I-40 CORRIDOR PROFILE STUDY

I-17 TO ARIZONA/NEW MEXICO BORDER

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Draft Working Paper 4: Performance-Based Needs Assessment

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LIST OF ABBREVIATIONS

Abbreviation	Name
ADOT	Arizona Department of Transportation
ADT	Average Daily Traffic
BLM	Bureau of Land Management
CAG	Central Arizona Governments
DMS	Dynamic Message Signs
FY	Fiscal Year
F+I	Fatal and Incapacitating
HPMS	Highway Performance Monitoring System
I	Interstate
LCCA	Life Cycle Cost Analysis
LPOE	Land Port of Entry
LRTP	Long Range Transportation Plan
MP	Milepost
MPD	Multimodal Planning Division
P2P	Planning to Programming Linkages
PDI	Pavement Distress Index
PSR	Pavement Serviceability Rating
PTI	Planning Time Index
SCMPO	Sun Corridor Metropolitan Planning Organization
SENTRI	Secure Electronic Network for Travelers Rapid Inspection
SHSP	Strategic Highway Safety Plan
SOV	Single Occupancy Vehicle
SR	State Route
TAC	Technical Advisory Committee
TI	Traffic Interchange
TTI	Travel Time Index
TPTI	Truck Planning Time Index
TTTI	Truck Travel Time Index
U.S.	United States
V/C	Volume to Capacity

1. INTRODUCTION

The Arizona Department of Transportation (ADOT) is the lead agency for this corridor profile study of Interstate 40 (I-40) East between I-17 in Flagstaff and the New Mexico state line. This study will look at key performance measures relative to the I-40 corridor, and use those as a means to prioritize future improvements in areas that show critical needs. The intent of the corridor profile program, and of the Planning to Programming process, is to conduct performance-based planning to identify areas of need and make the most efficient use of available funding to provide an efficient transportation network. ADOT is conducting eleven corridor profile studies. The eleven corridors are being evaluated within three separate groupings.

The first three studies (Round 1) began in spring 2014, and encompass:

- I-17: SR 101L to I-40
- I-19: Mexico International Border to I-10
- I-40: California State Line to I-17

The second round (Round 2) of studies, initiated in spring 2015, include:

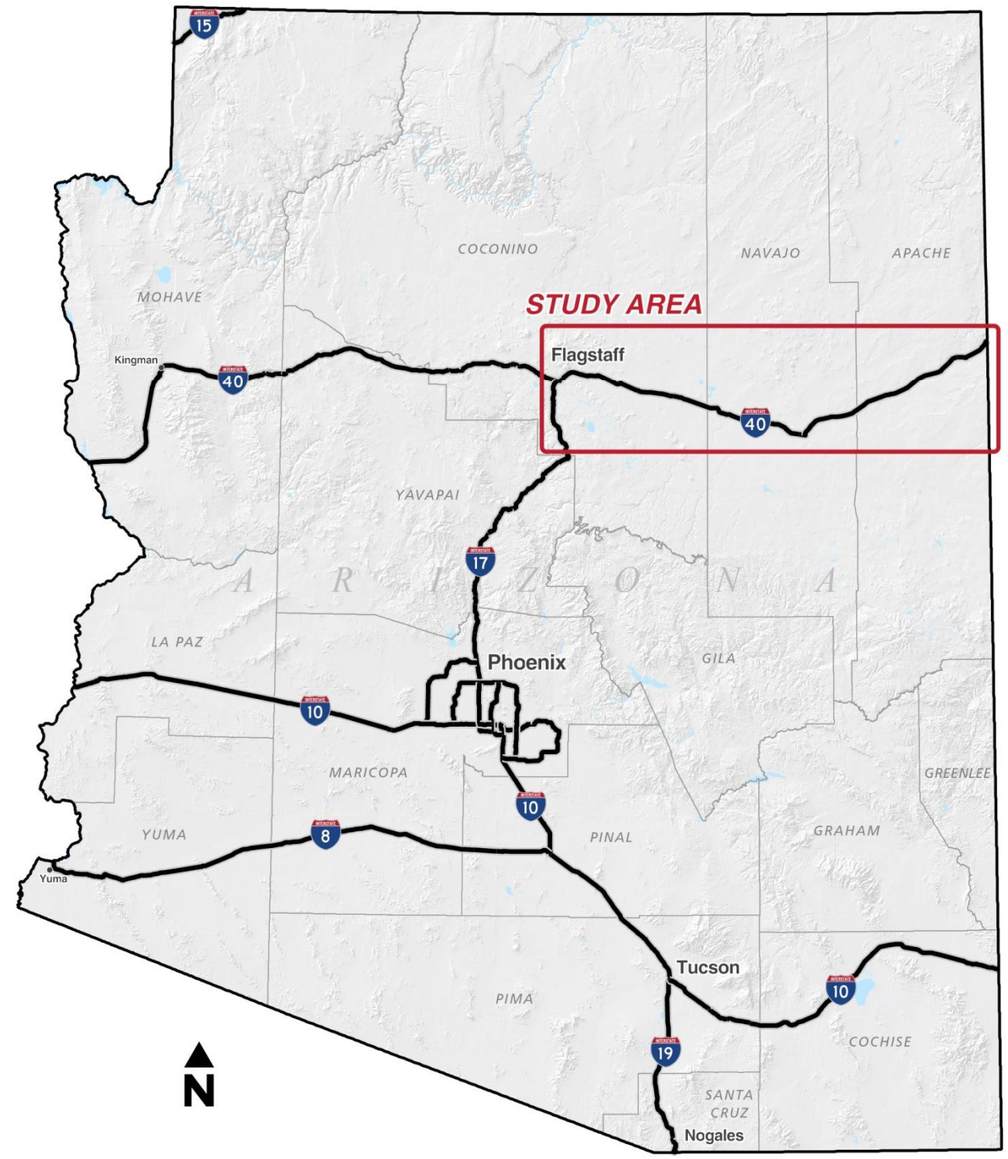
- I-8: California State Line to I-10
- I-40: I-17 to the New Mexico State Line
- SR 95: I-8 to I-40

The third round (Round 3) of studies, initiated in fall 2015, include:

- I-10: California State Line to SR 85 and SR 85: I-10 to I-8
- I-10: SR 202L to the New Mexico State Line
- SR 87/SR 260/SR 377: SR 202L to I-40
- US 60/US 70: SR 79 to US 191 and US 191: US 70 to SR 80
- US 60/US 93: Nevada State Line to SR 303L

I-40, I-17 to New Mexico State Line, depicted in **Figure 1**, is one of the strategic statewide corridors and the subject of this Corridor Profile Study (**Round 2**).

Figure 1: Corridor Study Area



1.1 Corridor Study Purpose

ADOT has instituted a new corridor planning approach to develop strategies and tools that incorporate life-cycle cost analysis and risk assessment to measure system performance. This Corridor Profile Study will follow the new process established by previous corridor profile studies for I-17, I-19 and I-40, to:

- Inventory past improvement recommendations.
- Assess the existing performance based on quantifiable performance measures.
- Propose various solutions to improve corridor performance.
- Identify specific projects that can provide quantifiable benefits in relation to the performance measures.

1.2 Corridor Study Goals and Objectives

The objective of this study is to identify a recommended set of potential strategic projects for consideration in future construction programs, derived from a transparent, defensible, logical, and replicable process. The I-40 Corridor Profile Study will define solutions and improvements for I-40 that can be evaluated and ranked to determine which investments offer the greatest benefit to the corridor in terms of enhancing performance.

The following goals have been identified as the outcome of this study:

- Link project decision-making and investments on key corridors to strategic goals
- Match solutions with deficiencies in measured performance
- Prioritize improvements that cost-effectively preserve, modernize, and expand transportation infrastructure

1.3 Working Paper 4 Overview

Working Paper 4 focuses on the performance-based needs identified for the I-40 corridor. Corridor Needs are defined as the gap between the baseline system performance (Task 2) and the performance objectives from Task 3. This multi-step process is based on the Performance System and will be supplemented by additional data required to more specifically identify needs at the corridor and segment level. The result of this analysis will define actionable performance needs that can be addressed through strategic investments.

1.4 Corridor Overview

The I-40 corridor is a major east-west transcontinental interstate highway that connects the east coast (North Carolina) to the west coast (California). I-40 is a major transportation artery route for freight as well as passenger vehicular traffic, connecting major metropolitan cities in the south-western United States. I-40 is also the primary transportation route connecting the Phoenix metropolitan area to central and north-eastern parts of the country. I-40, together with I-17, plays a key role in the transportation infrastructure of northern Arizona, contributing to its economic success.

I-40 provides the most direct and fastest link between Flagstaff (and Grand Canyon National Park), central and north-eastern United States to the east, and major Californian Cities to the west (Figure 1). I-40 provides a principal road link for freight traffic from the ports in California. This study builds on earlier planning efforts in developing and applying a performance-based process for prioritizing improvements to meet present and future needs in the corridor.

1.5 Study Location and Corridor Segments

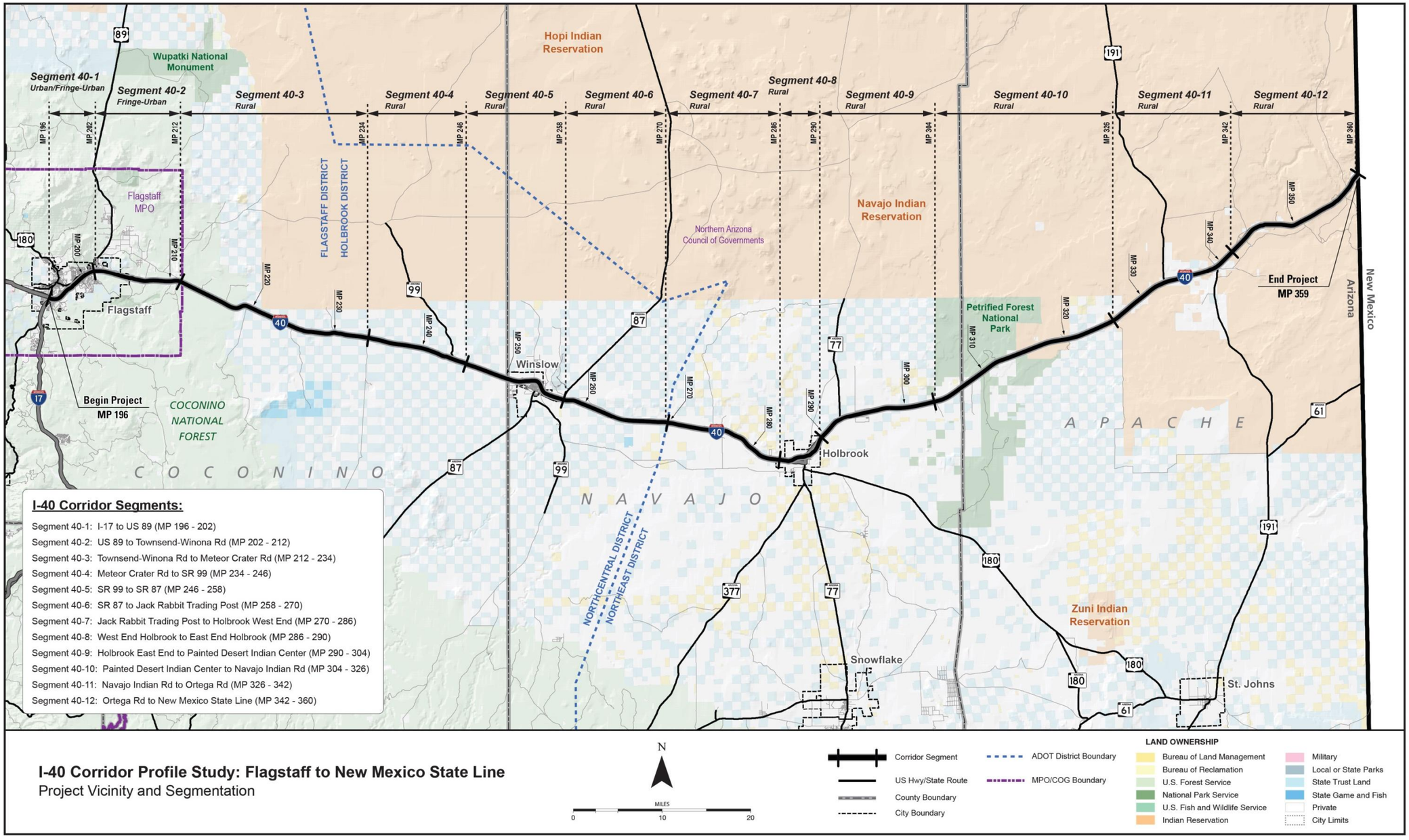
The I-40 corridor is being studied in two separate Corridor Profile Studies. One study extends from California to I-17 and this study extends from I-17 to New Mexico. For the purposes of this Corridor Profile Study, the portion from I-17 to New Mexico will be referred to as I-40 East.

The I-40 East corridor is 164 miles long, from I-17 (MP 196.0) to Arizona/New Mexico State Line (MP 359.0). The corridor has been divided into 12 distinct segments based on regionally significant intersecting routes, changes in topography, or natural or man-made landmarks along the corridor. The shortest segment is four miles long and the longest, a little over twenty-two miles. Corridor Segments have been described in **Table 1** below, and shown on a map in **Figure 2.**

Table 1: Corridor Segments and Descriptions

Corridor Segments							
Seg #	Begin/End Description	Begin MP	End MP	Length	Thru Lanes	AADT	Description
40-1	I-17 to US 89	196	202	6	4	37,684	This segment is generally urban/fringe-urban in nature, includes three interchanges, and is within the urbanized limits of the Flagstaff Metropolitan Area in Coconino County.
40-2	US 89 to Townsend-Winona Road	202	212	10	4	19,257	This segment is urban-fringe in nature, includes three interchanges, and is within Coconino County.
40-3	Townsend-Winona Road to Meteor Crater Road	212	234	22	4	15,468	This segment is generally rural in nature, includes four interchanges, and is within Coconino County.
40-4	Meteor Crater Road to SR 99	234	246	12	4	15,067	This segment is rural in nature, includes two interchanges, and within Coconino County.
40-5	SR 99 to SR 87	246	258	12	4	15,422	This segment is rural in nature, includes four interchanges, and spans Coconino and Navajo Counties. This segment passes through Winslow.
40-6	SR 87 to Jack Rabbit Trading Post	258	270	12	4	14,604	This segment is rural in nature, includes two interchanges, and is located within Navajo County.
40-7	Jack Rabbit Trading Post to Holbrook West End	270	286	16	4	14,916	This segment is rural in nature, includes four interchanges, and is located within Navajo County.
40-8	Holbrook West End to Holbrook East End	286	290	4	4	14,124	This segment is rural in nature, includes three interchanges, and is located within Navajo County. This segment passes through Holbrook.
40-9	Holbrook East End to Painted Desert Indian Center	290	304	14	4	16,674	This segment is rural in nature, includes four interchanges, and is located within Navajo County.
40-10	Painted Desert Indian Center to Navajo Indian Road	304	326	22	4	15,519	This segment is rural in nature, includes three interchanges, and spans Navajo and Apache Counties.
40-11	Navajo Indian Road to Ortega Road	326	342	16	4	14,719	This segment is rural in nature, includes three interchanges, and is located within Apache County.
40-12	Ortega Road to New Mexico State Line	342	359	18	4	15,580	This segment is rural in nature, includes seven interchanges, and is located within Apache County.

Figure 2: Study Area/Segmentation Map



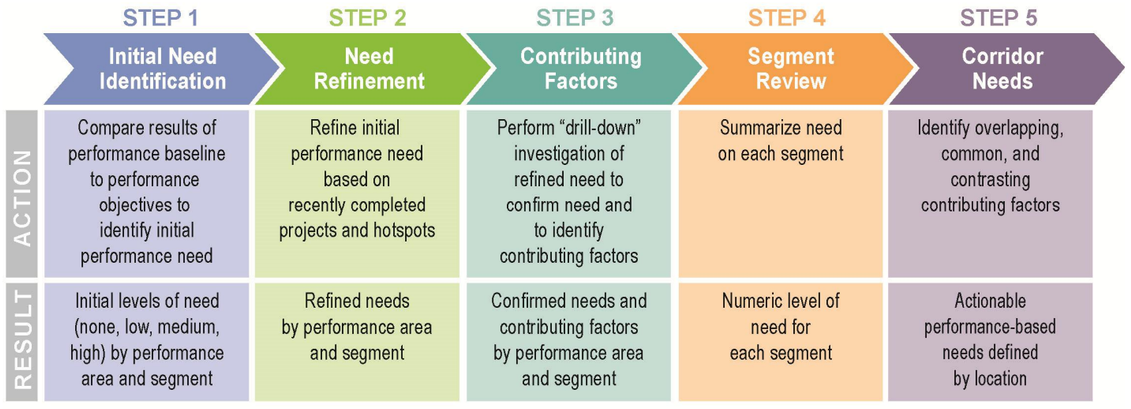
2.0 NEEDS ASSESSMENT PROCESS

The performance-based needs assessment will determine the difference in baseline performance (Working Paper #2) and the performance objectives (Working Paper #3) for each of the five performance areas used to characterize the health of the corridor: pavement, bridge, mobility, safety, and freight. The following guiding principles were used to develop the process.

- Corridor needs are defined as deficiencies in performance.
- The needs assessment process should be systematic, progressive, and repeatable.
- The process should consider all primary and secondary performance measures developed in Task 2 of the study.
- The process could develop multiple need levels including programmatic needs for the entire length of the corridor, performance area-specific needs, segment-specific needs, and location-specific needs.
- The process should be automated but also include engineering judgment.
- The process should produce actionable needs that can be addressed through strategic investments in corridor preservation, modernization, and expansion.

The performance-based needs assessment process is illustrated in **Figure 3** and described in the following sections of the working paper.

Figure 3: Needs Assessment Process



2.1 Step 1: Initial Need Identification

The first step in the needs assessment process links baseline (existing) corridor performance documented in Draft Working Paper 2 with performance objectives documented in Draft Working Paper 3. In this step, the baseline corridor performance is compared to the performance objectives to provide a starting point for the identification of performance-based needs. This mathematical comparison results in an initial need rating of None, Low, Medium, or High for each primary and secondary performance measure. An illustrative example of this process is shown in **Figure 4.**

Figure 4: Initial Need Ratings in Relation to Baseline Performance

Performance Thresholds	Performance Level	Initial Level of Need	Description
3.75	Good	None	All levels of Good and top 1/3 of Fair (>3.57)
	Good		
	Good		
	Fair		
	Fair	Low	Middle 1/3 of Fair (3.38-3.57)
3.20	Fair	Medium	Lower 1/3 of Fair and top 1/3 of Poor (3.02-3.38)
	Poor		
	Poor	High	Lower 2/3 of Poor (<3.02)
	Poor		

Initial levels of need for each primary and secondary performance measure are combined to produce a weighted initial need rating for each segment. Values of 0, 1, 2, and 3 are assigned to the initial need levels of None, Low, Medium, and High, respectively. A weight of 1.0 is applied to the Performance Index need and equal weights of 0.20 are applied to each need for each secondary performance measure. For directional secondary performance measures, each direction of travel receives a weight of 0.10. The secondary performance measure needs are added to the need from the Primary Index to create a cumulative measure of need. The resulting weighted initial level of need is assigned a level of None, Low, Medium, or High. With this approach, the resulting segment level of need will always be equal to or higher than the Primary Index need.

2.2 Step 2: Need Refinement

In Step 2, the initial level of need for each segment is refined using the following information and engineering judgment.

- If an initial need was not identified, the existence of hot spots in the segment could be a justification for increasing the initial level of need from None to Low.
- Recently completed projects or projects under construction may be justification for lowering or eliminating a need.
- Programmed projects should not be used to lower the initial need since the project may not be implemented as planned. In addition, further investigations may suggest that changes in the scope of a programmed project may be warranted.

The resulting final need (an increase or decrease from initial need) will be carried forward for further evaluation in Step 3.

2.3 Step 3: Contributing Factors

In Step 3, a more detailed review of the condition and performance data available from ADOT was conducted to confirm the final Needs and identify contributing factors to the need. Typically, the same databases that were used to develop the baseline performance served as the principle sources for the more detailed analysis. However, other supplemental databases were also useful sources of information. The databases used for diagnostic analysis are listed below.

Pavement Performance Area

- Pavement Rating Database

Bridge Performance Area

- Bridge Information and Storage System

Mobility Performance Area

- Highway Performance Monitoring System (HPMS) Database
- AZ Travel Demand Model (AZTDM)
- HERE Database
- Highway Conditions Reporting System (HCRS) Database

Safety Performance Area

- Crash Database

Freight Performance Area

- HERE Database
- HCRS Database

In addition, other sources were considered to help identify the contributing factors such as:

- Maintenance history, the level of past investments, or trends in historical data were used to help provide context for pavement and bridge history.
- Field observations from ADOT district personnel could be used to provide additional information regarding a need that has been identified.
- Previous studies could be used to provide additional information regarding a need that has been identified.

Step 3 resulted in the identification of performance-based Needs and contributing factors by segment (and milepost locations, if appropriate) that can be addressed through investments in preservation, modernization, and expansion projects to improve corridor performance.

2.4 Step 4: Segment Review

In this step, the Needs from Step 3 will be quantified for each segment to numerically estimate the level of need for each segment. Values of 0, 1, 2, and 3 are assigned to the final need levels (from Step 3) of None, Low, Medium, and High, respectively. A weight factor is applied to the performance areas that were identified as Emphasis Areas for each corridor in Draft Working Paper 3 and a weighted average need is calculated for each segment. The resulting need value can be used to compare across corridors and to determine the location of the highest Needs on a given corridor.

2.5 Step 5: Corridor Needs

In this step, the Needs and contributing factors for each performance area are reviewed on a segment-by-segment basis to identify actionable Needs and to facilitate the formation of solution sets that address multiple performance areas and contributing factors. The intent of this process is to identify overlapping, common, and contrasting Needs to help develop strategic solutions. This step will result in the identification of corridor Needs by specific location.

3.0 PAVEMENT PERFORMANCE AREA NEEDS

The following sections describe Steps 1 through 3 of the Needs Assessment process for the I-40 East corridor for the Pavement Performance Area. The methodology for performing Steps 1 through 3 is provided in the Appendix.

3.1 Step 1: Initial Pavement Needs

Step 1 uses the Pavement Index and two secondary performance measures (Directional PSR and Percent Pavement Failure) that were documented in Working Paper #2 to establish the baseline performance data. The baseline performance data and performance objectives (Working Paper #3) for the I-40 East corridor were used to determine the Initial Needs as described in Section 2.1. The pavement condition data used to calculate baseline performance was provided by ADOT for the timeframe from 2014 to 2015. The results of Step 1 are shown in **Table 2.** The I-40 East initial pavement needs indicate that there is a low need in Segment 2, based primarily on a percentage of pavement failure on the segment.

3.2 Step 2: Refined Pavement Needs

The Initial Needs for the I-40 East corridor were refined as described in Section 2.2. The locations of pavement failure hot spots and recent projects that would supersede the condition data were used to refine the Needs. A summary of this process is shown in **Table 3**.

Pavement Hot Spots

The locations of pavement failure (hot spots) are listed in Table 3. If an Initial Need was not identified in Step 1, the existence of hot spots would be justification for increasing the Need from None to Low in Step 2.

Previous Projects

Previous projects which would supersede the pavement conditions data are listed in Table 3. In Step 2, this information was used to lower or eliminate Needs on segments where recent paving projects have been completed.

Table 3 also includes information on pavement-related programmed projects. While programmed projects did not influence the level of Need, they were documented for future reference during the development of solutions to address identified Needs. Programmed projects were identified using the 2016-2020 Five-Year Transportation Facilities Construction Program.

There were two previous pavement preservation projects that were implemented along I-40 subsequent to the pavement condition data provided by ADOT. However, one of the improvement locations did not coincide with any calculated need locations. There are three segments that increased to a Low need due to presence of hot spots. There were three programed projects along the corridor identified for pavement preservation.

Table 2: Pavement Initial Needs (Step 1)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Facility Type	Pavement Index			Directional PSR					% Pavement Failure			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score		Performance Objective	Level of Need		Performance Score	Performance Objective	Level of Need	
							EB	WB		EB	WB				
40-1	6	196-202	Interstate	4.17	Fair or Better	None	3.90	4.01	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-2	10	202-212	Interstate	3.83	Fair or Better	None	3.47	3.85	Fair or Better	Low	None	25.00%	Fair or Better	High	Low
40-3	22	212-234	Interstate	4.22	Fair or Better	None	4.12	4.04	Fair or Better	None	None	5.00%	Fair or Better	None	None
40-4	12	234-246	Interstate	4.40	Fair or Better	None	4.20	4.30	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-5	12	246-258	Interstate	4.05	Fair or Better	None	3.90	3.93	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-6	12	258-270	Interstate	4.10	Fair or Better	None	3.92	4.00	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-7	16	270-286	Interstate	3.96	Fair or Better	None	3.89	3.86	Fair or Better	None	None	3.00%	Fair or Better	None	None
40-8	4	286-290	Interstate	4.41	Fair or Better	None	4.13	4.20	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-9	14	290-304	Interstate	4.16	Fair or Better	None	3.99	4.04	Fair or Better	None	None	4.00%	Fair or Better	None	None
40-10	22	304-326	Interstate	4.41	Fair or Better	None	4.18	4.31	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-11	16	326-342	Interstate	4.31	Fair or Better	None	4.23	4.18	Fair or Better	None	None	0.00%	Fair or Better	None	None
40-12	17.63	342-359.63	Interstate	4.08	Fair or Better	None	4.08	4.21	Fair or Better	None	None	6.00%	Fair or Better	None	None
Emphasis Area?	Yes	Weighted Average		4.18	Good	None									

Table 3: Refined Pavement Needs (Step 2)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Need	Need Adjustments		Final Need	Comments (may include programmed projects or issues from previous reports)
				Hot Spots	Previous Projects (which supersede condition data)		
40-1	6	196-202	None	-	None	None	No need identified. full pavement replacement MP 196 to 202 recommended (DCR)
40-2	10	202-212	Low	EB MP 203-204 and MP 209-212; WB MP 211-212	None	Low	Maintain Low but had one recent project (which superseded conditions data) at two of the three hotspot locations.
40-3	22	212-234	None	WB MP 212-213 and MP 214-215	None	None	No need identified; Due to recent project (which superseded conditions data) at both hotspot locations.
40-4	12	234-246	None	-	None	None	No need identified.
40-5	12	246-258	None	-	Repaving done in 2015 EB/WB at MP 250.24 - 268.	None	No need identified.
40-6	12	258-270	None	-	Repaving done in 2015 EB/WB at MP 250.24 - 268.	None	No need identified; Project is programed in FY 2020 EB/WB MP 268-278
40-7	16	270-286	None	WB MP 274-275	None	Low	Presence of hotspot elevated need from None to Low; Project is programed in FY 2020 (FY 19 in Tentative Program) MP 268-278
40-8	4	286-290	None	-	None	None	No need identified.
40-9	14	290-304	None	EB MP 302-303	None	Low	Presence of hotspot elevated need from None to Low; Project is programed in FY 2016 MP 297-303
40-10	22	304-326	None	-	None	None	No need identified.
40-11	16	326-342	None	-	None	None	No need identified.
40-12	17.63	342-359.63	None	EB MP 354-356	None	Low	Presence of hotspot elevated need from None to Low; Project is programed in FY 2016 MP 354-360

3.3 Step 3: Pavement Contributing Factors

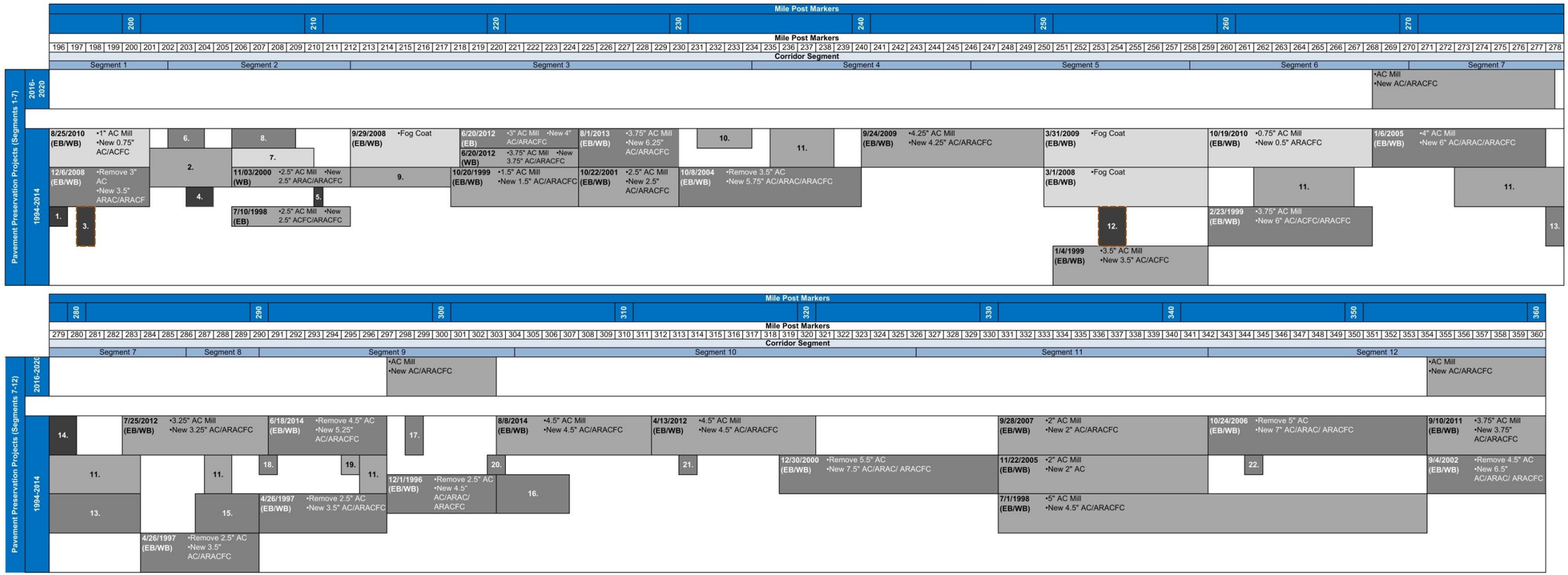
The Final Needs for the I-40 East corridor were further investigated as described in Section 2.3. ADOT provided pavement rehabilitation project data for the last 20 years which was used to estimate the level of historical investment in each segment and is summarized in **Figure 5**. In addition, PeCOS data was collected for each segment to estimate the level of pavement maintenance activity. If the PeCOS data showed a high level of maintenance investment, the overall historical investment was elevated by one (from “Medium” to “High”, for example). Additional information regarding the determination of the level of historical investment is contained in the Appendix.

