# Appendix D:
# Traffic and Safety Memoranda and Analyses

# US 550 South Connection to US 160
# SUPPLEMENT to the US Highway 160 from Durango to Bayfield EIS
# APPENDIX D: TRAFFIC AND SAFETY MEMORANDA AND ANALYSES

## INDEX

# SEH MEMORANDUM

# US 160 FEIS Grandview Section—Year 2025 Traffic Analysis

# September 17, 2010

SEH

MEMORANDUM

TO: Mike McVaugh, PE - CDOT Region 5

FROM: Philip T. Weisbach, PE
Jon E. Larson, PE

Philip T. Weisbach
Jon E. Larson

DATE: September 17, 2010

RE: US 160 FEIS Grandview Section – Year 2025 Traffic Analysis
SEH No. CODOT - 105181

## Executive Summary


Alternatives for the US 550 connection to the US 160 corridor were originally evaluated in the US Highway 160 from Durango to Bayfield Final Environmental Impact Statement (US 160 FEIS) dated May 2006. The US 160 Highway from Durango to Bayfield Record of Decision (US 160 ROD) documented selection of Grandview Alternative G Modified which included an interchange at US 160/US 550 approximately 0.6 miles east of the current intersection.

The technical traffic analysis data for this memo is included in the attached appendices at the end of this document.

The following traffic analysis was performed:

A. Evaluate the interchanges along US 160 as shown in the Alternative G Modified to confirm that the original work performed in the FEIS is valid;

B. Evaluate the option of an at-grade intersection at US 550 and US 160 Alternative G Modified connection in-lieu of an interchange.

The purpose and need for improvements to the US 160 corridor include increasing travel efficiency and capacity to meet current and future needs, while improving safety for the traveling public by reducing the number and severity of accidents, and controlling access.


## Evaluation Criteria

The interchange was evaluated to determine if it met operational level of service requirements as described in the Executive Summary of the FEIS, based on guidance in the AASHTO Policy on Geometric Design of Highways and Streets 2004 (AASHTO Green Book) and capacity analysis performed according to the methods described in the Highway Capacity Manual[1] (HCS). This memorandum deals with the capacity analysis and not design. Traffic volumes used in the analysis are year 2025 volumes documented in Appendix A, Traffic Report, Figure 8 of the US 160 FEIS.

The following criteria were used to determine the capacity need in the US 160 FEIS:

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1 Highway Capacity Manual - Special Report 209. Transportation Research Board. National Research Council. 2000.

- A Level of Service (LOS) D or better for an urban signalized intersection, including signalized intersections at single point urban interchanges (SPUI), and its individual legs during the peak hour in year 2025; and
- A LOS D or better for urban interchange merge, diverge, weaving, auxiliary lanes and freeway sections in the Grandview Section during the peak hour in year 2025.

Anything worse than LOS D for any urban intersection, leg or section is considered "failing", and not meeting the purpose and need. These same criteria were applied to the evaluation of the US 160 FEIS in this memorandum.

For the purposes of this analysis, US 160 is assumed to be east/west and US 550 is assumed to be north/south.

## Alternative (G Modified) Analysis – Figure 1, Tables 1 & 2

This evaluation was performed to validate the analysis in the FEIS. The Alternative G Modified from US 160 FEIS was evaluated using year 2025 traffic volumes from Figure 8 of the FEIS. The G Modified alternative includes four through lanes throughout the Grandview Section with an eastbound and westbound auxiliary lanes extending from the US 160 / US 550 / Grandview interchange to the west end of the Grandview Section. Single point urban interchanges are assumed at CR 233 (Three Springs) and SH 172 / CR 234. A SPUI is similar to a diamond interchange. However, where there are two intersections that control the ramps of a diamond interchange, there is only one intersection that controls the ramps of a SPUI. The SPUI interchange allows US 160 to pass over an intersection maintaining a free-flow condition for traffic on US 160 while the approach roads have a single signalized intersection underneath the overpass to meter traffic on and off of US 160. The freeway segment and ramp merge/diverge analysis includes the same assumptions as the US 160 FEIS. The analysis worksheets are contained in Appendix A for reference.

**Alternative G Modified**

The results of the analysis (Figure 1) based on the Alternative G Modified interchange configuration show that the freeway segments and ramp merge/diverge operations are expected to operate at LOS D or better during the morning and evening peak periods. The results match the results from the US 160 FEIS.

**Conclusion**

Based on the analysis, the results support the finding that Alternative G Modified satisfies the purpose and need. The interchange geometry described in the FEIS is adequate to accommodate the projected volumes at LOS D or better.

## Alternative (G Modified) Analysis (At-Grade, Signalized Intersection) – Figure 2

The Alternative G Modified interchange location was evaluated as a signalized intersection using year 2025 traffic volumes from Figure 8 of the FEIS. The purpose of this analysis is to determine if an intersection at this location would meet the capacity LOS D requirements for the purpose and need in the FEIS.

The assumed lane configuration on US 160 at the intersection includes two left turn lanes, two through lanes, and one right turn lane in both directions. On the US 550 northbound approach, the lane configuration includes two left turn lanes, one through lane and one right turn lane. The US 550 southbound approach includes one lane each for the left turn, through and right turn movements.

The results of the analysis (Figure 2) show that the signalized intersection is expected to operate at LOS F in the morning and evening peak periods in the year 2025. Numerous individual movements are shown to exhibit LOS F during the morning and evening peak periods as well. This analysis supports the findings in the FEIS that an at-grade intersection as described will not meet the capacity requirements of the Purpose and need. The analysis worksheets are contained in Appendix B for reference.

In an attempt to improve the LOS to acceptable levels, additional lanes were added to particularly heavy movements and signal timing was optimized. Even with providing three lanes in each direction through the intersection on US 160 and analyzing triple left turn lanes, the LOS D evaluation criteria for signalized intersections and individual movements could not be achieved. Appendix B contains the LOS table to support these findings.

**Conclusion**

Based on the analysis, the results support the findings from the US 160 FEIS that an interchange is necessary for the Alternative G Modified to satisfy the capacity requirements of the purpose and need.

jel
Attachments
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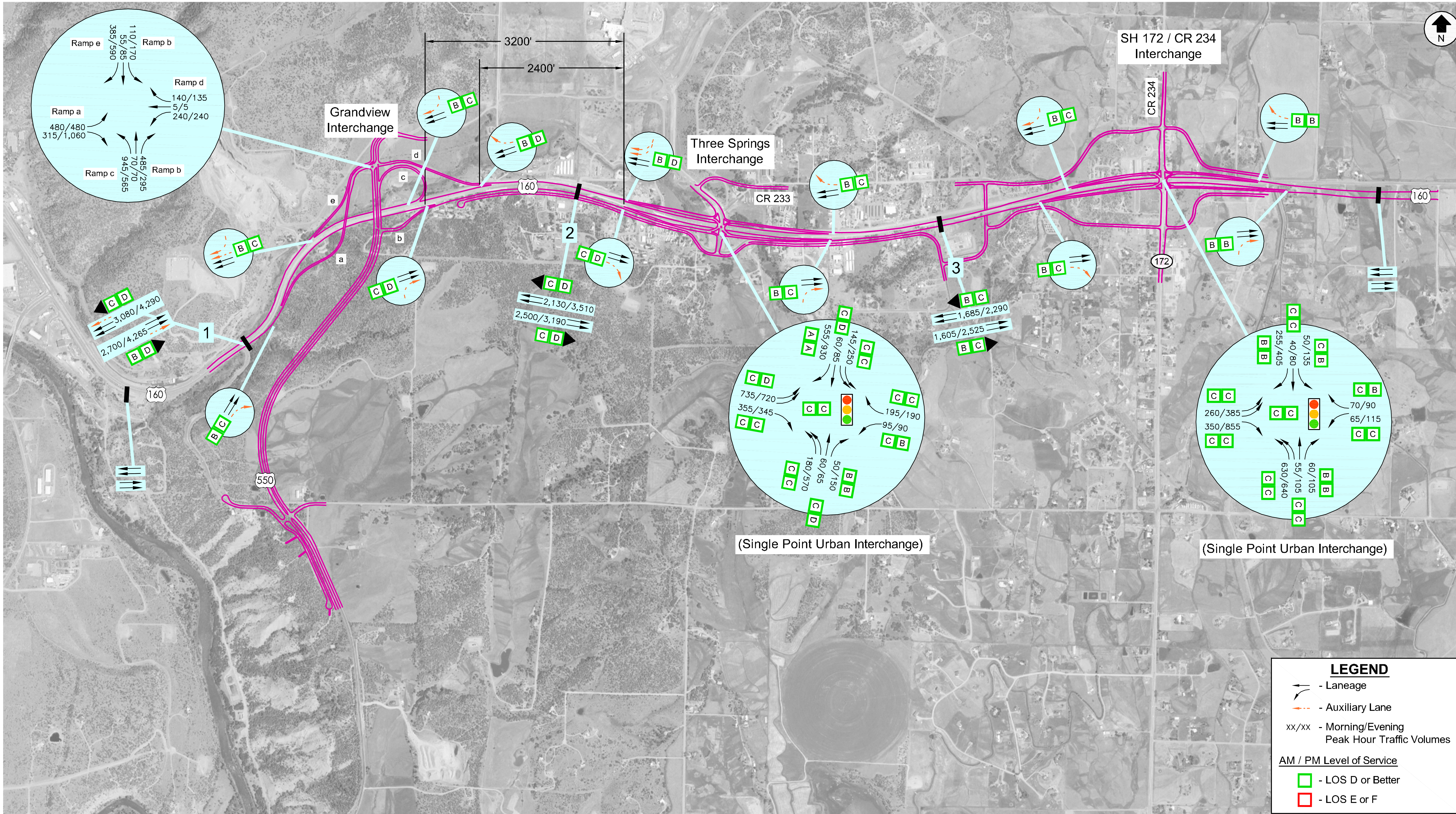



# Year 2025 Traffic Volumes

SEH

US 160 FEIS Grandview Section - Year 2025 Analysis
US 160 Preferred Alternative (Modified G) Analysis

| Scale | 1"=1500' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 | Figure | 1 |
|---|---|---|---|---|---|---|---|---|---|

# Preferred Alternative (G Modified) Analysis

## Comparison between US 160 FEIS and SEH[1]

### Table 1a Highway Segment

| US 160 Highway Segment | Eastbound | | | | Westbound | | | |
|---|---|---|---|---|---|---|---|---|
| | US 160 FEIS | | SEH | | US 160 FEIS | | SEH | |
| | AM Peak LOS | PM Peak LOS | AM Peak LOS | PM Peak LOS | AM Peak LOS | PM Peak LOS | AM Peak LOS | PM Peak LOS |
| West of US 550 (south) | B | D | B | D | C | D | C | D |
| US 550 (south) to CR 233 (west) | C | D | C | D | C | D | C | D |
| CR 233 (west) to SH 172/CR 234 | B | C | B | C | B | C | B | C |

### Table 1b Ramp Merge/Diverge and Weaving Area

| US 160 Highway Segment | Merge/Diverge Area | | | | Weaving Area | | | |
|---|---|---|---|---|---|---|---|---|
| | US 160 FEIS | | SEH | | US 160 FEIS | | SEH | |
| | AM Peak LOS | PM Peak LOS | AM Peak LOS | PM Peak LOS | AM Peak LOS | PM Peak LOS | AM Peak LOS | PM Peak LOS |
| **Eastbound** | | | | | | | | |
| Off-Ramp to US 550 (south) | B | C | B | C | | | | |
| On-Ramp from US 550 (south) | C | D | C | D | | | | |
| Off-Ramp to CR 233 (west) | C | D | C | D | | | | |
| On-Ramp from CR 233 (west) | B | C | B | C | | | | |
| Off-Ramp to SH 172/CR 234 | B | C | B | C | | | | |
| On-Ramp from SH 172/CR 234 | B | B | B | B | | | | |
| **Westbound** | | | | | | | | |
| Off-Ramp to SH 172/CR 234 | B | B | B | B | | | | |
| On-Ramp from SH 172/CR 234 | B | C | B | C | | | | |
| Off-Ramp to CR 233 (west) | B | C | B | C | | | | |
| On-Ramp from CR 233 (west) | N/A | N/A | N/A | N/A | | | | |
| Between CR 233 (west) On-Ramp and US 550 (south) Off Ramp | | | | | B | D | B | D |
| On-Ramp from northbound US 550 (south) (Loop) | B | C | B | C | | | | |
| On-Ramp from southbound US 550 (south) | B | C | B | C | | | | |

Note:

1) SEH used the same assumptions as the US 160 Final EIS for its analysis of the Preferred Modified G Alternative.

# Preferred Alternative (G Modified) Analysis

## Comparison between US 160 FEIS and SEH[1]

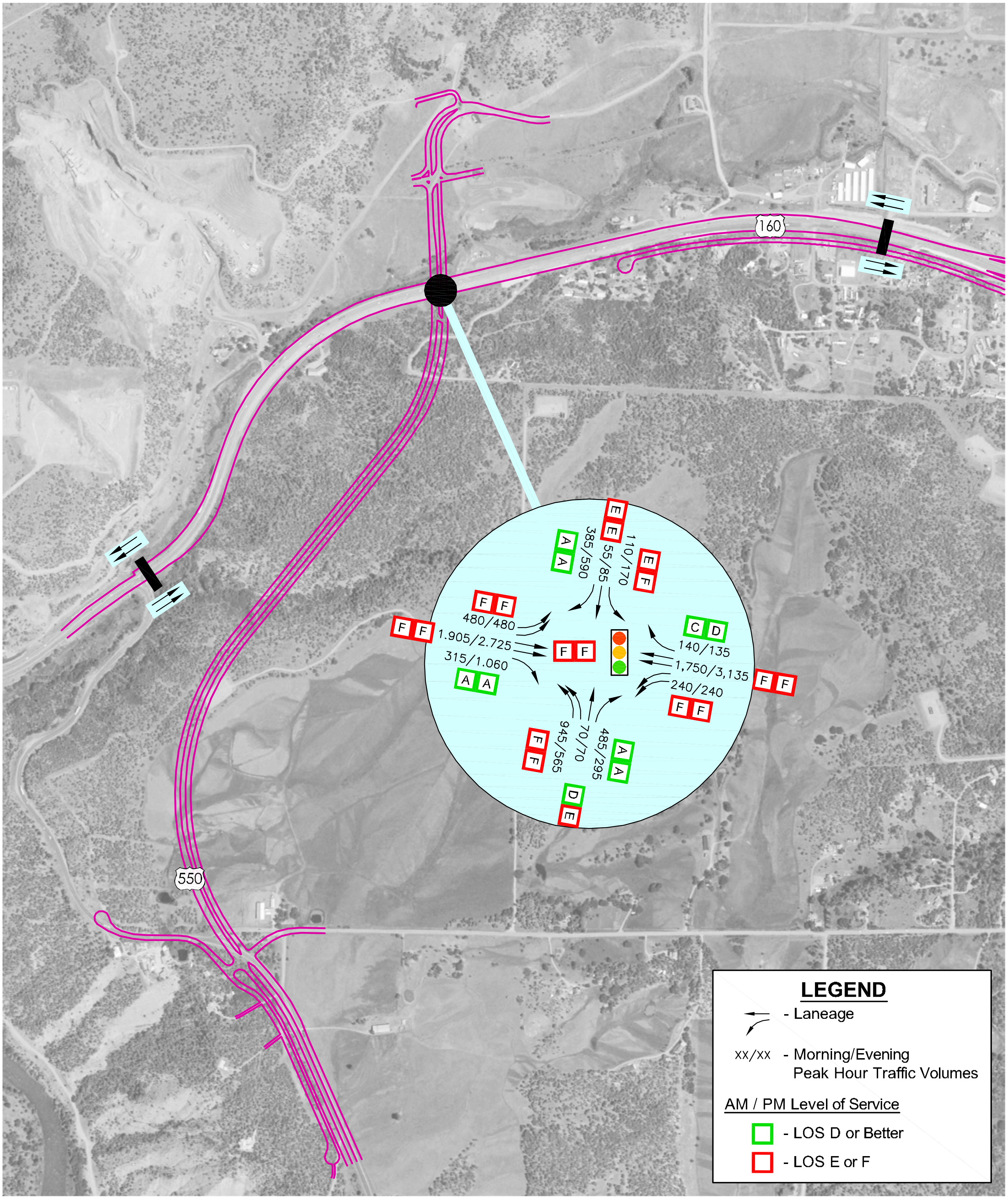
**Table 2. US 160 Analysis - Intersection Operations at Single-Point Interchange**

| Intersection and Approaches | Year 2025 Traffic Volumes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | AM Peak Hour | | | | PM Peak Hour | | | |
| | US 160 FEIS | | SEH | | US 160 FEIS | | SEH | |
| | Delay[2] | LOS | Delay[2] | LOS | Delay[2] | LOS | Delay[2] | LOS |
| **SIGNAL CONTROL** | | | | | | | | |
| **SH 172/CR 234 & US 160** | **24.7** | **C** | **27.9** | **C** | **28.8** | **C** | **25.0** | **C** |
| Eastbound Left | *23.3* | *C* | *32.6* | *C* | *42.6* | *D* | *29.7* | *C* |
| Eastbound Right | *33.4* | *C* | *27.2* | *C* | *34.2* | *C* | *32.4* | *C* |
| Westbound Left | *22.3* | *C* | *34.1* | *C* | *35.6* | *D* | *29.6* | *C* |
| Westbound Right | *23.3* | *C* | *24.4* | *C* | *9.0* | *A* | *18.6* | *B* |
| Northbound Left | *28.7* | *C* | *32.5* | *C* | *10.6* | *B* | *23.0* | *C* |
| Northbound Through | *28.3* | *C* | *24.2* | *C* | *40.6* | *D* | *28.6* | *C* |
| Northbound Right | *8.0* | *A* | *14.6* | *B* | *22.4* | *C* | *10.7* | *B* |
| Southbound Left | *22.8* | *C* | *24.9* | *C* | *9.3* | *A* | *19.9* | *B* |
| Southbound Through | *28.0* | *C* | *23.9* | *C* | *38.5* | *D* | *27.8* | *C* |
| Southbound Right | *9.3* | *A* | *17.3* | *B* | *39.8* | *D* | *13.5* | *B* |
| **Three Springs Blvd/CR 233 & US 160** | **18.7** | **B** | **22.4** | **C** | **17.5** | **B** | **24.7** | **C** |
| Eastbound Left | *22.3* | *C* | *30.2* | *C* | *34.8* | *C* | *53.7* | *D* |
| Eastbound Right | *30.5* | *C* | *30.8* | *C* | *18.7* | *B* | *20.6* | *C* |
| Westbound Left | *17.9* | *B* | *21.3* | *C* | *25.0* | *C* | *14.7* | *B* |
| Westbound Right | *23.4* | *C* | *23.4* | *C* | *16.1* | *B* | *34.7* | *C* |
| Northbound Left | *21.2* | *C* | *30.9* | *C* | *17.0* | *B* | *23.0* | *C* |
| Northbound Through | *37.6* | *D* | *31.0* | *C* | *38.8* | *D* | *42.3* | *D* |
| Northbound Right | *9.2* | *A* | *11.1* | *B* | *15.6* | *B* | *19.7* | *B* |
| Southbound Left | *21.0* | *C* | *30.5* | *C* | *15.1* | *B* | *20.4* | *C* |
| Southbound Through | *37.6* | *D* | *31.0* | *C* | *38.8* | *D* | *42.3* | *D* |
| Southbound Right | *0.1* | *A* | *0.8* | *A* | *0.7* | *A* | *2.4* | *A* |

Notes:

1) SEH used the same assumptions as the US 160 Final EIS for its analysis of the Preferred Modified G Alternative.

2) Delay measured as seconds per vehicle




US 160 FEIS Grandview Section - Year 2025 Analysis

Preferred Alternative (G Modified) Analysis (At-Grade, Signalized Intersection)

| Scale | 1"=1000' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 | Figure | 2 |
|---|---|---|---|---|---|---|---|---|---|

# APPENDIX A and APPENDIX B on CD

## US 160 FEIS Grandview Section—Year 2025 Traffic Analysis

**September 17, 2010**

# SEH MEMORANDUM

# Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS

# September 17, 2010

# MEMORANDUM

TO: Mike McVaugh, PE - CDOT Region 5

FROM: Phil Weisbach, PE
Jon E. Larson, PE

Philip J. Weisbach
Jon E. Larson

DATE: September 17, 2010

RE: Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS
SEH No. CODOT – 105181

## Executive Summary

Alternatives for the US 550 connection to the US 160 corridor were originally evaluated in the US Highway 160 from Durango to Bayfield Final Environmental Impact Statement (FEIS) dated May 2006. The US 160 Highway from Durango to Bayfield Record of Decision (US 160 ROD) documented selection of Grandview Alternative G Modified as the Preferred Alternative which included an interchange of US 160 with US 550 approximately 0.6 miles east of the current intersection.

This analysis updates the traffic operations analysis from the FEIS to the year 2030 for several alternatives listed below and for at-grade intersections. An additional memo will analyze options for the US 160 Section 4(f) which includes some of the alternatives from the US 160 FEIS. This analysis looks at projected traffic in the year 2030 to evaluate if the roadway will meet the capacity requirements for the purpose and need 20 years into the future. The technical documentation of this analysis is included in the appendices of this memo.

This analysis addresses several questions:

A. Does the US 160 Alternative G Modified continue to meet the capacity requirements of the purpose and need in the design year 2030?
B. Do the future connections at Alternative G Modified, Three Springs/CR 233, and SH 172/CR 234 in the design year 2030 need to be interchanges?
C. In the year 2030, does Alternative F Modified from the US 160 FEIS meet the capacity requirements of the purpose and need?

The purpose for improvements to the US 160 corridor include increasing travel efficiency and capacity to meet current and future needs, while improving safety for the traveling public by reducing the number and severity of accidents, and controlling access. The design year of the US 160 FEIS was 2025. The analysis performed in this memorandum will be the same as the FEIS except the design year is changed to 2030.

**Summary of Results:** The results of the analysis performed are summarized below:

| YEAR 2030 Analysis | Purpose and Need for Capacity | |
|---|---|---|
| | Met | Not Met |
| Alternative (G Modified) | ✓ | |
| Alternative (F Modified) | | ✓ |
| **At-Grade Signalized Intersections** | | |
| US 160 @ 172/CR 234 | | ✓ |
| US 160 @ CR 233 (Three Springs) | | ✓ |
| US 160 @ Grandview | | ✓ |

# Analysis Performed

## Evaluation Criteria

The interchange alternatives were evaluated to determine if each alternative met operational level of service requirements as described in the Executive Summary of the FEIS, based on guidance in the AASHTO Policy on Geometric Design of Highways and Streets 2004 (AASHTO Green Book) and capacity analysis performed according to the methods described in the Highway Capacity Manual[1] (HCS). This memorandum deals with the capacity analysis and not design. Traffic volumes used in the analysis are year 2030 peak hour volumes that were projected from the year 2025 volumes documented in Appendix A, Traffic Report, Figure 8 of the US 160 FEIS. The 2025 background traffic volumes were projected based on the background annual growth rates in the accepted methodology in the FEIS to calculate the year 2030 background scenario. For this scenario it is assumed the approved development of the 2004 Grandview Area Plan by the City of Durango and La Plata County is fully built out in the year 2030. The trips generated by the Grandview development were combined with the year 2030 background volumes to generate the year 2030 total peak hour volumes used in the analysis.

The capacity requirement for the purpose and need of the Grandview Section is as follows:

- A Level of Service (LOS) D or better for an urban signalized intersection, including signalized intersections at single point urban interchanges (SPUI), and its individual legs or movements during the peak hour in year 2030; and
- A LOS D or better for urban interchange merge, diverge, weaving area, auxiliary lanes, and/or freeway sections during the peak hour in year 2030.

Anything worse than LOS D for any intersection, leg, movement, ramp or freeway section is considered "failing," and not meeting the purpose and need. These criteria were applied to the alternatives analyzed in this memorandum.

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1 Highway Capacity Manual - Special Report 209. Transportation Research Board. National Research Council. 2000.

For the purposes of this analysis, US 160 is assumed to be east/west and US 550 is assumed to be north/south. Each analysis verifies the capacity requirements of each interchange that is a part of the Grandview Section as described in the FEIS.

**US 160 Continuous Through Lanes**

**US 160 FEIS**

Using year 2025 projected traffic volumes, the Alternative G Modified in the US 160 FEIS included a four-lane typical section, two continuous lanes in each direction, throughout the corridor with a westbound auxiliary lane and eastbound climbing lane from the Grandview Section limit at MP 88 to the future connection of US 160 and US 550. Auxiliary lanes were added to maintain an operational level of service of D by improving the merge, diverge and weave movements, thus helping to make safer lane transitions to and from the future location US 160/US 550 interchange.

**Year 2030 Traffic Operations Analysis**

In the analysis, the projected traffic volumes were extended to the year 2030. The background traffic on US 160 was increased from the year 2025 to 2030, and the trip generation from a fully developed Grandview Area Plan increased traffic on the US 160 mainline as well as the entering and exiting traffic volumes to US 160. Due to the increased entering/exiting volumes, auxiliary lanes will need to be extended, from those assumed in the US 160 FEIS. The auxiliary lanes in the year 2030 need to be extended to the future CR 233 (Three Springs) interchange to maintain a LOS D for the traffic operations of the merge, diverge and weaving movements along US 160.

