5000 + $400,000 ~ $500,000

VP RECOMMENDATION No. 03
ABC Construction

Function: Span Roadway

IDEA NO(s).SR-1, SR-2, SR-4

Baseline:

- The base line design assumed conventional bridge construction

Recommendation:

- Use Accelerated Bridge Construction (ABC)
- Use precast panels for the bridge deck
- Use adjacent precast concrete box beams

Advantages:

- Reduces construction duration
- Precast panels for the bridge deck
  - Eliminates deck forming
  - May avoid closure during deck placement
- Precast concrete box beams
  - Lower profile
  - Less Earthwork required for mainline
  - Reduces construction duration
  - Eliminates deck forming
  - May avoid closure during deck placement

Disadvantages

- Precast panels for the bridge deck
  - Still requires an overlay
  - Could cost more
  - Could have Long Term maintenance issues
- Precast concrete box beams
  - Could cost more
  - Limited span length
  - Maybe limited suppliers
  - Utilities across the bridge may be hard to accommodate

COST SUMMARY	COST
Baseline	**Not Quantified**
Recommendation	**Not Quantified**
Cost Savings	**Not Quantified**

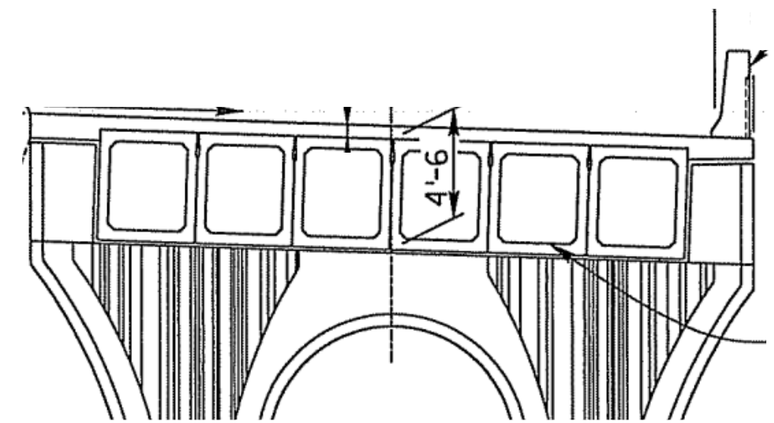
FHWA Functional Benefits

Safety	Operations	Environment	Construction	ROW

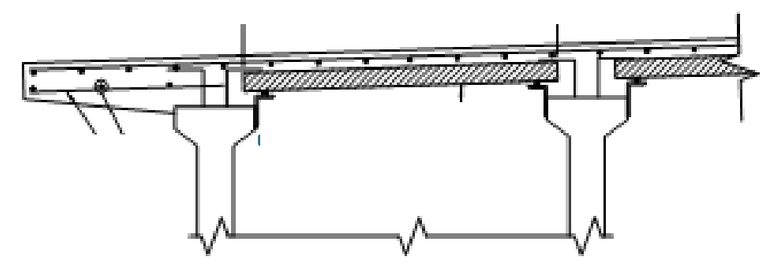
VP RECOMMENDATION No. 03
ABC Construction

Discussion/Justification/Sketches/Photos:

Typical Precast Box Beam (130' span) shown below:



Typical Deck Panel shown below:



VP RECOMMENDATION No. 03
ABC Construction

Assumptions and Calculations:

Consider using precast panels or precast box beams at the following locations:

- 16th Street
- 7th Street
- Central Avenue
- 7th Avenue
- 15th Avenue
- 19th Avenue

VP RECOMMENDATION No. 04
Reverse Ramps, 19th Avenue to 7th Avenue, 7th Street to 16th Street

Function: Widen Roadway	**IDEA NO(s).** SR-24

Baseline: Baseline design assumes replacing all bridges and pavement on the mainline and ramps, adding 7 feet through the corridor length to bring shoulders up to standards, and adding auxiliary lanes between 19th Avenue to 7th Avenue, 7th Avenue to 7th St, and 7th St to 16th Street.

Recommendation: This recommendation proposes to reverse the ramp configuration between 19th Avenue and 7th Avenue with a split diamond at 11th Avenue and 15th Avenue, and between 7th Street and 16th Street with a frontage road level collector-distributor road. Reverse ramps do not appear to be feasible between 7th Avenue and 7th Street due to the increase in traffic crossing volume of Central Avenue, and how this will conflict with the LRT line in that corridor.

Advantages:

- Eliminates Off-ramp to crossroad weave section at the westbound 19th Avenue off ramp, the eastbound 7th Avenue off ramp, the westbound 7th Street off ramp, and the eastbound 16th Street off ramp.
- Shifts four aux lanes from the elevated mainline to the at grade frontage road, saving money on embankment, walls, and mid mile bridge widening's.
- Steep west side 7th Avenue ramps are replaced with much flatter ramps.
- Ramps can be located where space permits to avoid pinch points. Leaves adequate width for mainline HOV lane.
- Mainline operations are improved by shifting the "weave" to off the mainline. Off-ramps will likely not backup onto mainline now.
- 7th Avenue eastbound off and westbound on ramps, and the 7th Street eastbound on and westbound off ramps, could be used to access frontage roads for certain MOT phasing schemes.

Disadvantages

- Additional bridge widening at 19th Avenue, 7th Avenue, 16th Street, and possibly 7th Street.
- May need to add mainline eastbound aux lane between 7th Street on-ramp and I-10 off ramp.
- 12th Street pedestrian tunnel will need to be removed / abandoned.
- Some ROW would be warranted, but the ramps can be shifted horizontally to acquire vacant or low utilized parcels. Do not expect the incremental ROW to induce significant impacts.
- Westbound 19th Avenue traffic now has to cross 11th Avenue (RR spur crossing) and 15th Avenue at grade. Eastbound 7th Avenue traffic now has to cross 15th Avenue and 11th Avenue (RR spur crossing) at grade. These are lightly traveled roadways, so operational issues are not expected to be significant with proper signal design.
- Westbound off-ramp to 11th/15th/19th Avenue could queue up onto mainline during times when a train passes on 11th Avenue. A traffic micro-simulation will need to be performed based on train frequency, length and time of day use to determine if this is an issue. If it is, westbound off-ramp gore may need to shift as far east as possible to maximize queuing storage on the ramp and consider making it a two-lane exit condition.
- Will require a change of access report

COST SUMMARY	COST
Baseline	**$0 M**
Recommendation	**$3.7 M**
Cost Added	**$3.7 M x 42.4% markups = $5.3 M**

FHWA Functional Benefits

Safety	Operations	Environment	Construction	ROW

VP RECOMMENDATION No. 04
Reverse Ramps, 19th Avenue to 7th Avenue, 7th Street to 16th Street

Discussion/Justification/Sketches/Photos:

Between 19th Avenue and 7th Avenue, reversing the ramps will avoid the steep profile ramp grades on the west side 7th Avenue TI due to the RR spur crossing at 11th Avenue. The frontage road between 15th Avenue and 11th Avenue will continue to operate as a connector roadway between those two cross streets, essentially creating a split diamond configuration that avoids ROW issues. Possible ROW issues (access) may exist north of freeway between 11th Avenue and 7th Avenue, and north of freeway between 19th Avenue and 15th Avenue, but they appear to be minor.

Between 7th Street and 16th Street, the right-in/right-out intersections on the frontage road with 12th Street will require special treatment by barrier separating the intersection from the frontage road ramp weave section. See detail below.

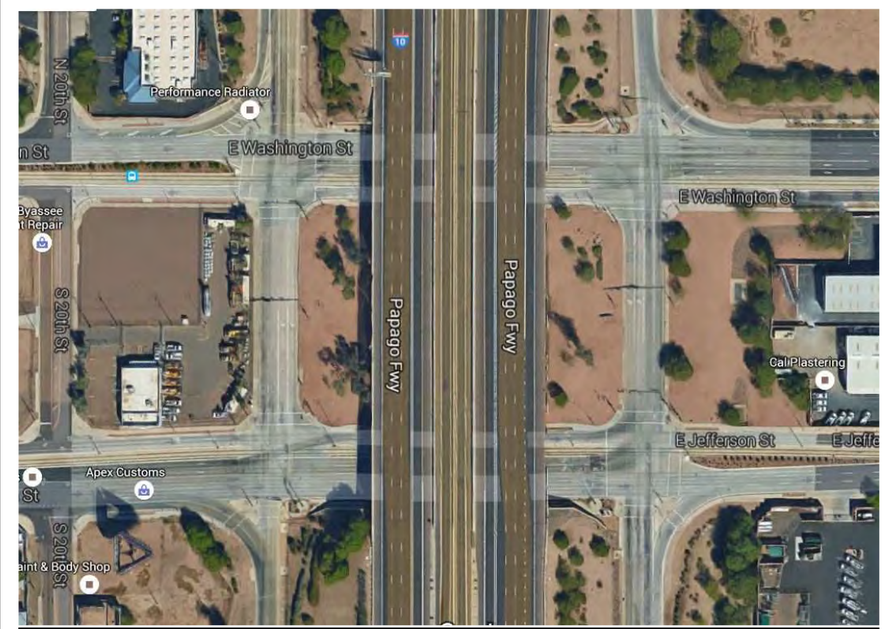
<u>19th Avenue to 7th Avenue (Split diamond at 15th/11th Avenue):</u>

Frontages roads between 15th Avenue and 11th Avenue remain as is. Realign frontage roads between 19th Avenue and 15th Avenue to take advantage of low utilized or vacant parcels to improve ramp geometry and location. Would suggest cul-de-sacing 16th Avenue on south side of freeway to eliminate frontage road connection. If not possible, utilize strategy shown below to barrier separate a right-in/right-out connection to 16th Avenue.

The split diamond configuration proposed between 15th Avenue and 11th Avenue with full signal control at all four frontage road/ramp terminal intersections (including railroad gates at 11th Avenue) should alleviate any access control concerns. Similar applications have been applied around the country. The first occurs right here in Phoenix at the Washington/Jefferson split diamond at I-10 in which light rail tracks run down both of the one-way arterials (similar to the railroad spur in 11th Avenue). A second application can be seen on I-20 in southwest Dallas. Exhibits for both installations are shown below:

VP RECOMMENDATION No. 04
Reverse Ramps, 19th Avenue to 7th Avenue, 7th Street to 16th Street

I-20/Main St/Duncanville Road Split Diamond, SW Dallas

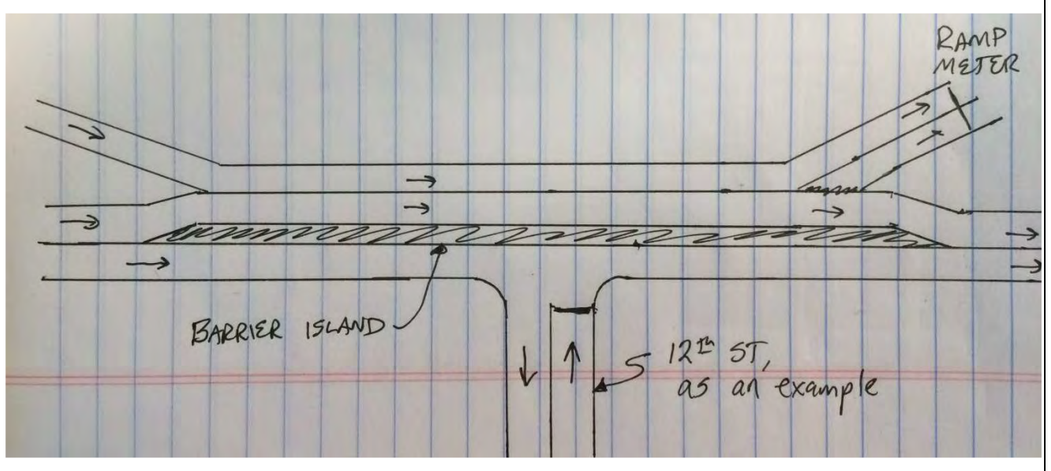


VP RECOMMENDATION No. 04
Reverse Ramps, 19th Avenue to 7th Avenue, 7th Street to 16th Street

7th Street to 16th Street (C-D at frontage road)

Suggest realigning WB frontage road approaching 7th Street to utilize vacant parcel up to Durango Street to maximize desirability of ramp geometry. Because of the local street and driveway access along both frontage roads within weave section, need to split the road as shown below. Because of this design, the 12th Street pedestrian tunnel needs to be removed or abandoned.

7th Street to 16th Street Frontage Road modification to add C-D road:



VP RECOMMENDATION No. 04
Reverse Ramps, 19th Avenue to 7th Avenue, 7th Street to 16th Street

Assumptions and Calculations:

19th Avenue to 7th Avenue, WB direction: (cost increase of $800K w/o markups)

Assume: Ramp and Aux lane paving, walls, drainage, and paving items the same.

Cost Savings: (-$390K)

- Aux Lane EW embankment – 25K CY borrow @ $7/CY = $175K
- 15th Avenue Bridge widening 12' reduction – 960 SF @ $120/SF = $115K
- 11th Avenue Bridge widening 12' reduction – 840 SF @ $120/SF = $100K

Cost Additions: (+$1,192K)

- 1250' frontage road realignment – 4000 SY @ $45/SQ = $180K
- New ROW (triangular parcel with 2 billboards) – 1.75 AC = $500K
- 7th Avenue WB structure widening for 19th Avenue exit taper – 2600SF @ $120/SF = $312K
- New frontage road/15th Avenue and 11th Avenue signals (2 total @ $100K ea) = $200K

19th Avenue to 7th Avenue, EB direction: (cost increase of $550K w/o markups)

Assume: Ramp and Aux lane paving, walls, drainage, and paving items the same.

Cost Savings: (-$390K)

- Aux Lane EW embankment – 25K CY borrow @ $7/CY = $175K
- 15th Avenue Bridge widening 12' reduction – 960 SF @ $120/SF = $115K
- 11th Avenue Bridge widening 12' reduction – 840 SF @ $120/SF = $100K

Cost Additions: (+$942K)

- 1250' frontage road realignment – 4000 SY @ $45/SQ = $180K
- New ROW sliver between 19th Avenue and 16th Avenue – 1.0 AC = $150K
- 19th Avenue EB structure widening for 7th Avenue exit taper – 2600SF @ $120/SF = $312K
- Cul-de-sac 16th Avenue = $100K
- New frontage road/15th Avenue and 11th Avenue signals (2 total @ $100K ea) = $200K

7th St to 16th St, WB direction: (cost increase of $860K w/o markups)

Assume: Ramp and Aux lane paving, walls, drainage, and paving items the same.

Cost Savings: (-$175K)

- Aux Lane EW embankment – 25K CY borrow @ $7/CY = $175K

Cost Additions: (+$1,036K),

VP RECOMMENDATION No. 04
Reverse Ramps, 19th Avenue to 7th Avenue, 7th Street to 16th Street

- 1250' frontage road realignment – 4000 SY @ $45/SQ = $180K
- New ROW sliver south of Durango Road – 1.0 AC = $100K
- 7th St WB structure widening for 16th St entrance taper – 2600SF @ $120/SF = $312K
- 16th St WB structure widening for 7th St. exit taper – 2200SF @ $120/SF = $264K
- WB frontage road barrier separation – 3000 ft @ $60/ft = $180K

7th St to 16th St, EB direction: (cost increase of $1.5M w/o markups)

Assume: Ramp and Aux lane paving, walls, drainage, and paving items the same.

Cost Savings: (-$175K)

- Aux Lane EW embankment – 25K CY borrow @ $7/CY = $175K

Cost Additions: (+$1,720K),

- 7th Street to I-10 Aux Lane Paving – 6000 SY @ $45/SQ = $270K
- 7th Street to I-10 Aux Lane E/W – 25K CY borrow @ $7/CY = $175K
- 7th Street to I-10 Aux Lane barrier, traffic, drainage – 2500 (linear feet) lf @ $150/LF = $375K
- 7th St EB structure widening for 16th St exit taper – 2600SF @ $120/SF = $312K
- 16th St EB structure widening for 7th St. entrance taper – 2200SF @ $120/SF = $264K
- EB frontage road barrier separation – 3000 ft @ $60/ft = $180K
- 1000' frontage road realignment – 3200 SY @ $45/SQ = $144K

VP RECOMMENDATION No. 05
Walls at Frontage Roads

Function: Reduce Risk	**IDEA NO(s).** RR-3

Baseline: Install permanent walls to accommodate bridge/roadway widening to ADOT and AASHTO standards and raise vertical profile of the roadway to accommodate underpass vertical clearances. Replace with like-kind lanes, full shoulders, and add auxiliary lanes in certain locations (i.e. between on/off ramps and I-10 EB to I-17 NB). No provisions for future HOV lanes or other widening is included in the baseline design.

Recommendation: Place permanent walls to the inside edge of frontage roads to allow the widest possible mainline width in order to accommodate both present and future widening so that the walls will never need to be removed.

Advantages:

- Provides flexibility for future widening.
- Ease of construction building walls near the frontage road as opposed to near the elevated mainline.
- Improved construction phasing.

Disadvantages

- Will increase cost
- May have ROW impacts with frontage road realignments in pinch areas.
- Construction impacts to the frontage roads, both in terms of pavement removals and replacement, and frontage road traffic impacts.

COST SUMMARY	COST
Baseline	**$24.0M**
Recommendation	**$33.0 M**
Cost Increase	**$9.0 M + 42.4% markup = $12.8 M**

FHWA Functional Benefits

Safety	Operations	Environment	Construction	ROW

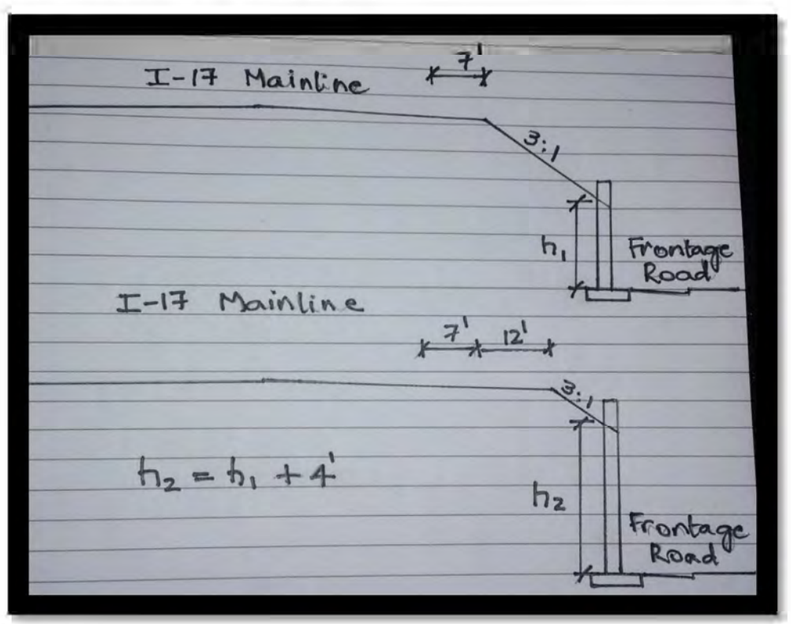
VP RECOMMENDATION No. 05
Walls at Frontage Roads

Discussion/Justification/Sketches/Photos:

The base includes almost $24 million (without markups) of wall area that will accommodate Near Term widening to replace the existing roadway to meet AASHTO standard roadway shoulder widths and auxiliary lanes in certain locations. These walls may then require replacement when the project corridor is widened to accept a future HOV lane. To avoid potential replacement of these Near Term walls, the alternative is to install walls at the inside shoulders of the frontage roads and to the ultimate height to accommodate a future 12' mainline widening project.

A detailed analysis was undertaken to locate wall locations with the base design described above. As part of this analysis, 475,000 SF of wall was computed over a total wall length of 40,700 LF. At $50/SF, this equates to about $24M in wall costs without markups. This analysis assumed the walls were located at either the inside of the frontage road, or the left edge of the ramps, which ever applied. Height was computed based on Google mapping elevation information, and available offset for 3:1 slopes between the mainline/ramp and the frontage road. Three extra feet was added for foundations and parapets.

Because of the methodology used for the base design, the incremental wall height would have to increase approximately 4 feet everywhere to accommodate an additional 12 feet of widening on the mainline in each direction. 40,700 LF X 4 FT = 163,000 SF. At $50/SF (without markups), this equates to $8.2M more dollars just in wall cost.



VP RECOMMENDATION No. 05
Walls at Frontage Roads

Assumptions and Calculations:

Added Wall Height:

Assume 40,700 LF of wall is increased 4 extra feet in height: (40,700)(4)($50/SF) = $8.2M

Added Embankment:

Assume 40,700 LF long, 4 LF high, and 25 LF wide (25 feet being the assumed average width remaining between the mainline and the frontage road after the HOV widening): (40,700)(4)(25)/27 = 150,000 CY borrow at $7/CY = $1.05M

Item Description	Unit	Baseline			Recommendation		
		Qty	Unit Cost	Total	Qty	Unit Cost	Total
Retaining Wall	SF	475,000	$50	$24,000,000	638,000	$50	$31,900,000
Borrow	CY				150,000	$7	$1,050,000
Total Cost			**Baseline**	**$24,000,000**	**Recommendation**		**$32,950,000**
						Cost Added	**$8,950,000**

VP RECOMMENDATION No. 06

Roadway Section

Function: Widen Roadway	**IDEA NO(s).** WR-3

Baseline: The baseline assumes three GP lanes and 12-foot inside and outside shoulders

Recommendation: Build the roadway and bridges to accommodate future HOV lane

Advantages:

- Eliminates impacts to I-17 when additional HOV is added
- Extra width for maintenance

Disadvantages

- Extra width to maintain
- Added cost
- May not need extra width for several years
- May have ROW impacts

COST SUMMARY	COST
Baseline	
Recommendation	**See Calculations**
Cost Added	**$5.68 M + 42.4% markup = $8.09 M**

FHWA Functional Benefits

Safety	Operations	Environment	Construction	ROW

VP RECOMMENDATION No. 06

Roadway Section

Discussion/Justification/Sketches/Photos:

The baseline assumes 12-foot inside and outside shoulders

Baseline Roadway with Aux Lanes

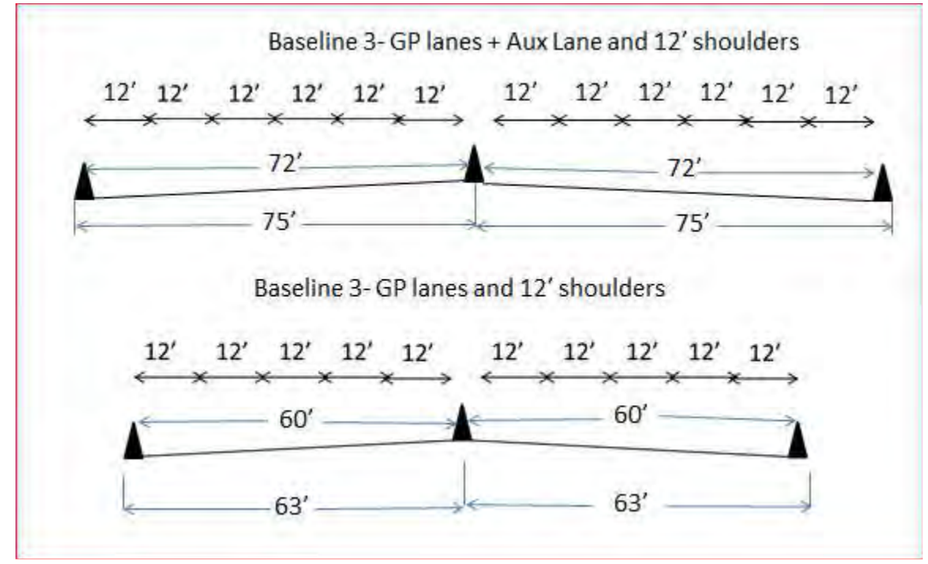
= 2 x 12-foot shoulders + 3 x 12-foot GP Lanes + 1 x 12-foot Aux lane

= 72 feet (inside to inside); 75 feet (centerline of barrier to outside of barrier)

Baseline Roadway without Aux Lanes

= 2 x 12-foot shoulders + 3 x 12-foot GP Lanes

= 60 feet (inside to inside); 63 feet (centerline of barrier to outside of barrier)



VP RECOMMENDATION No. 06

Roadway Section

This recommendation is to widen the roadway and bridges to accommodate the ultimate need of an HOV GP lane in each direction. This will eliminate the future impacts to I-17 to widen for this additional capacity requirement. Adding HOV to this section is in the current long term program. It does not make since to complete the Aux lane project in 2021 and come back in 2023 to add HOV.

By implementing the recommendations for the X-ramps and walls there is enough room to build to full standards including HOV

Recommended Roadway 3 GP lane 1 HOV lane and 1 Aux Lanes between 7th Street and 7th Avenue

= 2 x 12-foot shoulders + 3 x 12-foot GP Lanes + 1 x 12-foot Aux lane + 1 12 foot HOV lane

= 84 feet (inside to inside); 87 feet (centerline of barrier to outside of barrier)

Recommended Roadway without Aux Lanes

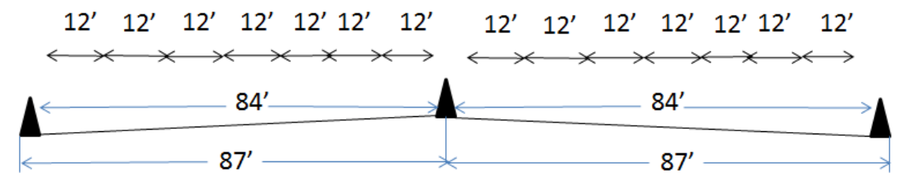
= 2 x 12 -foot shoulders + 3 x 12-foot GP Lanes + 1 12-foot HOV lane

= 72 feet (inside to inside); 75 feet (centerline of barrier to outside of barrier)

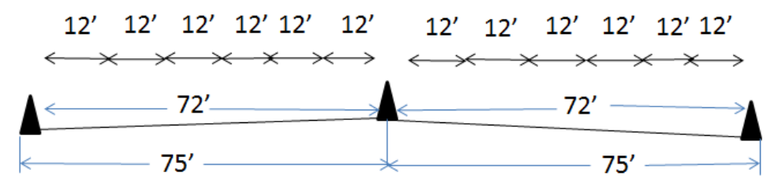
VP RECOMMENDATION No. 06

Roadway Section

Recommend 7th St to 7th Ave
3- GP lanes + HOV+ Aux Lane and 12' shoulders



Recommend 3- GP lanes + HOV and 12' shoulders



VP RECOMMENDATION No. 06

Roadway Section

Assumptions and Calculations:

For adding an HOV lane in each direction

Pavement:

Length: 3.57 miles *5280 feet/mile -1200 feet (for bridge lengths)

Width: 24 feet (one lane in each direction)

Area: 47,066 sq. yd.

Price: $45 per sq. yd.

Cost: $2,117,952

ARFC:

ARFC Overlay: 47,066*118/2000 = 2,777 Tons

Price: $40 per ton

Cost: $111,076

Bridge costs 1200 feet by 24' wide =28,800 sf

Price $120 sf

Cost $3,456,000

Total Cost: $5,684,028

$5,864,028 * 42.2% markups = $8.09M

48.09M/24 =$0.34M per foot of widening

If we use 10" shoulders you can reduce the roadway width by 8 feet and reduce the cost by $2.7M

Recommend full standards

VP RECOMMENDATION No. 07

MOT & Project Staging

Function: Maintain Traffic

IDEA NO(s).

Baseline: The base project is to construct the corridor in the ultimate configuration with a raised profile, revised ramps to place auxiliary lanes on both the frontage roads and mainline, and construct retaining walls to accommodate both current and future widening plans (HOV and auxiliary lanes). The base cost for MOT assumes that a median traffic shift will be implemented with temporary widening on one side of the freeway to accommodate both NB and SB I-17 traffic. This allows one side of the freeway to be constructed all at once. Traffic will then shift to the new side and the remaining construction will be completed. All ramps will be closed along the corridor with the exception of the utilization of ramps North of 19th Ave and new ramps to be placed east of 16th Street.

Recommendation: The recommendation is to use the frontage roads to accommodate detour traffic from I-17 following installation of permanent drainage, retaining walls, and any temporary features required to accommodate traffic along the frontage roads. Once traffic is diverted to the frontage roads, the mainline of I-17 will be closed to allow construction to be completed using detours and bypass routes. Traffic will be returned to the mainline once construction is complete. This scenario is dependent on a traffic study to determine if the frontage roads need to be widened to possibly three lanes in certain areas and the permanent wall locations do not limit the traffic volume through the detour section. It is also dependent on the opening of the South Mountain Freeway to accommodate the main alternate route for both hazardous materials and bypass traffic. Both frontage roads and other arterial routes will be used to accommodate local traffic.

Advantages:

- Develops preliminary traffic/construction staging plan
- May improve mobility during construction
- May improve local traffic flow
- May decrease construction schedule

Disadvantages

- May add cost
- May require additional analysis prior to implementation
- Scenario 1 depending upon opening of South Mountain Freeway
- Restricts access
- May increase construction schedule

COST SUMMARY	COST
Baseline	**$17M**
Recommendation	**$8.5M**
Cost Savings	**$8.5M x Effective Markup 42.4% = $12.5M**

FHWA Functional Benefits

Safety	Operations	Environment	Construction	ROW

VP RECOMMENDATION No. 07
MOT & Project Staging

Discussion/Justification/Sketches/Photos:

There have been three scenarios established to accommodate MOT through the project corridor.

Scenario 1 utilizes a median crossover option with both NB and SB traffic moved to one side of the freeway. This option involves temporarily widening one side of the existing freeway to accommodate both NB and SB I-17 traffic. This widening will still allow many permanent features to be installed, including retaining walls, drainage and embankment that will be left in place, shortening the time frame that traffic is shifted. Once either NB or SB traffic is moved to one side, the other side of the freeway may be constructed. Once the first stage is complete, traffic will then be moved to the new alignment, allowing the remaining side of the freeway to be constructed. It is assumed that temporary ramps will be constructed at the beginning and end of the corridor to accommodate the exit ramps and entrance ramps that will be closed for one side of traffic.

Scenario 2 assumes that the frontage roads will accommodate detour traffic from I-17 following installation of both permanent drainage and retaining walls along the frontage roads. Once traffic is diverted to the frontage roads, the mainline of I-17 will be closed to allow construction to be completed using detours and bypass routes. Traffic will be returned to the mainline once construction is complete. This scenario is dependent on a traffic study to determine if the frontage roads need to be widened to possibly three lanes in certain areas and the permanent wall locations do not limit the traffic volume through the detour section. It is also dependent on the opening of the South Mountain Freeway to accommodate the main alternate route for both hazardous materials and bypass traffic. Both frontage roads and other arterial routes will be used to accommodate local traffic.

Scenario 3 has been established to consider an alternative of incorporating both Scenario 1 and Scenario 2 together. The frontage road work with permanent walls will be constructed first, followed by the implementation of a median crossover configuration to accommodate I-17 NB and NB traffic. This alternative would essentially limit the adverse affects to mobility, allow construction of one side of the freeway at a time, and decrease the amount of time I-17 capacity is limited. The option does increase MOT costs based on the requirement to both manage traffic on the frontage roads during the first phase of construction and develop the median crossover and temporary ramps during the next phase(s) of construction. In summary, the frontage road work with permanent drainage and wall construction would be performed during the first phase. Next, the median crossover would place both NB and SB I-17 on one side of the freeway, requiring temporary widening as described in Scenario 1. The configuration would then allow one side of the freeway to be constructed at a time, switching traffic to the new alignment once the first side, either NB or SB is complete. This option is the least restrictive to mobility, allowing the frontage roads and the temporary alignment to accommodate the same volume of traffic that exists today.

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Scenario 1: This scenario is the base traffic plan.

Stage 1:

1) Close frontage as needed to install permanent drainage features, retaining walls, and roadway/structure widening on one side required for median crossover configuration. Close lanes of mainline as required to install median crossover ramps, striping, temporary barrier, etc.
2) Shift either the NB traffic to the SB side or vice-versa.
3) Construct the NB or SB side of the entire corridor.

Stage 2:

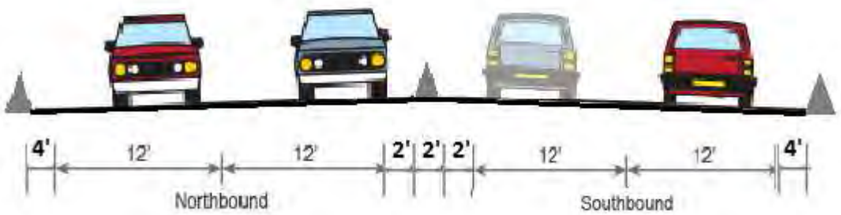
1) Shift both NB and SB traffic to the completed side of the newly constructed corridor.
2) Complete construction on the other side of the freeway.

Stage 3:

1) Open all traffic to the new alignments.

Median Crossover Typical Section

VP RECOMMENDATION No. 07
MOT & Project Staging



Median Crossover Cross Section

Scenario 2:

Stage 1 :

1) Close frontage roads.
2) Install permanent drainage on frontage roads and temporarily tie mainline drainage to permanent drainage on frontage roads. Drainage will run parallel with mainline and crossings will occur at cross streets.
3) Construct permanent retaining walls on frontage roads to accommodate mainline widening.
4) Complete temporary frontage road traffic modifications to accommodate detour traffic

Stage 2: **This requires South Mountain Freeway to be open first**

1) Close I-17 between 16th Street on the South and Buckeye Street to the North
2) Detour I-17 local traffic to frontage roads. Traffic will utilize I-10 and the South Mountain Freeway.
3) Construct I-17 mainline bridges and widen roadway
4) Open I-17 once construction is complete.

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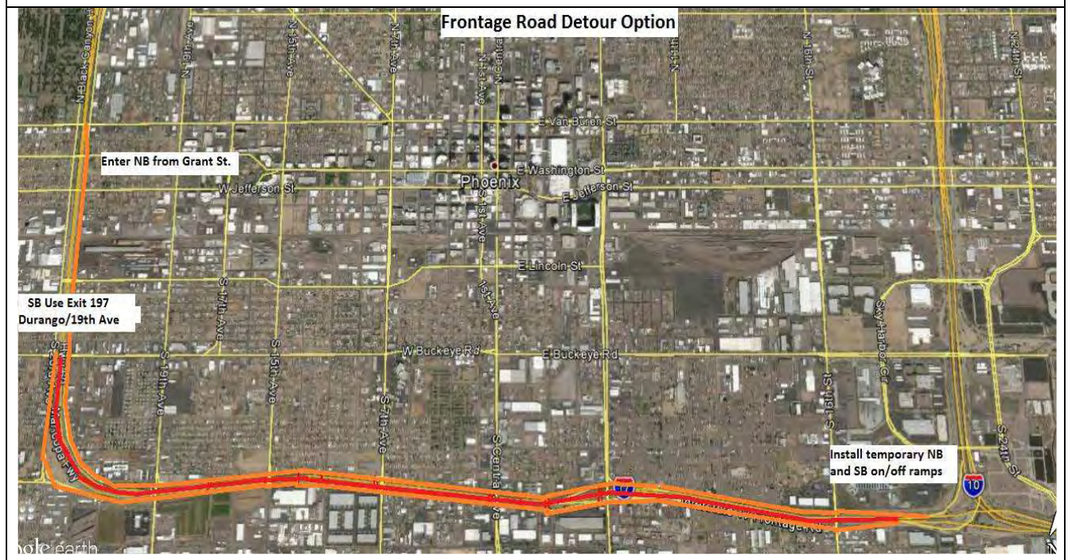

Scenario 3

Stage 1 :

1) Close frontage roads.
2) Install permanent drainage on frontage roads and temporarily tie mainline drainage to permanent drainage on frontage roads. Drainage will run parallel with mainline and crossings will occur at cross streets.
3) Construct permanent retaining walls on frontage roads to accommodate mainline widening.
4) Complete temporary frontage road traffic modifications to accommodate detour traffic

Stage 2

1) Close lanes of mainline as required to install median crossover ramps, striping, temporary barrier, etc.
2) Shift either the NB traffic to the SB side or vice-versa.
3) Construct the NB or SB side of the entire corridor.

Stage 3:

1) Shift both NB and SB traffic to the completed side of the newly constructed corridor.
2) Complete construction on the other side of the freeway.

Stage 4:

1) Open all traffic to the new alignments.

VP RECOMMENDATION No. 07
MOT & Project Staging

Assumptions and Calculations:

Base estimate has $17M allocated for MOT to perform the planned median traffic switch and close the ramps. The recommendation assumes approximately $2.5M per mile to perform frontage road upgrades, both for the NB and SB side. The potential savings is estimated to be $8.5M. Scenario 3, due to the complexity and combination of both Scenario 1 and Scenario 2 configurations, is estimated to be slightly higher in cost versus Scenario 1, potentially raising the MOT costs to $20M. This would increase the baseline costs $3M to accommodate traffic.

Item Description	Unit	Baseline			Recommendation		
		Qty	Unit Cost	Total	Qty	Unit Cost	Total
Traffic Control	LS	1	$17,000,000	$17,000,000	1	$8,500,000	$8,500,000
Total Cost			**Baseline**	**$17,000,000**		**Recommendation**	**$8,500,000**
						Cost Avoidance	**$8,500,000**

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Analysis of Results

In evaluating the risk for the project, a cost risk assessment/value engineering or CRAVE process was utilized. The cost risk assessment portion of the evaluation was used to identify the range of unexpected project costs as it relates to total project cost, as well as potential delays in schedule that might arise.

The Value Planning Team discussed the potential risk events and elements facing the project. During the discussion of the project, the Team identified high risk elements or potential events, which may occur and that would impact the project. For each significant risk event that was identified, the probability of the risk and its impact to cost, schedule, or both was estimated.

The risk assessment process includes identifying high risk areas and risk elements as threats (or opportunities where appropriate) to a project, quantifying the identified risk elements, developing appropriate risk response strategies, and quantifying the effects of the risk response strategies to be employed.

The risk assessment process quantified risk events by establishing the expected probability of occurrence and range of impacts through elicitation of information from the Value Planning Team. The range of impacts defines the representative distribution to be used when modeling the risk. The probability determines the relative frequency (or likelihood) of an event transpiring.

Risk Analysis

New and innovative approaches inherently carry risk; the team identified the risks associated with these types of VE recommendations and risk response strategies.

To quantify these impacts, the VE recommendations and the response strategies were input into scenario models as opportunities or threats in terms of their likely impact, as well as the probability of the implementation of the recommendation. Risk response strategies were defined and quantified for each of the risks that were not modified by VE recommendations.

At this point, a cumulative cost curve was generated that represented both the impacts of responding to the risk elements and partially or fully implementing the VE recommendations. By treating the VE recommendations as an opportunity to increase value through performance increases and cost reductions, it was demonstrated that further cost and schedule efficiencies could be obtained for the project.

The Team identified 25 active risks that pose potential schedule and/or cost threats as well as opportunities for the project:

1. CNS 10.01 Maintenance of Traffic Ultimate Configuration
2. CNS 10.02 Detour Costs
3. CNS 900.02 Construction Change Orders
4. CTR 10.01 Change in Project Delivery
5. DES 10.01 ADA at Intersections
6. DES 10.02 Sidewalks on Frontage Roads

7. DES 10.04 Third Avenue Bridge
8. DES 10.05 Structure Length Modifications
9. DES 10.06 SR-30 Connection at Durango Curve
10. DES 10.08 Unsuitable Material
11. DES 10.09 Reverse Ramps
12. DES 50.03 ITS/FMS Ultimate
13. DES 900.02 Opportunity to Reduce Design Time
14. DES 900.03 Design Schedule
15. ENV 10.01 Environmental Documentation – Ultimate
16. ENV 40.01 Cultural
17. ENV 50.01 Hazardous Materials in Existing Structures
18. ENV 70.01 Drainage – Ultimate
19. PSP 900.01 Coordination with Stakeholders
20. ROW 60.01 ROW Impacts (Drainage, Intersections, ADA, Access Control) – Ultimate
21. RR 20.01 Railroad Coordination and Flagging
22. STG 10.02 Central Avenue – Ultimate
23. STG 10.03 11th Avenue Substructure
24. STG 10.04 Wall Types – Ultimate
25. STG 900.01 ABC and Other Bridge Construction Methods

Other risks that were either changed to 'Inactive' status or 'Retired' based on current input include:

26. DES 10.03 Design Elements
27. DES 10.07 19th Avenue Overpass
28. STG 20.02 Geotechnical Opportunity – Ultimate
29. ENV 90.01 Noise Walls – Ultimate
30. PSP 20.01 Public Relations
31. STG 20.01Slopes - Ultimate

The Risk Data Sheets provided in the Appendix of this report shows additional information specific to each risk as identified by the team.

Top Risk Factors

After the risks were identified, the Value Planning Team focused on responding to those risks that were the most likely to happen or which held a significant impact if the risk event occurs. Using the information portrayed in the tornado diagrams, the highest risk elements received the most focus.

The expected value (likelihood multiplied by expected risk outcome) tornado diagrams depict the actual expected values of the identified risks and help summarize the evolution the project has gone through by engaging in the CRAVE process (see appendix). Not all risks identified require immediate management. Often, a project team needs to prioritize the risks for which it plans to develop strategies in the future in an effort to make the best use of the time available. An example would be to begin with the risks with the highest cost and schedule impacts.

Within the diagrams, the risks have the expected values plotted prior to responding to the risks and implementing the VE recommendations and risk response strategies (red bars) and after responding to the risks and implementing VE recommendations at their expected likelihood (green bars).

The tornado diagrams for the top risks impacting both cost and schedule for the project are provided in Figure 5 and Figure 6 respectively.

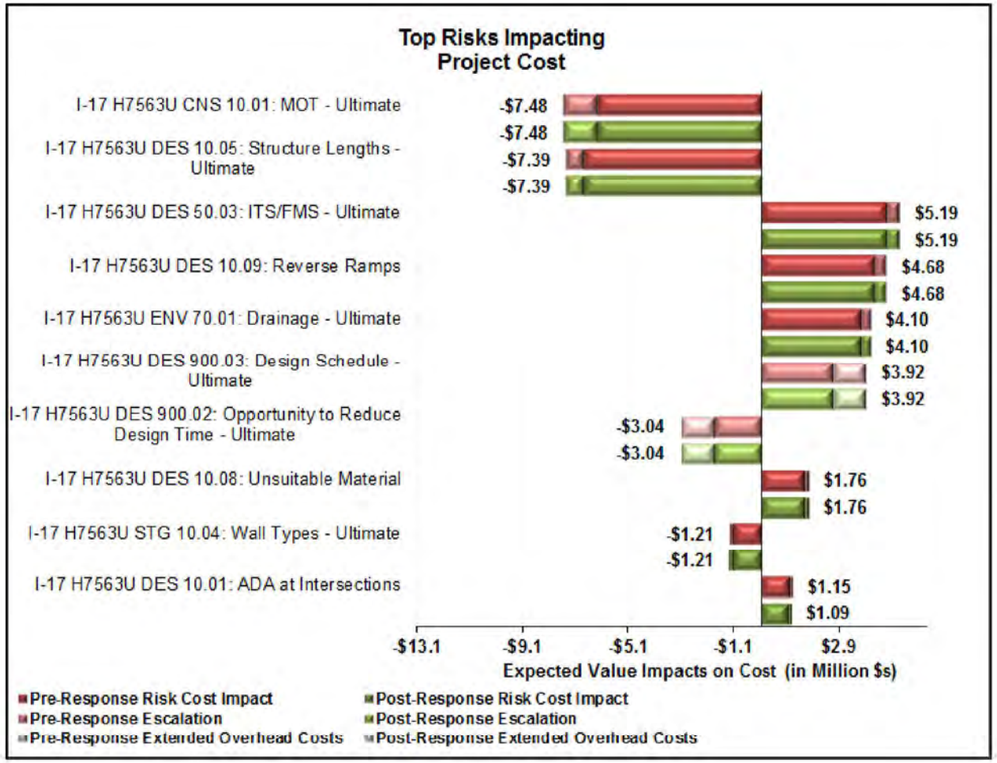


Figure 5: Top Cost Risks

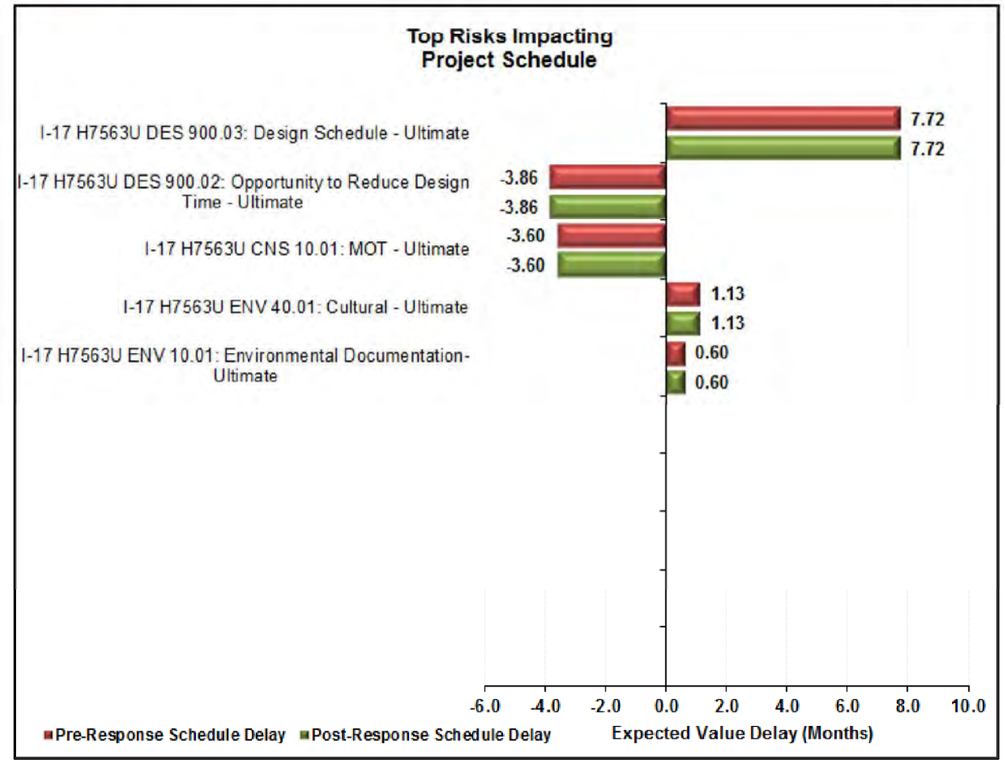


Figure 6: Top Schedule Risks

The next step was to determine the appropriate risk response strategies for the identified high risk areas. Four risk response strategies, are considered when addressing threat risks. Those strategies are to avoid, accept, transfer, or mitigate the risk threat (opportunity).

Avoiding a risk may cost more money up front, but may prevent or reduce a more significant impact.

Accepting a risk means that there is not much that can be done or relatively little benefit in addressing the risk.

Transferring a risk allows for the risk owner to move the liability of the risk to another party that is better able to respond to the risk.

Mitigation of a risk addresses risk by reducing (enhancing) the likelihood of the risk occurring or lessen (increasing) the impact through proactive efforts.

Each of the risks that were identified had a unique response strategy developed to address it, as well as the identification of the risk owner. Identifying a risk response and risk owner, along with review intervals for the risk, a framework for a risk management plan is established. This allows proactive management of risk throughout the life of the project.

For risks that did not have a VE recommendation, the Value Planning Team Leader and the Project Manager determined the appropriate risk response strategies.

Tracking, Monitoring, and Control

By engaging in this cost risk analysis process to evaluate the project, the overall expectations of cost and schedule were quantified in relation to identified risks, the associated impacts of those risk elements, the use of a Risk Management Plan to respond to those risk elements, and impacts to the project bottom line of creating value for the project.

Through this process, value can simultaneously be created for the project through the VE portion of the workshop, while risks can be proactively monitored and controlled to reduce potential impacts to the project cost and schedule.

The risk register provided in the Appendix can serve as a risk tracking tool and contains columns for risk response and planning. The project team should assign a "risk owner" to track and record the effectiveness of the strategies and any changes to the project risk profile, as follows:

- Document the response action by describing the action, the work activities it will affect, and the cost of the response action.
- Identify the person(s) responsible for successful implementation of the response action.
- Document whether response actions have a positive or negative effect on achieving project objectives in the Risk Management Plan.
- Consider the time impacts of the response action and how the risk response may affect the overall project and/or other risks.

Risk Analysis Results

The risk analysis results are given in the form of graphs showing the relationship between cost and the probability of not exceeding that cost. Risk-based analysis provides a distribution of probabilities that a project will not exceed an estimated dollar figure. Typically, agencies report the project risk-based estimation using the 70 percent confidence interval. Each graph represents the best opinion of the cost ranges by the workshop participants at the time of the analysis.

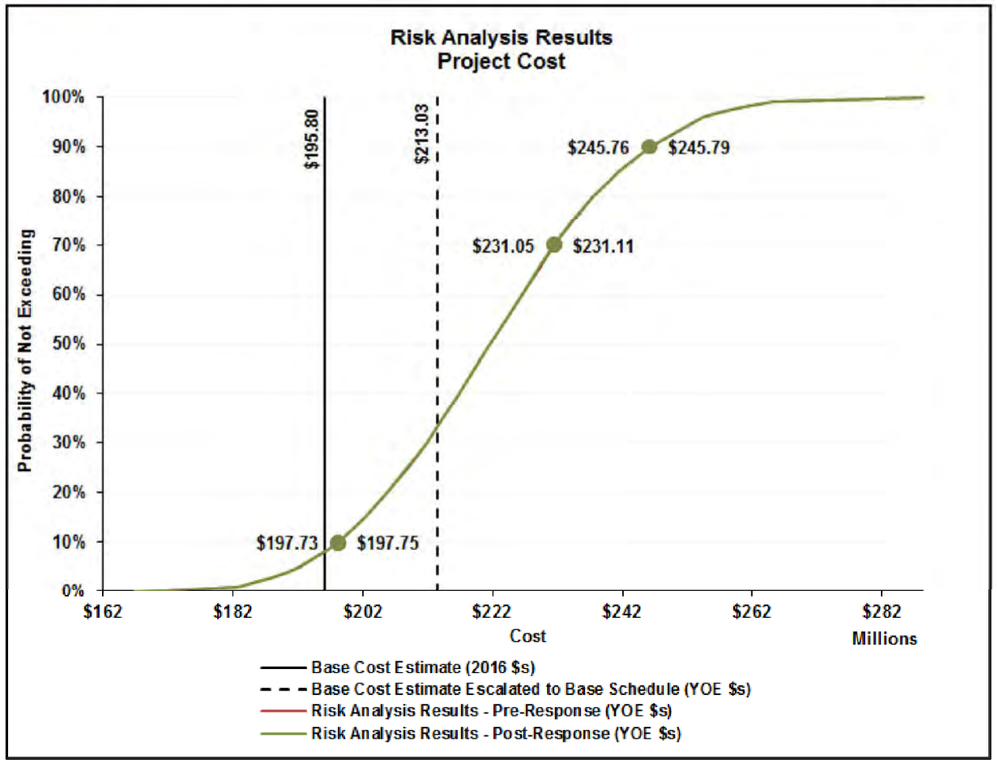


Figure 7: Ultimate Project Cost Risk Analysis Results

The base cost is the cost without any contingencies or any factored escalation. The gray vertical solid line shown in Figure 7 above (small dashes) represents the base cost in 2016 dollars, at $195.87 million. This amount, represented by the vertical dashed line is $231.03 million at year of-expenditure. The s-curve, with risk results factored into the analysis, shows that the project will be less than **$231.05 million** at a 70% confidence level with current mitigation strategies in place.

The same analysis was performed to generate results for the schedule and is shown in Figure 8.

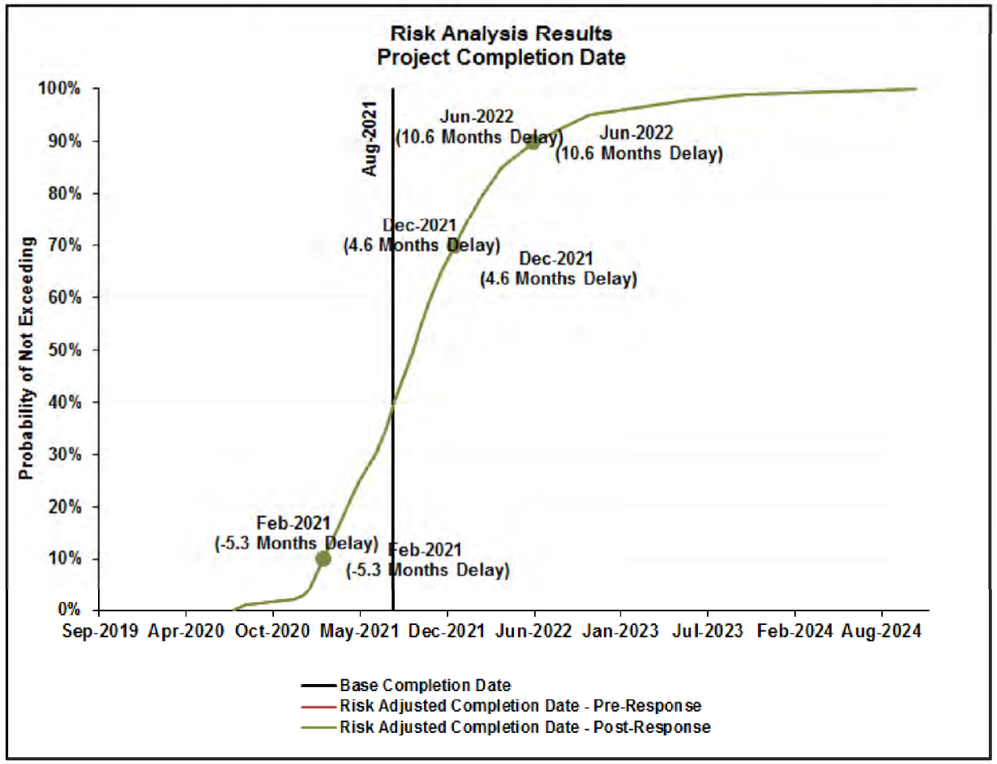


Figure 8: Ultimate Construction Schedule Risk Analysis Results

The baseline schedule had a completion date of August 2021 after 36 months of construction. The confidence interval, described by the completion range between the 10th percentile and 90th percentile figures, reveals that the completion of construction will fall between February 2021 and June 2022. There is 70 percent probability that the project will be completed by **December 2021**.

CRAVE Process Summary

The cost risk analysis provided an evaluation of the estimated project total cost and schedule and included four major steps.

The first step was to establish a base cost and schedule and then identify and quantify the major risk elements and how they impact cost and schedule. The second step was to identify how to respond to the highest likelihood and impact risk elements. The third step was to quantify the effects of implementation of the risk response strategies. The final step was to quantify the effects on project cost and schedule by implementing the VE recommendations.

The information provided by a CRA Workshop and the Value Planning Study gives valuable tools to project managers to help them deliver a successful project on time and within budget. When a multi-disciplined team of experts is assembled in a workshop environment, maximum benefit can be achieved by using this combined cost risk assessment/value engineering process.

Appendix

- Near Term Project Cost Estimate/Schedule Review and Risk Analysis
- Base Cost Estimate and Schedule Review - Ultimate
- Risk Data Sheets – Ultimate
- Value Planning Study Agenda
- CRAVE Study Attendees
- CRAVE Study Report Out Presentation
- Value Engineering Process
- VE Study Process
- CRAVE Process
- Performance Based Results
- Reporting
- VE Study Recommendation Approval Form

Near Term Project Cost Estimate and Risk Analysis

During the workshop, the team began with an assessment of Near Term project costs and risks. As the workshop progressed, this Near Term project was recommended to be replaced with the ultimate project configuration. Much of the cost estimate data used for the ultimate configuration comes from the Near Term base cost estimate. These costs and quantities developed for the ultimate project configuration were then verified by the project team based on revised quantities and other known information. Please see the following pages for the base cost estimate for the Near Term project. A cost and schedule model analysis was also performed to compare the Near Term project analysis results with the ultimate project analysis results.

Base Cost Estimate Review – Near Term Project

			Unit Cost					Quantity					Total			Reviewed previously awarded projects for a comparison of unit prices
	Item	Unit	Low	%	Most Likely	%	High	Low	%	Most Likely	%	High	Low	Most Likely	High	Cost Lead Revisions
2010011	CLEARING AND GRUBBING	ACRE	$1,350	-10%	$1,500	10%	$1,650	5.7	-5%	6.0	5%	6.3	$7,695	$9,000	$10,395	
2020021	REMOVAL OF CONCRETE CURB AND GUTTER	L.FT.	$2.25	-10%	$2.50	10%	$2.75	24,452	-5%	25,739	5%	27,026	$55,017	$64,348	$74,321	
2020027	REMOVAL OF CONCRETE BARRIER (WITH SCREEN WALL)	L.FT.	$27	-10%	$30	10%	$33	6,261	-5%	6,591	5%	6,921	$169,059	$197,730	$228,378	
2020029	REMOVAL OF ASPHALTIC CONCRETE PAVEMENT	SQ.YD.	$1.75	-13%	$2.00	50%	$3.00	42,746	-5%	44,996	5%	47,246	$74,806	$89,992	$141,737	
2020042	REMOVAL OF PIPE (36" AND UNDER)	L.FT.	$18.00	-10%	$20.00	10%	$22.00	335	-5%	353	5%	371	$6,036	$7,060	$8,154	
2020052	REMOVE (CONDUCTORS)	L.SUM	$9,000	-10%	$10,000	10%	$11,000	1	0%	1	0%	1	$9,000	$10,000	$11,000	
2020053	REMOVE (PULL BOX)	EACH	$135	-10%	$150	10%	$165	22	0%	22	0%	22	$2,970	$3,300	$3,630	
2020054	REMOVE (CATCH BASINS)	EACH	$540	-10%	$600	10%	$660	38	0%	38	0%	38	$20,520	$22,800	$25,080	
2020071	REMOVE GUARD RAIL	L.FT.	$1.80	-10%	$2.00	10%	$2.20	24,452	-5%	25,739	5%	27,026	$44,014	$51,478	$59,457	
2020081	REMOVE BITUMINOUS PAVEMENT (MILLING) (1")	SQ.YD.	$0.75	-12%	$0.85	12%	$0.95	158,220	-5%	166,547	5%	174,874	$118,665	$141,563	$166,133	
2020157	REMOVE (MANHOLE)	EACH	$550	-8%	$600	8%	$650	1	0%	1	0%	1	$550	$600	$650	
2020201	SAW CUTTING	L.FT.	$0.90	-10%	$1.00	10%	$1.10	26,250	-5%	27,632	5%	29,014	$23,625	$27,632	$31,915	
2030301	ROADWAY EXCAVATION	CU.YD.	$9.00	-10%	$10.00	10%	$11.00	80,750	-5%	85,000	5%	89,250	$726,750	$850,000	$981,750	
2090005	FURNISH WATER	M.GAL.	$2.75	-8%	$3.00	8%	$3.25	95,000	-5%	100,000	5%	105,000	$261,250	$300,000	$341,250	
3030022	AGGREGATE BASE, CLASS 2	CU.YD.	$27	-10%	$30	10%	$33	7,077	-5%	7,449	5%	7,821	$191,067	$223,470	$258,108	
4010009	PORTLAND CEMENT CONCRETE PAVEMENT (9")	SQ. YD	$27	-10%	$30	17%	$35	63,686	-5%	67,038	5%	70,390	$1,719,525	$2,011,140	$2,463,647	
4040111	BITUMINOUS TACK COAT	TON	$450	-10%	$500	10%	$550	76	-5%	80	5%	84	$34,200	$40,000	$46,200	
4040116	APPLY BITUMINOUS TACK COAT	HOUR	$135	-10%	$150	10%	$165	50	-5%	53	5%	56	$6,797	$7,950	$9,182	
4140040	ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER)	TON	$35	-13%	$40	13%	$45	11,938	-5%	12,566	5%	13,194	$417,820	$502,640	$593,744	
4140042	ASPHALT RUBBER MATERIAL (FOR AR-ACFC)	TON	$550	-8%	$600	8%	$650	1,074	-5%	1,131	5%	1,188	$590,948	$678,600	$771,908	
4140044	MINERAL ADMIXTURE (FOR AR-ACFC)	TON	$85	-11%	$90	11%	$100	107	-5%	113	5%	119	$9,588	$10,170	$11,865	
5010107	PIPE, CORRUGATED METAL, SLOTTED, 18"	L.FT.	$90	-10%	$100	10%	$110	456	-5%	480	5%	504	$41,040	$48,000	$55,440	
5012524	STORM DRAIN PIPE, 24"	L.FT.	$40	-11%	$45	11%	$50	3,189	-5%	3,357	5%	3,525	$127,560	$151,065	$176,243	
5030192	ADJUST CATCH BASIN TO GRADE	EACH	$450	-10%	$500	10%	$550	2	0%	2	0%	2	$900	$1,000	$1,100	
5030604	CONCRETE CATCH BASIN (C-15 80)	EACH	$2,075	-10%	$2,300	10%	$2,525	3	0%	3	0%	3	$6,225	$6,900	$7,575	
5030605	CONCRETE CATCH BASIN (C-15 92)	EACH	$2,250	-10%	$2,500	10%	$2,750	111	0%	111	0%	111	$249,750	$277,500	$305,250	
5030606	CONCRETE CATCH BASIN (CONCRETE CAP)	EACH	$450	-10%	$500	10%	$550	32	0%	32	0%	32	$14,400	$16,000	$17,600	
5050001	MANHOLE (C-18.10) (NO. 1) (FOR PIPES 6" TO 36")	EACH	$3,150	-10%	$3,500	10%	$3,850	4	0%	4	0%	4	$12,600	$14,000	$15,400	
5050089	MANHOLE (ADJUST TO GRADE)	EACH	$360	-10%	$400	10%	$440	1	0%	1	0%	1	$360	$400	$440	
6011110	F-SHAPED BRIDGE CONCRETE BARRIER (32")	L.FT.	$50	-9%	$55	9%	$60	26,490	-5%	27,884	5%	29,278	$1,324,490	$1,533,620	$1,756,692	
6060046	BRIDGE SIGN STRUCTURE (SD9.20, TYPE 2F)	EACH	$54,000	-10%	$60,000	10%	$66,000	2	0%	2	0%	2	$108,000	$120,000	$132,000	
6060076	FOUNDATION FOR BRIDGE SIGN STRUCTURE (SD9.20, TYPE 2F)	EACH	$6,300	-10%	$7,000	11%	$7,750	4	0%	4	0%	4	$25,200	$28,000	$31,000	
6060133	CANTILEVER SIGN STRUCTURE (SD9.10, TYPE 3C)	EACH	$32,400	-10%	$36,000	10%	$39,600	7	0%	7	0%	7	$226,800	$252,000	$277,200	
6060134	CANTILEVER SIGN STRUCTURE (SD9.10, TYPE 4C)	EACH	$40,500	-10%	$45,000	10%	$49,500	10	0%	10	0%	10	$405,000	$450,000	$495,000	
6060256	FOUNDATION FOR CANTILEVER SIGN STRUCTURE (SD9.10, TYPE 3C)	EACH	$6,300	-10%	$7,000	10%	$7,700	7	0%	7	0%	7	$44,100	$49,000	$53,900	
6060257	FOUNDATION FOR CANTILEVER SIGN STRUCTURE (SD9.10, TYPE 4C)	EACH	$6,300	-10%	$7,000	10%	$7,700	10	0%	10	0%	10	$63,000	$70,000	$77,000	
6061001	SIGN MOUNT ASSEMBLY (FOR BRIDGE FASCIA)	EACH	$2,475	-10%	$2,750	10%	$3,025	1	0%	1	0%	1	$2,475	$2,750	$3,025	
6070002	BREAKAWAY SIGN POST S4X7 7	L.FT.	$22	-12%	$25	12%	$28	154	-5%	162	5%	170	$3,386	$4,050	$4,763	
6070004	BREAKAWAY SIGN POST W6X12	L.FT.	$31	-11%	$35	11%	$39	374	-5%	394	5%	414	$11,603	$13,790	$16,134	
6070022	FOUNDATION FOR BREAKAWAY SIGN POST S4X7 7	EACH	$225	-10%	$250	10%	$275	12	0%	12	0%	12	$2,700	$3,000	$3,300	
6070024	FOUNDATION FOR BREAKAWAY SIGN POST W6X12	EACH	$450	-10%	$500	10%	$550	22	0%	22	0%	22	$9,900	$11,000	$12,100	
6070038	SLIP BASE (FOR PERFORATED POST)	EACH	$120	-8%	$130	10%	$143	36	0%	36	0%	36	$4,320	$4,680	$5,148	
6070054	SIGN POST (PERFORATED) (2 S)	L.FT.	$7.25	-9%	$8.00	10%	$8.80	452	-5%	476	5%	500	$3,278	$3,808	$4,398	
6070055	SIGN POST (PERFORATED) (2 1/2 S)	L.FT.	$9.00	-10%	$10.00	10%	$11.00	627	-5%	660	5%	693	$5,643	$6,600	$7,623	
6070057	SIGN POST (PERFORATED) (2 1/2 T)	L.FT.	$10.75	-10%	$12.00	10%	$13.25	228	-5%	240	5%	252	$2,451	$2,880	$3,339	
6070060	FOUNDATION FOR SIGN POST (CONCRETE)	EACH	$165	-11%	$185	11%	$205	88	0%	88	0%	88	$14,520	$16,280	$18,040	

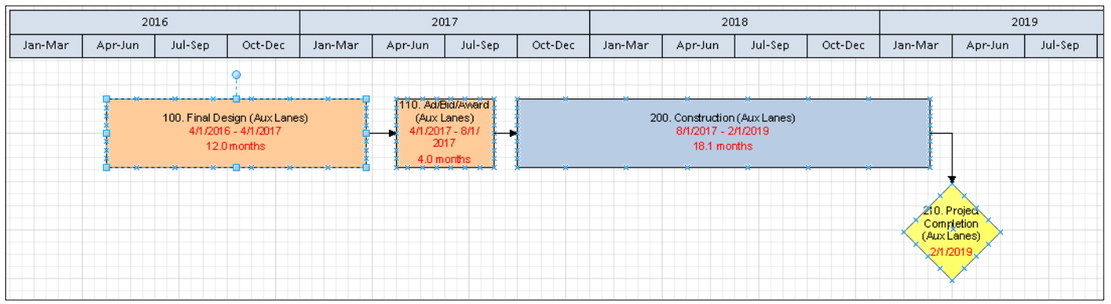
			Unit Cost					Quantity					Total			Reviewed previously awarded projects for a comparison of unit prices
	Item	Unit	Low	%	Most Likely	%	High	Low	%	Most Likely	%	High	Low	Most Likely	High	Cost Lead Revisions
6080005	REGULATORY,WARN, OR MARKER SIGN PANEL W/TYP IX/XI SHEET	SQ FT	$22	-12%	$25	8%	$27	742	-5%	781	5%	820	$16,323	$19,525	$22,141	
6080018	EXTRUDED ALUMINUM SIGN PANEL,TYP IX/XI SHEET	SQ FT	$22	-12%	$25	8%	$27	3,275	-5%	3,447	5%	3,619	$72,042	$86,175	$97,722	
6080025	FLAT SHEET ALUM W/DIR-APP OR SLK SCRN CHAR.,TYP IX/XI SHEET	SQ FT	$26	-10%	$29	10%	$32	160	-5%	168	5%	176	$4,150	$4,872	$5,645	
6080101	MISCELLANEOUS WORK (SIGNS) (REMOVE AND SALVAGE)	L.SUM	$78,300	-10%	$87,000	10%	$95,700	1	0%	1	0%	1	$78,300	$87,000	$95,700	
7015052	OBLITERATE PAVEMENT MARKING (STRIPE)	L.FT.	$0.45	-10%	$0.50	10%	$0.55	39,822	-5%	41,918	5%	44,014	$17,920	$20,959	$24,208	
7020008	IMPACT ATTENUATION DEVICE (SMART CUSHION)	EACH	$18,000	-10%	$20,000	10%	$22,000	3	0%	3	0%	3	$54,000	$60,000	$66,000	
7030090	REFERENCE MARKER (M-30)	EACH	$90	-10%	$100	10%	$110	18	0%	18	0%	18	$1,620	$1,800	$1,980	
7030095	MILEPOST MARKER (S-10)	EACH	$270	-10%	$300	10%	$330	6	0%	6	0%	6	$1,620	$1,800	$1,980	
7046005	PAVEMENT MARKING (WHITE THERMOPLASTIC) (ALKYD EXTRUDED) (0.090")	L.FT.	$0.32	-10%	$0.35	10%	$0.39	104,991	-5%	110,517	5%	116,043	$33,072	$38,681	$44,676	
7049006	PAVEMENT MARKING (YELLOW THERMOPLASTIC) (ALKYD EXTRUDED) (0.09	L.FT.	$0.32	-9%	$0.35	10%	$0.39	72,020	-5%	75,863	5%	79,656	$23,062	$26,552	$30,668	
7040072	PAVEMENT MARKING (TRANSVERSE) (THERMOPLASTIC) (ALKYD) (0.090")	L.FT.	$0.45	-10%	$0.50	9%	$0.55	513	-5%	540	5%	567	$231	$270	$309	
7040073	PAVEMENT LEGEND (EXTRUDED THERMOPLASTIC) (ALKYD) (0.090")	EACH	$110	-8%	$120	8%	$130	12	0%	12	0%	12	$1,320	$1,440	$1,560	
7040074	PAVEMENT SYMBOL (EXTRUDED THERMOPLASTIC) (ALKYD) (0.090")	EACH	$100	-9%	$110	9%	$120	41	0%	41	0%	41	$4,100	$4,510	$4,920	
7042031	PRIMER-SEALER FOR PCCP THERMOPLASTIC STRIPING	L.FT.	$0.25	-17%	$0.30	17%	$0.35	10,481	-5%	11,033	5%	11,585	$2,620	$3,310	$4,055	
7050047	PAVEMENT MARKING, PREFORMED, PATTERNED, WHITE STRIPE	L.FT.	$2.70	-10%	$3.00	10%	$3.30	51,780	-5%	54,505	5%	57,230	$139,805	$163,515	$188,860	
7060013	PAVEMENT MARKER, RAISED, TYPE C	EACH	$3.60	-10%	$4.00	10%	$4.40	4,379	0%	4,379	0%	4,379	$15,764	$17,516	$19,268	
7060017	PAVEMENT MARKER, RAISED, TYPE E	EACH	$3.60	-10%	$4.00	10%	$4.40	1,622	0%	1,622	0%	1,622	$5,839	$6,488	$7,137	
7080001	PERMANENT PAVEMENT MARKING (PAINTED) (WHITE)	L.FT.	$0.11	-8%	$0.12	25%	$0.15	122,602	-5%	128,423	5%	134,244	$13,420	$15,411	$20,227	
7080011	PERMANENT PAVEMENT MARKING (PAINTED) (YELLOW)	L.FT.	$0.11	-8%	$0.12	25%	$0.15	48,046	-5%	50,575	5%	53,104	$5,285	$6,069	$7,966	
7080301	PAINT BULL NOSE	EACH	$68	-9%	$75	11%	$83	6	0%	6	0%	6	$408	$450	$498	
7310060	POLE (TYPE F)	EACH	$3,150	-10%	$3,500	10%	$3,850	1	0%	1	0%	1	$3,150	$3,500	$3,850	
7310070	POLE (TYPE G) (STANDARD BASE)	EACH	$1,170	-10%	$1,300	10%	$1,430	45	0%	45	0%	45	$52,650	$58,500	$64,350	
7310130	POLE (TYPE Q)	EACH	$3,150	-10%	$3,500	10%	$3,850	2	0%	2	0%	2	$6,300	$7,000	$7,700	
7310190	POLE (55 FT CCTV WITH CAMERA LOWERING DEVICE)	EACH	$9,000	-10%	$10,000	10%	$11,000	2	0%	2	0%	2	$18,000	$20,000	$22,000	
7310197	BREAKAWAY BASE FOR LIGHTING POLE OR SIGNAL FLASHER	EACH	$360	-10%	$400	10%	$440	45	0%	45	0%	45	$16,200	$18,000	$19,800	
7310250	POLE FOUNDATION (TYPE F)	EACH	$1,350	-10%	$1,500	10%	$1,650	1	0%	1	0%	1	$1,350	$1,500	$1,650	
7310260	POLE FOUNDATION (TYPE G) (STANDARD BASE)	EACH	$675	-10%	$750	10%	$825	45	0%	45	0%	45	$30,375	$33,750	$37,125	
7310310	POLE FOUNDATION (TYPE Q)	EACH	$1,350	-10%	$1,500	10%	$1,650	2	0%	2	0%	2	$2,700	$3,000	$3,300	
7310371	POLE FOUNDATION (CCTV POLE)	EACH	$2,700	-10%	$3,000	10%	$3,300	5	0%	5	0%	5	$13,500	$15,000	$16,500	
7310500	MAST ARM (8 FT.) (TAPERED)	EACH	$270	-10%	$300	10%	$330	1	0%	1	0%	1	$270	$300	$330	
7310505	MAST ARM (6 FT.) (TAPERED)	EACH	$225	-10%	$250	10%	$275	45	0%	45	0%	45	$10,125	$11,250	$12,375	
7310551	MAST ARM (26 FT.) (TAPERED)	EACH	$720	-10%	$800	10%	$880	3	0%	3	0%	3	$2,160	$2,400	$2,640	
7310561	MAST ARM (25 FT.) (TAPERED)	EACH	$1,080	-10%	$1,200	10%	$1,320	2	0%	2	0%	2	$2,160	$2,400	$2,640	
7310812	REMOVE AND SALVAGE EXISTING LIGHTING POLES	EACH	$225	-10%	$250	10%	$275	23	0%	23	0%	23	$5,175	$5,750	$6,325	
7320030	ELECTRICAL CONDUIT (1") (PVC)	L.FT.	$3.60	-10%	$4.00	10%	$4.40	428	-5%	450	5%	473	$1,539	$1,800	$2,079	
7320050	ELECTRICAL CONDUIT (2") (PVC)	L.FT.	$4.50	-10%	$5.00	10%	$5.50	12,246	-5%	12,890	5%	13,535	$55,105	$64,450	$74,440	
7320070	ELECTRICAL CONDUIT (3") (PVC)	L.FT.	$5.40	-10%	$6.00	10%	$6.60	8,255	-5%	8,689	5%	9,123	$44,575	$52,134	$60,215	
7320073	ELECTRICAL CONDUIT (2-3") (PVC)	L.FT.	$13.50	-10%	$15.00	10%	$16.50	6,650	-5%	7,000	5%	7,350	$89,775	$105,000	$121,275	
7320291	ELECTRICAL CONDUIT (2-3" HDPE, DIRECTIONAL DRILL)	L.FT.	$23	-8%	$25	12%	$28	950	-5%	1,000	5%	1,050	$21,850	$25,000	$29,400	
7320293	ELECTRICAL CONDUIT (3-3" HDPE, DIRECTIONAL DRILL)	L.FT.	$27	-10%	$30	10%	$33	950	-5%	1,000	5%	1,050	$25,650	$30,000	$34,650	
7320294	ELECTRICAL CONDUIT (1-3" HDPE, DIRECTIONAL DRILL)	L.FT.	$20	-11%	$22.00	11%	$25	190	-5%	200	5%	210	$3,705	$4,400	$5,145	
7320297	ELECTRICAL CONDUIT (3-3") (PVC)	L.FT.	$13.50	-10%	$15.00	10%	$16.50	3,800	-5%	4,000	5%	4,200	$51,300	$60,000	$69,300	
7320298	ELECTRICAL CONDUIT (4-3") (PVC)	L.FT.	$18.00	-10%	$20.00	10%	$22.00	190	-5%	200	5%	210	$3,420	$4,000	$4,620	
7320420	PULL BOX (NO. 7)	EACH	$540	-10%	$600	10%	$660	39	0%	39	0%	39	$21,060	$23,400	$25,740	
7320437	PULL BOX (NO. 4B)	EACH	$495	-10%	$550	10%	$605	44	0%	44	0%	44	$21,780	$24,200	$26,620	
7320439	PULL BOX (NO. 6B)	EACH	$675	-10%	$750	10%	$825	6	0%	6	0%	6	$4,050	$4,500	$4,950	
7320455	PULL BOX (NO. 9)	EACH	$2,250	-10%	$2,500	10%	$2,750	3	0%	3	0%	3	$6,750	$7,500	$8,250	
7320456	PULL BOX (SPLIT NO.9)	EACH	$3,600	-10%	$4,000	10%	$4,400	17	0%	17	0%	17	$61,200	$68,000	$74,800	
7320503	CONDUCTOR (NO. 12)	L.FT.	$0.35	-13%	$0.40	13%	$0.45	855	-5%	900	5%	945	$299	$360	$425	
7320510	CONDUCTOR (NO. 10)	L.FT.	$0.45	-10%	$0.50	10%	$0.55	24,491	-5%	25,780	5%	27,069	$11,021	$12,890	$14,888	

			Unit Cost					Quantity					Total			Reviewed previously awarded projects for a comparison of unit prices
	Item	Unit	Low	%	Most Likely	%	High	Low	%	Most Likely	%	High	Low	Most Likely	High	Cost Lead Revisions
7320520	CONDUCTOR (NO. 8)	L.FT.	$0.55	-8%	$0.60	8%	$0.60	26,940	-5%	28,358	5%	29,776	$14,817	$17,015	$19,054	
7320530	CONDUCTOR (NO. 6)	L.FT.	$0.80	-11%	$0.90	11%	$1.00	40,410	-5%	42,537	5%	44,664	$32,328	$38,283	$44,664	
7320640	CONDUCTOR (NO. 4)	L.FT.	$1.10	-8%	$1.20	8%	$1.30	18,136	-5%	19,090	5%	20,045	$19,949	$22,908	$26,058	
7320560	CONDUCTOR (NO. 2)	L.FT.	$1.70	-8%	$1.85	11%	$2.05	13,470	-5%	14,179	5%	14,888	$22,899	$26,231	$30,520	
7320580	CONDUCTOR (BARE BOND)	L.FT.	$0.55	-8%	$0.60	8%	$0.65	13,898	-5%	14,629	5%	15,360	$7,644	$8,777	$9,984	
7320765	SINGLE MODE FIBER OPTIC CABLE (12 FIBERS)	L.FT.	$1.55	-11%	$1.75	11%	$1.95	2,375	-5%	2,500	5%	2,625	$3,681	$4,375	$5,119	
7320787	SINGLE MODE FIBER OPTIC CABLE (144 FIBERS)	L.FT.	$1.75	-13%	$2.00	10%	$2.20	6,175	-5%	6,500	5%	6,825	$10,806	$13,000	$15,015	
7320794	FIBER OPTIC SPLICE CLOSURE (FMS)	EACH	$1,350	-10%	$1,500	10%	$1,650	14	0%	14	0%	14	$18,900	$21,000	$23,100	
7330060	TRAFFIC SIGNAL FACE (TYPE F)	EACH	$360	-10%	$400	10%	$440	4	0%	4	0%	4	$1,440	$1,600	$1,760	
7330135	TRAFFIC SIGNAL FACE (TYPE R)	EACH	$450	-10%	$500	10%	$550	1	0%	1	0%	1	$450	$500	$550	
7330211	PEDESTRIAN SIGNAL (COUNT DOWN)	EACH	$315	-10%	$350	10%	$385	1	0%	1	0%	1	$315	$350	$385	
7330310	TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE II)	EACH	$135	-10%	$150	10%	$165	5	0%	5	0%	5	$675	$750	$825	
7330340	TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE V)	EACH	$315	-10%	$350	10%	$385	1	0%	1	0%	1	$315	$350	$385	
7330410	POLE FLASHER	EACH	$1,800	-10%	$2,000	10%	$2,200	12	0%	12	0%	12	$21,600	$24,000	$26,400	
7330446	RAMP METER SIGNAL AND SUPPORT ASSEMBLY	EACH	$2,700	-10%	$3,000	10%	$3,300	12	0%	12	0%	12	$32,400	$36,000	$39,600	
7340103	CONTROL CABINET (CCTV)	EACH	$2,250	-10%	$2,500	10%	$2,750	2	0%	2	0%	2	$4,500	$5,000	$5,500	
7340304	CONTROL CABINET FOUNDATION (RAMP & COUNTER WITH TRANSFORMER)	EACH	$720	-10%	$800	10%	$880	10	0%	10	0%	10	$7,200	$8,000	$8,800	
7340305	CONTROL CABINET FOUNDATION (DMS WITH TRANSFORMER)	EACH	$720	-10%	$800	10%	$880	2	0%	2	0%	2	$1,440	$1,600	$1,760	
7340401	TRANSFORMER FOUNDATION	EACH	$540	-10%	$600	10%	$660	5	0%	5	0%	5	$2,700	$3,000	$3,300	
7350030	LOOP DETECTOR FOR TRAFFIC SURVEILLANCE (6' X 6')	EACH	$540	-10%	$600	10%	$660	128	0%	128	0%	128	$69,120	$76,800	$84,480	
7350051	DETECTOR CARD	EACH	$110	-8%	$120	8%	$130	64	0%	64	0%	64	$7,040	$7,680	$8,320	
7350165	LOOP DETECTOR LEAD-IN CABLE	L.FT.	$0.54	-10%	$0.60	10%	$0.66	24,700	-5%	26,000	5%	27,300	$13,338	$15,600	$18,018	
7360078	LUMINAIRE (HIGH MAST) (LED)	EACH	$1,350	-10%	$1,500	10%	$1,650	106	0%	106	0%	106	$143,100	$159,000	$174,900	
7360104	LUMINAIRE (HORIZONTAL MOUNT) (LED)	EACH	$675	-10%	$750	10%	$825	48	0%	48	0%	48	$32,400	$36,000	$39,600	
7370403	TRANSFORMER (3KV-A)	EACH	$1,800	-10%	$2,000	10%	$2,200	2	0%	2	0%	2	$3,600	$4,000	$4,400	
7370426	ELECTRICAL SYSTEM (FLASHER UNIT-MODEL 204)	EACH	$45	-10%	$50	10%	$55	12	0%	12	0%	12	$540	$600	$660	
7370457	MISCELLANEOUS ELECTRICAL (1" INNERDUCT)	L.FT.	$0.70	-7%	$0.75	7%	$0.80	2,375	-5%	2,500	5%	2,625	$1,663	$1,875	$2,100	
7370666	SWITCH PACK (LOAD SWITCH) (MODEL 200)	EACH	$63	-10%	$70	10%	$77	6	0%	6	0%	6	$378	$420	$462	
7370705	CCTV FIELD EQUIPMENT	EACH	$4,500	-10%	$5,000	10%	$5,500	2	0%	2	0%	2	$9,000	$10,000	$11,000	
8070001	LANDSCAPING ESTABLISHMENT ($50K PER ACRE FOR 6 ACRES)	L.SUM	$270,000	-10%	$300,000	10%	$330,000	1	0%	1	0%	1	$270,000	$300,000	$330,000	
9100008	CONCRETE BARRIER (C-10.52) (4.5' GUTTER)	L.FT.	$40	-10%	$50	10%	$55	11,880	-5%	11,932	5%	12,029	$510,053	$596,600	$659,973	
9100009	CONCRETE BARRIER (WITH SCREEN WALL) (DETAIL X)	L.FT.	$59	-10%	$65	11%	$72	6,261	-5%	6,591	5%	6,921	$366,295	$428,415	$498,280	
9100114	CONCRETE BARRIER TRANSITION (For DMS Structure)	EACH	$13,500	-10%	$15,000	10%	$16,500	4	0%	4	0%	4	$54,000	$60,000	$66,000	
9140153	RETAINING WALL (REINFORCED CONCRETE)	SQ.FT.	$55	-8%	$60	8%	$65	203,780	-5%	214,505	5%	225,230	$11,207,886	$12,870,300	$14,639,966	How tall? How many locations?
9240119	MISCELLANEOUS WORK (SIGN MOUNT BRACKET FOR LIGHT OR SIGNAL POI	EACH	$225	-10%	$250	10%	$275	14	0%	14	0%	14	$3,150	$3,500	$3,850	
9240120	MISCELLANEOUS WORK (CCTV POLE, CAMERA,CABINET AND TRANSFORMI	EACH	$3,600	-10%	$4,000	10%	$4,400	3	0%	3	0%	3	$10,800	$12,000	$13,200	
9240121	MISCELLANEOUS WORK (RAMP METERING/COUNTER CABINET & TRANSFOI	EACH	$1,800	-10%	$2,000	10%	$2,200	10	0%	10	0%	10	$18,000	$20,000	$22,000	
9240122	MISCELLANEOUS WORK (DMS, CABINET AND TRANSFORMER)	EACH	$2,700	-10%	$3,000	10%	$3,300	2	0%	2	0%	2	$5,400	$6,000	$6,600	
999X003	BRIDGE WIDENING (16TH STREET TOP NB)	SQ.FT.	$110	-8%	$120	13%	$135	1,329	-2%	1356	2%	1,383	$146,177	$162,720	$186,721	What are the bridge types and span lengths?
999X003	BRIDGE WIDENING (3RD STREET OP NB)	SQ.FT.	$110	-8%	$120	13%	$135	3,522	-2%	3,594	2%	3,666	$387,433	$431,280	$494,894	
999X003	BRIDGE WIDENING (3RD STREET OP SB)	SQ.FT.	$110	-8%	$120	13%	$135	2,946	-2%	3,006	2%	3,066	$324,047	$360,720	$413,926	
999X003	BRIDGE WIDENING (CENTRAL AVENUE OP NB)	SQ.FT.	$135	-10%	$150	10%	$165	1,964	-2%	2,004	2%	2,044	$265,129	$300,600	$337,273	
999X003	BRIDGE WIDENING (CENTRAL AVENUE OP SB)	SQ.FT.	$135	-10%	$150	10%	$165	2,030	-2%	2,071	2%	2,112	$273,993	$310,650	$348,549	
999X003	BRIDGE WIDENING (11TH AVENUE OP NB)	SQ.FT.	$135	-10%	$150	10%	$165	3,847	-2%	3,926	2%	4,005	$519,410	$588,900	$660,746	
999X003	BRIDGE WIDENING (11TH AVENUE OP SB)	SQ.FT.	$135	-10%	$150	10%	$165	1,503	-2%	1,534	2%	1,565	$202,948	$230,100	$258,172	
999X003	BRIDGE WIDENING (15TH AVENUE OP NB)	SQ.FT.	$110	-8%	$120	13%	$135	1,069	-2%	1,088	2%	1,110	$117,288	$130,560	$149,848	
999X003	BRIDGE WIDENING (15TH AVENUE OP SB)	SQ.FT.	$110	-8%	$120	13%	$135	1,145	-2%	1168	2%	1,191	$125,910	$140,160	$160,834	
												Bid Item subtotal	$23,568,901	$27,069,344	$31,008,033	

	Maintenance and Protection of Traffic	10.00%	$2,356,890	$3,100,000	$3,100,803						$2,356,890	$3,100,000	$3,100,803	
	Dust and Water Palliative	0.75%	$176,767	$203,020	$232,560						$176,767	$203,020	$232,560	
	Contractor Quality Control	0.75%	$176,767	$203,020	$232,560						$176,767	$203,020	$232,560	
	Contractor Surveying	1.25%	$294,611	$338,367	$387,600						$294,611	$338,367	$387,600	
	Erosion Control	0.50%	$117,845	$135,347	$155,040						$117,845	$135,347	$155,040	
										Subtotal A	$26,691,780	$31,049,097	$35,116,597	
	Miscellaneous Item Allowance (Unidentified Items)	5.00%	$1,334,589	$1,552,455	$1,755,830						$1,334,589	$1,552,455	$1,755,830	was 20% lowered to 5%, very detailed estimate
										Subtotal B	$28,026,369	$32,601,552	$36,872,427	
	Mobilization	8.00%	$2,242,110	$2,608,124	$2,949,794						$2,242,110	$2,608,124	$2,949,794	was $3.3M
										Subtotal C	$30,268,479	$35,209,676	$39,822,221	
										Contract Total	$30,268,479	$35,209,676	$39,822,221	
										Uncertainty	-14.0%		13.1%	
	Engineering & Contingency													
	Construction Engineering	9.00%	$2,724,163	$3,168,871	$3,584,000						$2,724,163	$3,168,871	$3,584,000	
	Design	8.00%	$2,286,478	$2,666,774	$3,020,778						$2,286,478	$2,666,774	$3,020,778	
	Construction Contingency	5.00%	$1,513,424	$1,760,484	$1,991,111									
										Subtotal D	$35,279,120	$41,045,521	$46,420,998	
	Non-Bid Project Costs													
	Environmental Mitigation (Unknown at this time)													
	PCCP Quality Incentive	SY	$2	$2	$2	65,697	-2%	67,038	2%	68,379	$ 98,546	$ 100,557	$ 102,568	
	AR-ACFC Smoothness Incentive	MILE	$11,000	$11,000	$11,000	30.0	0%	30.0	0%	30.0	$330,000	$330,000	$330,000	
	Right-of-Way	LS	$0	$0	$0						$0	$0	$0	
	Ad-Bid-Award		$135,000	$150,000	$165,000						$135,000	$150,000	$165,000	subtracted from design costs
											$35,842,666	$41,625,878	$47,024,567	
	Indirect Cost Allocation	10.35%	$3,709,716	$4,308,278	$4,867,043						$3,709,716	$4,308,278	$4,867,043	
	Costs spent to date										$0		$0	
										Project Total	$39,552,382	$45,934,157	$51,891,609	
												$ 3,456,849	CE with ICAP	
												$ 39,326,958	Raw CN with ICAP	

Unit costs provided for the Near Term project were used to develop the ultimate configuration cost estimate, with verification conducted during the Value Planning portion of the workshop. Please see the next pages for the detailed breakdown of the ultimate configuration project costs.

Base Schedule Review – Near Term



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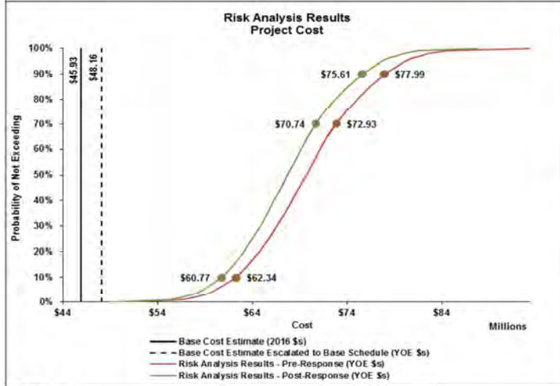
Analysis of Results – Near Term

CRA Workshop Cost Summary Sheet	I-17 I-10 Near-Term Improvements Last Updated February 2016	Level of Project Design: Low – Medium – High

Project Description

The purpose of this project is to improve the operation and safety of I-17. The proposed near-term improvements would add auxiliary lanes between the entrance and exit ramps in both the northbound and southbound directions of travel between 16th Street and 19th Avenue and would extend the I-10/I-17 Traffic Interchange (TI) East-to-North (EN) Ramp auxiliary lane to the Seventh Street Northbound Exit Ramp.



Cost Results

The S-curves reveal that, prior to risk response, there was a **70 percent** chance of the total project costs being less than **$72.9 million** in year-of-expenditure (YOE).

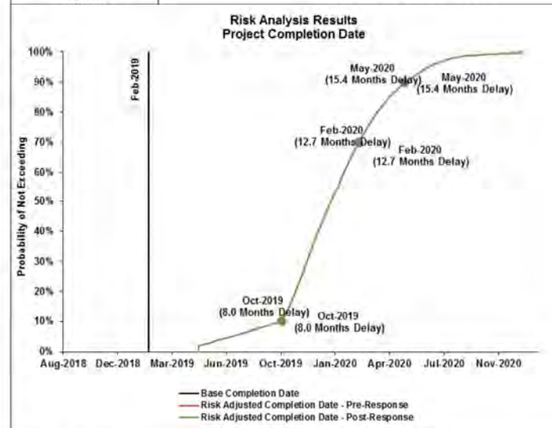
With the risk response strategies included, project costs now have a **70 percent** chance of being less than **$70.7 million** YOE.

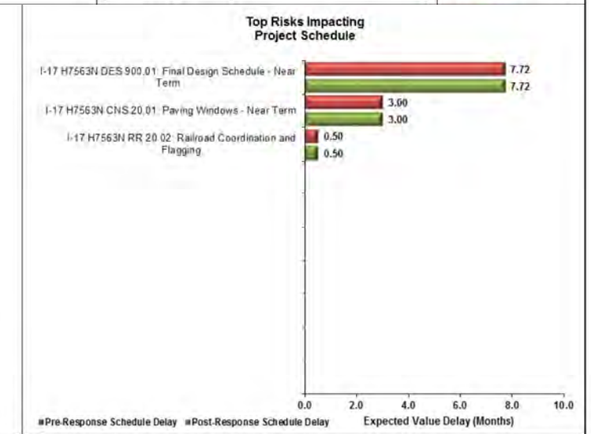
These results indicate that by implementing the risk response strategies developed at the CRA workshop, project costs are expected to be reduced by **$2.2 million**.

Risk-Adjusted Cost Results (in Millions $s)

Category	Base Cost 2016 $s	Base Cost YOE $s	70th Percentile 2016 $s	70th Percentile YOE $s
Pre-Response Results Total Project	$45.9	$48.2	$68.2	$72.9
Post-Response Results Total Project			$66.2	$70.7
Post-Response Preliminary Engineering	$3.1	$3.2	$4.3	$4.5
Post-Response Right-of-Way	$0.0	$0.0	$0.0	$0.0
Post-Response Construction	$42.8	$45.0	$61.9	$66.2

CRA Workshop Schedule Summary Sheet	I-17 I-10 Near-Term Improvements Last Updated February 2016	Level of Project Design: Low – Medium – High





Schedule Results

Under the base schedule, the project is expected to be completed in **February, 2019**. The S-curves reveal that, prior to risk response, there is a **70 percent** chance that the project will be completed by **February, 2020** indicating a risk of potential delay to project completion of approximately **12.7 months**.

After including the risk response strategies developed at the CRA workshop, the project completion delay is reduced to approximately **12.7 months** with the project being completed in **February, 2020**.

By employing the risk response strategies developed within the CRA, project completion can be achieved **0.0 months** earlier.

Risk-Adjusted Schedule Results

Category	Base Date	Project Completion Date Range: 10th Percentile	70th Percentile	90th Percentile
Pre-Response Results	Feb-2019	Oct-2019	Feb-2020	May-2020
Post-Response Results		Oct-2019	Feb-2020	May-2020
Post-Response Advertisement Date	Apr 2017	Aug 2017	Jan 2018	Apr 2018
Post-Response Construction Duration	18.0 Months	21.1 Months	21.1 Months	21.1 Months

Base Cost Estimate Review – Ultimate

		Unit Cost					Quantity					Total			
				Most					Most						
Item	Unit	Low	%	Likely	%	High	Low	%	Likely	%	High	Low	Most Likely	High	Cost Lead/Revisions
CLEARING & GRUBBING ($100K/Mile)	MILE	$85,000	-15%	$100,000	25%	$125,000	3.57	0%	3.57	0%	3.57	$303,450	$357,000	$446,250	
REMOVAL, BRIDGE	SQ.FT.	$30	-14%	$35	14%	$40	98,895	-5%	104,100	5%	109,305	$2,966,850	$3,643,500	$4,372,200	
REMOVAL, PAVEMENT (CEMENT CONCRETE PAVEMENT)	SQ.YD.	$10.00	-17%	$12.00	25%	$15.00	211,090	-5%	222,200	5%	233,310	$2,110,900	$2,666,400	$3,499,650	Pavement removal is concrete.
REMOVAL, OTHER ($250K/Mile)	MILE	$200,000	-20%	$250,000	20%	$300,000	3.57	0%	3.57	0%	3.57	$714,000	$892,500	$1,071,000	
ROADWAY EXCAVATION	CU.YD.	$12.00	-20%	$15.00	20%	$18.00	9,500	-5%	10,000	5%	10,500	$114,000	$150,000	$189,000	Range between 12 to 15 dollars. Increased from 'most likely' from 5 to 15 due to urban setting. Bid data shows between 12 and 30/cy for similar quantities. I moved this up from 7 to 15/cy due to access limitations. This was lowered down to $10/cy during the value planning portion of the workshop.
BORROW (Less Topsoil)	CU.YD.	$7.00	-50%	$10.00	20%	$12.00	192,660	-5%	202,800	5%	212,940	$1,348,620	$2,028,000	$2,555,280	
FURNISH WATER SUPPLY (10% of Total Earthwork Cost)	L.SUM	$126,687	-50%	$253,500	26%	$319,053	1	0%	1	0%	1	$126,687	$253,500	$319,053	
CONCRETE PAVEMENT (Includes Base Material)	SQ.YD.	$40	-11%	$45	11%	$50	279,015	-5%	293,700	5%	308,385	$11,160,600	$13,216,500	$15,419,250	Appears reasonable based on large quantity. Bumped up 'most likely' category up from $45 to $50/sy to accommodate base material.
ARFC OVERLAY (1" Rubberized Overlay)	TONS	$35	-13%	$40	13%	$45	16,530	-5%	17,400	5%	18,270	$578,550	$696,000	$822,150	
ON-SITE DRAINAGE (Various 25% of Pvmt Cost)	L.SUM	$2,934,788	-16%	$3,478,125	17%	$4,060,350	1	0%	1	0%	1	$2,934,788	$3,478,125	$4,060,350	Should we increase 'most likely' $1.5M to $3M due to urban setting and possibility of jack and bore methods
OFF-SITE DRAINAGE (Various 10% of Pvmt Cost)	L.SUM	$1,173,915	-16%	$1,391,250	17%	$1,624,140	1	0%	1	0%	1	$1,173,915	$1,391,250	$1,624,140	Should we increase 'most likely' value from $1.5 to $2M due to similar issue as that listed above.
19th AVE OP	SQ. FT.	$110	-8%	$120	8%	$130	21,090	-5%	22,200	5%	23,310	$2,319,900	$2,664,000	$3,030,300	
12TH AVE OP	SQ. FT.	$110	-6%	$120	6%	$130	23,008	-5%	24,200	5%	25,410	$2,529,000	$2,904,000	$3,306,000	
11TH AVE OP	SQ. FT.	$110	-8%	$120	8%	$130	19,285	-5%	20,300	5%	21,315	$2,121,350	$2,436,000	$2,770,950	
7TH AVE OP	SQ. FT.	$110	-8%	$120	8%	$130	19,760	-5%	20,800	5%	21,840	$2,173,600	$2,496,000	$2,839,200	Adjustments were made to structure costs during the value planning workshop based on more accurate information.
CENTRAL AVE OP	SQ. FT.	$110	-6%	$120	8%	$130	26,895	-5%	28,300	5%	29,505	$2,936,450	$3,372,000	$3,835,650	
7TH ST OP	SQ. FT.	$110	-8%	$120	8%	$130	20,330	-5%	21,400	5%	22,470	$2,236,300	$2,568,000	$2,921,100	
16TH ST OP	SQ. FT.	$110	-8%	$120	8%	$130	20,805	-5%	21,900	5%	22,995	$2,288,550	$2,628,000	$2,989,350	
3RD ST PED CROSSING	SQ. FT.	$55	-8%	$60	8%	$65	1,615	-5%	1,700	5%	1,785	$88,825	$102,000	$116,025	
12th ST PED CROSSING	SQ.FT.	$55	-8%	$60	8%	$65	0	-5%	0	5%	0	$0	$0	$0	Assume protect existing ped x-ing.
SIGNING & PAVEMENT MARKING ($0.5M/Mile)	MILE	$450,000	-10%	$500,000	10%	$550,000	3.57	0%	3.57	0%	3.57	$1,606,500	$1,785,000	$1,963,500	
LIGHTING/FMS ($1M/Mile)	MILE	$800,000	-20%	$1,000,000	25%	$1,250,000	3.57	0%	3.57	0%	3.57	$2,856,000	$3,570,000	$4,462,500	
LANDSCAPING ($450K/Mile)	MILE	$400,000	-11%	$450,000	11%	$500,000	3.57	0%	3.57	0%	3.57	$1,428,000	$1,606,500	$1,785,000	
TOPSOIL	CU.YD.	$9.00	-10%	$10.00	20%	$12.00	47,500	-5%	50,000	5%	52,500	$427,500	$500,000	$630,000	
RETAINING WALLS	SQ.FT.	$45	-10%	$50	10%	$55	451,250	-5%	475,000	5%	498,750	$20,306,250	$23,750,000	$27,431,250	Assume reinf. Concrete cantilever wall. Changed in workshop from $65 to $50 based on discussion of wall price and large quantity.
SOUND WALLS	SQ.FT.	$30	-14%	$35	14%	$40	141,260	-5%	150,800	5%	158,340	$4,297,600	$5,278,000	$6,333,600	Appears reasonable. Noise wall was 30 - 40 per sf on aether ADOT project.
ROADWAY APPURTENANCES ($1M/Mile)	MILE	$900,000	-10%	$1,000,000	25%	$1,250,000	3.57	0%	3.57	0%	3.57	$3,213,000	$3,570,000	$4,462,500	
DPS TRAFFIC CONTROL ($250K/Mile)	MILE	$225,000	-10%	$250,000	10%	$275,000	3.57	0%	3.57	0%	3.57	$803,250	$892,500	$981,750	Department of Public Safety - Highway Patrol
											Bid Item subtotal	$75,235,355	$88,918,775	$104,261,598	
EROSION CONTROL (8% of Bid Items)	8%	$793,294	11%	$880,000	17%	$1,029,494	1	0%	1	0%	1	$793,294	$880,000	$1,029,494	
TRAFFIC CONTROL (20% of Bid Items)	20%	$15,047,071	-15%	$17,781,750	17%	$20,852,320	1	0%	1	0%	1	$15,047,071	$17,781,750	$20,852,320	Large range established based on high impact to traveling public, existing profile, urban environment and high profile area.
CONTRACTOR QUALITY CONTROL (2% of Bid Items)	2%	$1,504,707	-15%	$1,778,175	17%	$2,085,232	1	0%	1	0%	1	$1,504,707	$1,778,175	$2,085,232	Applied range around original assumption
CONSTRUCTION SURVEYING (2% of Bid Items)	2%	$1,504,707	-15%	$1,778,175	17%	$2,085,232	1	0%	1	0%	1	$1,504,707	$1,778,175	$2,085,232	Applied range around original assumption
CONTRACTOR INCENTIVES (3.5% of Pvmt Cost)	4%	$410,870	-16%	$486,938	17%	$568,449	1	0%	1	0%	1	$410,870	$486,938	$568,449	Increased slightly from base due to adjustment in pavement costs above
											Subtotal A	$94,455,063	$111,635,406	$130,895,947	
Miscellaneous Item Allowance	25%	$23,613,766		$27,908,852		$32,723,862	1	0%	1	0%	1	$23,613,766	$27,908,852	$32,723,862	
											Subtotal B	$118,068,829	$139,544,258	$163,659,808	
MOBILIZATION (8% of Subtotal B)	8%	$9,445,506.34	-15%	$11,163,540.63	17%	$13,089,544.65	1		1		1	$7,556,405	$8,930,833	$10,471,636	
											Contract Total	$125,625,234	$148,475,090	$174,090,944	
											Uncertainty	-15.4%		17.3%	
PRELIM/FINAL DESIGN (10% of contract total)	10%	$12,562,523	-15%	$14,847,509	17%	$17,409,094	1	0%	1	0%	1	$12,562,523	$14,847,509	$17,409,094	
CONSTRUCTION ENGINEERING (9% of Contract total)	9%	$8,500,956	-15%	$10,047,187	17%	$11,780,590	1	0%	1	0%	1	$8,500,956	$10,047,187	$11,780,590	
PRIOR RIGHT UTIL RELOC & SERV AGREEMENTS ($1M/Mile)	MILE	$900,000	-10%	$1,000,000	20%	$1,200,000	3.57	0%	3.57	0%	3.57	$3,213,000	$3,570,000	$4,284,000	
CONSTRUCTION CONTINGENCIES (5% contract total)	5%	$6,281,262	-15%	$7,423,919	17%	$8,213,080	0	0%	0	0%	0	$0	$0	$0	
Public Relations	1%	$500,000	-50%	$500,000	100%	$1,000,000	1		1		1	$500,000	$500,000	$1,000,000	
											Project Subtotal	$150,203,715	$177,439,786	$208,544,628	
ICAP	10.95%	$15,545,877	-15%	$18,365,018	18%	$21,586,439						$15,545,877	$18,365,018	$21,586,439	
											Contract Total	$165,747,591	$195,804,804	$230,131,067	
												-15.4%		17.5%	

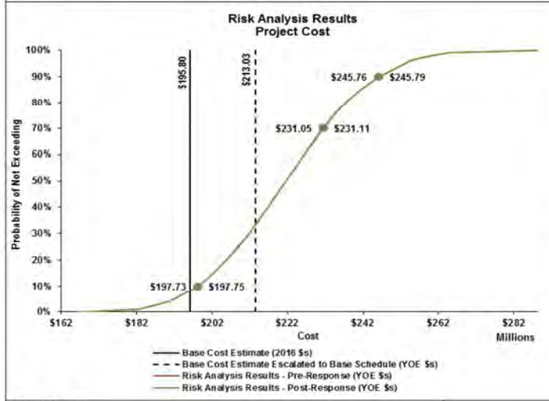
Base Schedule Review – Ultimate

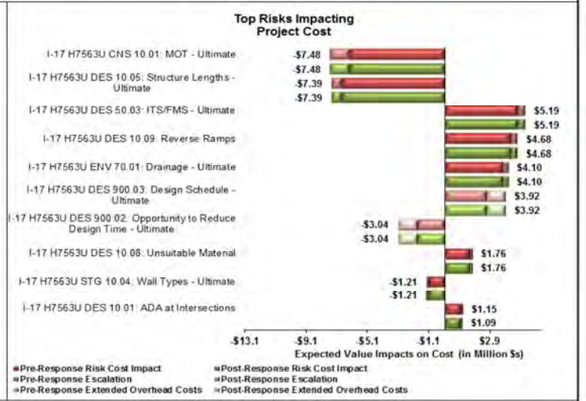
Analysis of Results – Ultimate

CRA Workshop Cost Summary Sheet	I-17 I-10 Ultimate Last Updated February 2016	Level of Project Design	Low	Medium	High

Project Description

The purpose of this project is to improve the operation and safety of I-17. The proposed ultimate improvements would add auxiliary lanes between the entrance and exit ramps in both the northbound and southbound directions of travel between 16th Street and 19th Avenue and extend the I-10/I-17 Traffic Interchange (TI) East-to-North (EN) Ramp auxiliary lane to the Seventh Street Northbound Exit Ramp. The project will replace all structures and pavement and brings the roadway up to current standards.





Cost Results

The S-curves reveal that, prior to risk response, there was a **70 percent** chance of the total project costs being less than **$231.1 million** in year-of-expenditure (YOE).

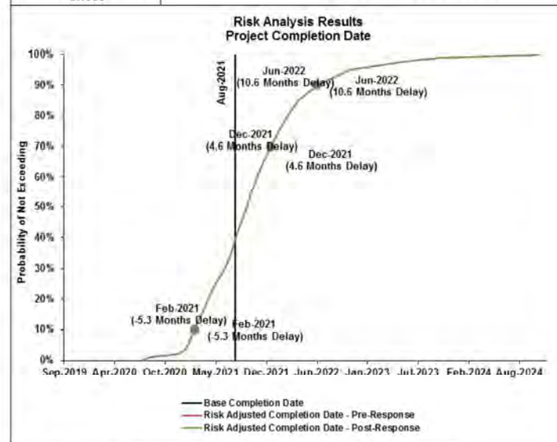
With the risk response strategies included, project costs now have a **70 percent** chance of being less than **$231.1 million** YOE.

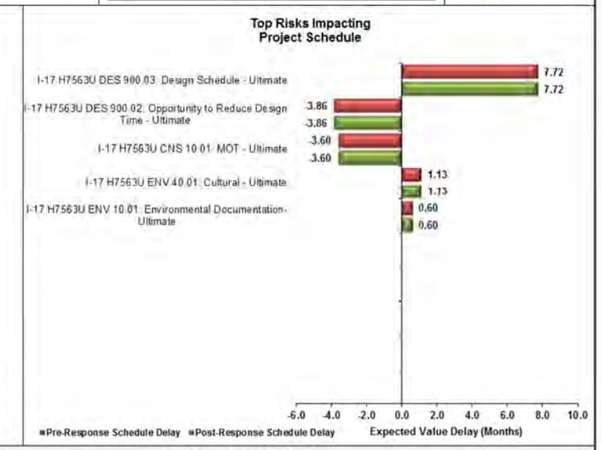
These results indicate that by implementing the risk response strategies developed at the CRA workshop, project costs are expected to be reduced by **$0.1 million**.

Risk-Adjusted Cost Results (in Millions $s)

Category	Base Cost 2016 $s	Base Cost YOE $s	70th Percentile 2016 $s	70th Percentile YOE $s
Pre-Response Results Total Project	$195.8	$213.0	$210.5	$231.1
Post-Response Results Total Project			$210.4	$231.1
Post-Response Preliminary Engineering	$16.4	$17.3	$19.2	$20.6
Post-Response Right-of-Way	$0.0	$0.0	$0.0	$0.0
Post-Response Construction	$179.4	$195.8	$191.2	$210.5

CRA Workshop Schedule Summary Sheet	I-17 I-10 Ultimate Last Updated February 2016	Level of Project Design	Low	Medium	High





Schedule Results

Under the base schedule, the project is expected to be completed in **August, 2021**. The S-curves reveal that, prior to risk response, there is a **70 percent** chance that the project will be completed by **December, 2021** indicating a risk of potential delay to project completion of approximately **4.6 months**.

After including the risk response strategies developed at the CRA workshop, the project completion delay is reduced to approximately **4.6 months** with the project being completed in **December, 2021**.

By employing the risk response strategies developed within the CRA, project completion can be achieved **0.0 months** earlier.

