AZ-83 Roadway Assessment

Rosemont Copper Project

July 2009
AZ-83 Roadway Assessment Report

Rosemont Copper Project

Prepared for:

ROSEMONT COPPER

4500 Cherry Creek South Drive, Suite 1040
Denver, Colorado  80246
(303) 300-0138
Fax (303) 300-0135

Prepared by:

TETRA TECH

16241 Laguna Canyon Road, Suite 200
Irvine, CA  92618
(949) 727-7099
Fax (949) 727-7097
Tetra Tech Project: 134-20192-09001A, 134-20192-09002, & 114-320794

July 2009
TABLE OF CONTENTS

EXECUTIVE SUMMARY .................................................................................................................. 1

1.0 INTRODUCTION .......................................................................................................................... 2
  1.1 Site Description ......................................................................................................................... 2
  1.2 Report Contents ....................................................................................................................... 2

2.0 AZ-83 ROADWAY ASSESSMENT ............................................................................................... 3
  2.1 Traffic Speeds .......................................................................................................................... 3
    2.1.1 MP 58.3 (I-10 Interchange) to MP 46 ............................................................................ 3
    2.1.2 MP 46 (STA 750+00) to MP 43.6 (STA 910+00) ......................................................... 4
    2.1.3 MP 43.6 (STA 910+00) to MP 32.4 (intersection of AZ-83 and AZ-82) ................. 5
  2.2 Horizontal Alignment .............................................................................................................. 5
    2.2.1 Clear Zone or Recovery Zone ......................................................................................... 7
    2.2.2 Shoulder ......................................................................................................................... 8
    2.2.3 Sight distance ............................................................................................................... 10
  2.3 Vertical Alignment ................................................................................................................. 14
  2.4 Existing School Bus Stops ..................................................................................................... 16
  2.5 Guardrails ............................................................................................................................... 17
  2.6 ADOT Future Projects ......................................................................................................... 18
    2.6.1 AZ-83 MP 31.6 to 44.5 Pavement Project ............................................................... 18
    2.6.2 AZ-83 MP 44 to 45.5 Safety Project ........................................................................... 18
    2.6.3 I-10 MP 288.4 to 290.5 Cienega Creek-Marsh Station Traffic Interchange Reconstruction ........................................................................................................... 19

3.0 ACCIDENT ANALYSIS ............................................................................................................ 20
  3.1 AZ-83 Accident Analysis ........................................................................................................ 22
    3.1.1 Annual Accident Frequency ........................................................................................... 23
    3.1.2 Accident Prone Location Analysis ............................................................................... 23
    3.1.3 Accident Involved Vehicle Type ................................................................................... 26
    3.1.4 Accident Collision Manner .......................................................................................... 27
    3.1.5 Accident Injury Type ........................................................................................................ 28
    3.1.6 Accident Major Causes .................................................................................................. 29
    3.1.7 AZ-83 Accident Analysis Summary ............................................................................ 29
    3.1.8 AZ-83 MP 44 Accident Analysis Summary ............................................................... 30
  3.2 AZ-77 Accident Analysis ........................................................................................................ 32
    3.2.1 Annual Accident Frequency ........................................................................................... 33
    3.2.2 Accident Prone Location analysis ............................................................................... 33
    3.2.3 Accident Involved Vehicle Type ................................................................................... 36
    3.2.4 Accident Collision Manner .......................................................................................... 37
    3.2.5 Accident Injury Type ........................................................................................................ 38
    3.2.6 Accident Major Causes .................................................................................................. 39
    3.2.7 AZ-77 Accident Analysis Summary ............................................................................ 39

4.0 AZ-83 POTENTIAL ROADWAY IMPROVEMENTS ................................................................. 41
4.1 Design Vehicle ........................................................................................................41
4.2 Primary Access Road “T” Intersection ...............................................................41
4.3 School Bus Stops ..................................................................................................41
4.4 Wide Load Truck Turnout ....................................................................................42
4.5 Utilities ..................................................................................................................42
4.6 Shoulder Upgrade ...............................................................................................44

REFERENCES ...............................................................................................................47

LIST OF TABLES
Table 2.1 Existing Horizontal Curve ...........................................................................6
Table 2.2 Existing Vertical Curve ................................................................................14
Table 3.1 AZ-83 Annual AADT (2002 to 2007) ..........................................................22

LIST OF ILLUSTRATIONS
Illustration 2.1 Advanced Curvy Alignment Warning Sign .........................................4
Illustration 2.2 Curvy Segment Between MP 44 to 45 .................................................5
Illustration 2.3 Narrow Shoulder without Sufficient Recovery Zone .........................8
Illustration 2.4 Example of Deteriorated Shoulder (Hilton Ranch Road) ..................9
Illustration 2.5 Example of Deteriorated Shoulder (MP 46.9) ...................................9
Illustration 2.6 Poor Horizontal Sight Distance .......................................................11
Illustration 2.7 Limited Sight Distance due to Tight Horizontal Curve (MP 44 to 45) 12
Illustration 2.8 Limited Sight Distance due to Steep Road Cut ................................12
Illustration 2.9 Warning Rockfall Sign .......................................................................13
Illustration 2.10 Warning Sign for Curvy Horizontal Alignment (MP 44 to 45) ........ 13
Illustration 2.11 Advanced Warning Sign for Steep Slope (MP 44 to 45) .................16
Illustration 2.12 Typical Substandard Guardrail (Sahuarita Road) ............................17
Illustration 2.13 Typical Substandard Guardrail (Near Hidden Valley Road) ........ 18
Illustration 3.1 Safety Diagram ..................................................................................20
Illustration 3.2 AZ-83 Annual Accident Frequency (2002 to 2008) .........................23
Illustration 3.3 AZ-83 Accident Frequency per Location (2002 to 2008) ..................24
Illustration 3.4 AZ-83 Accident Rate per Location (2002 to 2008) ..........................25
Illustration 3.5 AZ-83 Accident Involved Vehicle Type (2002 to 2008) ...................26
Illustration 3.6 AZ-83 Accident Collision Manner (2002 to 2008) .........................27
Illustration 3.7 AZ-83 Accident Injury Types (2002 to 2008) ..................................28
Illustration 3.8 AZ-83 Accident Major Causes (2002 to 2008) ................................29
Illustration 3.11 MP 44 Accident Vehicle Type (2002 to 2007) ................................30
Illustration 3.12 MP 44 Accident Collision Manner (2002 to 2007) .......................31
Illustration 3.13 MP 44 Accident Injury Type (2002 to 2007) ..................................31
Illustration 3.14 MP 44 Accident Major Causes (2002 to 2007) .............................32
Illustration 3.15 AZ-77 Annual Accident Frequency (2003 to 2007) .......................33
Illustration 3.16 AZ-77 Accident Frequency (2003 to 2007) .....................................34
Illustration 3.17 AZ-77 Accident Rate per Location (2006 to 2007) .......................35
LIST OF FIGURES

Figure 1 Vicinity Map
Figure 2 ADOT Roadway Functional Classification Map
Figure 3 Existing Primary Access Road Photos
Figure 4 AZ-83 Potential Roadway Improvements
Figure 5 Arizona Top 5% Accident Locations
Figure 6 Arizona Truck Volumes
Figure 7 AZ-83 Accident Locations and Existing Conditions
Figure 8 AZ-77 Accident Analysis and Mine Locations
Figure 9 Sight Distance Exhibit

LIST OF APPENDICES

Appendix A Arizona Department of Transportation (ADOT) Table 101.3
Appendix B Existing AZ-83 Roadway Plan and Profile Sheets
Appendix C Arizona Department of Transportation (ADOT) Table 303.2A
Appendix D Technical Memoranda – “T” Intersection Upgrade Alternatives
  Appendix D1 Stop Sign and Speed Reduction Alternative
  Appendix D2 Acceleration Lane Alternative
  Appendix D3 Bypass Lane Alternative
Appendix E Arizona Department of Transportation (ADOT) Table 204.3
Appendix F Technical Memorandum – School Bus Stop
Appendix G Arizona Department of Transportation (ADOT) American Recovery and
  Reinvestment Act (ARRA) Approved Project List
Appendix H Arizona Department of Transportation (ADOT) Table 407.2
Appendix I Technical Memorandum – Wide Load Truck Turnout
Appendix J Arizona Department of Transportation (ADOT) Table 302.4
EXECUTIVE SUMMARY

State Route 83 (AZ-83) will be used as main transport corridor for the Rosemont Copper Project (Project). An assessment which analyzed the current roadway geometry and safety conditions was completed along AZ-83 between Interstate 10 (I-10) and State Route 82 (AZ-82). The analysis was based on the Arizona Department of Transportation (ADOT) Roadway Design Guidelines, the American Association of State Highways and Officials (AASHTO) Policy on Geometric Design of Highways and Streets, and AASHTO Roadside Design. Substandard design elements were identified for AZ-83 and included: 1) tight reverse horizontal curves, 2) improper guardrail placement, and 3) insufficient roadway shoulder widths.

Accident data from ADOT was collected for the period between 2002 to 2008 in order to complete a detailed accident assessment for AZ-83. The top five (5) accident prone locations were identified to be Mile Post (MP) 44, 45, 46, 55, and 58. In particular, the roadway segment between MP 44.5 to 44.0 has the highest accident frequency for all fatal accidents along AZ-83. Additionally, locations where substandard designs are present coincide with the high accident frequency locations. The proposed Primary Access Road leading to the Rosemont Project off AZ-83 is located at MP 46.9. This location shows relatively low accident frequency and rate. In summary, the major causes of accidents on AZ-83 are speeding in combination with the curvy roadway geometry. Incidents involving trucks show a relatively low accident rates, suggesting that trucks are not the major vehicle type that contributes to roadway accidents along AZ-83. Therefore, additional truck traffic from the Rosemont Project will not necessarily affect the current roadway safety along AZ-83.

State Route 77 (AZ-77), which also has been and is currently used by several mining operations, was selected for a comparison analysis. Accident analysis results show that the driver’s behavior, especially speeding, and the roadway elements have a significant impact on accident occurrence when compared to vehicle collisions caused by truck traffic. Therefore, truck traffic related to the local mining operations also did not necessarily affect the roadway safety for AZ-77.

Various potential roadway improvements for AZ-83 were suggested in order to improve traffic flow and safety. These improvements included: 1) various designs at the Project’s Primary Access Road “T” Intersection with AZ-83, 2) wide load truck turnouts, 3) school bus stop turnouts, and 4) shoulder upgrades. Additionally, future ADOT projects in the area were reviewed and summarized. Some of these projects will address the current substandard design elements identified in this study.
1.0 INTRODUCTION

1.1 Site Description

Rosemont Copper Company is proposing a new mining operation (Project) located on the east side of the Santa Rita Mountains, approximately 30 miles southeast of Tucson, Arizona (AZ) and west of State Route 83 (AZ-83). Figure 1 shows the location of the Project site. The anticipated life of the Project is 25 to 30 years which includes construction, operations, and closure period. AZ-83 will serve as the major access route to the Project site. With additional traffic loads due to the new Project, it was necessary to analyze potential changes to the AZ-83 network circulation and traffic operation. In March of 2009, Tetra Tech issued a Traffic Analysis Report which examined the existing and future traffic conditions along AZ-83 (Tetra Tech, 2009). This Roadway Assessment Report is a sequential in-depth analysis of the existing roadway geometry, safety, and a collection of Technical Memoranda prepared by Tetra Tech that address potential roadway improvements related to school bus turnouts, wide load truck turnouts, and design alternatives for the Primary Access Road intersection into the Project site. This report also provides a complete documentation of design criteria and standards used for the geometric analysis and the potential roadway improvements. A detail description of the report contents is presented in Section 1.2.

AZ-83 is an existing paved, north-south roadway that begins at Interstate 10 (I-10) and terminates at Parker Canyon Lake. It passes through the counties of Pima, Cochise, and Santa Cruz and the towns of Sonoita and Elgin. The route is sparsely populated and serves as a scenic state highway. Currently, there is one (1) southbound lane and one (1) northbound lane. The posted speed limit ranges from 35 miles per hour (MPH) to 55 MPH. AZ-83 is a fairly curvilinear route, which winds its way through the scenic, high-country vistas of the Coronado National Forest region. A segment of AZ-83 is listed in the top 5% of Arizona’s most accident prone locations per the Federal Highway Administration (FHWA) Highway Safety Improvement Program. Based on site visits to AZ-83, a significant amount of passing and sight distance problems were due to side slopes and/or the curvilinear nature of AZ-83.

1.2 Report Contents

This report consists of four (4) sections including this introduction. The existing roadway geometry of AZ-83 is reviewed and described in Section 2.0. Tetra Tech also conducted site visits to gather field information on roadway curvature, roadway geometrics, potential substandard geometric design features, sight distance elements, and information on current school bus operations. A description of the roadway speed limits and the horizontal and vertical alignments are also presented in Section 2.0. Section 3.0 contains an accident analysis of AZ-83 using the Arizona Department of Transportation (ADOT) accident database for the past six (6) years. An accident analysis of State Route 77 (AZ-77) is also provided in Section 3.0 in order to assess the effect of local mining operations on the roadway. In Section 4.0, various potential roadway improvements to AZ-83 are proposed in order to enhance traffic circulation and roadway safety. The design guidelines used in these roadway improvements were based on the ADOT and American Association of State Highways and Transportation Officials (AASHTO) roadway design guidelines as well as the Manual on Uniform Traffic Control Devices (MUTCD). Detailed information on the proposed roadway improvements are also presented as Technical Memoranda in the appendices of this report.
2.0 AZ-83 ROADWAY ASSESSMENT

The existing AZ-83 roadway geometrics, as well as speed limits along AZ-83, are discussed in this section. AZ-83 is currently classified as a rural major collector per the ADOT approved functional classification map (Figure 2). The roadway is also classified as a rural non-divided highway in mountainous terrain. Per Table 101.3 in the ADOT Roadway Design Guidelines (Appendix A), the design speed for rural, non-divided mountainous terrain is 55 miles per hour (MPH). The design speed is a major element in determining roadway design factors such as curvature and sight distance. The following elements were analyzed to assess the roadway geometrics of AZ-83 and to identify any existing substandard designs.

1. Traffic Speeds
2. Vertical Alignment
3. Horizontal Alignment
4. Existing School Bus Stops
5. Guardrails

The study area considered for this roadway assessment included the entire segment of AZ-83 between the intersection of Interstate 10 (I-10) and State Route 82 (AZ-82) (Figure 1). The existing topography for this study area was provided by Chartiff (http://www.chartiff.com/index.html) with a 25-foot contour interval. Based on the topographic map and field visits, it was determined that the maximum superelevation rate along AZ-83 should not exceed 8%. The superelevation rate is the tilt or bank of a roadway along a horizontal curve. This tilt is designed to allow vehicles to travel through the curve at a higher speed without the need for a larger curve.

While translating the topographic data into computer-aided design data, stationing was set to start at the AZ-83 / I-10 interchange. This starting station is identified as STA 100+00 and is located at approximate Milepost (MP) 58.3 on AZ-83. The end station, STA 1450+75, is located at the intersection of AZ-83 and AZ-82, at MP 32.4. The proposed Primary Access Road for the Project site is located at MP 46.9 or STA 740+75. A plan and profile layout of AZ-83 is presented in Appendix B.

2.1 Traffic Speeds

The traffic speed is a major element in determining roadway design components such as curvature and stopping sight distances. Traffic speed is also used to assess substandard designs. Within the study limits, the design speed varies along AZ-83 and is further explained in Sections 2.1.1 through 2.1.3.

2.1.1 MP 58.3 (I-10 Interchange) to MP 46

For the most part, the posted speed limit on AZ-83 from I-10 to MP 46 (just south of the exiting Rosemont Junction intersection at approximately STA 750+00) is 55 MPH. The majority of this section is straight and the observed actual vehicle driving speeds ranged from 50 to 60 MPH. There is a short section along AZ-83 between MP 47.7 (STA 700+50) and MP 47.2 (STA 730+00) that has multiple curves and an advisory speed of 45 MPH. Within this segment, the observed actual driving speeds ranged from 45 to 55 MPH.
2.1.2 **MP 46 (STA 750+00) to MP 43.6 (STA 910+00)**

The posted speed south of Rosemont Junction to MP 43.6 (STA 910+00) is 45 MPH. There are multiple curves with advisory speeds of 35 MPH (10 MPH less than the posted speed) in both the northbound and southbound directions. The observed actual driving speeds for vehicles travelling northbound were approximately 40 MPH for trucks with trailers and 45 to 55 MPH for passenger cars. The actual speeds going southbound ranged from 38 to 50 MPH for trucks with trailers and 45 to 55 MPH for passenger cars. Illustrations 2.1 and 2.2 show a curvy segment of AZ-83 where the advisory speed is 35 MPH.

**Illustration 2.1**  Advanced Curvy Alignment Warning Sign

Note: Photo is taken at the reverse curve (W1-4R) before MP 44 with an advisory speed of 35 MPH.
2.1.3 **MP 43.6 (STA 910+00) to MP 32.4 (intersection of AZ-83 and AZ-82)**

The final section of AZ-83, from MP 43.6 to MP 32.4 (intersection of AZ-83 and AZ-82), has a posted speed limit of 55 MPH. Due to the lack of tight curves in this section, the observed speeds for both trucks with trailers and passenger cars averaged around the posted speed limit.

### 2.2 Horizontal Alignment

The existing horizontal curves along AZ-83, including their corresponding curve information, is provided in Table 2.1. Also included in the table is the minimum required horizontal curve radius based on ADOT’s Roadway Design Guidelines. The main objective of this table is to identify the location of substandard designs which in turn are used to investigate any potential negative impacts to the AZ-83 network circulation. Additional detailed curve information, such as curve length and curvature degree, is described in Appendix B. Most of the curves within the study area show standard radius values except for three (3) locations: 1) MP 49.1, 2) MP 47.7 to 47.5, and 3) MP 44.3 to 44.1. It should be noted that the locations where the substandard designs are present coincide with high accident frequency locations. In particular, the roadway segment between MP 44.5 and 44.0 is ranked as the highest accident rate and the highest accident frequency for all fatal accidents along AZ-83. Additional analysis of accidents on AZ-83 is further discussed in Section 3.0. Per ADOT Roadway Design Guidelines section 203.7, it is recommended to avoid tight reverse curves due to safety issues.

“Reverse curves should be avoided. If used, reverse simple curves should have a tangent between them which allows the superelevation runoff lengths for each curve to be applied to each curve from its standard location without overlapping.”
## Table 2.1 Existing Horizontal Curve

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Milepost</th>
<th>Station</th>
<th>Curve Radius (feet)</th>
<th>Required Minimum Curve Radius (feet)</th>
<th>Design Speed (MPH)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58.3</td>
<td>130+00</td>
<td>3,050</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>2</td>
<td>52.8</td>
<td>430+00</td>
<td>10,000</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>3</td>
<td>52.3</td>
<td>465+00</td>
<td>420</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>4</td>
<td>51.5</td>
<td>500+00</td>
<td>6,250</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>5</td>
<td>51.0</td>
<td>525+00</td>
<td>2,500</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>6</td>
<td>50.7</td>
<td>542+00</td>
<td>2,000</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>7</td>
<td>50.3</td>
<td>565+00</td>
<td>6,500</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>8</td>
<td>49.5</td>
<td>605+00</td>
<td>2,750</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>9</td>
<td>49.1</td>
<td>630+00</td>
<td>650</td>
<td>877</td>
<td>55</td>
<td>Substandard</td>
</tr>
<tr>
<td>10</td>
<td>48.8</td>
<td>640+00</td>
<td>1,000</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>11</td>
<td>48.6</td>
<td>660+00</td>
<td>1,700</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>12</td>
<td>48.2</td>
<td>680+00</td>
<td>1,000</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>13</td>
<td>47.7</td>
<td>695+00</td>
<td>550</td>
<td>877</td>
<td>55</td>
<td>Substandard</td>
</tr>
<tr>
<td>14</td>
<td>47.6</td>
<td>705+00</td>
<td>500</td>
<td>877</td>
<td>55</td>
<td>Substandard</td>
</tr>
<tr>
<td>15</td>
<td>47.5</td>
<td>710+00</td>
<td>550</td>
<td>877</td>
<td>55</td>
<td>Substandard</td>
</tr>
<tr>
<td>16</td>
<td>47.4</td>
<td>715+00</td>
<td>1,000</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>17</td>
<td>47.3</td>
<td>725+00</td>
<td>1,800</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>18</td>
<td>46.4</td>
<td>770+00</td>
<td>1,000</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>19</td>
<td>46.1</td>
<td>785+00</td>
<td>750</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>20</td>
<td>45.9</td>
<td>798+00</td>
<td>700</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>21</td>
<td>45.5</td>
<td>825+00</td>
<td>700</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>22</td>
<td>45.0</td>
<td>845+00</td>
<td>700</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>23</td>
<td>44.7</td>
<td>853+00</td>
<td>800</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>24</td>
<td>44.5</td>
<td>865+00</td>
<td>650</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>25</td>
<td>44.3</td>
<td>875+00</td>
<td>500</td>
<td>540</td>
<td>45</td>
<td>Substandard</td>
</tr>
<tr>
<td>26</td>
<td>44.2</td>
<td>885+00</td>
<td>250</td>
<td>540</td>
<td>45</td>
<td>Substandard</td>
</tr>
<tr>
<td>27</td>
<td>44.1</td>
<td>890+00</td>
<td>400</td>
<td>540</td>
<td>45</td>
<td>Substandard</td>
</tr>
</tbody>
</table>
### Table 2.1 Existing Horizontal Curve

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Milepost</th>
<th>Station</th>
<th>Curve Radius (feet)</th>
<th>Required Minimum Curve Radius (feet)</th>
<th>Design Speed (MPH)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>43.9</td>
<td>905+00</td>
<td>1,500</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>29</td>
<td>43.5</td>
<td>920+00</td>
<td>3,400</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>30</td>
<td>42.8</td>
<td>960+00</td>
<td>3,000</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>31</td>
<td>42.5</td>
<td>975+00</td>
<td>1,000</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>32</td>
<td>42.4</td>
<td>985+00</td>
<td>1,750</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>33</td>
<td>42.2</td>
<td>995+00</td>
<td>1,400</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>34</td>
<td>42.0</td>
<td>1003+00</td>
<td>800</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>35</td>
<td>41.5</td>
<td>1030+00</td>
<td>4,800</td>
<td>540</td>
<td>45</td>
<td>Standard</td>
</tr>
<tr>
<td>36</td>
<td>40.0</td>
<td>1110+00</td>
<td>7,200</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
<tr>
<td>37</td>
<td>36.5</td>
<td>1295+00</td>
<td>12,000</td>
<td>877</td>
<td>55</td>
<td>Standard</td>
</tr>
</tbody>
</table>

#### 2.2.1 Clear Zone or Recovery Zone

The AASHTO Roadside Design Guide defines a “clear zone” or “recovery zone” as the total roadside border area (starting at the edge of the traveled way) available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. In other words, it is an unobstructed, relatively flat area beyond the edge of the traveled way which allows a driver to stop safely or regain control of a vehicle that leaves the traveled way. A minimum recovery zone/clear zone should be provided in order to meet the AASHTO safety standards. The recovery area width or horizontal clearance to obstructions should be determined by speed, volume, and embankment slope in accordance with Table 303.2A from the ADOT Roadway Design Guidelines (Appendix C). During site visits to AZ-83, proper recovery zone allowances were not observed along the roadway. Illustration 2.3 shows an example of a substandard recovery zone along with a narrow shoulder.
Illustration 2.3 Narrow Shoulder without Sufficient Recovery Zone

Note: The photo also shows a steep grade below the roadway without any protective equipment such as a guardrail.