For the Pavement Performance Area, no additional data is readily available so the contributing factors simply identify the specific locations of Needs, the level of historical investment, and any additional supporting information available from the ADOT Districts. A summary of this process is shown in **Table 4**.

Table 4: Pavement Contributing Factors (Step 3)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Final Need	Historical Investment	Contributing Factors and Comments
40-1	6	196-202	None	High	Northcentral District reported issue with pavement in both the westbound and eastbound directions of this segment.
40-2	10	202-212	Low	High	Failure hotspots on EB MP 203-204
40-3	22	212-234	None	Medium	
40-4	12	234-246	None	Low	
40-5	12	246-258	None	High	
40-6	12	258-270	None	High	
40-7	16	270-286	Low	High	Failure hotspots on WB MP 274-275; Project is programed in FY 2020 (FY 19 in Tentative Program) MP 268-278; should mitigate issues but may need to look at LCCA with high investment
40-8	4	286-290	None	High	
40-9	14	290-304	Low	High	Failure hotspots on EB MP 302-303; Project is programed in FY 2016 MP 297-303; should mitigate issues but may need to look at LCCA with high investment
40-10	22	304-326	None	Low	
40-11	16	326-342	None	High	
40-12	17.63	342-359.63	Low	High	Failure hotspots on EB MP 354-356; Project is programed in FY 2016 MP 354-360; should mitigate issues but may need to look at LCCA with high investment

Figure 5: Pavement History



Pavement Treatment Reference Numbers

1. **7/8/2003 (WB):** New 18" AB, New 10" AC/ARACFC
2. **6/19/2006 (EB/WB):** 3" AC Mill, New 3" ARAC/ARACFC
3. **7/10/2006 (EB/WB):** New 8" AB, New 14" PCCP
4. **6/29/1994 (EB):** New 5.5" AC/ARACFC
5. **7/10/1998 (WB):** New 7" AB, New 10.5" AC/ARACFC
6. **6/27/2003 (EB):** 2" AC Mill, New 2.5" AC/ARACFC
7. **6/22/2010 (EB):** 0.5" AC Mill, New 0.5" ACFC
8. **6/22/2010 (WB):** 0.25" AC Mill, New 2" AB, New 7.5" AC/ACFC
9. **9/5/1998 (EB)**: Remove 5.5" AC, New 5.5" AC/ARAC/ARACFC
10. **7/28/2010 (WB)**: 2.5" AC Mill, New 2.5" AC/ACFC, Fog Coat
11. **7/28/2010 (EB/WB):** 2.5" AC Mill, New 2.5" AC/ACFC, Fog Coat *(Note: Spot Improvement Job, Table Shows Representative Combined Segment Project Lengths at Midpoint of Total Segment Project Improvement Areas)*
12. **8/31/2007 (EB/WB)**: New 4" AB, New 14" PCCP, New 0.5" ARACFC
13. **9/29/2000 (EB/WB)**: 4" AC Mill, New 5" AC/ARAC/ARACFC
14. **9/12/2001 (EB/WB)**: New 13" AC/ARAC/ARACFC
15. **7/26/2002 (EB/WB):** 4" AC Mill, New 4.5" AC/ARACFC
16. **1/26/1998 (EB/WB)**: 3" AC Mill, New 5.5" AC/ARAC/ARACFC
17. **12/3/2007 (EB/WB)**: 1" AC Mill, New 3.25" AC/ARACFC
18. **12/3/2007 (WB)**: 0.5" AC Mill, New 3.5" AC/ARACFC
19. **12/3/2007 (WB)**: 2.5" AC Mill, New 2.5" AC/ACFC
20. **12/3/2007 (EB)**: 1.5" AC Mill, New 3" AC/ACFC
21. **12/3/2007 (EB)**: 1.5" AC Mill, New 3" AC/ACFC
22. **11/20/2000 (WB)**: 1.5" AC Mill, New 1.75" AC/ACFC, Fog Coat

Legend

- New Paving or Reconstruction
- Mill and Overlay (Adding Structural Thickness)
- Mill and Replace (No Change Structural Thickness)
- Fog Coat or Thin Overlay Treatments
- PCCP Pavement Border
- AC Pavement Border

4.0 BRIDGE PERFORMANCE AREA NEEDS

The following sections describe Steps 1 through 3 of the Needs Assessment process for the I-40 East corridor for the Bridge Performance Area. The methodology for performing Steps 1 through 3 is provided in the Appendix.

4.1 Step 1: Initial Bridge Needs

Step 1 uses the Bridge Index and three secondary performance measures (Bridge Rating, Bridge Sufficiency, and Percent Functionally Obsolete Bridges) that were documented in Working Paper #2 to establish the baseline performance data. The baseline performance data and performance objectives (Working Paper #3) for the I-40 East corridor were used to determine the Needs as described in Section 2.1. The bridge condition data used to calculate baseline performance was provided by ADOT for the timeframe from 2011 to 2014. The results of Step 1 are shown in **Table 5.**

The initial bridge needs analysis indicates that all segments have some level of bridge need. Seven of the twelve segments have an initial need of High or Medium. Segment 10 has a high need overall with medium needs in the Index, Rating, and Obsolete Bridges.

Table 5: Bridge Initial Needs (Step 1)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Number of Bridges in Segment	Bridge Index			Bridge Rating			Bridge Sufficiency			% Functionally Obsolete Bridges			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	
40-1	6	196-202	9	6.19	Fair or Better	None	5	Fair or Better	Low	92.9	Fair or Better	None	7.9%	Fair or Better	None	Low
40-2	10	202-212	6	5.83	Fair or Better	Low	5	Fair or Better	Low	96.9	Fair or Better	None	18.3%	Fair or Better	None	Low
40-3	22	212-234	11	5.03	Fair or Better	Medium	4	Fair or Better	Medium	88.6	Fair or Better	None	0.0%	Fair or Better	None	Medium
40-4	12	234-246	5	6.05	Fair or Better	None	5	Fair or Better	Low	95.9	Fair or Better	None	0.0%	Fair or Better	None	Low
40-5	12	246-258	16	5.12	Fair or Better	Medium	4	Fair or Better	Medium	90.5	Fair or Better	None	0.0%	Fair or Better	None	Medium
40-6	12	258-270	6	5.15	Fair or Better	Medium	5	Fair or Better	Low	86.2	Fair or Better	None	29.1%	Fair or Better	Low	Medium
40-7	16	270-286	15	5.31	Fair or Better	Medium	4	Fair or Better	Medium	85.3	Fair or Better	None	0.0%	Fair or Better	None	Medium
40-8	4	286-290	8	5.43	Fair or Better	Medium	4	Fair or Better	Medium	84.1	Fair or Better	None	14.8%	Fair or Better	None	Medium
40-9	14	290-304	9	7.19	Fair or Better	None	6	Fair or Better	None	96.2	Fair or Better	None	22.4%	Fair or Better	Low	Low
40-10	22	304-326	8	5.45	Fair or Better	Medium	4	Fair or Better	Medium	82.8	Fair or Better	None	42.2%	Fair or Better	Medium	High
40-11	16	326-342	4	6.81	Fair or Better	None	5	Fair or Better	Low	95.4	Fair or Better	None	59.3%	Fair or Better	High	Low
40-12	17.63	342-359.63	15	5.94	Fair or Better	Low	4	Fair or Better	Medium	92.7	Fair or Better	None	57.5%	Fair or Better	High	Medium
Emphasis Area?	Yes	Weighted Avg		5.76	Good	Medium										

4.2 Step 2: Refined Bridge Need

The Initial Needs for the I-40 East corridor were refined as described in Section 2.2. The locations of bridge failure hot spots and recent projects that would supersede the condition data were used to refine the Needs. A summary of this process is shown in **Table 6**.

Bridge Hot Spots
The locations of bridges with a single rating of 4 or less, or multiple ratings of 5 (hot spots) are listed in Table 6. If an Initial Need was not identified in Step 1, the existence of hot spots would be justification for increasing the Need from None to Low in Step 2. There are 8 segments which include hot spot locations along the I-40 East corridor; however, with all segments with an initial need of at least Low, there is no modifications to the need level based on hot spot locations.

Previous Projects
Previous projects which would supersede the bridge condition data are listed in Table 6. In Step 2, this information was used to lower or eliminate Needs on segments where recent rehabilitation projects have been completed.

ADOT provided historical bridge rating data for the last 17 years which was used to investigate historical trends for each bridge and is summarized in **Figure 6**. Bridges that were identified with possible historical concerns are identified in Table 6. The number of functionally obsolete bridges is also shown in Table 6. While historical concerns and functional obsolescence were not used to adjust the level of Need, they were listed in Table 6 as input to the identification of contributing factors.

Table 6 also includes information on bridge-related programmed projects. While programmed projects did not influence the level of Need, they were documented for future reference during the development of solutions to address identified Needs. Programmed projects were identified using the 2016-2020 Five-Year Transportation Facilities Construction Program.

There were nine previous bridge projects that were implemented along I-40 subsequent to the bridge condition data provided by ADOT which improved a total of 19 bridges along the corridor with various level of repair to replacement. The improvements coincide with multiple bridges in segments of Medium and High need. Two of the twelve segments decreased at least one level of need with the implementation of these projects. Therefore, the final bridge needs result in seven segments with Low need, four segments with Medium needs, and one segment with High needs.

4.3 Step 3: Bridge Contributing Factors

The Final Needs for the I-40 East corridor were further investigated as described in Section 2.3. The current bridge ratings were reviewed to determine which rating (or ratings) were less than 6 (Deck, Superstructure, Substructure, or Structural Evaluation Rating). **Table 7** provides a summary of this information and also identifies the bridges with potential historical concerns, and provides any additional information related to the contributing factors.

Table 6: Refined Bridge Needs (Step 2)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Number of Bridges in Segment	Initial Need	Need Adjustments		Final Need	Historical Review	# Functionally Obsolete Bridges	Comments
					Hot Spots (Rating of 4 or multiple 5's)	Previous Projects (which supersede condition data)				
40-1	6	196-202	9	Low	Lone Tree Road OP WB and EB		Low	Lone Tree Rd OP EB and WB, 4th St UP WB	2	Lone Tree Road OP EB and WB, and 4th St. UP EB and WB; Design Bridge Rehab on 4th St UP and Butler Ave programmed for FY 2016
40-2	10	202-212	6	Low	-		Low	-	2	Winona TI UP
40-3	22	212-234	11	Medium	Canyon Padre Br EB, Twin Arrows TI UP, Babbits Tank Br WB, Buffalo Range TI OP EB and WB, Canyon Diablo Br WB	Project completed 2015 Padre Canyon Br EB Bridge Deck Replacement	Medium	Canyon Padre Br EB, Twin Arrows TI UP, Buffalo Range TI OP WB, Canyon Diablo Br WB	0	Canyon Padre Br EB, Twin Arrows TI UP, Babbits Tank Br WB, Buffalo Range TI OP EB and WB, Canyon Diablo Br WB and EB, Two Guns TI UP, and Meteor Crater TI UP; Bridge deck Rehab on Twin Arrows TI and Canyon Diablo Bridges programmed for FY 2016; Canyon Padre Br EB improvements will possibly make the bridge no longer a hot spot, but it still has one 5 rating.
40-4	12	234-246	5	Low	-		Low	Sunshine BNSF RR OP WB	0	Sunshine BNSF RR OP WB, Meteor City TI OP EB and WB, and Leupp TI UP SR 99; Bridge deck rehab on Meteor City TI OP's programmed for FY 2019
40-5	12	246-258	16	Medium	Tucker Flat Br EB, Ruby Wash Br EB and WB, Maple St. OP WB and EB, E Winslow TI OP EB and WB, SR 87 TI UP	Project completed Dec. 2014, replaced bridge decks at Ruby Wash, Maple Street, and East Winslow TI bridges. Also sealed bridge decks at Little CO River Bridges, Bridge Deck rehabilitation at SR 87 UP	Low	Little Colo Rv Br EB and WB	0	Tucker Flat Br EB; Changed from Medium to Low due to recent project (which superseded conditions data) on 7 of the 8 hot spot bridges
40-6	12	258-270	6	Medium	Cottonwood Br WB and EB, Jackrabbit TI OP EB and WB	Bridge Deck replacement Jackrabbit TI OP 2015	Low	-	4	Cottonwood Br WB and EB; Bridge deck rehab on Cottonwood Bridges programmed for 2017; Changed from Medium to Low due to recent project (which superseded conditions data) on 2 of the 4 hot spot bridges
40-7	16	270-286	15	Medium	Manila Wash Br WB, Tanner Wash Br EB, Leroux Wash Br EB and WB	Replaced scour at Manila Wash bridges. Leroux Wash Br EB and WB replaced approach slabs and bridge deck rehab. Tanner Wash Br EB replaced bridge	Medium	W Joseph City TI UP, Tanner Wash Br EB, Hunt Rd TI UP, Leroux Wash Br EB and WB	0	W Joseph City TI UP, Manila Wash Br WB, Hunt Rd TI UP, and Leroux Wash Br EB and WB. Manila Wash improvements will possibly make the bridge no longer a hot spot, but it still has one 5 rating. Tanner Wash Br EB was replaced and will no longer be a hotspot or historical issue. Leroux Br EB and WB did not fix all the needs therefore it's still a hot spot.
40-8	4	286-290	8	Medium	E Holbrook TI OP WB and EB	Girder repair and rocker replacement at E Holbrook TI bridges.	Medium	E Holbrook TI OP EB and WB	2	Hermosa Dr UP and E Holbrook TI OP EB and WB. E Holbrook TI OP had girder repair and rocker replacement but still has structural issues.
40-9	14	290-304	9	Low	-	Bridge Slab replacements EB Big/Little Lithodendreaon Bridges completed 2014	Low	-	5	No hot spot bridges and no historical issues; MP 298 Utility OP CBC extension programmed for 2016
40-10	22	304-326	8	High	Painted Desert TI UP, Dead River Br EB, Crazy Creek Br WB	Superstructure replaced at the underpass bridge at Painted Desert TI.	High	Painted Desert TI UP, Navajo TI UP	3	Painted Desert TI UP, Petrified Forest UP, Dead River Br EB, Crazy Creek Br WB, and Navajo TI UP. Painted Desert TI UP improvements fixed the superstructure but the deck is still a 4 rating.
40-11	16	326-342	4	Low	-		Low	McCarroll TI UP, Chambers TI UP, Ortega Rd TI UP	3	McCarroll TI UP, Chambers TI UP, and Ortega Rd TI UP
40-12	17.63	342-359.63	15	Medium	Window Rock TI OP WB, Lupton TI OP WB and EB		Medium	Black Creek Br EB, Window Rock TI OP WB	11	Black Creek Br EB, Houck TI UP, Allentown TI UP, Window Rock TI OP WB, and Lupton TI OP WB and EB

Figure 6: Bridge History

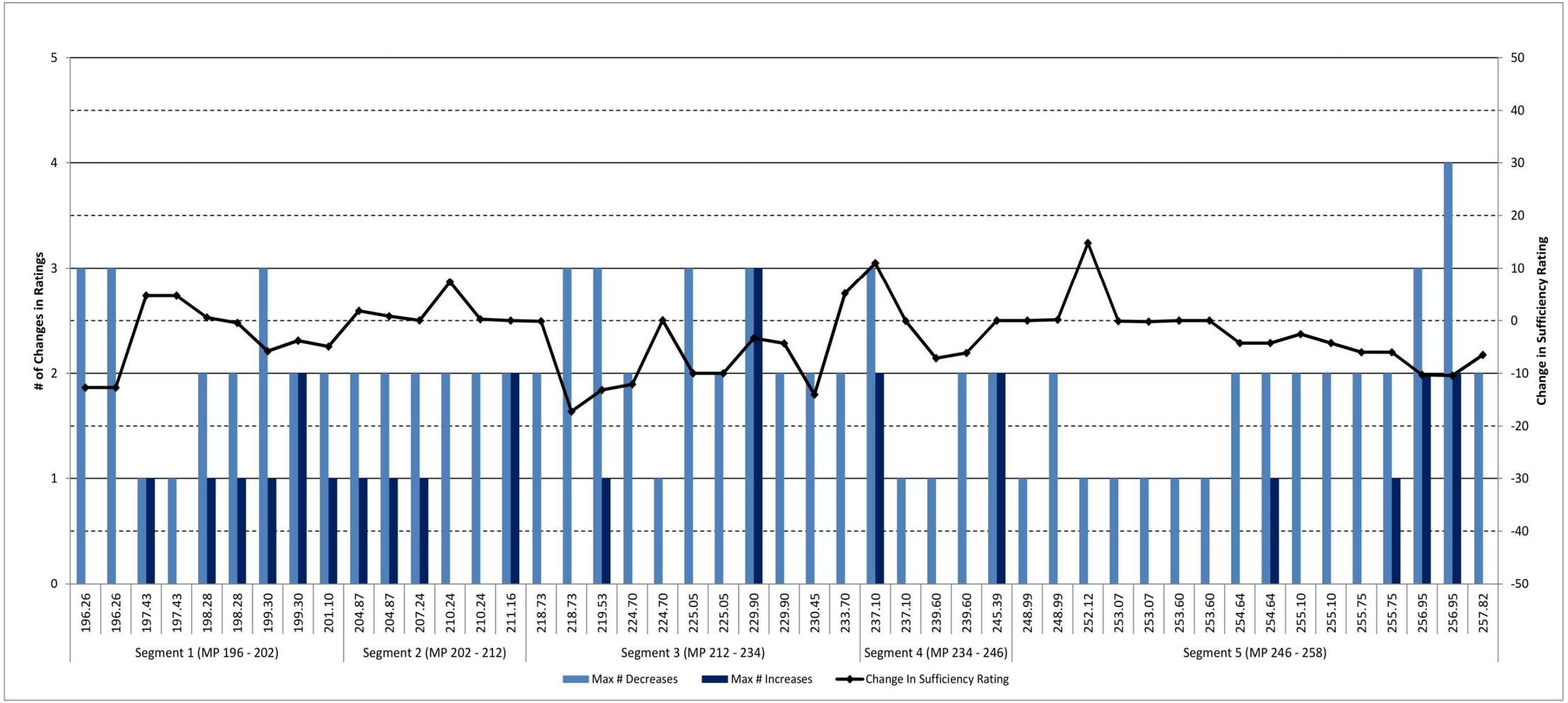


Figure 6: Bridge History (Continued)

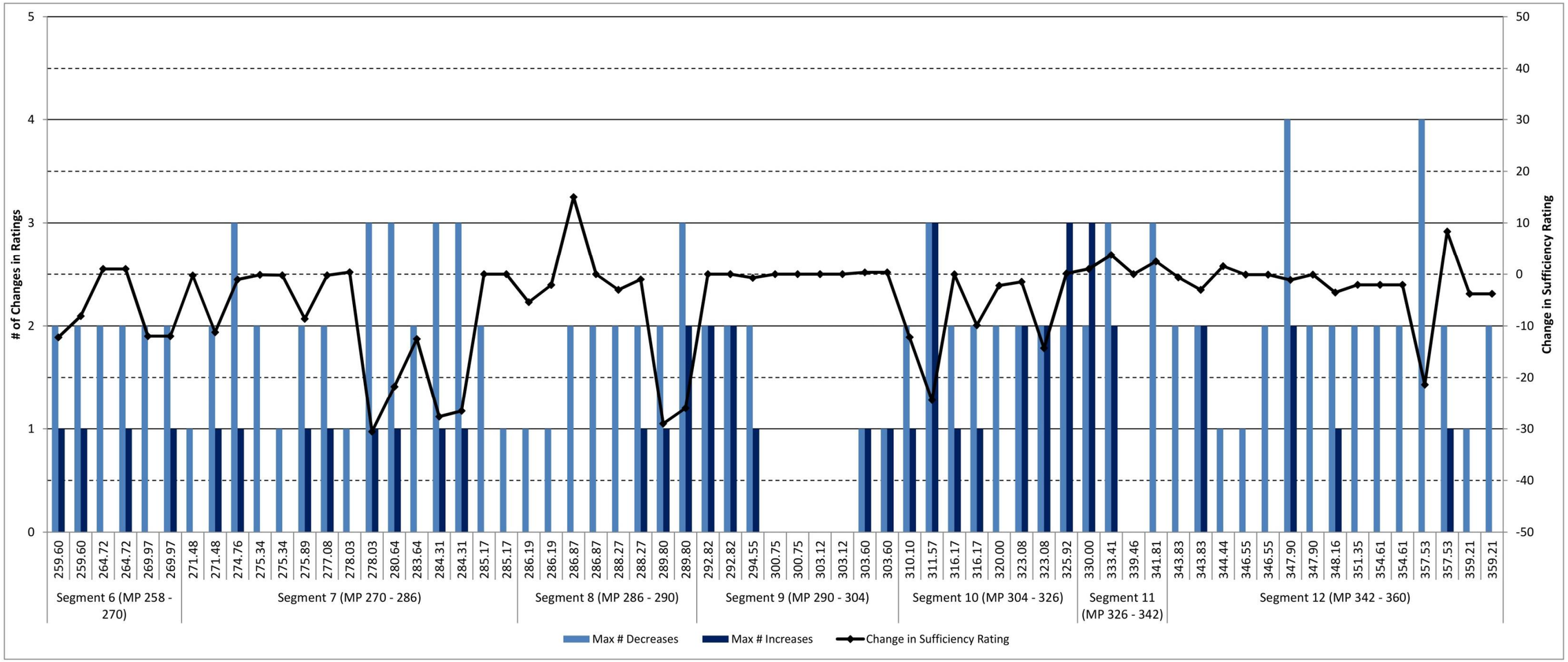


Table 7: Bridge Contributing Factors (Step 3)

Segment	Segment Length (Miles)	Segment Mileposts (MP)	Number of Bridges in Segment	# Functionally Obsolete Bridges	Final Need	Contributing Factors			Comments
						Bridge	Current Ratings	Historical Review	
40-1	6	196-202	9	2	Low	Lone Tree Rd OP EB (#1180) (MP 196.26)	Current Deck Rating 5, Current Sub Rating 5	Could have a repetitive investment issue	DCR recommended replacement
						Lone Tree Rd OP WB (#1181) (MP 196.26)	Current Deck Rating 5, Current Sub Rating 5	Could have a repetitive investment issue	DCR recommended replacement
						4th St UP EB (#1182) (MP 199.30)	Current Super Rating 5	This structure was not identified in historical review	Project is programmed in FY 16 DCR recommended replacement
						4th St UP WB (#1183) (MP 199.30)	Current Super Rating 5	Could have a repetitive investment issue	Project is programmed in FY 16 DCR recommended replacement
40-2	10	202-212	6	2	Low	Winona TI UP WB (#1084) (MP 211.16)	Current Deck Rating 5	This structure was not identified in historical review	DCR recommended replacement
40-3	22	212-234	11	0	Medium	Canyon Padre Br EB (#1670) (MP 218.73)	Current Deck Rating 4, Current Sub Rating 5	Could have a repetitive investment issue	Previous Project Fixed Deck Issue
						Twin Arrows TI UP (#1363) (MP219.53)	Current Deck Rating 4	Could have a repetitive investment issue	Project is programmed in FY 16
						Babbitts Tank Br WB (#1385) (MP 224.7)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	
						Buffalo Range TI OP EB (#1386) (MP 225.05)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	
						Buffalo Range TI OP WB (#1387) (MP 225.05)	Current Deck Rating 5, Current Sub Rating 5	Could have a repetitive investment issue	
						Canyon Diablo Br WB (#845) (MP 229.90)	Current Sub Rating 5, Current Super Rating 5	Could have a repetitive investment issue	Project is programmed in FY 16
						Canyon Diablo Br EB (#1671) (MP 229.90)	Current Deck Rating 5	This structure was not identified in historical review	Project is programmed in FY 16
						Two Guns TI UP (#1388) (MP 230.45)	Current Deck Rating 5	This structure was not identified in historical review	
						Meteor Crater TI UP (#1389) (MP 233.7)	Current Deck Rating 5	This structure was not identified in historical review	
40-4	12	234-246	5	0	Low	Sunshine BNSF RR OP WB (#1390) (MP 237.10)	No Current Ratings less than 6	Could have a repetitive investment issue	
						Meteor City TI OP EB (#1391) (MP 239.60)	Current Deck Rating 5	This structure was not identified in historical review	Project is programmed in FY 19
						Meteor City TI OP WB (#1392) (MP 239.60)	Current Deck Rating 5	This structure was not identified in historical review	Project is programmed in FY 19
						Leupp TI UP SR 99 (#1317) (MP 245.39)	Current Deck Rating 5	This structure was not identified in historical review	
40-5	12	246-258	16	0	Low	Tucker Flat Br EB (#336) (MP 248.99)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	
40-6	12	258-270	6	4	Low	Cottonwood Br WB (#520) (MP 259.60)	Current Deck Rating 5, Current Super Rating 5	This structure was not identified in historical review	Project is programmed in FY 17 (FY 18 in Tentative Program)
						Cottonwood Br EB (#519) (MP 259.60)	Current Deck Rating 5, Current Super Rating 5	This structure was not identified in historical review	Project is programmed in FY 17 (FY 18 in Tentative Program)

Table 7: Bridge Contributing Factors (Step 3) (Continued)

Segment	Segment Length (Miles)	Segment Milepost s (MP)	Number of Bridges in Segment	# Functionally Obsolete Bridges	Final Need	Contributing Factors			Comments
						Bridge	Current Ratings	Historical Review	
40-7	16	270-286	15	0	Medium	Manila Wash Br WB (#852) (MP 271.48)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	Previous Project May Have Fixed Sub Issue
						W Joseph City TI UP (#1893) (MP 274.76)	No Current Ratings less than 6	Could have a repetitive investment issue	
						Hunt Rd TI UP (#930) (MP 280.64)	Current Sub Rating 5	Could have a repetitive investment issue	
						Leroux Wash Br EB (#1772) (MP 284.31)	Current Sub Rating 5, Current Super Rating 4	Could have a repetitive investment issue	
						Leroux Wash Br WB (#1773) (MP 284.31)	Current Super Rating 4	Could have a repetitive investment issue	
40-8	4	286-290	8	2	Medium	Hermosa Dr UP (#1368) (MP 288.27)	Current Deck Rating 5	This structure was not identified in historical review	
						E Holbrook TI OP WB (#1370) (MP 289.80)	Current Deck Rating 5, Current Sub Rating 4, Current Super Rating 5	Could have a repetitive investment issue	Previous Project May Have Fixed Sub Issue
						E Holbrook TI OP EB (#1369) (MP 289.80)	Current Sub Rating 4, Current Super Rating 5	Could have a repetitive investment issue	Previous Project May Have Fixed Sub Issue
40-9	14	290-304	9	5	Low	No bridges with current ratings less than 6			
40-10	22	304-326	8	3	High	Petrified Forest UP (#589) (MP 310.10)	Current Sub Rating 5	This structure was not identified in historical review	
						Painted Desert TI UP (#590) (MP 311.57)	Current Deck Rating 4, Current Super Rating 4	This structure was not identified in historical review	Previous Project Fixed Super Issue
						Dead River Bridge EB (#565) (MP 316.17)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	
						Crazy Creek Br WB (#461) (MP 323.08)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	
						Navajo TI UP (#709) (MP 325.92)	No Current Ratings less than 6	Could have a repetitive investment issue	
40-11	16	326-342	4	3	Low	McCarroll TI UP (#710) (MP 330.00)	No Current Ratings less than 6	Could have a repetitive investment issue	
						Chambers TI UP (#814) (MP 333.41)	No Current Ratings less than 6	Could have a repetitive investment issue	
						Ortega Rd TI UP (#816) (MP 341.81)	Current Deck Rating 5	Could have a repetitive investment issue	
40-12	17.63	342-359.63	15	11	Medium	Black Creek Br EB (#1134) (MP 347.90)	Current Deck Rating 5	Could have a repetitive investment issue	
						Houck TI UP (#955) (MP 348.16)	Current Deck Rating 5	This structure was not identified in historical review	
						Allentown TI UP (#956) (MP 351.35)	Current Deck Rating 5	This structure was not identified in historical review	
						Window Rock TI OP WB (#678) (MP 357.53)	Current Deck Rating 4, Current Sub Rating 4	Could have a repetitive investment issue	
						Lupton TI OP WB (#680) (MP 359.21)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	
						Lupton TI OP EB (#679) (MP 359.21)	Current Deck Rating 5, Current Sub Rating 5	This structure was not identified in historical review	

5.0 MOBILITY PERFORMANCE AREA NEEDS

The following sections describe the first three steps of the five-step needs assessment process described in Section 2 for the I-40 East corridor for the Mobility Performance Area. The detailed methodology for performing Steps 1-3 is provided in the **Appendix**.

5.1 Step 1: Initial Mobility Needs

The baseline performance scores (from Working Paper #2) and performance objectives (from Working Paper #3) for the I-40 East corridor were used to determine the initial mobility needs, as described in Section 2.1.

Step 1 uses the scores for the Mobility Index primary performance measure and six secondary performance measures to determine the level of need for each performance measure by segment. The six secondary performance measures are Future Daily Volume-to-Capacity (V/C), Existing Directional Peak Hour V/C, Directional Closure Extent, Directional Travel Time Index (TTI), Directional Planning Time Index (PTI), and Bicycle Accommodation. The mobility condition data used to calculate baseline performance was provided by ADOT for 2014 for the existing traffic volumes and travel time data, 2014 for bicycle accommodation data, 2035 for future traffic volumes, and 2010-2014 for the closure data. The performance scores, objectives and initial levels of need for each mobility performance measure and for all mobility performance measures combined are shown in **Table 8**.

The initial need represents a weighted sum of individual mobility performance measure levels of need. The initial need for a given segment may subsequently be modified (in Step 2) based on relevant recently completed or under-construction projects that have or will improve mobility performance compared to the baseline performance condition.

Nine of the twelve segments report an initial need of Low along the I-40 corridor. There are no high or medium needs.