Risk-Adjusted Schedule Results

Category	Base Date	Project Completion Date Range		
		10th Percentile	70th Percentile	90th Percentile
Pre-Response Results	Aug-2021	Feb-2021	Dec-2021	Jun-2022
Post-Response Results		Feb 2021	Dec 2021	Jun 2022
Post-Response Advertisement Date	Apr-2018	Apr-2018	Nov-2018	May-2019
Post-Response Construction Duration	36.0 Months	30.0 Months	36.0 Months	36.0 Months

Risks Data Sheets – Ultimate

Project	I-17	**Risk ID**	I-17 H7563U CNS 10.01
Sub-Project	I-10 Split to 19th Aux Lanes	**Status**	Active

MOT - Ultimate

Risk Trigger		**Flowchart Activity**	510
Dependency & Correlation			

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	15%	60%	25%		3	4	
Cost ($M)	$0.00	-$8.50	$3.00	-$4.35	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)	0.00	-6.00	0.00	-3.60	3	4	

Scenario 1: The base assumes $17M in MOT cost and 3 years for construction. Scenario 2: Assumes routing the traffic down the frontage roads with improvements to the frontage roads and temporary ramps; closing I-17 mainline for construction. This will be 2.5 years of construction and $8.5M cost. Scenario 3: Assumes improvements of the frontage roads and shift mainline traffic, half at a time. This is 3 years of construction and $20 M cost.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	15%	60%	25%			
Cost ($M)	$0.00	-$8.50	$3.00	-$4.35	**Strategy**	2/10/2016
Schedule (Mo)	0.00	-6.00	0.00	-3.60		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

February 23, 2016 Risk Register Page 1 of 31

Project	I-17	Risk ID	I-17 H7563U CNS 10.02
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Detour Costs - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					14	6	
Cost ($M)	$0.25	$0.50	$1.00	$0.27	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	14	6	

Added costs for repairing local streets used as detours. Local agencies may require repairs.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.25	$0.50	$1.00	$0.27	Strategy	1/27/2016
Schedule (Mo)				0.00		

Coordinate with the local agencies

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	1/27/2016
Next Review	**Risk Assignment**
	Owner

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Project	I-17	Risk ID	I-17 H7563U CNS 900.02
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Change Orders in Construction - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					2	6	
Cost ($M)	$5.40	$6.90	$8.40	$5.18	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	2	6	

Use 3 to 5% of construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$5.40	$6.90	$8.40	$5.18	Strategy	2/10/2016
Schedule (Mo)				0.00		

Hold a reserve for change orders

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

February 23, 2016 Risk Register Page 3 of 31

Project	I-17	Risk ID	I-17 H7563U CTR 10.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Change in Project Delivery - Ultimate

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)				0.00	16	6	

Base assumes DBB. If funds are available, there could be a change to DB or CMAR. This is a watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

ADA at Intersections

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
95%					8	6	
Cost ($M)	$0.40	$0.60	$1.20	$0.63	Project Rank Cost	Project Rank Schedule	1/26/2016
Schedule (Mo)				0.00	8	6	

Current design does not include items for ADA at the intersections. There is a significant risk that at the time of final design or construction, the sidewalks and ramps might need to be brought up to ADA standards. There is a potential that this may trigger some ROW and/or utility impacts. Assume most likely is 6 intersections at 100k each.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
95%						
Cost ($M)	$0.40	$0.60	$1.20	$0.63	Strategy	2/10/2016
Schedule (Mo)				0.00		

Have a discussion with ADOT roadway design to exempt this project from ADA improvements, since this project is not impacting the intersections.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	1/26/2016
Next Review	**Risk Assignment**
5/1/2016	Owner

Project	I-17	Risk ID	I-17 H7563U DES 10.02
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Sidewalks on Frontage Roads

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
90%					9	6	
Cost ($M)	$0.40	$0.60	$0.70	$0.53	Project Rank Cost	Project Rank Schedule	1/26/2016
Schedule (Mo)				0.00	9	6	

Currently most of the frontage road stretches do not have sidewalks. Assume 40,000 lf @ $15/lf.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
90%						
Cost ($M)	$0.40	$0.60	$0.70	$0.53	Strategy	2/10/2016
Schedule (Mo)				0.00		

Have a discussion with ADOT Roadway group.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.04
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Third Ave - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation	Modeling Note: No Markups		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					9	6	
Cost ($M)	-$0.75	-$0.70	-$0.65	-$0.53	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	9	6	

Consider closing the Third Ave or minimizing the structure. Value planning recommendation #2: Remove 3rd St Bridge. The base assumed a 10x10 box; Value Planning removes the box. By filling this in, it may change the drainage pattern. Total removal of bridge may necessitate adding a box culvert. Majority of the savings is in lowering the mainline profile and reducing the wall height.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	-$0.75	-$0.70	-$0.65	-$0.53	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.05
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Structure Lengths - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation	Modeling Note: No markups		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
90%					1	6	
Cost ($M)	-$8.00	-$7.40	-$7.00	-$6.69	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	1	6	

Construct the bridge to accommodate future widening of cross streets. Value Planning recommendation #1 evaluated the required length for each crossing and calculated a savings of approximately $7.4M

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
90%						
Cost ($M)	-$8.00	-$7.40	-$7.00	-$6.69	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.06
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

SR-30 Connection at Durango Curve - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)				0.00	16	6	

Possible provisions for an interchange at 19th Avenue. This is a watch list risk, which could have potential impacts to cost and schedule of this project. Also, the footprint at the west end of the project might increase.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.08
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Unsuitable Material

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					7	6	
Cost ($M)	$1.00	$1.50	$2.00	$1.13	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	7	6	

There is a risk that the base material might be unsuitable and might require over excavation. Replacing all of the pavement, there might be some unsuitable material, which might need to be replaced.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$1.00	$1.50	$2.00	$1.13	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.09
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Reverse Ramps

Risk Trigger		Flowchart Activity	510
Dependency & Correlation	Modeling Note: No Markups		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					4	6	
Cost ($M)	$5.00	$5.30	$6.50	$4.09	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	4	6	

Value Planning Recommendation #4 recommends reconfiguring the ramps. This adds a cost of $5.3M. This allows the project to be built at full standards among other things and improves the operations of the current ramps.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$5.00	$5.30	$6.50	$4.09	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	**Risk ID**	I-17 H7563U DES 50.03
Sub-Project	I-10 Split to 19th Aux Lanes	**Status**	Active

ITS/FMS - Ultimate

Risk Trigger		**Flowchart Activity**	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					6	6	
Cost ($M)	$1.50	$1.75	$2.00	$1.31	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	6	6	

The base has $0.5M/mile. This risk accounts for technology changes, unsalvageable hardware, and upgrades.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$1.50	$1.75	$2.00	$1.31	**Strategy**	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	**Risk ID**	I-17 H7563U DES 900.02
Sub-Project	I-10 Split to 19th Aux Lanes	**Status**	Active

Opportunity to Reduce Design Time - Ultimate

Risk Trigger		**Flowchart Activity**	310, 320
Dependency & Correlation	Full Impact to both activities equally		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					16	3	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)	-6.00	-6.00	-4.00	-4.25	16	3	

Base assumes 12 months for Environmental and Preliminary Design and 12 months for Final Design. The opportunity is to have the preliminary design and final design as one design project. This could reduce the time by 6 months.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)				$0.00	**Strategy**	2/10/2016
Schedule (Mo)	-6.00	-6.00	-4.00	-4.25		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 900.03
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Design Schedule - Ultimate

Risk Trigger		Flowchart Activity	300, 310
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
95%					16	2	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)	5.00	6.00	12.00	6.49	16	2	

Base assumes design schedule beginning 4/1/16. The decision for the ultimate vs. the near term may not be until March 2016. Needs 3 months time to procure a designer.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
95%						
Cost ($M)				$0.00	Strategy	2/10/2016
Schedule (Mo)	5.00	6.00	12.00	6.49		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U ENV 10.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Environmental Documentation- Ultimate

Risk Trigger		Flowchart Activity	300
Dependency & Correlation			

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	15%	75%	2%		16	1	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)	-3.00	12.00	24.00	9.03	16	1	

The risk is that if this project expands and has significant impacts, an EA, even an EIS, might be required. EA typically takes 24 months. If the impacts are mitigated an EIS might not be needed. It could be part of a larger document. The base has 12 months for the environmental document. Prob1 - revision to CE; prob 2 - EA; prob 3 - EIS.

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	15%	75%	2%			
Cost ($M)				$0.00	Strategy	2/10/2016
Schedule (Mo)	-3.00	12.00	24.00	9.03		

Minimize significant impacts to cover with a CE.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U ENV 40.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Cultural - Ultimate

Risk Trigger		Flowchart Activity	300
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					16	5	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)	1.00	1.50	2.00	1.13	16	5	

If TCE's are required, additional cultural consultation will be required.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)				$0.00	Strategy	2/10/2016
Schedule (Mo)	1.00	1.50	2.00	1.13		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U ENV 50.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Hazardous Materials in Existing Structures

Risk Trigger		Flowchart Activity	510
Dependency & Correlation	Full impact to each		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
95%					12	6	
Cost ($M)	$0.20	$0.25	$1.00	$0.35	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	12	6	

Existing structures may contain lead paint or other hazardous materials, which need to be accounted for in the construction cost. Central Ave and RR bridges are the most likely. The risk is that hazardous materials might have to be treated with this project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
95%						
Cost ($M)	$0.20	$0.25	$1.00	$0.35	Strategy	2/10/2016
Schedule (Mo)				0.00		

Add in bid items for removal of lead paint.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U ENV 70.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Drainage - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%					5	6	
Cost ($M)	$2.00	$3.50	$5.00	$2.63	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	5	6	

If widening to full standards or adding capacity, the additional impervious surface would require upsizing the existing drainage system. This could trigger ROW, utility, and environmental impacts. The base has $4.8M for drainage.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$2.00	$3.50	$5.00	$2.63	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U PSP 900.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Coordination with Stakeholders

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)				0.00	16	6	

Coordination with COP, Valley Metro, Railroads, airport, and other relevant stakeholders. Will require continuous coordination regarding sports and other events as the project progresses to final design. This is a watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U ROW 60.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

ROW Impacts (Drainage, Intersection, ADA, Access Control) - Ultimate

Risk Trigger		Flowchart Activity	400
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/26/2016
Schedule (Mo)				0.00	16	6	

There are potential ROW impacts from drainage, intersection improvements, ADA compliance, and access control. This could be a significant impact. ADA and drainage improvements would be the most probable impacts. This is a watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U RR 20.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Railroad Coordination and Flagging

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%					15	6	
Cost ($M)	$0.05	$0.10	$0.20	$0.11	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	15	6	

Base cost does not include cost for flagging. There may be additional coordination required during design.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	$0.05	$0.10	$0.20	$0.11	Strategy	2/10/2016
Schedule (Mo)				0.00		

Coordinate with the Railroad during final design and add appropriate quantities to the final estimate.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	1/27/2016
Next Review	**Risk Assignment**
	Owner

Project	I-17	Risk ID	I-17 H7563U STG 10.02
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Central Avenue - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)				0.00	16	6	

A 3-span or a 2-span bridge at Central Avenue. Foundations would need to be put into place prior to January 2022. The construction of the bridge needs to be completed by October 2022. Valley Metro project may begin ROW acquisition by the end of 2017 - need decision on ultimate Central Avenue structure by June 2017 for design; but would prefer to have the decision by June 2016 for the purpose of grant application. This is a watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U STG 10.03
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

11th Ave Substructure - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					11	6	
Cost ($M)	-$1.20	-$1.00	-$0.75	-$0.50	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	11	6	

There might be an opportunity to reuse some of the existing substructures. Since we are not lengthening this structure, there is an opportunity to potentially reuse some of the substructure.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	-$1.20	-$1.00	-$0.75	-$0.50	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U STG 10.04
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

Wall Types - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
90%					13	6	
Cost ($M)	-$4.00	$0.00	$2.00	-$0.30	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	13	6	

Base assumes CIP cantilever walls; some areas may not have room for construction and might require a different wall type or provide temporary shoring. There may be areas where MSE might work and there may be areas where soil nail might be required.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
90%						
Cost ($M)	-$4.00	$0.00	$2.00	-$0.30	Strategy	2/10/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U STG 900.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Active

ABC and Other Bridge Construction Methods - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	1/27/2016
Schedule (Mo)				0.00	16	6	

There might be opportunities to use accelerated bridge construction methods. See Value Planning Recommendation #3.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Risk ID	I-17 H7563U DES 10.03
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Inactive

Design Elements - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	16	6	

Standards per value planning exercise

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	I-17	Risk ID	I-17 H7563U DES 10.07
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Inactive

19th Ave Overpass - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	16	6	

In the ultimate, the 19th Ave structure needs to be reconstructed. There might be significant utility conflicts. 19th Ave structure reconstruction is included in the base cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	I-17	Risk ID	I-17 H7563U STG 20.02
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Inactive

Geotechnical Opportunity - Ultimate

Risk Trigger		Flowchart Activity	310
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	16	6	

Consider a load test for foundation requirements on bridge widening. There is not enough substructure to justify the cost of load test. This is a retired risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	I-17	Risk ID	I-17 H7563U ENV 90.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Retired

Noise Walls - Ultimate

Risk Trigger		Flowchart Activity	510
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
20%					16	6	
Cost ($M)	-$1.00	$0.00	$0.50	$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	16	6	

Adding capacity and/or widening to standards could trigger noise walls in the areas of high density receptors. Base has $5.0M for noise walls. This risk is covered in the base cost uncertainty; retire the risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
20%						
Cost ($M)	$2.00	$3.00	$4.00	$0.00	Strategy	1/26/2016
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	I-17	Risk ID	I-17 H7563U PSP 20.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Retired

Public Relations - Ultimate

Risk Trigger		Flowchart Activity	320, 510
Dependency & Correlation	Weighted		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%					16	6	
Cost ($M)	$1.00	$1.50	$2.00	$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	16	6	

There is a possibility that in case of full closure, public outreach efforts will be needed. Detour routes, website, public information campaigns, etc. might be needed. This may require alternate modes of transportation. This risk is retired; cost included in the updated base cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$1.00	$1.50	$2.00	$0.00	Strategy	1/27/2016
Schedule (Mo)				0.00		

Design and implement a public awareness program.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	1/27/2016
Next Review	**Risk Assignment**
	Owner

Project	I-17	Risk ID	I-17 H7563U STG 20.01
Sub-Project	I-10 Split to 19th Aux Lanes	Status	Retired

Slopes - Ultimate

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
					16	6	
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/10/2016
Schedule (Mo)				0.00	16	6	

There might be an opportunity to reevaluate the side slopes to use 2:1 reinforced slopes to reduce wall heights and/or change wall types and foot print. Revised design retires this risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Value Planning Study Agenda

I-17, I-10 Split to 19th Avenue

February 8-10, 2016

Location: MAG 302 N 1st Ave. Suite 200, Multiple Conference Rooms

Meeting Objectives:

This Value Planning Study is directed at improving constructability, reducing risk, capital and/or operating costs.

Monday February, 08, 2016	Topic
8:30 - 8:45	Welcome, sign-in, updates, etc. Introductions Agenda Review
8:45 - 9:00	Overview of Value Planning
9:00 - 10:00	Review of Cost Estimate
10:00 - 10:15	Break
10:15 - 10:30	Flowchart (Schedule)
10:30 - 10:45	Review of Top Risks from CRA
10:45 - 12:00	Brainstorm (Speculation)
12:00 - 1:00	Lunch
1:00 - 3:00	Brainstorm Issues (Speculation)
3:00 - 3:15	Break
3:15 - 5:00	Evaluation of Ideas

Tuesday February, 09, 2016	Topic
8:30 - 10:30	Evaluation (continued)
10:30 - 10:45	Break
10:45 - 12:00	Development
12:00 - 1:00	Lunch
1:00 - 3:00	Development (continued)
3:00 - 3:15	Break
3:15 - 5:00	Development (continued)

Wednesday February, 10, 2016	Topic
8:30 - 10:30	Development (continued)
10:30 - 10:45	Break
10:45 - 12:00	Development (continued)
12:00 - 1:00	Lunch
1:00 - 3:00	Development (continued)
3:00 - 3:15	Break
3:15 - 5:00	Re-evaluate risks

Workshop Attendees

CRA and Value Planning Study Attendees
I-17: I-10 Split to 19th Avenue Project

2016 January (CRA) 26	2016 January (CRA) 27	2016 February (VE) 8	2016 February (VE) 9	2016 February (VE) 10	NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE Office	TELEPHONE Cell	E-MAIL
☒	☒	☒	☒	☒	Ken Smith	HDR	Risk/VE Lead	360-570-4415	360-451-2527	Ken.l.smith@hdrinc.com
☒	☒	☒	☒	☒	Suresh Raghavendra	HDR	Workshop Assistant	602-522-4328		Suresh.raghavendra@hdrinc.com
☒	☒	☒	☒	☒	Chaun Hill	MAG	Senior Transportation Engineer	602-254-6300		chill@azmag.gov
☒	☒	☒	☒	☒	Quinn Castro	MAG	Transportation Engineer	602-254-6300		Qcastro@azmag.gov
		☒	☒	☒	Trent Eakin	HDR	SME/Modeler	360-570-7270		trent.eakin@hdrinc.com
☒		☒	☒	☒	John Misik	HDR	VE/Structures	602-522-7735	480-294-5715	John.misik@hdrinc.com
☒	☒	☒	☒	☒	Brian Bombardier	HDR	Spine Study Liaison/SME	602-778-7324		Brian.bombardier@hdrinc.com
☒	☒	☒	☒	☒	Dave Moody	MAG	Associate		602-809-0358	dmoody@azmag.gov
☒	☒	☒	☒	☒	Madhu Reddy	ADOT	District Engineer – Central District	602-712-8965		mreddy@azdot.gov
		☒	☒	☒	Kole Dea	ADOT	Resident Engineer – Central District		602-708-8992	kdea@azdot.gov

CRA and Value Planning Study Attendees
I-17: I-10 Split to 19th Avenue Project

2016 January (CRA) 26	2016 January (CRA) 27	2016 February (VE) 8	2016 February (VE) 9	2016 February (VE) 10	NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE Office	TELEPHONE Cell	E-MAIL
		☒		☒	Bob Hazlett	MAG	Senior Engineering Manager	602-254-6300		bhazlett@azmag.gov
			☒		Trent Kelso	ADOT	Engineering Manager		602-291-7433	tkelso@azdot.gov
☒	☒				Dale Drost	ADOT CD	Maintenance	602-245-0241	602-712-8395	ddrost@azdot.gov
☒					Mustafa Muradvich	ADOT EP	Environmental Planner	602-712-7760		mmuradvich@azdot.gov
☒	☒				John Louis	PB	Senior Engineer	480-449-7738	623-229-8642	Louis@pbworld.com
☒					Matt Tolman	ADOT	ROW/CPA Liaison	602-712-4701		mtolman@azdot.gov
☒					Dave Edwards	ADOT	R/W	602-712-8803		dedwards@azdot.gov
☒	☒				Thomas O'Reilly	PB	Project Manager	480-449-4937		oreillyt@pbworld.com
☒	☒				Eric Prosnier	ADOT	Project Manager			eprosnier@azdot.gov
☒					Don Smith	PB	Environmental Manager	480-449-4604	480-403-1377	smithdon@pbworld.com
☒					Abhishek Dayal	Valley Metro	Manager of Capital Development		602-744-5572	adayal@valleymetro.org

CRA and Value Planning Study Attendees
I-17: I-10 Split to 19th Avenue Project

2016					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
January (CRA)		February (VE)						Office	Cell
26	27	8	9	10				E-MAIL	
☒	☒				Glenn Gaelick	ADOT	Roadway	602-712-7039	
								rgaelick@azdot.gov	
☒	☒				Gary Sun	PB	Drainage	480-921-6897	602-790-0585
								sung@pbworld.com	
☒	☒				Maurice Goyette	COP	Light Rail Coordinator	602-206-4495	
								Maurice.gayette@phoenix.gov	
☒	☒				Scott Gehrke	Valley Metro	Transit Engineer	480-254-0174	
								sgehrke@valleymetro.org	
☒	☒				Scott Miller	Valley Metro	Transit Planner	602-744-5558	480-363-3985
								smiller@valleymetro.org	
☒					William Downes	ADOT	Bridge Group	602-712-7115	
								wdownes@azdot.gov	
☒					Aryan Lirange	FHWA		602-382-8973	602-999-2921
								Aryan.lirange@dot.gov	
☒	☒				Rados Gluscevic	ADOT	Traffic Group	602-712-7311	
								rgluscevic@azdot.gov	
	☒				David Benton	ADOT	Bridge Engineer	602-712-7910	
								Dbenton@azdot.gov	

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CRAVE Study Report Out

Safety First

- *Emergency Exits*
  - *Muster point*
- *CPR*
- *The number for "911"*

Plan the Work and Work the Plan

Introductions

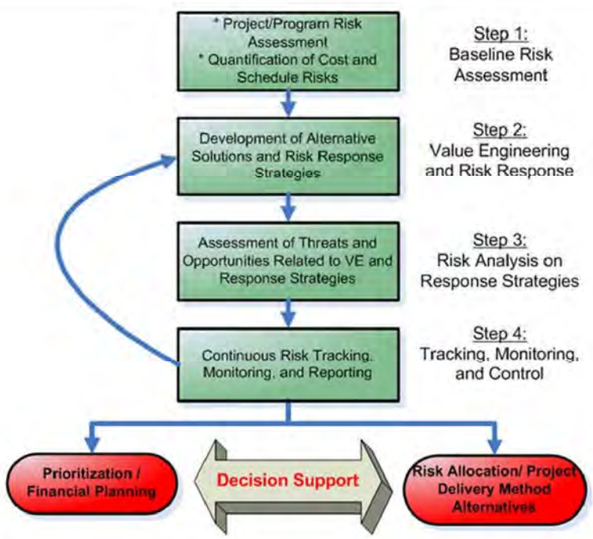
- Who are you?
- What do you do?
- Have you been on a Cost Risk Assessment or Value Engineering workshop before?

Comparison of the two processes

Both use a team approach

Cost Risk Assessment	Value Engineering
Learn about project	Investigate
Identify Risks	**Functional analysis**
Strategize how to handle	Creative
Qualify and Quantify	Evaluate
Develop response plans and triggers	Develop

5



Decision Support

- **I-17 I-10 split to 19th Ave (Near Term Auxiliary lanes) 15% design**
  - Auxiliary Lanes on I-17 between ramps, below standard roadway widths and geometrics
  - Widen existing bridges and roadway
  - Potential for throwaway for walls, structures and pavement
  - Within existing ROW
- **I-17 I-10 split to 19th Ave (Ultimate) 0% design – Value Planning**
  - Replace bridges and mainline and ramp pavement
  - Walls in ultimate location to accommodate future widening
  - Fix below standard roadway widths and geometrics
  - Minimal ROW impacts

Addressing Cost and Schedule Concerns

Usual Questions

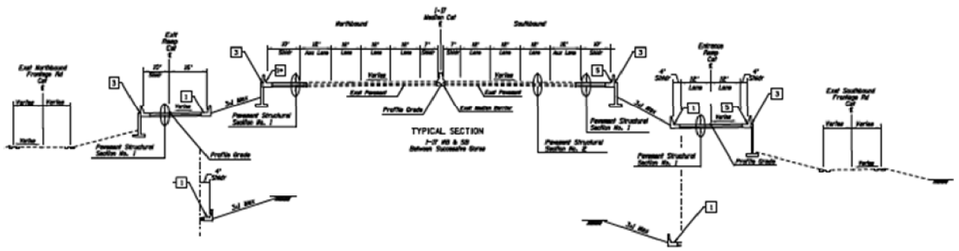
- How much will it cost?
- How long will it take?
- Why does it cost that much?
- Why does it take that long?

Analysis Needs

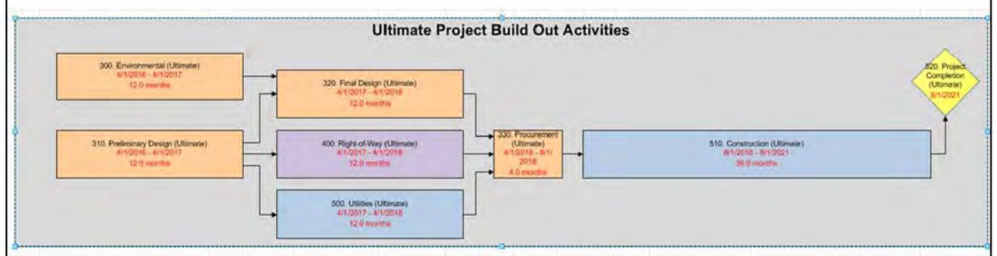
- Risk Identification
- Qualitative and Quantitative Risk Analysis
- Value Engineering &Mitigation Strategies
- Risk Monitoring & Control

8

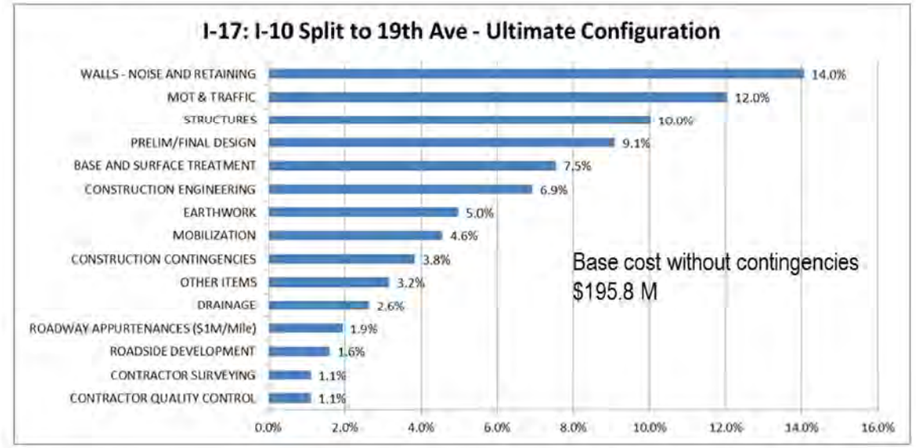
I-17, I-10 Split to 19th Ave
Near Term Auxiliary Lane Project



$45M- $50M in 2015$
Construction duration 18 months complete in 2019



Value Planning



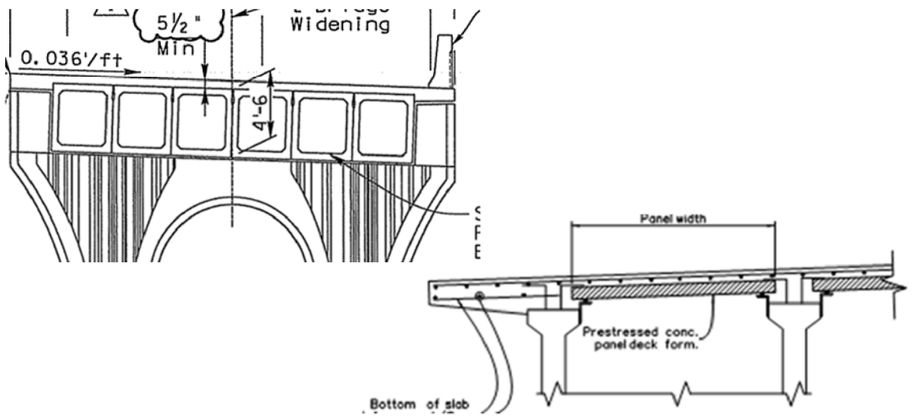
Recommendation #1 Bridge Lengths

The base line assumes adding 30 feet of span length (total span length of 60 feet) to each side of the cross street to accommodate future needs of the existing street facility

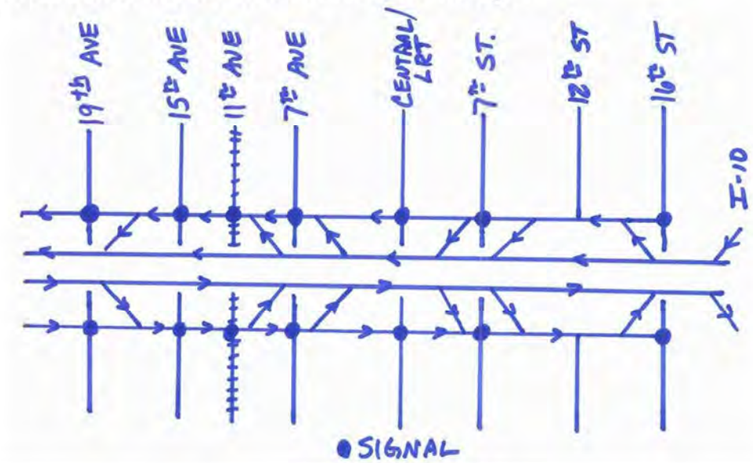
16th Street – Arterial
7th Street – Major Arterial
Central Avenue – Arterial
7th Avenue – Arterial (assume a Major Arterial for this study)
15th Avenue – Minor Collector
19th Avenue - Major Arterial

Recommendation # 2 Remove 3rd St Bridge

Recommendation # 3 Accelerated Bridge Construction (ABC)



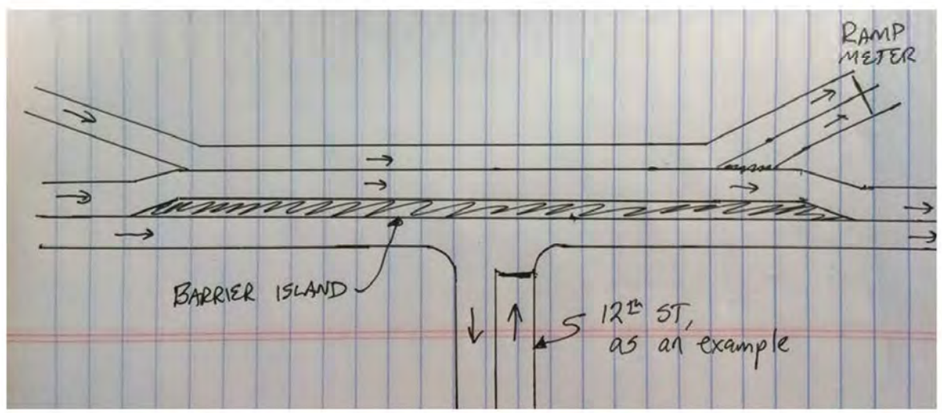
Recommendation #4 Reverse Ramps



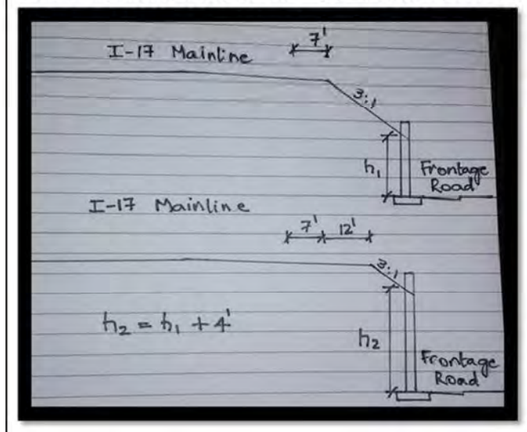
Recommendation #4 Reverse Ramps

Recommendation #4 Reverse Ramps

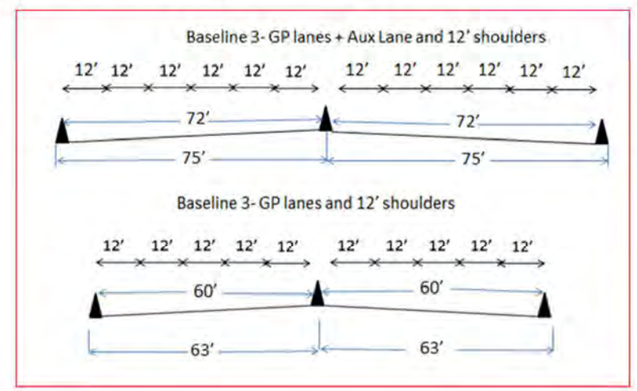
Recommendation #4 Reverse Ramps



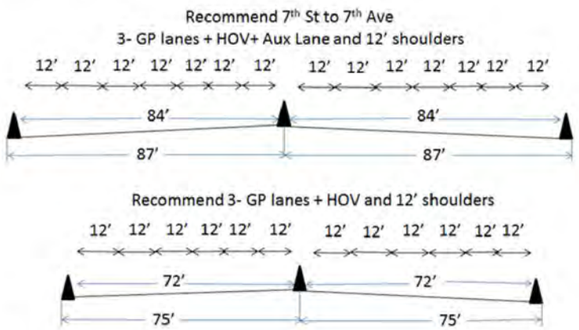
Recommendation #5 Walls at Frontage Roads



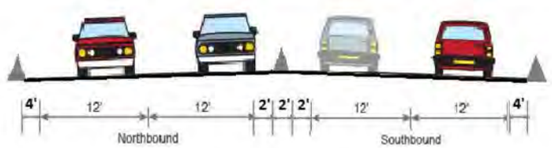
Recommendation # 6 Roadway Width



Recommendation # 6 Roadway Width



Recommendation # 7 MOT $17M 36 months



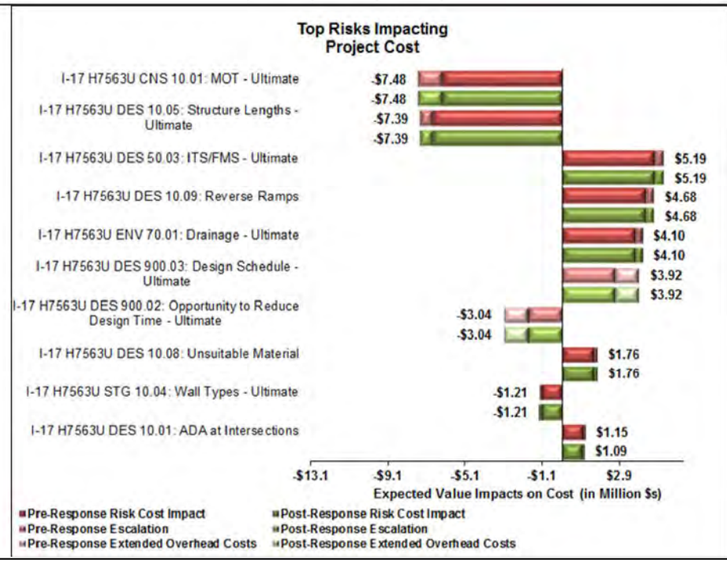
Recommendation # 7 MOT $8.5M 30 months

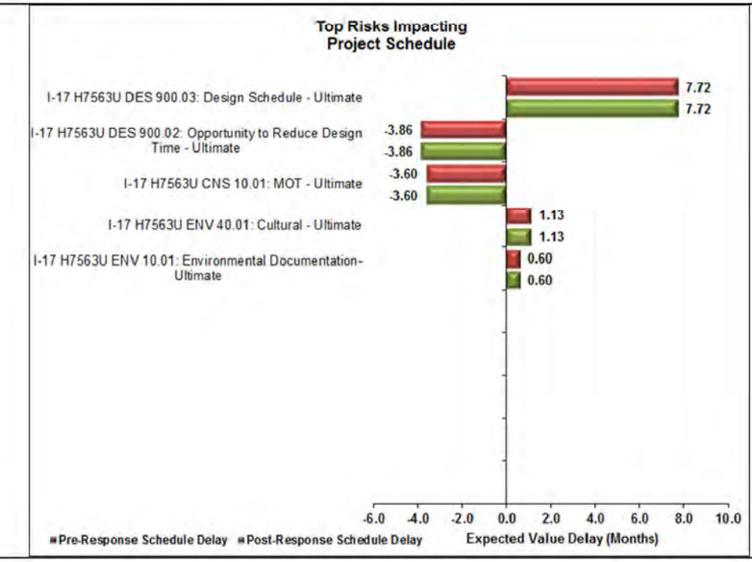
MOT Scenarios

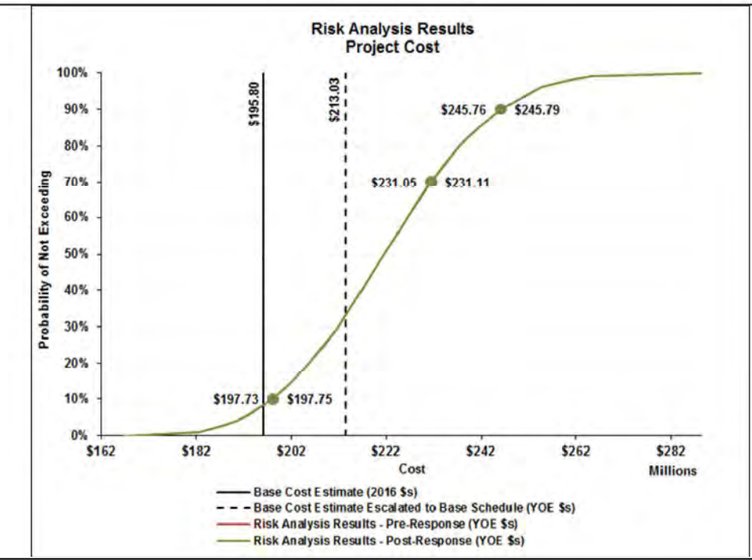
- 15% Scenario A $17M 36 months two lanes in each direction on I-17
- 60% Scenario B $8.5M 30 months two lane on frontage roads I-17 closed
- 25% Scenario C $20M 36 months two lane each direction on I-17 and improvements to Frontage roads

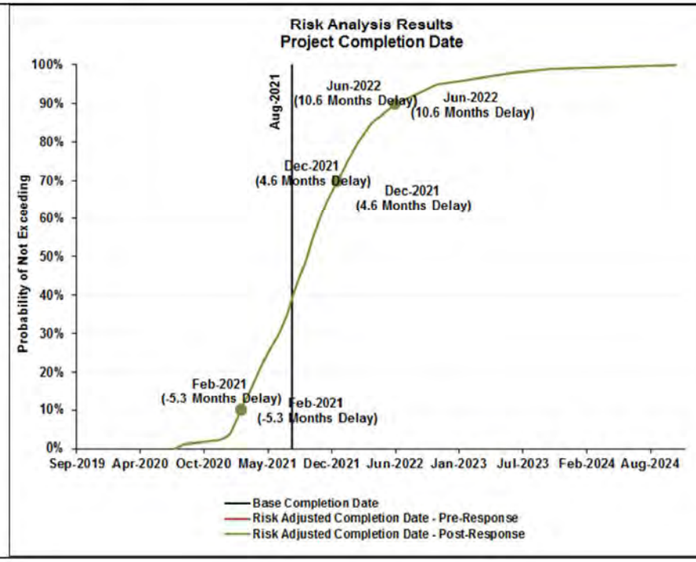
Value Planning Recommendation Summary

#	Description	Value ($M)	Probability
1	Bridge Lengths	-7.4	90%
2	3rd Street Bridge	-0.7	75%
3	ABC Bridge	NQ	
4	Reverse Ramps	5.3	75%
5	Walls - HOV	12.8	
6	Roadway & Bridge Widths –HOV	8.09	
7	MOT	-12.5	60%









Decision Support

- **I-17 I-10 split to 19th Ave (Near Term Auxiliary lanes) 15% design**
  - 18-20 months construction complete in 2019
  - $45.9 M (2015$); $66.2 M @ 70th Percentile (2016 $)
- **I-17 I-10 split to 19th Ave (Ultimate) 0% design – Value Planning**
  - 24-36 months construction complete in 2022
  - $210.6M @ 70th percentile (2016 $)
- **I-17 I-10 split to 19th Ave (Ultimate) + HOV 0% design – Value Planning**
  - 24-36 months construction complete in 2022
  - $232M @ 70th percentile (2016 $)

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Value Engineering Process

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

The primary objective of a VE Study is value improvement. The value improvements might relate to scope definition, functional design, constructability, coordination (both internal and external), or the schedule for project development. Other possible value improvements are reduced environmental impacts, reduced public inconvenience, or reduced project cost.

Value Engineering Job Plan

The Value Engineering Job Plan was employed in analyzing the project. This process is recommended by SAVE International and is composed of the following phases:

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

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

Creative - During this phase the team employed creative techniques such as team brainstorming to develop a number of alternative concepts that satisfy the project's primary functions.

Evaluation - The purpose of this phase was to evaluate the alternative concepts developed by the VE Team during the brainstorming sessions. The team used a number of tools to determine the qualitative and quantitative merits of each concept.

Development - Those concepts that ranked highest in the evaluation were further developed into VE recommendations. Narratives, drawings, calculations, and cost estimates were prepared for each recommendation.

Presentation - The VE Team presented their finding in the form of a written report. In addition, an oral presentation was made to the owner and the design team to discuss the VE recommendations.

Implementation/Resolution - Evaluate, resolve, document and implement all approved recommendations.

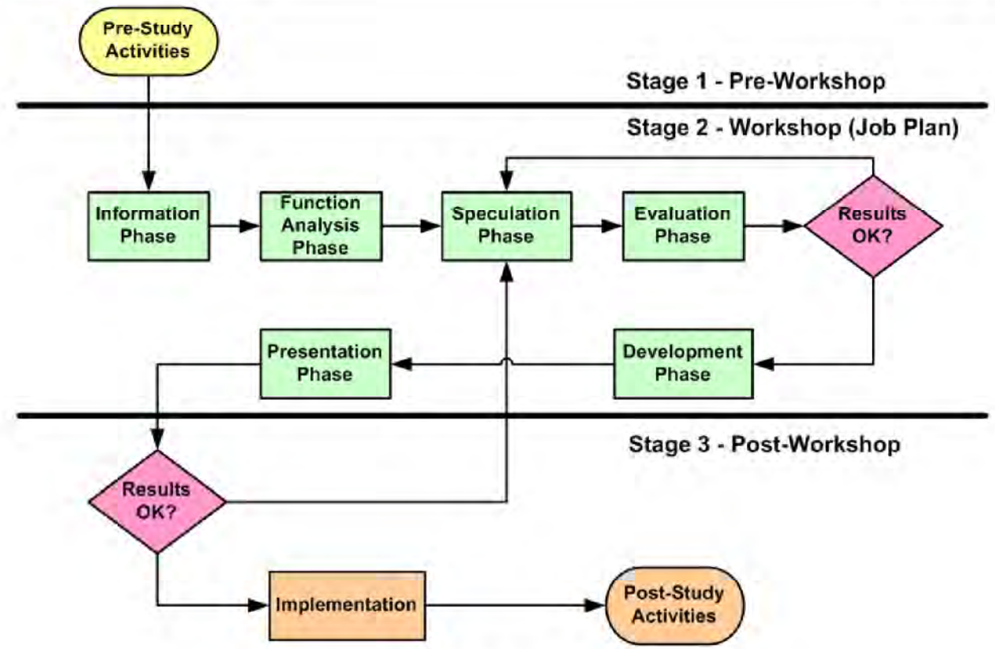

Figure 1 – Value Engineering Job Plan

CRAVE Process

CRAVE is an advanced project management process that has combined the proven tools and processes from Cost Risk Assessment Workshops and Value Engineering Studies into a single process. Each of these processes has been extremely successful in assisting agencies in delivering capitol projects. CRAVE is an iterative process between risk analysis and value engineering, in order to seek the most effective and efficient solutions to deliver the projects and therefore provide decision support throughout the project delivery lifecycle.

The main objectives of CRAVE can be summarized as follows:

- Encouraging pro-activity and early planning;
- Building confidence and credibility in project's plans and estimates;
- Developing targeted mitigation strategies for all anticipated threats;
- Better allocation of risks and identification of project delivery methods; and
- Ensuring transparency, integrity, and accountability throughout the life-cycle of the project.
- Deliverables: Risk Management Plan and Value Engineering Recommendations

Step 1: Baseline Risk Assessment

a) Review baseline cost
b) Review baseline schedule
c) Identify risks related to baseline project
d) Assess and quantify risks in terms of project's cost and schedule

Step 2: Value Engineering & Risk Response

a) Develop value engineering recommendations that further mitigate or avoid high risk elements
b) Develop recommendations that add value by modifying project scope and/or schedule

Step 3: Risk Analysis on Response Strategies

a) Identify risks related to response strategies
b) Assess and quantify threats and opportunities in terms of project's cost and schedule

Step 4: Tracking, Monitoring, and Control

a) Identify risk owners, monitoring frequency
b) Continuously update risk management plan
c) Document and report progress
d) At key milestones, update cost and schedule

Pre-CRAVE Study

Prior to the start of a CRAVE Study, the Project Manager, CRAVE Team Leader, and the State Value Engineering Coordinator/Manager typically carry out the following three activities:

- Initiate Study
  - Prepare CRAVE Study request
  - Define scope, objective and goals of the study
  - Define study timing

- Organize Study
  - Conduct Pre-Study meeting
  - Select team members
  - Identify performance attributes (if applicable)
- Prepare Data
  - Collect and distribute data
  - Prepare cost models
  - Prep for study.

All of the information gathered prior to the CRAVE Study is given to the team members for their use.

Performance Based Results

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

Introduction

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

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

The VE Team Leader will lead the team and external stakeholders through the methodology, using the power of the process to distill subjective thought into an objective language that everyone can relate to and understand. The dialog that develops forms the basis for the VE Teams' understanding of the performance requirements of the project, and to what degree the current design concept is meeting those requirements. From this baseline, the VE Team can focus on developing alternative concepts that will quantify both performance and cost and contribute to overall project value.

Performance based value engineering yields the following benefits:

- Builds consensus among project stakeholders (especially those holding conflicting views)
- Develops a better understanding of a project's goals and objectives

- Develops a baseline understanding of how the project is meeting performance goals and objectives
- Identifies areas where project performance can be improved through the VE process
- Develops a better understanding of a VE recommendation's effect on project performance
- Develops an understanding of the relationship between performance and cost in determining value
- Uses value as the true measurement for the basis of selecting the right project or design concept
- Provides decision makers with a means of comparing costs and performance (i.e., costs vs. benefits) in a way that can assist them in making better decisions

Methodology
The application of performance based value engineering consists of the following steps:

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

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

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

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

Step 1 – Determine the Major Performance Attributes
Performance attributes can generally be divided between Project Scope components (Highway Operations, Environmental Impacts, and System Preservation) and Project Delivery components.

It is important to make a distinction between performance attributes and performance requirements. Performance requirements are mandatory. All performance requirements MUST be met by any idea being considered.

Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and construction of a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be Project Schedule which means that a wide range of alternatives could be acceptable that had different durations.

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

The information that comes out of this discussion will be valuable to both the VE Team and the Project Owner. It is important that the attribute be discretely defined, and they must be quantifiable in some form. The vast majority of performance attributes that typically appear in transportation value studies have been standardized. This standardized list can be used "as is" or adopted with minor adjustments as required. Every effort should be made to make the ratings as objective as possible.

Step 2 – Determine the Relative Importance of the Attributes
Once the group has agreed upon the project's performance attributes, the next step is to determine their relative importance in relation to each other. This is accomplished through the use of an evaluative tool termed in this report as the "Performance Attribute Matrix."

This matrix compares the performance attributes in pairs, asking the question: "An improvement in which attribute will provide the greatest benefit to the project relative to purpose and need?" A letter code (e.g., "a") is entered into the matrix for each pair, identifying which of the two is more important. If a pair of attributes is considered to be of essentially equal importance, both letters (e.g., "a/b") are entered into the appropriate box. This, however, should be discouraged, as it has been found that in practice a tie usually indicates that the pairs have not been adequately discussed.

When all pairs have been discussed, the number of "votes" for each is tallied and percentages (which will be used as weighted multipliers later in the process) are calculated. It is not uncommon for one attribute to not receive any "votes." If this occurs, the attribute is given a token "vote", as it made the list in the first place and should be given some degree of importance.

Step 3 – Establish the Performance "Baseline" for the Original Design
The next step is to define the baseline as it pertains to each performance attribute. The baseline is then given a score of 5 on a scale of 0 to 10 for each attribute.

Step 4 – Evaluate the Performance of the CRAVE Recommendations

Once the performance of the baseline has been established for the original design concept, it can be used to help the VE Team develop performance ratings for individual VE recommendations as they are developed during the course of the value study. The Performance Measures form at the back of each recommendation is used to capture this information.

It is important to consider the recommendation's impact on the entire project, rather than on discrete components.

Step 5 – Compare the Performance Ratings of Recommendations to the "Baseline" Project

The last step in the process is to develop the performance ratings for the original design concept. The VE Team groups the recommendation into a scenario (or scenarios) to provide the decision makers a clear picture of how the recommendations fit together into possible solutions. At least one scenario is developed to present the VE Team's consensus of what should be implemented. Additional scenarios are developed as necessary to present other combinations to the decision makers that should be considered. The scenario(s) of VE recommendations are rated and compared against the original concept. The performance ratings developed for the VE Scenarios are entered into the matrix, and the summary portion of is completed. The summary provides details on net changes to cost, performance, and value, using the following calculations.

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

Reporting

Following the CRAVE Study, the Team Leader assembles all study documentation into the draft/final reports:

- Publish Results – Prepare a draft and a final CRAVE Study Report; distribute printed and electronic copies as needed.

The CRAVE Study is complete when the report is issued as a record of the CRAVE Team's analysis and development work, as well as the Project Team's implementation dispositions for the recommendations.

VE Study Recommendation Approval Form

I-17: I-10 Split to 19th Avenue Project

	Recommendation	Approved Y/N	FHWA Functional Benefit: Safety	Operations	Environment	Construction	ROW	VE Team Estimated Cost Avoidance or Cost Added (millions $)	Project Manager Justification for not recommending or potential implementation issues
1	Bridge Lengths					✓		-7.4	
2	Remove 3rd Street Bridge					✓		-0.7	
3	Accelerated Bridge Const. (ABC)							NQ	
4	Reverse Ramps							5.3	
5	Walls at Frontage Roads							12.8	
6	Roadway Width							8.1	
7	Maintenance of Traffic (MOT)							-12.5	

Please provide justification if the value engineering workshop recommendations are **not** approved or are implemented in a modified form.

The Project Manager will review and evaluate the VE Team's recommendation(s) that are included in the Final Report. The Project Manager shall complete the VE Recommendation Approval form that is included in this report.

For each recommendation that is not approved or is modified by the Project Manager, justification needs to be provided. This justification shall include a summary statement containing the Project Manager's decision not to use the recommendation in the project.

The completed VE Recommendation Approval form including justification for any recommendations not approved or modified shall be sent to the Project Manager by October 1 of each year so the results can be included in the annual Value Engineering Report to FHWA.

Signature Project Manager _____ Date _____

Name (please print) _____

FHWA Functional Benefit Criteria

Each year, State DOT's are required to report on VE recommendations to FHWA. In addition to cost implications, FHWA requires the DOT's to evaluate each approved recommendation in terms of the project feature or features that recommendation benefits. If a specific recommendation can be shown to provide benefit to more than one feature described below, count the recommendation in ***each category that is applicable.***

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 can be categorized as any impacts to base design right of way conditions.

I-17/Camelback TI CRA & Value Planning Workshop Results

(in coordination with Valley Metro Phoenix West/Glendale Extension LRT)

June 27-30, 2016

I-17 / Camelback Road / Light Rail Crossing
Value Planning Study

Final Report

Prepared for:
Maricopa Association of Governments

Lead Authors:
Ken Smith
Suresh Raghavendra

Prepared By:
HDR

Date:
June 27-30, 2016

Disclaimer:

The information contained in this report is the professional opinions of the Team members during the Value Planning Study. These opinions were based on the information provided to the Team at the time of these workshops.

As the project continues to develop, new information will become available, and this information will need to be evaluated on how it may affect the recommendations and findings in this report. All costs displayed in the report are also based on best available information at the time of the study and, unless otherwise noted, are in 2016 dollars.

This report was prepared by:

3200 East Camelback Road
Suite 350
Phoenix, AZ 85018

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Executive Summary

Introduction

This Value Planning report summarizes the events of the workshop conducted for the Maricopa Association of Governments (MAG) and facilitated by HDR, Inc. The project under review was I-17 / Camelback Road / Light Rail Crossing. The workshop was conducted on June 27-30, 2016. The presentation of the Value Planning recommendations (alternatives) was held on June 30, 2016.

Value Planning Summary

Number of Alternatives: 4

Total Number of Team Members: 38

MAG: 6

Valley Metro: 3

ADOT: 9

FHWA: 2

City of Phoenix: 8

City of Glendale: 1

AECOM: 2

HDR: 7

Facilitator: HDR Engineering, Inc.

The primary objectives of the Team through the application of Value Engineering tools were to:

- Conduct a thorough review and analysis of the key project issues using a multidisciplinary, cross-functional Team;
- Develop, verify or improve upon the various concepts for each alternative;
- Improve the value of each alternative through innovative measures aimed at improving the performance while reducing costs; and,
- Perform a cost risk analysis on each alternative.

Project Overview

The Regional Transportation Plan (RTP) identifies a five-mile West Phoenix/Central Glendale (WPCG) corridor in Glendale and Phoenix, Arizona as a future high-capacity transit (HCT) route and part of the RTP adopted in 2004. This corridor would connect the existing light rail transit (LRT) line at 19th Avenue with downtown Glendale.

In 2013, Valley Metro, in partnership with cities of Phoenix and Glendale, initiated a transit corridor study for the West Phoenix/Central Glendale area to identify HCT service options to connect downtown Glendale to the existing light rail system. The purpose of the WPCG Transit Corridor Study is to determine the type of transit and route that will best meet mobility needs by providing a dependable and efficient service to connect employment, activity centers, educational facilities, and residential areas in West Phoenix and Central Glendale.

The leading alternative is a seven-mile route that includes about 3 miles on Camelback Road in the City of Phoenix, 2 miles on 43rd Avenue (which forms the boundary between the cities of Phoenix and Glendale), and about 2 miles on Glendale Avenue and Glenn Drive within the City of Glendale.

Concurrently, MAG initiated the “Spine” project that is studying the I-10 / I-17 corridor, approximately 35 miles long, from I-10 / SR-202L (Santan) intersection in the south to I-17 / SR-

101L (North Stack) in the north. The Spine project is developing a Corridor Master Plan, which, among other recommendations, is considering improving I-17 / Camelback Road intersection in the City of Phoenix. In addition to the overlap in the project area of I-17 / Camelback Road intersection, the project schedules also appear to overlap / conflict.

In order to minimize rework and throwaway, and reduce inconvenience to travelling public and businesses in the area, MAG commissioned this Value Planning workshop to study the I-17 / Camelback Road / Light Rail Crossing location and develop comprehensive solution alternatives to this key intersection.

Value Planning Study

Within the Camelback Road portion of the LRT corridor, MAG’s Spine project is considering options to improve the I-17 / Camelback Road Traffic Interchange (TI). This TI work will directly impact both the design and schedule of the LRT project. Therefore, a Risk Assessment and Value Planning workshop was commissioned to comprehensively study the I-17 / Camelback Road / Light Rail Crossing location and suggest solution alternatives. The key considerations of the study Team were:

- Restricted left turn access on Camelback Road;
- Potential for changes to property access;
- Impacts and duration of construction;
- Visibility of businesses;
- Right-of-way requirements; and
- Pedestrian safety.

As the risk assessment process began, it was apparent that without a defined project, the risks were largely unquantifiable and that there were multiple alternatives for both the LRT project and the roadway project (I-17 / Camelback Road TI). Therefore, a “design competition” was conducted to evaluate the various LRT and TI scenarios comprehensively. Each Team was tasked to develop combined transit and roadway solutions by identifying the best LRT option for each of the TI alternatives. This became the basis of the Value Planning exercise.

Value Planning Alternatives

The Teams developed four alternatives, which combined LRT and TI options in each of them. The Value Planning alternatives are shown in Table 1 and are detailed in the Development Phase section of this report. These alternatives show what the Team’s developed over the course of the workshop and will provide a preliminary solution that will likely be acceptable to the agency stakeholders involved.

While these alternatives may or may not advance, - perhaps even be modified as the project progresses - they will provide the basis to ensure that the project moves forward successfully.

Table 1: List of Alternatives				
Alternatives		Performance	Cost	Value Index
1	SPUI with LRT Elevated to North	571	$51.2 M	11.16
2	Tight Diamond with LRT Fly Over	662	$64.8 M	10.22
3	Platform Diamond with LRT Fly Over	752	$56.6 M	13.29
4	SPUI with Elevated LRT and Fly Over	638	$51.9 M	12.29

The Value Planning Team wishes to express its appreciation to the project design Team and management for the excellent support they provided during the workshop. It is the Team's expectation that their evaluation of each alternative will assist management in the decision support process to move the project forward.

Ken L. Smith, PE, CVS®
Value Planning Team Lead

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Introduction

This report summarizes the events of the Value Planning study conducted for the Maricopa Association of Governments (MAG), facilitated by HDR Engineering, Inc. The subject of the study was the I-17 / Camelback Road / Light Rail Crossing project.

Project Description

The Regional Transportation Plan (RTP) identifies a five-mile West Phoenix/Central Glendale (WPCG) corridor in Glendale and Phoenix, Arizona as a future high-capacity transit (HCT) route and part of the RTP adopted in 2004. This corridor would connect the existing light rail transit (LRT) line at 19th Avenue with downtown Glendale.

In 2013, Valley Metro, in partnership with cities of Phoenix and Glendale, initiated a transit corridor study for the West Phoenix/Central Glendale area to identify HCT service options to connect downtown Glendale to the existing light rail system. The purpose of the WPCG Transit Corridor Study is to determine the type of transit and route that will best meet mobility needs by providing a dependable and efficient service to connect employment, activity centers, educational facilities, and residential areas in West Phoenix and Central Glendale.

The leading alternative is a seven-mile route that includes about 3 miles on Camelback Road in the City of Phoenix, 2 miles on 43rd Avenue (which forms the boundary between the cities of Phoenix and Glendale), and about 2 miles on Glendale Avenue and Glenn Drive within the City of Glendale.

Concurrently, MAG initiated the “Spine” project that is studying the I-10 / I-17 corridor, approximately 35 miles long, from I-10 / SR-202L (Santan) intersection in the south to I-17 / SR-101L (North Stack) in the north. The Spine project is developing a Corridor Master Plan, which, among other recommendations, is considering improving I-17 / Camelback Road intersection in the City of Phoenix. In addition to the overlap in the project area of I-17 / Camelback Road intersection, the project schedules also appear to overlap / conflict.

In order to minimize rework and throwaway, and reduce inconvenience to travelling public and businesses in the area, MAG commissioned this Value Planning workshop to study the I-17 / Camelback Road / Light Rail Crossing location and develop comprehensive solution alternatives to this key intersection.

Scope of the Value Planning Study

The scope of the workshop was to develop alternative concepts for the I-17 / Camelback Road / Light Rail Crossing project. The primary objectives of the Team through the application of Value Engineering tools were to:

- Conduct a thorough review and analysis of the key project issues using a multidisciplinary, cross-functional Team;
- Develop, verify or improve upon the various concepts for each alternative;

- Improve the value of each alternative through innovative measures aimed at improving the performance while reducing costs; and,
- Perform a cost risk analysis on each alternative.

Value Planning Study Timing

The timing of the study was based on a conceptual layout for the project. The workshop was held at the MAG building in downtown Phoenix from June 27 - 30, 2016. The presentation of the findings was held on June 30, 2016.

Value Planning Team Members

The list of Team members who participated in the Value Planning is provided in Table 2. Other attendees and their participation during the workshop are identified on the sign-in sheets provided in the Appendix.

Table 2: CRA & Value Planning Team Members

Name	Organization	Position/Discipline
Ken Smith	HDR	Risk/Value Planning Lead
Suresh Raghavendra	HDR	Workshop Assistant
Bob Hazlett	MAG	Transportation Manager
Chaun Hill	MAG	Senior Transportation Engineer
Audra Koester Thomas	MAG	Transit Planning Project Manager
Quinn Castro	MAG	Transportation Engineer
David Moody	MAG	Associate
Abhishek Dayal	Valley Metro	Capital Development Manager
Jay Yenerich	Valley Metro	Conceptual Design
Jennifer Pyne	AECOM	Project Manager
Omar Jaff	AECOM	Transit & Rail Manager
Trent Eakin	HDR	Construction SME/Modeler
Brian Bombardier	HDR	Roadway SME
Jason Nauman	HDR	Structures SME
Scott Gehrke	HDR	Transit SME
James Slaker	HDR	Transit SME
David Lochner	ADOT	Construction Central District
Clem Ligocki	ADOT	Planning & Programming Manager
Dale Drost	ADOT	Maintenance
Raul Amavisca	ADOT	Maintenance
Eric Prosnier	ADOT	Project Manager
Maurice Goyette	COP	Lead Light Rail Engineer

Figure 1: Value Planning Team

Information Phase

Summary of Analysis

The following analysis tools were used to study the project:

- Constraints and Controlling Decisions
- Investigation Observations
- Project Schedule Review
- Performance Attributes
- Performance Attribute Matrix

Constraints and Controlling Factors

As part of the project briefing, the Value Planning Teams were given the following project constraints and controlling factors when considering alternatives:

- Limit right-of-way impacts;
- Maintain access to businesses during and after construction.
- Regional significance of the Camelback Road corridor.
- Current and future expansion plans for Grand Canyon University.
- Traffic movements through the I-17 / Camelback Road intersection
- Utilize Value Planning with a Value Engineering Approach to develop best comprehensive solutions.
- Develop preliminary planning and design concepts to guide the design Team as the project advances.

Investigation Observations

The first day of the workshop included a presentation from the Project Team. The following summarizes key project drivers, observations, and considerations identified during the session.

- Coordination between LRT and roadway projects and the corresponding stakeholders is crucial.
- Development of a solution that is compatible with the needs and objectives of both LRT and roadway projects is needed.
- Mitigation of potentially conflicting schedules of LRT and roadway projects is a priority.
- Maintenance of access and Minimization of visual impacts to the adjoining businesses – such as the car dealerships – during and after construction is important.
- Current and future land use and expansion plans of the Grand Canyon University should be considered.
- Right-of-way and Environmental Justice issues within the corridor are important factors of consideration.
- Safety of pedestrians and bikes, and their access should be accommodated.
- Congestion of I-17 / Camelback Road TI, especially during morning and evening peak hours should be considered while designing the TI.

- Camelback Road is a roadway of regional significance beyond the section containing the Light Rail; the east-west through movement should be considered in the design.

Table 3 presents a list of project issues identified by the Value Planning Team, and the number of participants identifying the issue.

Table 3: Project Issues	
Description	**No. of Participants Identifying the Issue**
Project Coordination	10
Grade Separation/Geometrics	7
Safety/Conflicts	7
Right-of-way/Environmental Documentation	6
East-West/North-South Movements	5
Grand Canyon University	4
Public Involvement	3
Modal Interconnectivity (e.g. bikes and peds)	3
Drainage	2
Stakeholder Impacts;-Continuous Involvement	2
Utility Relocation/Coordination	2
Schedule	2
Light Rail Alignment	1
2 Designers/2 Contractors	1
FHWA/NEPA	1
Construction Staging/Coordination	1
Structure Modifications	1
Signalization	1
Federal Funds-Competitiveness	1

Project Schedule Review

A preliminary schedule was developed to provide a date range for known project activities and milestones including environmental, design, right-of-way, utility, and construction activities. These activities, highlighted in yellow in Table 4, are then cost loaded to allow the risks to impact a specific activity that will either lengthen or reduce the baseline schedule. This provides a more reasonable cost outcome based on risk impacts that carry schedule impacts. The preliminary schedule was reviewed by the entire Team and updated as necessary throughout the workshop. Table 4 on the following page shows the activities and their estimated start and end dates. Please see the Appendix for the flowchart activity diagram for an illustration of the project schedule.

Table 4: Project Activity Ultimate Baseline Schedule			
Activity ID	**Activity Name**	**Start Date**	**End Date**
100	Alt. Analysis / Preliminary Engineering	6/16/2016	7/1/2017
110	Environmental	6/16/2016	6/30/2017
115	Approval to Enter Engineering	6/16/2016	6/30/2017
120	Final Engineering	6/16/2016	6/30/2017
125	FFGA	6/16/2016	6/30/2017
130	Right-of-Way Acquisition	11/1/2016	6/30/2017
140	Utilities	6/30/2017	6/30/2017
150	Ad/Bid/Award	6/30/2017	10/31/2017
160	Transit Vehicle Procurement	10/31/2017	10/31/2017
200	Construction	10/31/2017	10/31/2019
210	Revenue Service Date	10/31/2019	10/31/2019
220	Project Closeout	10/31/2019	10/31/2019
230	Project Completion	10/31/2019	10/31/2019

Performance Attributes

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

Performance attributes can generally be divided between project scope components (roadway operations, transit operations, etc.) and project delivery components (construction impacts, environmental impacts, etc.). It is important to make a distinction between performance attributes and performance requirements. Performance requirements are mandatory and binary in nature. All performance requirements **must** be met by any Value Planning alternative being considered.

Performance attributes possess a range of acceptable levels of performance. For example, if the project was to design and construct a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives that have different durations could be acceptable.

The Value Planning Team, along with the Project Team, identified and defined the performance attributes for this project. The performance attributes shown in Table 5 were used throughout the study to identify, evaluate, and document ideas and alternatives.

Table 5: Performance Attributes	
Performance Attribute	**Definition**
Roadway Operations	An assessment of traffic operations and safety on I-17 mainline and ramps, Camelback Road and all cross streets within the project limits. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance and lane and shoulder widths.
Transit Operations	An assessment of transit operations and safety on the guideway and associated stations. Operational considerations include level of service relative to the projections, geometric considerations and operations of the stations.
Maintainability	An assessment of the long-term maintainability of the facility. Maintenance considerations include the overall durability, longevity, and maintainability of structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel, including sediment and debris removal.
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to existing utilities; impacts to businesses and residents relative to access, visual effects, noise, vibration, dust, and construction traffic; environmental impacts.
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts; impacts to cultural, recreational and historic resources.
Promotes Economic Growth	An assessment how the alternative assists in promoting growth and Transit Oriented Development (TOD) along the corridor.

Performance Attribute Matrix

A matrix was used to determine the relative importance of the individual performance attributes for the project. The Project and Value Planning Teams evaluated the relative importance of the performance attributes that would be used to evaluate the creative ideas.

These attributes were compared in pairs, asking the question: "Which one is more important to the purpose and need of the project?" The letter code (e.g., "A") was entered into the matrix for each pair. After all pairs were discussed they were tallied (after normalizing the scores by adding a point to each attribute) and the percentages calculated.

Table 6 - Performance Attributes Criteria Matrix								
Paired Comparison								
							Total points	% of Total
Roadway Operations	A	A/B	A	A	A	A/F	5.0	23.8%
Transit Operations		B	B	B	B	B/F	5.0	23.8%
Maintainability			C	C	C	F	3.0	14.4%
Construction Impacts				D	E	F	1.0	4.7%
Environmental Impacts					E	F	2.0	9.5%
Promotes Economic Growth						F	5.0	23.8%
						Total	21.0	100.0%

A = A is of greater importance

A/B = A and B are of equal importance

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Creative Phase

The Value Planning Team brainstormed six LRT routes and three different TI alternatives. These ideas were based on the available information given at the time of the study.

LRT Routes:

- LRT median running at grade, alignment shifted north
- LRT median running elevated, alignment shifted north (assume vertical clearance over frontage roads only)
- LRT North side running at grade (just north of Camelback Road)
- LRT North side running, elevated (just north of Camelback Road)
- LRT North alignment along Colter Road/Street
- LRT North side running along Camelback, elevated from 19th Ave. to 43rd Ave.

TI Alternatives

- I-17 / Camelback Road platform diamond TI
- I-17 / Camelback Road tight diamond TI
- I-17 / Camelback Road maintaining SPUI

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Design Competition

In order to develop combined solutions, a design competition was organized. The Value Planning Team was divided into three groups. Each group was tasked with identifying the best LRT solution for one of the three TI alternatives.

To achieve consistency in the design competition, the groups were given the following directions and assumptions:

Design Assumptions

- Camelback Road six lanes (three in each direction) 33' minimum width per direction (curb to curb:12'-11'-11') with min 9' curb to right-of-way
- Camelback Road project limits 23rd Avenue to 27th Avenue – 3275' Linear Feet (LF)
- LRT width 26.5' on roadway, 32' on structure
- One station near 27th Avenue

Design Instructions

- I-17 – do not reduce current width of 120'
- Accommodate all current turn movements
- Document any current access that will be closed or modified

Cost Assumptions

Structures

- Precast roadway $100 Square Feet (SF)
- Precast transit $110 SF
- Cast in Place (CIP) roadway $120 SF
- CIP transit $135 SF
- Steel long span roadway $200 SF
- Steel long span transit $220 SF
- Walls $60 SF

Pavements

- Concrete $45 Square Yard (SY)
- Asphalt $35 SY
- Sidewalks $4 SF

Right-Of-Way

- $25 SF for acquisitions

Utilities

- $700 LF for high allowance
- $400 LF for medium allowance

Traffic Signals Systems

- $ 300,000 each

Transit

- $ 2,200 per LF of track
- $ 3,000,000 for station

Markups Total 60%

- Maintenance of traffic (MOT) 10%
- Miscellaneous item allowance 15%
- Mobilization 8%
- Design engineering 12%
- Construction administration 10%
- Construction change orders 5%

Development Phase

Based on the evaluation process, individual alternatives were developed. Each alternative consists of a description of the alternative, a listing of its advantages and disadvantages, and a brief narrative that includes justification, sketches, photos, assumptions and calculations (where applicable) as developed by the Team. It is to be noted that the cost of the alternative is only the blended cost of the LRT and roadway solutions within the project boundary defined in the design competition.

The Value Planning Alternatives are presented as written by the groups during the workshop. While they have been edited in the report to correct errors or better clarify the alternative, they represent the Team's findings during the study.

Alternative No. 1 - SPUI with Light Rail elevated to the North

This option constructs a new bridge just north of the existing single point urban interchange for the light rail line.

Advantages:	Disadvantages
▪ Right-of-way needed only on the north side ▪ May reduce the right-of-way cost ▪ Minimizes utility impacts ▪ Minimizes construction impacts to Camelback Road ▪ Grade separates the LRT from the ramps and frontage roads ▪ Minimizes impacts to the existing TI operations	▪ Crossover to and from the median at 21st. and 26th avenues ▪ 6-minute headways interrupts westbound Camelback at 21st and 26th avenues ▪ Signal progression band on Camelback Road is shortened because of the staging area for westbound Camelback traffic at 26th avenue ▪ Visual impacts due to added structure

Cost Summary	
Alternative No. 1	**$24.66 M @ 60% markup + $2.39 M right-of-way = $41.85 M**

Evaluation of Light Rail Options for Alternative No. 1

#	Description	Advantages	Disadvantages
LT-1	LRT median running at grade, alignment shifted north	▪ Reduces cost ▪ Access management is easiest ▪ Equal access to both sides of the road ▪ Accommodates TOD ▪ Avoid purchasing right-of-way on the south side of Camelback Road	▪ Relocate Utilities ▪ May need to rebuild the entire I-17 structure ▪ Temporary closure of Camelback Road ▪ May require a configuration change to the interchange ▪ Potential for traffic queuing onto the freeway
Justification/Comments: Significant construction impacts, right-of-way and left turn movements. Dropped from consideration with this alternative.			
#	**Description**	**Advantages**	**Disadvantages**
LT-2	LRT median running elevated, alignment shifted north (Assume vertical clearance over frontage roads only)	▪ Access management is easiest ▪ Equal access to both sides of the road ▪ Accommodates TOD ▪ Avoid purchasing right-of-way on the south side of Camelback Road	▪ No left turns between 23rd Ave. and I-17 and I-17 and 27th Ave. ▪ Increases Cost ▪ Relocate Utilities ▪ May need to rebuild the entire I-17 structure ▪ Temporary closure of Camelback Road ▪ May require a configuration change to the interchange ▪ Visual impacts
Justification/Comments: Extensive existing bridge reconstruction costs and new bridge construction. Dropped from consideration with this alternative.			

Alternative No. 1 - SPUI with Light Rail elevated to the North

#	Description	Advantages	Disadvantages
LT-3	North side running at grade (just north of Camelback Road)	▪ Right-of-way needed only on the north side ▪ May reduce the right-of-way cost ▪ Minimizes utility impacts ▪ Minimized construction impacts to Camelback Road	▪ Crossover out of the median at 21st Ave. ▪ 6-minute headways shuts down Camelback Road ▪ Signal progression on Camelback Road could get worse ▪ North side business access (Cactus Jack's)
Justification/Comments: At-grade crossings are required at the on/off ramps to from I-17 on the north side. This did not rate quite as high as the elevated crossing on the north side of Camelback for the light rail.			
#	**Description**	**Advantages**	**Disadvantages**
LT-4	North side running, elevated (just north of Camelback Road)	▪ Right-of-way needed only on the north side ▪ May reduce the right-of-way cost ▪ Minimizes utility impacts ▪ Minimized construction impacts to Camelback Road ▪ Grade separates the ramps and frontage roads ▪ Minimized impacts to the existing TI operations	▪ Crossover out of the median at 21st Ave. ▪ 6-minute headways shuts down Camelback Road ▪ Signal progression on Camelback Road could get worse
Justification/Comments: This was moved forward as the option to use with the existing interchange.			
#	**Description**	**Advantages**	**Disadvantages**
LT-5	North alignment along Colter Road	▪ Does not constrain the I-17 improvements ▪ Could add additional bike and ped crossing I-17 ▪ Minimize impacts to Camelback Road	▪ Significant traffic impacts due to train turning movements ▪ Trains through the neighborhood ▪ May increase costs ▪ High Maintenance costs due to curves ▪ Extra travel time (adverse travel) added to the route ▪ Noise impacts ▪ Potential EJ issues
Justification/Comments: This requires Environmental Justice and has other issues including additional turns and construction through a non-arterial corridor. Dropped from consideration with this alternative.			

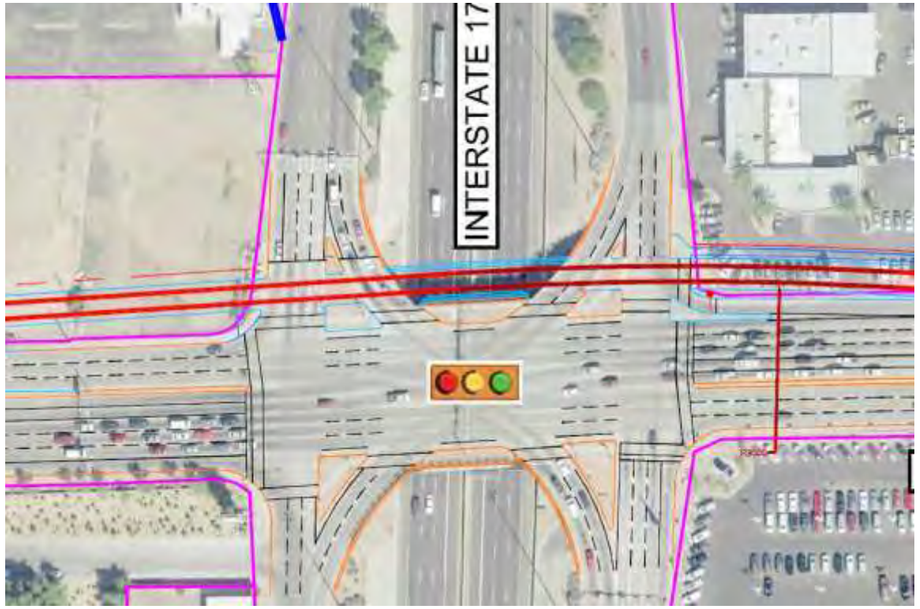
Alternative No. 1 - SPUI with Light Rail elevated to the North

#	Description	Advantages	Disadvantages
LT-6	North side running along Camelback, elevated from 19th to 43rd avenues.	▪ Minimizes business impacts on Camelback Road ▪ Minimal impact to traffic ▪ Operational speed of the LRT ▪ Minimal impacts to cross traffic on Camelback Road ▪ Could minimize construction impacts	▪ Visual impacts ▪ Elevated stations ▪ May increase cost ▪ May impact TOD ▪ Less visibility of users of the station ▪ May impact the sight distance ▪ Public acceptance of elevated structures

Justification/Comments: This was not moved forward based on costs and access issues. Valley Metro stressed the importance of at-grade facilities for aesthetics, safety and public perception.

Discussion/Justification/Sketches/Photos:

LRT elevated via a new bridge constructed just north of the existing Camelback Road overpass over I-17 for the LRT. This configuration requires LRT to run on the north side of Camelback from 23rd to 27th avenues. The current SPUI at I-17 and Camelback Road will be essentially left intact with no modifications required.



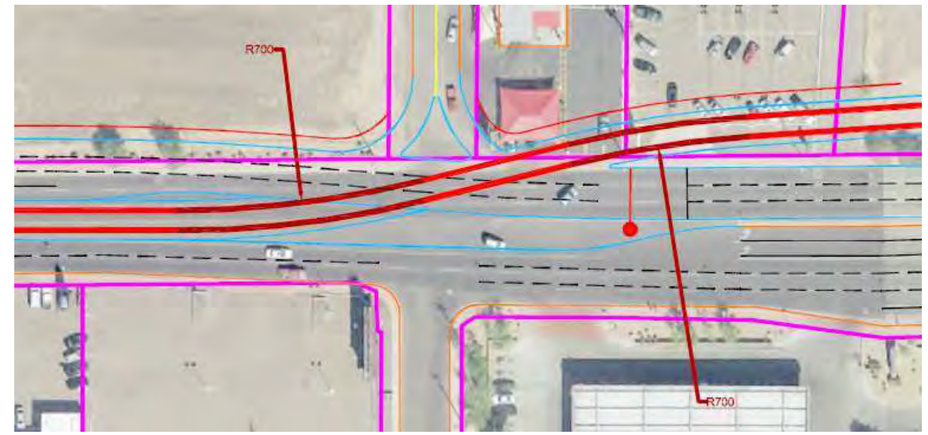
Intersection Plan View

Traffic on I-17 mainline and frontage roads and Camelback Road will be maintained during construction in the current configuration while the light rail structure is built on the north side

Alternative No. 1 - SPUI with Light Rail elevated to the North

of Camelback Road.

At- grade transitions will occur where LRT transitions from the north side to the median. Signals may be required where these transitions occur.



Transition Section Plan View

Item Description	Unit	Recommendation		
		Qty	Unit Cost	Total
Roadway - Asphalt	SY	216,150	$35	$7,565,250
Light Rail Structure	SF	19,200	$110	$2,112,000
Light Rail	LF	3,375	$2,200	$7,425,000
Walls	SF	16,000	$60	$960,000
Wall Backfill	Cubic Yards (CY)	10,000	$10	$100,000
Station	EA	1	$3,000,000	$3,000,000
Traffic Signals	EA	3	$300,000	$900,000
Utilities (Medium Impact)	LF	1,500	$400	$600,000
I-17 Widening Construction Accommodations	LS	1	$2,000,000	$2,000,000
Construction Total				$24,662,250
Plus 60% Markup (Construction x 1.6)				**$39,459,600**
Right-of-way	SF	95,546	$25	$2,388,650
Total Cost				**$41,848,250**

Alternative No. 1 - SPUI with Light Rail elevated to the North

Risk Identification and Quantification

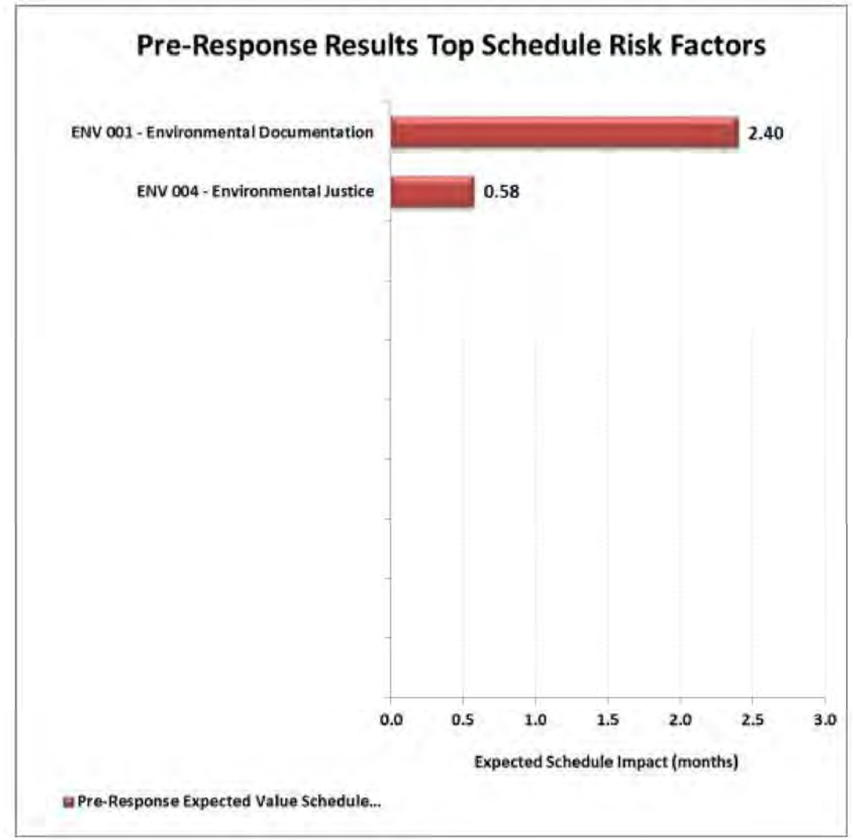
After the alternative was developed the Value Planning Team discussed the potential risk events and elements that would be facing the alternative. For each significant risk event that was identified, the probability of the risk and its impact to cost, schedule, or both were estimated. The risk assessment process included identifying high risk areas and risk elements as threats (or opportunities where appropriate) to a project and quantifying the identified risk elements.

The Risk Data Sheets provided in the Appendix of this report shows additional information specific to each risk as identified by the Team for all the alternatives.

The tornado diagrams for the top risks impacting both cost and schedule for this alternative are provided below.

Alternative No. 1 - SPUI with Light Rail elevated to the North

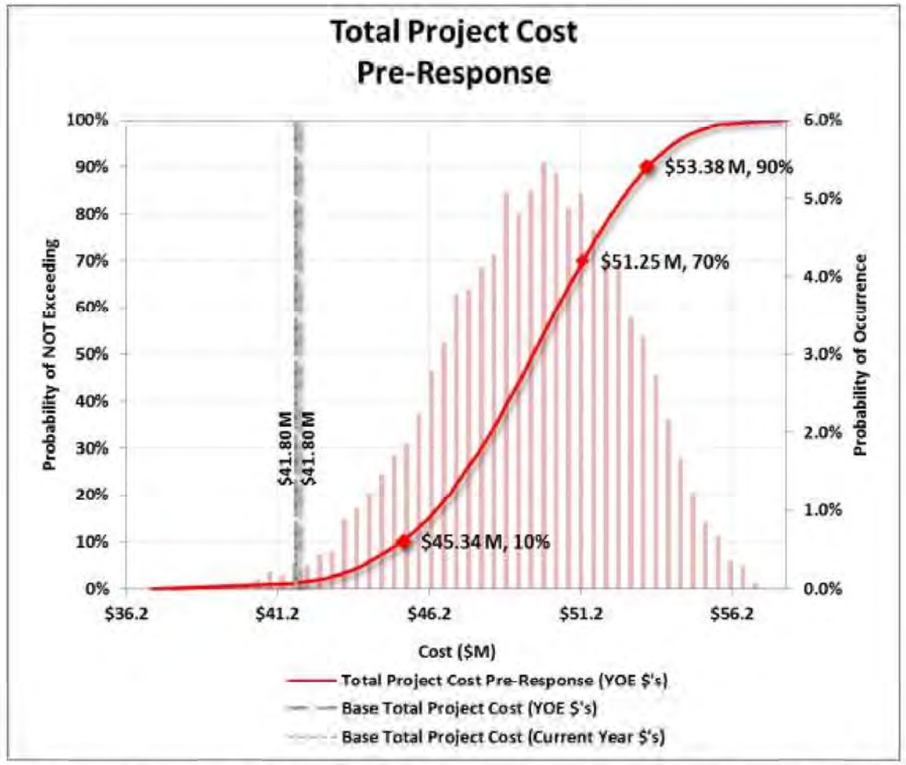
The expected value (likelihood multiplied by expected risk outcome) tornado diagrams depict the actual expected values of the identified risks. Not all risks identified require immediate management. Often, a project Team needs to prioritize the risks for which it plans to develop strategies in the future in an effort to make the best use of the time available. An example would be to begin with the risks with the highest cost and schedule impacts.



Alternative No. 1 - SPUI with Light Rail elevated to the North

Risk Analysis Results

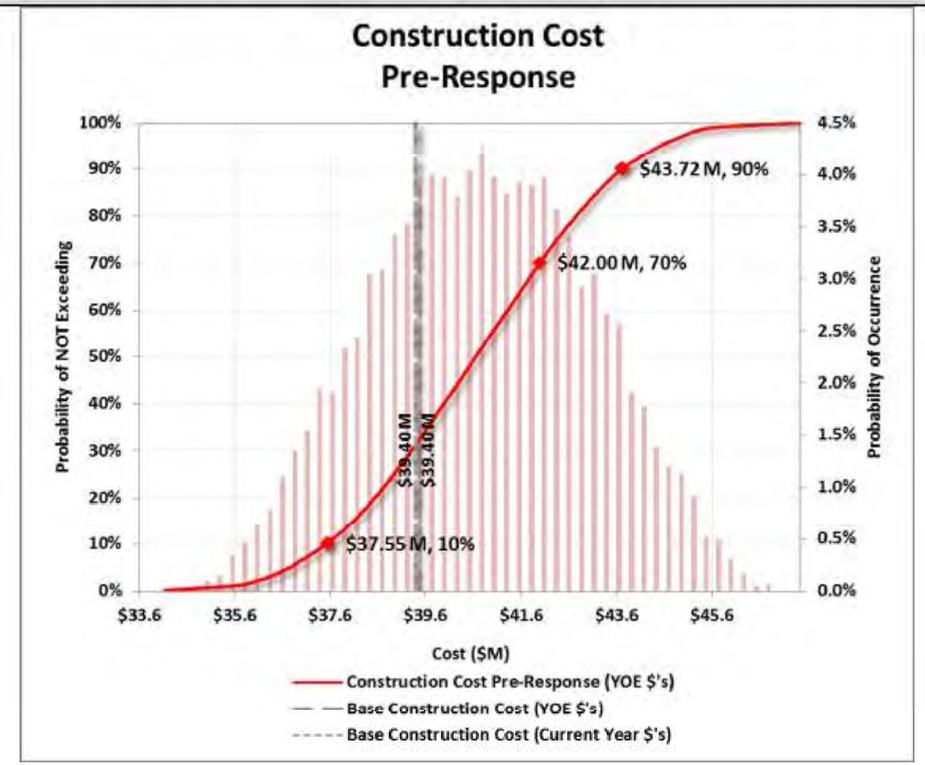
The risk analysis results are given in the form of graphs showing the relationship between cost and the probability of not exceeding that cost. Risk-based analysis provides a distribution of probabilities that a project will not exceed an estimated dollar figure. Typically, agencies report the project risk-based estimation using the 70 percent confidence interval. Each graph represents the best opinion of the cost ranges by the workshop participants at the time of the analysis.



The total project base cost is the cost without any contingencies or factored escalation, shown by the gray vertical lines at $41.80 million.

The s-curve, with risk results factored into the analysis, shows that the Alternative 1 will be less than **$51.25 million** at a 70% confidence level.

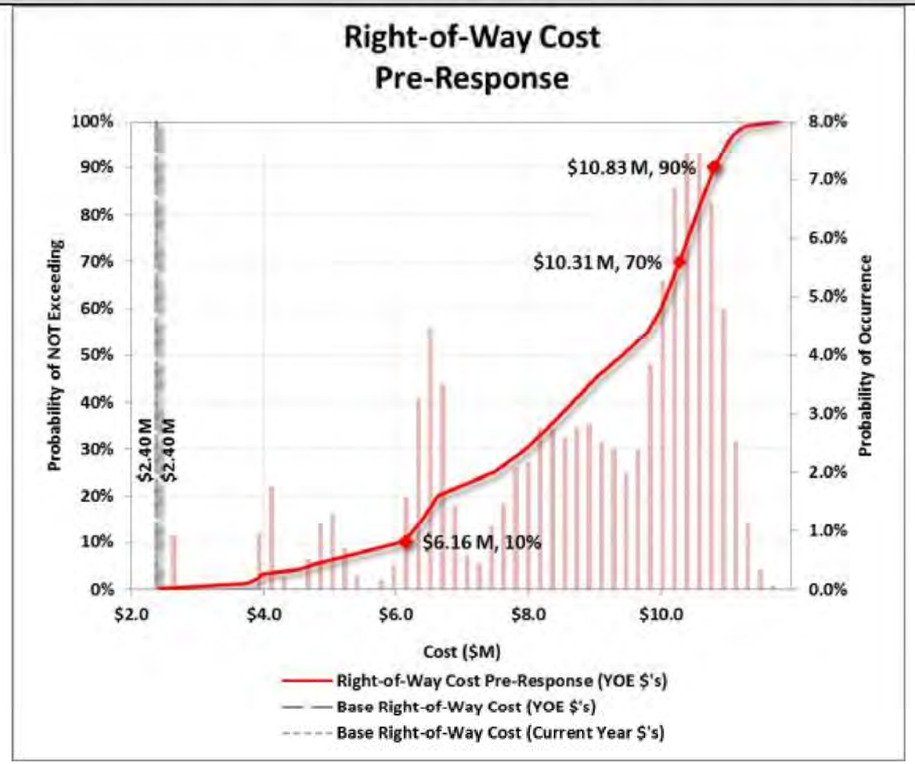
Alternative No. 1 - SPUI with Light Rail elevated to the North



The total base cost for design/construction for Alternative #1 is $39.40 million.

The s-curve, with risk results factored into the analysis, shows that the design/construction costs for Alternative 1 will be less than **$42.00 million** at a 70% confidence level.

Alternative No. 1 - SPUI with Light Rail elevated to the North



The total base cost for right-of-way for Alternative #1 is $2.40 million.

The s-curve, with risk results factored into the analysis, shows that the right-of-way costs for Alternative 1 will be less than **$10.31 million** at a 70% confidence level.

The next step will be to determine the appropriate risk response strategies for the identified high risk areas. Risk response strategies were not identified as part of this Value Planning workshop. Four risk response strategies are considered when addressing threat risks. Those strategies are to avoid, accept, transfer, or mitigate the risk threat (opportunity).

Alternative No. 1 - SPUI with Light Rail elevated to the North

PERFORMANCE MEASURES Attributes and Rating Rationale for Recommendation		Alternative Scoring
Roadway Operations	Rating	5
- LRT crossing westbound lanes of Camelback at 26th and 21st avenues + LRT is grade separated from frontage road and ramps - Does not provide additional capacity to the roadway structures	Weight	23.8
	Contribution	119.0
Transit Operations	Rating	6
- LRT crossing westbound lanes of Camelback at 26th and 21st avenues - Slowdown due to curves + Exclusive guideway through interchange preserves travel times	Weight	23.8
	Contribution	142.8
Maintainability	Rating	6
- No bridge replacement (older bridge to maintain) + No pavement replacement - Additional bridge - Additional maintenance for gates (double gates)	Weight	14.4
	Contribution	86.4
Construction Impacts	Rating	7
- Temporary closures of Camelback Road and I-17 + Building offline and minimal impacts to Camelback Road + No bridge removal	Weight	4.7
	Contribution	32.9
Environmental Impacts	Rating	5
- Visual impacts - Tall walls in front of businesses - Limits access to businesses on the north side of Camelback Road	Weight	9.5
	Contribution	47.5
Promotes Economic Growth	Rating	6
- Traffic operations might be adversely impacted + Least amount of elevated structures	Weight	23.8
	Contribution	142.8
	Total Performance:	**571.0**

Alternative No. 2 - Tight Diamond with LRT Fly Over

Description

This alternative changes the existing traffic interchange from a single point urban interchange (SPUI) to a tight diamond interchange.

Advantages:	Disadvantages
♦ Separates modes ♦ Increases safety for pedestrians and bikes ♦ Improves transit operations ♦ Improves traffic operations by adding left turn storage ♦ Shortens the distance between stop bars ♦ Reduces right-of-way impacts ♦ Improves access management with median running LRT ♦ Provides equal access to both sides of the road ♦ Avoids purchasing right-of-way on the south side of Camelback Road	♦ Eliminates left turns between 23rd Ave. and I-17 and I-17 and 27th Ave. ♦ Structure expands with longer elevated LRT ♦ Increases adverse visual impacts ♦ Constricts the ability to widen Camelback Road due to the straddle bent ♦ Potential utility impacts ♦ Complications associated with building approximately 150 feet long straddle bents ♦ Closes through North-South traffic on 22nd Ave. ♦ Does little to improve capacity of East-West Camelback Road

Cost Summary	
Alternative No. 2 Cost	**$32.93 M @ 60% markup + $1.75 M right-of-way = $54.44 M**

Evaluation of Light Rail Options for Alternative No. 2

#	Description	Advantages	Disadvantages
LT-1	LRT median running at grade, alignment shifted north	▪ Provides more left-turn storage length on Camelback Road ▪ Increases safety for peds and bikes ▪ Improves traffic operations ▪ Shortens the distance between stop bars ▪ Cheaper compared to the grade-separated option ▪ Requires one structure as opposed to two – easier than the grade-separated option to construct ▪ Minimal utility impacts (assume utilities are located on the south side of Camelback Road)	▪ May need to rebuild the entire I-17 structure ▪ Temporary closure of Camelback Road ▪ Requires widening of the bridge (approximately 15 feet) ▪ Might delay transit operations ▪ Will have adverse right-of-way impacts to Cactus Jack's and GCU

Justification/Comments: Dropped from further consideration with this alternative.

Alternative No. 2 - Tight Diamond with LRT Fly Over

#	Description	Advantages	Disadvantages
LT-2	LRT median running elevated, alignment shifted north (Assume vertical clearance over frontage roads only)	▪ Separation of modal traffic ▪ Increases safety for peds and bikes ▪ Improves transit operations ▪ Improves traffic operations ▪ Shortens the distance between stop bars ▪ Moderate right-of-way impacts ▪ Access management is easiest ▪ Equal access to both sides of the road ▪ Accommodates TOD ▪ Avoid purchasing right-of-way on the south side of Camelback Road	▪ No left turns between 23rd Ave. and I-17 and I-17 and 27th Ave. ▪ Increases Cost ▪ May need to rebuild the entire I-17 structure ▪ Temporary closure of Camelback Road ▪ Visual impacts ▪ More structure; costs more ▪ Adverse visual impacts ▪ Constricts the ability to widen Camelback Road ▪ Potential utility impacts

Justification/Comments: Moved to further development with this alternative

Alternative No. 2 - Tight Diamond with LRT Fly Over

#	Description	Advantages	Disadvantages
LT-3	North side running at grade (just north of Camelback Road)	▪ Provides more left-turn storage length on Camelback Road ▪ Increases safety for peds and bikes ▪ Improves traffic operations ▪ Shortens the distance between stop bars ▪ Cheaper compared to the grade-separated option ▪ Requires one structure as opposed to two – easiest to construct ▪ Minimal utility impacts (assume utilities are located on the south side of Camelback Road) ▪ Separates LRT from the Roadway ▪ Right-of-way needed only on the north side ▪ May reduce the right-of-way cost ▪ Minimizes utility impacts ▪ Minimized construction impacts to Camelback Road	▪ Crossover out of the median at 21st Ave. ▪ 6-minute headways shuts down Camelback Road ▪ Signal progression on Camelback Road could get worse ▪ North side business access (Cactus Jack's) ▪ Requires widening of the bridge (approximately 15 feet) ▪ Might delay transit operations ▪ Will have adverse right-of-way impacts to Cactus Jack's and GCU ▪ SB I-17 exiting traffic will be adversely impacted, potentially backing on to the I-17 ▪ Safety concerns with turning traffic possibly stuck on the light rail track ▪ SB I-17 exit and northbound I-17 entrance movements will be significantly constricted ▪ Inherently less safe for the access (to cross two directions of LRT traffic) ▪ Issues associated with shifting of LRT from the median to the north and back to the median

Justification/Comments: This LRT option was dropped from further consideration with alternative.

Alternative No. 2 - Tight Diamond with LRT Fly Over

#	Description	Advantages	Disadvantages
LT-4	North side running, elevated (just north of Camelback Road)	▪ Right-of-way needed only on the north side ▪ May reduce the right-of-way cost ▪ Minimizes utility impacts ▪ Minimized construction impacts to Camelback Road ▪ Grade separates the ramps and frontage roads ▪ Minimized impacts to the existing TI operations ▪ Separation of modal traffic ▪ Increases safety for peds and bikes ▪ Improves transit operations ▪ Improves traffic operations ▪ Shortens the distance between stop bars ▪ Minimal utility impacts (assume utilities are located on the south side of Camelback Road) ▪ Moderate right-of-way impacts	▪ Crossover out of the median at 21st Ave. ▪ 6-minute headways shuts down Camelback Road ▪ Signal progression on Camelback Road could get worse ▪ More structure; costs more ▪ Adverse visual impacts ▪ Constricts the ability to widen Camelback Road ▪ Inherently less safe for the access (to cross 2 directions of light rail traffic) ▪ Issues associated with shifting of LRT from the median to the north and back to the median

Justification/Comments: This option was dropped from further consideration with this alternative.

#	Description	Advantages	Disadvantages
LT-5	North alignment along Colter	▪ Does not constrain the I-17 improvements ▪ Could add additional bike and ped crossing I-17 ▪ Minimize impacts to Camelback Road	▪ Significant traffic impacts due to train turning movements ▪ Trains through the neighborhood ▪ May increase costs ▪ High Maintenance costs due to curves ▪ Extra travel time (adverse travel) added to the route ▪ Noise impacts ▪ Potential EJ issues

Justification/Comments: Not evaluated due to non-applicability to this exercise.

Alternative No. 2 - Tight Diamond with LRT Fly Over

#	Description	Advantages	Disadvantages
LT-6	North side running along Camelback, elevated from 19th to 43rd avenues	▪ Minimizes business impacts on Camelback Road ▪ Minimal impact to traffic ▪ Operational speed of the LRT ▪ Minimal impacts to cross traffic on Camelback Road ▪ Could minimize construction impacts ▪ Separation of modal traffic ▪ Increases safety for peds and bikes ▪ Improves transit operations ▪ Improves traffic operations ▪ Shortens the distance between stop bars ▪ Minimal utility impacts (assume utilities are located on the south side of Camelback Road) ▪ Moderate right-of-way impacts	▪ Visual impacts ▪ Elevated stations ▪ May increase cost ▪ May impact TOD ▪ Less visibility of users of the station ▪ May impact the sight distance ▪ Public acceptance of elevated structures ▪ More structure; significantly more costs ▪ Most adverse visual impacts ▪ Constricts the ability to widen Camelback Road

Justification/Comments: This option was dropped from further consideration with this alternative.

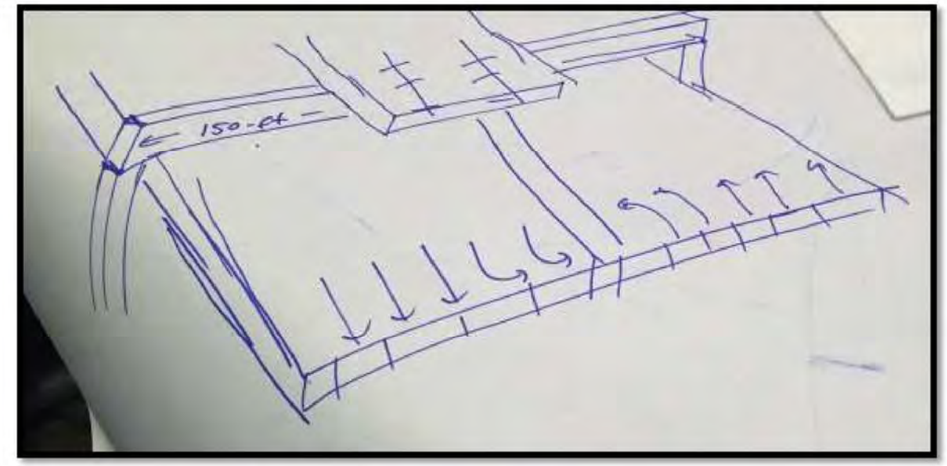
Discussion/Justification/Sketches/Photos:

This alternative changes the existing TI from a SPUI to a Tight Diamond Interchange. This alternative largely preserves existing TI and right-of-way with LRT overhead. LRT bridge structure is constructed using straddle bents.

LRT will run along the median of Camelback Road and will be elevated over the I-17 / Camelback Road TI. LRT will traverse on an elongated bridge to the east to preserve view-shed between and access to the two car dealerships.

- Provides for median left-turn only lane instead of bi-directional left turns.
- Structure extended eastward to preserve view-shed of car dealers.
- Left turn access out of both the car dealerships is restricted leaving only ¾ access, allowing for entering left turns to the property.
- Eliminate through North-South movement on 22nd Ave., across Camelback Road; preserves through-movements at 23rd and 21st avenues.
- 26th Ave. only right-in, right-out access.
- Quick Trip only right-in, right-out access.
- The LRT station will be located west of 27th Ave.
- Existing I-17 / Camelback Road bridge will be rehabbed (re-decked/striped/surfaced)

Alternative No. 2 - Tight Diamond with LRT Fly Over



Alternative No. 2 - Tight Diamond with LRT Fly Over

Assumptions and Calculations:

- 11-foot lanes through the TI on Camelback Road.
- Straddle bents at I-17 / Camelback Road.
- LRT structure will not be attached to the existing TI structure.
- Existing TI structure will not need to be widened.
- Maintaining the existing ADOT access control.
- Right-of-way needs are vastly minimized and limited to north side only.
- Assume $ 20 per SF for bridge re-decking.
- Assumes use of straddle bents allows alternative to be constructible.

Item Description	Unit	Recommendation		
		Qty	Unit Cost	Total
LRT Structure	SF	48,000	110	5,280,000
Approaches (East and West)	SF	54,000	110	5,940,000
Straddle Bent	L. Sum	3	750,000	2,250,000
Retaining Wall (East and West)	SF	42,460	60	2,547,600
Retained Fill	CY	35,000	10	350,000
Traffic Signal Work	Each	5	150,000	750,000
Bridge Re-decking	L.Sum	1	416,000	416,000
Removal	SF	2,500	15	37,500
Rail	LF	3,275	2,200	7,205,000
Utilities	LF	1,000	400	400,000
AC Pavement	SY	78,000	35	2,730,000
Portland Cement Concrete Pavement (PCCP)	SY	600	45	27,000
Light Rail Station	Each	1	3,000,000	3,000,000
I-17 Widening Construction Accommodations	LS	1	$2,000,000	$2,000,000
Construction Total				**$32,933,100**
Plus 60% Markup (Construction x 1.6)				$52,692,960
Right-of-way	SF	70,000	25	$1,750,000
Total Cost				**$54,442,960**

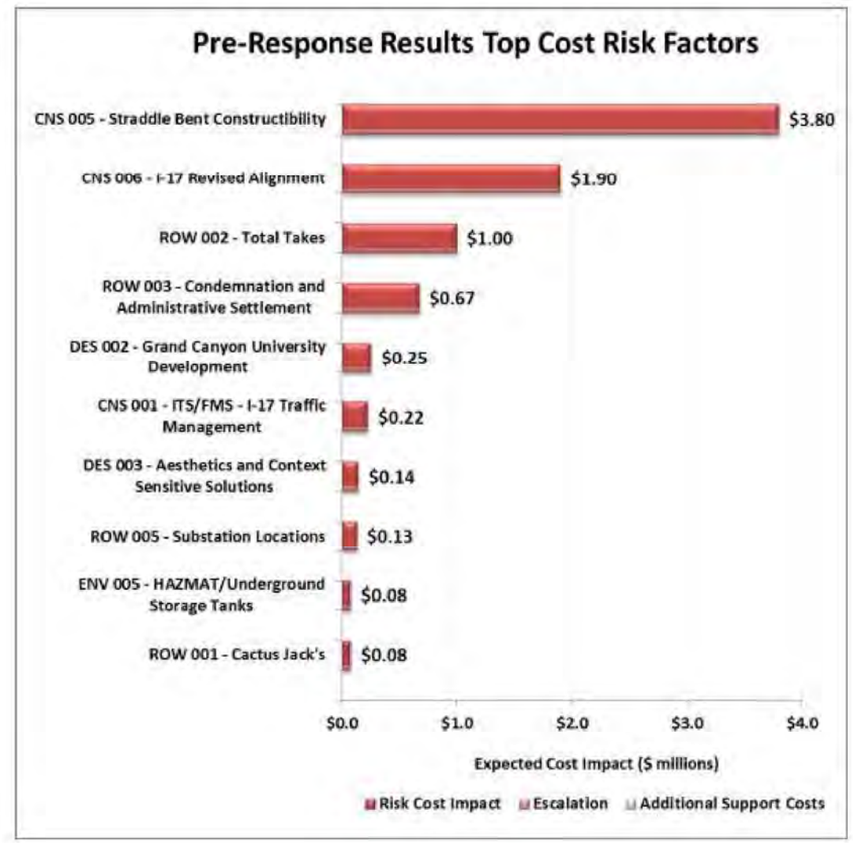
Alternative No. 2 - Tight Diamond with LRT Fly Over

Risk Identification and Quantification

After the alternative was developed, the Value Planning Team discussed the potential risk events and elements that would be facing the alternative. For each significant risk event that was identified, the probability of the risk and its impact to cost, schedule, or both were estimated. The risk assessment process included identifying high risk areas and risk elements as threats (or opportunities where appropriate) to a project and quantifying the identified risk elements.

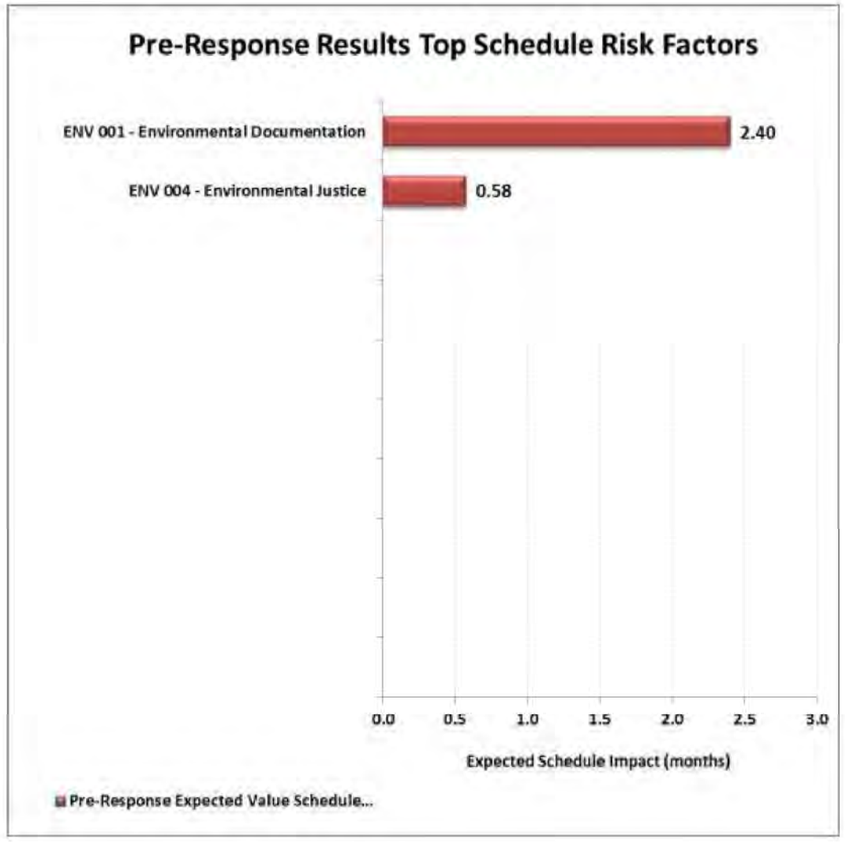
The Risk Data Sheets provided in the Appendix of this report shows additional information specific to each risk as identified by the Team for all the alternatives.

The tornado diagrams for the top risks impacting both cost and schedule for this alternative are provided below.



Alternative No. 2 - Tight Diamond with LRT Fly Over

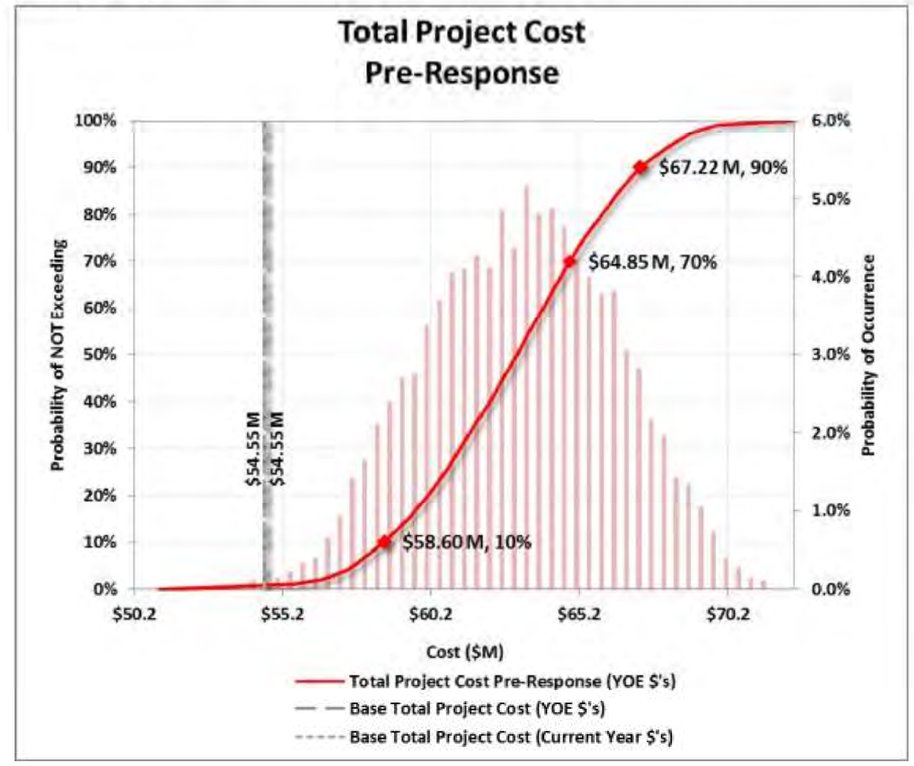
The expected value (likelihood multiplied by expected risk outcome) tornado diagrams depict the actual expected values of the identified risks. Not all risks identified require immediate management. Often, a project Team needs to prioritize the risks for which it plans to develop strategies in the future in an effort to make the best use of the time available. An example would be to begin with the risks with the highest cost and schedule impacts.



Alternative No. 2 - Tight Diamond with LRT Fly Over

Risk Analysis Results

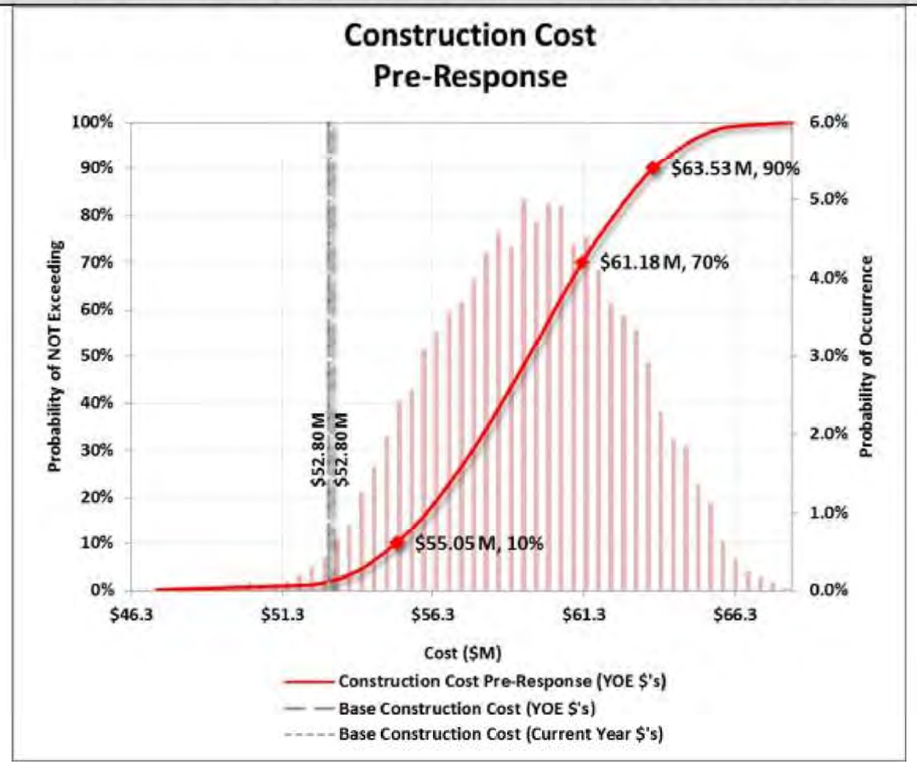
The risk analysis results are given in the form of graphs showing the relationship between cost and the probability of not exceeding that cost. Risk-based analysis provides a distribution of probabilities that a project will not exceed an estimated dollar figure. Typically, agencies report the project risk-based estimation using the 70 percent confidence interval. Each graph represents the best opinion of the cost ranges by the workshop participants at the time of the analysis.



The base cost is the cost without any contingencies or factored escalation, is at $54.55 million.

The s-curve, with risk results factored into the analysis, shows that the Alternative 2 will be less than **$64.85 million** at a 70% confidence level.

Alternative No. 2 - Tight Diamond with LRT Fly Over



The base cost for design/construction for Alternative 2 is $52.80 million.

The s-curve, with risk results factored into the analysis, shows that the design/construction costs for Alternative 2 will be less than **$61.18 million** at a 70% confidence level.