2.2.2 Shoulder

Shoulders along AZ-83 were also found to be substandard in most cases. Furthermore, deterioration of many pavement edges was noticed during the site visit. The deterioration is due to the lack of a shoulder backing system and having an abrupt change from asphalt pavement to dirt. Illustrations 2.4 and 2.5 show deteriorated shoulders along AZ-83. Widening of the shoulder along AZ-83 is proposed as one of the potential roadway improvements proposed in Section 4.0. Increasing the shoulder width will also improve some of the sight distance issues discussed in Section 4.5.
Illustration 2.4  Example of Deteriorated Shoulder (Hilton Ranch Road)

Illustration 2.5  Example of Deteriorated Shoulder (MP 46.9)
2.2.3 Sight distance

The stopping sight distance for horizontal curves is evaluated by examining the potential obstructions along the inside region of a curve. The existing roadway conditions and sight distance for a horizontal alignment within the vicinity of the proposed Primary Access Road was examined. The roadway conditions and sight distance at the intersection of Sahaurita Road (MP 55.4) and Hilton Ranch Road (MP 49.1) were also evaluated. These two (2) intersections are locations of proposed roadway improvements which are further discussed in Section 4.2. In addition, the curvy alignment of AZ-83 from MP 44 to 46 was also examined since poor sight distances were observed.

2.2.3.1 Sahaurita Road (MP 55.4)

At the intersection of AZ-83 and Sahaurita Road, the roadway is flat and has no horizontal or vertical curves within one (1) mile in either direction. The sight distance at the Sahaurita Road intersection is approximately 2,500 feet in both directions. This sight distance provides safe entry from Sahaurita Road onto AZ-83.

2.2.3.2 Hilton Ranch Road (MP 49.1)

Near the Hilton Ranch Road and AZ-83 intersection, the combination of a hill and a horizontal curve contribute to a substandard sight distance at this location (Illustration 2.6). The alignment in the vicinity of Hilton Ranch Road is also a concern because the intersection is on blind curve, which makes southbound left turn movements from AZ-83 onto Hilton Ranch Road difficult. Based on the curve data in Table 2.2, this area also has a substandard horizontal curve alignment. Therefore, the fairly sharp curve, coupled with a steep slope, heavy vegetation, and no shoulder, contributes to the poor sight distance at this intersection. Finally, the roadway pavement ends less than one (1) foot beyond the white edge stripe causing shoulder deterioration.
2.2.3.3 Proposed Primary Access Road (MP 46.9)

The intersection of the proposed Primary Access Road and AZ-83 is at a location that provides a clear line of sight for up to 2,500 feet in each direction. The current location of the proposed Primary Access Road is currently undeveloped, has almost no shoulder, and the pavement along the edges are cracking and separating. There is heavy vegetation along both sides of AZ-83; however, the adjacent land is fairly flat. The grade of the roadway in this area is also relatively flat, and there are no utilities, horizontal curves, or outstanding vertical curves within the area. Figure 3 shows the existing roadway conditions at the proposed Primary Access Road intersection (MP 46.9) including pictures taken from different directions. The design of Primary Access Road intersection will be a “T” intersection with AZ-83 that provides safe ingress and egress from the Project site. The proposed “T” intersection design was described in the Mine Plan of Operations (MPO) (Westland, 2007) is also shown on Figure 3. Additional information regarding the MPO design and alternative design options for the proposed “T” intersection is provided in Section 4.0 and Appendix D.

2.2.3.4 MP 44 to 46

A tight horizontal reverse curve (Illustration 2.7), combined with a 6% downgrade, deteriorates the sight distance along AZ-83 between MP 44 and 46. Moreover, the steep road cuts within this area also obstruct the sight distance along the horizontal curves (Illustration 2.8). Some road cuts are also areas of potential rockfall hazards along AZ-83 (Illustration 2.9).
Illustration 2.7  Limited Sight Distance due to Tight Horizontal Curve (MP 44 to 45)

Illustration 2.8  Limited Sight Distance due to Steep Road Cut
Illustration 2.9  Rockfall Warning Sign

Illustration 2.10  Warning Sign for Curvy Horizontal Alignment (MP 44 to 45)
2.3 Vertical Alignment

Vertical curves documented throughout the study area consisted of nine (9) crest curves and nine (9) sag curves. Per ADOT Roadway Design Guidelines, the required minimum vertical grade is 0.4% for proper drainage. Per Table 204.3 of ADOT Roadway Design Guidelines (Appendix E), a maximum of 7% vertical grade is allowed for a 55 MPH rural, non-divided highway in mountainous terrain. In the study area, the observed maximum vertical grade was 6% at approximately MP 44. Therefore, the vertical alignments are standard for the existing grades along AZ-83. With regard to the stopping sight distance in the vertical alignment, the difference in the vertical curve length and grade between the approach and departure grades are major factors in determining a safe stopping sight distance and the required minimum vertical curve length. Table 2.2 presents the existing vertical curve components and associated design elements. It should be noted that unlike the horizontal alignment, the vertical alignment meets the ADOT standard roadway design guidelines. However, a segment along AZ-83 where the vertical alignment was close to falling below the standard was coincident with the segment where the horizontal alignment was below ADOT standards. The major reason the vertical alignment is close to falling below the standard is due to a combination of tight horizontal curves with a relatively steep (at 6%) vertical curve. This segment is located between MP 44 and 45.5.

The vertical stopping sight distance is determined by reviewing both the approach and departure grades for a vertical curve. Except for curves 7 and 8, all of the curves were evaluated for a proper vertical stopping sight distance using a 55 MPH speed. For curves 7 and 8, the speed limit is 45 MPH and thus a 45 MPH speed was used. As shown in Table 2.2, all the vertical curve lengths meet or exceed the minimum required curve length. Therefore, all the vertical curves satisfy the minimum vertical stopping sight distance. In addition, incoming and outgoing grades for all the vertical curves listed in Table 2.2 are within the minimum range (0.4%) and maximum range (7%) requested per the ADOT Roadway Design Guidelines.

### Table 2.2 Existing Vertical Curve

<table>
<thead>
<tr>
<th>Curve Number</th>
<th>Milepost</th>
<th>Station</th>
<th>Vertical Curve Length (feet)</th>
<th>Required Minimum Curve Length (feet)</th>
<th>Incoming Grade/Outgoing Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57.5</td>
<td>185+00</td>
<td>1,200</td>
<td>342</td>
<td>Incoming 2% Outgoing -1%</td>
</tr>
<tr>
<td>2</td>
<td>56.9</td>
<td>215+00</td>
<td>1,000</td>
<td>230</td>
<td>Incoming -1% Outgoing 1%</td>
</tr>
<tr>
<td>3</td>
<td>52.6</td>
<td>440+00</td>
<td>800</td>
<td>798</td>
<td>Incoming 4% Outgoing -3%</td>
</tr>
<tr>
<td>4</td>
<td>52.0</td>
<td>475+00</td>
<td>400</td>
<td>345</td>
<td>Incoming -2% Outgoing 1%</td>
</tr>
<tr>
<td>5</td>
<td>49.2</td>
<td>625+00</td>
<td>800</td>
<td>456</td>
<td>Incoming 2% Outgoing -2%</td>
</tr>
<tr>
<td>6</td>
<td>48.8</td>
<td>640+00</td>
<td>600</td>
<td>345</td>
<td>Incoming -2% Outgoing 1%</td>
</tr>
<tr>
<td>7 *</td>
<td>45.9</td>
<td>798+00</td>
<td>500</td>
<td>183</td>
<td>Incoming 2% Outgoing -1%</td>
</tr>
<tr>
<td>8 *</td>
<td>45.6</td>
<td>815+00</td>
<td>900</td>
<td>395</td>
<td>Incoming -1% Outgoing 4%</td>
</tr>
<tr>
<td>Curve Number</td>
<td>Milepost</td>
<td>Station</td>
<td>Vertical Curve Length (feet)</td>
<td>Required Minimum Curve Length (feet)</td>
<td>Incoming Grade/Outgoing Grade</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>---------</td>
<td>-----------------------------</td>
<td>--------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>9</td>
<td>43.4</td>
<td>927+00</td>
<td>800</td>
<td>366</td>
<td>Incoming 4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing -2%</td>
</tr>
<tr>
<td>10</td>
<td>43.0</td>
<td>950+00</td>
<td>600</td>
<td>575</td>
<td>Incoming -2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing 3%</td>
</tr>
<tr>
<td>11</td>
<td>42.5</td>
<td>975+00</td>
<td>700</td>
<td>570</td>
<td>Incoming 3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing -2%</td>
</tr>
<tr>
<td>12</td>
<td>40.7</td>
<td>1073+00</td>
<td>500</td>
<td>460</td>
<td>Incoming -2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing 2%</td>
</tr>
<tr>
<td>13</td>
<td>40.3</td>
<td>1090+00</td>
<td>800</td>
<td>570</td>
<td>Incoming 2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing -3%</td>
</tr>
<tr>
<td>14</td>
<td>38.6</td>
<td>1185+00</td>
<td>800</td>
<td>460</td>
<td>Incoming -2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing 2%</td>
</tr>
<tr>
<td>15</td>
<td>37.5</td>
<td>1242+00</td>
<td>400</td>
<td>342</td>
<td>Incoming 2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing -1%</td>
</tr>
<tr>
<td>16</td>
<td>37.3</td>
<td>1250+00</td>
<td>500</td>
<td>345</td>
<td>Incoming -1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing 2%</td>
</tr>
<tr>
<td>17</td>
<td>35.0</td>
<td>1372+00</td>
<td>1,500</td>
<td>342</td>
<td>Incoming 2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing -1%</td>
</tr>
<tr>
<td>18</td>
<td>34.2</td>
<td>1415+00</td>
<td>600</td>
<td>230</td>
<td>Incoming -1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outgoing 1%</td>
</tr>
</tbody>
</table>

* Indicates the design speed was 45 MPH.
Illustration 2.11  Advanced Warning Sign for Steep Slope (MP 44 to 45)

Note: The Horizontal 6% Downgrade

2.4 Existing School Bus Stops

Tetra Tech completed a site visit to document the locations and traffic patterns associated with the existing school bus stops along AZ-83 for the Vail School District. A total of seven (7) school bus stops were identified and are shown on Figure 1 in Appendix F. The current school bus traffic pattern consists of two (2) separate loops. One (1) loop runs from Sahaurita Road to the Rest Stop at MP 46.9 on AZ-83. The Rest Stop is located just south of the proposed Primary Access Road. The second school bus loop runs from AZ-82 to Greaterville Road. Figure 1 in Appendix F also shows the traffic patterns for the two (2) school bus loops. Currently the school bus pick-up and drop-off spots are located such that students do not have to cross the roadway in order to get to the bus stop (i.e., pick-up and drop-off occur at the same location on the respective side of AZ-83). With the exception of the Hilton Ranch Road school bus stop, the bus stops do not have a pull-off area along AZ-83 (i.e., the buses stop within the through lane of AZ-83). At the Hilton Ranch Road school bus stop, a wide compacted dirt area was observed on the east side of AZ-83.

Each of the bus stop locations were evaluated for potential improvements with regard to safety and traffic flow conditions. For all of the school bus stops except the Hilton Ranch Road, a pull-off area for loading and unloading students is not available. This increases the chances of a rear-end collision when the buses are loading and unloading students. Furthermore, traffic on AZ-83 is delayed since all traffic must stop and cannot pass during student loading and unloading. Proposed improvements to the school bus stop locations are presented in Section 4.3.
2.5 Guardrails

Most of guardrails along AZ-83 fail to meet ADOT design standards since they are outdated and located too close to the edge of the paved roadway. These guardrails are present throughout the AZ-83 study area between MP 33 and 52. Illustrations 2.12 and 2.13 show an example of a typical substandard guardrail.

Illustration 2.12 Typical Substandard Guardrail (Sahuarita Road)
2.6 ADOT Future Projects

ADOT has approved several projects listed in the American Recovery and Reinvestment Act (ARRA). Two (2) of the projects are located within the AZ-83 study area and one (1) project generally affects the traffic along AZ-83 (Figure 4). A partial list of ARRA projects is provided in Appendix G. The projects within or affecting the study area are described in Sections 2.6.1 through 2.6.3.

2.6.1 AZ-83 MP 31.6 to 44.5 Pavement Project

The existing pavement between MP 31 and 44 has several cracks and areas where the pavement layers are separating. A pavement preservation project to fix the pavement between MP 31 and 44 is identified as Tracs number H747001C and ADOT project number ARRA-083-A(201)A. This project will enhance the roadway safety by providing a better skidding factor for a smoother and faster vehicle stop. This project is also listed as one of the ARRA projects with a priority of 18 out of 28 projects within the greater Arizona region. The pavement project is approximately 11.9 miles long and expected to take 70 working days to complete.

2.6.2 AZ-83 MP 44 to 45.5 Safety Project

The existing roadway conditions along AZ-83 between MP 44 and 45 contains tight horizontal curves. As part of the ADOT Safety Project, the horizontal curves within this roadway segment will be realigned, fixing the substandard curve radii. The project will also replace the existing substandard guardrails, widen the roadway shoulders, flatten the road cuts, and install new signs and striping. These improvements will increase the motorist sight distance and the overall safety of this roadway segment. This safety project is identified as Tracs number H705701C and ADOT project number 083-A(200)A. As of April 14, 2009, the project was still waiting for environmental clearance.
2.6.3 I-10 MP 288.4 to 290.5 Cienega Creek-Marsh Station Traffic Interchange Reconstruction

Although the Cienega Creek-Marsh Station Traffic Interchange Reconstruction project is not within the study area, it is expected to affect the truck traffic on AZ-83. This project is listed as an ARRA project with a priority of 3 out of 8 projects within the Pima Association of Governments Region (Appendix G). The project is identified as Tracs number H239001C and ADOT project number 010-E. Currently AZ-83 is the alternate route for many wide or oversized semi trucks that are restricted by the low vertical clearance at the Marsh Station Railroad Bridge along I-10. As shown on Figure 1, trucks traveling between Tucson and Wilcox on I-10 that are restricted by the vertical clearance at the bridge must take an alternate route along AZ-83, AZ-82, and State Route 90. The proposed reconstruction project will eliminate the need for wide load trucks to use AZ-83 since the improvements will remove the vertical clearance issues at the Marsh Station Railroad Bridge.
3.0 ACCIDENT ANALYSIS

The highway design, the vehicle types, and the individual users are the three (3) integral parts of transportation safety and efficiency. Illustration 3.1 shows how the various traffic components relate to overall traffic safety. Completing a detailed accident analysis helps identify the main reasons behind accident prone locations. This analysis also aids in deciding the selection of safety programs and which countermeasures to implement. The analysis also assists in evaluating the countermeasure’s effectiveness.

Illustration 3.1 Safety Diagram

In order to fully assess if the Rosemont Copper Project will have an affect on the safety of AZ-83, a comprehensive accident analysis was performed. Accident data from ADOT was collected between 1-10 (MP 58.3) and AZ-82 (MP 32.4) from 2002 to 2008 in order to establish the current roadway safety conditions. In addition, accident data for State Route 77 (AZ-77) was also collected since this route has been used, and is currently being used, by several mining operations.

Per the Federal Highway Administration (FHWA) Safety Program, and in accordance with Sections 148(c)(1)(D) and 148(g)(3)(A) of Title 23, United States Code, each state is required to identify at least 5% of their roadway locations which currently exhibit the most severe highway safety needs or accident locations. The requirements to be designated as a location in the top 5% are:

- Location should have at least one (1) crash (fatal, any type of injury or property damage only) in three (3) consecutive years.
- Location should have at least one (1) fatal crash in three (3) years.
- At least one (1) crash should be a “run-off-road”, intersection, or pedestrian related. It should be noted that the intersection related crashes considered here are the crashes in which the first harmful event occurred on an approach to or exit from an intersection and resulted from an activity, behavior, or control related to the movement of traffic units through the intersection.

- The total number of fatal or incapacitating injury crashes must be equal to or greater than three (3) for three (3) consecutive years.

Based on the 2008 FHWA accident analysis (http://safety.fhwa.dot.gov/hsip/fivepercent/2008/08az.htm#toc645), the segment of AZ-83 between MP 44 and 45 is listed in the top 5% of all accident locations in Arizona. Figure 5 shows all of the top 5% accident locations in the State of Arizona per the FHWA Highway Safety Program.

In this report, the following six (6) indices were investigated to further analyze the current roadway safety condition and to understand the nature of the past accidents so that appropriate countermeasures could be selected which would improve future roadway conditions.

- Annual accident number: This index represents the total reported accident frequency for a given location. An annual accident frequency analysis is also used to identify trends for a given location.

- Accident Prone Location: In order to improve roadway safety, it is crucial to identify accident prone locations. The two (2) methods commonly used by agencies to identify accident prone locations are the Accident Frequency Method and the Accident Rate Method. These two (2) methods are defined below.
  
  o Frequency Method: This method ranks an accident prone location by the number of total reported accidents for a selected analysis period.

  o Accident Rate Method: Per the Institute of Transportation Engineers (ITE) Manual, agencies also use accident rates to identify accident prone locations. The accident rate method compares the number of accidents at a location with the number of vehicles or traveled vehicle miles for a location. This comparison results in an accident rate. Accident rates account for exposure, which is the chance that an accident will happen to a particular driver/vehicle or along a highway segment. Furthermore, the Annual Average Daily Traffic (AADT) is embedded in the accident rate, which eliminates the bias originating from different traffic volumes. For example, a roadway segment with an AADT of 32,000 and an accident frequency value of 10 should be considered less prone to accidents compared to a roadway segment with an AADT of 1,000 with the same accident frequency of 10. Accident rates are computed in terms of accidents per 100 million vehicle miles using the following formula:

  \[
  RSEC_i = \left( \frac{100,000,000 \times A_i}{365 \times T_i \times V_i \times L_i} \right)
  \]

  \(RSEC_i\) : accident rate for the section \(i\)

  \(A_i\) : number of reported accidents within section \(i\)

  \(T_i\) : time frame of the analysis, years

  \(V_i\) : Average Annual Daily Traffic for section \(i\)

  \(L_i\) : length of the section \(i\), miles
Collision Manner: The ADOT accident database contains a total of 13 different collision manners when classifying an accident.

Vehicle Type: The ADOT accident database classifies vehicles into 26 different types for each recorded accident.

Major Causes: The ADOT accident database contains a total of 19 different reasons or causes for each accident. Speeding or passing in a no passing zone are some examples of the major cause categories.

Injury Type: The ADOT accident database contains a total of six (6) categories for types of injuries resulting from an accident.

### 3.1 AZ-83 Accident Analysis

As mentioned in Section 1.1, AZ-83 is designated as a major rural collector and is a two-lane highway that begins at I-10 and ends at Parker Canyon Lake. For the accident analysis presented in Section 3.1, only accident data for AZ-83 between 1-10 (MP 58.3) and AZ-82 (MP 32.4) was considered. Table 3.1 shows the ADOT AADT values between 2002 and 2007 for AZ-83. Based on the 2007 AADT data, AZ-83 has a T factor of 5% which indicates that 5% of total AADT consists of truck traffic. Figure 6 provides the truck volume along all of the major highways in Arizona. For AZ-83, the accident data from 2003 to 2008 was analyzed and a detailed description of each accident analysis index is presented in Sections 3.1.1 through 3.1.8.

### Table 3.1 AZ-83 Annual AADT (2002 to 2007)

<table>
<thead>
<tr>
<th>Year</th>
<th>AADT</th>
<th>Percent Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>2,300</td>
<td>-</td>
</tr>
<tr>
<td>2003</td>
<td>2,300</td>
<td>0.0 %</td>
</tr>
<tr>
<td>2004</td>
<td>2,400</td>
<td>+4.0 %</td>
</tr>
<tr>
<td>2005</td>
<td>3,000</td>
<td>+25.0 %</td>
</tr>
<tr>
<td>2006</td>
<td>2,400</td>
<td>-20.0 %</td>
</tr>
<tr>
<td>2007</td>
<td>2,100</td>
<td>-12.5 %</td>
</tr>
</tbody>
</table>
3.1.1 Annual Accident Frequency

Illustration 3.2 shows the annual accident frequency trend over the six (6) years analyzed. The accident frequency peaked during 2004 with total of 39 reported accidents. Starting from 2006, a decrease in the number of total accidents has occurred, especially between the years 2007 and 2008 where there was a 29% decrease.

Illustration 3.2 AZ-83 Annual Accident Frequency (2002 to 2008)

3.1.2 Accident Prone Location Analysis

Based on the accident frequency method and the accident rate method, the top five (5) accident prone locations were identified to be MP 44, 45, 46, 55, and 58. The proposed Primary Access Road for the Rosemont Project is located at MP 46.9. This location shows a relatively low accident frequency and rate. Figure 7 shows the top five (5) accident prone locations for AZ-83 as well as the proposed Primary Access Road.
3.1.2.1 Accident Frequency Method

As shown on Illustration 3.3, MP 44 and 45 show a significantly higher accident frequency when compared to the rest of the AZ-83 roadway segments. For example, 26% of the total accidents which occur along AZ-83 are located at MP 44. In Section 2.0, the roadway segment between MP 44 to MP 46 was identified as a curvy area with tight horizontal substandard curves. This is a clear indication that the roadway geometry has an influence on accident frequency.

Illustration 3.3 AZ-83 Accident Frequency per Location (2002 to 2008)
3.1.2.2 Accident Rate Method

In order to eliminate the AADT bias on accident frequencies, the accident rate was also examined. No variation in AADT values along AZ-83 was observed. Therefore, the accident rate per location showed the same pattern when compared to the accident frequency. Illustration 3.4 shows a comparison in accident rates between 2006 and 2007. It should be noted that out of the top five (5) accident prone locations, MP 44, 45, and 46 show an increasing accident rate while MP 55 and 58 shown a decreasing accident rate.

Illustration 3.4 AZ-83 Accident Rate per Location (2002 to 2008)
3.1.3 Accident Involved Vehicle Type

Illustration 3.5 shows the distribution of different vehicle types involved in accidents between 2002 and 2008. This illustration indicates that approximately 49% and 30% of the total accidents on AZ-83 are associated with passenger cars and motorcycles, respectively. Accidents involving semi trucks (i.e. truck tractor) show a relatively low value of approximately 3.8%. This low value suggests that trucks are not the major vehicle type that contributes to roadway accidents along AZ-83. Therefore, it is expected that truck traffic added from the Rosemont Project operations will not necessarily affect the current roadway safety for AZ-83. The final vehicle type shown in Illustration 3.5 is a school bus and it accounts for 0.54% of the total accidents between 2002 and 2008.

Illustration 3.5 AZ-83 Accident Involved Vehicle Type (2002 to 2008)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Car</td>
<td>90</td>
</tr>
<tr>
<td>Pickup Truck</td>
<td>32</td>
</tr>
<tr>
<td>Truck Tractor</td>
<td>5</td>
</tr>
<tr>
<td>School Bus</td>
<td>1</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>56</td>
</tr>
<tr>
<td>Other Truck Combination</td>
<td>2</td>
</tr>
</tbody>
</table>
### 3.1.4 Accident Collision Manner

A detailed analysis of the accident collision manner for AZ-83 shows that more than 80% of accidents are a single vehicle collision. Sideswipe and rear-end collision manner types were ranked as 2\textsuperscript{nd} and 3\textsuperscript{rd} respectively. Illustration 3.6 shows the distribution of different collisions manners for accidents between 2002 and 2008.