Table 8: Mobility Initial Needs (Step 1)

Segment	Segment Mileposts	Segment Length (miles)	Environment Type	Facility Operation	Mobility Index			Future Daily V/C			Existing Peak Hour V/C					Closure Extent (occurrences/year/mile)				
					Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score		Performance Objective	Level of Need		Performance Score		Performance Objective	Level of Need	
											EB	WB		EB	WB	EB	WB		EB	WB
40-1	196-202	6	Urban	Uninterrupted	0.71	Fair or Better	None	0.90	Fair or Better	Medium	0.40	0.39	Fair or Better	None	None	0.63	0.17	Fair or Better	Medium	None
40-2	202-212	10	Urban	Uninterrupted	0.42	Fair or Better	None	0.58	Fair or Better	None	0.20	0.16	Fair or Better	None	None	0.54	0.20	Fair or Better	Medium	None
40-3	212-234	22	Rural	Uninterrupted	0.49	Fair or Better	None	0.69	Fair or Better	Low	0.22	0.20	Fair or Better	None	None	0.51	0.11	Fair or Better	Medium	None
40-4	234-246	12	Rural	Uninterrupted	0.49	Fair or Better	None	0.69	Fair or Better	Low	0.19	0.19	Fair or Better	None	None	0.50	0.17	Fair or Better	Medium	None
40-5	246-258	12	Rural	Uninterrupted	0.52	Fair or Better	None	0.73	Fair or Better	Medium	0.21	0.20	Fair or Better	None	None	0.30	0.18	Fair or Better	None	None
40-6	258-270	12	Rural	Uninterrupted	0.39	Fair or Better	None	0.53	Fair or Better	None	0.18	0.17	Fair or Better	None	None	0.11	0.00	Fair or Better	None	None
40-7	270-286	16	Rural	Uninterrupted	0.51	Fair or Better	None	0.71	Fair or Better	Medium	0.21	0.20	Fair or Better	None	None	0.03	0.05	Fair or Better	None	None
40-8	286-290	4	Rural	Uninterrupted	0.40	Fair or Better	None	0.54	Fair or Better	None	0.21	0.21	Fair or Better	None	None	0.05	0.05	Fair or Better	None	None
40-9	290-304	14	Rural	Uninterrupted	0.48	Fair or Better	None	0.65	Fair or Better	Low	0.28	0.28	Fair or Better	None	None	0.10	0.21	Fair or Better	None	None
40-10	304-326	22	Rural	Uninterrupted	0.46	Fair or Better	None	0.63	Fair or Better	Low	0.23	0.24	Fair or Better	None	None	0.15	0.07	Fair or Better	None	None
40-11	326-342	16	Rural	Uninterrupted	0.44	Fair or Better	None	0.60	Fair or Better	None	0.20	0.19	Fair or Better	None	None	0.12	0.07	Fair or Better	None	None
40-12	342-359.63	17.63	Rural	Uninterrupted	0.47	Fair or Better	None	0.64	Fair or Better	Low	0.24	0.24	Fair or Better	None	None	0.11	0.11	Fair or Better	None	None
Mobility Emphasis Area		No	Weighted Average		0.48	Fair or Better	None													

Table 8: Mobility Initial Needs (Step 1) (Continued)

Segment	Segment Mileposts	Segment Length (miles)	Environment Type	Facility Operation	Directional TTI (all vehicles)					Directional PTI (all vehicles)					Bicycle Accommodation			Initial Need
					Performance Score		Performance Objective	Level of Need		Performance Score		Performance Objective	Level of Need		Performance Score	Performance Objective	Level of Need	
					EB	WB		EB	WB	EB	WB		EB	WB				
40-1	196-202	6	Urban	Uninterrupted	1.01	1.03	Fair or Better	None	None	1.13	1.20	Fair or Better	None	None	100%	Fair or Better	None	Low
40-2	202-212	10	Urban	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.21	1.31	Fair or Better	None	None	100%	Fair or Better	None	Low
40-3	212-234	22	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.23	1.26	Fair or Better	None	None	100%	Fair or Better	None	Low
40-4	234-246	12	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	2.24	1.30	Fair or Better	High	None	100%	Fair or Better	None	Low
40-5	246-258	12	Rural	Uninterrupted	1.06	1.04	Fair or Better	None	None	1.45	1.44	Fair or Better	Medium	Medium	100%	Fair or Better	None	Low
40-6	258-270	12	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.20	1.19	Fair or Better	None	None	100%	Fair or Better	None	None
40-7	270-286	16	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.24	1.24	Fair or Better	None	None	100%	Fair or Better	None	Low
40-8	286-290	4	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.29	1.21	Fair or Better	None	None	100%	Fair or Better	None	None
40-9	290-304	14	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.41	1.42	Fair or Better	Low	Low	98%	Fair or Better	None	Low
40-10	304-326	22	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.27	1.25	Fair or Better	None	None	100%	Fair or Better	None	Low
40-11	326-342	16	Rural	Uninterrupted	1.00	1.01	Fair or Better	None	None	1.29	1.35	Fair or Better	None	None	96%	Fair or Better	None	None
40-12	342-359.63	17.63	Rural	Uninterrupted	1.00	1.00	Fair or Better	None	None	1.24	1.30	Fair or Better	None	None	90%	Fair or Better	None	Low

5.2 Step 2: Refined Mobility Need

Once the initial mobility needs by segment for the I-40 East corridor were established, they were then refined in Step 2 as described in Section 2.2 to more accurately reflect existing needs. An evaluation of relevant recently completed and under-construction projects was performed to determine if segment need levels required adjustment. The initial needs were then refined based on this assessment to determine the final need for each segment. Planned and programmed future projects were noted for future reference in developing solutions that address identified needs. The Step 2 process is described in more detail below and summarized in **Table 9**.

Recently Completed and Under-Construction Mobility Projects
ADOT provided information on potentially relevant recently completed and under-construction projects that were not previously reflected in the baseline performance data. This includes any projects completed or under construction after 2014 that have the potential to mitigate a mobility need on a corridor segment. If a recently completed or under-construction project has a high likelihood to improve or address a performance need, the level of need for that segment was decreased.

Two relevant projects were identified: DMS signs were installed in Segment 1 and 11. It was determined that these projects likely will not modify performance and as such are not expected to modify the current level of need.

Planned or Programmed Projects
Information was noted on mobility-related planned and programmed projects were identified through the ADOT Five-Year Facilities Construction Program and other studies identified in Working Paper #1. Planned and programmed projects and identified issues do not influence the level of need, but were documented for future reference in developing solutions that address identified needs.

Table 9: Refined Mobility Needs (Step 2)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Initial Need	Need Adjustments	Final Need	Planned and Programmed Future Projects
				Recent Projects Since 2014		
40-1	196-202	6	Low	DMS installed at MP 197.56	Low	Planned: Widen the mainline to six lanes (DCR), Construct a new TI at Lone Tree (MP 196.7) (DCR), Construct braided ramps between I-17 and Lone Tree Rd (DCR) Reconstruct Butler TI (MP 198.28) (DCR) with parallel exit/entrance ramps Construct auxiliary lanes between Lone Tree Rd and Butler Rd (DCR) Install DMS on westbound I-40 at MP 197.5, 200, and 204 (DCR)
40-2	202-212	10	Low	None	Low	Planned: Widen the mainline to six lanes (DCR), Reconstruct the TI at Walnut Canyon (MP 204.8) (DCR) Reconstruct the existing TI at Winona (MP 211.16) (DCR)
40-3	212-234	22	Low	None	Low	Planned: Widen the mainline to six lanes (DCR)
40-4	234-246	12	Low	None	Low	Planned: Widen the mainline to six lanes (BQAZ)
40-5	246-258	12	Low	None	Low	Planned: Widen the mainline to six lanes (BQAZ)
40-6	258-270	12	None	None	None	Planned: Widen the mainline to six lanes (BQAZ)
40-7	270-286	16	Low	None	Low	Planned: Widen the mainline to six lanes (BQAZ)
40-8	286-290	4	None	None	None	Planned: Widen the mainline to six lanes (BQAZ)

Table 9: Refined Mobility Needs (Step 2) (Continued)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Initial Need	Need Adjustments	Final Need	Planned and Programmed Future Projects
				Recent Projects Since 2014		
40-9	290-304	14	Low	None	Low	Planned: Widen the mainline to six lanes (BQAZ)
40-10	304-326	22	Low	None	Low	Programmed: Port of Entry improvements at Crazy Horse POE (MP 322) FY 17 Planned: Widen the mainline to six lanes (BQAZ)
40-11	326-342	16	None	DMS installed at MP 340.44	None	Planned: Widen the mainline to six lanes (BQAZ)
40-12	342-359.63	17.63	Low	None	Low	Planned: Widen the mainline to six lanes (BQAZ), Lupton Traffic Interchange (MP 359.21) - construct a new TI (DCR)

5.3 Step 3: Mobility Contributing Factors

As described in Section 2.3, Step 3 identifies potential contributing factors to the performance needs calculated in Step 2. These contributing factors provide information on what types of improvements may help improve performance. Contributing factors include:

- Roadway variables
- Traffic variables
- Relevant mobility-related existing infrastructure
- Closure type
- Non-actionable conditions

Roadway Variables

Roadway variables include functional classification, environmental type (e.g., urban, rural), terrain, number of lanes, speed limit, presence of auxiliary lanes, if a roadway is divided or non-divided, and how often passing is not allowed. These variables are described in more detail below:

- Functional classification indicates if a roadway is an interstate, state highway, or arterial. Capacity equations and parameters differ depending on a roadway's functional classification.
- Environmental type refers to how developed the land is adjacent to the roadway. Environmental types include urban, fringe urban, and rural. Capacity thresholds differ depending on the environmental type as higher congestion levels are more acceptable in urbanized areas than in rural areas.
- Terrain (described as level, rolling, or mountainous) indicates the general roadway grade, which influences how quickly vehicles can accelerate or decelerate or maintain a constant speed.
- The number of lanes in each direction indicates how many general purpose through lanes exist.
- The speed limit indicates the posted speed limit.
- The presence of auxiliary lanes for turning, weaving, or passing can improve mobility performance by maintaining more consistent speeds in mainline through lanes.
- A roadway is considered divided if it has a raised or depressed median separating the directions of traffic that cannot easily be traversed. A roadway with a painted paved median is considered a non-divided roadway. Dividing a roadway generally increases the roadway capacity.
- The presence of no-passing zones restricts the movement of vehicles around slower-moving vehicles.

Traffic Variables

Traffic variables include existing and future level of service (LOS), percent (%) trucks, and the buffer index (difference between PTI and TTI). The existing and future LOS, percentage of trucks, and buffer index can indicate how well a corridor is performing in terms of overall mobility and why certain segments of a corridor may be performing worse than others.

Existing and Future LOS

The existing and future LOS provide a letter "grade" between "A" and "F" for mobility that is generally reflective of Existing and Future V/C calculations. LOS values of "A", "B", and "C" are generally considered highly acceptable. A LOS value of "D" is generally considered moderately acceptable. LOS values of "E" and "F" are generally considered unacceptable.

Truck Traffic

The amount of truck traffic in a given segment of the corridor can be represented as a percentage of the overall total traffic volume for that specific segment. The truck volume on a corridor can impact overall mobility based on truck travel speed, corridor grades, required inspection points and number of lanes.

Buffer Index

The Buffer Index is calculated by subtracting the segment level TTI value (ratio of peak hour speed to free flow speed) from the segment level PTI value (95th percentile speed). The TTI and PTI values were determined in Working Paper #2. The buffer index expresses the amount of extra time necessary to be on-time 95 percent of the time for any given trip. This calculation provides information on the reliability of a corridor.

Mobility-Related Infrastructure

Mobility-related infrastructure refers to devices or features at specific locations that influence mobility performance. Examples include dynamic message signs (DMS), passing lanes, climbing lanes, ports of entry (POE), rest areas, and parking areas.

Closure Type

The relative frequency of types of closures within each segment helps indicate potential causes of mobility-related needs. Closure types consist of closures due to an incident/crash, obstruction, or weather condition. The number of each type of closure and the corresponding percentage of all closures that are of each type are noted.

Non-Actionable Conditions

Non-actionable conditions are features or characteristics that result in poor mobility performance that cannot be addressed through an engineered solution. Examples include border patrol checkpoints that require all vehicles to slow down or stop for inspection.

Mobility Needs Contributing Factors

Table 10 summarizes the potential contributing factors to mobility needs on the I-40 East corridor.

Table 10: Mobility Contributing Factors (Step 3)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Refined Need	Roadway Variables								Traffic Variables					Relevant Mobility Related Existing Infrastructure
				Functional Classification	Environmental Type (Urban/Rural)	Terrain	# of Lanes/ Direction	Speed Limit	Aux Lanes	Divided/ Non-Divided	% No Passing	Existing LOS	Future 2035 LOS	% Trucks	EB Buffer Index (PTI-TTI)	WB Buffer Index (PTI-TTI)	
40-1	196-202	6	Low	Interstate	Urban	Rolling	2	65	No	Divided	0%	A-C	E/F	22%	0.12	0.17	I-17 System Interchange MP 196, Transit Rail Station MP 196, Permanent Traffic Counter MP 196, DMS Sign MP 199
40-2	202-212	10	Low	Interstate	Fringe/Urban	Rolling	2	75	No	Divided	0%	A-C	A-C	27%	0.21	0.31	DMS Sign MP 212
40-3	212-234	22	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	17%	0.23	0.26	Road Weather Information MP 229
40-4	234-246	12	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	5%	1.24	0.30	Open Rest Area MP 240
40-5	246-258	12	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	23%	0.39	0.40	DMS Sign MP 250, Transit Rail Station MP 254, Road Weather Information MP 256
40-6	258-270	12	None	Interstate	Rural	Level	2	75	No	Divided	0%	A/B	A/B	36%	0.20	0.19	Traffic Counter MP 260, DMS Sign MP 260, Road Weather Information MP 269
40-7	270-286	16	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	22%	0.24	0.24	Traffic Counter MP 275, DMS Sign MP 281
40-8	286-290	4	None	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	A/B	57%	0.29	0.21	None
40-9	290-304	14	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	25%	0.41	0.42	Weigh Station MP 291, DMS Sign MP 295
40-10	304-326	22	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	28%	0.27	0.25	DMS Sign MP 310, Road Weather Information MP 312
40-11	326-342	16	None	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	38%	0.29	0.34	DMS Sign MP 330, Weigh Station MP 341
40-12	342-359.63	17.63	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	33%	0.24	0.30	Open Rest Area MP 357, DMS Sign MP 357, Road Weather Information MP 358

Table 10: Mobility Contributing Factors (Step 3) (Continued)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Refined Need	Closure Extent							Non-Actionable Conditions	Contributing Factors
				Total Number of Closures	# Incidents/ Accidents	% Incidents/ Accidents	# Obstructions/ Hazards	% Obstructions/ Hazards	# Weather Related	% Weather Related		
40-1	196-202	6	Low	14	12	86%	0	0%	2	14%	None	-Congested Levels with Future Daily V/C -Elevated Number of Closures
40-2	202-212	10	Low	19	17	89%	0	0%	2	11%	None	-89% of Closure Incidents/Accident Related, 11% Remaining are Weather Related
40-3	212-234	22	Low	26	24	92%	0	0%	2	8%	None	-92% of Closure Incidents/Accident Related, 8% Remaining are Weather Related
40-4	234-246	12	Low	13	10	77%	0	0%	3	23%	None	-High need in PTI -77% of Closure Incidents/Accident Related, 23% Remaining are Weather Related -High NB Buffer Performance Need
40-5	246-258	12	Low	19	16	84%	1	5%	2	11%	None	-Elevated Performance need for EB & WB PTI
40-6	258-270	12	None	6	6	100%	0	0%	0	0%	None	-No Reported Performance Needs -100% of Closure Incidents/Accident Related
40-7	270-286	16	Low	6	6	100%	0	0%	0	0%	None	-100% of Closure Incidents/Accident Related
40-8	286-290	4	None	2	2	100%	0	0%	0	0%	None	-No Reported Performance Needs -100% of Closure Incidents/Accident Related
40-9	290-304	14	Low	13	13	100%	0	0%	0	0%	None	-100% of Closure Incidents/Accident Related
40-10	304-326	22	Low	14	14	100%	0	0%	0	0%	None	-No Reported Performance Needs -100% of Closure Incidents/Accident Related
40-11	326-342	16	None	9	9	100%	0	0%	0	0%	None	-100% of Closure Incidents/Accident Related
40-12	342-359.63	17.63	Low	17	16	94%	1	6%	0	0%	None	-No Reported Performance Needs -94% of Closure Incidents/Accident Related, 6% Remaining are Obstruction Related

6.0 SAFETY PERFORMANCE AREA NEEDS

The following sections describe the first three steps of the five-step needs assessment process described in Section 2 for the I-40 East corridor for the Safety Performance Area. The detailed methodology for performing Steps 1-3 is provided in the **Appendix**.

6.1 Step 1: Initial Safety Needs

The baseline performance scores (from Working Paper No. 2) and performance objectives (from Working Paper No. 3) for the I-40 East corridor were used to determine the initial safety needs, as described in Section 2.1.

Step 1 uses the scores for the Safety Index primary performance measure and two of the five secondary safety performance measures to determine the initial level of need by segment for each performance measure individually as well as for all performance measures combined. The two secondary performance measures used are the Directional Safety Index and the Strategic Highway Safety Plan (SHSP) Top 5 Emphasis Area Behaviors. The three other secondary safety performance measures (Truck-Involved Crashes, Motorcycle-Involved Crashes, and Non-Motorized Crashes) exhibited small crash sample sizes in their entirety and were not considered in the Safety Performance Area needs assessment (refer to sample size criteria documented in Working Paper No. 2). The SHSP Top 5 Emphasis Area secondary measure was also excluded from the calculation on corridor segments that exhibited small crash sample sizes for that measure. The performance scores, performance objectives, and initial levels of need for each safety performance measure and for all safety performance measures combined are shown in **Table 11.**

The initial need for all safety performance measures represents a weighted sum of individual safety performance measure levels of need. The initial need for a given segment may subsequently be modified (in Step 2) considering crash hot spots as well as relevant recently completed or under-construction projects that have or will improve safety performance compared to the baseline performance condition.

For the initial Safety Needs analysis, eleven of the twelve segments along I-40 East corridor indicate a need with five Medium or High.

Table 11: Safety Initial Needs (Step 1)

Segment	Operating Environment	Segment Length (miles)	Segment Mileposts (MP)	Safety Index			Directional Safety Index					% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors		
				Performance Score	Insufficient Data	Level of Need	EB Directional Safety Index	WB Directional Safety Index	Performance Objective	EB Level of Need	WB Level of Need	Performance Score	Performance Objective	Level of Need
40-1	Urban 4 Lane Freeway	6	196-202	1.77	Average or Better	High	1.56	1.97	Average or Better	High	High	69%	Average or Better	High
40-2	Rural 4 Lane Freeway with Daily Volume < 25,000	10	202-212	1.89	Average or Better	High	2.41	1.36	Average or Better	High	Medium	76%	Average or Better	High
40-3	Rural 4 Lane Freeway with Daily Volume < 25,000	22	212-234	1.35	Average or Better	Medium	1.46	1.23	Average or Better	High	Medium	68%	Average or Better	High
40-4	Rural 4 Lane Freeway with Daily Volume < 25,000	12	234-246	0.07	Average or Better	None	0.04	0.11	Average or Better	None	None	Insufficient Data	Average or Better	N/A
40-5	Urban 4 Lane Freeway	12	246-258	0.42	Average or Better	None	0.10	0.75	Average or Better	None	None	83%	Average or Better	High
40-6	Rural 4 Lane Freeway with Daily Volume < 25,000	12	258-270	1.14	Average or Better	Medium	1.16	1.13	Average or Better	Medium	Medium	55%	Average or Better	Medium
40-7	Rural 4 Lane Freeway with Daily Volume < 25,000	16	270-286	0.24	Average or Better	None	0.40	0.08	Average or Better	None	None	80%	Average or Better	High
40-8	Rural 4 Lane Freeway with Daily Volume < 25,000	4	286-290	0.94	Average or Better	Low	0.11	1.78	Average or Better	None	High	Insufficient Data	Average or Better	N/A
40-9	Rural 4 Lane Freeway with Daily Volume < 25,000	14	290-304	0.32	Average or Better	None	0.50	0.14	Average or Better	None	None	56%	Average or Better	High
40-10	Rural 4 Lane Freeway with Daily Volume < 25,000	22	304-326	0.66	Average or Better	None	0.93	0.39	Average or Better	Low	None	47%	Average or Better	Low
40-11	Rural 4 Lane Freeway with Daily Volume < 25,000	16	326-342	0.64	Average or Better	None	0.49	0.80	Average or Better	None	None	75%	Average or Better	High
40-12	Rural 4 Lane Freeway with Daily Volume < 25,000	17.63	342-359.63	1.24	Average or Better	Medium	1.77	0.71	Average or Better	High	None	27%	Average or Better	None
Safety Emphasis Area?		Yes	Weighted Average	0.84	Above Average	Low								

Table 11: Safety Initial Needs (Step 1) (Continued)

Segment	Operating Environment	Segment Length (miles)	Segment Mileposts (MP)	% of Fatal + Incapacitating Injury Crashes Involving Trucks			% of Fatal + Incapacitating Injury Crashes Involving Motorcycles			% of Fatal + Incapacitating Injury Crashes Involving Non-Motorized Travelers			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	
40-1	Urban 4 Lane Freeway	6	196-202	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
40-2	Rural 4 Lane Freeway with Daily Volume < 25,000	10	202-212	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
40-3	Rural 4 Lane Freeway with Daily Volume < 25,000	22	212-234	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
40-4	Rural 4 Lane Freeway with Daily Volume < 25,000	12	234-246	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	None
40-5	Urban 4 Lane Freeway	12	246-258	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low
40-6	Rural 4 Lane Freeway with Daily Volume < 25,000	12	258-270	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
40-7	Rural 4 Lane Freeway with Daily Volume < 25,000	16	270-286	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low
40-8	Rural 4 Lane Freeway with Daily Volume < 25,000	4	286-290	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low
40-9	Rural 4 Lane Freeway with Daily Volume < 25,000	14	290-304	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low
40-10	Rural 4 Lane Freeway with Daily Volume < 25,000	22	304-326	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low
40-11	Rural 4 Lane Freeway with Daily Volume < 25,000	16	326-342	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low
40-12	Rural 4 Lane Freeway with Daily Volume < 25,000	17.63	342-359.63	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Medium

6.2 Step 2: Refined Safety Needs

Once the initial safety needs by segment for the I-40 East corridor were established, they were then refined in Step 2 as described in Section 2.2 to more accurately reflect existing needs.

An evaluation of crash hot spots as well as relevant recently completed and under-construction projects was performed to determine if segment need levels required adjustment. The initial needs were then refined based on this assessment to determine the final need for each segment. Planned and programmed future projects and other issues identified in previous reports were noted for future reference in developing solutions that address identified needs. The Step 2 process is described in more detail below and summarized in **Table 12**.

Crash Hot Spots
Directional crash concentration locations, as determined in the baseline performance evaluation, are considered crash hot spots. If a segment has an initial need level of None but contains a crash hot spot, the need level should be adjusted to Low to indicate there is a need on the segment. If a segment has some level of initial need (besides None) and also has a crash hot spot, no adjustment to the need level should be made.

There are two crash hot spots on I-40 East, but as these segments are already identified as having needs, no further adjustment was made to the need level.

Recently Completed and Under-Construction Projects
ADOT provided information on potentially relevant recently completed and under-construction projects that were not previously reflected in the baseline performance data. This includes any projects completed or under construction after 2014 that have the potential to mitigate a safety need on a corridor segment. If a recently completed or under-construction project has a high likelihood to improve or address a performance need, the level of need for that segment was decreased.

There are two potentially relevant recently completed projects identified on the I-40 East corridor; these improvements include reconstruction of the roadway between milepost 205 to 208 and inlaid pavement markings were incorporated between mileposts 217.9-221.0 in 2015. Although both of these improvements would have some impact on crashes, it is assumed that the previous crashes do not have a direct correlation to these improvements and no futher adjustment was made to the need level.

Planned or Programmed Projects
Information was noted on safety-related planned and programmed projects and other issues identified in previous reports in Working Paper No. 1. Planned and programmed projects and identified issues do not influence the level of need, but were documented for future reference in developing solutions that address identified needs.

Table 12: Refined Safety Needs (Step 2)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Need	Hot Spots	Relevant Recently Completed or Under Construction Projects (which supersede performance data)*	Final Need	Comments (may include tentatively programmed projects with potential to address need or other relevant issues identified in previous reports)
40-1	6	196-202	High	WB Hotspot in East Flagstaff area: MP 198-199		High	No programmed project with potential to address need DCR recommended realignment and rockfall mitigation near 4th St, and CCTV at Butler TI, and Country Club TI
40-2	10	202-212	High	EB Hotspot near Winona area: MP 210-212	Reconstruct roadway including reprofiling vertical curves from MP 205 to 208 in 2010.	High	No programmed project with potential to address need. Reprofiling may have addressed some of the need prior to 2010. DCR recommended realignment near Cosnino TI; CCTV at Walnut Canyon TI, Cosnino TI, and Winona TI; and partial interchange lighting at Walnut Canton TI, Cosnino TI and Winona TI
40-3	22	212-234	High	None	Inlaid Pavement Markings MP 217.9-221.0 in 2015	High	Programmed: Twin Arrows TI and Canyon Diablo Bridge Deck Rehabilitations
40-4	12	234-246	None	None		None	No Identified Need
40-5	12	246-258	Low	None		Low	No programmed project with potential to address need
40-6	12	258-270	High	None		High	Programmed: Cottonwood Bridge Deck Rehabilitation; Pavement Preservation Project MP 268-278

Table 12: Refined Safety Needs (Step 2) (Continued)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Need	Hot Spots	Relevant Recently Completed or Under Construction Projects (which supersede performance data)*	Final Need	Comments (may include tentatively programmed projects with potential to address need or other relevant issues identified in previous reports)
40-7	16	270-286	Low	None		Low	Programmed: Pavement Preservation Project MP 268-278; Rockfall Mitigation Project MP 279.2-279.7
40-8	4	286-290	Low	None		Low	No programmed project with potential to address need
40-9	14	290-304	Low	None		Low	Programmed: Pavement Preservation Project MP 297-303; Sign Rehabilitation Project beginning at MP 297
40-10	22	304-326	Low	None		Low	No programmed project with potential to address need
40-11	16	326-342	Low	None		Low	No programmed project with potential to address need
40-12	17.63	342-359.63	Medium	None		Medium	Programmed: Pavement Preservation Project MP 354-360

6.3 Step 3: Safety Contributing Factors

As described in Section 2.3, Step 3 identifies potential contributing factors to the performance needs calculated in Step 2. These contributing factors provide information on what types of improvements may help improve performance. Contributing factors can be derived from:

- Hot spot crash summaries
- Previously completed safety-related projects
- District input on safety concerns
- Segment crash type summaries
- Section 6.2 of the 2010 Highway Safety Manual

Hot Spot Crash Summaries

Crash summaries were developed for each identified crash hot spot to identify observable crash patterns. These crash summaries are based on crashes of all severity levels (not just fatal and incapacitating injury) to provide more information for use in identifying crash patterns.

Previously Completed Safety-Related Projects

Recently completed safety-related projects may provide insight into previously identified contributing factors along the corridor. Some recently completed safety-related projects may already address some of the crash patterns evident in the crash analysis. Other safety-related projects completed before the crash analysis time period (i.e., more than five years old) may have exceeded their respective design life and rehabilitation or replacement could increase their effectiveness. Examples include rumble strips that are worn down or retroreflective materials that have lost their retroreflectivity.

District Input on Safety Concerns

ADOT maintenance personnel provided information on locations where they had observed potential safety needs. Locations were defined by approximate milepost limits and assigned to the appropriate corridor segment. District safety concerns that corroborated the segment crash type summaries or crash hot spots summaries were noted.

Segment Crash Type Summaries

Crash frequencies for each possible crash type descriptor within each of the eight crash type summary categories were summarized for fatal and incapacitating injury crashes for each corridor segment that contained at least five crashes of that crash type descriptor (lower crash totals were not considered to have a sufficient sample size for analysis purposes). For an even more robust data set, crash types for crashes of all severity levels (not just fatal and incapacitating injury) can be reviewed to determine if crash patterns are readily identifiable. If this more detailed analysis is conducted, it is recommended that it only be conducted on segments with medium or high levels of need to minimize analysis effort.

The proportional occurrence of each possible crash type descriptor compared to the total number of fatal plus incapacitating injury crashes occurring in that respective segment was also calculated and expressed as a percentage. These segment-level crash type descriptor frequency percentages were then compared with the corresponding statewide crash type descriptor frequency percentages for all state highways with similar operating environments (as defined in the baseline corridor performance in Working Paper #2). Segment crash type descriptor frequency percentages that exceeded the corresponding statewide frequency percentage were identified as likely contributing factors to the level of need (illustrated with a red font). The crash type descriptors include the following components:

- First Harmful Event Type
  - Collision with Motor Vehicle
  - Overturning
  - Collision with Pedestrian
  - Collision with Pedalcyclist
  - Collision With Animal
  - Collision with Fixed Object
  - Collision with Non-Fixed Object
  - Vehicle Fire or Explosion
  - Other Non-Collision
  - Unknown
- Collision Type
  - Single Vehicle Collisions
  - Angle
  - Left Turn
  - Rear End
  - Head On
  - Sideswipe (same)
  - Sideswipe (opposite)
  - Rear to Side
  - Rear to Rear
  - Other
  - Unknown
- Violation or Behavior Type
  - No Improper Action
  - Speed too Fast for Conditions
  - Exceeded Lawful Speed
  - Failure to Yield Right-of-Way
  - Followed Too Closely
  - Ran Stop Sign
  - Disregarded Traffic Signal
  - Made Improper Turn
  - Drove in Opposing Lane
  - Faulty/Missing Equipment
  - Motorcycle Safety Equipment Use
  - Passed in No Passing Zone
  - Unsafe Lane Change
  - Failure to Keep in Proper Lane
  - Other Unsafe Passing
  - Inattention/Distraction
  - Electronic Communications Device
  - Other
- Type of Lighting Conditions
  - Daylight
  - Dawn
  - Dusk
  - Dark-Lighted
  - Dark-Unlighted
  - Dark-Unknown Lighting
- Type of Road Surface Conditions
  - Dry
  - Wet
  - Snow
  - Slush
  - Ice/Frost
  - Water (standing or moving)
  - Sand
  - Mud, Dirt, Gravel
  - Oil
  - Other
  - Unknown
- First Unit Event Description
  - Collision with Animal
  - Collision with Fixed Object
  - Ran Off the Road (Left)
  - Ran Off the Road (Right)
  - Crossed Centerline
  - Crossed Median
  - Collision with Pedestrian
  - Motor Vehicle in Transport
  - Overturn
  - Equipment Failure
  - Collision with Falling Object
  - Other Non-Collision
  - Other Non-Fixed Object
  - Unknown
- Driver Physical Condition
  - Under the Influence of Drugs or Alcohol
  - Fatigued/Fell Asleep
  - No Apparent Influence
  - Had Been Drinking
  - Medications
  - Illness
  - Physical Impairment
  - Other
  - Unknown
- Safety Device Usage
  - Shoulder and Lap Belt
  - Child Restraint System
  - None Used
  - Helmet Used
  - Air Bag Deployed/Shoulder-Lap Belt

- Air Bag Deployed
- Other
- Unknown
- Not Applicable
- Lap Belt
- Not Reported

Section 6.2 of the 2010 Highway Safety Manual

Section 6.2 of the *2010 Highway Safety Manual* (HSM) provides potential contributing factors for corresponding crash types and patterns. Crash patterns within the corridor that match crash patterns in the HSM can reasonably be expected to have similar potential contributing factors to those listed in the HSM.