Since the number of continuous through lanes remains constant throughout the US 160 corridor and auxiliary lanes are not carried through any of the interchanges, auxiliary lanes are not considered capacity-adding improvement measures. However, they can be utilized to improve the traffic operations between two successive interchanges and to assist in accommodating high entering/exiting traffic volumes. Without auxiliary lanes at high volume locations, bottleneck areas can result due to poor levels of service for the merging, diverging, and weaving movements. Areas of congestion such as bottleneck locations typically coincide with areas that exhibit poor accident ratings.

**Special Case: Alternative F Modified**

Though Alternative F modified does not include a Grandview interchange, the auxiliary lane assumptions for this alternative do not change. From the west project limit to the Alternative F Modified Interchange (Three Springs interchange) there would be two through lanes in each direction with an eastbound climbing lane and a westbound auxiliary lane. This is true for the US 160 FEIS as well in the year 2030 analysis.

**US 160 Interchanges and Signalized Intersections**

- **Highway Segments, Ramp Merge/Diverge, Weaving Sections.** The capacity of each of these features was evaluated based on HCS criteria with a minimum LOS D or better as the operational goal. The Year 2025 projected traffic volumes from the FEIS were adjusted to reflect projected Year 2030 volumes, and were used to evaluate LOS for each alternative.
- **Signalized Intersections.** The capacities of signalized intersections were evaluated using HCS criteria with a minimum LOS D or better for the intersection and the individual legs of the intersection. An individual leg having an LOS of E or F is also a failing criteria for the intersection.

## Alternative G Modified (FEIS) Analysis (Year 2030) – Figure 1

This evaluation was performed to determine whether the Alternative G Modified (FEIS) meets the capacity requirements of the purpose and need for the design year 2030. The analysis assumes two through lanes in each direction through the Grandview Section with a westbound auxiliary lane and eastbound climbing lane from the Grandview Section limit at MP 88 to the future connection of US 160 and US 550, similar to the US 160 FEIS, but with additional eastbound and westbound auxiliary lanes between the US 160/US 550 interchange and CR 233 (Three Springs) interchange. A trumpet interchange is assumed at the US 550 Grandview Interchange and Single Point Urban Interchange (SPUI) is assumed at both the CR 233 (Three Springs) and SH 172 / CR 234 interchanges.

The results of the analysis (Figure 1) show that the freeway segments and ramp merge/diverge operations for all of the interchanges are expected to operate at LOS D or better during the morning and evening peak periods. The analysis worksheets are contained in Appendix A for reference.

**Conclusion**

Based on the analysis, the results show that this alternative satisfies the capacity requirements of the purpose and need in the year 2030. This alternative accommodates the projected year 2030 volumes at LOS D or better.

## At-Grade, Signalized Intersection Analysis – Figure 2

For this scenario, it is assumed that US 550 connects to US 160 at the existing connection or west of that location. The traffic volumes on US 550 were routed as through volumes on US 160 based on historic directional splits at the existing US 550 / US 160 intersection.

The connections evaluated in the US 160 FEIS Alternative G Modified were analyzed as at-grade, signalized intersections using year 2025 peak hour traffic volumes. This analysis is to determine if these connections could operate as at-grade intersections in the year 2030. Figure 2 illustrates the intersection laneage configurations, traffic volumes and the traffic operations analysis results. The analysis worksheets are contained in Appendix B for reference.

**SH 172 / CR 234 – Signalized Intersection**

The assumed lane configuration on US 160 includes two left turn lanes (eastbound), one left turn lane (westbound), two through lanes and one right turn lane in each direction. On CR 234 (southbound), the lane configuration includes one lane each for the left turn, through and right turn movements. On SH 172 (northbound), the lane configuration includes two left turn lanes, one through lane and one right turn lane.

The signalized intersection is expected to operate at LOS D in the morning peak period and LOS E in the evening peak period. Numerous individual movements are shown to exhibit LOS E during the morning peak period and LOS F during the evening peak period as well. A triple left turn lane on northbound SH 172 is a critical improvement in that this intersection could not meet the LOS D capacity requirements in the year 2030 without it. However, there is a local cemetery on the southwest corner of the intersection and on the east side of the intersection approximately 1500 feet south there is a local elementary school. These two features constrain the intersection and its ability to carry more lanes of traffic. To avoid impacts to the cemetery and the school, the FEIS selected a SPUI to address the traffic volumes at this intersection. The limits of the proposed interchange in the FEIS do not encroach on either of these properties. An at-grade signalized intersection would encroach on one or both properties if additional lanes were added to SH 172 to accommodate the traffic volumes at the intersection.

**CR 233 (Three Springs) – Signalized Intersection**

The assumed lane configuration on US 160 includes two left turn lanes (eastbound), one left turn lane (westbound), two through lanes and one right turn lane in each direction. On Three Springs Blvd., the lane configuration includes two left turn lanes, one through lane and one right turn lane southbound and one through lane, left turn lane, and right turn lane northbound.

The signalized intersection is expected to operate at LOS D in the morning peak period and LOS F in the evening peak period. Numerous individual movements are shown to exhibit LOS F during the morning and evening peak periods as well.

In an attempt to improve the LOS to acceptable levels, additional lanes were added to particularly heavy movements and signal timing was optimized. Even with providing three lanes in each direction through the intersection on US 160 and analyzing triple left turn lanes, the LOS D evaluation criteria for signalized intersections and individual movements could not be achieved.

**Grandview – Signalized Intersection**

The assumed lane configuration on US 160 includes two left turn lanes, two through lanes, and one right turn lane in each direction. On the Grandview approach, the lane configuration includes two left turn lanes, one through lane and one right turn lane in each direction.

The signalized intersection is expected to operate at LOS C in the morning peak period and LOS F during the evening peak period. Numerous individual movements are shown to exhibit LOS F during the morning and evening peak periods as well.

In an attempt to improve the LOS to acceptable levels, additional lanes were added to particularly heavy movements and signal timing was optimized. Even with providing three lanes in each direction through the intersection on US 160 and analyzing triple left turn lanes, the LOS D evaluation criteria for signalized intersections and individual movements could not be achieved.

**Conclusion**

Based on the analysis of the three intersections, the results show that interchanges are necessary for the three connections to satisfy the capacity requirements for the purpose and need.

## Alternative F Modified (FEIS) Analysis (Year 2030) - Figure 3

This evaluation was performed to determine whether Alternative F Modified (Figure 3) meets the capacity requirements of the purpose and need in the year 2030, while utilizing the same evaluation criteria as in the FEIS. Though Alternative F modified (Three Springs Interchange) does not include a Grandview interchange, the auxiliary lane assumptions for this alternative do not change. From the west project limit to the Three Springs interchange would be two through lanes in each direction with an eastbound climbing lane and a westbound auxiliary lane. This is true for the US 160 FEIS as well as the year 2030 analysis. Interchanges evaluated where the SPUI interchanges at SH 172/CR 234 and CR 233 (Three Springs) with US 550 connecting at CR 233 (Three Springs). The Three Springs development traffic was distributed equally (50/50) to the CR 233 (Three Springs) and SH 172/CR 234 interchanges. The analysis worksheets are contained in Appendix C for reference.

**SH 172 / CR 234 Interchange**

The interchange will have single lane ramps with merge and diverge movements that will continue to operate acceptably at LOS B during the morning peak period and LOS C or better during the evening peak period. The signalized intersection in the center of the interchange will continue to operate acceptably at LOS C during the morning and evening peak periods with individual movements operating at LOS D or better during both peak periods.

**CR 233 (Three Springs) Interchange**

The merge, diverge, and weave movements will continue to operate acceptably at LOS C or better during the morning and evening peak periods except for the westbound on-ramp which is expected to operate at LOS F. The signalized intersection in the center of the interchange will continue to operate acceptably at LOS C during the morning peak period and LOS D during the evening peak period. However, the eastbound right turn, northbound left turn, northbound through and southbound through movements will degrade to an unacceptable LOS E during the evening peak period.

**Conclusion**

With the additional traffic at the CR 233 (Three Springs) interchange for the Alternative F Modified configuration, the operational capacity does not satisfy the capacity requirements for the purpose and need due to the failing LOS for the US 160 westbound on-ramp merge to southbound US 550 at the CR 233 (Three Springs) interchange and the failing LOS southbound from CR 233 (Three Springs) to US 160 westbound right turn movement. This alternative does not meet the capacity requirement for the purpose and need in the year 2030.

## Conclusions

The following conclusions answer three questions fundamental to the purpose of the traffic operations analysis in this memorandum:

*Does the US 160 Alternative G Modified continue to meet the capacity requirements of the purpose and need in the design year 2030?*

**Alternative G Modified (FEIS) Analysis (Year 2030).** With year 2030 traffic volumes, this alternative meets the LOS criteria for the purpose and need.

*Do the future connections at Alternative G Modified, Three Springs/CR 233, and SH 172/CR 234 in the design year 2030 need to be interchanges?*

**At-Grade, Signalized Intersections Analysis.** The signalized intersections are expected to operate at a failing LOS at the Grandview and CR 233 (Three Springs) intersections even with the absence of a northbound US 550 connection. The SH 172 / CR 234 intersection has environmental and other constraints that do not allow SH 172 to be widened to accommodate the 2030 traffic volumes. The results show that interchanges are necessary for the three connections to US 160 to satisfy the capacity requirements of the purpose and need.

*In the year 2030, does Alternative F Modified from the US 160 FEIS meet the capacity requirements of the purpose and need?*

**Alternative F Modified (FEIS) Analysis (Year 2030).** The CR 233 (Three Springs) interchange exceeds the LOS D threshold, therefore this alternative fails to meet the capacity requirements for the purpose and need.

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Attachments

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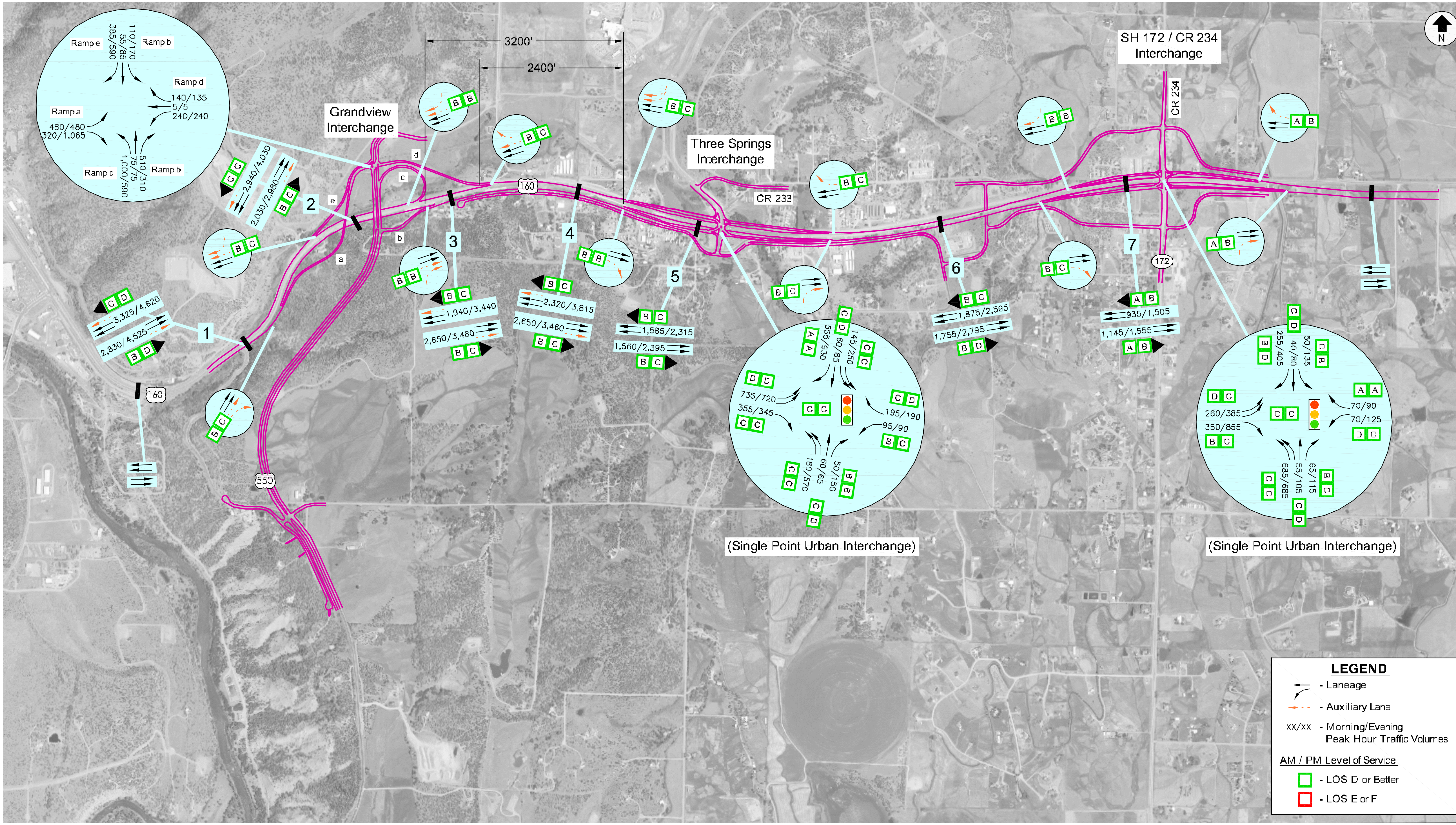


# Year 2030 Traffic Volumes

SEH

Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS
US 160 FEIS Alternative G (Modified) - Interchange Analysis

| Scale | 1"=1500' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 | Figure | 1 |
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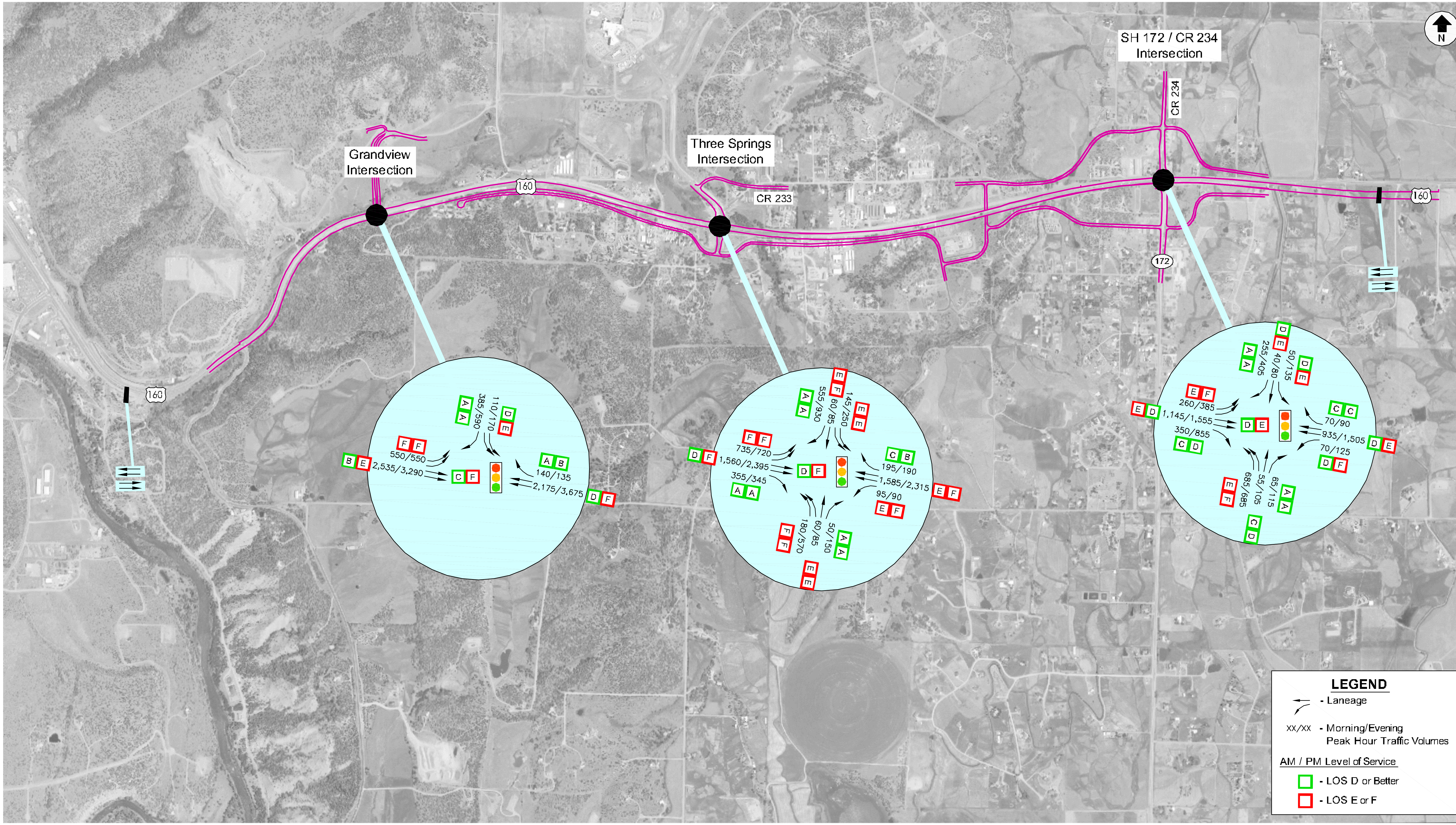


# Year 2030 Traffic Volumes

SEH

Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS
US 160 FEIS Alternative G (Modified) - At-Grade, Signalized Intersection Analysis

| Scale | 1"=1500' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 | Figure | 2 |
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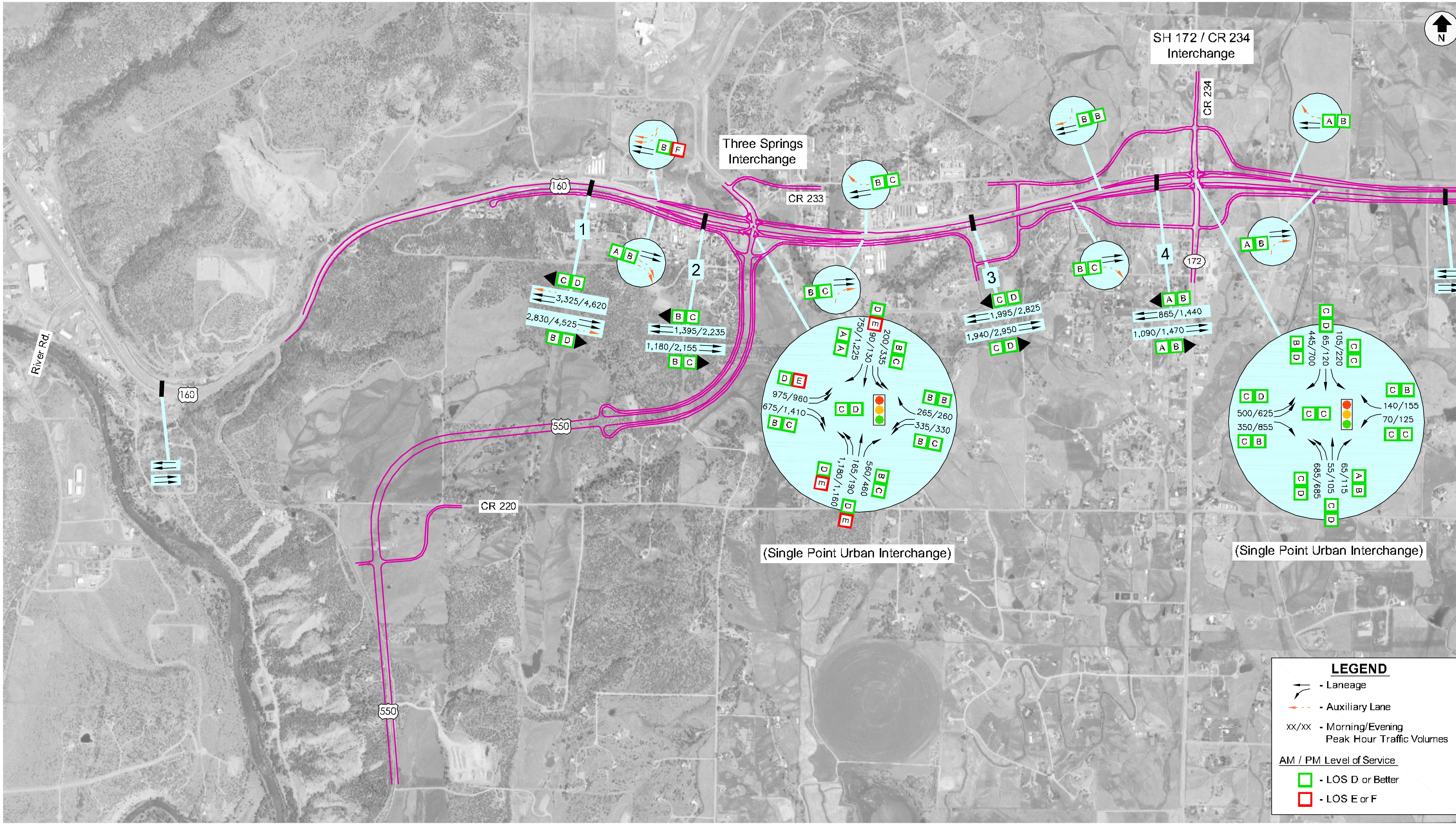


# Year 2030 Traffic Volumes

SEH

| Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS<br>US 160 FEIS Alternative F (Modified) - Interchange Analysis | | | | | | | |
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| Scale | 1"= 1500' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 |
| Figure | 3 | | | | | | |

# APPENDIX A, APPENDIX B, and APPENDIX C on CD

## Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS

## September 17, 2010

# SEH MEMORANDUM

# Year 2030 Traffic Operations Analysis for the US 550 at US 160 Section 4(f) Alternatives

## December 23, 2010

# MEMORANDUM

TO: Mike McVaugh, PE - CDOT Region 5

FROM: Phil Weisbach, PE
Jon E. Larson, PE

Philip J. Weisbach
Jon E. Larson

DATE: December 23, 2010

RE: Year 2030 Traffic Operations Analysis for the US 550 at US 160 Section 4(f) Alternatives
SEH No. CODOT - 105181

## Executive Summary

Alternatives for the US 550 connection to the US 160 corridor were originally evaluated in the US Highway 160 from Durango to Bayfield Final Environmental Impact Statement (FEIS) dated May 2006. The US 160 Highway from Durango to Bayfield Record of Decision (US 160 ROD) documented selection of Grandview Alternative G Modified as the Preferred Alternative which included an interchange of US 160 with US 550 approximately 0.6 miles east of the current intersection. In the Preferred Alternative, the US 550 connection crossed a large ranch property owned by the Webb family. CDOT is currently re-evaluating the connection of US 550 to US 160 due to late discoveries including the designation of a portion of the Webb Ranch as an eligible historic property.

This memo analyzes whether the alternatives being considered in the 4(f) analysis meet the capacity requirements of the purpose and need in the year 2030. This analysis looks at projected traffic in the year 2030 to evaluate if the roadway will meet the capacity requirements for the purpose and need 20 years into the future. The Section 4(f) alternatives focus on the connection of US 550 to US 160 in the Grandview Section. All of the alternatives assume that there is an existing Grandview trumpet interchange and single point urban interchanges (SPUIs) at CR 233 (Three Springs) and SH 172/CR 234. The need for these three interchanges in the Grandview Section is explained in a separate technical memorandum: *Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS* dated December 4, 2009. The traffic volumes have been adjusted to the year 2030 requiring the auxiliary lanes in each direction to extend from the west limit of the Grandview Section to the CR 233 (Three Springs) Interchange. The modified auxiliary lanes are included in each of the alternatives. For example; G Modified is the same as in the FEIS except it includes auxiliary lanes in each direction from the west limit of the Grandview Section to the CR 233 (Three Springs) Interchange. F Modified is the same as in the FEIS except it includes the Grandview Interchange and auxiliary lanes in each direction from the west limit of the Grandview Section to the CR 233 (Three Springs) Interchange. Preliminary Alternative A is the same as in the FEIS except it includes the Grandview Interchange and auxiliary lanes in each direction from west limit of the Grandview Section to the CR 233 (Three Springs). For these reasons, "Revised" has been added to the titles of these alternatives.

The technical results and supporting data of these analyses are included in the appendices of this memo.

The following describes the alternatives being considered for the Section 4(f) analysis:

A. **US 550 at US 160 At-Grade Intersection Alternative.** This alternative includes a revised US 550 at US 160 signalized intersection at its current location in the year 2030 (Feasibility Alternative 1B in the FEIS). The analysis for this alternative also addresses design variations T.1.4, T.1.6, and T.4.4 (These design variations are similar except for

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minor differences in vertical grade and horizontal alignment which do not affect the traffic operational analysis at the intersection). This alternative assumes there is a Grandview trumpet interchange east of the intersection and SPUIs at CR 233 (Three Springs) and SH 172/CR 234.

B. **Partial Interchange at the Existing US 550 / US 160 Intersection.** This alternative includes a partial interchange at the existing US 550/US 160 location. The analysis for this alternative also addresses design variations T.2.4, T.2.6, T.3.4, and T.3.6 (These design variations are similar except for minor differences in vertical grade and horizontal alignment which do not affect the traffic operational analysis). This alternative assumes there is a Grandview trumpet interchange east of the partial interchange and SPUIs at CR 233 (Three Springs) and SH 172/CR 234.