**Illustration 3.6** AZ-83 Accident Collision Manner (2002 to 2008)
3.1.5 Accident Injury Type

Between 2002 and 2008, about 47% of the accidents on AZ-83 resulted in no injury and 24% resulted in non-incapacitating injuries. There were three (3) fatal accidents which accounted for 1.6% of the total accidents between 2002 and 2008. All three (3) of the fatal accidents occurred at MP 44; therefore, putting this location in the top 5% accident locations per the FHWA Highway Safety Program. Illustration 3.7 shows the distribution of injury types for accidents between 2002 and 2008.

Illustration 3.7 AZ-83 Accident Injury Types (2002 to 2008)

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Injury</td>
<td>88</td>
</tr>
<tr>
<td>Possible Injury</td>
<td>17</td>
</tr>
<tr>
<td>Non-incapacitating</td>
<td>45</td>
</tr>
<tr>
<td>Incapacitating</td>
<td>28</td>
</tr>
<tr>
<td>Fatal</td>
<td>3</td>
</tr>
<tr>
<td>Unknown</td>
<td>16</td>
</tr>
</tbody>
</table>
3.1.6 Accident Major Causes

As shown in Illustration 3.8, speeding is the major cause of accidents along AZ-83, accounting for 51% of total accidents. About 23% of the accidents are due to no improper driving, which means the driver's behavior was not the main cause of accident; indicating possible problems with the roadway alignment.

Illustration 3.8 AZ-83 Accident Major Causes (2002 to 2008)

3.1.7 AZ-83 Accident Analysis Summary

In summary, the major causes of accidents on AZ-83 are speeding along with the curvy roadway geometry. Additionally, the narrow roadway shoulder and lack of adequate pull off locations along AZ-83 adds to the safety issues since it prevents slow moving vehicles from pulling over and allowing cars to pass. The narrow shoulder and lack of pullouts are also safety concerns for tourists who want to enjoy the scenic views along AZ-83. Potential roadway improvements that address the lack of an adequate shoulder, or places to pull off along AZ-83, are discussed in Section 4.0.

Accidents involving semi trucks (i.e. truck tractor) show a relatively low value of approximately 3.8%. This low value suggests that trucks are not the major vehicle type that contributes to roadway accidents along AZ-83. Therefore, it is expected that truck traffic added from the Rosemont Project operations will not necessarily affect the current roadway safety for AZ-83. As mentioned in Section 3.1.3, one (1) school bus was involved in an accident along AZ-83 between 2002 and 2007. Section 4.0 also describes potential improvements to the existing school bus stops along AZ-83.
3.1.8 **AZ-83 MP 44 Accident Analysis Summary**

A detailed analysis of the fatal injury accidents for the six (6) years of accident data indicated that a total of three (3) fatal accidents occurred at location MP 44. In all three (3) cases, the vehicle type associated with the corresponding accidents was a motorcycle and speeding was the major accident cause. All these accidents were also a single vehicle collision. Tight horizontal reverse curvature, combined with a 6% downgrade and a speed limit too fast for the roadway geometry, suggests motorist’s disregard the advance speed reduction warning signs. Countermeasures which could reduce accidents at MP 44 include widening of the shoulder and modifying the side slopes to enhance sight distance for drivers. The future ADOT Safety Improvement Project, discussed in Section 2.6.2, should enhance the traffic conditions at MP 44 since the project will realign the tight horizontal curve, widen the shoulder to standards, and replace the substandard guardrails.

Since 26% of the total accidents and all fatal accidents along AZ-83 were observed at MP 44, additional analysis was conducted for this location. The most common vehicle type involved in accidents at MP 44 were motorcycles at 69%. Passenger cars accounted for only 19% at MP 44. However, passenger vehicles also only account for 49% of the total accidents along the entire AZ-83 study area. Illustration 3.11 shows the distribution of vehicle types for accidents at MP 44.

**Illustration 3.11 MP 44 Accident Vehicle Type (2002 to 2007)**
Similar to the entire AZ-83 study area, a total of 98% of the accidents at MP 44 resulted in a single collision manner. As shown in Illustration 3.12, the remaining 2% of accidents were categorized as an "other collision" manner.

Illustration 3.12  MP 44 Accident Collision Manner (2002 to 2007)

At MP 44, 40% of the accident injury types were reported as non-incapacitating while 22% resulted in no injuries (Illustration 3.13). Fatal injuries accounted for 6% at MP 44, while fatal injuries for the entire AZ-83 study area was only 1.6%. When analyzing the accidents that resulted in no injuries, MP 44 showed a lower rate (22%) when compared to the entire study area (47%). This indicates a safety issue with the roadway condition at MP 44.

Illustration 3.13  MP 44 Accident Injury Type (2002 to 2007)
As shown in Illustration 3.14, speeding was identified as the major cause of accidents at MP 44, with a value of 74%. This value is higher than the percentage of accidents caused by speeding along the entire AZ-83 study area (51%). The second major accident cause at MP 44 was no improper driving at a value of 12%.

Illustration 3.14 MP 44 Accident Major Causes (2002 to 2007)

3.2 AZ-77 Accident Analysis

AZ-77 is a north-south highway stretching from its northern terminus at the boundary of the Navajo Nation (approximately at MP 408.93), north of Holbrook, to its junction with I-10 in Tucson (approximately at MP 68.10). Per the ADOT roadway functional classification map (Figure 2), AZ-77 is classified as an urban minor arterial, rural principal arterial, and a rural minor arterial depending on the segment location. The 2007 AADT data shows a wide range of values for AZ-77. For instance in 2007, the AADT was 4,400 vehicles from MP 118 to 134 and the AADT was 47,000 vehicles from MP 77 to 78. The T factor also ranged from 8% (MP 91 to 135) to 15% (rest AZ-77 segments). Accident data from 2003 to 2007 was collected for AZ-77 between MP 77 and 134 (Figure 8). This section of AZ-77 was selected since it is the major access route for several local mining operations. Figure 8 illustrates the location of the active and inactive mines along AZ-77, as well as the top five (5) accident locations for this segment of AZ-77. The following sections describe the results of an accident analysis conducted for AZ-77 between MP 77 to 134.
3.2.1 Annual Accident Frequency

Illustration 3.15 shows the annual accident frequency trend of AZ-77 over the five (5) years analyzed. In 2004, the accident frequency was the highest at a value of 112. A steep change in accident frequency was observed between 2006 and 2007 when the frequency dropped by 32%.

Illustration 3.15  AZ-77 Annual Accident Frequency (2003 to 2007)

3.2.2 Accident Prone Location analysis

The top five (5) accident prone locations between MP 77 to 134 were identified by analyzing the accident frequency and accident rate at each MP. Unlike AZ-83, AZ-77 shows a varying AADT value per roadway segment. Therefore, identifying the top five (5) accident locations varies depending if the accident frequency or accident rate is used. Section 3.2.2.1 describes the top five (5) accident locations using the Accident Frequency Method and Section 3.2.2.2 describes the top five (5) accident locations using the Accident Rate Method.
3.2.2.1 Accident Frequency Method

As shown on Illustration 3.16, MP 86, 85, 87, 88, and 106 were identified as the top five (5) accident prone locations based on the Accident Frequency Method. All of these locations also have a relatively high AADT value. From MP 77 to 91, the AADT value ranged from 30,000 to 47,000 and from MP 92 to 117 the AADT value ranged from 6,300 to 7,600. These values are relatively high when compared to the average AADT value of 4,400 between MP 118 and 134.

Illustration 3.16 AZ-77 Accident Frequency (2003 to 2007)
3.2.2.2 Accident Rate Method

Based on the Accident Rate Method, the top five (5) accident prone locations for AZ-77 were MP 103, 105, 106, 112, and 124. These locations are different from the top five (5) locations following the Accident Frequency Method because the accident rate method uses an adjustment factor based on the AADT value. MP 106, however, is identified in the top five (5) accident prone locations using both the accident frequency and accident rate methods. As shown on Illustration 3.17, most of the MP locations showed a decreasing pattern from 2006 to 2007.

Illustration 3.17 AZ-77 Accident Rate per Location (2006 to 2007)
3.2.3 **Accident Involved Vehicle Type**

As shown on Illustration 3.18, approximately 61% and 31% of the accidents along AZ-77 between 2003 and 2007 were associated with a passenger car and pick-up truck, respectively. Accidents involving semi trailer trucks (i.e. truck tractor) accounted for only 4.3% of the total accidents between 2003 and 2007.

**Illustration 3.18** **AZ-77 Accident Involved Vehicle Types (2003 to 2007)**
3.2.4 Accident Collision Manner

Illustration 3.19 shows the different collision manners for accidents between 2003 and 2007. Approximately 53% of the total accidents were single vehicle collisions and 18% of the total accidents were rear-end collisions. Sideswipe and angle collisions accounted for only 8% of the total accidents.

Illustration 3.19 AZ-77 Accident Collision Manner (2003 to 2007)
3.2.5 **Accident Injury Type**

As shown on Illustration 3.20, approximately 70% of the total accidents between 2003 and 2007 resulted in no injuries. Approximately 11.5% of the total accidents between 2003 and 2007 resulted in non-incapacitation injuries. A total of three (3) fatal accidents were observed between 2003 and 2007 at three (3) different locations (MP 93, 106, and 107). It should be noted that MP 106 is also identified as a top five (5) accident prone location following both the accident frequency and accident rate methods.

**Illustration 3.20**  **AZ-77 Accident Injury type (2003 to 2007)**
3.2.6 Accident Major Causes

As shown on Illustration 3.21, the two (2) major causes for accidents between 2003 and 2007 are speeding (29.5%) and no improper driving (27%). As previously mentioned, when no improper driving is identified as the accident cause, possible issues with the roadway alignment may be present since the driver’s behavior was not the major cause of the accident. Failure to yield and inattention were both 9.8% of the total accident major causes between 2003 and 2007.

Illustration 3.21 AZ-77 Major Accident Causes (2003 to 2007)

3.2.7 AZ-77 Accident Analysis Summary

The two (2) major causes of accidents on AZ-77 between MP 77 and 134 are speeding and no improper driving. Accidents due to no improper driving suggest a possible problem with the roadway geometry alignment. When comparing the existing road alignment with ADOT guidelines, MP 109 was found to have a substandard horizontal curve. MP 106 was identified as a top five (5) accident prone location by both the accident frequency and accident rate methods and also had one (1) fatal accident between 2003 and 2007. However, the overall accident rate and accident frequency showed decreasing trend for AZ-77.

Fatal accidents on AZ-77 occurred at MP 93, 106, and 107 between 2003 and 2007. In all cases, the major cause of the fatal accident was driving in the opposing lane, resulting in a head on collision. The three (3) locations were all spots with a curvy horizontal alignment.

Accidents involving semi trucks (i.e. truck tractor) show a relatively low value of approximately 4.3%. This low value suggests that trucks are not the major vehicle type that contributes to
roadway accidents along AZ-77. Therefore, the truck traffic added from the local mining operations along AZ-77 does not necessarily affect the current roadway safety.
4.0 AZ-83 POTENTIAL ROADWAY IMPROVEMENTS

Potential improvements to AZ-83 focus on eliminating possible delays from tailgating semi trucks as well as improving overall traffic safety by providing standard roadway design features. The proposed roadway improvements follow the ADOT Roadway Design Guidelines, the AASHTO Geometric Design of Highways and Streets, and the AASHTO Roadside Design Guides. Proposed improvements that include roadway striping and sign installation follow the Manual on Unified Traffic Control Devices (MUTCD) and Standard Highway Signs. All potential roadway improvements were designed not to affect existing utilities or guardrails.

4.1 Design Vehicle

In order to assess the design options for a potential roadway improvement, the design vehicle must first be established. Based on Table 407.2 in the ADOT Roadway Design Guidelines (Appendix H), a WB-62 type, Interstate Semi Trailer is recommended as the design vehicle for intersections along a State Route. In AASHTO’s Geometric Design of Highways and Streets, a WB-65 type is recommended as the minimum sized design vehicle for intersections on state highways that carry high volumes of traffic and/or provide local access for large trucks. Therefore, a WB-65 type was chosen as design vehicle since a safe truck turning with WB-65 will also satisfy a safe truck turning for a WB-62.

When assessing potential improvements for existing school bus stops on AZ-83, the large, S-BUS-40 school bus was chosen as the design vehicle. This vehicle was selected since it also satisfies requirements for the more common smaller school bus type, S-BUS-36. A detailed illustration of the S-BUS-40 is presented in the Technical Memorandum provided in Appendix F.

4.2 Primary Access Road “T” Intersection

The “T” intersection design presented in the MPO (WestLand, 2007) consisted of the Primary Access Road being “stop” controlled with traffic along AZ-83 being uncontrolled (i.e., no stop sign). The intersection design also included a 12-foot wide, 500-foot long center lane to the south of the intersection. This center lane allows northbound traffic to make a left turn onto the Primary Access Road without impeding northbound traffic. A deceleration and right turn lane was also proposed along the western edge of AZ-83, north of the intersection. The lane also continues to the south of the intersection and serves as an acceleration lane for Project related traffic going south on AZ-83. Standard shoulders were added along both sides of the road affected by widening. Figure 3 illustrates this intersection configuration. A widened shoulder with gravel was also added along the west side of AZ-83 near the intersection to allow trucks to pull off.

An in-depth analysis of the MPO “T” intersection design was completed as part of this study. A total of four (4) alternatives were identified and included: 1) a three-way stop sign, 2) a speed limit reduction, 3) an acceleration lane with both 55 and 35 MPH speed limits, and 4) a bypass lane. Design information about each of these alternative designs, including before and after photos, are provided in Appendix D.

4.3 School Bus Stops

The current locations and traffic patterns for the school bus stops along AZ-83 were previously described in Section 2.4. For all of the school bus stops, except the Hilton Ranch Road location, a pull-off area for loading and unloading students is not available. This increases the chance of a rear-end collision when the buses are loading and unloading students. Furthermore, traffic on
AZ-83 is delayed since all traffic must stop and cannot pass during student loading and unloading. Potential improvements to the school bus stop locations include the development of a designated turnout area off AZ-83. The proposed turnout design includes a 210-foot long, and 20-foot wide paved area with a merging lane or taper to enable easy re-entry onto AZ-83. For the Hilton Ranch Road location, only minimal grading is required since the area is fairly flat. The remaining locations will require grading in order to construct a school bus turnout. Detailed design information for the proposed school bus turnouts, including before and after photos, are presented in Appendix F.

### 4.4 Wide Load Truck Turnout

As mentioned in Section 3.1.7, the lack of adequate places to pull off along AZ-83 adds to safety issues since it prevents slow moving trucks from pulling over and allowing cars to pass. Two (2) potential locations for wide load truck turnouts were identified along AZ-83. These locations are at MP 55.4 near Sahuarita Road and MP 47.2 just north of the proposed Primary Access Road. The proposed design for the truck turnouts include a 400-foot long, 20-foot wide paved area with entry and exit tapers. Both of the proposed locations are fairly flat and the alignment of AZ-83 in these areas has no horizontal or vertical curves, thus providing an adequate sight distance (Section 2.2.3). Design information for the proposed wide load truck turnouts, including before and after photos, are presented in Appendix I.

### 4.5 Utilities

In order to avoid conflicts or utility relocation, existing utility lines were documented and reviewed for all locations where potential roadway improvements are proposed (Figure 4). Such locations include: 1) proposed wide load truck turnouts at Sahuarita Road and north of the Primary Access Road, 2) existing school bus stops, and 3) the “T” intersection of the Primary Access Road. No overhead utility lines were present at the Sahuarita Road intersection area. However, a power company pedestal was observed in the unpaved parking area directly north of the intersection. This suggests possible underground power lines. The development of a wide load truck turnout at this location will not affect this pedestal. At Hilton Ranch Road, major overhead utility lines run through the shoulder as shown on Illustrations 4.1 and 4.2. The school bus turnout proposed at this location, including any of the other existing school bus stops, are not expected to impact the existing utility lines. No utility lines were observed within the vicinity of the proposed Primary Access Road area.
Illustration 4.1 Utility Lines on East Side of AZ-83 at Hilton Ranch Road

Illustration 4.2 Utility Lines on East Side of AZ-83 North of Hilton Ranch Road
4.6 Shoulder Upgrade

The shoulders along AZ-83 are cracked and at most locations the width is less than the standard required 6-foot width. This standard shoulder width is based on Table 302.4 in the ADOT Roadway Design Guidelines (Appendix J). One of the planned ADOT projects highlighted in Section 2.6 focuses on upgrading shoulders to the required standards. Shoulder widening will enhance traffic safety along AZ-83 by providing an improved sight distance and consequently providing more reaction time to drivers who need to act in order to prevent an accident. Moreover, potential dangerous situations such as rock falls from road cuts can be avoided since a wide shoulder serves as a buffer zone. Figure 9 shows the improved sight distance that can be achieved by implementing standard shoulder widths. In order to access the visual changes associated with shoulder widening, before and after photos are provided in Illustrations 4.3 through 4.5.
Illustration 4.3  Before Shoulder Widening and Recovery Zone Improvement

Illustration 4.4  After Shoulder Widening and Recovery Zone Improvement
Illustration 4.5  Before Shoulder Widening

Illustration 4.6  After Shoulder Widening
REFERENCES


U.S. Department of Transportation Federal Highway Administration (2004) *Standard Highway Signs*

FIGURES
Legend:
ROW - Right of Way

Location:
Mile Post 46.9
Intersection of SR-83 and Primary Access Road

Note:
"T" Intersection design shown is from the Mine Plan of Operations.
Source:
Arizona 2008 Highway Safety Improvement Program Top 5% Report, prepared for Arizona Department of Transportation.

Note:
The Lane Departure symbol denotes accidents that result from a single flow of traffic, not at any intersection. The Intersection Accidents symbol denotes accidents that result from 2 or more traffic flows intersecting, either in a controlled or uncontrolled environment.
Source: Multimodal Freight Analysis Study, prepared for Arizona Department of Transportation
Shoulder Widening Designed Per:

Location:
Mile Post 48.5
### Table 101.3

Relation of Highway Type to Design Speed

<table>
<thead>
<tr>
<th>Highway Type</th>
<th>Design Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled Access Highways</td>
<td></td>
</tr>
<tr>
<td>Level terrain*</td>
<td>75</td>
</tr>
<tr>
<td>Rolling terrain</td>
<td>75</td>
</tr>
<tr>
<td>Mountainous terrain</td>
<td>65</td>
</tr>
<tr>
<td>Urban/Fringe Urban areas</td>
<td>65</td>
</tr>
<tr>
<td>Rural Divided Highways</td>
<td></td>
</tr>
<tr>
<td>Level terrain</td>
<td>70</td>
</tr>
<tr>
<td>Rolling terrain</td>
<td>65</td>
</tr>
<tr>
<td>Mountainous terrain</td>
<td>60</td>
</tr>
<tr>
<td>Rural Non-divided Highways</td>
<td></td>
</tr>
<tr>
<td>Level terrain</td>
<td>70</td>
</tr>
<tr>
<td>Rolling terrain</td>
<td>65</td>
</tr>
<tr>
<td>Mountainous terrain</td>
<td>55**</td>
</tr>
<tr>
<td>Urban/Fringe Urban Highways</td>
<td></td>
</tr>
<tr>
<td>Arterial streets (C &amp; G With Development)</td>
<td>30 – 50</td>
</tr>
<tr>
<td>Urban Highways</td>
<td>30 – 60</td>
</tr>
</tbody>
</table>

*Note: Throughout this document, level, rolling and mountainous terrain are defined as follows:

**LEVEL TERRAIN:** Any combination of geometric design elements that permits trucks to maintain speeds that equal or approach speeds of passenger cars.

**ROLLING TERRAIN:** Any combination of geometric design elements that causes trucks to reduce speed substantially below that of passenger cars on some sections of the highway but which does not involve sustained crawl speeds by trucks for any substantial distance.

**MOUNTAINOUS TERRAIN:** Any combination of geometric design elements that will cause trucks to operate at crawl speed for considerable distances or at frequent intervals.

**Note:** The Designer should try to achieve a 60 mph design speed if there is the expectation of future development to a 4-lane divided highway.
APPENDIX B
EXISTING AZ-83 ROADWAY PLAN AND PROFILE SHEETS
Note:
25-Foot Contour Interval

Legend:
MP - Mile Post
VC - Vertical Curve
Note: 25-Foot Contour Interval
Legend:
- MP - Mile Post
- VC - Vertical Curve
Note:
25-Foot Contour Interval

Legend:
MP - Mile Post
VC - Vertical Curve
Note: 25-Foot Contour Interval

Legend:
- MP - Mile Post
- VC - Vertical Curve
303.2 - Roadside Recovery Area

Many highway crashes are the result of a vehicle leaving the pavement and striking an obstruction before having an opportunity to recover. The number and severity of the crashes may be reduced by providing a recovery area or clear zone outward from each outer travel lane that is free of obstructions and non-traversable slopes.

The recovery area width or horizontal clearance to obstructions should be determined based upon speed, volume, and embankment slope in accordance with Table 303.2A. Modification of the recovery area width for horizontal curvature using the factors in Table 303.2B is not required unless the crash history indicates otherwise. The recovery area width is designed and determined based upon the horizontal distance from the roadway plans typical section travel lane (normally 12 ft) to the near side of the obstruction.

<table>
<thead>
<tr>
<th>DESIGN SPEED</th>
<th>DESIGN ADT</th>
<th>FILL SLOPES</th>
<th>cut slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6:1 OR FLATTER</td>
<td>5:1 TO 4:1 INCL</td>
</tr>
<tr>
<td>40 MPH OR LESS</td>
<td>Under 750</td>
<td>7-10</td>
<td>7-10</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>10-12</td>
<td>12-14</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>12-14</td>
<td>14-16</td>
</tr>
<tr>
<td></td>
<td>Over 6000</td>
<td>14-16</td>
<td>16-18</td>
</tr>
<tr>
<td>45-50 MPH</td>
<td>Under 750</td>
<td>10-12</td>
<td>12-14</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>12-14</td>
<td>16-20</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>16-18</td>
<td>20-26</td>
</tr>
<tr>
<td></td>
<td>Over 6000</td>
<td>18-20</td>
<td>24-28</td>
</tr>
<tr>
<td>55 MPH</td>
<td>Under 750</td>
<td>12-14</td>
<td>14-18</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>16-18</td>
<td>20-24</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>20-22</td>
<td>24-30</td>
</tr>
<tr>
<td></td>
<td>Over 6000</td>
<td>22-24</td>
<td>26-30</td>
</tr>
<tr>
<td>60 MPH</td>
<td>Under 750</td>
<td>16-18</td>
<td>20-24</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>20-24</td>
<td>26-30</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>26-30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Over 6000</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>≥ 65 MPH</td>
<td>Under 750</td>
<td>18-20</td>
<td>20-26</td>
</tr>
<tr>
<td></td>
<td>750-1500</td>
<td>24-26</td>
<td>28-30</td>
</tr>
<tr>
<td></td>
<td>1500-6000</td>
<td>28-30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Over 6000</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Where fixed object obstructions are placed on cut backslopes the recovery area width requirement should meet the recovery area width indicated by the fill slope table shown utilizing the foreslope of the cut as the appropriate fill slope rate.
APPENDIX D
TECHNICAL MEMORANDA – “T” INTERSECTION UPGRADE ALTERNATIVES
APPENDIX D1
STOP SIGN AND SPEED REDUCTION
Technical Memorandum

<table>
<thead>
<tr>
<th>To:</th>
<th>Kathy Arnold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company:</td>
<td>Rosemont Copper Company</td>
</tr>
<tr>
<td>Re:</td>
<td>Rosemont “T” Intersection Analysis – Stop</td>
</tr>
<tr>
<td></td>
<td>Sign and Speed Reduction</td>
</tr>
<tr>
<td>CC:</td>
<td>Jamie Sturgess (Rosemont)</td>
</tr>
<tr>
<td></td>
<td>David Krizek and Jamie Joggerst (Tt)</td>
</tr>
<tr>
<td>From:</td>
<td>Seri Park</td>
</tr>
<tr>
<td>Date:</td>
<td>June 4, 2009</td>
</tr>
<tr>
<td>Doc #:</td>
<td>101/09-320842-5.3</td>
</tr>
</tbody>
</table>

1.0 Introduction

This Technical Memorandum was prepared by Tetra Tech and presents design alternatives for the proposed Primary Access Road associated with the Rosemont Copper Project (Rosemont). The Primary Access Road intersection is proposed to consist of a basic “T” intersection that allows access from the mine property to State Route 83 (AZ-83). As shown on Figure 1, the location of the Primary Access Road “T” intersection occurs at Milepost (MP) 46.9 along AZ-83. The current topography conditions at the “T” intersection consist of an undeveloped area. Adding a “T” intersection at this location will require the area to be upgraded per Arizona Department of Transportation (ADOT) and American Association of State Highways and Transportation Officials (AASHTO) roadway design guidelines.