Safety Needs Contributing Factors

Likely contributing factors were developed based on the information obtained through the hot spot crash summaries, previously completed safety-related projects, District input on safety concerns, segment crash type summaries, and HSM potential contributing factors. These contributing factors provide guidance on the types of solutions that will likely promote improved safety performance. **Table 13** summarizes the likely contributing factors to safety needs on the I-40 East corridor.

Table 13: Safety Contributing Factors (Step 3)

Segment Number		40-1	40-2	40-3	40-4	40-5	40-6	40-7	40-8	40-9	40-10	40-11	40-12	Corridor-Wide Crash Characteristics
Segment Length (miles)		6	10	22	12	12	12	16	4	14	22	16	17.63	
Segment Milepost (MP)		196-202	202-212	212-234	234-246	246-258	258-270	270-286	286-290	290-304	304-326	326-342	342-359.63	
Final Need		High	High	High	None	Low	High	Low	Low	Low	Low	Low	Medium	
Segment Crash Overview		7 Crashes were fatal	6 Crashes were fatal	9 Crashes were fatal	0 Crashes were fatal	2 Crashes were fatal	4 Crashes were fatal	1 Crashes were fatal	1 Crashes were fatal	1 Crashes were fatal	4 Crashes were fatal	3 Crashes were fatal	7 Crashes were fatal	45 Crashes were fatal
		6 Crashes had incapacitating injuries	11 Crashes had incapacitating injuries	10 Crashes had incapacitating injuries	4 Crashes had incapacitating injuries	4 Crashes had incapacitating injuries	7 Crashes had incapacitating injuries	4 Crashes had incapacitating injuries	3 Crashes had incapacitating injuries	8 Crashes had incapacitating injuries	11 Crashes had incapacitating injuries	5 Crashes had incapacitating injuries	4 Crashes had incapacitating injuries	77 Crashes had incapacitating injuries
		0 Crashes involve trucks	1 Crashes involve trucks	4 Crashes involve trucks	1 Crashes involve trucks	2 Crashes involve trucks	2 Crashes involve trucks	0 Crashes involve trucks	0 Crashes involve trucks	1 Crashes involve trucks	4 Crashes involve trucks	0 Crashes involve trucks	1 Crashes involve trucks	16 Crashes involve trucks
		0 Crashes involve Motorcycles	0 Crashes involve Motorcycles	1 Crashes involve Motorcycles	0 Crashes involve Motorcycles	0 Crashes involve Motorcycles	0 Crashes involve Motorcycles	1 Crashes involve Motorcycles	0 Crashes involve Motorcycles	1 Crashes involve Motorcycles	1 Crashes involve Motorcycles	0 Crashes involve Motorcycles	0 Crashes involve Motorcycles	4 Crashes involve Motorcycles
Segment Crash Summaries (Fatal and Serious Injury Crashes)	First Harmful Event Type	38% Involve Overturning	45% Involve Overturning	42% Involve Overturning	N/A - Sample size too small	50% Involve Overturning	73% Involve Overturning	60% Involve Overturning	N/A - Sample size too small	56% Involve Overturning	53% Involve Overturning	75% Involve Overturning	36% Involve Overturning	52% Involve Overturning
		31% Involve Collision with Pedestrian	27% Involve Collision with Fixed Object	32% Involve Collision with Motor Vehicle		50% Involve Collision with Pedalcyclist	18% Involve Collision with Fixed Object	40% Involve Collision with Motor Vehicle		33% Involve Collision with Motor Vehicle	20% Involve Collision with Motor Vehicle	13% Involve Collision with Fixed Object	27% Involve Collision with Pedestrian	17% Involve Collision with Motor Vehicle
		15% Involve Other Non-Collision	9% Involve Collision with Motor Vehicle	16% Involve Collision with Fixed Object			9% Involve Other Non-Collision			11% Involve Collision with Fixed Object	7% Involve Vehicle Fire or Explosion	13% Involve Other Non-Collision	18% Involve Collision with Motor Vehicle	11% Involve Collision with Fixed Object
	Collision Type	46% Involve Single Vehicle	73% Involve Single Vehicle	63% Involve Single Vehicle	N/A - Sample size too small	50% Involve Single Vehicle	100% Involve Single Vehicle	60% Involve Single Vehicle	N/A - Sample size too small	67% Involve Single Vehicle	73% Involve Single Vehicle	100% Involve Single Vehicle	55% Involve Single Vehicle	70% Involve Single Vehicle
		31% Involve Other	9% Involve Head On	21% Involve Rear End		50% Involve Sideswipe (same)		20% Involve Angle		22% Involve Rear End	13% Involve Rear End		27% Involve Other	11% Involve Other
		8% Involve Head On	9% Involve Sideswipe (same)	5% Involve Head On				20% Involve Rear End		11% Involve Other	7% Involve Sideswipe (same)		9% Involve Angle	9% Involve Rear End
	Violation or Behavior	15% Involve No Improper Action	27% Involve Speed too Fast for Conditions	37% Involve Inattention/ Distraction	N/A - Sample size too small	50% Involve Failure to Keep in Proper Lane	55% Involve Speed too Fast for Conditions	40% Involve Speed too Fast for Conditions	N/A - Sample size too small	22% Involve Speed too Fast for Conditions	27% Involve Failure to Keep in Proper Lane	50% Involve Failure to Keep in Proper Lane	55% Involve Unknown	26% Involve Speed too Fast for Conditions
		15% Speed too Fast for Conditions	18% Involve Inattention/Distraction	26% Involve Speed too Fast for Conditions		50% Involve Inattention/ Distraction	27% Involve Inattention/Distraction	20% Involve Followed Too Closely		22% Involve Failure to Keep in Proper Lane	20% Involve Speed too Fast for Conditions	38% Involve Speed too Fast for Conditions	18% Involve Speed too Fast for Conditions	20% Involve Inattention/Distraction
		15% Inattention/ Distraction	9% Involve Drove in Opposing Lane	5% Involve Drove in Opposing Lane			18% Involve Exceeded Lawful Speed	20% Involve Drove in Opposing Lane		22% Involve Inattention/Distraction	13% Involve No Improper Action	13% Involve Unknown	9% Involve Failure to Keep in Proper Lane	16% Involve Failure to Keep in Proper Lane

Table 13: Safety Contributing Factors (Step 3) (Continued)

	Segment Number	40-1	40-2	40-3	40-4	40-5	40-6	40-7	40-8	40-9	40-10	40-11	40-12	Corridor-Wide Crash Characteristics
	Segment Length (miles)	6	10	22	12	12	12	16	4	14	22	16	17.63	
	Segment Milepost (MP)	196-202	202-212	212-234	234-246	246-258	258-270	270-286	286-290	290-304	304-326	326-342	342-359.63	
	Final Need	High	High	High	None	Low	High	Low	Low	Low	Low	Low	Medium	
Segment Crash Summaries (Fatal and Serious Injury Crashes)	Lighting Conditions	69% Occur in Dark-Unlighted Conditions 23% Occur in Daylight Conditions 8% Occur in Dusk Conditions	64% Occur in Dark-Unlighted Conditions 27% Occur in Daylight Conditions 9% Occur in Dusk Conditions	58% Occur in Daylight Conditions 37% Occur in Dark-Unlighted Conditions 5% Occur in Dark-Lighted Conditions	N/A - Sample size too small	50% Occur in Dawn Conditions 50% Occur in Dark-Unknown Lighting	73% Occur in Daylight Conditions 18% Occur in Dark-Unlighted Conditions 9% Occur in Dusk Conditions	100 % Occur in Daylight Conditions	N/A - Sample size too small	56% Occur in Daylight Conditions 44% Occur in Dark-Unlighted Conditions	60% Occur in Daylight Conditions 40% Occur in Dark-Unlighted Conditions	38% Occur in Dark-Unlighted Conditions 13% Occur in Dawn Conditions 13% Occur in Dusk Conditions	27% Occur in Daylight Conditions 27% Dark-Unknown Lighting 18% Occur in Dawn Conditions	50% Occur in Daylight Conditions 38% Occur in Dark-Unlighted Conditions 4% Occur in Dawn Conditions
	Surface Conditions	85% Involve Dry Conditions 15% Involve Ice/Frost Conditions	73% Involve Dry Conditions 18% Involve Wet Conditions 9% Involve Snow Conditions	89% Involve Dry Conditions 5% Involve Slush Conditions 5% Ice/Frost	N/A - Sample size too small	100 % Involve Dry Conditions	82% Involve Dry Conditions 9% Involve Wet Conditions 9% Involve Slush Conditions	80% Involve Dry Conditions 20% Involve Slush Conditions	N/A - Sample size too small	100 % Involve Dry Conditions	93% Involve Dry Conditions 7% Involve Ice/Frost Conditions	75% Involve Dry Conditions 13% Involve Slush Conditions 13% Involve Ice/Frost Conditions	45% Involve Dry Conditions 36% Involve Unknown Conditions 18% Involve Snow Conditions	82% Involve Dry Conditions 6% Involve Ice/Frost Conditions 3% Involve Wet Conditions
	First Unit Event	38% Involve a first unit event of Ran Off the Road (Left)	45% Involve a first unit event of Ran Off the Road (Left)	42% Involve a first unit event of Ran Off the Road (Left)	N/A - Sample size too small	50% Involve a first unit event of Ran Off the Road (Left)	45% Involve a first unit event of Ran Off the Road (Left)	60% Involve a first unit event of Ran Off the Road (Left)	N/A - Sample size too small	44% Involve a first unit event of Ran Off the Road (Left)	33% Involve a first unit event of Ran Off the Road (Left)	63% Involve a first unit event of Ran Off the Road (Left)	27% Involve a first unit event of Ran Off the Road (Left)	43% Involve a first unit event of Ran Off the Road (Left)

Table 13: Safety Contributing Factors (Step 3) (Continued)

Segment Number		40-1	40-2	40-3	40-4	40-5	40-6	40-7	40-8	40-9	40-10	40-11	40-12	Corridor-Wide Crash Characteristics
Segment Length (miles)		6	10	22	12	12	12	16	4	14	22	16	17.63	
Segment Milepost (MP)		196-202	202-212	212-234	234-246	246-258	258-270	270-286	286-290	290-304	304-326	326-342	342-359.63	
Final Need		High	High	High	None	Low	High	Low	Low	Low	Low	Low	Medium	
Segment Crash Summaries (Fatal and Serious Injury Crashes)		31% Involve a first unit event of Motor Vehicle in Transport 15% Involve a first unit event of Crossed Median	27% Involve a first unit event of Ran Off the Road (Right) 18% Involve a first unit event of Motor Vehicle in Transport	26% Involve a first unit event of Motor Vehicle in Transport 16% Involve a first unit event of Ran Off the Road (Right)		50% Involve a first unit event of Motor Vehicle in Transport	18% Involve a first unit event of Ran Off the Road (Right) 18% Involve a first unit event of Other Non-Collision	20% Involve a first unit event of Ran Off the Road (Right) 20% Involve a first unit event of Motor Vehicle in Transport		33% Involve a first unit event of Motor Vehicle in Transport 11% Involve a first unit event of Ran Off the Road (Right)	20% Involve a first unit event of Ran Off the Road (Right) 20% Equipment Failure	38% Involve a first unit event of Ran Off the Road (Right)	9% Involve a first unit event of Crossed Centerline 9% Involve a first unit event of Collision with Pedestrian	22% Involve a first unit event of Motor Vehicle in Transport 15% Involve a first unit event of Ran Off the Road (Right)
	Driver Physical Condition	46% Under the Influence of Drugs or Alcohol 38% No Apparent Influence 15% Unknown	27% Under the Influence of Drugs or Alcohol 9% Fatigued/Fell Asleep 9% Medications	53% No Apparent Influence 16% Under the Influence of Drugs or Alcohol 16% Fatigued/Fell Asleep	N/A - Sample size too small	50% Under the Influence of Drugs or Alcohol 50% No Apparent Influence	45% Unknown 18% Under the Influence of Drugs or Alcohol 9% Fatigued/Fell Asleep	60% No Apparent Influence 40% Fatigued/Fell Asleep	N/A - Sample size too small	44% No Apparent Influence 33% Under the Influence of Drugs or Alcohol 22% Unknown	40% No Apparent Influence 20% Under the Influence of Drugs or Alcohol 20% Fatigued/Fell Asleep	38% Fatigued/Fell Asleep 38% No Apparent Influence 13% Under the Influence of Drugs or Alcohol	73% Unknown 27% No Apparent Influence	43% No Apparent Influence 22% Unknown 21% Under the Influence of Drugs or Alcohol
	Safety Device Usage	38% None Used 38% Not Applicable 15% Shoulder And Lap Belt Used	64% Shoulder And Lap Belt Used 18% Not Applicable 9% None Used	53% Shoulder And Lap Belt Used 16% Air Bag Deployed/Shoulder-Lap Belt 11% None Used	N/A - Sample size too small	50% None Used 50% Helmet Used	73% Shoulder And Lap Belt Used 27% None Used	40% Shoulder And Lap Belt Used 20% Air Bag Deployed	N/A - Sample size too small	44% Shoulder And Lap Belt Used 22% None Used 22% Unknown	67% Shoulder And Lap Belt Used 13% None Used 7% Air Bag Deployed	63% None Used 38% Shoulder And Lap Belt Used	27% Shoulder And Lap Belt Used 18% None Used 18% Air Bag Deployed/Shoulder-Lap Belt	48% Shoulder And Lap Belt Used 26% None Used 10% Not Applicable
Hot Spot Crash Summaries		WB Hotspot in East Flagstaff area: MP 198-199	EB Hotspot near Winona area: MP 210-212	None	None	None	None	None	None	None	None	None	None	
Previously Completed Safety-Related Projects		None	Reconstruct roadway including reprofiling vertical curves from MP 205 to 208 in 2010.	Inlaid Pavement Markings MP 217.9-221.0 in 2015	None	None	None	None	None	None	None	None	None	

Table 13: Safety Contributing Factors (Step 3) (Continued)

Segment Number	40-1	40-2	40-3	40-4	40-5	40-6	40-7	40-8	40-9	40-10	40-11	40-12	Corridor-Wide Crash Characteristics
Segment Length (miles)	6	10	22	12	12	12	16	4	14	22	16	17.63	
Segment Milepost (MP)	196-202	202-212	212-234	234-246	246-258	258-270	270-286	286-290	290-304	304-326	326-342	342-359.63	
Final Need	High	High	High	None	Low	High	Low	Low	Low	Low	Low	Medium	
District Interviews/ Discussions													
Contributing Factors	● Urban operating conditions ● Overturning ● Shoulder/rumble strip condition ● Slippery/wet pavement surface ● Debris in roadway ● Roadway departure ● Lack of nighttime lighting ● Crossed Median ● Pedestrian ● Driving Under the Influence ● Lack of restraint usage ● Work Zone ● Objects fallen or thrown from 4th Street bridge	● Shoulder/rumble strip condition ● Slippery/wet pavement surface ● Lack of nighttime lighting ● Driving Under the Influence ● Wild Game Animals ● Roadway departure ● Driving Under the Influence ● Work Zone Comment: Reprofiling vertical curves from MP 205 to 208 in 2010 may have helped to address safety need.	● Driver inattention/distraction ● Slippery/wet pavement surface ● Lack of nighttime lighting ● Roadway departure ● Driving fatigued / fell asleep ● Casino and landmark attractions Comment: Programmed pavement preservation project may help address safety need	N/A - Sample size too small	● Overturning ● Improper lane changes ● Roadway departure ● Driver inattention/distraction ● Bicyclist ● Lack of nighttime lighting ● Driving Under the Influence ● Lack of restraint usage	● Overturning ● Speed too fast for conditions ● Driver inattention/distraction ● Slippery/wet pavement surface ● Roadway departure ● Shoulder/rumble strip condition ● Pavement surface condition Comment: Programmed pavement preservation and bridge deck replacement projects may help address safety need	● Overturning ● Speed too fast for conditions ● Slippery/wet pavement surface ● Roadway departure ● Driving fatigued / fell asleep	N/A - Sample size too small	● Overturning ● Driver inattention/distraction ● Improper lane changes ● Lack of nighttime lighting ● Roadway departure ● Driving Under the Influence	● Overturning ● Improper lane changes ● Slippery/wet pavement surface ● Lack of nighttime lighting ● Roadway departure ● Driving fatigued / fell asleep	● Overturning ● Improper lane changes ● Slippery/wet pavement surface ● Lack of nighttime lighting ● Roadway departure ● Driving fatigued / fell asleep ● Lack of restraint usage	● Improper lane changes ● Pedestrian ● Slippery/wet pavement surface ● Lack of nighttime lighting ● Cross winds ● Pavement Surface Condition ● Objects fallen or thrown from Allentown bridge ● Roadway geometry - curves ● Merging vehicles Comment: Programmed pavement preservation project may help address safety need	

7.0 FREIGHT PERFORMANCE AREA NEEDS

The following sections describe the first three steps of the five-step needs assessment process described in Section 2 for the I-40 East corridor for the Freight Performance Area. The detailed methodology for performing Steps 1-3 is provided in the **Appendix**.

7.1 Step 1: Initial Freight Needs

The baseline performance scores (from Working Paper No. 2) and performance objectives (from Working Paper No. 3) for the I-40 East corridor were used to determine the initial freight needs, as described in Section 2.1. Step 1 uses the scores for the Freight Index primary performance measure and four secondary performance measures to determine the initial level of need by segment for each performance measure individually as well as for all performance measures combined. The four secondary performance measures are Directional Truck Travel Time Index (TTTI), Directional Truck Planning Time Index (TPTI), Directional Closure Duration, and Bridge Vertical Clearance. The performance scores, performance objectives, and initial levels of need for each freight performance measure and for all freight performance measures combined are shown in **Table 14**.

The initial need for all freight performance measures represents a weighted sum of individual freight performance measure levels of need. The initial need for a given segment may subsequently be modified (in Step 2) considering Vertical Clearance Hot Spots as well as relevant recently completed or under-construction projects that have or will improve freight performance compared to the baseline performance condition.

Ten of the twelve segments along I-40 East corridor have an initial level of need; nine of those are Low need. Segment 4 has a High level of need, with the segment including a medium or high need in three areas in the eastbound direction.

Table 14: Initial Freight Needs (Step 1)

Segment	Facility Operations	Segment Mileposts (MP)	Segment Length (miles)	Freight Index			Directional TTI (trucks only)					Directional PTI (trucks only)				
				Performance Score	Performance Objective	Level of Need	Performance Score		Performance Objective	Level of Need		Performance Score		Performance Objective	Level of Need	
							EB	WB		EB	WB	EB	WB		EB	WB
40-1	Uninterrupted	196-202	6	0.84	Fair or Better	None	1.05	1.08	Fair or Better	None	None	1.16	1.21	Fair or Better	None	None
40-2	Uninterrupted	202-212	10	0.88	Fair or Better	None	1.02	1.06	Fair or Better	None	None	1.10	1.16	Fair or Better	None	None
40-3	Uninterrupted	212-234	22	0.89	Fair or Better	None	1.03	1.05	Fair or Better	None	None	1.12	1.13	Fair or Better	None	None
40-4	Uninterrupted	234-246	12	0.65	Fair or Better	Medium	1.07	1.06	Fair or Better	None	None	1.90	1.19	Fair or Better	High	None
40-5	Uninterrupted	246-258	12	0.78	Fair or Better	None	1.11	1.09	Fair or Better	None	None	1.29	1.26	Fair or Better	None	None
40-6	Uninterrupted	258-270	12	0.91	Fair or Better	None	1.03	1.03	Fair or Better	None	None	1.11	1.09	Fair or Better	None	None
40-7	Uninterrupted	270-286	16	0.87	Fair or Better	None	1.05	1.04	Fair or Better	None	None	1.15	1.14	Fair or Better	None	None
40-8	Uninterrupted	286-290	4	0.88	Fair or Better	None	1.05	1.02	Fair or Better	None	None	1.17	1.11	Fair or Better	None	None
40-9	Uninterrupted	290-304	14	0.78	Fair or Better	None	1.06	1.06	Fair or Better	None	None	1.28	1.27	Fair or Better	None	None
40-10	Uninterrupted	304-326	22	0.87	Fair or Better	None	1.04	1.04	Fair or Better	None	None	1.15	1.13	Fair or Better	None	None
40-11	Uninterrupted	326-342	16	0.85	Fair or Better	None	1.04	1.05	Fair or Better	None	None	1.18	1.18	Fair or Better	None	None
40-12	Uninterrupted	342-359.63	17.63	0.88	Fair or Better	None	1.03	1.04	Fair or Better	None	None	1.13	1.15	Fair or Better	None	None
Emphasis Area?	No	Weighted Average		0.84	Fair or Better	None										

Table 14: Initial Freight Needs (Step 1) (Continued)

Segment	Facility Operations	Segment Mileposts (MP)	Segment Length (miles)	Directional Closure Duration (minutes/mile/year)					Bridge Vertical Clearance (feet)			Initial Need
				Performance Score		Performance Objective	Level of Need		Performance Score	Performance Objective	Level of Need	
				EB	WB		EB	WB				
40-1	Uninterrupted	196-202	6	240.70	21.10	Fair or Better	High	None	16.23	Fair or Better	Low	Low
40-2	Uninterrupted	202-212	10	211.46	76.44	Fair or Better	High	Low	16.03	Fair or Better	Medium	Low
40-3	Uninterrupted	212-234	22	219.43	26.30	Fair or Better	High	None	16.52	Fair or Better	None	Low
40-4	Uninterrupted	234-246	12	191.15	43.57	Fair or Better	High	None	16.85	Fair or Better	None	High
40-5	Uninterrupted	246-258	12	107.58	41.57	Fair or Better	Medium	None	16.32	Fair or Better	Low	Low
40-6	Uninterrupted	258-270	12	23.77	0.00	Fair or Better	None	None	No UP	Fair or Better	None	None
40-7	Uninterrupted	270-286	16	3.09	15.64	Fair or Better	None	None	16.09	Fair or Better	Medium	Low
40-8	Uninterrupted	286-290	4	4.75	3.60	Fair or Better	None	None	16.87	Fair or Better	None	None
40-9	Uninterrupted	290-304	14	27.63	81.13	Fair or Better	None	Low	16.16	Fair or Better	Medium	Low
40-10	Uninterrupted	304-326	22	42.22	26.00	Fair or Better	None	None	16.02	Fair or Better	Medium	Low
40-11	Uninterrupted	326-342	16	25.81	16.89	Fair or Better	None	None	16.00	Fair or Better	Medium	Low
40-12	Uninterrupted	342-359.63	17.63	25.54	36.65	Fair or Better	None	None	16.06	Fair or Better	Medium	Low

7.2 Step 2: Refined Freight Needs

Once the initial freight needs by segment for the I-40 East corridor were established, they were then refined in Step 2 as described in Section 2.2 to more accurately reflect existing needs. An evaluation of vertical clearance hot spots as well as relevant recently completed and under-construction projects was performed to determine if segment need levels required adjustment. The initial needs were then refined based on this assessment to determine the final need for each segment. Planned and programmed future projects and other issues identified in previous reports were noted for future reference in developing solutions that address identified needs. The Step 2 process is described in more detail below and summarized in **Table 15**.

Vertical Clearance Hot Spots

Bridges that provide less than 16.25 feet of vertical clearance above the corridor mainline through lanes and that cannot be ramped around are considered vertical clearance hot spots. If a segment has an initial need level of None but contains a vertical clearance hot spot, the need level should be adjusted to Low to indicate there is a need on the segment. If a segment has some level of initial need (besides None) and also has a vertical clearance hot spot, no adjustment to the need level should be made. There are no vertical clearance hot spots on I-40 East so no adjustment was made to need levels.

Recently Completed and Under-Construction Freight Projects

ADOT provided information on potentially relevant recently completed and under-construction projects that were not previously reflected in the baseline performance data. This includes any projects completed or under construction after 2014 that have the potential to mitigate a freight need on a corridor segment. If a recently completed or under-construction project has a high likelihood to improve or address a performance need, the level of need for that segment was decreased.

Two relevant projects were identified: DMS signs were installed in Segment 1 and 11. It was determined that these projects likely will not modify performance and as such are not expected to modify the current level of need.

Planned or Programmed Projects

Information was noted on freight-related planned and programmed projects and other issues identified in previous reports in Working Paper No. 1. Planned and programmed projects and identified issues do not influence the level of need, but were documented for future reference in developing solutions that address identified needs.

Table 15: Refined Freight Needs (Step 2)

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Need	Truck Height Restriction Hot Spots (Clearance < 16')	Relevant Recently Completed or Under Construction Projects (which supersede performance data)*	Final Need	Comments (may include tentatively programmed projects with potential to address needs or other relevant issues identified in previous reports)
40-1	6	196-202	Low	None	DMS installed at MP 197.56 WB	Low	Westbound DMS proposed in Master Plan between 4th St. and Country Club Install DMS on westbound I-40 at MP 197.5, 200, and 204 (DCR)
40-2	10	202-212	Low	None	None	Low	DCR recommended realignment near Cosnino TI, elimination of loop ramp, and lowering the mainline
40-3	22	212-234	Low	None	None	Low	
40-4	12	234-246	High	None	None	High	
40-5	12	246-258	Low	None	None	Low	
40-6	12	258-270	None	None	None	None	
40-7	16	270-286	Low	None	None	Low	
40-8	4	286-290	None	None	None	None	
40-9	14	290-304	Low	None	None	Low	
40-10	22	304-326	Low	None	None	Low	
40-11	16	326-342	Low	None	DMS installed at MP 340.44 WB	Low	
40-12	17.63	342-359.63	Low	None	None	Low	

7.3 Step 3: Freight Contributing Factors

As described in Section 2.3, Step 3 identifies potential contributing factors to the performance needs calculated in Step 2. These contributing factors provide information on what types of improvements may help improve performance. Contributing factors include:

- Roadway variables
- Traffic variables
- Relevant freight-related existing infrastructure
- Closure type
- Non-actionable conditions

Roadway Variables

Roadway variables include functional classification, environmental type (e.g., urban, rural), terrain, number of lanes, speed limit, presence of auxiliary lanes, if a roadway is divided or non-divided, and how often passing is not allowed. These variables are described in more detail below:

- Functional classification indicates if a roadway is an interstate, state highway, or arterial. Capacity equations and parameters differ depending on a roadway's functional classification.
- Environmental type refers to how developed the land is adjacent to the roadway. Environmental types include urban, fringe urban, and rural. Capacity thresholds differ depending on the environmental type as higher congestion levels are more acceptable in urbanized areas than in rural areas.
- Terrain (described as level, rolling, or mountainous) indicates the general roadway grade, which influences how quickly vehicles can accelerate or decelerate or maintain a constant speed.
- The number of lanes in each direction indicates how many general purpose through lanes exist.
- The speed limit indicates the posted speed limit.
- The presence of auxiliary lanes for turning, weaving, or passing can improve mobility performance by maintaining more consistent speeds in mainline through lanes.
- A roadway is considered divided if it has a raised or depressed median separating the directions of traffic that cannot easily be traversed. A roadway with a painted paved median is considered a non-divided roadway. Dividing a roadway generally increases the roadway capacity.
- The presence of no-passing zones restricts the movement of vehicles around slower-moving vehicles.

Traffic Variables

Traffic variables include existing and future level of service (LOS), percent (%) trucks, and the buffer index (difference between PTI and TTI). The existing and future LOS, percentage of trucks, and buffer index can indicate how well a corridor is performing in terms of overall mobility and why certain segments of a corridor may be performing worse than others.

Existing and Future LOS

The existing and future LOS provide a letter "grade" between "A" and "F" for mobility that is generally reflective of Existing and Future V/C calculations. LOS values of "A", "B", and "C" are generally considered highly acceptable. A LOS value of "D" is generally considered moderately acceptable. LOS values of "E" and "F" are generally considered unacceptable.

Truck Traffic

The amount of truck traffic in a given segment of the corridor can be represented as a percentage of the overall total traffic volume for that specific segment. The truck volume on a corridor can impact overall mobility based on truck travel speed, corridor grades, required inspection points and number of lanes.

Buffer Index

The Buffer Index is calculated by subtracting the segment level TTI value (ratio of peak hour speed to free flow speed) from the segment level PTI value (95th percentile speed). The TTI and PTI values were determined in Working Paper #2. The buffer index expresses the amount of extra time necessary to be on-time 95 percent of the time for any given trip. This calculation provides information on the reliability of a corridor.

Freight-Related Infrastructure

Freight related infrastructure refers to devices or features at specific locations that influence freight performance. Examples include dynamic message signs (DMS), passing lanes, climbing lanes, ports of entry (POE), weigh stations, rest areas, and parking areas.

Closure Type

The relative frequency of types of closures within each segment helps indicate potential causes of freight-related needs. Closure types consist of closures due to an incident/crash, obstruction, or weather condition. The number of each type of closure and the corresponding percentage of all closures that are of each type are noted.

Non-Actionable Conditions

Non-actionable conditions are features or characteristics that result in poor freight performance that cannot be addressed through an engineered solution. Examples include border patrol checkpoints that require all vehicles to slow down or stop for inspection. There are no non-actionable conditions along I-40 East.

Freight Needs Contributing Factors

Table 16 summarizes the potential contributing factors to freight needs on the I-40 East corridor.