C. **Revised Preliminary Alternative A.** This alternative includes grade-separated trumpet interchanges at the existing US 550/US 160 connection and at the Grandview Interchange with SPUIs at SH 172/CR 234 and CR 233 (Three Springs).

D. **Revised G Modified.** This alternative connects US 550 to US 160 via the Grandview trumpet interchange, and CR 233 (Three Springs) and SH 172/ CR 234 would be SPUI interchanges.

E. **Revised F Modified and Eastern Realignment Alternative.** These two alternatives will both connect to the CR 233 (Three Springs) interchange. The Revised F Modified includes an additional trumpet interchange at the Grandview Interchange, and SPUI interchanges at CR 233 (Three Springs) and SH 172/CR 234. US 550 would connect to US 160 at the CR 233 (Three Springs) interchange. The Eastern Realignment Alternative has a different US 550 alignment when compared to the Revised F Modified US 550 alignment, but both alignments connect to US 160 at the Three Springs/ CR 233 interchange. The traffic operational analysis for both alternatives is the same.

F. **Western Realignment Alternative.** This alternative would relocate the existing US 550/US 160 intersection to the west where it would intersect US 160 with a directional interchange. This alternative assumes there is a Grandview trumpet interchange and SPUIs at CR 233 (Three Springs) and SH 172/CR 234.

The purpose for improvements to the US 160 corridor include increasing travel efficiency and capacity to meet current and future needs, while improving safety for the traveling public by reducing the number and severity of accidents, and controlling access. The design year of the US 160 FEIS was 2025. The analysis performed in this memorandum will use the same methodology as the FEIS except the design year is adjusted to 2030.

**Summary of Results:** The results of the analysis performed are summarized below:

| Year 2030 Analysis | | Purpose and Need for Capacity: Met | Purpose and Need for Capacity: Not Met |
|---|---|---|---|
| A | US 550 @ US 160 At-Grade Intersection Alternatives | | ✓ |
| B | Partial Interchange @ Existing US 550 / US 160 | ✓ | |
| C | Revised Preliminary Alternative A | ✓ | |
| D | Revised G Modified | ✓ | |
| E | Revised F Modified & Eastern Realignment Alternative | ✓ | |
| F | Western Realignment Alternative | | ✓ |

## Evaluation Criteria

The interchange alternatives were evaluated to determine if each alternative met operational level of service requirements as described in the Executive Summary of the FEIS, based on guidance in the AASHTO Policy on Geometric Design of Highways and Streets 2004 (AASHTO Green Book) and capacity analysis performed according to the methods described in the Highway Capacity Manual[1] (HCS). This memorandum deals with the capacity analysis and not design. Traffic volumes used in the analysis are year 2030 peak hour volumes that were projected from the year 2025 volumes documented in Appendix A, Traffic Report, Figure 8 of the US 160 FEIS. The 2025 background traffic volumes were projected based on the background annual growth rates in the accepted methodology in the FEIS to calculate the year 2030 background scenario. The trips generated by the Grandview development were combined with the year 2030 background volumes to generate the year 2030 total peak hour volumes used in the analysis.

For the purposes of this analysis, US 160 is assumed to be east/west and US 550 is assumed to be north/south.

**US 160 Interchanges and Signalized Intersections**
The capacity requirement for the purpose and need of the Grandview Section is as follows:

- A Level of Service (LOS) D or better for an urban signalized intersection, including signalized intersections at single point urban interchanges (SPUI), and its individual legs or movements during the peak hour in year 2030; and
- A LOS D or better for urban interchange merge, diverge, weaving area, auxiliary lanes. and/or freeway sections during the peak hour in year 2030.

1 Highway Capacity Manual - Special Report 209. Transportation Research Board. National Research Council. 2000.

Anything worse than LOS D for any intersection, leg, movement, ramp, auxiliary lane, or freeway section is considered “failing,” and not meeting the purpose and need. These criteria were applied to the alternatives analyzed in this memorandum.

**US 160 Continuous Through Lanes**

**Preferred Alternative**

The Preferred Alternative in the US 160 FEIS included a four-lane typical section, two continuous lanes in each direction, throughout the corridor with a westbound auxiliary lane and eastbound climbing lane from the west limit of the Grandview Section to the future connection of US 160 and US 550. Auxiliary lanes were added to maintain an operational level of service of D by improving the merge, diverge and weave movements, by helping to make safer lane transitions to and from the future US 160/US 550 interchange.

**Year 2030 Traffic Operations Analysis**

In the analysis, the projected traffic volumes were extended to the year 2030. The background traffic on US 160 was increased from the year 2025 to 2030, and the trip generation from a fully developed Grandview Area Plan increased traffic on the US 160 mainline as well as the entering and exiting traffic volumes to US 160. Due to the increased entering/exiting volumes, auxiliary lanes will need to be extended, from those assumed in the US 160 FEIS. The auxiliary lanes in the year 2030 need to be extended to the future CR 233 (Three Springs) interchange to maintain a LOS D for the traffic operations of the merge, diverge and weaving movements along US 160.

Since the number of continuous through lanes remains constant throughout the US 160 corridor and auxiliary lanes are not carried through any of the interchanges, auxiliary lanes are not considered capacity-adding improvement measures. However, they can be utilized to improve the traffic operations between two successive interchanges and to assist in accommodating high entering/exiting traffic volumes. Without auxiliary lanes at high volume locations, bottleneck areas can result due to poor levels of service for the merging, diverging, and weaving movements. Areas of congestion such as bottleneck locations typically coincide with areas that exhibit poor accident ratings. Auxiliary lanes help to solve merge, diverge and weave issues as well as improve the safety complications associated with poor traffic operations.

## Section 4(f) Alternatives Under Consideration

Utilizing the year 2030 volumes developed along the US 160 corridor five alternatives were analyzed. The alternatives were evaluated to determine if each met capacity requirements as described in the purpose and need of the FEIS but in the design year 2030. The analysis considers two through lanes in each direction and one auxiliary lane in each direction extending from the CR 233 (Three Springs) interchange to the west end of the Grandview Section. The auxiliary lanes are not continuous over the entire distance from CR 233 to the west end of the Grandview Section. The auxiliary lanes drop off at the off ramps for the Grandview Interchange and begin again where the Grandview Interchange on ramps merge with US 160.

### A. US 550 at US 160 At-Grade Intersection Alternative – Figure 1

The EIS considered a signalized intersection at the existing US 550/US 160 intersection (Feasibility Alternative 1B) and determined that this option did not meet the purpose and need. This alternative is being re-evaluated in light of new information, including traffic information provided by Krager and Associates in a letter sent by attorney Thomas McNeill on behalf of the owners of the Webb Ranch to the FHWA. This analysis also addresses the capacity requirements for the design variations T.1.4, T.1.6, and T.4.4.

Each design variation illustrates US 550 intersecting US 160 as an at-grade intersection at the existing US 550/US 160 intersection location. The intersection geometry is also the same for T.1.4, T.1.6 and T.4.4 as illustrated in Figure 1. The differences occur approximately 500 feet away from the US 550/US 160 intersection where the horizontal curvature and grade varies. The design variations are contained in Appendix A for reference.

- **Design Variation T.1.4** shows a 1050-foot radius and a 4% grade;
- **Design Variation T.1.6** shows a 925-foot radius and a 6% grade; and
- **Design Variation T.4.4** shows a 1250-foot radius and a 4% grade.

Since these design variations occur away from US 550 / US 160, they do not influence the traffic operations at the intersection and do not affect the results of the analysis.

**Connection of US 550 to US 160**

The Krager and Associates analysis states that an at-grade signalized intersection will operate at LOS C with three through lanes in each direction on US 160. While the volumes used in the analysis were derived from the year 2025 volumes found in Figure 8 of the US 160 FEIS (refer to Appendix A of this memo), this analysis only accounts for the volumes on three legs of the Grandview interchange and does not include the traffic accessing US 160 from the north leg of the Grandview interchange. The Krager and Associates conclusions were erroneously based on traffic volumes that are lower than what was documented in the US 160 FEIS. Using volumes that account for all of the traffic that would be expected at the intersection in the year 2030, the intersection is expected to operate at LOS D during the morning peak period (80 second cycle length) and LOS E during the evening peak period (90 second cycle length) with the number of lanes proposed by Krager and Associates. In addition, the volume to capacity ratios (v/c) for the individual lanes are approaching a v/c ratio of 1.0 and traffic queues expected during the evening peak period will be in excess of 1,750 feet (Approximately 88 vehicles). Modifying/increasing the traffic signal cycle lengths will further degrade the intersection level of service and no additional capacity can be achieved for this alternative.

**Adjacent interchanges in the Grandview Section**

This analysis also evaluated the LOS conditions for the other interchanges identified in the Grandview Section. The analysis verified that the other interchanges in the section all meet the capacity requirements for the purpose and need in the year 2030. The analysis worksheets are contained in Appendix A for reference.

**Conclusion**

This alternative does not meet capacity requirements for the purpose and need because an intersection is not adequate to maintain LOS D in the evening peak hour.

## B. Partial Interchange at the Existing US 550 at US 160 Intersection – Figure 2

This alternative proposes to modify the signalized intersection at US 160/US 550 by eliminating the left turn movement from northbound US 550 to westbound US 160 and replacing it with a loop ramp to service the left turn volumes at the intersection. To accommodate the through volumes, US 160 would have two through lanes and one auxiliary lane westbound from the CR 233 (Three Springs) interchange through the US 550 intersection. US 160 eastbound would have two through lanes and one climbing lane from west of the US 550 intersection to the CR 233 / Three Springs interchange. This analysis will also address the capacity requirements for the design variations T.2.4, T.2.6, T.3.4, and T.3.6.

Each design variation illustrates US 550 intersecting US 160 as an at-grade intersection at the existing US 550/US 160 intersection location but with a flyover to accommodate the northbound left turn movement. The intersection geometry and flyover ramp movement are the same for T.2.4, T.2.6, T.3.4

and T.3.6 as illustrated in Figure 2. The differences occur approximately 500 feet away from the US 550/US 160 intersection where the horizontal curvature and grade varies, and the location and radius of the flyover. The design alternatives are contained in Appendix B for reference.

- **Design Variation T.2.4** shows a 1050-foot radius and a 4% grade. The location of the flyover has half of the loop on each the north and south side of US 160;
- **Design Variation T.2.6** shows a 925-foot radius and 6% grade. The location of the flyover has half of the loop on each the north and south side of US 160;
- **Design Variation T.3.4** shows a 1050-foot radius and a 4% grade. The location of the flyover loop is entirely on the north side of US 160; and
- **Design Variation T.3.6** shows a 925-foot radius and a 6% grade. The location of the flyover loop is entirely on the north side of US 160.

Since these design variations occur away from US 550 / US 160, they do not influence the traffic operations at the intersection and do not affect the results of the analysis.

**Connection of US 550 to US 160**

The signalized intersection is expected to operate at LOS A in the morning (60 second cycle length) and LOS A in the evening (90 second cycle length). The loop ramp has an approximate design speed of 30 MPH and the merge for the loop ramp is expected to operate at LOS B in the morning peak hour and LOS C in the evening peak hour. The westbound to southbound double-left turn movement is expected to operate at LOS C in the morning and LOS D in the evening. During the evening peak period the eastbound through movement is expected to operate at LOS C and traffic queues are expected to be in excess of 900 feet. All other movements are expected to operate at LOS A during the both peak periods. In addition, the volume to capacity ratios (v/c) for the individual lanes are approaching a v/c ratio of 1.0 during the evening peak period.

**Adjacent interchanges in the Grandview Section**

This analysis also evaluated the LOS conditions for the other interchanges identified in the Grandview Section. The analysis verified that the other interchanges in the section all meet the capacity requirements for the purpose and need in the year 2030. The analysis worksheets are contained in Appendix B for reference.

**Conclusion**

The alternative does satisfy the capacity requirements for the purpose and need in the year 2030.

## C. Revised Preliminary Alternative A – Figure 3

The FEIS considered an interchange at US 550/US 160 (Preliminary Alternative A). However, the Preliminary Alternative A was not considered to be a reasonable alternative because it has poor geometry which combines 6 percent grades, sharp curves and maximum super-elevation on a north-facing slope that will create icing conditions and hazards in the winter. In part, because of these reasons, Preliminary Alternative A from the EIS was not considered to be reasonable or practicable and was dismissed without the traffic operations being analyzed. This alternative is being re-evaluated despite the geometric problems to determine whether the traffic operations will meet the purpose and need for capacity.

The Revised Preliminary Alternative A proposes a Single Point Urban Interchange (SPUI) at SH 172/CR 234 and CR 233 (Three Springs) with a grade separated trumpet interchange at the existing US 550/US 160 connection. This alternative has been revised from the FEIS to include a grade separated trumpet interchange (Grandview Interchange) east of the existing US 550/US 160 Intersection. To accommodate the through volumes, US 160 would have two through lanes and one auxiliary lane westbound from the

CR 233 (Three Springs) interchange through the US 550 interchange. US 160 eastbound would have two through lanes and one climbing lane from west of the US 550 interchange to the CR 233 (Three Springs) interchange. The analysis worksheets are contained in Appendix C for reference.

**Connection of US 550 to US 160**

The weaving segment for eastbound US 160 between US 550 interchange and Grandview interchange is expected to operate at LOS B during the morning peak period and LOS C during the evening peak period. All merge and diverge sections between US 550 and US 160 are expected to operate at LOS B during the morning peak period and LOS C during the evening peak period.

**Adjacent interchanges in the Grandview Section**

This analysis also evaluated the LOS conditions for the other interchanges identified in the Grandview Section. The analysis verified that the other interchanges in the section all meet the capacity requirements for the purpose and need in the year 2030.

**Conclusion**

This alternative satisfies the capacity requirements of the purpose and need. The planned interchange and auxiliary lane configurations are adequate to accommodate the projected volumes at LOS D or better with US 550 connecting to this location.

## D. Revised G Modified – Figure 4

This alternative includes two through lanes in each direction through the Grandview Section with eastbound and westbound auxiliary lanes from the CR 233 (Three Springs) interchange to the west end of the section. A trumpet interchange is assumed at the Grandview location and a SPUI is assumed at the CR 233 (Three Springs) and SH 172 / CR 234 interchanges.

**Connection of US 550 to US 160**

The merge and diverge movements at the Grandview Interchange are expected to operate at LOS B or better during the morning peak period and LOS C or better during the evening peak period. The weaving segment for westbound US 160 between Three Springs interchange and Grandview interchange is expected to operate at LOS B during the morning peak period and LOS C during the evening peak period.

The roundabout at the intersection between US 550 and the US 160 ramps is expected to operate at LOS A during the morning and evening peak periods. Each approach to the roundabout is expected to operate at LOS A during the morning and evening peak periods as well. The analysis worksheets are contained in Appendix D for reference.

**Adjacent interchanges in the Grandview Section**

This analysis also evaluated the LOS conditions for the other interchanges identified in the Grandview Section. The analysis verified that the other interchanges in the section all meet the capacity requirements for the purpose and need in the year 2030.

**Conclusion**

The analysis shows that this alternative satisfies the capacity requirements of the purpose and need in the year 2030. This alternative accommodates the projected year 2030 volumes at LOS D or better.

## E. Revised F Modified and Eastern Realignment Alternative – Figure 5

These two alternatives will both connect to the CR 233 (Three Springs) interchange. The Revised F Modified includes an additional trumpet interchange at the Grandview Interchange, and SPUI interchanges at CR 233 (Three Springs) and SH 172/CR 234. US 550 would connect to US 160 at CR

233 (Three Springs) interchange. The Eastern Realignment Alternative has a different US 550 alignment when compared to the Revised F Modified US 550 alignment, but both alignments connect to US 160 at the CR 233 (Three Springs) interchange. The traffic operational analysis is the same for both alternatives where they connect to US 160. Frontage roads will parallel both alignments from US 160 to CR 220. These roads will provide local access to the properties south of US 160. US 160 will have two through lanes and one auxiliary lane in each direction from the west ramps of the Grandview Interchange to the west ramps of the CR 233 (Three Springs) interchange. The analysis assumes two through lanes in each direction through the Grandview Section with eastbound and westbound auxiliary lanes from the CR 233 (Three Springs) interchange to the west end of the section. The analysis worksheets are contained in Appendix E for reference.

**Connection of US 550 to US 160**

The merge and diverge movements at the CR 233 (Three Springs) Interchange are expected to operate at LOS B or better during the morning peak period and LOS C or better during evening peak period. The weaving segment for westbound US 160 between Three Springs interchange and Grandview interchange is expected to operate at LOS B during the morning peak period and LOS C during the evening peak period.

The signalized intersection in the center of the interchange is expected to operate at LOS C during the morning and evening peak periods (90 second cycle AM, 110 second cycle PM), and all of individual movements are expected to operate at LOS D or better during both peak periods. During the evening peak period, the individual movements operating at-capacity are the eastbound left turn and right turn movements as well as the northbound left turn movement which are expected to operate at volume to capacity ratios (v/c) near 1.0. Traffic queues are expected to be in excess of 600 feet.

**Adjacent interchanges in the Grandview Section**

This analysis also evaluated the LOS conditions for the other interchanges identified in the Grandview Section. The analysis verified that the other interchanges in the section all meet the capacity requirements for the purpose and need in the year 2030.

**Conclusion**

This alternative satisfies the capacity requirements of the purpose and need. The interchange is adequate to accommodate the projected volumes at LOS D or better with US 550 connecting to this location.

## F. Western Realignment Alternative - Figure 6 & 7

This alternative proposes to relocate US 550 to the west where it would intersect US 160 with a directional interchange thus eliminating the signalized intersection of US 160/US 550. The alignment would include two river crossings requiring bridges. Two of the ramps from the interchange would terminate approximately 700 feet from the existing River Road signalized intersection on US 160. The traffic operational results for the interchange do not include the impacts of the traffic signal operation at River Road. Impacts due to the proximity of River Road are described below. The analysis worksheets are contained in Appendix F for reference.

**Connection of US 550 to US 160**

The Western Realignment Interchange is expected to operate at LOS C or better during the morning and evening peak periods in the analysis. However, when the interaction of the River Road signalized intersection with the interchange is analyzed, there is a queuing of traffic in the evening peak period of approximately 1,700 feet (85 vehicles) on US 160 (Figure 7). The queues on US 160 will force queues to form on the ramp itself, congesting the merge area such that a free flow merge could not occur.

Ramp merge calculations in the HCS software assume free flow operations and cannot analyze the queue impacts from a closely spaced signalized intersection downstream from the ramp merge point. The results of the HCS analysis determines the ramp merge has acceptable operations even though the proximity of the traffic signal would cause congestion on the ramp. Our operations analysis evaluated this relationship and determined that the expected vehicle stoppages at the interchange merge area is a capacity failure.

Unlike the other alternatives, this interchange will experience congestion and capacity problems due to the close proximity of the River Road signalized intersection to the westbound on ramp to US 160. Intersection queues, westbound at River Road, during the evening peak period will extend beyond the merge for the US 550 to US 160 on ramp. This will cause vehicles to stop on the ramp during the evening peak period. Approaching vehicles on US 550 would not be able to see the stopped vehicles due to the interchange ramp design and curvature. The speed differential between approaching vehicles and stopped vehicles on the ramp will create an unsafe condition that could result in a high probability of sideswipe and rear-end accidents. This alternative does not meet the purpose and need for capacity, resulting in an unsafe roadway condition between the interchange and the adjacent signalized intersection. This is considered a failing condition as it is not consistent with the purpose and need to have a known design that contributes to congestion and safety issues. The analysis worksheets are contained in Appendix G for reference.

**Adjacent interchanges in the Grandview Section**

This analysis also evaluated the LOS conditions for the other interchanges identified in the Grandview Section. The analysis verified that the other interchanges in the section all meet the capacity requirements for the purpose and need in the year 2030.

**Conclusion**

The proximity of River Road to the US 550 westbound on-ramp to US 160 will create queue conflicts, congestion, and backups at the westbound interchange on-ramp. The Western Realignment does not meet the purpose and need for capacity resulting in an unsafe roadway condition between the interchange and the adjacent signalized intersection.

## Conclusions

**US 550 at US 160 At-Grade Intersection Alternative.** This includes design variations T.1.4, T.1.6, T.4.4. This alternative does not meet the capacity requirements of the purpose and need because the geometry of the US 160/US550 intersection is not adequate to maintain LOS D in the evening peak hour.

**Partial Interchange at the Existing US 550 at US 160 Intersection.** This analysis also addresses the capacity requirements for the design variations T.2.4, T.2.6, T.3.4, and T.3.6. The alternative does satisfy the capacity requirements for the purpose and need.

**Revised Preliminary Alternative A.** This alternative satisfies the capacity requirements of the purpose and need. The planned interchange and auxiliary lane configurations are adequate to accommodate the projected volumes at LOS D or better with US 550 connecting to this location.

**Revised G Modified.** With year 2030 traffic volumes, this alternative meets the capacity requirements in the purpose and need.

**Revised F Modified and Eastern Realignment Alternative.** Both of these alternatives meet the capacity requirements of the purpose and need due to the additional Grandview Interchange which reduces the traffic impacts of the fully developed residential and commercial area in Grandview to the north of the CR 233 (Three Springs) interchange.

**Western Realignment Alternative.** Capacity is a criteria of the purpose and need, this alternative does not satisfy the capacity requirement of the purpose and need. The proximity of River Road to US 550 northbound to westbound US 160 on-ramp causes capacity queuing conflicts with the on-ramp and potential safety issues, this alternative does not satisfy the purpose and need.

## Capacity Analysis and Comparison of Alternatives beyond the Horizon Year of 2030

In a separate report (*US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis – The Degree to Which Each Alternative Meets the Purpose and Need for the Project*, dated December 23, 2010) an analysis was performed to determine which of alternatives that met the criteria of LOS D or better for the 2030 traffic capacity analysis performed best if traffic were increased beyond the volumes used for the 2030 analysis. In this analysis, traffic was increased at the intersections of US 160/US 550 in 2% increments until a movement failed (i.e., resulted in LOS E or worse) that could not be corrected by simply optimizing the traffic operations at the intersections and without adding additional lanes at the intersection. The results of this analysis showed that the signalized US 160/US 550 (Three Springs Interchange) intersection for Revised F Modified and the Eastern Realignment alternative failed with the first 2% increase of traffic at the intersection, while the roundabout intersection in Revised G Modified remained at LOS A for the overall intersection and all movements with the same 2% increase in traffic. This analysis showed that the US 160/US 550 intersection in Revised F Modified and the Eastern Realignment was approaching capacity with the 2030 traffic volumes, and exceeded the capacity of the intersection with only a slight increase in traffic beyond the 2030 volumes while the roundabout intersection in Revised G Modified had substantial reserve capacity beyond the 2030 volumes. As a result of this analysis, ***it was concluded that the roundabout at the Grandview Interchange (Revised G Modified) has more reserve capacity than a signalized intersection at the Three Springs Interchange (Revised F Modified) and thus Revised G Modified better meets the project purpose and need.***

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Attachments
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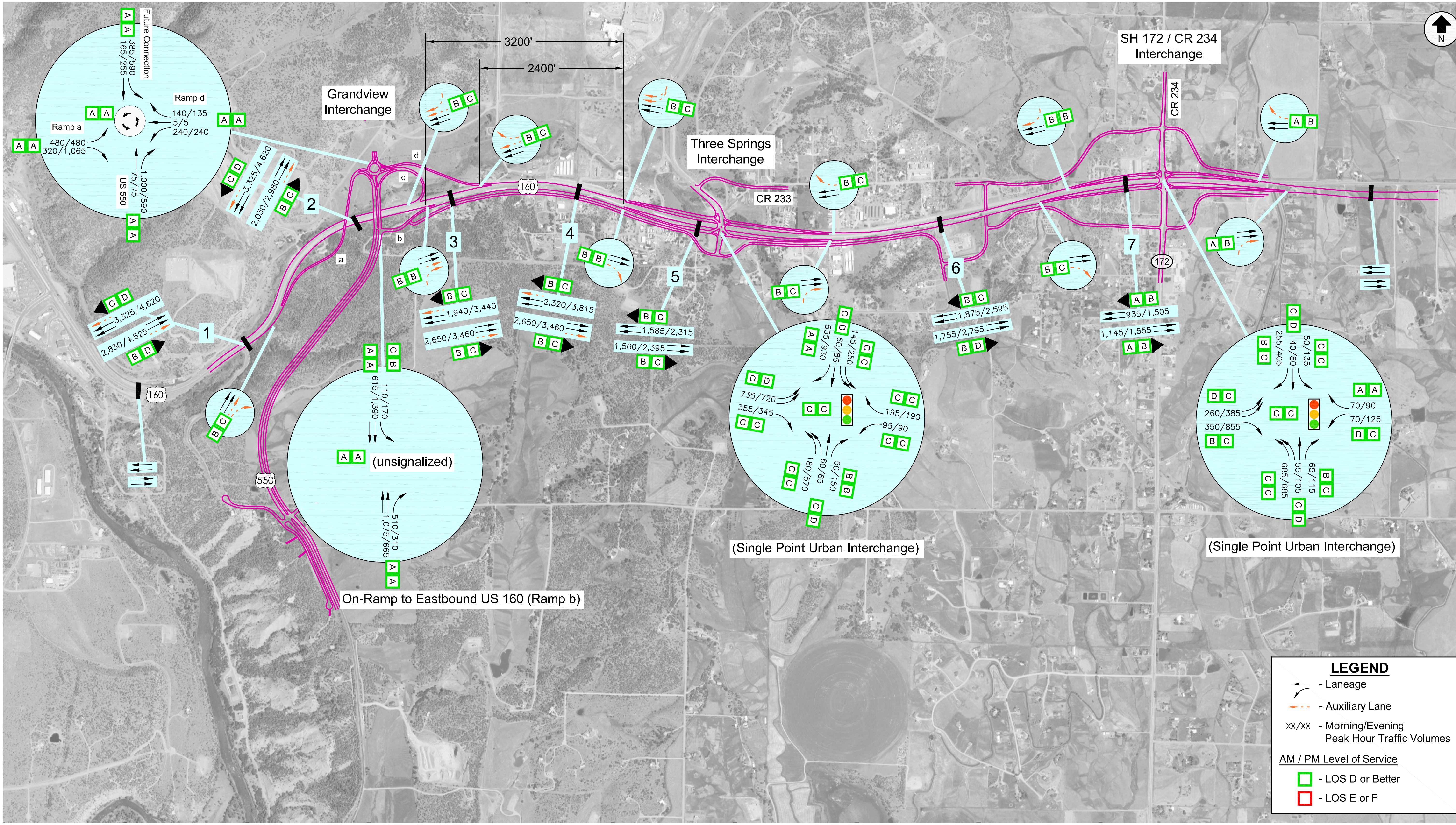


# Year 2030 Traffic Volumes

Year 2030 Traffic Operation Analysis for the US 550 at US 160 Section 4(f) Alternatives
Revised Alternative G Modified

| Scale | 1"=1500' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 | Figure | 4 |
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# SEH MEMORANDUM

# US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis—The Degree to Which Each Alternative Meets the Purpose and Need for the Project

## January 5, 2011

# MEMORANDUM

TO: Mike McVaugh, PE - CDOT Region 5

FROM: Phil Weisbach, PE
Jon E. Larson, PE

Phil J. Weisbach
Jon E. Larson

DATE: January 5, 2011

RE: US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis – The Degree to Which Each Alternative Meets the Purpose and Need for the Project
SEH No. CODOT - 105181

## Executive Summary

Alternatives for the US 550 connection to the US 160 corridor were originally evaluated in the US Highway 160 from Durango to Bayfield Final Environmental Impact Statement (FEIS) dated May 2006. The US 160 Highway from Durango to Bayfield Record of Decision (US 160 ROD) documented selection of Grandview Alternative G Modified as the Preferred Alternative which included an interchange of US 160 with US 550 approximately 0.6 miles east of the current intersection.