Alternative No. 2 - Tight Diamond with LRT Fly Over

The base cost for right-of-way for Alternative 2 is $1.75 million.

The s-curve, with risk results factored into the analysis, shows that the right-of-way costs for Alternative 2 will be less than **$4.10 million** at a 70% confidence level.

The next step will be to determine the appropriate risk response strategies for the identified high risk areas. Risk response strategies were not identified as part of this Value Planning workshop. Four risk response strategies are considered when addressing threat risks. Those strategies are to avoid, accept, transfer, or mitigate the risk threat (opportunity).

Alternative No. 2 - Tight Diamond with LRT Fly Over

PERFORMANCE MEASURES Attributes and Rating Rationale for Recommendation		Alternative Scoring
Roadway Operations + Minimizes modal conflicts + Provides access management along Camelback Road + Increases storage length for left turns on Camelback Road, increasing the green time for exiting I-17 exiting traffic	Rating	6
	Weight	23.8
	Contribution	142.8
Transit Operations + Dedicated right-of-way, minimized modal conflict + LRT has increased speed due to grade separation and reduced traffic conflict + Straight LRT alignment - Shorter touchdown ramps	Rating	9
	Weight	23.8
	Contribution	214.2
Maintainability - No bridge replacement; older bridge to maintain - Additional structures to maintain - Longer LRT bridge + Maintains existing TI while rehabbing the deck	Rating	5
	Weight	14.4
	Contribution	72.0
Construction Impacts - Temporary closures of I-17 and Camelback Road + No bridge removals - Large columns in I-17 median for straddle bents - Constructability issues with large straddle bent caps	Rating	2
	Weight	4.7
	Contribution	9.4
Environmental Impacts - Visual impacts due to longer elevated span of LRT + Minimal impacts to businesses	Rating	6
	Weight	9.5
	Contribution	57.0
Promotes Economic Growth + Maintaining business access + Enhancement of traffic movement and access	Rating	7
	Weight	23.8
	Contribution	166.6
	Total Performance:	**662.0**

Alternative No. 3 - Platform Diamond with Median LRT

Alternative Description:

Build a third level over the existing interchange to create a platform (or 3-level diamond TI) that would accommodate double-track LRT and two traffic lanes in each direction (about 90 feet total).

Advantages:	Disadvantages:
♦ Allows free-flowing east-west traffic movements (heaviest flows) that are separated from the turning movements associated with the interchange. Significant increase in capacity of the interchange. ♦ Benefits transit travel time by removing conflicts with vehicular turning movements. ♦ Improves safety by isolating turning movements from through-traffic and transit. ♦ Avoid relocation of utilities currently through the south side of the bridge. ♦ Perpetuates right-in/right-out access along both sides of Camelback.	♦ Right-of-way requirements would significantly impact properties on the north side of Camelback Road. ♦ Awkward left turns at 27th and 23rd avenues (southbound) from Camelback would need to be addressed. ♦ Visual impacts resulting from new third level structure.

Cost Summary	
Alternative Cost	**$25.78 M @ 60% markup + $3.0 M right-of-way = $44.25 M**

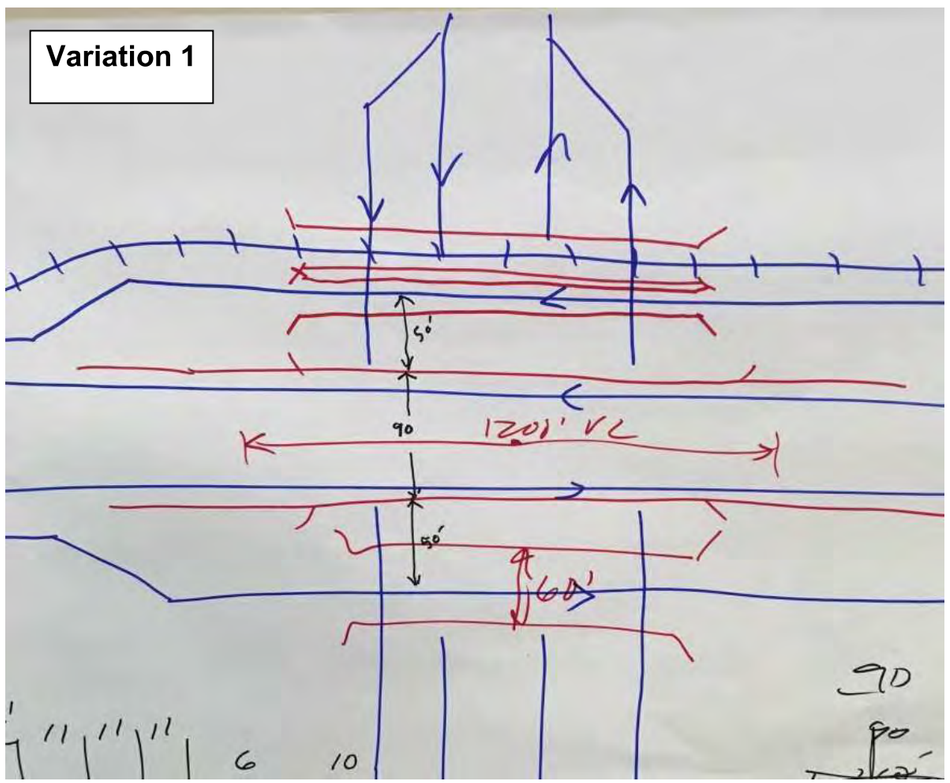
Alternative No. 3 - Platform Diamond with Median LRT

Evaluation of Light Rail Options for Alternative No. 3

Alternative Variations Discussed and Dropped:

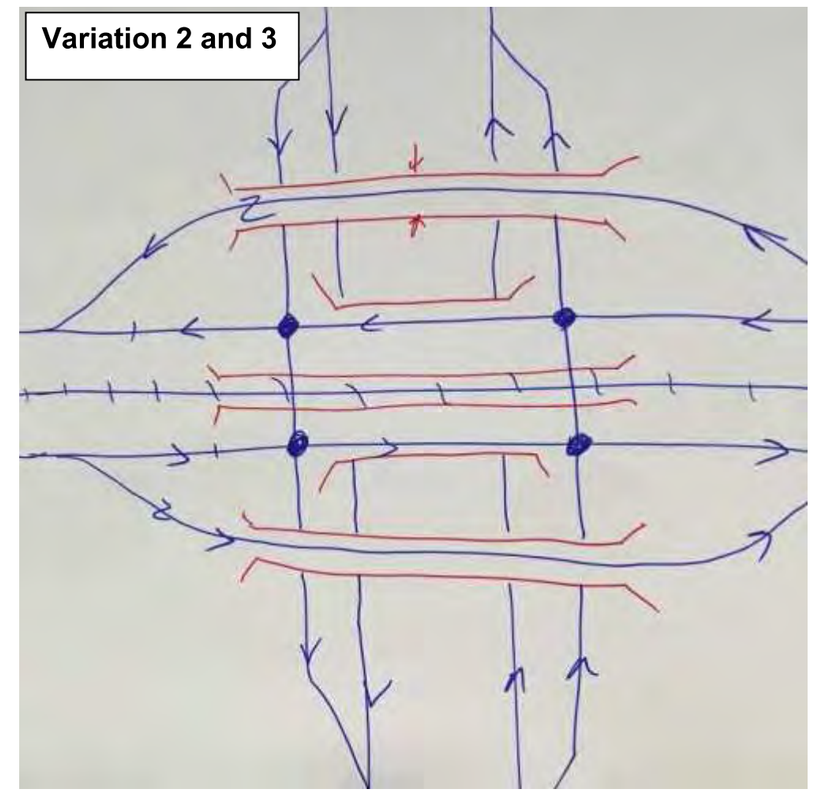
Three alternative variations of the platform diamond interchange configuration were briefly discussed and dismissed during the evaluation of this alternative:

1. Variation 1 stripped the LRT out of the median EB-WB flyover and put it on a separate grade separated flyover over the I-17 TI to the north of the proposed westbound Camelback Road travelway. This variation was dismissed because the Team concluded that it lost the combined benefit of a single bridge for both roadway and LRT, complicated construction, increased cost, and made the LRT alignment less desirable from both an operations and economic growth perspective.



Alternative No. 3 - Platform Diamond with Median LRT

2. Variation 2 splits the eastbound and westbound through movements on Camelback Road into their own separate flyovers on the outside of the interchange as opposed to the inside. With this variation, the LRT would remain at-grade through the median through the middle of the interchange turning platform. The advantage would be that the LRT stays at-grade and in the median of the road – the most desirable from and LRT perspective. The disadvantage of this variation is that the LRT would have to run through the TI turning movements at-grade, and would add two additional signals (for a total of six) within the platform level. This variation was dismissed as the LRT crossings within the TI would be highly undesirable for both Valley Metro and ADOT, and the exterior flyover ramps would sever access to the adjacent parcels completely between 23rd and 27th avenues.

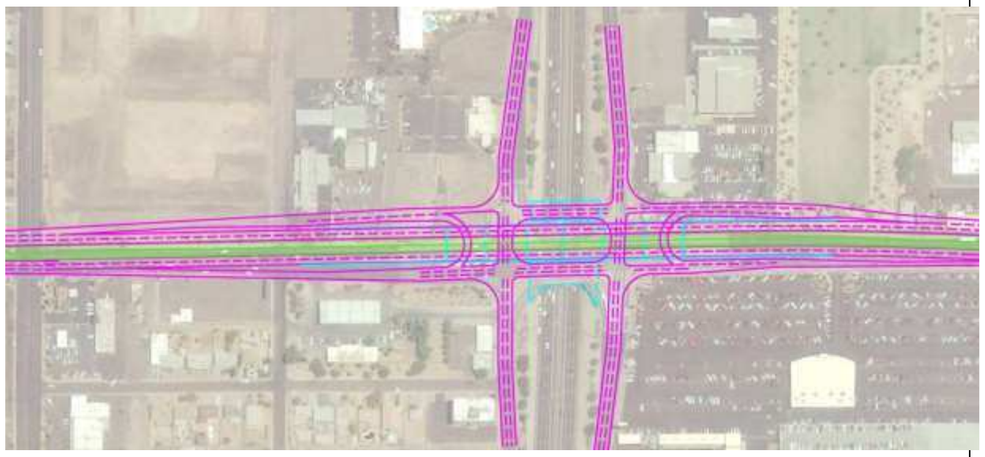


3. Variation 3 would utilize the same layout as Variation 2, but would grade separate the LRT movement through the center with a third dedicated LRT flyover over the TI movements. While an overall good solution for operations, the right-of-way and access impacts between 23rd and 27th avenues are still significant due to the exterior flyover ramps.

Alternative No. 3 - Platform Diamond with Median LRT

Discussion/Justification/Sketches/Photos:

Build a third level over the existing interchange to create a platform (or 3-level diamond TI) that would accommodate double track light rail and two traffic lanes in each direction (about 90 feet total). Modify and expand the at-grade bridge to accommodate three traffic lanes in each direction, a bike lane, and sidewalks (about 60 feet on the south side and 50 feet on the north side). All turning movements at the TI would occur at this level; design options include four 2-phase signals or four small modern roundabouts. Total width of the facility would expand to about 210 feet from the current 130 feet.



Assumptions:

- Entire TI PCCP replaced.
- EB-WB flyover ramp approaches are all PCCP.
- All other pavements are asphalt.
- Estimate assumes signals at all four platform intersections, and new signals at 23rd and 27th avenues.
- Concept includes U-turns under flyover abutments.
- Major utilities within TI are avoided (by keeping south 60 feet of existing bridge). Utility relocations within the arterial under the approaches are accounted for.
- MOT phasing would construct new westbound Camelback Road direction first, shift traffic, and then open the Camelback Road median to construct the long flyover.
- Right-of-way take is based on neat line, but probably underestimates total takes and business relocations.

Alternative No. 3 - Platform Diamond with Median LRT

Assumptions and Calculations:

3 level structure	Unit	Unit cost	Quantity	Total
LRT Guideway	TF	$2,200	3,275	$7,205,000
EB/WB/LRT Flyover	SF	$110	58,000	$6,380,000
WB Camelback Bridge	SF	$100	9,000	$900,000
Removals - Structure	SF	$15	17,000	$255,000
Retaining walls	SF	$60	20,000	$1,200,000
Fill	CY	$10	70,000	$700,000
LRT Platform	Each	$3,000,000	1	$ 3,000,000
Traffic signals	Each	$300,000	4	$1,200,000
Pavement				
Concrete	SY	$45	8,000	$360,000
Asphalt	SY	$35	12,000	$ 420,000
Sidewalk	SF	$4	5,000	$140,000
Utility				
Major	LF	$700	2,600	$1,820,000
Medium	LF	$400	500	$200,000
I-17 Widening Construction Accommodations	LS	$2,000,000	1	$2,000,000
Construction subtotal				$25,780,000
MARK-UP	**Plus 60% Markup (Construction x 1.6)**			$41,248,000
Right-of-way	LS	$ 3,000,000	1	$3,000,000
Total				**$44,248,000**

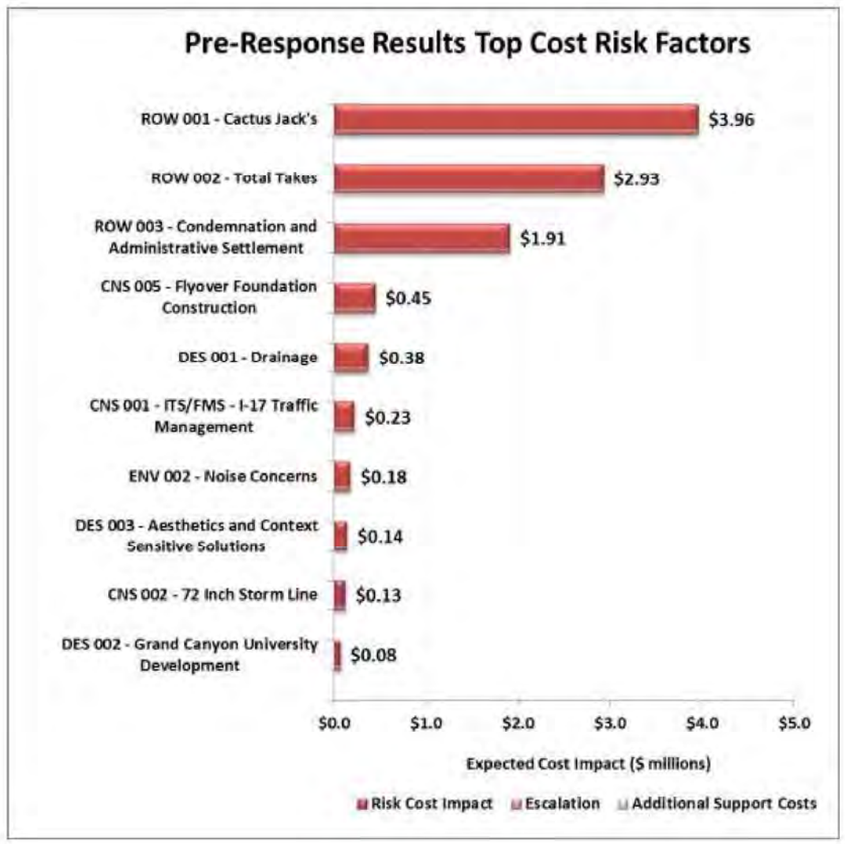
Alternative No. 3 - Platform Diamond with Median LRT

Risk Identification and Quantification

After the alternative was developed the Value Planning Team discussed the potential risk events and elements that would be facing the alternative. For each significant risk event that was identified, the probability of the risk and its impact to cost, schedule, or both were estimated. The risk assessment process included identifying high risk areas and risk elements as threats (or opportunities where appropriate) to a project and quantifying the identified risk elements.

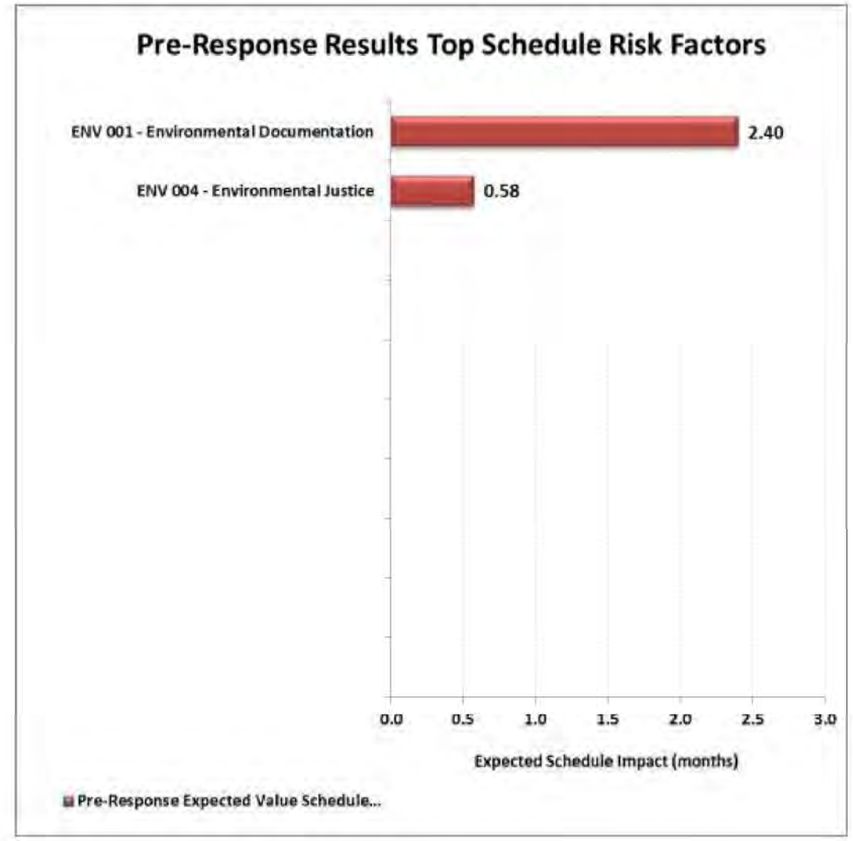
The Risk Data Sheets provided in the Appendix of this report shows additional information specific to each risk as identified by the Team for all the alternatives.

The tornado diagrams for the top risks impacting both cost and schedule for this alternative are provided below.



Alternative No. 3 - Platform Diamond with Median LRT

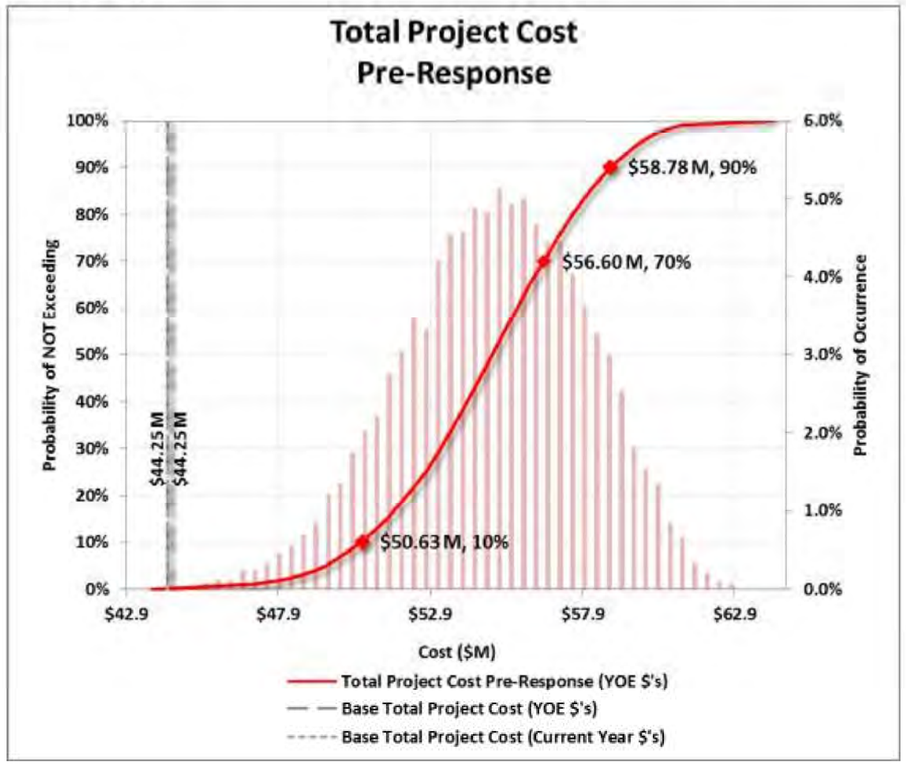
The expected value (likelihood multiplied by expected risk outcome) tornado diagrams depict the actual expected values of the identified risks. Not all risks identified require immediate management. Often, a project Team needs to prioritize the risks for which it plans to develop strategies in the future in an effort to make the best use of the time available. An example would be to begin with the risks with the highest cost and schedule impacts.



Alternative No. 3 - Platform Diamond with Median LRT

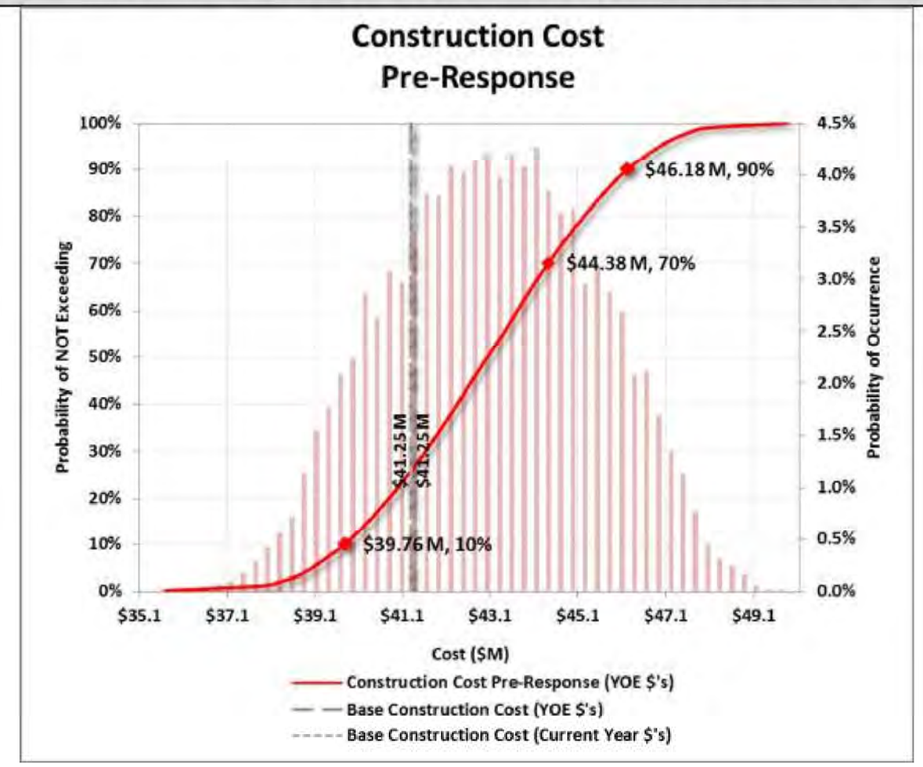
Risk Analysis Results

The risk analysis results are given in the form of graphs showing the relationship between cost and the probability of not exceeding that cost. Risk-based analysis provides a distribution of probabilities that a project will not exceed an estimated dollar figure. Typically, agencies report the project risk-based estimation using the 70 percent confidence interval. Each graph represents the best opinion of the cost ranges by the workshop participants at the time of the analysis.



The base cost is the cost without any contingencies or factored escalation, shown by the gray vertical lines at $44.25 million. The s-curve, with risk results factored into the analysis, shows that the Alternative 3 will be less than **$56.60 million** at a 70% confidence level.

Alternative No. 3 - Platform Diamond with Median LRT



The base cost for design/construction for Alternative 3 is $41.25 million.

The s-curve, with risk results factored into the analysis, shows that the design/construction costs for Alternative 3 will be less than **$44.38 million** at a 70% confidence level.

Alternative No. 3 - Platform Diamond with Median LRT

The base cost for right-of-way for Alternative 3 is $3.00 million.

The s-curve, with risk results factored into the analysis, shows that the right-of-way costs for Alternative 3 will be less than **$13.21 million** at a 70% confidence level.

The next step will be to determine the appropriate risk response strategies for the identified high risk areas. Risk response strategies were not identified as part of this Value Planning workshop. Four risk response strategies are considered when addressing threat risks. Those strategies are to avoid, accept, transfer, or mitigate the risk threat (opportunity).

Alternative No. 3 - Platform Diamond with Median LRT

PERFORMANCE MEASURES Attributes and Rating Rationale for Recommendation		Alternative
Roadway Operations + Emphasizes East-West movement on Camelback by having this heavy movement avoid the TI signal(s). + 2-phase signals at all TI ramp terminals, but could also be roundabouts. - Left turn movements to the on-ramps and from the off-ramps have three signal systems to pass through (this may be eliminated with the use of roundabouts). - Potential weaving traffic where roadway connects back to grade near the 27th and 23rd avenues intersections. + U-turns under flyover help maintain driveway and business access along retaining walls. - Design speed of flyover would be between 45 mph and 35 mph.	Rating	8
	Weight	23.8
	Contribution	190.4
Transit Operations + Preferred center running + No signal to crossing. + Serves both sides of Camelback outside of TI block.	Rating	9
	Weight	23.8
	Contribution	214.2
Maintainability - Adds much more bridge. - New concrete pavement. - Access to the LRT bridge from the roadway.	Rating	5
	Weight	14.4
	Contribution	72.0
Construction Impacts + Minimal if phased properly (construct westbound level 2, demo half of existing and build new structure). - Requires LRT and the Camelback Road flyover to be built as one bridge. - Temporary driveway and business impacts will be substantial for the duration of construction, which will probably be close up to 2 yrs.	Rating	5
	Weight	4.7
	Contribution	23.5
Environmental Impacts - Business impacts along north side of Camelback Road. - Visual impacts; walls in front of the businesses. - Right-in right-out access to businesses. - May increase traffic noise.	Rating	4
	Weight	9.5
	Contribution	38.0
Promotes Economic Growth + With center running, both side of Camelback Road can be developed to support LRT. + Facility promotes regional East-West movement, making the Camelback Road corridor more attractive to users.	Rating	9
	Weight	23.8
	Contribution	214.2
	Total Performance:	**752.0**

Alternative No. 4 -SPUI with Elevated LRT and Fly Over

Alternative Description:

The existing single point urban interchange (SPUI) and Camelback Road will largely remain unchanged. LRT will run along the median of Camelback Road east and west of I-17 but crosses to the north side of Camelback Road to cross I-17. This concept would use an LRT viaduct from east of 21st Ave. to approximately the 25th Ave. alignment.

Advantages:	Disadvantages
♦ Separation of modal traffic. ♦ Increases safety for pedestrians and bikes. ♦ Minor right-of-way impacts. ♦ Access management is fairly simple. ♦ Equal access to both sides of the road. ♦ Avoid purchasing right-of-way on the south side of Camelback Road. ♦ Retains line of sight along Camelback Road to the businesses between I-17 and 23rd avenues. ♦ Relatively low cost. ♦ Largely preserves the existing TI.	♦ No left turns between 23rd Ave. and I-17 and between 23rd and 21st avenues. ♦ No notable capacity changes to Camelback Road or the I-17 TI. ♦ Temporary closure of Camelback Road to construct the viaduct and straddle bents. ♦ More structure; more maintenance. ♦ Adds adverse visual impacts. ♦ Constricts the ability to widen Camelback Road. ♦ Potential significant utility impacts. ♦ Does little to improve capacity for East-West Camelback traffic.

Cost Summary	
Alternative No. 4 Cost	**$26.67 M @ 60% markup + $1.67 M right-of-way = $44.34 M**

Alternative No. 4 -SPUI with Elevated LRT and Fly Over

Discussion/Justification/Sketches/Photos:

The existing single point urban interchange (SPUI) and Camelback Road will largely remain unchanged. LRT will run along the median of Camelback Road east and west of I-17 but crosses to the north side of Camelback Road to cross I-17. This concept would use an LRT viaduct from east of 21st Ave. to approximately the 25th Ave. alignment.

- Median instead of bi-directional left turns.
- Structure extended east of 23rd Ave. to preserve view-shed of car dealers.
- Left turn access out of both the car dealerships are restricted (provide only 3/4 access).
- Eliminate through movement on 22nd Ave., across Camelback Road; preserve through movements at 23rd and 21st avenues.
- 26th Ave. only right-in right-out access.
- Quick Trip only right-in right-out access.
- The LRT station will be located west of 27th Ave.
- Existing I-17 / Camelback Road bridge will only be re-decked.
- The main advantage of Alternative 4 over Alternative 2 is that the very long and difficult to construct straddle bents have been replaced by a few short straddle bents that only span over WB Camelback Road.

Alternative No. 4 -SPUI with Elevated LRT and Fly Over

Assumptions and Calculations:

- 11-foot lanes
- Straddle bents needed to cross LRT from median to north roadway edge on both sides of the TI. Straddle bents only span the westbound roadway of Camelback Road and we assume we only need one on the east side of the TI, and two on the west side of I-17.
- LRT structure will not be attached to the existing structure.
- The existing structure will not need to be widened.
- Maintaining the existing ADOT access control.
- Right-of-way needs are minimized and limited to north side only.
- Assume, if necessary, $ 20/SF for bridge re-decking

Item Description	Unit	Recommendation		
		Qty	Unit Cost	Total
LRT Structure	SF	60,800	$110	$6,688,000
Straddle Bents	L. Sum	3	$400,000	$1,200,000
Retaining Wall (East and West)	SF	19,800	$60	$1,188,000
Retained Fill	CY	20,000	$10	$200,000
Traffic Signal Work	Each	2	$300,000	$600,000
Bridge Re-decking	L.Sum	1	$416,000	$416,000
Rail	Lf	3,375	$2,200	$7,425,000
Utilities	Lf	3,000	$400	$1,200,000
AC Pavement	SY	78,000	$35	$2,730,000
PCCP	SY	600	$45	$27,000
Light Rail Station	Each	1	$3,000,000	$3,000,000
I-17 Widening Construction Accommodations	LS	1	$2,000,000	$2,000,000
Total				$26,674,000
Plus 60% Markup (Construction x 1.6)				**$42,678,400**
Right-of-way	SF	$66,600	25	$1,665,000
Total Cost				**$44,343,400**

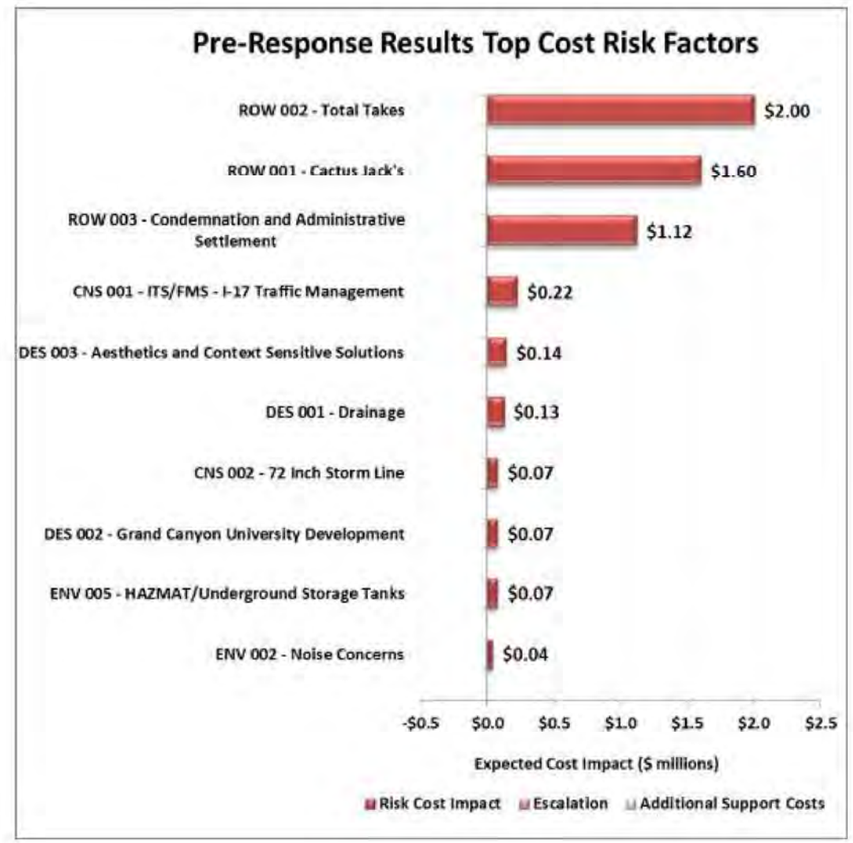
Alternative No. 4 -SPUI with Elevated LRT and Fly Over

Risk Identification and Quantification

After the alternative was developed the Value Planning Team discussed the potential risk events and elements that would be facing the alternative. For each significant risk event that was identified, the probability of the risk and its impact to cost, schedule, or both were estimated. The risk assessment process included identifying high risk areas and risk elements as threats (or opportunities where appropriate) to a project and quantifying the identified risk elements.

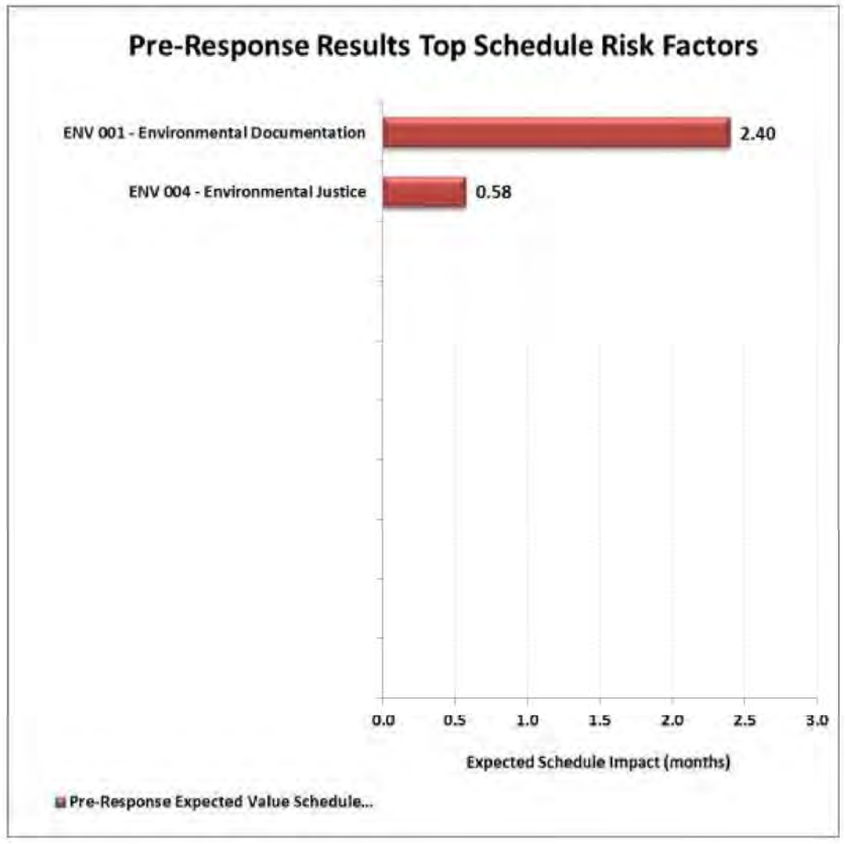
The Risk Data Sheets provided in the Appendix of this report shows additional information specific to each risk as identified by the Team for all the alternatives.

The tornado diagrams for the top risks impacting both cost and schedule for this alternative are provided below.



Alternative No. 4 -SPUI with Elevated LRT and Fly Over

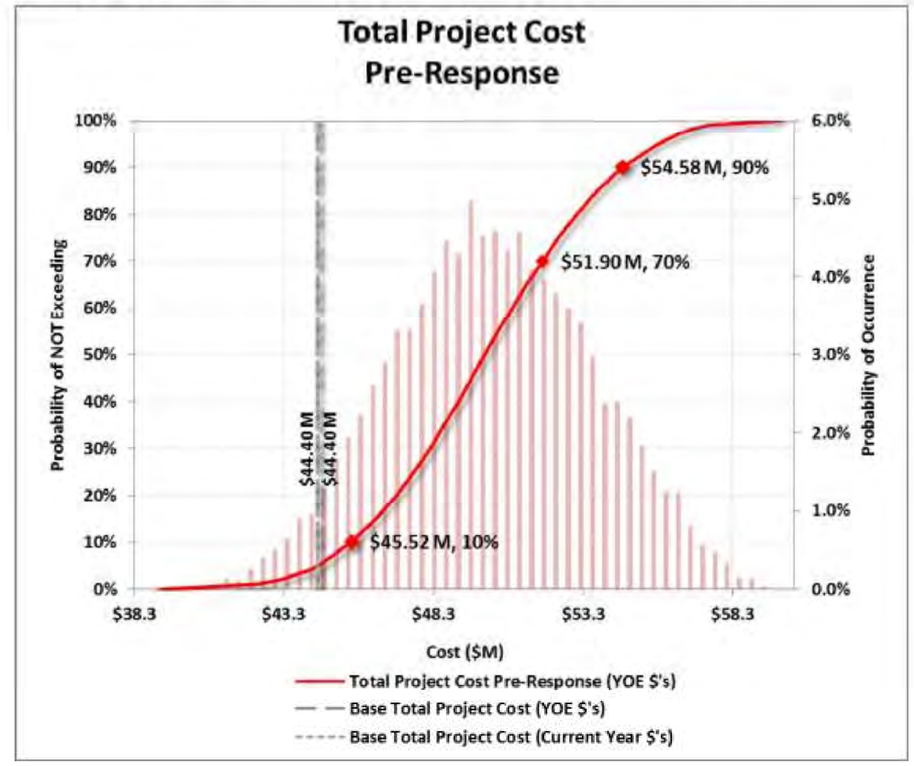
The expected value (likelihood multiplied by expected risk outcome) tornado diagrams depict the actual expected values of the identified risks. Not all risks identified require immediate management. Often, a project Team needs to prioritize the risks for which it plans to develop strategies in the future in an effort to make the best use of the time available. An example would be to begin with the risks with the highest cost and schedule impacts.



Alternative No. 4 -SPUI with Elevated LRT and Fly Over

Risk Analysis Results

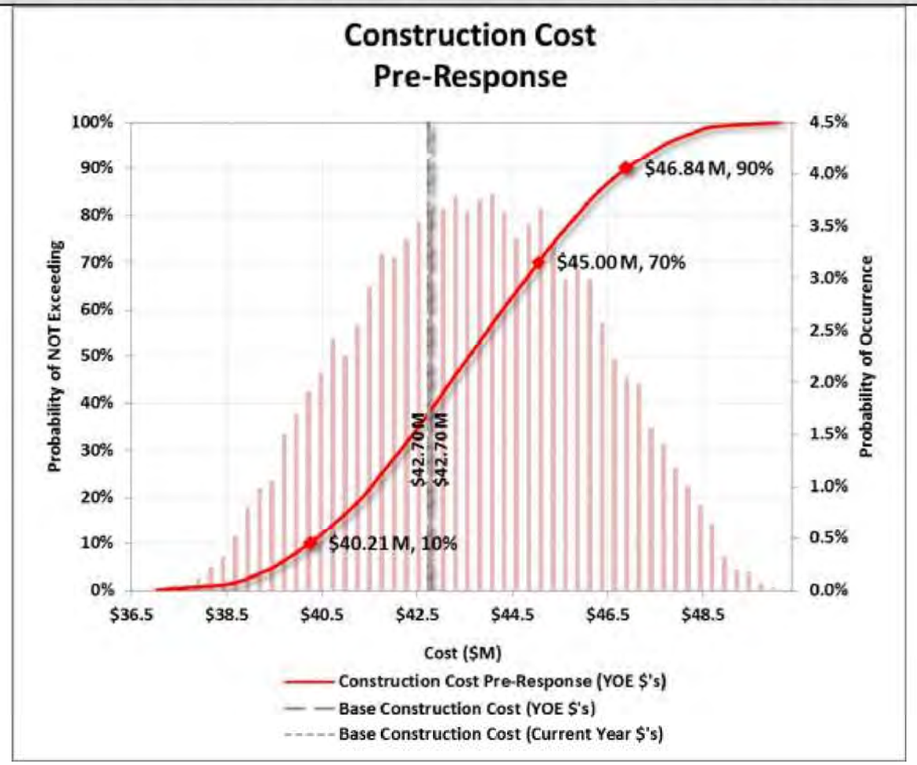
The risk analysis results are given in the form of graphs showing the relationship between cost and the probability of not exceeding that cost. Risk-based analysis provides a distribution of probabilities that a project will not exceed an estimated dollar figure. Typically, agencies report the project risk-based estimation using the 70 percent confidence interval. Each graph represents the best opinion of the cost ranges by the workshop participants at the time of the analysis.



The base cost is the cost without any contingencies or factored escalation, shown by the gray vertical line at $44.40 million.

The s-curve, with risk results factored into the analysis, shows that the Alternative 4 will be less than **$51.90 million** at a 70% confidence level.

Alternative No. 4 -SPUI with Elevated LRT and Fly Over



The base cost for design/construction for Alternative 4 is $42.70 million.

The s-curve, with risk results factored into the analysis, shows that the design/construction costs for Alternative 4 will be less than **$45.00 million** at a 70% confidence level.

MARICOPA ASSOCIATION of GOVERNMENTS

Alternative No. 4 -SPUI with Elevated LRT and Fly Over

The base cost for right-of-way for Alternative 4 is $1.70 million.

The s-curve, with risk results factored into the analysis, shows that the right-of-way costs for Alternative 4 will be less than **$8.06 million** at a 70% confidence level.

The next step will be to determine the appropriate risk response strategies for the identified high risk areas. Risk response strategies were not identified as part of this Value Planning workshop. Four risk response strategies are considered when addressing threat risks. Those strategies are to avoid, accept, transfer, or mitigate the risk threat (opportunity).

Alternative No. 4 -SPUI with Elevated LRT and Fly Over

PERFORMANCE MEASURES Attributes and Rating Rationale for Recommendation		Alternative
Roadway Operations + Minimizes modal conflicts. + Maintains most access along Camelback Road, except along touch down ramp lengths.	Rating	6
	Weight	23.8
	Contribution	142.8
Transit Operations + Dedicated right-of-way, minimized conflict. + Increased speed. + Straight LRT alignment, except for shoe-fly alignment at I-17 crossing. + Approximately 5% grades on approaches.	Rating	8
	Weight	23.8
	Contribution	190.4
Maintainability - Additional structures to maintain. - Longer LRT bridge. + New bridge deck structure. - Not replacing bridge; older bridge to maintain.	Rating	5
	Weight	14.4
	Contribution	72.0
Construction Impacts - Temporary closures of I-17 and Camelback Road. - Most of Camelback Road will have to be reconstructed due to impacts of constructing the LRT bridge overhead.	Rating	4
	Weight	4.7
	Contribution	18.8
Environmental Impacts - Visual impacts. + Minimal impacts to businesses.	Rating	5
	Weight	9.5
	Contribution	47.5
Promotes Economic Growth + Maintaining TOD compatibility. + Maintaining traffic movement and access for business access.	Rating	7
	Weight	23.8
	Contribution	166.6
	Total Performance:	**638**

Value Planning Approach

Understanding the relationship of cost, performance, and value is essential in evaluating different alternatives. Comparing the performance and cost suggests which recommendations are potentially as good as or better than the project baseline concept in terms of overall value.

Value Engineering, Analysis or Planning has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that value analysis can play to improve project performance. To address this issue, a performance-based approach was used.

The primary objective of any workshop is to improve the value of the project. A simple way to think of value in terms of an equation is shown at right. While project costs are fairly easy to quantify and compare through traditional estimating techniques, performance is not so easily quantifiable.

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

The use of performance attributes acts the cornerstone of this performance-based process by giving a systematic and structured way of considering the relationship of a project's performance and cost as it relates to value. Project performance must be properly defined and agreed on by the stakeholders at the beginning of the workshop. The performance attributes and requirements that are developed are then used throughout the study to identify, evaluate and document alternatives.

The application of performance-based value planning consists of the following steps:

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

The following are the key project performance attributes that were used in this Value Planning Study:

- Roadway Operations
- Transit Operations
- Maintainability
- Construction Impacts
- Environmental Impacts
- Promotes Economic Growth

Alternatives Performance Assessment and Summary

As the Value Planning Team developed the alternatives, the performance of each is rated against the others. Changes in performance are always based upon the overall impact to the total project. Once performance and cost data have been developed by the Team, the net change in value of the alternatives can be compared to the baseline concept.

The resulting value improvement scores provide a way to assess the potential impact of each alternative on total project value.

Table 7 - Recommendation Total Performance				
Performance Attribute Ratings				
Attribute	Attribute Weight	Alternative	Performance Rating	Total Performance
Roadway Operations	23.8	1	5	119.0
		2	6	142.8
		3	8	190.4
		4	6	142.8
Transit Operations	23.8	1	6	142.8
		2	9	214.2
		3	9	214.2
		4	8	190.4
Maintainability	14.4	1	6	86.4
		2	5	72.0
		3	5	72.0
		4	5	72.0
Construction Impacts	4.7	1	7	32.9
		2	2	9.4
		3	5	23.5
		4	4	18.8
Environmental Impacts	9.5	1	5	47.5
		2	6	57.0
		3	4	38.0
		4	5	47.5
Promotes Economic Growth	23.8	1	6	142.8
		2	7	166.6
		3	9	214.2
		4	7	166.6

The performance score thus developed is divided by the risk adjusted total project cost to compute the value index of each alternative developed. Table 8 provides a summary of the alternatives generated and their performance, cost, and value index. It can seen from Table 8

that Alternative 3 (Platform Diamond with LRT Fly Over), with the highest value index, is the best of the alternatives developed.

Table 8: List of Alternatives				
Alternatives		Performance	Cost	Value Index
1	SPUI with LRT elevated to North	571	$51.2 M	11.16
2	Tight Diamond with LRT Fly Over	662	$64.8 M	10.22
3	Platform Diamond with LRT Fly Over	752	$56.6 M	13.29
4	SPUI with Elevated LRT and Fly Over	638	$51.9 M	12.29

Appendix

- Base Schedule Review
- Risk Data Sheets
- Value Planning Agenda
- Value Planning Attendees
- Value Planning Report Out
- Performance Based Results

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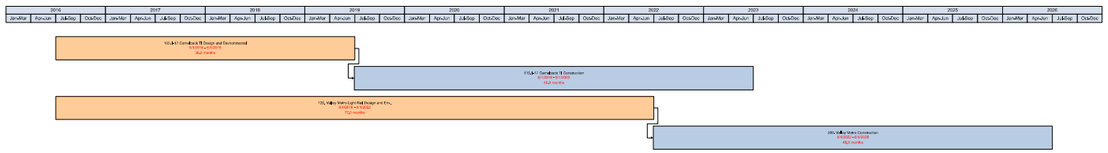
Base Schedule Review



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Risk Data Sheets – Alternative 1

Project	I-17 & Camelback Alternative 1	Risk ID	CNS 001

ITS/FMS - I-17 Traffic Management

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.50 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.23 M	0.00 Mo.

There is a risk that would add ITS/FMS alternatives for the I-17 corridor. This may result in infrastructure upgrades that would add costs to the project to accommodate these additional facilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 1 of 13

Project	I-17 & Camelback Alternative 1	Risk ID	CNS 002

72 Inch Storm Line

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.25 M	$0.50 M	$0.75 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.13 M	0.00 Mo.

The 72 inch line is running along the west side of I-17 and may conflict with bridge pier construction. The risk is to relocate the storm line or revise the bridge design to avoid the line.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 1	Risk ID	DES 001

Drainage

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Construction	
Cost ($M)	$0.05 M	$0.08 M	$0.10 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.06 M	0.00 Mo.

There is a risk that the existing drainage basin will need to be replaced or modified to accommodate additional capacity. This alternative is filling in part of the flood control basin.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 3 of 13

Project	I-17 & Camelback Alternative 1	Risk ID	DES 002

Grand Canyon University Development

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$1.00 M	$2.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.51 M	0.00 Mo.

This alternative is removing access from I-17 to 26th Ave that may impact known development plans for GCU. Design modifications may be required to accommodate their plans. These modifications could include pedestrian and vehicle access that will add costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 4 of 13

Project	I-17 & Camelback Alternative 1	Risk ID	DES 003

Aesthetics and Context Sensitive Solutions

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.14 M	0.00 Mo.

Extensive stakeholder involvement may add costs for mitigation for design elements not yet captured in the base costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 5 of 13

Project	I-17 & Camelback Alternative 1	Risk ID	ENV 001

Environmental Documentation

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	12.00 Mo.	24.00 Mo.	36.00 Mo.	Yes	$0.00 M	2.40 Mo.

It is assumed that there will be 2 different environmental documents (one for I-17 and one for VM). These documents might conflict and need to be coordinated. Two federal agencies requiring different levels of documentation and different public outreach requirements. Light Rail needs a NEPA decision by September 2018. The base schedule has not been defined for the I-17 environmental work (the earliest start of this work is FY 2018, after the CMP is approved).

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 6 of 13

Project	I-17 & Camelback Alternative 1	Risk ID	ENV 002

Noise Concerns

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$1.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.04 M	0.00 Mo.

Evaluation of noise and mitigation will depend on impacts to sensitive receptors and mitigation will be implemented as necessary. The light rail is elevated to the north and an analysis will need to be performed to determine the impacts to the surrounding residences and businesses. Noise mitigation may be required that will add costs to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 7 of 13

Project	I-17 & Camelback Alternative 1	Risk ID	ENV 003

Historical/Cultural

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.

This location is previously disturbed and there are no known historical/cultural locations. This is a watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 1	Risk ID	ENV 004

Environmental Justice

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
5%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	3.00 Mo.	12.00 Mo.	18.00 Mo.	Yes	$0.00 M	0.58 Mo.

This a potential schedule risk for time required to evaluate additional factors as they arise. The probability is low based on the time frame between when the process begins and when construction starts.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 1	Risk ID	ENV 005

HAZMAT/Underground Storage Tanks

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.20 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

There is a risk of encountering hazardous materials and underground storage tanks during construction.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 1	Risk ID	ROW 001

Cactus Jack

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
80%				Active	Right-of-Way	
Cost ($M)	$3.00 M	$4.00 M	$5.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$3.20 M	0.00 Mo.

The retaining wall and access revisions results in a total take of the dealership property. This location is the headquarters for all of their other dealerships in the region.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 1	Risk ID	ROW 002

Total Takes

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
80%				Active	Right-of-Way	
Cost ($M)	$2.00 M	$2.50 M	$3.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$2.00 M	0.00 Mo.

The estimate was developed for neat line of ROW required. There is a risk that total takes are required that will result in an increase of 100,000 sf of ROW to be purchased at $25/sf.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 1	Risk ID	ROW 003

Condemnation and Administrative Settlement

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Right-of-Way	
Cost ($M)	$1.30 M	$1.55 M	$1.80 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$1.16 M	0.00 Mo.

The risk adjusted ROW costs is approximately $4.4M. Typically a ROW contingency is held for 30 to 40% of ROW costs. This includes relocation and demolition.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Risk Data Sheets – Alternative 2

Project	I-17 & Camelback Alternative 2	Risk ID	CNS 001

ITS/FMS - I-17 Traffic Management

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.50 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.23 M	0.00 Mo.

There is a risk that would add ITS/FMS alternatives for the I-17 corridor. This may result in infrastructure upgrades that would add costs to the project to accommodate these additional facilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 1 of 15

Project	I-17 & Camelback Alternative 2	Risk ID	CNS 005

Straddle Bent Constructability

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
95%				Active	Construction	
Cost ($M)	$3.00 M	$4.00 M	$5.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$3.80 M	0.00 Mo.

There are three straddle bents for this option, two end bents and one in the median. There are significant construction challenges associated with construction of these straddle bents over Camelback that involve falsework construction, MOT, staging, and sequencing that involve significant risk. There is no available area in the median or along the structure on Camelback over I-17 that allow construction of falsework towers and increased permanent structure height to accommodate falsework beams.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 2 of 15

Project	I-17 & Camelback Alternative 2	Risk ID	CNS 006

I-17 Revised Alignment

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
95%				Active	Construction	
Cost ($M)	$1.00 M	$2.00 M	$3.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$1.90 M	0.00 Mo.

The median of I-17 requires widening to accommodate the new structure foundation along the new Camelback overpass. This will require a new traffic alignment for I-17.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	DES 001

Drainage

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
15%				Active	Construction	
Cost ($M)	$0.05 M	$0.08 M	$0.10 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.01 M	0.00 Mo.

There is a risk that the existing drainage basin will need to be replaced or modified to accommodate additional capacity. The flood control area may need to be modified due to widening of Camelback.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	DES 002

Grand Canyon University Development

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.05 M	$0.50 M	$1.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.25 M	0.00 Mo.

This alternative is removing access from I-17 to 26th Ave that may impact known development plans for GCU. Design modifications may be required to accommodate their plans. These modifications could include pedestrian and vehicle access that will add costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	DES 003

Aesthetics and Context Sensitive Solutions

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.14 M	0.00 Mo.

Extensive stakeholder involvement may add costs for mitigation for design elements not yet captured in the base costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	ENV 001

Environmental Documentation

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	12.00 Mo.	24.00 Mo.	36.00 Mo.	Yes	$0.00 M	2.40 Mo.

It is assumed that there will be 2 different environmental documents (one for I-17 and one for VM). These documents might conflict and need to be coordinated. Two federal agencies requiring different levels of documentation and different public outreach requirements. Light Rail needs a NEPA decision by September 2018. The base schedule has not been defined for the I-17 environmental work (the earliest start of this work is FY 2018, after the CMP is approved).

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	ENV 002

Noise Concerns

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$1.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.04 M	0.00 Mo.

Evaluation of noise and mitigation will depend on impacts to sensitive receptors and mitigation will be implemented as necessary. The light rail is elevated to the north and an analysis will need to be performed to determine the impacts to the surrounding residences and businesses. Noise mitigation may be required that will add costs to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 8 of 15

Project	I-17 & Camelback Alternative 2	Risk ID	ENV 003

Historical/Cultural

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.

This location is previously disturbed and there are no known historical/cultural locations. This is a watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	ENV 004

Environmental Justice

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
5%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	3.00 Mo.	12.00 Mo.	18.00 Mo.	Yes	$0.00 M	0.58 Mo.

This a potential schedule risk for time required to evaluate additional factors as they arise. The probability is low based on the time frame between when the process begins and when construction starts.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 2	Risk ID	ENV 005

HAZMAT/Underground Storage Tanks

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.20 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

There is a risk of encountering hazardous materials and underground storage tanks during construction.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 2	Risk ID	ROW 001

Cactus Jack's

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Right-of-Way	
Cost ($M)	$0.05 M	$0.15 M	$0.25 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

Closing the right in-right out access within the clearance limits of the interchange will affect the property.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 2	Risk ID	ROW 002

Total Takes

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
80%				Active	Right-of-Way	
Cost ($M)	$1.00 M	$1.25 M	$1.50 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$1.00 M	0.00 Mo.

The estimate was developed for neat line of ROW required. There is a risk that total takes are required that will result in an increase of 50,00 sf of ROW to be purchased at $25/sf for the transition sections at the bridge ends.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 2	Risk ID	ROW 003

Condemnation and Administrative Settlement

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Right-of-Way	
Cost ($M)	$0.80 M	$0.90 M	$1.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.68 M	0.00 Mo.

The risk adjusted ROW costs is approximately $2.75M. Typically a ROW contingency is held for 30 to 40% of ROW costs. This includes relocation and demolition.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 2	Risk ID	ROW 005

Substation Locations

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
100%				Active	Right-of-Way	
Cost ($M)	$0.10 M	$0.13 M	$0.16 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.13 M	0.00 Mo.

The elevated guideway will require substations outside of the roadway prism that does not define ROW areas at this time. Assume there will be at least one in this area, approximately 50' x 100' @ $25/sf.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Risk Data Sheets – Alternative 3

Project	I-17 & Camelback Alternative 3	Risk ID	CNS 001

ITS/FMS - I-17 Traffic Management

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.50 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.23 M	0.00 Mo.

There is a risk that would add ITS/FMS alternatives for the I-17 corridor. This may result in infrastructure upgrades that would add costs to the project to accommodate these additional facilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

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Project	I-17 & Camelback Alternative 3	Risk ID	CNS 002

72 Inch Storm Line

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.25 M	$0.50 M	$0.75 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.13 M	0.00 Mo.

The 72 inch line is running along the west side of I-17 and may conflict with bridge pier construction. The risk is to relocate the storm line or revise the bridge design to avoid the line or protect in place.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 2 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	CNS 005

Flyover Foundation Construction

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
90%				Active	Construction	
Cost ($M)	$0.30 M	$0.50 M	$0.70 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.45 M	0.00 Mo.

The flyover foundation will be built in the median where the existing structure foundation exists. Similar issues may be encountered at the abutments. Alignment adjustments will also be required along I-17 to accommodate the new median width.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 3	Risk ID	DES 001

Drainage

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Construction	
Cost ($M)	$0.40 M	$0.50 M	$0.60 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.38 M	0.00 Mo.

There is a risk that the existing drainage basin will need to be replaced or modified to accommodate additional capacity. This alternative will have added cost for drainage conveyance and is filling in part of the flood control basin.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 3	Risk ID	DES 002

Grand Canyon University Development

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$0.15 M	$0.20 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

This alternative is providing right in-right out access from I-17 to 26th Ave. Design modifications may be required to accommodate their plans. These modifications could include pedestrian and vehicle access that will add costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 5 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	DES 003

Aesthetics and Context Sensitive Solutions

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.14 M	0.00 Mo.

Extensive stakeholder involvement may add costs for mitigation for design elements not yet captured in the base costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 6 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	ENV 001

Environmental Documentation

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	12.00 Mo.	24.00 Mo.	36.00 Mo.	Yes	$0.00 M	2.40 Mo.

It is assumed that there will be 2 different environmental documents (one for I-17 and one for VM). These documents might conflict and need to be coordinated. Two federal agencies requiring different levels of documentation and different public outreach requirements. Light Rail needs a NEPA decision by September 2018. The base schedule has not been defined for the I-17 environmental work (the earliest start of this work is FY 2018, after the CMP is approved).

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 7 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	ENV 002

Noise Concerns

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.30 M	$0.75 M	$1.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.18 M	0.00 Mo.

Evaluation of noise and mitigation will depend on impacts to sensitive receptors and mitigation will be implemented as necessary. The traffic and light rail is elevated and an analysis will need to be performed to determine the impacts to the surrounding residences and businesses. Noise mitigation may be required that will add costs to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 8 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	ENV 003

Historical/Cultural

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.

This location is previously disturbed and there are no known historical/cultural locations. This is a watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 3	Risk ID	ENV 004

Environmental Justice

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
5%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	3.00 Mo.	12.00 Mo.	18.00 Mo.	Yes	$0.00 M	0.58 Mo.

This a potential schedule risk for time required to evaluate additional factors as they arise. The probability is low based on the time frame between when the process begins and when construction starts.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 3	Risk ID	ENV 005

HAZMAT/Underground Storage Tanks

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.20 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

There is a risk of encountering hazardous materials and underground storage tanks during construction.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 11 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	ROW 001

Cactus Jack's

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
99%				Active	Right-of-Way	
Cost ($M)	$3.00 M	$4.00 M	$5.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$3.96 M	0.00 Mo.

The roadway widening and access revisions may result in a total take of the dealership property. This location is the headquarters for all of their other dealerships in the region.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 12 of 14

Project	I-17 & Camelback Alternative 3	Risk ID	ROW 002

Total Takes

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
80%				Active	Right-of-Way	
Cost ($M)	$2.00 M	$3.75 M	$5.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$2.93 M	0.00 Mo.

The estimate was developed for neat line of ROW required. There is a risk that total takes are required that will result in an increase of 150,000 sf of ROW to be purchased at $25/sf.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 3	Risk ID	ROW 003

Condemnation and Administrative Settlement

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Right-of-Way	
Cost ($M)	$2.10 M	$2.55 M	$3.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$1.91 M	0.00 Mo.

The risk adjusted ROW costs is approximately $7M. Typically a ROW contingency is held for 30 to 40% of ROW costs. This includes relocation and demolition.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Risk Data Sheets – Alternative 4

Project	I-17 & Camelback Alternative 4	Risk ID	CNS 001

ITS/FMS - I-17 Traffic Management

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.50 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.23 M	0.00 Mo.

There is a risk that would add ITS/FMS alternatives for the I-17 corridor. This may result in infrastructure upgrades that would add costs to the project to accommodate these additional facilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 1 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	CNS 002

72 Inch Storm Line

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
15%				Active	Construction	
Cost ($M)	$0.25 M	$0.50 M	$0.75 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

The 72 inch line is running along the west side of I-17 and may conflict with bridge pier construction. The risk is to relocate the storm line or revise the bridge design to avoid the line or protect in place.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 2 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	DES 001

Drainage

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.40 M	$0.50 M	$0.60 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.13 M	0.00 Mo.

There is a risk that the existing drainage basin will need to be replaced or modified to accommodate additional capacity. This alternative will have added cost for drainage conveyance and is filling in part of the flood control basin.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 3 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	DES 002

Grand Canyon University Development

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$0.15 M	$0.20 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

This alternative is providing right in-right out access from I-17 to 26th Ave. Design modifications may be required to accommodate their plans. These modifications could include pedestrian and vehicle access that will add costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 4 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	DES 003

Aesthetics and Context Sensitive Solutions

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
50%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.14 M	0.00 Mo.

Extensive stakeholder involvement may add costs for mitigation for design elements not yet captured in the base costs.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 5 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	ENV 001

Environmental Documentation

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	12.00 Mo.	24.00 Mo.	36.00 Mo.	Yes	$0.00 M	2.40 Mo.

It is assumed that there will be 2 different environmental documents (one for I-17 and one for VM). These documents might conflict and need to be coordinated. Two federal agencies requiring different levels of documentation and different public outreach requirements. Light Rail needs a NEPA decision by September 2018. The base schedule has not been defined for the I-17 environmental work (the earliest start of this work is FY 2018, after the CMP is approved).

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 6 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	ENV 002

Noise Concerns

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
10%				Active	Construction	
Cost ($M)	$0.10 M	$0.30 M	$1.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.04 M	0.00 Mo.

Evaluation of noise and mitigation will depend on impacts to sensitive receptors and mitigation will be implemented as necessary. The light rail is elevated and an analysis will need to be performed to determine the impacts to the surrounding residences and businesses. Noise mitigation may be required that will add costs to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 7 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	ENV 003

Historical/Cultural

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.

This location is previously disturbed and there are no known historical/cultural locations. This is a watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 8 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	ENV 004

Environmental Justice

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
5%				Active	Design/Permitting	
Cost ($M)				Critical Path?	EV Cost	EV Sched
Schedule (Mo)	3.00 Mo.	12.00 Mo.	18.00 Mo.	Yes	$0.00 M	0.58 Mo.

This a potential schedule risk for time required to evaluate additional factors as they arise. The probability is low based on the time frame between when the process begins and when construction starts.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 4	Risk ID	ENV 005

HAZMAT/Underground Storage Tanks

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
25%				Active	Construction	
Cost ($M)	$0.20 M	$0.30 M	$0.40 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$0.08 M	0.00 Mo.

There is a risk of encountering hazardous materials and underground storage tanks during construction.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

Project	I-17 & Camelback Alternative 4	Risk ID	ROW 001

Cactus Jack's

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
40%				Active	Right-of-Way	
Cost ($M)	$3.00 M	$4.00 M	$5.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$1.60 M	0.00 Mo.

The roadway widening and access revisions may result in a total take of the dealership property. This location is the headquarters for all of their other dealerships in the region.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 11 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	ROW 002

Total Takes

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
80%				Active	Right-of-Way	
Cost ($M)	$2.00 M	$2.50 M	$3.00 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$2.00 M	0.00 Mo.

The estimate was developed for neat line of ROW required. There is a risk that total takes are required that will result in an increase of 100,000 sf of ROW to be purchased at $25/sf.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 12 of 13

Project	I-17 & Camelback Alternative 4	Risk ID	ROW 003

Condemnation and Administrative Settlement

Pre-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Activity Impacted	
75%				Active	Right-of-Way	
Cost ($M)	$1.25 M	$1.50 M	$1.70 M	Critical Path?	EV Cost	EV Sched
Schedule (Mo)					$1.12 M	0.00 Mo.

The risk adjusted ROW costs is approximately $4.2M. Typically a ROW contingency is held for 30 to 40% of ROW costs. This includes relocation and demolition.

Post-Response Quantification

Probability	Low	Most Likely	High	Risk Status	Risk Owner	
Cost ($M)				Strategy	EV Cost	EV Sched
Schedule (Mo)					$0.00 M	0.00 Mo.
Cost to Mitigate						

July 8, 2016 Risk Register Page 13 of 13

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Value Planning Agenda

Cost Risk Assessment & Value Planning Workshop Agenda
I-17 / Camelback Road / Light Rail Crossing
June 27 – 30, 2016

Location: *MAG 302 N 1st Ave. Suite 200, Saguaro Conference Room*

Meeting Objectives:
1. Common understanding among participants of the Cost Risk Analysis and Value Planning Process.
2. Describe project characteristics, schedule, cost, and risk issues.
3. Review project schedule and cost estimate.
4. Develop Risk Response Strategies.

Participants: All Workshop Participants need to be present at 8:30 AM on Day 1 and then return at the designated time in the agenda.

Core Group: Bob Hazlett, Chaun Hill, Quinn Castro, Ken Smith, Jeremy Neuman, Brian Bombardier, Jason Nauman, Trent Eakin, Scott Gehrke, Jim Slaker, Jenn Pyne, Abhi Dayal, Audra Thomas, Omar Jaff, Jay Yenerich, Eric Prosnier, Eunice Chan, Maurice Goyette, Carla Kahn

Monday 6/27/2016	*Topic*	*Lead*	*Attendees*
8:30 – 8:45	**Welcome, sign-in, updates, introductions, & agenda review**	Ken Smith	All
8:45 – 9:15	**Overview of CRA & VP process** **Expectation and Goal Setting**	Ken Smith	All
	Information Phase		
9:15 – 9:45	**Project Briefing** Project presentation • I-10/I-17 "Spine" • Valley Metro Crossings • City of Phoenix T2050	Project Team	All
9:45 – 10:15	**Flowchart Finalization & Concurrence** Review Flowchart, revise if necessary	Ken Smith	All
10:15 – 10:30	**Break**		
10:30 – 11:00	**Brainstorm Issues**	Ken Smith	All
11:00 – 11:15	**Environmental, Permitting & ROW** • Environmental Documentation • Required Permits • ROW	Ken Smith	Core Group
11:15 – 12:00	**Valley Metro** • Light Rail Crossing Alternatives / Constraints **Response Strategies**	Ken Smith	Core Group
12:00 – 1:00	**Lunch**		
1:00 – 2:00	**Valley Metro** • Light Rail Crossing Alternatives / Constraints • Response Strategies	Ken Smith	Core Group

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2:00 – 2:30	**Utilities** • Utility Relocation Needs • Response Strategies	Ken Smith	Core Group, Jamie Erickson
2:30 – 2:45	**Break**		
2:45 – 3:45	**Design** • Drainage • Structures • MOT / Traffic • Signals • Response Strategies	Ken Smith	Core Group, Bruce Littleton, Dave Benton, Ken Akoh Arrey
3:45 – 4:30	**Management and Stakeholders** • Define risks • Response Strategies	Ken Smith	Core Group
4:30 – 5:00	**Construction / Maintenance Issues** • Define risks • Response Strategies	Ken Smith	Core Group, Madhu Reddy, David Locher, Raul Amavisca Dale Drost
5:00	**Adjourn**		

Tuesday 6/28/2016	*Topic*	*Lead*	*Attendees*
	Evaluation Phase		
8:30 – 10:00	• **Brainstorm on functions and large risk areas**	Ken Smith	Core Group
10:00 – 10:15	**Break**		
10:15 – 12:00	• **Evaluate ideas**	Ken Smith	Core Group
12:00 – 1:00	**Lunch**		
	Development Phase		
1:00 – 2:30	• **Development of recommendations**	Ken Smith	Core Group
2:30 – 2:45	**Break**		
2:45 – 5:00	• **Continue development of recommendations**	Ken Smith	Core Group
5:00	**Adjourn**		

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Wednesday 6/29/2016	Topic	Lead	Attendees
8:30 – 10:00	• Continue development of recommendations	Ken Smith	Core Group
10:00 – 10:15	Break		
10:15 – 12:00	• Continue development of recommendations	Ken Smith	Core Group
12:00 – 1:00	Lunch		
1:00 – 2:30	• Complete development of recommendations	Ken Smith	Core Group
2:30 – 2:45	Break		
2:45 – 5:00	• Performance evaluation and risk assessment of recommendations	Ken Smith	Core Group
5:00	Adjourn		

Thursday 6/30/2016	Topic	Lead	Attendees
8:30 – 10:00	• Review results and prepare presentation	Ken Smith	Core Group
10:00 – 10:15	Break		
10:15 – 12:00	• Review results and prepare presentation	Ken Smith	Core Group
12:00 – 1:00	Lunch		
1:00 – 2:30	• Rehearse Presentation	Ken Smith	Core Group
2:30 – 4:00	Present Results	CRA & VP Team	Invitees
4:00	Adjourn		

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Value Planning Attendees

MARICOPA ASSOCIATION of GOVERNMENTS

I-17 / Camelback Road / Light Rail Crossing Value Planning
June 27 – 30, 2016

DATE 6/27	6/28	6/29	6/30	NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE OFFICE	CELL	EMAIL
✓	✓	✓	✓	Ken Smith	HDR	Risk Lead	360 570 4415	360 451 2527	Ken.l.smith@hdrinc.com
✓	✓	✓	✓	Trent Eakin	HDR	SME	360 570 7270		trent.eakin@hdrinc.com
✓	✓	✓	✓	~~Jeremy Neuman~~ Suresh Rajbhandari	HDR	Workshop Assistant	602 778 7345		~~Jeremy.neuman@hdrinc.com~~
✓	✓	✓	✓	Brian Bombardier	HDR	SME	602 778 7324		Brian.bombardier@hdrinc.com
✓	✓	✓	✓	Jason Nauman	HDR	SME	602 522 7708	935-707-5002	Jason.nauman@hdrinc.com
✓	✓	✓	✓	Scott Gehrke	HDR	SME	602 792 8807		Scott.gehrke@hdrinc.com
✓	✓	✓	✓ NOT ATTEND	Jim Slaker	HDR	SME	602 322 4432		James.slaker@hdrinc.com
X	X	X	✓	Bob Hazlett	MAG	Senior Engineering Manager	602 254 6300		bhazlett@azmag.gov
✓	X	✓	✓	Chaun Hill	MAG	Senior Transportation Engineer	602 254 6300		chill@azmag.gov
✓	✓	✓	✓	Quinn Castro	MAG	Transportation Engineer	602 254 6300		qcastro@azmag.gov

MARICOPA ASSOCIATION of GOVERNMENTS

I-17 / Camelback Road / Light Rail Crossing Value Planning
June 27 – 30, 2016

DATE 6/27	6/28	6/29	6/30	NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE OFFICE	CELL	EMAIL
✓	✓	Ü	✓	Audra Thomas	MAG	Transit Planning Project Manager	602 452 5058		akthomas@azmag.gov
✓	✓	✓	✓	Raul Amavisca	ADOT IDO	District Engr-Admin	602-206-2543		ramavisca@azdot.gov
✓	✓	✓	✓	DAVE DROST	ADOT IDO	MAINTENANCE	602-712-8395	602-245-0241	ddrost@azdot.gov
✓	✓	✓		David Lehr	ADOT IDO	Project Development	602-712-2317	602-324-7431	dlehr@azdot.gov
✓	✓	✓	✓	Clemence Ligocki	ADOT MPD	Planning + Programming Mgr	602-712-8143	480-688-5952	cligocki@azdot.gov
✓	✓		✓	Adri Doyal	Valley Metro	Planning Manager	602-744-5572		adoyal@valleymetro.org
✓	✓	✓	X	MAURICE GOYETTE	CUP	Local Light Rail ENGINEER	602-256-4095		maurice.goyette@phoenix.gov
✓	X		✓	Jay Henerich	Valley Metro	Design Manager / Engineering	602-595-5209		jhenerich@valleymetro.org
✓	✓	✓		JIM SLAKER	HDR/VALLEY METRO	CONCEPTUAL DESIGN	602-792-8830	480-620-5239	JSLAKER@VALLEYMETRO.ORG

MARICOPA ASSOCIATION of GOVERNMENTS

I-17 / Camelback Road / Light Rail Crossing Value Planning
June 27 – 30, 2016

DATE 6/27	6/28	6/29	6/30	NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE OFFICE	TELEPHONE CELL	EMAIL
✓	✓	✓	✓	Jennifer Pyne	AECOM/ Valley Metro	Planning	602 648 7335	480 366 0645	jpyne@valleymetro.org
✓	✓	✓	✓	OMAR JAFF	AECOM	Engineering	503 478 7664	503 329 4848	omar.jaff@AECOM.com
✓				Bruce L. Littleton	COP		602-262-4690	302-423-6599	bruce.littleton@phoenix.gov
✓			✓	Eunice Chan	FHWA	Area Engineer	602-382-9965		eunice.chan@dot.gov.
✓			✓	Megan Casey	Valley Metro	Community Relations	602-495-5274	602-639-3677	mcasey@valleymetro.org
✓				Syed Alam	ADOT	Sr. Drainage Engineer	602-712-8701	602-311-6823	salam@azdot.gov
✓				[illegible]	COP	Project Mgr	[illegible]		[illegible]
✓				Jami Spear	COP	Real Estate	602-534-4793	602-501-2872	jami.spear@phoenix.gov
✓				Jami Erickson	COP	Water Services Dept Water/Sewer	602 261 8289		jami.erickson@phoenix.gov
✓	✓	✓	✓	ERIC PRESSNER	ADOT	VPM	602 712 8435		epressner@azdot.gov

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I-17 / Camelback Road / Light Rail Crossing Value Planning
June 27 – 30, 2016

DATE 6/27	6/28	6/29	6/30	NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE OFFICE	TELEPHONE CELL	EMAIL
X		X	X	Albert Sanders	COP	Asst to the City Mgr/ Light Rail			
X			X	Ray Dovalina	"	City of Phx Street Transp. Director			
X	X	X	X	David Moody	MAG	Assc			
~~X~~				~~[illegible]~~	~~[illegible]~~	~~[illegible]~~			
X			X	Carla Kahn	City of Phoenix	LR Coordinator			
	X			Annette Riley	ADOT				
		X	X	Madhu Reddy	ADOT	District Engineer			
X			X	Steve Boschen	ADOT	Division Director IDD			
			X	Eric Anderson	MAG	Transportation Div.			

MARICOPA ASSOCIATION of GOVERNMENTS

I-17 / Camelback Road / Light Rail Crossing Value Planning
June 27 – 30, 2016

DATE				NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
6/27	6/28	6/29	6/30				OFFICE	CELL
							EMAIL	
			X	Debbie Albert	City of Glendale	Transportation	623/930-2939	623/293-0894
							dalbert@glendaleaz.com	
			X	Tom Deutring	FHWA	Project Delivery Team Leader	602 382 8971	
							thomas.deutring@dot.gov	

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Value Planning Report Out

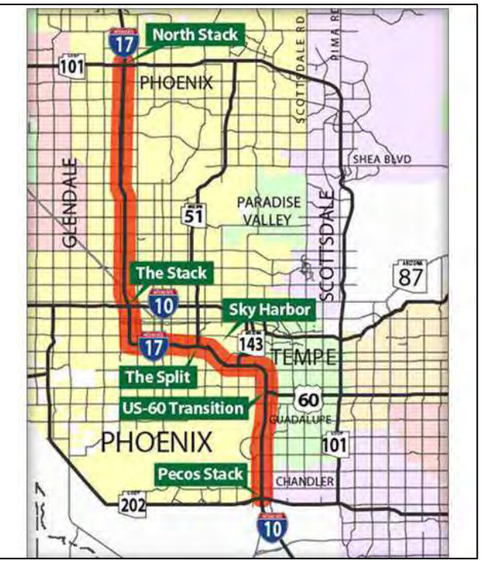
Safety First

- *Emergency Exits*
  - *Muster point*
- *CPR*
- *The number for "911"*

2

2

Plan the Work and Work the Plan



3

Introductions

- Who are you?
- What do you do?
- Have you been on a Cost Risk Assessment or Value Engineering workshop before?

4

Addressing Cost and Schedule Concerns

Usual Questions

- How much will it cost?
- How long will it take?
- Why does it cost that much?
- Why does it take that long?

Analysis Needs

- Risk Identification
- Qualitative and Quantitative Risk Analysis
- Value Engineering &Mitigation Strategies
- Risk Monitoring & Control

5

I-17 / Camelback TI Vicinity Map

6

MARICOPA ASSOCIATION of GOVERNMENTS

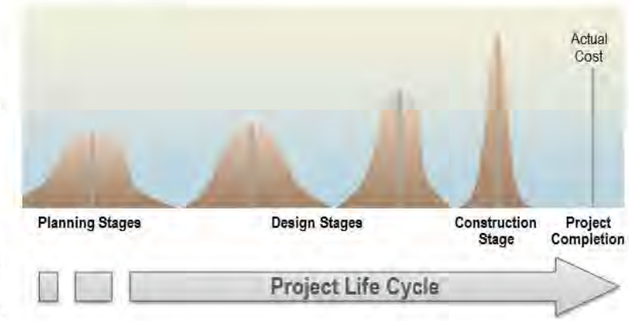
Overview of Project Cost

Base cost estimate serves as the basis against which cost risks and uncertainties are assessed

Estimating is not an exact science:

- Cost estimate is only an approximation of the probable costs
- Composed of many elements that may not be completely or equally defined at the time the estimate is prepared

A numerical value of uncertainty is an estimate of the error or tolerance within the quantity or unit price of an item. Level of uncertainty is directly related to its position in the project life cycle



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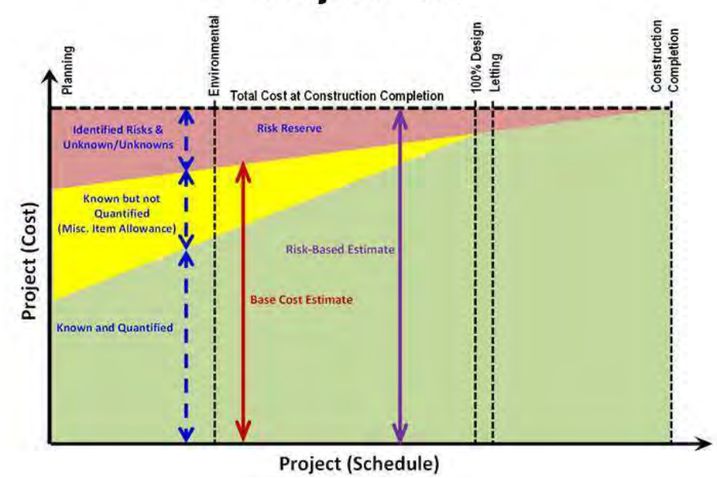
Project Cost



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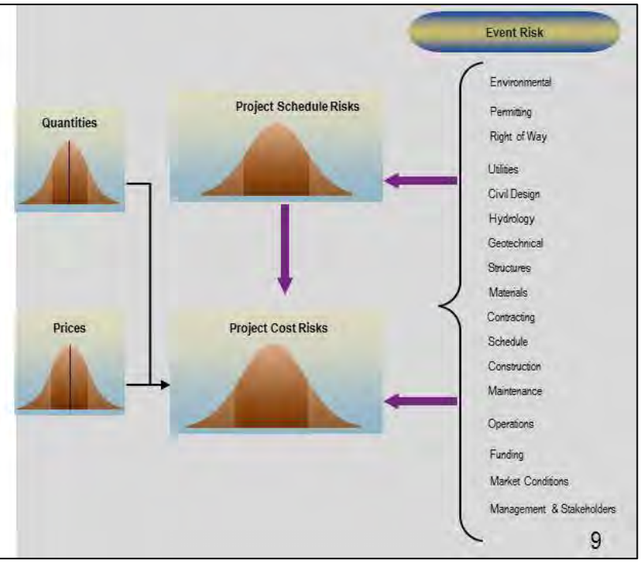
How the Modeling Works

- Monte Carlo Simulation
  - Base cost and uncertainties
  - Cost Event Risks
  - Schedule Event Risk

Making the "black box" transparent



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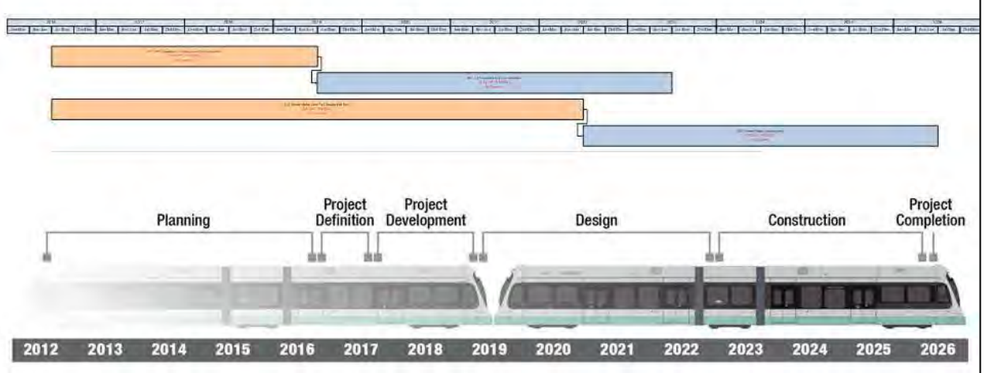
Schedule



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Leading Preferred Alternative

11

I-17 / Camelback TI East-West Demand Issues

12

I-17 / Camelback TI Interchange PM Operations - 2040

13

I-17 Light Rail Crossing Stakeholder Focus Group - Key Concerns

- Restricted left turn access on Camelback
- Potential for changes to property access
- Impacts and duration of construction
- Visibility of businesses
- ROW requirements
- Pedestrian safety

14

LR Option A – At-grade crossing in Camelback median

15

LR Option B (1, 2, 3) – North side of Camelback

16

LR Option C – Colter Street crossing

17

LR Option D – Colter Street crossing

18

LR Option E – North of Interchange

19

Performance Based Value Planning

Value Planning is not just about reducing project costs, but can also improve project performance

- Roadway Operations
- Transit Operations
- Maintainability
- Construction Impacts
- Environmental Impacts
- Promotes Economic Growth

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

20

Performance Weighting

Performance Attributes Criteria Matrix								
False Paired Comparison								
							Total points	% of Total
Roadway Operations	A	A/B	A	A	A	A/F	5.0	23.8%
Transit Operations		B	B	B	B	B/F	5.0	23.8%
Maintainability			C	C	C	F	3.0	14.4%
Construction Impacts				D	E	F	1.0	4.7%
Environmental Impacts					E	F	2.0	9.5%
Promotes Economic Growth						F	5.0	23.8%
						Total	21.0	100.0%

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Value Planning Process

- **Design competition** to evaluate the three roadway scenarios with the five transit scenarios
- Combined the best transit scenario for each of the three roadway alternatives
- Scored performance of each of the alternatives developed
- Performed a risk assessment of each of the alternatives developed
- Defined a value index for each of the alternatives.

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Rules of Design Competition

- Each team must include:
- Project limits 23rd to 27th 3275' LF of LR
- One station near 27th
- Interchange improvements
- ROM estimate
  - Construction costs (2016 $)
    - Mark ups of 60% for:
      - Miscellaneous Items 15%
      - MOT 10%
      - Mobilization 8%
      - Design Engineering 12%
      - Construction Administration 10%
      - Construction Change orders 5%
  - ROW costs
  - Utilities allowance

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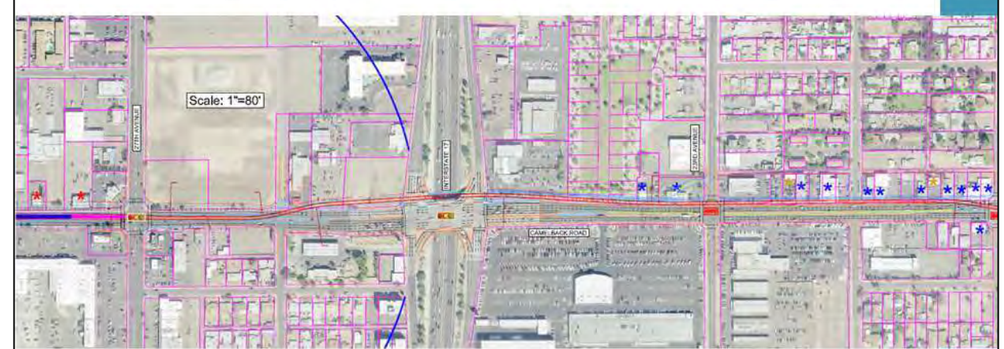
Alternative 1 SPUI Light Rail Elevated, North Side



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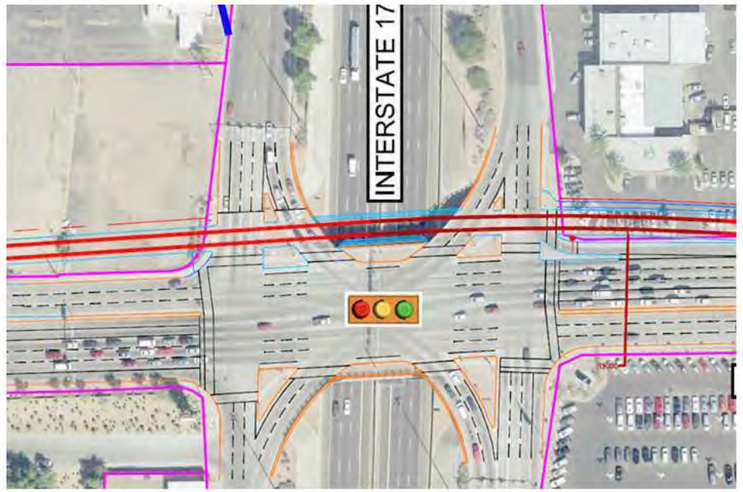
Alternative 1 SPUI Light Rail Elevated, North Side



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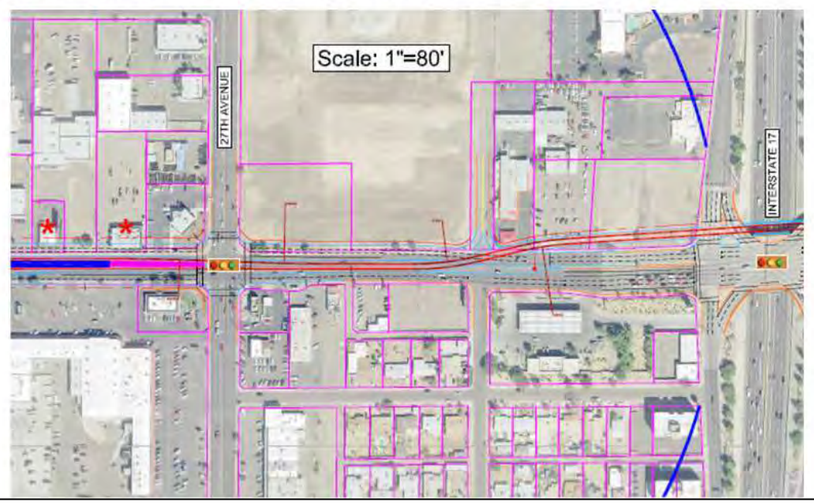
Alternative 1 SPUI Light Rail Elevated, North Side



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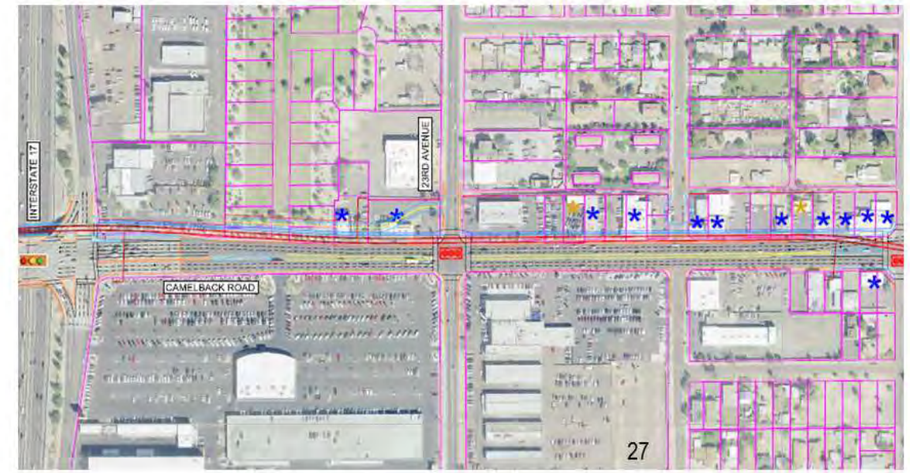
Alternative 1 SPUI Light Rail Elevated, North Side



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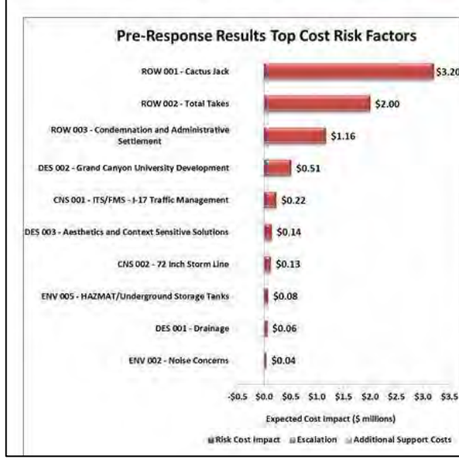
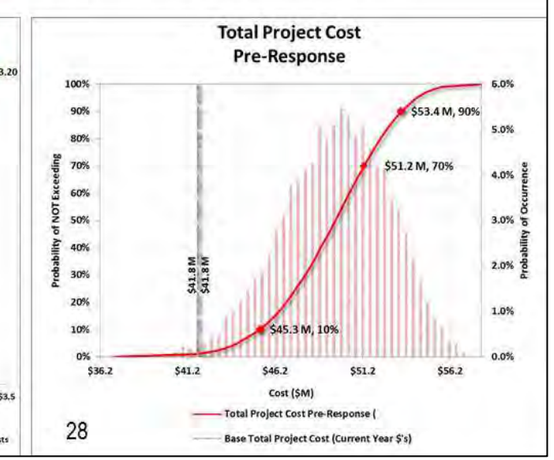
Alternative 1 SPUI Light Rail Elevated, North Side





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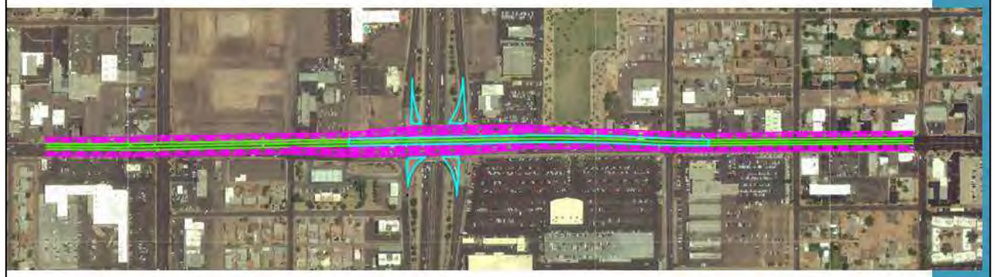
Alternative 2 Tight Diamond-Light Rail Median Running Grade Separated



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Alternative 2 Tight Diamond-Light Rail Median Running Grade Separated

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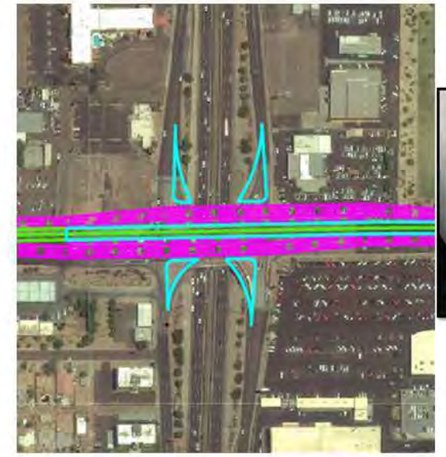
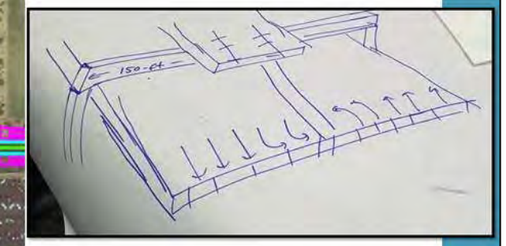
MARICOPA ASSOCIATION of GOVERNMENTS

Alternative 2 Tight Diamond-Light Rail Median Running Grade Separated





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Alternative 2 Tight Diamond-Light Rail Median Running Grade Separated

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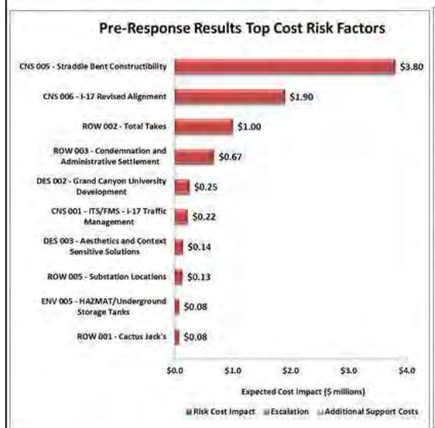
Alternative 2 Tight Diamond-Light Rail Median Running Grade Separated



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Alternative 3 Platform Diamond with Median LRT

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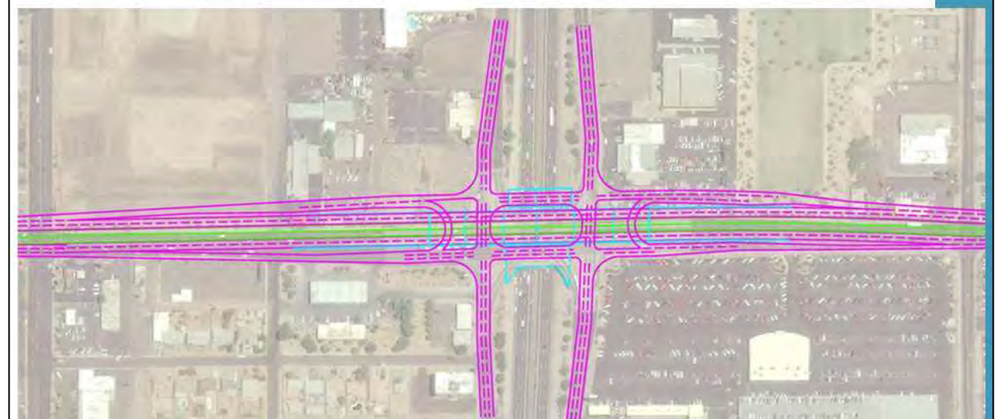
Alternative 3 Platform Diamond with Median LRT



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Alternative 3 Platform Diamond with Median LRT

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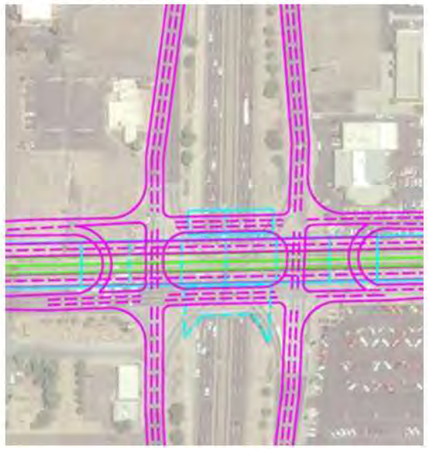
Alternative 3 Platform Diamond with Median LRT



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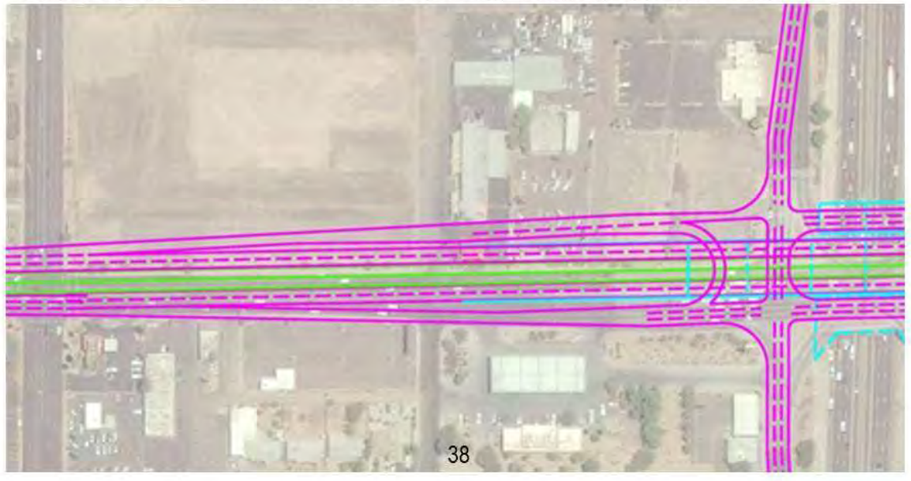
Alternative 3 Platform Diamond with Median LRT



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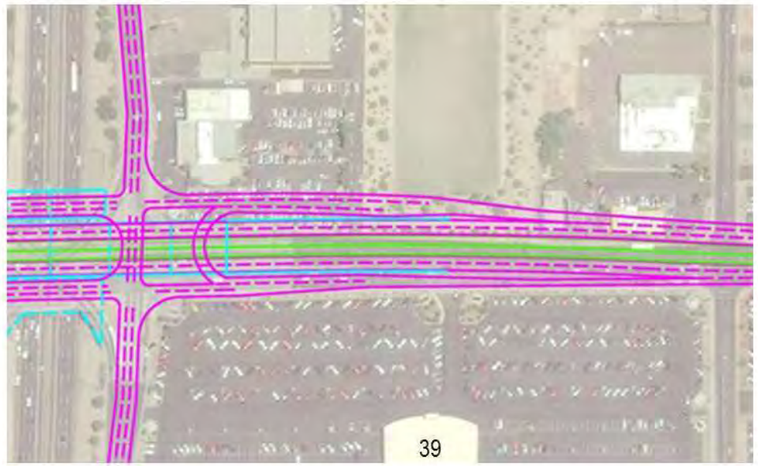
MARICOPA ASSOCIATION of GOVERNMENTS

Alternative 3 Platform Diamond with Median LRT



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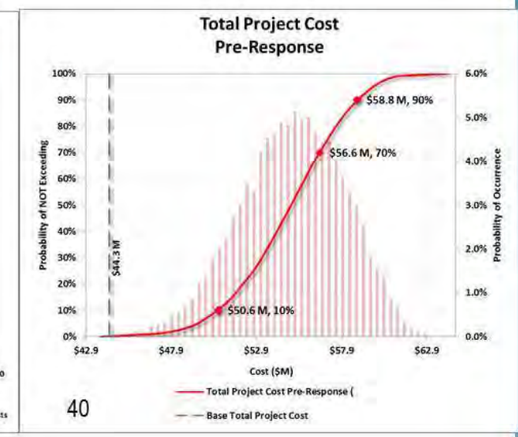
Alternative 3 Platform Diamond with Median LRT



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Alternative 4 - SPUI with Elevated Light Rail Median Running with I-17 Grade Separation north of the existing SPUI bridge

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Alternative 4 - SPUI with Elevated Light Rail Median Running with I-17 Grade Separation north of the existing SPUI bridge

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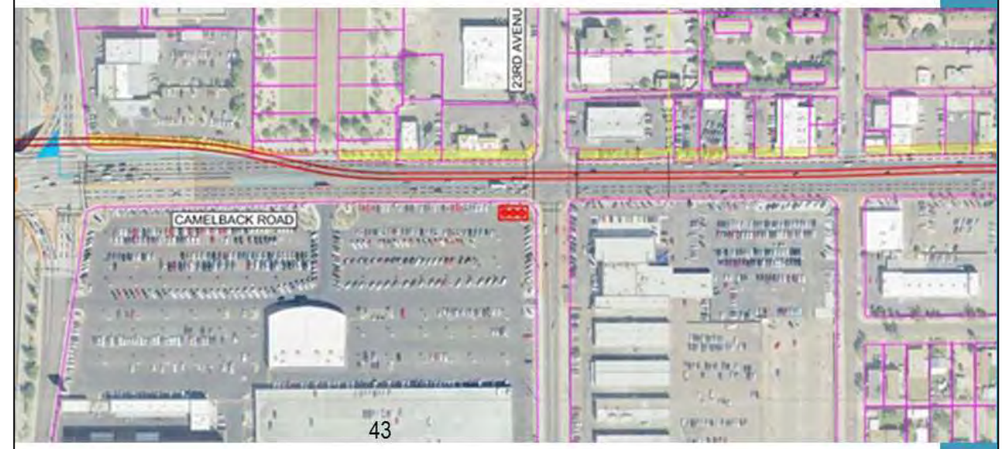
MARICOPA ASSOCIATION of GOVERNMENTS

Alternative 4 - SPUI with Elevated Light Rail Median Running with I-17 Grade Separation north of the existing SPUI bridge



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Alternative 4 - SPUI with Elevated Light Rail Median Running with I-17 Grade Separation north of the existing SPUI bridge

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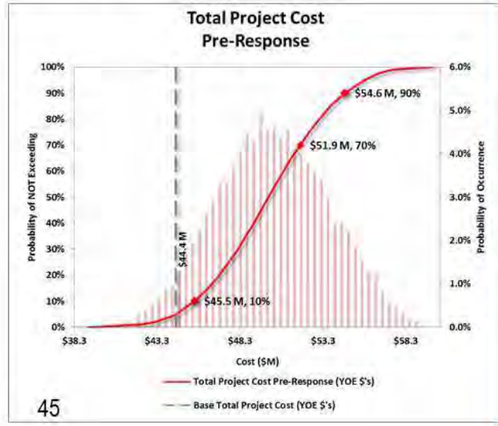
Alternative 4 - SPUI with Elevated Light Rail Median Running with I-17 Grade Separation north of the existing SPUI bridge



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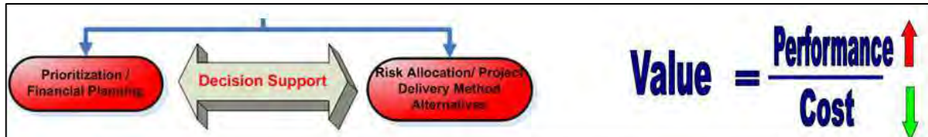

Recommendation Value Improvement				
Value Index				
Recommendations		Performance (P)	Cost (C) $ millions	Value Index
1	SPUI LRT elevated to North	571	$51.2	11.16
2	Tight Diamond LRT Fly Over	662	$64.8	10.22
3	Platform Diamond LRT Fly Over	752	$56.6	13.29
4	SPUI Elevated LRT and Fly Over	638	$51.9	12.29

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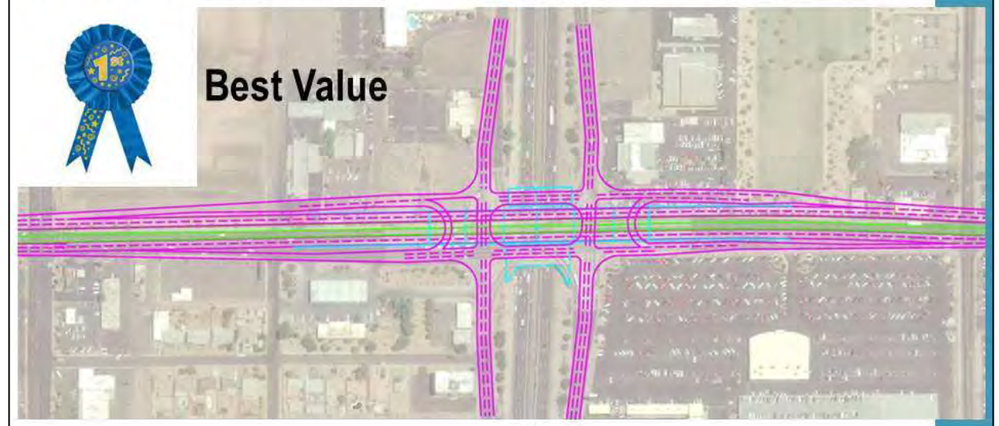
Alternative 3 Platform Diamond with Median LRT



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Alternative 4 - SPUI with Elevated Light Rail Median Running with I-17 Grade Separation north of the existing SPUI bridge

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Performance Based Results

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

Introduction

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

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

The Value Planning Team Leader will lead the Team and external stakeholders through the methodology, using the power of the process to distill subjective thought into an objective language that everyone can relate to and understand. The dialog that develops forms the basis for the Value Planning Teams' understanding of the performance requirements of the project, and to what degree the current design concept is meeting those requirements. From this baseline, the Value Planning Team can focus on developing alternative concepts that will quantify both performance and cost and contribute to overall project value.

Performance based value engineering yields the following benefits:

- Builds consensus among project stakeholders (especially those holding conflicting views)
- Develops a better understanding of a project's goals and objectives
- Develops a baseline understanding of how the project is meeting performance goals and objectives
- Identifies areas where project performance can be improved through the VE process
- Develops a better understanding of a VE recommendation's effect on project performance
- Develops an understanding of the relationship between performance and cost in determining value
- Uses value as the true measurement for the basis of selecting the right project or design concept
- Provides decision makers with a means of comparing costs and performance (i.e., costs vs. benefits) in a way that can assist them in making better decisions

Methodology

Performance based value engineering process consists of the following steps:

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

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

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

Assumptions

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

Step 1 – Determine the Major Performance Attributes

Performance attributes can generally be divided between Project Scope components (Highway Operations, Environmental Impacts, and System Preservation) and Project Delivery components.

It is important to make a distinction between performance attributes and performance requirements. Performance requirements are mandatory. All performance requirements MUST be met by any idea being considered.

Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and construction of a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be Project Schedule which means that a wide range of alternatives, which have different durations, could be acceptable.

The Value Planning Team Leader will initially request that representatives from project Team and external stakeholders identify performance attributes that they feel are essential to meeting

the overall need and purpose of the project. Usually four to seven attributes are selected. It is important that all potential attributes be thoroughly discussed.

The information that comes out of this discussion will be valuable to both the Value Planning Team and the Project Owner. It is important that the attribute be discretely defined, and they must be quantifiable in some form. The vast majority of performance attributes that typically appear in transportation value studies have been standardized. This standardized list can be used "as is" or adopted with minor adjustments as required. Every effort should be made to make the ratings as objective as possible.

Step 2 – Determine the Relative Importance of the Attributes
Once the group has agreed upon the project's performance attributes, the next step is to determine their relative importance. This is accomplished through the use of an evaluative tool, termed in this report as the "Performance Attribute Matrix."

This matrix compares the performance attributes in pairs, asking the question: "An improvement in which attribute will provide the greatest benefit to the project relative to purpose and need?" A letter code (e.g., "a") is entered into the matrix for each pair, identifying which of the two is more important. If a pair of attributes is considered to be of equal importance, both letters (e.g., "a/b") are entered into the appropriate box. This, however, should be discouraged, as it has been found that in practice a tie usually indicates that the pairs have not been adequately discussed.

When all pairs have been discussed, the number of "votes" for each is tallied and percentages (which will be used as weighted multipliers later in the process) are calculated. It is not uncommon for one attribute to not receive any "votes." If this occurs, the attribute is given a token "vote", as it made the list in the first place and should be given some degree of importance.

Step 3 – Establish the Performance "Baseline" for the Original Design
The next step is to define the baseline as it pertains to each performance attribute. The baseline is then given a score of 5 on a scale of 0 to 10 for each attribute.

Step 4 – Evaluate the Performance of the CRAVE Recommendations
Once the performance of the baseline has been established for the original design concept, it can be used to help the Value Planning Team develop performance ratings for individual VE recommendations as they are developed during the course of the value study. The Performance Measures Form at the back of each recommendation is used to capture this information.

It is important to consider the recommendation's impact on the entire project, rather than on discrete components.

Step 5 – Compare the Performance Ratings of Recommendations to the "Baseline" Project

The last step in the process is to develop the performance ratings for the original design concept. The Value Planning Team groups the recommendation into a scenario (or scenarios) to provide the decision makers a clear picture of how the recommendations fit together into possible solutions. At least one scenario is developed to present the Value Planning Team's consensus of what should be implemented. Additional scenarios are developed as necessary to present other combinations to the decision makers that should be considered. The scenario(s) of VE recommendations are rated and compared against the original concept. The performance ratings developed for the VE Scenarios are entered into the matrix and the summary portion of is completed. The summary provides details on net changes to cost, performance, and value, using the following calculations.

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

I-10/West Sky Harbor Access Value Planning Workshop Results

February 13-17, 2017

I-10 West Sky Harbor Access
Value Planning Study

FINAL Report

Prepared for:
Maricopa Association of Governments

Lead Authors:
Ken Smith
Trent Eakin

Prepared By:
HDR Engineering, Inc.

Date:
February 2017

Disclaimer:

The information contained in this report is the professional opinions of the Team members during the Value Planning Study. These opinions were based on the information provided to the Team at the time of this workshop.

As the project continues to develop, new information will become available and this information will need to be evaluated on how it may affect the recommendations and findings in this report. All costs displayed in the report are also based on best available information at the time of the study and are in 2017 dollars unless otherwise noted.

This report was prepared by:

3200 East Camelback Road
Suite 350
Phoenix, AZ 85018

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Executive Summary

Introduction

This Value Planning report summarizes the events of the workshop conducted for the City of Phoenix Aviation Department, the Arizona Department of Transportation, and the Maricopa Association of Governments (MAG), facilitated by HDR Engineering, Inc.

The project under review was the I-10 West Sky Harbor Access project. The workshop was conducted on February 13-17, 2017. The presentation of the Value Planning design alternatives developed during the workshop was held February 17, 2017.

Value Planning Summary

Number of Alternatives: 3

Total Number of Team Members: 32

MAG: 3

City of Phoenix: 11

ADOT: 5

FHWA: 1

Consultants: 12

Facilitator: HDR Engineering, Inc.

The primary objectives of the Team through the application of Value Engineering and Risk Management tools were to:

- Conduct a thorough review and analysis of the key project issues using a multidisciplinary, cross-functional team
- Develop, various concepts for meeting the transportation and access needs in and out of Sky Harbor Airport
- Improve the value of each alternative through innovative measures aimed at improving the performance while reducing costs
- Perform a cost risk analysis on each alternative (access/roadway portion only)

Project Overview

The I-10 West Sky Harbor Access project, as it relates to the focus of this study, is a series of major projects planned to expand the capacity of the Sky Harbor Airport and enhance airport access from the I-10/I-17 corridor, the local roadway system, and the Rental Car Center (RCC); the RCC is now only accessible with the use of shuttles. A number of agencies are involved with the planning and development of these projects including the City of Phoenix, the Arizona Department of Transportation, and the Maricopa Association of Governments, to name a few.

The complexity of the type of projects involved, their impacts to one another, and the goal to limit the adverse impacts to the facility users and reduce as much temporary work as possible requires special planning and coordination between multiple agencies. To accommodate this initiative, a Value Planning/Cost Risk Assessment was commissioned to develop an initial roadmap, or management plan, that defines the goals of each party and documents the information currently available. During this workshop, the team developed preliminary design ideas that are aimed to create solutions and mitigate many of the risks and exploit opportunities found on the program.

The study focused on the following areas surrounding the expansion of the airport and the long term growth plan for the region. These focus areas included:

1. Sky Harbor Airport – Sky Train Expansion and Future Terminal
2. I-10/I-17 Corridor and Sky Harbor Airport access plan
3. Sky Harbor Boulevard/Local arterial route enhancements
4. Rental Car Center access
5. Future land development plans/restrictions
6. Cargo/freight access

The Sky Train project is scheduled to be advertised in late 2017 with construction scheduled to begin in early 2018. The Regional Transportation Plan also has plans for expansion of the freeway corridor, including plans that are aimed to improve airport and rental car facility access, reduce congestion, and enhance the social and economic goals of the region. Additional enhancements include the accommodations for future airport expansion including a new west terminal, a new ground transportation facility (West GTC), major modifications to Sky Harbor Boulevard, and the construction of new taxiways to name a few.