Table 16: Freight Contributing Factors (Step 3)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Final Need	Roadway Variables								Traffic Variables					Relevant Freight Related Existing Infrastructure
				Functional Classification	Environmental Type (Urban/Rural)	Terrain	# of Lanes/ Direction	Speed Limit	Aux Lanes	Divided/ Non-Divided	% No Passing	Existing LOS	Future 2035 LOS	% Trucks	NB/EB Buffer Index (TPTI-TTTI)	SB/WB Buffer Index (TPTI-TTTI)	
40-1	196-202	6	Low	Interstate	Urban	Rolling	2	65	No	Divided	0%	A-C	E/F	22%	0.11	0.13	I-17 System Interchange MP 196, Transit Rail Station MP 196, Permanent Traffic Counter MP 196, DMS Sign MP 199
40-2	202-212	10	Low	Interstate	Fringe Urban	Rolling	2	75	No	Divided	0%	A-C	A-C	27%	0.08	0.10	DMS Sign MP 212
40-3	212-234	22	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	17%	0.09	0.08	Road Weather Information MP 229
40-4	234-246	12	High	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	5%	0.83	0.13	Open Rest Area MP 240
40-5	246-258	12	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	23%	0.18	0.17	DMS Sign MP 250, Transit Rail Station MP 254, Road Weather Information MP 256
40-6	258-270	12	None	Interstate	Rural	Level	2	75	No	Divided	0%	A/B	A/B	36%	0.08	0.06	Traffic Counter MP 260, DMS Sign MP 260, Road Weather Information MP 269
40-7	270-286	16	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	22%	0.10	0.10	Traffic Counter MP 275, DMS Sign MP 281
40-8	286-290	4	None	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	A/B	57%	0.12	0.09	None
40-9	290-304	14	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	25%	0.22	0.21	Weigh Station MP 291, DMS Sign MP 295
40-10	304-326	22	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	28%	0.11	0.09	DMS Sign MP 310, Road Weather Information MP 312
40-11	326-342	16	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	38%	0.14	0.13	DMS Sign MP 330, Weigh Station MP 341
40-12	342-359.63	17.63	Low	Interstate	Rural	Rolling	2	75	No	Divided	0%	A/B	C	33%	0.10	0.11	Open Rest Area MP 357, DMS Sign MP 357, Road Weather Information MP 358

Table 16: Freight Contributing Factors (Step 3) (Continued)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Final Need	Closure Extent							Non-Actionable Conditions	Programmed and Planned Projects or Issues from Previous Documents Relevant to Final Need	Contributing Factors
				Total Number of Closures	# Incidents/ Accidents	% Incidents/ Accidents	# Obstructions/ Hazards	% Obstructions/ Hazards	# Weather Related	% Weather Related			
40-1	196-202	6	Low	14	12	86%	0	0%	2	14%	None	Planned DMS between 4th St. and Country Club (WB)	-High EB Freight Closure Need -Elevated Bridge Clearance Need
40-2	202-212	10	Low	19	17	89%	0	0%	2	11%	None		-High EB Freight Closure Need, Elevated for WB -Elevated Bridge Clearance Need -89% of Closure Incidents/Accident Related, 11% Remaining are Weather Related
40-3	212-234	22	Low	26	24	92%	0	0%	2	8%	None		-High EB Freight Closure Need
40-4	234-246	12	High	13	10	77%	0	0%	3	23%	None		-High EB Freight Performance Index Need -High EB Need in PTI -High EB Freight Closure Need -High NB Buffer Performance Need
40-5	246-258	12	Low	19	16	84%	1	5%	2	11%	None		-Elevated EB Freight Closure Need -Elevated Bridge Clearance Need
40-6	258-270	12	None	6	6	100%	0	0%	0	0%	None		-No Reported Performance Need -100% of Closure Incidents/Accident Related
40-7	270-286	16	Low	6	6	100%	0	0%	0	0%	None		-Elevated Bridge Clearance Need -100% of Closure Incidents/Accident Related
40-8	286-290	4	None	2	2	100%	0	0%	0	0%	None		-No Reported Performance Need -100% of Closure Incidents/Accident Related
40-9	290-304	14	Low	13	13	100%	0	0%	0	0%	None		-Elevated WB Freight Closure Need -Elevated Bridge Clearance Need -100% of Closure Incidents/Accident Related
40-10	304-326	22	Low	14	14	100%	0	0%	0	0%	None		-Elevated Bridge Clearance Need -100% of Closure Incidents/Accident Related
40-11	326-342	16	Low	9	9	100%	0	0%	0	0%	None		-Elevated Bridge Clearance Need -100% of Closure Incidents/Accident Related
40-12	342-359.63	17.63	Low	17	16	94%	1	6%	0	0%	None		-Elevated Bridge Clearance Need -94% of Closure Incidents/Accident Related, 6% Remaining are Obstruction Related

8.0 SEGMENT REVIEW (STEP 4)

As part of Step 4, the final needs results for each segment were combined to estimate the average level of need for each segment of I-40 East, as described in Section 2.4. During the Corridor Goals and Objectives process for I-40 East, the Pavement, Bridge and Safety Performance Areas were identified as Emphasis Areas. Therefore, a weighting factor of 1.50 was applied to those needs as discussed in Section 2.4. A summary of the segment needs is shown in **Table 17**. The results in Table 18 can be used to compare the level of need across corridors. **Figure 7** shows the range of segment deficiencies for the I-40 East corridor.

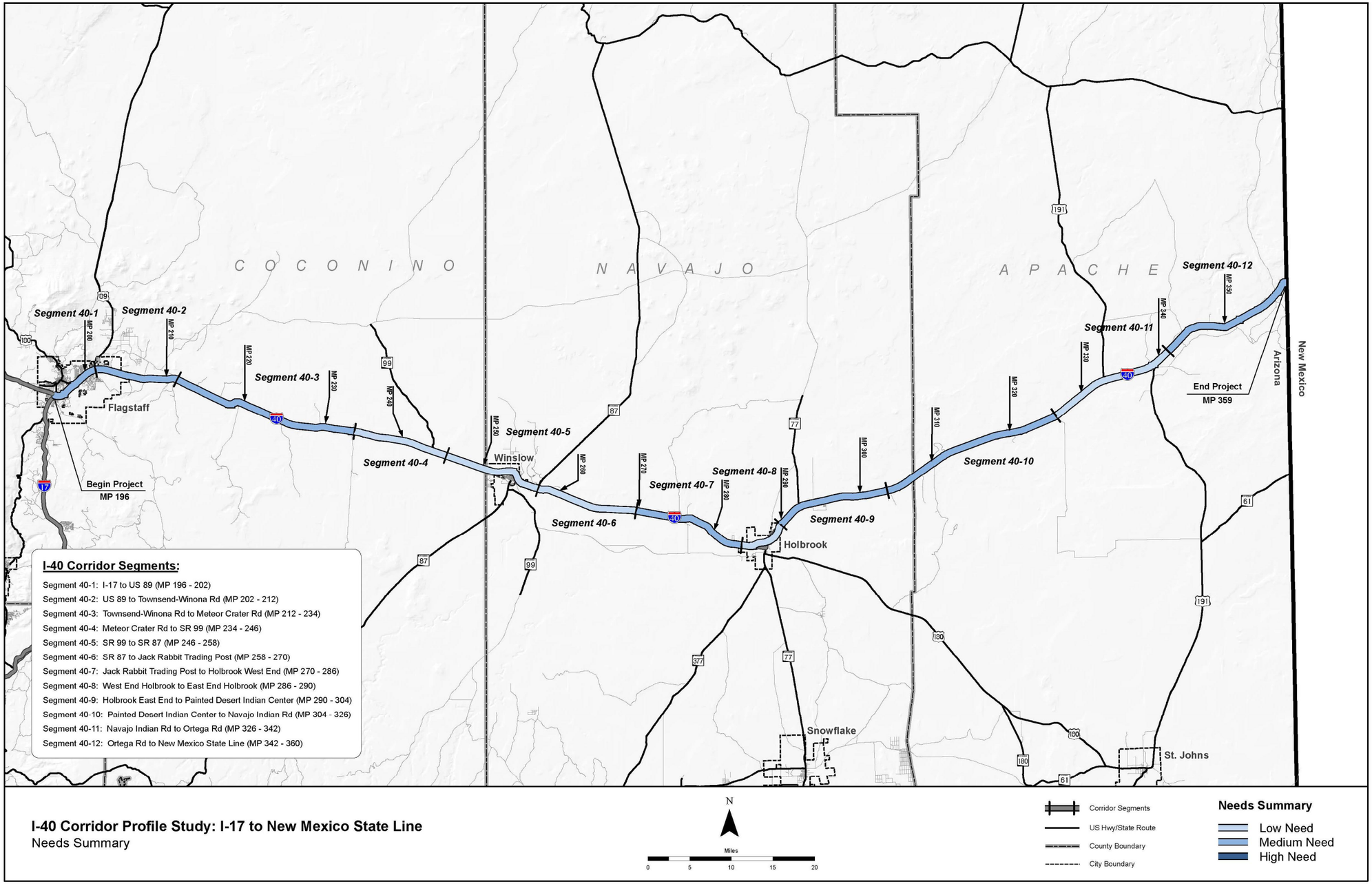
Table 17: Segment Deficiency Summary

Performance Area	40-1	40-2	40-3	40-4	40-5	40-6	40-7	40-8	40-9	40-10	40-11	40-12
	MP 196-202	MP 202-212	MP 212-234	MP 234-246	MP 246-258	MP 258-270	MP 270-286	MP 286-290	MP 290-304	MP 304-326	MP 326-342	MP 342-359.63
Pavement*	None	Low	None	None	None	None	Low	None	Low	None	None	Low
Bridge*	Low	Low	Medium	Low	Low	Low	Medium	Medium	Low	High	Low	Medium
Mobility	Low	Low	Low	Low	Low	None	Low	None	Low	Low	None	Low
Safety*	High	High	High	None	Low	High	Low	Low	Low	Low	Low	Medium
Freight	Low	Low	Low	High	Low	None	Low	None	Low	Low	Low	Low
Average Need (0-3)	1.23	1.46	1.46	0.85	0.77	0.92	1.23	0.69	1.00	1.23	0.62	1.46

***** Identified as Emphasis Area for I-40 East corridor

Deficiency Category	Deficiency Score	Average Deficiency Range
None	0	< 0.1
Low	1	0.1 - 1.0
Medium	2	1.0 - 2.0
High	3	>2.0

Figure 7: Needs Summary



9.0 CORRIDOR NEEDS (STEP 5)

In Step 5, performance-based needs by segment are transformed into corridor needs. Needs are defined as "actionable" to facilitate development of solution sets for strategic investments in preserving, modernizing, and expanding the corridor. The intent of this process is to identify overlapping and common needs to help develop strategic solutions. This step results in the identification of corridor needs by specific location. A summary of the corridor needs is provided below.

Figure 8 shows the corridor needs for each performance area and the programmed projects that have not yet been constructed. For additional details on specific needs, please refer to the information in Sections 3.3, 4.3, 5.3, 6.3, and 7.3.

Pavement Performance Area

The Pavement Performance Area is an Emphasis Area for the I-40 East corridor. Pavement Needs were identified on 9 miles of eastbound I-40 East and 9 miles of westbound I-40 East (5% of corridor) spread throughout the corridor.

- EB MP 202 - 205
- EB MP 274 - 275
- EB MP 276 – 277
- EB MP 278 - 279
- EB MP 297 – 298
- EB MP 302 - 303
- EB MP 350 - 351
- EB MP 354 – 358
- WB MP 270 - 271
- WB MP 273 - 276
- WB MP 282 - 283

Pavement failure hot spots were identified on 4 miles of eastbound I-40 East and 1 mile of westbound I-40 East spread throughout the corridor.

- EB MP 203 - 204
- EB MP 302 - 303
- EB MP 354 - 356
- WB MP 274 - 275

Three pavement rehabilitation projects (MP 268-278, MP 297-303, MP 354-360) are programmed in FY 2020, FY 2016, and FY 2017, respectively (in Current Program). These projects could address approximately 8 miles of the identified need. Key contributing factors/needs are summarized below:

- The eastbound direction of I-40 East appears to have a higher level of performance need which may warrant consideration of alternative treatments on the eastbound roadway.
- A high level of historical investment has occurred on approximately 108 miles (66% of centerline miles) of the corridor (MP 196-212, MP 246-304 and MP 326-360) which may warrant further investigation or alternative solutions.

Bridge Performance Area

The Bridge Performance Area is an Emphasis Area for the I-40 East corridor. Bridge Needs were identified at 43 of the 112 bridges (38%) along the I-40 East corridor.

- Lone Tree Rd OP EB & WB (MP 196.26)
- 4th St. UP EB & WB (MP 199.3)
- Winona TI UP (MP 211.16)
- Canyon Padre Br EB (MP 218.73)
- Twin Arrows TI UP (MP 219.53)
- Babbitts Tank Br WB (MP 224.7)
- Buffalo Range TI OP EB & WB (MP 225.05)
- Canyon Diablo Br EB & WB (MP 229.90)
- Two Guns TI UP (MP 230.45)
- Meteor Crater TI UP (MP 233.7)
- Sunshine BNSF RR OP WB (MP 237.1)
- Meteor City IT OP EB & WB (MP 239.6)
- Leupp TI UP SR 99 (MP 245.39)
- Tucker Flat Br EB (MP 248.99)
- Cottonwood Br EB & WP (MP 259.6)
- Manila Wash Br WB (MP 271.48)
- W Joseph City TI UP (MP 274.76)
- Hunt Rd TI UP (MP 280.64)
- Leroux Wash Br EB (MP 284.31)
- Hermosa Dr UP (MP 288.247)
- E Holbrook TI EB & WB OP (MP 389.8)
- Petrified Forest UP (MP 310.1)
- Painted Desert TI UP (MP 311.57)
- Dead River Bridge EB (MP 316.17)
- Crazy Creek Br WB (MP 323.08)
- Navajo TI UP (MP 325.92)
- McCarroll TI UP (MP 330.0)
- Chambers TI UP (MP 333.41)
- Ortega Rd TI UP (MP 341.81)
- Black Creek Br EB (MP 347.90)
- Houck TI UP (MP 348.16)
- Allentown TI UP (MP 351.35)
- Window Rock TI OP WB (MP 357.53)
- Lupton TI OP EB & WB (MP 359.21)

Five bridge rehabilitation projects are programmed in FY 2016 - FY 2019 (in Current Program) which could address the deficiencies at the 4th St UP (EB & WB), Twin Arrows TI UP, Canyon Diablo Br (EB & WB) and Meteor City TI OP (EB & WB).

Key contributing factors/needs are summarized below:

- 16 bridges have current ratings of one 5.
- 14 bridges have current ratings of multiple 5's.
- 6 bridges have current ratings of 4 or less.
- 30 bridges have current deck ratings of 5 or less.
- 20 bridges have potential repetitive investment issues which may be candidates for life-cycle cost analysis to evaluate alternative solutions.

Mobility Performance Area

Mobility Needs were identified on 132 miles (80%) of the I-40 East corridor.

- MP 196 - 258
- MP 270 - 286
- MP 290 - 326
- MP 342 - 360

Key contributing factors/needs are summarized below:

- Future (2035) travel demand is anticipated to exceed capacity on approximately 4% of corridor, generally in Flagstaff near the I-17 System Interchange.
- A higher than average number of closures due to accidents, incidents, obstructions, or hazards occur from MP 196 to 258 primarily due to weather.
- The lowest trip reliability on corridor is along eastbound I-40 between MP 234 and 246. This segment coincides with closures that may also be due to weather.

Safety Performance Area

The Safety Performance Area is an Emphasis Area for the I-40 East corridor. Safety Needs were identified on 150 miles (92%) of the I-40 East corridor.

- MP 196 - 234
- MP 246 - 360

Key contributing factors/needs are summarized below:

- The highest levels of need have been identified from MP 196 to 234 and from MP 258 to 270.
- Approximately 70% of the crashes along the corridor were Single Vehicle crashes, and 52% involved an overturning vehicle with 43% involves a first unit event of ran off the road (left).
- Approximately 21% of the crashes involved under the influence of drugs or alcohol.
- MP 196-202 and MP 246-258 crashes involved a higher percentage of pedestrian and pedalcyclist crashes than similar operating environments.
- Crash hot spots near MP 198 to 199 westbound and 210 to 212 eastbound may be weather and/or lighting related.

Freight Performance Area

Freight Needs were identified on 148 miles (90%) of the I-40 East corridor.

- MP 196 - 258
- MP 270 - 286
- MP 290 - 360

Key contributing factors/needs are summarized below:

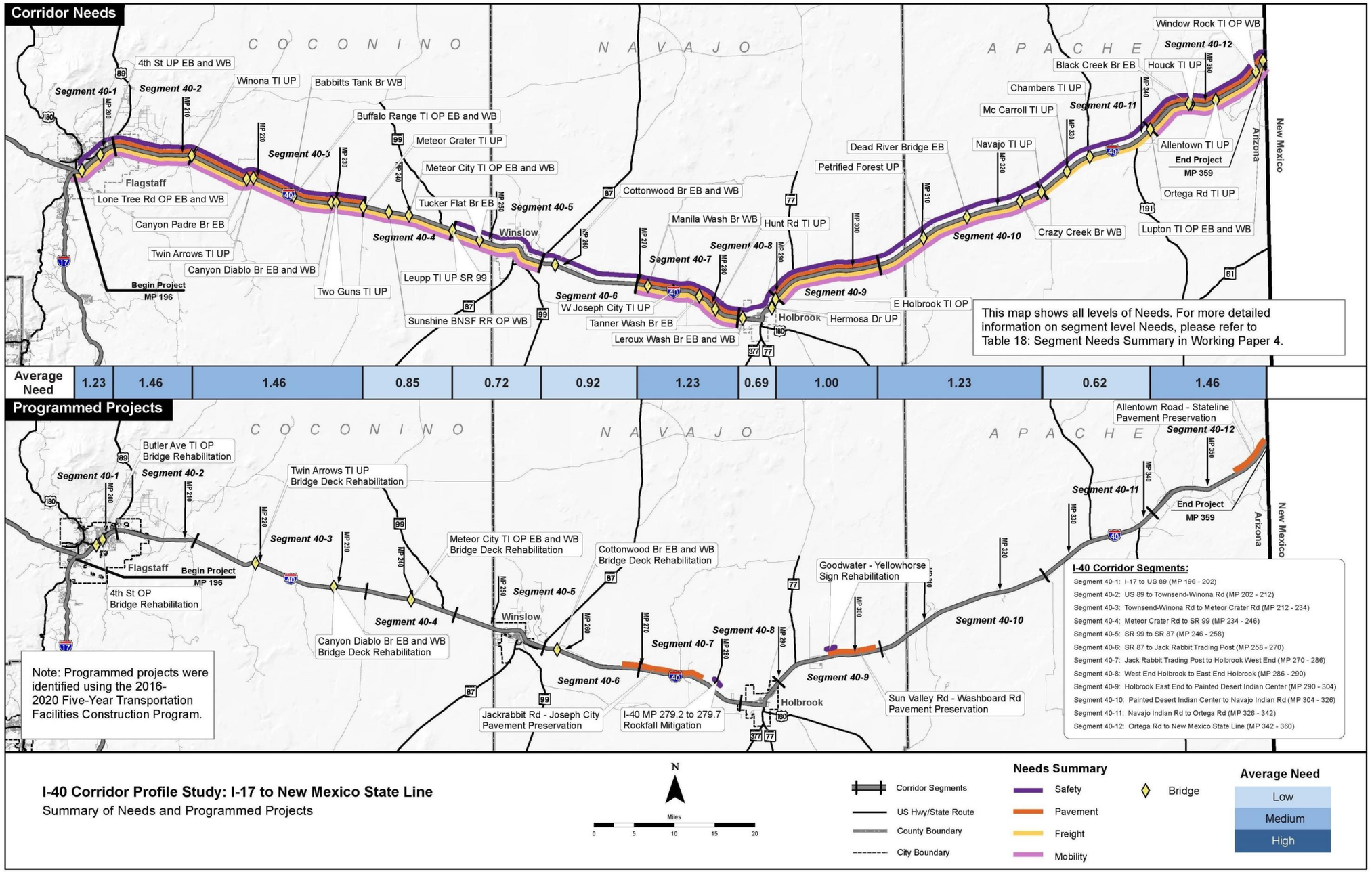
- The highest level of need was identified from MP 234 to 246, this segment was identified to have closure and PTI issues which maybe weather related. ADOT Districts confirmed that this segment of roadway have been closed multiple times due to wind.
- A higher than average number of closures due to accidents, incidents, obstructions, or hazards occurs from MP 196 to 258 primarily due to weather.

Overlapping Needs

This section identifies overlapping performance needs on I-40 East which provides guidance to develop strategic solutions that address more than one performance area. Completing projects that address multiple needs may present the opportunity for cost savings as well as more effectively improving overall performance. The map in Figure 8 shows the extent of overlapping needs along the I-40 East corridor. A summary of the overlapping needs that relate to locations with elevated levels of deficiency is provided below.

- MP 212 to 234 has overlapping needs in the Bridge and Safety performance areas with high and medium levels of needs. The bridge needs include nine bridges, 3 of which have programed projects in FY 16. This area experiences overturning crashes, single-vehicle crashes, and crashes that involve a high percentage of first unit ran off the road (left).
- MP 242 to 360 has overlapping needs in the Bridge and Safety performance areas with medium levels of need in both areas. The bridge needs include six bridges. This area experiences overturning crashes, single-vehicle crashes, and crashes that involve a high percentage of first unit ran off the road (left).

Figure 8: Summary of Needs and Programmed Projects



10.0 NEXT STEPS

The principal objective of the corridor profile study is to identify performance-based strategic solutions (investments) to ensure that available funds result in maximizing the performance of the State's most strategic transportation corridors.

Actionable performance needs documented in Working Paper 4 will serve as a foundation for developing strategic investments for corridor preservation, modernization, and expansion. Strategic investments are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in performance-based programming in the P2P Link process. Rather, strategic investments are intended to complement ADOT‟s traditional project development processes with non-traditional projects to address performance needs in one or a combination of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Strategic investments developed for strategic corridors will be considered along with other candidate projects in the ADOT programming process.

Investment strategies will be developed in Tasks 5-7 of the Corridor Profile Study process. The process includes collaboration with the Technical Advisory Committee and ADOT groups to identify strategic solutions to address corridor needs and to evaluate these alternatives through a systematic analysis of life cycle costs and risks.

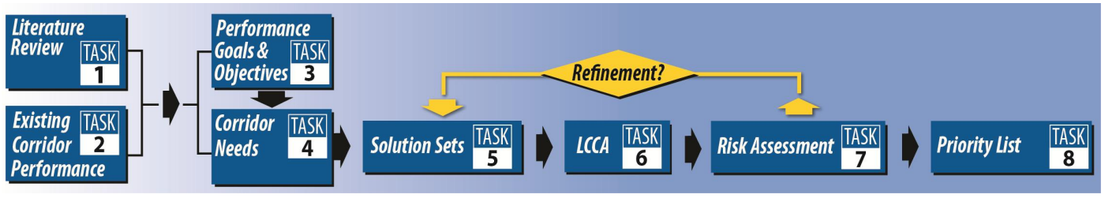
The strategic solutions identified in this study will focus on projects that maximize the use of funds to achieve corridor goals and objectives.

Illustrative examples of strategic investments include:

- *Projects that address significant performance needs*. Projects that address a Medium or High performance need identified in the corridor profile study that have a high probability to significantly improve corridor performance may be identified as strategic investments. These projects may include a project in the current program, a planned project not in the current program, or a new project recommended in the corridor profile study.
- *Combining projects to address needs in multiple performance areas.* For example, a single project to rehabilitate the pavement surface and multiple bridge decks on a segment of roadway would address multiple performance areas (Pavement and Bridge) and could result in significant cost savings in traffic control (as compared to traffic control costs for separate projects to rehabilitate pavement surface and bridge decks). Another example would be that a travel lane pavement rehabilitation project could be expanded to include shoulder rehabilitation and rumble strip construction to reduce road departure safety needs.
- *Projects that address repetitive issues.* For example, if there is a history of high levels of maintenance activities at a particular bridge or segment of pavement, there may be an underlying need that if addressed properly will reduce the need for future maintenance. Higher-cost strategic capital investments to correct repetitive maintenance issues can result in life cycle cost savings by reducing maintenance costs over time.
- *Phased projects to achieve a long-term improvement objective.* For example, a life cycle cost analysis may recommend total pavement reconstruction to address a subgrade failure; however the cost of reconstruction is not feasible from a funding perspective. A strategic investment may be recommended to extend the life of the current pavement infrastructure until funding availability allows for full pavement reconstruction.
- *Modernization Projects.* This corridor profile study will focus on solutions that extend the operational life of the corridor without adding capacity, where possible. Examples could include electronic communication systems that help travelers avoid congestion or truck climbing lanes that enhance flow in shorter congested areas or with low scores in the Travel Time Index or Planning Time Index.

Figure 9 identifies the remaining tasks for this Corridor Profile Study.

Figure 9: Corridor Profile Study Process



APPENDIX: Methodologies for Determining Performance Area Deficiencies (Steps 1-3)

Pavement Needs Assessment Methodology (Steps 1-3)

This section documents the approach for conducting the first three steps of a 5-step needs assessment process for the Pavement Performance Area. The 5-step process is listed below:

- Step 1: Initial Needs
- Step 2: Final Needs
- Step 3: Contributing Factors
- Step 4: Segment Review
- Step 5: Corridor Needs

Step 1: Initial Needs

The Step 1 example is illustrated in **Table 1** for the I-17 corridor.

The input required to populate the Step 1 template includes transferring the existing performance score for each segment to the appropriate "Performance Score" columns. This includes the primary and secondary measures for Pavement. As each performance score is input into the template, the Initial Need (Column P) will populate based on the weighted scoring system for each measure.

The Level of Need for each performance measure has levels of "None" (score = 0), "Low" (score = 1), "Medium" (score = 2), and "High" (score = 3). The assignment of these levels to individual performance measures for segments is determined by the table entitled "Needs Assessment Scales" within the Step 1 template (Table 1).

To develop an aggregate Initial Need for each segment, the primary and secondary measures are combined by summing the weighted scored, with the primary measure having a weight of 1.0 while each secondary measure has a weight of 0.2 (0.1 each direction if directional). The Initial Need for each segment (combining the primary and secondary measures) has levels of "None" (score < 0.01), "Low" (score $\geq$ 0.01 and < 1.5), "Medium" (score $\geq$ 1.5 and < 2.5), and "High" (score $\geq$ 2.5).

The steps include:

Step 1.1: Enter the appropriate segment information into the columns titled "Segment", "Segment Length", "Segment Mileposts" and "Facility Type".

Step 1.2: Populate the Step 1 template with the existing (baseline) performance scores for all primary and secondary performance measures from Task 2/WP#2 into the appropriate "Performance Score" columns (columns E, H, I, and M). Copy the performance score for each segment to the appropriate "Performance Score" column. Paste only the "values" and do not overwrite the formatting.

Step 1.3: Indicate if Pavement is an Emphasis Area by selecting "Yes" or "No" in the row immediately below the segment information.

Step 1.4: Confirm that that the Step 1 template is generating the appropriate "Level of Need" for each primary and secondary measure by reviewing the relationship of baseline performance score to level of need.

Step 2: Final Needs

The Initial Need will be carried over to Step 2 (Column D). The Step 2 example is illustrated in **Table 2** for the I-17 corridor.

The steps required to complete Step 2 are as follows:

Step 2.1: Confirm that the template has properly populated the segment information and the initial needs from the Step 1 template to the "Initial Need" column (column D) of the Step 2 template.

Step 2.2: Note in the "Hot Spots" column (column E) any pavement failure hot spots identified as part of the baseline corridor performance. For each entry, include the milepost limits of the hot spot. Hot spots are identified in the Pavement Index spreadsheet by the red cells in the columns titled "% Pavement Failure". These locations are based on the following criteria:

Interstates: IRI > 105 or Cracking > 15

Non-Interstates: IRI > 142 or Cracking > 15

Every segment that has a % Pavement Failure greater than 0% will have at least one hot spot. Hot spot locations should be described as extending over consecutive miles. For example, if there is a pavement failure location that extends 5 consecutive miles, it should be identified as one hot spot, not 5 separate hot spots.

Step 2.3: Identify recently completed or under construction paving projects in the "Previous Projects" column (column F). Include only projects that were completed after the pavement condition data period (check dates in pavement condition data provided by ADOT) that would supersede the results of the performance system.

Step 2.5: Update the "Final Need" column (column G) using the following criteria:

- If "None" but have a hot spot (or hot spots), the Final Need = Low, and note the reason for the change in the "Comments" column (column H).
- If a recent project (Column F) has superseded the performance rating data, change the Final Need to "None" and note the reason for the change in the "Comments" column (column H).

Table 1 - Step 1 Example

Segment	Segment Length (miles)	Segment Mileposts (MP)	Facility Type	Pavement Index			Directional PSR					% Pavement Failure			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score		Performance Objective	Level of Need		Performance Score	Performance Objective	Level of Need	
							NB	SB		NB	SB				
17-1	7	215 - 222	Interstate	4.19	Fair or Better	None	4.24	4.14	Fair or Better	None	None	0.00%	Fair or Better	None	None
17-2	10	222 - 232	Interstate	4.16	Fair or Better	None	4.13	4.15	Fair or Better	None	None	0.00%	Fair or Better	None	None
17-3	13	232 - 245	Interstate	3.85	Fair or Better	None	3.92	3.86	Fair or Better	None	None	3.80%	Fair or Better	None	None
17-4	8	245 - 253	Interstate	4.25	Fair or Better	None	3.65	4.25	Fair or Better	None	None	0.00%	Fair or Better	None	None
17-5	10	253 - 263	Interstate	4.25	Fair or Better	None	4.09	4.02	Fair or Better	None	None	0.00%	Fair or Better	None	None
17-6	16	263 - 279	Interstate	4.26	Fair or Better	None	4.08	4.02	Fair or Better	None	None	0.00%	Fair or Better	None	None
17-7	9	279 - 288	Interstate	3.92	Fair or Better	None	3.78	3.93	Fair or Better	None	None	16.70%	Fair or Better	Medium	Low
17-8	11	288 - 299	Interstate	4.32	Fair or Better	None	4.01	4.17	Fair or Better	None	None	4.50%	Fair or Better	None	None
17-9	8	299 - 307	Interstate	4.21	Fair or Better	None	3.77	4.18	Fair or Better	None	None	18.80%	Fair or Better	Medium	Low
17-10	9	307 - 316	Interstate	4.19	Fair or Better	None	4.01	4.06	Fair or Better	None	None	0.00%	Fair or Better	None	None
17-11	7	316-323	Interstate	3.73	Fair or Better	None	3.50	3.82	Fair or Better	Low	None	21.40%	Fair or Better	Medium	Low
17-12	17	323-340	Interstate	3.70	Fair or Better	None	3.49	3.82	Fair or Better	Low	None	25.70%	Fair or Better	High	Low
Emphasis Area?	No	Weighted Average		4.07	Fair or Better	None									

Pavement Index Performance Thresholds	Level of Need		Description
3.75	Good	None	All of Good Performance and upper 1/3rd of Fair Performance
	Good		
	Good		
	Fair		
	Fair	Low	Middle 1/3rd of Fair Performance
3.2	Fair	Medium	Lower 1/3rd of Fair and top 1/3rd of Poor Performance
	Poor		
	Poor	High	Lower 2/3rd of Poor Performance
	Poor		

Needs Assessment Scale for Interstates

Measure	None >=	Low >=	> Medium <		High <=
Pavement Index (corridor non-emphasis area)	3.57	3.38	3.38	3.02	3.02
Pavement Index (corridor emphasis area)	3.93	3.57	3.57	3.20	3.20
Pavement Index (segments)	3.57	3.38	3.38	3.02	3.02
Directional PSR	3.57	3.38	3.38	3.02	3.02
%Pavement Failure	10%	15%	15%	25%	25%

Table 2 - Step 2 Example

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Need	Need Adjustments		Final Need	Comments (may include programmed projects or issues from previous reports)
				Hot Spots	Previous Projects (which supersede condition data)		
17-1	7	215 - 222	None	-	-	None	Recent projects repaved this area with PCCP
17-2	10	222 - 232	None	-	-	None	Recent projects repaved this area with PCCP
17-3	13	232 - 245	None	NB MP 236-237	-	Low	Presence of Hotspot elevated Need from None to Low; Project is programmed in FY 17
17-4	8	245 - 253	None	-	-	None	
17-5	10	253 - 263	None	-	-	None	
17-6	16	263 - 279	None	-	-	None	
17-7	9	279 - 288	Low	NB MP 281-282 and 286-287, SB MP 281-282	Pavement preservation project is currently under construction	None	Project is currently under construction so need was eliminated
17-8	11	288 - 299	None	NB MP 289-290	Pavement preservation project is currently under construction	None	Project is currently under construction so need was eliminated
17-9	8	299 - 307	Low	NB MP 302-305	Recent pavement preservation project	None	Final DCR (2012) stated that the most severe cracks were located in NB near MP 301. Need eliminated due to recent preservation project
17-10	9	307 - 316	None	-	-	None	
17-11	7	316-323	Low	NB MP 316-317 and 320-322	-	Low	
17-12	17	323-340	Low	NB MP 326-327, 328-330, 332-334, 339-340, and SB MP 339-340	-	Low	Project is programmed in FY 19

Step 2.6

Note any programmed projects that could have the potential to mitigate pavement needs in in the "Comments" column (column H). Programmed projects are provided as information and do not impact the need rating. The program information can be found in ADOT's 5-year construction program. If there are other comments relevant to the needs analysis (such as information from previous reports), they can be entered in the "Comments" column (column H). However, only include information related to needs that have been identified through this process. Do not add or create needs from other sources.