The “T” intersection design presented in the Mine Plan of Operation (MPO) (WestLand, 2007) consisted of the Primary Access Road being “stop” controlled with traffic along AZ-83 being uncontrolled (i.e., no stop sign). The intersection design also included a 500-foot long center lane to the south of the intersection. This center lane would allow northbound traffic to make a left turn onto the Primary Access Road. A 220-foot long deceleration and right turn lane was also proposed along the western edge of AZ-83, north of the intersection. The lane would also continue to the south of the intersection for 500 feet and serve as an accelerating lane for traffic going south on AZ-83. Figure 2 illustrates the “T” intersection configuration and corresponding typical section taken from the MPO.

Tetra Tech completed an in-depth analysis of the “T” intersection in order to assess potential traffic flow issues and to recommend designs that will allow traffic to safely merge from the Primary Access Road onto AZ-83. A total of four (4) alternatives to the MPO design were evaluated for this “T” intersection. These four (4) alternatives include:
- A three-way stop sign;
- A speed limit reduction;
- An acceleration lane with both 55 and 35 miles per hour (MPH) speed limits; and
- A bypass lane.

In all of the above listed alternatives, gravel was added along the west side of AZ-83, at the “T” intersection location, allowing for a temporary pull-off area for trucks. This Technical Memorandum presents details and discusses the advantages and disadvantages for the three-way stop sign and the speed limit reduction design alternatives. The remaining design alternatives are presented in other Technical Memorandums prepared by Tetra Tech.

2.0 Design Vehicle

In order to assess the various intersection design alternatives for the “T” intersection, the design vehicle must first be established. Based on Table 407.2 in the ADOT Roadway Design Guidelines, a WB-62 type, Interstate Semi Trailer is recommended as the design vehicle for intersections along a State Route. In AASHTO’s Geometric Design of Highways and Streets, a WB-65 type is recommended as the minimum sized design vehicle for intersections on state highways that carry high volumes of traffic and/or provide local access for large trucks. Therefore, in this Technical Memorandum, a WB-65 type was chosen as design vehicle since a safe truck turning with a WB-65 type will also satisfy a safe truck turning for a WB-62 type.

3.0 Three-Way Stop Design Alternative Criteria

Adding a “STOP” sign along AZ-83 will make the “T” intersection a three-way stop intersection. All the vehicles arriving at the intersection will be required to make a full stop regardless of the opposite or entering traffic. The layout of this proposed alternative is provided on Figure 3. The selection of sign locations followed the guideline in the Manual on Uniform Traffic Control Devices (MUTCD) from the Federal Highway Administration (FHA). In Attachment A, a before and after photo comparison is provided to illustrate the visual changes with regards to the three-way stop intersection.

Geometric Design Elements:

With the newly installed “STOP” sign (R1-1) along AZ-83, additional striping, a white strip starting from the roadway centerline to the shoulder, is required per MUTCD.

Sign Installation:

If a “STOP” sign (R1-1) is placed at each leg of the “T” intersection, advanced warning signs are required to alert the upcoming traffic of the stop sign. Advance warning signs, such as “STOP SIGN AHEAD” (W3-1), should be placed per the MUTCD Table 2C-4 (Attachment B) in the Guidelines for Advance Placement of Warning Signs. Based on this table, a W3-1 warning sign
along the Primary Access Road (road speed of 35 MPH) should be placed approximately 125 feet ahead of the “STOP” sign. A W3-1 warning sign along AZ-83 (road speed of 55 MPH) should also be placed approximately 325 feet ahead of the “STOP” sign for each direction of traffic (i.e., north bound and south bound lanes). Sign installation should follow ADOT’s Roadway Design Guidelines, Section 303.2, which states:

“Roadside obstacles, non-traversable hazards and fixed objects, should be removed, made ‘breakaway’, relocated or shielded by a barrier if they are within the minimum recovery area width”

Therefore, all new signs will need to be “breakaway” and any existing signs will need to be evaluated in order to ensure they meet the breakaway criteria. In addition, roadside clearing of large trees will need to be coordinated with ADOT in order to maintain a safe clear recovery area beyond the pavement limits. Clearing and Grubbing will conform to the guidelines specified in Landscape and Irrigation Design Guidelines for Arizona Department of Transportation Encroachment Permit Applications as presented in Attachment C.

3.1 Three-Way Stop Alternative Advantage and Disadvantage

Advantages:

- Safer merging movement for trucks leaving the Project site and entering AZ-83.
- The additional cost beyond basic intersection widening is minimal and would include: 1) adding the various “STOP” and advanced warning signs and 2) adding stripping at each “STOP” sign.
- No intersection sight distance criteria is applicable (per ADOT Roadway Design Guidelines Section 400-26, AASHTO Case E Intersection Control)

Disadvantages:

- Adding a “STOP” sign to AZ-83 will increase traffic delays and reduce roadway capacity.
- Potential safety issues arise since a “STOP” sign on AZ-83 will increase speed variance along AZ-83 and require drivers to come to a complete stop from a traveling speed of 55 MPH.

4.0 Speed Limit Reduction Alternative Design Criteria

Prior to developing a speed limit reduction design, a determination of what the new speed limit should be must first be analyzed. The current AZ-83 roadway layout has a posted speed limit of 55 MPH north of MP 47, near the proposed Primary Access Road “T” intersection. From MP 47 to MP 43.6, the speed limit varies between 35 and 45 MPH. Since the design vehicle is a WB-62 type Interstate Semi Trailer, it is recommended that the speed limit be reduced to 35 MPH in
order to achieve a safe turning speed for all traffic entering and exiting the Project site. Reducing the speed limit to 35 MPH along AZ-83 allows traffic to continue to flow while also creating a safer condition for truck traffic turning onto AZ-83. Figure 4 describes the proposed speed limit reduction alternative. Similar to the previous alternative, a before and after photo comparison is provided in Attachment D in order to illustrate the visual changes with regards to this speed limit reduction design alternative.

**Geometric Design Elements:**

No additional modification to the “T” intersection configuration presented in the MPO is required.

**Sign Installation:**

In MUTCD Section 2B.18, the following statement is presented regarding the placement and location of the Speed Limit (R2-1) signs:

“Speed Limit (R2-1) signs, indicating speed limits for which posting is required by law, shall be located at the points of change from one speed limit to another. At the end of the section to which a speed limit applies, a Speed Limit sign showing the next speed limit shall be installed. Additional Speed Limit signs shall be installed beyond major intersections and at other locations where it is necessary to remind road users of the speed limit that is applicable.”

Since the speed limit north of the “T” intersection is 55 MPH, this design alternative will require a speed reduction to 45 MPH at approximately 2,000 feet north of the “T” intersection and a speed reduction to 35 MPH approximately 1,000 feet north of the “T” intersection in order to avoid a sudden speed limit change. Since the speed limit south of the “T” intersection is 45 MPH, this design alternative will require a speed reduction to 35 MPH at approximately 1,000 feet south of the intersection. Furthermore, any existing signs that conflict with this speed change will be removed.

At a minimum, an advanced warning sign stating “SPEED REDUCED AHEAD” (W3-4) will need to be installed following the MUTCD Table 2C-4 in the Guidelines for Advance Placement of Warning Signs. The MUTCD table suggests adding a warning sign 950 feet in advance of the speed reduction for a beginning speed of 55 MPH. However, Tetra Tech recommends a distance of 1,000 feet in order to allow more reaction time for the drivers. Similar to the previous alternative, all new signs will need to be “breakaway” and any existing signs that remain will need to be evaluated to ensure they meet the breakaway criteria.

### 4.1 Speed Limit Reduction Alternative Advantage and Disadvantage

**Advantages:**

- Safer merging movement for trucks leaving the Project site and entering AZ-83.
- The only additional cost beyond basic intersection widening is for adding the various speed limit and advanced warning signs. No additional geometric design elements or striping is needed.
No intersection sight distance criteria is applicable (per ADOT Roadway Design Guidelines Section 400-26, AASHTO Case E Intersection Control)

Disadvantages:

- Speed reductions may increase traffic delay along AZ-83 considering through vehicles and merging traffic will require acceleration time.
- Trucks heading northbound do not have a dedicated acceleration lane.
REFERENCES


Arizona Department of Transportation (2007) *Roadway Design Guidelines*


U.S. Department of Transportation Federal Highway Administration (2004) *Standard Highway Signs*

FIGURES
**Steering Angle**

- **Lock to Lock Time**
- **Articulating Angle**

**Trailer Track**

- **Trailer Width**
- **Tractot Track**
- **Tractor Width**

**WB-65**

- **19.50 feet**
- **4.00 feet**
- **8.50 feet**
- **8.00 feet**

**WB-43**

- **3.00 feet**
- **43.50 feet**
- **15.00 feet**
- **53.00 feet**

**12' Lane**

- **6' Shoulder**

**20' Gravel Area**

- **20' Right Turn Lane**
- **12' Lane**
- **Var**

**Location:**

- **Mile Post 46.9**
- **Intersection of SR-83 and Primary Access Road**

**Legend:**

- **ROW - Right of Way**

**Intersection Widening Designed Per:**

Intersection Widening Designed Per:

Legend:
- ROW - Right of Way

Location:
- Mile Post 46.9
- Intersection of SR-83 and Primary Access Road
Intersection Widening Designed Per:

Legend:
- ROW - Right of Way

Location:
- Mile Post 46.9
- Intersection of SR-83 and Primary Access Road

WB-65
- Tractor Width: 8.00 feet
- Trailer Width: 8.50 feet
- Tractor Track: 8.00 feet
- Trailer Track: 8.50 feet
- Steering Angle: 6.00
- Articulating Angle: 70.00
- Lock to Lock Time: 5.00

20' Gravel Area
20' Right Turn Lane
12' Lane
Var 0'-11'
12' Lane
6' Shoulder

20' Gravel Area
20' Right Turn Lane
12' Lane
Var 0'-11'
12' Lane
6' Shoulder

SECTION A-A
ATTACHMENT A
PHOTOS FOR THE STOP SIGN “T” INTERSECTION ALTERNATIVE
Existing Roadway Layout at the Primary Access Road (Milepost 46.9 – looking south)
Stop Sign “T” Intersection Alternative (looking south)
ATTACHMENT B
TABLE 2C-4 IN MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)
### Table 2C-4. Guidelines for Advance Placement of Warning Signs
(English Units)

<table>
<thead>
<tr>
<th>Posted or 85th-Percentile Speed</th>
<th>Condition A: Speed reduction and lane changing in heavy traffic</th>
<th>Condition B: Deceleration to the listed advisory speed (mph) for the condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mph</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A²</td>
</tr>
<tr>
<td>25 mph</td>
<td></td>
<td>N/A²</td>
</tr>
<tr>
<td>30 mph</td>
<td></td>
<td>N/A²</td>
</tr>
<tr>
<td>35 mph</td>
<td></td>
<td>N/A²</td>
</tr>
<tr>
<td>40 mph</td>
<td></td>
<td>125 ft</td>
</tr>
<tr>
<td>45 mph</td>
<td></td>
<td>175 ft</td>
</tr>
<tr>
<td>50 mph</td>
<td></td>
<td>200 ft</td>
</tr>
<tr>
<td>55 mph</td>
<td></td>
<td>325 ft</td>
</tr>
<tr>
<td>60 mph</td>
<td></td>
<td>400 ft</td>
</tr>
<tr>
<td>65 mph</td>
<td></td>
<td>475 ft</td>
</tr>
<tr>
<td>70 mph</td>
<td></td>
<td>550 ft</td>
</tr>
<tr>
<td>75 mph</td>
<td></td>
<td>650 ft</td>
</tr>
</tbody>
</table>

Notes:

1. The distances are adjusted for a sign legibility distance of 175 ft for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 250 ft, which is appropriate for an alignment warning symbol sign.

2. Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge and Right Lane Ends. The distances are determined by providing the driver a PIEV time of 14.0 to 14.5 seconds for vehicle maneuvers (2001 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E) minus the legibility distance of 175 ft for the appropriate sign.

3. Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2001 AASHTO Policy, Stopping Sight Distance, Exhibit 3-1, providing a PIEV time of 2.5 seconds, a deceleration rate of 11.2 ft/second², minus the sign legibility distance of 175 ft.

4. Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve. The distance is determined by providing a 2.5 second PIEV time, a vehicle deceleration rate of 10 ft/second², minus the sign legibility distance of 250 ft.

5. No suggested distances are provided for these speeds, as the placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.
LANDSCAPE AND IRRIGATION

DESIGN GUIDELINES

ARIZONA DEPARTMENT OF TRANSPORTATION

ENCROACHMENT PERMIT APPLICATIONS

PREPARED BY:

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
ROADSIDE DEVELOPMENT SERVICES
INTRODUCTION

The Arizona Department of Transportation, Highways Division, encourages the landscaping of its rights of way through the cooperative efforts with local governments and adjacent property owners. Because the right of way is a public area, of prime importance with relation to landscaping is the protection of the public and its safe access to the facilities as well as the improvement of aesthetic considerations.

Landscaping, being composed of living plant material, is in a constant state of change and must consider the ultimate growth of plants. Additionally, other considerations are the use of low water requirement plant materials and any other local jurisdictional requirements, such as sidewalks, signing setbacks and other requirements in relation to each specific roadway. After all of these factors have been considered the completion of the landscaping can greatly enhance the beauty of the roadway and the community.
I. GENERAL

An approved Encroachment Permit is required before any landscape improvements may be incorporated within the ADOT Highway right-of-way. This applies to work performed under nationwide programs such as Global Releaf as well as individual efforts. Landscaping by local governments may be constructed and maintained within the control of access on the crossroads of major highways under a fully executed Intergovernmental Landscape Maintenance Agreement prepared by the State and an approved Encroachment Permit.

The highway roadside is an integral unit of a total highway facility. The term "roadside" generally refers to the area between the outer edge of the roadway and the right-of-way boundary. These include all unpaved areas within the right-of-way.

Permit applicants are encouraged to employ competent design professionals such as Registered Landscape Architects, Architects or Engineers, and to direct their work toward securing a product that fully represents the owner's needs and desires and meets the Arizona Department of Transportation (ADOT) standards, before submitting such plans for review and approval. Permit applicants and design professionals are encouraged
to discuss landscape needs and proposals with District Permits
Supervisors and Roadside Development Services Landscape Architects before
commencing work on final construction plans.

All plans and specifications shall be sufficiently complete and detailed
for easy analysis and compliance inspection. Plans shall be designed to
select plant materials appropriate for the intended use and location, to
arrange plants for optimum effect of color, texture, form and to ensure
reasonable maintenance within the capability of the proposed permittee.
Permit applications will be reviewed for consideration of the following
factors which can affect the safe and efficient operation of the highway
facility.

II. DRAWINGS

A. PLANS:

Drawings must be legible, accurate and drawn to scale. They shall
include a north arrow, name of development, designer and design firm
with appropriate phone numbers and location of project.

B. PLANT MATERIALS:

Plants proposed for use must be clearly located, showing mature
sizes, and identified as to botanical name (genus species, variety),
planting size, quantity and spacing used.
Areas within an Arizona Department of Water Resources Active Management Areas must adhere to the plant list provided for that area. (See attached Plant Lists.)

C. EXISTING FEATURES:

Existing features such as curbs, sidewalks, pipe culverts, drainage structures, retention basins, driveways, highway and non-highway signs, overhead lines, underground utilities, irrigation lines, manholes, service cabinets, etc, shall be shown. In addition, the posted speed limit for the highway shall be indicated. Existing trees and shrubs shall be incorporated into the design wherever feasible. Clearing of trees and shrubs will not be permitted unless approved through the permit process. When planters are cut out of existing sidewalk areas, sufficient space must remain for compliance with ARS statutes relating to accessibility by the physically handicapped. The use of steel tree grates is recommended to maximize usable sidewalk space and to maintain a safe walking surface.

D. SLOPES:

Existing or proposed slopes shall be identified with respect to elevation differences between top and bottom and rate of slope between.
III. DESIGN

A. EROSION CONTROL:

Erosion control measures must be employed to prevent surface drainage from eroding soil surfaces and carrying the resultant silt into natural or man made drainage systems, highways or private properties.

B. SAFETY SETBACKS FOR FIXED OBJECTS:

Minimum setbacks from the travel way for newly planted trees with an ultimate trunk diameter of more than 4 inches or other hazardous fixed objects should be as follows:

1. 50 MPH or Greater Design Speed:

a. Minimum setback from the edge of the traffic lane should be 35 feet unless one of the following reasons will allow for a lesser distance.

1) Cuts of 3 to 1 or steeper - obstacles are allowed 10 feet behind the point of vertical intersection (P.V.I.) at the toe of the slope. (See illustration 'A'.)

2) Where concrete barriers, walls, abutments, or other rigid obstructions are used - fixed objects may be placed 4' behind the obstructions. (See illustration 'B')
3) Where flexible guardrail (box-beam, W-beam, or cable) is used - 6 to 20 feet behind the face of the guardrail, depending upon the type. (See illustration 'C'.)

4) Where there are barrier curbs (5" or more vertical face) near a traveled lane 6 feet behind the face of the curb (see illustration 'D'); adjacent to a parking lane - no definite setback distance.

b. Where limited right-of-way or the necessity for planting would result in less clearance, all factors in the particular problem area should be weighed to decide if a special exception is warranted.

2. **50 MPH or less design speed:**

   a. Minimum setback of a fixed object from the edge of the traffic lane may be 30 feet unless one of the reasons set forth under (1) will allow for a lesser distance.

   b. On curves, adequate sight distance for the design speed of the highway must be maintained.

C. ** REQUIREMENTS FOR SIGHT DISTANCE:**

   A clear line of sight must be maintained at all highway intersections and entrances. Generally, shrubs, plantings or other obstructions in
this zone must be limited to an ultimate height of 18" or less to allow a clear line of sight down the highway in either direction for at least 400' from the front of the vehicle located 10' behind the edge of the highway to be entered. (See illustration 'E'.)

D. CULTURAL REQUIREMENTS FOR PLANTS:

Use plants that require minimal maintenance and are hardy to the area. Avoid plants that are messy, brittle, short lived or subject to infestations of insects or disease. Plants used in areas where sight distance must be maintained shall have a mature height of 18" or less.

E. VISIBILITY OF HIGHWAY FEATURES:

The visibility of highway signs, delineators, edges of sidewalks, curbs, roadway or guardrail must be maintained at all times. Therefore, provide sufficient plant setbacks and plants with mature sizes that will not outgrow spaces to avoid costly trimming as plants mature.

IV. DETAILS

A. Plans shall include, as appropriate, planting details for trees, shrubs, ground cover, vines, and cacti showing size of planting pit in relation to size of plant ball. (See planting details.)
B. Plans should include staking or guying details as required by the size and species of plant proposed. (See planting/staking details.)

C. Plans should identify problem soils and propose appropriate measures to overcome them.

D. If a mineral surface treatment is proposed, details should be included to indicate the depth, gradation, color and the vertical relationship to the roadway curb or sidewalk. A pre-emergent herbicide should be specified to preclude weeds in these areas. (See Granite and Rock Mulch details.)

E. Details for headers, signs, walls, sidewalks, planters, etc., should be included whenever proposed.

V. MAINTENANCE

A. Problems in maintenance shall be anticipated during the design phase. Changes in environmental conditions should be anticipated.

B. It shall be the responsibility of the permittee to assure that all landscaping and irrigation can be maintained to the satisfaction of ADOT.
ILLUSTRATION 'B'

CONCRETE BARRIER

ROADWAY

4' Min.
to Face

TREE or OTHER
FIXED OBJECT
ILLUSTRATION 'C'
ATTACHMENT D
PHOTOS FOR THE SPEED LIMIT REDUCTION “T” INTERSECTION ALTERNATIVE
Existing Roadway Layout at Primary Access Road (Milepost 46.9 – looking south)
Speed Limit Reduction Alternative (looking south) (note: speed limit signs are outside of the photo extents)
Technical Memorandum

To: Kathy Arnold
Company: Rosemont Copper
Re: Rosemont “T” Intersection Analysis – Acceleration Lane
CC: Jamie Sturgess (Rosemont)
       David Krizek and Jamie Joggerst (Tt)

From: Seri Park
Date: June 4, 2009
Doc #: 102/09-320842-5.3

1.0 Introduction

This Technical Memorandum was prepared by Tetra Tech and presents design alternatives for the proposed Primary Access Road associated with the Rosemont Copper Project (Rosemont). The Primary Access Road intersection is proposed to consist of a basic “T” intersection that allows access from the mine property to State Route 83 (AZ-83). As shown on Figure 1, the location of the Primary Access Road “T” intersection occurs at Milepost (MP) 46.9 along AZ-83. The current topography conditions at the “T” intersection consist of an undeveloped area. Adding a “T” intersection at this location will require the area to be upgraded per Arizona Department of Transportation (ADOT) and American Association of State Highways and Transportation Officials (AASHTO) roadway design guidelines.

The “T” intersection design presented in the Mine Plan of Operation (MPO) (WestLand, 2007) consisted of the Primary Access Road being “stop” controlled with traffic along AZ-83 being uncontrolled (i.e., no stop sign). The intersection design also included a 500-foot long center lane to the south of the intersection. This center lane would allow northbound traffic to make a left turn onto the Primary Access Road. A 220-foot long deceleration and right turn lane was also proposed along the western edge of AZ-83, north of the intersection. The lane would also continue to the south of the intersection for 500 feet and serve as an accelerating lane for traffic going south on AZ-83. Figure 2 illustrates the “T” intersection configuration and corresponding typical section taken from the MPO.