The outcome of the Value Planning workshop is to improve the overall value of the program by analyzing current plans using a cross functional approach, identify project risks, expand risk mitigation strategies, and develop design alternatives the team feels is the best approach to solve the known issues.

Value Planning Study

The workshop included a team of representatives from the agencies involved and was supported by a group of subject matter experts (SME's). The workshop participants, or 'Team' as it will be referred to throughout this report, developed a list of issues at the beginning of the study. This strategy provided the team an opportunity to weigh the issues and determine which issues required the most attention, a process that helped utilize the team's time most effectively. Following the capture of these issues, a brainstorm session was conducted with the team to brainstorm ideas that may reduce the adverse impacts of the issues or even eliminate them altogether. These ideas were then evaluated and a list of advantages and disadvantages were established for each. The team then rated these ideas on a scale of one to five, a process that excludes lower performing ideas the design team already has eliminated or inevitably will eliminate as design progresses. This rating process has the advantage to only move forward the ideas with the best probability of implementation.

With the total number of ideas limited and related ideas grouped into separate categories, the 'team' was divided into three separate teams and a design competition was held. This approach allowed three different teams to all evaluate the project separately and develop their own approach to solve many of the challenges and issues identified. As a result, three separate evaluations were created, each with its own unique approach to developing a preliminary plan the design team may refer to for decision support.

For additional decision support, each alternative went through a preliminary 'Cost Risk Assessment' exercise. This exercise not only included base costs in the analysis, it captured and quantified individual risks and opportunities that may impact each alternative. Both risks and opportunities for each alternative were captured these risks were modeled with the base costs and base schedule. The results of the analysis generated a 'S-curve' for each alternative, a tool that provides managers with a range of costs based on these inputs.

The costs results at the 70th percentile, a programming percentile as recommended by the FHWA, were ultimately used for the denominator of the value equation to help determine which alternative provided the best overall value. Please keep in mind that only the airport access, from both freeways and local roads, and the Rental Car Center (RCC) access portion of the project was considered for the cost analysis, ignoring the sky train, new west terminal, and other airport projects to simplify the analysis. The goal of the alternative development was to continue to focus on access accommodations for these projects, and how future development and programmatic goals may impact other projects planned on and near the airport.

Value Planning Alternatives

Three individual teams at the workshop each evaluated ideas that rated the highest and moved forward for further development. In summary, each team developed their own alternative that may be considered by the design team. While one individual design alternative itself may not be the final solution, the three alternatives will provide a roadmap for the design team to consider and may choose to incorporate elements of more than one alternative.

In addition to rating the ideas, the design alternatives were rated in a team environment using the Value Engineering performance rating criteria, a strategy that resulted in one alternative becoming the design 'winner'. The performance criteria was defined by the project team and used as part of the value equation. This helped determine which alternative provided the best overall value. The three alternatives, their performance score, their CRA modeled cost at the 70th percentile, and their 'Value Index' score (performance/cost) is provided in Table 1.

Table 1: List of Alternatives

Alternatives	Performance	Cost (70th Percentile)	Value Index (Performance/Cost)
Alternative 1	856	$166.7	5.13
Alternative 2	760	$134.0	5.67
Alternative 3	805	$104.5	7.71

Additional information related to each alternative and their write-ups as developed by each team at the workshop may be found in the 'Development Phase' section of this report.

The Value Planning Team wishes to express its appreciation to the project design Team and management for the excellent support they provided during the workshop. It is the Team's expectation that their evaluation of each alternative will assist management with decision support as the program moves forward.

Ken L. Smith, PE, CVS®
Value Planning Team Lead

Introduction

This Value Planning report summarizes the events of the workshop conducted with the City of Phoenix Aviation Department, the Arizona Department of Transportation, and the Maricopa Association of Governments (MAG), facilitated by HDR, Inc. The project under review was the I-10 West Sky Harbor Access project.

Project Description

The I-10 West Sky Harbor Access project is a series of major projects planned to expand the capacity of the Sky Harbor Airport and enhance airport access from the I-10/I-17 corridor, the local roadway system, and the Rental Car Center (RCC). A number of agencies are involved with the planning and development of these projects including but not limited to the City of Phoenix, the Arizona Department of Transportation, and the Maricopa Association of Governments, to name a few.

The study focused on the following areas surrounding the expansion of the airport and the long term growth strategy for the region. These focus areas include:

1. Sky Harbor Airport – Sky Train Expansion and Future Terminal
2. I-10/I-17 Corridor and I-10 West Sky Harbor access plan
3. Sky Harbor Boulevard/Local arterial route enhancements
4. Rental Car Center access
5. Future land development plans/restrictions
6. Cargo/base access accommodations

The Sky Train project is currently scheduled to be advertised later in 2017 with construction scheduled to begin in early 2018. The route for the Sky Train has been established based on the alignment developed by the design team and approved by the aviation department. The Regional Transportation Plan also has plans for expansion of the freeway corridor, including plans that are aimed to improve airport access, reduce congestion, and enhance the social and economic goals of the region. Additional enhancements include the accommodations for future airport expansion plans including a new west terminal, major modifications to Sky Harbor Boulevard, the construction of new taxiways, and enhancements to meet current design standards for safety and multi-modal transportation as much as possible

Scope of the Value Planning Study

The scope of the workshop was to develop alternative concepts for the I-10 West Sky Harbor Access program and develop creative solutions for the design team to consider based on the project's long term goals. The primary objectives of the Team through the application of Value Engineering and Risk Management tools were to:

- Conduct a thorough review and analysis of the key project issues using a multidisciplinary, cross-functional Team;
- Develop various concepts for meeting the transportation needs in and out of Sky Harbor Airport

- Improve the value of each alternative through innovative measures aimed at improving the performance while reducing costs; and,
- Perform a cost risk analysis for each alternative.

Value Planning Study Timing

The timing of the study was based on a conceptual layout for the project. The workshop was held at the City of Phoenix Aviation facilities from February 13-17, 2017. The presentation of the alternative and their preliminary cost risk analysis results was held the afternoon of February 17, 2017.

Value Planning Team Members

The list of Team members who participated in the Value Planning is provided in Table 2. Other attendees and their participation during the workshop are identified on the sign-in sheets provided in the Appendix.

Table 2: Value Planning Team Members

Name	Organization	Position/Discipline
Ken Smith	HDR	Risk/Value Planning Lead
Suresh Raghavendra	HDR	Workshop Assistant
Chaun Hill	MAG	Senior Transportation Engineer
Audra Koester Thomas	MAG	Transit Planning Project Manager
Quinn Castro	MAG	Transportation Engineer
Trent Eakin	HDR	Construction SME/Modeler
Brian Bombardier	HDR	Roadway SME
Jesse Gutierrez	ADOT	Deputy State Engineer
Madhu Reddy	ADOT	District Engineer
Todd Emery	ADOT	
Scott Beck	ADOT	
Trent Kelso	Teek Engineering	
Aryan Lirange	FHWA	Engineer
Eileen Yazzie	City of Phoenix	
Jordan Feld	City of Phoenix	
Sarah Carter	City of Phoenix	
Robyn Sahid	City of Phoenix	
Molly Monserud	City of Phoenix	Project Manager - Planning
Floyd Johnson	City of Phoenix	
Jazmine Hayes	City of Phoenix	
Nicole Swanson	City of Phoenix	
Randall Payne	City of Phoenix	
Carl Siebe	HDR	Senior Aviation Consultant
Scott Sikel	HDR	Aviation
Jessica Wyatt	HNTB	
Nate Walnum	Kimley Horn	

Table 2: Value Planning Team Members		
Name	**Organization**	**Position/Discipline**
Kim Carrol	Kimley Horn	Traffic
John Kissinger	Kimley Horn	Traffic/ITS
Mark Pilwallis	Gannett Fleming	
Reed Henry	ADOT	Roadway Engineer
Curtis Richardson	City of Phoenix	
Mark Milstone	City of Phoenix	CE III

Figure 1: Value Planning Teams

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Information Phase

The workshop began with a presentation of the planned and proposed projects from the planning managers and project representatives. Projects include the long term plan for the Sky Harbor Airport including terminal modernizations and a new ground transportation facility, Sky Train expansion, Rental Car Center access, I-10/I-17 corridor connections and enhancements, and local roadway accommodations. This allowed the team to capture the overall concept and utilize the value engineering methodology combined with risk management tools to evaluate the constraints and develop alternatives to accommodate future development and reduce throw away work.

Figure 2 below provides an illustration of the proposed West Ground Transportation facility just to the west of I-10 and directly adjacent to 24th Street. The team recognized the complexities of the improvements to the airport in addition to how access was going to be improved to the interstate system, local roadways, the rental car center, and cargo and freight operations currently located on adjacent to airport property.

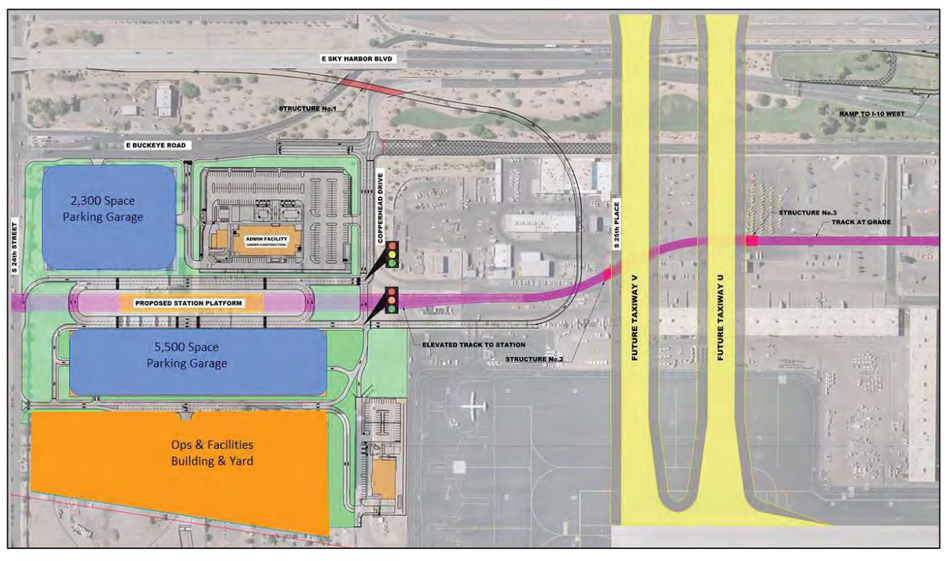


Figure 2: West GTC Long Term Concept

Summary of Analysis

The following analysis tools were used to study the project:

- Constraints and Controlling Decisions
- Investigation Observations - 'Project Issues List'
- Project Schedule Review
- Performance Attributes

- Performance Attribute Matrix
- Creative Idea Development
- Evaluation of Ideas
- Alternative Development
- Performance Based Results – Value Index
- Cost Risk Assessment

Constraints and Controlling Factors

As part of the project briefing, the Value Planning Team was given the following project constraints and controlling factors when considering alternatives:

- The Sky Train alignment from the terminals to the Rental Car Center has already been established and may not be altered
- The roadway crossover (traffic switch for vehicles entering from the west side of the airport) for Sky Harbor Boulevard will need to occur to the west of the new airport taxiways (Taxiways U & V)
- The FAA regulates both the zones above the airport but also on the ground at the ends of each runway, otherwise known as runway protection zones (RPZ's)

Investigation Observations

The first day of the workshop included a presentation from the Project Team. The following summarizes key project drivers, observations, and considerations identified during this session. Table 3 presents a list of project issues identified by the Value Planning Team and the number of participants who identified the issue.

Table 3: Project Issues

Description	No. of Participants Identifying the Issue
Interactions with highway DOT changes and west access	11
Circuitous route from west GTC	10
Cargo growth and accommodations	5
Access/egress to rental car center/terminals	5
Multi-modal - explore all aspects and types	5
Airport security changes - cut through traffic	3
Technological changes - autonomous vehicles/ride share	3
Phasing plan (financial)	3
Access to and from I-10	3
Growth on east and west may impact traffic	2
Changing security requirements during design	2
All modes of traffic (complete streets)	2
Changes to interchange (I-10/I-17) and conflicts with Airport layout	2

Table 3: Project Issues	
Description	**No. of Participants Identifying the Issue**
No I-10 backups eastbound	2
Construction phasing	2
Access prioritization	2
24th street goal conflicts	2
Cul-de-sac airport - one way in/out	1
24th street running through RPZ	1
Accommodating airport support facilities	1
Terminal 2 access and egress	1
Growth of employment at Sky Harbor Center	1
Airline growth	1
Parking to terminal access and accommodations	1
Directional signing/construction impacts	1
Entry/exit plazas	1
Airspace protection	1
Transit access and safety	1
Balance between airport accommodations and I-10	1
Potential development and growth in land use area west of 16th street	1
Conflicts between goals	1
ITS	1
Land use changes west of I-10 and traffic growth - new interchange?	1
West GTC access and impacts	1
Extension of Sky Train to Central Ave?	1

Project Schedule Review

A preliminary schedule was developed to provide a date range for known project activities and milestones including terminal modernizations, West Ground Transportation facility construction, the Sky Train, taxiways, and roadway construction. These activities are then cost loaded to allow the risks to impact a specific activity that will either lengthen or reduce the baseline schedule. This provides a more reasonable cost outcome based on risk impacts that also carry schedule impacts.

The preliminary schedule was reviewed by the entire Team and updated as necessary throughout the workshop. To simplify the analysis, only the roadway access portion of the project was used in the cost risk assessment model (highlighted in yellow in Table 4 below) as these activities are shaped by the scheduled major airport activities and are the activities with

the most risk but also hold the potential for the most opportunity; better timing for road projects that accommodate the opening of the west GTC for example.

Table 4 shows major activities for the program and their estimated start and end dates. Please see the Appendix for the flowchart activity diagram for an illustration of the project schedule and their relationship to succeeding activities, where applicable.

Table 4: Project Activity Ultimate Baseline Schedule			
Activity ID	**Activity Name**	**Start Date**	**End Date**
101	Sky Train/West GTC Design	1/1/2017	1/1/2018
105	Sky Train/West GTC Construction	1/1/2018	12/1/2021
108	Sky Trains Systems Const. & Testing	12/1/2020	12/1/2021
110	T2/T3 Modernization	3/1/2019	3/1/2020
120	West Terminal & Roadways	6/1/2024	6/1/2026
200	Taxiway Construction – U & V	1/1/2023	1/1/2024
210	Roadway – Sky Harbor Boulevard	1/1/2023	1/1/2024
220	Air Cargo	1/1/2023	1/1/2024
300	Roadway Design	4/1/2019	4/1/2022
305	Environmental	4/1/2021	4/1/2022
310	Right of Way	4/1/2021	4/1/2022
315	Ad-Bid-Award	4/1/2022	7/1/2022
320	Roadway/Highway Construction	7/1/2022	12/31/2024

Performance Attributes

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

Performance attributes can generally be divided between project scope components (roadway operations, transit operations, etc.) and project delivery components (construction impacts, environmental impacts, etc.). It is important to make a distinction between performance attributes and performance requirements. Performance requirements are mandatory and binary in nature. All performance requirements **must** be met by any Value Planning alternative being considered.

Performance attributes possess a range of acceptable levels of performance. For example, if the project was to design and construct a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be project schedule, which means that a wide range of alternatives that have different durations could be acceptable.

The Value Planning Team, along with the Project Team, identified and defined the performance attributes for this project. The performance attributes shown in Table 5 were used throughout the study to identify, evaluate, and develop ideas and alternatives.

Table 5: Performance Attributes		
Evaluative Criteria		
Performance Attribute	**Description**	**Comments**
Freeway Operations	An assessment of capacity, access, and safety on I-10, I-17, SR-143, and SR-202L. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, and lane and shoulder widths.	Currently, I-10 half diamond to the south and direct access between the north and the east. 44th St, SR-202L and SR-143 current access point to the airport. Frontage road between Jefferson and Sky Harbor Circle.
Airport Operations	An assessment of airport airside and landside operations and safety. Operational metrics include airspace protection and landside movements.	Access to airport facilities. Ability to accommodate the growth of passengers (20 million more in 20 years); currently, 44 million. Current bus service into terminal 2; this will truncate at west GTC when Sky Train Phase 2 opens. Freight operations within the airport. Security within the Sky Harbor airport.
Maintainability	An assessment of the long-term maintainability of the facilities. Maintenance considerations include the overall durability, longevity, and maintainability of structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel, including sediment and debris removal.	Pavements, structures, storm drainage, access to ITS and utilities, landscaping
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to existing utilities; impacts to businesses and residents relative to access, visual effects, noise, vibration, dust, and construction traffic; environmental impacts.	Construction access of laydown areas for various projects.
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e., flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts; impacts to shore edge; impacts to cultural, recreational and historic resources.	Conditional environmental approvals on the airport projects. For airport-roadway projects, environmental process has not started. Separate environmental documents for airport and airport-roadway projects.

Table 5: Performance Attributes		
Evaluative Criteria		
Performance Attribute	**Description**	**Comments**
Promotes Economic Growth	An assessment how the alternative assists in promoting growth and airport oriented development.	Protecting the future plans for growth outside of the airport properties.
Security	Ability to screen the vehicles entering the airport core. Ability to quickly change with regulation change. Considerations of how to protect critical facilities such as sky train and control center.	Currently, there is no method in place to screen the vehicles. Temp plans are in place; enhancements could be permanent.
Local Roadway Operations	Sky Harbor Boulevard, Sky Harbor Circle, 44th Street, 24th Street, Old Town Road, and Buckeye Road	24th Street must stay open as an airport access. Light rail station at 44th St and Washington. Planned BRT and bike lanes on 24th St and existing bus service.

Performance Attribute Matrix

A matrix was used to determine the relative importance of the individual performance attributes for the project. The Project and Value Planning Teams evaluated the relative importance of the performance attributes that would be used to evaluate the creative ideas.

These attributes were compared in pairs, asking the question: "Which one is more important to the purpose and need of the project?" The letter code (e.g., "A") was entered into the matrix for each pair. After all pairs were discussed they were tallied (after normalizing the scores by adding a point to each attribute) and the percentages calculated.

Table 6: Performance Attributes Criteria Matrix

Paired Comparison									Total Points	% of Total
Freeway Operations	A	A/B	A	A	A	A	A	A	7.5	20.8%
Airport Operations		B	B	B	B	B	G	B	6.5	18.0%
Maintainability			C	C/D	C	F	G	H	2.5	6.9%
Construction Impacts				D	D/E	F	G	H	2.0	5.5%
Environmental Impacts					E	F	G	H	1.5	4.1%
Promotes Economic Growth						F	G	F/H	4.5	12.5%
Security							G	G	7.0	19.8%
Local Roadway Operations								H	4.5	12.5%
								Total	36.0	100%

The performance attribute criteria matrix exercise resulted in the following order of precedence during the workshop.

1. Freeway Operations
2. Security
3. Airport Operations
4. Promote Economic Growth
5. Local Roadway Operations
6. Maintainability
7. Construction Impacts
8. Environmental Impacts

These results are then carried forward and are used in the establishment of a performance score for each of the alternatives. These were ranked to allow the team to rate the alternatives based on their impacts, either adversely or positively, to the performance attributes and how they compare with current concepts, how they accommodate future development, and how they compare to the other alternatives that were developed.

Creative Phase

The Value Planning Team held a brainstorm session following the development of the issue list as a method to develop ideas that may reduce the impacts or resolve many of these identified issues. The ideas were based on the available information given at the time of the study and do not necessarily solve all issues that may be encountered in the future.

The focus of the brainstorm session is not to evaluate any ideas during this process, but only to come up with a list of potential ideas that will be assessed in the next step of the workshop, the evaluation phase.

The list of ideas are categorized by options for I-10, Buckeye, 24th Street, Sky Harbor Circle, Sky Harbor Circle, Sky Harbor Boulevard (reduce cut through traffic), and 'Other'. Similarities may be evident with some ideas in separate categories and these ideas may be combined into one design alternative based on the results of the evaluation.

I-10 Options

1. Braid Sky Harbor Circle north ramps with Jefferson south side ramps
2. Reverse ramps between Sky Harbor Circle north and south
3. Rebuild I-10 and Buckeye interchange as 2-level diamond style interchange
4. Rebuild I-10 and Buckeye interchange as 3-level platform diamond or SPUI interchange
5. Rebuild I-10 and Buckeye interchange as 3-level DDI
6. CD roads along I-10 from SR-51 to I-17
7. Add ramp braids to reduce weaves on I-10 mainline
8. Use Copperhead Road to access I-10 WB
9. West GTC over 24th Street on ramp I-10 WB (Sketch 1)
10. Flyover ramps from I-10 to RCC
11. Add aux lanes on I-10 EB between SR-51 and Sky Harbor Circle
12. Realign I-10 along the 16th Street alignment

Buckeye Road Options

13. Grade separate 24th Street and Buckeye Road
14. Reconfigure Buckeye Road and Sky Harbor Circle intersection to favor west to south movement
15. Grade separate Buckeye Road and Sky Harbor Circle intersection
16. Roundabout at Buckeye Road and Sky Harbor Circle
17. Continuous Flow Interchange (CFI) at Buckeye Road and Sky Harbor Circle
18. Terminate Buckeye Road at Sky Harbor Circle
19. Make Buckeye Road and Sky Harbor Boulevard one-way (couplet terminating at a SPUI)
20. Realign Sky Train to Buckeye Road
21. Half DDI at Buckeye Road

24th Street Options

22. Move Sky Train to north of WGTC and combine the Sky Train trench with Sky Harbor Boulevard trench under U&V taxiways
23. Depress 24th Street within the proximity of Buckeye Road

24. 24th Street split south of Jefferson and run as I-10 Frontage Road (moves outside of RPZ's); Maintain the existing 24th Street for bike/pedestrians
25. Restrict use of 24th Street to bike/ped and transit (BRT), and limit direct airport access
26. Slip ramp from I-17 SB to I-10 WB directional ramp to 24th Street
27. Convert 24th into Sky Harbor Circle; add a grade separation at Buckeye; and restrict access on 24th Street to ped/bike between SHC north and south

Sky Harbor Circle Options

28. Complete the SHC loop on the east of I-10 (integrate with the reverse ramps concept and keep Sky Train on the outside of the loop) (integrate with the terminate Buckeye concept)

Deter Cut-Through Traffic Options

29. Tolling
30. Roundabouts
31. Signalized intersections
32. Photo Enforcement
33. East and west Cul-de-sac
34. Cul-de-sac the east end
35. Reduced speed limit (15 mph)
36. ITS (mandatory inspection)
37. Random inspections
38. Modify SR-202L access at Priest Drive

Other Options

39. ITS for travel times using different airport access
40. Managed Lanes through airport core

Evaluation Phase

Although each project is different, the evaluation process for each Value Planning effort can be thought of in its simplest form as a way of combining, evaluating, and narrowing ideas until the team agrees on the ideas to be forwarded to the development phase.

Taking into consideration the constraints and controlling decisions, the team discussed each idea and documented the advantages and disadvantages compared to the existing facility and the criteria to meet the needs of future development.

Each idea was then carefully evaluated with the Team reaching consensus on the overall rating of the idea (zero through five). High-rated ideas (four or higher) were developed further; those that were considered to be equivalent to the baseline (rated three) were documented as design considerations; and low-rated ones (two or lower) were dropped from further consideration; however, the team provided a short description and justification to support the low rating. The rating values are shown below:

5 = Great Opportunity
4 = Good Opportunity
3 = Design Consideration (comparable to project team's approach)
2 = Minor Value Degradation
1 = Major Value Degradation
0 = Fatal Flaw (unacceptable impact or doesn't meet the project purpose and need)

= Advanced as recommendation

= Forwarded as design consideration

= Dropped from future consideration

As the workshop evolved, three additional categories were added to the evaluation table to allow the team to also consider three major elements important to the program. These three categories are Airport Access, Rental Car Center Access, and Freight Access. The addition of these categories allowed the team to consider if the idea positively or adversely affected the function of important program goals. Evaluation of the ideas is categorized in the same manner as the creative list; I-10, Buckeye, 24th Street, Sky Harbor Circle, Sky Harbor Boulevard cut through reduction, and 'Other'.

I-10 Options

#	Description	Advantages	Disadvantages
1	Braid Sky Harbor Circle north ramps with Jefferson south side ramps	▪ Avoids RCC traffic going across the Light Rail ▪ Current ramps backup; this idea could improve freeway operations ▪ Could improve access to RCC	▪ Adding another set of ramps could impede freeway operations

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍👎							👍

Airport Access		RCC Access	👍	Freight Access	

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
2	Reverse ramps between Sky Harbor Circle north and south	▪ Simplifies RCC signing ▪ Could reduce east to west cut-through traffic ▪ Could reduce weaves on I-10 ▪ Improves private economic growth ▪ All access on Buckeye providing area for vehicle screening	▪ Eliminates the interchange at Buckeye ▪ Circuitous route to airport from I-10 ▪ Impacts to existing signal at Buckeye ▪ Hinders airport economic growth

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍👎	👎				👍👎	👍	👎

Airport Access	👎	RCC Access	👍	Freight Access	👍

Cost:	*Justification/Comments: Maybe combined with the CD road idea.*
Rating: 1	

#	Description	Advantages	Disadvantages
3	Rebuild I-10 and Buckeye interchange as 2-level diamond style interchange	▪ Full access interchange ▪ Single point of access to RCC for all directions ▪ Relatively easy modification without affecting the mainline ▪ Low cost	▪ Could slowdown RCC access – SHC/Buckeye intersection operations could breakdown ▪ Risk of potential backup on to mainline

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👎	👎						

Airport Access		RCC Access		Freight Access	
	👍		👍		👍

Cost:	*Justification/Comments: Could be improved with a third level S-E flyover. May require braiding of ramps. Consider variations of Buckeye and 24th St intersection.*
Rating: 3.5	

#	Description	Advantages	Disadvantages
4	Rebuild I-10 and Buckeye interchange as 3-level platform diamond or SPUI interchange	▪ Higher capacity ▪ Full access ▪ Promotes economic growth	▪ Additional signals on Buckeye ▪ Eliminates free flowing movements ▪ Encourage cut-through traffic ▪ Height and depth constraints ▪ Traffic control – close Buckeye

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍👎		👎	👎		👍		👍

Airport Access		RCC Access		Freight Access	
	👍		👍		

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
5	Rebuild I-10 and Buckeye interchange as 3-level DDI	▪ Higher capacity ▪ Full access ▪ Promotes economic growth ▪ Provides more free flow movements	▪ Encourage cut-through traffic ▪ Height and depth constraints ▪ Traffic control – close Buckeye ▪ Connection with 24th Street

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍		👎	👎		👍		👍

Airport Access		RCC Access		Freight Access	
	👍		👍		

Cost:	*Justification/Comments: Half DDI could accommodate the crossover required by the airport.*
Rating: 2	

#	Description	Advantages	Disadvantages
6	CD roads along I-10 from SR-51 to I-17	▪ Cleans up I-10 operations ▪ Eliminates high-speed weaves	▪ Could be costly ▪ Signing can be challenging

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍							

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
7	Add ramp braids to reduce weaves on I-10 mainline	▪ Eliminates weaves	▪ Cost ▪ Profiles ▪ ROW

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍				👎			

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other ideas.*
Rating: 3	

#	Description	Advantages	Disadvantages
8	Use Copperhead Road to access I-10 WB	▪ Utilizes old 24th Street separation	▪ Conflicting movement with Buckeye traffic

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍👎						👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other ideas.*
Rating: 3	

#	Description	Advantages	Disadvantages
9	West GTC over 24th Street on ramp I-10 WB (Sketch 1)	▪ One access to airport from I-10 ▪ Consistent with existing plans for airport improvements ▪ Eliminates weaves on I-10	▪ Cost ▪ Potential impacts to the SW corner of Buckeye and 24th Street ▪ Circuitous route from EB Buckeye to I-10 WB

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍	👍					👍	👍

Airport Access	👍	RCC Access	👍	Freight Access	👍

Cost:	*Justification/Comments: Moved forward to further development.*
Rating: 5	

#	Description	Advantages	Disadvantages
10	Flyover ramps from I-10 to RCC	▪ Easy access to/from RCC	▪ Potential vertical clearance issues with OEI's ▪ Cost ▪ Introduces additional weaves on I-10

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👎	👎						

Airport Access		RCC Access	👍	Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 1	

#	Description	Advantages	Disadvantages
11	Add aux lanes on I-10 EB between SR-51 and Sky Harbor Circle	▪ Potentially improves operations on I-10	▪ May add additional weaves

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍👎							

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other ideas.*
Rating: 3	

#	Description	Advantages	Disadvantages
12	Realign I-10 along the 16th Street alignment	▪ Provides more space for the airport	▪ Cost ▪ Community impacts ▪ Delays the projects

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍			👎			

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 0.5	

Buckeye Road Options

#	Description	Advantages	Disadvantages
13	Grade separate 24th Street and Buckeye Road	▪ Eliminates at-grade intersection ▪ May eliminate potential conflicts of signal adjacent to I-10	▪ Eliminates turning movements from Buckeye and 24th Street and vice versa ▪ May have considerable utility impacts

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍	👎						👍👎

Airport Access		RCC Access		Freight Access	
	👎				

Cost:	Justification/Comments: Must be combined with other options for airport access from 24th Street.
Rating: 3	

#	Description	Advantages	Disadvantages
14	Reconfigure Buckeye Road and Sky Harbor Circle intersection to favor west to south movement	▪ Improves access from Sky Harbor Circle ▪ Could discourage Buckeye through traffic through airport	▪ Buckeye continuity is disrupted ▪ May disrupt future airport and land use plans

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍				👎		👎

Airport Access		RCC Access		Freight Access	

Cost:	Justification/Comments: Dropped from further consideration.
Rating: 2	

#	Description	Advantages	Disadvantages
15	Grade separate Buckeye Road and Sky Harbor Circle intersection	▪ Reduces signal phases; increase intersection capacity; reduces delay; improves operations	▪ Cost ▪ Adjacent land access could be impacted

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
					👎		👍

Airport Access		RCC Access		Freight Access	

Cost:	Justification/Comments: Could be combined with other options. Could also make the intersection a roundabout under the bridge.
Rating: 3	

#	Description	Advantages	Disadvantages
16	Roundabout at Buckeye Road and Sky Harbor Circle	▪ Eliminates left turns	▪ Driver unfamiliarity with multilane roundabouts ▪ High volume multilane

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍						👍👎

Airport Access		RCC Access		Freight Access	

Cost:	Justification/Comments: Dropped from further consideration.
Rating: 1.5	

#	Description	Advantages	Disadvantages
17	CFI at Buckeye Road and Sky Harbor Circle	▪ Reduces delay ▪ Increases capacity	▪ Drive expectancy ▪ Additional ROW ▪ Reduces access to adjacent land

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
				👎	👎		👍👎

Airport Access		RCC Access		Freight Access	

Cost:	Justification/Comments: Dropped from further consideration.
Rating: 1	

#	Description	Advantages	Disadvantages
18	Terminate Buckeye Road at Sky Harbor Circle	▪ Minimizes cut-through traffic ▪ Eliminates traffic in the vicinity of I-10 interchange	▪ Eliminates direct access to airport from Buckeye ▪ Complicates local business access between I-10 and Sky Harbor Circle

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍					👎		👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 0.5	

#	Description	Advantages	Disadvantages
19	Make Buckeye Road and Sky Harbor Boulevard one-way (couplet terminating at a SPUI)	▪ Lines up with the airport's plan for Sky Harbor Boulevard	▪ Need to address 24th Street ▪ Crossings under the cross taxiways

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍👎						

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other options.*
Rating: 3	

#	Description	Advantages	Disadvantages
20	Realign Sky Train to Buckeye Road		▪ Constrains access to I-10 from Buckeye ▪ Eliminates access to properties on the south side of Buckeye ▪ May add another level to the interchange ▪ Drainage conflicts ▪ Inconsistent with the interchange at Buckeye

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍	👎		👎		👎		👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other options.*
Rating: 1	

#	Description	Advantages	Disadvantages
21	Half DDI at Buckeye Road	▪ Eliminates the crossover on airport property	▪ Requires additional road network to access WGTC

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍						👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other ideas. Requires modifications to 24th Street, Sky Harbor Boulevard, and the I-10 interchange.*
Rating: 3	

24th Street Options

#	Description	Advantages	Disadvantages
22	Move Sky Train to north of WGTC and combine the Sky Train trench or Sky Harbor Boulevard roadway trenches under U&V taxiways to minimize bridge area	▪ Reduces structure required over roadways when the taxiways are built	▪ Constructability

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
			👍👎				

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Must be combined with other ideas.*
Rating: 2.5	

#	Description	Advantages	Disadvantages
23	Depress 24th Street within the proximity of Buckeye Road	▪ Eliminates at-grade intersection ▪ May eliminate potential conflicts of signal adjacent to I-10 ▪ Reduces the fill heights of Sky Harbor Boulevard crossing 24th Street	▪ Eliminates turning movements from Buckeye and 24th Street and vice versa ▪ May have considerable utility impacts

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
👍			👍👎				👍👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
24	24th Street split south of Jefferson and run as I-10 Frontage Road (moves outside of RPZ's); Maintain the existing 24th Street for bike/ped		▪ May require a railway crossing ▪ Requires an additional roadway bridge ▪ Cost ▪ Significant property impacts ▪ Could impact freight operations on the south side

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
					👎		

Airport Access		RCC Access		Freight Access	👎

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 1	

#	Description	Advantages	Disadvantages
25	Restrict use of 24th Street to bike/ped and transit (BRT), and limit direct airport access		▪ Discontinuity of a major north-south movement ▪ Freight access

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
							👍

Airport Access		RCC Access		Freight Access	👎

Cost:	*Justification/Comments: Maybe combined with other options that provide continuity north-south.*
Rating: 1.5	

#	Description	Advantages	Disadvantages
26	Slip ramp from I-17 SB to I-10 WB directional ramp to 24th Street		▪ RPZ challenges ▪ Geometry

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👎					👎	

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 1	

#	Description	Advantages	Disadvantages
27	Convert 24th Street into Sky Harbor Circle; add a grade separation at Buckeye; and restrict access on 24th Street to ped/bike between Sky Harbor Circle north and south	▪ Reduced travel time on 24th Street due to reduced signals ▪ Encourages economic development west of I-10 ▪ Improves RPZ condition ▪ Eliminates the at-grade intersection of Buckeye and 24th Street ▪ Eliminates the grade separation required for 24th Street and Sky Harbor Boulevard ▪ Improves intersection of Buckeye and Sky Harbor Circle	▪ May change access in the vicinity of Buckeye and Sky Harbor Circle

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
					👍	👍	👍👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Could be combined with other interchange solutions.*
Rating: 4	

Sky Harbor Circle Options

#	Description	Advantages	Disadvantages
28	Complete the Sky Harbor Circle loop on the east of I-10 (integrate with the reverse ramps concept and keep Sky Train on the outside of the loop) (integrate with the terminate Buckeye Road concept)	▪ Discourage cut-through traffic	▪ Circuitous airport access ▪ Forces some freight traffic with airport-destination traffic

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👎				👍👎		

Airport Access		RCC Access		Freight Access	
	👎		👍		👎

Cost:	*Justification/Comments: Must be integrated with the reverse ramps concept.*
Rating: 1.5	

Deter Cut-Through Traffic Options

#	Description	Advantages	Disadvantages
29	Tolling	▪ Reduces cut-through traffic	▪ Perception issues ▪ Implementation

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍						

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Could be considered as a peak hour solution.*
Rating: 4	

#	Description	Advantages	Disadvantages
30	Roundabouts	▪ Reduces cut-through traffic	▪ Driver expectancy ▪ Reverse flow fatal flaws this idea

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👎						👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 0	

#	Description	Advantages	Disadvantages
31	Signalized intersections		

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: No intersection available to signalize.*
Rating: 0	

#	Description	Advantages	Disadvantages
32	Photo Enforcement	▪ Reduces speed	▪ May require a law to support this

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍						

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 1.5	

#	Description	Advantages	Disadvantages
33	East and west Cul-de-sac of Sky Harbor Boulevard	▪ Eliminates pass-through traffic	▪ Requires redundant roadways

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍						👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 0.5	

#	Description	Advantages	Disadvantages
34	Cul-de-sac the east end only	▪ Reduces pass-through traffic	▪ Requires redundant roadways

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍						👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 0.5	

#	Description	Advantages	Disadvantages
35	Reduced speed limit (15 mph)	▪ Ease of implementation	▪ Requires enforcement ▪ May reduce airport operation

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👎						

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Combine with photo enforcement. Consider variable speed limit.*
Rating: 3	

#	Description	Advantages	Disadvantages
36.	ITS (mandatory inspection)	▪ Could enhance security	▪ Enforcement

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
						👍	

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Dropped from further consideration.*
Rating: 2.5	

#	Description	Advantages	Disadvantages
37	Random inspections	▪ May deter pass-through traffic	▪ Cost

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍					👍	👎

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Design Consideration*
Rating: 3	

#	Description	Advantages	Disadvantages
38	Modify SR-202L access at Priest Drive		▪ Addresses only a small amount of EB pass-through

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Does not address all pass-through traffic and outside of the purview of this study.*
Rating: 1	

Other Options

#	Description	Advantages	Disadvantages
39	ITS for travel times using different airport access	▪ Informs drivers	▪ Could increase pass-through

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👎						

Airport Access	👍	RCC Access		Freight Access	

Cost:	*Justification/Comments: This is ADOT's current practice for the interstates.*
Rating: 2.5	

#	Description	Advantages	Disadvantages
40	Managed Lanes through airport core (lane control)	▪ Allows reconfiguring lanes ▪ May reduce cut-through traffic	▪ Can create congestion ▪ Airport operations

Freeway Operations	Airport Operations	Maintainability	Construction Impacts	Environmental Impacts	Promotes Economic Growth	Security	Local Roadway Operations
	👍👎						

Airport Access		RCC Access		Freight Access	

Cost:	*Justification/Comments: Maybe better served with variable speed limit or other concepts.*
Rating: 2	

Development Phase

In order to develop combined solutions, a design competition was organized to create a competitive environment where the best ideas with the greatest value were moved forward.

The Value Planning Team was divided into three separate groups with the goal to include a design expert from each division; aviation, roadway, structures, construction, etc. Each group was tasked with identifying the best ideas from the evaluation phase and incorporating these ideas into their alternative write-ups. Design considerations, those ideas rated a three or above, were also incorporated where appropriate.

The end result was the development of three separate write-ups with their own unique approach to solve many of the issues the program faces. Each write up from the teams, a preliminary estimate, and a preliminary design concept with graphics and assumptions is provided in the 'Development Phase' section of this report.

To help achieve consistency in the design competition, the groups were given the following directions and assumptions:

1. The Sky Train alignment from the terminals to the Rental Car Center has already been established and may not be altered
2. The roadway crossover (traffic switch for vehicles entering from the west side of the airport) for Sky Harbor Boulevard will need to occur to the west of the new airport taxiways (Taxiways U & V)
3. The FAA regulates both the zones above the airport but also on the ground at the ends of each runway, otherwise known as runway protection zones (RPZ's)
4. Focus on the ideas that will bring a solution to the highest rated performance attributes established at the beginning of the workshop

A unique solution was developed by each of the three teams and is documented in the following section. Surprisingly, you will find that each team had a different approach to accommodate program objectives. The result was a value rating process that opened up a constructive dialogue to determine which alternative would become the design 'winner'. Even though one alternative ranked higher using the value performance rating system than the other two alternatives, it does not mean the design team will choose to implement only one alternative. They may wish to incorporate ideas from multiple alternatives into the design as the program advances. Please refer to the 'Value Planning Approach' and 'Performance Based Results' section in the appendix for additional detail related to the value planning performance rating system and how it was applied in this workshop.

Each alternative consists of a description of the alternative, a listing of its advantages and disadvantages, and a brief narrative that includes justification, sketches, photos, assumptions and calculations (where applicable) as developed by the Team. It is to be noted that the cost of the alternative is only the blended cost of the access or roadway portion of the project where the cutoff or hold point was to the west of Copperhead Drive. Terminal modernization costs, Sky

Train, taxiway, Sky Harbor Boulevard (east of Copperhead Drive), and other airport improvements are not included in the cost of the analysis.

The Value Planning Alternatives are presented as written by the groups during the workshop. While they have been edited in the report to correct errors or better clarify the alternative, they represent the each team's recommendation as developed and reviewed by the teams during the study.

	Alternative No. 1 Diamond TI with SE Fly Over	Idea #'s 1, 4, 7, 11, 13, 19, 23, 20, 32, 36, 37, 40

Recommendation:

Provides full access TI at I-10 and Buckeye, provides simple east/west Buckeye operations in/out of the airport, provide security check point, provides direct access to WGTC from I-10, provides full access to RCC to/from I-10 and I-17 via Buckeye TI, and eliminated weave sections on all four quadrants of I-10/Buckeye Road TI.

Advantages:

- Full access to/from Sky Harbor and RCC at the Buckeye Road TI
- Fully driver expectant, and easy to sign/wayfind.
- Operationally provides continuous east/west flow on Buckeye Road between downtown and airport
- Long Term solution for I-10 access to Sky Harbor and WGTC
- Additional access for Freight from I-10 and Buckeye to Sky Harbor Cir to 24th St.
- Security Check Point to screen prior to crossing under the taxiways.
- Fix weave on I-10 between Jefferson and Buckeye
- Fix weave on I-10 between I-17 and Buckeye
- Consistent with airport plans for Sky Train to/from RCC
- Removes at grade crossing of light rail for all airport users.

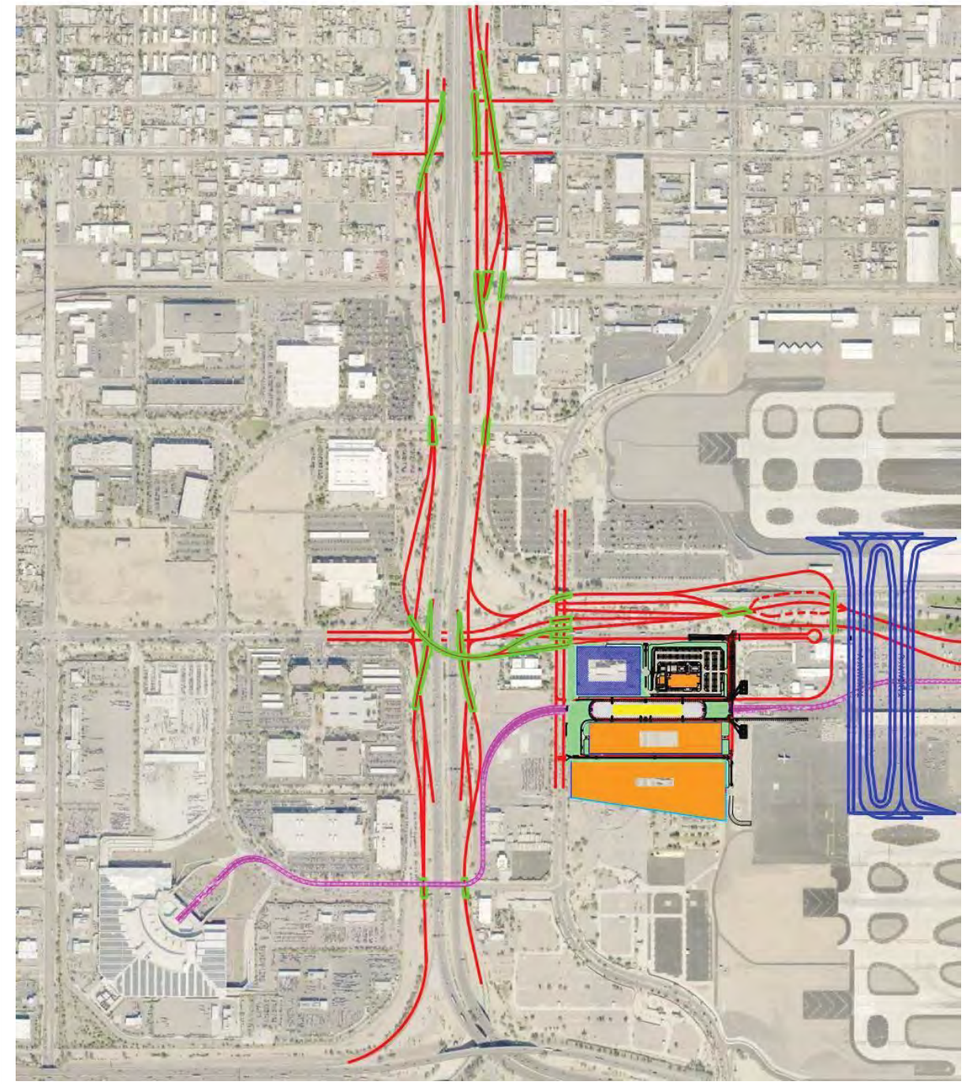
Disadvantages

- Does not deter cut through traffic, and could make it worse.
- Cost
- Constructability/Maintenance of Traffic
- Creates a new weave on I-10 between the Jefferson south side ramps and the I-17 system ramps, but resulting weave section is in excess of 2000 feet.
- Relocate Community Tire Center
- Relocate Gray Hound Bus Depot
- Lose the direct connection between 24th Street and Buckeye Road.

BASE COST SUMMARY	COST
Recommendation	**$132,100,000**

	Alternative No. 1 Diamond TI with SE Fly Over	Idea #'s 1, 4, 7, 11, 13, 19, 23, 20, 32, 36, 37, 40

Discussion/Justification/Sketches/Photos:



	Alternative No. 1 Diamond TI with SE Fly Over	Idea #'s 1, 4, 7, 11, 13, 19, 23, 20, 32, 36, 37, 40

Assumptions and Calculations:

1. Bridges are single lane along I-10 all 25 feet wide with 12 ft lane, 8' shoulder, 5' shoulder (90,000 SF)
    a. Southbound I-10 Ramp Bridges
        i. L1= 800 x 25 = 20K
        ii. L2=200 x 25 = 5K
        iii. L3=800 x 25 = 20K
        iv. L4=200 x 25 = 5K
    b. Northbound I-10 Ramp Bridge
        i. L1 = 600 x25 = 15K
        ii. L2= 200 x 25 = 5K
        iii. L3 = 800 x 25 = 20K
    c. Northbound I-10 Widening bridge at Sky Harbor Cir N. (1200 SF)
        i. L= 200 x 6
2. I-10 Ramp Roadway Lengths
    a. Southbound Side = 9,000 LF x 25 = 25,000 SY
    b. Northbound Side = 7,100 LF x 25 = 19,725 SY
3. I-10 to EB Buckeye Flyover:
    a. Assume two lane (2-EB 12' lanes, 8' shoulder, 8' shoulder)(40')
    b. L – 1,500 x 40 = 61,000 SF
4. Traffic Signalized Intersection at Buckeye
    a. 2 ramp termini = 2 signals one at each ramp termini
    b. 24th Street and Sky Harbor
    c. 24th Street and south side WGTC (??)
5. Pavement Marking and Signing
    a. I-10 = 3 miles (total for both directions)
    b. Buckeye = 1.0 mile (total for both directions)
6. Lighting
    a. I-10 Lighting = 3 Miles (both directions)
    b. Buckeye Lighting = 1 Mile (both directions)
7. Earthwork
    a. Buckeye Earthwork: Assume 500K CY
    b. I-10 Ramps Assume 500K CY
8. Removals
    a. I-10 Ramp Pavement Removal (
        i. SB Removal 7,000 SY
        ii. NB Removal 2,000 SY
9. Buckeye Road Bridges
    a. Buckeye Eastbound
        i. Buckeye Over 24th Street Bridge (2 lane) = 6600 SF
        ii. Buckeye to WGTC Bridge over 24th Street (2-lane) = 4900 sf
        iii. Buckeye cross over bridge = 7800 SF
    b. Buckeye Westbound
        i. WGTC to Westbound crossing of Sky Harbor Blvd = 9900 SF
        ii. Westbound Sky Harbor Blvd over 24th St = 5000 SF
10. Buckeye Road

	Alternative No. 1 Diamond TI with SE Fly Over	Idea #'s 1, 4, 7, 11, 13, 19, 23, 20, 32, 36, 37, 40

    a. PCCP (from crossing to reconstruction) 2900 LF x 80 foot = 25000 SY
    b. Asphalt (at grade) 30 feet (wide) x 380 = 11,500 SY
11. Security Plaza Pavement
    a. Asphalt = 8500 SY
12. 24th Street
    a. Asphalt 1,500 lf x = 13,000 SF

Team 1 Recommendation Cost Estimate

Item Description	Unit	Freeway QTY	Local QTY	Unit Cost	Freeway Total	Local Total	Total (Most Likely)	% Under	% Over	$ Under	$ Over
Removals											
Pavement Removal	SY	13,000	15,000	$ 5.00	$ 65,000	$ 75,000	$ 140,000	-25%	25%	$ 105,000	$ 175,000
Earthwork											
General Earthwork	CY	500,000	500,000	$ 7.00	$ 3,500,000	$ 3,500,000	$ 7,000,000	-25%	25%	$ 5,250,000	$ 8,750,000
Base and Surface Treatment											
Concrete Pavement	SY	75,000		$ 45.00	$ 3,375,000	$ -	$ 3,375,000	-15%	15%	$ 2,868,750	$ 3,881,250
Asphalt Pavement	SY		33,000	$ 35.00		$ 1,155,000	$ 1,155,000	-10%	10%	$ 1,039,500	$ 1,270,500
Drainage											
On-Site	MILE	1.5	0.5	$500,000	$ 750,000	$ 250,000	$ 1,000,000	-10%	30%	$ 900,000	$ 1,300,000
Off-Site	LS	1000000	500000	$1	$ 1,000,000	$ 500,000	$ 1,500,000	-25%	20%	$ 1,125,000	$ 1,800,000
Pump Station	EACH	0	1	$2,000,000	$ -	$ 2,000,000	$ 2,000,000	-10%	10%	$ 1,800,000	$ 2,200,000
Structures											
Walls	SF	215,000	100,000	$ 65.00	$ 13,975,000	$ 6,500,000	$ 20,475,000	-30%	10%	$ 14,332,500	$ 22,522,500
Flyover	SF	61,000		$ 165.00	$ 10,065,000		$ 10,065,000	-10%	10%	$ 9,058,500	$ 11,071,500
Single Level (AASHTO)	SF	122,000	34,000	$ 125.00	$ 15,250,000	$ 4,250,000	$ 19,500,000	-15%	15%	$ 16,575,000	$ 22,425,000
Widening Bridge	SF	1,200		$ 185.00	$ 222,000		$ 222,000	-10%	10%	$ 199,800	$ 244,200
Traffic Engineering											
Ramp TI Signals	EA	3	1	$ 200,000.00	$ 600,000	$ 200,000	$ 800,000	-10%	10%	$ 720,000	$ 880,000
Pavement Marking & Signing	MILE	3	1	$ 150,000.00	$ 450,000	$ 150,000	$ 600,000	-10%	10%	$ 540,000	$ 660,000
Lighting	MILE	3	1	$ 350,000.00	$ 1,050,000	$ 350,000	$ 1,400,000	-10%	10%	$ 1,260,000	$ 1,540,000
ITS (Reconstruction & New)	LS	70%	30%	$ 1,000,000.00	$ 700,000	$ 300,000	$ 1,000,000	-10%	10%	$ 900,000	$ 1,100,000
Item Subtotal					$ 51,002,000	$ 19,230,000	$ 70,232,000	-19%	14%	$ 56,674,050	$ 79,819,950
Misc Item Allowance (10%)				10%	$ 5,100,200	$ 1,923,000	$ 7,023,200	-19%	14%	$ 5,667,405	$ 7,981,995
Traffic Control (10%)				10%	$ 5,100,200	$ 1,923,000	$ 7,023,200	-19%	14%	$ 5,667,405	$ 7,981,995
Mobilization				8%	$ 4,080,160	$ 1,538,400	$ 5,618,560	-19%	14%	$ 4,533,924	$ 6,385,596
Dust and Water Palliative	0.75%			0.75%	$ 382,515	$ 144,225	$ 526,740	-19%	14%	$ 425,055	$ 598,650
Contractor Quality Control	2.00%			2%	$ 1,020,040	$ 384,600	$ 1,404,640	-19%	14%	$ 1,133,481	$ 1,596,399
Contractor Surveying	2.00%			2%	$ 1,020,040	$ 384,600	$ 1,404,640	-19%	14%	$ 1,133,481	$ 1,596,399
Erosion Control	0.30%			0.30%	$ 153,006	$ 57,690	$ 210,696	-19%	14%	$ 170,022	$ 239,460
Construction Total					$ 67,858,161	$ 25,585,515	$ 93,443,676	-19%	14%	$ 75,404,824	$ 106,200,443
Engineering Items											
Construction Engineering				9%	$ 6,107,234	$ 2,302,696	$ 8,409,931	-19%	14%	$ 6,786,434	$ 9,558,040
Design Costs - Consultant				10%	$ 6,785,816	$ 2,558,552	$ 9,344,368	-19%	14%	$ 7,540,482	$ 10,620,044
Construction Contingency				5%	$ 3,392,908	$ 1,279,276	$ 4,672,184	-19%	14%	$ 3,770,241	$ 5,310,022
Right of Way											
Misc Right-of-Way					$ 500,000		$ 500,000	-25%	50%	$ 375,000	$ 750,000
Business 1					$ 2,000,000		$ 2,000,000	-10%	10%	$ 1,800,000	$ 2,200,000
Business 2					$ 4,000,000		$ 4,000,000	-10%	10%	$ 3,600,000	$ 4,400,000
Warehouse Take North of UPRR and East of I-10					$ 2,000,000		$ 2,000,000	-10%	20%	$ 1,800,000	$ 2,400,000
Project Subtotal					$ 92,644,120	$ 31,726,039	$ 124,370,158	-19%	14%	$ 101,076,981	$ 141,438,550
ICAP ADOT				8.36%	$ 7,745,048		$ 7,745,048				
Airport Indirect				4.50%		$ 1,427,672	$ 1,427,672				
PROJECT TOTAL					**$ 100,400,000**	**$31,700,000**	**$ 132,100,000**	**-23%**	**7%**	**$101,100,000**	**$141,400,000**

Recommendation Total Base Cost	$132,100,000

Alternative 1 Performance Evaluation		
PERFORMANCE MEASURES **Attributes and Rating Rationale for Recommendation**	***Performance***	***Alternative***
Freeway Operations Fix weave on I-10 between Jefferson and Buckeye Fix weave on I-10 between I-17 and Buckeye Full access to/from Sky Harbor and RCC at Buckeye Simple and Conventional Diamond interchange for driver expectancy for unfamiliar users Single interchange to access airport and RCC from every freeway direction Long Term solution for I-10 access to Sky Harbor and WGTC Removed at grade crossing for airport traffic at light rail crossings	***Rating***	**10**
	Weight	**20.8**
	Contribution	**208**
Airport Operations Operationally provides free-flow east/west on Buckeye Road east of I-10 Long Term solution for I-10 access to Sky Harbor and WGTC Additional access for Freight from I-10 and Buckeye to Sky Harbor Cir to 24th St. Security Check Point to screen Provides full access to/from RCC Meets airport plans for Sky Train to/from RCC Removed at grade crossing for RCC traffic at light rail crossings With RCC bus operations being removed, the need for improving Buckeye/Sky Harbor Cir was not necessary. Direct freeway access to/from the WGTC, indirect access to/from WGTC to airport core May encourage cut through traffic Freight operations on south side will have to use Sky Harbor Circle and Buckeye	***Rating***	**9**
	Weight	**18.0**
	Contribution	**162**
Maintainability Requires additional infrastructure Room to maintain infrastructure	***Rating***	**5**
	Weight	**6.9**
	Contribution	**34.5**
Construction Impacts Phasing and maintenance of traffic Utility Impacts, possibly at 24th Street, but also along the old 24th Street corridor	***Rating***	**5**
	Weight	**5.5**
	Contribution	**27.5**
Environmental Impacts Not residential area	***Rating***	**8**

Alternative 1 Performance Evaluation		
PERFORMANCE MEASURES **Attributes and Rating Rationale for Recommendation**	***Performance***	***Alternative***
Greyhound station and community tire displacement Change of Access Report, but solution should only improve interstate operations Removed signals - Air quality	***Weight***	**4.1**
	Contribution	**32.8**
Promotes Economic Growth Maintain Washington and Jefferson Access Fully compatible with Spine recommendations Promotes economic and access opportunities on Buckeye and on Sky Harbor Cir. To I-10 Maintain majority of Greyhound Parcel for redevelopment - potentially for WGTC parking expansion over 24th Street. Could hinder future use for existing Gray Hound site Ped/Bike opportunities on 24th Street	***Rating***	**9**
	Weight	**12.5**
	Contribution	**112.5**
Security Security Plaza dual purpose for tolling ITS Camera and communication Room for Photo Enforcement	***Rating***	**9**
	Weight	**19.8**
	Contribution	**178.2**
Local Roadway Operations Maintaining all existing access points except 24th Street access to I-10 via Buckeye Improves Freight access from Buckeye via Sky Harbor Cir/24th St. Indirect access for west Buckeye to 24th Street Provides direct I-10 access to/from WGTC Promotes direct BRT/Bikes/Ped intermodal connection to WGTC With RCC bus operations being removed, the need for improving Buckeye/Sky Harbor Cir was not necessary, but could be improved as needed in the future.	***Rating***	**8**
	Weight	**12.5**
	Contribution	**100**
	Total Performance Score	**855.5**

	Alternative No. 2 Re-route 24th Street to Sky Harbor Circle	Idea #'s 9, 13/15, 27

Recommendation:

The concept provides new access rental car access to I-10 from the terminals, West GTC and rental car center by the realignment of 24th Street with removal of the north-south 24th Street alignment between the Sky Harbor Circle intersections eliminates an at-grade intersection with Buckeye in close proximity to the I-10 ramps. The existing 24th Street alignment would merge onto Sky Harbor Circle on both north and south termini and traffic would continue/reroute on the west side of I-10. In conjunction with higher volumes on Sky Harbor Circle, the intersection with Buckeye will be grade-separated. Local access will be maintained through a "quadrant" or partial clover-leaf intersection with potential access and land development options within the NE and NW quadrants, including new fueling station.

Figure 3: Alternative 2 Concept

Ramps to/from Eastbound I-10 will largely remain in their existing configuration with the EB I-10 off-ramp providing a directional ramp into the airport north of Buckeye Road. A significant improvement will be providing a spur ramp from the existing off-ramp for Westbound Buckeye. This will provide access to the Rental Car center and Buckeye but will be free-flow and not signalized as EB Buckeye is not served. The EB I-10 on-ramp will remain as existing. See Figure 4 below for additional details.

Ramps to/from Westbound I-10 will be significantly improved to better serve airport and local traffic with the addition of a WB I-10 on-ramp for local and Rental Car traffic. The SE quadrant of the interchange will provide a quadrant ramp for WB I-10 off-ramp and WB I-10 on-ramp serving both

	Alternative No. 2 Re-route 24th Street to Sky Harbor Circle	Idea #'s 9, 13/15, 27

airport and Buckeye traffic. The existing directional WB I-10 on-ramp serving the main airport exit will largely remain in the existing configuration. The Westbound I-10 on-ramp at Buckeye and Sky Harbor Blvd will join prior to merging onto WB I-10. Refer to Figures 4 and 5 below.

Buckeye Road will be terminated at the current (but planned to be abandoned) 24th Street alignment. The termination intersection will be signalized and accommodate most turning movements with the intent of moving all traffic to Sky Harbor Boulevard. Please see Figure 5 below for the new Buckeye Road/I-10 access configuration.

Access to/from the West GTC will be managed on the eastside of the facility through a combination of at-grade and grade-separated access points. Inbound traffic will not be stopped and a free-flow ramp will cross over the outbound Sky Harbor Boulevard. Outbound traffic from the WGTC will generally turn left and have access to both directions of I-10, WB Buckeye, or turn back to the airport through the ramp signal. Please see Figure 6 for an illustration of access to/from the West GTC facility.

Total Recommendation Base Cost (see Appendix for cost assumptions and backup) = **$77,513,000**

	Alternative No. 2 Re-route 24th Street to Sky Harbor Circle	Idea #'s 9, 13/15, 27

Advantages:

- Improve I-10 interchanges at Washington and Jefferson St by improving rental car access at Buckeye interchange
- Ramps to/from I-10 maintain existing footprint and location on mainline
- PHX Sky Train alignment remains as planned
- Remove 24th traffic out of a portion of the RPZ; eliminates 24th/Buckeye intersection and related movements
- Develops/creates directional switch of Sky Harbor Boulevard close to I-10 and outside of airport
- Maintains space for future security plaza screening outside of RPZ and Sky Harbor Boulevard, compatible with designed solution for in-flow traffic
- Simplified way finding for vehicles accessing the airport (limited and direct decision points)
- Simplifies rental car customer way finding to/from the rental car facility (all access is from Buckeye Rd)
- Increases development potential for fueling station on NE or NW corner of Sky Harbor Circle and Buckeye Rd (enroute for RCC traffic)
- Limited signals for realigned 24th Street with grade separation at Buckeye (lengthens route but shortens travel time)
- Eliminates weave movements for I-10 RCC traffic with grade separated Sky Harbor Circle
- Removal of 24th Street between Sky Harbor Circle intersections allows expansion of the south portion of the West GTC development
- BRT enhanced from realignment of 24th to Sky Harbor Cir to allow access to RCC/Sky Train
- Includes enhanced bike lane to ensure continuous regional bike flow (via 24th Street/I-10 crossing per Phoenix Bike Plan, Spine Corridor Master Plan Recommendations

Disadvantages:

- Short section of "British" roadway on east side of West GTC (traditional travel directions switched); can be mitigated with curbing
- Longer route for vehicles along 24th Street (mitigated with shorter travel time) for local traffic must use Buckeye to access airport
- No major change to proximity of I-10 Buckeye ramps to the I-17/I-10 Split

Constrains Greyhound property reuse

	Alternative No. 2 Re-route 24th Street to Sky Harbor Circle	Idea #'s 9, 13/15, 27

Discussion/Justification/Sketches/Photos:

Slip ramp from I-10 EB will allow rental car traffic to exit directly to WB Buckeye Road. Customers will stay in the right lane to Sky Harbor Circle (New 24th Street) to access the partial cloverleaf to 24th Street. Vehicles can remain in the right lane all the way to the rental car center eliminating any lane changes or weaving which simplifies decision making. Potential for quadrant intersection instead of cloverleaf.

Figure 4: I-10 EB off-ramp and rental car access

Rental cars accessing I-10 Westbound will be served by a new loop off of Buckeye Road east of I-10. This improves current rental car operations by allowing vehicles to exit the facility along Sky Harbor Blvd. making a right onto Buckeye and a right onto the 1-10 on-ramp (west of I-10 for EB and east of 1-10 for WB).

	Alternative No. 2 Re-route 24th Street to Sky Harbor Circle	Idea #'s 9, 13/15, 27

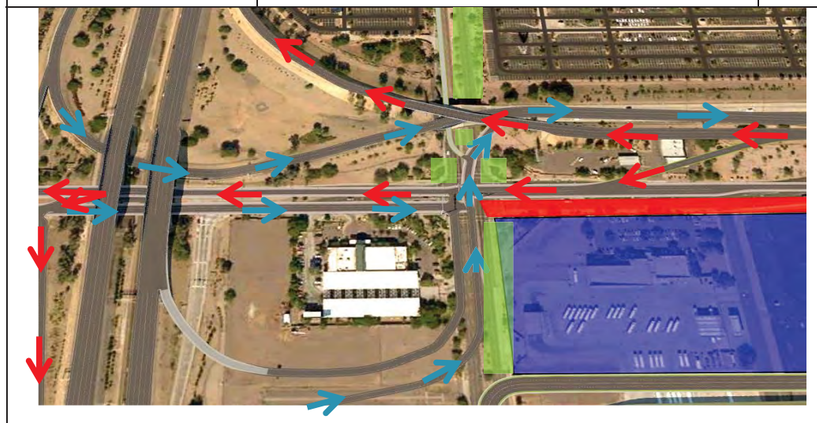


Figure 5: I-10 Access

Simplified way finding with one decision point off I-10 in each direction. Additional decisions are made as drivers access the terminal – first to the West GTC and then to the terminal.

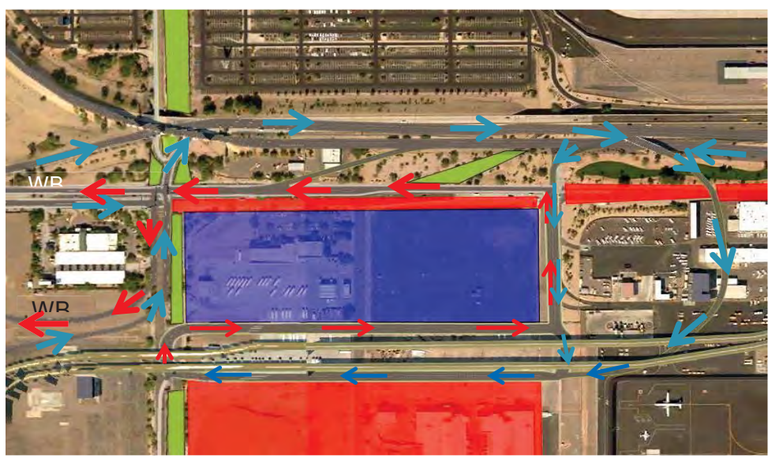


Figure 6: West GTC Access

The GTC access plan as described above.

Alternative 2 Performance Evaluation		
PERFORMANCE MEASURES **Attributes and Rating Rationale for Recommendation**	***Performance***	***Alternative***
Freeway Operations Relieving traffic at Washington and Jefferson by adding a free flow ramp at Buckeye Remove some of the traffic from Washington and Jefferson Single interchange to access airport and RCC from every freeway direction Maximum utilization of existing infrastructure for I-10 access to Sky Harbor and WGTC By shifting north/south traffic from 24th street to Sky Harbor Circle allows Buckeye to better serve the airport	***Rating***	**6**
	Weight	**20.8**
	Contribution	**124.8**
Airport Operations Provides single decision point east/west on Buckeye Road east of I-10 Long Term solution for I-10 access to Sky Harbor and WGTC Additional access for Freight from I-10 and Buckeye to Sky Harbor Cir to 24th St. Plaza Check Point to screen for security or toll for controlling cut through Provides intuitive access to/from RCC via Sky Harbor Circle Meets airport plans for Sky Train to/from RCC Single decision Point access to/from the WGTC with all right hand turns Freight operations on south side will have to use Sky Harbor Circle removes 24th from RPZ	***Rating***	**9**
	Weight	**18.0**
	Contribution	**162**
Maintainability Minimal additional features to maintain Room to maintain infrastructure with focus on fills and slopes vs. retaining walls	***Rating***	**7**
	Weight	**6.9**
	Contribution	**48.3**
Construction Impacts Phasing for grade separation at Buckeye and Sky Harbor Circle is on critical path Most of new can be built off line	***Rating***	**7**
	Weight	**5.5**
	Contribution	**38.5**
Environmental Impacts No residential area impacts Greyhound station and community tire will be purchased and displaced Should be accomplished with an EA	***Rating***	**8**
	Weight	**4.1**

Alternative 2 Performance Evaluation		
PERFORMANCE MEASURES **Attributes and Rating Rationale for Recommendation**	***Performance***	***Alternative***
Removed signals which will improve air quality by limiting queue times at signals	***Contribution***	**32.8**
Promotes Economic Growth Limited access Sky Harbor Circle and Buckeye my deter economic growth in the north quadrants Promotes economic and access opportunities on Buckeye and on Sky Harbor Cir Area south of existing Gray Hound site is available for future development	***Rating***	**8**
	Weight	**12.5**
	Contribution	**100**
Security Security Plaza dual purpose for tolling ITS Camera and communication Room for Photo Enforcement	***Rating***	**9**
	Weight	**19.8**
	Contribution	**178.2**
Local Roadway Operations Rerouting 24th Street to Sky Harbor Cir will reduce travel time on 24th by eliminating signals Freight access from continues via Sky Harbor Cir/24th St. Promotes direct BRT/Bikes/Ped intermodal connection to WGTC Rerouting 24th Street to Sky Harbor Cir increase time if destination is Sky train Stakeholder acceptance of rerouting 24th	***Rating***	**6**
	Weight	**12.5**
	Contribution	**75**
	Total Performance Score	**759.6**

Alternative No. 3
Connection and Access Modifications

Recommendation:

Modify I-10 Connections:

1. Eliminate the lane drop (4 lanes to 3 lanes) north of Washington.
2. Add south connector road from Jefferson to Sky Harbor Circle North, continue to new on-ramp to I-10 EB. Eliminate existing Jefferson to I-10 EB on-ramp.
3. Relocate I-10 EB off-ramp to Sky Harbor Boulevard to the north to set up two-lane exit that splits to a new Rental Car Center (RCC) access to Buckeye Road.
4. Eliminate I-10 ramps (entry and exit) at Buckeye Road to the south.
5. Maintain I-17 EB to I-10 WB and maintain connection to Buckeye Road to accommodate airport bound passengers from I-17.
6. Add new off-ramp from I-10 WB to Sky Harbor Circle North and maintain frontage road connector from Sky Harbor Circle North to Jefferson.
7. Remove off-ramp to Jefferson.
8. Maintain existing I-10 EB exit ramp to Sky Harbor Boulevard – split for direct access to West GTC and terminals (with large area reserved for security/toll plaza).
9. Add new direct on-ramps to I-10 WB from Sky Harbor Boulevard WB and West GTC.
10. Change RCC egress to I-10 EB so that it is now direct from 24th St and Sky Harbor Circle.

Add airport West GTC connections/features:

1. Add new direct ramp from Sky Harbor Boulevard WB to I-10 WB.
2. Add new direct ramp from West GTC to I-10 WB that also accommodates RCC traffic.
3. Moved Sky Harbor Boulevard “cross-over” as far west as possible.
4. Created large area for airport security/toll plaza.

Alternative No. 3
Connection and Access Modifications

Advantages:

- Improved RCC ingress and egress
- Direct freeway access to Terminals and West GTC
- Direct freeway access from Terminal to I-10 WB and West GTC
- Realistic phasing that is independent from other airport program items
- Consolidate airport and RCC access (4 ramps into 2)
- Mainline I-10 weaving removed: I-17 to I-10 west weave; SR-51 to airport exit; airport exit to I-10 WB removed weave with Jefferson
- Aux lane from SR-51 to airport (removed pinch point approaching airport exit)
- I-17 access to airport maintained to Buckeye Road via frontage road, to preserve airport access from that important route (I-17)
- I-17 access to WB I-10 maintained
- Local street access to and from airport maintained
- System can be further enhanced with ITS additions both on freeway and within airport
- Large area created on airport for security and toll plaza to address cut-through traffic
- Sky Harbor Boulevard "cross over" moved far west (4,500 feet), freeing up valuable terminal expansion space
- Local street development opportunities and access maintained and enhanced
- Construction impacts are minimal – no I-10 mainline impacts, no Sky Train impacts, no West GTC impacts, new ramps are low impact /offline construction
- Compatible with current program for Taxiways U/V, Sky Train and West Terminal

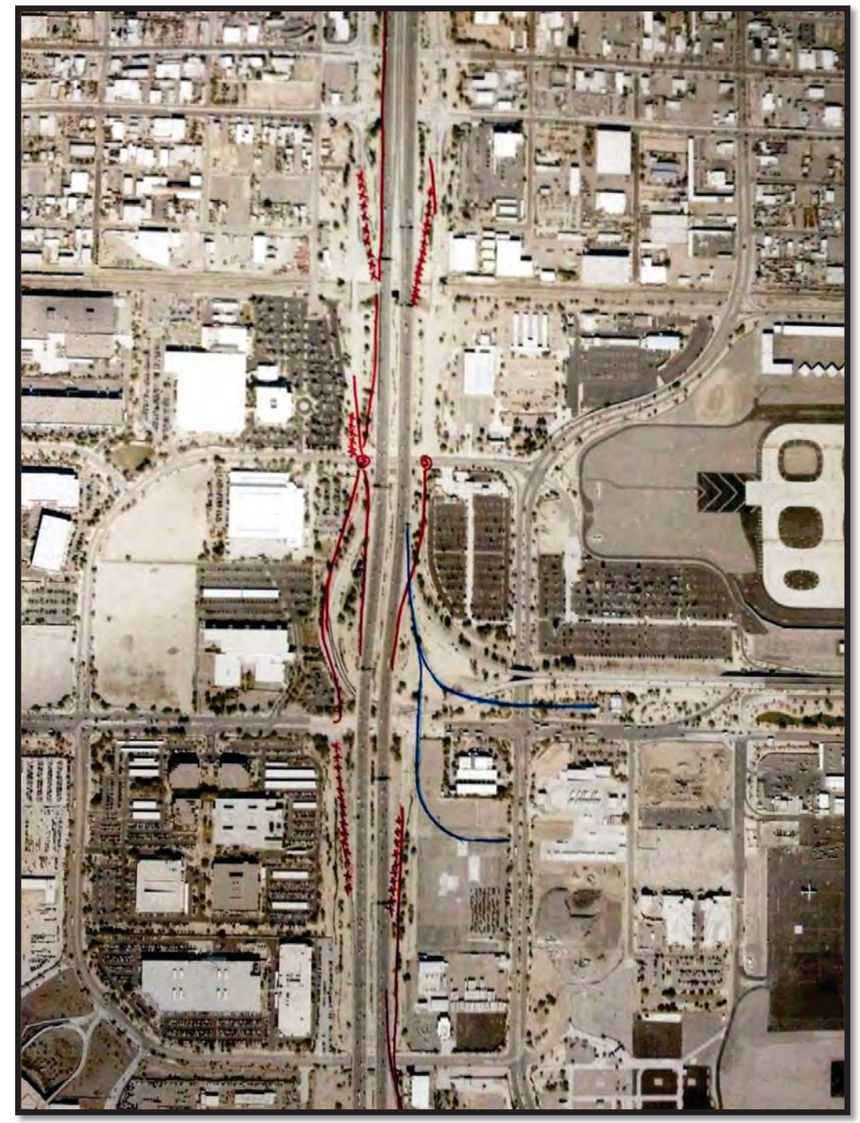
Disadvantages:

- Terminal exit to EB I-10 is slightly longer than current connection; although, this is a low volume movement and the proposed solution will eliminate the current unprotected left turn movement off of Buckeye Road to I-10

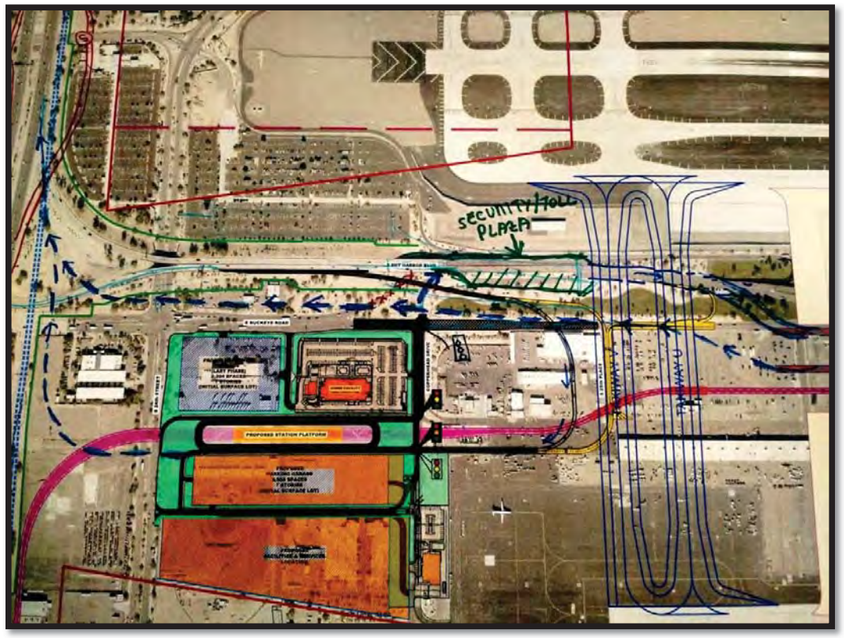
BASE COST SUMMARY	COST
Recommendation	**$66,264,978**

Alternative No. 3
Connection and Access Modifications

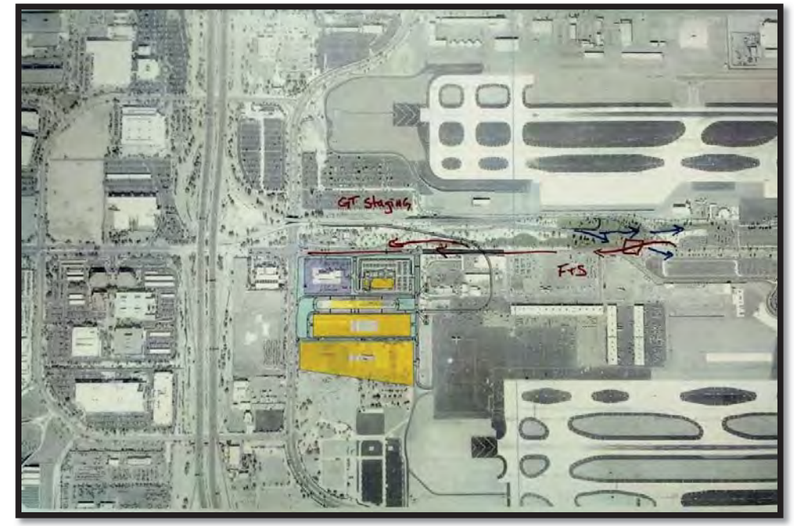
Discussion/Justification/Sketches/Photos:



Alternative No. 3
Connection and Access Modifications



Alternative No. 3
Connection and Access Modifications



Alternative 3 Performance Evaluation		
PERFORMANCE MEASURES **Attributes and Rating Rationale for Recommendation**	***Performance***	***Alternative***
Freeway Operations Consolidated access may over tax the volumes Improved weaving Maintained important connection to the airport Reduced demand on Washington/Jefferson Off Ramp Eliminated pinch points between SR-51 and Airport Exit Increased capacity by adding an Aux lane Increased transit reliability through improved I-10 EB operations	***Rating***	**7**
	Weight	**20.8**
	Contribution	**145.6**
Airport Operations Increase access to and from the RCC Phasing of the improvements can be independent of the airport projects Direct freeway access to and from the terminals and the GTC (except terminal exit to I-10 EB) Allocated space for toll plaza and security screening area without creating backups to deter cut-through traffic Enhanced development potential along city streets Maintained all local street access to the terminals and the GTC Maintained cargo access Identified GT staging area with improved access to and from terminals Includes one intersections Identified electronic monitoring and tolling to deter cut-through traffic	***Rating***	**9**
	Weight	**18.0**
	Contribution	**162**
Maintainability Improved the ease of access to maintenance vehicles Limited disruptions to airport operations during maintenance activities	***Rating***	**7**
	Weight	**6.9**
	Contribution	**48.3**
Construction Impacts Freeway improvements can be completed independent of airport operations Maintained freeway operations during construction Airport improvements can be completed independent of other airport programs Maintained airport operations during construction	***Rating***	**7**
	Weight	**5.5**
	Contribution	**38.5**

Alternative 3 Performance Evaluation		
PERFORMANCE MEASURES **Attributes and Rating Rationale for Recommendation**	***Performance***	***Alternative***
Environmental Impacts Eliminated the frontage road stop sign approaching Jefferson Avoided the I-10 storm drain tunnel Eliminated circuitous routes in and out of the RCC Minimized ROW requirements	***Rating***	**8**
	Weight	**4.1**
	Contribution	**32.8**
Promotes Economic Growth Local street network optimizes the potential for future development Maintained access to cargo locations Improved access to and from Sky Harbor Circle Accommodated future airport growth Improved access to and from the RCC provides higher customer satisfaction Improved access to existing and future commercial developments	***Rating***	**8**
	Weight	**12.5**
	Contribution	**100**
Security Allocated space for security screening area without creating backups and to deter cut-through traffic Identified electronic monitoring and tolling to deter cut-through traffic Identified security screening location prior to the taxiways Created alternative passenger drop-off and pickup route for heightened security situations Provided flexibility to accommodate changing security mandates	***Rating***	**9**
	Weight	**19.8**
	Contribution	**178.2**
Local Roadway Operations Provided ample opportunities to connect transit to the west GTC Separated airport traffic from local traffic on Sky Harbor Circle at 16th Street Improved access to existing and future commercial developments Better directional access to and from the RCC Keeps 24th at grade through the airport	***Rating***	**8**
	Weight	**12.5**
	Contribution	**100**
	Total Performance Score	**805.4**

Alternative Performance Assessment Summary

After the Value Planning Team developed the alternatives, the performance of each alternative was rated against the others. Changes in performance are always based upon the overall impact to the total project. Once performance and cost data have been developed by the Team, the net change in value of the alternatives can be compared.

The resulting value improvement scores provide a way to assess the potential impact of each alternative on total project value. There is no base concept to compare to as the program is in the planning stages and no initial overall concept has been established. Each attribute was weighted on a scale of 1 to 10 for each alternative with a 1 being poor performance and ten being high performance. These attributes were compared to the current condition, the conditions that will exist after airport projects are complete, and compared to the other alternatives during the assessment.

Table 7: Performance Attribute Ratings

Performance Attribute Ratings				
Attribute	**Attribute Weight**	**Alternative**	**Performance Rating**	**Total Performance**
Freeway Operations	20.8	1	10	208.0
		2	6	124.8
		3	7	145.6
Airport Operations	18.0	1	9	162.0
		2	9	162.0
		3	9	162.0
Maintainability	6.9	1	5	34.5
		2	7	48.3
		3	7	48.3
Construction Impacts	5.5	1	5	27.5
		2	7	38.5
		3	7	38.5
Environmental Impacts	4.1	1	8	32.8
		2	8	32.8
		3	8	32.8
Promotes Economic Growth	12.5	1	9	112.5
		2	8	100.0
		3	8	100.0
Security	19.8	1	9	178.2
		2	9	178.2
		3	9	178.2
Local Roadway Operations	12.5	1	8	100.0
		2	6	75.0
		3	8	100.0

The total performance score for each alternative is divided by the risk adjusted total project cost (Performance ÷ Cost) to compute the value index of each alternative. Table 8 provides a summary of the alternatives generated and their performance, cost, and value index. It can be seen from Table 8 that Alternative 3, the highest value index is the 'winner' of the design competition and provides the best overall value based on the team's performance rating criteria established during the workshop. Please refer to the 'Performance Attribute Criteria Matrix' shown in Table 6 for additional information regarding the ratings of each attribute.

Table 8: List of Alternatives

Alternatives		Performance	Cost (YOE)	Value Index (Performance/Cost)
1	Alternative 1	875	$166.7	5.13
2	Alternative 2	760	$134.0	5.67
3	**Alternative 3**	**805**	**$104.5**	**7.71**

Cost Risk Assessment Results

The results in the table below summarize the 'Cost Risk Assessment' (CRA) analysis of each alternative modeled with their own risks separately. These results were evaluated and the risk adjusted amount at the 70th percentile was used for the cost in the value equation. This approach ultimately determined a 'winner' of the design competition and allowed the team to focus on specific risks that affect each alternative. Table 9 and Table 10 show the modeled cost results and schedule results for each alternative, respectively including escalation and extended overhead costs.

Table 9: Risk Analysis Cost Results

Category	Base Cost (Million $ 2017)	Risk-Adjusted Cost Results
		70th Percentile (Million $ YOE)
Alternative 1	$134.77	$166.7
Alternative 2	$77.51	$134.0
Alternative 3	$66.26	**$104.5**

Table 10: Risk-Adjusted Schedule Results

Category	Base Schedule Date	Project Completion Schedule Date		
		10th Percentile	70th Percentile	90th Percentile
Alternative 1	December 2024	May-2025	Mar-2026	Aug-2026
Alternative 2	July 2024	Jul-2024	Mar-2025	Jul-2025
Alternative 3	January 2024	Jan-2024	Jan-2025	Jul-2025

The risks captured and quantified for each alternative, or the 'Risk Management Plan' is provided in the appendix. Additional information including tornado diagrams and schedule and cost 'S-curves' are provided for decision support, also provided in the appendix.

The management team will refer to this document as design progresses and make continuous updates to the plan based on risk status; either active, inactive or retired. Risks may be added to the plan based on recent developments that occur throughout design. The most important aspect of risk management is to monitor and control the identified risks to ensure the project maintains the proper risk reserve as design progresses. Too much risk reserve may prevent other important projects from moving forward, just as not enough reserve will severely impact the project and may require potential costly or unnecessary steps to secure funding in the future if risks are not managed appropriately.

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Appendix

- Base Cost Preliminary Development
- Program Base Schedule Review
- Alternative Cost Risk Assessment Results
  - Alternative 1 Cost and Schedule 'S-Curves
  - Alternative 1 Cost and Schedule Tornado Diagrams
  - Alternative 2 Cost and Schedule 'S-Curves
  - Alternative 2 Cost and Schedule Tornado Diagrams
  - Alternative 3 Cost and Schedule 'S-Curves
  - Alternative 3 Cost and Schedule Tornado Diagrams
- Alternative Risk Data Sheets
  - Alternative 1 Risk Data Sheets
  - Alternative 2 Risk Data Sheets
  - Alternative 3 Risk Data Sheets
- Value Planning Agenda
- Value Planning Attendees
- Value Planning Report Out
- Value Planning Approach
- Performance Based Results

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MARICOPA ASSOCIATION of GOVERNMENTS

Base Cost Preliminary Development

Item Description	Unit	Recommended I-10 QTY	Buckeye QTY	Unit Cost	I-10 Total	Buckeye Total	Total (Most Likely)	% Under	% Over	$ Under	$ Over
Removals											
Pavement Removal	SY	13,000	15,000	$ 5.00	$ 65,000.00	$ 75,000.00	$ 140,000.00	-25%	25%	$ 105,000	$ 175,000
Earthwork											
General Earthwork	CY	500,000	500,000	$ 7.00	$ 3,500,000.00	$ 3,500,000.00	$ 7,000,000.00	-25%	25%	$ 5,250,000	$ 8,750,000
Base and Surface Treatment											
Concrete Pavement	SY	75,000		$ 45.00	$ 3,375,000.00	$ -	$ 3,375,000.00	-15%	15%	$ 2,868,750	$ 3,881,250
Asphalt Pavement	SY		33,000	$ 35.00		$ 1,155,000.00	$ 1,155,000.00	-10%	10%	$ 1,039,500	$ 1,270,500
Drainage											
On-Site	MILE	1.5	0.5	$500,000	$ 750,000.00	$ 250,000.00	$ 1,000,000.00	-10%	30%	$ 900,000	$ 1,300,000
Off-Site	LS	1000000	500000	$1	$ 1,000,000.00	$ 500,000.00	$ 1,500,000.00	-25%	20%	$ 1,125,000	$ 1,800,000
Pump Station	EACH	0	1	$2,000,000	$ -	$ 2,000,000.00	$ 2,000,000.00	-10%	10%	$ 1,800,000	$ 2,200,000
Structures											
Walls	SF	215,000	100,000	$ 65.00	$ 13,975,000.00	$ 6,500,000.00	$ 20,475,000.00	-30%	10%	$ 14,332,500	$ 22,522,500
Flyover	SF	61,000		$ 165.00	$ 10,065,000.00		$ 10,065,000.00	-10%	10%	$ 9,058,500	$ 11,071,500
Single Level (AASHTO)	SF	122,000	34,000	$ 125.00	$ 15,250,000.00	$ 4,250,000.00	$ 19,500,000.00	-15%	15%	$ 16,575,000	$ 22,425,000
Widening Bridge	SF	1,200		$ 185.00	$ 222,000.00		$ 222,000.00	-10%	10%	$ 199,800	$ 244,200
Traffic Engineering											
Ramp TI Signals	EA	3	1	$ 200,000.00	$ 600,000.00	$ 200,000.00	$ 800,000.00	-10%	10%	$ 720,000	$ 880,000
Pavement Marking & Signing	MILE	3	1	$ 150,000.00	$ 450,000.00	$ 150,000.00	$ 600,000.00	-10%	10%	$ 540,000	$ 660,000
Lighting	MILE	3	1	$ 350,000.00	$ 1,050,000.00	$ 350,000.00	$ 1,400,000.00	-10%	10%	$ 1,260,000	$ 1,540,000
ITS (Reconstruction & New)	LS	70%	30%	$ 1,000,000.00	$ 700,000.00	$ 300,000.00	$ 1,000,000.00	-10%	10%	$ 900,000	$ 1,100,000
Item Subtotal					$ 51,002,000.00	$ 19,230,000.00	$ 70,232,000.00	-19%	14%	$ 56,674,050	$ 79,919,950
Misc Item Allowance (10%)				10%	$ 5,100,200.00	$ 1,923,000.00	$ 7,023,200.00	-19%	14%	$ 5,667,405	$ 7,991,995
Traffic Control (10%)				10%	$ 5,100,200.00	$ 1,923,000.00	$ 7,023,200.00	-19%	14%	$ 5,667,405	$ 7,991,995
Mobilization				8%	$ 4,080,160.00	$ 1,538,400.00	$ 5,618,560.00	-19%	14%	$ 4,533,924	$ 6,385,596
Dust and Water Palliative	0.75%			0.75%	$ 382,515.00	$ 144,225.00	$ 526,740.00	-19%	14%	$ 425,055	$ 598,650
Contractor Quality Control	2.00%			2%	$ 1,020,040.00	$ 384,600.00	$ 1,404,640.00	-19%	14%	$ 1,133,481	$ 1,596,399
Contractor Surveying	2.00%			2%	$ 1,020,040.00	$ 384,600.00	$ 1,404,640.00	-19%	14%	$ 1,133,481	$ 1,596,399
Erosion Control	0.30%			0.30%	$ 153,006.00	$ 57,690.00	$ 210,696.00	-19%	14%	$ 170,022	$ 239,460
Construction Total					$ 67,858,161.00	$ 25,585,515.00	$ 93,443,676.00	-19%	14%	$ 75,404,824	$ 106,200,443
Engineering Items											
Construction Engineering				9%	$ 6,107,234.49	$ 2,302,696.35	$ 8,409,930.84	-19%	14%	$ 6,786,434	$ 9,558,040
Design Costs - Consultant				10%	$ 6,785,816.10	$ 2,558,551.50	$ 9,344,367.60	-19%	14%	$ 7,540,482	$ 10,620,044
Construction Contingency				5%	$ 3,392,908.05	$ 1,279,275.75	$ 4,672,183.80	-19%	14%	$ 3,770,241	$ 5,310,022
Right of Way											
Misc Right-of-Way					$ 500,000.00		$ 500,000.00	-25%	50%	$ 375,000	$ 750,000
Community Tire Relocate					$ 2,000,000.00		$ 2,000,000.00	-10%	10%	$ 1,800,000	$ 2,200,000
Greyhound Relocate					$ 4,000,000.00		$ 4,000,000.00	-10%	10%	$ 3,600,000	$ 4,400,000
Warehouse Take North of UPRR and East of I-10					$ 2,000,000.00		$ 2,000,000.00	-10%	20%	$ 1,800,000	$ 2,400,000
Project Subtotal					$ 92,644,119.64	$ 31,726,038.60	$ 124,370,158.24	-19%	14%	$ 101,076,981	$ 141,438,550
ICAP ADOT				8.36%	$ 7,745,048.40		$ 7,745,048.40				
Airport Indirect				4.50%		$ 1,427,671.74	$ 1,427,671.74				
PROJECT TOTAL					**$ 100,389,168.04**	**$ 31,726,038.60**	**$ 133,542,878.38**	-24%	6%	**$ 101,076,981.17**	**$ 141,438,549.91**

Figure 7: Alternative 1 Base Estimate

MARICOPA ASSOCIATION of GOVERNMENTS

Item	Unit	USE	West of I-10	Cost		East of I-10	Base Cost			
Earthwork					$633,348.05					$3,391,288.00
Clearing and Removals	LS	$30,000			Minor pavement removal	LS	$80,000			Demo Greyhound
Roadway Excavation	CY	$7.00	2700	$18,900.00		CY	$7.00	223000	$1,561,000.00	
Drainage Excavation	CY			$0.00		CY			$0.00	
Borrow	CY	$8.00	75300	$602,400.00		CY	$8.00	224300	$1,794,400.00	
Furnish Water	2%		$12,048.00	$12,048.00		2%		$35,888.00	$35,888.00	
Base and Surface Treatment					$630,000.00					$1,736,000.00
Concrete Pavement	SY	$45		$0.00		SY	$45		$0.00	
Asphalt Pavement	SY	$35	18000	$630,000.00		SY	$35	49600	$1,736,000.00	
				$0.00					$0.00	
Drainage					$500,000.00					$650,000.00
On-Site	MILE	$500,000	1	$500,000.00		MILE	$500,000	1.3	$650,000.00	
Off-Site	LS			$0.00		LS			$0.00	
Pump Station	EACH	$1,000,000		$0.00		EACH	$1,000,000		$0.00	
Other	LS			$0.00		LS			$0.00	
Structures					$1,375,000.00					$5,683,800.00
Single level AASHOT	SF	$125	11000	$1,375,000.00		SF	$125	1500	$187,500.00	
Flyover	SF	$165		$0.00		SF	$165		$0.00	
Widening	SF	$185		$0.00		SF	$185	7680	$1,420,800.00	
Retaining Walls	SF	$65		$0.00		SF	$65	62700	$4,075,500.00	
Sound Walls	SF	$35		$0.00		SF	$35		$0.00	
Traffic Engineering					$386,493.64					$2,018,704.39
Traffic Control	10%		$1,251,300.00	$125,130.00		10%		$5,091,400.00	$509,140.00	
Signing and Pavement Marking	MILE	$150,000	0.435606061	$65,340.91		MILE	$150,000	2.819128788	$422,869.32	
Lighting	MILE	$350,000	0.435606061	$152,462.12		MILE	$350,000	2.819128788	$986,695.08	
Signal (per interchange or intersection)	EACH	$100,000		$0.00		EACH	$100,000	1	$100,000.00	
FMS	MILE	$100,000	0.435606061	$43,560.61		MILE	$100,000	0	$0.00	
Roadside Development					$63,190.65					$0.00
Topsoil	MILE			$0.00		MILE			$0.00	
Landscaping	MILE			$0.00		MILE			$0.00	
Utilities local street	MILE			$0.00		MILE			$0.00	
	MILE			$0.00		MILE			$0.00	
Dust and Water Palliative	0.75%		$1,251,300.00	$9,384.75		0.75%		$5,091,400.00	$38,185.50	
Contractor Quality Control	2.00%		$1,251,300.00	$25,026.00		2.00%		$5,091,400.00	$101,828.00	
Contractor Surveying	2.00%		$1,251,300.00	$25,026.00		2.00%		$5,091,400.00	$101,828.00	
Erosion Control	0.30%		$1,251,300.00	$3,753.90		0.30%		$5,091,400.00	$15,274.20	
Subtotal A					$3,588,032.29					$13,479,792.39
Miscellaneous Item Allowance	10.0%			$358,803.23		10.0%			$1,347,979.24	
Subtotal B					$3,946,835.52					$14,827,771.63
Mobilization	8%			$315,746.84		8%			$1,186,221.73	
Contract Total					$11,122,900.09					$41,787,356.42
Engineering & Contingency										
Construction Engineering	9%			$1,001,061.01		9%			$3,760,862.08	
Design Costs - Consultant	10.0%			$1,112,290.01		10.0%			$4,178,735.64	$5,291,025.65 Design
Construction Contingency	5%			$0.00		5%			$0.00	
Subtotal					$2,113,351.02					$7,939,597.72
Non-Bid Project Costs										
DPS Traffic Control				$0.00					$0.00	
Prior Right Utility Relocations & Service				$0.00		Tire shop and Greyhound			$6,000,000.00	
PCCP Quality Incentive	SY	$1.5	1500	$2,250.00		SY	$1.5	1500	$2,250.00	
AR-ACFC Smoothness Incentive	MILE	$11,000	0.12109091	$1,354.17		MILE	$11,000	0.12109091	$1,354.17	
Right-of-Way other	SF	$4	21300	$85,200.00		SF	$4	342000	$1,368,000.00	$7,453,200.00 ROW Grey Hound relo, tire center
Subtotal					$88,804.17					$7,371,604.17
Indirect Cost Allocation (ICAP)	8.36%			$1,113,974.62	$1,113,974.62	8.36%			$4,773,439.47	$4,773,439.47
Roadway Project Total					$14,439,029.89					$61,871,997.78
Add or credit for Sky Harbor BVD east of 27th										$63,566,802.02 Construction
Grand Total										$76,311,027.67 $76,311,027.67 TRUE

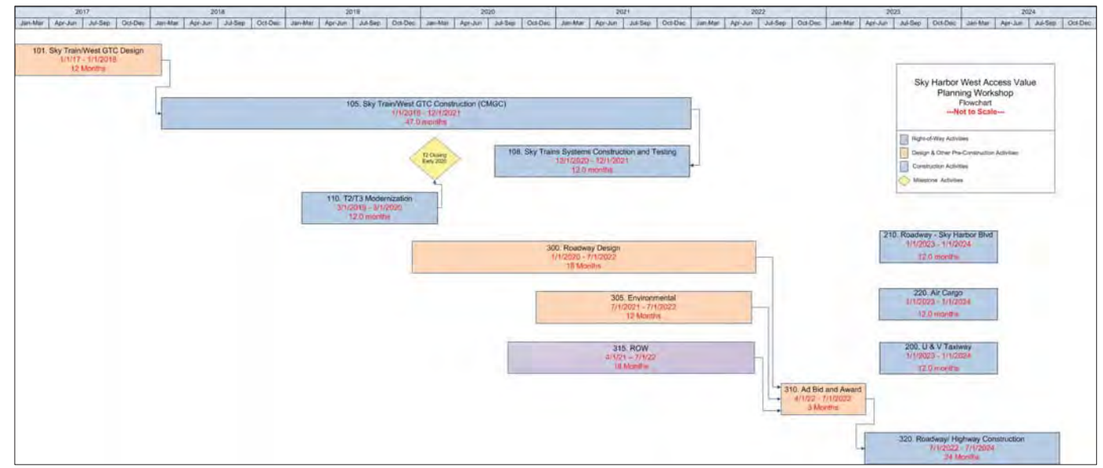
	Low	Most Likely	High
Roadway Design	$ 4,727,151.52	$ 5,561,354.73	$ 6,395,557.94
Environmental	$ 134,921.23	$ 158,730.85	$ 182,540.48
Right of Way	$ 6,864,844.39	$ 8,076,287.52	$ 9,287,730.65
Ad-Bid-Award	$ 125,000.00	$ 150,000.00	$ 175,000.00
Roadway/Highway Construction	$ 53,906,781.72	$ 63,566,802.02	$ 73,101,522.33

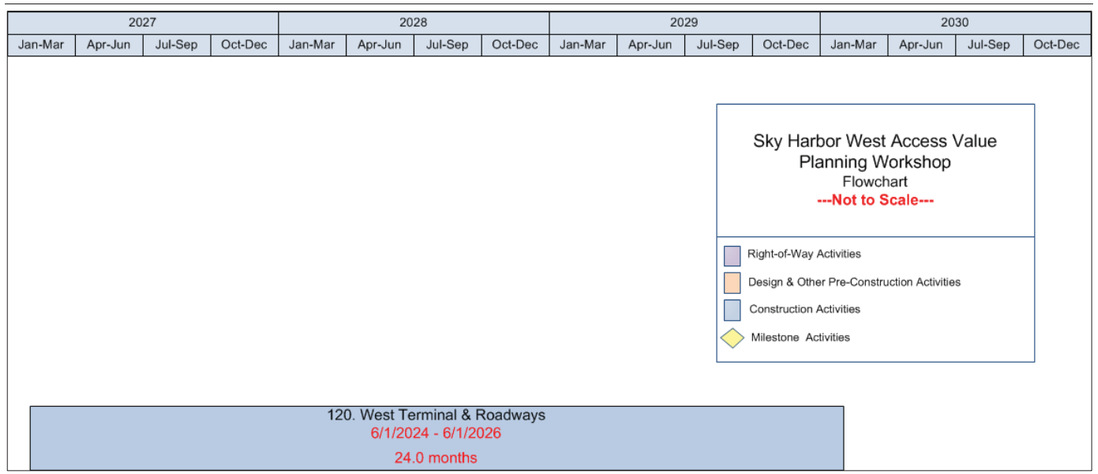
Figure 8: Alternative 2 Base Estimate

			Freeway		Airport Time			
Item	Unit	Unit	Quantity	Estimate	Quantity	Estimate		Airport Notes
Earthwork								
Clearing and Removal (include 4 cargo clearing)	LS	$1,500,000	1	$1,500,000	1	$500,000		Removal EB cargo area airport
Roadway Excavation	CY	$7.00	2051.3	$14,360				
Drainage Excavation	CY			$0				
Borrow	CY	$8.00	43750.7	$350,000	190,000	$1,520,000		FG Sky new 127C and temporal hauling to I-10
Potable Water	PC			$250,000		$34,000		
Base and Surface Treatment								
Concrete Pavement	SY	$45	19,582	$880,000	$3,333	$2,410,000		(3,000 ft new bumps by 40 ft long width
Type of Pavement	BY	$58						
Drainage								
On-Site	MILE	$400,000	1.5	$750,000	2.5	$1,250,000		(1.5 miles new roads
Off Site	LS							
Pump Station	EACH	$750,000	1	$750,000				
Other	LS							
Structures								
Single level SA/SHCF	SF	$125	108,000	$13,500,000	48000	$6,000,000		(210 LF new bridge, 45 feet wide (used trackless, 24ft and Supperhead
Shelter	SF	$180		$0				
Widening	SF	$180	12960	$2,333,000				
Retaining Walls	SF	$40	10000	$875,000	40000	$3,500,000		AB Bridge(Lane over Hoop, Sky 2020 LF by 29 ft bed load)
Sound Walls	SF	$95		$0				
Traffic Engineering								
Traffic Control	LS			$400,000		$1,398,400		
Signing and Pavement Marking	MILE	$180,000	1.5	$270,000	2.5	$499,000		
Lighting	MILE	$350,000	1.5	$525,000	3.5	$1,225,000		
Signals (per intersection or interchange)	EACH	$200,000	2	$400,000	2	$400,000		
ITS	MILE	$100,000	1.5	$150,000	3.5	$350,000		
Roadside Development								
Topsoil	MILE			$0				
Landscaping	MILE	$200,000	1.5	$300,000	2.5	$500,000		
Utilities (not street)	MILE	$800,000		$0	2	$1,600,000		(Non-mainstreets)
Grouting piers	MILE					$2,000,000		
				$13,273,936		**$25,782,400**		
Joint and Crack Repairs	2.79%			$96,562		$193,868		
Innovative Quality Duties	3.00%			$398,472		$399,640		
Contractor Surveying	2.00%			$265,472		$319,640		
Erosion Control	0.30%			$39,821		$38,587		
Subtotal A				**$15,043,813**		**$27,734,035**		
Mobilization (varies depending on size)	20.0%			$3,108,763		$4,346,807		
Subtotal B				**$18,152,575**		**$32,080,842**		
Mobilization	8%			$1,338,618.04		$2,087,607.48		
Contract Total				**$19,491,193**		**$34,168,449**		
Engineering & Contingency								
Construction Engineering	8%			$1,559,416.02		$2,733,443.96		
Design Costs - Consultant	16.0%			$3,117,111		$5,914,275.08	$4,625,491.20	
Construction Contingency	5%			$975,360.56		$1,709,126.05		
Subtotal				**$25,143,429**		**$44,565,294**		
Non-Bid Project Costs								
GPS Traffic Control								
Pre Bid Utility Relocations & Service	Sum	$1,000,000	1	$1,000,000				
PCCP Quality Investigation	$/t	$1.5	16587.7	$25,782				
AZ ADOT Specimens Installed	MILE	$11,000	1	$11,000				
Right-of-Way	SY	$4	20000	$100,000			$2,000,000	
ROW Tax	1%			$2,000,000				
				$29,580,776.88		**$44,565,294**		
Indirect Cost Allocation(ICAP)	2.98%			$2,131,677.46		$3,317,531.51		
Roadway Project Total				**$27,484,953.46**		**$37,966,000.04**	**$10,927,332.90**	
					Grand Total =	**$65,152,734.10**	**$65,152,734.10**	
							TRUE	
							TRUE	
				Roadway Design	$ 4,875,940.58	$ 4,881,722.20	$ 5,880,980.33	
				Environmental	$ 18,320.20	$ 190,762.53	$ 172,878.10	
				Right of Way	$ 2,000,000.00	$ 2,275,000.00	$ 2,516,666.00	
				Ad Bid Award	$ 18,000.00	$ 160,000.00	$ 173,000.00	
				Construction/Design Support	$ 38,484,599.47	$ 38,927,312.80	$ 54,433,410.30	

Figure 9: Alternative 3 Base Estimate

Base Schedule Review





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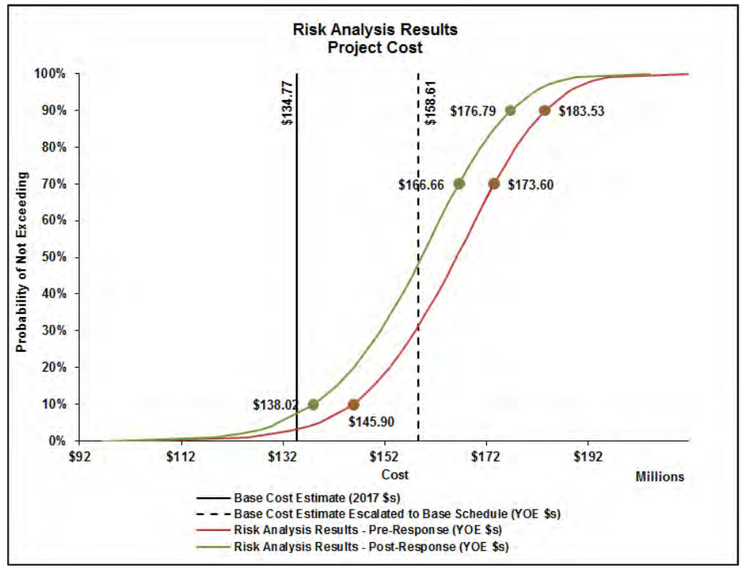
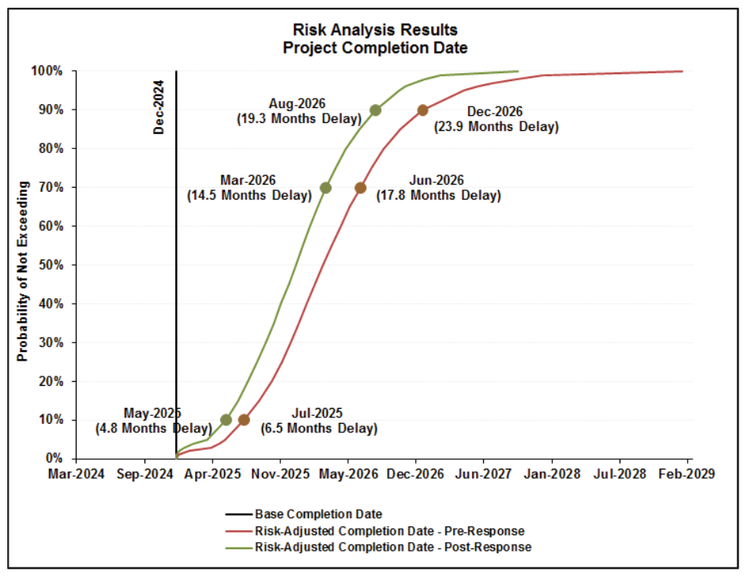
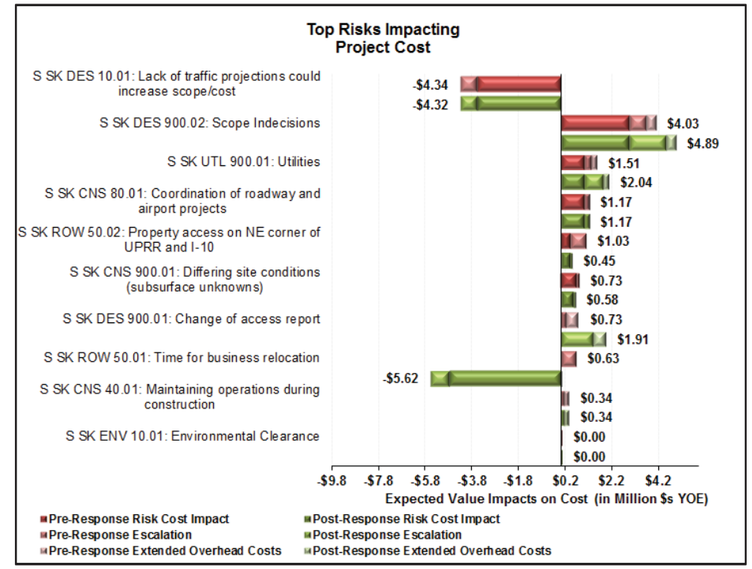
Alternative Cost Risk Assessment Results

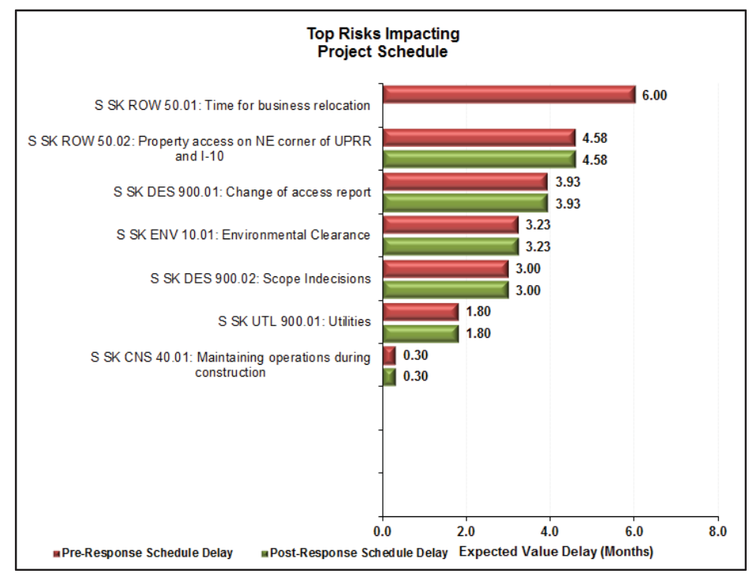
Alternative 1 – Cost & Schedule 'S-Curve'