Step 3: Contributing Factors

The Final Need ratings from Step 2 will populate into the Step 3 tab (Column D). The Step 3 example is illustrated in **Table 3** for the I-17 corridor.

The steps to complete Step 3 include:

Step 3.1

Input the level of historical investment for each segment. This will be determined from the numeric score from the Pavement History Table based on the following thresholds:

- Low = < 4.60
- Medium = 4.60 – 6.60
- High = > 6.60

If the PECOS data shows a high level of maintenance investment, increase the historical investment rating by one level.

Step 3.2

Note the milepost ranges of pavement failure hot spots into the column titled "Contributing Factors and Comments" (column F)

Step 3.3

Note any other information that may be contributing to the deficiency, or supplemental information, in the "Contributing Factors and Comments" column (column F). This could come from discussions with ADOT District staff, ADOT Materials/Pavement Group, previous reports, or the historical investment data.

Step 3.4

Include any programmed projects from ADOT's 5-year construction program in the "Contributing Factors and Comments" column (column F).

Table 3 - Step 3 Example

Segment	Segment Length (miles)	Segment Mileposts (MP)	Final Need	Historical Investment	Contributing Factors and Comments
17-1	7	215 - 222	None	High	
17-2	10	222 - 232	None	High	
17-3	13	232 - 245	Low	Medium	Failure hot spot on NB (MP 236-237); Project is programmed in FY 17 (MP 232-240); should mitigate issues
17-4	8	245 - 253	None	Medium	
17-5	10	253 - 263	None	Medium	
17-6	16	263 - 279	None	Low	
17-7	9	279 - 288	None	Medium	
17-8	11	288 - 299	None	High	
17-9	8	299 - 307	None	High	
17-10	9	307 - 316	None	Medium	
17-11	7	316-323	Low	Low	Issues likely due to lack of recent investment; Failure hotspots on NB MP 316-317 and 320-322
17-12	17	323-340	Low	High	Several miles of failure (25% of segment); pavement failing with high level of previous investment; lower performance on NB than on SB; According to Flagstaff District, NB MP 334 to 337 center line is unraveling due to not being treating by leveling micro-seal treatment, and SB was placed on concrete and the concrete is failing

Bridge Needs Assessment Methodology (Steps 1-3)

This section documents the approach for conducting the first three steps of a 5-step needs assessment process for the Bridge Performance Area. The 5-step process is listed below:

- Step 1: Initial Needs
- Step 2: Final Needs
- Step 3: Contributing Factors
- Step 4: Segment Review
- Step 5: Corridor Needs

Step 1: Initial Needs

The Step 1 sample template is illustrated in **Table 1** for the I-17 corridor.

The input required to populate the Step 1 template includes transferring the existing performance score for each segment to the appropriate "Performance Score" columns. This includes the primary and secondary measures for Bridge. As each performance score is input into the template, the Initial Need (Column Q) will populate based on the weighted scoring system for each measure.

The Level of Need for each performance measure has levels of "None" (score = 0), "Low" (score = 1), "Medium" (score = 2), and "High" (score = 3). The assignment of these levels to individual performance measures for segments is determined by the table entitled "Needs Assessment Scales" within the Step 1 template (Table 1).

To develop an aggregated Initial Need for each segment, the primary and secondary measures are combined by summing the weighted scored, with the primary measure having a weight of 1.0 while each secondary measure has a weight of 0.2 (0.1 each direction if directional). The Initial Deficiency for each segment (combining the primary and secondary measures) has levels of "None" (score < 0.01), "Low" (score $\geq$ 0.01 and < 1.5), "Medium" (score $\geq$ 1.5 and < 2.5), and "High" (score $\geq$ 2.5).

The steps include:

Step 1.1

Enter the appropriate segment information into the columns titled "Segment", "Segment Length", "Segment Mileposts" and "Number of Bridges".

Step 1.2

Populate the Step 1 template with the existing (baseline) performance scores for all primary and secondary performance measures from Task 2/WP#2 into the appropriate "Performance Score" columns (columns E, H, K, and N). Copy the performance score for each segment to the appropriate "Performance Score" column. Paste only the "values" and do not overwrite the formatting.

Step 1.3

Indicate if Bridge is an Emphasis Area by selecting "Yes" or "No" in the row immediately below the segment information.

Step 1.4

Confirm that that the Step 1 template is generating the appropriate "Level of Need" for each primary and secondary measure by reviewing the relationship of baseline performance score to level of need.

Step 2: Final Needs

The Initial Need will be carried over to Step 2 (Column E). The Step 2 sample template is illustrated in **Table 2** for the I-17 corridor.

The steps required to complete Step 2 are as follows:

Step 2.1

Confirm that the template has properly populated the initial needs from the Step 1 template to the "Initial Need" column (column E) of the Step 2 template.

Step 2.2

Note in the column titled "Hot Spots" (Column F) any bridge hot spots identified as part of the baseline corridor performance. For each entry, note the specific location. Hot spots are identified as having any bridge rating of 4 or less, or multiple ratings of 5 in the deck, substructure, or superstructure ratings.

Step 2.3

Identify recently completed or under construction bridge projects in the "Previous Projects" column (column G). Include only projects that were completed after the bridge condition data period (check dates in bridge condition data provided by ADOT) that would supersede the results of the performance system.

Step 2.4

Update the Final Need (column H) on each segment based on the following criteria:

- If the Initial Need is "None" and there is at least one hot spot located on the segment, change the Final Need to "Low".
- If a recent project (Column G) has superseded the performance rating data, the performance data should be adjusted to increase the specific ratings and the resulting need should be reduced to account for the project.

- Note the reason for any change in the “Comments” column (Column K).

Step 2.5

Historical bridge rating data was tabulated and graphed to find any bridges that had fluctuations in the ratings. Note in the “Historical Review” column (Column I) any bridge that was identified as having a potential historical rating concern based on the following criteria:

- Ratings increase or decrease (bar chart) more than 2 times
- Sufficiency rating drops more than 20 points

This is for information only and does not affect the level of need.

Step 2.6

Note the number of functionally obsolete bridges in each segment in the column titled “# Functionally Obsolete Bridges” (Column J). This is for information only and does not affect the level of need.

Step 2.7

Identify each bridge “of concern” in the “Comments” column (Column K). Note any programmed projects that could have the potential to mitigate bridge deficiencies in Column K. Programmed projects are provided as information and do not impact the need rating. The program information can be found in ADOT’s 5-year construction program. If there are other comments relevant to the needs analysis (such as information from previous reports), they can be entered in the “Comments” column (Column K). However, only include information related to needs that have been identified through this process. Do not add or create needs from other sources.

Table 1 - Step 1 Example

Segment	Segment Length (miles)	Segment Mileposts (MP)	Number of Bridges in Segment	Bridge Index			Bridge Rating			Bridge Sufficiency			% Functionally Obsolete Bridges			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	
17-1	7	215 - 222	13	6.76	Fair or Better	None	5	Fair or Better	Low	91.0	Fair or Better	None	31.1%	Fair or Better	Medium	Low
17-2	10	222 - 232	11	6.79	Fair or Better	None	6	Fair or Better	None	92.7	Fair or Better	None	14.6%	Fair or Better	None	None
17-3	13	232 - 245	15	6.39	Fair or Better	None	5	Fair or Better	Low	91.1	Fair or Better	None	31.3%	Fair or Better	Medium	Low
17-4	8	245 - 253	4	5.71	Fair or Better	Low	5	Fair or Better	Low	94.0	Fair or Better	None	60.9%	Fair or Better	High	Medium
17-5	10	253 - 263	10	7.25	Fair or Better	None	6	Fair or Better	None	96.4	Fair or Better	None	15.0%	Fair or Better	None	None
17-6	16	263 - 279	10	6.19	Fair or Better	None	5	Fair or Better	Low	94.8	Fair or Better	None	8.5%	Fair or Better	None	Low
17-7	9	279 - 288	5	6.31	Fair or Better	None	6	Fair or Better	None	91.4	Fair or Better	None	0.0%	Fair or Better	None	None
17-8	11	288 - 299	7	6.04	Fair or Better	None	4	Fair or Better	Medium	89.2	Fair or Better	None	13.6%	Fair or Better	None	Low
17-9	8	299 - 307	2	6.00	Fair or Better	None	6	Fair or Better	None	93.0	Fair or Better	None	100.0%	Fair or Better	High	Low
17-10	9	307 - 316	2	6.52	Fair or Better	None	6	Fair or Better	None	94.0	Fair or Better	None	100.0%	Fair or Better	High	Low
17-11	7	316 - 323	9	6.91	Fair or Better	None	5	Fair or Better	Low	96.5	Fair or Better	None	3.4%	Fair or Better	None	Low
17-12	17	323-340	10	5.80	Fair or Better	Low	5	Fair or Better	Low	92.0	Fair or Better	None	62.3%	Fair or Better	High	Medium
Emphasis Area?	No	Weighted Avg		6.34	Fair or Better	None										

Bridge Index Performance Thresholds	Level of Deficiency		Description
	Good	None	All of Good Performance and upper 1/3rd of Fair Performance
	Good		
	Good		
6.5	Fair		
	Fair	Low	Middle 1/3rd of Fair Performance
	Fair	Medium	Lower 1/3rd of Fair and top 1/3rd of Poor Performance
5.0	Poor		
	Poor	High	Lower 2/3rd of Poor Performance
	Poor		

Needs Assessment Scale

Measure	None >=	Low >=	> Medium <		High <=
Bridge Index (corridor non-emphasis area)	6.0	5.5	5.5	4.5	4.5
Bridge Index (corridor emphasis area)	7.0	6.0	6.0	5.0	5.0
Bridge Index (segments)	6.0	5.5	5.5	4.5	4.5
Bridge Sufficiency	70	60	60	40	40
Bridge Rating	6.0	5.0	4.0	4.0	3.0
%Functionally Obsolete Bridges	21.0%	31.0%	31.0%	49.0%	49.0%

Table 2 - Step 2 Example

Segment	Segment Length (miles)	Segment Mileposts (MP)	Number of Bridges in Segment	Initial Need	Need Adjustments		Final Need	Historical Review	# Functionally Obsolete Bridges	Comments
					Hot Spots (Rating of 4 or multiple 5's)	Previous Projects (which supersede condition data)				
17-1	7	215 - 222	13	Low	-	-	Low	-	6	Pinnacle Peak TI and Happy Valley TI; Both of these bridges were identified for replacement in Final DCR (2004); Likely to be programmed in future MAG update
17-2	10	222 - 232	11	None	-	-	None	-	1	No bridges with current ratings of 4 or 5 and no historical issues
17-3	13	232 - 245	15	Low	Moores Gulch SB	-	Low	Moores Gulch SB	7	Moores Gulch SB and Little Squaw Creek NB; Little Squaw Creek NB was identified as Structurally Deficient in Final DCR (2004); Moores Gulch SB programmed in FY 17
17-4	8	245 - 253	4	Medium	-	-	Medium	-	2	Bumble Bee TI NB
17-5	10	253 - 263	10	None	-	-	None	-	4	No bridges with current ratings of 4 or 5 and no historical issues
17-6	16	263 - 279	10	Low	SR 169 TI	-	Low	Dugas Rd TI and Ceinga Creek NB	2	Ash Creek SB, SR 169 TI, Dugas Rd TI SB, Ceinga Creek NB
17-7	9	279 - 288	5	None	-	-	None	-	0	No bridges with current ratings of 4 or 5 and no historical issues
17-8	11	288 - 299	7	Low	McGuireville TI, SR 179 TI SB	-	Low	McGuireville TI, Middle Verde Rd TI, and Dry Beaver Creek SB	2	McGuireville TI, Middle Verde TI, Dry Beaver Creek SB, SR 179 TI SB; McGuireville TI programmed in FY 15
17-9	8	299 - 307	2	Low	-	-	Low	-	2	No bridges with current ratings of 4 or 5 and no historical issues
17-10	9	307 - 316	2	Low	-	-	Low	-	2	No bridges with current ratings of 4 or 5 and no historical issues
17-11	7	316 - 323	9	Low	-	-	Low	-	2	Woods Canyon TI (Fox Ranch Rd TI)
17-12	17	323-340	10	Medium	Willard Springs TI NB and Airport Rd TI	-	Medium	Willard Springs TI NB and Airport Rd TI	7	Willard Springs TI NB and Airport Rd TI; Willard Springs TI identified for deck and superstructure replacement in Final DCR (2012); JW Powell TI identified for replacement in Final DCR (2012); Willard Springs TI programmed in FY 17

Step 3: Contributing Factors

The Final Need ratings from Step 2 will populate into the Step 3 tab (Column F). The Step 3 sample template is illustrated in **Table 3** for the I-17 corridor.

The steps to compete Step 3 include:

Step 3.1

Input the bridge name, structure number, and milepost into Column G for each bridge “of concern” resulting from Step 2.

Step 3.2

For bridges that have a current rating of 5 or less, enter the specific rating in Column H, or state “No current ratings less than 6”.

Step 3.3

For bridges that were identified for a historical review (step 2.5), state “Could have a repetitive investment issue” in Column I. If a bridge was not identified for a historical review, state “This structure was not identified in historical review”.

Step 3.4

Input any programmed projects from ADOT’s 5-year construction program into Column J. Note any other information that may be contributing to the deficiency, or supplemental information, in Column J. This could come from discussions with ADOT District staff, ADOT Bridge Group, or previous reports.

Table 3 - Step 3 Example

Segment	Segment Length (Miles)	Segment Mileposts (MP)	Number of Bridges in Segment	# Functionally Obsolete Bridges	Final Need	Contributing Factors			Comments
						Bridge	Current Ratings	Historical Review	
17-1	7	215 - 222	13	6	Low	Pinnacle Peak TI (#821)(MP 217.10)	Current Deck Rating of 5	This structure was not identified in historical review	Likely to be replaced to facilitate mainline widening; will be included in updated MAG program; currently in DCR phase
						Happy Valley TI (#822)(MP 218.01)	Current Deck Rating of 5	This structure was not identified in historical review	
17-2	10	222 - 232	11	1	None	No bridges with current ratings less than 6 and no historical issues			
17-3	13	232 - 245	15	7	Low	Moores Gulch SB (#339)(MP 238.60)	Current Deck and Superstructure ratings of 5	Could have a repetitive investment issue	Project is programmed in FY 17
						Little Squaw Creek NB (#968)(MP 239.20)	Current Deck Rating of 5	This structure was not identified in historical review	
17-4	8	245 - 253	4	2	Medium	Bumble Bee TI NB (#1171)(MP 248.40)	Current Deck Rating of 5	This structure was not identified in historical review	
17-5	10	253 - 263	10	4	None	No bridges with current ratings less than 6 and no historical issues			
17-6	16	263 - 279	10	2	Low	Dugas Rd TI SB (#1080)(MP 268.75)	No Current Ratings less than 6	Could have a repetitive investment issue	
						Ash Creek SB (#389)(MP 269.11)	Current Structural Evaluation Rating of 5	This structure was not identified in historical review	
						Ceinga Creek NB (#428)(MP 277.93)	Current Substructure Rating of 5	Could have a repetitive investment issue	
						SR 169 TI (#1734)(MP 278.40)	Current Deck and Superstructure Ratings of 5	This structure was not identified in historical review	
17-7	9	279 - 288	5	0	None	No bridges with current ratings less than 6 and no historical issues			
17-8	11	288 - 299	7	2	Low	Middle Verde Rd TI (#1733)(MP 289.97)	No Current Ratings less than 6	Could have a repetitive investment issue	
						McGuireville TI (#652)(MP 293.26)	Current Superstructure Rating of 4	Could have a repetitive investment issue	Project in programmed in FY 15
						Dry Beaver Creek SB (#654)(MP 293.40)	No Current Ratings less than 6	Could have a repetitive investment issue	
						SR 179 TI SB (#1061)(MP 298.96)	Current Deck and Substructure Ratings of 5	This structure was not identified in historical review	
17-9	8	299 - 307	2	2	Low	No bridges with current ratings less than 6 and no historical issues			Due to # of functionally obsolete bridges

17-10	9	307 - 316	2	2	Low	No bridges with current ratings less than 6 and no historical issues			Due to # of functionally obsolete bridges
17-11	7	316 - 323	9	2	Low	Woods Canyon TI (Fox Ranch Rd)(#1655) (MP 317.86)	Current Substructure Rating of 5	This structure was not identified in historical review	
17-12	17	323-340	10	7	Medium	Willard Springs TI NB (#1583) (MP 326.20)	Current Deck and Superstructure Ratings of 5	Could have a repetitive investment issue	Project is programmed in FY 17
						Airport Rd TI (#632) (MP 337.39)	Current Substructure and Superstructure Ratings of 5	Could have a repetitive investment issue	

Mobility Needs Assessment Methodology (Steps 1-3)

This section documents the approach for conducting the first three steps of a 5-step needs assessment process for the Mobility Performance Area. The 5-step process is listed below. After completion of Step 3 for all performance areas (Pavement, Bridge, Mobility, Safety, and Freight), Step 4 will review each corridor segment to quantify a total level of deficiency that combines all performance areas. Corridor deficiencies are then translated to needs in Step 5 of the process in order to identify needs by type and overlapping needs throughout the corridor.

- Step 1: Initial Deficiencies
- Step 2: Refined Deficiencies
- Step 3: Contributing Factors
- Step 4: Segment Review
- Step 5: Corridor Needs

Step 1: Initial Deficiencies

The input required to populate the Step 1 template includes transferring the existing performance score for each segment to the appropriate "Performance Score" columns from Task 2/Working Paper #2. This includes the primary and secondary measures for Mobility. As each performance score is input into the template, the Initial Need (Column/Row S/33) will populate based on the weighted scoring system for each measure.

The Level of Need for each performance measure has levels of "None" (score = 0), "Low" (score = 1), "Medium" (score = 2), and "High" (score = 3). The assignment of these levels to individual performance measures for segments is determined by the table entitled "Needs Assessment Scales" in the Step 1 tab.

To develop an aggregated Initial Need for each segment, the primary and secondary measures are combined by summing the weighted scores, with the primary measure having a weight of 1.0 while each secondary measure has a weight of 0.2 (0.1 each direction if directional). The Initial Need for each segment (combining the primary and secondary measures) has levels of "None" (score < 0.01), "Low" (score $\geq$ 0.01 and < 1.5), "Medium" (score $\geq$ 1.5 and < 2.5), and "High" (score $\geq$ 2.5).

The steps include:

Step 1.1

Input the accurate number of segments for your corridor in the column titled 'Segment' and the appropriate segment milepost limits and segment lengths in adjacent columns (Columns A-C).

Step 1.2

Select the appropriate 'Environment Type' and 'Facility Operation Type' from the drop down menus as defined in Task 2 - Existing Performance Analysis (Columns D and E).

Step 1.3

Select 'Yes' or 'No' form the drop down list to not if the Mobility Performance Area is an Emphasis Area for your corridor in cell C30.

Step 1.4

Populate the Step 1 template with the existing (baseline) performance scores for all primary and secondary performance measures from Task 2/Working Paper #2. Copy the performance score for each segment to the appropriate "Performance Score" column. PASTE VALUES ONLY.

Step 1.5

Confirm that that the Step 1 template is generating the appropriate "Level of Need" for each primary and secondary measure by reviewing the relationship of baseline performance score to level of need.

The step 1 template and scales for the mobility index are illustrated below for the I-19 corridor.

Step 2: Final Needs

The Initial Need will be carried over to Step 2 (Column D). The Step 2 sample template is illustrated in **Table 2** for the I-19 corridor.

The steps required to complete Step 2 are as follows:

Step 2.1

Confirm that the template has properly populated the initial deficiencies from the Step 1 template to Column D of the Step 2 template.

Step 2.2

Identify recently completed or under construction projects (Column E&F) that would be considered relevant to mobility performance. Include only projects that were constructed after 2014 for which the 2014 HPMS data used for traffic volumes would not include. Any completed or under construction roadway project after 2014 that has the potential to mitigate a mobility issue on a corridor segment should be listed in the template. Such projects should include the construction of

new travel lanes or speed limit changes on the main corridor only. Do not include projects involving frontage roads or crossings as they would not impact the corridor level performance.

Step 2.3

Update the Final Need (Column G) using the following criteria:

- If a recent project (Column E&F) has superseded the performance rating data and it is certain the project addressed the deficiency, change the deficiency rating to “None”.
- If a recent project (Column E&F) has superseded the performance rating data but it is uncertain that a project addressed the deficiency, maintain the current deficiency rating and note the uncertainty as a comment in Column H.

Step 2.5

Note any programmed or planned projects that have the potential to mitigate any mobility deficiency on the segment in Column H. Programmed and Planned projects are provided as information and do not impact the deficiency rating. Future projects will be reviewed in the development of solution sets for identified needs and deficiencies. The source of future projects can be found in ADOT’s 5-year construction program or other planning documents. Other comments relevant to the needs analysis can be entered in the right-most column (Column H).

Step 1 Template - Mobility

Mobility

Segment	Segment Mileposts	Segment Length (miles)	Environment Type	Facility Operation	Mobility Index			Future Daily V/C			Existing Peak Hour V/C					Closure Extent (occurrences/year/mile)				
					Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score		Performance Objective	Level of Need		Performance Score		Performance Objective	Level of Need	
											NB	SB		NB	SB	NB	SB		NB	SB
19-1	0-3	3	Urban	Uninterrupted	0.22	Fair or Better	None	0.27	Fair or Better	None	0.14	0.14	Fair or Better	None	None	0.27	0.27	Fair or Better	None	None
19-2	3-18	15	Rural	Uninterrupted	0.40	Fair or Better	None	0.49	Fair or Better	None	0.25	0.26	Fair or Better	None	None	0.30	0.20	Fair or Better	None	None
19-3	18-30	12	Rural	Interrupted	0.32	Fair or Better	None	0.39	Fair or Better	None	0.19	0.20	Fair or Better	None	None	0.11	0.19	Fair or Better	None	None
19-4	30-40	9	Urban	Uninterrupted	0.41	Fair or Better	None	0.50	Fair or Better	None	0.24	0.25	Fair or Better	None	None	0.25	0.20	Fair or Better	None	None
19-5	40-57	18	Urban	Uninterrupted	0.69	Fair or Better	None	0.81	Fair or Better	Low	0.46	0.44	Fair or Better	None	None	0.29	0.23	Fair or Better	None	None
19-6	57-64	7	Urban	Uninterrupted	1.32	Fair or Better	High	1.59	Fair or Better	High	0.87	0.74	Fair or Better	Medium	None	0.31	0.34	Fair or Better	None	None
Mobility Emphasis Area		Yes	Weighted Average		0.56	Good	None													

Segment	Segment Mileposts	Segment Length (miles)	Environment Type	Facility Operation	Directional TTI (all vehicles)					Directional PTI (all vehicles)					Bicycle Accomodation			Initial Level of Need
					Performance Score		Performance Objective	Level of Need		Performance Score		Performance Objective	Level of Need		Performance Score	Performance Objective	Level of Need	
					NB	SB		NB	SB	NB	SB		NB	SB				
19-1	0-3	3	Urban	Uninterrupted	1.40	1.01	Fair or Better	High	None	2.28	1.30	Fair or Better	High	None	100%	Fair or Better	None	Low
19-2	3-18	15	Rural	Uninterrupted	1.16	1.13	Fair or Better	None	None	1.25	1.22	Fair or Better	None	None	100%	Fair or Better	None	None
19-3	18-30	12	Rural	Interrupted	1.58	1.10	Fair or Better	Low	None	2.50	1.17	Fair or Better	None	None	100%	Fair or Better	None	Low
19-4	30-40	9	Urban	Uninterrupted	1.06	1.06	Fair or Better	None	None	1.08	1.12	Fair or Better	None	None	100%	Fair or Better	None	None
19-5	40-57	18	Urban	Uninterrupted	1.06	1.08	Fair or Better	None	None	1.11	1.15	Fair or Better	None	None	100%	Fair or Better	None	Low
19-6	57-64	7	Urban	Uninterrupted	1.00	1.04	Fair or Better	None	None	1.03	1.14	Fair or Better	None	None	100%	Fair or Better	None	High

Scale

Measure		None <=	Low >=	> Medium <		High <=
Mobility Index (Corridor Emphasis Area)		0.58	0.71	0.71	0.84	0.84
Mobility Index (Corridor Non-Emphasis Area)		0.71	0.77	0.77	0.90	0.90
Mobility Index (Segment)	Urban	0.77	0.83	0.83	0.95	0.95
	Rural	0.63	0.69	0.69	0.83	0.83
Future Daily V/C	Urban	0.77	0.83	0.83	0.95	0.95
	Rural	0.63	0.69	0.69	0.83	0.83
Existing Peak hour V/C	Urban	0.77	0.83	0.83	0.95	0.95
	Rural	0.63	0.69	0.69	0.83	0.83
Closure Extent		0.74	1.10	1.10	1.82	1.82
Directional TTI	Uninterrupted	1.21	1.27	1.27	1.39	1.39
	Interrupted	1.53	1.77	1.77	2.23	2.23
Directional PTI	Uninterrupted	1.37	1.43	1.43	1.57	1.57
	Interrupted	2.67	3.33	3.33	4.67	4.67
Bicycle Accomodation		80%	70%	70%	50%	50%

Example Scale for Corridor Average Mobility Index if Mobility is Emphasis Area

Performance Thresholds	Initial Need	Description
	None	(<0.65)
0.71	Low	Lower 1/3 of Good and Upper 1/3 of Fair Performance (0.65 - 0.77)
	Medium	Middle 1/3 and Lower 1/3 of Fair Perf. (0.77 - 0.89)
0.89	High	(>0.89)

Example Scales for Level of Need

Performance Thresholds	Initial Need	Description
0.71	None	(<0.77)
	Low	Middle 1/3rd of Fair Perf. (0.77 - 0.83)
0.89	Medium	Lower 1/3rd of Fair and top 1/3rd of Poor Performance (0.83-0.95)
	High	Lower 2/3rd of Poor Performance (>0.95)

NOTE: The value of the 1/3 sections was defined by the range of the "fair" rating.
In this example, each 1/3 section has a value of 0.06. [(0.89-0.71)/3=0.06].

Table 1 - Step 2 Example

Segment	Segment Mileposts (MP)	Segment Length (miles)	Initial Need	Need Adjustments Recent Projects Since 2013	Final Need	Planned and Programmed Future Projects
19-1	0-3	3	Low	None	Low	Planned I-19, I-19B Terminus to West Street - Roadway Improvements for Future Capacity I-19 and Mariposa TI reconfiguration
19-2	3-18	15	None	None	None	Planned I-19, SR 189/Mariposa Road TI to Tumacocori TI – Roadway Improvements for Future Capacity I-19, Exit 22 (Peck Canyon Rd) to Exit 48 (Arivaca Road) – Interchange Improvements I-19 Safety Corridor Improvements MP 8.4 - 9.4
19-3	18-30	12	Low	None	Low	Programmed (FY 2015) Canoa Shooulders - Construct Shoulder Widening
19-4	30-40	9	None	None	None	Nothing planned or programmed in this segment
19-5	40-57	18	Low	None	Low	Planned Esperanza, Duval Mine Rd, Helmet Peak, Pima Mine Rd, Papago TI reconstruction projects listed in various planning documents Widen to six lanes MP 39 - 58 in PAG 2040 RTP
19-6	57-64	7	High	None	High	Programmed Ajo Way TI - Reconstruct TI and Mainline (2015, 2018) Irvington Road and I-19 – Design and reconstruct new TI (SPUI) Planned Capacity expansion planned entire segment listed in various planning documents Reconstruct I-19 to four lanes in each direction between San Xavier Road and I-10 (I-19 DCR) All interchanges planned for upgrade

Step 3: Contributing Factors

The Final Need ratings from Step 2 will populate into the Step 3 tab (Column D). The Step 3 sample template is illustrated in **Table 3** for the I-19 corridor.

The steps to compete Step 3 include:

Step 3.1

Input data from Mobility Index worksheet and corridor observations in appropriate columns for Roadway Variables (Column E through Column L).

Step 3.2

Input traffic variable data in appropriate columns as indicated in Columns M-O, Buffer Index scores will auto populate in Columns P and Q.

Step 3.3

In Column R input relevant mobility related infrastructure located within each segment as appropriate

Step 3.4

In the lower portion of Column E – Column M input the Closure Extents that have occurred along the study corridor. Road closure information can be detailed out by the reason for the closure as documented in Highway Condition Reporting System (HCRS) data analyzed as part of the baseline corridor performance. Closure reasons include incident/accidents, winter storms, obstruction hazards, and undefined closures. Statewide average percentages for the various closure reasons have been calculated for 2009-2013 on ADOT's 11 designated strategic corridors. Compare these statewide average percentages to the corridor percentages for the various closure reasons to identify higher than average percentages of one or more closure reasons on any given segment. Input the closures as follows and use red text to indicate that the segment percentage exceeds statewide averages:

- Total Number of Closures (Column E)
- % Closures (No Reason) (Column F)
- % Incidents/Accidents (Column H)
- % Obstructions/Hazards (Column J)
- % Weather Related (Column L)

Step 3.5

In the lower portion of Column N/O, list the non-actionable conditions that are present within each segment by milepost if possible. Non-Actionable conditions are conditions that exist within the environment of each segment that cannot be improved through an engineered solution. For example, the border patrol check point in Segment 3 of I-19 is a non-actionable condition.