Tetra Tech completed an in-depth analysis of the “T” intersection in order to assess potential traffic flow issues and to recommend designs that will allow traffic to safely merge from the Primary Access Road onto AZ-83. A total of four (4) alternatives to the MPO design were evaluated for this “T” intersection.
These four (4) alternatives include:

- A three-way stop sign;
- A speed limit reduction;
- An acceleration lane with both 55 and 35 miles per hour (MPH) speed limits; and

A bypass lane. In all of the above listed alternatives, gravel was added along the west side of AZ-83, at the “T” intersection location, allowing for a temporary pull-off area for trucks. This Technical Memorandum presents details and discusses the advantages and disadvantages for the acceleration lane with both 55 and 35 MPH speed limits design alternatives. The remaining design alternatives are presented in other Technical Memorandums prepared by Tetra Tech.

2.0 Design Vehicle

In order to assess the various intersection design alternatives for the “T” intersection, the design vehicle must first be established. Based on Table 407.2 in the ADOT Roadway Design Guidelines, a WB-62 type, Interstate Semi Trailer is recommended as the design vehicle for intersections along a State Route. In AASHTO’s Geometric Design of Highways and Streets, a WB-65 type is recommended as the minimum sized design vehicle for intersections on state highways that carry high volumes of traffic and/or provide local access for large trucks. Therefore, in this Technical Memorandum, a WB-65 type was chosen as design vehicle since a safe truck turning with a WB-65 type will also satisfy a safe truck turning for a WB-62 type.

3.0 Acceleration Lane (55 MPH) Alternative Design Criteria

Providing a dedicated acceleration lane on AZ-83 allows trucks leaving the Project site to accelerate to normal traffic speeds before merging with on-coming northbound through traffic. This will enhance the traffic flow of AZ-83 by minimizing interruptions caused by slow speed vehicles entering the traffic stream. Additionally, having a dedicated acceleration lane will increase the roadway capacity of AZ-83. Under this alternative, the existing speed limit of 55 MPH will be maintained as the posted speed limit. The acceleration lane should be long enough to provide drivers an adequate distance to accelerate to 85 percent of the entering highway speed. A detailed layout of this design alternative is shown on Figure 3. In Attachment A, before and after photos are provided to illustrate the visual changes with regards to a 55 MPH acceleration lane design alternative.

Roadway Geometric Element:

The acceleration lane design alternative requires the construction of an additional northbound lane and an overall widening of the “T” intersection. Per Figure 408.12 in the ADOT Roadway Design Guidelines (Attachment B), the length of the acceleration lane should be 650 feet for a design speed of 55 MPH. In addition to the acceleration lane, a standard merging taper is also required in order to gradually allow merging traffic to enter the through traffic. The length of the
taper is calculated by using the ratio of the design speed in MPH to one (V:1), as specified in ADOT Roadway Design Guidelines Section 408.12 and in the Manual on Uniform Traffic Control Devices (MUTCD) Figure 3B-12 (Attachment C). Furthermore, the “T” intersection would need to be widened to accommodate the 12-foot wide acceleration lane, per the ADOT Roadway Design Guidelines, Section 408.12.

Sign Installation:

When an extra lane is provided for slower moving traffic, a sign stating “LANE ENDS” or a sign showing a lane ends symbol (W4-2) should be installed in advance of the end of the acceleration lane. Per MUTCD Table 2C-4 (Attachment D), the advanced warning sign should be placed at 950 feet ahead of the end of the acceleration lane for a posted speed limit of 55 MPH. Since the length of the proposed acceleration lane is less than 950 feet, it is recommended that the W4-2 sign be placed at the beginning of the acceleration lane. For the Primary Access Road, a “STOP” (R1-1) sign and a “STOP AHEAD” (W3-1) sign should be placed 125 feet apart from each other as per Table 2C-4 of the MUTCD (Attachment D). In regards to sign installation, Section 303.2 in the ADOT Roadway Design Guidelines states:

“Roadside obstacles, non-traversable hazards and fixed objects, should be removed, made ‘breakaway’, relocated or shielded by barrier if they are within the minimum recovery area width”

Therefore, all new signs will need to be “breakaway” and any existing signs will need to be evaluated in order to ensure they meet the breakaway criteria. In addition, roadside clearing of large trees will need to be coordinated with ADOT in order to maintain a safe clear recovery area beyond the pavement limits. Clearing and Grubbing will conform to the guidelines specified in the Landscape and Irrigation Design Guidelines for Arizona Department of Transportation Encroachment Permit Applications (Attachment E).

3.1 Acceleration Lane (55 MPH) Alternative Advantage and Disadvantage

Advantages:

- Minimizes delays of through traffic on AZ-83
- Increase AZ-83 roadway capacity by allowing more through traffic onto the corresponding roadway
- Allows for safe merging and acceleration of trucks

Disadvantages:

- Increased cost to widen intersection in order to accommodate the acceleration lane as well as the longer merging taper
4.0 Acceleration Lane (35 MPH) Alternative Design Criteria

Adding a dedicated acceleration lane to AZ-83 allows for trucks leaving the Project site to accelerate to normal traffic speeds before merging with on-coming northbound through traffic. Reducing the speed limit on AZ-83 from 55 to 35 MPH at the “T” intersection will further increase the safety for trucks merging onto AZ-83. Figure 4 describes the layout for this proposed alternative. Before and after photos are provided in Attachment F to illustrate the visual changes with regards to a 35 MPH acceleration lane design alternative.

Roadway Geometric Elements:

Based on Figure 408.12A in the ADOT Roadway Design Guidelines (Attachment B), a 300-foot long acceleration lane is required for a design speed of 35 MPH. The transition from the acceleration lane to the through lane will be achieved by way of a taper lane. The length of the taper lane is calculated from the ratio of the design speed in MPH to the width of the acceleration lane. Therefore, the taper lane for a design speed of 35 MPH would be 120 feet long. This taper lane design method follows the ADOT Roadway Design Guidelines, Section 408.12 and the MUTCD Figure 3B-12 (Attachment C). Additionally, the “T” intersection would need to be widened to accommodate the 12-foot wide acceleration lane.

Sign Installation:

Similar to the previously mentioned alternative, a “lane ends” advanced warning sign (W4-2) should be placed prior to the end of the acceleration lane. Based on Table 2C-4 in the MUTCD (Attachment D), the distance of the advanced warning sign from the end of the acceleration lane should be 550 feet for a design speed of 35 MPH. However, since the acceleration lane is less than 550 feet long, the advanced warning sign should be placed at the beginning of the acceleration lane. For the Primary Access Road, a “STOP” sign (R1-1) and a “STOP AHEAD” sign (W3-1) sign should be placed 125 feet apart from each other as per Table 2C-4 of the MUTCD (Attachment D). Similar to the previous alternative, all new signs should be “breakaway” and any existing signs that remain in place should be evaluated to ensure they meet the breakaway criteria.

4.1 Acceleration Lane (35 MPH) Alternative Advantage and Disadvantage

Advantages:

- Minimizes delays to through-traffic
- Increase AZ-83 roadway capacity
- Allows for safe merging and acceleration of trucks
- Slower speed limit reduces chances of accidents
- If the speed limit on AZ-83 is reduced from 55 to 35 MPH, the acceleration and taper lanes are shorter, thus less widening is required along AZ-83
Disadvantages:

- Increased cost to widen intersection in order to accommodate the acceleration lane and merging taper
- Increased delays to traffic AZ-83 if the speed limit is reduced from 55 to 35 MPH
REFERENCES


Arizona Department of Transportation (2007) Roadway Design Guidelines


Intersection Widening Designed Per:

Legend:
- ROW - Right of Way

Location:
- Mile Post 46.9
- Intersection of SR-83 and Primary Access Road
Intersection Widening Designed Per:

Legend:
- ROW - Right of Way
- Intersection of SR-83 and Primary Access Road

Location:
- Mile Post 46.9
- Intersection of SR-83 and Primary Access Road
Intersection Widening Designed Per:

Legend:
ROW - Right of Way
Location:
Mile Post 46.9
Intersection of SR-83 and Primary Access Road
ATTACHMENT A
PHOTOS FOR THE ACCELERATION LANE (55 MPH)
“T” INTERSECTION ALTERNATIVE
Existing Roadway Layout at the Primary Access Road (Milepost 46.9 – looking south)
Existing Roadway Layout at the Primary Access Road (Milepost 46.9 – looking north)
Acceleration Lane (55 mph) Alternative (looking north)
**Acceleration Distance Table**

<table>
<thead>
<tr>
<th>Design Speed (MPH)</th>
<th>Distance (FT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>30</td>
<td>150</td>
</tr>
<tr>
<td>40</td>
<td>300</td>
</tr>
<tr>
<td>45</td>
<td>400</td>
</tr>
<tr>
<td>50</td>
<td>500</td>
</tr>
<tr>
<td>55</td>
<td>650</td>
</tr>
<tr>
<td>60</td>
<td>800</td>
</tr>
<tr>
<td>70</td>
<td>1300</td>
</tr>
<tr>
<td>75</td>
<td>1600</td>
</tr>
</tbody>
</table>

*V = Design Speed in MPH, Acceleration Taper is Relative to Adjacent Through Lane Edge.*

**Acceleration Lane Configuration**

**Figure 408.12A**

**Minimum Acceleration Lane Configuration**

**Figure 408.12B**

*V = Design Speed in MPH, Acceleration Taper is Relative to Adjacent Through Lane Edge.*
Figure 3B-12. Examples of Lane Reduction Markings

a - From 3 lanes to 2 lanes

b - From 4 lanes to 3 lanes

c - From 4 lanes to 2 lanes

L = Length in meters (feet)
S = Posted, 85th-percentile, or statutory speed in km/h (mph)
W = Offset in meters (feet)
d = Advance warning distance (see Section 2C.05)

See Section 3D.04 for delineator spacing.

For speeds 70 km/h (45 mph) or more:

\[ L = 0.62 WS \]

For speeds less than 70 km/h (45 mph):

\[ L = \frac{WS^2}{155} \left( L = \frac{WS^2}{60} \right) \]
ATTACHMENT D
TABLE 2C-4 IN MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)
### Table 2C-4. Guidelines for Advance Placement of Warning Signs
*(English Units)*

<table>
<thead>
<tr>
<th>Condition A: Speed reduction and lane changing in heavy traffic¹</th>
<th>Condition B: Deceleration to the listed advisory speed (mph) for the condition⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posted or 85th-Percentile Speed</td>
<td>0¹</td>
</tr>
<tr>
<td>20 mph</td>
<td>225 ft</td>
</tr>
<tr>
<td>25 mph</td>
<td>325 ft</td>
</tr>
<tr>
<td>30 mph</td>
<td>450 ft</td>
</tr>
<tr>
<td>35 mph</td>
<td>550 ft</td>
</tr>
<tr>
<td>40 mph</td>
<td>650 ft</td>
</tr>
<tr>
<td>45 mph</td>
<td>750 ft</td>
</tr>
<tr>
<td>50 mph</td>
<td>850 ft</td>
</tr>
<tr>
<td>55 mph</td>
<td>950 ft</td>
</tr>
<tr>
<td>60 mph</td>
<td>1100 ft</td>
</tr>
<tr>
<td>65 mph</td>
<td>1200 ft</td>
</tr>
<tr>
<td>70 mph</td>
<td>1250 ft</td>
</tr>
<tr>
<td>75 mph</td>
<td>1350 ft</td>
</tr>
</tbody>
</table>

Notes:

¹ The distances are adjusted for a sign legibility distance of 175 ft for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 250 ft, which is appropriate for an alignment warning symbol sign.

² Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge and Right Lane Ends. The distances are determined by providing the driver a PIEV time of 14.0 to 14.5 seconds for vehicle maneuvers (2001 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E) minus the legibility distance of 175 ft for the appropriate sign.

³ Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2001 AASHTO Policy, Stopping Sight Distance, Exhibit 3-1, providing a PIEV time of 2.5 seconds, a deceleration rate of 11.2 ft/second², minus the sign legibility distance of 175 ft.

⁴ Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve. The distance is determined by providing a 2.5 second PIEV time, a vehicle deceleration rate of 10 ft/second², minus the sign legibility distance of 250 ft.

⁵ No suggested distances are provided for these speeds, as the placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.
ATTACHMENT E
LANDSCAPE AND IRRIGATION DESIGN GUIDELINES
FOR ARIZONA DEPARTMENT OF TRANSPORTATION
ENCROACHMENT PERMIT APPLICATIONS
LANDSCAPE AND IRRIGATION
DESIGN GUIDELINES
ARIZONA DEPARTMENT OF TRANSPORTATION
ENCROACHMENT PERMIT APPLICATIONS

PREPARED BY:
ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
ROADSIDE DEVELOPMENT SERVICES

0967r
INTRODUCTION

The Arizona Department of Transportation, Highways Division, encourages the landscaping of its rights of way through the cooperative efforts with local governments and adjacent property owners. Because the right of way is a public area, of prime importance with relation to landscaping is the protection of the public and its safe access to the facilities as well as the improvement of aesthetic considerations.

Landscaping, being composed of living plant material, is in a constant state of change and must consider the ultimate growth of plants. Additionally, other considerations are the use of low water requirement plant materials and any other local jurisdictional requirements, such as sidewalks, signing setbacks and other requirements in relation to each specific roadway. After all of these factors have been considered the completion of the landscaping can greatly enhance the beauty of the roadway and the community.
LANDSCAPING

I. GENERAL

An approved Encroachment Permit is required before any landscape improvements may be incorporated within the ADOT Highway right-of-way. This applies to work performed under nationwide programs such as Global Releaf as well as individual efforts. Landscaping by local governments may be constructed and maintained within the control of access on the crossroads of major highways under a fully executed Intergovernmental Landscape Maintenance Agreement prepared by the State and an approved Encroachment Permit.

The highway roadside is an integral unit of a total highway facility. The term "roadside" generally refers to the area between the outer edge of the roadway and the right-of-way boundary. These include all unpaved areas within the right-of-way.

Permit applicants are encouraged to employ competent design professionals such as Registered Landscape Architects, Architects or Engineers, and to direct their work toward securing a product that fully represents the owner's needs and desires and meets the Arizona Department of Transportation (ADOT) standards, before submitting such plans for review and approval. Permit applicants and design professionals are encouraged
to discuss landscape needs and proposals with District Permits Supervisors and Roadside Development Services Landscape Architects before commencing work on final construction plans.

All plans and specifications shall be sufficiently complete and detailed for easy analysis and compliance inspection. Plans shall be designed to select plant materials appropriate for the intended use and location, to arrange plants for optimum effect of color, texture, form and to ensure reasonable maintenance within the capability of the proposed permittee. Permit applications will be reviewed for consideration of the following factors which can affect the safe and efficient operation of the highway facility.

II. DRAWINGS

A. PLANS:

Drawings must be legible, accurate and drawn to scale. They shall include a north arrow, name of development, designer and design firm with appropriate phone numbers and location of project.

B. PLANT MATERIALS:

Plants proposed for use must be clearly located, showing mature sizes, and identified as to botanical name (genus species, variety), planting size, quantity and spacing used.
Areas within an Arizona Department of Water Resources Active Management Areas must adhere to the plant list provided for that area. (See attached Plant Lists.)

C. **EXISTING FEATURES:**

Existing features such as curbs, sidewalks, pipe culverts, drainage structures, retention basins, driveways, highway and non-highway signs, overhead lines, underground utilities, irrigation lines, manholes, service cabinets, etc, shall be shown. In addition, the posted speed limit for the highway shall be indicated. Existing trees and shrubs shall be incorporated into the design wherever feasible. Clearing of trees and shrubs will not be permitted unless approved through the permit process. When planters are cut out of existing sidewalk areas, sufficient space must remain for compliance with ARS statutes relating to accessibility by the physically handicapped. The use of steel tree grates is recommended to maximize usable sidewalk space and to maintain a safe walking surface.

D. **SLOPES:**

Existing or proposed slopes shall be identified with respect to elevation differences between top and bottom and rate of slope between.
III. DESIGN

A. EROSION CONTROL:

Erosion control measures must be employed to prevent surface drainage from eroding soil surfaces and carrying the resultant silt into natural or man made drainage systems, highways or private properties.

B. SAFETY SETBACKS FOR FIXED OBJECTS:

Minimum setbacks from the travel way for newly planted trees with an ultimate trunk diameter of more than 4 inches or other hazardous fixed objects should be as follows:

1. 50 MPH or Greater Design Speed:

   a. Minimum setback from the edge of the traffic lane should be 35 feet unless one of the following reasons will allow for a lesser distance.

      1) Cuts of 3 to 1 or steeper - obstacles are allowed 10 feet behind the point of vertical intersection (P.V.I.) at the toe of the slope. (See illustration 'A'.)

      2) Where concrete barriers, walls, abutments, or other rigid obstructions are used - fixed objects may be placed 4' behind the obstructions. (See illustration 'B')
3) Where flexible guardrail (box-beam, w-beam, or cable) is used - 6 to 20 feet behind the face of the guardrail, depending upon the type. (See illustration 'C'.)

4) Where there are barrier curbs (5" or more vertical face) near a traveled lane 6 feet behind the face of the curb (see illustration 'D'); adjacent to a parking lane - no definite setback distance.

b. Where limited right-of-way or the necessity for planting would result in less clearance, all factors in the particular problem area should be weighed to decide if a special exception is warranted.

2. 50 MPH or less design speed:

a. Minimum setback of a fixed object from the edge of the traffic lane may be 30 feet unless one of the reasons set forth under (1) will allow for a lesser distance.

b. On curves, adequate sight distance for the design speed of the highway must be maintained.

C. REQUIREMENTS FOR SIGHT DISTANCE:

A clear line of sight must be maintained at all highway intersections and entrances. Generally, shrubs, plantings or other obstructions in
this zone must be limited to an ultimate height of 18" or less to allow a clear line of sight down the highway in either direction for at least 400' from the front of the vehicle located 10' behind the edge of the highway to be entered. (See illustration 'E'.)

D. CULTURAL REQUIREMENTS FOR PLANTS:

Use plants that require minimal maintenance and are hardy to the area. Avoid plants that are messy, brittle, short lived or subject to infestations of insects or disease. Plants used in areas where sight distance must be maintained shall have a mature height of 18" or less.

E. VISIBILITY OF HIGHWAY FEATURES:

The visibility of highway signs, delineators, edges of sidewalks, curbs, roadway or guardrail must be maintained at all times. Therefore, provide sufficient plant setbacks and plants with mature sizes that will not outgrow spaces to avoid costly trimming as plants mature.

IV. DETAILS

A. Plans shall include, as appropriate, planting details for trees, shrubs, ground cover, vines, and cacti showing size of planting pit in relation to size of plant ball. (See planting details.)
B. Plans should include staking or guying details as required by the size and species of plant proposed. (See planting/staking details.)

C. Plans should identify problem soils and propose appropriate measures to overcome them.

D. If a mineral surface treatment is proposed, details should be included to indicate the depth, gradation, color and the vertical relationship to the roadway curb or sidewalk. A pre-emergent herbicide should be specified to preclude weeds in these areas. (See Granite and Rock Mulch details.)

E. Details for headers, signs, walls, sidewalks, planters, etc., should be included whenever proposed.

V. MAINTENANCE

A. Problems in maintenance shall be anticipated during the design phase. Changes in environmental conditions should be anticipated.

B. It shall be the responsibility of the permittee to assure that all landscaping and irrigation can be maintained to the satisfaction of ADOT.
ILLUSTRATION 'A'
ILLUSTRATION 'C'

6'-20' Depending on type of Barrier

GUARD RAIL

TREE or OTHER FIXED OBJECT

ROADWAY

[Drawing of road with guard rail and tree]
ATTACHMENT F
PHOTOS FOR THE ACCELERATION LANE (35 MPH)
“T” INTERSECTION ALTERNATIVE
Existing Roadway Layout at the Primary Access Road (Milepost 46.9)
Acceleration Lane (35 mph) Alternative
Existing Roadway Layout at the Primary Access Road (Milepost 46.9 – looking north)
Acceleration Lane (35 mph) Alternative (looking north)
APPENDIX D3
BYPASS LANE ALTERNATIVE
Technical Memorandum

To: Kathy Arnold
From: Seri Park
Company: Rosemont Copper
Date: June 4, 2009
Re: Rosemont “T” Intersection Analysis – Bypass Lane
Doc #: 103/09-320842-5.3
CC: Jamie Sturgess (Rosemont)
David Krizek and Jamie Joggerst (Tt)

1.0 Introduction

This Technical Memorandum was prepared by Tetra Tech and presents design alternatives for the proposed Primary Access Road associated with the Rosemont Copper Project (Rosemont). The Primary Access Road intersection is proposed to consist of a basic “T” intersection that allows access from the mine property to State Route 83 (AZ-83). As shown on Figure 1, the location of the Primary Access Road “T” intersection occurs at Milepost (MP) 46.9 along AZ-83. The current topography conditions at the “T” intersection consist of an undeveloped area. Adding a “T” intersection at this location will require the area to be upgraded per Arizona Department of Transportation (ADOT) and American Association of State Highways and Transportation Officials (AASHTO) roadway design guidelines.

The “T” intersection design presented in the Mine Plan of Operation (MPO) (WestLand, 2007) consisted of the Primary Access Road being “stop” controlled with traffic along AZ-83 being uncontrolled (i.e., no stop sign). The intersection design also included a 500-foot long center lane to the south of the intersection. This center lane would allow northbound traffic to make a left turn onto the Primary Access Road. A 220-foot long deceleration and right turn lane was also proposed along the western edge of AZ-83, north of the intersection. The lane would also continue to the south of the intersection for 500 feet and serve as an accelerating lane for traffic going south on AZ-83. Figure 2 illustrates the “T” intersection configuration and corresponding typical section taken from the MPO.

Tetra Tech completed an in-depth analysis of the “T” intersection in order to assess potential traffic flow issues and to recommend designs that will allow traffic to safely merge from the Primary Access Road onto AZ-83. A total of four (4) alternatives to the MPO design were evaluated for this “T” intersection. These four (4) alternatives include:
A three-way stop sign;
- A speed limit reduction;
- An acceleration lane with both 55 and 35 miles per hour (MPH) speed limits; and
- A bypass lane.

In all of the above listed alternatives, gravel was added along the west side of AZ-83, at the “T” intersection location, allowing for a temporary pull-off area for trucks. This Technical Memorandum presents details and discusses the advantages and disadvantages for the bypass lane design alternative. The remaining design alternatives are presented in other Technical Memorandums prepared by Tetra Tech.

2.0 Design Vehicle

In order to assess the various intersection design alternatives for the “T” intersection, the design vehicle must first be established. Based on Table 407.2 in the ADOT Roadway Design Guidelines, a WB-62 type, Interstate Semi Trailer is recommended as the design vehicle for intersections along a State Route. In AASHTO’s Geometric Design of Highways and Streets, a WB-65 type is recommended as the minimum sized design vehicle for intersections on state highways that carry high volumes of traffic and/or provide local access for large trucks. Therefore, in this Technical Memorandum, a WB-65 type was chosen as design vehicle since a safe truck turning with a WB-65 type will also satisfy a safe truck turning for a WB-62 type.

3.0 Bypass Lane Alternative Design Criteria

In this alternative emphasis on channelization by means of traffic control devices are presented. In Section 403.3 of the ADOT Roadway Design Guidelines, it is stated that proper intersection channelization of traffic movement using pavement markings, delineators, or other suitable means will enhance/facilitate safe and orderly intersection traffic flow. Under this alternative, 55 MPH will be maintained as the design speed along AZ-83. Figure 3 describes the proposed alternative layout and Attachment A shows before and after photos to illustrate the visual changes with regards to the corresponding alternative.