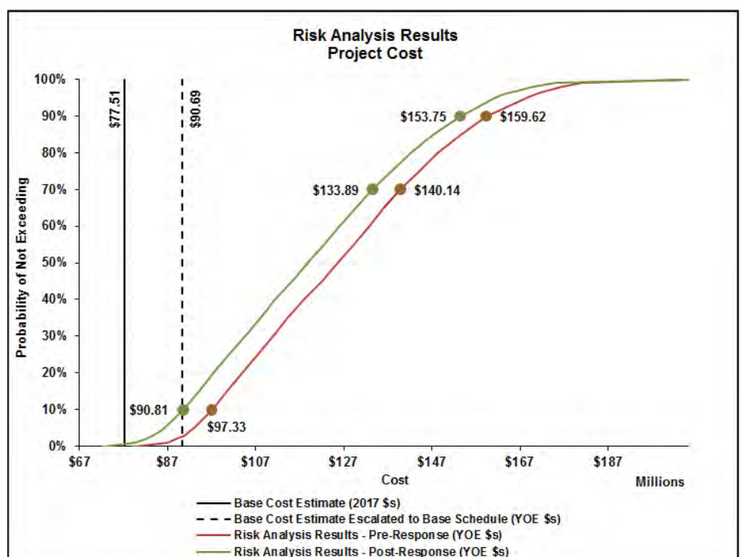


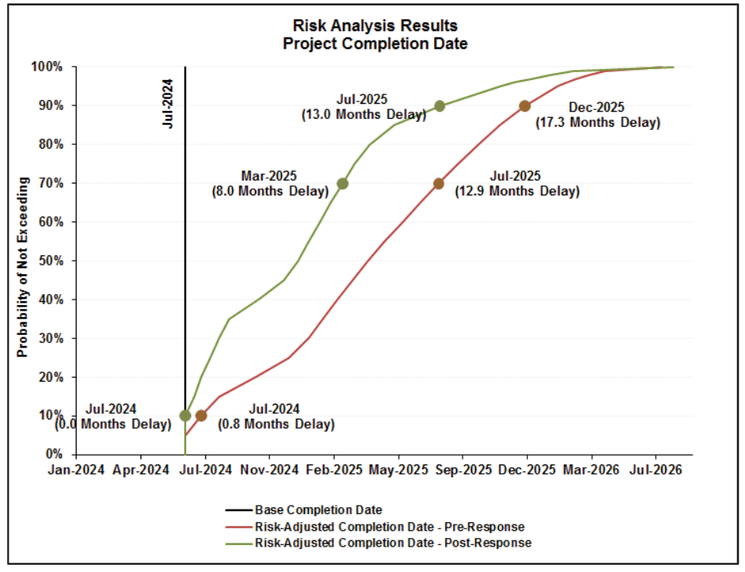
Alternative 1 – Cost & Schedule Tornado Diagrams



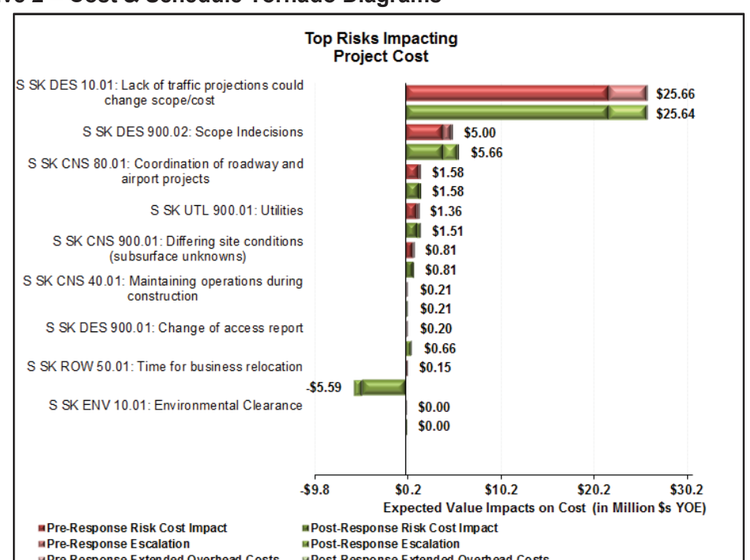


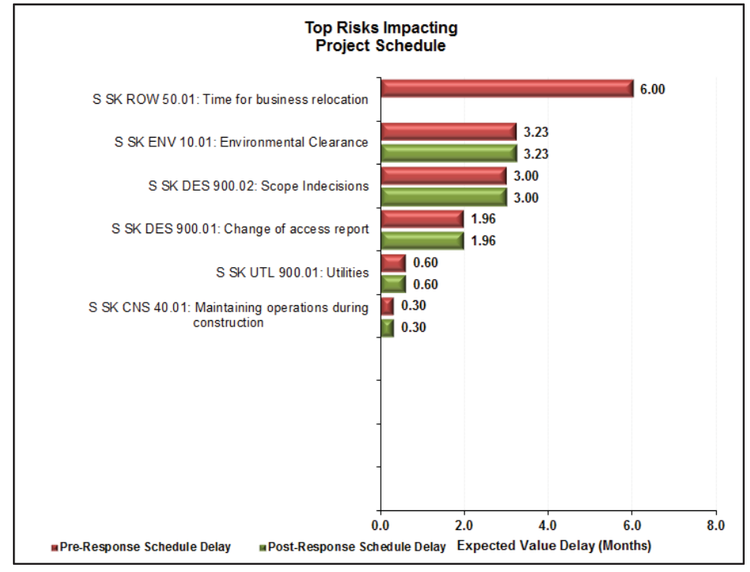
Alternative 2 – Cost & Schedule 'S-Curves'



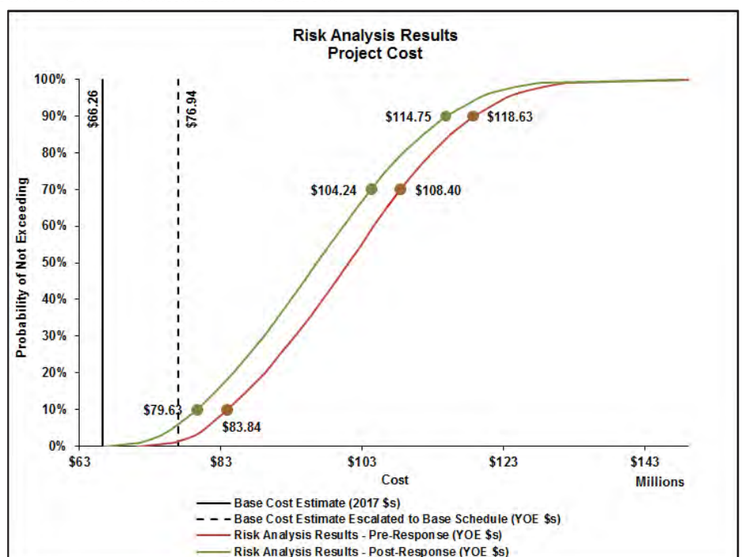


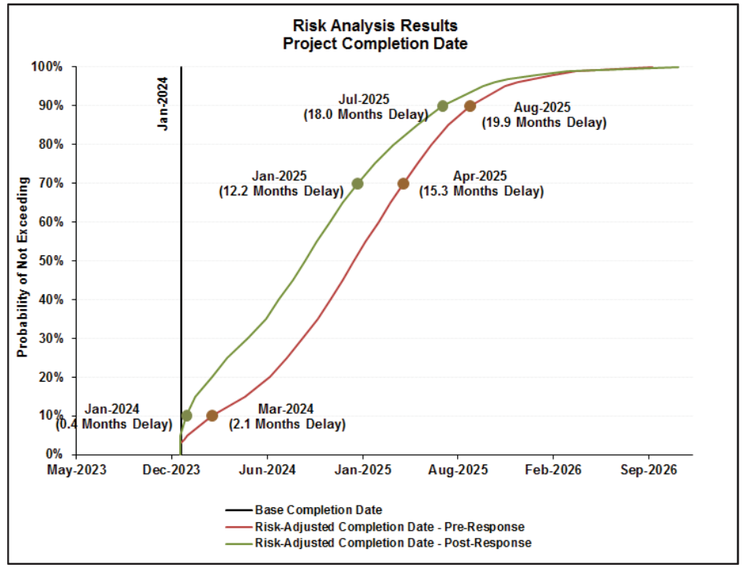
Alternative 2 – Cost & Schedule Tornado Diagrams



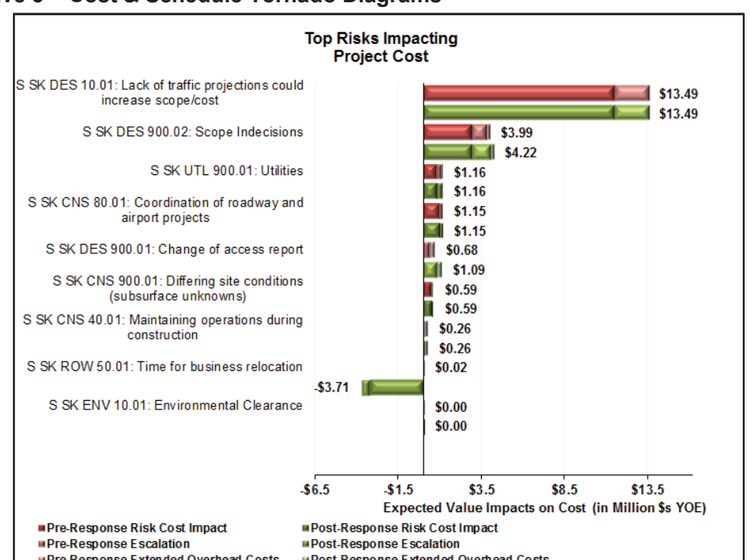


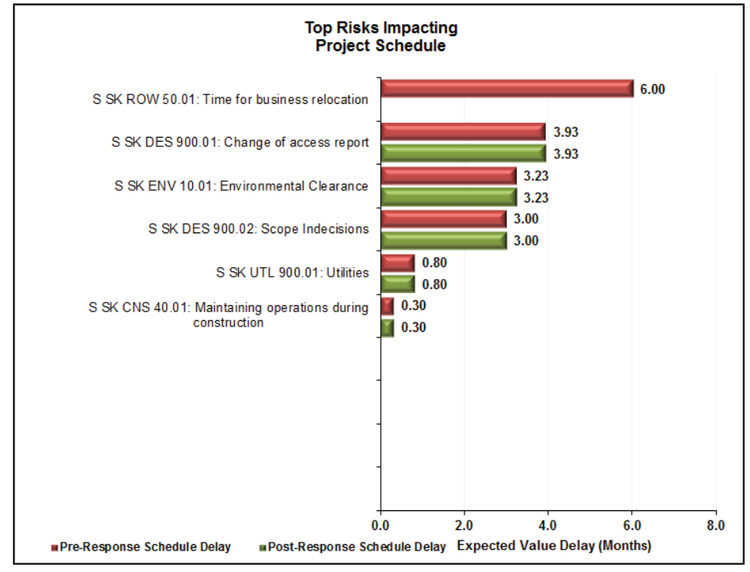
Alternative 3 – Cost & Schedule 'S-Curves'





Alternative 3 – Cost & Schedule Tornado Diagrams





Risk Data Sheets

Alternative 1 Risk Data Sheets

Project	Sky Harbor Airport	Risk ID	S SK ROW 50.01
Sub-Project	Sky Harbor	Status	Active

Time for business relocation

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	6.00	12.00	18.00	6.00			

Greyhound and Community Tire have to be relocated. They are both on airport property. However, the acquisition could be longer than the allocated time delaying the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	-$6.00	-$6.00	-$6.00	-$4.80	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

In the lease agreements, specify the time the businesses need to be relocated. Base schedule has advertisement date of 4/1/2022. This will avoid the schedule delay and could save the project $6 million.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

July 5, 2017 Risk Register Page 1 of 10

Project	Sky Harbor Airport	Risk ID	S SK DES 10.01
Sub-Project	Sky Harbor	Status	Active

Lack of traffic projections could increase scope/cost

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	-$25.00	-$10.00	-$5.00	-$2.92	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

At the planning level, traffic analysis has not been started. Upon further analysis, additional infrastructure may be required to mitigate this issue. This could be an opportunity for Alt-1. One example is revising access or not requiring all the braided ramps

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	-$25.00	-$10.00	-$5.00	-$2.92	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Advance the project and make necessary decisions.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

July 5, 2017 Risk Register Page 2 of 10

Project	Sky Harbor Airport	Risk ID	S SK ENV 10.01
Sub-Project	Sky Harbor	Status	Active

Environmental Clearance

Risk Trigger		Flowchart Activity	305
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	-4.00	6.00	12.00	4.00			

Obtaining environmental clearance and who is the lead fed agency. Base schedule assumes 12 months. Savings could be a lower level clearance document will be required. Delay could be a higher level document will be required.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	-4.00	6.00	12.00	4.00	Accept	

Advance the design and update the schedule.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	Sky Harbor Airport	Risk ID	S SK DES 900.01
Sub-Project	Sky Harbor	Status	Active

Change of access report

Risk Trigger		Flowchart Activity	300
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	3.00	9.00	12.00	4.25			

Change of Access report for I-10 would require FHWA HQ approval. There is only 9 months for the approval process in the 18-month design schedule. FHWA requires 3 months for review and approval. The risk is submitting at 50% design.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	3.00	9.00	12.00	4.25	Mitigate	

FHWA can give DEOA (determination of engineering operational acceptability) prior to NEPA approval.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	Sky Harbor Airport	Risk ID	S SK CNS 900.01
Sub-Project	Sky Harbor	Status	Active

Differing site conditions (subsurface unknowns)

Risk Trigger		Flowchart Activity	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.50	$1.00	$2.00	$0.54	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

5% for change order contingency has remained in the base cost. This risk is on and above that due to no geotechnical information and potential hazardous materials / contaminated soils.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)	$0.50	$1.00	$2.00	$0.43	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Conduct geotechnical investigations and site studies.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

MARICOPA ASSOCIATION of GOVERNMENTS

Project	Sky Harbor Airport	Risk ID	S SK UTL 900.01
Sub-Project	Sky Harbor	Status	Active

Utilities

Risk Trigger		Flowchart Activity	cost to 320; schedule to 300

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%							
Cost ($M)	$1.00	$2.00	$4.00	$0.87	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	3.00	4.50	6.00	1.80			

No utility investigations have been made and there is no allowance in the current base cost for utilities. Roadway relocation and excavation can have utility impacts. This risk includes building bridges over railroad.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)	$1.00	$2.00	$4.00	$0.87	Strategy	6/29/2017
Schedule (Mo)	3.00	4.50	6.00	1.80	Mitigate	

Conduct SUE and update the estimate.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	**Risk ID**	S SK CNS 80.01
Sub-Project	Sky Harbor	**Status**	Active

Coordination of roadway and airport projects

Risk Trigger		**Flowchart Activity**	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.50	$1.00	$2.00	$0.87	**Project Rank Cost**	**Project Rank Schedule**	2/16/2017
Schedule (Mo)				0.00			

In order to make temporary connections with other planned projects, there maybe requirements for temporary infrastructure.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.50	$1.00	$2.00	$0.87	**Strategy**	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate roadway and airport projects; consider phasing of projects to minimize impacts.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	**Risk ID**	S SK DES 900.02
Sub-Project	Sky Harbor	**Status**	Active

Scope Indecisions

Risk Trigger		**Flowchart Activity**	Schedule 300; cost 320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$1.00	$5.00	$10.00	$2.58	**Project Rank Cost**	**Project Rank Schedule**	2/16/2017
Schedule (Mo)	4.00	6.00	8.00	3.00			

Separating needs and wants, and building consensus on the scope could result in delays to design and added infrastructure. Some scope creep items such as pavement overlay, structure rehabs, sign rehabs, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$1.00	$5.00	$10.00	$2.58	**Strategy**	6/29/2017
Schedule (Mo)	4.00	6.00	8.00	3.00	Mitigate	

Early and continued coordination with stakeholders.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK CNS 40.01
Sub-Project	Sky Harbor	Status	Active

Maintaining operations during construction

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	0.25	0.50	1.00	0.27			

There maybe temporary moratoriums on impacts on traffic during holidays that could delay the construction activities.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	0.25	0.50	1.00	0.27	Mitigate	

Develop MOT plans and update the schedule.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

MARICOPA ASSOCIATION of GOVERNMENTS

Project	Sky Harbor Airport	Risk ID	S SK ROW 50.02
Sub-Project	Sky Harbor	Status	Active

Property access on NE corner of UPRR and I-10

Risk Trigger		Flowchart Activity	310
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.40	$0.80	$1.00	$0.38	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	1.00	4.00	18.00	2.92			

Scenario 1 has an impact to a trucking warehouse (the property on the NE corner of UPRR and I-10). Base assumes $2 million. This could have a cost and schedule delay for relocation. Hold a 40% contingency for administrative settlement and relocation.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.40	$0.80	$1.00	$0.38	Strategy	6/29/2017
Schedule (Mo)	1.00	4.00	18.00	2.92	Mitigate	

Start early coordination; update estimate accordingly.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Alternative 2 Risk Data Sheets

Project	Sky Harbor Airport	Risk ID	S SK ROW 50.01
Sub-Project	Sky Harbor	Status	Active

Time for business relocation

Risk Trigger		Flowchart Activity	310
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	6.00	12.00	18.00	6.00			

Greyhound and Community Tire have to be relocated. They are both on airport property. However, the acquisition could be longer than the allocated time delaying the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	-$6.00	-$6.00	-$6.00	-$4.80	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

In the lease agreements, specify the time the businesses need to be relocated. Base schedule has advertisement date of 4/1/2022. This will avoid the schedule delay and could save the project $6 million.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

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Project	Sky Harbor Airport	Risk ID	S SK DES 10.01
Sub-Project	Sky Harbor	Status	Active

Lack of traffic projections could change scope/cost

Risk Trigger		Flowchart Activity	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$5.00	$25.00	$50.00	$19.38	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

At the planning level, traffic analysis has not been started. Upon further analysis, additional infrastructure may be required to mitigate this issue. One example is revising access or requiring braided ramps.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$5.00	$25.00	$50.00	$19.38	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Advance the project and make necessary decisions.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

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Project	Sky Harbor Airport	Risk ID	S SK ENV 10.01
Sub-Project	Sky Harbor	Status	Active

Environmental Clearance

Risk Trigger		Flowchart Activity	305
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	-4.00	6.00	12.00	4.00			

Obtaining environmental clearance and who is the lead fed agency. Base schedule assumes 12 months. Savings could be a lower level clearance document will be required. Delay could be a higher level document will be required.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	-4.00	6.00	12.00	4.00	Accept	

Advance the design and update the schedule.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	Sky Harbor Airport	Risk ID	S SK DES 900.01
Sub-Project	Sky Harbor	Status	Active

Change of access report

Risk Trigger		Flowchart Activity	300
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	3.00	9.00	12.00	2.13			

Change of Access report for I-10 would require FHWA HQ approval. There is only 9 months for the approval process in the 18-month design schedule. FHWA requires 3 months for review and approval. The risk is submitting at 50% design.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	3.00	9.00	12.00	2.13	Mitigate	

FHWA can give DEOA (determination of engineering operational acceptability) prior to NEPA approval.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	Risk Assignment

Project	Sky Harbor Airport	Risk ID	S SK CNS 900.01
Sub-Project	Sky Harbor	Status	Active

Differing site conditions (subsurface unknowns)

Risk Trigger		Flowchart Activity	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

5% for change order contingency has remained in the base cost. This risk is on and above that due to no geotechnical information and potential hazardous materials / contaminated soils.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Conduct geotechnical investigations and site studies.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK UTL 900.01
Sub-Project	Sky Harbor	Status	Active

Utilities

Risk Trigger		Flowchart Activity	cost to 320; schedule to 300

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%							
Cost ($M)	$1.00	$2.00	$3.00	$0.80	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	1.00	1.50	2.00	0.60			

No utility investigations have been made and there is no allowance in the current base cost for utilities. Roadway relocation and excavation can have utility impacts.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)	$1.00	$2.00	$3.00	$0.80	Strategy	6/29/2017
Schedule (Mo)	1.00	1.50	2.00	0.60	Mitigate	

Conduct SUE and update the estimate.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	**Risk ID**	S SK CNS 80.01
Sub-Project	Sky Harbor	**Status**	Active

Coordination of roadway and airport projects

Risk Trigger		**Flowchart Activity**	320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.50	$1.00	$2.00	$0.87	**Project Rank Cost**	**Project Rank Schedule**	2/16/2017
Schedule (Mo)				0.00			

In order to make temporary connections with other planned projects, there maybe requirements for temporary infrastructure.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.50	$1.00	$2.00	$0.87	**Strategy**	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate roadway and airport projects; consider phasing of projects to minimize impacts.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	**Risk ID**	S SK DES 900.02
Sub-Project	Sky Harbor	**Status**	Active

Scope Indecisions

Risk Trigger		**Flowchart Activity**	Schedule 300; cost 320
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$1.00	$5.00	$10.00	$2.58	**Project Rank Cost**	**Project Rank Schedule**	2/16/2017
Schedule (Mo)	4.00	6.00	8.00	3.00			

Separating needs and wants, and building consensus on the scope could result in delays to design and added infrastructure. Some scope creep items such as pavement overlay, structure rehabs, sign rehabs, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$1.00	$5.00	$10.00	$2.58	**Strategy**	6/29/2017
Schedule (Mo)	4.00	6.00	8.00	3.00	Mitigate	

Early and continued coordination with stakeholders.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK CNS 40.01
Sub-Project	Sky Harbor	Status	Active

Maintaining operations during construction

Risk Trigger		Flowchart Activity	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	0.25	0.50	1.00	0.27			

There maybe temporary moratoriums on impacts on traffic during holidays that could delay the construction activities.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	0.25	0.50	1.00	0.27	Mitigate	

Develop MOT plans and update the schedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

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Alternative 3 Risk Data Sheets

Project	Sky Harbor Airport	Risk ID	S SK ROW 50.01
Sub-Project	Sky Harbor	Status	Active

Time for business relocation

Risk Trigger		Flowchart Activity	310

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	6.00	12.00	18.00	6.00			

Community Tire has to be relocated. This is on airport property. However, the acquisition could be longer than the allocated time delaying the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	-$4.00	-$4.00	-$4.00	-$3.20	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

In the lease agreements, specify the time the businesses need to be relocated. Base schedule has advertisement date of 4/1/2022. This will avoid the schedule delay and could save the project $6 million.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

July 5, 2017 Risk Register Page 1 of 9

Project	Sky Harbor Airport	Risk ID	S SK DES 10.01
Sub-Project	Sky Harbor	Status	Active

Lack of traffic projections could increase scope/cost

Risk Trigger		Flowchart Activity	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$5.00	$15.00	$25.00	$11.25	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

At the planning level, traffic analysis has not been started. Upon further analysis, additional infrastructure may be required to mitigate this issue. One example is revising access or requiring all the braided ramps

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$5.00	$15.00	$25.00	$11.25	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Advance the project and make necessary decisions.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK ENV 10.01
Sub-Project	Sky Harbor	Status	Active

Environmental Clearance

Risk Trigger		Flowchart Activity	305

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	-4.00	6.00	12.00	4.00			

Obtaining environmental clearance and who is the lead fed agency. Base schedule assumes 12 months. Savings could be a lower level clearance document will be required. Delay could be a higher level document will be required.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	-4.00	6.00	12.00	4.00	Accept	

Advance the design and update the schedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK DES 900.01
Sub-Project	Sky Harbor	Status	Active

Change of access report

Risk Trigger		Flowchart Activity	300

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	3.00	9.00	12.00	4.25			

Change of Access report for I-10 would require FHWA HQ approval. There is only 9 months for the approval process in the 18-month design schedule. FHWA requires 3 months for review and approval. The risk is submitting at 50% design.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	Strategy	6/29/2017
Schedule (Mo)	3.00	9.00	12.00	4.25	Mitigate	

FHWA can give DEOA (determination of engineering operational acceptability) prior to NEPA approval.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK CNS 900.01
Sub-Project	Sky Harbor	Status	Active

Differing site conditions (subsurface unknowns)

Risk Trigger		Flowchart Activity	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

5% for change order contingency has remained in the base cost. This risk is on and above that due to no geotechnical information and potential hazardous materials / contaminated soils.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Conduct geotechnical investigations and site studies.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	Risk ID	S SK UTL 900.01
Sub-Project	Sky Harbor	Status	Active

Utilities

Risk Trigger		Flowchart Activity	cost to 320; schedule to 300

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
40%							
Cost ($M)	$1.00	$2.00	$3.00	$0.80	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)	1.00	2.00	3.00	0.80			

No utility investigations have been made and there is no allowance in the current base cost for utilities. Roadway relocation and excavation can have utility impacts.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
40%						
Cost ($M)	$1.00	$2.00	$3.00	$0.80	Strategy	6/29/2017
Schedule (Mo)	1.00	2.00	3.00	0.80	Mitigate	

Conduct SUE and update the estimate.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

MARICOPA ASSOCIATION of GOVERNMENTS

Project	Sky Harbor Airport	Risk ID	S SK CNS 80.01
Sub-Project	Sky Harbor	Status	Active

Coordination of roadway and airport projects

Risk Trigger		Flowchart Activity	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.50	$1.00	$2.00	$0.87	Project Rank Cost	Project Rank Schedule	2/16/2017
Schedule (Mo)				0.00			

In order to make temporary connections with other planned projects, there maybe requirements for temporary infrastructure.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.50	$1.00	$2.00	$0.87	Strategy	6/29/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate roadway and airport projects; consider phasing of projects to minimize impacts.

Monitoring and Control

Risk Owner		Risk Aging	From		Status Interval
			To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Sky Harbor Airport	**Risk ID**	S SK DES 900.02
Sub-Project	Sky Harbor	**Status**	Active

Scope Indecisions

Risk Trigger		**Flowchart Activity**	Schedule 300; cost 320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$1.00	$5.00	$10.00	$2.58	**Project Rank Cost**	**Project Rank Schedule**	2/16/2017
Schedule (Mo)	4.00	6.00	8.00	3.00			

Separating needs and wants, and building consensus on the scope could result in delays to design and added infrastructure. Some scope creep items such as pavement overlay, structure rehabs, sign rehabs, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$1.00	$5.00	$10.00	$2.58	**Strategy**	6/29/2017
Schedule (Mo)	4.00	6.00	8.00	3.00	Mitigate	

Early and continued coordination with stakeholders.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

July 5, 2017 Risk Register Page 8 of 9

Project	Sky Harbor Airport	**Risk ID**	S SK CNS 40.01
Sub-Project	Sky Harbor	**Status**	Active

Maintaining operations during construction

Risk Trigger		**Flowchart Activity**	320

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	**Project Rank Cost**	**Project Rank Schedule**	2/16/2017
Schedule (Mo)	0.25	0.50	1.00	0.27			

There maybe temporary moratoriums on impacts on traffic during holidays that could delay the construction activities.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	**Strategy**	6/29/2017
Schedule (Mo)	0.25	0.50	1.00	0.27	Mitigate	

Develop MOT plans and update the schedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

July 5, 2017 Risk Register Page 9 of 9

Value Planning Agenda

I-10 West T. I. Access with Phoenix Sky Harbor Projects
CRA / Value Planning / Agenda

February 13 – 17, 2017

Location: 2485 E. Buckeye Road, Phoenix AZ.

Core Group: Chaun Hill, Quinn Castro, Sarah Carter, Molly Monserud, Jordan Feld, Ken Smith, Suresh Raghavendra, Brian Bombardier

Monday 8:00 AM	• Introduction / Background • Presentation of Design Elements and Constraints & Controlling Decisions o West Access TI at I-10 o T2 / T3 o Sky Train o U & V Taxiways o Roadway o West GTC o Air Cargo/Freight o West Terminal o Other
Monday 12:30 PM	• Airport Needs / Wants • COP Needs / Wants • ADOT Needs / Wants • Evaluation Criteria • Paired Comparison
Tuesday 8:00 AM	• Footprint Map o Identify elements that are set in space (layout) and time (schedule) • Brainstorm Ideas (Creative Phase)
Tuesday 12:30 PM	• Group Scoring of Ideas • Shortlist 2 or 3 Themes (family of ideas)
Wednesday 8:00 AM	• Design Competition to Develop Solutions
Thursday 8:00 AM	• Conduct CRA on the Alternatives • Evaluation to Select the Best Value Solution
Friday 8:00 AM	• Develop Master Schedule (to include all the design elements) and Cash Flow • Presentation Preparation
Friday 1:00 PM	• Presentation
Friday 2:30 PM	• Adjourn

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Value Planning Attendees

MARICOPA ASSOCIATION of GOVERNMENTS					I-10 West T. I. Access with Phoenix Sky Harbor Projects – Design Charrette Feb 13 – 17, 2017			HDR	
DATE					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
Feb 13	Feb 14	Feb 15	Feb 16	Feb 17				OFFICE	CELL
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X	X	X	X	X	Ken Smith	HDR	Workshop Facilitator	360 570 4415	360 451 2527
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X	X	X	X	X	Suresh Raghavendra	HDR	Workshop Assistant	602 522 4328	
								Suresh.raghavendra@hdrinc.com	
X	X	X	X	X	Trent Eakin	HDR	Modeler	360 570 7270	
								Trent.eakin@hdrinc.com	
X				X	Eric Anderson	MAG	Transportation Director	602 254 6300	
								eanderson@azmag.gov	
X	X	X	X	X	Chaun Hill	MAG	Senior Transportation Engineer	602 254 6300	
								chill@azmag.gov	
QQ	QQ	QQ	QQ	QQ	Quinn Castro	MAG	Transportation Engineer	602 254 6300	
								qcastro@azmag.gov	
			X		Bob Hazlett	MAG	Senior Engineering Manager	602 254 6300	
								bhazlett@azmag.gov	
AKT	AKT	AKT	AKT	AKT	Audra Koester Thomas	MAG	Transit Planning Project Manager	602 254 6300	
								akthomas@azmag.gov	
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								tstrow@azmag.gov	
X		X		X	Jesse Gutierrez	ADOT	Deputy State Engineer	928 200 1054	
								jgutierrez@azdot.gov	
X				X	Steve Boschen	ADOT	Infrastructure Delivery and Operations, Director	9	
								sboschen@azdot.gov	

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DATE					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
Feb 13	Feb 14	Feb 15	Feb 16	Feb 17				OFFICE	CELL
								EMAIL	
AR				X	Annette Riley	ADOT	Asst. State Engineer		
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								temery@azdot.gov	
–	SB	SB	–	SB	Scott Beck	ADOT			
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								Thomas.remes@phoenix.gov	

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Feb 13 – 17, 2017

HDR

DATE					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
Feb 13	Feb 14	Feb 15	Feb 16	Feb 17				OFFICE	CELL
								EMAIL	
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								Myesha.harris@phoenix.gov	
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								eileen.yazzie@phoenix.gov	

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I-10 West T. I. Access with Phoenix Sky Harbor Projects – Design Charrette
Feb 13 – 17, 2017

HDR

DATE					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
Feb 13	Feb 14	Feb 15	Feb 16	Feb 17				OFFICE	CELL
								EMAIL	
✓	✓	✓	X	X	Jordan Feld	COP			
								jordan.feld@phoenix.gov	
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								Sarah.Carter@pheonix.gov	
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								Robyn.sahid@phoenix.gov	
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								Katherine.coles@phoenix.gov	
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								floyd.johnson@cphoenix.gov	
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								Nicole.swanson@phoenix.gov	
X	X	X	X	X	RANDALL PAYNE	COP			

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Feb 13 – 17, 2017

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DATE					NAME	ORGANIZATION	POSITION/DISCIPLINE	TELEPHONE	
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								EMAIL	
KN				X	Katherine Nickel	COP			
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X	X	X	X	X	Nate Warnum	Kimley Horn			
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	✓	X	X	X	Kim Carroll	Kimley Horn	TRAFFIC	602-906-1122	602-525-9078
								kim.carroll@kimley-horn.com	
X	X	X	X	X	John Kissinger	Kimely Horn	Traffic / ITS		
								John.kissinger@kimley-horn.com	
X	X	X		X	Mark Pilwallis	Gannett Fleming			
								mpilwallis@gfnet.com	
X	X	X	X	X	Reed Henry	ADOT	Roadway Eng	602-712-6490	
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X					CHRIS YOUNG	CO PHX	DCM	602 534-7602	
								CHRISTOPHER.YOUNG@PHOENIX.GOV	
X	X	X	X	X	NATE WALNUM	KIMLEY-HORN	SKYTRAIN CIVIL ENG.	602-906-1111	602-478-7746
								nate.walnum@kimley-horn.com	
X				X	Kyle Eshel	FAA	Planner		
								kyle.eshel@faa.gov	
X	X			X	Jason Bernard	B&N			
X					Courtney Carter	COP	Planner II	602-683-2633	
								courtney.carter@phoenix.gov	
	X				Curtis Richardson	COP	Aux. Pv II	602 273-4310	
								Curtis.richardson@phoenix.gov	
	X	X		X	Rimpal Shah	ADOT	ADOT, PMG	602-712-2167	

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Feb 13	Feb 14	Feb 15	Feb 16	Feb 17				OFFICE	CELL
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X	X	X	X	X	Molly Monserud	City of Phoenix Aviation (P&E)	Project Manager - Planning	602-273-2097	
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X	X	X	X	X	Floyd Johnson	City of Phoenix AVN OPS	Landside Supervisor Tenant OPERATIONS	602-273-2165	
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X	X	X		X	Mark Milstone	City of Phx Streets/Trans	CE III		
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Value Planning Report Out

Safety First

- *Emergency Exits*
  - *Muster point*
- *CPR*
- *The number for "911"*

2

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Introductions

- Who are you?
- Who are you representing?
- Were you on the Value Planning / Cost Risk Assessment Team?

3

3

Plan the Work and Work the Plan

4

MARICOPA ASSOCIATION of GOVERNMENTS

Addressing Cost and Schedule Concerns

Usual Questions

- How much will it cost?
- How long will it take?
- Why does it cost that much?
- Why does it take that long?

Analysis Needs

- Risk Identification
- Qualitative and Quantitative Risk Analysis
- Value Engineering &Mitigation Strategies
- Risk Monitoring & Control

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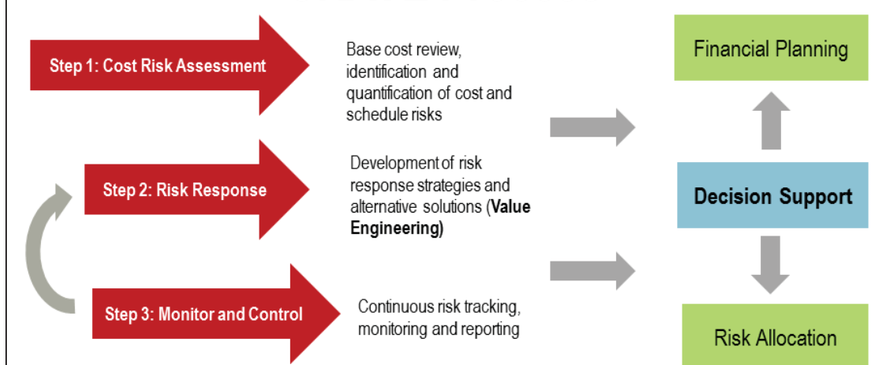
CRAVE Process



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Value Planning / CRA Process

- Brainstorm and evaluate ideas
- Design competition
  - Combining ideas and planned projects
  - Defining access to and from the airport facilities
  - Assessing Risks
  - Mitigating risks

Performance Based Value Planning

Value Planning is not just about reducing project costs, but can also improve project performance

- Roadway Operations
- Airport Operations
- Maintainability
- Construction Impacts
- Environmental Impacts
- Promotes Economic Growth

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

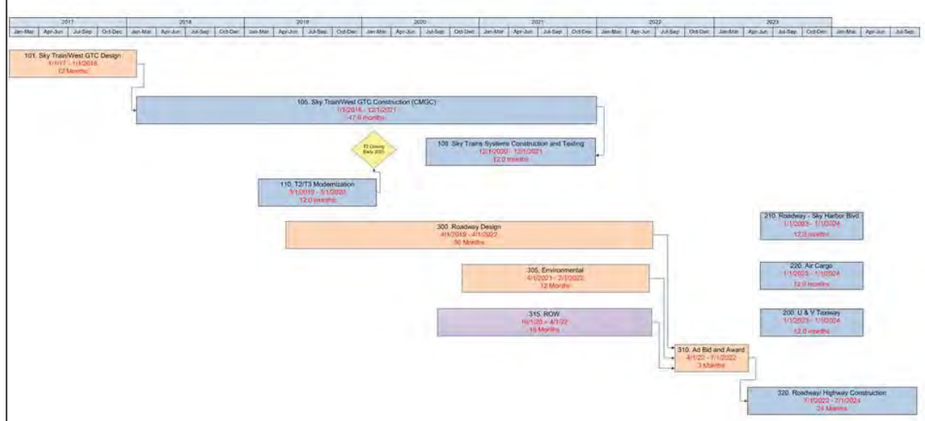
8

Weighting of Performance Attributes

Performance Attributes Criteria Matrix										
Paired Comparison										
									Total points	% of Total
Freeway Operations	A	A/B	A	A	A	A	A	A	7.5	20.8%
Airport Operations		B	B	B	B	B	G	B	6.5	18.0%
Maintainability			C	C/D	C	F	G	H	2.5	6.9%
Construction Impacts				D	D/E	F	G	H	2.0	5.5%
Environmental Impacts					E	F	G	H	1.5	4.1%
Promotes Economic Growth						F	G	F/H	4.5	12.5%
Security							G	G	7.0	19.8%
Local Roadway Operations								H	4.5	12.5%
								Total	36.0	100%

9

Assumed Schedule



10

Design Competition Goals

- Each team was challenged with improving the regional transportation facilities:
  - Overall concept
  - Access to and from the airport
  - Access to and from RCC
  - Access to and from GTC
  - Access for cargo

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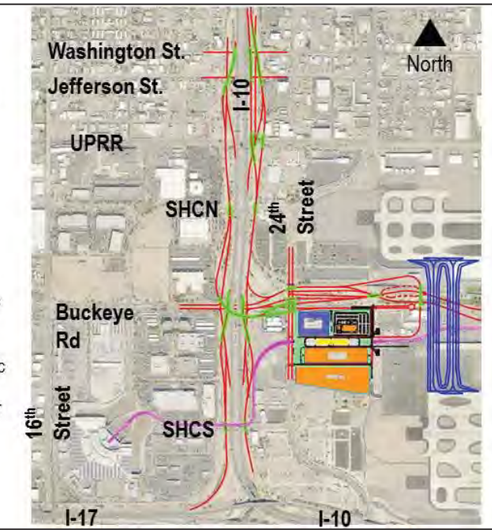
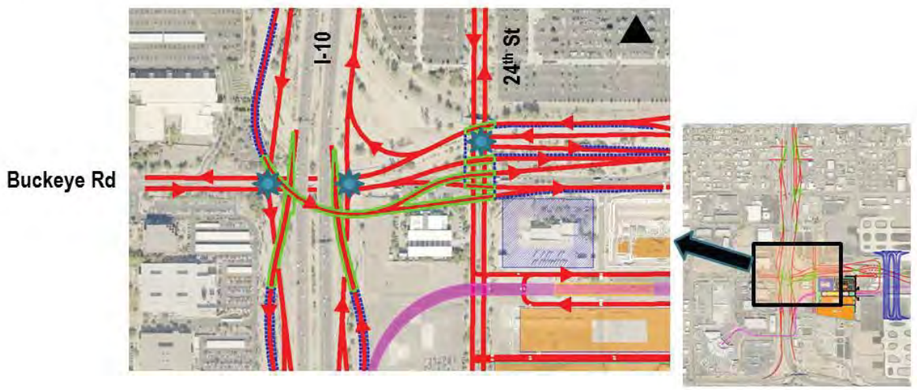
Team 1 Concept Overview

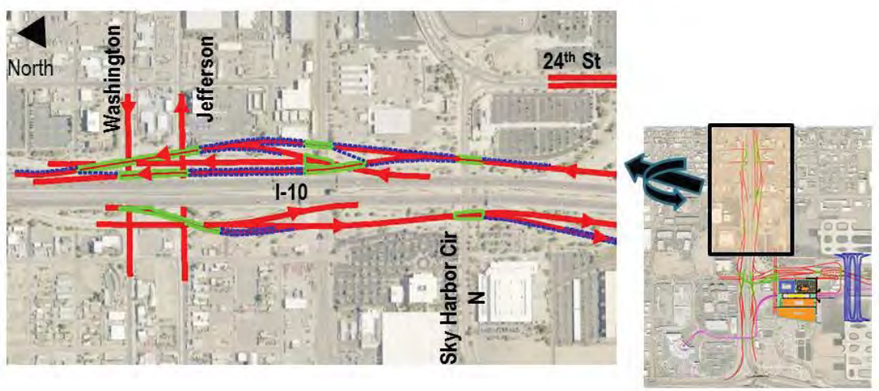
- Full Access Traffic Interchange on I-10 serving both sides of freeway
  - Encourage south to east and west to north movements
- Fix I-10 weaving issues surrounding airport interchange
- Direct non-stop access between I-10/I-17 freeways and airport core
- Direct non-stop access between I-10/I-17 freeways and WGTC
- Simple and non-circuitous routing of RCC traffic from I-10/I-17 freeways
- Maintain WGTC clockwise access
- Ability to perform security inspection for all traffic entering core
- Cross over traffic for reverse flow on Sky Harbor Blvd west of taxiway
- 24th Street BRT/Bike/Pedestrian intermodal connection to WGTC



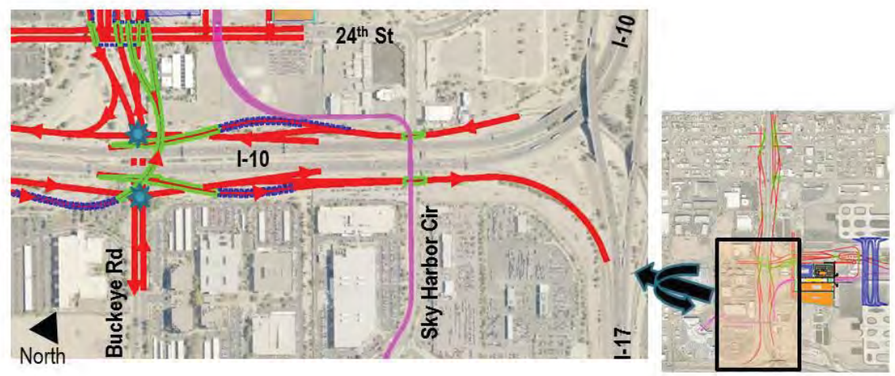
I-17 Interchange at Buckeye Road/Sky Harbor Blvd.



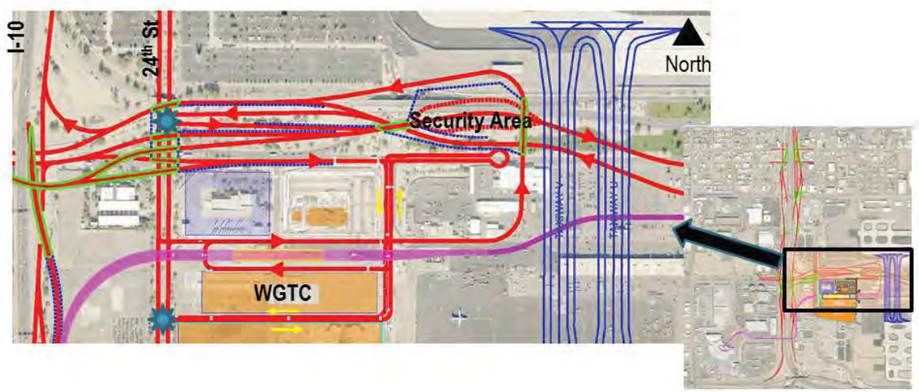
I-10 between Washington and Buckeye Road



I-10 between Buckeye Road and I-17



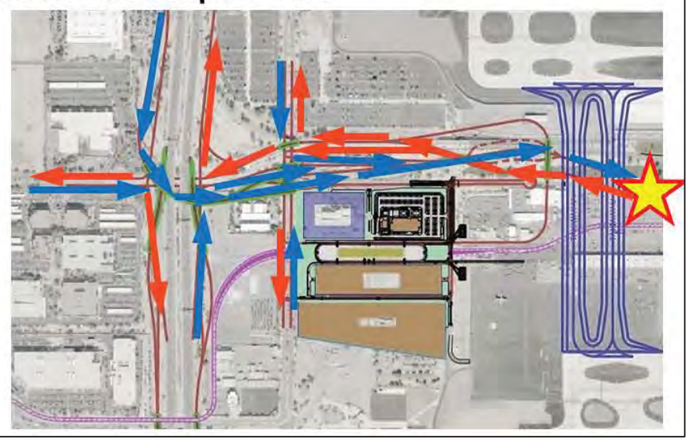
Sky Harbor Boulevard



Primary Access to/from Airport Core

To Core

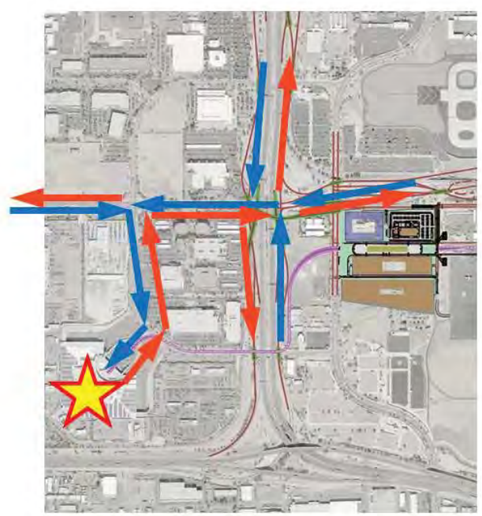
From Core



Primary Access to/from RCC

To RCC

From RCC



Primary Access for WGTC (north, south, and west)

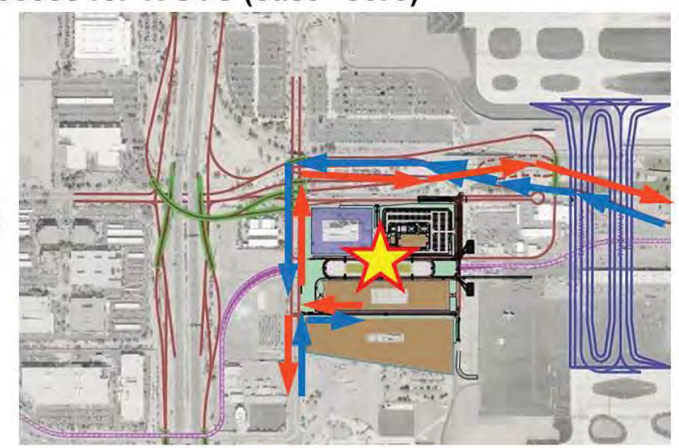
To WGTC

From WGTC

Secondary Access for WGTC (east - core)

To WGTC

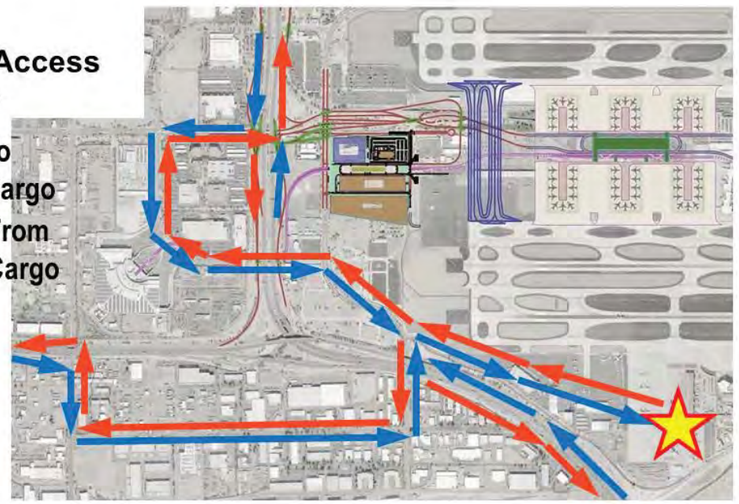
From WGTC



Freeway Access for Cargo

To Cargo

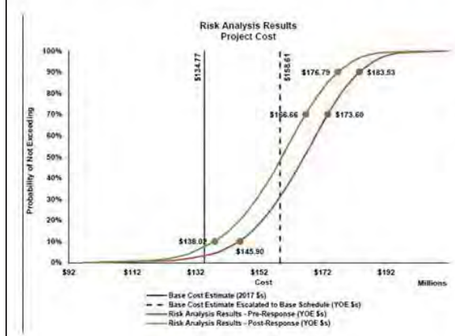
From Cargo

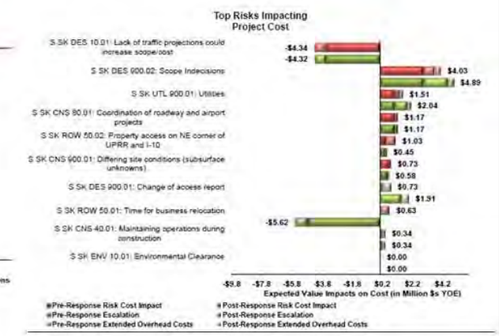


Group 1 Takeaways

- A single access point on I-10 that serves the airport to the east and the future planned land use to the west is critical.
- The interchange design should be simple, driver expectant, and easy to sign destinations.
- Improving I-10 between I-17 and SR-51 is complex and expensive, but essential to serving the economic hub (airport and downtown Phoenix) of the region for the long term.

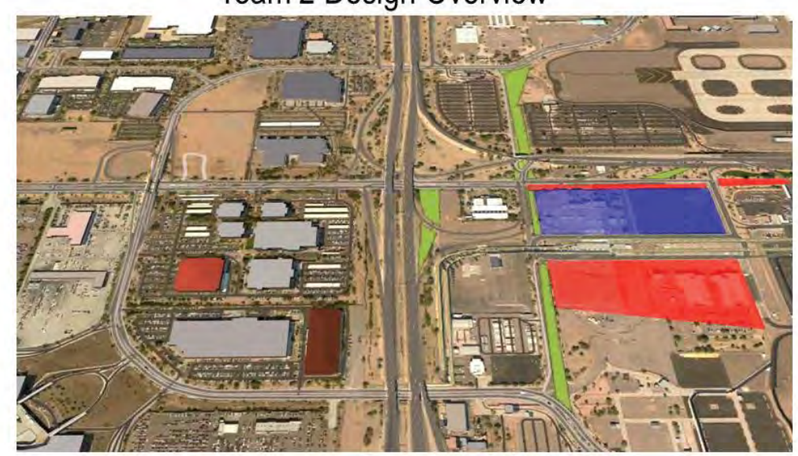
Team 1 Modeled Results





23

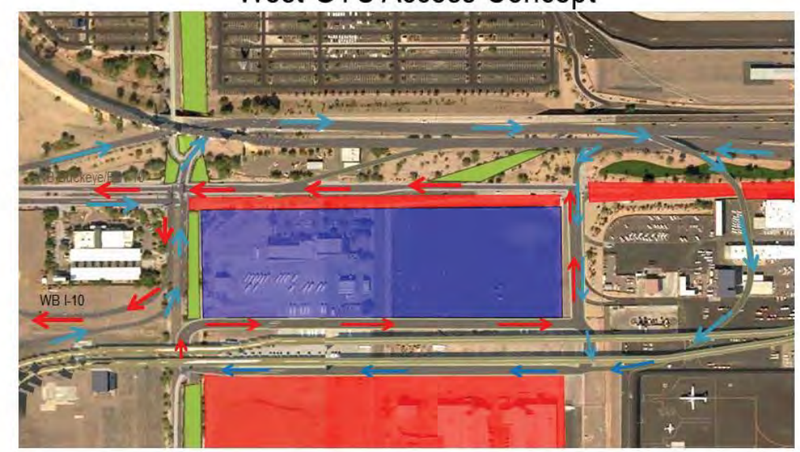
Team 2 Design Overview



Airport Access Concept

RCC Access Concept

West GTC Access Concept



LEGEND: IN OUT

Cargo Access Concept

LEGEND:
IN
OUT

Sky Harbor Circle – Buckeye Interchange

Sky Harbor Circle – Buckeye Interchange Alternative

Sky Harbor Circle to 24th Street – North Side

24th Street to Sky Harbor Circle – South Side

Takeaways

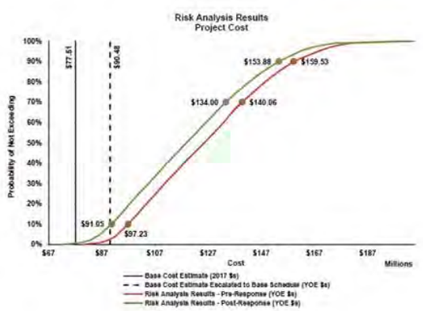
Rental Car Center Focus

- Free-flow from EB Buckeye to I-10 WB (North)
- Enhanced right-only access from EB I-10 to RCC; right-only exit from RCC to I-10

Creative Options

- Doesn't limit freeway enhancements
- Minimizes existing RPZ conflicts
- Offers ways to optimize existing investments and phasing (e.g., expanded RCC opportunity, multimodal considerations)

Team 2 Modeled Results



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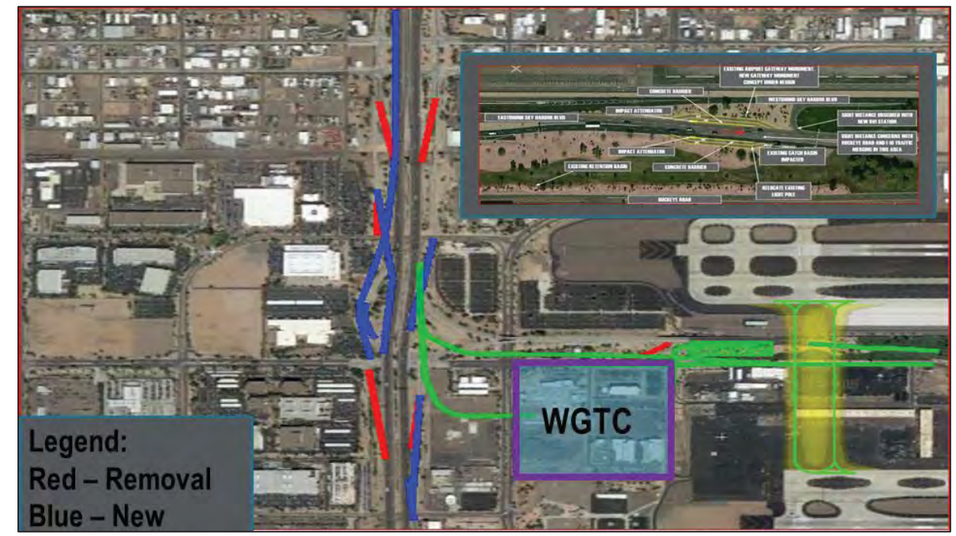
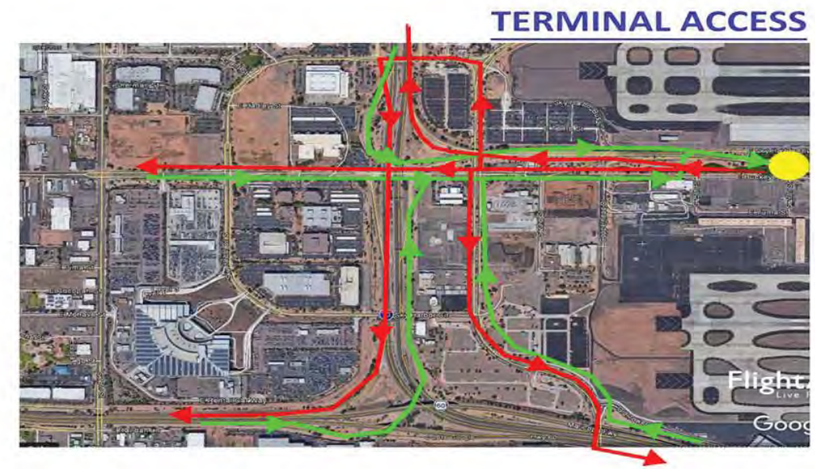
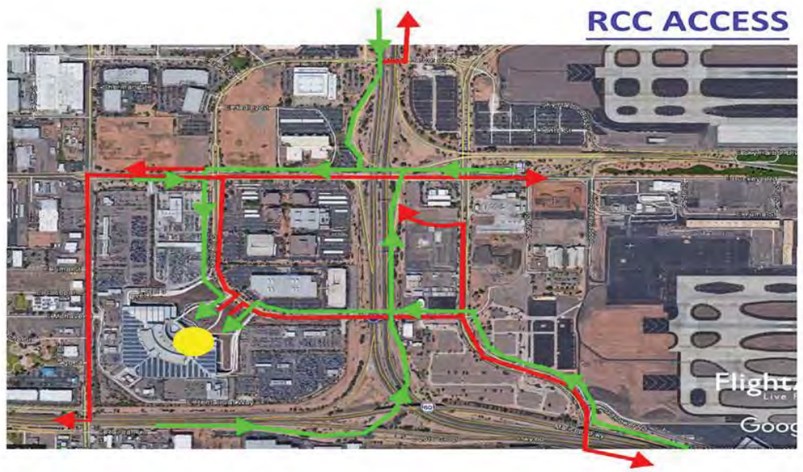
MARICOPA ASSOCIATION of GOVERNMENTS



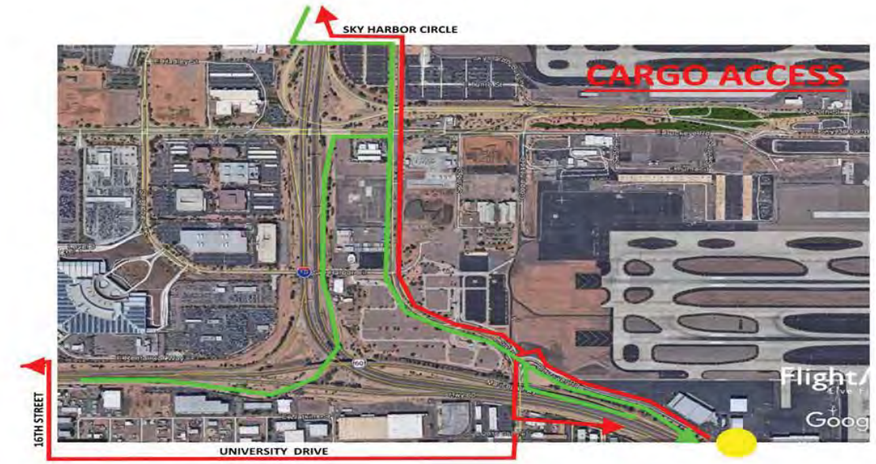


RCC ACCESS

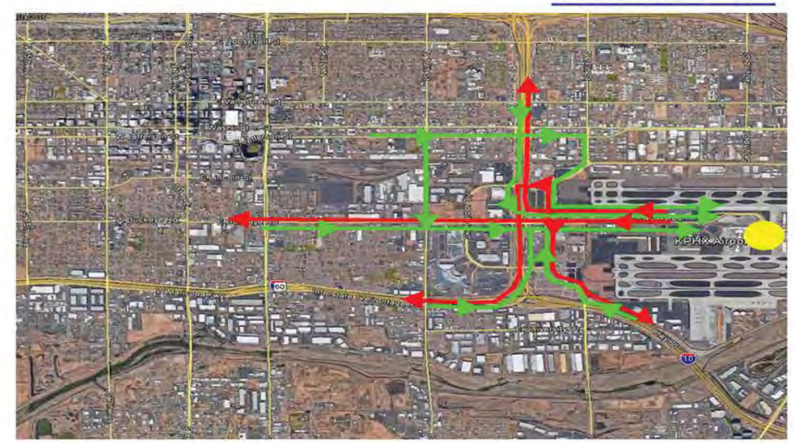


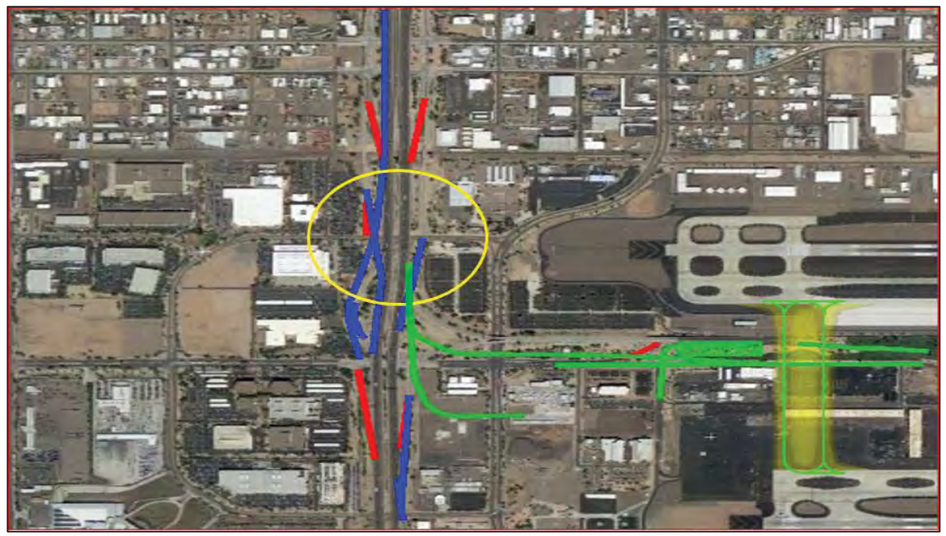
WGTC ACCESS

CARGO ACCESS

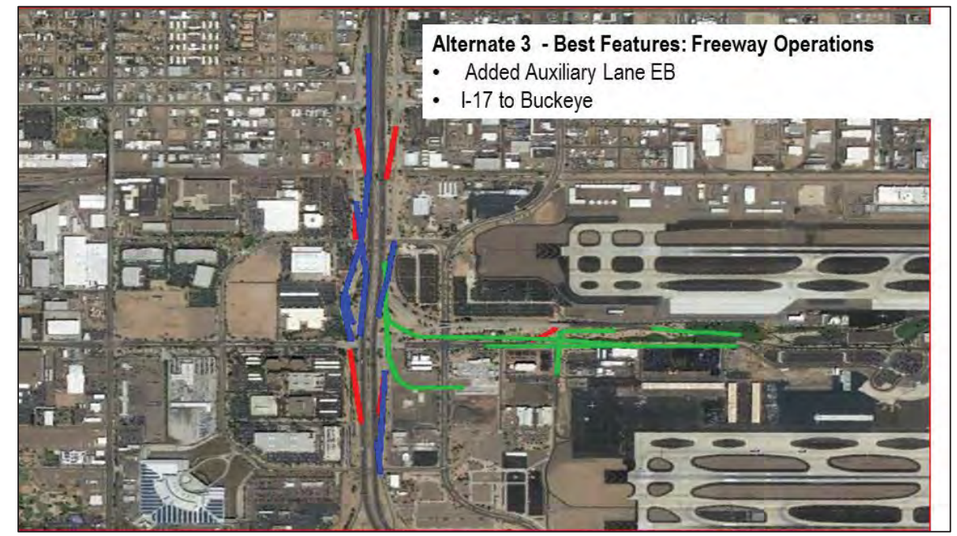


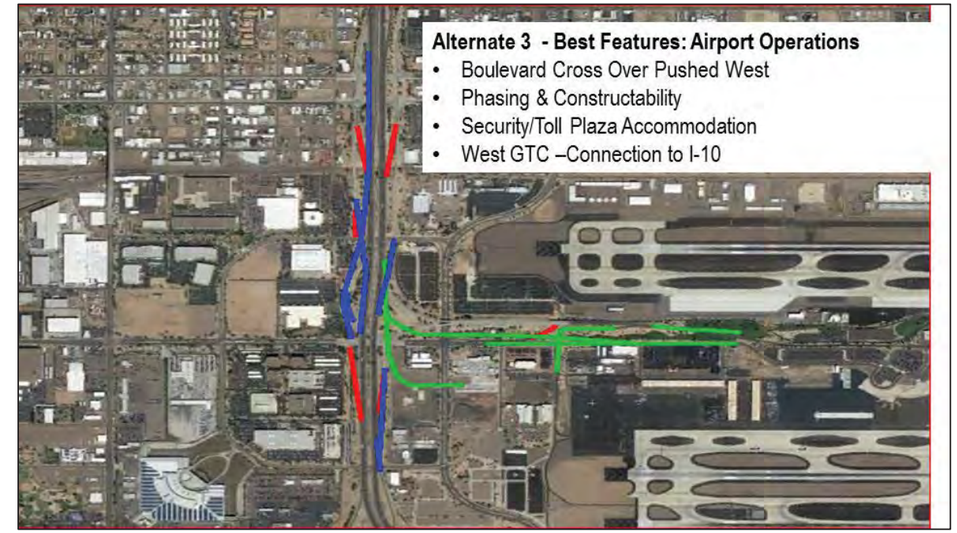
Local ACCESS



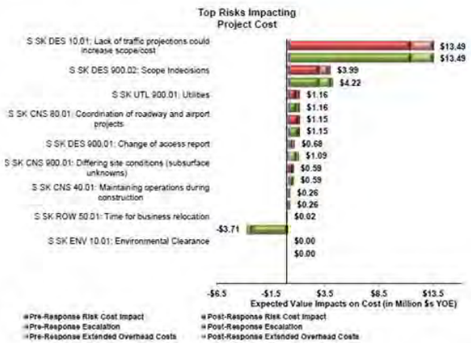


Airport to I-17
Possible Alternative


Alternate 3 - Best Features: Freeway Operations
• Added Auxiliary Lane EB
• I-17 to Buckeye


Alternate 3 - Best Features: Airport Operations
• Boulevard Cross Over Pushed West
• Phasing & Constructability
• Security/Toll Plaza Accommodation
• West GTC –Connection to I-10

Team 3 Modeled Results



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Performance

Performance Attribute Ratings				
Attribute	Attribute Weight	Concept	Performance Rating	Total Performance
Freeway Operations	20.8	1	10	208.0
		2	6	124.8
		3	7	145.6
Airport Operations	18.0	1	8	144.0
		2	9	162.0
		3	9	162.0
Maintainability	6.9	1	5	34.5
		2	7	48.3
		3	7	48.3
Construction Impacts	5.5	1	5	27.5
		2	7	38.5
		3	7	38.5

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Performance

Performance Attribute Ratings				
Attribute	Attribute Weight	Concept	Performance Rating	Total Performance
Environmental Impacts	4.1	1	8	32.8
		2	8	32.8
		3	8	32.8
Promotes Economic Growth	12.5	1	9	112.5
		2	8	100.0
		3	8	100.0
Security	19.8	1	8	198.0
		2	8	198.0
		3	8	198.0
Local Roadway Operations	12.5	1	8	100.0
		2	6	75.0
		3	8	100.0

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Best Value

Concept Value Improvement				
Value Index				
Concept		Performance (P)	Cost (C) $ millions	Value Index
1	Alternative 1	856	$166.7	5.13
2	Alternative 2	760	$134.0	5.67
3	Alternative 3	805	$104.5	7.71

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Value Planning Approach

Understanding the relationship of cost, performance, and value is essential in evaluating different alternatives. Comparing the performance and cost suggests which recommendations are potentially as good as or better than the current condition in terms of overall value.

Value Engineering, Analysis, or Planning has traditionally been perceived as an effective means for reducing project costs. This paradigm only addresses one part of the value equation, oftentimes at the expense of overlooking the role that value analysis can play to improve project performance. To address this issue, a performance-based approach was used.

The primary objective of any workshop is to improve the value of the project. A simple way to think of value in terms of an equation is shown at right. While project costs are fairly easy to quantify and compare through traditional estimating techniques, performance is not so easily quantifiable.

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

The use of performance attributes acts the cornerstone of this performance-based process by giving a systematic and structured way of considering the relationship of a project's performance and cost as it relates to value. Project performance must be properly defined and agreed on by the stakeholders at the beginning of the workshop. The performance attributes and requirements that are developed are then used throughout the study to identify, evaluate and document alternatives.

The application of performance-based value planning consists of the following steps:

1) Identify key project (scope and delivery) performance attributes and requirements for the project.
2) Establish the hierarchy and impact of these attributes on the project.
3) Identify the change in performance of alternative project concepts generated by the study.
4) Measure the aggregate effect of alternative concepts relative to the current condition and how it affects future development plans as a measure of overall value improvement.

The following are the key project performance attributes that were used in this Value Planning Study:

- Roadway Operations
- Transit Operations
- Maintainability
- Construction Impacts
- Environmental Impacts
- Promotes Economic Growth
- Security
- Local Roadway Operations

Performance Based Results

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

Introduction

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

The Value Planning Team Leader will lead the Team and external stakeholders through the methodology, using the power of the process to distill subjective thought into an objective language that everyone can relate to and understand. The dialog that develops forms the basis for the Value Planning Teams' understanding of the performance requirements of the project, and to what degree the current concept is meeting those requirements. From this approach, the Value Planning Team can focus on developing alternative concepts that will quantify both performance and cost and contribute to overall project value.

Performance based value planning yields the following benefits:

- Builds consensus among project stakeholders (especially those holding conflicting views)
- Develops a better understanding of a project's goals and objectives
- Develops a common understanding of how the project is meeting performance goals and objectives
- Identifies areas where project performance can be improved through the VE process
- Develops a better understanding of a VE recommendation's effect on project performance
- Develops an understanding of the relationship between performance and cost in determining value
- Uses value as the true measurement for the basis of selecting the right project or design concept
- Provides decision makers with a means of comparing costs and performance (i.e., costs vs. benefits) in a way that can assist them in making better decisions

Methodology

Performance based value planning process consists of the following steps:

1. Identify key project (scope and delivery) performance attributes and requirements for the project
2. Establish the hierarchy and impact of these attributes on the project

3. Establish the current concept and future development performance by evaluating and rating the effectiveness of the proposed design concepts
4. Identify the change in performance of alternative project concepts generated by the study
5. Measure the aggregate effect of alternative concepts relative to the current condition as a measure of overall value improvement

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

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

Assumptions

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

Step 1 – Determine the Major Performance Attributes

Performance attributes can generally be divided between Project Scope components (Highway Operations, Environmental Impacts, and System Preservation) and Project Delivery components.

It is important to make a distinction between performance attributes and performance requirements. Performance requirements are mandatory. All performance requirements MUST be met by any idea being considered.

Performance attributes possess a range of acceptable levels of performance. For example, if the project was the design and construction of a new bridge, a performance requirement might be that the bridge must meet all current seismic design criteria. In contrast, a performance attribute might be Project Schedule which means that a wide range of alternatives, which have different durations, could be acceptable.

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

The information that comes out of this discussion will be valuable to both the Value Planning Team and the Project Owner. It is important that the attribute be discretely defined, and they must be quantifiable in some form. The vast majority of performance attributes that typically

appear in transportation value studies have been standardized. This standardized list can be used "as is" or adopted with minor adjustments as required. Every effort should be made to make the ratings as objective as possible.

Step 2 – Determine the Relative Importance of the Attributes
Once the group has agreed upon the project's performance attributes, the next step is to determine their relative importance. This is accomplished through the use of an evaluative tool, termed in this report as the "Performance Attribute Matrix."

This matrix compares the performance attributes in pairs, asking the question: "An improvement in which attribute will provide the greatest benefit to the project relative to purpose and need?" A letter code (e.g., "a") is entered into the matrix for each pair, identifying which of the two is more important. If a pair of attributes is considered to be of equal importance, both letters (e.g., "a/b") are entered into the appropriate box. This, however, should be discouraged, as it has been found that in practice a tie usually indicates that the pairs have not been adequately discussed.

When all pairs have been discussed, the number of "votes" for each is tallied and percentages (which will be used as weighted multipliers later in the process) are calculated. It is not uncommon for one attribute to not receive any "votes." If this occurs, the attribute is given a token "vote", as it made the list in the first place and should be given some degree of importance.

Step 3 – Evaluate the Performance of the Value Planning Alternatives
Once the performance of the current concept and future plans have been established, it can be used to help the Value Planning Team develop performance ratings for individual Value Planning alternatives as they are developed during the course of the value study. The Performance Measures Form at the back of each recommendation is used to capture this information.

It is important to consider the recommendation's impact on the entire project, rather than on discrete components.

Step 4 – Compare the Performance Ratings of Recommendations to the Current Concepts and Future Development Plans
The last step in the process is to develop the performance ratings for the current concept and future development plans. The Value Planning Team groups the recommendation into an alternative (or alternatives) to provide the decision makers a clear picture of how the recommendations fit together into possible solutions. At least one alternative is developed to present the Value Planning Team's consensus of what should be implemented. Additional scenarios are developed as necessary to present other combinations to the decision makers that should be considered. The scenario(s) of Value Planning recommendations are rated and compared against the current concept and how they accommodate future development. The performance ratings developed for the Value Planning alternatives are entered into the matrix and the summary portion is completed. The summary provides details on net changes to cost, performance, and value, using the following calculations.

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

I-17/Central Avenue Bridge Replacement CRA Workshop Results

(in coordination with Valley Metro South Central LRT)

May 2, 2017

Decision Support Document
Advance I-17 / Central Avenue Overpass
Ultimate Construction

Baseline: To purchase ROW in all 4 corners and spread the frontage rods to provide vertical clearance for the overhead contact wires.

Recommendation: Build the ultimate I-17 over Central Avenue structure as a separate project prior to the need for VM's Central LRT project. The highway construction is anticipated to be completed by Dec 2020; VM needs the highway construction to be completed by Dec 2021.

Advantages:

- Bridge is not built in phases which eliminates potential operational impacts of constructing over live LRT traffic
- Reduces cost of ROW for VM project; eliminates ROW and roadway work to the north of I-17; $1.5 – 2.5 million
- Reduces throwaway or reconstruction
- Eliminates the need for bus bridge during ADOT I-17 construction
- Demonstrates a coordinated effort between agencies
- Provides an opportunity to reduce MOT cost and phases during ADOT I-17 construction

Disadvantages

- ROW on the south of I-17 could be perceived as acquired for a different need
- May require long term temporary barrier on I-17
- A portion of the new bridge would not be used for a long duration

Decision Support Document
Advance I-17 / Central Avenue Overpass
Ultimate Construction

Discussion/Justification/Sketches/Photos:

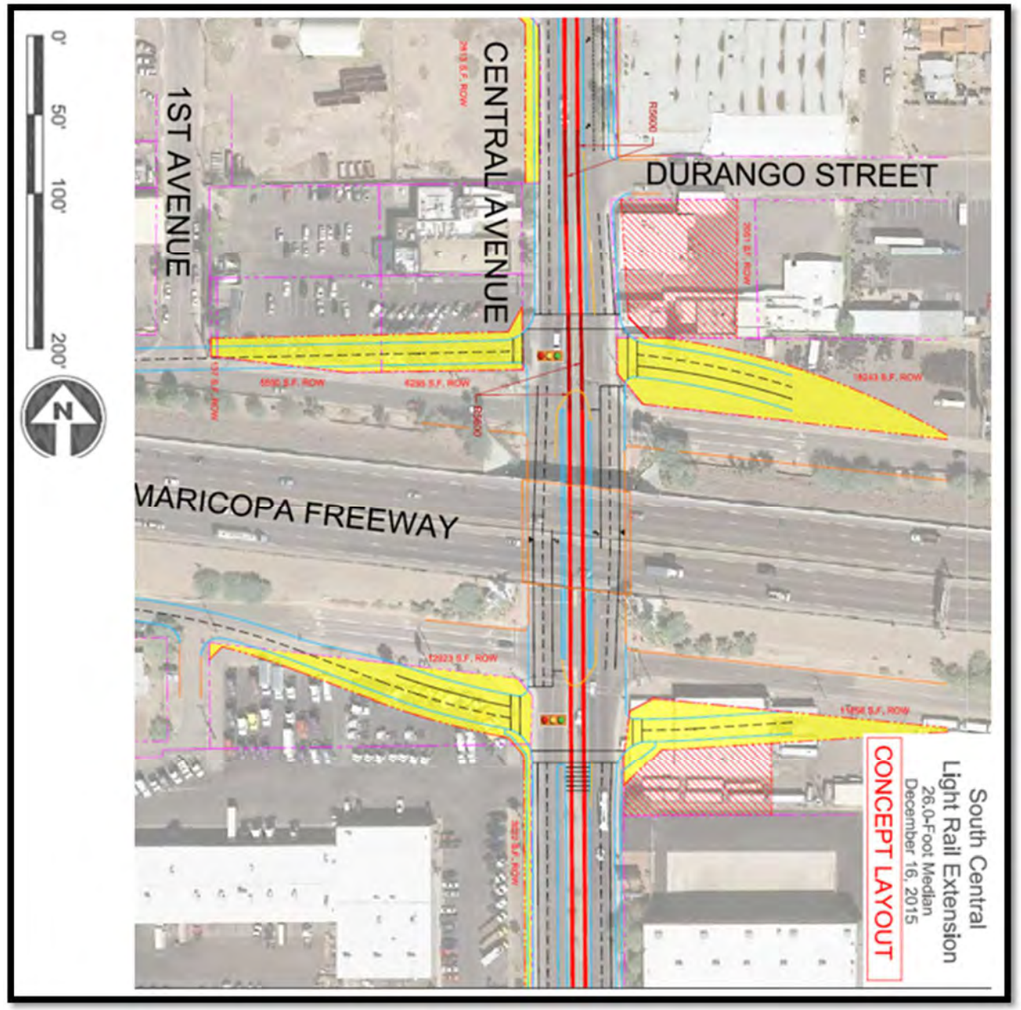


Figure 1: Existing Plan for Valley Metro

Figure 2: Ultimate Plan for I-17 at Central Avenue

Justification:

The operational shutdown window is 3 to 4 hours per day. The options are to have a bus bridge, which could reduce ridership resulting in a long term impact to VM or to incur a 25% premium on the ADOT project for demo and construction over live LRT.

The new bridge could be built in 3 phases to the south.

The VM project is a CMAR and there may be a possibility of adding the ADOT I-17 bridge construction to the VM CMAR scope if it would be an advantage to the project delivery.

Project	South Central CR	Risk ID	VM VMSC PRO 80.03_01
Sub-Project	VM South Central	Status	Active

Consistent communication by stakeholders to public

Risk Trigger		Flowchart Activity	30% Design Milestone

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	1.00			

Potentially there will be multiple PI teams - ADOT, VM, COP, and contractors. The risk is there might be different messages from the agencies and might be confusing to public. The public could lose confidence if they get misinformation from different sources. Might cause rework, additional work, and delays. I-17 will be covered by a PI through ADOT PI on-call; VM will be covered by VM PI.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.50	Mitigate	

Develop a communication plan and hierarchy with a single point of contact to the public for each agency as it relates to the I-17 / Central Avenue crossing. Consider a PI summit that analyzes the comprehensive impacts of valley projects.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Howard Steere		To		Weekly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.03_02
Sub-Project	VM South Central	Status	Active

Stakeholder consensus and communication

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$2.00	$3.00	$5.00	$2.38	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	1.50			

Early agreement and ongoing communication of design criteria between ADOT and VM as it relates to I-17 crossing on 7th Ave, Central Ave, and 7th St. The risk is that the decisions made may change causing redesign, rework, and delays, including during construction. Assume 25% of the $20 M for the high.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$1.00	$1.50	$2.50	$0.79	Strategy	5/2/2017
Schedule (Mo)	0.00	1.00	2.00	0.50	Mitigate	

Develop a MOA and JPA for design criteria between ADOT, VM, MAG, and COP by the end of 2017.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC SIT 40.09_01
Sub-Project	VM South Central	Status	Active

Geometric Compatibility between interim and ultimate configurations

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	-$10.00	-$2.00	$5.00	-$1.08	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	2.00	4.00	6.00	2.00			

The current design has the overhead contact system dipping down under the existing structure at I-17. To attain vertical clearance at the frontage rods, the frontage roads are being flared out. The risk is the uncertainty around the I-17 / Central Ave structure.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	-$10.00	-$2.00	$5.00	-$1.08	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	1.00	Mitigate	

Potential strategies are 1.investigate lowering Central and the associated utility and reainage impacts, 2. raise I-17 profile, 3. structure types to reduce structure depth. Hold a alternative analysis workshop with VM and ADOT to evaluate alternatives and include the decision in the MOU.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM, ADOT PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.01_01
Sub-Project	VM South Central	Status	Active

IGA - agreements between stakeholders

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.20			

The agreements are not currently in place. The risk is that the agreements might take a long time to be executed. The delays could be due to legal reviews and the decisions to be drafted into agreements not being made. The FFGA submittal is around Jan 2019.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.20		

Begin working on the framework of the MOA. Continue to discuss the MOA iusses and requirements at upcoming monthly coordination meeting. Get legal staff from both agencies involved earlier on.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC SIT 40.05_01
Sub-Project	VM South Central	Status	Active

Coordination between ADOT and VM contractors - Specifications

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	1.00			

The risk is that the I-17 project overlaps with the VM project. There could be conflicts between contractors resulting in delay claims. Assume $500,000 per month in delay cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.50	$1.00	$1.50	$0.25	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.50	Mitigate	

Coordination with ADOT to specify windows within the contract for contractor to work within the I-17 / Central Ave area. Include a buffer within the schedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM Design Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC SIT 40.02_01
Sub-Project	VM South Central	Status	Active

Utility coordination

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

There is a large COP water infrastructure project along Central Avenue. Other significant utilities are sanitary sewer and communication. These utilities can conflict not only with the track work but also with the I-17 structure. This is a not quantifiable watchlist risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00	Mitigate	

Valley Metro is beginning a SUE contract; consider early order of work in the vicinity of I-17 to prepare for alternative analysis workshop in August 2017.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC ROW 60.01_01
Sub-Project	VM South Central	Status	Active

ROW

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

Current plan requires properties in all 4 corners of I-17 and Central and one small portion at 7th Avenue. Decisions yet to be made on the scope of work could have positive or negative impacts to the ROW.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00		

Define the ROW footprint in the vicinity of I-17 in the alternatives workshop.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
ADOT PM, VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.09_01
Sub-Project	VM South Central	Status	Active

Light rail operations if freeway construction happens after VM

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

The risk is that if VM builds their project per EIS design, there is a risk to the ADOT I-17 work of building in close proximity to live LRT. This may require a bus-bridge through the construciton site. This may have a cost to VM; the cost might have to be borne by ADOT. This might also impact ridership. ADOT would have to pay a premium for bridge demo over live track; there could be 25% premium on ADOT work. There is an operational shutdown window of 3 hours per day at night.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00		

Build the ultimate bridge before the LRT; at a minimum complete the foundation work prior to the LRT work.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.03_03
Sub-Project	VM South Central	Status	Active

ADOT Resources

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

Permanent PM is not yet assigned to the ADOT I-17 project. The risk is if there is inexperience in this area, with the complexitites involved, it could affect coordination and agreements of the VM project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00		

Develop mentorship and escalation plans for key resouces. Consider augmenting with contract PM staff, as required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.04_01
Sub-Project	VM South Central	Status	Active

Procurement - technical issues

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$1.00	$2.00	$3.00	$1.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

Procurement documents for the projects need to be coordinated between VM and ADOT. Clearly defining the technical requirements with the ADOT project is the risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$1.00	$2.00	$3.00	$0.50	Strategy	5/2/2017
Schedule (Mo)				0.00	Mitigate	

Conitnuous coordination with ADOT to prioritize and define requirements and include them in the procurement documents.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC SIT 40.09_01
Sub-Project	VM South Central	Status	Active

Geometric Compatibility between interim and ultimate configurations

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	-$10.00	-$2.00	$5.00	-$1.08	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	2.00	4.00	6.00	2.00			

The current design has the overhead contact system dipping down under the existing structure at I-17. To attain vertical clearance at the frontage rods, the frontage roads are being flared out. The risk is the uncertainty around the I-17 / Central Ave structure.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	-$10.00	-$2.00	$5.00	-$1.08	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	1.00	Mitigate	

Potential strategies are 1.investigate lowering Central and the associated utility and drainage impacts, 2. raise I-17 profile, 3. structure types to reduce structure depth. Hold a alternative analysis workshop with VM and ADOT to evaluate alternatives and include the decision in the MOU.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM, ADOT PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.01_01
Sub-Project	VM South Central	Status	Active

IGA - agreements between stakeholders

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.20			

The agreements are not currently in place. The risk is that the agreements might take a long time to be executed. The delays could be due to legal reviews and the decisions to be drafted into agreements not being made. The FFGA submittal is around Jan 2019.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.20		

Begin working on the framework of the MOA. Continue to discuss the MOA issues and requirements at upcoming monthly coordination meeting. Get legal staff from both agencies involved earlier on.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC SIT 40.05_01
Sub-Project	VM South Central	Status	Active

Coordination between ADOT and VM contractors - Specifications

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	1.00			

The risk is that the I-17 project overlaps with the VM project. There could be conflicts between contractors resulting in delay claims. Assume $500,000 per month in delay cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.50	$1.00	$1.50	$0.25	Strategy	5/2/2017
Schedule (Mo)	1.00	2.00	3.00	0.50	Mitigate	

Coordination with ADOT to specify windows within the contract for contractor to work within the I-17 / Central Ave area. Include a buffer within the schedule.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM Design Manager		To		Quarterly

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC SIT 40.02_01
Sub-Project	VM South Central	Status	Active

Utility coordination

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

There is a large COP water infrastructure project along Central Avenue. Other significant utilities are sanitary sewer and communication. These utilities can conflict not only with the track work but also with the I-17 structure. This is a not quantifiable watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00	Mitigate	

Valley Metro is beginning a SUE contract; consider early order of work in the vicinity of I-17 to prepare for alternative analysis workshop in August 2017.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC ROW 60.01_01
Sub-Project	VM South Central	Status	Active

ROW

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

Current plan requires properties in all 4 corners of I-17 and Central and one small portion at 7th Avenue. Decisions yet to be made on the scope of work could have positive or negative impacts to the ROW.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00		

Define the ROW footprint in the vicinity of I-17 in the alternatives workshop.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
ADOT PM, VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.09_01
Sub-Project	VM South Central	Status	Active

Light rail operations if freeway construction happens after VM

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

The risk is that if VM builds their project per EIS design, there is a risk to the ADOT I-17 work of building in close proximity to live LRT. This may require a bus-bridge through the construction site. This may have a cost to VM; the cost might have to be borne by ADOT. This might also impact ridership. ADOT would have to pay a premium for bridge demo over live track; there could be 25% premium on ADOT work. There is an operational shutdown window of 3 hours per day at night.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00		

Build the ultimate bridge before the LRT; at a minimum complete the foundation work prior to the LRT work.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.03_03
Sub-Project	VM South Central	Status	Active

ADOT Resources

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

Permanent PM is not yet assigned to the ADOT I-17 project. The risk is if there is inexperience in this area, with the complexities involved, it could affect coordination and agreements of the VM project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/2/2017
Schedule (Mo)				0.00		

Develop mentorship and escalation plans for key resources. Consider augmenting with contract PM staff, as required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	South Central CR	Risk ID	VM VMSC PRO 80.04_01
Sub-Project	VM South Central	Status	Active

Procurement - technical issues

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$1.00	$2.00	$3.00	$1.00	Project Rank Cost	Project Rank Schedule	5/2/2017
Schedule (Mo)				0.00			

Procurement documents for the projects need to be coordinated between VM and ADOT. Clearly defining the technical requirements with the ADOT project is the risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$1.00	$2.00	$3.00	$0.50	Strategy	5/2/2017
Schedule (Mo)				0.00	Mitigate	

Continuous coordination with ADOT to prioritize and define requirements and include them in the procurement documents.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/2/2017
Next Review	**Risk Assignment**

I-17/Mountain View CRA Workshop Results

(in coordination with Valley Metro Northwest Extension LRT)

May 3, 2017

Project	Valley Metro North West II CR	Risk ID	VM VMNW GUI 10.04_01
Sub-Project	VM North West II	Status	Active

Bridge over I-17 (clearance)

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
	25%	50%	1%				
Cost ($M)	$0.50	$2.00	$5.00	$1.18	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

There have been discussions on vertical clearance over I-17. The risk is that a vehicle with non-standard height could hit the structure. Since this will be a LRT only bridge, there is a higher risk of damage and LRT operations being impacted. ADOT design standard for clearance is 16'6". Increasing the clearance will impact the slopes, station height, and 25th Ave crossing. There is a risk cost associated with adding mitigation for potential over-height load. prob 3 - raising structure and stations; prob 2 - sacrificial structure; prob 1 - warning signs

Post-Response Quantification

Discrete Risk	Prob 1	Prob 2	Prob 3	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
	25%	50%	1%			
Cost ($M)	$0.50	$2.00	$5.00	$1.18	Strategy	5/3/2017
Schedule (Mo)				0.00	Mitigate	

Assume 16'6" clearance and investigate structures to mitigate impacts that affect operations. This may include sacrificial beams (additional girders). Internal discussions at VM to determine the risk appetite due to over-height damage that could affect LRT operations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.02_01
Sub-Project	VM North West II	Status	Active

Spine compatibility, drainage

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

Current plan is a 72" drainage pipe under the frontage road, directly under the LRT station. The risk is that there has not been any coordination with the VM design. This is a non-quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00	Mitigate	

The drainage design should be accommodative of the VM preliminary concept design. Coordination with ADOT drainage design to get the drainage in the optimal location.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM Design Manager, ADOT Design Manager		To		Weekly

Review Comments

Risk workshop planned for the ADOT drainage project on 5/17/17.

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.02_02
Sub-Project	VM North West II	Status	Active

Drainage construction coordination

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)	1.00	2.00	3.00	1.00			

The risk is that a 72" at 25-feet down will more than likely close the frontage road during construction. This is in the vicinity of the LRT station, which might also require frontage road closure during construction. There could be holiday moratoriums in the vicinity of the mall, which might constrain the construction. Depending on the timing of the work, this could delay one or both projects.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)	1.00	2.00	3.00	1.00	Mitigate	

Specify an order of work in the contracts for both projects that stipulates any moratorium dates and that the ADOT drainage work should precede the VM work. Consider putting the station drilled shafts in first then trenching the pipe in between the drilled shafts. Consider the frontage road closure to be continuous for VM and ADOT projects.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM, ADOT PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.09_01
Sub-Project	VM North West II	Status	Active

Spine compatibility, freeway

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The Spine conceptual drawings show a 4-foot buffer b/w the freeway and the frontage road. This could be utilized to reduce the impacts to APS transmission lines. This is a non-quantifiable watch list item list.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Continue to communicate with ADOT if as design progresses the buffer is being utilized.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM; ADOT PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.07_01
Sub-Project	VM North West II	Status	Active

Spine compatibility, frontage roads

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The risk is that underneath the station, SB frontage road is reduced to one lane. This is a non-quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00	Mitigate	

Share VM traffic modeling with ADOT and get concurrence to reduce the frontage road to one through lane underneath the station. Document the decision in an MOA.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW PRO 80.03_01
Sub-Project	VM North West II	Status	Active

Locking down design decisions early - MOU/JPA/IGA

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.25	$0.35	$0.50	$0.29	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)	1.00	2.00	3.00	1.60			

The risk is that ADOT is not interested in agreements until after 30% design. It will be a challenge that the assumptions in the 15 to 30% design might change causing a delay to the VM project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.25	$0.35	$0.50	$0.29	Strategy	5/3/2017
Schedule (Mo)	1.00	2.00	3.00	1.60		

Lockdown key decisions such as number of lanes, and roadway and shoulder widths on frontage road, constructability requirements, pier locations, and vertical clearance prior to 30% design. Elevate the agreement discussions, if necessary. Assign a single point contact for each agency.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW PRO 80.03_02
Sub-Project	VM North West II	Status	Active

Consistent communication from stakeholders to public

Risk Trigger		Flowchart Activity	
Modeling Notes			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The ADOT drainage project and the VM station and guideway project will have the public appearance as one project. The risk is that there might be inconsistent communication, if not coordinated between agencies. This is a non-quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00	Mitigate	

Develop a communication plan and hierarchy with a single point of contact to the public for each agency as it relates to the 2 projects. Consider a PI summit that analyzes the comprehensive impacts to the valley projects. Develop a fact-sheet for each project.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM; ADOT PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.08_01
Sub-Project	VM North West II	Status	Active

Risk Trigger		Flowchart Activity	
Modeling Notes			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	
Schedule (Mo)				0.00			

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.08_02
Sub-Project	VM North West II	Status	Active

MOT - Plans and approvals

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

Temporary shift for median pier work. Short duration (weekend) closures for setting girders and deck pours will all place constraints on the VM project. This may require 3 or 4 weekend closures over the entire construction duration. Potentially there will be other ADOT work on I-17 that may conflict and should be coordinated with. This is a non-quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Get information from ADOT about planned I-17 closures. Consider using the mall ring road as detour for total closure of SB frontage road during construction.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.02_03
Sub-Project	VM North West II	Status	Active

APS clearance

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The risk is that raising the guideway gets into the clearance issues with APS. The base design assumes raising the poles. The risk is the delta based on the difference in height required due to vertical clearance decision over the freeway. It is a long lead design and procurement for this type of construction. This is a nonquantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00	Mitigate	

Get an agreement on the bridge height and depth, and communicate that with APS.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.07_02
Sub-Project	VM North West II	Status	Active

Construction sequencing / ADOT and VM contractor coordination

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The risk is that of having multiple projects/contractors working in the same area.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Insert key milestone dates in each contract and specify access and order of work as it relates to the work in the vicinity of the frontage road. Leverage the expertise of CMAR to provide input into construction sequencing. Suggest ADOT to consider a CMAR for their project.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.05_01
Sub-Project	VM North West II	Status	Active

Visual impacts and aesthetics

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.10	$0.50	$1.50	$0.30	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The retained fill along Mountain View may be viewed as a visual impact. There is a risk that the fill might be replaced with a clear span, adding cost to the project. Exotic aesthetic treatment for walls could exceed allowance (1%) in the base cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.10	$0.50	$1.50	$0.30	Strategy	5/3/2017
Schedule (Mo)				0.00	Mitigate	

Conduct stakeholder outreach and engage the PI group to convey consistent message. Consider investing in graphics to convey the correct message. (avoid homeless camps and conduct threat and vulnerability risk analysis).

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW SIT 40.02_04
Sub-Project	VM North West II	Status	Active

Utilities over drainage

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

Risk is that the drainage project will be relocating utilities, which could be in conflict with the VM project. This is a nonquantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Collaboration between VM and ADOT project to coordinate utility relocations. Along the frontage road, coordinate SUE efforts between ADOT and VM projects.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM, ADOT PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW PRO 80.09_01
Sub-Project	VM North West II	Status	Active

Project Cost and schedule

Risk Trigger		Flowchart Activity	

Modeling Notes	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The risk is that typical projects experience cost growth from startup to completion.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Planning a couple of risk assessment workshops and a value engineering workshop prior to Spring 2018. Consider focusing the VE on the risk as well as the scope.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW PRO 80.03_03
Sub-Project	VM North West II	Status	Active

Collaboration with ADOT; ADOT permitting

Risk Trigger		Flowchart Activity	
Modeling Notes			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The risk is that knowing ADOT's expectations and requirements.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Meet with ADOT to understand ADOT's expectations and requirements.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

Project	Valley Metro North West II CR	Risk ID	VM VMNW PRO 80.01_01
Sub-Project	VM North West II	Status	Active

Access to Business north of Mountain View

Risk Trigger		Flowchart Activity	
Modeling Notes			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/3/2017
Schedule (Mo)				0.00			

The risk is that the stakeholders may request revisions to access that could affect the design of the project. This can affect the cost and schedule of the project. This is a nonquantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/3/2017
Schedule (Mo)				0.00		

Conduct stakeholder outreach to get the input. Mitigate the risk with design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
VM PM		To		

Review Comments

Last Review	Date MC Last Updated
	5/3/2017
Next Review	**Risk Assignment**

I-17/Indian School TI,
I-17/Northern TI,
I-17/Glendale TI,
I-17/Thunderbird TI, and
I-17/Bell TI CRA Workshop Results

May 16 & 18, 2017

Cost Risk Assessment (CRA)

Results

Project Name: I-17 & Indian School Platform TI

TRACS Number: U0006

Project Description: Upgrade the I-17 and Indian School interchange to a three level platform diamond, by adding a new east-west flyover over the interchange along Indian School Road.

CRA Cost and Schedule Results

Cost Results (Millions 2017 $s)	Base Cost 2017 $s	10th Percentile 2017 $s	70th Percentile 2017 $s	90th Percentile 2017 $s
Post-Response Results Total Project Cost (2017 $s)	$41.0	$39.4	$44.2	$46.3
Schedule Results	**Base Completion**	**10th Percentile Completion**	**70th Percentile Completion**	**90th Percentile Completion**
Post-Response Project Completion	Jul 2022	Jul 2022	Sep 2022	Jan 2023

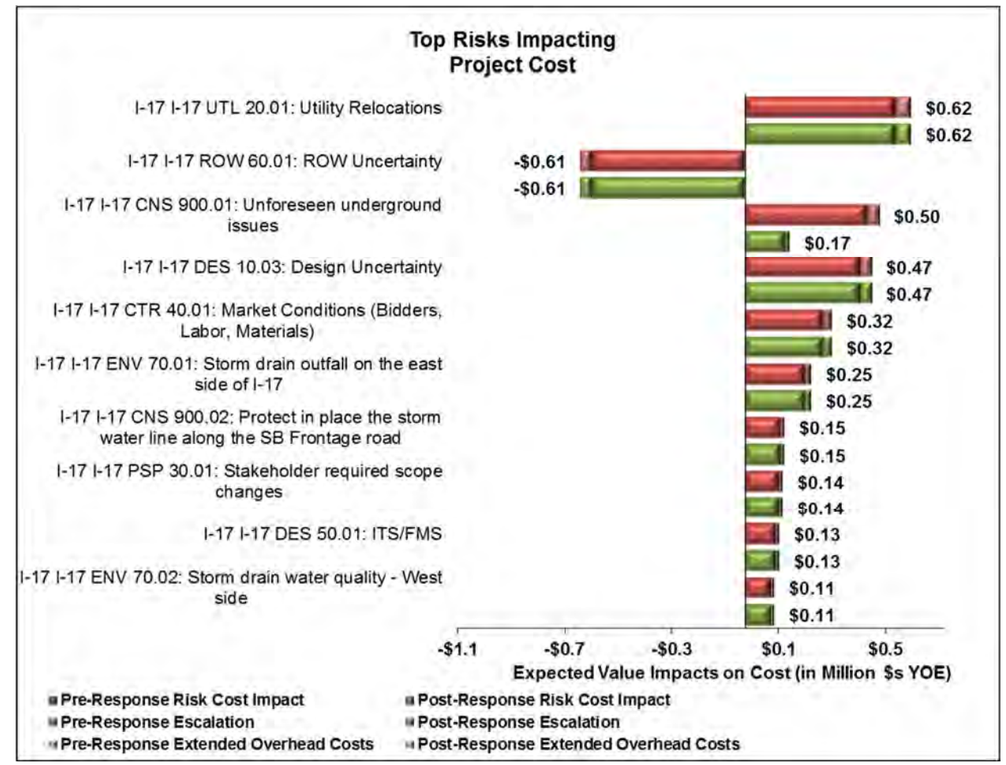
Base Costs by Activity

Activity ID	Activity Name	Total		
		Low	Base	High
100	Design / Environmental	$2,051,585	$2,253,575	$2,496,259
200	Right-of-Way / Utilities	$7,159,100	$7,159,100	$7,159,100
300	Construction	$26,767,829	$29,394,491	$32,560,322
310	Construction Engineering	$2,021,437	$2,204,656	$2,442,762
400	Project Completion	$0	$0	$0
Total		**$37,999,952**	**$41,011,822**	**$44,658,443**

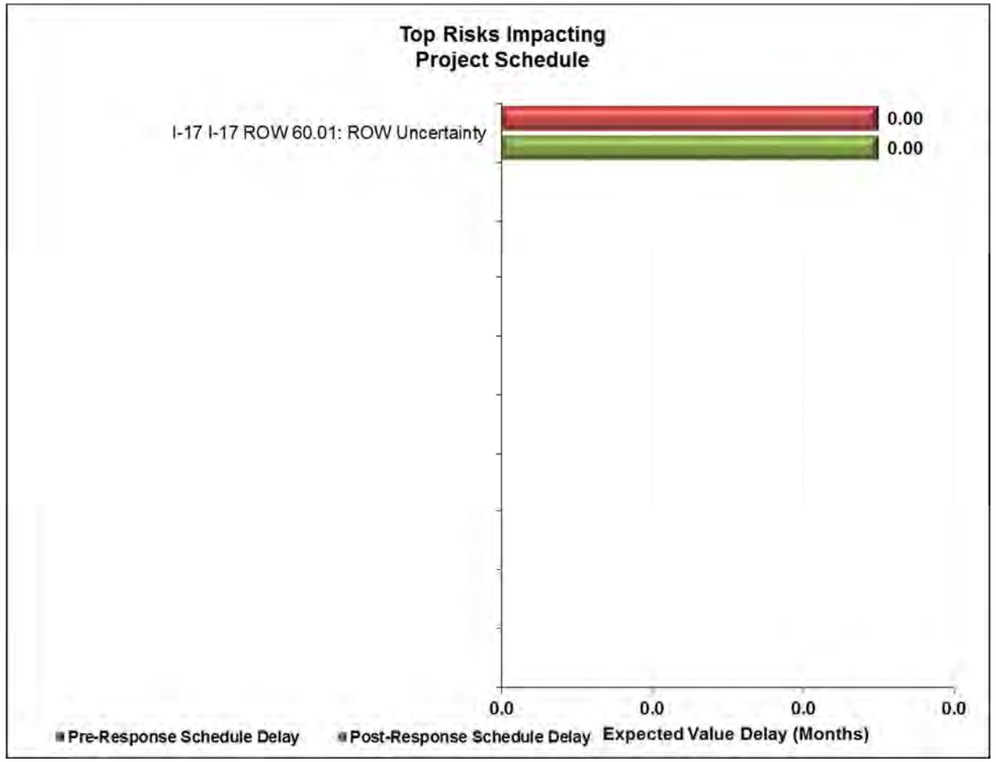
Base Schedule by Activity

Activity ID	Activity Name	Start Date	End Date	Duration (Months)
100	Design / Environmental	10/11/17	6/10/20	32.00
200	Right-of-Way / Utilities	9/10/18	9/9/20	24.02
300	Construction	6/10/20	7/5/22	24.84
310	Construction Engineering	6/10/20	7/5/22	24.84
400	Project Completion	7/5/22	7/5/22	0.03

Tornado Chart of Top Cost Risks



Tornado Chart of Top Schedule Risks



Note: ROW Uncertainty risk is quantified with a range of +/- 6 months impact but the expected value impact is zero months as depicted in the chart.

Project	I-17	Scenario	Risk ID	I-17 I-17 UTL 20.01
Sub-Project	I-17	Indian School	Status	Active

Utility Relocations

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.50	$0.75	$1.00	$0.56	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The assumption is that the utilities in the south bridge are not impacted. There is an existing 48-inch PCCP waterline along the south side of Indian School Road. East and west of I-17, the waterline skews north to run along the median. The risk is that the exact location of the line is unknown and might need to be relocated, especially at the embankments. The base has a $2 M allowance for utilities. Approximately 600 feet on both sides of the freeway might need to be relocated. Other utilities such as 8-inch sewer, smaller waterlines, SW Gas, telecommunication, 12-inch irrigation, and other miscellaneous utilities. The risk that the $2 M allowance might not be sufficient.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$0.50	$0.75	$1.00	$0.56	Strategy	5/16/2017
Schedule (Mo)				0.00	Mitigate	

Advance the design and coordination with City of Phoenix. Consider acquiring ROW early to accommodate utility relocations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Utility Coordinator / Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ROW 60.01
Sub-Project	I-17	Indian School	Status	Active

ROW

Risk Trigger		Flowchart Activity	ROW
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%							
Cost ($M)	-$2.00	-$1.00	$1.00	-$0.83	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)	-6.00	0.00	6.00	0.00			

The base includes $6.5 M based on 2.6 acres of impacts (neat line) at $2.5 M / acre. This area does not include any additional property required for full takes or access control. At this level of design and estimation, there is an uncertainty that it could be $2 M lower or $1 M higher and the schedule could be more or less depending on relocation. The Motel 6 and restaurant on the northwest corner; billboards and sliver takes on the northeast corner.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	-$2.00	-$1.00	$1.00	-$0.83	Strategy	5/16/2017
Schedule (Mo)	-6.00	0.00	6.00	0.00	Mitigate	

Refine design and ROW estimates.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.03
Sub-Project	I-17	Indian School	Status	Active

Design Uncertainty

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%							
Cost ($M)	-$2.00	$0.00	$3.00	$0.17	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

These are concept level designs, There is an opportunity that optimization could be done by minimizing median widths, landscaping buffers, and possibly even turn lanes. There is also a potential for added scope for items such as turn lanes, lengthening the project to accommodate tie-ins, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	-$2.00	$0.00	$3.00	$0.17	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete preliminary design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 30.01
Sub-Project	I-17	Indian School	Status	Active

Aesthetics: decorative bridge railing and ped fencing

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	
Schedule (Mo)				0.00			

The base does not assume complex aesthetic treatments and railing. There is a risk that stakeholders may require complex aesthetics and railings. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.01
Sub-Project	I-17	Indian School	Status	Active

Storm drain outfall on the east side of I-17

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.80	$1.50	$0.21	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The base assumes $400 k for retrofitting onsite drainage, The risk is that the added impervious on the east side needs to drain into the city outfall. To mitigate the peak flows on site, it may require detention basins for quality and quantity,. Adding cost to the project. On the northeast corner, there is minimal ROW for basin location and ROW may need to be acquired.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.30	$0.80	$1.50	$0.21	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete preliminary design and coordinate with the city. Consider total take ROW remainders for basin locations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.02
Sub-Project	I-17	Indian School	Status	Active

Storm drain water quality - West side

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Base assumes all onsite water pre and post construction outfalls directly to ADOT storm drain pipe in the SB Frontage road. This risk addresses the possibility that water quality requirements will have to be met before the water gets dumped into the outfall.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Consider total take ROW remainders for basin locations, if required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 900.01
Sub-Project	I-17	Indian School	Status	Active

Concept Approval by Agency Officials

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Elected and agency officials may want an opportunity to approve the conceptual design since platform diamonds are a new concept to the area. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/16/2017
Schedule (Mo)				0.00		

Present the concept design (including visualization and proof of concept) to the concerned officials.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 30.01
Sub-Project	I-17	Indian School	Status	Active

Stakeholder required scope changes

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.10	$0.15	$0.25	$0.12	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The design is not fully vetted with stakeholders. There is a risk that the stakeholders might request additional scope adding cost to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$0.10	$0.15	$0.25	$0.12	Strategy	5/16/2017
Schedule (Mo)				0.00		

Work with stakeholders to identify the requirements early.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.01
Sub-Project	I-17	Indian School	Status	Active

Unforeseen underground issues

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.25	$0.50	$1.00	$0.41	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Geotechnical, unknown or abandoned utilities. The infrastructure in this area is dated and there is a high likelihood of unknown and/or abandoned utilities

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.25	$0.50	$1.00	$0.14	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete geotechnical investigation and SUE investigations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.02
Sub-Project	I-17	Indian School	Status	Active

Protect in place the storm water line along the SB Frontage road

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.05	$0.10	$0.30	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The existing storm water drain behind the existing abutment structures along the SB Frontage road will need to be protected in place during the demo and construction of the structures. This may require temporary or permanent walls not included in the base cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.05	$0.10	$0.30	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Consider using secant wall abutments, temporary shoring, sheet pile wall evaluated against storm water pipe relocation.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 20.01
Sub-Project	I-17	Indian School	Status	Active

COA Reports

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

These projects may or may not require COA reports. Base cost does not include COA costs, which may be up to $750 k.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$0.30	$0.40	$0.50	$0.04	Strategy	5/16/2017
Schedule (Mo)				0.00		

Coordinate with FHWA a proof of concept.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.01
Sub-Project	I-17	Indian School	Status	Active

ITS/FMS

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
30%							
Cost ($M)	$0.20	$0.30	$0.60	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The risk is that the planned advanced ITS/FMS that might be in place at the time of this project construction would need to be maintained, updated, or reconstructed. An additional risk is that the planned advanced ITS/FMS is not in place, but would be included in this project, Base assumes $150 k and only the current infrastructure exists.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
30%						
Cost ($M)	$0.20	$0.30	$0.60	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate with the ITS improvements project on I-17 with ADOT TSMO and with the COP for their arterial ITS improvements; advance the design; and update the cost.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments	Last Review	Date MC Last Updated
		5/16/2017
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 CTR 40.01
Sub-Project	I-17	Indian School	Status	Active

Market Conditions (Bidders, Labor, Materials)

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.29	$0.59	$0.88	$0.29	Project Rank Cost	Project Rank Schedule	5/22/2017
Schedule (Mo)				0.00			

There could be a shortage of skilled labor and / or project materials and /or a reduced number of bidders due to the large number of projects in the Greater Phoenix area when this project is expected to be constructed. The cost is a range of 1%, 2%, or 3% of the base construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.29	$0.59	$0.88	$0.29	Strategy	5/22/2017
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Cost Risk Assessment (CRA)

Results

Project Name: I-17 & Northern Platform TI

TRACS Number: U0008

Project Description: Upgrade the I-17 and Northern interchange to a three level platform diamond, by adding a new east-west flyover over the interchange along Northern Avenue.

CRA Cost and Schedule Results

Cost Results (Millions 2017 $s)	Base Cost 2017 $s	10th Percentile 2017 $s	70th Percentile 2017 $s	90th Percentile 2017 $s
Post-Response Results Total Project Cost (2017 $s)	$44.0	$41.2	$45.9	$48.0
Schedule Results	**Base Completion**	**10th Percentile Completion**	**70th Percentile Completion**	**90th Percentile Completion**
Post-Response Project Completion	Jul 2022	Jul 2022	Mar 2023	Aug 2023

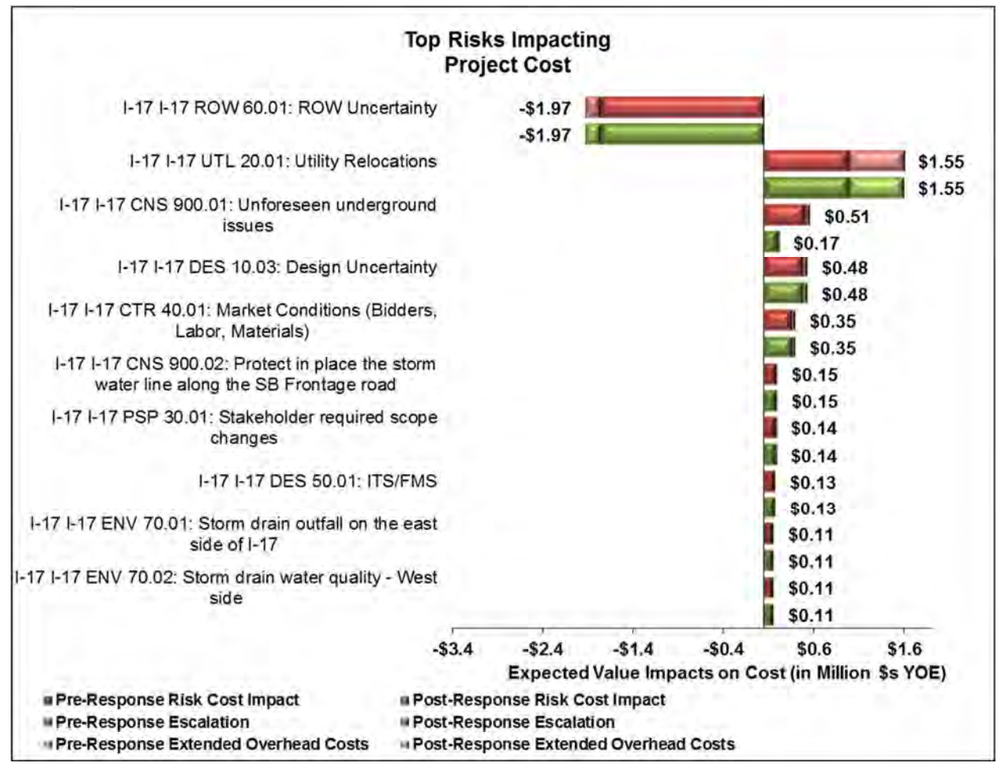
Base Costs by Activity

Activity ID	Activity Name	Total		
		Low	Base	High
100	Design / Environmental	$2,167,833	$2,396,301	$2,639,145
200	Right-of-Way / Utilities	$7,985,150	$7,985,150	$7,985,150
300	Construction	$28,220,927	$31,259,300	$34,346,401
310	Construction Engineering	$2,021,437	$2,349,966	$2,442,762
400	Project Completion	$0	$0	$0
Total		**$40,395,347**	**$43,990,717**	**$47,413,458**

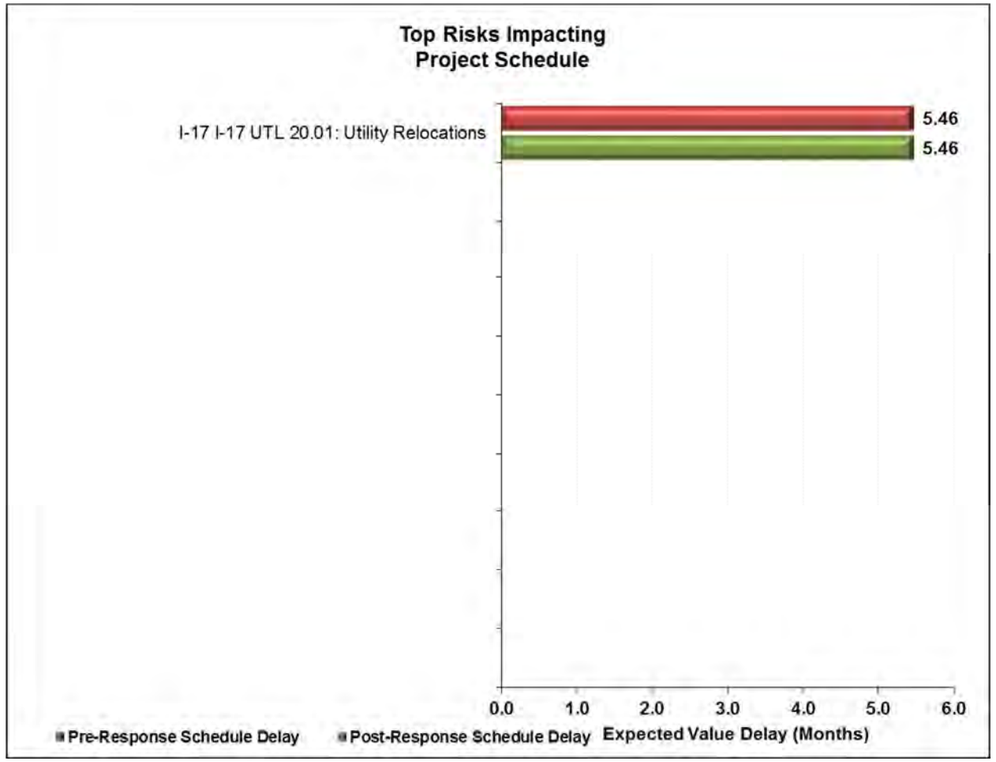
Base Schedule by Activity

Activity ID	Activity Name	Start Date	End Date	Duration (Months)
100	Design / Environmental	10/11/17	6/10/20	32.00
200	Right-of-Way / Utilities	4/11/19	10/12/20	18.10
300	Construction	6/10/20	7/5/22	24.84
310	Construction Engineering	6/10/20	7/5/22	24.84
400	Project Completion	7/5/22	7/5/22	0.03

Tornado Chart of Top Cost Risks



Tornado Chart of Top Schedule Risks



Note: ROW Uncertainty risk is quantified with a range of +/- 6 months impact but the expected value impact is zero months and is NOT depicted in the chart.