A separate memo entitled *Year 2030 Traffic Operations Analysis for the US 550 at US 160 Section 4(f)* (December 23, 2010) analyzes whether the alternatives being considered in the 4(f) analysis meet the capacity requirements of the purpose and need in the year 2030. The analysis looks at projected traffic in the year 2030 to evaluate if the roadway will meet the capacity requirements for the purpose and need 20 years into the future. The Section 4(f) alternatives focus on the connection of US 550 to US 160 in the Grandview Section. All of the alternatives assume that there is an existing Grandview trumpet interchange and single point urban interchanges (SPUIs) at CR 233 (Three Springs) and SH 172/CR 234. The need for these three interchanges in the Grandview Section is explained in a separate technical memorandum: *Year 2030 Traffic Operations Analysis for Alternatives of the US 160 FEIS* dated September 17, 2010.

Of the alternatives considered in the Section 4(f) analysis, three alternatives are being considered under the least harm analysis. These alternatives include Revised G Modified, Revised F Modified, and the Eastern Realignment. One of the balancing factors when considering the least overall harm is the degree to which each alternative meets the purpose and need for the project This analysis evaluates the degree to which these alternatives meet the purpose and need and focuses specifically on the connection of US 550 to US 160. The alternative that exhibits the highest degree of meeting the purpose and need provides the most overall benefit to the access, safety and capacity of US 160 throughout its 20-year design.

The technical traffic analysis data for this memo is included in the attached appendices at the end of this document.

This analysis addresses several fundamental questions:

A. Which alternative exhibits more desirable access control along US 160?

B. Which alternative is 'more safe' and exhibits the least overall potential for harm to the motorists?

C. Which alternative exhibits the most reserve capacity at the intersection where US 550 connects with US 160?

D. Which alternative has the highest degree of meeting the purpose and need for access, safety and capacity?

The purpose for improvements to the US 160 corridor include increasing travel efficiency and capacity to meet current and future needs, while improving safety for the traveling public by reducing the number and severity of accidents, and controlling access. The design year of the US 160 FEIS was 2025. The analysis performed in this memorandum will be the same as the FEIS except the design year is changed to 2030.

**Summary of Results:** The results of the analysis performed are summarized below:

**Fundamental Questions**

| US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis | Revised G Modified | Revised F Modified[1] | Eastern Realignment[1] |
|---|---|---|---|
| Which alternative exhibits more desirable access control along US 160? | ✓ | ✓ | ✓ |
| Which alternative is 'more safe' and exhibits the least overall potential for harm to the motorists? | ✓ | | |
| Which alternative exhibits the most reserve capacity at the intersection where US 550 connects with US 160? | ✓ | | |
| Which alternative has the highest degree of meeting the purpose and need for access, safety and capacity? | ✓ | | |

Note:
1. The Revised F Modified and Eastern Realignment alternatives have different alignments, but both alternatives connect to US 160 at Three Springs. The traffic capacity, access, and safety analysis are the same for Revised F Modified and Eastern Realignment alternatives.

## Section 4(f) Alternatives Evaluated

The following describes the alternatives being considered in the least harm analysis for the Section 4(f) Evaluation:

A. **Revised G Modified – Figure 1.** This alternative connects US 550 to US 160 via the Grandview trumpet interchange which intersects with US 550 via a roundabout, and CR 233 (Three Springs) and SH 172/ CR 234 would be SPUI interchanges.

B. **Revised F Modified and Eastern Realignment Alternative – Figure 2.** These two alternatives will both connect to the CR 233 (Three Springs) interchange. The Revised F Modified includes an additional trumpet interchange at the Grandview Interchange, and SPUI interchanges at CR 233 (Three Springs) and SH 172/CR 234. US 550 would connect to US 160 at the CR 233 (Three Springs) interchange. The Eastern Realignment Alternative has a different US 550 alignment when compared to the Revised F Modified US 550 alignment, but both alignments connect to US 160 at the Three Springs/ CR 233 interchange. The traffic operational analysis for both alternatives is the same.

Figures 1 and 2 illustrate the alignments for these alternatives as well as the year 2030 traffic operations analysis from the Section 4(f) alternatives evaluation. The traffic volumes, interchange traffic control/laneage and interchange spacing will be used as the basis for the analysis to determine which alternative is more beneficial to the purpose and need.

# Evaluation of the Degree with which Alternatives Meet Purpose and Need

## A. Access

Access control was evaluated to determine which alternative better promotes an access management system that meets the expectations of a high-speed, high volume highway through appropriate control of access frequency and spacing.

**Revised G Modified – Figure 1**

This alternative includes two through lanes in each direction through the Grandview Section with interchanges at the Grandview location, CR 233 (Three Springs) and SH 172 / CR 234. Local access within this corridor will be managed with a local frontage road system to limit direct access to the highway only at the interchanges. Additionally, this alternative includes establishing an access line along the corridor to preclude future additional accesses. Within the Grandview Section, there are no other accesses proposed other than the three interchanges. The approximate distances between the interchanges are tabulated below:

- Between Grandview Interchange & Three Springs Interchange = 5,600 feet
- Between Three Springs Interchange & SH 172 / CR 234 = 7,150 feet

**Revised F Modified and Eastern Realignment Alternative – Figure 2**

This alternative includes two through lanes in each direction through the Grandview Section with interchanges at the Grandview location, CR 233 (Three Springs) and SH 172 / CR 234. Local access within this corridor will be managed with a local frontage road system to limit direct access to the highway only at the interchanges. Additionally, this alternative includes an access line along the corridor to preclude future additional accesses. Within the Grandview Section, there are no other accesses proposed other than the three interchanges. The approximate distances between the interchanges are tabulated below:

- Between Grandview Interchange & Three Springs Interchange = 5,600 feet
- Between Three Springs Interchange & SH 172 / CR 234 = 7,150 feet

**Conclusion**

The analysis shows that access for the three alternatives exhibit the same frequency and spacing. Regardless of where US 550 connects to US 160, local access to US 160 is managed by a frontage road system to minimize access to US 160 only at the planned interchanges. ***Therefore, the degree with which the alternatives meet purpose and need for access is the same for all three alternatives.***

## B. Safety

Safety was evaluated to determine which alternative more safely accommodates the traffic volumes associated with the connection of US 550 to US 160.

**Revised G Modified – Figure 1**

This alternative connects US 550 to US 160 via the Grandview trumpet interchange. However, traffic on US 550 is accommodated at its intersection with US 160 by a roundabout that is expected to operate at an acceptable level of service in the year 2030.

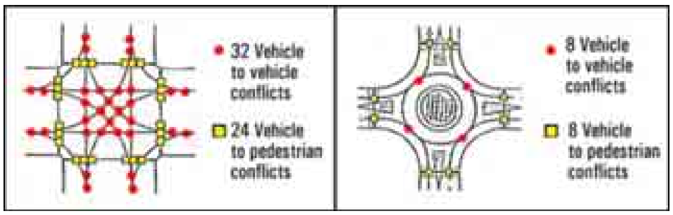
**Revised F Modified and Eastern Realignment Alternative – Figure 2**

This alternative connects US 550 to US 160 via the Three Springs SPUI interchange. Traffic on US 550 is accommodated at its intersection with US 160 by a SPUI and controlled by a traffic signal that is expected to operate at an acceptable level of service in the year 2030.

**<u>Roundabouts Versus Traffic Signals</u>**

One of the benefits of roundabout installations is the improvement in overall safety performance to other traffic control installations. Though the frequency of crashes is not always lower for roundabouts, there is a pronounced reduction in injury rates. The typical reasons for the increased safety level at roundabouts are[1]:

- **Roundabouts have fewer conflict points.** The frequency of crashes at an intersection is related to the number of conflict points. At a four-legged conventional signalized intersection, there are 32 vehicle-to-vehicle conflicts and 24 vehicle-to-pedestrian conflicts. At a four-legged roundabout, this number is reduced to 8 as shown in the figure below. The four dots in the roundabout illustrations represent two conflict points each for the merge conflict and the diverge conflict.




- **Lower speeds and lower speed differential.** Lower speeds associated with roundabouts allow drivers more time to react to potential conflicts.
- **Fewer number of driver decisions.** Drivers only need to be aware of vehicles to their left at entry of roundabouts. Drivers at traffic signals need to be aware of traffic coming from as many as three directions at any time. In addition the driver must remain aware of the signal indication while monitoring the vehicle movements through the intersection.
- **Less severe crashes.** Severity of crashes is based on the relative speed and angle of the conflicting streams. Most vehicles travel at similar speeds through roundabouts with a small angle between the vehicle paths. The potential for hazardous conflicts, such as right angle and left turn head-on crashes is eliminated in roundabout use.

Research shows that roundabouts can be an effective way to improve safety at intersections. In a review of 55 sites that were converted from four-way intersections to roundabouts, before and after crash data shows a reduction in crashes 35% (1,122 to 726). More importantly, the severe injury crashes were reduced 76% (from 296 to 72). [2]

**<u>Conclusion</u>**

The analysis shows that a roundabout controlled intersection is more likely to provide safer operations than a conventional traffic signal due to the lower speeds, fewer conflicting movements and the elimination of head-on and broad-side crashes that are typically associated with injury crashes. Regarding safety, to accommodate the significant volume of traffic from US 550, use of a roundabout at the Grandview Interchange would be safer than sending US 550 to a traffic signal at the Three Springs Interchange. ***Therefore, the Revised G Modified has a higher degree of safety benefit compared to Revised F Modified and the Eastern Realignment Alternative.***

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[1] <u>Roundabouts: An Information Guide</u>. Federal Highway Administration (Report No. FHWA-RD-00-067). June 2000

[2] <u>Roundabouts in the United States</u>. National Cooperative Highway Research Program (Report 572). Transportation Research Board. 2007.

## C. Capacity

The capacity analysis evaluates the connection of US 550 to US 160 to determine which alternative can accommodate more future traffic volume growth beyond the year 2030 forecasted volumes. The year 2030 volumes and traffic represent the basis for which the reserve capacity is measured in the additional analysis. The procedure involved in evaluating the alternatives consists of:

- Begin with the Year 2030 traffic volumes and report results;
- Inflate the traffic volumes at the intersection of US 550 / US 160 in 2% increments until an intersection or individual movement for an alternative fails;
- For the traffic signal operations, the signal phasing and cycle length is then optimized to see if a timing solution could extend the capability of the traffic operations to have capacity for more volume;
- After optimization of the signal phasing and cycle length, the volumes are increased to the point where a movement cannot meet LOS D or better, the alternative is considered to fail; then
- The last alternative that continues to meet the purpose and need for capacity is considered to have the most reserve capacity.

Table 1 illustrates the level of service analysis results. Level of service worksheets are contained in Appendix A for reference.

**Revised G Modified**

This alternative connects US 550 to US 160 via the Grandview trumpet interchange. Traffic on US 550 is accommodated at its intersection with US 160 by a roundabout. The roundabout configuration has 220-foot inscribed circle diameter and includes two circulation lanes with right turn bypass lanes for the eastbound and northbound directions. The US 550 northbound connection to US 160 westbound (Ramp C) is accomplished by a right-turn bypass at the roundabout. The roundabout also connects to Ramp C for any vehicles that need to go westbound on US 160.

The roundabout was analyzed using RODEL. To be consistent with the US 160 Section 4(f) analysis, the roundabout was analyzed with a capacity factor of 0.9 for the two-lane approaches. Additionally, it was evaluated at an 85% confidence level, which simulates the worst few minutes of the peak period instead of the average delay spread across the peak period. The results in RODEL with these assumptions are considered conservative, which provides an increased level of confidence that the results are dependable.

**Year 2030 Traffic Volumes.** The roundabout overall and each approach are expected to operate well at LOS A during the morning and evening peak periods. The merge from Ramp C is expected to operate at LOS B during the morning peak period and LOS C during the evening peak period.

**Year 2030 Traffic Volumes + 2% Inflation.** This scenario evaluates the roundabout approaches and Ramp C, but inflates the year 2030 traffic volumes on each approach by 2% to determine if the roundabout is able to absorb this level of volume increase beyond the year 2030. The roundabout as well as each approach is expected to operate well at LOS A during the morning and evening peak periods. The merge from Ramp C is expected to operate at LOS B during the morning peak period and LOS C during the evening peak period. The roundabout would have to exhibit an 84% increase in traffic volume beyond the year 2030 traffic volumes before it experiences a failing LOS E at one of its movements. Consequently, Ramp C would have to exhibit a 67% increase in traffic volume beyond the year 2030 traffic volumes before the merge operations diminish from an acceptable LOS D to a failing LOS F.

**Revised F Modified and Eastern Realignment Alternative**

This alternative connects US 550 to US 160 via the Three Springs interchange. Traffic on US 550 is accommodated at its intersection with US 160 by a SPUI. The intersection configuration includes the following:

- Eastbound approach – Two left turn lanes and two right turn lanes.
- Westbound approach – Two left turn lanes and one right turn lane.
- Northbound approach – Two left turn lanes, one through lane and one right turn lane.
- Southbound approach – Two left turn lanes, one through lane and one right turn lane.

The traffic signal was modeled in Synchro to emulate SPUI operations which are more efficient than a conventional intersection.

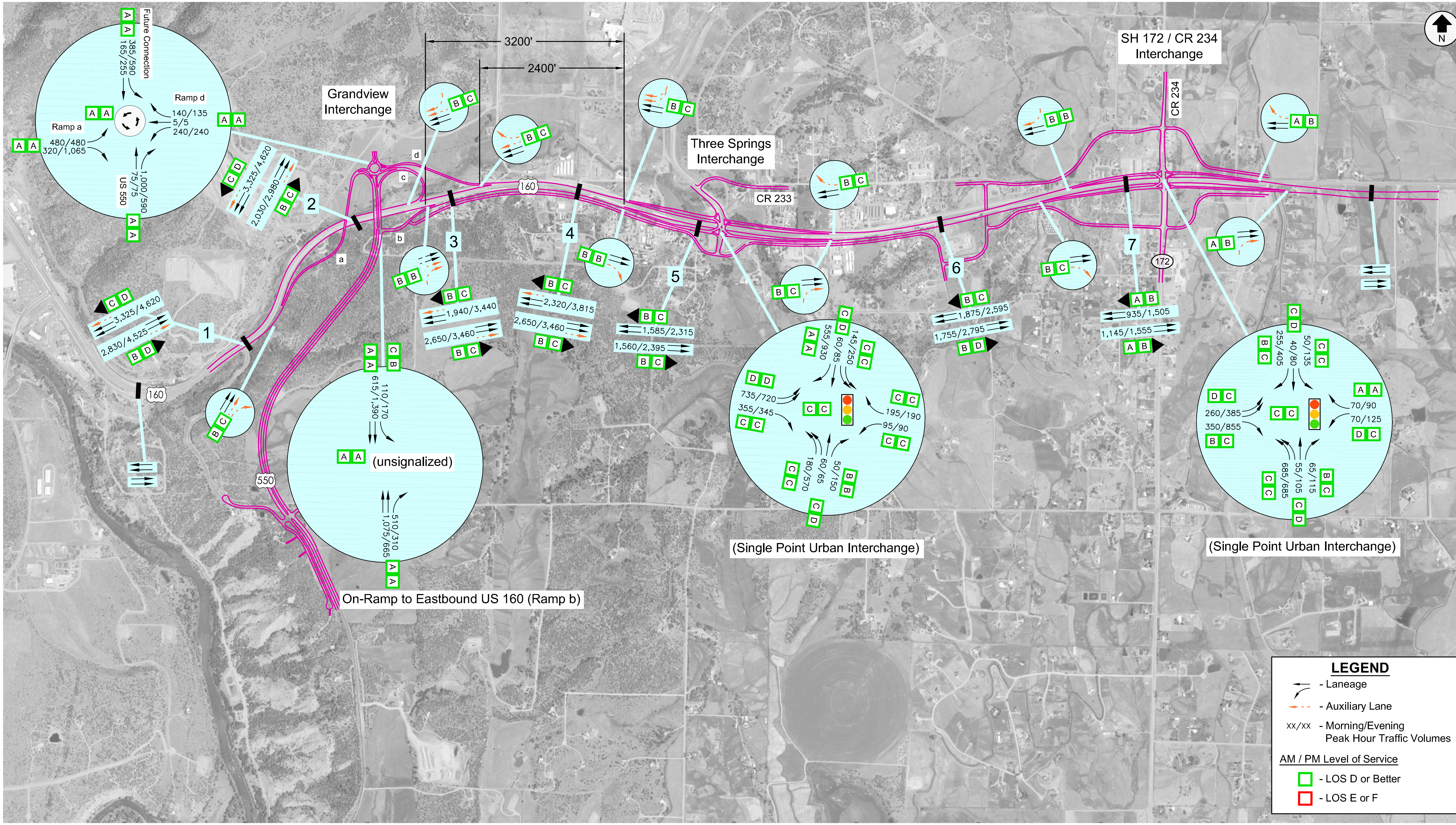
**Year 2030 Traffic Volumes.** The signalized intersection at the Three Springs SPUI is expected to operate at LOS C during the morning and evening peak periods and all of individual movements are expected to operate at LOS D or better during both peak periods.

**Year 2030 Traffic Volumes + 2% Inflation.** This scenario evaluates the SPUI, but inflates the year 2030 traffic peak hour turning movements by 2% to determine if the intersection is able to absorb this level of volume increase beyond the year 2030. The signalized intersection at the Three Springs SPUI is expected to operate at acceptable LOS C during the morning and evening peak periods. However, the northbound left turn is expected to operate at LOS E during evening peak period. Numerous signal phasing and cycle length combinations were attempted, but the signal operations could not be improved to acceptable levels. A 2% increase for the northbound left turn equates to approximately 25-30 vehicles in the morning and evening peak periods. This minor increase creates a failing northbound left turn movement.

**Conclusion**

The analysis shows that the traffic signal fails if traffic volumes were increased by 2% beyond the year 2030 projected traffic volumes. The analysis shows that the roundabout can be expected to accommodate an increase in traffic by 84% and Ramp C can be expected to accommodate an increase in traffic by 67% beyond the year 2030 projected traffic volumes. Therefore, it is clear that there is more reserve capacity with the roundabout than the traffic signal. ***Therefore, the roundabout at the Grandview Interchange (Revised G Modified) has more reserve capacity than a signalized intersection at the Three Springs Interchange (Revised F Modified).***

jel
Attachments
p:\ae\c\codot\105181\to #3 - us 160 interchange analysis\project____final memos_december 2010\4\4_degree of purpose-need_us 160 section 4f_1-05-2011_jel.docx

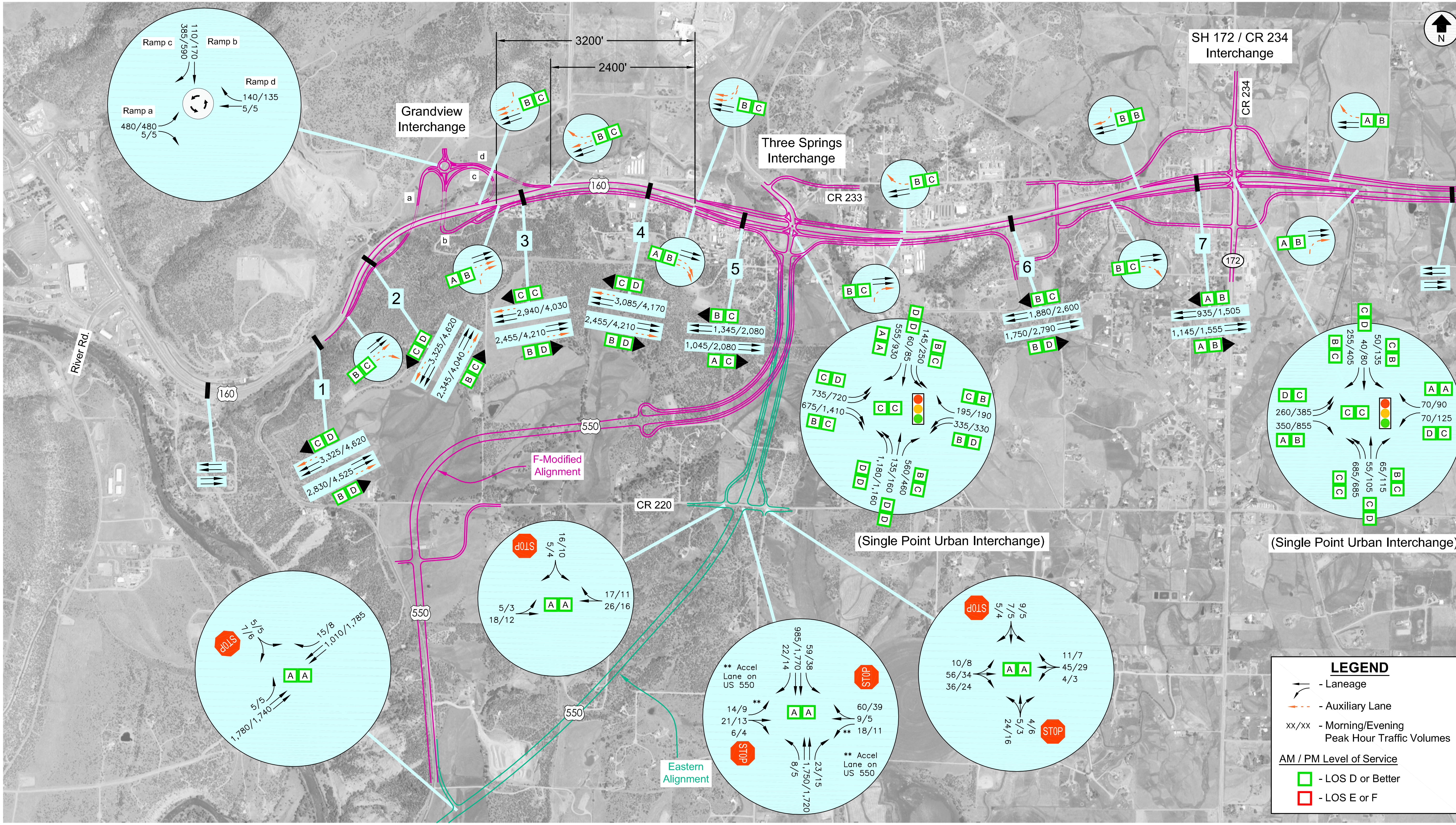



# Year 2030 Traffic Volumes

SEH

US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis
Revised Alternative G Modified

| Scale | 1"=1500' | Date | 12/23/10 | Drawn by | JEL | Job # | 105181 | Figure | 1 |
|---|---|---|---|---|---|---|---|---|---|