Roadway Geometric Element:

In this alternative, in addition to adding a northbound dedicated acceleration lane along AZ-83, a 2-foot buffer between the acceleration lane and the through traffic lane will be added to implement the proposed bypass concept. Therefore, the intersection will be widened to accommodate this 2-foot buffer and channelizers will be placed in the buffer to keep traffic from crossing over into the acceleration lane, thus creating clear and efficient traffic separation. Similar to an acceleration lane design, the inside lane will be at least 650 feet long plus a standard taper, however channelizers will be utilized to force through traffic to stay to the right, allowing proper acceleration of trucks before the two lanes merge. Figure 3 illustrates a typical
section of the bypass lane configuration including the additional 2 feet buffer and the channelizers. The acceleration and through lanes will both be standard 12-foot lanes based on ADOT roadway design guidelines. A truck turning template was also performed to ensure safe truck turns.

Sign and Channelizer Installation:

When an extra lane is provided for slower moving traffic, a sign stating “LANE ENDS” or a sign showing a lane ends symbol (W4-2) should be installed in advance of the end of the acceleration lane. Per MUTCD Table 2C-4 (Attachment B), the advanced warning sign should be placed at 950 feet ahead of the end of the acceleration lane for a posted speed limit of 55 MPH. Since the length of the proposed acceleration lane is less than 950 feet, it is recommended that the W4-2 sign be placed at the beginning of the acceleration lane. For the Primary Access Road, a “STOP” (R1-1) sign and a “STOP AHEAD” (W3-1) sign should be placed 125 feet apart from each other as per Table 2C-4 of the MUTCD (Attachment B). In regards to sign installation, Section 303.2 in the ADOT Roadway Design Guidelines states:

“Roadside obstacles, non-traversable hazards and fixed objects, should be removed, made ‘breakaway’, relocated or shielded by barrier if they are within the minimum recovery area width”

Therefore, all new signs will need to be “breakaway” and any existing signs will need to be evaluated in order to ensure they meet the breakaway criteria. In addition, roadside clearing of large trees will need to be coordinated with ADOT in order to maintain a safe clear recovery area beyond the pavement limits. Clearing and Grubbing will conform to the guidelines specified in the Landscape and Irrigation Design Guidelines for Arizona Department of Transportation Encroachment Permit Applications (Attachment C).

Channelizers will be placed from the beginning of the 250-foot left turn pocket and extend until approximately 400 feet into the proposed acceleration lane. The spacing between each channelizer will be 25 feet based on the standard channelizer spacing stated in the MUTCD.

3.1 Bypass Lane alternative Advantage and Disadvantage

Advantages:

- Creates a clear safety buffer between through traffic and accelerating/left turning traffic
- Minimizes delay caused by accelerating traffic, especially left turning truck traffic onto AZ-83 from the Primary Access Road
- Increases roadway capacity by allowing easier though-traffic flow

Disadvantages:

- Increased cost to widen the intersection to accommodate the acceleration lane, merging taper, additional 2-foot buffer zone and the cost for purchasing channelizers
Unusual design may confuse drivers unfamiliar with the area
REFERENCES


Arizona Department of Transportation (2007) *Roadway Design Guidelines*


U.S. Department of Transportation Federal Highway Administration (2004) *Standard Highway Signs*

Intersection Widening Designed Per:

Legend:
- ROW - Right of Way

Location:
- Mile Post 46.9
- Intersection of SR-83 and Primary Access Road
Intersection Widening Designed Per:

Legend:
- ROW - Right of Way

Location:
- Mile Post 46.9
- Intersection of SR-83 and Primary Access Road
ATTACHMENT A
PHOTOS FOR THE BYPASS LANE ALTERNATIVE
Existing Roadway Layout at the Primary Access Road (Milepost 46.9 – looking south)
Bypass Lane Alternative (looking south)
Existing Roadway Layout at the Primary Access Road (Milepost 46.9 – looking north)
Bypass Lane Alternative (looking north)
ATTACHMENT B
TABLE 2C-4 IN MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)
Table 2C-4. Guidelines for Advance Placement of Warning Signs
(English Units)

<table>
<thead>
<tr>
<th>Posted or 85th-Percentile Speed</th>
<th>Advance Placement Distance ¹</th>
<th>Condition B: Deceleration to the listed advisory speed (mph) for the condition ⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Condition A: Speed reduction and lane changing in heavy traffic³</td>
<td>0 ¹</td>
</tr>
<tr>
<td>20 mph</td>
<td>225 ft</td>
<td>N/A ³</td>
</tr>
<tr>
<td>25 mph</td>
<td>325 ft</td>
<td>N/A ³</td>
</tr>
<tr>
<td>30 mph</td>
<td>450 ft</td>
<td>N/A ³</td>
</tr>
<tr>
<td>35 mph</td>
<td>550 ft</td>
<td>N/A ³</td>
</tr>
<tr>
<td>40 mph</td>
<td>650 ft</td>
<td>125 ft</td>
</tr>
<tr>
<td>45 mph</td>
<td>750 ft</td>
<td>175 ft</td>
</tr>
<tr>
<td>50 mph</td>
<td>850 ft</td>
<td>250 ft</td>
</tr>
<tr>
<td>55 mph</td>
<td>950 ft</td>
<td>325 ft</td>
</tr>
<tr>
<td>60 mph</td>
<td>1100 ft</td>
<td>400 ft</td>
</tr>
<tr>
<td>65 mph</td>
<td>1200 ft</td>
<td>475 ft</td>
</tr>
<tr>
<td>70 mph</td>
<td>1250 ft</td>
<td>550 ft</td>
</tr>
<tr>
<td>75 mph</td>
<td>1350 ft</td>
<td>650 ft</td>
</tr>
</tbody>
</table>

Notes:

¹ The distances are adjusted for a sign legibility distance of 175 ft for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 250 ft, which is appropriate for an alignment warning symbol sign.

² Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge and Right Lane Ends. The distances are determined by providing the driver a PIEV time of 14.0 to 14.5 seconds for vehicle maneuvers (2001 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E) minus the legibility distance of 175 ft for the appropriate sign.

³ Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2001 AASHTO Policy, Stopping Sight Distance, Exhibit 3-1, providing a PIEV time of 2.5 seconds, a deceleration rate of 11.2 ft/second ², minus the sign legibility distance of 175 ft.

⁴ Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve. The distance is determined by providing a 2.5 second PIEV time, a vehicle deceleration rate of 10 ft/second ², minus the sign legibility distance of 250 ft.

⁵ No suggested distances are provided for these speeds, as the placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.
ATTACHMENT C
LANDSCAPE AND IRRIGATION DESIGN GUIDELINES FOR ARIZONA DEPARTMENT OF TRANSPORTATION ENCROACHMENT PERMIT APPLICATION
LANDSCAPE AND IRRIGATION

DESIGN GUIDELINES

ARIZONA DEPARTMENT OF TRANSPORTATION

ENCROACHMENT PERMIT APPLICATIONS

PREPARED BY:

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
ROADSIDE DEVELOPMENT SERVICES
INTRODUCTION

The Arizona Department of Transportation, Highways Division, encourages the landscaping of its rights of way through the cooperative efforts with local governments and adjacent property owners. Because the right of way is a public area, of prime importance with relation to landscaping is the protection of the public and its safe access to the facilities as well as the improvement of aesthetic considerations.

Landscaping, being composed of living plant material, is in a constant state of change and must consider the ultimate growth of plants. Additionally, other considerations are the use of low water requirement plant materials and any other local jurisdictional requirements, such as sidewalks, signing setbacks and other requirements in relation to each specific roadway. After all of these factors have been considered the completion of the landscaping can greatly enhance the beauty of the roadway and the community.
LANDSCAPING

I. GENERAL

An approved Encroachment Permit is required before any landscape improvements may be incorporated within the ADOT Highway right-of-way. This applies to work performed under nationwide programs such as Global Releaf as well as individual efforts. Landscaping by local governments may be constructed and maintained within the control of access on the crossroads of major highways under a fully executed Intergovernmental Landscape Maintenance Agreement prepared by the State and an approved Encroachment Permit.

The highway roadside is an integral unit of a total highway facility. The term "roadside" generally refers to the area between the outer edge of the roadway and the right-of-way boundary. These include all unpaved areas within the right-of-way.

Permit applicants are encouraged to employ competent design professionals such as Registered Landscape Architects, Architects or Engineers, and to direct their work toward securing a product that fully represents the owner's needs and desires and meets the Arizona Department of Transportation (ADOT) standards, before submitting such plans for review and approval. Permit applicants and design professionals are encouraged
to discuss landscape needs and proposals with District Permits Supervisors and Roadside Development Services Landscape Architects before commencing work on final construction plans.

All plans and specifications shall be sufficiently complete and detailed for easy analysis and compliance inspection. Plans shall be designed to select plant materials appropriate for the intended use and location, to arrange plants for optimum effect of color, texture, form and to ensure reasonable maintenance within the capability of the proposed permittee. Permit applications will be reviewed for consideration of the following factors which can affect the safe and efficient operation of the highway facility.

II. DRAWINGS

A. PLANS:

Drawings must be legible, accurate and drawn to scale. They shall include a north arrow, name of development, designer and design firm with appropriate phone numbers and location of project.

B. PLANT MATERIALS:

Plants proposed for use must be clearly located, showing mature sizes, and identified as to botanical name (genus species, variety), planting size, quantity and spacing used.
Areas within an Arizona Department of Water Resources Active Management Areas must adhere to the plant list provided for that area. (See attached Plant Lists.)

C. EXISTING FEATURES:

Existing features such as curbs, sidewalks, pipe culverts, drainage structures, retention basins, driveways, highway and non-highway signs, overhead lines, underground utilities, irrigation lines, manholes, service cabinets, etc, shall be shown. In addition, the posted speed limit for the highway shall be indicated. Existing trees and shrubs shall be incorporated into the design wherever feasible. Clearing of trees and shrubs will not be permitted unless approved through the permit process. When planters are cut out of existing sidewalk areas, sufficient space must remain for compliance with ARS statutes relating to accessibility by the physically handicapped. The use of steel tree grates is recommended to maximize usable sidewalk space and to maintain a safe walking surface.

D. SLOPES:

Existing or proposed slopes shall be identified with respect to elevation differences between top and bottom and rate of slope between.
III. DESIGN

A. EROSION CONTROL:

Erosion control measures must be employed to prevent surface drainage from eroding soil surfaces and carrying the resultant silt into natural or man made drainage systems, highways or private properties.

B. SAFETY SETBACKS FOR FIXED OBJECTS:

Minimum setbacks from the travel way for newly planted trees with an ultimate trunk diameter of more than 4 inches or other hazardous fixed objects should be as follows:

1. 50 MPH or Greater Design Speed:

   a. Minimum setback from the edge of the traffic lane should be 35 feet unless one of the following reasons will allow for a lesser distance.

      1) Cuts of 3 to 1 or steeper - obstacles are allowed 10 feet behind the point of vertical intersection (P.V.I.) at the toe of the slope. (See illustration 'A'.)

      2) Where concrete barriers, walls, abutments, or other rigid obstructions are used - fixed objects may be placed 4' behind the obstructions. (See illustration 'B')
3) Where flexible guardrail (box-beam, w-beam, or cable) is used - 6 to 20 feet behind the face of the guardrail, depending upon the type. (See illustration 'C'.)

4) Where there are barrier curbs (5" or more vertical face) near a traveled lane 6 feet behind the face of the curb (see illustration 'D'); adjacent to a parking lane - no definite setback distance.

b. Where limited right-of-way or the necessity for planting would result in less clearance, all factors in the particular problem area should be weighed to decide if a special exception is warranted.

2. 50 MPH or less design speed:

a. Minimum setback of a fixed object from the edge of the traffic lane may be 30 feet unless one of the reasons set forth under (1) will allow for a lesser distance.

b. On curves, adequate sight distance for the design speed of the highway must be maintained.

C. REQUIREMENTS FOR SIGHT DISTANCE:

A clear line of sight must be maintained at all highway intersections and entrances. Generally, shrubs, plantings or other obstructions in
this zone must be limited to an ultimate height of 18" or less to allow a clear line of sight down the highway in either direction for at least 400' from the front of the vehicle located 10' behind the edge of the highway to be entered. (See illustration 'E'.)

D. CULTURAL REQUIREMENTS FOR PLANTS:

Use plants that require minimal maintenance and are hardy to the area. Avoid plants that are messy, brittle, short lived or subject to infestations of insects or disease. Plants used in areas where sight distance must be maintained shall have a mature height of 18" or less.

E. VISIBILITY OF HIGHWAY FEATURES:

The visibility of highway signs, delineators, edges of sidewalks, curbs, roadway or guardrail must be maintained at all times. Therefore, provide sufficient plant setbacks and plants with mature sizes that will not outgrow spaces to avoid costly trimming as plants mature.

IV. DETAILS

A. Plans shall include, as appropriate, planting details for trees, shrubs, ground cover, vines, and cacti showing size of planting pit in relation to size of plant ball. (See planting details.)
B. Plans should include staking or guying details as required by the size and species of plant proposed. (See planting/staking details.)

C. Plans should identify problem soils and propose appropriate measures to overcome them.

D. If a mineral surface treatment is proposed, details should be included to indicate the depth, gradation, color and the vertical relationship to the roadway curb or sidewalk. A pre-emergent herbicide should be specified to preclude weeds in these areas. (See Granite and Rock Mulch details.)

E. Details for headers, signs, walls, sidewalks, planters, etc., should be included whenever proposed.

V. MAINTENANCE

A. Problems in maintenance shall be anticipated during the design phase. Changes in environmental conditions should be anticipated.

B. It shall be the responsibility of the permittee to assure that all landscaping and irrigation can be maintained to the satisfaction of ADOT.
ILLUSTRATION 'B'

CONCRETE BARRIER

ROADWAY

4' Min.
to Face

TREE or OTHER
FIXED OBJECT
6' - 20'
Depending on type of Barrier

GUARD RAIL

TREEm or OTHER  
FIXED OBJECT

ROADWAY

ILLUSTRATION  'C'
204.3 - Grades

A) Minimum grades: The desirable minimum grade for a highway with a curb and gutter section is 0.4 percent. Special care should be taken in checking storm water drainage requirements to keep the spread of water on the traveled way within tolerable limits.

Above 4000 ft elevation the minimum grade for roadways with curb and gutter shall be 0.5 percent.

Level grades may be used on rural highways below 4000 ft elevation with adequate roadway crown and with proper consideration of drainage requirements.

B) Maximum grades: The maximum grades which may be used are shown in Table 204.3 for each type of highway and its allowable range of design speeds.

Exceptions to the maximums shown in Table 204.3 shall require the approval of the Assistant State Engineer, Roadway Engineering Group.

<table>
<thead>
<tr>
<th>Table 204.3</th>
<th>Relation of Highway Types to Maximum Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions</td>
<td>Design Speed (mph)</td>
</tr>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Controlled Access Highways</td>
<td></td>
</tr>
<tr>
<td>Level Terrain</td>
<td>3%</td>
</tr>
<tr>
<td>Rolling Terrain</td>
<td>4%</td>
</tr>
<tr>
<td>Mountainous Terrain</td>
<td>6%</td>
</tr>
<tr>
<td>Urban/Fringe Urban Areas</td>
<td>4%</td>
</tr>
<tr>
<td>Rural Divided Highways</td>
<td></td>
</tr>
<tr>
<td>Level Terrain</td>
<td>3%</td>
</tr>
<tr>
<td>Rolling Terrain</td>
<td>5%</td>
</tr>
<tr>
<td>Mountainous Terrain</td>
<td>7%</td>
</tr>
<tr>
<td>Rural Non-Divided Highways</td>
<td></td>
</tr>
<tr>
<td>Level Terrain</td>
<td>3%</td>
</tr>
<tr>
<td>Rolling Terrain</td>
<td>5%</td>
</tr>
<tr>
<td>Mountainous Terrain</td>
<td>7%</td>
</tr>
<tr>
<td>Urban/Fringe Urban Highways</td>
<td></td>
</tr>
<tr>
<td>Arterial Streets</td>
<td></td>
</tr>
<tr>
<td>Level Terrain</td>
<td>8%</td>
</tr>
<tr>
<td>Rolling Terrain</td>
<td>9%</td>
</tr>
<tr>
<td>Mountainous Terrain</td>
<td>11%</td>
</tr>
</tbody>
</table>

Note: Maximum grades shown in **bold** correspond to the design speed for given conditions, see Table 101.3. Grades at other design speeds are for information only.
# Technical Memorandum

<table>
<thead>
<tr>
<th>To:</th>
<th>Kathy Arnold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company:</td>
<td>Rosemont Copper</td>
</tr>
<tr>
<td>Re:</td>
<td>State Route 83 School Bus Stop Improvements</td>
</tr>
<tr>
<td>Date:</td>
<td>June 25, 2009</td>
</tr>
<tr>
<td>Doc #:</td>
<td>115/09-320842-5.3</td>
</tr>
</tbody>
</table>

## 1.0 Introduction

This Technical Memorandum was prepared by Tetra Tech and presents potential improvements for the current school bus stops along State Route 83 (AZ-83). This memorandum also discusses the design criteria used for the improvements as well as the advantages and disadvantages related to the improvements.

Tetra Tech completed a field visit to document the locations and traffic patterns associated with the existing school bus stops along AZ-83. A total of seven (7) school bus stops were identified and are shown on Figure 1. The current school bus traffic pattern consists of two (2) separate loops. One (1) loop runs from Sahaurita Road to the Rest Stop at Milepost (MP) 46.9 on AZ-83. The Rest Stop is located just south of the proposed Primary Access Road leading to the Rosemont Copper Project. The second school bus loop runs from State Route 82 (AZ-82) to Greaterville Road. Figure 1 also shows the traffic patterns for the two (2) school bus loops. Currently the school bus pick-up and drop-off spots are located such that students do not have to cross the roadway in order to get to the bus stop (i.e., pick-up and drop-off occur at the same location on the respective side of AZ-83). With the exception of the Hilton Ranch Road school bus stop, the bus stops do not have a designated pull-off area along AZ-83 (i.e., the buses stop within the through lane of AZ-83). At the Hilton Ranch Road school bus stop, a wide compacted dirt area was observed on the east side of AZ-83.

Tetra Tech held a meeting with the Transportation Supervisor for the Vail School District on May 19, 2009. At this meeting, Tetra Tech learned that the district is open to improving the existing school bus stops along AZ-83 to avoid stopping in the through lane. The district also supports upgrades to any of the existing school bus stops in order to avoid any potential future traffic conflicts.

---

PLEASE NOTE: This message, including any attachments, may include privileged, confidential and/or inside information. Any distribution or use of this communication by anyone other than the intended recipient is strictly prohibited and may be unlawful. If you are not the intended recipient, please notify the sender by replying to this message and then delete it from your system.
2.0 Design Vehicle

The large, S-BUS-40 school bus was chosen as the design vehicle for assessing potential improvements to the school bus stops. This vehicle was selected since it also satisfies requirements for the more common smaller school bus type, S-BUS-36. A detailed illustration of the S-BUS-40 is presented on Figure 2.

3.0 School Bus Stop Design Criteria

An example of a proposed improved school bus stop is illustrated on Figure 2. This figure is also specific to the proposed Hilton Ranch Road school bus stop improvement. The guidelines used in the design of this improved bus stop are discussed in the following paragraphs. In Attachment A, before and after photos are provided to illustrate the visual changes with regards to adding the proposed improved school bus stop at Hilton Ranch Road.

Geometric Design Element

The Vail School District does not have any specific design guidelines for school bus stops or turnouts. The Vail school district agreed that the American Association of State Highway and Transportation Officials (AASHTO) bus turnout Exhibit 4-27 (Attachment B), presented at the meeting, is an acceptable design guideline. The district was also willing to relocate existing bus stops up to 300 feet from their current location if the construction of the turnout would be more feasible within those limits. The only restriction the school district had is that buses cannot stop within 50 feet of any intersection. This restriction was considered when assessing improvements to the school bus stops.

Per AASHTO guidelines, bus turnouts should consist of the following three (3) items: 1) a deceleration lane or taper to permit easy entrance into the loading area, 2) a standing space sufficiently long enough to accommodate the maximum number of vehicles expected to occupy the space at one time, and 3) a merging lane or taper to enable easy re-entry into the through lane. AASHTO also recommends providing a 50-foot long loading area for the bus and entry and exit tapers. The entry taper should be no less than 5 to 1 length to width and the exit taper should be no less than 3 to 1. AASHTO’s Exhibit 4-27, provided in Attachment B, also indicates that the minimum width for a bus turnout is 20 feet. In this Technical Memorandum, the proposed turnouts for the school bus stops were designed to be 50 feet long and 20 feet wide with a 100-foot entry taper and a 60-foot exit taper in order to meet all the above mentioned guidelines. This proposed turnout for the school bus stops also conforms to the Arizona Department of Transportation (ADOT) Roadway Design Guidelines Section 105-4, Pullout.

Tetra Tech also proposes adding markings, striping, and asphalt at each bus stop. Markings would mainly consist of directional arrows to clarify the ingress and egress of the school bus. The striping would consist of 4 inch wide white strips located at the edge of the shoulder.
Sign Installation

Per the Manual on Uniform Traffic Control Devices (MUTCD) Figure 7B-1 (Attachment C), a “SCHOOL BUS STOP AHEAD” (S3-1) sign should be installed to warn drivers about the school bus stop. The sign should be placed approximately 500 feet in advance of the bus stop per Section 7B.10 of the MUTCD. An additional sign will also be posted to address concerns from the Vail school district about other vehicles using the school bus stops for non-school bus activities. Furthermore, sign installation should follow ADOT’s Roadway Design Guidelines, Section 303.2, which states:

“Roadside obstacles, non-traversable hazards and fixed objects, should be removed, made ‘breakaway’, relocated or shielded by a barrier if they are within the minimum recovery area width.”

Therefore, all new signs will need to be “breakaway”. In addition, roadside clearing of large trees will need to be coordinated with ADOT in order to maintain a safe clear recovery area beyond the pavement limits. This process will also conform to the guidelines specified in the Landscape and Irrigation Design Guidelines for Arizona Department of Transportation Encroachment Permit Applications as presented in Attachment D.

3.1 School Bus Stop Improvement Advantages and Disadvantages

Advantages:

- Adding a designated turnout area for the school bus stops along AZ-83 will improve traffic flow by allowing through traffic to proceed without impedance
- Increase traffic safety by providing better sight distance for through vehicles
- Safer students loading and unloading
- Eliminate potential rear-end accidents

Disadvantages:

- Ingress and egress point will need to be maintained
- Except for the Hilton Ranch Road school bus stop, the remaining six (6) bus stops will require grading
REFERENCES


Arizona Department of Transportation (2007) *Roadway Design Guidelines*


U.S. Department of Transportation Federal Highway Administration (2004) *Standard Highway Signs*

Vail School District (http://www.vail.k12.az.us/facilities_transportation/busroutes.htm)
Bus Turnout Designed Per:

Legend:
- ROW - Right of Way

Location:
Mile Post 49.1
Intersection of State Route 83 and Hilton Ranch Road

SCHOOL BUS
Proposed 20’ Bus Turnout
Existing 12’ Lane
Existing 12’ Lane
ATTACHMENT A
PHOTOS OF HILTON RANCH ROAD SCHOOL BUS STOP
Existing School Bus Stop at Hilton Ranch Road (looking north)
Proposed School Bus Stop at Hilton Ranch Road (looking north)
Exhibit 4-27. Bus Turnouts

Where the turnout is on the near side of an intersection, the width of cross street is usually great enough to provide the needed merging space.