Project	I-17	Scenario	Risk ID	I-17 I-17 UTL 20.01
Sub-Project	I-17	Northern	Status	Active

Utility Relocations

Risk Trigger		Flowchart Activity	Construction / ROW
Dependency & Correlation	Cost to construction; schedule to ROW		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$1.00	$1.25	$1.50	$0.94	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)	3.00	6.00	12.00	4.88			

The assumption is that the utilities in the north half of the bridge are impacted. The base has a $2 M allowance for utilities such as 12-inch waterline, 8-inch SW Gas, Century Link telecommunication, SRP electrical bank, and other miscellaneous utilities. There is a 69 kV line that needs relocated along the north side of Northern. The 69 kV would require early ROW for relocation and could be a schedule risk with design and long lead for the poles. The risk is that the $2 M allowance might not be sufficient. Temporary relocation of some of these utilities maybe required based on construction phasing.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$1.00	$1.25	$1.50	$0.94	Strategy	5/16/2017
Schedule (Mo)	3.00	6.00	12.00	4.88	Mitigate	

Early agreement on the decision to widen Northern to the north. Early coordination with the 69 kV utility company. Advance the design and coordination with City of Phoenix. Consider acquiring ROW early to accommodate utility relocations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Utility Coordinator / Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ROW 60.01
Sub-Project	I-17	Northern	Status	Active

ROW

Risk Trigger		Flowchart Activity	ROW
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%							
Cost ($M)	-$3.00	-$2.00	$0.00	-$1.83	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)	-6.00	0.00	6.00	0.00			

The base includes $7.25 M based on 2.9 acres of impacts (neat line) at $2.5 M / acre. This area does not include any additional property required for full takes or access control. Concept design assumes impacts to 4 structures (2 operating businesses). At this level of design and estimation, there is an uncertainty that it could be $3 M lower and the schedule could be more or less depending on relocation. The actual business parcels could be closer to 3.5 acres (includes a partial acquisition of the K-Mart building). Because majority of the parcels are currently vacant, the base cost of $2.5 M per acre maybe on the high side.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	-$3.00	-$2.00	$0.00	-$1.83	Strategy	5/16/2017
Schedule (Mo)	-6.00	0.00	6.00	0.00	Mitigate	

Refine design and ROW estimates. Consider early acquisitions on current vacant properties (K-Mart, Village Inn, and the parcel on the northeast corner).

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.03
Sub-Project	I-17	Northern	Status	Active

Design Uncertainty

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%							
Cost ($M)	-$2.00	$0.00	$3.00	$0.17	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

These are concept level designs, There is an opportunity that optimization could be done by minimizing median widths, landscaping buffers, and possibly even turn lanes. There is also a potential for added scope for items such as turn lanes, lengthening the project to accommodate tie-ins, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	-$2.00	$0.00	$3.00	$0.17	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete preliminary design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 30.01
Sub-Project	I-17	Northern	Status	Active

Aesthetics: decorative bridge railing and ped fencing

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	
Schedule (Mo)				0.00			

The base does not assume complex aesthetic treatments and railing. There is a risk that stakeholders may require complex aesthetics and railings. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.01
Sub-Project	I-17	Northern	Status	Active

Storm drain outfall on the east side of I-17

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The base assumes $400 k for retrofitting onsite drainage, The risk is that the added impervious on the east side needs to drain into the city outfall. To mitigate the peak flows on site, it may require detention basins for quality and quantity,. Adding cost to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete preliminary design and coordinate with the city. Consider total take ROW remainders for basin locations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.02
Sub-Project	I-17	Northern	Status	Active

Storm drain water quality - West side

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Base assumes all onsite water pre and post construction outfalls directly to ADOT storm drain pipe in the SB Frontage road. This risk addresses the possibility that water quality requirements will have to be met before the water gets dumped into the outfall.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Consider total take ROW remainders for basin locations, if required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 900.01
Sub-Project	I-17	Northern	Status	Active

Concept Approval by Agency Officials

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Elected and agency officials may want an opportunity to approve the conceptual design since platform diamonds are a new concept to the area. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/16/2017
Schedule (Mo)				0.00		

Present the concept design (including visualization and proof of concept) to the concerned officials.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 30.01
Sub-Project	I-17	Northern	Status	Active

Stakeholder required scope changes

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.10	$0.15	$0.25	$0.12	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The design is not fully vetted with stakeholders. There is a risk that the stakeholders might request additional scope adding cost to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$0.10	$0.15	$0.25	$0.12	Strategy	5/16/2017
Schedule (Mo)				0.00		

Work with stakeholders to identify the requirements early.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.01
Sub-Project	I-17	Northern	Status	Active

Unforeseen underground issues

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.25	$0.50	$1.00	$0.41	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Geotechnical, unknown or abandoned utilities. The infrastructure in this area is dated and there is a high likelihood of unknown and/or abandoned utilities

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.25	$0.50	$1.00	$0.14	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete geotechnical investigation and SUE investigations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.02
Sub-Project	I-17	Northern	Status	Active

Protect in place the storm water line along the SB Frontage road

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.05	$0.10	$0.30	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The existing storm water drain behind the existing abutment structures along the SB Frontage road will need to be protected in place during the demo and construction of the structures. This may require temporary or permanent walls not included in the base cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.05	$0.10	$0.30	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Consider using secant wall abutments, temporary shoring, sheet pile wall evaluated against storm water pipe relocation.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 20.01
Sub-Project	I-17	Northern	Status	Active

COA Reports

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

These projects may or may not require COA reports. Base cost does not include COA costs, which may be up to $750 k.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$0.30	$0.40	$0.50	$0.04	Strategy	5/16/2017
Schedule (Mo)				0.00		

Coordinate with FHWA a proof of concept.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 900.03
Sub-Project	I-17	Northern	Status	Active

Project deferral

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Project deferral of Northern due to overlap with LRT construction on Dunlap. Deferring this project could also help with the ROW acquisition and the utility relocation, specifically the OH power, and also with the temporary relocation of the utilities in the north half of the bridge. Northern would have to be deferred 2.5 years to not have any overlap with the construction on Dunlap. This is a watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.01
Sub-Project	I-17	Northern	Status	Active

ITS/FMS

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
30%							
Cost ($M)	$0.20	$0.30	$0.60	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The risk is that the planned advanced ITS/FMS that might be in place at the time of this project construction would need to be maintained, updated, or reconstructed. An additional risk is that the lanned advanced ITS/FMS is not in place, but would be included in this project, Base assumes $150 k and only the current infrastructure exists.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
30%						
Cost ($M)	$0.20	$0.30	$0.60	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate with the ITS improvements project on I-17 with ADOT TSMO and with the COP for their arterial ITS improvements; advance the design; and update the cost.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CTR 40.01
Sub-Project	I-17	Northern	Status	Active

Market Conditions (Bidders, Labor, Materials)

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.31	$0.63	$0.94	$0.31	Project Rank Cost	Project Rank Schedule	5/22/2017
Schedule (Mo)				0.00			

There could be a shortage of skilled labor and / or project materials and /or a reduced number of bidders due to the large number of projects in the Greater Phoenix area when this project is expected to be constructed. The cost is a range of 1%, 2%, or 3% of the base construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.31	$0.63	$0.94	$0.31	Strategy	5/22/2017
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Cost Risk Assessment (CRA)

Results

Project Name: I-17 & Glendale Platform TI

TRACS Number: U0007

Project Description: Upgrade the I-17 and Glendale interchange to a three level platform diamond, by adding a new east-west flyover over the interchange along Glendale Avenue.

CRA Cost and Schedule Results

Cost Results (Millions 2017 $s)	Base Cost 2017 $s	10th Percentile 2017 $s	70th Percentile 2017 $s	90th Percentile 2017 $s
Post-Response Results Total Project Cost (2017 $s)	$43.0	$40.1	$46.3	$49.2
Schedule Results	**Base Completion**	**10th Percentile Completion**	**70th Percentile Completion**	**90th Percentile Completion**
Post-Response Project Completion	Feb 2027	Feb 2027	May 2027	Aug 2027

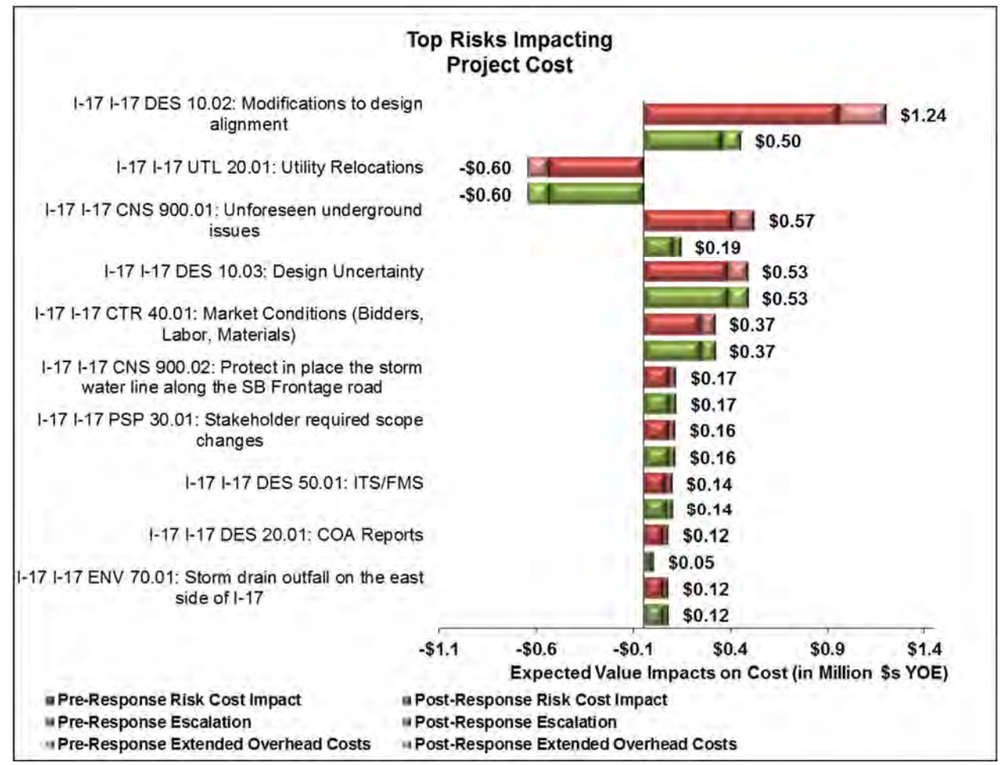
Base Costs by Activity

Activity ID	Activity Name	Total		
		Low	Base	High
100	Design / Environmental	$2,052,421	$2,254,601	$2,496,285
200	Right-of-Way / Utilities	$9,086,550	$9,086,550	$9,086,550
300	Construction	$26,778,282	$29,407,905	$32,560,654
310	Construction Engineering	$2,021,437	$2,205,702	$2,442,762
400	Project Completion	$0	$0	$0
Total		**$39,938,691**	**$42,954,758**	**$46,586,251**

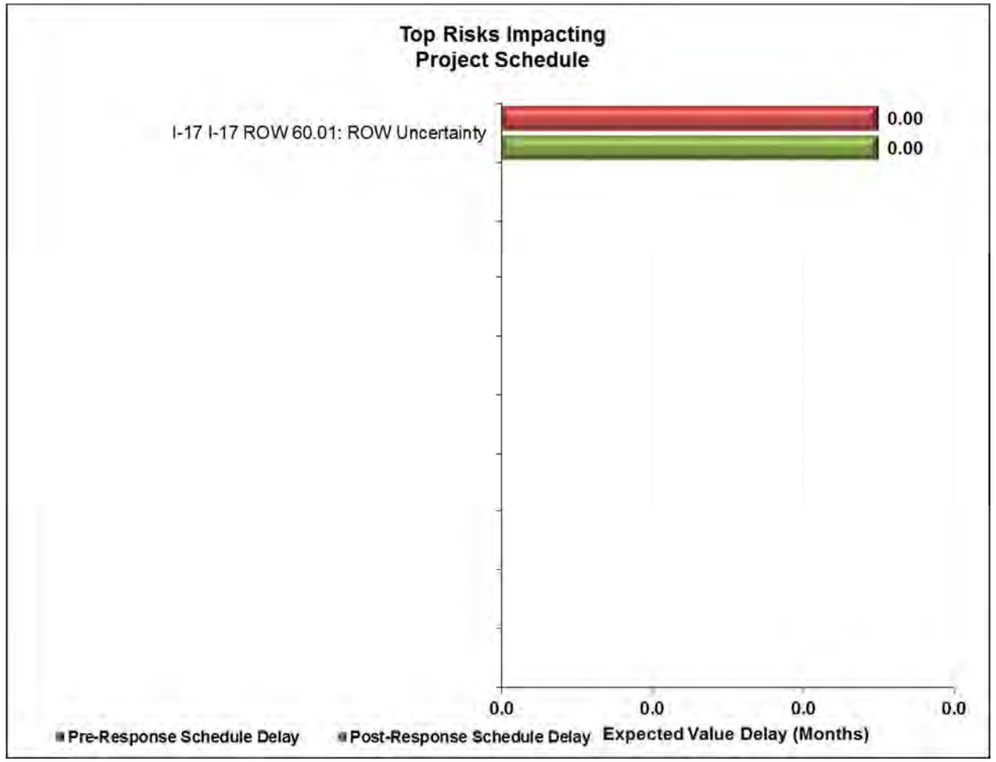
Base Schedule by Activity

Activity ID	Activity Name	Start Date	End Date	Duration (Months)
100	Design / Environmental	5/18/22	1/15/25	32.00
200	Right-of-Way / Utilities	9/15/23	5/19/25	20.14
300	Construction	1/15/25	2/9/27	24.84
310	Construction Engineering	1/15/25	2/9/27	24.84
400	Project Completion	2/9/27	2/9/27	0.03

Tornado Chart of Top Cost Risks



Tornado Chart of Top Schedule Risks



Note: ROW Uncertainty risk is quantified with a range of +/- 6 months impact but the expected value impact is zero months as depicted in the chart.

Project	I-17	Scenario	Risk ID	I-17 I-17 UTL 20.01
Sub-Project	I-17	Glendale	Status	Active

Utility Relocations

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	-$1.00	-$0.75	-$0.25	-$0.53	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The assumption is that the utilities in the south bridge are not impacted. The base has a $2 M allowance for utilities such as sewer, smaller waterlines, SW Gas, telecommunication, irrigation, and other miscellaneous utilities. The opportunity is that the $2 M allowance might not be excessive.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	-$1.00	-$0.75	-$0.25	-$0.53	Strategy	5/16/2017
Schedule (Mo)				0.00	Mitigate	

Advance the design and coordination with City of Phoenix. Consider acquiring ROW early to accommodate utility relocations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Utility Coordinator / Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.02
Sub-Project	I-17	Glendale	Status	Active

Modifications to design alignment

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$3.00	$4.00	$5.00	$1.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Design concept assumes TI shifts completely to the north. There is a risk that the impacts to Homestead park could require some revisions to the alignment to avoid impacts to the park. This would have significant utility impacts (including the irrigation siphon, and water and sewer lines). Additional ROW impacts to the south side of Glendale. Utilities in the south side of the bridge would all need to be relocated since that portion of the bridge would need to be removed.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$3.00	$4.00	$5.00	$0.40	Strategy	5/16/2017
Schedule (Mo)				0.00	Mitigate	

Refine the design to minimize impacts to the park and design mitigation for any potential impacts to the park.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ROW 60.01
Sub-Project	I-17	Glendale	Status	Active

ROW

Risk Trigger		Flowchart Activity	ROW
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%							
Cost ($M)	-$3.00	$0.00	$3.00	$0.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)	-6.00	0.00	6.00	0.00			

The base includes $8.25 M based on 3.3 acres of impacts (neat line) at $2.5 M / acre. This area does not include any additional property required for full takes or access control. Concept design assumes impacts to 5 businesses. At this level of design and estimation, there is an uncertainty that it could be $3 M lower or higher and the schedule could be more or less depending on relocation.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	-$3.00	$0.00	$3.00	$0.00	Strategy	5/16/2017
Schedule (Mo)	-6.00	0.00	6.00	0.00	Mitigate	

Refine design and ROW estimates.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.03
Sub-Project	I-17	Glendale	Status	Active

Design Uncertainty

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
100%							
Cost ($M)	-$2.00	$0.00	$3.00	$0.17	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

These are concept level designs, There is an opportunity that optimization could be done by minimizing median widths, landscaping buffers, and possibly even turn lanes. There is also a potential for added scope for items such as turn lanes, lengthening the project to accommodate tie-ins, etc.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
100%						
Cost ($M)	-$2.00	$0.00	$3.00	$0.17	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete preliminary design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 30.01
Sub-Project	I-17	Glendale	Status	Active

Aesthetics: decorative bridge railing and ped fencing

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The base does not assume complex aesthetic treatments and railing. There is a risk that stakeholders may require complex aesthetics and railings. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.01
Sub-Project	I-17	Glendale	Status	Active

Storm drain outfall on the east side of I-17

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The base assumes $400 k for retrofitting onsite drainage, The risk is that the added impervious on the east side needs to drain into the city outfall. To mitigate the peak flows on site, it may require detention basins for quality and quantity,. Adding cost to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete preliminary design and coordinate with the city. Consider total take ROW remainders for basin locations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.02
Sub-Project	I-17	Glendale	Status	Active

Storm drain water quality - West side

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Base assumes all onsite water pre and post construction outfalls directly to ADOT storm drain pipe in the SB Frontage road. This risk addresses the possibility that water quality requirements will have to be met before the water gets dumped into the outfall.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Consider total take ROW remainders for basin locations, if required.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 900.01
Sub-Project	I-17	Glendale	Status	Active

Concept Approval by Agency Officials

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Elected and agency officials may want an opportunity to approve the conceptual design since platform diamonds are a new concept to the area. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/16/2017
Schedule (Mo)				0.00		

Present the concept design (including visualization and proof of concept) to the concerned officials.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 30.01
Sub-Project	I-17	Glendale	Status	Active

Stakeholder required scope changes

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.10	$0.15	$0.25	$0.12	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The design is not fully vetted with stakeholders. There is a risk that the stakeholders might request additional scope adding cost to the project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$0.10	$0.15	$0.25	$0.12	Strategy	5/16/2017
Schedule (Mo)				0.00		

Work with stakeholders to identify the requirements early.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.01
Sub-Project	I-17	Glendale	Status	Active

Unforeseen underground issues

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.25	$0.50	$1.00	$0.41	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

Geotechnical, unknown or abandoned utilities. The infrastructure in this area is dated and there is a high likelihood of unknown and/or abandoned utilities

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.25	$0.50	$1.00	$0.14	Strategy	5/16/2017
Schedule (Mo)				0.00		

Complete geotechnical investigation and SUE investigations.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.02
Sub-Project	I-17	Glendale	Status	Active

Protect in place the storm water line along the SB Frontage road

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.05	$0.10	$0.30	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The existing storm water drain behind the existing abutment structures along the SB Frontage road will need to be protected in place during the demo and construction of the structures. This may require temporary or permanent walls not included in the base cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.05	$0.10	$0.30	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00		

Consider using secant wall abutments, temporary shoring, sheet pile wall evaluated against storm water pipe relocation.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 20.01
Sub-Project	I-17	Glendale	Status	Active

COA Reports

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
25%							
Cost ($M)	$0.30	$0.40	$0.50	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

These projects may or may not require COA reports. Base cost does not include COA costs, which may be up to $750 k.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$0.30	$0.40	$0.50	$0.04	Strategy	5/16/2017
Schedule (Mo)				0.00		

Coordinate with FHWA a proof of concept.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.01
Sub-Project	I-17	Glendale	Status	Active

ITS/FMS

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
30%							
Cost ($M)	$0.20	$0.30	$0.60	$0.10	Project Rank Cost	Project Rank Schedule	5/16/2017
Schedule (Mo)				0.00			

The risk is that the planned advanced ITS/FMS that might be in place at the time of this project construction would need to be maintained, updated, or reconstructed. An additional risk is that the planned advanced ITS/FMS is not in place, but would be included in this project, Base assumes $150 k and only the current infrastructure exists.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
30%						
Cost ($M)	$0.20	$0.30	$0.60	$0.10	Strategy	5/16/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate with the ITS improvements project on I-17 with ADOT TSMO and with the COP for their arterial ITS improvements; advance the design; and update the cost.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/16/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CTR 40.01
Sub-Project	I-17	Glendale	Status	Active

Market Conditions (Bidders, Labor, Materials)

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.29	$0.59	$0.88	$0.29	Project Rank Cost	Project Rank Schedule	5/22/2017
Schedule (Mo)				0.00			

There could be a shortage of skilled labor and / or project materials and /or a reduced number of bidders due to the large number of projects in the Greater Phoenix area when this project is expected to be constructed. The cost is a range of 1%, 2%, or 3% of the base construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.29	$0.59	$0.88	$0.29	Strategy	5/22/2017
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Cost Risk Assessment (CRA)

Results

Project Name: I-17 & Thunderbird Platform TI

TRACS Number: U0010

Project Description: Upgrade the I-17 and Thunderbird interchange to a three level platform diamond by elevating I-17 to a third level over the current interchange.

CRA Cost and Schedule Results

Cost Results (Millions 2017 $s)	Base Cost 2017 $s	10th Percentile 2017 $s	70th Percentile 2017 $s	90th Percentile 2017 $s
Post-Response Results Total Project Cost (2017 $s)	$82.9	$72.1	$81.5	$86.7
Schedule Results	**Base Completion**	**10th Percentile Completion**	**70th Percentile Completion**	**90th Percentile Completion**
Post-Response Project Completion	Jan 2025	Jan 2025	Jan 2025	Jan 2025

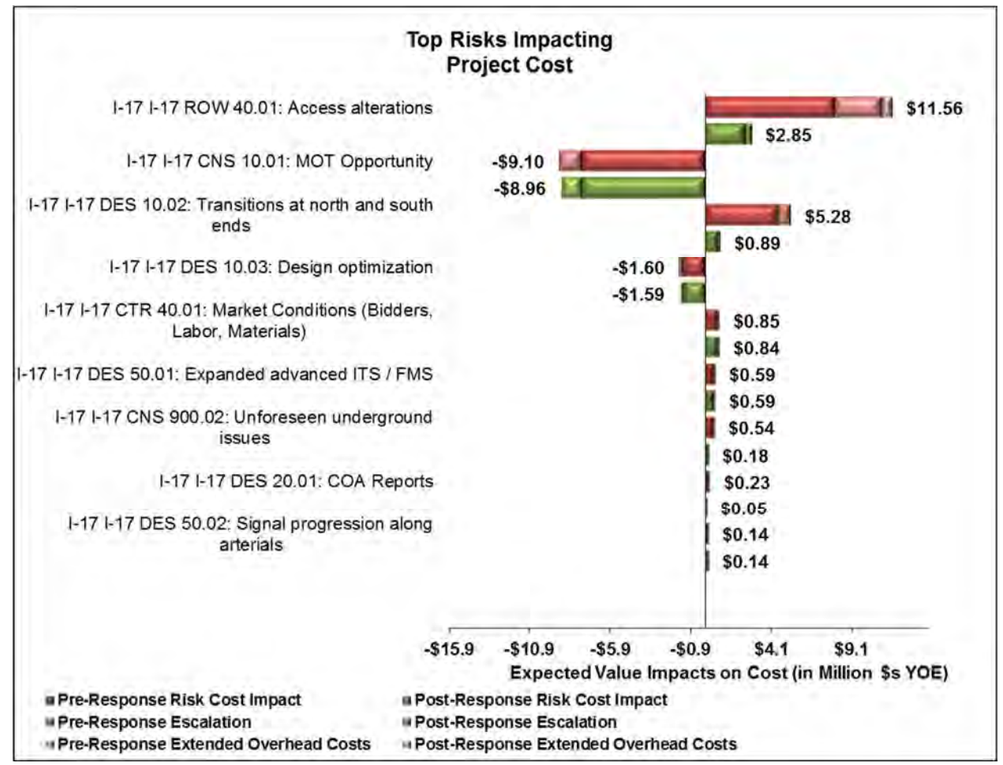
Base Costs by Activity

Activity ID	Activity Name	Total		
		Low	Base	High
100	Design / Environmental	$5,144,308	$5,481,792	$5,898,751
200	Right-of-Way / Utilities	$385,490	$385,490	$385,490
300	Construction	$67,176,149	$71,573,120	$77,015,968
310	Construction Engineering	$5,170,138	$5,491,303	$5,906,839
400	Project Completion	$0	$0	$0
Total		**$77,876,085**	**$82,931,704**	**$89,207,048**

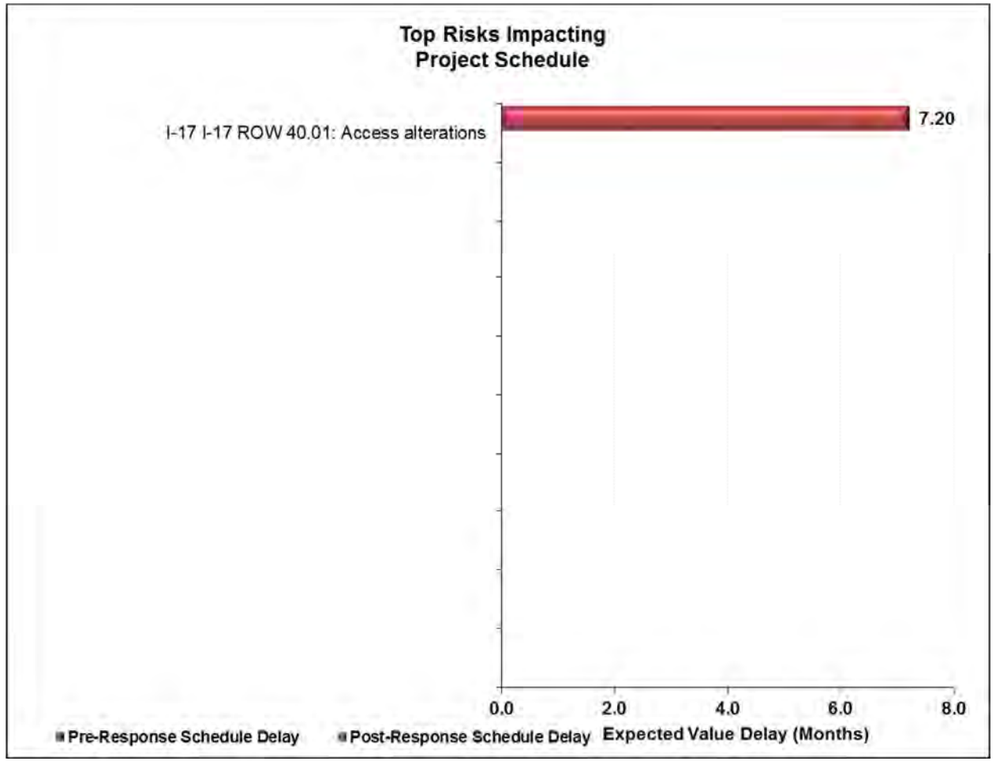
Base Schedule by Activity

Activity ID	Activity Name	Start Date	End Date	Duration (Months)
100	Design / Environmental	11/7/19	7/6/22	31.97
200	Right-of-Way / Utilities	8/5/21	11/7/22	15.11
300	Construction	7/6/22	1/14/25	30.36
310	Construction Engineering	7/6/22	1/14/25	30.36
400	Project Completion	1/14/25	1/14/25	0.03

Tornado Chart of Top Cost Risks



Tornado Chart of Top Schedule Risks



Project	I-17	Scenario	Risk ID	I-17 I-17 ROW 40.01
Sub-Project	I-17	Thunderbird	Status	Active

Access alterations

Risk Trigger		Flowchart Activity	ROW
Dependency & Correlation	Cost to ROW; schedule to design		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$5.00	$10.00	$15.00	$8.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)	6.00	9.00	12.00	7.20			

On the west side: Currently large businesses such as Best Buy, Lowe's, QT, and others have full access at the signal of 28th Ave and Thunderbird. The concept design may cut off left turns and through traffic on 28th Ave - essentially making their access right-in right-out. This could have high impacts to those businesses. Base estimate does not have any cost for accommodations for access.
On the east side: there is a Home Depot at the signal that would require access modifications. Since these costs are not included in the base cost, there is a risk that design alterations and expensive mitigation might be required.
The schedule would be a delay in building consensus around design concept.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$1.00	$3.00	$5.00	$2.40	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

On the west side: Consider adding a bulb U-turn at 28th Ave to accommodate access to the businesses on the southwest corner.
On the east side: Mitigate through frontage road access.
Advance predesign 12 months to mitigate potential delays; and, early coordination with business owners on concept design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 10.01
Sub-Project	I-17	Thunderbird	Status	Active

MOT Opportunity

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
85%							
Cost ($M)	-$10.00	-$9.00	-$8.00	-$7.65	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The base estimate has $14 M for items such as temporary structures, mainline detours, phasing, staging, etc. At 0% design, the construction staging plans are not developed. However, the structures required for the platform on Level 2 are very close to the existing profile of I-17. And, if built first could be used for mainline detours. This is an opportunity to reduce the assumed MOT cost and impacts. Some temporary paving and walls maybe required in the west side due to the close proximity of the existing ramps.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
85%						
Cost ($M)	-$10.00	-$9.00	-$8.00	-$7.65	Strategy	5/18/2017
Schedule (Mo)				0.00	Exploit	

Confirm interchange type; develop MOT plans; and exploit the opportunity.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.01
Sub-Project	I-17	Thunderbird	Status	Active

Combine Thunderbird and drainage projects

Risk Trigger		Flowchart Activity	Watch List
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

There is a possibility that the thunderbird and drainage projects could get combined to realize better efficiencies and eliminate throwaway or rebuilding on the drainage basins. Another option is that the drainage project can be split into 2 projects. However, the economies of scale of the specialized work on the drainage project will not be realized if the drainage project is split into 2 projects. Upon further discussion, it is not prudent to split the drainage project.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.01
Sub-Project	I-17	Thunderbird	Status	Active

Expanded advanced ITS / FMS

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.80	$1.00	$1.20	$0.50	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Base assumes $0.5 M for existing FMS modifications and perpetuating operations through construction, but nothing for next generation ITS. This risk adds $1 M for scope expansion to include the next generation ITS.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.80	$1.00	$1.20	$0.50	Strategy	5/18/2017
Schedule (Mo)				0.00	Accept	

Coordinate with the ITS improvements project on I-17 with ADOT TSMO and with the COP for their arterial ITS improvements; advance the design; and update the cost.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 20.01
Sub-Project	I-17	Thunderbird	Status	Active

COA Reports

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.30	$0.40	$0.50	$0.20	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

These projects may or may not require COA reports. Base cost does not include COA costs, which may be up to $750 k.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$0.30	$0.40	$0.50	$0.04	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate with FHWA a proof of concept.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.02
Sub-Project	I-17	Thunderbird	Status	Active

Signal progression along arterials

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
60%							
Cost ($M)	$0.15	$0.20	$0.25	$0.12	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Signal progression to the next intersections out would need to be synchronized with platform diamond signals. Signal revisions at 28th Ave and the business on the east side could add additional cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
60%						
Cost ($M)	$0.15	$0.20	$0.25	$0.12	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

Advance the design and run microsimulation to evaluate removal of signals at 28th Ave and business access on the east side or relocating the 28th Ave signal to the west, 325 feet.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.02
Sub-Project	I-17	Thunderbird	Status	Active

Unforeseen underground issues

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.25	$0.50	$1.00	$0.41	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Geotechnical, unknown or abandoned utilities. The infrastructure in this area is dated and there is a high likelihood of unknown and/or abandoned utilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.25	$0.50	$1.00	$0.14	Strategy	5/18/2017
Schedule (Mo)				0.00		

Complete geotechnical investigation.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.02
Sub-Project	I-17	Thunderbird	Status	Active

Transitions at north and south ends

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$2.00	$5.00	$10.00	$4.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The base assumes that the ramps could be tied in within existing ROW. The ultimate I-17 shows these ramps impacting drainage features, utilities, and extending outside of the current ROW.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$1.00	$3.00	$5.00	$0.75	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

Vertically tie-in the ramps sooner; narrow the I-17 walls at the transitions to maintain within existing ROW. This may require minor reconstruction with the ultimate project.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.03
Sub-Project	I-17	Thunderbird	Status	Active

Design optimization

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	-$6.00	-$3.00	$3.00	-$2.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The design is incomplete. There are opportunities to refine the design that could result in opportunities that reduce cost and impacts not defined in others.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	-$6.00	-$3.00	$3.00	-$2.00	Strategy	5/18/2017
Schedule (Mo)				0.00	Exploit	

Advance the design and perform a VE study on the updated design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 20.02
Sub-Project	I-17	Thunderbird	Status	Active

Public and stakeholder involvement

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Elected and agency officials / stakeholders may want an opportunity to approve the conceptual design since platform diamonds are a new concept to the area. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CTR 40.01
Sub-Project	I-17	Thunderbird	Status	Active

Market Conditions (Bidders, Labor, Materials)

Risk Trigger		Flowchart Activity	

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.72	$1.43	$2.15	$0.72	Project Rank Cost	Project Rank Schedule	5/22/2017
Schedule (Mo)				0.00			

There could be a shortage of skilled labor and / or project materials and /or a reduced number of bidders due to the large number of projects in the Greater Phoenix area when this project is expected to be constructed. The cost is a range of 1%, 2%, or 3% of the base construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.72	$1.43	$2.15	$0.72	Strategy	5/22/2017
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Cost Risk Assessment (CRA)

Results

Project Name: I-17 & Bell Platform TI

TRACS Number: U0009

Project Description: Upgrade the I-17 and Bell interchange to a three level platform diamond by elevating I-17 to a third level over the current interchange. Scope also includes expanding the existing park and ride in the southwest quadrant.

CRA Cost and Schedule Results

Cost Results (Millions 2017 $s)	Base Cost 2017 $s	10th Percentile 2017 $s	70th Percentile 2017 $s	90th Percentile 2017 $s
Post-Response Results Total Project Cost (2017 $s)	$96.1	$85.5	$96.3	$101.9
Schedule Results	**Base Completion**	**10th Percentile Completion**	**70th Percentile Completion**	**90th Percentile Completion**
Post-Response Project Completion	Feb 2027	Feb 2027	Feb 2027	Feb 2027

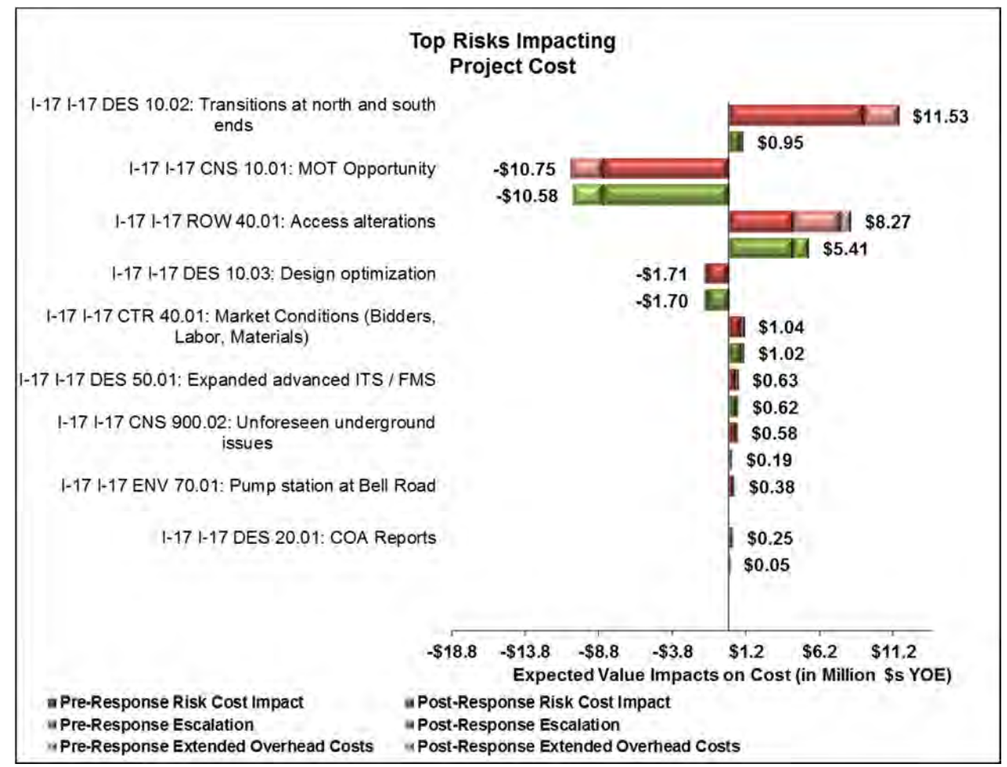
Base Costs by Activity

Activity ID	Activity Name	Total		
		Low	Base	High
100	Design / Environmental	$5,872,446	$6,316,798	$6,849,566
200	Right-of-Way / Utilities	$991,260	$991,260	$991,260
300	Construction	$76,689,720	$82,482,986	$89,438,944
310	Construction Engineering	$5,911,455	$6,341,422	$6,874,863
400	Project Completion	$0	$0	$0
Total		**$89,464,882**	**$96,132,466**	**$104,154,633**

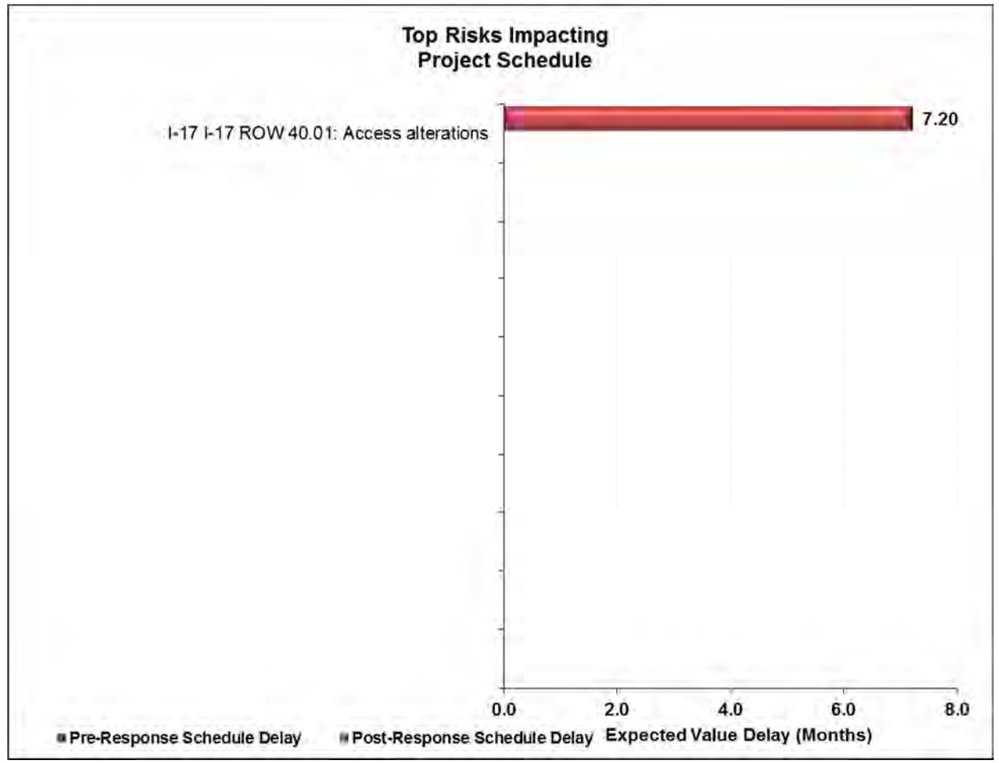
Base Schedule by Activity

Activity ID	Activity Name	Start Date	End Date	Duration (Months)
100	Design / Environmental	5/18/22	1/15/25	32.00
200	Right-of-Way / Utilities	9/15/23	5/19/25	20.14
300	Construction	1/15/25	2/9/27	24.84
310	Construction Engineering	1/15/25	2/9/27	24.84
400	Project Completion	2/9/27	2/9/27	0.03

Tornado Chart of Top Cost Risks



Tornado Chart of Top Schedule Risks



Project	I-17	Scenario	Risk ID	I-17 I-17 ROW 40.01
Sub-Project	I-17	Bell	Status	Active

Access alterations

Risk Trigger		Flowchart Activity	ROW
Dependency & Correlation	Cost to ROW; schedule to design		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$3.00	$5.00	$8.00	$4.13	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)	6.00	9.00	12.00	7.20			

On the west side: The park and ride, Fry's, and Red Roof Inn could all have access impacts.
On the west side: Auto Nation, Waffle House, Shell, and Fairfield Inn could all have access impacts.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$3.00	$5.00	$8.00	$4.13	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

Change the design to provide adequate access to the businesses.
Advance predesign 12 months to mitigate potential delays; and, early coordination with business owners on concept design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 ENV 70.01
Sub-Project	I-17	Bell	Status	Active

Pump station at Bell Road

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
20%							
Cost ($M)	$1.00	$1.50	$2.00	$0.30	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

There is a pump station at the northwest corner. The concept design clips a corner of the pump station and may require relocation. The pump station will be required in the ultimate project. The base cost has no cost to address this.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
0%						
Cost ($M)	$1.00	$1.50	$2.00	$0.00	Strategy	5/18/2017
Schedule (Mo)				0.00	Avoid	

Optimize the design to accommodate the pump station at its current location.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 10.01
Sub-Project	I-17	Bell	Status	Active

MOT Opportunity

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
85%							
Cost ($M)	-$11.00	-$10.00	-$9.00	-$8.50	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The base estimate has $14 M for items such as temporary structures, mainline detours, phasing, staging, etc. At 0% design, the construction staging plans are not developed. However, the structures required for the platform on Level 2 are very close to the existing profile of I-17. And, if built first could be used for mainline detours. This is an opportunity to reduce the assumed MOT cost and impacts.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
85%						
Cost ($M)	-$11.00	-$10.00	-$9.00	-$8.50	Strategy	5/18/2017
Schedule (Mo)				0.00	Exploit	

Confirm interchange type; develop MOT plans; and exploit the opportunity.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.01
Sub-Project	I-17	Bell	Status	Active

Park and ride improvements at Bell - use of highway funds

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The base assumes $8 M for park and ride improvements. The risk is whether or not these improvements will be part of this project. The ramp realignment will require moving the existing dedicated bus stop to the park and ride. This is a non-quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/18/2017
Schedule (Mo)				0.00		

There needs to be discussion between MAG, ADOT, and VM regarding plans to improve the park and ride.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.01
Sub-Project	I-17	Bell	Status	Active

Expanded advanced ITS / FMS

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.80	$1.00	$1.20	$0.50	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Base assumes $0.5 M for existing FMS modifications and perpetuating operations through construction, but nothing for next generation ITS. This risk adds $1 M for scope expansion to include the next generation ITS.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.80	$1.00	$1.20	$0.50	Strategy	5/18/2017
Schedule (Mo)				0.00	Accept	

Coordinate with the ITS improvements project on I-17 with ADOT TSMO and with the COP for their arterial ITS improvements; advance the design; and update the cost.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 20.01
Sub-Project	I-17	Bell	Status	Active

Stakeholder coordination (Transit)

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The park and ride lot operations during construction requires public involvement / Valley Metro coordination efforts prior to construction. This is non-quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 20.01
Sub-Project	I-17	Bell	Status	Active

COA Reports

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.30	$0.40	$0.50	$0.20	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

These projects may or may not require COA reports. Base cost does not include COA costs, which may be up to $750 k.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$0.30	$0.40	$0.50	$0.04	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

Coordinate with FHWA a proof of concept.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 50.02
Sub-Project	I-17	Bell	Status	Active

Signal progression along arterials

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Signal progression to the next intersections out would need to be synchronized with platform diamond signals. This is a non-quantifiable watch list item. The work can be done with the base cost and its uncertainties.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CNS 900.02
Sub-Project	I-17	Bell	Status	Active

Unforeseen underground issues

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.25	$0.50	$1.00	$0.41	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Geotechnical, unknown or abandoned utilities. The infrastructure in this area is dated and there is a high likelihood of unknown and/or abandoned utilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$0.25	$0.50	$1.00	$0.14	Strategy	5/18/2017
Schedule (Mo)				0.00		

Complete geotechnical investigation.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.02
Sub-Project	I-17	Bell	Status	Active

Transitions at north and south ends

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$5.00	$10.00	$20.00	$8.13	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The base assumes that the ramps could be tied in within existing ROW. The ultimate I-17 shows these ramps impacting drainage features, utilities, and extending outside of the current ROW.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
25%						
Cost ($M)	$1.00	$3.00	$5.00	$0.75	Strategy	5/18/2017
Schedule (Mo)				0.00	Mitigate	

Vertically tie-in the ramps sooner; narrow the I-17 walls at the transitions to maintain within existing ROW. This may require minor reconstruction with the ultimate project.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 DES 10.03
Sub-Project	I-17	Bell	Status	Active

Design optimization

Risk Trigger		Flowchart Activity	Design
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	-$6.00	-$3.00	$3.00	-$2.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

The design is incomplete. There are opportunities to refine the design that could result in opportunities that reduce cost and impacts not defined in others.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	-$6.00	-$3.00	$3.00	-$2.00	Strategy	5/18/2017
Schedule (Mo)				0.00	Exploit	

Advance the design and perform a VE study on the updated design.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/18/2017
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 PSP 20.02
Sub-Project	I-17	Bell	Status	Active

Public and stakeholder involvement

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/18/2017
Schedule (Mo)				0.00			

Elected and agency officials / stakeholders may want an opportunity to approve the conceptual design since platform diamonds are a new concept to the area. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17	Scenario	Risk ID	I-17 I-17 CTR 40.01
Sub-Project	I-17	Bell	Status	Active

Market Conditions (Bidders, Labor, Materials)

Risk Trigger		Flowchart Activity	

Dependency & Correlation	

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.82	$1.65	$2.47	$0.82	Project Rank Cost	Project Rank Schedule	5/22/2017
Schedule (Mo)				0.00			

There could be a shortage of skilled labor and / or project materials and /or a reduced number of bidders due to the large number of projects in the Greater Phoenix area when this project is expected to be constructed. The cost is a range of 1%, 2%, or 3% of the base construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.82	$1.65	$2.47	$0.82	Strategy	5/22/2017
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

I-17 Drainage Improvements; ACDC Canal to Greenway Road CRA Workshop Results

May 17, 2017

Cost Risk Assessment (CRA)

Results

Project Name: I-17 Drainage Improvements

TRACS Number: U0011

Project Description: Replace four existing pumpstations at Peoria, Cactus, Thunderbird, and Greenway TIs on I-17 with a gravity storm drain pipe to the ACDC canal, running largely under the SB frontage road. Pipe sizes vary from 24" to 72" and can be up to 25 deep to the flowline. The infields at Thunderbird will be excavated for new detention basins.

CRA Cost and Schedule Results

Cost Results (Millions 2017 $s)	Base Cost 2017 $s	10th Percentile 2017 $s	70th Percentile 2017 $s	90th Percentile 2017 $s
Post-Response Results Total Project Cost (2017 $s)	$25.3	$25.7	$29.2	$30.9
Schedule Results	**Base Completion**	**10th Percentile Completion**	**70th Percentile Completion**	**90th Percentile Completion**
Post-Response Project Completion	Dec 2020	Dec 2020	Mar 2021	May 2021

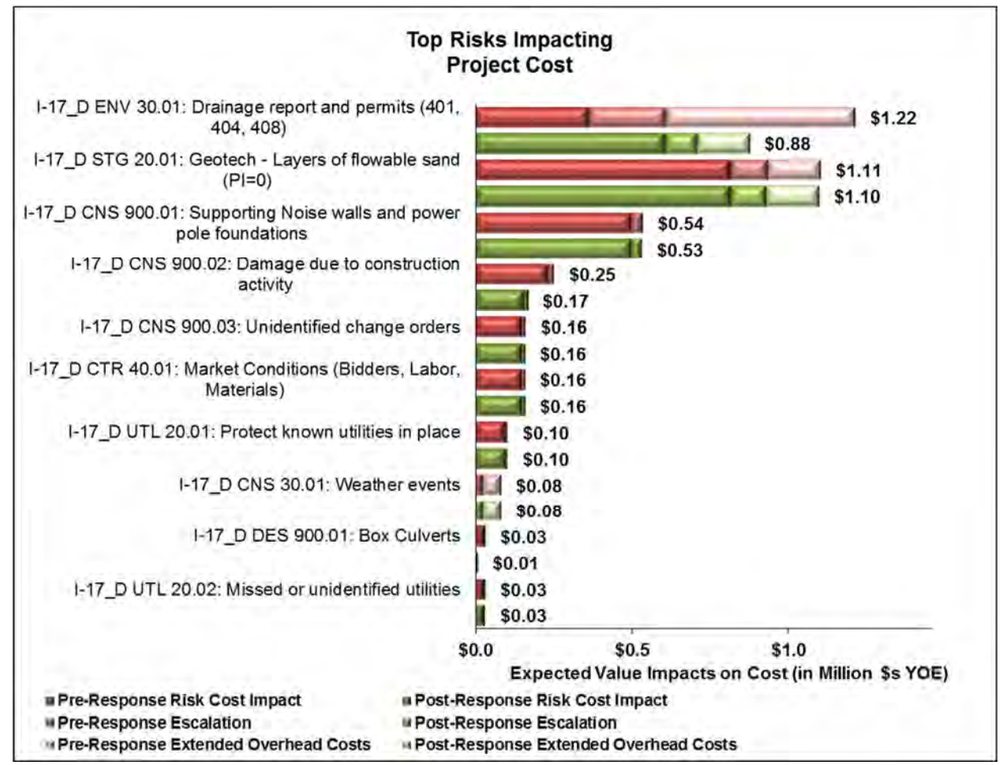
Base Costs by Activity

Activity ID	Activity Name	Total		
		Low	Base	High
100	Design / Environmental	$550,700	$550,700	$550,700
200	Right-of-Way / Utilities	$0	$0	$0
300	Construction	$20,060,889	$22,697,696	$25,416,068
310	Construction Engineering	$1,792,098	$2,027,924	$2,271,090
400	Project Completion	$0	$0	$0
Total		**$22,403,687**	**$25,276,320**	**$28,237,858**

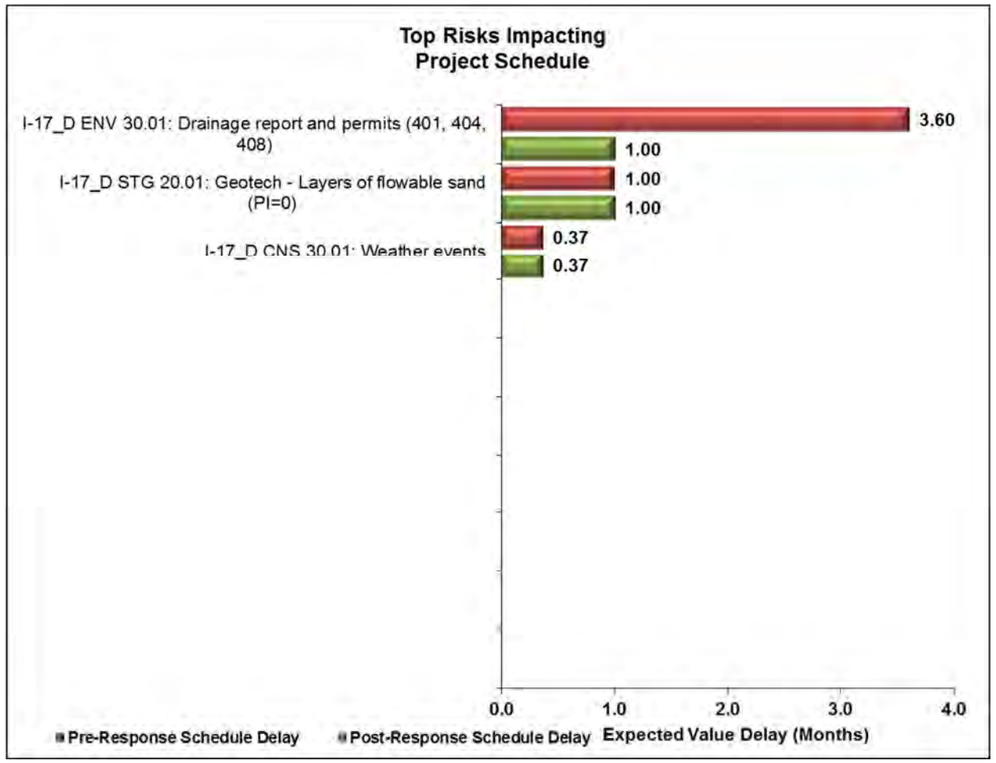
Base Schedule by Activity

Activity ID	Activity Name	Start Date	End Date	Duration (Months)
100	Design / Environmental	12/19/17	1/15/19	12.91
200	Right-of-Way / Utilities	8/13/18	5/17/19	9.13
300	Construction	1/15/19	12/14/20	23.00
310	Construction Engineering	1/15/19	12/14/20	23.00
400	Project Completion	12/14/20	12/14/20	0.03

Tornado Chart of Top Cost Risks



Tornado Chart of Top Schedule Risks



Project	I-17 Drainage	Risk ID	I-17_D I-17_D UTL 20.01
Sub-Project	I-17 Drainage	Status	Active

Protect known utilities in place

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)	$0.05	$0.10	$0.20	$0.09	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

Greenway - 54" sewer, 48" water. Close proximity, COP requires 4-foot offset from pressurized water pipe during construction (may require more per revised standards). The risk is that the waterline might need shutting down. COP allows shutdowns between Oct and Apr. This is a schedule risk. At Greenway, this is a non quantifiable watch list item.
Quarter mile south of Thunderbird - existing 28" water line is noted as abandoned in place by COP.
Between I-17 Sta 705 and 710 - a new COP waterline crosses I-17 (24" pipe in a 48" sleeve). This needs to be protected in place. This is not shown on the plans.
Sweetwater - gravity sewer in a steel sleeve. The risk is that the sewer line is lower than shown on plans and might be in conflict with the storm drain.
The cost for protecting utilities in place is part of the unit cost for installation of the pipe. This risk cost is the uncertainty in bidder's reaction.
The contract plans show locations for gas, communications, irrigation, and power that need protected in place.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	$0.05	$0.10	$0.20	$0.09	Strategy	5/17/2017
Schedule (Mo)				0.00		

Get exact location of the existing sewer line around Sta 699+50. Include a bid item to field verify the location of the sewer line.
Add a bid item for protect in place utilities that includes a table of the known utilities that need to be protected in place.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D UTL 20.02
Sub-Project	I-17 Drainage	Status	Active

Missed or unidentified utilities

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
10%							
Cost ($M)	$0.10	$0.25	$0.50	$0.03	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

The 95% plans indicate known and possible utility locations. The risk is that additional utilities might be found during construction that conflict with the design, resulting in change orders. This could be protect in place or relocate. The noise wall project exposed a number of utilities resulting in low probability of finding additional unknown utilities.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
10%						
Cost ($M)	$0.10	$0.25	$0.50	$0.03	Strategy	5/17/2017
Schedule (Mo)				0.00	Accept	

Hold a reserve for change orders.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D STG 20.01
Sub-Project	I-17 Drainage	Status	Active

Geotech - Layers of flowable sand (PI=0)

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.10	$1.00	$3.00	$0.59	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)	1.00	2.00	3.00	1.00			

Project records indicate that at some locations along the project there are incidences of flowable sand (PI=0). And, the condition is worse in wet conditions. The risk is that a pocket of flowable sand could result in overexcavation and potential sink holes in adjacent sites. Field repairs can vary between $100k and $3M. In reviewing the constructability report, this issue was noted; but, it could not be found in the boring logs. May require additional shoring in the areas where the flowable sand is not very deep.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.10	$1.00	$3.00	$0.59	Strategy	5/17/2017
Schedule (Mo)	1.00	2.00	3.00	1.00	Mitigate	

Ascertain the limits and extents with further geotechnical investigations, and include boring logs in the plans.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D ENV 10.01
Sub-Project	I-17 Drainage	Status	Active

Environmental document update

Risk Trigger		Flowchart Activity	Watch List
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

The original environmental document is a CE, which has not been reevaluated since 2006. The risk is that a new CE will be required. This is a non quantifiable watch list item

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D ENV 30.01
Sub-Project	I-17 Drainage	Status	Active

Drainage report and permits (401, 404, 408)

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
30%							
Cost ($M)	$0.50	$1.00	$2.00	$0.33	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)	6.00	12.00	18.00	3.60			

The risk is that the permit condition for 401 could require quality treatments that are not currently in the base design, especially in the 3 downstream miles. This could require ROW and basins or large underground tanks.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.50	$1.00	$2.00	$0.54	Strategy	5/17/2017
Schedule (Mo)	1.00	2.00	3.00	1.00	Mitigate	

Coordinate with Corps to determine applicability of water quality to this project. Offer that we have the ability to treat in our basins 50% of the flow, upstream of Thunderbird; this is an improvement over the existing condition.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		Monthly

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CNS 900.01
Sub-Project	I-17 Drainage	Status	Active

Supporting Noise walls and power pole foundations

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

Power pole foundations are mitigated by drilled shafts. Noise walls are on shallow spread footings. These may require additional shoring during construction. Base estimate has $1,500 per foot to jack and bore a 72-inch pipe. Between Cactus and Peoria, there is a pinch point on noise walls approximately 1000 feet that requires additional shoring or jack and bore.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.50	$1.00	$1.50	$0.50	Strategy	5/17/2017
Schedule (Mo)				0.00	Mitigate	

Conduct an industry outreach / constructability review. Include in advertisement for final designer experienced construction advisor. Evaluate shoring cost versus jack and bore at the pinch points.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CNS 80.01
Sub-Project	I-17 Drainage	Status	Active

Construction sequencing with VM NW Phase II and other projects

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.10	$0.20	$0.30	$0.10	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)	0.25	0.50	1.00	0.27			

VM is scheduled to be under construction Aug 2019 through Spring 2023. The last mile of the outfall is in direct conflice with the plans for the station. There is a risk if both contractors are in the same area at the same time leading to potential delays to one or both projects. This is a nonquantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)	-$0.30	-$0.20	-$0.10	-$0.16	Strategy	5/17/2017
Schedule (Mo)				0.00		

There must be coordination with the VM NW Phase II project. Consider specifying the order of work to complete thd downstream outfall first to eliminate conflicts with VM NW Phase II station and guideway work. Consider coordination with the VM work for them to do their work on the closed section of the SB frontage road prior to reopening the frontage road. Revise the drainage project to avoid full pavement and curb on the frontage road in the vicinity of the LRT project.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D ROW 60.01
Sub-Project	I-17 Drainage	Status	Active

Temporary Construction Easements

Risk Trigger		Flowchart Activity	Watch List
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

Base cost assumes all construction within the existing ROW. The risk is that temporary construction easements maybe required for construction activities not currently defined. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/17/2017
Schedule (Mo)				0.00		

The final designer to identify TCE required for constructability.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CNS 10.01
Sub-Project	I-17 Drainage	Status	Active

MOT

Risk Trigger		Flowchart Activity	Watch List
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

The base schedule assumes 13 months for construction. However, due to the vicinity of the mall in the last downstream mile of the project, there might be moratoriums on construction between Thanksgiving and New Year's. Additionally, the closure of the frontage road required for this project and the VM project needs to be coordinated. Lastly, access to properties and businesses adjacent to the project might be impacted. This is a non quantifiable watch list risk.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/17/2017
Schedule (Mo)				0.00		

Review and coordinate special provisions with COP and VM, and with fire and life safety (access requirements).

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CNS 900.02
Sub-Project	I-17 Drainage	Status	Active

Damage due to construction activity

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.15	$0.25	$0.50	$0.21	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

The risk is that the contractor might bid a premium because of the dense urban characteristics of the project area knowing that he will be responsible for any damages. Example damages could be to the surrounding sidewalks, curbs, and homes damaged by the vibration during compaction and/or heavy equipment.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.15	$0.25	$0.50	$0.14	Strategy	5/17/2017
Schedule (Mo)				0.00	Mitigate	

Document damages to the existing infrastructure around the project area to minimize the probability of change orders.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Construction manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CNS 30.01
Sub-Project	I-17 Drainage	Status	Active

Weather events

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation	no contractor overhead		

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
80%							
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)	0.10	0.50	0.75	0.38			

The risk is that the deep trenches are susceptible to work shutdowns due to heavy rains. This project is a multi season project; therefore it could have multiple project shutdowns.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
80%						
Cost ($M)				$0.00	Strategy	5/17/2017
Schedule (Mo)	0.10	0.50	0.75	0.38		

Do not charge the contractor working days during weather events.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D DES 900.01
Sub-Project	I-17 Drainage	Status	Active

Box Culverts

Risk Trigger		Flowchart Activity	Construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
5%							
Cost ($M)	$0.25	$0.50	$1.00	$0.03	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

There is a risk of removing the box culverts between Thunderbird and Greenway along the NB Frontage Road. Base estimate does not show cost for box culverts (details D1 & D2). The risk is that a significant weather event while a portion of the box culvert is removed for excavation could trigger severe flooding.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
1%						
Cost ($M)	$0.25	$0.50	$1.00	$0.01	Strategy	5/17/2017
Schedule (Mo)				0.00	Mitigate	

Require an approved workplan to execute the work at an appropriate time of the year and an expedited work plan for the box culvert work. Consider using precast box culvert elements or temporary piping to mitigate this risk.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Design Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CTR 10.01
Sub-Project	I-17 Drainage	Status	Active

Delivery method

Risk Trigger		Flowchart Activity	Watch list
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
Cost ($M)				$0.00	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

The assumed base is D-B-B. The risk is that the complexity of the work involved does not lend itself to the lowest bid. This is a non quantifiable watch list item.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
Cost ($M)				$0.00	Strategy	5/17/2017
Schedule (Mo)				0.00		

Conduct an industry outreach / constructability review. Include in advertisement for final designer experienced construction advisor. Consider using a D-B-B with ATC's.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments

Last Review	Date MC Last Updated
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CNS 900.03
Sub-Project	I-17 Drainage	Status	Active

Unidentified change orders

Risk Trigger		Flowchart Activity	construction
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
75%							
Cost ($M)	$0.10	$0.20	$0.30	$0.15	Project Rank Cost	Project Rank Schedule	5/17/2017
Schedule (Mo)				0.00			

Assume approximately 1% of the $ 23 M is not covered in the other identified risks.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
75%						
Cost ($M)	$0.10	$0.20	$0.30	$0.15	Strategy	5/17/2017
Schedule (Mo)				0.00	Accept	

Hold a reserve for unknown unknowns.

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
Project Manager		To		

Review Comments

Last Review	Date MC Last Updated
	5/17/2017
Next Review	**Risk Assignment**

Project	I-17 Drainage	Risk ID	I-17_D I-17_D CTR 40.01
Sub-Project	I-17 Drainage	Status	Active

Market Conditions (Bidders, Labor, Materials)

Risk Trigger		Flowchart Activity	
Dependency & Correlation			

Pre-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Program Rank Cost	Program Rank Schedule	Date Pre Last Updated
50%							
Cost ($M)	$0.15	$0.30	$0.45	$0.15	Project Rank Cost	Project Rank Schedule	5/22/2017
Schedule (Mo)				0.00			

There could be a shortage of skilled labor and / or project materials and /or a reduced number of bidders due to the large number of projects in the Greater Phoenix area when this project is expected to be constructed. The cost is a range of 1%, 2%, or 3% of the base construction cost.

Post-Response Quantification

Probability	Low	Most Likely	High	Total Expected Value Impact	Additional Cost to Respond	Date Post Last Updated
50%						
Cost ($M)	$0.15	$0.30	$0.45	$0.15	Strategy	5/22/2017
Schedule (Mo)				0.00		

Monitoring and Control

Risk Owner	Risk Aging	From		Status Interval
		To		

Review Comments	Last Review	Date MC Last Updated
	Next Review	Risk Assignment

Appendix E. Crash Diagrams

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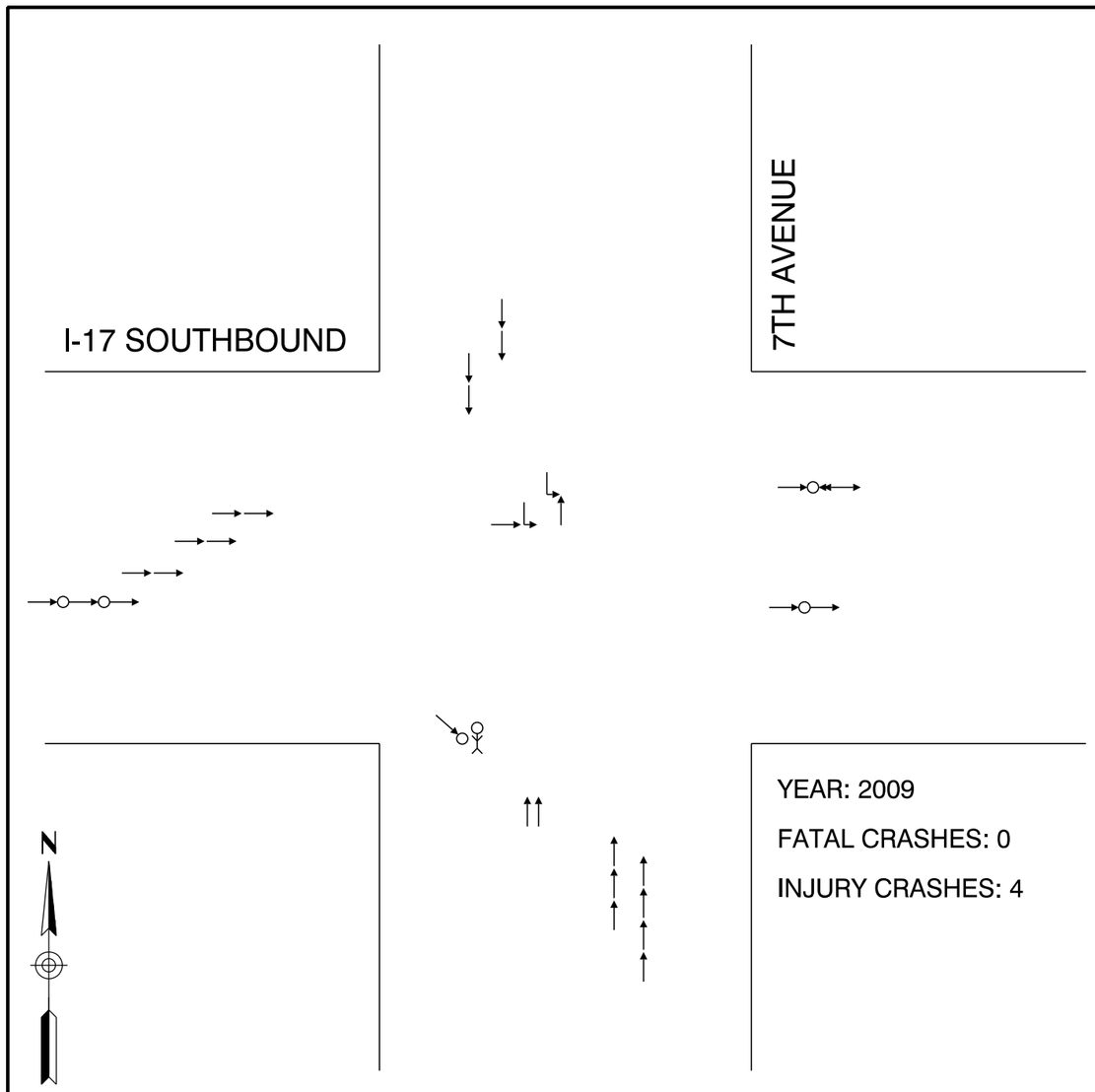
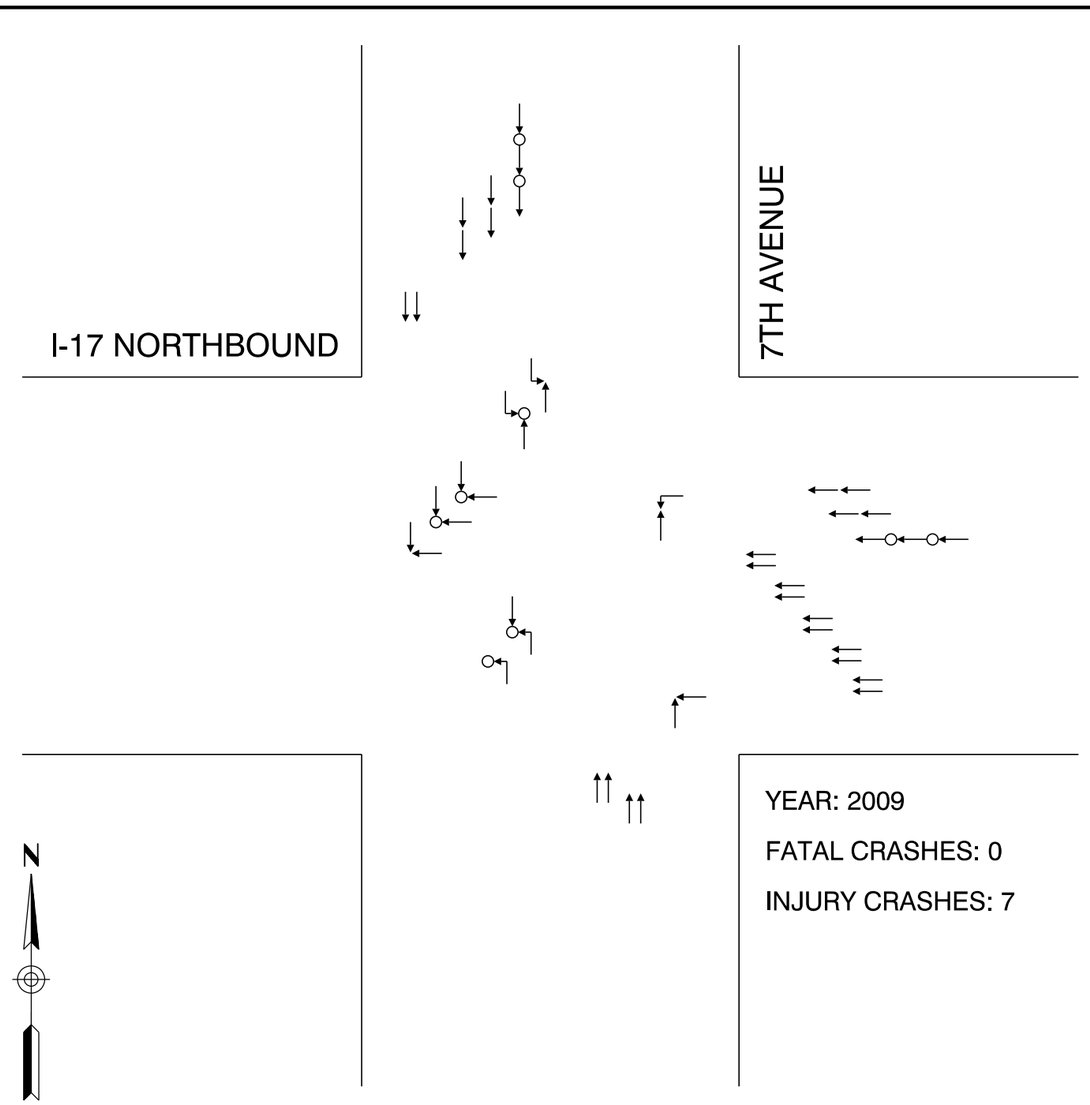




LEGEND

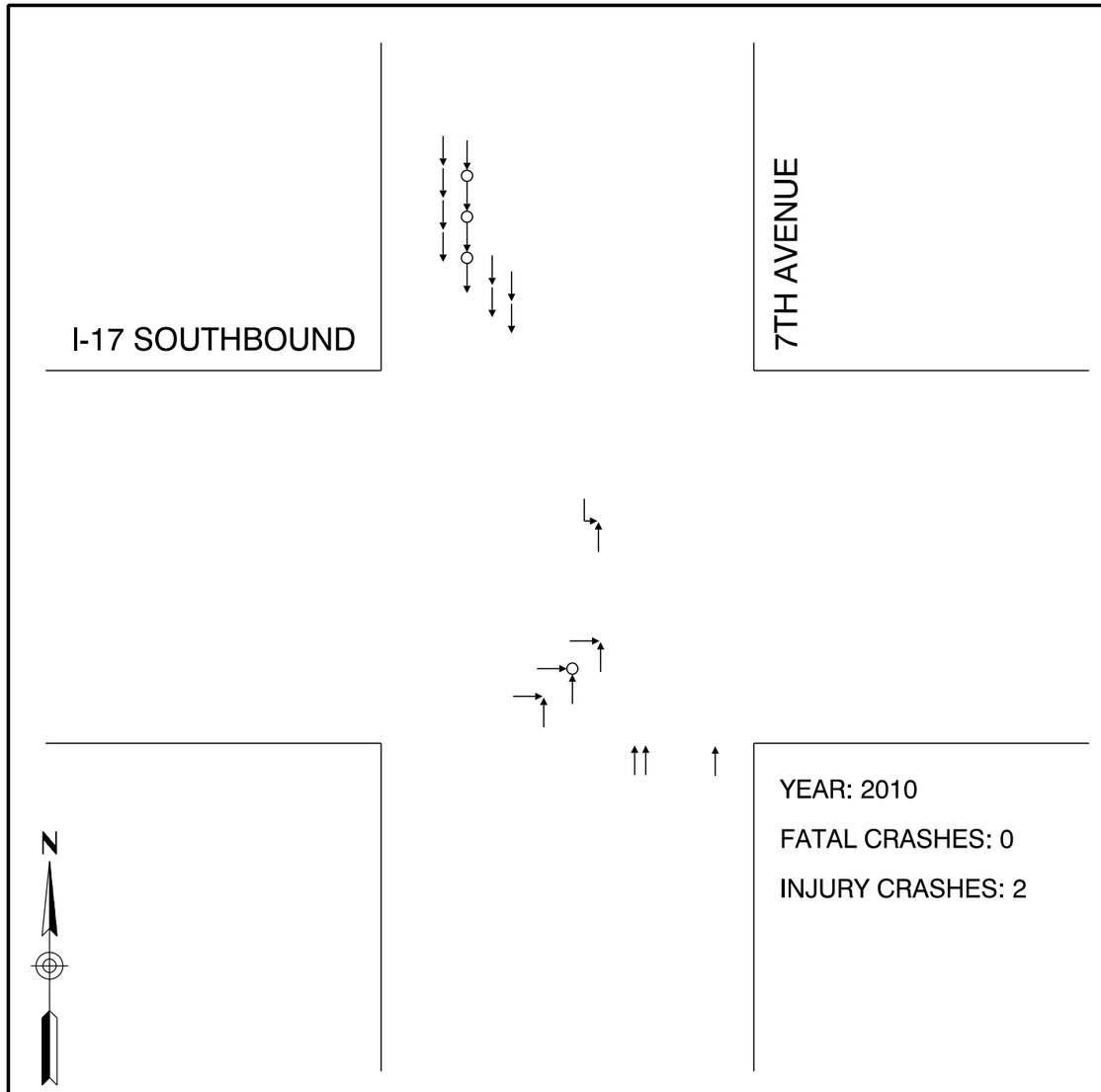
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

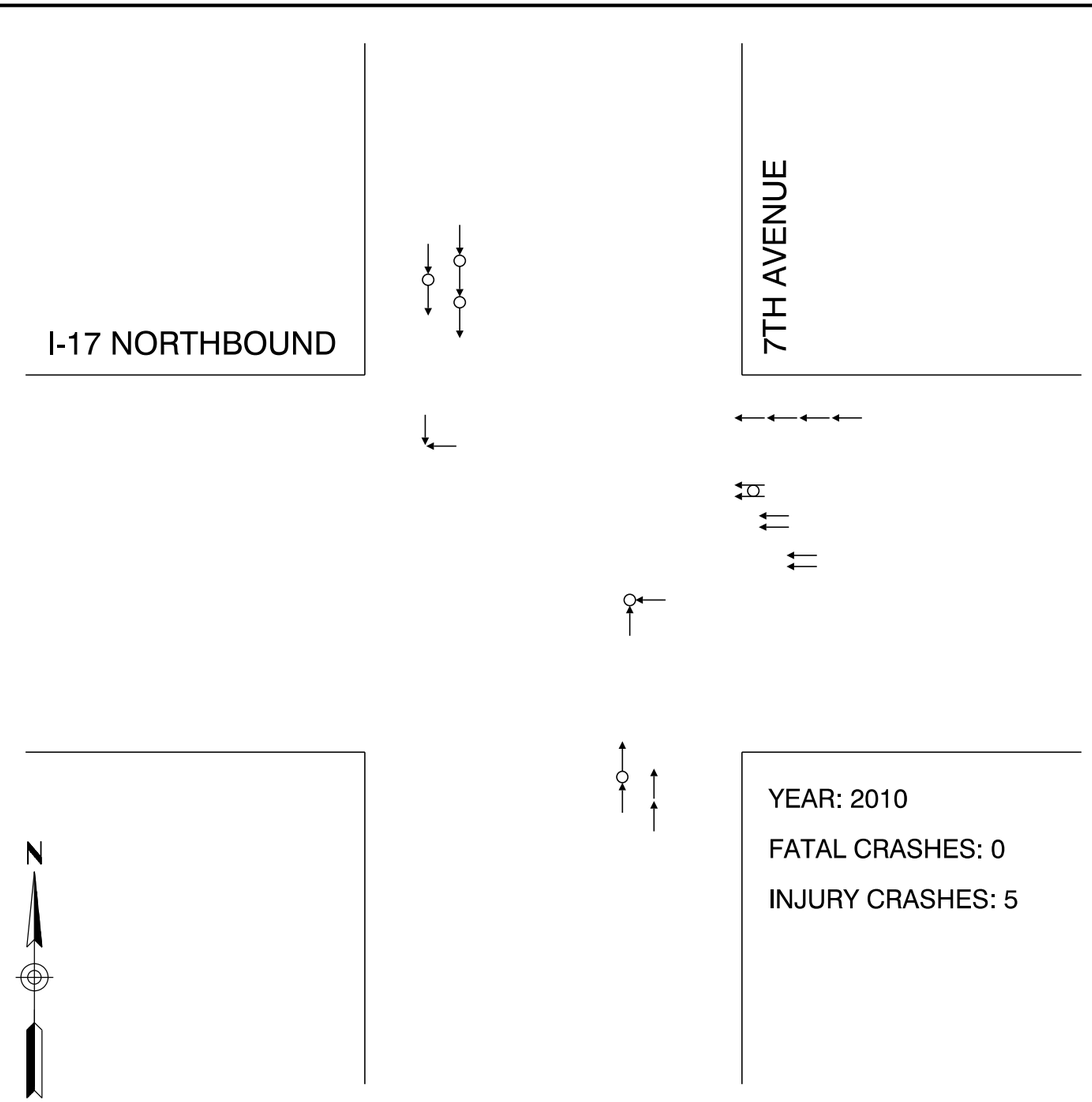
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 7TH AVENUE

SPINE Corridor Master Plan 10 17





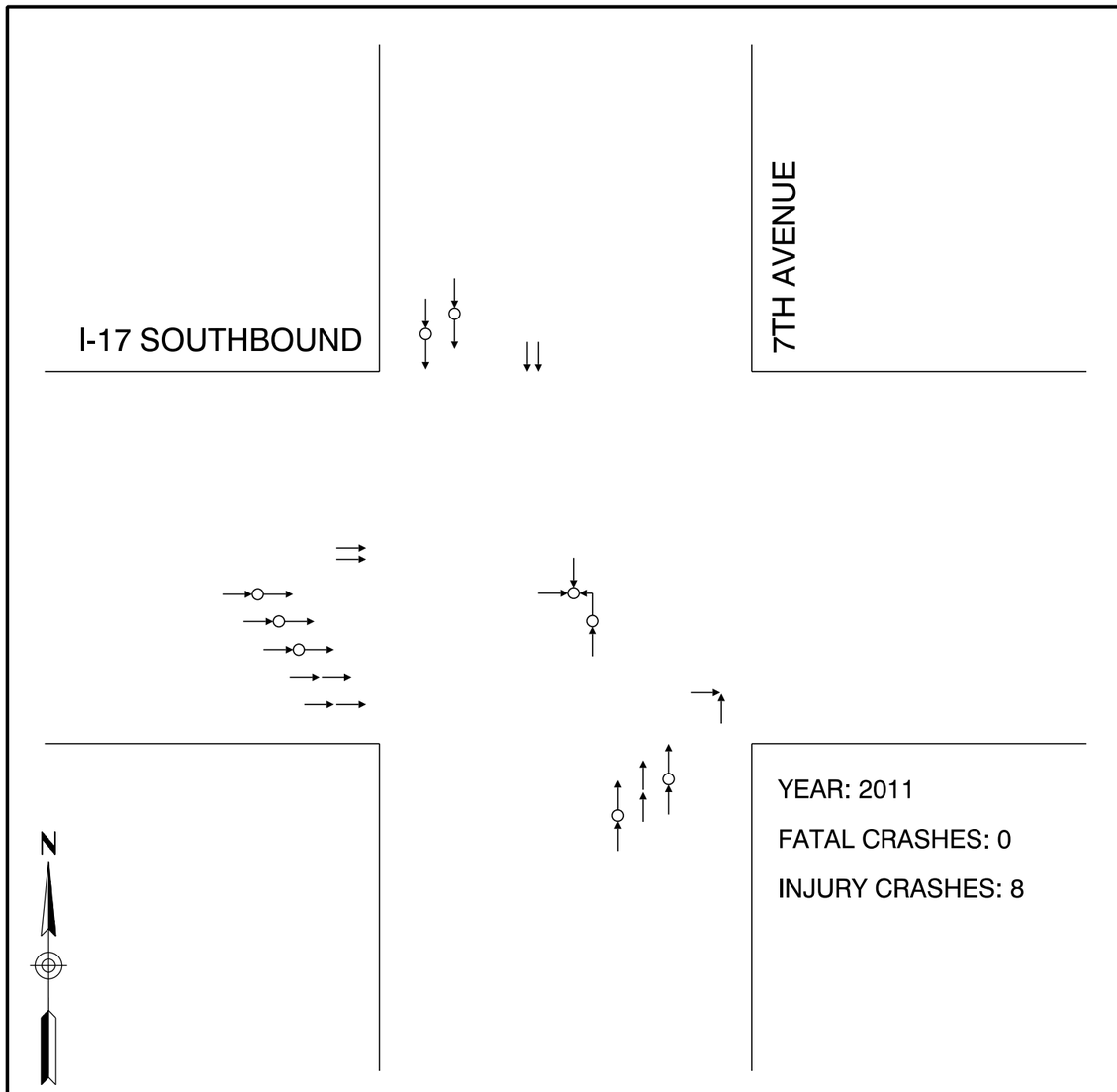
LEGEND

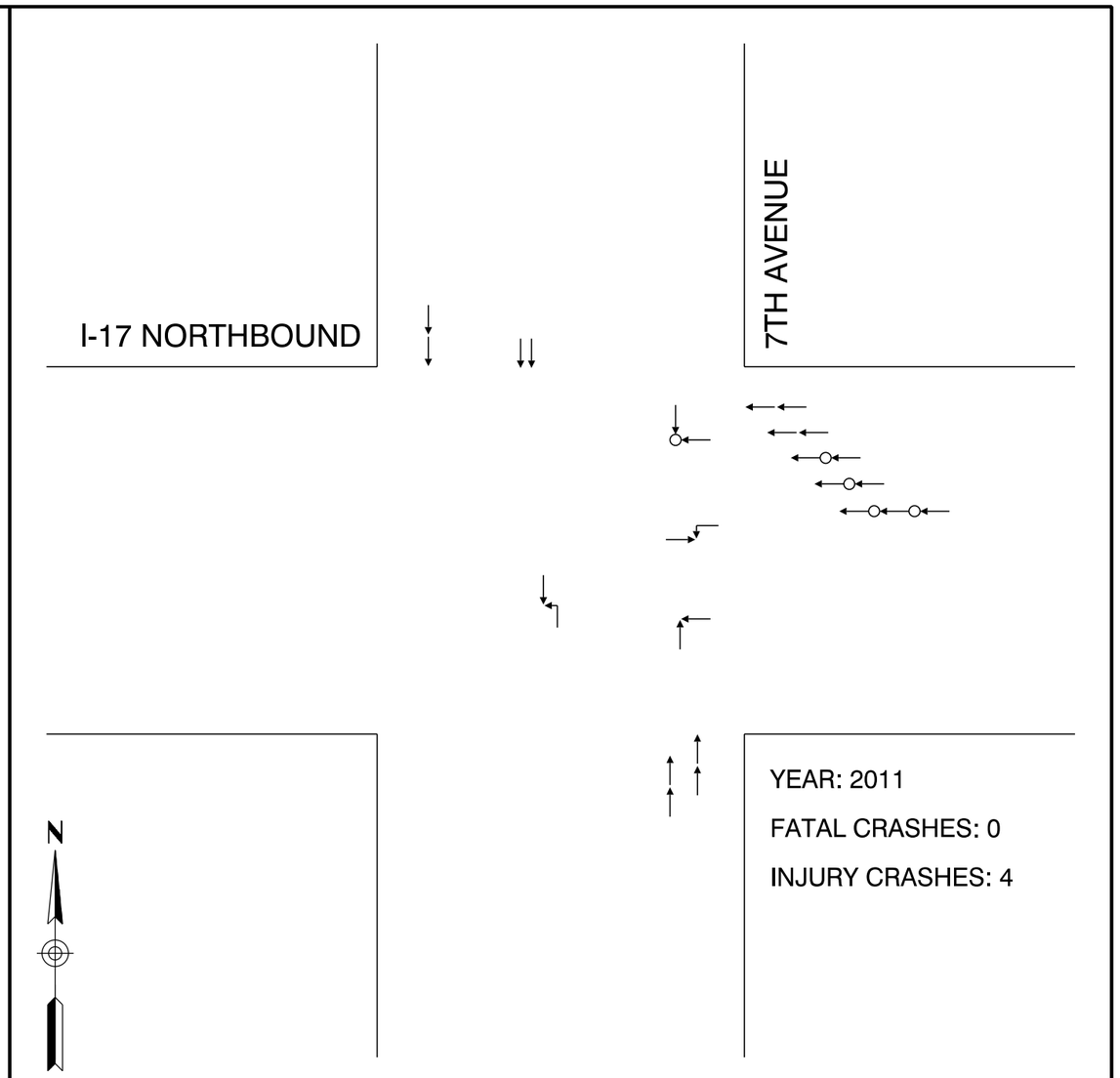
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 7TH AVENUE





LEGEND

- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
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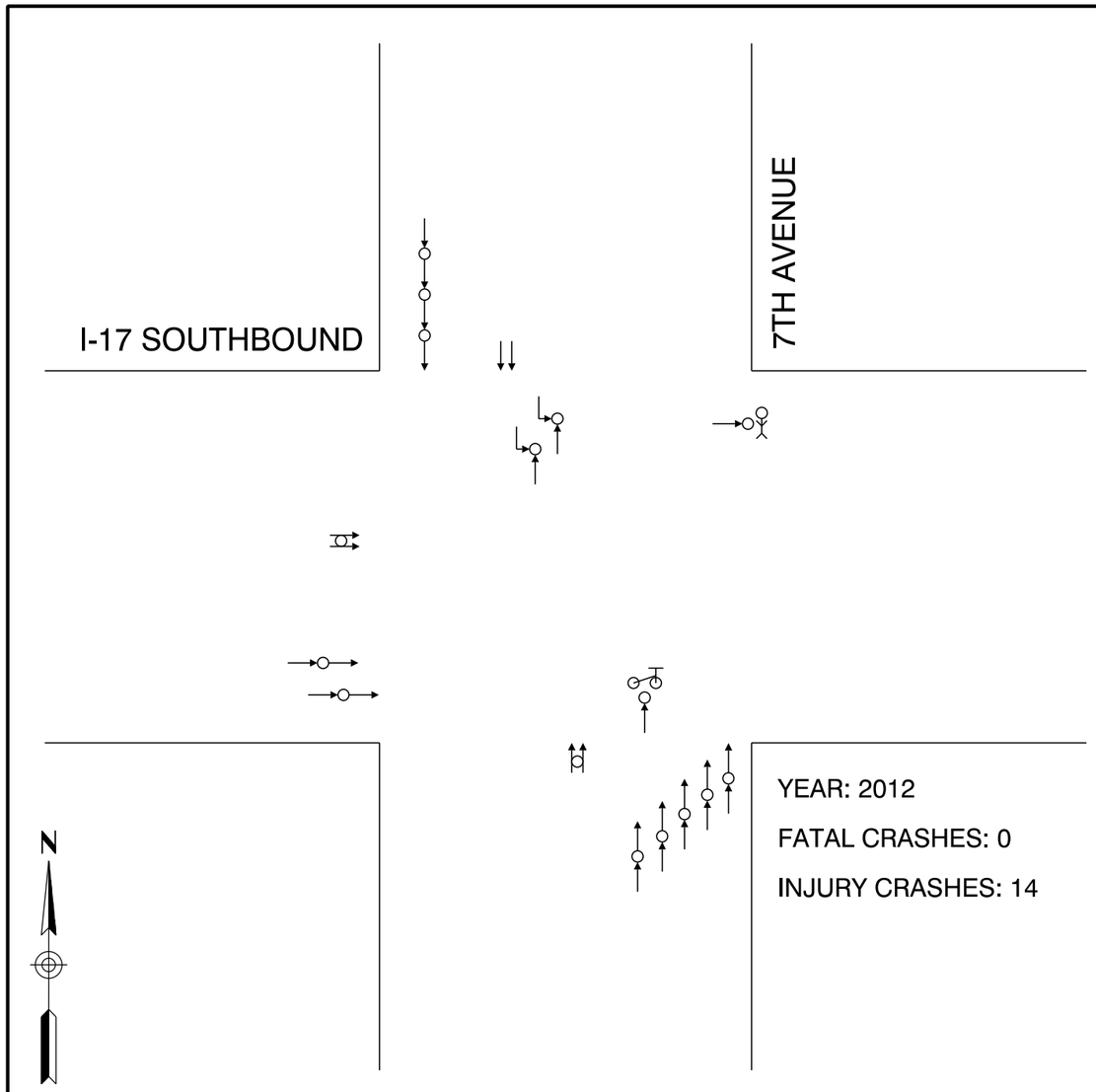
- Fatal
- Injury

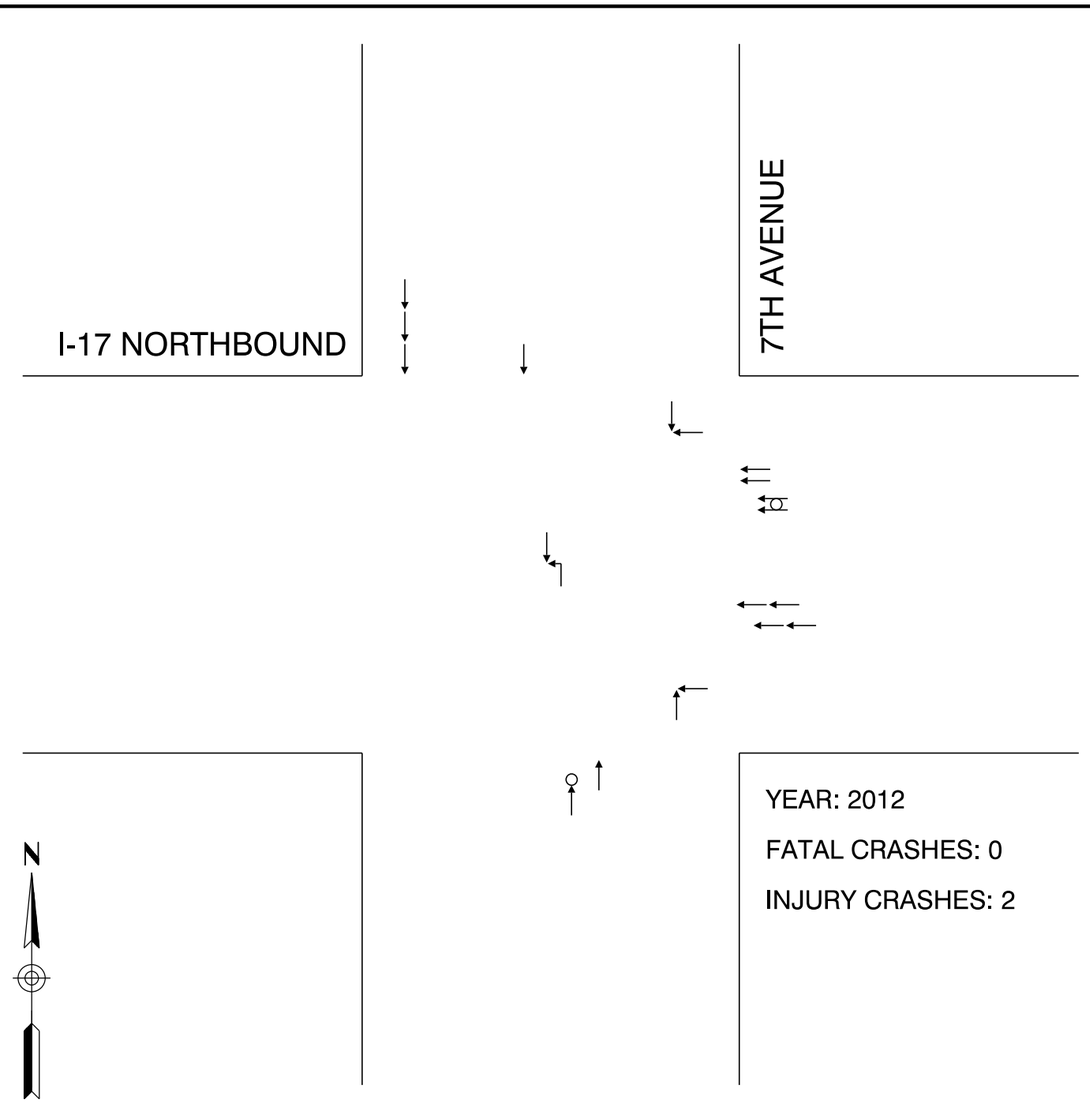
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 7TH AVENUE

SPINE Corridor Master Plan 10 17





LEGEND

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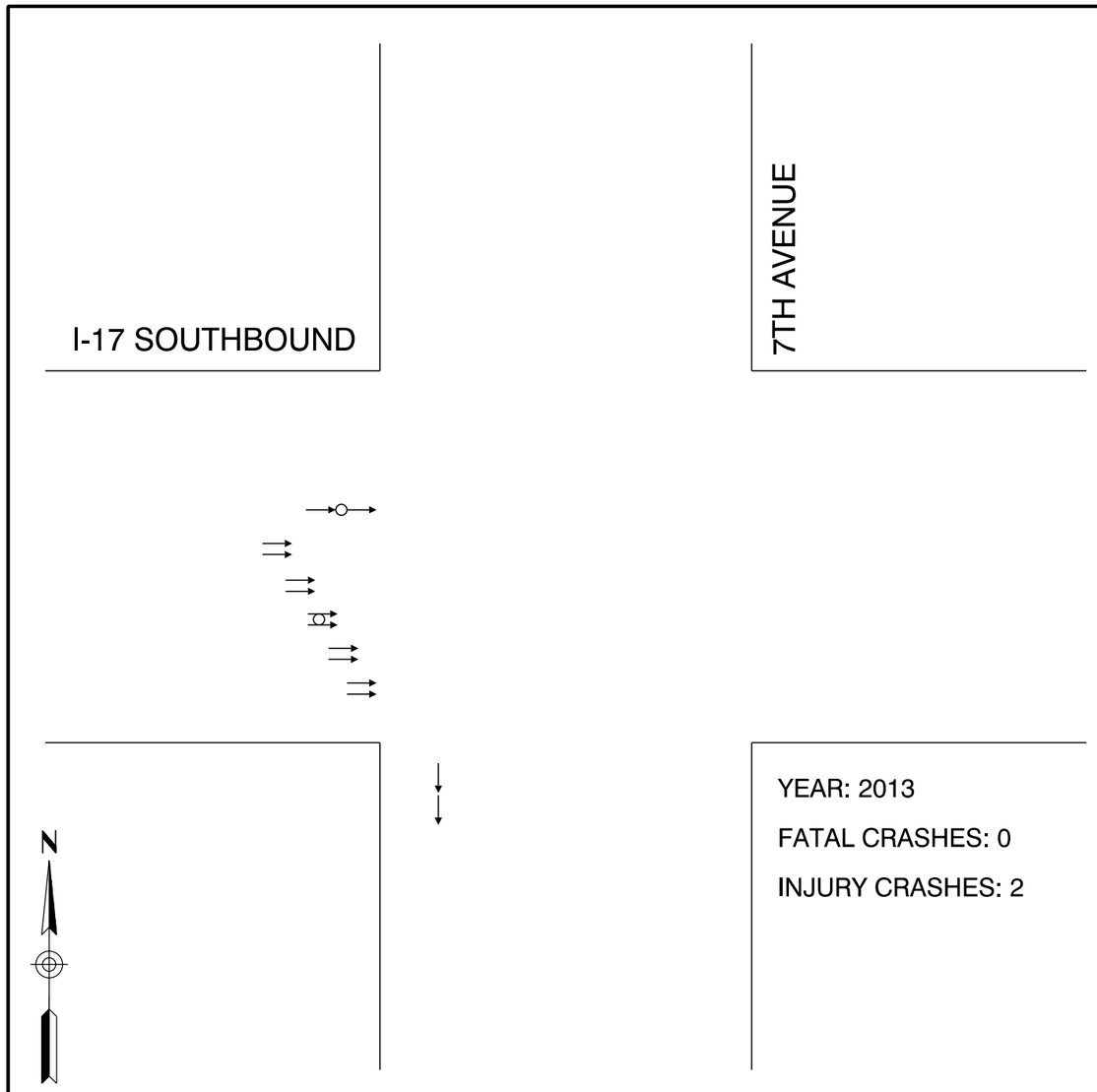
- Injury

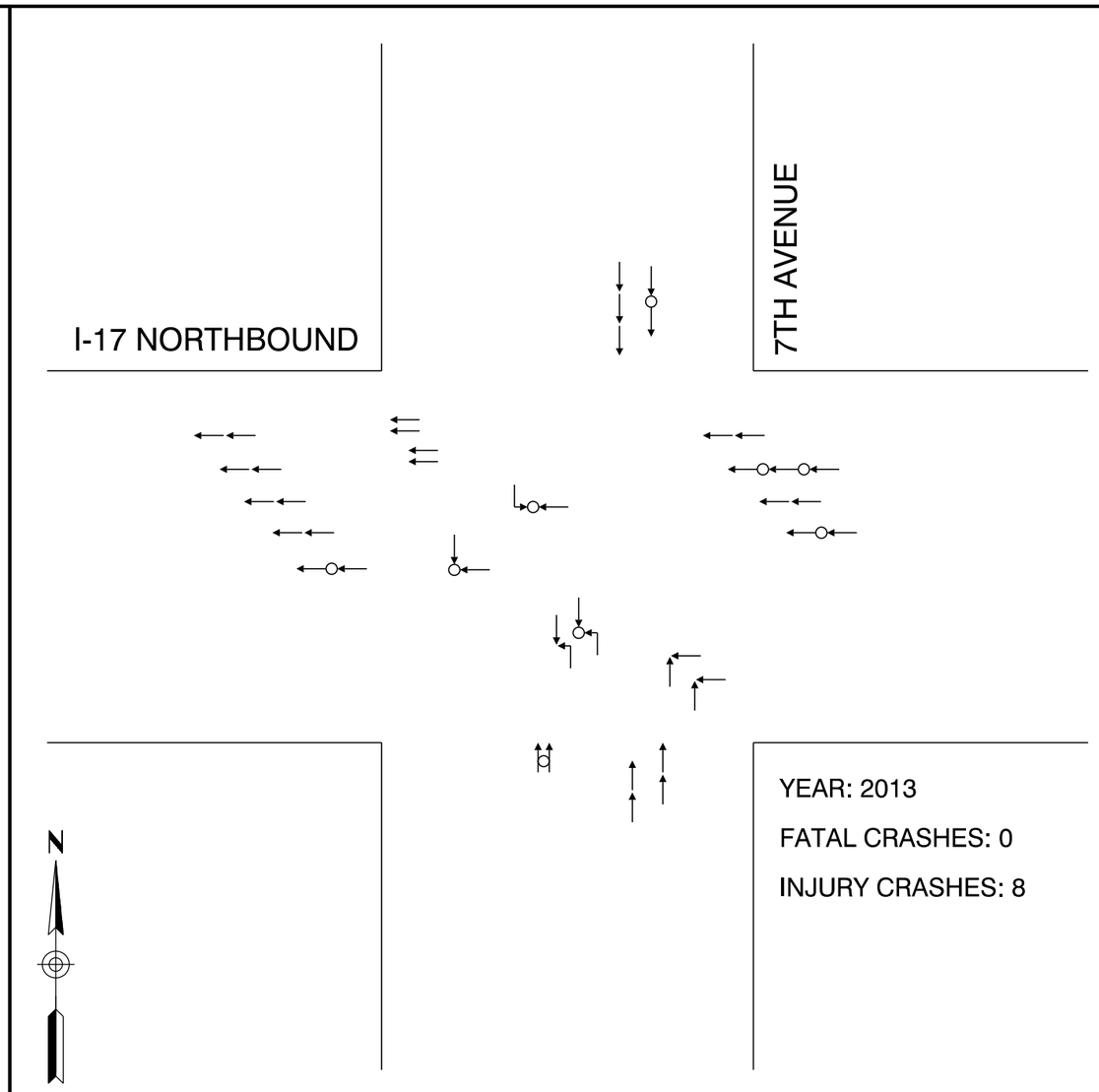
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 7TH AVENUE

SPINE Corridor Master Plan 10 17





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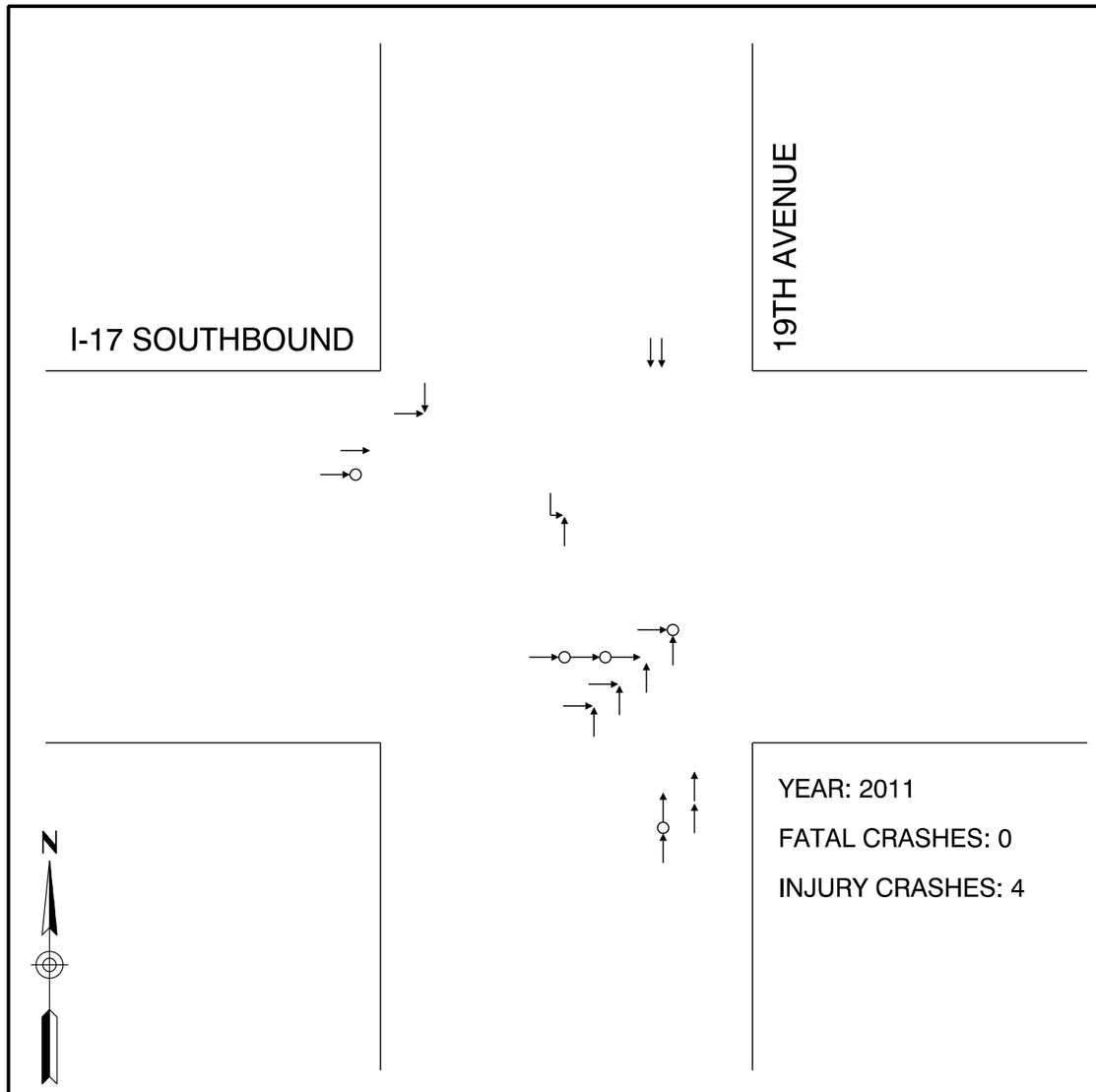
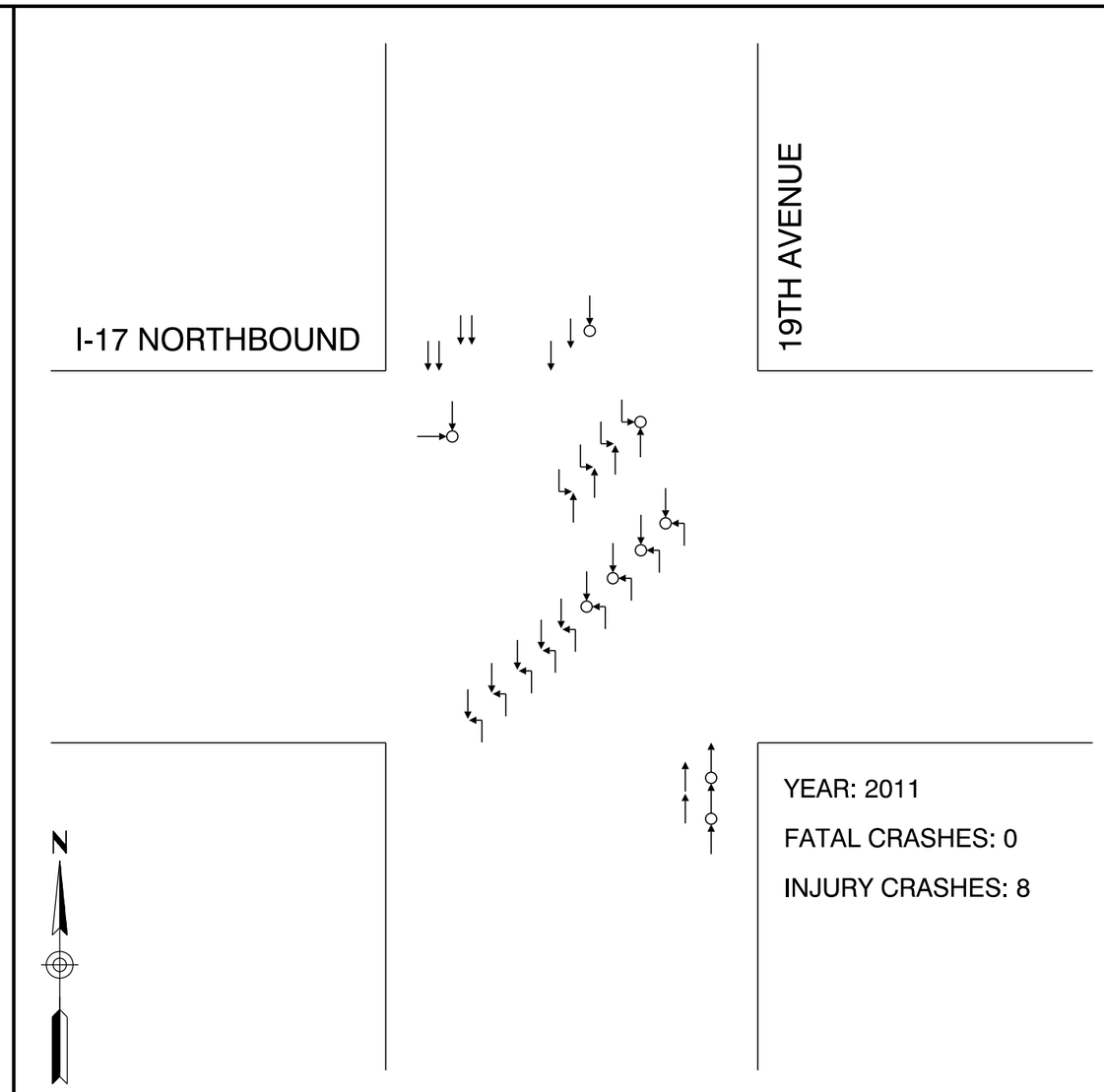
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 7TH AVENUE