# Year 2030 Traffic Volumes

SEH

US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis
Revised Alternative F Modified and Eastern Realignment Alternative

| Scale | 1"=1500' | Date | 12/23/10 | Drawn by | JEL | Job # | 105181 | Figure | 2 |
|---|---|---|---|---|---|---|---|---|---|

**Table 1. Reserve Capacity Comparison - Roundabout (Alt G) vs. Traffic Signal (Alt F)**

| Intersection and Critical Movements | Year 2030 Traffic Volumes[1] | | | | Year 2030 Traffic Volumes + 2% Inflation | | | |
|---|---|---|---|---|---|---|---|---|
| | AM Peak Hour | | PM Peak Hour | | AM Peak Hour | | PM Peak Hour | |
| | Delay[2] | LOS | Delay[2] | LOS | Delay[2] | LOS | Delay[2] | LOS |
| **Revised G Modified** | | | | | | | | |
| **US 550 @ Grandview (Roundabout)** | **2.6** | **A** | **3.1** | **A** | **2.3** | **A** | **2.7** | **A** |
| Eastbound Approach | *3.0* | A | *3.6* | A | *2.4* | A | *3.0* | A |
| Northbound Approach | *4.2* | A | *4.8* | A | *4.2* | A | *5.4* | A |
| Westbound Approach | *2.4* | A | *2.4* | A | *2.4* | A | *2.4* | A |
| Southbound Approach | *2.4* | A | *3.0* | A | *1.8* | A | *2.4* | A |
| **Revised F Modified & Eastern Realignment Alternative** | | | | | | | | |
| **US 550 @ Three Springs (Traffic Signal)** | **25.8** | **C** | **30.9** | **C** | **26.6** | **C** | **32.5** | **C** |
| Eastbound Left | *31.6* | C | *52.5* | D | *33.4* | C | *54.9* | D |
| Eastbound Right | *10.1* | B | *21.0* | C | *10.1* | B | *22.1* | C |
| Westbound Left | *10.2* | B | *35.2* | D | *25.9* | C | *35.3* | D |
| Westbound Right | *21.9* | C | *10.4* | B | *9.2* | A | *10.4* | B |
| Northbound Left | *50.2* | D | *54.8* | D | *50.0* | D | *59.7* | E |
| Northbound Through | *42.9* | D | *53.0* | D | *42.7* | D | *53.6* | D |
| Northbound Right | *17.0* | B | *23.8* | C | *17.3* | B | *24.1* | C |
| Southbound Left | *18.9* | B | *24.2* | C | *19.2* | B | *24.2* | C |
| Southbound Through | *36.1* | D | *44.7* | D | *36.6* | D | *44.9* | D |
| Southbound Right | *1.5* | A | *2.1* | A | *1.2* | A | *2.2* | A |

Notes:

**1.** Traffic volumes referenced from Year 2030 Traffic Operations Analysis for the US 550 at US 160 Section 4(f) Alternatives Technical Memo (12-23-2010)

**2.** Delay is measured as seconds/vehicle.

US 160 Section 4(f) Alternatives Considered in the Least Harm Analysis – The Degree to Which Each Alternative Meets the Purpose and Need for the Project

# Appendix A

## Level of Service Worksheets

**Grandview Interchange Roundabout Analysis (Revised Alternative G Mod)**

**Year 2030 Traffic Volumes:** 2-Lane Roundabout (ICD 220') with right turn bypass lanes for EB&NB (AM) (85% Confidence Level)

C:\WINDOWS\system32\cmd.exe

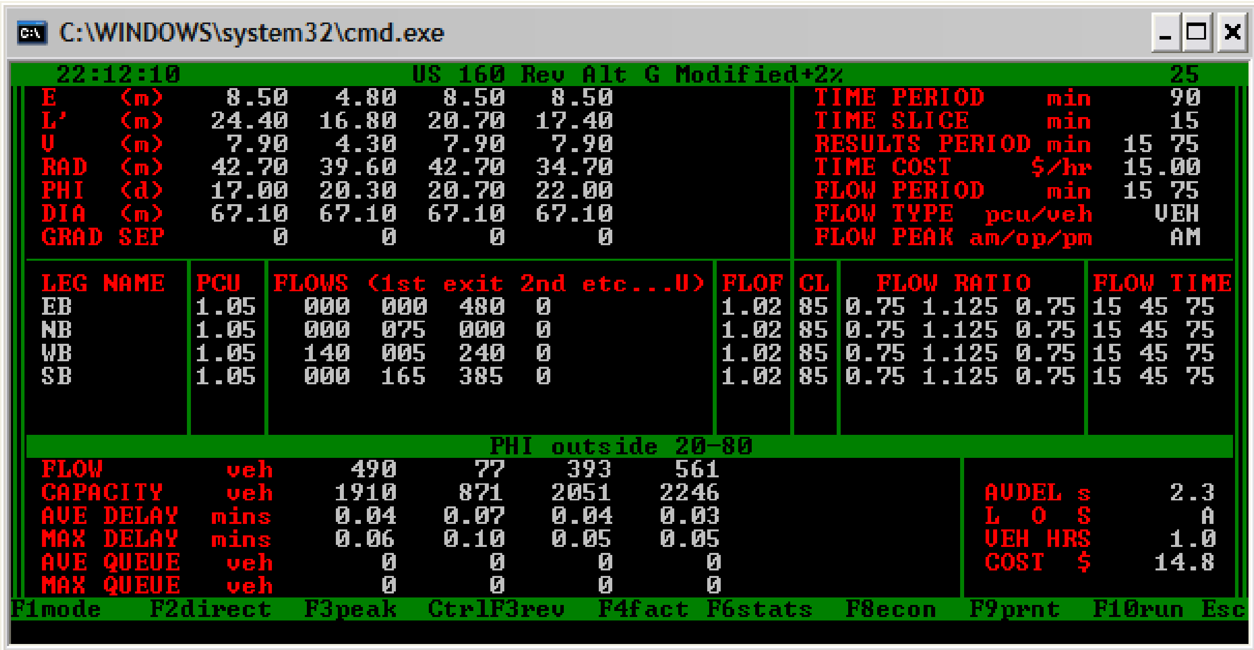
```
 22:12:10                     US 160 Rev Alt G Modified                    13
 E     (m)    8.50   4.80   8.50   8.50         TIME PERIOD      min       90
 L'    (m)   24.40  16.80  20.70  17.40         TIME SLICE       min       15
 V     (m)    7.90   4.30   7.90   7.90         RESULTS PERIOD min    15  75
 RAD   (m)   42.70  39.60  42.70  34.70         TIME COST       $/hr   15.00
 PHI   (d)   17.00  20.30  20.70  22.00         FLOW PERIOD      min  15  75
 DIA   (m)   67.10  67.10  67.10  67.10         FLOW TYPE  pcu/veh       VEH
 GRAD SEP        0      0      0      0         FLOW PEAK am/op/pm        AM

 LEG NAME  PCU  FLOWS (1st exit 2nd etc...U) CAPF CL   FLOW RATIO    FLOW TIME
 EB        1.05   000  000  480  0           0.90 85 0.75 1.125 0.75 15 45 75
 NB        1.05   000  075  000  0           1.00 85 0.75 1.125 0.75 15 45 75
 WB        1.05   140  005  240  0           0.90 85 0.75 1.125 0.75 15 45 75
 SB        1.05   000  165  385  0           0.90 85 0.75 1.125 0.75 15 45 75

                                  PHI outside 20-80
 FLOW        veh      480     75    385    550
 CAPACITY    veh     1729    880   1853   2025              AVDEL s       2.6
 AVE DELAY  mins     0.05   0.07   0.04   0.04              L  O  S         A
 MAX DELAY  mins     0.06   0.10   0.05   0.05              VEH HRS       1.1
 AVE QUEUE   veh        0      0      0      0              COST  $      16.3
 MAX QUEUE   veh        0      0      0      0
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

**Year 2030 Traffic Volumes:** 2-Lane Roundabout (ICD 220') with right turn bypass lanes for EB&NB (PM) (85% Confidence Level)

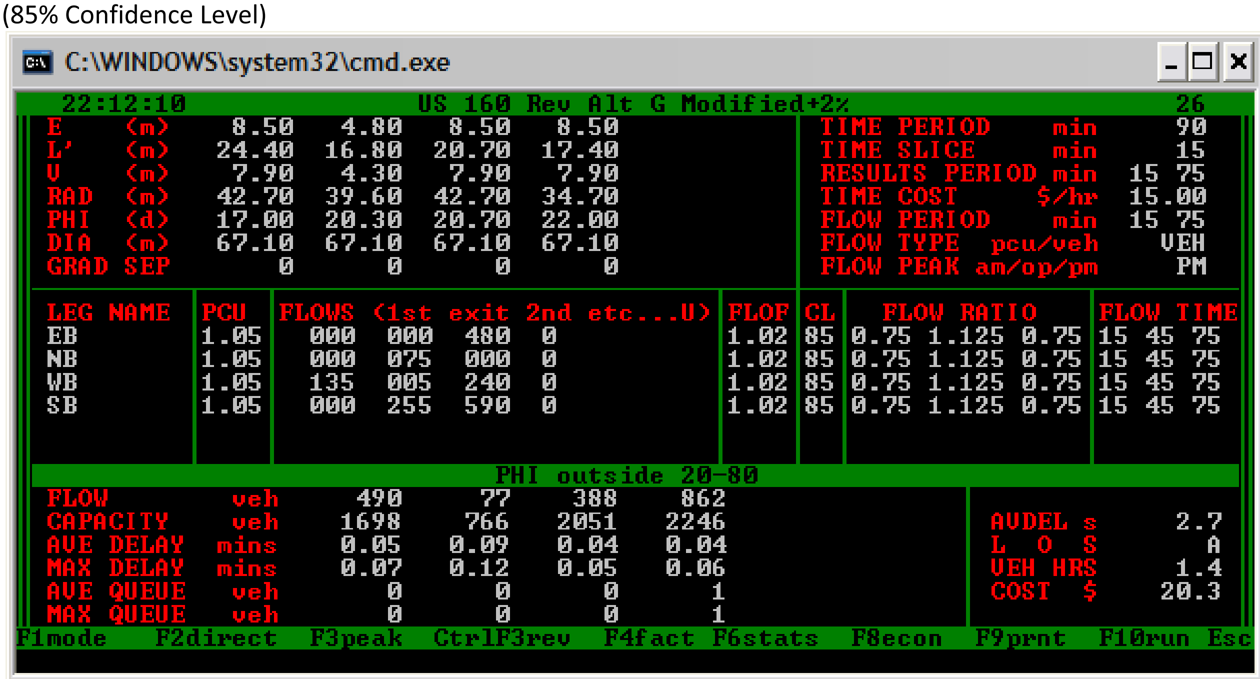
C:\WINDOWS\system32\cmd.exe

```
 22:12:10                     US 160 Rev Alt G Modified                    12
 E     (m)    8.50   4.80   8.50   8.50         TIME PERIOD      min       90
 L'    (m)   24.40  16.80  20.70  17.40         TIME SLICE       min       15
 V     (m)    7.90   4.30   7.90   7.90         RESULTS PERIOD min    15  75
 RAD   (m)   42.70  39.60  42.70  34.70         TIME COST       $/hr   15.00
 PHI   (d)   17.00  20.30  20.70  22.00         FLOW PERIOD      min  15  75
 DIA   (m)   67.10  67.10  67.10  67.10         FLOW TYPE  pcu/veh       VEH
 GRAD SEP        0      0      0      0         FLOW PEAK am/op/pm        PM

 LEG NAME  PCU  FLOWS (1st exit 2nd etc...U) CAPF CL   FLOW RATIO    FLOW TIME
 EB        1.05   000  000  480  0           0.90 85 0.75 1.125 0.75 15 45 75
 NB        1.05   000  075  000  0           1.00 85 0.75 1.125 0.75 15 45 75
 WB        1.05   135  005  240  0           0.90 85 0.75 1.125 0.75 15 45 75
 SB        1.05   000  255  590  0           0.90 85 0.75 1.125 0.75 15 45 75

                                  PHI outside 20-80
 FLOW        veh      480     75    380    845
 CAPACITY    veh     1542    777   1853   2025              AVDEL s       3.1
 AVE DELAY  mins     0.06   0.08   0.04   0.05              L  O  S         A
 MAX DELAY  mins     0.08   0.11   0.05   0.07              VEH HRS       1.5
 AVE QUEUE   veh        0      0      0      1              COST  $      22.7
 MAX QUEUE   veh        1      0      0      1
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

**Year 2030 Traffic Volumes + 2%:** 2-Lane Roundabout (ICD 220') with right turn bypass lanes for EB&NB (AM) (85% Confidence Level)




**Year 2030 Traffic Volumes + 2%:** 2-Lane Roundabout (ICD 220') with right turn bypass lanes for EB&NB (PM) (85% Confidence Level)



**Year 2030 Traffic Volumes + 84%:** 2-Lane Roundabout (ICD 220’) with right turn bypass lanes for EB&NB (AM) (85% Confidence Level)

```
C:\WINDOWS\system32\cmd.exe
  5:1:11                   US 160 Rev Alt G Modified+X%                       40
 E    (m)    8.50    4.80    8.50    8.50           TIME PERIOD      min      90
 L'   (m)   24.40   16.80   20.70   17.40           TIME SLICE       min      15
 V    (m)    7.90    4.30    7.90    7.90           RESULTS PERIOD min     15 75
 RAD  (m)   42.70   39.60   42.70   34.70           TIME COST       $/hr   15.00
 PHI  (d)   17.00   20.30   20.70   22.00           FLOW PERIOD      min   15 75
 DIA  (m)   67.10   67.10   67.10   67.10           FLOW TYPE   pcu/veh      VEH
 GRAD SEP       0       0       0       0           FLOW PEAK  am/op/pm       AM

 LEG NAME  PCU   FLOWS (1st exit 2nd etc...U) FLOF CL  FLOW RATIO     FLOW TIME
 EB        1.05   000  000  480  0            1.84 85 0.75 1.125 0.75 15 45 75
 NB        1.05   000  075  000  0            1.84 85 0.75 1.125 0.75 15 45 75
 WB        1.05   140  005  240  0            1.84 85 0.75 1.125 0.75 15 45 75
 SB        1.05   000  165  385  0            1.84 85 0.75 1.125 0.75 15 45 75

                               PHI outside 20-80
 FLOW         veh     883     138     708    1012
 CAPACITY     veh    1454     513    1734    2108          AVDEL s        4.9
 AVE DELAY   mins    0.12    0.17    0.06    0.05          L  O  S          A
 MAX DELAY   mins    0.19    0.26    0.08    0.08          VEH HRS        3.7
 AVE QUEUE    veh       2       0       1       1          COST  $       55.7
 MAX QUEUE    veh       3       1       1       1
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

**Year 2030 Traffic Volumes + 84%:** 2-Lane Roundabout (ICD 220’) with right turn bypass lanes for EB&NB (PM) (85% Confidence Level)

```
C:\WINDOWS\system32\cmd.exe
  5:1:11                   US 160 Rev Alt G Modified+X%                       41
 E    (m)    8.50    4.80    8.50    8.50           TIME PERIOD      min      90
 L'   (m)   24.40   16.80   20.70   17.40           TIME SLICE       min      15
 V    (m)    7.90    4.30    7.90    7.90           RESULTS PERIOD min     15 75
 RAD  (m)   42.70   39.60   42.70   34.70           TIME COST       $/hr   15.00
 PHI  (d)   17.00   20.30   20.70   22.00           FLOW PERIOD      min   15 75
 DIA  (m)   67.10   67.10   67.10   67.10           FLOW TYPE   pcu/veh      VEH
 GRAD SEP       0       0       0       0           FLOW PEAK  am/op/pm       PM

 LEG NAME  PCU   FLOWS (1st exit 2nd etc...U) FLOF CL  FLOW RATIO     FLOW TIME
 EB        1.05   000  000  480  0            1.84 85 0.75 1.125 0.75 15 45 75
 NB        1.05   000  075  000  0            1.84 85 0.75 1.125 0.75 15 45 75
 WB        1.05   135  005  240  0            1.84 85 0.75 1.125 0.75 15 45 75
 SB        1.05   000  255  590  0            1.84 85 0.75 1.125 0.75 15 45 75

                               PHI outside 20-80
 FLOW         veh     883     138     699    1555
 CAPACITY     veh    1071     324    1735    2108          AVDEL s       20.9
 AVE DELAY   mins    0.98    0.38    0.06    0.12          L  O  S          C
 MAX DELAY   mins    2.21    0.68    0.08    0.19          VEH HRS       19.0
 AVE QUEUE    veh      15       1       1       3          COST  $      285.3
 MAX QUEUE    veh      34       1       1       5
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 720 | 0 | 1410 | 330 | 0 | 190 | 1160 | 160 | 460 | 250 | 85 | 930 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 0.88 | 0.97 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 758 | 0 | 1484 | 347 | 0 | 200 | 1221 | 168 | 484 | 263 | 89 | 979 |
| RTOR Reduction (vph) | 0 | 0 | 121 | 0 | 0 | 6 | 0 | 0 | 260 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 758 | 0 | 1363 | 347 | 0 | 194 | 1221 | 168 | 224 | 263 | 89 | 979 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 6 | | | 5 6 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 27.0 | | 65.5 | 27.0 | | 65.5 | 40.0 | 16.5 | 52.0 | 40.0 | 16.5 | 110.0 |
| Effective Green, g (s) | 27.0 | | 65.5 | 27.0 | | 65.5 | 40.0 | 16.5 | 43.5 | 40.0 | 16.5 | 101.5 |
| Actuated g/C Ratio | 0.25 | | 0.60 | 0.25 | | 0.60 | 0.36 | 0.15 | 0.40 | 0.36 | 0.15 | 0.92 |
| Clearance Time (s) | 9.0 | | | 9.0 | | | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | | 3.0 | | | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 843 | | 1660 | 843 | | 943 | 1248 | 279 | 626 | 1248 | 279 | 1461 |
| v/s Ratio Prot | c0.22 | | | 0.10 | | | c0.36 | 0.09 | | 0.08 | 0.05 | |
| v/s Ratio Perm | | | c0.49 | | | 0.12 | | | 0.14 | | | 0.62 |
| v/c Ratio | 0.90 | | 0.82 | 0.41 | | 0.21 | 0.98 | 0.60 | 0.36 | 0.21 | 0.32 | 0.67 |
| Uniform Delay, d1 | 40.2 | | 17.6 | 34.8 | | 10.3 | 34.6 | 43.7 | 23.4 | 24.1 | 41.7 | 0.9 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 12.3 | | 3.4 | 0.3 | | 0.1 | 20.2 | 9.3 | 0.4 | 0.1 | 3.0 | 1.2 |
| Delay (s) | 52.5 | | 21.0 | 35.2 | | 10.4 | 54.8 | 53.0 | 23.8 | 24.2 | 44.7 | 2.1 |
| Level of Service | D | | C | D | | B | D | D | C | C | D | A |
| Approach Delay (s) | | 31.7 | | | 26.1 | | | 46.6 | | | 9.3 | |
| Approach LOS | | C | | | C | | | D | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 30.9 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.86 | | |
| Actuated Cycle Length (s) | 110.0 | Sum of lost time (s) | 18.0 |
| Intersection Capacity Utilization | 105.3% | ICU Level of Service | G |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 735 | 0 | 677 | 337 | 0 | 195 | 1180 | 135 | 560 | 145 | 60 | 555 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | | 6.0 | 5.0 | | 6.0 | 6.0 | 6.0 | 5.0 | 6.0 | 6.0 | 5.0 |
| Lane Util. Factor | 0.97 | | 0.88 | 0.97 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 774 | 0 | 713 | 355 | 0 | 205 | 1242 | 142 | 589 | 153 | 63 | 584 |
| RTOR Reduction (vph) | 0 | 0 | 183 | 0 | 0 | 16 | 0 | 0 | 327 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 774 | 0 | 530 | 355 | 0 | 189 | 1242 | 142 | 262 | 153 | 63 | 584 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 6 | | | 5 6 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 27.0 | | 52.0 | 27.0 | | 52.0 | 33.0 | 13.0 | 46.0 | 33.0 | 13.0 | 90.0 |
| Effective Green, g (s) | 27.0 | | 52.0 | 27.0 | | 52.0 | 33.0 | 13.0 | 40.0 | 33.0 | 13.0 | 78.0 |
| Actuated g/C Ratio | 0.30 | | 0.58 | 0.30 | | 0.58 | 0.37 | 0.14 | 0.44 | 0.37 | 0.14 | 0.87 |
| Clearance Time (s) | 5.0 | | | 5.0 | | | 6.0 | 6.0 | | 6.0 | 6.0 | |
| Vehicle Extension (s) | 3.0 | | | 3.0 | | | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 1030 | | 1610 | 1030 | | 915 | 1259 | 269 | 704 | 1259 | 269 | 1372 |
| v/s Ratio Prot | c0.23 | | | 0.10 | | | c0.36 | c0.08 | | 0.04 | 0.03 | |
| v/s Ratio Perm | | | 0.19 | | | 0.12 | | | 0.17 | | | 0.37 |
| v/c Ratio | 0.75 | | 0.33 | 0.34 | | 0.21 | 0.99 | 0.53 | 0.37 | 0.12 | 0.23 | 0.43 |
| Uniform Delay, d1 | 28.5 | | 9.9 | 24.6 | | 9.1 | 28.3 | 35.7 | 16.6 | 18.9 | 34.1 | 1.3 |
| Progression Factor | 1.00 | | 1.00 | 0.41 | | 2.40 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 3.1 | | 0.1 | 0.2 | | 0.1 | 21.9 | 7.2 | 0.3 | 0.0 | 2.0 | 0.2 |
| Delay (s) | 31.6 | | 10.0 | 10.2 | | 21.9 | 50.2 | 42.9 | 17.0 | 18.9 | 36.1 | 1.5 |
| Level of Service | C | | B | B | | C | D | D | B | B | D | A |
| Approach Delay (s) | | 21.3 | | | 14.5 | | | 39.8 | | | 7.5 | |
| Approach LOS | | C | | | B | | | D | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 25.8 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.82 | | |
| Actuated Cycle Length (s) | 90.0 | Sum of lost time (s) | 17.0 |
| Intersection Capacity Utilization | 77.2% | ICU Level of Service | D |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 720 | 0 | 1410 | 330 | 0 | 190 | 1160 | 160 | 460 | 250 | 85 | 930 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 0.88 | 0.97 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 758 | 0 | 1484 | 347 | 0 | 200 | 1221 | 168 | 484 | 263 | 89 | 979 |
| RTOR Reduction (vph) | 0 | 0 | 121 | 0 | 0 | 6 | 0 | 0 | 260 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 758 | 0 | 1363 | 347 | 0 | 194 | 1221 | 168 | 224 | 263 | 89 | 979 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 6 | | | 5 6 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 27.0 | | 65.5 | 27.0 | | 65.5 | 40.0 | 16.5 | 52.0 | 40.0 | 16.5 | 110.0 |
| Effective Green, g (s) | 27.0 | | 65.5 | 27.0 | | 65.5 | 40.0 | 16.5 | 43.5 | 40.0 | 16.5 | 101.5 |
| Actuated g/C Ratio | 0.25 | | 0.60 | 0.25 | | 0.60 | 0.36 | 0.15 | 0.40 | 0.36 | 0.15 | 0.92 |
| Clearance Time (s) | 9.0 | | | 9.0 | | | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | | 3.0 | | | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 843 | | 1660 | 843 | | 943 | 1248 | 279 | 626 | 1248 | 279 | 1461 |
| v/s Ratio Prot | c0.22 | | | 0.10 | | | c0.36 | 0.09 | | 0.08 | 0.05 | |
| v/s Ratio Perm | | | c0.49 | | | 0.12 | | | 0.14 | | | 0.62 |
| v/c Ratio | 0.90 | | 0.82 | 0.41 | | 0.21 | 0.98 | 0.60 | 0.36 | 0.21 | 0.32 | 0.67 |
| Uniform Delay, d1 | 40.2 | | 17.6 | 34.8 | | 10.3 | 34.6 | 43.7 | 23.4 | 24.1 | 41.7 | 0.9 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 12.3 | | 3.4 | 0.3 | | 0.1 | 20.2 | 9.3 | 0.4 | 0.1 | 3.0 | 1.2 |
| Delay (s) | 52.5 | | 21.0 | 35.2 | | 10.4 | 54.8 | 53.0 | 23.8 | 24.2 | 44.7 | 2.1 |
| Level of Service | D | | C | D | | B | D | D | C | C | D | A |
| Approach Delay (s) | | 31.7 | | | 26.1 | | | 46.6 | | | 9.3 | |
| Approach LOS | | C | | | C | | | D | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 30.9 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.86 | | |
| Actuated Cycle Length (s) | 110.0 | Sum of lost time (s) | 18.0 |
| Intersection Capacity Utilization | 105.3% | ICU Level of Service | G |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 735 | 0 | 677 | 337 | 0 | 195 | 1180 | 135 | 560 | 145 | 60 | 555 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | | 6.0 | 5.0 | | 6.0 | 6.0 | 6.0 | 5.0 | 6.0 | 6.0 | 5.0 |
| Lane Util. Factor | 0.97 | | 0.88 | 0.97 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 774 | 0 | 713 | 355 | 0 | 205 | 1242 | 142 | 589 | 153 | 63 | 584 |
| RTOR Reduction (vph) | 0 | 0 | 183 | 0 | 0 | 16 | 0 | 0 | 327 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 774 | 0 | 530 | 355 | 0 | 189 | 1242 | 142 | 262 | 153 | 63 | 584 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 6 | | | 5 6 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 27.0 | | 52.0 | 27.0 | | 52.0 | 33.0 | 13.0 | 46.0 | 33.0 | 13.0 | 90.0 |
| Effective Green, g (s) | 27.0 | | 52.0 | 27.0 | | 52.0 | 33.0 | 13.0 | 40.0 | 33.0 | 13.0 | 78.0 |
| Actuated g/C Ratio | 0.30 | | 0.58 | 0.30 | | 0.58 | 0.37 | 0.14 | 0.44 | 0.37 | 0.14 | 0.87 |
| Clearance Time (s) | 5.0 | | | 5.0 | | | 6.0 | 6.0 | | 6.0 | 6.0 | |
| Vehicle Extension (s) | 3.0 | | | 3.0 | | | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 1030 | | 1610 | 1030 | | 915 | 1259 | 269 | 704 | 1259 | 269 | 1372 |
| v/s Ratio Prot | c0.23 | | | 0.10 | | | c0.36 | c0.08 | | 0.04 | 0.03 | |
| v/s Ratio Perm | | | 0.19 | | | 0.12 | | | 0.17 | | | 0.37 |
| v/c Ratio | 0.75 | | 0.33 | 0.34 | | 0.21 | 0.99 | 0.53 | 0.37 | 0.12 | 0.23 | 0.43 |
| Uniform Delay, d1 | 28.5 | | 9.9 | 24.6 | | 9.1 | 28.3 | 35.7 | 16.6 | 18.9 | 34.1 | 1.3 |
| Progression Factor | 1.00 | | 1.00 | 0.41 | | 2.40 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 3.1 | | 0.1 | 0.2 | | 0.1 | 21.9 | 7.2 | 0.3 | 0.0 | 2.0 | 0.2 |
| Delay (s) | 31.6 | | 10.0 | 10.2 | | 21.9 | 50.2 | 42.9 | 17.0 | 18.9 | 36.1 | 1.5 |
| Level of Service | C | | B | B | | C | D | D | B | B | D | A |
| Approach Delay (s) | | 21.3 | | | 14.5 | | | 39.8 | | | 7.5 | |
| Approach LOS | | C | | | B | | | D | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 25.8 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.82 | | |
| Actuated Cycle Length (s) | 90.0 | Sum of lost time (s) | 17.0 |
| Intersection Capacity Utilization | 77.2% | ICU Level of Service | D |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