The minimum total length of turnout for a two-bus loading area should be about 55 m [180 ft] for a midblock location, 45 m [150 ft] for a near-side location, and 40 m [130 ft] for a far-side location. These dimensions are based on a loading area width of 3.0 m [10 ft]. They should be increased by 4 to 5 m [13 to 16 ft] for a width of 3.6 m [12 ft]. Greater lengths of bus turnouts expedite bus maneuvers, encourage full compliance on the part of bus drivers, and lessen interference with through traffic.

Exhibit 4-28 shows a bus turnout at a midblock location. The width of the turnout is 3.0 m [10 ft], and the length of the turnout, including tapers, is 63 m [210 ft]. The deceleration and acceleration tapers are 4:1.
ATTACHMENT C
MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD) FIGURE 7B-1
Figure 7B-1. School Area Signs

School Advance Warning Assembly
- S1-1
- W16-9p
- OR
- W16-2a
- OR
- 200 FT
- W16-2
- OR
- 200 FEET
- W16-2a
- OR
- 60 m
- W16-2a
- OR
- 60 METERS
- W16-2

School Crosswalk Warning Assembly
- S1-1
- W16-7p
- OR

School Speed Limit Assembly
- S4-3
- R2-1
- OR
- S4-1
- OR

School Bus Stop Ahead
- S3-1

20 MPH School Zone Ahead
- S4-5

30 km/h School Zone Ahead
- S4-5a

SCHOOL SPEED LIMIT 20
- S5-1
- OR

END SCHOOL ZONE
- S5-2
LANDSCAPE AND IRRIGATION
DESIGN GUIDELINES
ARIZONA DEPARTMENT OF TRANSPORTATION
ENCROACHMENT PERMIT APPLICATIONS

PREPARED BY:
ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
ROADSIDE DEVELOPMENT SERVICES
INTRODUCTION

The Arizona Department of Transportation, Highways Division, encourages the landscaping of its rights of way through the cooperative efforts with local governments and adjacent property owners. Because the right of way is a public area, of prime importance with relation to landscaping is the protection of the public and its safe access to the facilities as well as the improvement of aesthetic considerations.

Landscaping, being composed of living plant material, is in a constant state of change and must consider the ultimate growth of plants. Additionally, other considerations are the use of low water requirement plant materials and any other local jurisdictional requirements, such as sidewalks, signing setbacks and other requirements in relation to each specific roadway. After all of these factors have been considered the completion of the landscaping can greatly enhance the beauty of the roadway and the community.
LANDSCAPING

I. GENERAL

An approved Encroachment Permit is required before any landscape improvements may be incorporated within the ADOT Highway right-of-way. This applies to work performed under nationwide programs such as Global Releaf as well as individual efforts. Landscaping by local governments may be constructed and maintained within the control of access on the crossroads of major highways under a fully executed Intergovernmental Landscape Maintenance Agreement prepared by the State and an approved Encroachment Permit.

The highway roadside is an integral unit of a total highway facility. The term "roadside" generally refers to the area between the outer edge of the roadway and the right-of-way boundary. These include all unpaved areas within the right-of-way.

Permit applicants are encouraged to employ competent design professionals such as Registered Landscape Architects, Architects or Engineers, and to direct their work toward securing a product that fully represents the owner's needs and desires and meets the Arizona Department of Transportation (ADOT) standards, before submitting such plans for review and approval. Permit applicants and design professionals are encouraged
to discuss landscape needs and proposals with District Permits Supervisors and Roadside Development Services Landscape Architects before commencing work on final construction plans.

All plans and specifications shall be sufficiently complete and detailed for easy analysis and compliance inspection. Plans shall be designed to select plant materials appropriate for the intended use and location, to arrange plants for optimum effect of color, texture, form and to ensure reasonable maintenance within the capability of the proposed permittee. Permit applications will be reviewed for consideration of the following factors which can affect the safe and efficient operation of the highway facility.

II. DRAWINGS

A. PLANS:

Drawings must be legible, accurate and drawn to scale. They shall include a north arrow, name of development, designer and design firm with appropriate phone numbers and location of project.

B. PLANT MATERIALS:

Plants proposed for use must be clearly located, showing mature sizes, and identified as to botanical name (genus species, variety), planting size, quantity and spacing used.
Areas within an Arizona Department of Water Resources Active Management Areas must adhere to the plant list provided for that area. (See attached Plant Lists.)

C. EXISTING FEATURES:

Existing features such as curbs, sidewalks, pipe culverts, drainage structures, retention basins, driveways, highway and non-highway signs, overhead lines, underground utilities, irrigation lines, manholes, service cabinets, etc, shall be shown. In addition, the posted speed limit for the highway shall be indicated. Existing trees and shrubs shall be incorporated into the design wherever feasible. Clearing of trees and shrubs will not be permitted unless approved through the permit process. When planters are cut out of existing sidewalk areas, sufficient space must remain for compliance with ARS statutes relating to accessibility by the physically handicapped. The use of steel tree grates is recommended to maximize usable sidewalk space and to maintain a safe walking surface.

D. SLOPES:

Existing or proposed slopes shall be identified with respect to elevation differences between top and bottom and rate of slope between.
III. DESIGN

A. EROSION CONTROL:

Erosion control measures must be employed to prevent surface drainage from eroding soil surfaces and carrying the resultant silt into natural or man made drainage systems, highways or private properties.

B. SAFETY SETBACKS FOR FIXED OBJECTS:

Minimum setbacks from the travel way for newly planted trees with an ultimate trunk diameter of more than 4 inches or other hazardous fixed objects should be as follows:

1. 50 MPH or Greater Design Speed:

   a. Minimum setback from the edge of the traffic lane should be 35 feet unless one of the following reasons will allow for a lesser distance.

      1) Cuts of 3 to 1 or steeper - obstacles are allowed 10 feet behind the point of vertical intersection (P.V.I.) at the toe of the slope. (See illustration 'A'.)

      2) Where concrete barriers, walls, abutments, or other rigid obstructions are used - fixed objects may be placed 4' behind the obstructions. (See illustration 'B')
3) Where flexible guardrail (box-beam, w-beam, or cable) is used – 6 to 20 feet behind the face of the guardrail, depending upon the type. (See illustration 'C'.)

4) Where there are barrier curbs (5\" or more vertical face) near a traveled lane 6 feet behind the face of the curb (see illustration 'D'); adjacent to a parking lane – no definite setback distance.

b. Where limited right-of-way or the necessity for planting would result in less clearance, all factors in the particular problem area should be weighed to decide if a special exception is warranted.

2. 50 MPH or less design speed:

a. Minimum setback of a fixed object from the edge of the traffic lane may be 30 feet unless one of the reasons set forth under (1) will allow for a lesser distance.

b. On curves, adequate sight distance for the design speed of the highway must be maintained.

C. REQUIREMENTS FOR SIGHT DISTANCE:

A clear line of sight must be maintained at all highway intersections and entrances. Generally, shrubs, plantings or other obstructions in
this zone must be limited to an ultimate height of 18" or less to allow a clear line of sight down the highway in either direction for at least 400' from the front of the vehicle located 10' behind the edge of the highway to be entered. (See illustration 'E'.)

D. CULTURAL REQUIREMENTS FOR PLANTS:

Use plants that require minimal maintenance and are hardy to the area. Avoid plants that are messy, brittle, short lived or subject to infestations of insects or disease. Plants used in areas where sight distance must be maintained shall have a mature height of 18" or less.

E. VISIBILITY OF HIGHWAY FEATURES:

The visibility of highway signs, delineators, edges of sidewalks, curbs, roadway or guardrail must be maintained at all times. Therefore, provide sufficient plant setbacks and plants with mature sizes that will not outgrow spaces to avoid costly trimming as plants mature.

IV. DETAILS

A. Plans shall include, as appropriate, planting details for trees, shrubs, ground cover, vines, and cacti showing size of planting pit in relation to size of plant ball. (See planting details.)
B. Plans should include staking or guying details as required by the size and species of plant proposed. (See planting/staking details.)

C. Plans should identify problem soils and propose appropriate measures to overcome them.

D. If a mineral surface treatment is proposed, details should be included to indicate the depth, gradation, color and the vertical relationship to the roadway curb or sidewalk. A pre-emergent herbicide should be specified to preclude weeds in these areas. (See Granite and Rock Mulch details.)

E. Details for headers, signs, walls, sidewalks, planters, etc., should be included whenever proposed.

V. MAINTENANCE

A. Problems in maintenance shall be anticipated during the design phase. Changes in environmental conditions should be anticipated.

B. It shall be the responsibility of the permittee to assure that all landscaping and irrigation can be maintained to the satisfaction of ADOT.
ILLUSTRATION 'A'
## Pima Association of Governments Region

<table>
<thead>
<tr>
<th>Priority</th>
<th>Project ID</th>
<th>RT</th>
<th>Begin MP</th>
<th>Ending MP</th>
<th>CO</th>
<th>Project Name</th>
<th>Type of Work</th>
<th>Programmed</th>
<th>Cost</th>
<th>Accumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>112</td>
<td>86</td>
<td>145.69</td>
<td>148.3</td>
<td>PM</td>
<td>Brawley Wash Segment</td>
<td>Roadway Widening</td>
<td>No</td>
<td>$5,000,000</td>
<td>$ 5,000,000</td>
</tr>
<tr>
<td>2</td>
<td>113</td>
<td>10</td>
<td>260</td>
<td>267</td>
<td>PM</td>
<td>Valencia to I-19</td>
<td>FMS</td>
<td>No</td>
<td>$9,100,000</td>
<td>$ 14,100,000</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>10</td>
<td>288.4</td>
<td>290.5</td>
<td>PM</td>
<td>Cienega Creek – Marsh Station</td>
<td>Marsh Station TI Reconstruction</td>
<td>Yes</td>
<td>$18,000,000</td>
<td>$ 32,100,000</td>
</tr>
<tr>
<td>4</td>
<td>101</td>
<td>10</td>
<td>271.99</td>
<td>276</td>
<td>PM</td>
<td>Rita R. - Houghton</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$6,000,000</td>
<td>$ 38,100,000</td>
</tr>
<tr>
<td>5</td>
<td>104</td>
<td>86</td>
<td>166.4</td>
<td>169.5</td>
<td>PM</td>
<td>Kinney - La Cholla</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$3,500,000</td>
<td>$ 41,600,000</td>
</tr>
<tr>
<td>6</td>
<td>108</td>
<td>86</td>
<td>73.9</td>
<td>77.4</td>
<td>PM</td>
<td>MP 73.9 - MP 74.9 &amp; MP 76.6 – MP 77.4</td>
<td>Shoulder Widening</td>
<td>No</td>
<td>$3,327,000</td>
<td>$ 44,927,000</td>
</tr>
<tr>
<td>7</td>
<td>109</td>
<td>86</td>
<td>171</td>
<td>171</td>
<td>PM</td>
<td>Santa Cruz River Bridge # 528</td>
<td>Bridge Deck Rehabilitation</td>
<td>No</td>
<td>$200,000</td>
<td>$ 45,127,000</td>
</tr>
<tr>
<td>8</td>
<td>102</td>
<td>19</td>
<td>0</td>
<td>63.3</td>
<td>PM</td>
<td>MP 0 - MP 63</td>
<td>Sign Replacement</td>
<td>No</td>
<td>$1,500,000</td>
<td>$ 46,627,000</td>
</tr>
</tbody>
</table>

Accumulative Total: $46,627,000

American Recovery and Reinvestment Act - Approved Projects (March 13, 2009)
<table>
<thead>
<tr>
<th>Priority</th>
<th>Project ID</th>
<th>RT</th>
<th>Begin MP</th>
<th>Ending MP</th>
<th>CO</th>
<th>Project Name</th>
<th>Type of Work</th>
<th>Programmed</th>
<th>Cost</th>
<th>Accumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>10</td>
<td>119</td>
<td>126</td>
<td>MA</td>
<td>Verrado Way-Sarival Road</td>
<td>Construct General Purpose Lane</td>
<td>Yes</td>
<td>$43,200,000</td>
<td>$43,200,000</td>
</tr>
<tr>
<td>2</td>
<td>99</td>
<td>17</td>
<td>224</td>
<td>232</td>
<td>MA</td>
<td>SR74 – Anthem Way</td>
<td>Construct General Purpose Lane</td>
<td>Yes</td>
<td>$22,500,000</td>
<td>$65,700,000</td>
</tr>
<tr>
<td>3</td>
<td>802</td>
<td></td>
<td></td>
<td></td>
<td>MA</td>
<td>L 202 to Ellsworth</td>
<td>Design &amp; ROW</td>
<td>Yes</td>
<td>$20,000,000</td>
<td>$85,700,000</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>60</td>
<td>138</td>
<td>149</td>
<td>MA</td>
<td>SR 303L - 99th Ave</td>
<td>10 Miles Widening</td>
<td>Yes</td>
<td>$45,000,000</td>
<td>$110,700,000</td>
</tr>
<tr>
<td>4</td>
<td>93</td>
<td>60</td>
<td>148.9</td>
<td>150.5</td>
<td>MA</td>
<td>99th Ave - 83rd Ave</td>
<td>2.5 Miles Widening</td>
<td>Yes</td>
<td>$11,200,000</td>
<td>$121,900,000</td>
</tr>
<tr>
<td>5</td>
<td>84</td>
<td>101</td>
<td>15.8</td>
<td>17.5</td>
<td>MA</td>
<td>Beardsley Rd / Union Hills</td>
<td>TI Improvement – Widening Union Hills and Bridge with Beardsley connector</td>
<td>Yes</td>
<td>$9,125,000</td>
<td>$131,025,000</td>
</tr>
</tbody>
</table>
# Arizona Department of Transportation
## American Recovery and Reinvestment Act - Approved Projects (March 13, 2009)

### Greater Arizona

<table>
<thead>
<tr>
<th>Priority</th>
<th>Project ID</th>
<th>RT</th>
<th>Begin MP</th>
<th>Ending MP</th>
<th>CO</th>
<th>Project Name</th>
<th>Type of Work</th>
<th>Programmed</th>
<th>Cost</th>
<th>Accumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>60</td>
<td>243.2</td>
<td>251.8</td>
<td>GI</td>
<td>Miami CL – McMillan Wash</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$9,500,000</td>
<td>$9,500,000</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>69</td>
<td>262.8</td>
<td>267.6</td>
<td>YV</td>
<td>Jct I-17 - Big Bug 1</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$6,600,000</td>
<td>$6,100,000</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>10</td>
<td>307.9</td>
<td>322</td>
<td>CH</td>
<td>East Benson – Johnson Road (EB)</td>
<td>Pavement Preservation</td>
<td>Yes</td>
<td>$11,000,000</td>
<td>$27,100,000</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>10</td>
<td>213</td>
<td>218.7</td>
<td>PN</td>
<td>Picacho Peak – Town of Picacho</td>
<td>Roadway Widening</td>
<td>No</td>
<td>$30,000,000</td>
<td>$57,100,000</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>191</td>
<td>159.5</td>
<td>160.5</td>
<td>GE</td>
<td>Black Hills Back Country Byway at MP 159.5</td>
<td>Intersection Improvement</td>
<td>No</td>
<td>$750,000</td>
<td>$57,850,000</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>95</td>
<td>63</td>
<td>80</td>
<td>LA</td>
<td>Peligro - Clarks</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$1,000,000</td>
<td>$8,850,000</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>89</td>
<td>420</td>
<td>426</td>
<td>CN</td>
<td>Townsend – Fernwood</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$8,000,000</td>
<td>$76,850,000</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>191</td>
<td>427</td>
<td>436</td>
<td>AP</td>
<td>South Of Chinle</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$5,000,000</td>
<td>$81,850,000</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>93</td>
<td>104.1</td>
<td>106</td>
<td>M</td>
<td>OSB Ranch Road</td>
<td>Construct Parallel Roadway</td>
<td>Yes</td>
<td>$15,000,000</td>
<td>$96,850,000</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>70</td>
<td>338.88</td>
<td>338.98</td>
<td>GH</td>
<td>8th Avenue Intersection</td>
<td>Intersection Improvement</td>
<td>Yes</td>
<td>$191,000</td>
<td>$97,041,000</td>
</tr>
<tr>
<td>11</td>
<td>13</td>
<td>10</td>
<td>357.5</td>
<td>362.7</td>
<td>CH</td>
<td>Luzena - Bowie (EB)</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$3,000,000</td>
<td>$100,041,000</td>
</tr>
<tr>
<td>Priority</td>
<td>Project ID</td>
<td>RT</td>
<td>Begin MP</td>
<td>Ending MP</td>
<td>CO</td>
<td>Project Name</td>
<td>Type of Work</td>
<td>Programmed</td>
<td>Cost</td>
<td>Accumulative Total</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>----</td>
<td>----------</td>
<td>-----------</td>
<td>----</td>
<td>--------------</td>
<td>--------------</td>
<td>-------------</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Statewide</td>
<td>Chip Seal/ Slurry Seal</td>
<td>No</td>
<td>$4,500,000</td>
<td>$104,541,000</td>
</tr>
<tr>
<td>13</td>
<td>16</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Statewide</td>
<td>Culvert Lining</td>
<td>No</td>
<td>$3,600,000</td>
<td>$108,141,000</td>
</tr>
<tr>
<td>14</td>
<td>17</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>Statewide</td>
<td>Fence</td>
<td>No</td>
<td>$8,000,000</td>
<td>$16,141,000</td>
</tr>
<tr>
<td>15</td>
<td>19</td>
<td>0</td>
<td>0389.5</td>
<td>402</td>
<td>NA</td>
<td></td>
<td>Kayenta – Jct N 59</td>
<td>Yes</td>
<td>$4,400,000</td>
<td>$120,541,000</td>
</tr>
<tr>
<td>16</td>
<td>61</td>
<td>0</td>
<td>402</td>
<td>416</td>
<td>NA</td>
<td></td>
<td>Jct N 59 – Dennehotso</td>
<td>No</td>
<td>$6,000,000</td>
<td>$126,541,000</td>
</tr>
<tr>
<td>17</td>
<td>59</td>
<td>0</td>
<td>255</td>
<td>268</td>
<td>GI</td>
<td></td>
<td>Payson to Pine @ MP 255</td>
<td>No</td>
<td>$8,610,000</td>
<td>$135,151,000</td>
</tr>
<tr>
<td>18</td>
<td>21</td>
<td>0</td>
<td>31</td>
<td>43</td>
<td>SC</td>
<td></td>
<td>Sonoita North</td>
<td>Yes</td>
<td>$2,750,000</td>
<td>$137,901,000</td>
</tr>
<tr>
<td>19</td>
<td>22</td>
<td>0</td>
<td>278.8</td>
<td>286.4</td>
<td>GI</td>
<td></td>
<td>Timber Mountain - Seneca</td>
<td>No</td>
<td>$5,000,000</td>
<td>$142,901,000</td>
</tr>
<tr>
<td>20</td>
<td>23</td>
<td>0</td>
<td>175</td>
<td>185</td>
<td>GE</td>
<td></td>
<td>Lower Coronado Trail at MP 175</td>
<td>No</td>
<td>$400,000</td>
<td>$143,301,000</td>
</tr>
</tbody>
</table>
## Arizona Department of Transportation
### American Recovery and Reinvestment Act - Approved Projects (March 13, 2009)

### Greater Arizona

<table>
<thead>
<tr>
<th>Priority</th>
<th>Project ID</th>
<th>RT</th>
<th>Begin MP</th>
<th>Ending MP</th>
<th>CO</th>
<th>Project Name</th>
<th>Type of Work</th>
<th>Programmed</th>
<th>Cost</th>
<th>Accumulative Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>24</td>
<td>19</td>
<td>148.36</td>
<td>48.94</td>
<td>CH</td>
<td>Sunsites at High Street</td>
<td>Widen Roadway for Turn Lanes</td>
<td>Yes</td>
<td>$595,000</td>
<td>$143,896,000</td>
</tr>
<tr>
<td>22</td>
<td>25</td>
<td>16</td>
<td>0311.5</td>
<td>320.5</td>
<td>CN</td>
<td>Jct 89 - Vann's Trading Post</td>
<td>Pavement Preservation</td>
<td>Yes</td>
<td>$4,100,000</td>
<td>$147,996,000</td>
</tr>
<tr>
<td>23</td>
<td>42</td>
<td>40</td>
<td>205</td>
<td>208</td>
<td>CN</td>
<td>Walnut Canyon</td>
<td>Reconstruct Roadway</td>
<td>Yes</td>
<td>$12,000,000</td>
<td>$159,996,000</td>
</tr>
<tr>
<td>24</td>
<td>28</td>
<td>80</td>
<td>316.5</td>
<td>317.8</td>
<td>CH</td>
<td>Tombstone Streets</td>
<td>Pavement Preservation</td>
<td>No</td>
<td>$1,956,000</td>
<td>$161,952,000</td>
</tr>
<tr>
<td>25</td>
<td>30</td>
<td>40</td>
<td>347</td>
<td>348</td>
<td>AP</td>
<td>Black Creek Br. #1134, 1642 and 954</td>
<td>Bridge Rehabilitation</td>
<td>Yes</td>
<td>$700,000</td>
<td>$162,652,000</td>
</tr>
<tr>
<td>26</td>
<td>31</td>
<td>40</td>
<td>316</td>
<td>317</td>
<td>AP</td>
<td>Dead River Bridge EB (STR # 565)</td>
<td>Scour Retrofit</td>
<td>Yes</td>
<td>$280,000</td>
<td>$162,932,000</td>
</tr>
<tr>
<td>27</td>
<td>32</td>
<td>95</td>
<td>128.9</td>
<td>131.3</td>
<td>LA</td>
<td>Passing Lanes South of Bouse Wash</td>
<td>Construct Passing Lanes</td>
<td>Yes</td>
<td>$1,800,000</td>
<td>$164,732,000</td>
</tr>
<tr>
<td>28</td>
<td>115</td>
<td>95</td>
<td>24.2</td>
<td>24.8</td>
<td>YU</td>
<td>16th St @ MP 24.2 - 24.8</td>
<td>Roadway/Bridge Widening</td>
<td>No</td>
<td>$11,500,000</td>
<td>$176,232,000</td>
</tr>
</tbody>
</table>
## Greater Arizona

<table>
<thead>
<tr>
<th>County</th>
<th>TOTAL</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gila County</strong></td>
<td>TOTAL</td>
<td>$23,110,000</td>
</tr>
<tr>
<td><strong>Yavapai County</strong></td>
<td>TOTAL</td>
<td>$6,600,000</td>
</tr>
<tr>
<td><strong>Cochise County</strong></td>
<td>TOTAL</td>
<td>$16,551,000</td>
</tr>
<tr>
<td><strong>Pinal County</strong></td>
<td>TOTAL</td>
<td>$30,000,000</td>
</tr>
<tr>
<td><strong>Greenlee County</strong></td>
<td>TOTAL</td>
<td>$1,150,000</td>
</tr>
<tr>
<td><strong>La Paz County</strong></td>
<td>TOTAL</td>
<td>$12,800,000</td>
</tr>
<tr>
<td><strong>Coconino County</strong></td>
<td>TOTAL</td>
<td>$24,100,000</td>
</tr>
<tr>
<td><strong>Apache County</strong></td>
<td>TOTAL</td>
<td>$5,980,000</td>
</tr>
<tr>
<td><strong>Mohave County</strong></td>
<td>TOTAL</td>
<td>$15,000,000</td>
</tr>
<tr>
<td><strong>Graham County</strong></td>
<td>TOTAL</td>
<td>$191,000</td>
</tr>
<tr>
<td><strong>Navajo County</strong></td>
<td>TOTAL</td>
<td>$10,400,000</td>
</tr>
<tr>
<td><strong>Santa Cruz County</strong></td>
<td>TOTAL</td>
<td>$2,750,000</td>
</tr>
<tr>
<td><strong>Yuma County</strong></td>
<td>TOTAL</td>
<td>$11,500,000</td>
</tr>
<tr>
<td><strong>Statewide</strong></td>
<td>TOTAL</td>
<td>$16,100,000</td>
</tr>
</tbody>
</table>

**GRAND TOTAL** $176,232,000
intercity bus (BUS-40 and BUS-45); city transit bus (CITY-BUS); conventional school bus (S-BUS-36); large school bus (S-BUS-40); articulated bus (A-BUS); intermediate semi-trailer (WB-40 and WB-50); interstate semitrailer (WB-62, WB-65 and WB-67); double-trailer combination (WB-67D); motor home (MH); passenger car with camper trailer (P/T); passenger car with boat trailer (P/B); and motor home with boat trailer (MH/B). It is noted that the AASHTO triple-trailer combination (WB-100T) and turnpike-double combination (WB-109D) are restricted to specific routes in Arizona by legislative action. The configuration of the design vehicles and the minimum turning radii for a 180° turn are as shown in the AASHTO Green Book. Larger minimums may be possible for lesser degrees of turn.