SPINE Corridor Master Plan 10 17





LEGEND

- Angle
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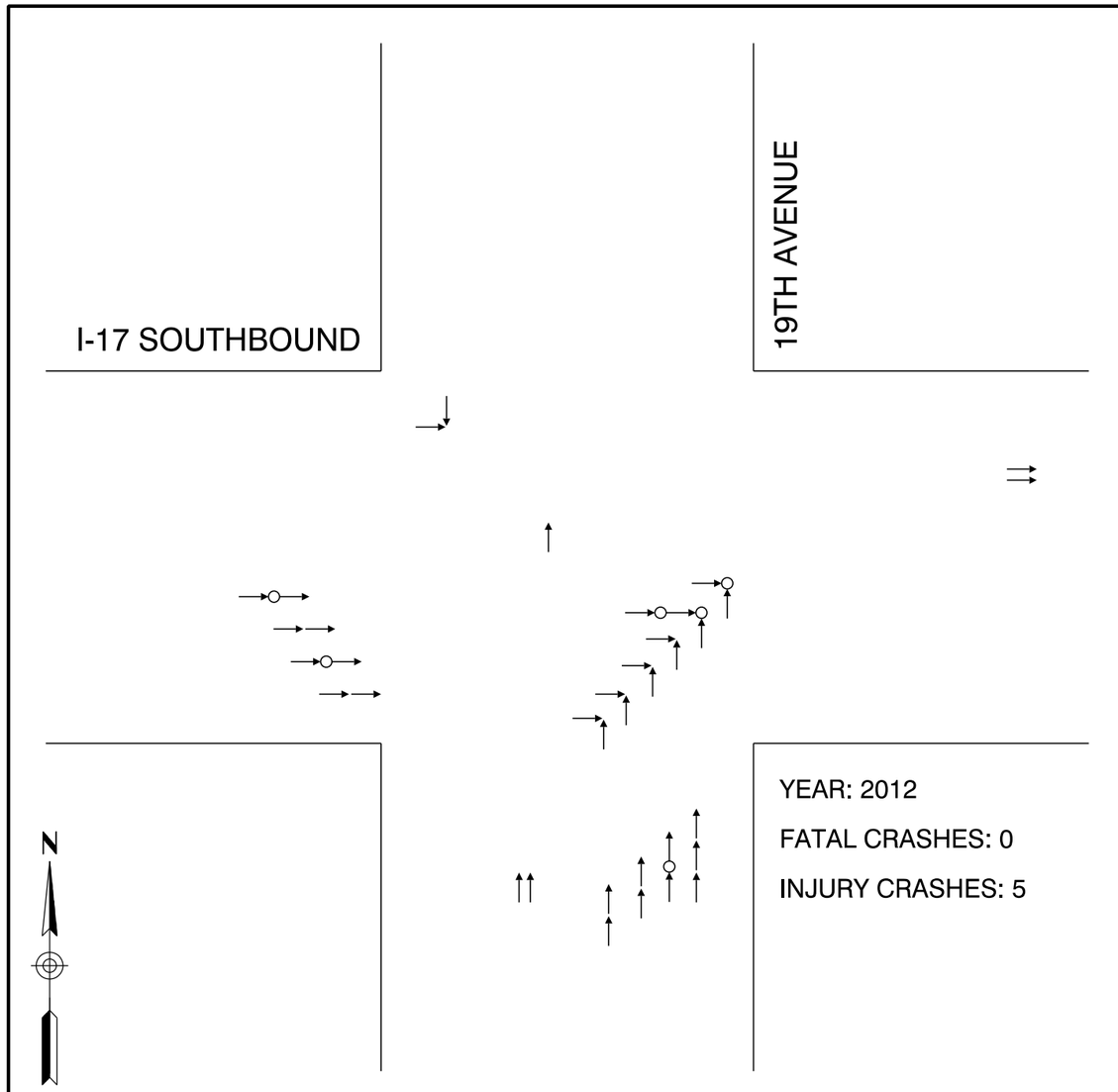
- Fatal
- Injury

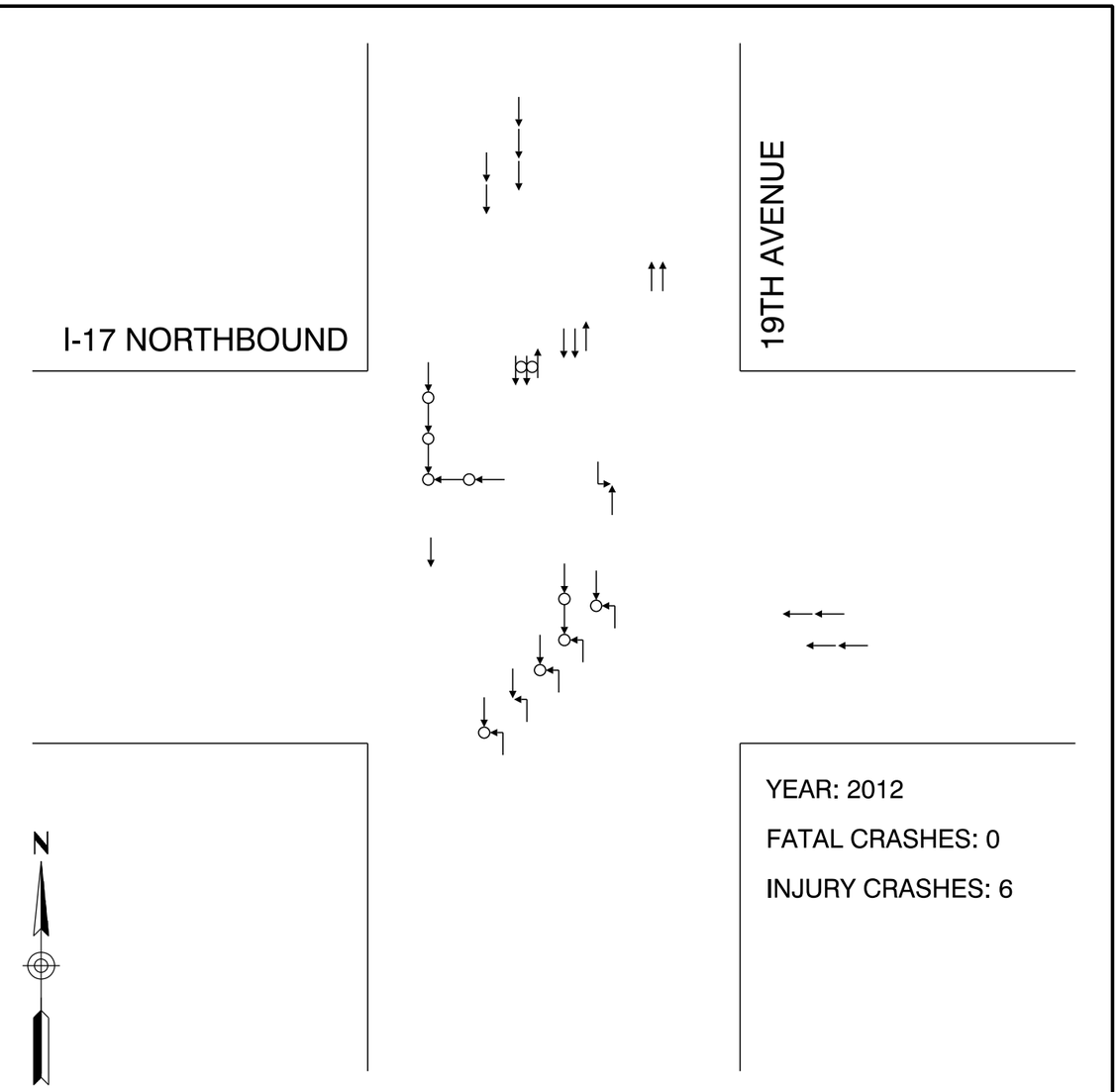
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 19TH AVENUE

SPINE Corridor Master Plan 10 17





LEGEND

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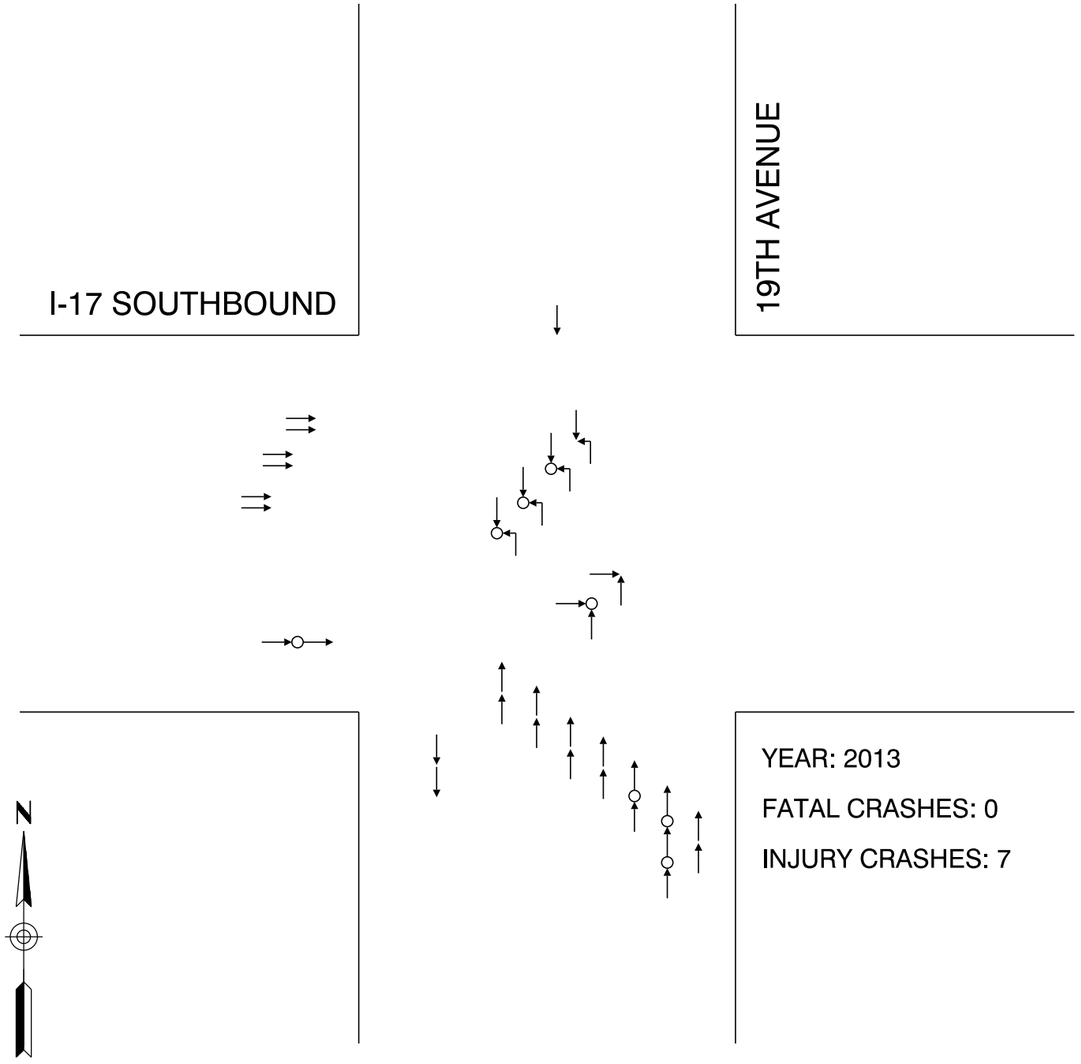
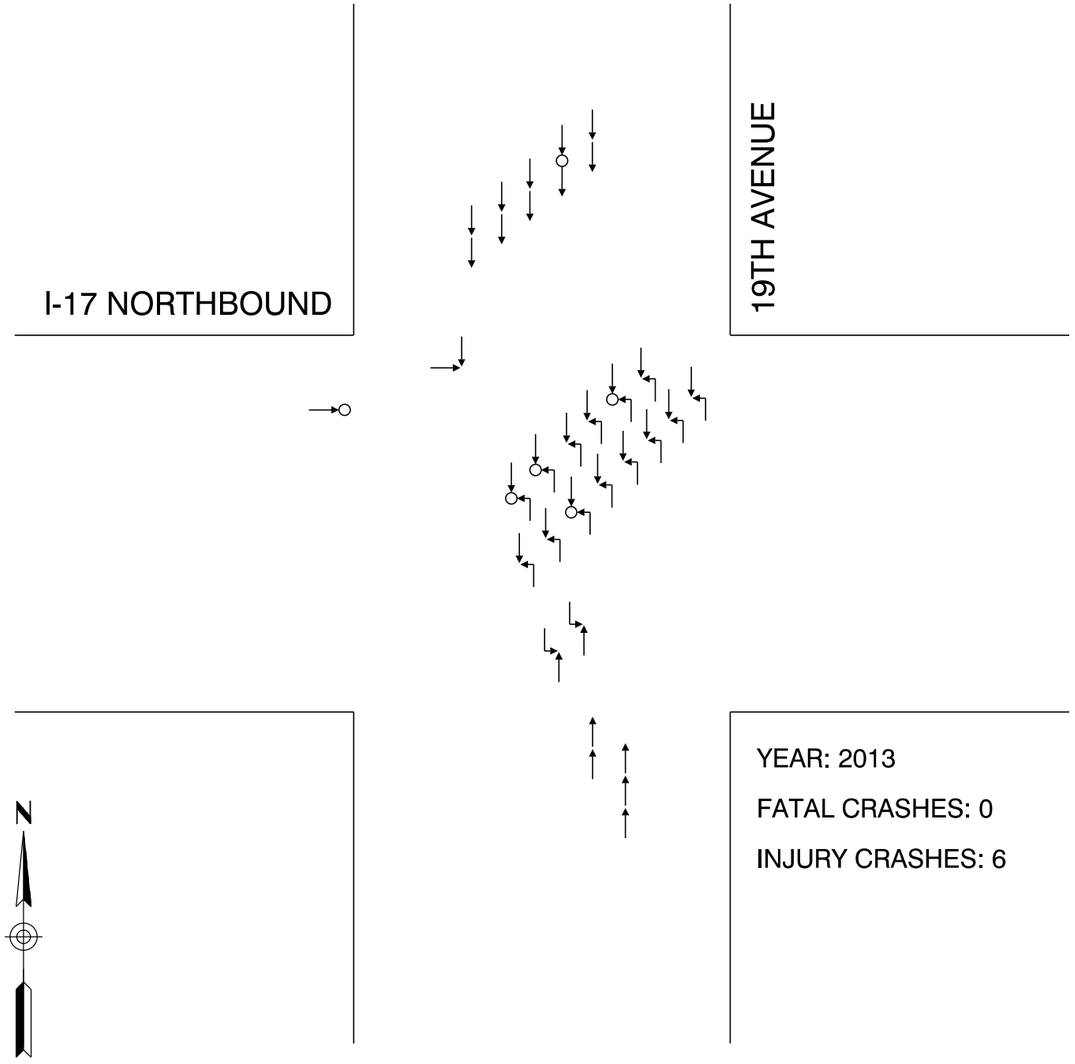
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 19TH AVENUE

SPINE Corridor Master Plan 10 17





LEGEND

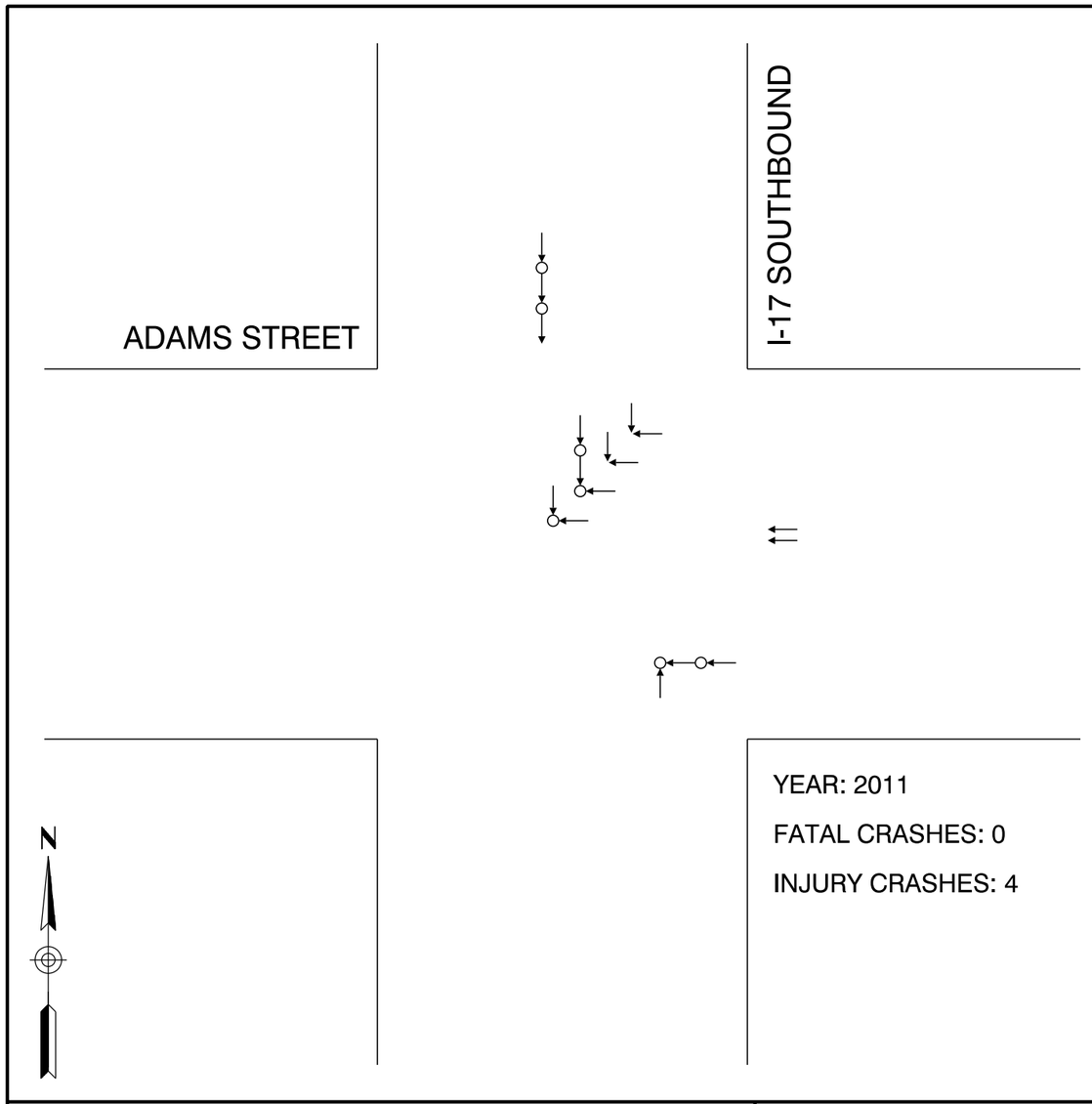
- Angle	- Left Turn	- Side Swipe
- Backing Up	- Pedestrian	- Single Vehicle
- Bicycle	- Rear End	- Fatal
- Head On	- Right Turn	- Injury

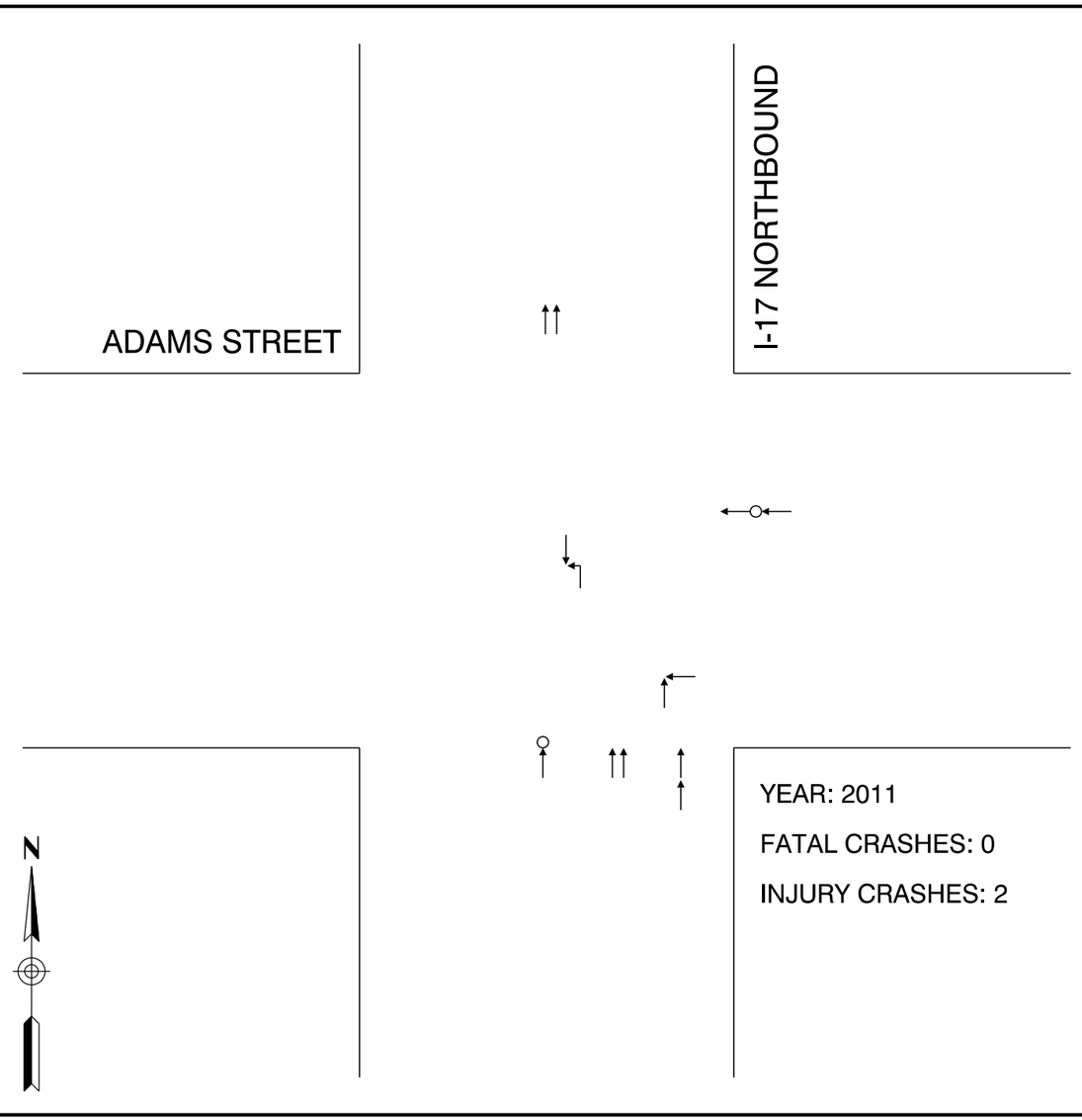
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

I-17 / 19TH AVENUE

SPINE Corridor Master Plan 10 17





LEGEND

- Angle
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- Left Turn
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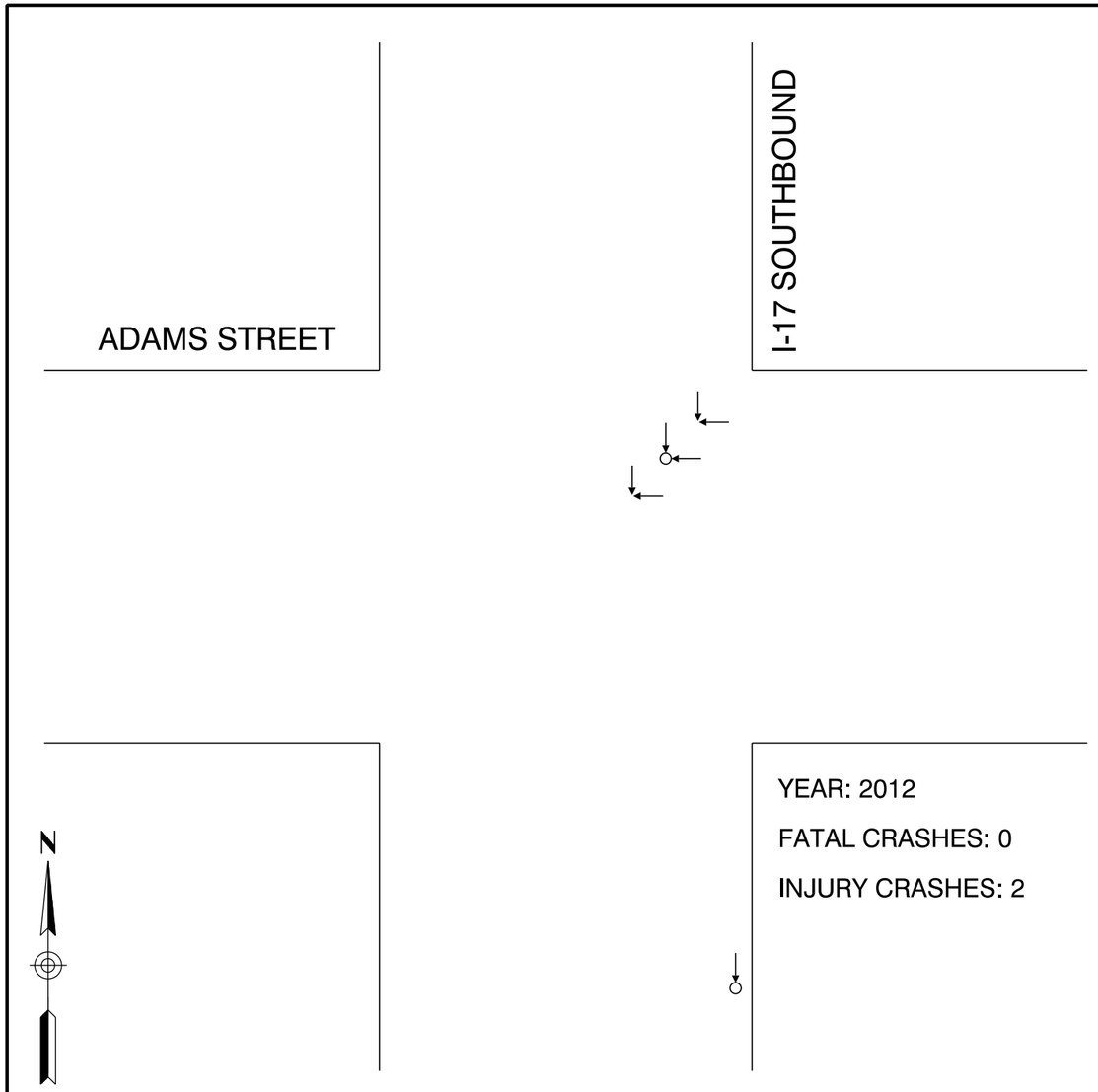
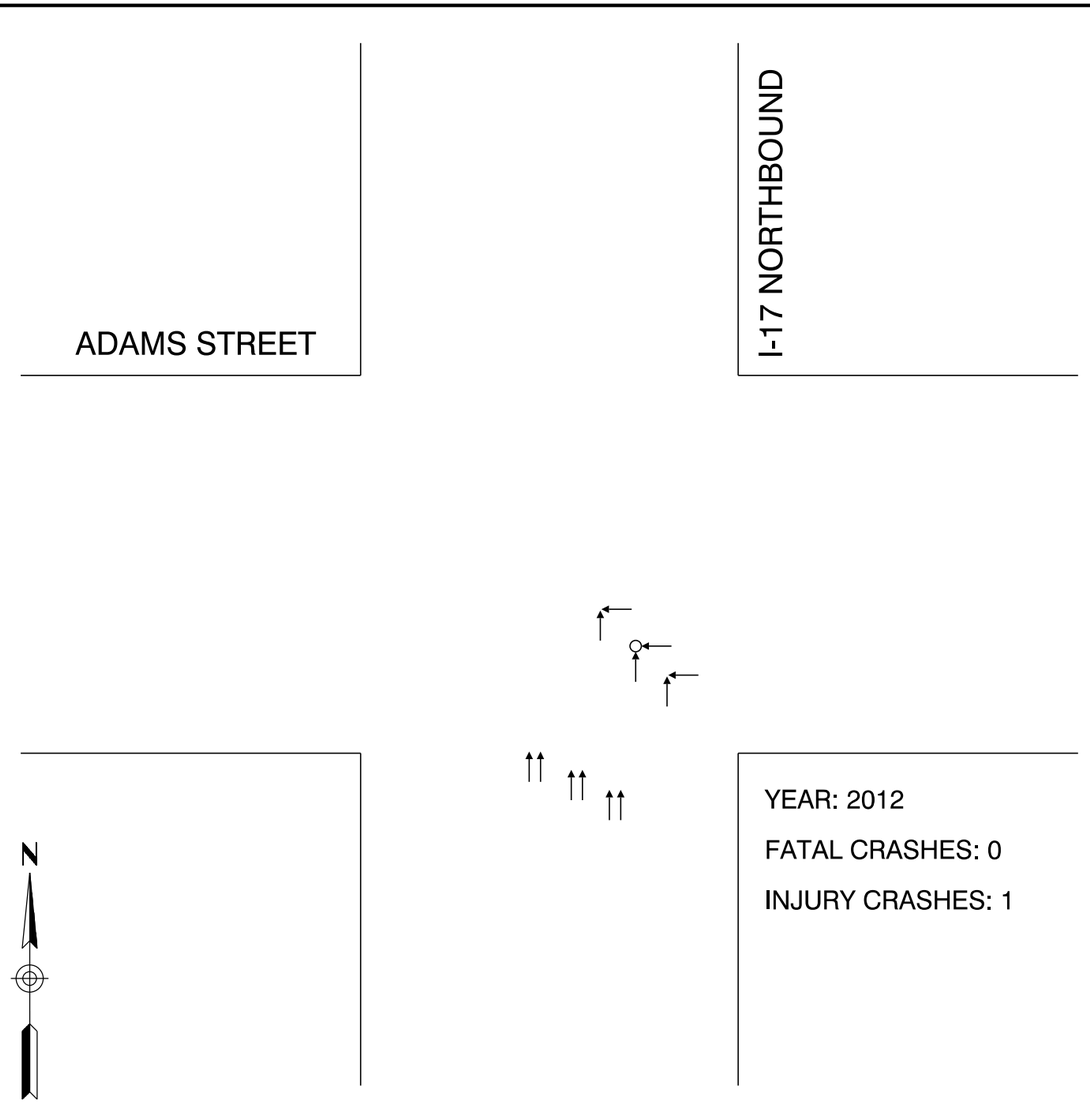
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

ADAMS STREET / I-17





LEGEND

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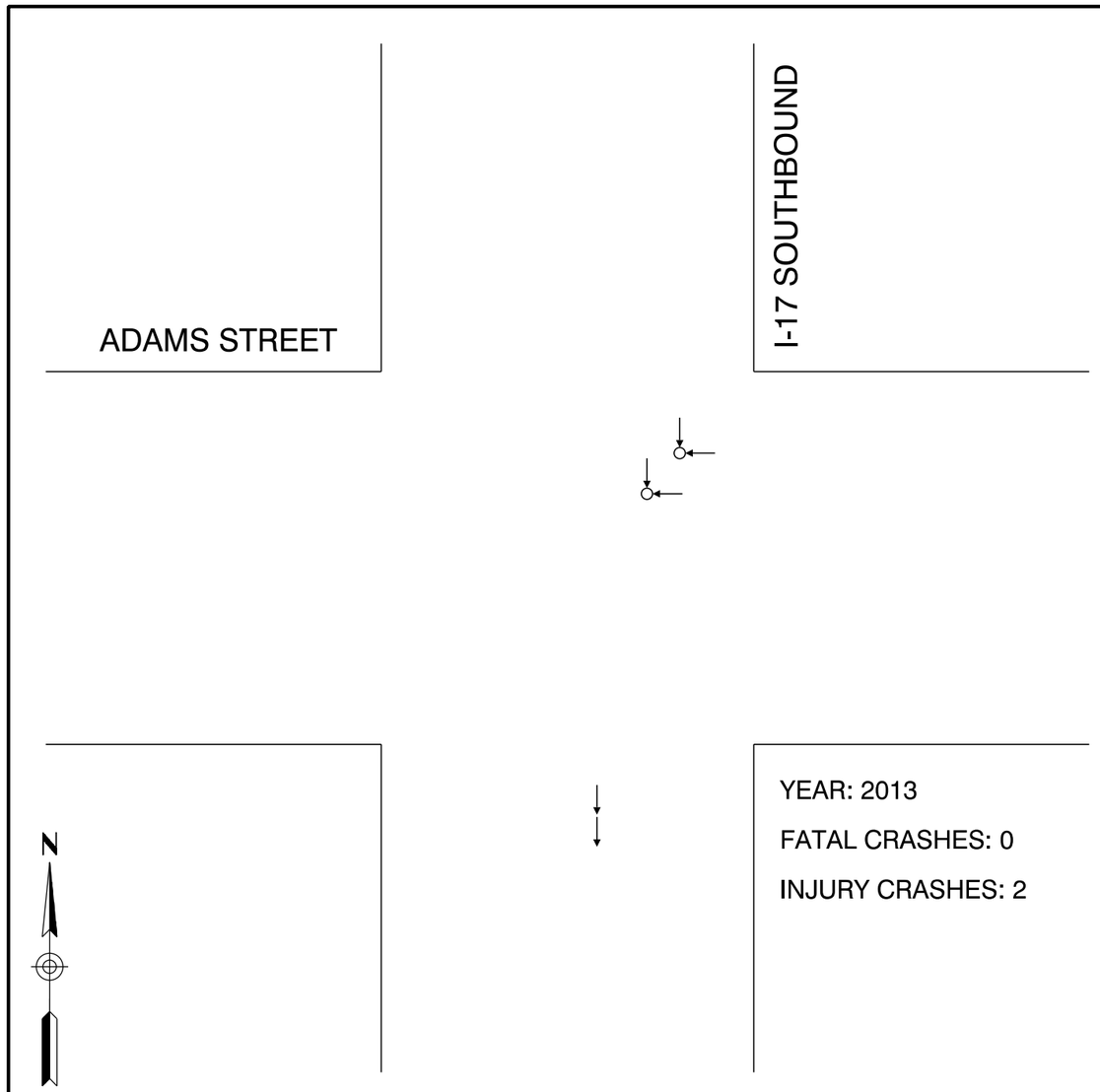
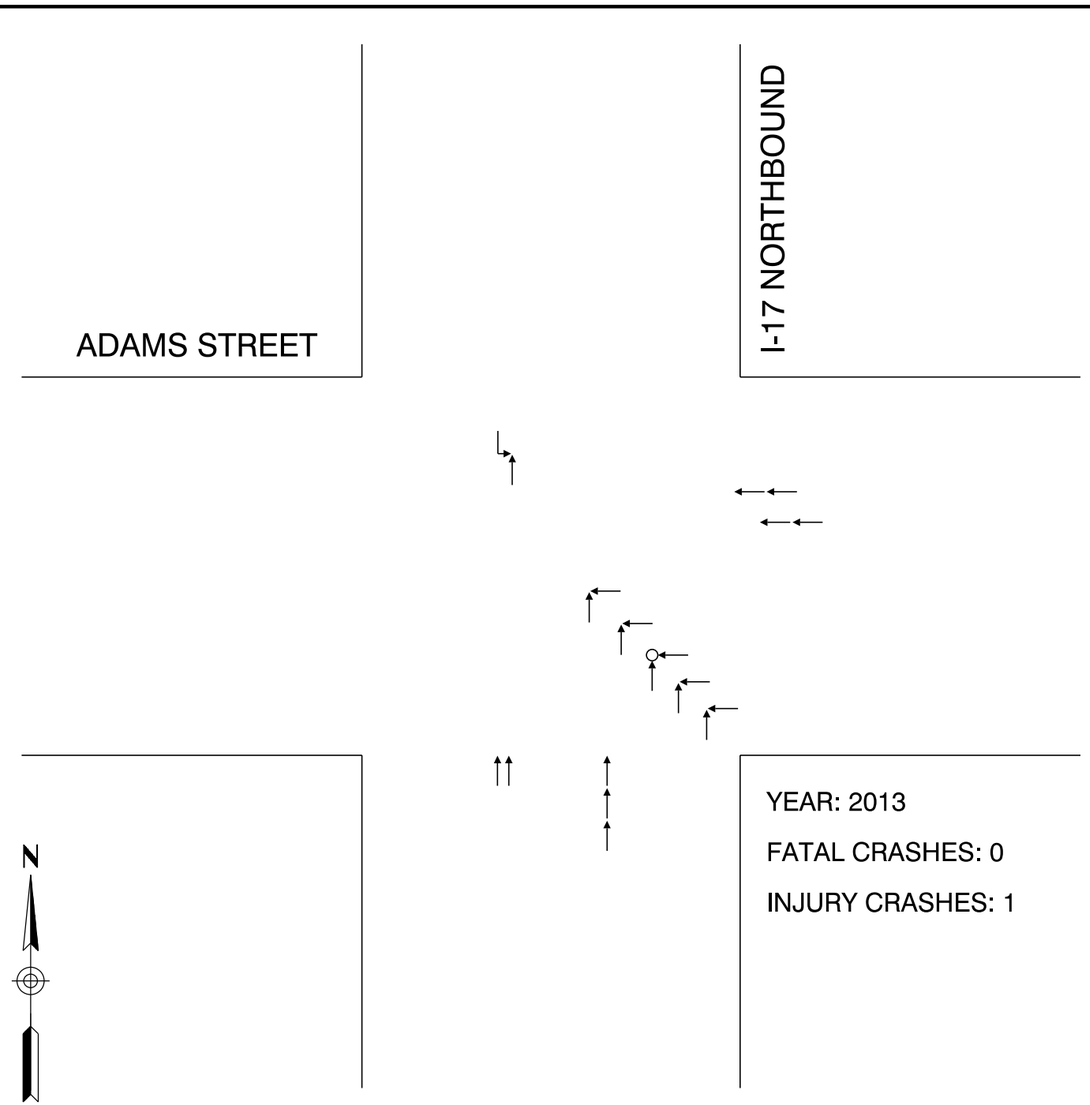
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

ADAMS STREET / I-17





LEGEND

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- Right Turn
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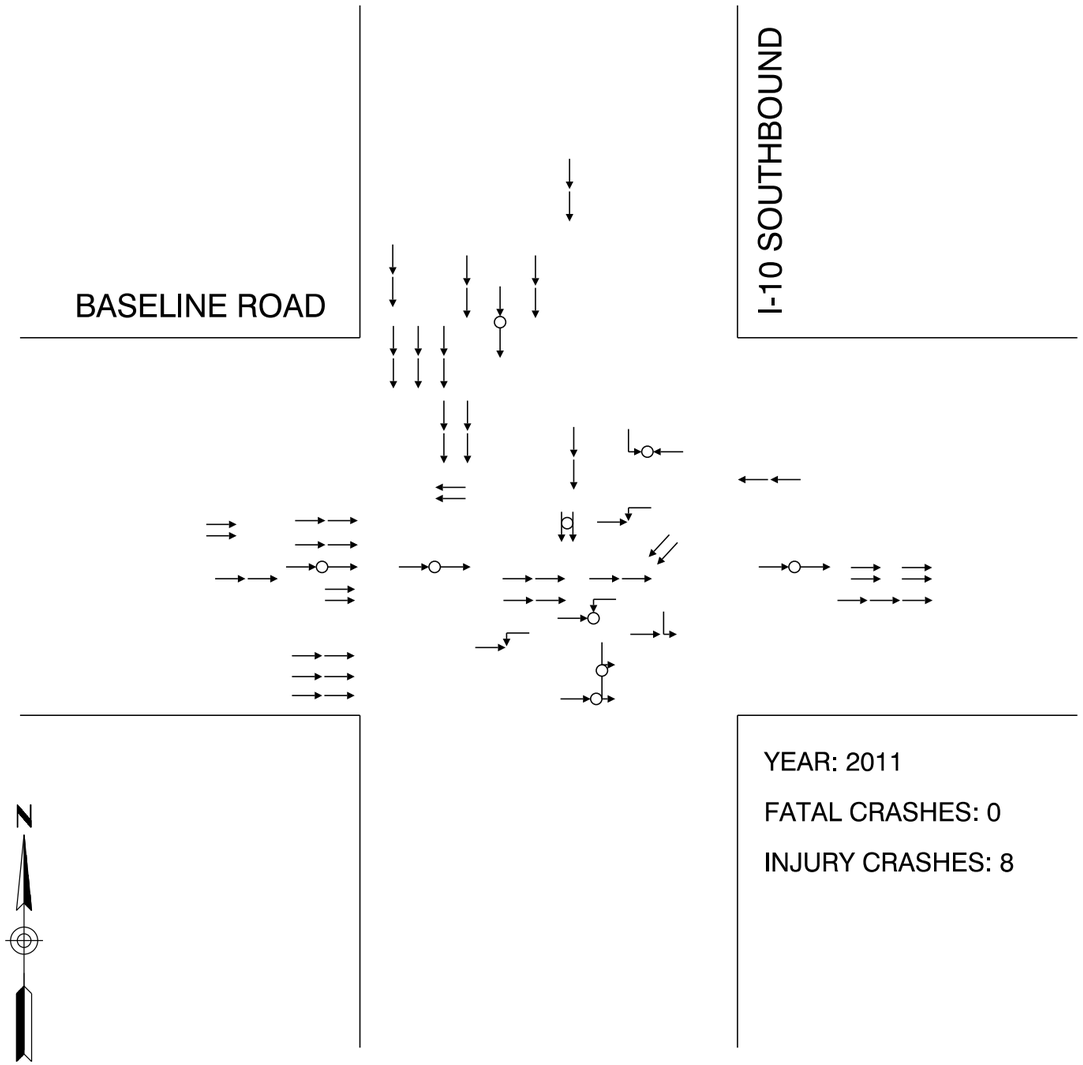
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

ADAMS STREET / I-17



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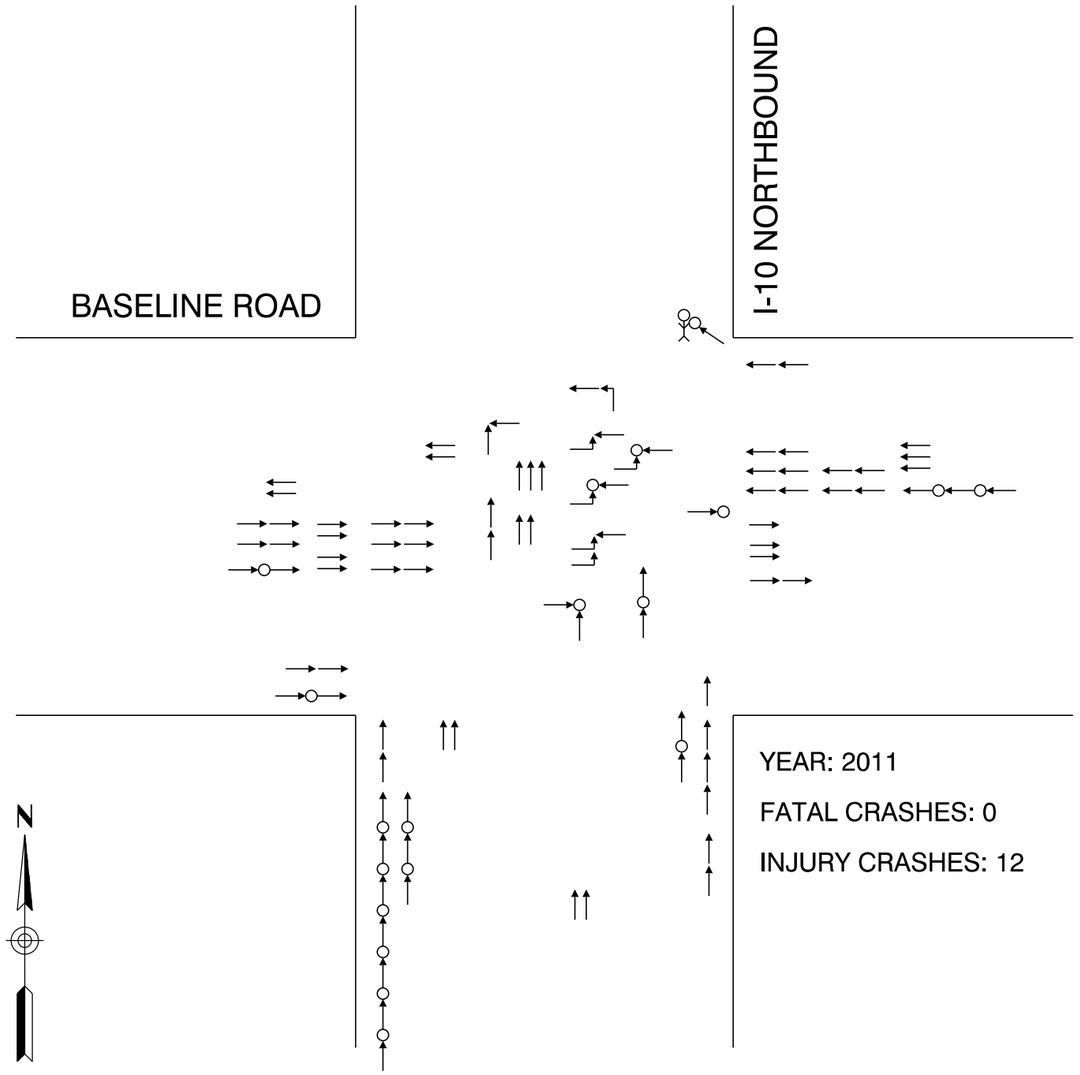
FATAL CRASHES: 0

INJURY CRASHES: 8



YEAR: 2011

FATAL CRASHES: 0

INJURY CRASHES: 12

LEGEND

- Angle
- Backing Up
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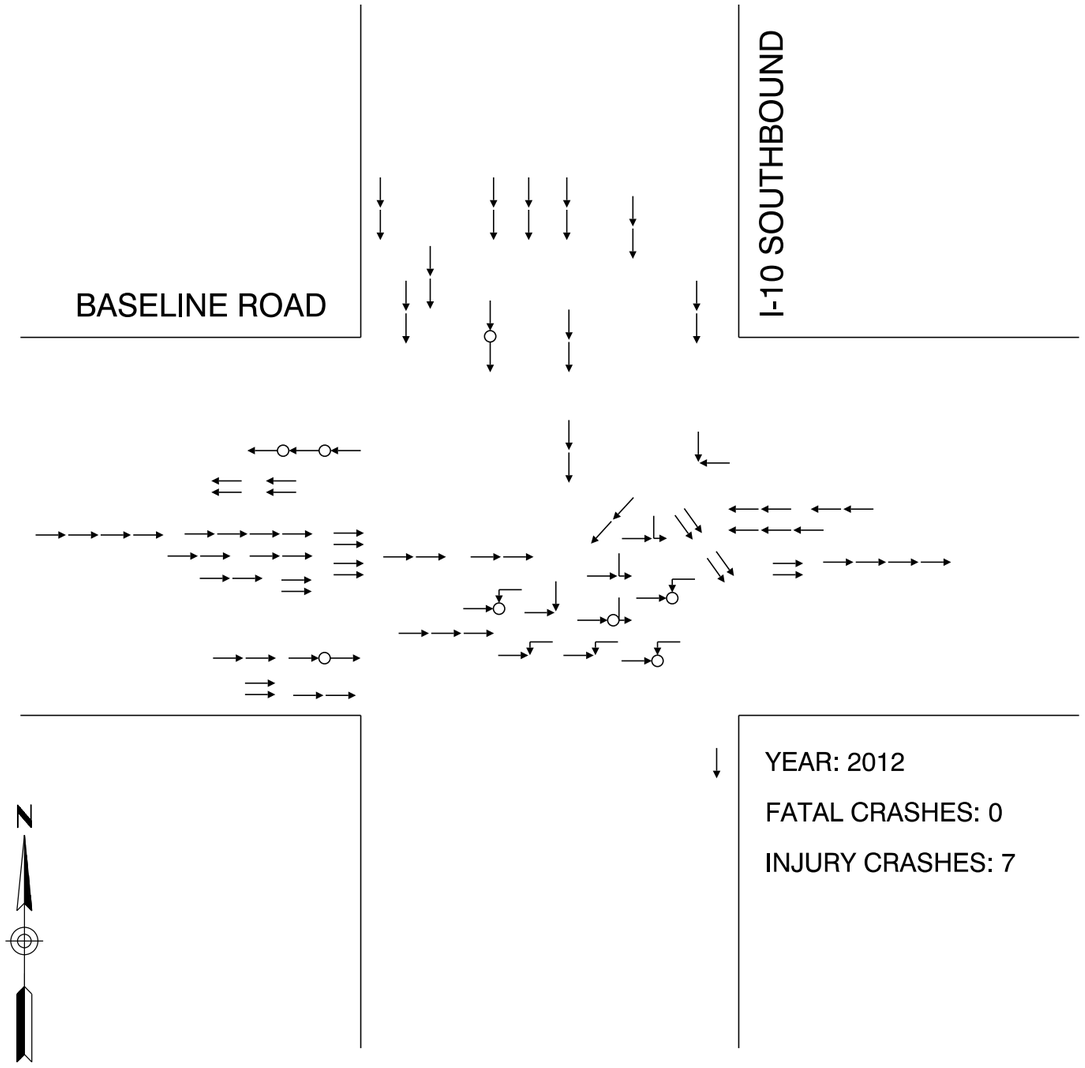
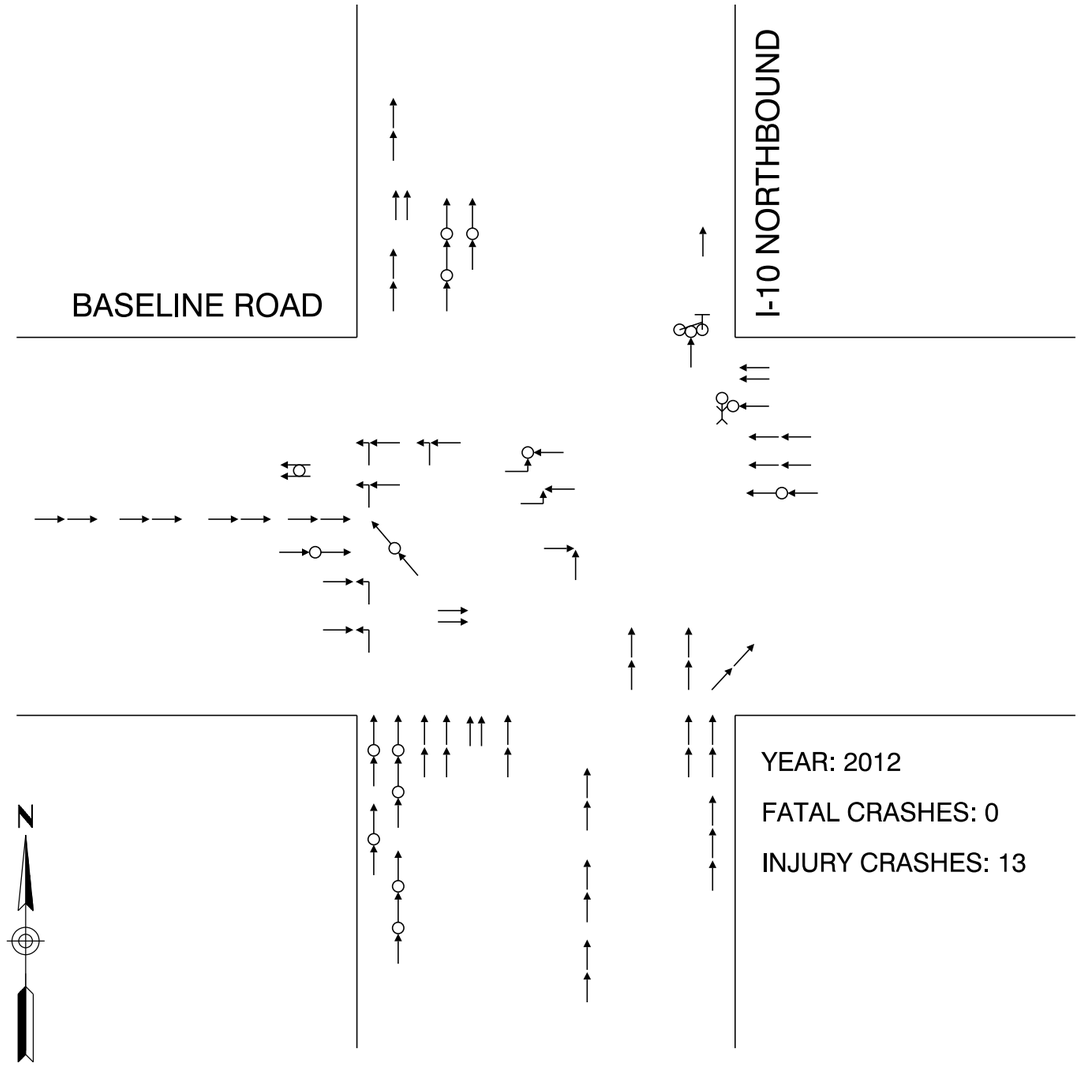
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

BASELINE ROAD / I-10





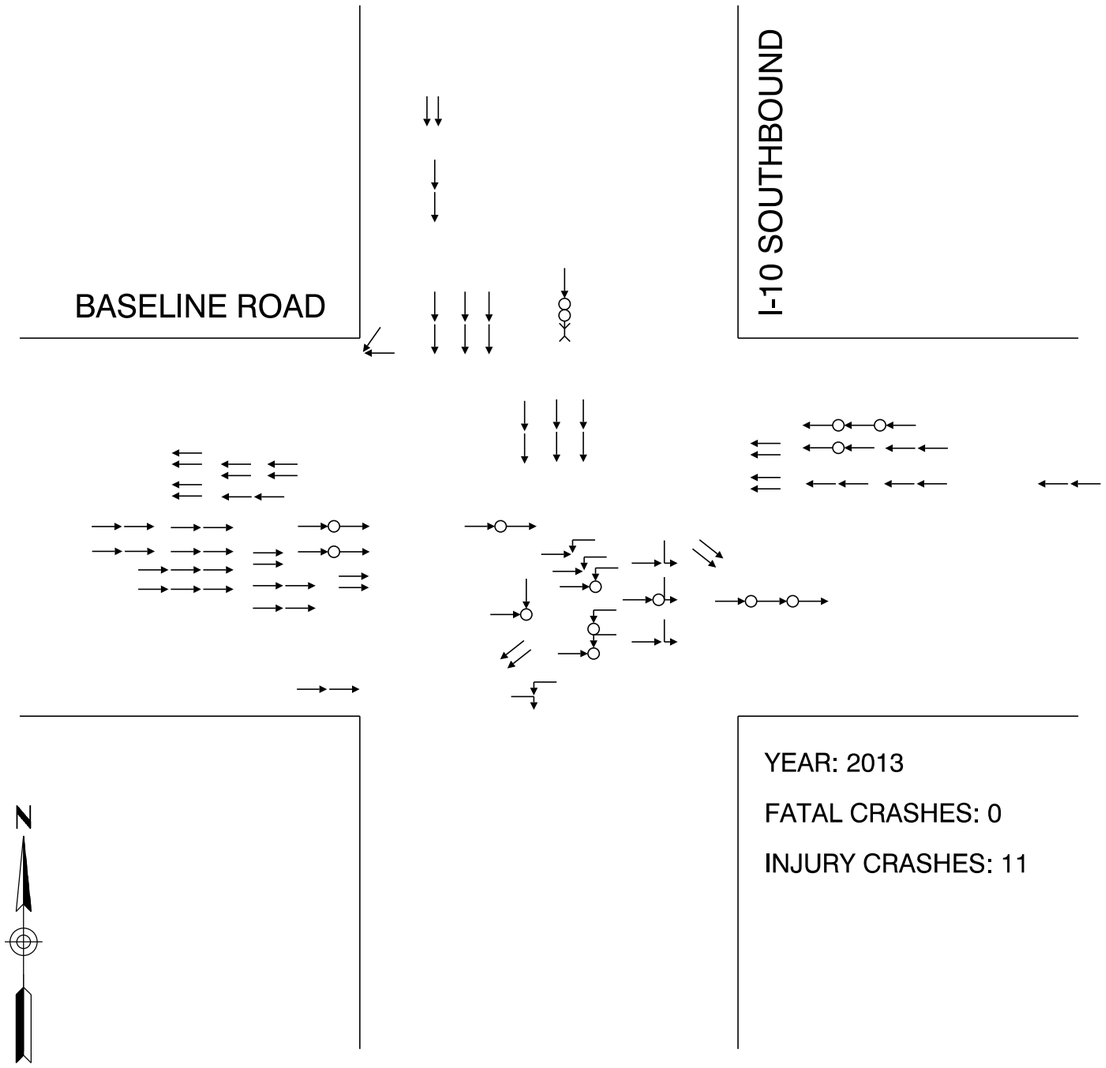
LEGEND

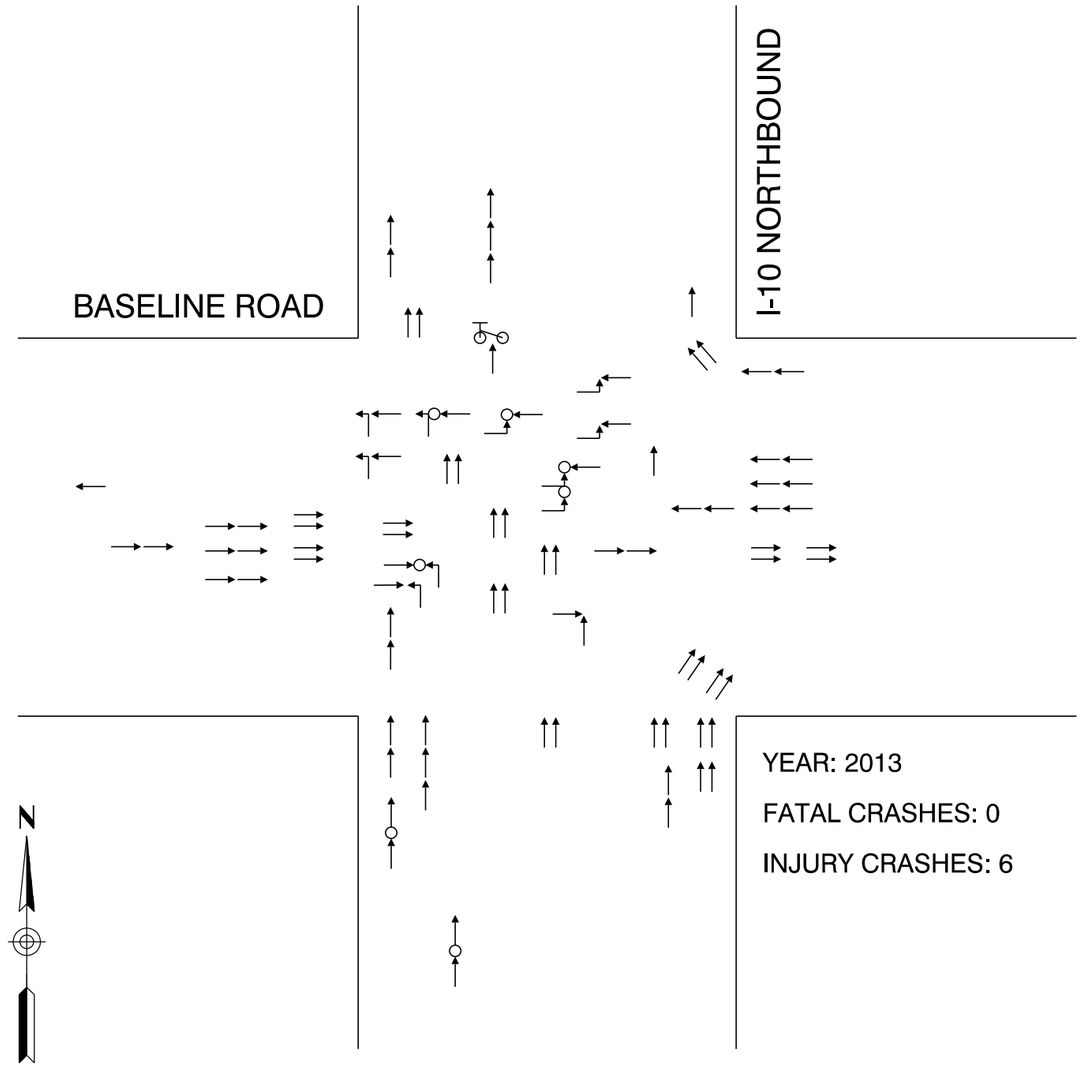
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

BASELINE ROAD / I-10





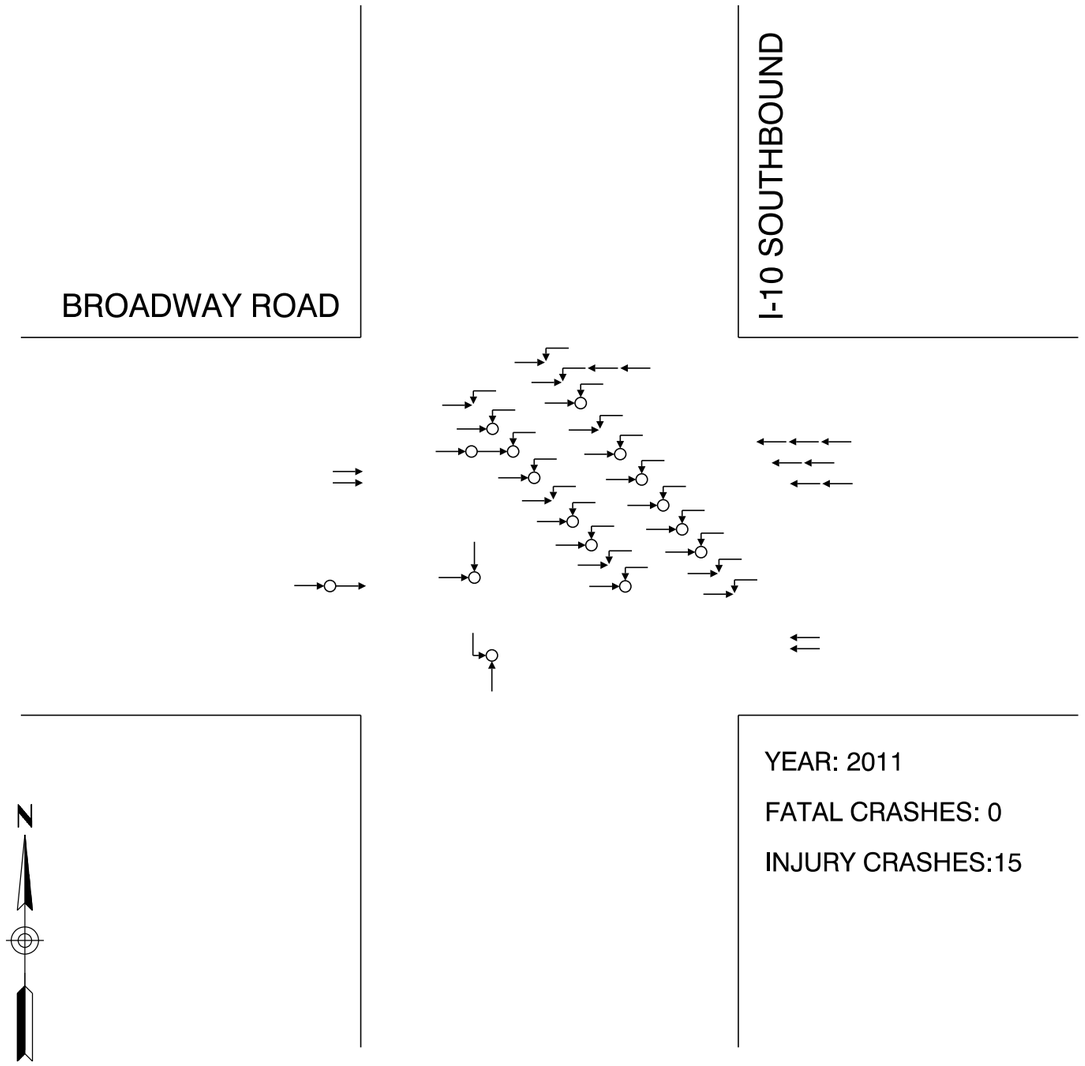
LEGEND

- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

BASELINE ROAD / I-10



YEAR: 2011

FATAL CRASHES: 0

INJURY CRASHES:15

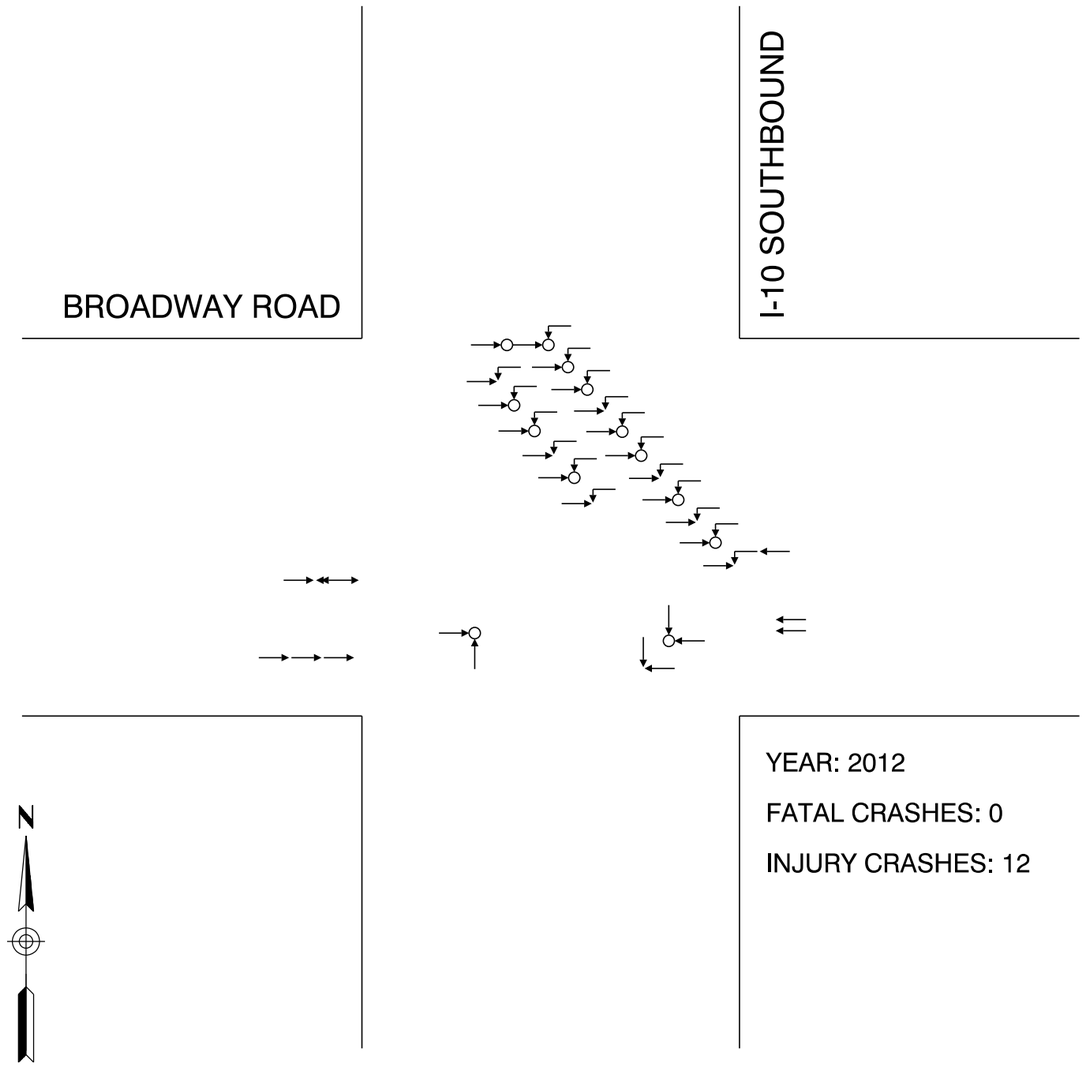
LEGEND

- Angle	- Left Turn	- Side Swipe
- Backing Up	- Pedestrian	- Single Vehicle
- Bicycle	- Rear End	- Fatal
- Head On	- Right Turn	- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

BROADWAY ROAD / I-10



YEAR: 2012

FATAL CRASHES: 0

INJURY CRASHES: 12

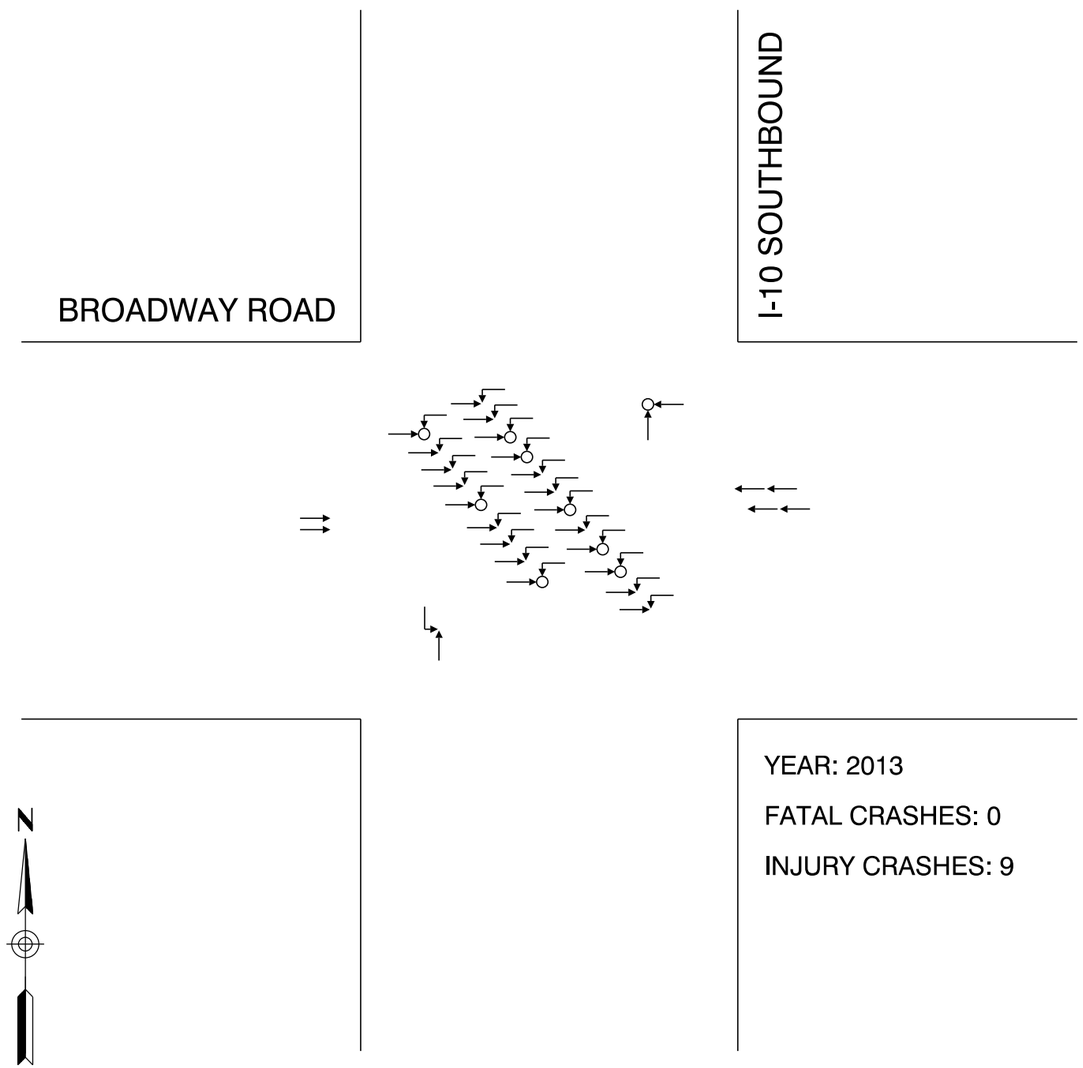
LEGEND

- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

BROADWAY ROAD / I-17



YEAR: 2013

FATAL CRASHES: 0

INJURY CRASHES: 9

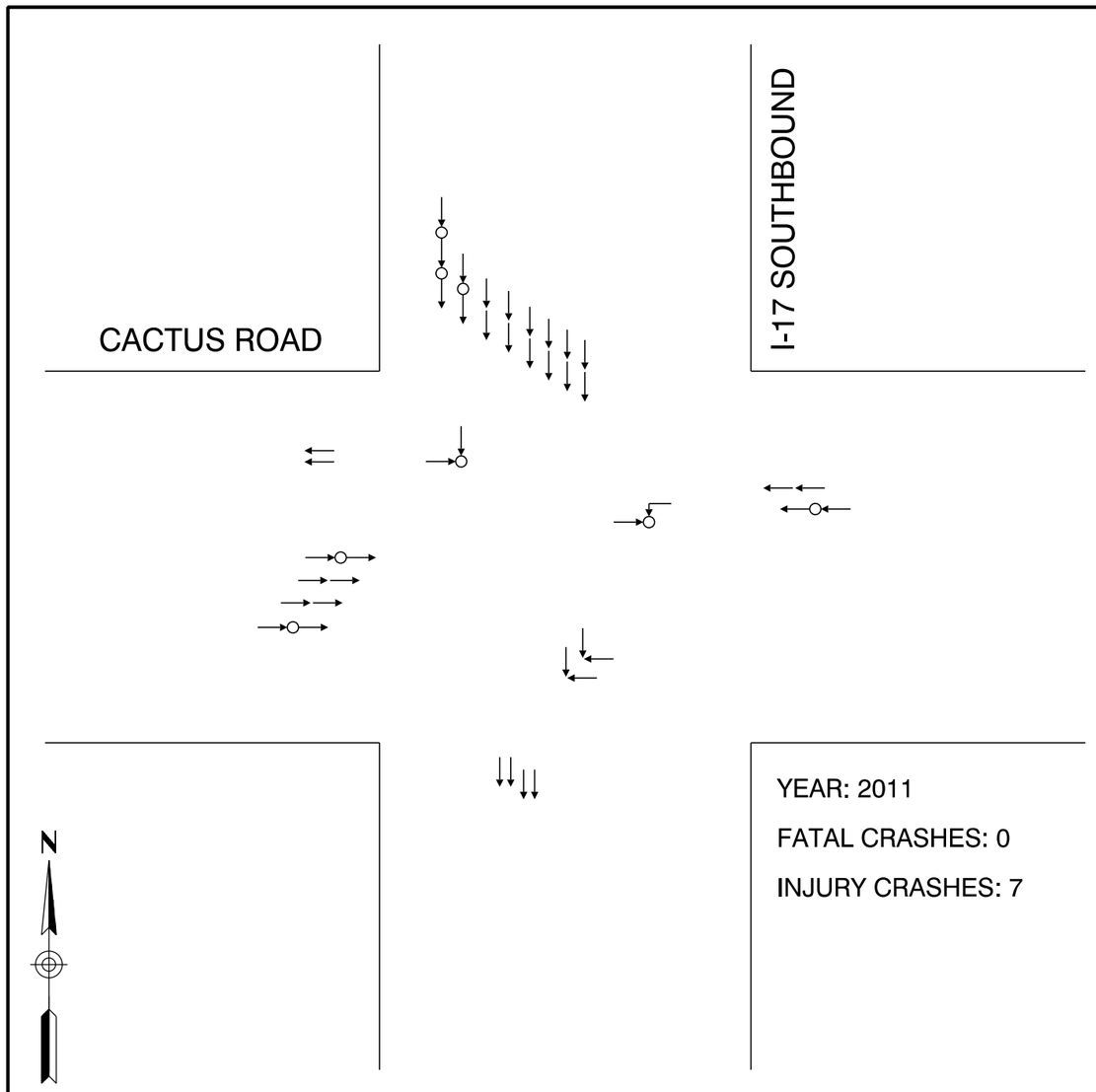
LEGEND

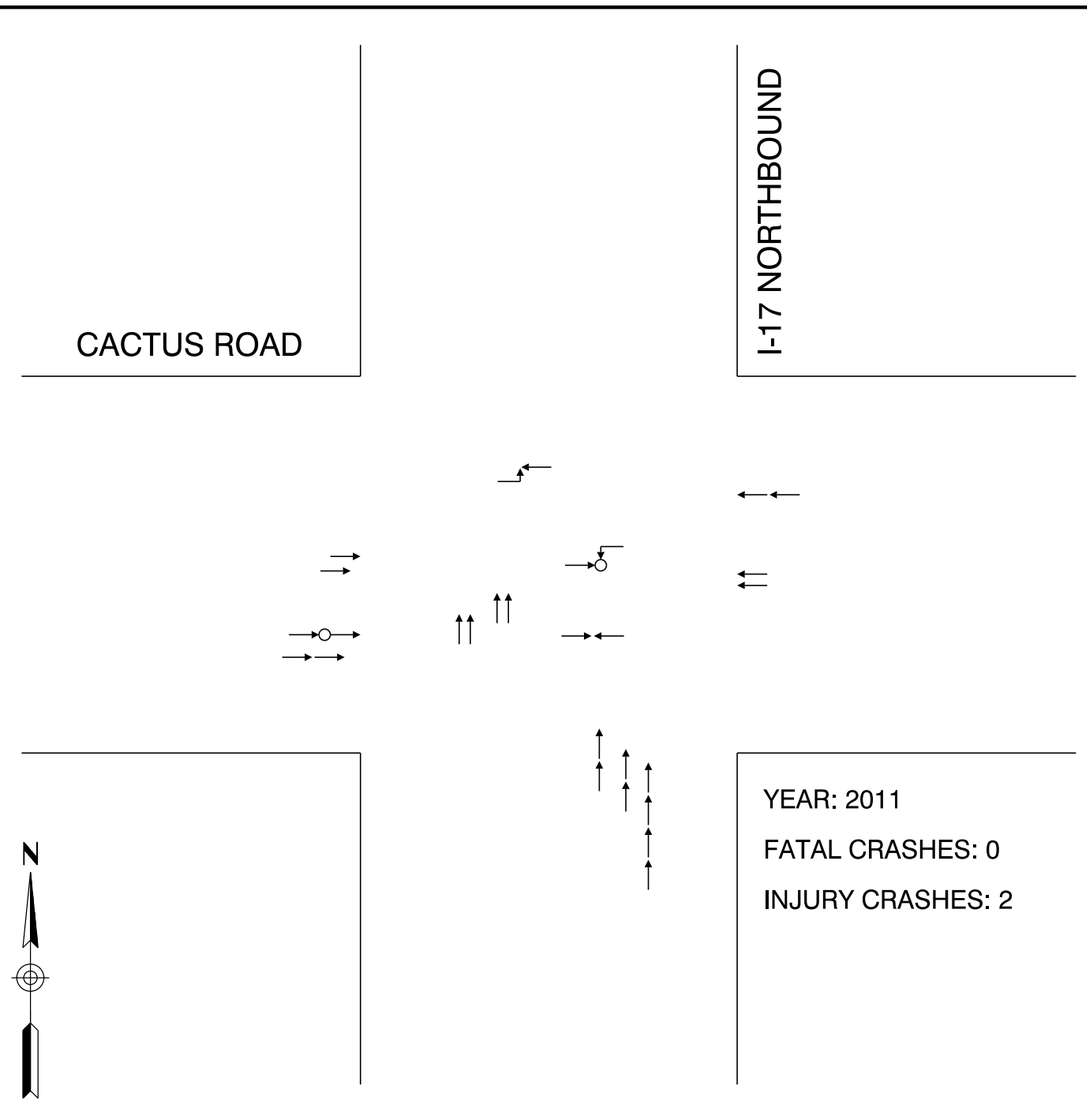
- Angle	- Left Turn	- Side Swipe
- Backing Up	- Pedestrian	- Single Vehicle
- Bicycle	- Rear End	- Fatal
- Head On	- Right Turn	- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

BROADWAY ROAD / I-10





LEGEND

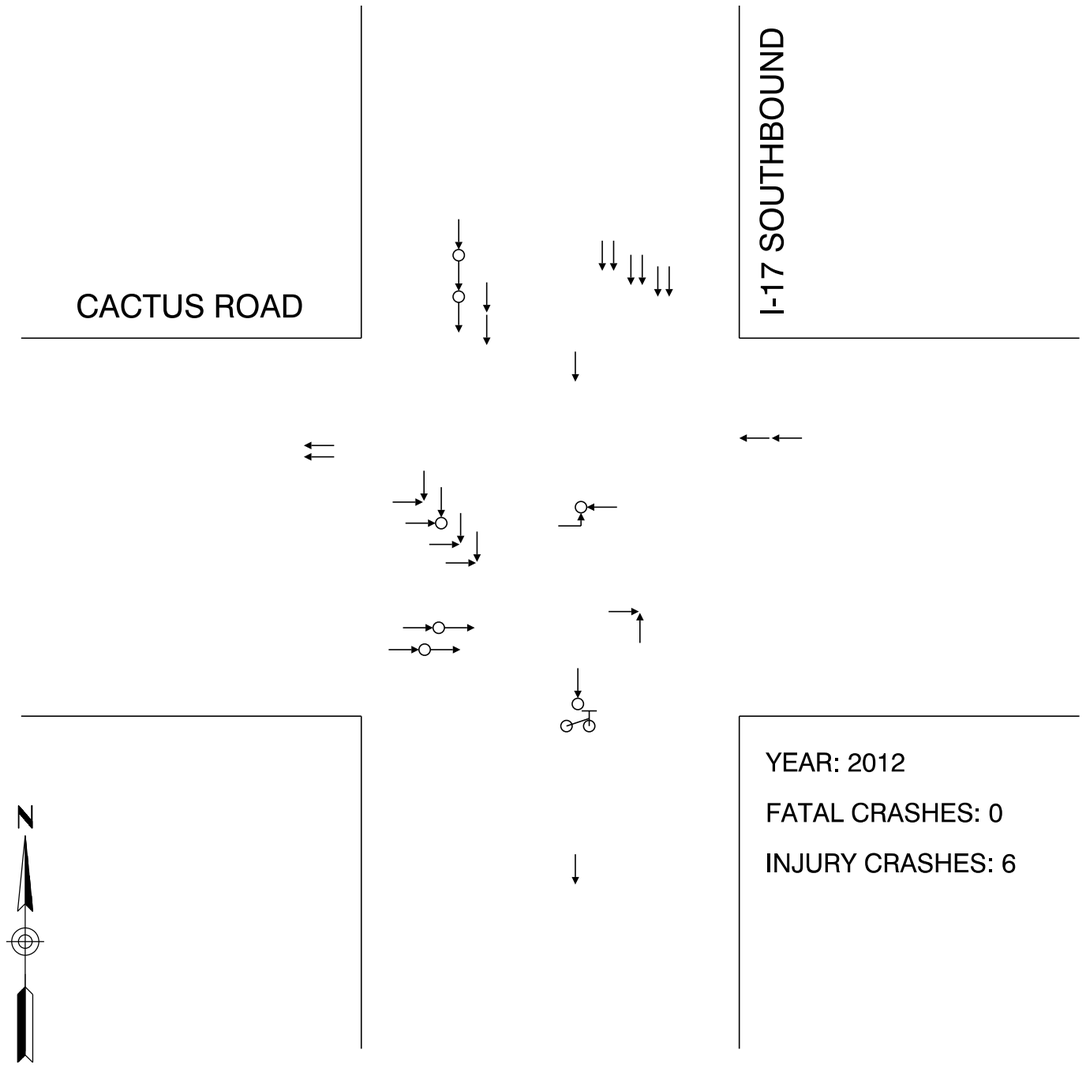
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

CACTUS ROAD / I-17

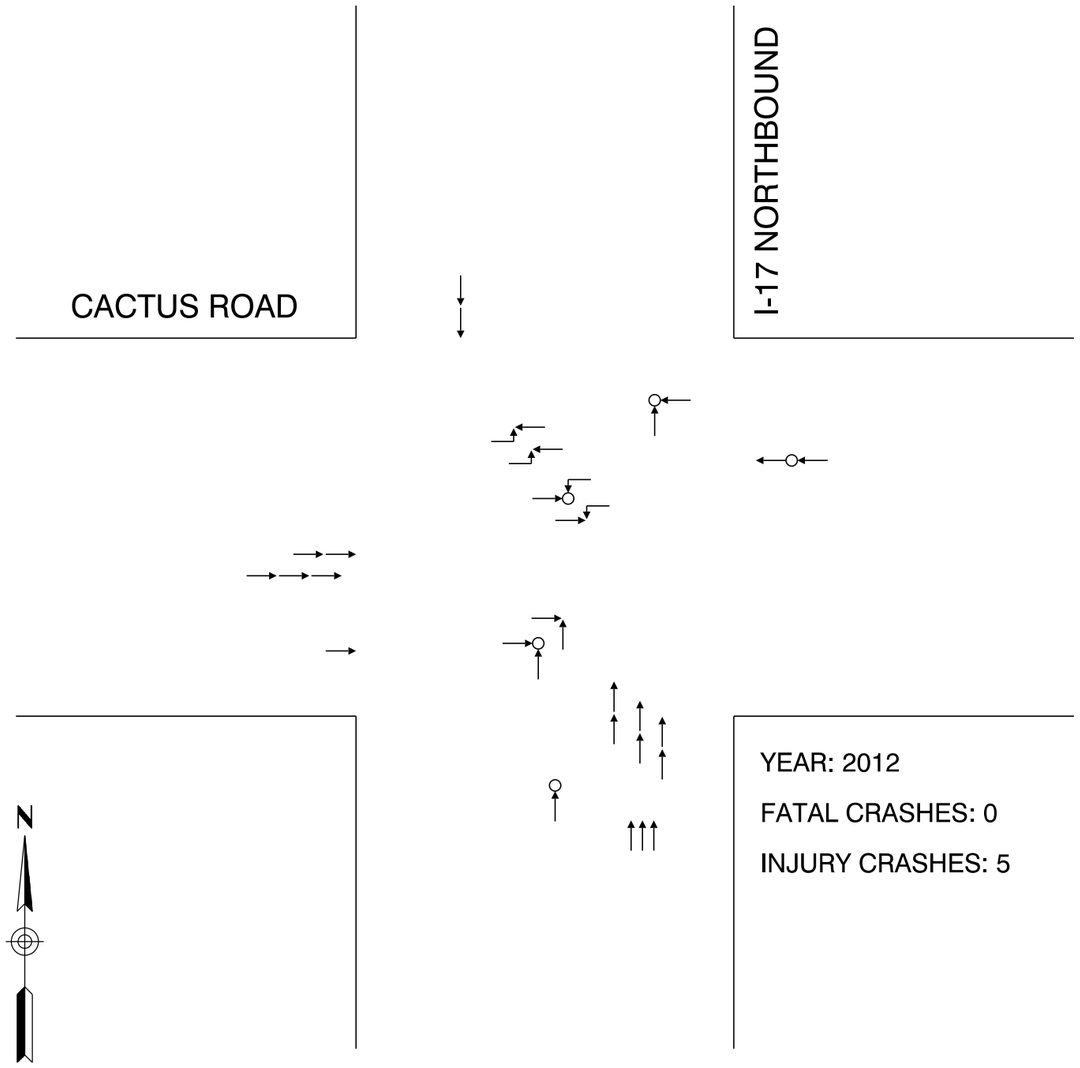
SPINE 10 17 Corridor Master Plan



YEAR: 2012

FATAL CRASHES: 0

INJURY CRASHES: 6



YEAR: 2012

FATAL CRASHES: 0

INJURY CRASHES: 5

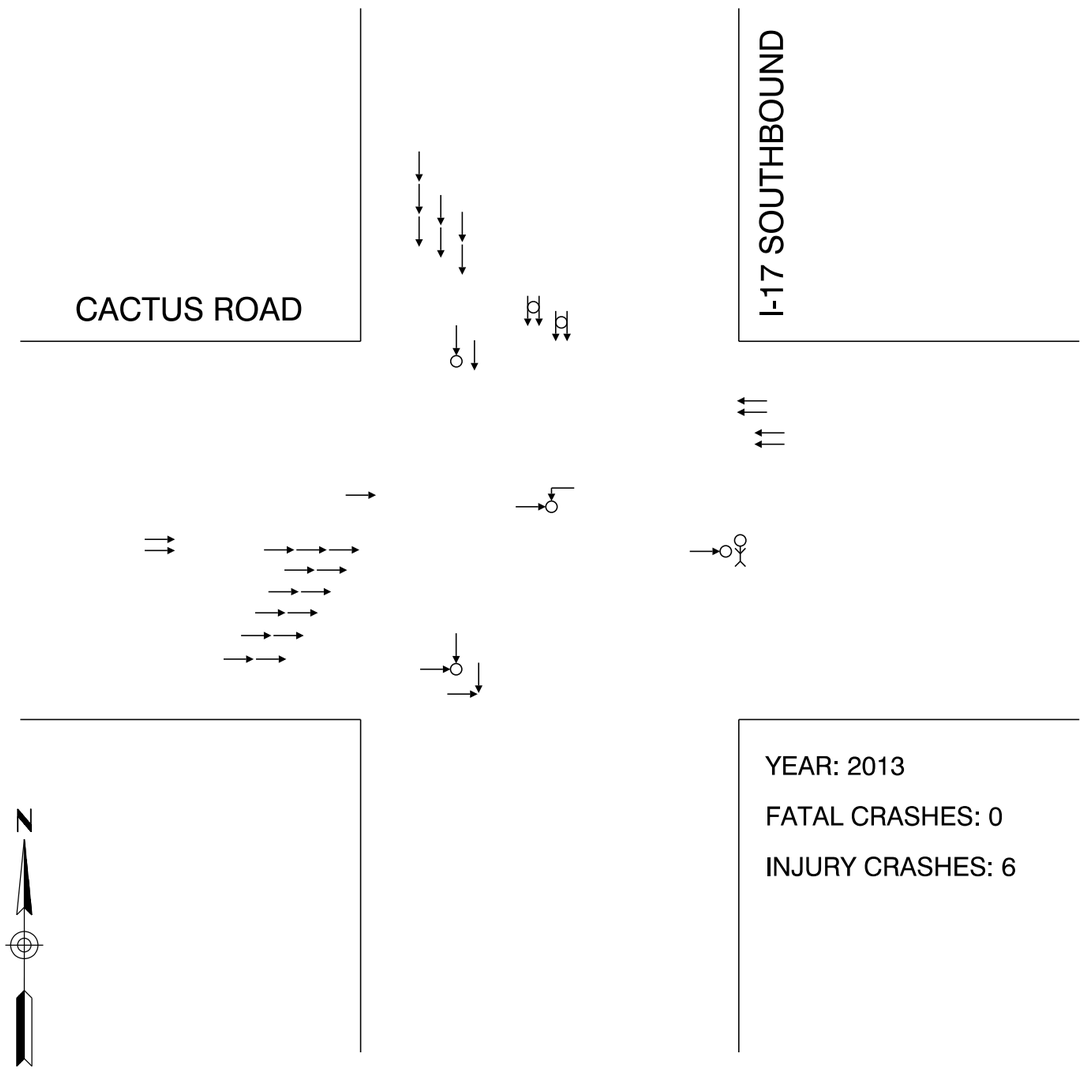
LEGEND

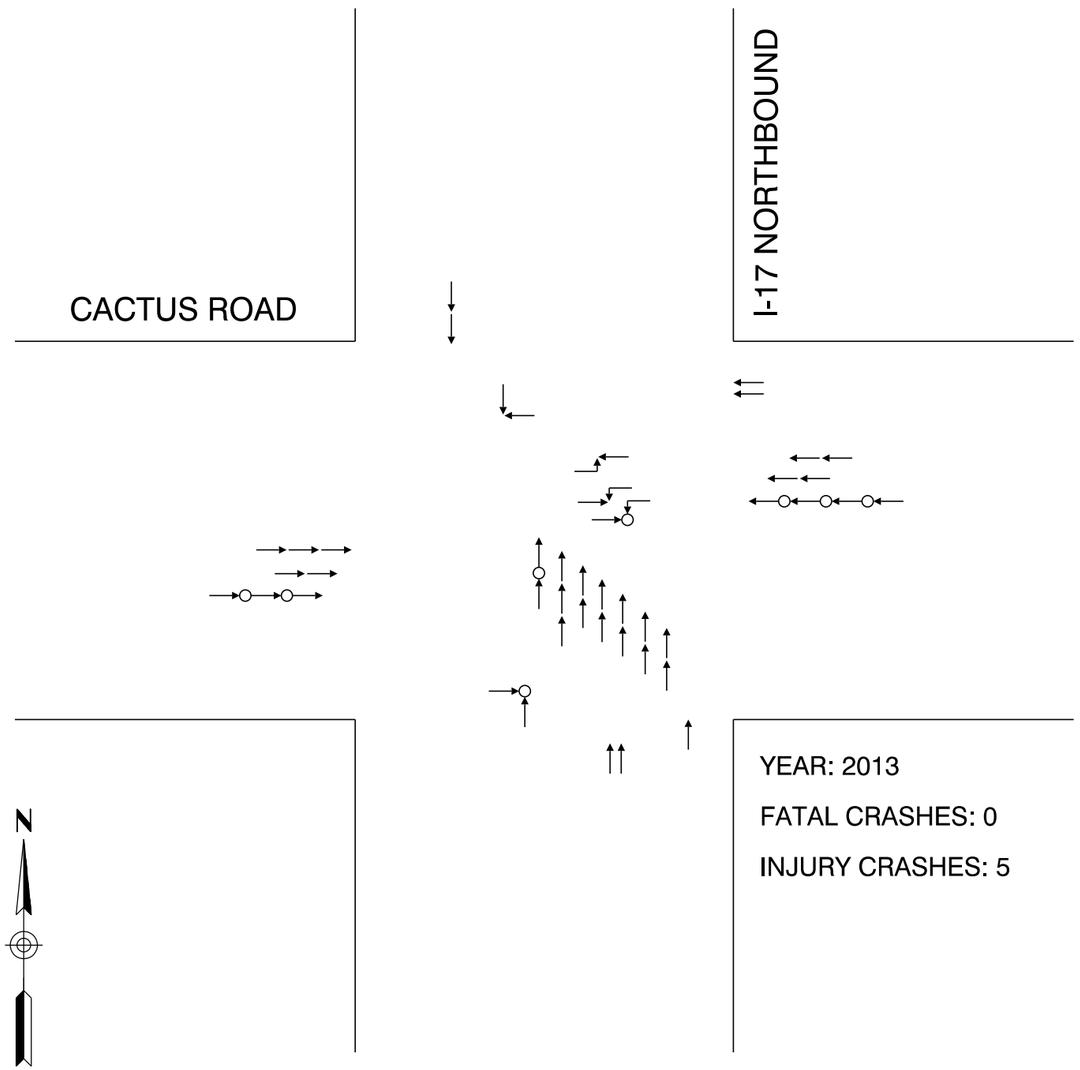
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

CACTUS ROAD / I-17





LEGEND

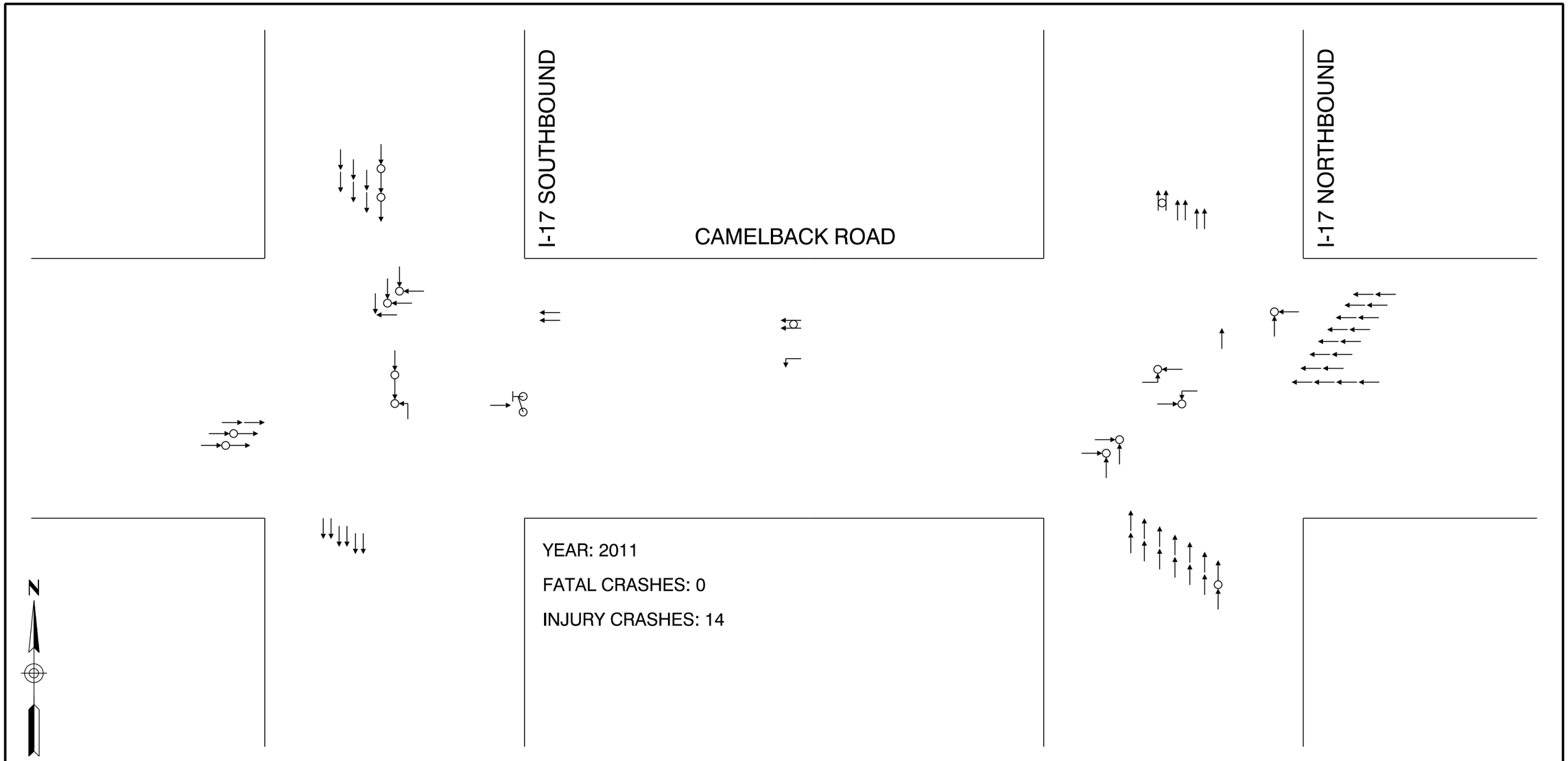
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

CACTUS ROAD / I-17

SPINE Corridor Master Plan 10 17



LEGEND

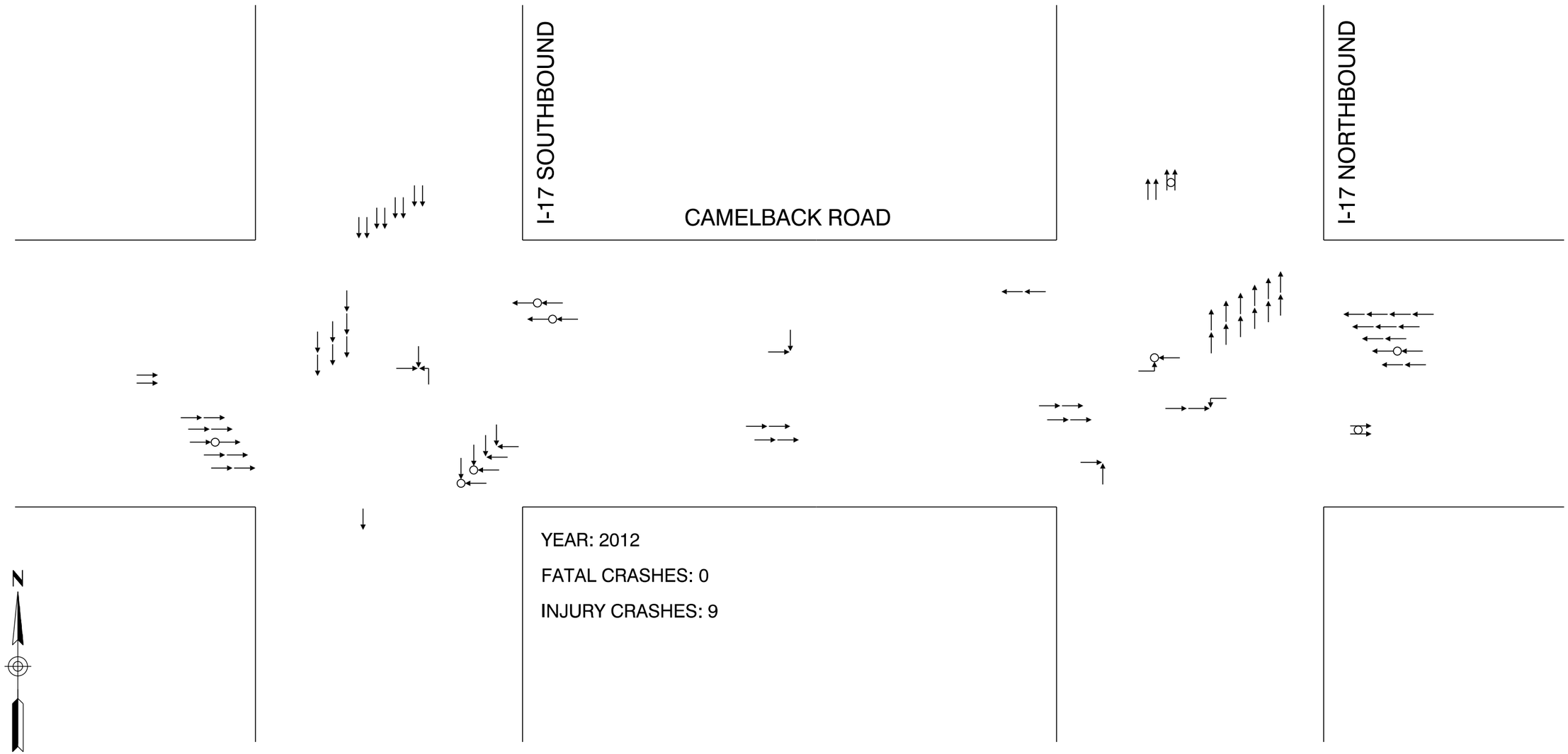
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

CAMELBACK ROAD / I-17

SPINE Corridor Master Plan 10 17



YEAR: 2012

FATAL CRASHES: 0

INJURY CRASHES: 9

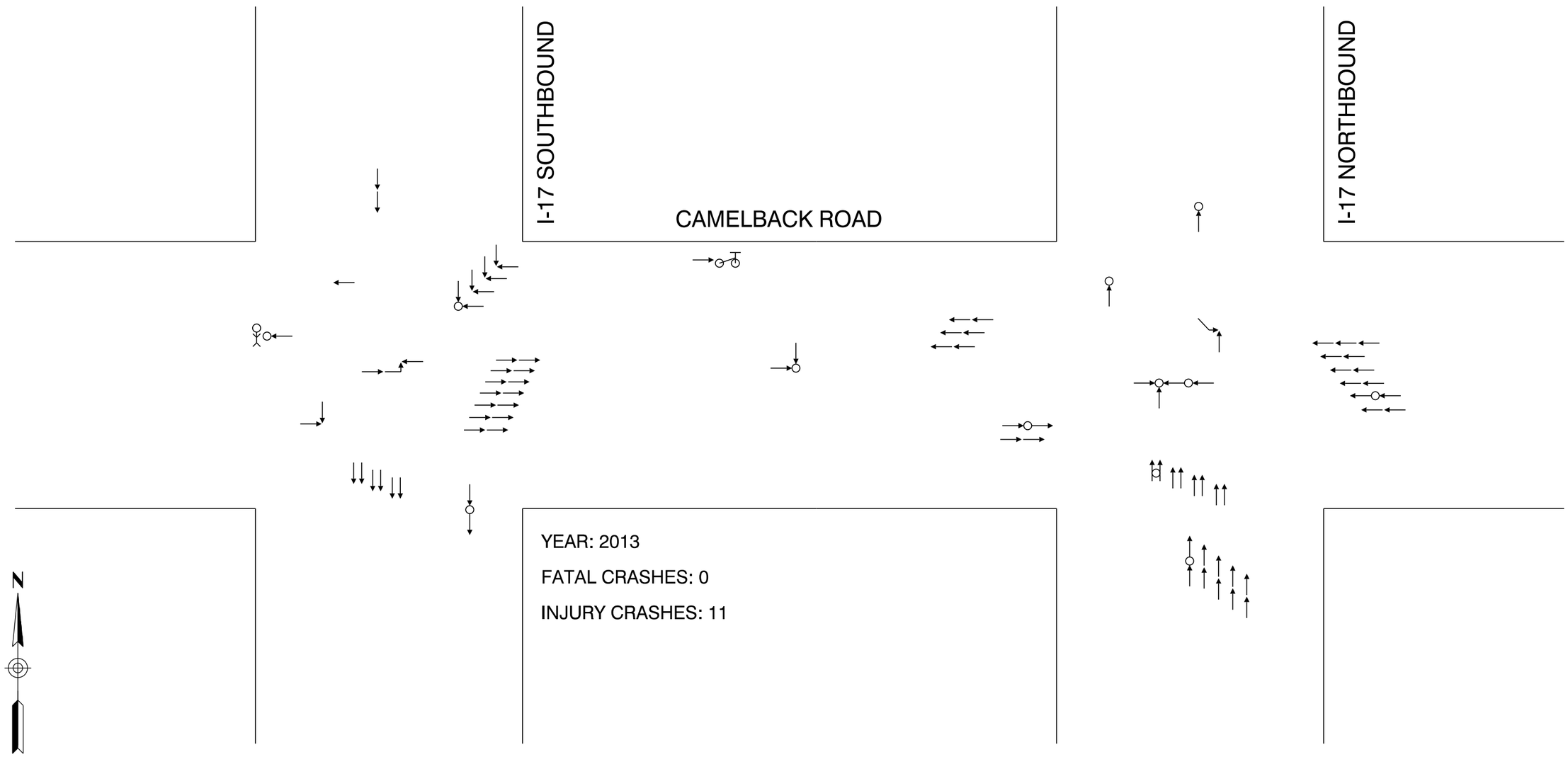
LEGEND

- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

CAMELBACK ROAD / I-17



LEGEND

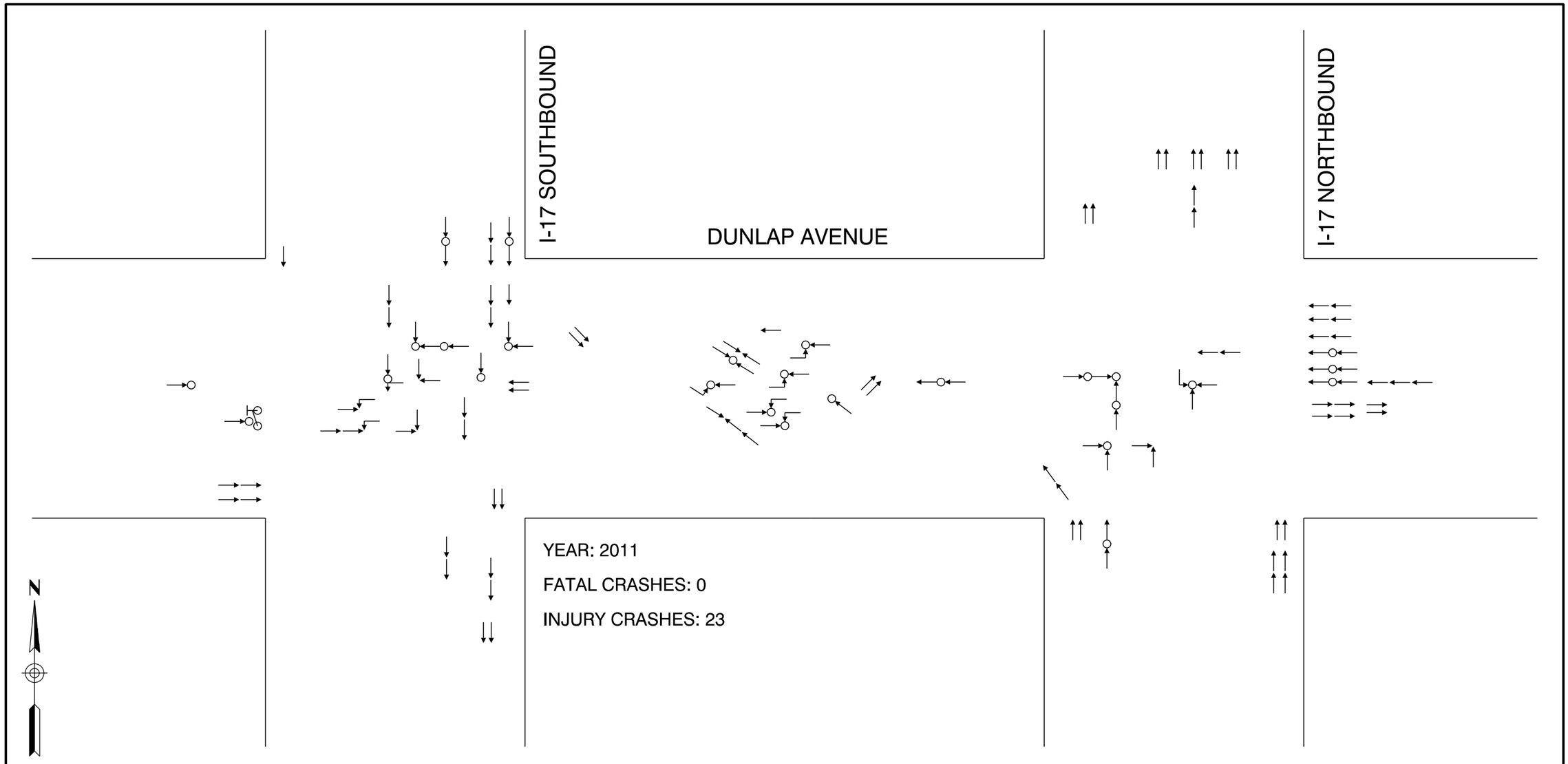
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