# RAMPS AND RAMP JUNCTIONS WORKSHEET

## General Information / Site Information

| | | | |
|---|---|---|---|
| Analyst2 | SEH Inc. | Freeway/Dir of Travel | US 160 Westbound |
| Agency or Company | | Junction | Grandview Ramp C |
| Date Performed | 1/5/2011 | Jurisdiction | |
| Analysis Time Period | AM Peak | Analysis Year | Year 2030 + 67% Inflation |

Project Description Year 2030 Analysis for the US 550 at Us 160 Section 4(f)

## Inputs

Upstream Adj Ramp

Yes On

No Off

$L_{up}$ = ft

$V_u$ = veh/h

Terrain Rolling

$S_{FF}$ = 60.0 mph $S_{FR}$ = 40.0 mph

Sketch ( show lanes, $L_A$, $L_D$,$V_R$,$V_f$)

Downstream Adj Ramp

Yes On

No Off

$L_{down}$ = ft

$V_D$ = veh/h

## Conversion to pc/h Under Base Conditions

| (pc/h) | V (Veh/hr) | PHF | Terrain | Truck | %Rv | $f_{HV}$ | $f_p$ | v=V/PHF $f_{HV}$ $f_p$ |
|---|---|---|---|---|---|---|---|---|
| Freeway | 1940 | 0.95 | Rolling | 5 | 0 | 0.930 | 1.00 | 2195 |
| Ramp | 2312 | 0.95 | Rolling | 2 | 0 | 0.971 | 1.00 | 2507 |
| UpStream | | | | | | | | |
| DownStream | | | | | | | | |

### Merge Areas

## Estimation of $v_{12}$

$V_{12} = V_F ( P_{FM})$

$L_{EQ}$ = (Equation 25-2 or 25-3)

$P_{FM}$= 0.631 using Equation 1

$V_{12}$= 1384 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $V_{FO}$ | 4702 | See Exhibit 25-7 | No |
| $V_{R12}$ | 3891 | 4600:All | No |

## Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

$D_R$ = 22.8 (pc/ m/ln)

LOS = C (Exhibit 25-4)

## Speed Estimation

$M_S$ = 0.360 (Exibit 25-19)

$S_R$= 53.5 mph (Exhibit 25-19)

$S_0$= 58.9 mph (Exhibit 25-19)

S= 54.4 mph (Exhibit 25-14)

### Diverge Areas

## Estimation of $v_{12}$

$V_{12} = V_R + (V_F - V_R)P_{FD}$

$L_{EQ}$ = (Equation 25-8 or 25-9)

$P_{FD}$ = using Equation

$V_{12}$ = pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $V_{FI}=V_F$ | | See Exhibit 25-14 | |
| $V_{12}$ | | 4400:All | |
| $V_{FO} = V_F - V_R$ | | See Exhibit 25-14 | |
| $V_R$ | | See Exhibit 25-3 | |

## Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

$D_R$ = (pc/ m/ln)

LOS= (Exhibit 25-4)

## Speed Estimation

$D_s$ = (Exhibit 25-19)

$S_R$= mph (Exhibit 25-19)

$S_0$= mph (Exhibit 25-19)

S = mph (Exhibit 25-15)

# RAMPS AND RAMP JUNCTIONS WORKSHEET

## General Information / Site Information

| | | | |
|---|---|---|---|
| Analyst2 | SEH Inc. | Freeway/Dir of Travel | US 160 Westbound |
| Agency or Company | | Junction | Grandview Ramp C |
| Date Performed | 1/5/2011 | Jurisdiction | |
| Analysis Time Period | PM Peak | Analysis Year | Year 2030 + 67% Inflation |

Project Description Year 2030 Analysis for the US 550 at Us 160 Section 4(f)

## Inputs

Upstream Adj Ramp

Yes On

No Off

$L_{up}$ = ft

$V_u$ = veh/h

Terrain Rolling

$S_{FF}$ = 60.0 mph $S_{FR}$ = 40.0 mph

Sketch ( show lanes, $L_A$, $L_D$,$V_R$,$V_f$)

Downstream Adj Ramp

Yes On

No Off

$L_{down}$ = ft

$V_D$ = veh/h

## Conversion to pc/h Under Base Conditions

| (pc/h) | V (Veh/hr) | PHF | Terrain | Truck | %Rv | $f_{HV}$ | $f_p$ | v=V/PHF $f_{HV}$ $f_p$ |
|---|---|---|---|---|---|---|---|---|
| Freeway | 3440 | 0.95 | Rolling | 5 | 0 | 0.930 | 1.00 | 3893 |
| Ramp | 1975 | 0.95 | Rolling | 2 | 0 | 0.971 | 1.00 | 2141 |
| UpStream | | | | | | | | |
| DownStream | | | | | | | | |

### Merge Areas

## Estimation of $v_{12}$

$V_{12} = V_F ( P_{FM})$

$L_{EQ}$ = (Equation 25-2 or 25-3)

$P_{FM}$= 0.631 using Equation 1

$V_{12}$= 2455 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $V_{FO}$ | 6034 | See Exhibit 25-7 | No |
| $V_{R12}$ | 4596 | 4600:All | No |

## Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

$D_R$ = 28.4 (pc/ m/ln)

LOS = D (Exhibit 25-4)

## Speed Estimation

$M_S$ = 0.555 (Exibit 25-19)

$S_R$= 50.0 mph (Exhibit 25-19)

$S_0$= 56.6 mph (Exhibit 25-19)

S= 51.4 mph (Exhibit 25-14)

### Diverge Areas

## Estimation of $v_{12}$

$V_{12} = V_R + (V_F - V_R)P_{FD}$

$L_{EQ}$ = (Equation 25-8 or 25-9)

$P_{FD}$ = using Equation

$V_{12}$ = pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $V_{FI}=V_F$ | | See Exhibit 25-14 | |
| $V_{12}$ | | 4400:All | |
| $V_{FO} = V_F - V_R$ | | See Exhibit 25-14 | |
| $V_R$ | | See Exhibit 25-3 | |

## Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

$D_R$ = (pc/ m/ln)

LOS= (Exhibit 25-4)

## Speed Estimation

$D_s$ = (Exhibit 25-19)

$S_R$= mph (Exhibit 25-19)

$S_0$= mph (Exhibit 25-19)

S = mph (Exhibit 25-15)

# RAMPS AND RAMP JUNCTIONS WORKSHEET

## General Information

| | |
|---|---|
| Analyst2 | SEH Inc. |
| Agency or Company | |
| Date Performed | 1/5/2011 |
| Analysis Time Period | PM Peak |

## Site Information

| | |
|---|---|
| Freeway/Dir of Travel | US 160 Westbound |
| Junction | Grandview Ramp C |
| Jurisdiction | |
| Analysis Year | Year 2030 +67% Inflation+5cars |

Project Description Year 2030 Analysis for the US 550 at Us 160 Section 4(f)

## Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☐ No ☐ Off

$L_{up}$ = ft

Vu = veh/h

Terrain Rolling

$S_{FF}$ = 60.0 mph $S_{FR}$ = 40.0 mph

Sketch ( show lanes, $L_A$, $L_D$, $V_R$, $V_f$)

Downstream Adj Ramp

☐ Yes ☐ On

☐ No ☐ Off

$L_{down}$ = ft

VD = veh/h

## Conversion to pc/h Under Base Conditions

| (pc/h) | V (Veh/hr) | PHF | Terrain | Truck | %Rv | $f_{HV}$ | $f_p$ | v=V/PHF $f_{HV}$ $f_p$ |
|---|---|---|---|---|---|---|---|---|
| Freeway | 3440 | 0.95 | Rolling | 5 | 0 | 0.930 | 1.00 | 3893 |
| Ramp | 1980 | 0.95 | Rolling | 2 | 0 | 0.971 | 1.00 | 2147 |
| UpStream | | | | | | | | |
| DownStream | | | | | | | | |

### Merge Areas

## Estimation of $v_{12}$

$V_{12} = V_F\ (P_{FM})$

$L_{EQ}$ = (Equation 25-2 or 25-3)

$P_{FM}$= 0.631 using Equation 1

$V_{12}$= 2455 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $V_{FO}$ | 6040 | See Exhibit 25-7 | No |
| $V_{R12}$ | 4602 | 4600:All | Yes |

## Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\ v_R + 0.0078\ V_{12} - 0.00627\ L_A$

$D_R$ = 28.5 (pc/ m/ln)

LOS = F (Exhibit 25-4)

## Speed Estimation

$M_S$ = 0.558 (Exibit 25-19)

$S_R$= 50.0 mph (Exhibit 25-19)

$S_0$= 56.6 mph (Exhibit 25-19)

S= 51.4 mph (Exhibit 25-14)

### Diverge Areas

## Estimation of $v_{12}$

$V_{12} = V_R + (V_F - V_R)P_{FD}$

$L_{EQ}$ = (Equation 25-8 or 25-9)

$P_{FD}$ = using Equation

$V_{12}$ = pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $V_{FI}=V_F$ | | See Exhibit 25-14 | |
| $V_{12}$ | | 4400:All | |
| $V_{FO} = V_F - V_R$ | | See Exhibit 25-14 | |
| $V_R$ | | See Exhibit 25-3 | |

## Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\ V_{12} - 0.009\ L_D$

$D_R$ = (pc/ m/ln)

LOS= (Exhibit 25-4)

## Speed Estimation

$D_s$ = (Exhibit 25-19)

$S_R$= mph (Exhibit 25-19)

$S_0$= mph (Exhibit 25-19)

S = mph (Exhibit 25-15)

# SEH MEMORANDUM

# US 160 and US 550 Year 2030 Traffic Volume Verification

# June 23, 2011

MEMORANDUM

TO: Mike McVaugh, CDOT Region 5 Traffic and Safety Engineer

FROM: Phil Weisbach, PE, Project Manager
Jon Larson, PE, Traffic Engineer

DATE: June 23, 2011

RE: US 160 and US 550 Year 2030 Traffic Volume Verification
SEH No. 112456-COTO5

Based on your direction, we have calculated a seasonal Year 2030 daily traffic volume on US 160 and US 550 using current traffic data. The updated Year 2030 daily traffic volumes are presented in this memo along with the future projected traffic volumes from the 2006 US 160 EIS (Year 2025), 2006 US 160 EIS (Updated to Year 2030) and 2005 US 550 EA (Year 2025).

The fundamental question this memo is intended to answer are:

1. How do the projected traffic volumes from the 2006 US 160 EIS (Updated to Year 2030) compare with the updated Year 2030 projected volumes using current data available?

**Summary of Results:**

| Year 2030 Projected Volumes | 2006 US 160 EIS | Current Data[1] | $\Delta^2$ |
|---|---|---|---|
| ADT on US 160<br>East of Farmington Hill | 91,450 | 85,900 | -6.5% |
| ADT on US 550<br>South of US 160 / US 550 | 19,000[3] | 19,550 | 2.9% |

Notes:

1) These are the Year 2030 projected volumes that will be used in this document.

2) The difference between the Year 2030 volumes used in the 2006 US 160 EIS and the Year 2030 volumes derived using current data.

3) The future projected volumes used in the 2006 US 160 EIS were referenced from the 2005 US 550 EA.

## Year 2030 Projected Traffic Volumes on US 160 (Figure 1)

Year 2025 future projected traffic volumes for the 2006 US 160 EIS were estimated using the available data at that time. Additional analysis was performed along the US 160 corridor using Year 2030 future projected traffic volumes that were developed based from the assumptions in the 2006 US 160 EIS. The purpose of the following analysis is to develop Year 2030 traffic volumes from the most current data while still utilizing the same set of assumptions for which the 2006 US 160 EIS Year 2025 volumes were developed. One daily volume location west of Grandview provided the anchor for which all of the daily traffic volumes were developed along the US 160 corridor in the 2006 US 160 EIS. Therefore, this location is the focus of our analysis. The Vehicle Miles Traveled (VMT) was calculated based on data provided on the CDOT website for the US 160 corridor between mileposts 88.316 and 91.478. The VMTs are included on Figure 1 with the summary of daily volumes.

**Year 2025 Projected Volumes Used in the 2006 US 160 EIS**

A 2025 seasonal background daily volume of 42,500 vehicles per day (vpd) was applied to the west of the project and used as a control volume for the project corridor through Grandview. The seasonal volumes are used in the analysis because it represents a worst case scenario. This background volume did not include the volume generated by the Grandview development. Trips generated by the Grandview development were added to the background traffic to estimate the total 2025 seasonal daily traffic volume. The trips were distributed to the network assuming 75% to/from the west, 20% to/from the east, and 5% to/from the south. Since the daily volume we are working to update is located to the west of the Grandview development, then traffic distributed to US 160 assumes 75% of the trips generated by the development are included in the year 2025 total traffic volume. The Year 2025 Total traffic volume includes the following calculations:

| | | |
|---|---|---|
| Year 2025 Background Volume | = | 42,500 vpd |
| **Year 2025 Total Volume** | = | **87,900 vpd** (Fig. 8 from 2006 US 160 EIS, App. A) |
| Grandview Trips (Daily) | = | 45,400 vpd (west of Grandview Development) |

**Year 2030 Projected Volumes Based on the 2006 US 160 EIS**

Traffic volumes from the Year 2025 are documented in Appendix A, Traffic Report, Figure 8 of the 2006 US 160 EIS. The 2025 background traffic volumes were projected based on the background annual growth rates in the accepted methodology in the 2006 US 160 EIS to calculate the year 2030 background scenario. For this scenario it is assumed the approved development of the 2004 Grandview Area Plan by the City of Durango and La Plata County is fully built out in the year 2030. The trips generated by the Grandview development were combined with the year 2030 background volumes to generate the year 2030 total peak hour volumes used in the analysis. Based on the CDOT website information, the design hour volume represents the 10% of the daily traffic volume. Therefore, it was assumed that the PM peak hour is a reasonable design hour period and represented 10% of the daily traffic volume. Taking the Year 2030 PM peak hour directional volume on US 160 just east of Farmington Hill and dividing by the 10% peak-to-daily ratio results in the following daily volume projection for Year 2030.

| | | |
|---|---|---|
| Year 2030 PM Peak Volume | = | 9,145 vph |
| PM Peak-to-Daily Ratio | = | 10% |
| **Year 2030 Total Volume** | **=** | **91,450 vpd** |

**Updated Year 2030 Projected Volumes w/Current Traffic Data**

Daily traffic volumes were collected each day for one year during 2010 via an automatic traffic recorder (ATR) installed at milepost 84 on US 160 within 4.5 miles of the project area. The volumes were averaged over the entire year to calculate the annual average daily traffic (AADT) volumes. However, the seasonal peak daily volumes are used in the traffic operations analysis for this document because the 2006 US 160 EIS bases its analysis on seasonal volumes, which is the worst case. Though, the recorder location is not within the study area for this document, the volumes at the recorder location were used to derive a seasonal peak factor that will be applied to an actual 2009 AADT that was collected within the study area.

The daily volumes from the ATR were averaged over the course of July and August to come up with an average daily traffic (ADT) volume for a typical day during the peak season in 2010. A typical day includes Tuesday, Wednesday, and Thursday, which means the data points for Friday, Saturday, Sunday, and Monday were removed from the dataset. The ratio of the seasonal peak ADT and the AADT represents the seasonal peak daily factor. The seasonal factor is 1.25. The 20-year growth factor referenced from CDOT's website is 1.56 or 2.25 percent annual average growth. Therefore, the 21-year growth factor is 1.60. The Year 2030 background daily traffic volume was calculated by multiplying the 21-year growth factor by the year 2010 seasonal ADT volume.

Over the past 10 years, a percentage of the Grandview development has since been constructed and is included in the existing traffic volumes. The *Trip Generation Study Status Report for Three Springs Development* (March 2011) concluded that the land use that is already constructed is currently generating 5,290 vehicles per day. Therefore, the net trips generated by the full Grandview development minus the trips from land use already constructed were combined with the year 2030 background volumes to generate the Year 2030 total daily traffic volume. The following calculations were used to derive the updated Year 2030 traffic volume:

**US 160 Automatic Traffic Recorder @ MP 84**

| | | | |
|---|---|---|---|
| AADT (Eastbound) | = | 15,117 veh/day | |
| AADT (Westbound) | = | 15,057 veh/day | |
| AADT | = | 30,174 veh/day | |
| Seasonal ADT (Eastbound) | = | 18,865 veh/day | |
| Seasonal ADT (Westbound) | = | 18,710 veh/day | |
| Seasonal ADT (July/August) | = | 37,575 veh/day | (Typical Weekday volumes Tues, Wed, Th) |
| Seasonal Factor | = | 37,575 / 30,174 | |
| | = | 1.25 | (Multiply AADT @ MP 88-91 by this factor to get seasonal ADT) |

**US 160 @ MP 88.316 to 91.478**

| | | | |
|---|---|---|---|
| 2009 AADT (Actual) | = | 22,300 veh/day (CDOT Website) | |
| 2009 Seasonal ADT | = | 22,300 * 1.25 | |
| | = | 27,875 veh/day | |
| 20-year factor | = | 1.56 OR 2.25% average annual growth (CDOT Website)<br>*Need to add one more year to get to Year 2030* | |
| 21-year factor | = | **1.60** | |
| Year 2030 Seasonal ADT | = | 27,875 * 1.60 | |
| | = | **44,478 veh/day** | **(Background Volume)** |

| | | |
|---|---|---|
| Grandview Development Trip Bank (For Westbound Trips) | = | 45,400 vpd |
| Existing Grandview Development Volume (Actual) | = | -5,290 vpd |
| West Distribution | = | 75% |
| Existing Grandview Development Volume To/From West | = | -3,968 vpd |
| Remaining Volume in Grandview Bank (For Westbound Trips) | = | **41,432 vpd** |

| | | | |
|---|---|---|---|
| Year 2030 Seasonal ADT | = | 44,478 veh/day | (Background Volume) |
| Grandview Trips Remaining | = | 41,432 veh/day | (Grandview Trip Bank) |
| Total Year 2030 Seasonal ADT | = | **85,910 veh/day** | **(Total Seasonal ADT)** |

**Comparison of Year 2030 Projected Volumes Based on the 2006 US 160 EIS to Updated Year 2030 Projected Volumes w/Current Traffic Data**

From the results above, the year 2030 projected volumes based on the 2006 US 160 EIS are 91,450 vpd compared to 85,900 vpd for updated year 2030 projected volumes using current traffic data. This is a difference of 5,550 vehicles per day or 6.5%. Because the 2030 projected volumes were reproduced within 6.5% of each other a decade apart, the above verification demonstrates that the traffic forecasts based on the 2006 US 160 EIS methodology for US 160 are fundamentally sound and reliable for traffic operations analysis purposes.

## Year 2030 Projected Traffic Volumes on US 550 (Figure 1)

Year 2025 future projected traffic volumes for the 2005 US 550 Environmental Assessment (EA) were estimated using the available data at that time. The purpose of the following analysis is to develop Year 2030 traffic volumes from the most current data utilizing the same set of assumptions for which the Year 2030 daily volumes on US 160 in the previous section. The Vehicle Miles Traveled (VMT) was calculated based on data provided on the CDOT website for the US 550 corridor between mileposts 15.682 and 16.561. The VMTs are included on Figure 1 with the summary of daily volumes. The methodology for projecting future volumes on US 550 is the same as the US 160 methodology above.

**Year 2025 Projected Volumes Used in the US 550 EA**

The 2005 US 550 EA determined that 15,583 vpd is a reasonable Year 2025 seasonal background daily volume. This background volume did not include the volume generated by the Grandview development. Trips generated by the Grandview development were added to the background traffic to estimate the total 2025 seasonal daily traffic volume. The trips were distributed to the network assuming 75% to/from the west, 20% to/from the east, and 5% to/from the south. Since the daily volume we are working to update is located to the south of the Grandview development, then traffic distributed to US 550 assumes 5% of the trips generated by the development are included in the year 2025 total traffic volume. The Year 2025 Total traffic volume includes the following calculations:

| | | |
|---|---|---|
| Year 2025 Background Volume | = | 15,583 vpd |
| Grandview Trips (Daily) | = | 3,430 (south of Grandview Development) |
| **Year 2025 Total Volume** | = | **19,000 vpd** |

**Updated Year 2030 Projected Volumes w/Current Traffic Data**

Daily traffic volumes were collected each day for one year during 2010 via an automatic traffic recorder (ATR) installed at milepost US 550 approximately 15 miles from the project area. The volumes were averaged over the entire year to calculate the annual average daily traffic (AADT) volumes. However, the seasonal peak daily volumes are used in the traffic operations analysis in this document. Though, the recorder location is not within the study area of this document, the volumes were used to derive a seasonal peak factor that will be applied to an actual 2009 AADT within mileposts 15.682 and 16.561 on the CDOT website.

The daily volumes from the ATR were averaged over the course of July and August to come up with an average daily traffic (ADT) volume for a typical day during the peak season in 2010. A typical day includes Tuesday, Wednesday, and Thursday, which means the data points for Friday, Saturday, Sunday, and Monday were removed from the dataset. The ratio of the seasonal peak ADT and the AADT represents the seasonal peak daily factor. The seasonal factor is 1.18. The 20-year growth factor referenced from CDOT's website is 1.59 or 2.35 percent annual average growth. Therefore, the 21-year growth factor is 1.63. The Year 2030 background daily traffic volume was calculated by multiplying the 21-year growth factor by the year 2010 seasonal ADT volume.