Step 3.6

Considering all information input, identify and list the contributing factors to the Final Need score (Lower portion of Column P).

Table 2 - Step 3 Example

Segment	Segment Mileposts (MP)	Segment Length (miles)	Final Need	Roadway Variables								Traffic Variables					Relevant Mobility Related Existing Infrastructure
				Functional Classification	Environmental Type (Urban/Rural)	Terrain	# of Lanes/ Direction	Speed Limit	Aux Lanes	Divided/ Non-Divided	% No Passing	Exisitng LOS	Future 2035 LOS	% Trucks	NB Buffer Index (PTI-TTI)	SB Buffer Index (PTI TTI)	
19-1	0-3	3	Low	Interstate	Fringe Urban	Rolling	2	25-65	None	Both	0%	A-C	A-C	7%	0.88	0.29	1/4 mile non-divived in Nogales
19-2	3-18	15	None	Interstate	Rural	Level	2	75	None	Divided	0%	A-C	A-C	8%	0.09	0.09	None
19-3	18-30	12	Low	Interstate	Rural	Level	2	75	None	Divided	0%	A-C	A-C	11%	0.92	0.06	None
19-4	30-40	9	None	Interstate	Fringe Urban	Level	2	65-75	None	Divided	0%	A-C	A-C	13%	0.03	0.06	None
19-5	40-57	18	Low	Interstate	Fringe Urban	Level	2	65-75	None	Divided	0%	A-C	D	14%	0.05	0.07	None
19-6	57-64	7	High	Interstate	Urban	Level	2	55-65	None	Divided	0%	A-C	E/F	7%	0.03	0.10	3 lanes each directon between Ajo (SR 86) TI and I-19/I-10 Interchange

Segment	Segment Mileposts (MP)	Segment Length (miles)	Refinied Need	Closure Extent									Non-Actionable Conditions	Contributing Factors
				Total Number of Closures	# of Closures	% Closures	# Incidents/ Accidents	% Incidents/ Accidents	# Obstructions/ Hazards	% Obstructions/ Hazards	# Weather Related	% Weather Related		
19-1	0-3	3	Low	6	0	0%	5	83%	0	0%	1	17%	1/4 mile of Non-freeway urban section	• Urban portion of I-19 within Nogales, beginning as a low-speed non-divided cross-section and transitioning to a higher-speed controlled access 4-lane interstate. • Existing and future traffic LOS is good, but the urban environment and rolling terrain may contribute to accident and weather-related closures. • High deficiencies in northbound TTI and PTI are likely related to lower posted speed limits on the non-divided section.
19-2	3-18	15	None	30	0	0%	29	97%	1	3%	0	0%	None	• Elevated incident/accident-related closures not sufficient to lower the TTI/PTI, but may be associated with periodic congestion at I-19/US 189 TI.
19-3	18-30	12	Low	9	0	0%	7	78%	2	22%	0	0%	Border Checkpoint in NB direction	• Elevated northbound TTI/PTI Need related to Border Patrol checkpoint near Tubac causes temporary delays and slower average speeds for length of segment. Non-actionable condition. • 78% of closures related to incidents/accidents.
19-4	30-40	9	None	12	1	8%	10	83%	1	8%	0	0%	None	• No reported performance deficiencies. • 83% of closures incidents/accidents-related.
19-5	40-57	18	Low	42	0	0%	42	100%	0	0%	0	0%	None	• Elevated number of closures 100% incident/accident-related • Multiple TI and ramp improvement projects planned for near-term expected to help maintain acceptable LOS and reduce accidents.
19-6	57-64	7	High	21	7	33%	14	67%	0	0%	0	0%	None	• High Mobility Index performance Need, based on heavy northbound flows entering Tucson urban area. • Congested levels existing peak hour V/C and future daily V/C. • The number of weekdays vs. weekend days in which traffic volumes exceed acceptable LOS are nearly equal. There is no spike in traffic that can be attributed to work-related (week day) or recreational (weekend) traffic. • 67% of closures incidents/accidents-related, with 33% unidentified. May be related to increased congestion in urban area.

Safety Needs Assessment Methodology (Steps 1-3)

This section documents the approach for conducting the first three steps of a 5-step needs assessment process for the Safety Performance Area. The 5-step process is listed below. When Step 3 is completed for all performance areas (Pavement, Bridge, Mobility, Safety, and Freight), Step 4 will review each corridor segment to identify common or overlapping deficiencies for multiple performance areas. Corridor deficiencies are then translated to needs in Step 5 of the process.

- Step 1: Initial Needs
- Step 2: Final Needs
- Step 3: Contributing Factors
- Step 4: Segment Review
- Step 5: Corridor Needs

The Task 4 – Safety Needs Assessment Excel spreadsheet contains 3 tabs, one each for Steps 1 - 3.

Step 1: Initial Needs

The Step 1 sample template is illustrated in Table 1 for the I-40 corridor:

Table 3 - Step 1 Template

Segment	Operating Environment	Segment Length (miles)	Segment Milepoints (MP)	Safety Index			Directional Safety Index					% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors		
				Performance Score	Performance Objective	Level of Need	NB Directional Safety Index	SB Directional Safety Index	Performance Objective	NB Level of Need	SB Level of Need	Performance Score	Performance Objective	Level of Need
1	Rural 4 Lane Freeway with Daily Volume <25,000	11	0-11	1.31	Average or Better	Medium			Average or Better	None	None	70%	Average or Better	High
2	Rural 4 Lane Freeway with Daily Volume <25,000	32	11-43	1.00	Average or Better	Low			Average or Better	None	None	62%	Average or Better	High
3	Urban 4 Lane Freeway	12	43-55	1.15	Average or Better	Medium			Average or Better	None	None	37%	Average or Better	Low
4	Rural 4 Lane Freeway with Daily Volume <25,000	19	55-74	1.79	Average or Better	High			Average or Better	None	None	20%	Average or Better	None
5	Rural 4 Lane Freeway with Daily Volume <25,000	6	74-80	0.85	Average or Better	None			Average or Better	None	None	Insufficient Data	Average or Better	N/A
6	Rural 4 Lane Freeway with Daily Volume <25,000	18	80-98	1.95	Average or Better	High			Average or Better	None	None	30%	Average or Better	None
7	Rural 4 Lane Freeway with Daily Volume <25,000	10	98-108	1.21	Average or Better	Medium			Average or Better	None	None	20%	Average or Better	None
8	Rural 4 Lane Freeway with Daily Volume <25,000	12	108-120	0.36	Average or Better	None			Average or Better	None	None	23%	Average or Better	None
9	Rural 4 Lane Freeway with Daily Volume <25,000	23	120-143	0.68	Average or Better	None			Average or Better	None	None	35%	Average or Better	None
10	Rural 4 Lane Freeway with Daily Volume <25,000	17	143-160	2.13	Average or Better	High			Average or Better	None	None	44%	Average or Better	None
11	Rural 4 Lane Freeway with Daily Volume <25,000	8	160-168	0.94	Average or Better	Low			Average or Better	None	None	75%	Average or Better	High
12	Rural 4 Lane Freeway with Daily Volume <25,000	16	168-184	0.33	Average or Better	None			Average or Better	None	None	33%	Average or Better	None
13	Rural 4 Lane Freeway with Daily Volume <25,000	6	184-190	0.55	Average or Better	None			Average or Better	None	None	Insufficient Data	Average or Better	N/A
14	Urban 4 Lane Freeway	6	190-196	0.42	Average or Better	Low			Average or Better	None	None	Insufficient Data	Average or Better	N/A
Safety Emphasis Area?		Yes	Weighted Average	1.06	Above Average	Medium								

Segment	Operating Environment	Segment Length (miles)	Segment Milepoints (MP)	% of Fatal + Incapacitating Injury Crashes Involving Trucks			% of Fatal + Incapacitating Injury Crashes Involving Motorcycles			% of Fatal + Incapacitating Injury Crashes Involving Non-Motorized Travelers			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	Performance Score	Performance Objective	Level of Need	
1	Rural 4 Lane Freeway with Daily Volume <25,000	11	0-11	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
2	Rural 4 Lane Freeway with Daily Volume <25,000	32	11-43	38%	Average or Better	High	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Medium
3	Urban 4 Lane Freeway	12	43-55	11%	Average or Better	Medium	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Medium
4	Rural 4 Lane Freeway with Daily Volume <25,000	19	55-74	8%	Average or Better	None	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
5	Rural 4 Lane Freeway with Daily Volume <25,000	6	74-80	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	None
6	Rural 4 Lane Freeway with Daily Volume <25,000	18	80-98	38%	Average or Better	High	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
7	Rural 4 Lane Freeway with Daily Volume <25,000	10	98-108	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Medium
8	Rural 4 Lane Freeway with Daily Volume <25,000	12	108-120	19%	Average or Better	Medium	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	None
9	Rural 4 Lane Freeway with Daily Volume <25,000	23	120-143	12%	Average or Better	None	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	None
10	Rural 4 Lane Freeway with Daily Volume <25,000	17	143-160	18%	Average or Better	Medium	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	High
11	Rural 4 Lane Freeway with Daily Volume <25,000	8	160-168	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Medium
12	Rural 4 Lane Freeway with Daily Volume <25,000	16	168-184	0%	Average or Better	None	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	None
13	Rural 4 Lane Freeway with Daily Volume <25,000	6	184-190	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	None
14	Urban 4 Lane Freeway	6	190-196	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Insufficient Data	Average or Better	N/A	Low

The input required to populate the Step 1 template includes transferring the corridor characteristics and existing performance score for each segment to the appropriate "Performance Score" columns. This includes the primary and secondary measures for safety. As each performance score is input into the template, the Level of Need will populate based on the weighted scoring system for each measure.

The Level of Need for each performance measure has levels of "None" (score = 0), "Low" (score = 1), "Medium" (score = 2), and "High" (score = 3). The assignment of these levels to individual performance measures for segments is determined by the table entitled "Needs Scale" within the Step 1 template.

To develop an aggregated Initial Need for each segment, the primary and secondary measures are combined by summing the weighted scored, with the primary measure having a weight of 1.0 while each secondary measure has a weight of 0.2 (0.1 each direction if directional). The Initial Need for each segment (combining the primary and secondary measures) has levels of "None" (score < 0.01), "Low" (score $\geq$ 0.01 and < 1.5), "Medium" (score $\geq$ 1.5 and < 2.5), and "High" (score $\geq$ 2.5).

The steps include:

Step 1.1

Populate the Step 1 template with the corridor characteristics information. This includes segment operating environments (Column B) and segment length (Column C). Also specify on cell D38 if the safety performance area is an emphasis area as determined in Task 3. The "Level of Need" is dependent on the input of the operating environment and "Emphasis Area" as the thresholds dynamically update accordingly.

Input the existing (baseline) performance scores for all primary and secondary performance measures from Task 2. Copy the performance score (paste values only) for each segment to the appropriate "Performance Score" column and conditional formatting should color each cell green, yellow, or red based on the corresponding performance thresholds.

Step 1.2

The thresholds for the corridor safety index are based on the segments' operating environments. To ensure that the correct corridor safety index threshold are applied, input the unique segment operating environments that exist with the corridor. Once the input is complete, the average of the Good/Fair and Fair/Poor thresholds for each of the operating environments is calculated and the "Level of Need" thresholds will be derived and applied to the main Step 1 Table.

Step 1.3

Confirm that the following criteria for "Insufficient Data" has been applied and that the resulting Level of Need has been shown as "N/A" where applicable.

- Crash frequency for a segment is less than 5 crashes over the 5-year crash analysis period.
- The change in +/- 1 crash results in the change of need level of 2 levels (i.e., changes from Good to Poor or changes from Poor to Good).
- The average segment crash frequency for the overall corridor (total fatal plus incapacitating injury crash frequency divided by the number of corridor segments) is less than 2 per segment over the 5-year crash analysis period.

Step 1.4

Confirm that the Step 1 template is generating the appropriate "Level of Need" for each primary and secondary measure by reviewing the relationship of baseline performance score to level of need.

<u>Step 2: Final Needs</u>

The Initial Need will be carried over to Step 2 (Column D). The Step 2 sample template is illustrated in **Table 2** for the I-40 corridor. The steps required to complete Step 2 are as follows:

Step 2.1

Confirm that the template has properly populated the initial needs from the Step 1 template to Column D of the Step 2 template.

Step 2.2

Using the crash concentration (hot spot) map developed as part of the baseline corridor performance, note the direction of travel and approximate milepost limits of each hot spot.

Step 2 Template

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Need	Hot Spots	Relevant Recently Completed or Under Construction Projects (which supersede performance data) *	Final Need	Comments (may include tentatively programmed projects with potential to address need or other relevant issues identified in previous reports)
1	11	0-11	High			High	No programmed project with potential to address need
2	32	11-43	Medium			Medium	Programmed: bridge deck rehabilitations at Boulder Wash EB, Chemehuevi Wash EB, Francona TI UP, Francona Wash EB, and Illiavar Wash EB in FY 2016 at MP 11-18 and Havilland Rest Area improvements in FY 2018 at MP 23
3	12	43-55	Medium	EB/WB crash concentration in Kingman area (MP 48 - 51)	Repaving done in 2015 WB at MP 43	Medium	Not clear if repaving done in 2015 addressed need Programmed: bridge deck rehabilitations at Holy Moses Wash EB/WB in FY 2017 at MP 46
4	19	55-74	High		Repaving done in 2014 EB/WB at MP 57-71.5. Repaving underway in 2015-2016 EB/WB at MP 72-74	High	Not clear if repaving done in 2014 and underway in 2015-2016 addressed need Programmed: Blake Ranch Road TI improvements in FY 2017 at MP 66 and Peacock Wash bridge rehabilitation in FY 2018 at MP 73
5	6	74-80	None		Repaving underway in 2015-2016 EB/WB at MP 74-79	None	No identified need
6	18	80-98	High		Repaving underway in 2015-2016 EB/WB at MP 86-98 includes guard rail and rumble strip installation and bridge repairs Bridge rehabilitation done in 2015 for Willow Creek Bridge #2 at MP 82-83	High	Not clear if repaving underway in 2015-2016 and bridge rehabilitation done in 2015 addressed need Programmed: pavement preservation in FY 2019 at MP 80-87, bridge deck rehabilitations at Willow Creek Br #1 EB, #3 EB, #4 EB, #5 EB in FY 2016 at MP 83-86, and rockfall mitigation in FY 2017 at MP 83
7	10	98-108	Medium		Repaving underway in 2015-2016 EB/WB at MP 98-108 includes guard rail and rumble strip installation and bridge repairs	Medium	Repaving underway in 2015-2016 could at least partially address need but uncertain at this point
8	12	108-120	None			None	Programmed: pavement preservation in FY 2019 at MP 108-120
9	23	120-143	None			None	Programmed: sign rehabilitation in FY 2017 at MP 125-143
10	17	143-160	High	WB crash concentration near Pine Springs (MP 157 - 158)	Rehabilitation of ten bridge decks near the West Ash Fork Traffic Interchange in 2015 at MP 144-147	High	Rehabilitation of bridge decks in 2015 could at least partially address need but uncertain at this point Programmed: sign rehabilitation in FY 2017 at MP 143-160
11	8	160-168	Medium			Medium	Programmed: sign rehabilitation in FY 2017 at MP 160-168, pavement preservation in FY 2019 at MP 161-165, pavement replacement in FY 2018 at MP 162-168, and bridge deck rehabilitation at E Williams RR OP EB/WB in FY 2019 at MP 165
12	16	168-184	None			None	No identified need
13	6	184-190	None			None	No identified need
14	6	190-196	Low			Low	No identified need

Step 2.3

Identify recently completed or under construction projects (Column F) that would be considered relevant to safety performance. Include only projects that were not taken into account during the crash data analysis period (2009 – 2013). Any completed or under construction roadway project after 2013 that has the potential to mitigate a safety issue on a corridor segment should be listed in the template. Sources of recent or current project activity can include ADOT MPD staff, ADOT public notices, and ADOT District staff.

Step 2.4

Update the Final Need (Column G) based on the following criteria:

- If there is a crash hot spot concentration on a "None" segment, upgrade the need rating to "Low".

Step 2.5

Note any programmed projects that could have the potential to mitigate any safety need on the segment in Column H. Programmed projects are provided as information and do not impact

the need rating. Programmed projects will be reviewed in the development of solution sets for identified needs. The source of the programming information can be found in ADOT's 5-year construction program. Any other relevant issues identified in previous reports should also be reported in Column H.

Step 3: Contributing Factors

The Final Need ratings from Step 2 will populate into the Step 3 tab (Row 22). The Step 3 sample template is illustrated in **Table 3** for the I-40 corridor.

Table 4 - Step 3 Template

Segment Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Segment Length(miles)	11	10	43.55	19	6	18	10	12	23	17	8	16	9	6	
Segment Milepost (MP)	0-11	11-21	21-65	65-74	74-80	80-98	98-108	108-120	120-143	143-160	160-168	168-184	184-193	193-199	Corridor Wide Crash Characteristics
Final Need	High	Medium	Medium	High	None	High	Medium	None	None	High	Medium	None	None	Low	
Segment Crash Overview	4 Crashes were fatal 4 Crashes had incapacitating injuries 1 Crash involved trucks	10 Crashes were fatal 12 Crashes had incapacitating injuries 9 Crashes involved trucks	7 Crashes were fatal 12 Crashes had incapacitating injuries 2 Crashes involved trucks	10 Crashes were fatal 25 Crashes had incapacitating injuries 2 Crashes involved trucks	1 Crash was fatal 3 Crashes had incapacitating injuries 1 Crash involved trucks	9 Crashes were fatal 15 Crashes had incapacitating injuries 4 Crashes involved trucks	3 Crashes were fatal 7 Crashes had incapacitating injuries 1 Crash involved trucks	3 Crashes were fatal 13 Crashes had incapacitating injuries 2 Crashes involved trucks	3 Crashes were fatal 23 Crashes had incapacitating injuries 3 Crashes involved trucks	12 Crashes were fatal 15 Crashes had incapacitating injuries 4 Crashes involved trucks	2 Crashes were fatal 6 Crashes had incapacitating injuries 1 Crash involved trucks	1 Crash was fatal 11 Crashes had incapacitating injuries 0 Crashes involved trucks	1 Crash was fatal 3 Crashes had incapacitating injuries 1 Crash involved trucks	1 Crash was fatal 3 Crashes had incapacitating injuries 1 Crash involved trucks	38 Crashes were fatal 101 Crashes had incapacitating injuries 32 Crashes involved trucks
First Harmful Event Type	40% Involve Collision with Fixed Object 40% Involve Overturning 10% Involve Collision with Pedestrian	50% Involve Overturning 17% Involve Collision with Fixed Object 16% Involve Collision with Motor Vehicle	47% Involve Overturning 17% Involve Collision with Motor Vehicle 13% Involve Collision with Fixed Object	40% Involve Overturning 16% Involve Collision with Motor Vehicle 12% Involve Collision with Fixed Object	N/A - Sample size too small	53% Involve Overturning 14% Involve Other Non-Collision 6% Involve Collision with Fixed Object	33% Involve Overturning 33% Involve Collision with Pedestrian 33% Involve Other Non-Collision	54% Involve Overturning 33% Involve Other Non-Collision 13% Involve Collision with Fixed Object	42% Involve Overturning 13% Involve Collision with Motor Vehicle 13% Involve Other Non-Collision	48% Involve Overturning 24% Involve Other Non-Collision 8% Involve Collision with Fixed Object	50% Involve Overturning 25% Involve Collision with Fixed Object 13% Involve Collision with Non-Fixed Object	50% Involve Overturning 17% Involve Collision with Fixed Object 17% Involve Collision with Motor Vehicle	N/A - Sample size too small	N/A - Sample size too small	52% Involve Overturning 17% Involve Collision with Motor Vehicle 14% Involve Collision with Fixed Object
Collision Type	44% Involve Single Vehicle 25% Involve Other 13% Involve Angle	61% Involve Single Vehicle 11% Involve Rear End 3% Involve Head On	58% Involve Single Vehicle 18% Involve Rear End 13% Involve Head On	56% Involve Single Vehicle 18% Involve Rear End 12% Involve Other	N/A - Sample size too small	77% Involve Single Vehicle 9% Involve Sideswipe (same) 9% Involve Rear End	67% Involve Single Vehicle 33% Involve Other	69% Involve Single Vehicle 9% Involve Angle 9% Involve Head On	61% Involve Single Vehicle 13% Involve Rear End 4% Involve Angle	68% Involve Single Vehicle 8% Involve Rear End 4% Involve Unknown	88% Involve Single Vehicle 13% Involve Other	50% Involve Single Vehicle 8% Involve Left Turn 8% Involve Other	N/A - Sample size too small	N/A - Sample size too small	74% Involve Single Vehicle 11% Involve Rear End 7% Involve Other
Violation or Behavior	30% Involve Speed too Fast for Conditions 20% Involve Inattention/Distraction 10% Involve No Improper Action	27% Involve Inattention/Distraction 27% Involve Speed Too Fast for Conditions 18% Unknown	47% Involve Speed too Fast for Conditions 13% Involve Other 13% Involve Unknown	32% Involve Speed too Fast for Conditions 25% Involve Unknown 12% Involve No Improper Action	N/A - Sample size too small	50% Involve Speed too Fast for Conditions 28% Involve Inattention/Distraction 14% Involve No Improper Action	40% Involve Speed too Fast for Conditions 33% Involve Fail to/Missing 33% Involve Exceeded Lawful Speed	33% Involve Speed too Fast for Conditions 33% Involve No Improper Action 8% Involve Failure to Keep in Proper Lane	43% Involve Speed too Fast for Conditions 23% Involve No Improper Action 13% Involve Other	40% Involve Speed too Fast For Conditions 20% Involve No Improper Action 12% Involve Other	63% Involve Speed too Fast for Conditions 13% Involve Exceeded Lawful Speed 13% Involve Inattention/Distraction	42% Involve Speed too Fast for Conditions 25% Involve Exceeded Lawful Speed 8% Involve Failure to Keep in Proper Lane	N/A - Sample size too small	N/A - Sample size too small	45% Involve Speed Too Fast for Conditions 17% Involve No Improper Action 12% Involve Inattention/Distraction
Lighting Conditions	70% Occur in Daylight Conditions 20% Occur in Dark-Unlighted Conditions 10% Occur in Dawn Conditions	50% Occur in Daylight Conditions 25% Occur in Dark-Unlighted Conditions 12% Occur in Dawn Conditions	53% Occur in Daylight Conditions 28% Occur in Dark-Unlighted Conditions 13% Occur in Dark-Lighted Conditions	60% Occur in Daylight Conditions 20% Occur in Dark-Unlighted Conditions 4% Occur in Dark-Lighted Conditions	N/A - Sample size too small	50% Occur in Dark-Unlighted Conditions 50% Occur in Daylight Conditions	33% Occur in Dark-Unlighted Conditions 40% Occur in Daylight Conditions 20% Occur in Dawn Conditions	33% Occur in Daylight Conditions 33% Occur in Dark-Unlighted Conditions	39% Occur in Daylight Conditions 23% Occur in Dark-Unlighted Conditions 8% Occur in Dusk Conditions	35% Occur in Daylight Conditions 29% Occur in Dark-Unlighted Conditions	50% Occur in Daylight Conditions 25% Occur in Dawn Conditions< 25% Occur in Dark-Unlighted Conditions	75% Occur in Dark-Unlighted Conditions 25% Occur in Daylight Conditions	N/A - Sample size too small	N/A - Sample size too small	52% Occur in Daylight Conditions 30% Occur in Dark-Unlighted Conditions 4% Occur in Dawn Conditions
Surface Conditions	100% Involve Dry Conditions	91% Involve Dry Conditions 9% Involve Ice/Frost Conditions	100% Involve Dry Conditions	90% Involve Dry Conditions 10% Involve Wet Conditions 4% Involve Slush Conditions	N/A - Sample size too small	72% Involve Dry Conditions 14% Involve Wet Conditions 9% Involve Ice/Frost Conditions	80% Involve Dry 20% Involve Ice/Frost Conditions	100% Involve Dry Conditions	83% Involve Dry Conditions 9% Involve Slush Conditions 8% Involve Ice/Frost Conditions	88% Involve Dry Conditions 8% Involve Wet Conditions 8% Involve Water (standing or moving) Conditions	88% Involve Dry Conditions 38% Involve Dry Conditions 13% Involve Slush Conditions	92% Involve Dry Conditions 25% Involve Snow Conditions 17% Involve Slush Conditions	N/A - Sample size too small	N/A - Sample size too small	80% Involve Dry Conditions 6% Involve Wet Conditions 6% Involve Ice/Frost Conditions
First Unit Event	50% Involve a first unit event of Rollover Vehicle in Transport 20% Involve a first unit event of Run Off the Road (Right) 10% Involve a first unit event of Other Non-Fixed Object	39% Involve a first unit event of Run Off the Road (Left) 39% Involve a first unit event of Motor Vehicle in Transport 18% Involve a first unit event of Run Off the Road (Right)	32% Involve a first unit event of Motor Vehicle in Transport 28% Involve a first unit event of Run Off the Road (Left) 28% Involve a first unit event of Equipment Failure	36% Involve a first unit event of Motor Vehicle in Transport 32% Involve a first unit event of Run Off the Road (Left) 12% Involve a first unit event of Overturn	N/A - Sample size too small	38% Involve a first unit event of Run Off the Road (Left) 18% Involve a first unit event of Run Off the Road (Right) 14% Involve a first unit event of Motor Vehicle in Transport	60% Involve a first unit event of Run Off the Road (Left) 20% Involve a first unit event of Equipment Failure 20% Involve a first unit event of Run Off the Road (Right)	46% Involve a first unit event of Run Off the Road (Left) 25% Involve a first unit event of Equipment Failure 25% Involve a first unit event of Run Off the Road (Right)	38% Involve a first unit event of Run Off the Road (Left) 13% Involve a first unit event of Motor Vehicle in Transport 13% Involve a first unit event of Equipment Failure	58% Involve a first unit event of Run Off the Road (Left) 24% Involve a first unit event of Motor Vehicle in Transport 12% Involve a first unit event of Run Off the Road (Right)	50% Involve a first unit event of Run Off the Road (Left) 25% Involve a first unit event of Collision with Fixed Object 13% Involve a first unit event of Other Non-Collision	33% Involve a first unit event of Run Off the Road (Left) 17% Involve a first unit event of Equipment Failure 17% Involve a first unit event of Run Off the Road (Right)	N/A - Sample size too small	N/A - Sample size too small	38% Involve a first unit event of Run Off the Road (Left) 18% Involve a first unit event of Run Off the Road (Right) 15% Involve a first unit event of Rollover Vehicle in Transport 15% Involve a first unit event of Run Off the Road (Right)
Driver Physical Condition	80% No Apparent Influence 20% Fatigued/Fell Asleep 20% Under the Influence of Drug or Alcohol	46% No Apparent Influence 27% Fatigued/Fell Asleep 14% Under the Influence of Drug or Alcohol	58% No Apparent Influence 28% Under the Influence of Drug or Alcohol 5% Fatigued/Fell Asleep	48% No Apparent Influence 32% Unknown 12% Under the Influence of Drug or Alcohol	N/A - Sample size too small	58% No Apparent Influence 18% Unknown 9% Under the Influence of Drug or Alcohol	73% No Apparent Influence 20% Unknown	77% No Apparent Influence 23% Fatigued/Fell Asleep	56% No Apparent Influence 23% Fatigued/Fell Asleep 13% Unknown	88% No Apparent Influence 20% Unknown 12% Under the Influence of Drug or Alcohol	88% No Apparent Influence 25% Fatigued/Fell Asleep 13% Under the Influence of Drug or Alcohol	83% No Apparent Influence 17% Fatigued/Fell Asleep	N/A - Sample size too small	N/A - Sample size too small	62% No Apparent Influence 25% Unknown 12% Fatigued/Fell Asleep
Safety Device Usage	50% None Used 20% Shoulder And Lap Belt Used 20% Air Bag Deployed	52% Shoulder And Lap Belt Used 18% None Used 8% Unknown	53% Shoulder And Lap Belt Used 23% None Used 13% Helmet Used	48% Shoulder And Lap Belt Used 20% None Used 12% Unknown	N/A - Sample size too small	55% Shoulder And Lap Belt Used 23% None Used 14% Air Bag Deployed/Shoulder-Lap Belt	80% Shoulder And Lap Belt Used 13% Air Bag Deployed/Shoulder-Lap Belt 13% Not Applicable	46% Shoulder And Lap Belt Used 25% Helmet Used 13% Air Bag Deployed/Shoulder-Lap Belt	70% Shoulder And Lap Belt Used 13% None Used 8% Air Bag Deployed/Shoulder-Lap Belt	75% Shoulder And Lap Belt Used 38% None Used 8% Not Applicable	75% Shoulder And Lap Belt Used 25% None Used	50% Shoulder And Lap Belt Used	N/A - Sample size too small	N/A - Sample size too small	51% Shoulder And Lap Belt Used 17% None Used 7% Air Bag Deployed/Shoulder-Lap Belt
Hot Spot Crash Summaries	No identified Hot Spot.	No identified Hot Spot.	Hot Spot from MP 48 - 51 (19 WB, 4 Fatal and 3 Incapacitating Injury crashes. 58% involve single vehicles overturning in dry conditions. 50% are a result of running off the road left or right.	No identified Hot Spot.	N/A - Sample size too small	No identified Hot Spot.	No identified Hot Spot.	No identified Hot Spot.	No identified Hot Spot.	Hot Spot from MP 157 - 158 (WB. 3 Fatal and 3 Incapacitating Injury crashes. 100% of crashes involve single vehicles running off the road left.	No identified Hot Spot.	No identified Hot Spot.	N/A - Sample size too small	N/A - Sample size too small	
Previously Completed Safety Related Projects	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction	2012. Rumble Strip Construction
District Interviews/Discussions	• Pavement heaving and deterioration may contribute to crashes. • Need a reason to drainage issues in some continuous water is not required to overlap on the interstate (MP 9-3).	• Significant truck crash issues. problem, segment is flat and straight with many non-off road crashes (rollovers). Fatigue matters for sleepy drivers. • Distressed pavement in the WB direction causing potholes in the pavement due to the age of the pavement. Currently no future pavement projects are programmed.	• Significant truck crash issues. Multi-passenger approaches have pavement failure and rollover due to sub-grade failure (MP 44 - 52).					• Severe roadway fatigue with large potholes with many public complaints filed (MP 112 - 121).	• Significant crack in pavement from initial sub-grade failure. Potential crash hazard (MP 121 - 124).	• Large potholes exist on roadway (MP 159 - 161) primarily due to deteriorated pavement. • Large potholes exist in the WB direction due to the concrete base failure (MP 152 - 161).					
Contributing Factors	• Roadway departure • Driver inattention/distraction • Pavement surface condition • Shoulder/rumble strip condition • Lack of restraint usage • Improper lane changes Comment: Berm deterioration may create future safety need	• Roadway departure • Driver inattention/distraction • Pavement surface condition • Shoulder/rumble strip condition • Clear zone slopes and obstructions • Driving under the influence Comment: District input supports crash pattern	• Speed too fast for conditions • Improper lane changes • Pavement surface condition • Shoulder/rumble strip condition • Clear zone slopes and obstructions • Urban operating conditions • Driving under the influence • Lack of restraint usage Comment: Programmed bridge deck replacement at MP 49 may help address ES/WB safety need	• Speed too fast for conditions • Improper lane changes • Night drift; volume operating conditions • Driving under the influence • Slippery/wet pavement surface Comment: Ongoing pavement preservation project may help address ES/WB safety need	N/A - Sample size too small	• Speed too fast for conditions • Driver inattention/distraction • Roadway departure • Pavement surface condition • Traffic control device ineffectivity • Shoulder/rumble strip condition • Clear zone slopes and obstructions • Lack of restraint usage • Slippery/wet pavement surface Comment: Ongoing pavement preservation, shoulder improvements, and bridge rehabilitation may help address safety need Comment: Programmed pavement preservation, bridge deck replacement, and rockfall mitigation projects may help address safety need	• Roadway departure • Traffic control device ineffectivity • Shoulder/rumble strip condition • Clear zone slopes and obstructions • Slippery/wet pavement surface Comment: Ongoing pavement preservation, shoulder improvements, and bridge rehabilitation may help address safety need	• Speed too fast for conditions • Driver inattention/distraction • Roadway departure • Pavement surface condition • Shoulder/rumble strip condition • Clear zone slopes and obstructions Comment: Programmed pavement preservation project may help address safety need	• Speed too fast for conditions • Driver inattention/distraction • Improper lane changes • Roadway departure • Pavement surface condition • Slippery/wet pavement surface Comment: Programmed sign rehabilitation may help address safety need	• Speed too fast for conditions • Roadway departure • Pavement surface condition • Shoulder/rumble strip condition • Lack of restraint usage • Clear zone slopes and obstructions • Slippery/wet pavement surface Comment: Ongoing bridge deck replacement may help address safety need Comment: Programmed sign rehabilitation. pavement preservation and replacement, and bridge deck replacement may help address safety need	• Speed too fast for conditions • Driver inattention/distraction • Roadway departure • Shoulder/rumble strip condition • Lack of restraint usage • Clear zone slopes and obstructions • Slippery/wet pavement surface	• Speed too fast for conditions • Driver inattention/distraction • Roadway departure • Pavement surface condition • Traffic control device ineffectivity • Shoulder/rumble strip condition • Clear zone slopes and obstructions • Slippery/wet pavement surface	N/A - Sample size too small	N/A - Sample size too small	• Speed too fast for conditions • Driver inattention/distraction • Improper lane changes • Roadway departure • Pavement surface condition • Shoulder/rumble strip condition • Clear zone slopes and obstructions • Slippery/wet pavement surface