CAMELBACK ROAD / I-17

SPINE Corridor Master Plan 10 17



LEGEND

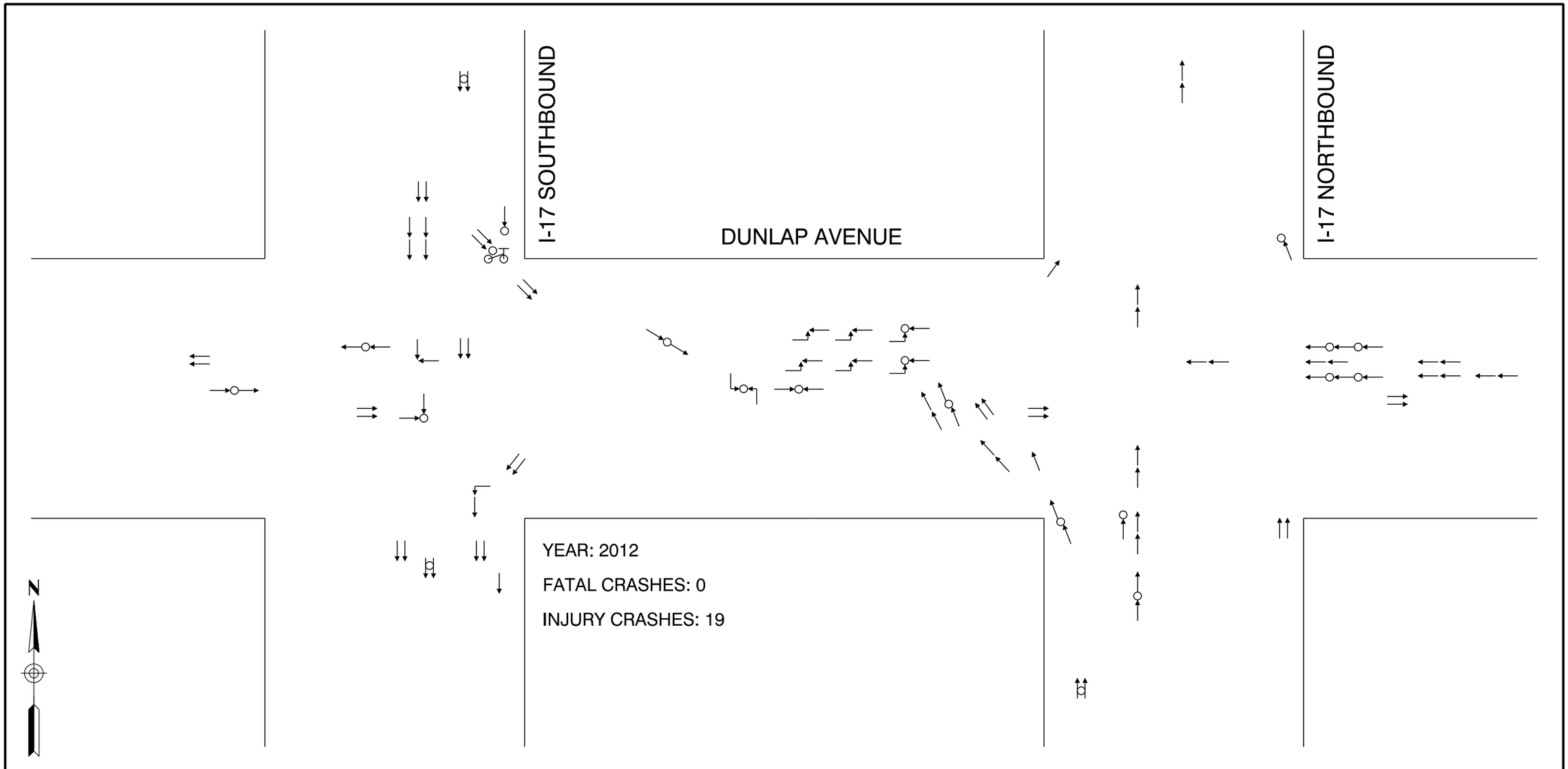
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

DUNLAP AVENUE / I-17

SPINE Corridor Master Plan 10 17



LEGEND

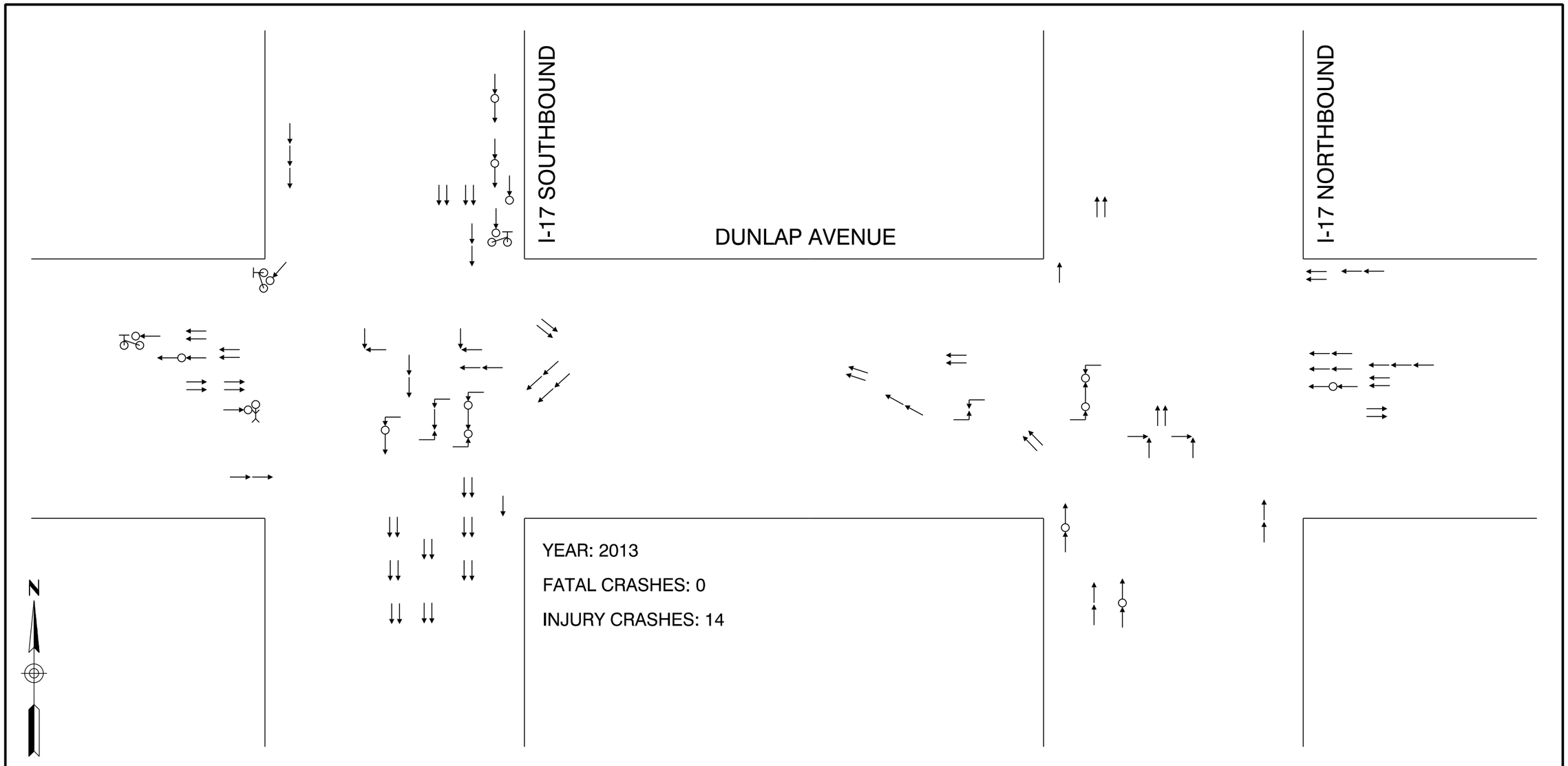
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

DUNLAP AVENUE / I-17

SPINE 10 17 Corridor Master Plan



LEGEND

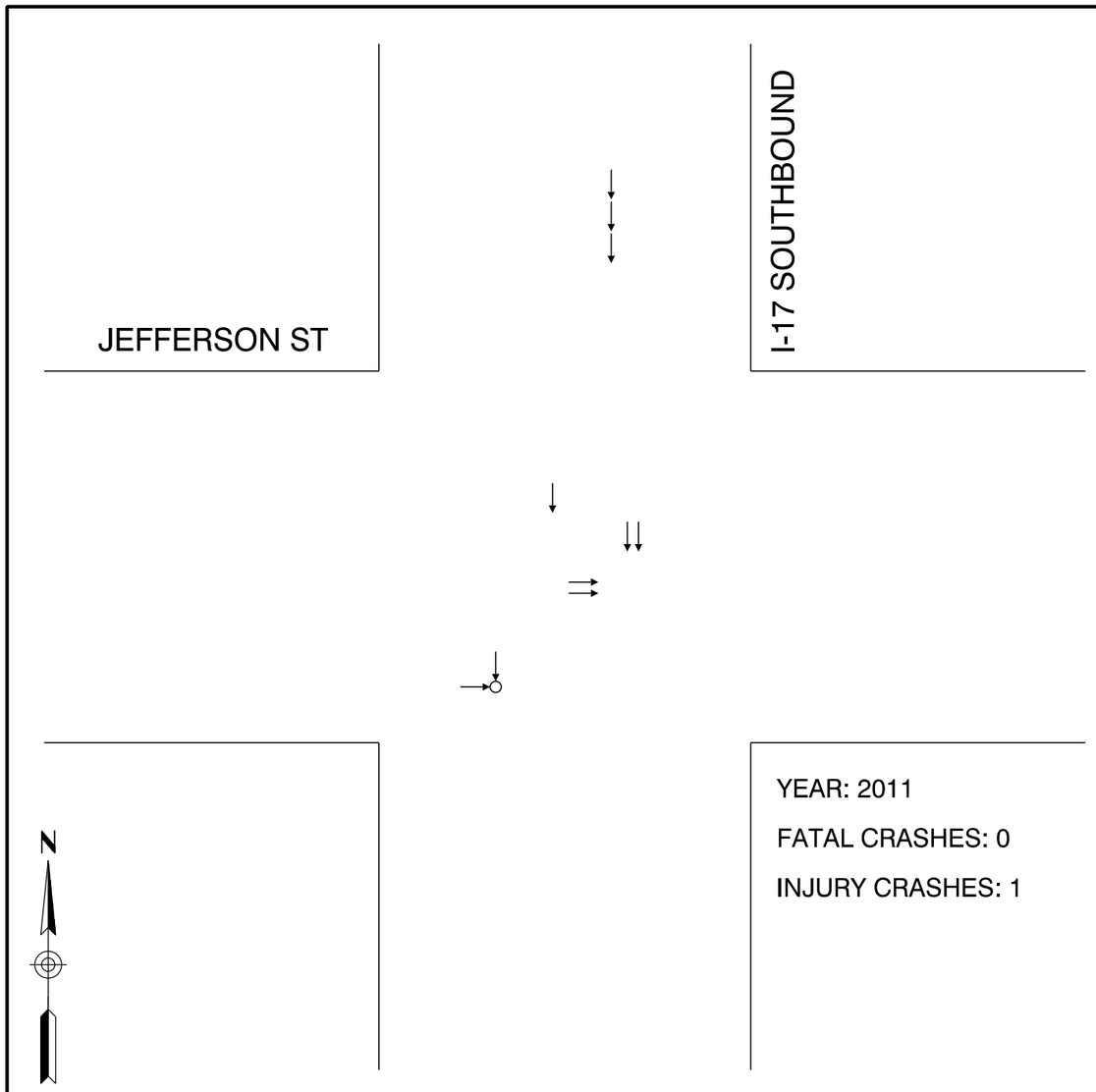
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

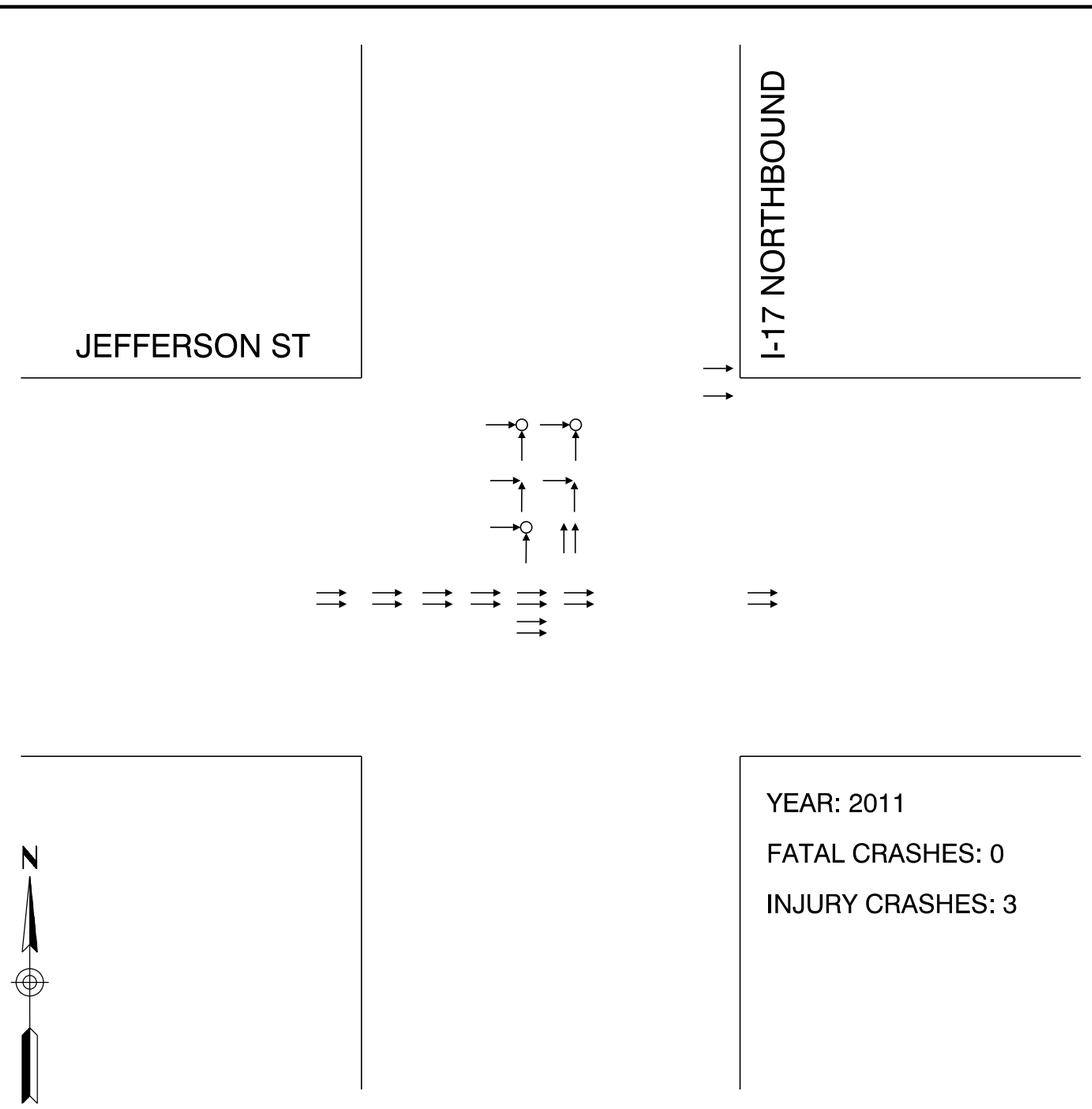
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

DUNLAP AVENUE / I-17

SPINE Corridor Master Plan 10 17





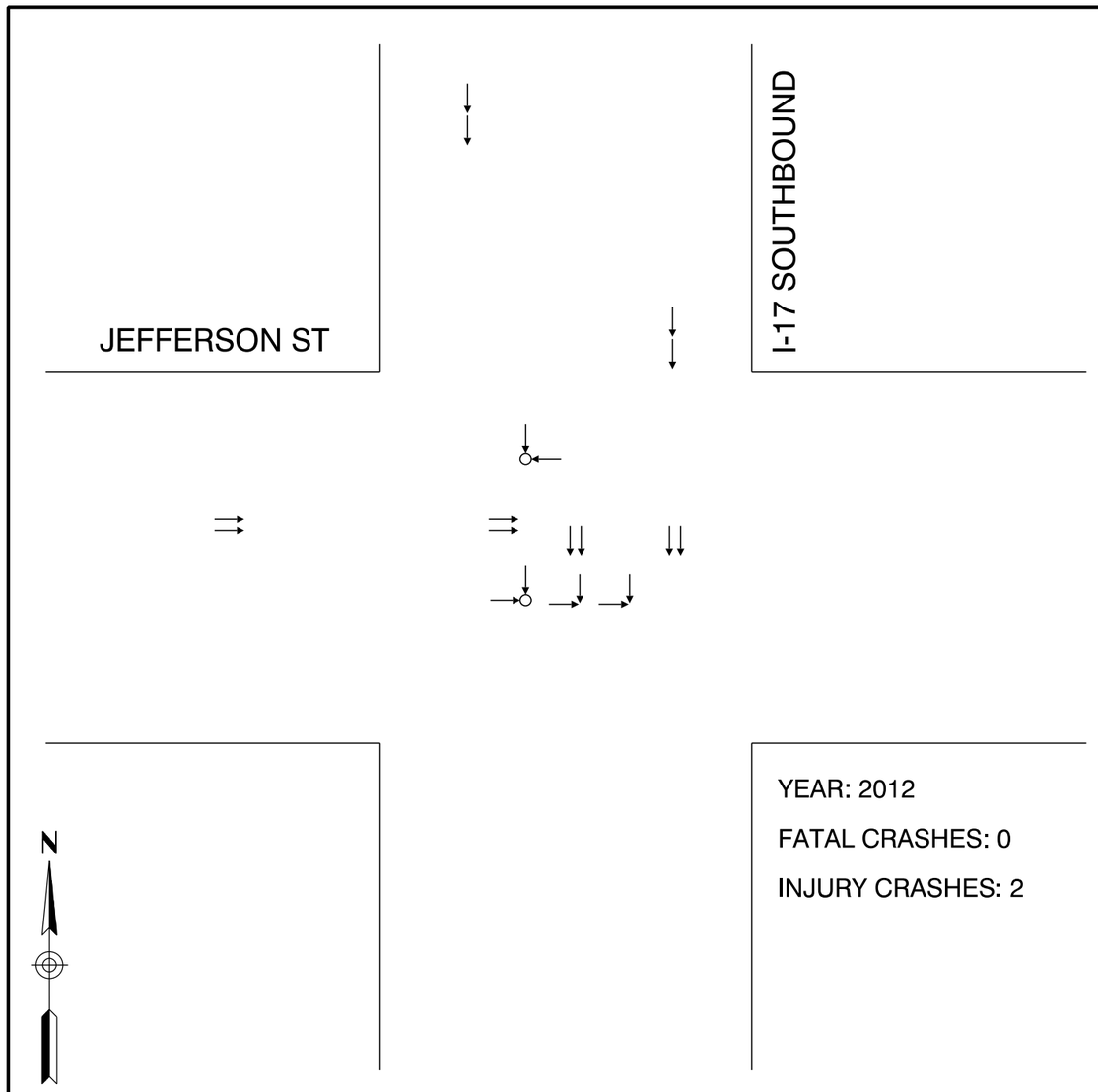
LEGEND

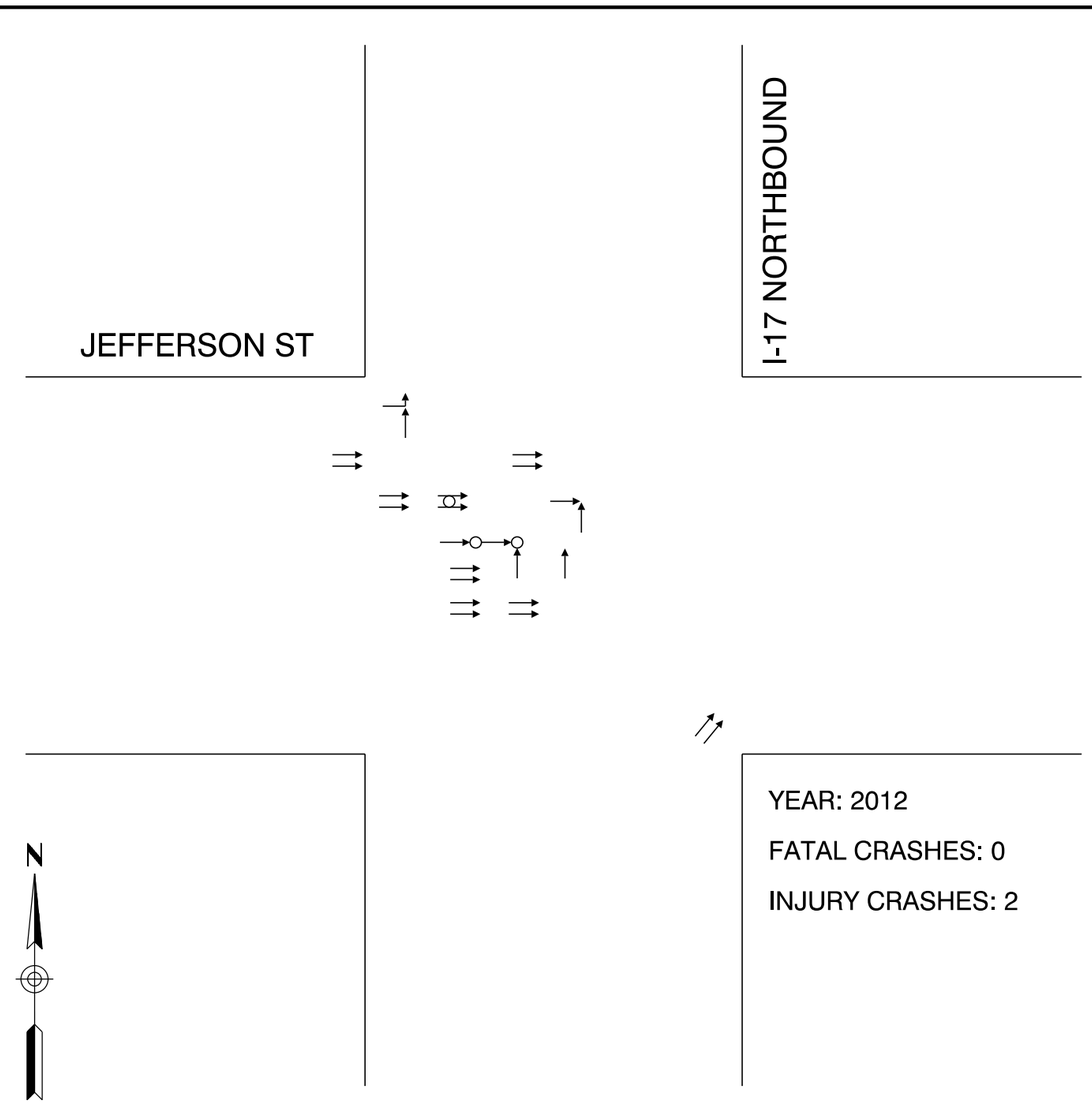
- Angle	- Left Turn	- Side Swipe
- Backing Up	- Pedestrian	- Single Vehicle
- Bicycle	- Rear End	- Fatal
- Head On	- Right Turn	- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

JEFFERSON STREET / I-17





LEGEND

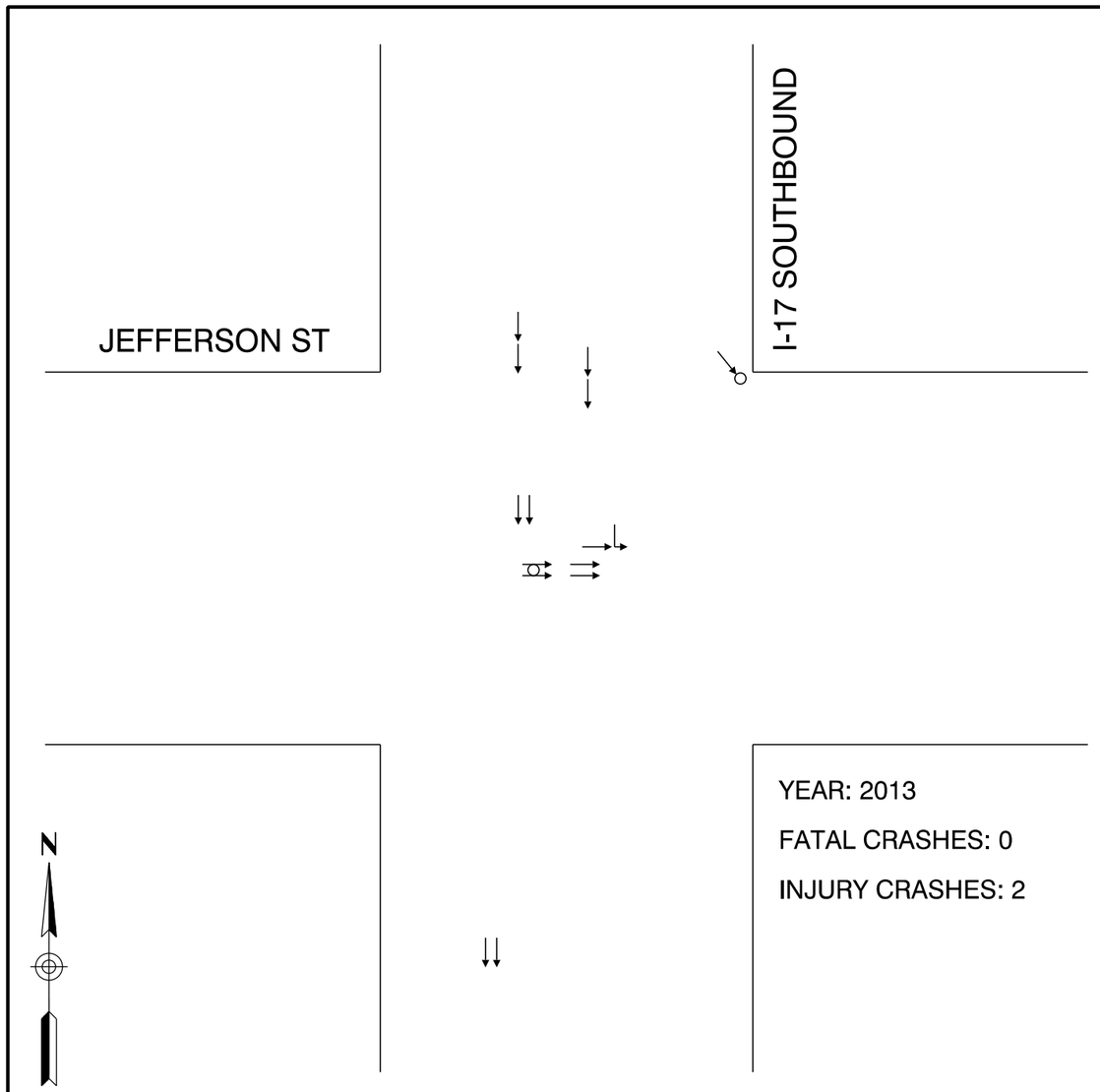
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

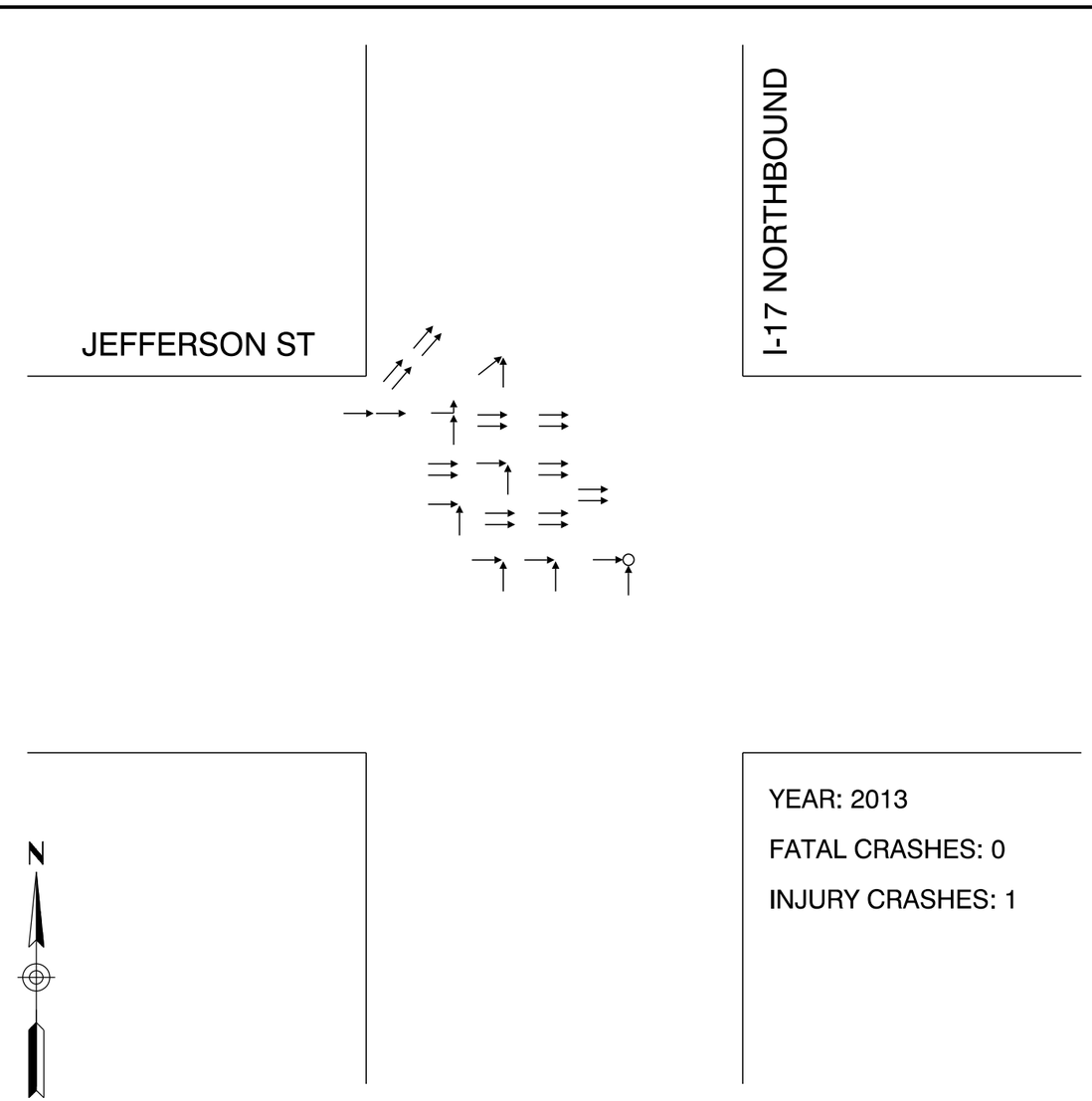
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

JEFFERSON STREET / I-17

SPINE Corridor Master Plan 10 17





LEGEND

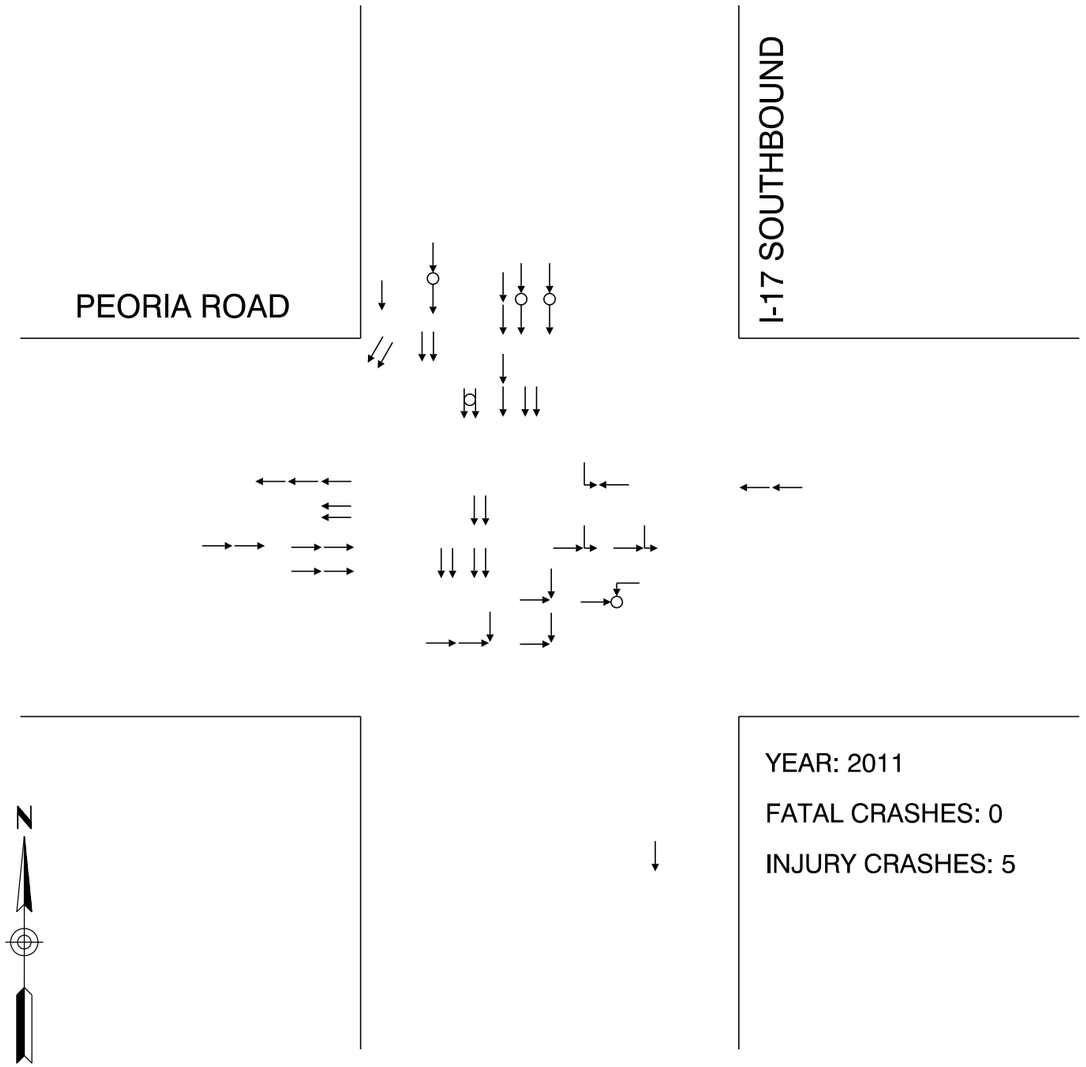
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

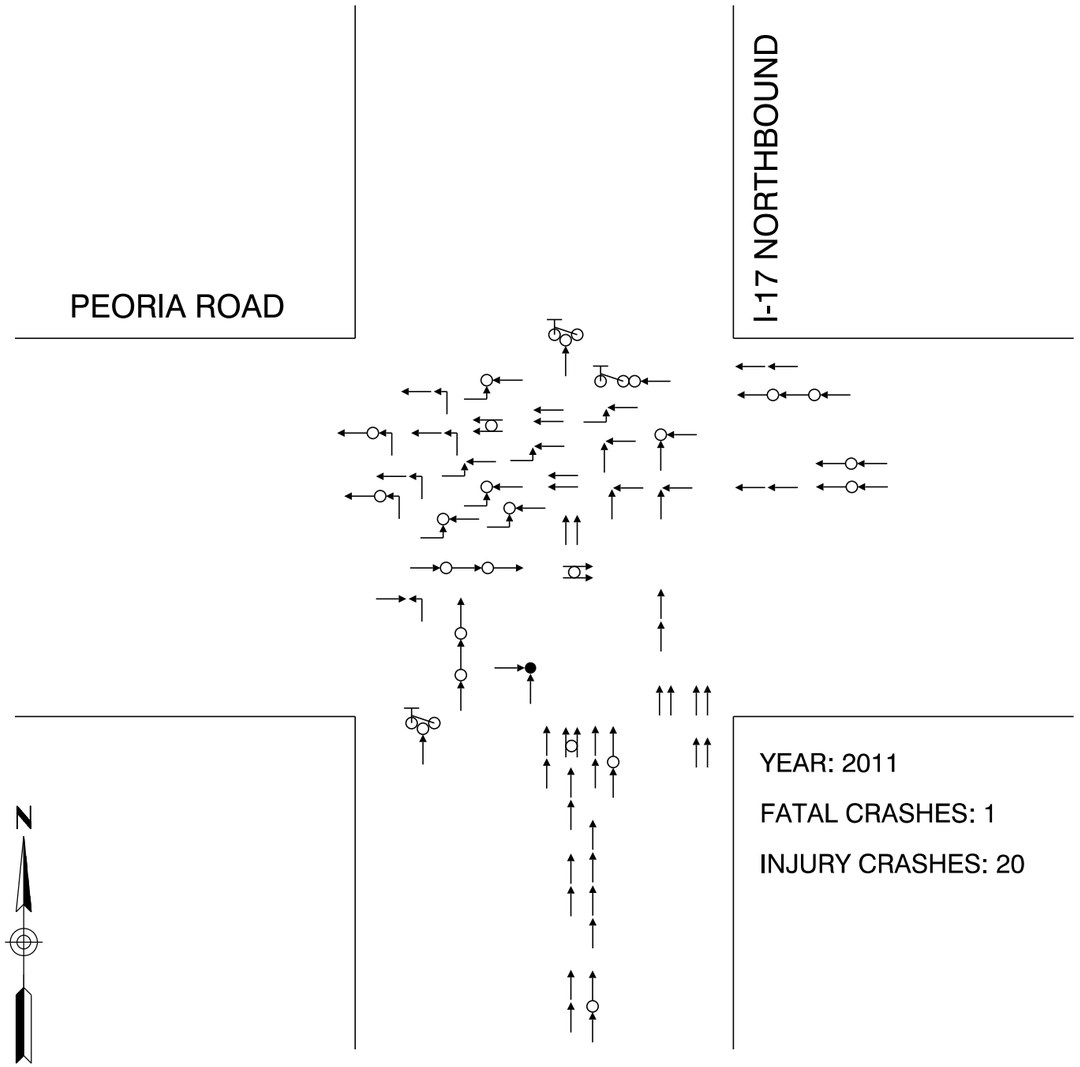
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

JEFFERSON STREET / I-17

SPINE Corridor Master Plan 10 17





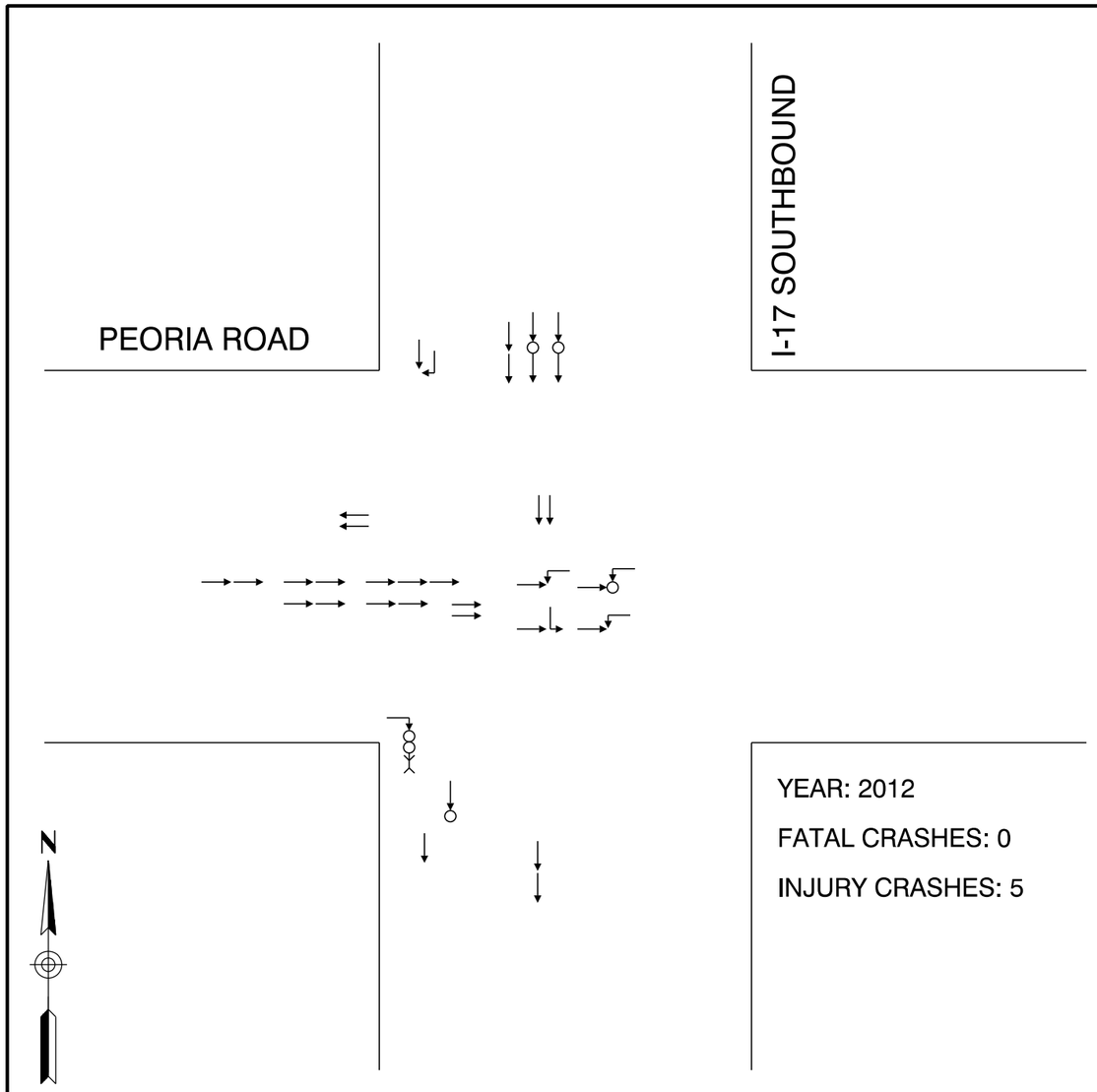
LEGEND

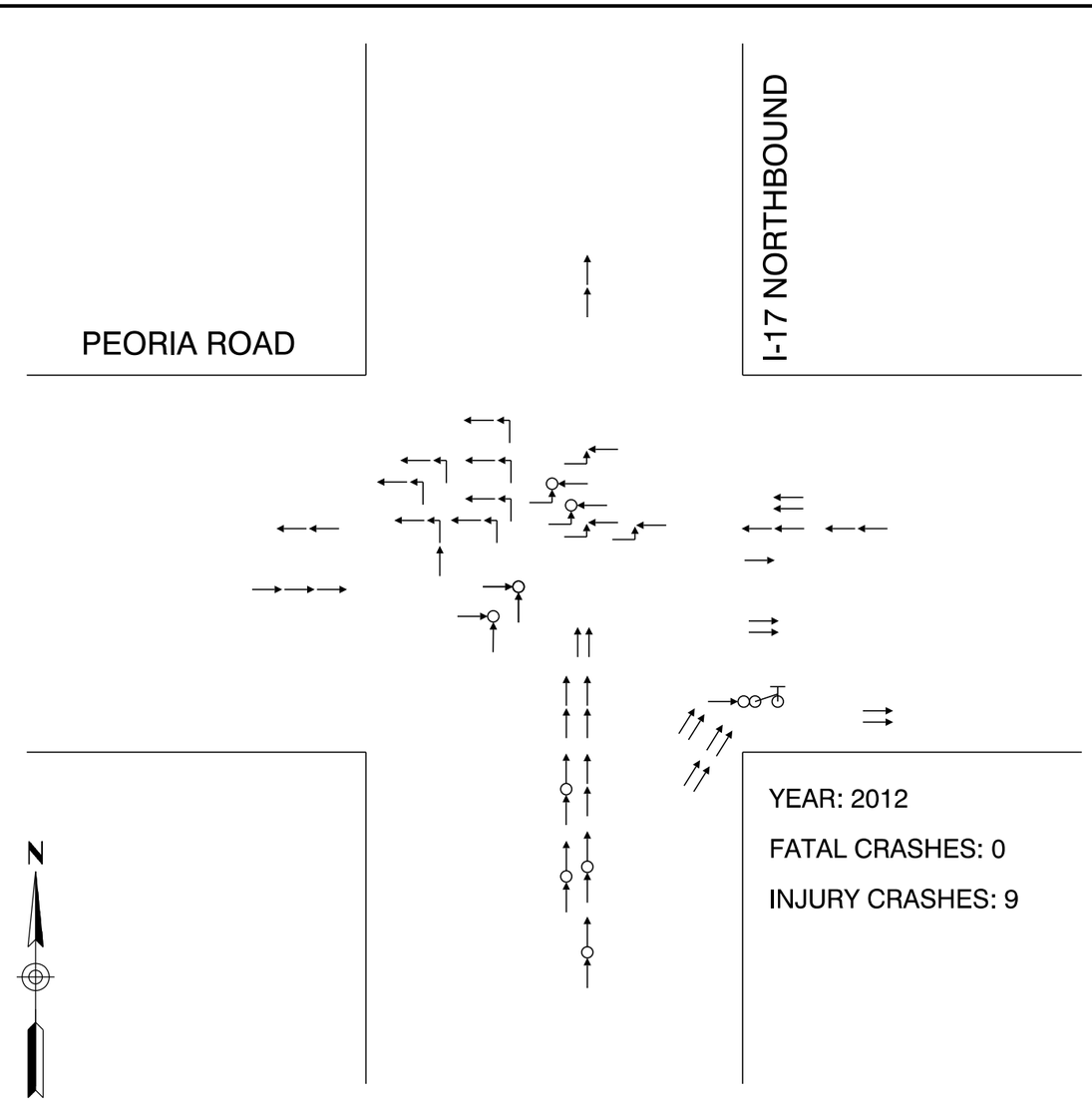
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

PEORIA ROAD / I-17





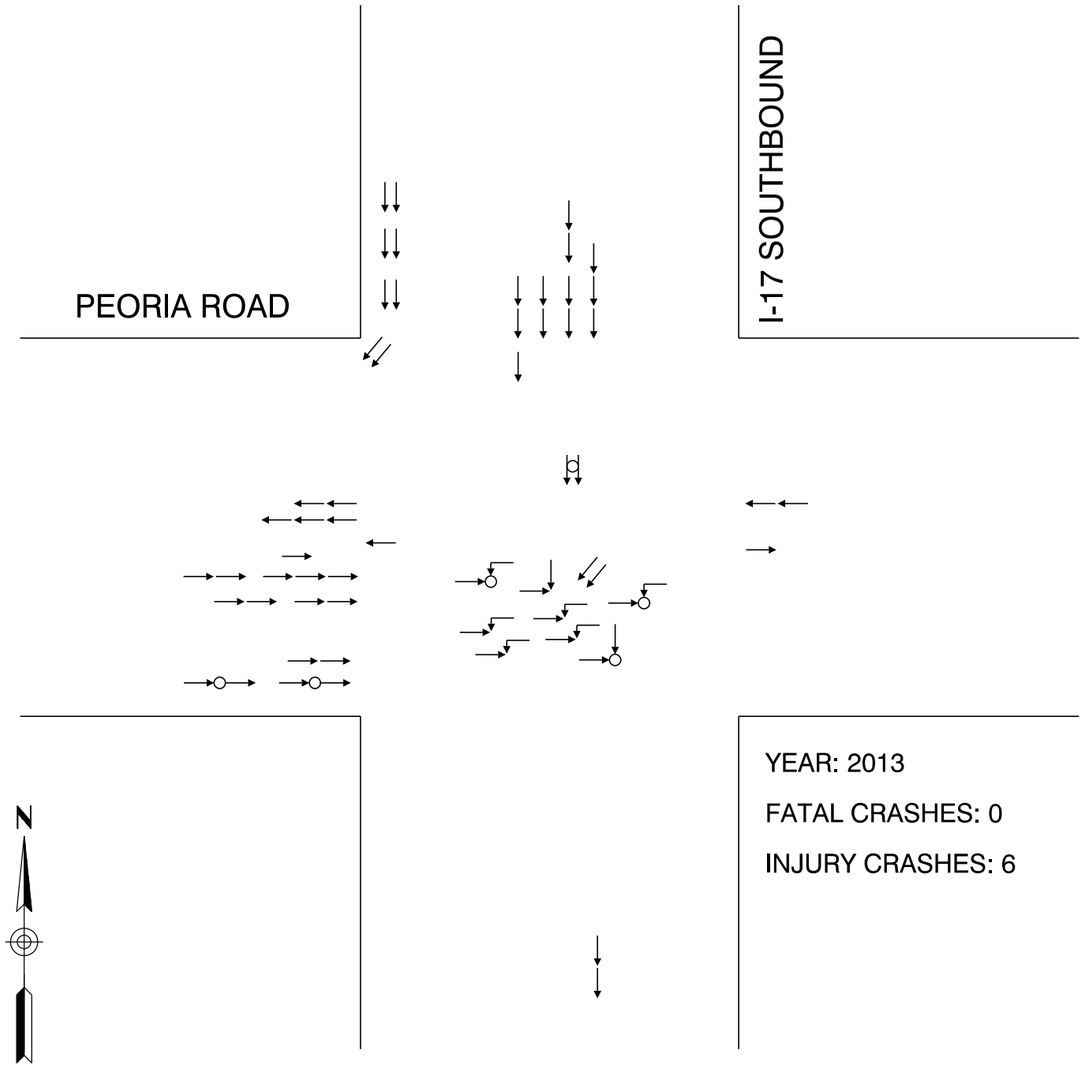
LEGEND

- Angle	- Left Turn	- Side Swipe
- Backing Up	- Pedestrian	- Single Vehicle
- Bicycle	- Rear End	- Fatal
- Head On	- Right Turn	- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

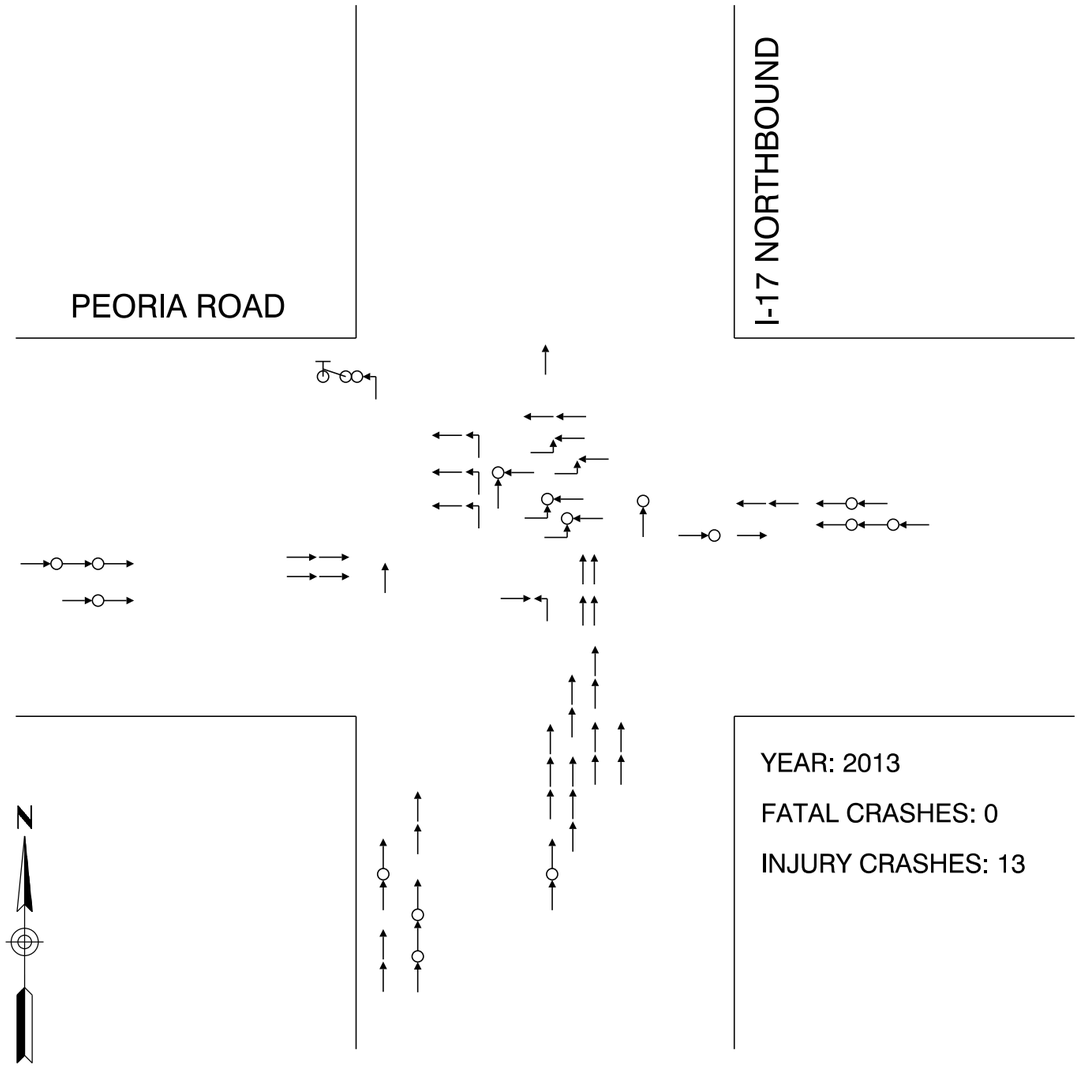
PEORIA ROAD / I-17



YEAR: 2013

FATAL CRASHES: 0

INJURY CRASHES: 6



YEAR: 2013

FATAL CRASHES: 0

INJURY CRASHES: 13

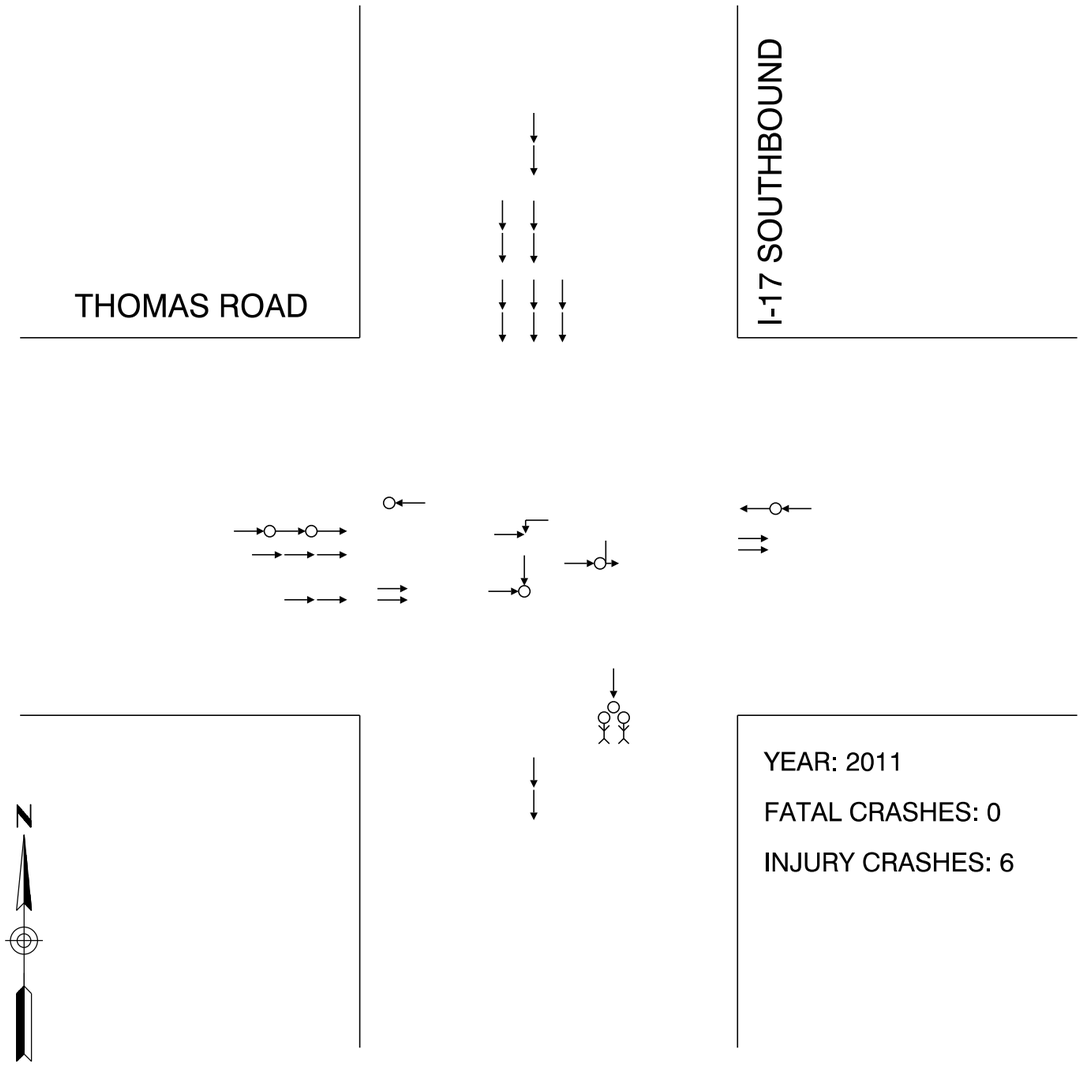
LEGEND

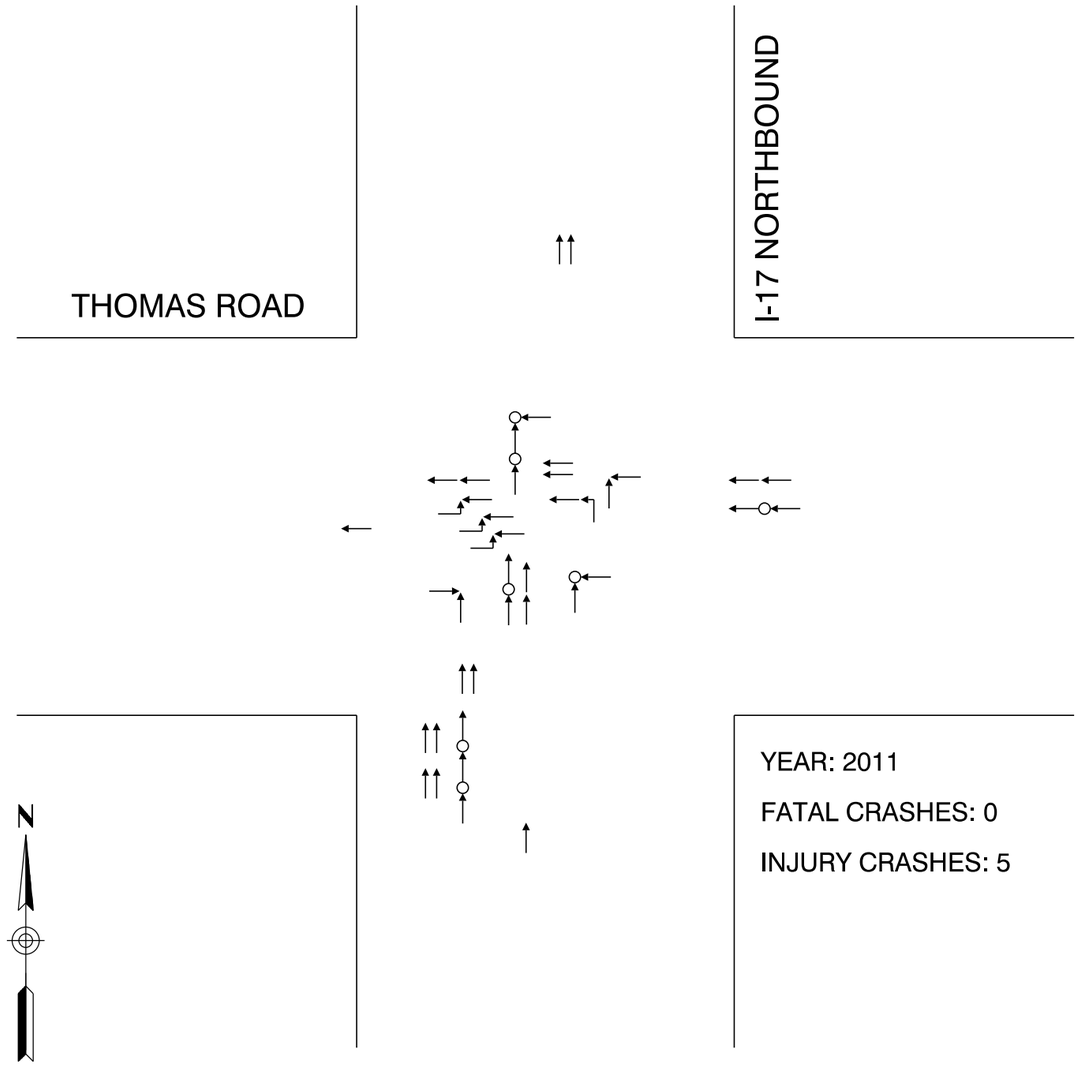
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

PEORIA ROAD / I-17





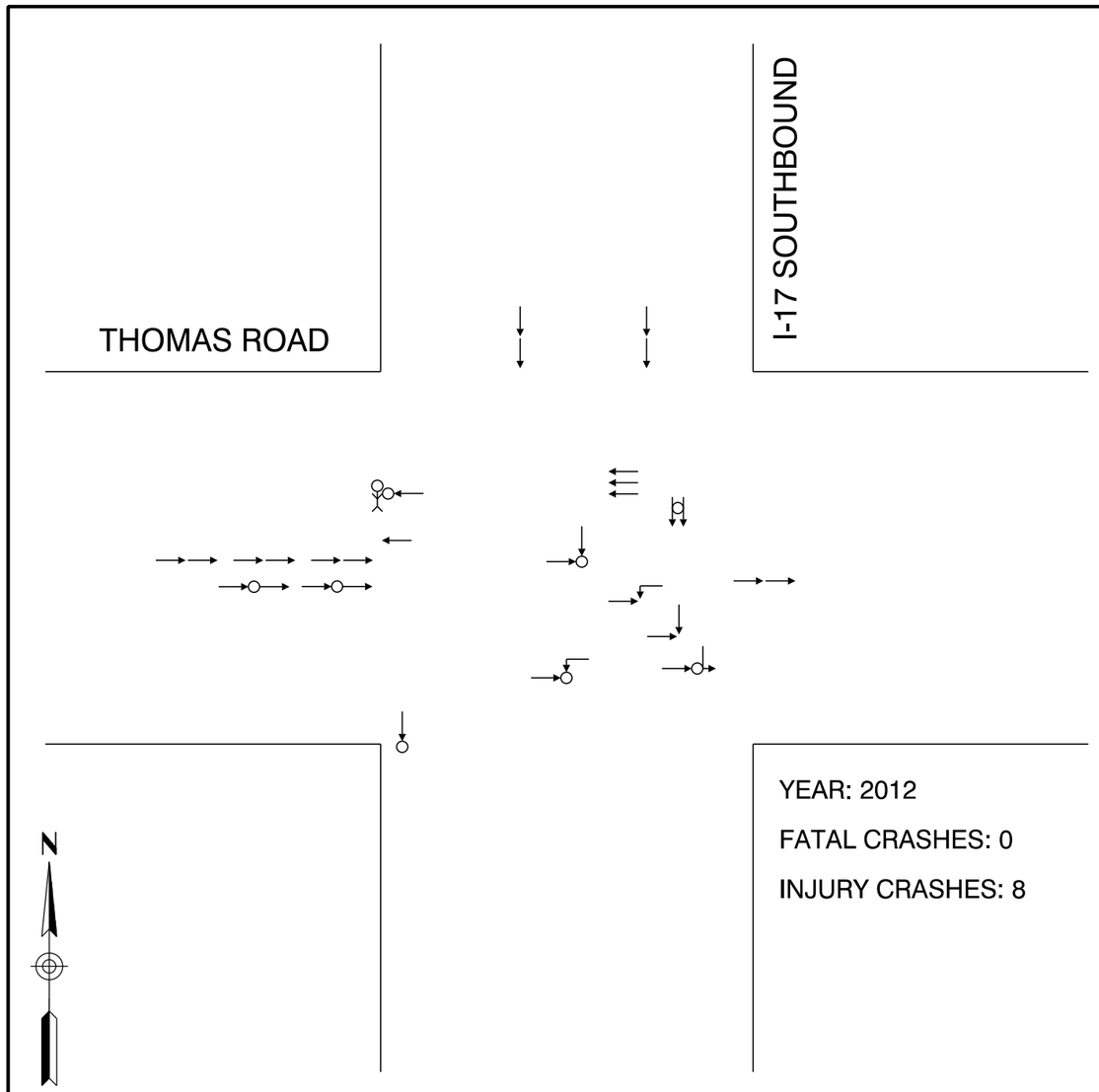
LEGEND

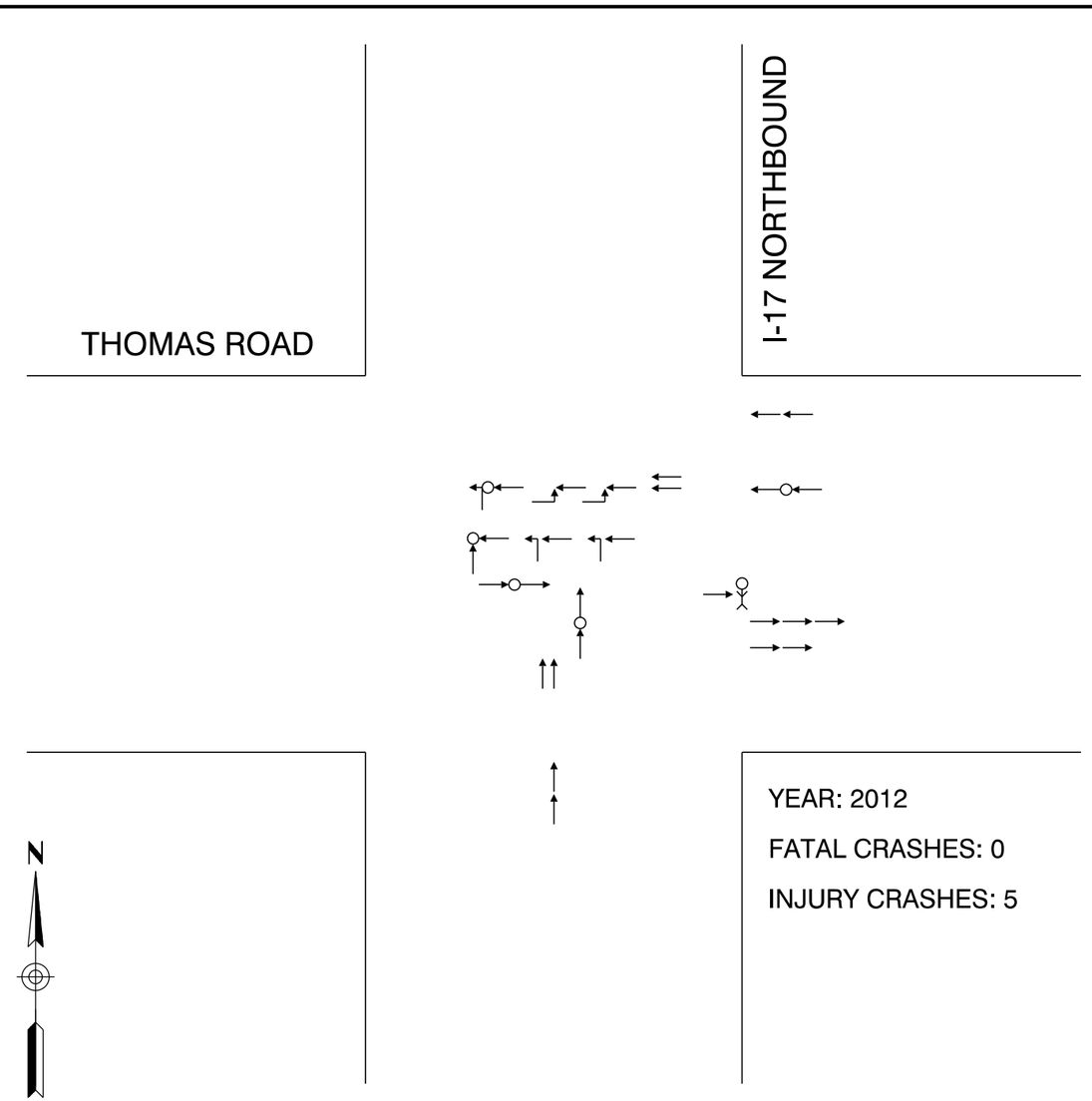
- Angle	- Left Turn	- Side Swipe
- Backing Up	- Pedestrian	- Single Vehicle
- Bicycle	- Rear End	- Fatal
- Head On	- Right Turn	- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

THOMAS ROAD / I-17





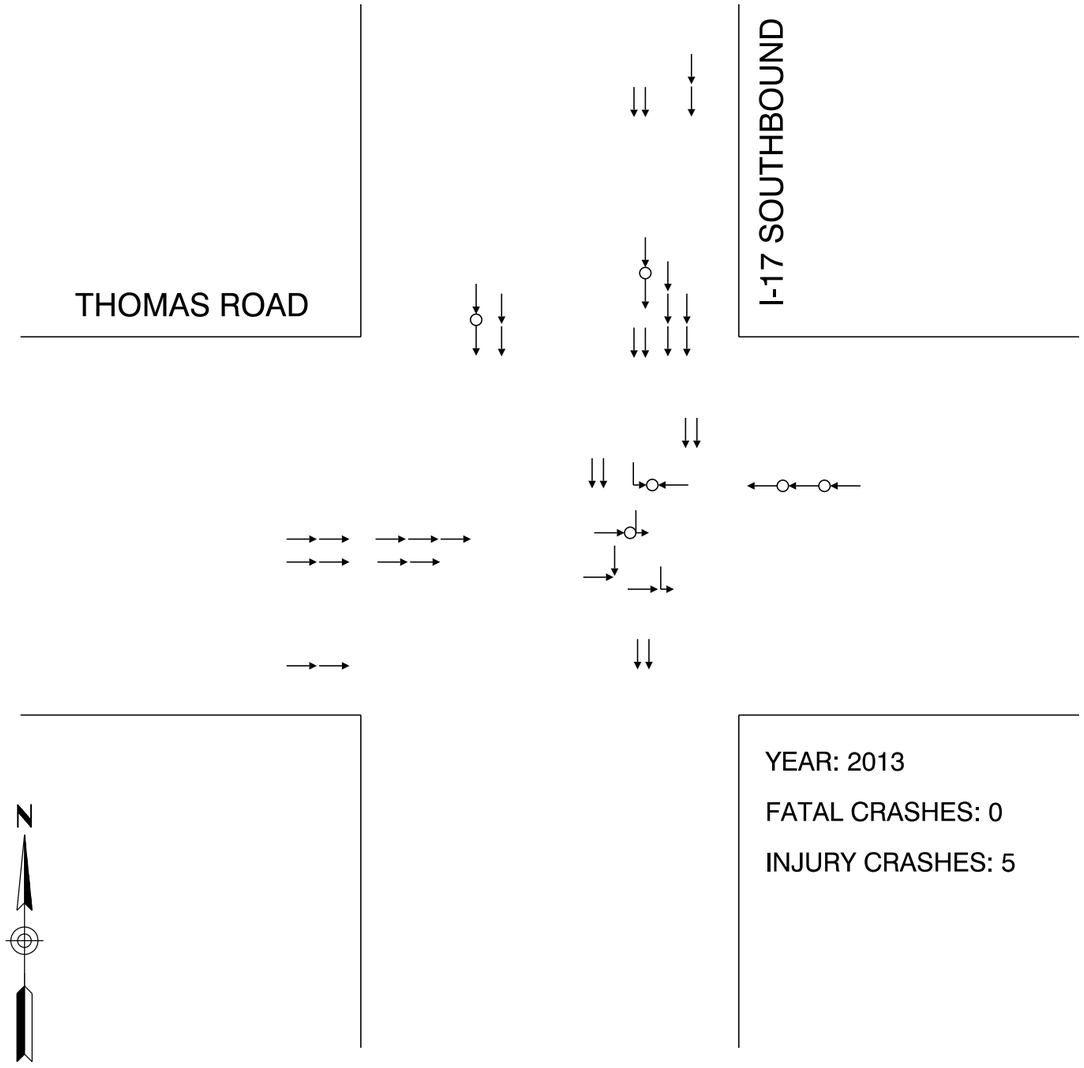
LEGEND

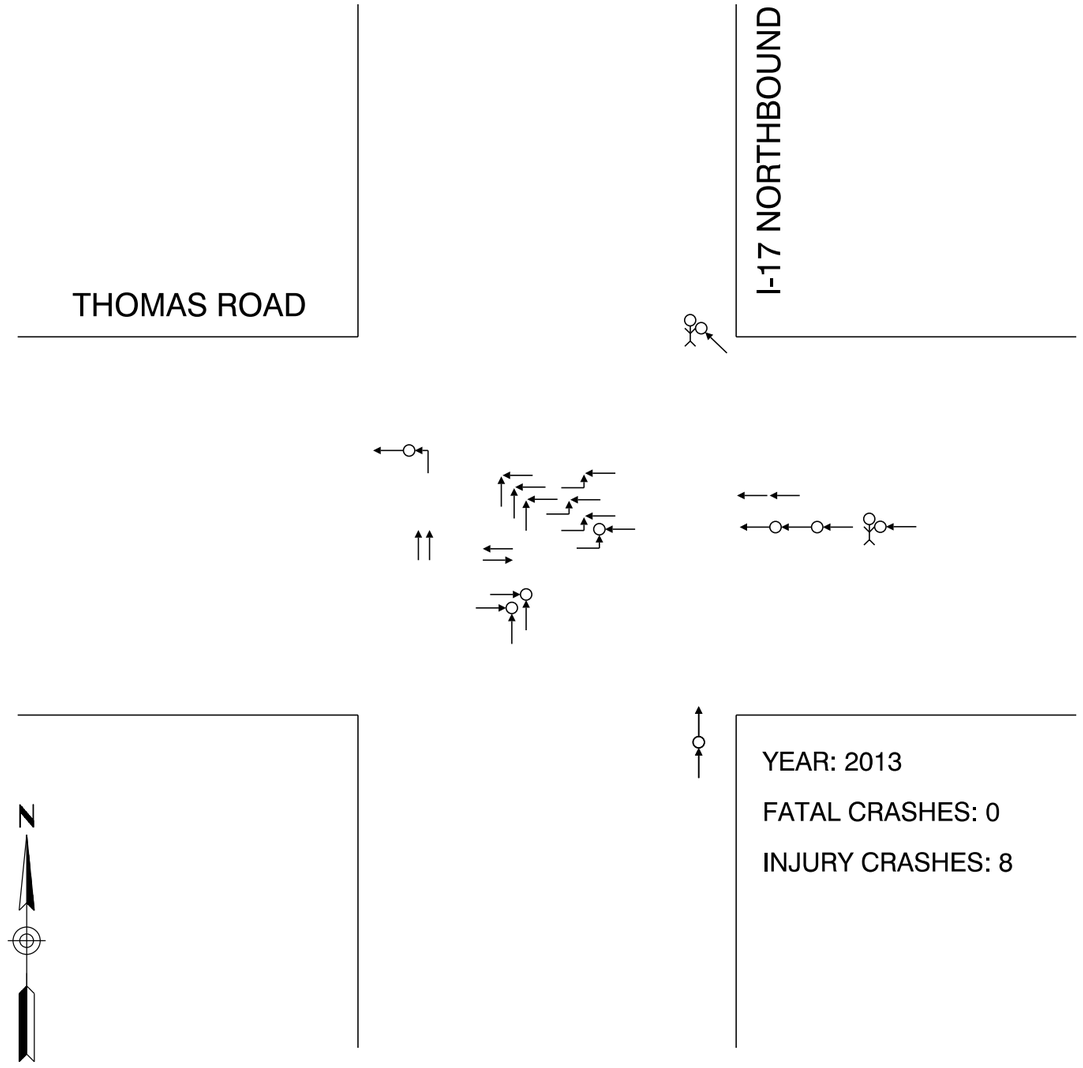
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

THOMAS ROAD / I-17





LEGEND

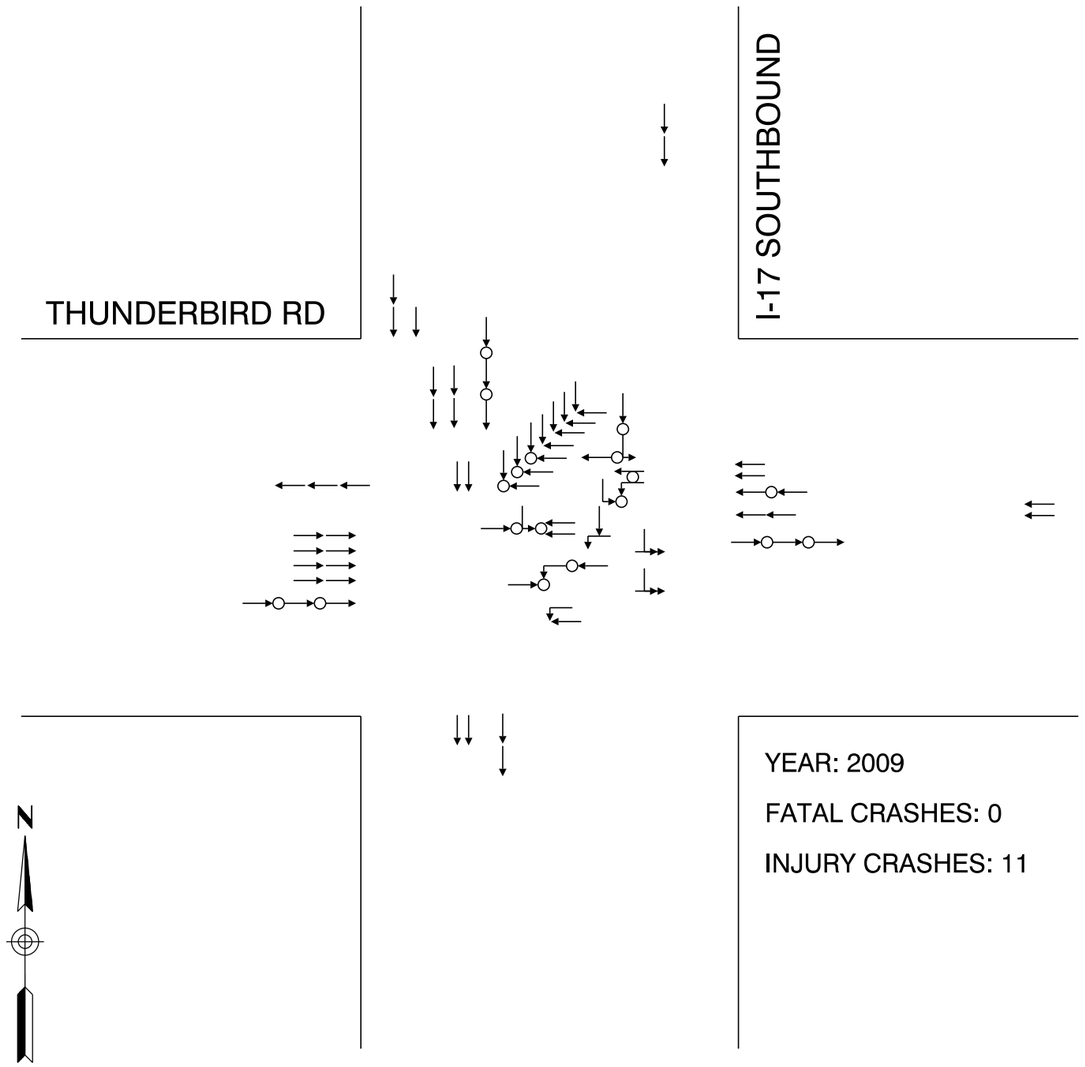
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

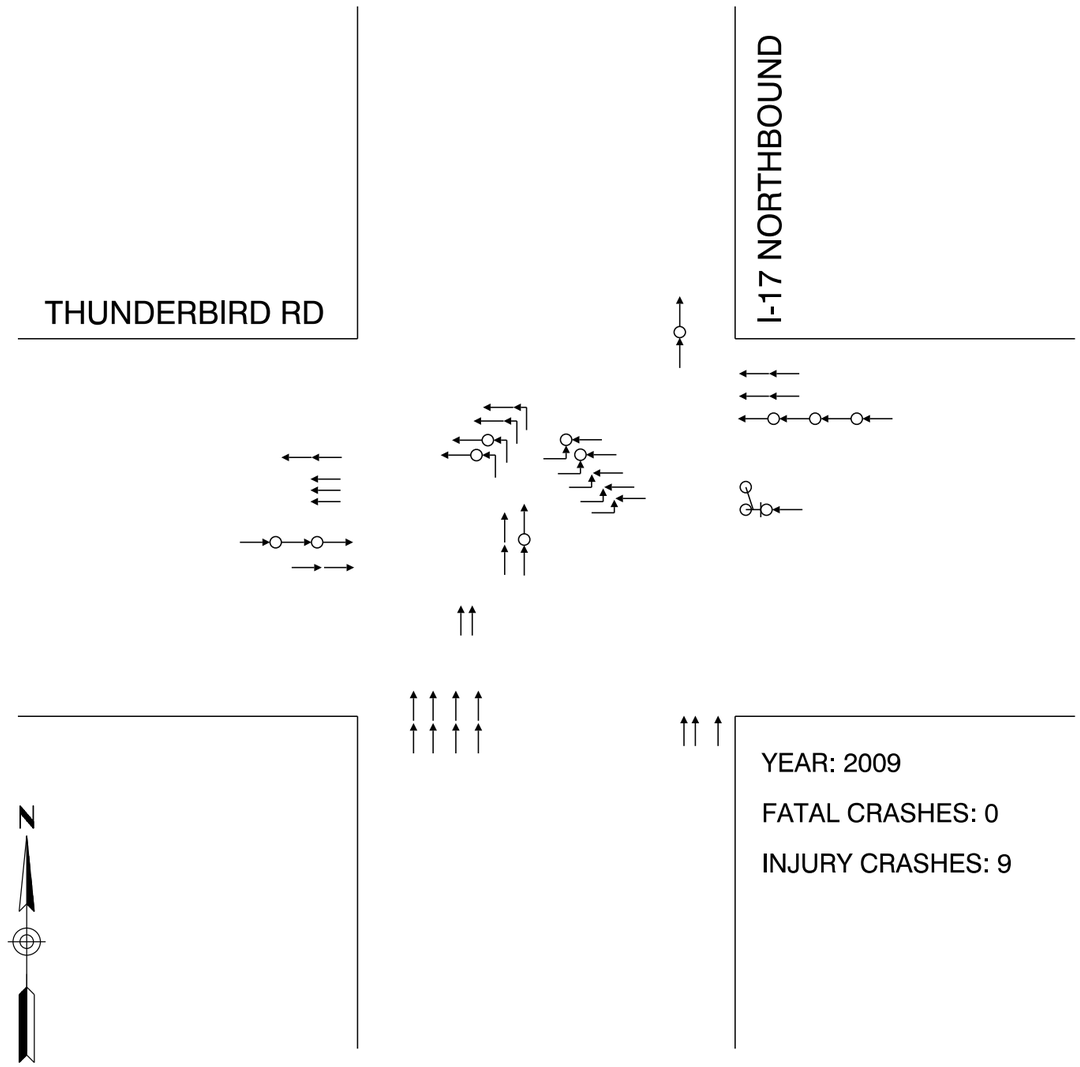
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

THOMAS ROAD / I-17

SPINE Corridor Master Plan 10 17





LEGEND

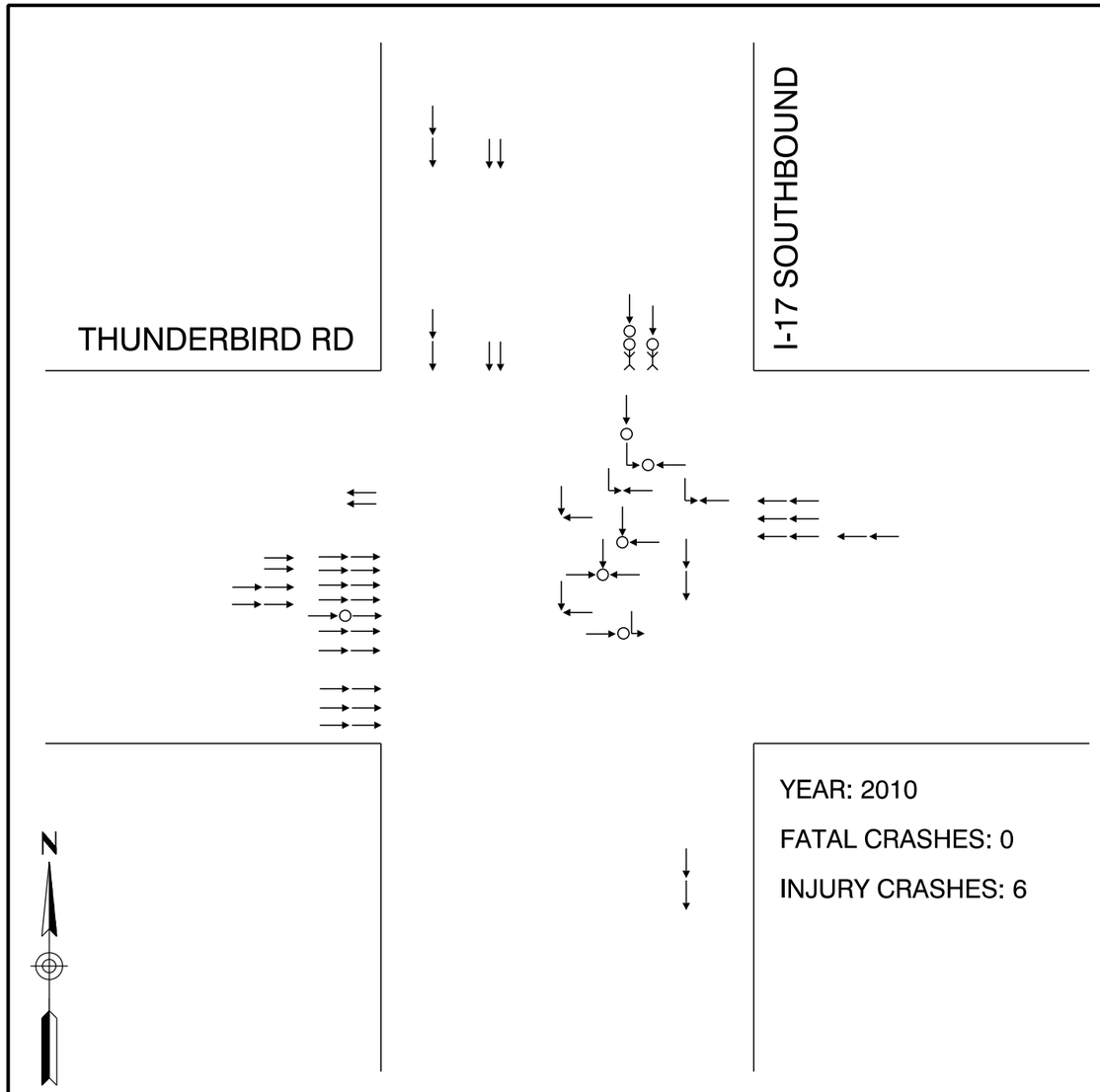
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

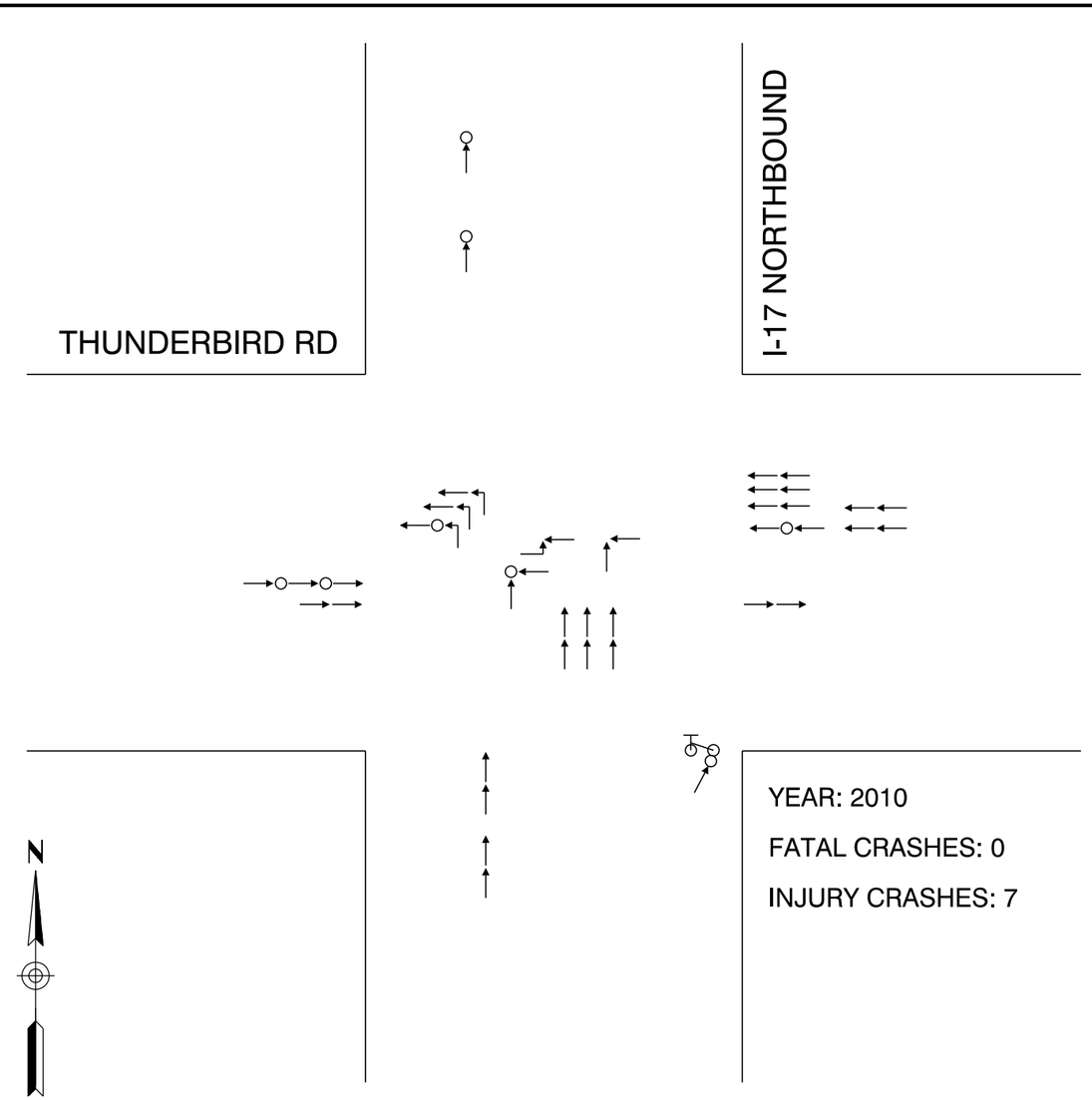
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

THUNDERBIRD ROAD / I-17

SPINE Corridor Master Plan 10 17





LEGEND

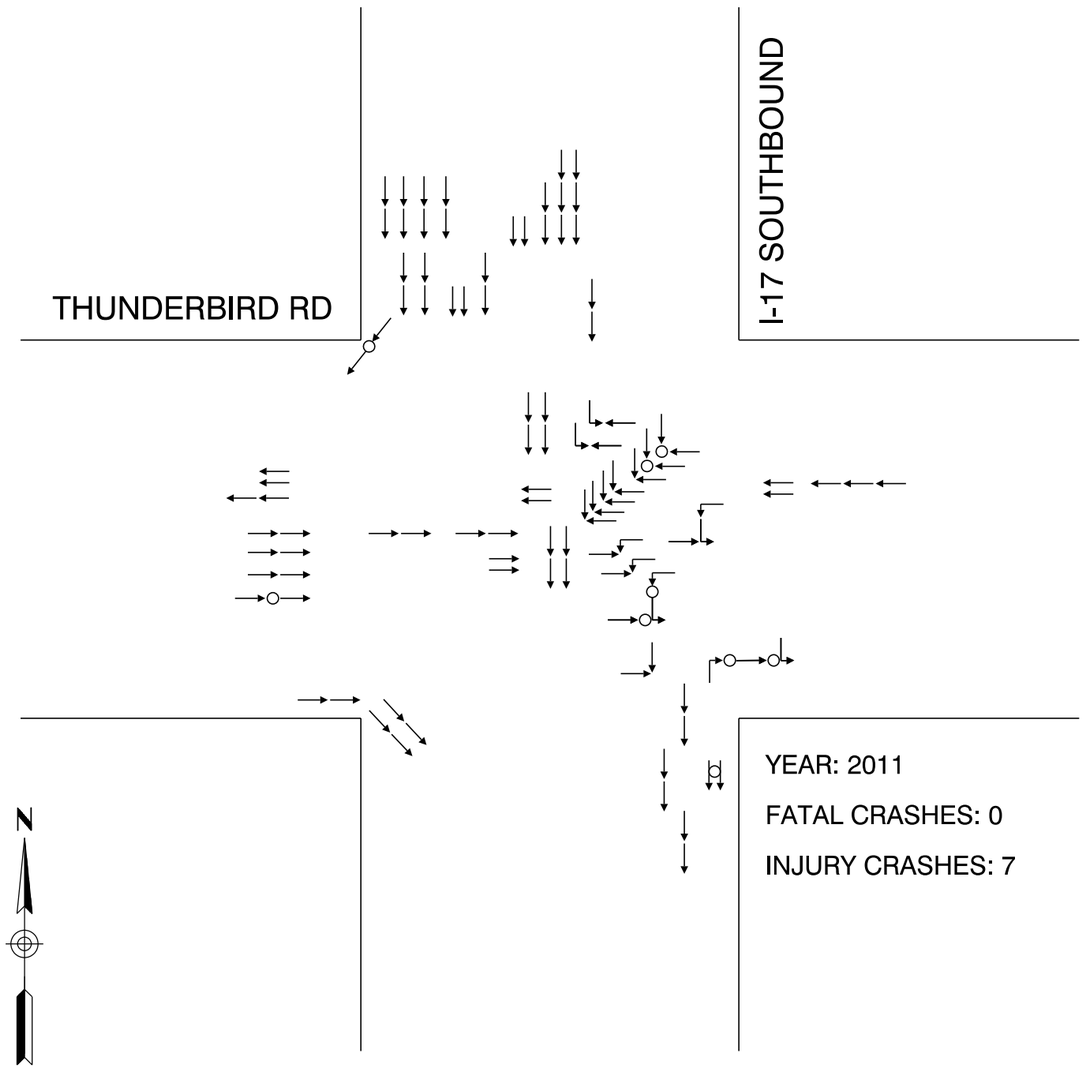
- Angle
- Backing Up
- Bicycle
- Head On
- Left Turn
- Pedestrian
- Rear End
- Right Turn
- Side Swipe
- Single Vehicle
- Fatal
- Injury

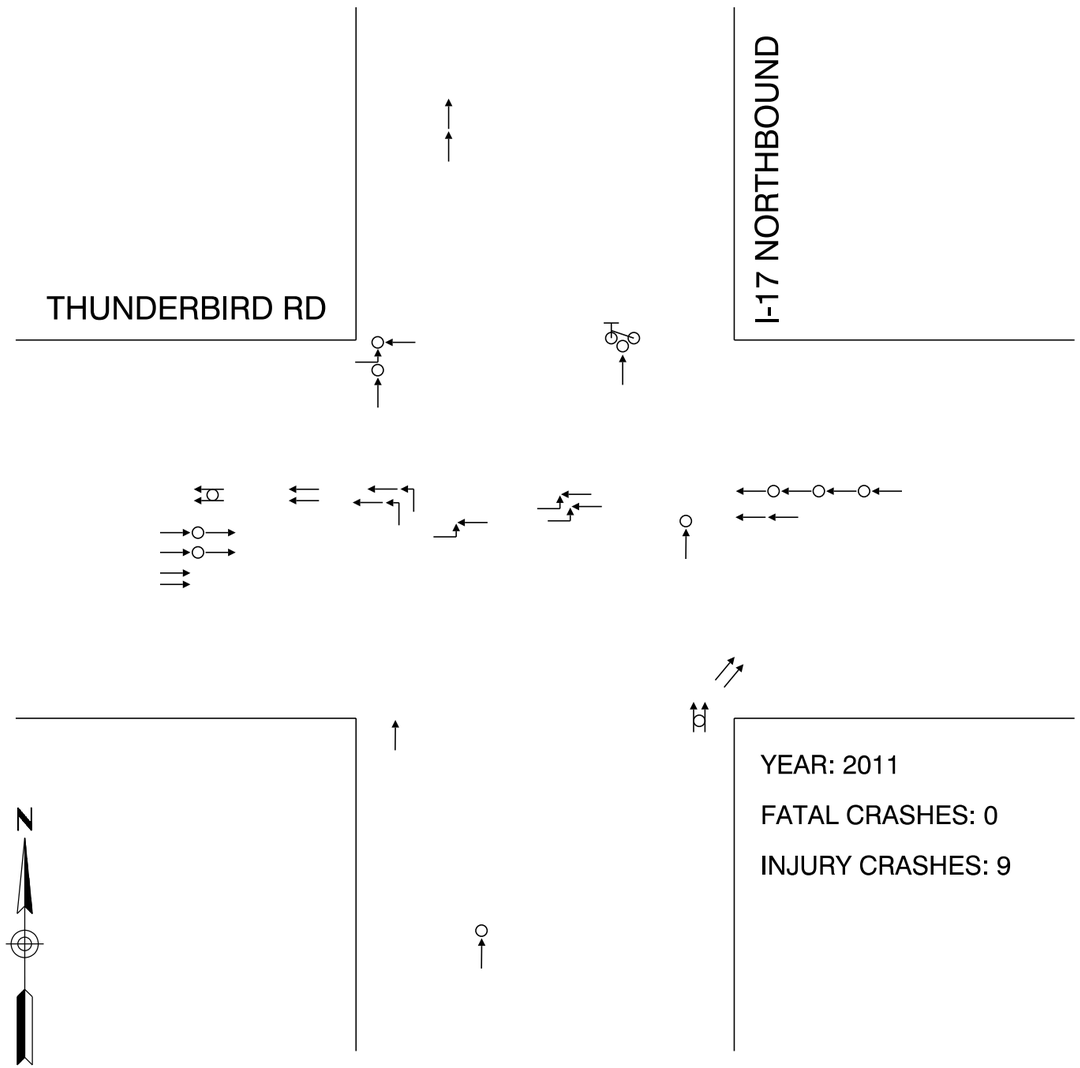
SPINE I-10/I-17 CORRIDOR MASTER PLAN

CRASH DIAGRAM

THUNDERBIRD ROAD / I-17

SPINE Corridor Master Plan 10 17





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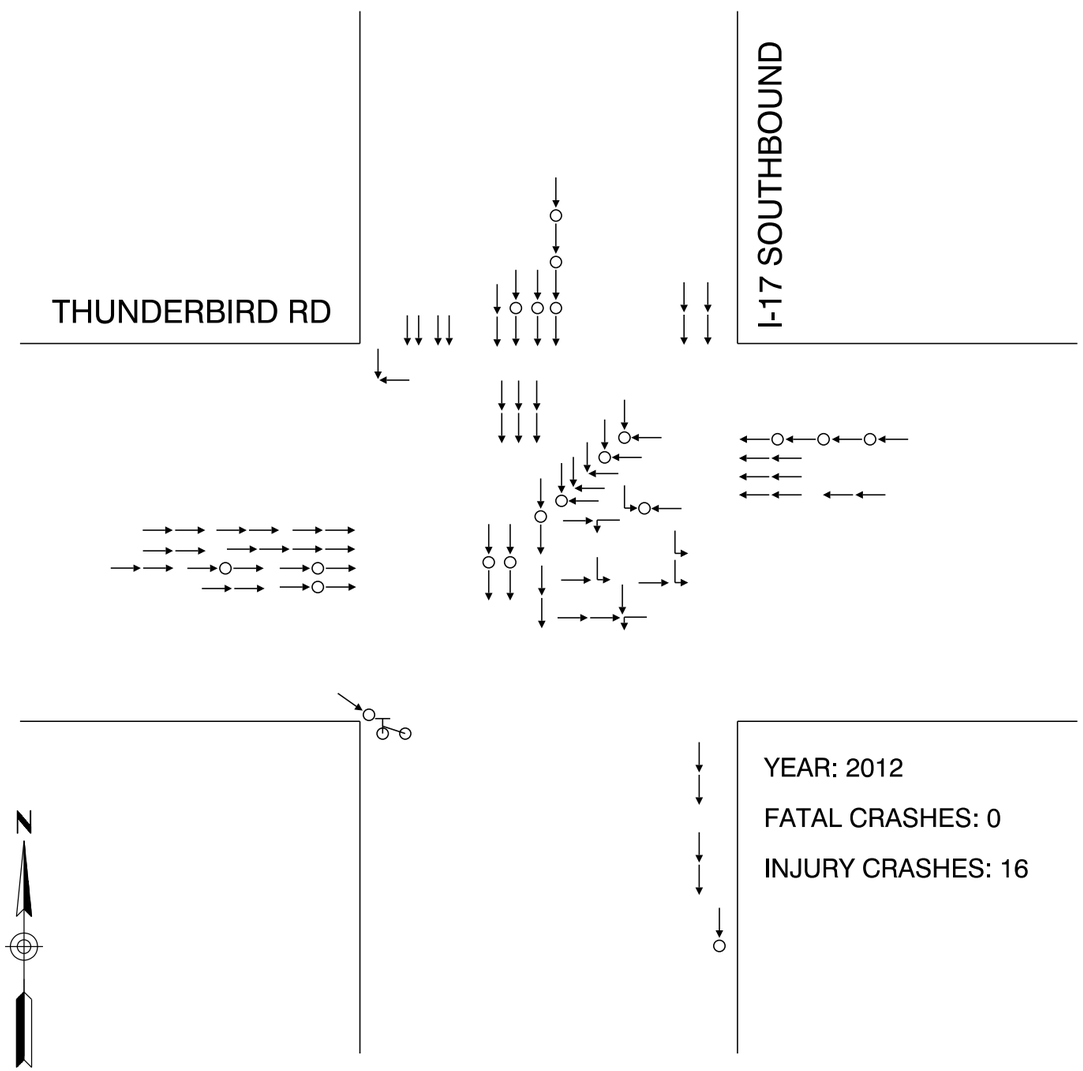

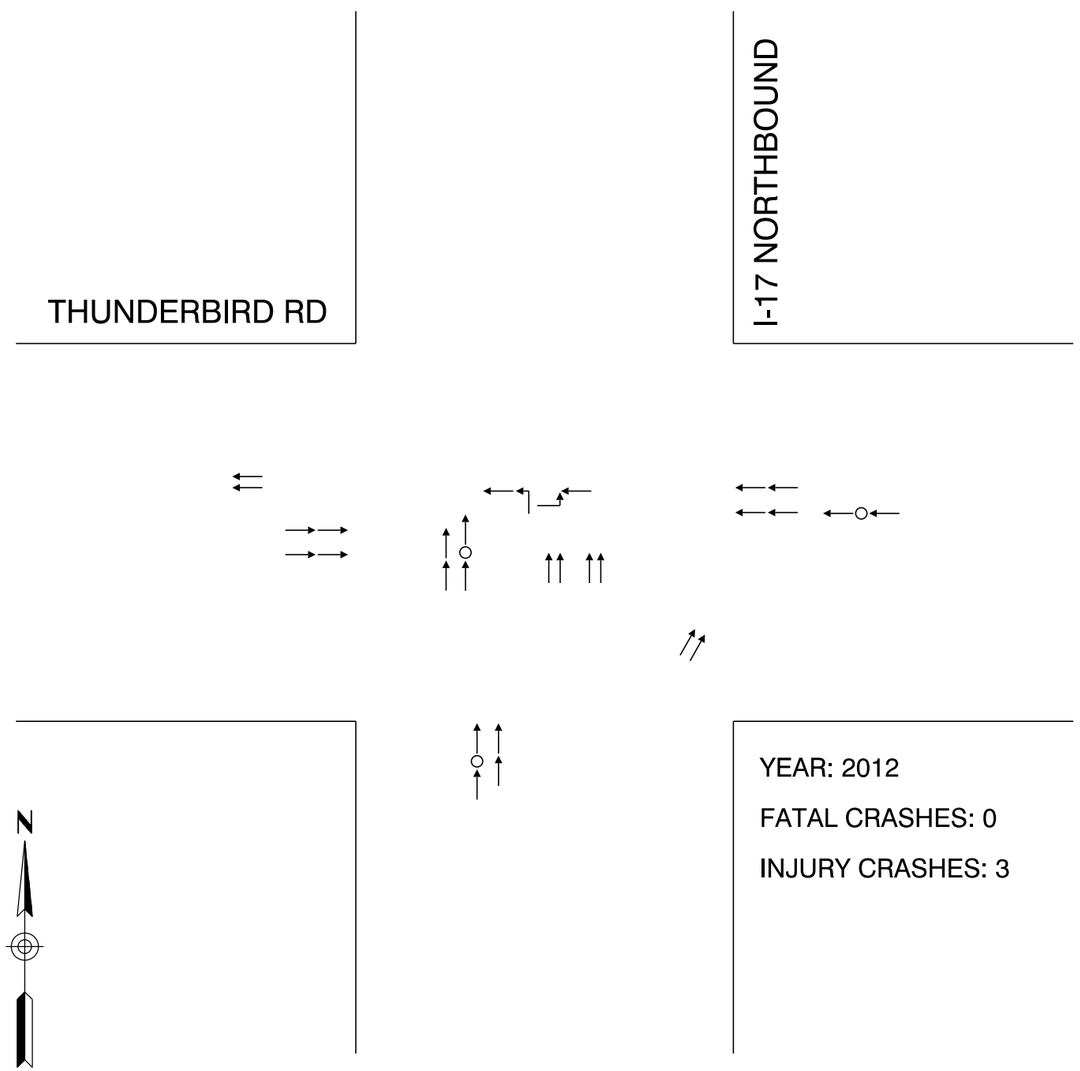

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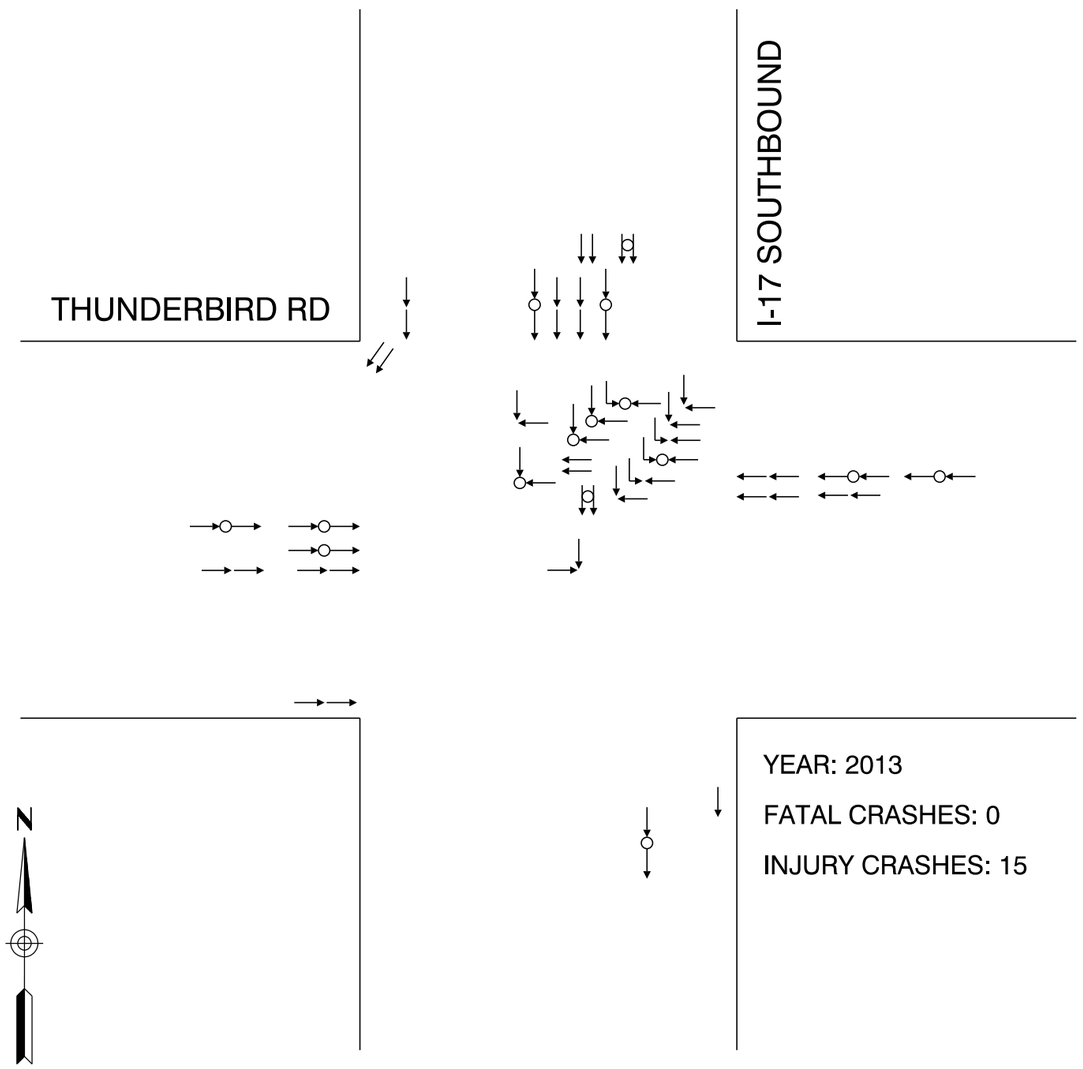

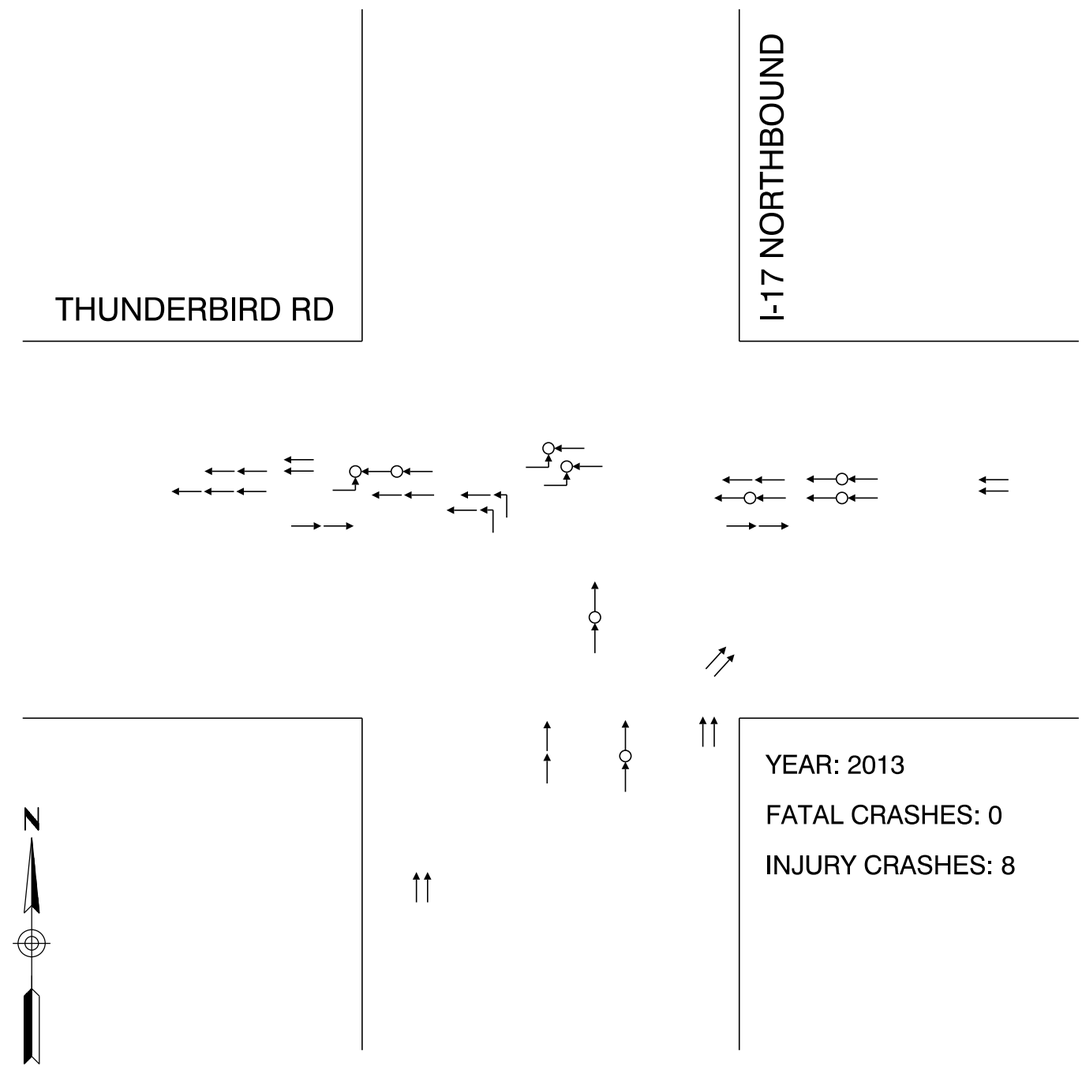

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