Over the past 10 years, a percentage of the Grandview development has since been constructed and is included in the existing traffic volumes. The *Trip Generation Study Status Report for Three Springs Development* (March 2011) concluded that the land use that is already constructed is currently generating 5,290 vehicles per day. Therefore, the net trips generated by the full Grandview development minus the trips from land use already constructed were combined with the year 2030 background volumes to generate the Year 2030 total daily traffic volume. The following calculations were used to derive the updated Year 2030 traffic volume:

**US 550 Automatic Traffic Recorder @ MP 0**

| | | | |
|---|---|---|---|
| AADT (Northbound) | = | 3,811 veh/day | |
| AADT (Southbound) | = | 3,774 veh/day | |
| AADT | = | 7,585 veh/day | |
| Seasonal ADT (Northbound) | = | 4,523 veh/day | |
| Seasonal ADT (Southbound) | = | 4,462 veh/day | |
| Seasonal ADT (July/August) | = | 8,985 veh/day | (Typical Weekday volumes Tues, Wed, Th) |
| Seasonal Factor | = | 8,985 / 7,585 | |
| | = | 1.18 | (Multiply AADT @ MP 88-91 by this factor to get seasonal ADT) |

**US 550 @ MP 15.682 to 16.561**

| | | | |
|---|---|---|---|
| 2009 AADT (Actual) | = | 8,400 veh/day (CDOT Website) | |
| 2009 Seasonal ADT | = | 8,400 * 1.18 | |
| | = | 9,950 veh/day | |
| 20-year factor | = | 1.59 OR 2.35% average annual growth (CDOT Website)<br>*Need to add one more year to get to Year 2030* | |
| 21-year factor | = | **1.63** | |
| Year 2030 Seasonal ADT | = | 9,950 * 1.63 | |
| | = | **16,205 veh/day** | **(Background Volume)** |

| | | |
|---|---|---|
| Grandview Development Trip Bank (For North/South Trips) | = | 3,430 vpd |
| Existing Grandview Development Volume (Actual) | = | -5,290 vpd |
| North/South Distribution<br>(Can use 3 highways to go north/south – US 550, Three Springs, SH 172) | = | 5% / 3 |
| Existing Grandview Development Volume To/From West | = | -90 vpd |

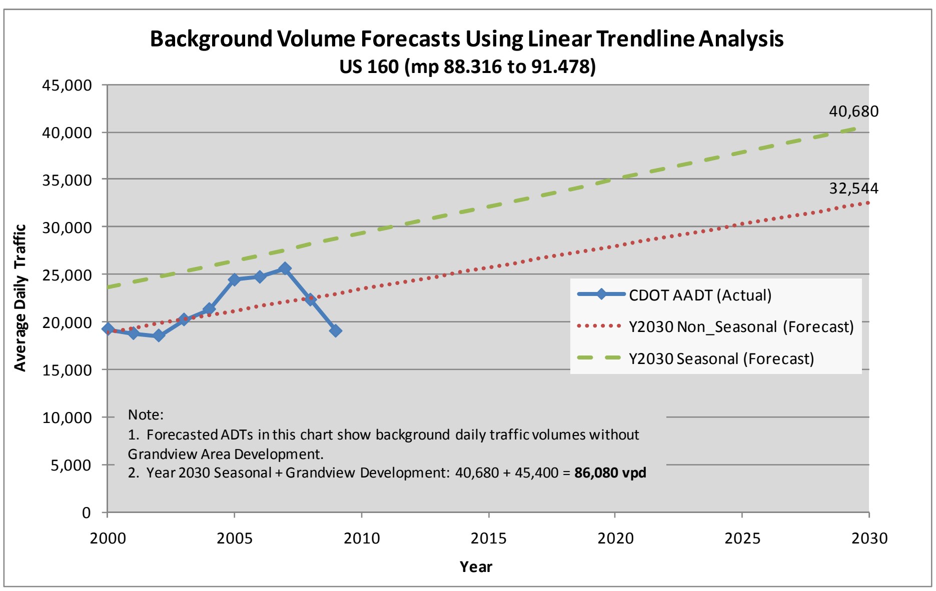
| Remaining Volume in Grandview Bank (For Westbound Trips) | = | **3,340 vpd** | |
|---|---|---|---|
| Year 2030 Seasonal ADT | = | 16,205 veh/day | (Background Volume) |
| Grandview Trips Remaining | = | 3,340 veh/day | (Grandview Trip Bank) |
| Total Year 2030 Seasonal ADT | = | **19,550 veh/day** | **(Total Seasonal ADT)** |

## Actual Versus Forecasted Volumes

The following traffic forecasts represent an alternative methodology to the official traffic forecast methods utilized above. The purpose of this section is to utilize historical CDOT AADT data to develop year 2030 ADTs along US 160 and US 550 using a trendline analysis to determine how well this methodology compares to the official method. The major difference in the historical AADT data used below is that the AADT from each year was developed from the collection of a few daily traffic volume data points throughout the respective year and then entered into an algorithm to derive the annual average daily traffic volume. The methodology in the previous section utilizes actual daily traffic volumes collected each day for 365 days and is averaged to develop an actual annual average daily traffic volume. The official method for projecting year 2030 daily traffic volumes is expected to provide a more reasonable estimation of the future traffic volumes since it is based on an actual AADT with 365 data points instead of an AADT based on 3 or 4 data points.

### US 160

Actual AADT volumes on US 160 within the study area of this document were collected yearly between 2001 and 2010. The actual AADTs were plotted on a graph and a linear trendline was used to forecast the volumes to the year 2030. The trendline was statistically calculated to represent the linear line that best fits the CDOT AADT dataset. The following graph shows the actual CDOT AADTs versus the non-seasonal and seasonal forecasted volumes.




The graph shows the following volume characteristics:

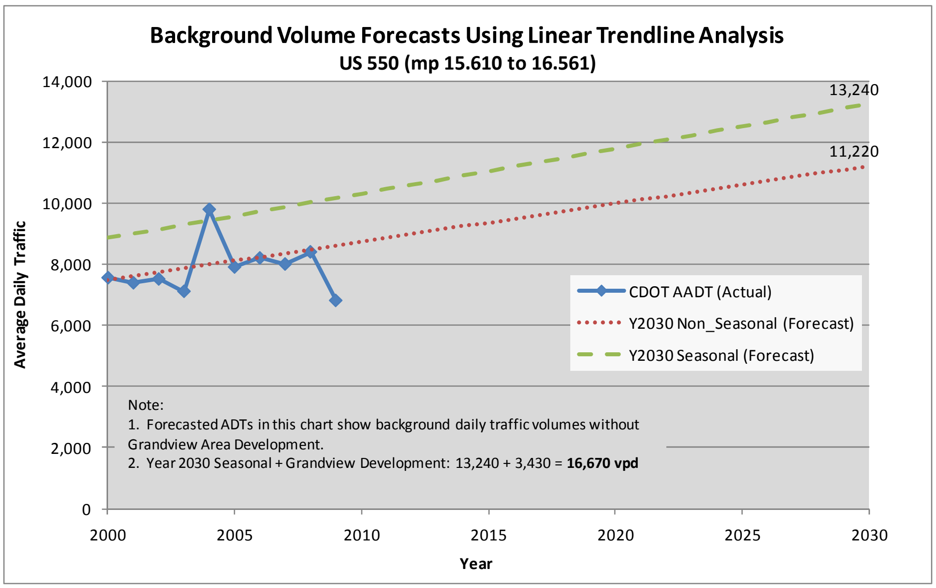
- From 2001 to 2003, measured traffic volumes remain nearly constant or exhibited a slight decrease.

- From 2003 to 2006, US 160 experienced a sharper than average increase in traffic volumes.
- From 2006 to 2008, traffic volumes increased on US 160 at a rate equal to the trendline rate.
- From 2008 to 2010, traffic volumes decreased sharply.

Though there are fluctuations in traffic volumes between each year, viewing the dataset as a whole shows that there is a general trend of increasing volumes per year based on the trendline analysis. The average growth rate using the linear regression analysis is approximately 2 percent per year. The average annual growth rate from the CDOT website is 2.25 percent per year. Finding: Calculating a year 2030 total daily volume that includes the Grandview development, using the separate but defensible trendline method, results in the 86,080 vehicles per day. ***Conclusion: The result is statistically the same as the official method used to calculate the volume of 85,900 described in this document.***

**US 550**

Actual AADT volumes on US 550 within the study area of this document were collected yearly between 2001 and 2010. The actual AADTs were plotted on a graph and a linear trendline was used to forecast the volumes to the year 2030. The trendline was statistically calculated to represent the linear line that best fits the CDOT AADT dataset. The following graph shows the actual CDOT AADTs versus the non-seasonal and seasonal forecasted volumes.




The graph shows the following volume characteristics:

- From 2001 to 2004, measured traffic volumes remain nearly constant.
- In 2005, US 550 experienced a sharper than average increase in traffic volumes.
- From 2006 to 2009, traffic volumes increased on US 550 at a rate equal to the trendline rate.
- In 2010, traffic volumes decreased sharply.

Though there are fluctuations in traffic volumes between each year, viewing the dataset as a whole shows that there is a general trend of increasing volumes per year based on the trendline analysis. The average growth rate using the linear regression analysis is approximately 1.6 percent per year. The average annual growth rate from the CDOT website is 1.3 percent per year. Finding: The calculation of the year 2030 total daily volume that includes the Grandview development using this separate but defensible trendline method results in 16,670 vehicles per day. ***Conclusion: The 16,670 vpd is approximately 17% fewer vehicles than the official method used to calculate the volume of 19,550 described in this document. Using the official 19,550 vpd in the SEIS provides the more conservative traffic analysis result. Any alternatives that operate at LOS D or better using the SEIS result of 19,550 vpd will operate at even a better LOS using the lower trendline traffic volume of 16,670 vpd. Nor is it anticipated that the relative operational efficiency among the Action Alternatives that resulted in acceptable LOS will change as a result of using the lower 16,670 traffic volume. The traffic operations failure of the No Action Alternative is so severe that even using the lower trendline result will still result in unacceptable LOS for the No Action Alternative.***

Additionally, a two-lane roadway of this type in mountainous terrain, 4% to 6% grades, 55 mile per hour free flow speed and no passing zones has an approximate acceptable capacity threshold of 13,500 vehicles per day. LOS along US 550 will diminish from LOS D to LOS E when the volumes exceed this threshold. Therefore, it is expected that US 550 will need to have four travel lanes to accommodate year 2030 daily volumes regardless of which volume forecast method is used.

Please feel free to contact Jon at 303.441.5417 or Phil at 303.441.5411 with any questions or comments.

jel

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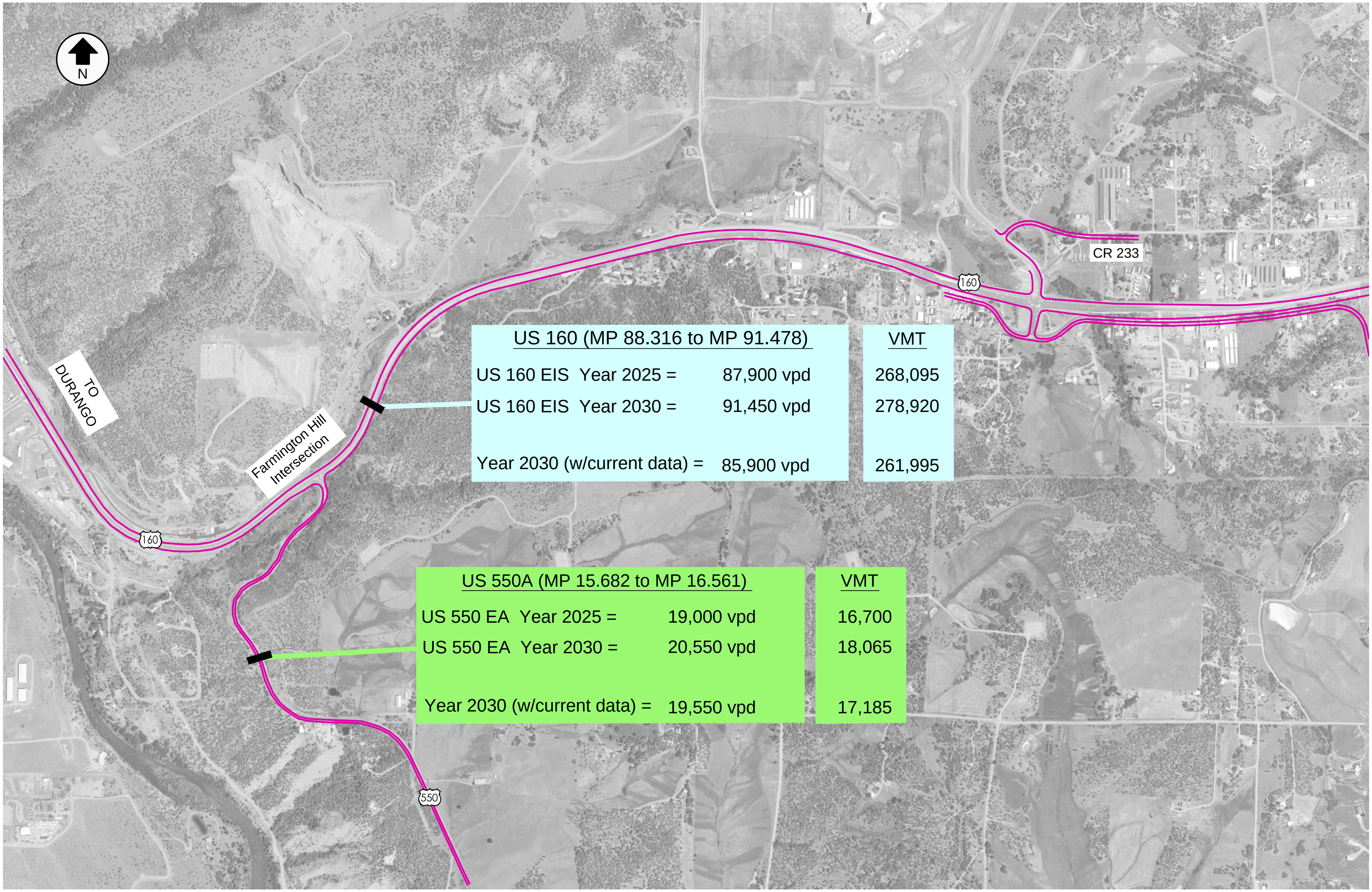



SEH

# US 550 Connection to US 160 in Grandview - Traffic Analysis
## Summary of Future Projected Daily Traffic Volumes

| Scale | 1"=1500' | Date | 6/23/11 | Drawn by | JEL | Job # | 112456 | Figure | 1 |
|---|---|---|---|---|---|---|---|---|---|

# SEH MEMORANDUM

# US 550 Connection to US 160 in Grandview SEIS— Traffic and Safety Analysis

# June 23, 2011

SEH MEMORANDUM

TO: Mike McVaugh, PE - CDOT Region 5

FROM: Phil Weisbach, PE Philip T. Weisbach
Jon E. Larson, PE Jon E. Larson

DATE: June 23, 2011[1]

RE: US 550 Connection to US 160 in Grandview SEIS - Traffic and Safety Analysis
SEH No. COTO5 - 112456

## Executive Summary

Alternatives for the US 550 connection to the US 160 corridor were originally evaluated in the 2006 US 160 EIS. The 2006 US 160 ROD documented selection of Grandview Alternative G Modified as the Preferred Alternative which included an interchange of US 160 with US 550 approximately 0.6 miles east of the current intersection.

A separate memo entitled *Year 2030 Traffic Operations Analysis for the US 550 at US 160 Section 4(f)* (December 23, 2010) analyzes whether the alternatives being considered in the 4(f) analysis meet the traffic carrying capacity requirements of the purpose and need in the year 2030.

On March 22, 2011 the FHWA approved the Draft Section 4(f) for the US 550 Connection to US 160 at Farmington Hill. As a result, the FHWA determined that the preparation of a Supplemental Environmental Impact Statement (SEIS) is required to supplement the existing 2006 US 160 EIS/ROD. However, this document need only be limited to the significant environmental impacts not evaluated in the 2006 US 160 EIS/ROD: **The US 550 Connection to US 160 at Farmington Hill**. (See attached FHWA directive)

This memo analyzes whether the alternatives being considered in this analysis meet the traffic carrying capacity requirements of the purpose and need in the year 2030 and comparatively evaluates the relative safety of the alternatives. As stated above, the alternatives in this document focus solely on the connection of US 550 to US 160 at Farmington Hill (See Figure 1).

The traffic volumes have been projected for a design period of 20 years to the year 2030. The analysis considers two through lanes in each direction and one auxiliary lane in each direction extending from the CR 233 (Three Springs) interchange to the west end of the Grandview Section, except for the No Action Alternative. The auxiliary lanes in the No Action Alternative begin east of the current US 160 / US 550 intersection location. The following is a summary description of the alternatives:

- **No Action Alternative** includes a US 160 / US 550 signalized intersection at its current location in the year 2030. The 3-legged intersection configuration remains unchanged and includes two through lanes and one free right turn lane in the eastbound direction, two through lanes and one exclusive left turn lane in the westbound direction, and one exclusive left turn lane and one exclusive right turn lane

[1] The only change made to the previous SEIS memo dated May 11, 2011 and this document was to add the LOS operations for the US 550 segment on the No Action alternative (Figure 2).

in the northbound direction. This alternative assumes a roundabout at the Grandview trumpet interchange and a SPUI at the Three Springs / CR 233 interchange.

- **Revised G Modified** is the same as G Modified from the 2006 US 160 EIS except it includes a roundabout at the Grandview Interchange ramp termini, removes the southbound to westbound US 160 on-ramp (ramp e), and combines this vehicle movement with northbound to westbound US 160 on-ramp (ramp c).
- **Revised F Modified** is the same as in the 2006 US 160 EIS except it includes the Grandview Interchange and auxiliary lanes in each direction from the west limit of the Grandview Section to the CR 233 (Three Springs) Interchange.
- **Eastern Realignment Alternative** is the same configuration as the Revised F Modified Alternative and connects to US 550 to US 160 at the Three Springs / CR 233 interchange. However, it has a different US 550 alignment when compared to the US 550 alignment in the Revised F Modified Alternative. Therefore, the traffic operational analysis for this alternative is the same as the Revised F Modified Alternative.

The technical results and supporting data of these analyses are included in the appendices of this memo.

The purpose for improvements to the US 160 corridor include increasing travel efficiency and capacity to meet current and future needs, while improving safety for the traveling public by reducing the number and severity of accidents, and controlling access. The design year of this document is 2030.

**Summary of Results:** The results of the analysis performed are summarized below:

| US 550 Connection to US 160 in Grandview SEIS | | Purpose and Need | | | |
|---|---|---|---|---|---|
| | | Capacity | | Safety | |
| | | Met | Not Met | Met | Not Met |
| A | No Action | | ✓ | | ✓ |
| B | Revised G Modified | ✓ | | ✓* | |
| C | Revised F Modified | ✓ | | ✓ | |
| D | Eastern Realignment | ✓ | | ✓ | |

* Greater potential for safety improvement at Revised G Modified Alternative with the addition of a roundabout over a signalized intersection at the US 550 connection to US 160.

## Evaluation Criteria for Capacity

The interchange alternatives were evaluated to determine if each alternative met operational level of service requirements as described in the Executive Summary of the 2006 US 160 EIS, based on guidance in the AASHTO Policy on Geometric Design of Highways and Streets 2004 (AASHTO Green Book) and capacity analysis performed according to the methods described in the Highway Capacity Manual[2] (HCS). This memorandum deals with the capacity analysis and not design. Traffic volumes used in the analysis are year 2030 seasonal peak hour volumes that were projected using year 2009 traffic count data, growth factors from the CDOT website, and trip generation estimates from the Grandview development. The 2030 background traffic volumes were projected based on the background annual growth rates in the accepted methodology in the *US 160 and US 550 Year 2030 Traffic Volume Verification* memo dated June 23, 2011 to calculate the year 2030 background scenario. The trips generated by the Grandview development were combined with the year 2030 background volumes to generate the year 2030 total seasonal peak hour volumes used in the analysis.

For the purposes of this analysis, US 160 is assumed to be east/west and US 550 is assumed to be north/south.

**US 160 Interchanges and Signalized Intersections**

The capacity requirement for the purpose and need of the Grandview Section is as follows:

- A Level of Service (LOS) D or better for an urban signalized intersection, including signalized intersections at single point urban interchanges (SPUI), and its individual legs or movements during the peak hour in year 2030; and
- A LOS D or better for urban interchange merge, diverge, weaving area, auxiliary lanes. and/or freeway sections during the peak hour in year 2030.

LOS is a measure used to describe operational conditions at an intersection. LOS categories ranging from A to F are assigned based on the predicted delay in seconds per vehicle for the intersection as a whole and for individual turning movements. LOS A indicates very good operations, and LOS F indicates poor, congested operations. Anything worse than LOS D for any intersection, leg, movement, ramp, auxiliary lane, or freeway section is considered “failing,” and not meeting the purpose and need. These criteria were applied to the alternatives analyzed in this memorandum.

## US 550 Connection to US 160 in Grandview Alternatives

Using the year 2030 volumes developed along the US 160 corridor, four alternatives were analyzed. The alternatives were evaluated to determine if each met capacity requirements as described in the purpose and need of the 2006 US 160 EIS but in the design year 2030. The analysis considers two through lanes in each direction and one auxiliary lane in each direction extending from the CR 233 (Three Springs) interchange to the west end of the Grandview Section, except for the No Action Alternative. The auxiliary lanes in the No Action Alternative begin east of the current US 160 / US 550 intersection location. The auxiliary lanes are not continuous over the entire distance from CR 233 to the west end of the Grandview Section on US 160. The auxiliary lanes drop off at the off-ramps for the Grandview and Three Springs Interchanges, and begin again where the Grandview and Three Springs Interchange on-ramps merge with US 160.

[2] Highway Capacity Manual - Special Report 209. Transportation Research Board. National Research Council. 2000.

## A. No Action Alternative – Figure 2

The No Action Alternative includes two through lanes in each direction on US 160 east and west of the current intersection location with US 550. The analysis considers two through lanes in each direction and one auxiliary lane in each direction that begins east of the existing US 550 / US 160 intersection location. The intersection of US 550 / US 160 connects at its existing location and is signalized. The existing laneage includes:

- *Eastbound Approach* – two through lanes and one exclusive free right turn lane;
- *Westbound Approach* – two through lanes and one exclusive left turn lane controlled by protected only phasing; and
- *Northbound Approach* – one exclusive left turn lane and one exclusive right turn lane both controlled by protected only phases.

This alternative assumes a roundabout at the Grandview trumpet interchange and a SPUI at the Three Springs / CR 233 interchange. The analysis worksheets are contained in Appendix A for reference.

**<u>Connection of US 550 to US 160</u>**
The analysis of the No-Action Alternative (Figure 2) shows that the signalized intersection and numerous individual movements are expected to operate at LOS F in the morning and evening peak periods. Numerous cycle lengths and splits were evaluated, however, an acceptable level of service could not be achieved. Additionally, without an auxiliary lane in each direction, the freeway segment to the west of the signalized intersection is expected to operate at LOS F during the evening peak period.

**<u>Adjacent interchanges in the Grandview Section</u>**
The merge and diverge movements at the Grandview and Three Springs interchanges are expected to operate at LOS B or better during morning peak period and LOS C or better during the evening peak period. The weaving segment for westbound US 160 between Three Springs interchange and Grandview interchange is expected to operate at LOS B or better during morning peak period and LOS C or better during the evening peak period as well.

The signalized intersection in the center of the Three Springs interchange is expected to operate at LOS C during the morning and evening peak periods (90 second cycle AM, 110 second cycle PM), and all of individual movements are expected to operate at LOS D or better during both peak periods.

**<u>Conclusion</u>**
This alternative does not meet capacity requirements for the purpose and need because the signalized US 550/US 160 intersection does not have the capacity to maintain LOS D or better in the morning and evening peak periods.

## B. Revised Alternative G Modified – Figure 3

This alternative includes two through lanes in each direction through the Grandview Section with eastbound and westbound auxiliary lanes from the CR 233 (Three Springs) interchange to the west end of the section. This alternative connects US 550 to US 160 via the Grandview trumpet interchange. Traffic on US 550 is accommodated at its intersection with US 160 by a roundabout. The roundabout configuration has 220-foot inscribed circle diameter and includes two circulation lanes with right turn bypass lanes for eastbound and northbound directions. The northbound right turn bypass is the westbound US 160 on-ramp. The analysis worksheets are contained in Appendix B for reference.

**Connection of US 550 to US 160**

The analyses (Figure 3) of the Revised G Modified Alternative shows that the freeway segments and ramp merge/diverge operations associated with the connection of US 550 to US 160 are expected to operate at LOS C or better during the morning peak period and LOS D or better during the evening peak period.

The roundabout was analyzed using RODEL. Doubling the circulating lanes from 1-lane to 2-lanes does not translate into the doubling of the capacity of the roundabout. There is slightly less capacity per lane with a dual lane roundabout. Therefore, the capacity factor for the roundabout was reduced to 0.9 for the two-lane approaches. Additionally, it was evaluated at an 85% confidence level, which simulates the worst few minutes of the peak period instead of the average delay across the whole peak period. The results in RODEL with these assumptions are considered conservative, which provides an increased level of confidence that the results are dependable. The analysis shows that the roundabout is expected to operate at LOS A during the morning and evening peak periods.

**Adjacent interchanges in the Grandview Section**

The merge and diverge movements at the Three Springs interchange are expected to operate at LOS B or better during morning peak period and LOS C or better during the evening peak period. The weaving segment for westbound US 160 between Three Springs interchange and Grandview interchange is expected to operate at LOS B or better during morning peak period and LOS C or better during the evening peak period as well.

The signalized intersection in the center of the Three Springs interchange is expected to operate at LOS C during the morning and evening peak periods (90 second cycle AM, 110 second cycle PM), and all of individual movements are expected to operate at LOS D or better during both peak periods.

**Conclusion**

The analysis shows that this alternative satisfies the capacity requirements of the purpose and need in the year 2030 because this alternative accommodates the projected year 2030 volumes at LOS D or better.

## D. Revised Alternative F Modified and Eastern Realignment Alternative– Figure 4

These two alternatives will both connect to the CR 233 (Three Springs) interchange. The Revised F Modified includes an additional trumpet interchange at the Grandview Interchange, and a SPUI interchange at CR 233 (Three Springs). US 550 would connect to US 160 at CR 233 (Three Springs) interchange. Because of the additional demand caused by the US 550 connection at the Three Springs interchange, it was necessary to add a lane each at the eastbound right turn and westbound left turn movements to maintain LOS D or better at this intersection.

The Eastern Realignment Alternative has a different US 550 alignment when compared to the Revised F Modified US 550 alignment, but both alignments connect to US 160 at the CR 233 (Three Springs) interchange. The traffic operational analysis is the same for both alternatives where they connect to US 160.