407.2 - Design Vehicle Selection

The selection of a design vehicle should be made with care, with consideration given to the appropriate uses of the intersection and the consequences of not providing for the largest vehicles anticipated. The design vehicle is determined by the types of roadways involved, the area where the intersection is located, and the types and volume of vehicles using the intersection. Recommended desirable and minimum design vehicles are given for various types of intersections in Table 407.2. The turning radii given are to the inside edge of the turning lane. (Three-centered curves may also be used at intersections. See Section 408.13).

Major street intersections on highways carrying articulated bus routes should be checked for lane encroachment by the A-BUS design vehicle.

<table>
<thead>
<tr>
<th>Intersection Design Vehicles</th>
<th>Design Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate - Ramp/ Crossroad</td>
<td>WB-67</td>
</tr>
<tr>
<td>Other Controlled Access - Ramp/ Crossroad</td>
<td>WB-67</td>
</tr>
<tr>
<td>Junction of Major Truck Routes</td>
<td>WB-67</td>
</tr>
</tbody>
</table>

| Junction of State Routes | WB-62, WB-50, WB-40          |
| Other Rural             | WB-50, WB-40, SU             |
| Urban Major Streets     | WB-50, WB-40, SU             |
| Other Urban             | WB-40, SU, P                 |

* Recommended Design Vehicle to be selected based upon anticipated intersection usage. Alternate Design Vehicles may be selected for special use areas (e.g. A-BUS).
Technical Memorandum

To: Kathy Arnold
From: Seri Park
Company: Rosemont Copper
Date: June 15, 2009
Re: Wide Load Truck Turnouts for State Route 83
Doc #: 111/09-320842-5.3
CC: Jamie Sturgess (Rosemont)
     David Krizek and Jamie Joggerst (Tt)

1.0 Introduction

This Technical Memorandum was prepared by Tetra Tech and presents two (2) potential locations for wide load truck turnouts along State Route 83 (AZ-83). This memorandum also discusses the design criteria used for the turnouts as well as their advantages and disadvantages.

The two (2) proposed wide load truck turnouts are shown on Figure 1 and located at Milepost (MP) 55.4 near Sahuarita Road and MP 47.2 just north of the proposed Primary Access Road to the Rosemont Copper Project site. The proposed locations of the two (2) wide load truck turnouts were identified during a meeting with Rosemont Copper Company on April 28, 2009.

In the American Association of State Highway and Transportation Officials (AASHTO) Roadway and Street Design Guidelines, a turnout is defined as:

"a widened, unobstructed shoulder area that allows slow-moving vehicles to pull out of the through lane to give passing opportunities to following vehicles".

In other words, a turnout provides an area for emergency stops and also allows slower moving vehicles to pull out of the through lane so that vehicles can pass. AASHTO suggests using turnouts when a low Average Daily Traffic (ADT) roadway does not have a high amount of trailing vehicles behind slower moving vehicles and when the topography within the area creates steep grades where the construction of an additional lane or passing lane may not be cost effective. Often such conditions are found in mountainous, coastal, and scenic areas where more than 10% of the total traffic volume is large trucks and recreational vehicles. It should be noted that AZ-83 between Interstate I-10 and Greaterville Road generally fits this condition.
2.0 Design Vehicle

In order to propose a wide load truck turnout, the design vehicle must first be established. Based on Table 407.2 in the Arizona Department of Transportation (ADOT) Roadway Design Guidelines, a WB-62 type, Interstate Semi Trailer is recommended as the design vehicle for intersections along a State Route. In AASHTO’s Geometric Design of Highways and Streets, a WB-65 type is recommended as the minimum sized design vehicle for intersections on state highways that carry high volumes of traffic and/or provide local access for large trucks. Therefore, in this Technical Memorandum, a WB-65 type was chosen as the design vehicle since a safe truck turning with WB-65 type will also satisfy a safe truck turning for a WB-62 type.

3.0 Wide Load Truck Turnout Design Criteria

Geometric Design Elements

The basic design guidelines for defining the proposed wide load truck turnouts presented herein followed Exhibit 3-64 in the AASHTO Roadway and Street Design Guidelines (Attachment A) and AASHTO Chapter 3 Elements of Design. Under these guidelines, the minimum turnout width is 12 feet. However, Tetra Tech recommends a turnout width of 16 feet and no larger. Also stated in the above mentioned guidelines, turnout designs should consider the following three (3) elements: 1) turnout length, including entry and exit tapers, 2) turnout width, and 3) the location of the turnout with respect to horizontal and vertical curves. Turnouts should not be located on or adjacent to a horizontal or vertical curve that limits the sight distance in either direction. Turnouts should be located so that approaching drivers have a clear view of the entire turnout in order to determine whether the turnout is available for use.

For both of the proposed wide load truck turnouts, clearing and grubbing will need to conform to the guidelines specified in the Landscape and Irrigation Design Guidelines for Arizona Department of Transportation Encroachment Permit Applications as presented in Attachment B.

The following paragraphs provide detailed information regarding the proposed wide load truck turnout for each location.

Wide Load Truck Turnout near Sahuarita Road (MP 55.4)

The wide load truck turnout near Sahuarita Road is proposed to be just south of the intersection along the west side so that it can be utilized by southbound truck traffic. There is a guardrail along the east side of AZ-83 at the intersection with Sahuarita Road. There is an additional guardrail on the west side of AZ-83 which starts approximately 600 feet south of the Sahuarita Road intersection. The proposed wide load truck turnout is located between the Sahuarita Road intersection and the west side guardrail.

Based on the existing speed limit on AZ-83 of 55 miles per hour (MPH) and AASHTO Exhibit 3-64, the turnout will need to be 550 feet long. This distance includes 100-foot long entry and exit tapers. As indicated in the AASHTO Exhibit 3-64, the maximum length of a turnout, including entry and exit tapers, should not exceed 600 feet. This maximum length is recommended in
order to prevent vehicles from using the turnout as a passing lane. The proposed truck turnout should also be 16 feet wide, be paved with asphalt, and have edge markings such as directional arrows for entry and exit traffic. Figure 2 provides a detailed design illustration of the truck turnout. The proposed location of this wide load truck turnout does not have horizontal or vertical curves and therefore has sufficient sight distance for ingress and egress. In Attachment C, a before and after photo comparison is provided to illustrate the visual changes with regards to adding a wide load truck turnout near Sahuarita Road.

Wide Load Truck Turnout near Project Primary Access Road (MP 47.2)

The proposed wide truck turnout near the Primary Access Road also has a relatively flat roadway geometry with regards to the horizontal and vertical alignment. As stated in Mine Plan of Operation (MPO) (WestLand, 2007), the location of the Primary Access Road provides a clear sight distance of up to 2,500 feet in both directions. The existing speed limit on AZ-83 is also 55 MPH at this proposed turnout location. Therefore the truck turnout will also be 550 feet long which includes 100-foot long entry and exit tapers. Similar to the turnout near Sahuarita Road, the turnout near the Primary Access Road should be 16 feet wide, be paved, and have edge markings. Figure 2 provides a detailed design illustration of the truck turnout.

Sign Installation

AASHTO Roadway and Street Design Guidelines recommend proper signing and pavement markings in order to maximize turnout usages and to assure safe operation. No specific signing guidelines pertaining to truck turnout is provided in the Manual on Uniform traffic Control Devices (MUTCD) 2003 or ADOT Roadway Design Guidelines. Therefore, guidelines from the California (CA) MUTCD were utilized. Exhibit 3B-108 in the CA MUTCD (Attachment D) shows an example diagram for a truck turnout with proper signage. Tetra Tech recommends installing signs to alert drivers of the wide load truck turnout following the CA MUTCD guidelines. However, the final sign type and location should be coordinated with ADOT prior to installation.

Should signs be installed for the truck turnout, installation should follow ADOT's Roadway Design Guidelines, Section 303.2, which states:

“Roadside obstacles, non-traversable hazards and fixed objects, should be removed, made ‘breakaway’, relocated or shielded by a barrier if they are within the minimum recovery area width”.

In addition, roadside clearing of large trees will need to conform to the guidelines specified in Landscape and Irrigation Design Guidelines.

3.1 Wide Load Truck Turnout Advantage and Disadvantage

Advantages:

- Having an area for wide load trucks to turnout and let traffic pass will improve traffic flow and maximize the roadway capacity
- Adding a turnout provides a safe parking area for large vehicle to inspect loads and conduct other miscellaneous safety activities
- Improves roadway safety by reducing potential accidents associated with vehicles passing wide load trucks
- Improves traffic safety by providing better and enhanced sight distance for through vehicles

Disadvantages:
- Ingress and egress points should be well maintained
- Grading work will be required
REFERENCES


Arizona Department of Transportation (2007) *Roadway Design Guidelines*


U.S. Department of Transportation Federal Highway Administration (2004) *Standard Highway Signs*


Proposed 16' Truck Turnout

Existing 12' Lane

Existing 12' Lane

8' Truck

Hot Mix Asphalt

Aggregate Base

SECTION A-A

Legend:
- ROW - Right of Way

Location:
- Mile Post 55.4
- Intersection of State Route 83 and East Sahaurita Road

Wide Load Truck Turnout Designed Per:

<table>
<thead>
<tr>
<th>WB-65</th>
<th>feet</th>
<th>Lock to Lock Time</th>
<th>Steering Angle</th>
<th>Articulating Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor Width</td>
<td>8.00</td>
<td>6.00</td>
<td>28.40</td>
<td>70.00</td>
</tr>
<tr>
<td>Trailer Width</td>
<td>8.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tractor Track</td>
<td>8.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trailer Track</td>
<td>8.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Proposed 16' Truck Turnout  Existing 12' Lane  Existing 12' Lane

SECTION A-A

Hot Mix Asphalt
Aggregate Base

8' Truck

15.00
53.00

3.00
43.50

0.00

4.00
19.50

Legend:
ROW - Right of Way

Location:
Mile Post 47.2

Wide Load Truck Turnout Designed Per:

Legend:

STATE ROUTE 83

TO INTERSTATE 10

TO SAGUARO

100' Taper

350' Turnout

100' Taper

WB-65

Tractor Width: 8.00
Trailer Width: 8.50
Tractor Track: 8.00
Trailer Track: 8.50

Lock to Lock Time: 6.00
Steering Angle: 28.40
Articulating Angle: 70.00

Hot Mix Asphalt
Aggregate

8' Truck

41.50
39.00
25.00
41.50
39.00
25.00
ATTACHMENT A

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

EXHIBIT 3-64
The recommended lengths for turnouts include entry and exit tapers. Typical entry and exit taper lengths range from 15 to 30 m [50 to 100 ft] (42, 43).

<table>
<thead>
<tr>
<th>Metric</th>
<th>Minimum Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach speed (km/h)</td>
<td>30</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>US Customary</th>
<th>Minimum Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach speed (mph)</td>
<td>20</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

* Maximum length should be 185 m (600 ft) to avoid use of the turnout as a passing lane.

**Exhibit 3-64. Recommended Lengths of Turnouts Including Taper**

The minimum width of the turnout is 3.6 m [12 ft] with widths of 5 m [16 ft] considered desirable. Turnouts wider than 5 m [16 ft] are not recommended.

A turnout should not be located on or adjacent to a horizontal or vertical curve that limits sight distance in either direction. The available sight distance should be at least 300 m [1,000 ft] on the approach to the turnout.

Proper signing and pavement marking are also needed both to maximize turnout usage and assure safe operation. An edge line marking on the right side of the turnout is desirable to guide drivers, especially in wider turnouts.

**Shoulder Driving**

In parts of the United States, a long-standing custom has been established for slow-moving vehicles to move to the shoulder when another vehicle approaches from the rear and return to the traveled way after that following vehicle has passed. The practice generally occurs where adequate paved shoulders exist and, in effect, these shoulders function as continuous turnouts. This custom is regarded as a courtesy to other drivers requiring little or no sacrifice in speed by either driver. While highway agencies may want to permit such use as a means of improving passing opportunities without a major capital investment, they should recognize that in many states shoulder driving is currently prohibited by law. Thus, a highway agency considering shoulder driving as a passing aid may need to propose legislation to authorize such use as well as develop a public education campaign to familiarize drivers with the new law.

Highway agencies should evaluate the mileage of two-lane highways with paved shoulders as well as their structural quality before deciding whether to allow their use as a passing aid. It should be recognized that, where shoulder driving becomes common, it will not be limited to selected sites but rather will occur anywhere on the system where paved shoulders are provided.
INTRODUCTION

The Arizona Department of Transportation, Highways Division, encourages the landscaping of its rights of way through the cooperative efforts with local governments and adjacent property owners. Because the right of way is a public area, of prime importance with relation to landscaping is the protection of the public and its safe access to the facilities as well as the improvement of aesthetic considerations.

Landscaping, being composed of living plant material, is in a constant state of change and must consider the ultimate growth of plants. Additionally, other considerations are the use of low water requirement plant materials and any other local jurisdictional requirements, such as sidewalks, signing setbacks and other requirements in relation to each specific roadway. After all of these factors have been considered the completion of the landscaping can greatly enhance the beauty of the roadway and the community.
LANDSCAPING

I. GENERAL

An approved Encroachment Permit is required before any landscape improvements may be incorporated within the ADOT Highway right-of-way. This applies to work performed under nationwide programs such as Global Releaf as well as individual efforts. Landscaping by local governments may be constructed and maintained within the control of access on the crossroads of major highways under a fully executed Intergovernmental Landscape Maintenance Agreement prepared by the State and an approved Encroachment Permit.

The highway roadside is an integral unit of a total highway facility. The term "roadside" generally refers to the area between the outer edge of the roadway and the right-of-way boundary. These include all unpaved areas within the right-of-way.

Permit applicants are encouraged to employ competent design professionals such as Registered Landscape Architects, Architects or Engineers, and to direct their work toward securing a product that fully represents the owner's needs and desires and meets the Arizona Department of Transportation (ADOT) standards, before submitting such plans for review and approval. Permit applicants and design professionals are encouraged
to discuss landscape needs and proposals with District Permits Supervisors and Roadside Development Services Landscape Architects before commencing work on final construction plans.

All plans and specifications shall be sufficiently complete and detailed for easy analysis and compliance inspection. Plans shall be designed to select plant materials appropriate for the intended use and location, to arrange plants for optimum effect of color, texture, form and to ensure reasonable maintenance within the capability of the proposed permittee. Permit applications will be reviewed for consideration of the following factors which can affect the safe and efficient operation of the highway facility.

II. DRAWINGS

A. PLANS:

Drawings must be legible, accurate and drawn to scale. They shall include a north arrow, name of development, designer and design firm with appropriate phone numbers and location of project.

B. PLANT MATERIALS:

Plants proposed for use must be clearly located, showing mature sizes, and identified as to botanical name (genus species, variety), planting size, quantity and spacing used.
Areas within an Arizona Department of Water Resources Active Management Areas must adhere to the plant list provided for that area. (See attached Plant Lists.)

C. EXISTING FEATURES:

Existing features such as curbs, sidewalks, pipe culverts, drainage structures, retention basins, driveways, highway and non-highway signs, overhead lines, underground utilities, irrigation lines, manholes, service cabinets, etc, shall be shown. In addition, the posted speed limit for the highway shall be indicated. Existing trees and shrubs shall be incorporated into the design wherever feasible. Clearing of trees and shrubs will not be permitted unless approved through the permit process. When planters are cut out of existing sidewalk areas, sufficient space must remain for compliance with ARS statutes relating to accessibility by the physically handicapped. The use of steel tree grates is recommended to maximize usable sidewalk space and to maintain a safe walking surface.

D. SLOPES:

Existing or proposed slopes shall be identified with respect to elevation differences between top and bottom and rate of slope between.
III. DESIGN

A. EROSION CONTROL:

Erosion control measures must be employed to prevent surface drainage from eroding soil surfaces and carrying the resultant silt into natural or man made drainage systems, highways or private properties.

B. SAFETY SETBACKS FOR FIXED OBJECTS:

Minimum setbacks from the travel way for newly planted trees with an ultimate trunk diameter of more than 4 inches or other hazardous fixed objects should be as follows:

1. 50 MPH or Greater Design Speed:

   a. Minimum setback from the edge of the traffic lane should be 35 feet unless one of the following reasons will allow for a lesser distance.

      1) Cuts of 3 to 1 or steeper - obstacles are allowed 10 feet behind the point of vertical intersection (P.V.I.) at the toe of the slope. (See illustration 'A'.)

      2) Where concrete barriers, walls, abutments, or other rigid obstructions are used - fixed objects may be placed 4' behind the obstructions. (See illustration 'B')
3) Where flexible guardrail (box-beam, w-beam, or cable) is used - 6 to 20 feet behind the face of the guardrail, depending upon the type. (See illustration 'C'.)

4) Where there are barrier curbs (5" or more vertical face) near a traveled lane 6 feet behind the face of the curb (see illustration 'D'); adjacent to a parking lane - no definite setback distance.

b. Where limited right-of-way or the necessity for planting would result in less clearance, all factors in the particular problem area should be weighed to decide if a special exception is warranted.

2. 50 MPH or less design speed:

a. Minimum setback of a fixed object from the edge of the traffic lane may be 30 feet unless one of the reasons set forth under (1) will allow for a lesser distance.

b. On curves, adequate sight distance for the design speed of the highway must be maintained.

C. REQUIREMENTS FOR SIGHT DISTANCE:

A clear line of sight must be maintained at all highway intersections and entrances. Generally, shrubs, plantings or other obstructions in
this zone must be limited to an ultimate height of 18" or less to allow a clear line of sight down the highway in either direction for at least 400' from the front of the vehicle located 10' behind the edge of the highway to be entered. (See illustration 'E'.)

D. CULTURAL REQUIREMENTS FOR PLANTS:

Use plants that require minimal maintenance and are hardy to the area. Avoid plants that are messy, brittle, short lived or subject to infestations of insects or disease. Plants used in areas where sight distance must be maintained shall have a mature height of 18" or less.

E. VISIBILITY OF HIGHWAY FEATURES:

The visibility of highway signs, delineators, edges of sidewalks, curbs, roadway or guardrail must be maintained at all times. Therefore, provide sufficient plant setbacks and plants with mature sizes that will not outgrow spaces to avoid costly trimming as plants mature.

IV. DETAILS

A. Plans shall include, as appropriate, planting details for trees, shrubs, ground cover, vines, and cacti showing size of planting pit in relation to size of plant ball. (See planting details.)
B. Plans should include staking or guying details as required by the size and species of plant proposed. (See planting/staking details.)

C. Plans should identify problem soils and propose appropriate measures to overcome them.

D. If a mineral surface treatment is proposed, details should be included to indicate the depth, gradation, color and the vertical relationship to the roadway curb or sidewalk. A pre-emergent herbicide should be specified to preclude weeds in these areas. (See Granite and Rock Mulch details.)

E. Details for headers, signs, walls, sidewalks, planters, etc., should be included whenever proposed.

V. MAINTENANCE

A. Problems in maintenance shall be anticipated during the design phase. Changes in environmental conditions should be anticipated.

B. It shall be the responsibility of the permittee to assure that all landscaping and irrigation can be maintained to the satisfaction of ADOT.
ILLUSTRATION 'B'
ILLUSTRATION 'C'
TREE or OTHER FIXED OBJECT

ROADWAY

6' Min.

5"+ HIGH CURB

ILLUSTRATION 'D'
Plants no taller than 18"

Sight Line 400'

Sight Line 400'

ILLUSTRATION 'E'
ATTACHMENT C
PHOTOS FOR WIDE LOAD TRUCK TURNOUT
(AZ-83/SAHUARITA ROAD NEAR MILEPOST 55.4)
Existing conditions at AZ-83 and Sahuarita Road Intersection (looking south)
AZ-83 and Sahuarita Road Intersection with the Wide Load Truck Turnout (looking south)
Figure 3B-108 (CA). Examples of Signing and Marking Turnouts

LEGEND

- Sign Location
- Direction of Travel

NOT TO SCALE

(This space left intentionally blank)
302.4 – Shoulder Width

The shoulder width given in Table 302.4 shall be the minimum continuous usable width of paved shoulder.

<table>
<thead>
<tr>
<th>Highway Type</th>
<th>Paved Shoulder Width (ft) (In Direction of Travel)</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controlled-access Highways</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 lanes</td>
<td></td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>6 or more lanes</td>
<td></td>
<td>10(^1, 2)</td>
<td>10^2</td>
</tr>
<tr>
<td>Auxiliary lanes</td>
<td>--</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>1-lane freeway to freeway directional ramp</td>
<td></td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>2-lane freeway to freeway directional ramp</td>
<td></td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>1-lane and 2-lane ramps</td>
<td></td>
<td>2</td>
<td>8(^4)</td>
</tr>
<tr>
<td>Ramp Termini at Crossroad</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Non-Controlled-access Highways</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural multi-lane divided</td>
<td></td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Rural 2-lane:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHV &gt; 200 vph</td>
<td>--</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>DHV &lt; 200 vph</td>
<td>--</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Fringe-urban multi-lane divided:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w/ curbed median</td>
<td></td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>w/o curbed median</td>
<td></td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Fringe-urban multi-lane undivided</td>
<td></td>
<td>--</td>
<td>8</td>
</tr>
<tr>
<td>Urban multi-lane divided</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Urban multi-lane undivided:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 or more lanes</td>
<td>--</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>4 lanes</td>
<td>--</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Right turn lanes (without curb and gutter)</td>
<td>--</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Acceleration lanes</td>
<td>--</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td><strong>Frontage Roads (2-lane)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-way</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Two-way</td>
<td>--</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td><strong>Passing Lanes/Climbing Lanes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) May be reduced to 8 ft in urban areas for interim conditions.

\(^2\) 12 ft desirable with truck traffic DDHV > 250

\(^3\) For shoulders with curb and gutter, widths include gutter pan.

\(^4\) Use 2 ft for two-lane dual metered ramps.