A separate *Crash Summary Sheet* file contains summaries for 8 crash attributes for the entire corridor, for each corridor segment, and for statewide roadways with similar operating environments (the database of crashes on roadways with similar operating environments was developed in Task 2 (the baseline corridor performance)). The crash attribute summaries are consistent with the annual ADOT Publication, *Crash Facts*. The 8 crash attribute summaries consist of the following:

- First Harmful Event (FHET)
- Crash Type (CT)
- Violation or Behavior (VB)
- Lighting Condition (LC)
- Roadway Surface Type (RST)
- First Unit Event (FUE)
- Driver Physical Condition (Impairment)
- Safety Device Usage (Safety Device)

Non-colored tabs in this spreadsheet auto-populate with filtered crash attributes. Each tab is described below:

- **Step_3_Summary** – This tab contains the filtered summary of crashes that exceed statewide thresholds for crashes on roadways with similar operating environments. Data in this tab are copied into the Step 3 template.
- **Statewide** – This tab contains a summary of statewide crashes from roadways with similar operating environments filtered by the 8 crash type summaries listed above. The crash type summaries calculate statewide crash thresholds (% total for fatal plus incapacitating crashes). The crash thresholds were developed to provide a statewide expected proportion of crash attributes against which the corridor segments' crash attributes can be compared. The crash thresholds were developed using the *Probability of Specific Crash Types Exceeding a Threshold Proportion* as shown in the Highway Safety Manual, Volume 1 (2010). The thresholds are automatically calculated within the spreadsheet. The threshold proportion was calculated as follows:

$$p*_i = \frac{\sum N_{Observed,i}}{\sum N_{Observed,i(total)}}$$

Where:

$p*_i$ = Threshold proportion

$\sum N_{Observed,i}$ = Sum of observed target crash frequency within the population

$\sum N_{Observed,i(total)}$ = Sum of total observed crash frequency within the population

A minimum crash sample size of 5 crashes over the 5-year crash analysis period is required for a threshold exceedance to be displayed in the Step 3 template. The probability of exceeding the crash threshold was not calculated to simplify the process.

- **Corridor** – A summary of corridor-wide crashes filtered by the 8 crash attribute summaries listed above.
- **Segment FHET** – A segment-by-segment summary of crashes filtered by first harmful event attributes.
- **Segment CT** – A segment-by-segment summary of crashes filtered by crash type attributes.
- **Segment VB** - A segment-by-segment summary of crashes filtered by violation or behavior attributes.
- **Segment LC** – A segment-by-segment summary of crashes filtered by lighting condition attributes.
- **Segment RST** – A segment-by-segment summary of crashes filtered by roadway surface attributes.
- **Segment FUE** – A segment-by-segment summary of crashes filtered by first unit event attributes.
- **Segment Impairment** – A segment-by-segment summary of crashes filtered by driver physical condition attributes related to impairment.
- **Segment Safety Device** – A segment-by-segment summary of crashes filtered by safety device usage attributes.

The data from the “STATE_DATA” tab for crashes in the corridor, including the 8 crash attribute categories, must be inserted into the appropriate column (highlighted in gray) of the “INPUT_CORRIDOR_DATA” tab in order for the 8 crash attribute tabs to be populated correctly. The “Calcs” tab includes formulas that draw on the information provided in the other tabs to generate the table in the Step_3_Summary tab.

The steps to compete Step 3 include:

Step 3.1

Using the Crash_Summary_Sheet.xlsx, go to the “Step_3_Summary” tab. Input the operating environments for each segment in the table (O3:Q27).

Step 3.2

Filter data from the ADOT database for the “CORRIDOR_DATA” tab by inserting the following data in the appropriate columns that are highlighted in gray for the “INPUT_CORRIDOR_DATA” tab:

- Incident ID: Column A
- Incident Crossing Feature (MP): Column B
- Segment Number (Non-native ADOT data – must be manually assigned based on the location of the crash): Column C
- Operating Environment (Non-native ADOT data – should already be assigned but if for some reason it isn’t, it will need to be manually assigned): Column D
- Incident Injury Severity: Column E
- Incident First Harmful Description: Column F
- Incident Collision Manner: Column H
- Incident Lighting Condition Description: Column I
- Unit Body Style: Column J
- Surface Condition: Column K
- First Unit Event Sequence: Column L
- Person Safety Equipment: Column N
- Personal Violation or Behavior: Column O
- Impairment: Column P

Note that columns highlighted in yellow (G, M, Q) perform a calculated input to aggregate specific crash descriptions. For example, crashes can contain various attributes for animal-involved crashes. The crash attributes that involve an animal were combined into a common attribute, such as “ANIMAL”. This will allow the summaries to be consistent with the ADOT *Crash Facts*.

The data in the Impairment category contains blank descriptions if it was found that there was “No Apparent Influence” or if it was “Unknown”. Using the crash data fields “PersonPhysicalDescription” 0 - 99, fill in the blank columns to reflect if the physical description is described as “No Apparent Influence” or “Unknown”. Note that the native physical description data from the ADOT database may need to be combined to a single column.

Step 3.3

Confirm that the crash database is being properly filtered by comparing crash frequencies from the summary tables with the frequencies developed in Task 2. For example, the lookup function will fail if the filter is for “NO IMPROPER ACTION” if the database has the attribute of “NO_IMPROPER_ACTION”.

Step 3.4

Copy and paste the Step_3_Summary into the Task 4 – Safety Needs Assessment spreadsheet in the Step 3 tab. Paste values only and remove the summaries with “0%s” for a clean display. Where duplicate values exist, go to the "Calcs" tab in the Crash_Summary_Sheet file to determine which categories have the same %. If there are more crash types with the same % than there is space in the table, select the crash type with the highest difference between the segment % and the statewide average %

Step 3.5

The Step 3 table in the Task 4 – Safety Needs Assessment spreadsheet should be similar to the Step 3 template. In the Segment Crash Summaries row, the top three crash attributes are displayed. Change the font color of the crash attributes that exceed the statewide crash threshold to red for emphasis. The attributes with a red font in the “Calcs” tab have exceeded statewide crash thresholds. Note that corridor-wide values are not compared to statewide values as corridor-wide values are typically a blend of multiple similar operating environments while the statewide values apply to one specific similar operating environment.

Step 3.6

Provide a summary of any observable patterns found within the crash Hot Spots, if any exist in the segments.

Step 3.7

Input any historic projects (going no further back than 2000) that can be related to improving safety. Projects more than five years old may have exceeded their respective design life and could be contributing factors to safety performance needs.

Step 3.8

Input key points from District interviews or any important information from past discussions with District staff that is consistent with needs and crash patterns identified as part of the performance and needs assessment as this may be useful in identifying contributing causes. This information may be obtained from District Maintenance personnel by requesting the mile post locations that may be considered safety issues.

Step 3.9

For segments with one or more of the following characteristics, review crashes of all severity levels (not just fatal and incapacitating injury crashes). Identify likely contributing factors and compare that to the above statewide average comparison findings already calculated for fatal and incapacitating injury crashes. Refine the contributing factors list accordingly.

- Segments with Medium or High need
- Segments with a crash hot spot concentration (but only review crashes at the concentration areas)
- Segments with no apparent predominant contributing factors based on the comparison of fatal and incapacitating crashes to statewide averages if the segment has a Medium or High need.

Step 3.10

Considering all information in Steps 1-3, list the contributing factors using engineering judgment and the information on contributing factors available in Section 6.2 of the 2010 Highway Safety Manual. Additional sources for determining contributing factors may include aerial, “streetview”, and/or ADOT photologs. Other documents such as Design Concept Reports (DCR) or Road Safety Assessments can provide insight into the study corridor’s contributing factors.

Add comments as needed on additional information related to contributing factors that may have been provided by input from ADOT staff.

Freight Needs Assessment Methodology (Steps 1-3)

This section documents the approach for conducting the first three steps of a five-step needs assessment process for the Freight Performance Area. The five-step process is listed below. When Step 3 is completed for all performance areas (Pavement, Bridge, Mobility, Safety, and Freight), Step 4 will review each corridor segment to identify common or overlapping needs for multiple performance areas. Corridor needs are then identified in Step 5 of the process.

- Step 1: Initial Needs
- Step 2: Final Needs
- Step 3: Contributing Factors
- Step 4: Segment Review
- Step 5: Corridor Needs

The Task 4 - Freight Needs Assessment Excel spreadsheet contains 3 tabs for Steps 1 - 3.

Step 1: Initial Needs

The Step 1 sample template is illustrated in **Table 1** for the I-40 corridor:

Table 5 - Step 1 Example

Segment	Facility Operations	Segment Milepoints (MP)	Segment Length (miles)	Freight Index			Directional TTI (truck only)						Directional PTI (truck only)						Closure Duration (hours/mile/year)					Bridge Clearance (feet)			Initial Need
				Performance Score	Performance Objective	Level of Need	Performance Score		Performance Objective		Level of Need		Performance Score		Performance Objective		Level of Need		Performance Score		Performance Objective		Level of Need	Performance Score	Performance Objective	Level of Need	
							EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB				
1	Uninterrupted	0-10	10	0.86	Fair or Better	None	1.11	1.04	Fair or Better	None	None	None	1.20	1.08	Fair or Better	None	None	None	1.58		Fair or Better	None	None	16.13	Fair or Better	Low	Low
2	Uninterrupted	10-43	33	0.87	Fair or Better	None	1.12	1.05	Fair or Better	None	None	None	1.21	1.09	Fair or Better	None	None	None	1.59		Fair or Better	None	None	16.14	Fair or Better	None	None
3	Uninterrupted	43-55	12	0.87	Fair or Better	None	1.12	1.05	Fair or Better	None	None	None	1.22	1.09	Fair or Better	None	None	None	1.59		Fair or Better	None	None	16.15	Fair or Better	None	None
4	Uninterrupted	55-74	19	0.91	Fair or Better	None	1.14	1.08	Fair or Better	None	None	None	1.31	1.17	Fair or Better	None	None	None	1.67		Fair or Better	None	None	16.25	Fair or Better	None	None
5	Uninterrupted	74-80	6	0.95	Fair or Better	None	1.50	1.10	Fair or Better	None	None	None	1.33	1.06	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.27	Fair or Better	None	Low
6	Uninterrupted	80-93	13	0.96	Fair or Better	None	1.14	1.10	Fair or Better	None	None	None	1.29	1.05	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.28	Fair or Better	Low	Low
7	Uninterrupted	93-103	10	0.95	Fair or Better	None	1.14	1.10	Fair or Better	None	None	None	1.27	1.05	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.26	Fair or Better	None	Low
8	Uninterrupted	103-120	17	0.95	Fair or Better	None	1.15	1.06	Fair or Better	None	None	None	1.28	1.12	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.27	Fair or Better	Low	Low
9	Uninterrupted	120-143	23	0.93	Fair or Better	None	1.12	1.08	Fair or Better	None	None	None	1.27	1.10	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.26	Fair or Better	Low	Low
10	Uninterrupted	143-160	17	0.93	Fair or Better	None	1.17	1.08	Fair or Better	None	None	None	1.32	1.10	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.27	Fair or Better	None	Low
11	Uninterrupted	160-168	8	0.93	Fair or Better	None	1.16	1.08	Fair or Better	None	None	None	1.27	1.09	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.26	Fair or Better	Low	Low
12	Uninterrupted	168-184	16	0.94	Fair or Better	None	1.19	1.01	Fair or Better	None	None	None	1.36	1.06	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.27	Fair or Better	Low	Low
13	Uninterrupted	184-189	5	0.95	Fair or Better	None	1.19	1.02	Fair or Better	None	None	None	1.37	1.05	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	17.50	Fair or Better	None	Low
14	Uninterrupted	189-199	10	0.95	Fair or Better	None	1.19	1.08	Fair or Better	None	None	None	1.38	1.15	Fair or Better	None	None	None	2.67		Fair or Better	Medium	None	16.27	Fair or Better	None	Low
Emphasis Area?	Yes	Weighted Average		0.90	Good	None																					

Needs Assessment Scale

Measure	None >=	> Low <		> Medium <		High <=
Corridor Freight Index (Emphasis Area)	0.80	0.80	0.74	0.74	0.67	0.67
Corridor Freight Index (Non-Emphasis Area)	0.74	0.74	0.70	0.70	0.64	0.64
Freight Index (Segment)						
Measure	None >=	> Low <		> Medium <		High <=
Interrupted	0.42	0.42	0.33	0.33	0.17	0.17
Uninterrupted	0.74	0.74	0.70	0.70	0.64	0.64
Measure	None <=	< Low >		< Medium >		High >=
Directional TTI						
Interrupted	1.53	1.53	1.77	1.77	2.23	2.23
Uninterrupted	1.21	1.21	1.27	1.27	1.39	1.39
Directional PTI						
Interrupted	2.67	2.67	3.33	3.33	4.67	4.67
Uninterrupted	1.37	1.367	1.43	1.43	1.57	1.57
Closure Duration						
All Facility Operations	7.49	7.49	12.76	12.76	23.32	23.32
Measure	None >=	> Low <		> Medium <		High <=
Bridge Clearance (feet)						
All Bridges	16.25	16.25	16.00	16.00	15.50	15.50

The input required to populate the Step 1 template includes transferring the existing performance score and color for each segment to the appropriate "Performance Score" columns. This includes the primary and secondary measures for Freight. As each performance score is input into the template, the Initial Need (Column Z) will populate based on the weighted scoring system for each measure.

The Level of Need for each performance measure has levels of "None" (score = 0), "Low" (score = 1), "Medium" (score = 2), and "High" (score = 3). The assignment of these levels to individual performance measures for segments is determined by the table entitled "Needs Assessment Scale" within the Step 1 template.

To develop an aggregated Initial Need for each segment, the primary and secondary measures are combined by summing the weighted score, with the primary measure having a weight of 1.0 while each secondary measure has a weight of 0.2 (0.1 each direction if directional). The Initial Need for each segment (combining the primary and secondary measures) has levels of "None" (score < 0.01), "Low" (score $\geq$ 0.01 and < 1.5), "Medium" (score $\geq$ 1.5 and < 2.5), and "High" (score $\geq$ 2.5).

The steps include:

Step 1.1

Populate the Step 1 template with the existing (baseline) performance scores for all primary and secondary performance measures from Task 2. Copy the performance score for each segment to the appropriate "Performance Score" column. Select the *Facility Operations* for each segment from the drop-down list (Column B) and input whether or not the performance area is an emphasis area (B41). The corridor needs assessment scales will be updated automatically.

Step 1.2

Confirm that that the Step 1 template is generating the appropriate "Level of Need" for each primary and secondary measure by reviewing the relationship of baseline performance score to level of need.

Step 2: Final Needs

The Initial Need will be carried over to Step 2 (Column D). The Step 2 sample template is illustrated in **Table 2** for the I-40 corridor.

Table 6 - Step 2 Example

Segment	Segment Length (miles)	Segment Mileposts (MP)	Initial Deficiency	Truck Height Restriction Hot Spots (Clearance < 16')	Relevant Recently Completed or Under Construction Projects (which supersede performance data)*	Refined Deficiency	Comments (may include tentatively programmed projects with potential to address deficiency or other relevant issues identified in previous reports)
40-1	11	0-11	None			None	
40-2	32	11-43	None	2 (MP 26 and MP 37) - can ramp around both		None	
40-3	12	43-55	None		New DMS at MP 45 (EB)	None	
40-4	19	55-74	None			None	
40-5	6	74-80	Low			Low	No programmed projects to correct closure restriction issue
40-6	18	80-98	Low			Low	No programmed projects to correct closure restriction issue
40-7	10	98-108	Low			Low	No programmed projects to correct closure restriction issue
40-8	12	108-120	Low	1 (MP 118) - cannot ramp around (15' 11")		Medium	No programmed projects to correct vertical clearance or closure restriction issue
40-9	23	120-143	Low	1 (MP 121) - can ramp around		Low	No programmed projects to correct closure restriction issue
40-10	17	143-160	Low		New DMS at MP 148 (WB)	Low	No programmed projects to correct closure restriction issue
40-11	8	160-168	Low	1 (MP 168) - can ramp around		Low	No programmed projects to correct closure restriction issue
40-12	16	168-184	Low	1 (MP 178) - can ramp around		Low	No programmed projects to correct closure restriction issue
40-13	6	184-190	Low			Low	No programmed projects to correct closure restriction issue
40-14	6	190-196	Low		New DMS at MP 198 (WB)	Low	No programmed projects to correct closure restriction issue
					*Data on projects that have been constructed since 12/31/2013 supersedes condition data.		

The steps required to complete Step 2 are as follows:

Step 2.1

Confirm that the template has properly populated the initial need from the Step 1 template to Column D of the Step 2 template.

Step 2.2

Note in Column E any truck height restriction hot spots (clearance < 16') identified as part of the baseline corridor performance. For each entry, note the milepost of the height restriction and if the height restriction can be detoured by ramping around the obstruction. If it is not possible for a truck to ramp around the height restriction, note the existing height as well.

Step 2.3

Identify recently completed or under construction projects (Column F) that would be considered relevant to freight performance. Include only projects that were not taken into account during the freight data analysis period. Any completed or under construction roadway project after the date of the data that has the potential to mitigate a freight issue on a corridor segment should be listed in the template. Such projects can include the construction of climbing lanes or Dynamic Message Signs (DMS) installation. Sources of recent or current project activity can be ADOT MPD staff, ADOT public notices, and ADOT District staff.

Step 2.4

Update the Final Need (Column G) using the following criteria:

- If there is one or more truck height restriction hot spots (Column E) where a truck cannot ramp around on a 'None' segment, increase (i.e., worsen) the need rating to 'Low'.
- If a recent project (Column F) has superseded the performance rating data and it is certain the project addressed the need, change the need rating to "None".
- If a recent project (Column F) has superseded the performance rating data but it is uncertain that a project addressed the need, maintain the current need rating and note the uncertainty as a comment in Column H.

Step 2.5

Note any programmed projects that could have the potential to mitigate any freight need on the segment in Column H. Programmed projects are provided as information and do not impact the need rating. Programmed projects will be reviewed in the development of solution sets for identified needs. The source of the programming information can be found in ADOT's 5-year construction program. If there are other comments relevant to the needs analysis, they can be entered in the right-most column (Column H).

Step 3: Contributing Factors

The Final Need ratings from Step 2 will populate into the Step 3 tab (Column D). The Step 3 sample template is illustrated in **Table 3** for the I-40 corridor.

Table 7 - Step 3 Example

				Roadway Variables										Traffic Variables					
Segment	Segment Mileposts (MP)	Segment Length (miles)	Final Need	Functional Classification	Environmental Type (Urban/Rural)	Terrain	# of Lanes/ Direction	Speed Limit	Aux Lanes	Divided/ Non-Divided	Sustained Grades	% No Passing	Existing LOS	Future 2035 LOS	% Trucks	NB/EB Buffer Index (TPTI-TTTI)	SB/WB Buffer Index (TPTI-TTTI)	Relevant Freight Related Existing Infrastructure
1	0-11	11	Low	Interstate	Rural	Rolling	2	75	No	Divided	No	0%	A-C	D	38%	0.09	0.04	Dynamic Message Sign (DMS) at MP 8 (EB); Topock Port-of-Entry (POE) at MP 4;
2	11-43	32	Low	Interstate	Rural	Level	2	75	No	Divided	No	0%	A-C	A-C	29%	0.04	0.04	Haviland Rest Area at MP 23 (EB/WB)
3	43-55	12	Low	Interstate	Fringe Urban	Mountainous	2	75	No	Divided	Yes	0%	A-C	D	29%	0.11	0.06	DMS at MP 45 (EB)
4	55-74	19	None	Interstate	Rural	Rolling	2	75	Yes	Divided	No	0%	A-C	D	24%	0.12	0.09	DMS at MP 55 (WB); DMS at MP 69 (EB); Climbing Lane at MP 66-71 (WB)
5	74-80	6	Low	Interstate	Rural	Rolling	2	75	No	Divided	No	0%	A-C	D	24%	0.03	0.06	
6	80-98	18	Low	Interstate	Rural	Rolling	2	75	Yes	Divided	No	0%	A-C	A-C	29%	0.15	0.05	Climbing Lane at MP 88-90 (EB)
7	98-108	10	Low	Interstate	Rural	Rolling	2	75	No	Divided	No	0%	A-C	A-C	27%	0.04	0.04	
8	108-120	12	Low	Interstate	Rural	Mountainous	2	75	No	Divided	Yes	0%	A-C	D	28%	0.03	0.06	
9	120-143	23	Low	Interstate	Rural	Rolling	2	75	No	Divided	No	0%	A-C	D	24%	0.05	0.05	DMS at MP 124 (WB); Weigh Station (MP 131) closed
10	143-160	17	Low	Interstate	Rural	Mountainous	2	75	Yes	Divided	Yes	0%	A-C	D	17%	0.15	0.06	DMS at MP 144 (EB); DMS at MP 148 (WB); Truck Parking Area at MP 155 (WB); Climbing Lane at MP 153-156 (WB) and 153-156 (EB)
11	160-168	8	Low	Interstate	Rural	Mountainous	2	75	No	Divided	Yes	0%	A-C	D	19%	0.09	0.05	DMS at MP 168 (WB)
12	168-184	16	Low	Interstate	Rural	Rolling	2	75	No	Divided	No	0%	A-C	D	18%	0.03	0.03	Parks Rest Area at MP 182 (EB/WB) closed
13	184-190	6	Low	Interstate	Rural	Rolling	2	75	No	Divided	No	0%	A-C	D	19%	0.04	0.03	DMS at MP 184 (EB)
14	190-196	6	Low	Interstate	Urban	Mountainous	2	65-75	No	Divided	Yes	0%	A-C	A-C	26%	0.03	0.07	DMS at MP 198 (WB)

Segment	Segment Mileposts (MP)	Segment Length (miles)	Final Need	Closure Extent									Non-Actionable Conditions	Programmed and Planned Projects or Issues from Previous Documents Relevant to Final Need	Contributing Factors
				Total Number of Closures	# of Closures	% Closures	# Incidents/ Accidents	% Incidents/ Accidents	# Obstructions/ Hazards	% Obstructions/ Hazards	# Weather Related	% Weather Related			
1	0-11	11	Low	14	1	7%	11	79%	0	0%	2	14%			N/A
2	11-43	32	Low	70	6	9%	31	44%	0.7	1%	32	46%			N/A
3	43-55	12	Low	37	0	0%	24	65%	1.11	3%	12	32%		Proposed Climbing Lane at MP 47-49 (EB) - Tier 2 Medium Priority	Bridge clearance is two inches short of standard clearance of 16 feet and no ramps exist
4	55-74	19	None	79	3	4%	46	58%	0	0%	30	38%			N/A
5	74-80	6	Low	66	6	9%	30	45%	0	0%	30	45%			Percentage of closures due to weather above statewide average (49% vs. 5%)
6	80-98	18	Low	191	17	9%	83	43%	0	0%	90	47%			Percentage of closures due to weather above statewide average (47% vs. 5%)
7	98-108	10	Low	98	10	10%	38	39%	0	0%	50	51%			Percentage of closures due to weather above statewide average (52% vs. 5%)
8	108-120	12	Low	117	12	10%	44	38%	0	0%	61	52%		Planned DMS at MP 120 (WB)	Bridge clearance is one inch short of standard clearance of 16 feet and no ramps exist Percentage of closures due to weather above statewide average (52% vs. 5%)
9	120-143	23	Low	186	22	12%	66	35%	0	0%	97	52%			Percentage of closures due to weather above statewide average (52% vs. 5%)
10	143-160	17	Low	189	30	16%	46	24%	11.34	6%	100	53%		Planned DMS at MP 160 (EB); Proposed Climbing Lane at MP 151-152 (EB) - Tier 2 Medium Priority; Proposed Climbing	Percentage of closures due to weather above statewide average (53% vs. 5%) Percentage of closures due to obstruction hazards above statewide average (6% vs.
11	160-168	8	Low	79	16	20%	6	8%	0.79	1%	56	71%		Proposed Climbing Lane at MP 162-163 (WB) - Tier 3 Low Priority	Percentage of closures due to weather above statewide average (71% vs. 5%) Percentage of undefined closures above statewide average (20% vs. 18%)
12	168-184	16	Low	139	32	23%	9	6%	32	23%	98	71%			Percentage of closures due to weather above statewide average (71% vs. 5%) Percentage of undefined closures above statewide average (23% vs. 18%)
13	184-190	6	Low	56	13	23%	11	20%	13	23%	32	57%		Proposed Climbing Lane at MP 188-190 (EB) - Tier 1 High Priority	Percentage of closures due to weather above statewide average (57% vs. 5%) Percentage of undefined closures above statewide average (23% vs. 18%)
14	190-196	6	Low	52	12	23%	10	19%	12	23%	30	58%		Proposed Climbing Lane at MP 191-193 (WB) - Tier 2 Medium Priority	Percentage of closures due to weather above statewide average (58% vs. 5%) Percentage of undefined closures above statewide average (23% vs. 18%)

The steps to compete Step 3 include:

Step 3.1

Input all roadway variable data that describe each segment (Columns E - M) into the appropriate columns. Note that this data can be copied from the Mobility Needs Assessment spreadsheet for Task 4.

Step 3.2

Input all traffic variables for each segment (Columns N - P) into the appropriate columns. The Buffer Index (Columns Q – R) will auto populate based on the TPTI and TTTI input in the Step 1 tab. Note that this data can be copied from the Mobility Needs Assessment spreadsheet for Task 4.

Step 3.3

Input any freight-related infrastructure (Column S) that currently exists on the corridor for each segment. The relevant infrastructure can include DMS locations, weigh stations, Ports of Entry (POE), rest areas, parking areas, and climbing lanes. Include the mileposts of the listed infrastructure. This data can be extracted from the most recent Highway Log and the 2015 Climbing and Passing Lane Prioritization Study.

Step 3.4

In the lower portion of Column E – Column M input the Closure Extents that have occurred along the study corridor. Road closure information can be detailed out by the reason for the closure as documented in Highway Condition Reporting System (HCRS) data analyzed as part of the baseline corridor performance. Closure reasons include incident/accidents, winter storms, obstruction hazards, and undefined closures. Statewide average percentages for the various closure reasons have been calculated for the analysis period on ADOT's 11 designated strategic corridors. Compare these statewide average percentages to the corridor percentages for the various closure reasons to identify higher than average percentages of one or more closure reasons on any given segment. Note that this data can be copied from the Mobility Needs Assessment spreadsheet for Task 4. Input the closures as follows and use red text to indicate that the segment percentage exceeds statewide averages:

- Total Number of Closures (Column E)
- % Closures (No Reason) (Column F)
- % Incidents/Accidents (Column H)
- % Obstructions/Hazards (Column J)
- % Weather Related (Column L)

Step 3.5

In the lower portion of Column N/O, list the non-actionable conditions that are present within each segment by milepost if possible. Non-Actionable conditions are conditions that exist within the environment of each segment that cannot be improved through an engineered solution. Examples of Non-Actionable conditions can include border patrol check points and other closures/restrictions not controlled by ADOT. Note that this data can be copied from the Mobility Needs Assessment spreadsheet for Task 4.

Step 3.6

Input any programmed and planned projects or issues that have been identified from previous documents or studies that are relevant to the Final Need (Column D). Sources for this data include the current Highway Log, the 2015 Climbing and Passing Lane Prioritization Study, and ADOT's 5-year construction program.

Step 3.7

Considering all information in Steps 1-3, identify the contributing factors to the Final Need (Column S). Potential contributing factors to freight performance needs include roadway vertical grade, number of lanes, traffic volume-to-capacity ratios, presence/lack of a climbing lanes, and road closures. Also identify higher than average percentages of one or more closure reasons on any given segment.