Frontage roads will parallel both alignments of US 550 from US 160 to CR 220. These roads will provide local access to the properties south of US 160. US 160 will have two through lanes and one auxiliary lane in each direction from the west ramps of the Grandview Interchange to the west ramps of the CR 233 (Three Springs) interchange. The analysis assumes two through lanes in each direction through the Grandview Section with eastbound and westbound auxiliary lanes from the CR 233 (Three Springs) interchange to the west end of the section. The analysis worksheets are contained in Appendix C for reference.

**Connection of US 550 to US 160**
The merge and diverge movements associated with the CR 233 (Three Springs) Interchange are expected to operate at LOS B or better during the morning peak period and LOS C or better during evening peak period. The weaving segment for westbound US 160 between Three Springs interchange and Grandview interchange is expected to operate at LOS B during the morning peak period and LOS C during the evening peak period.

The signalized intersection in the center of the interchange is expected to operate at LOS B during the morning period and LOS C during the evening peak period (90 second cycle AM, 110 second cycle PM). All of individual movements are expected to operate at LOS D or better during both peak periods.

**Adjacent interchanges in the Grandview Section**
The merge and diverge movements at the Grandview interchange are expected to operate at LOS B or better during morning peak period and LOS C or better during the evening peak period.

**Conclusion**
This alternative satisfies the capacity requirements of the purpose and need because the interchange is adequate to accommodate the projected volumes at LOS D or better with US 550 connecting to this location. However, compared to Revised Alternative G Modified, an additional eastbound right turn lane and westbound left turn lane at the signalized intersection was necessary to accommodate the additional demand from US 550.

## Traffic Operations Conclusions

**No Action Alternative.** This alternative does not meet capacity requirements for the purpose and need because the signalized US 550/US 160 intersection is not adequate to maintain LOS D in the morning and evening peak hours.

**Revised Alternative G Modified.** This alternative satisfies the capacity requirements of the purpose and need. The planned interchange, auxiliary lane configurations and roundabout are adequate to accommodate the projected volumes at LOS D or better with US 550 connecting to this location.

**Revised Alternative F Modified and Eastern Realignment Alternative.** This alternative satisfies the capacity requirements of the purpose and need due to the additional Grandview Interchange which reduces the traffic impacts of the fully developed residential and commercial area in Grandview to the north of the CR 233 (Three Springs) interchange.

## Evaluation Criteria for Safety

Safety was evaluated to determine which alternative has the highest relative potential to provide safer travel associated with the connection of US 550 to US 160. This analysis has to be qualitative in nature since we are not dealing with actual historical traffic data at the subject intersections. However, there are documented safety differences between an at-grade intersection and a grade separated interchange, as well as roundabout and signalized intersection types. Thus, the best indication of relative future safety is based on grade separation of intersections and intersection type.

### Safety of Grade Separated Versus At-Grade Intersection

Regardless of design, at-grade intersections have an ever present potential for vehicle versus vehicle type accidents due conflicting streams of traffic. Crashes caused by crossing or turning movements can be reduced by separating the grades of the intersecting roadways. The typical reasons for increased safety at grade separated intersections are:

- **Grade separated intersections have fewer conflicts points.** Stopping conflicting intersection movements is an intrinsic characteristic of placing intersecting roads at different levels. Grade separation provides a significant benefit to the operations of through movements because conflicts with the opposing and crossing traffic are eliminated. The reduction in conflict points also improves safety performance.
- **Improved access management.** Installing grade separated intersections reduces access conflicts along a highway corridor. Drivers make more mistakes and are more likely to have collisions when they are presented with the complex driving situations created by numerous conflict points. Full access control reduces or eliminates the events which the driver must respond. Simplifying the driving task contributes to improved traffic operations and fewer collisions.
- **Accident rates are lower for grade separated intersections.** The following accident rates for at-grade and grade separated intersections are based on a study of accidents in Texas from 1981 to 1986. The statistic is referenced from NCHRP Report 345 *Single Point Urban Interchange Design and Operations Analysis (1989)*. The lower the rate the better safety performance.

**Accident rates for intersections and interchanges by location**

(Accident Rate = ADT/1,000/# lanes)

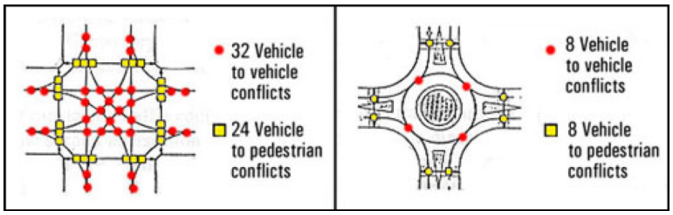
| | Type of Accident | | |
|---|---|---|---|
| | PDO | Injury | Fatality |
| Urban | | | |
| At Grade Stop | 0.94 | 0.52 | 0.010 |
| At Grade Signal | 0.46 | 0.21 | 0.002 |
| Interchange | 0.09 | 0.05 | 0.001 |
| | | | |
| Rural | | | |
| At Grade Stop | 0.84 | 0.55 | 0.031 |
| At Grade Signal | 0.87 | 0.36 | 0.008 |
| Interchange | 0.07 | 0.04 | 0.005 |

PDO => Property Damage Only

## Safety of Roundabouts Versus Traffic Signals

One of the benefits of roundabout installations is the improvement in overall safety performance to other traffic control installations. Though the frequency of crashes is not always lower for roundabouts, there is a pronounced reduction in injury rates. The typical reasons for the increased safety level at roundabouts are[3]:

- **Roundabouts have fewer conflict points.** The frequency of crashes at an intersection is related to the number of conflict points. At a four-legged conventional signalized intersection, there are 32 vehicle-to-vehicle conflicts and 24 vehicle-to-pedestrian conflicts. At a four-legged roundabout, this number is reduced to 8 as shown in the figure below. The four dots in the roundabout illustrations represent two conflict points each for the merge conflict and the diverge conflict.




- **Lower speeds and lower speed differential.** Lower speeds associated with roundabouts allow drivers more time to react to potential conflicts.
- **Fewer number of driver decisions.** Drivers only need to be aware of vehicles to their left at entry of roundabouts. Drivers at traffic signals need to be aware of traffic coming from as many as three directions at any time. In addition the driver must remain aware of the signal indication while monitoring the vehicle movements through the intersection.
- **Less severe crashes.** Severity of crashes is based on the relative speed and angle of the conflicting streams. Most vehicles travel at similar speeds through roundabouts with a small angle between the vehicle paths. The potential for hazardous conflicts, such as right angle and left turn head-on crashes is eliminated in roundabout use.

Research shows that roundabouts can be an effective way to improve safety at intersections. In a review of 55 sites that were converted from four-way intersections to roundabouts, before and after crash data shows a reduction in crashes 35% (1,122 to 726). More importantly, the severe injury crashes were reduced by 76% (from 296 to 72)[4].

## Alternatives

The following alternatives are being evaluated against the relative safety of at-grade intersections versus grade separated interchanges as well as roundabout versus traffic signal operations:

### No Action Alternative – Figure 2

This alternative connects US 550 to US 160 at its existing location via an at-grade signalized intersection. The capacity analysis for this alternative shows significant congestion at the intersection overall and the majority of the movements.

---

[3] Roundabouts: An Information Guide. Federal Highway Administration (Report No. FHWA-RD-00-067). June 2000

[4] Roundabouts in the United States. National Cooperative Highway Research Program (Report 572). Transportation Research Board. 2007.

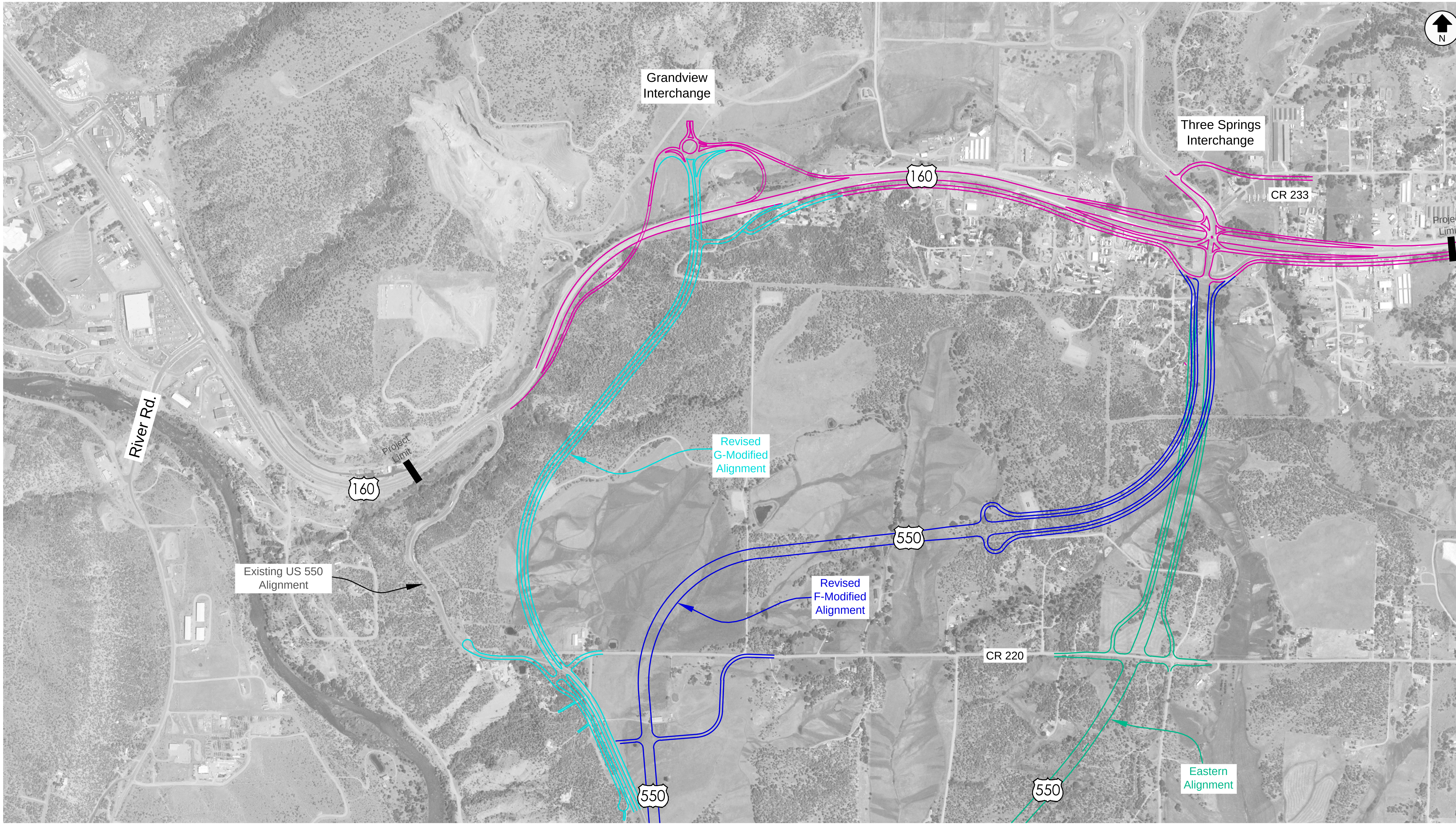
**Revised G Modified – Figure 3**
This alternative connects US 550 to US 160 via the Grandview trumpet interchange. However, traffic on US 550 is accommodated at its intersection with US 160 by a roundabout that is expected to operate at an acceptable level of service in the year 2030.

**Revised F Modified and Eastern Realignment– Figure 4**
This alternative connects US 550 to US 160 via the Three Springs SPUI interchange. Traffic on US 550 is accommodated at its intersection with US 160 by a SPUI and controlled by a traffic signal that is expected to operate at an acceptable level of service in the year 2030.

## Relative Potential for Safety Conclusions

The analysis shows that a grade separated intersection has a higher potential of providing safer traffic operations due to the reduction of conflict points, control of access and evidence of lower accident rates. Additionally, the analysis shows that a roundabout controlled intersection is more likely to provide safer operations than a conventional traffic signal due to the lower speeds, fewer conflicting movements and the elimination of head-on and broad-side crashes that are typically associated with injury and fatal crashes. To accommodate the significant volume of traffic from US 550, use of a roundabout at the grade separated Grandview Interchange would be safer than implementing a traffic signal as illustrated in the No Action, Revised F Modified and Eastern Realignment Alternatives. ***Therefore, the Revised G Modified has a greater potential for improved safety benefit compared to No Action, Revised F Modified and Eastern Realignment Alternatives.***

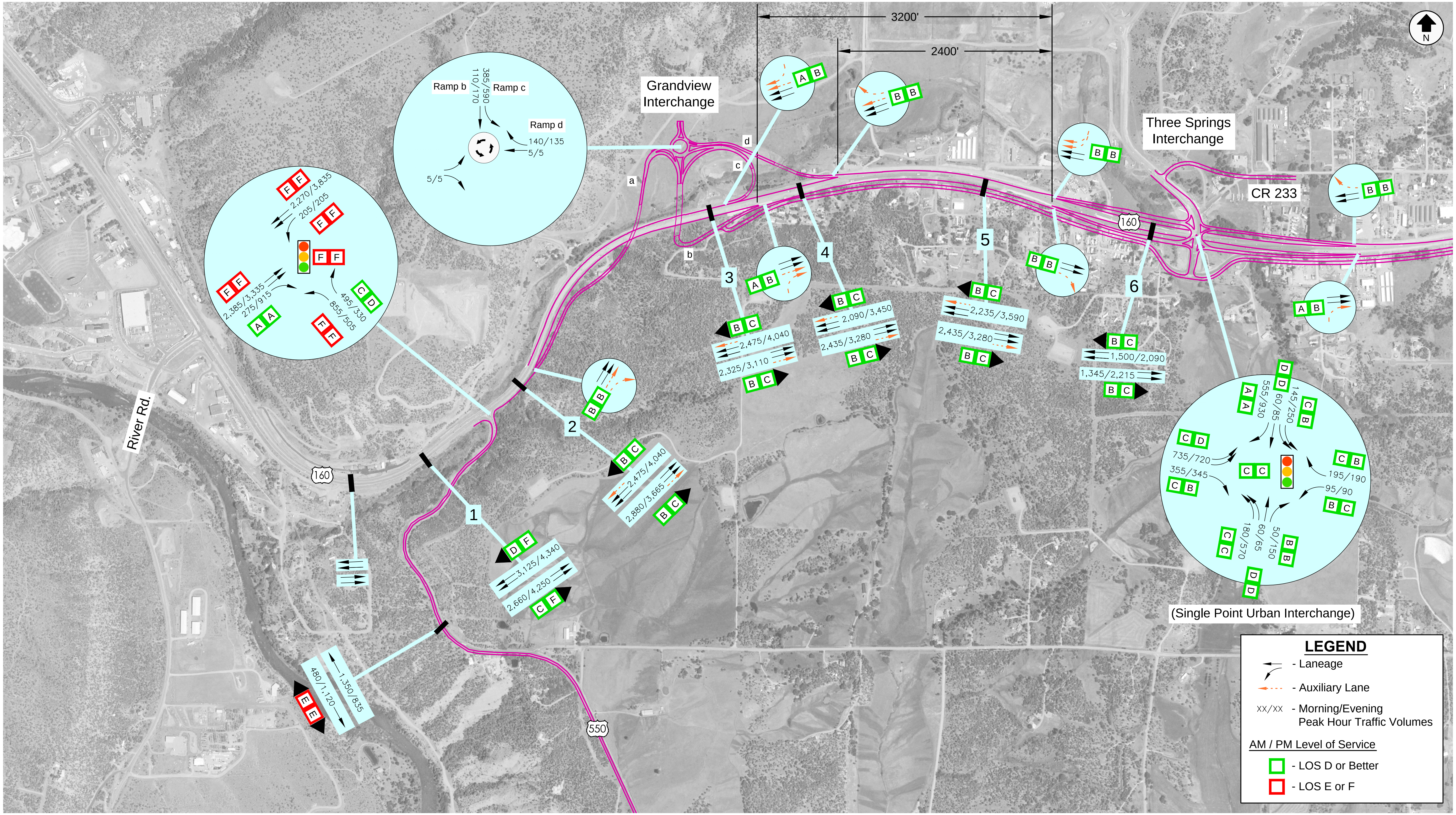
jel
Attachments
p:\ae\c\codot\105181\to #3 - us 160 interchange analysis\project___supplemental eis\june 2011 memos\seis\word\us 160 seis_2030 traffic ops analysis_6-23-2011.docx




SEH

Traffic Operation Analysis for the US 160 Supplemental EIS
Study Area

| Scale 1"=1000' | Date 6/23/11 | Drawn by JEL | Job # 112456 | Figure 1 |
|---|---|---|---|---|

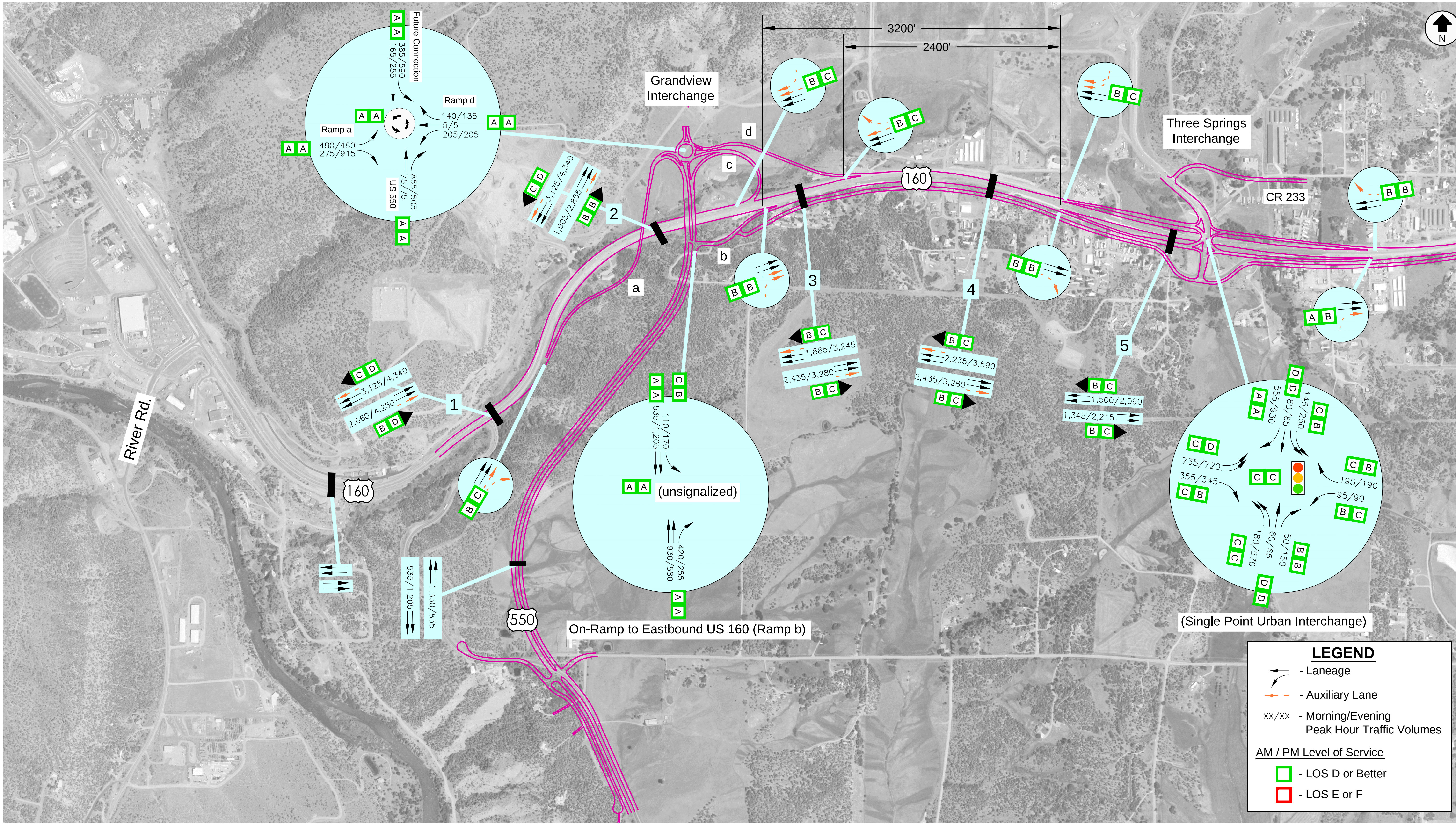



# Year 2030 Peak Hour Traffic Volumes

SEH

Traffic Operation Analysis for the US 160 Supplemental EIS
No Action Alternative

| Scale | 1"=1000' | Date | 6/23/11 | Drawn by | JEL | Job # | 112456 | Figure | 2 |
|---|---|---|---|---|---|---|---|---|---|

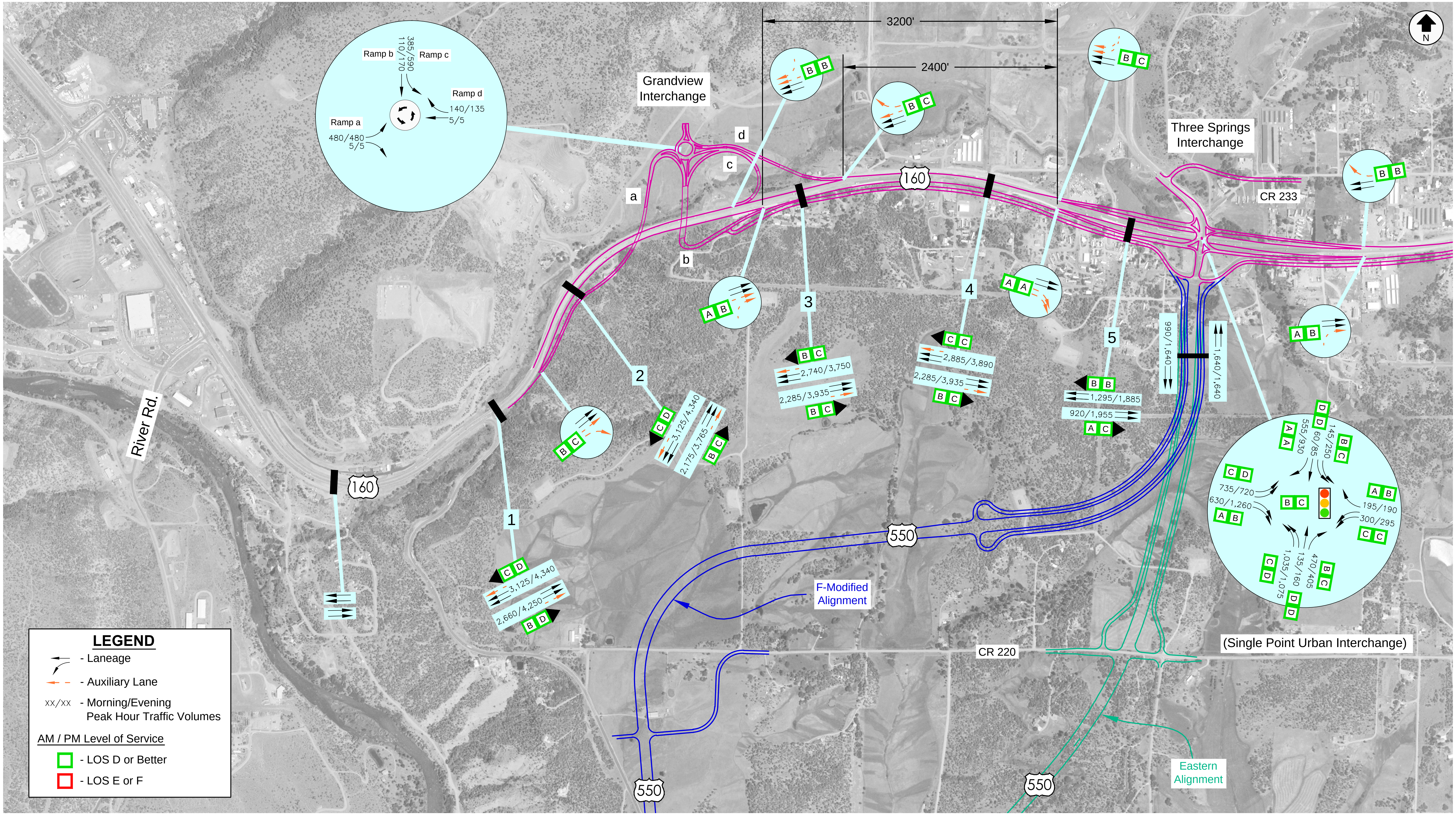



# Year 2030 Peak Hour Traffic Volumes

SEH

Traffic Operation Analysis for the US 160 Supplemental EIS
Revised Alternative G Modified

| Scale | 1"=1500' | Date | 6/23/11 | Drawn by | JEL | Job # | 105181 | Figure | 3 |
|---|---|---|---|---|---|---|---|---|---|




# Year 2030 Peak Hour Traffic Volumes

SEH

Traffic Operation Analysis for the US 160 Supplemental EIS
Revised Alternative F Modified and Eastern Realignment Alternative

| Scale | 1"=1000' | Date | 6/23/11 | Drawn by | JEL | Job # | 112456 | Figure | 4 |
|---|---|---|---|---|---|---|---|---|---|

U.S. Department of Transportation
**Federal Highway Administration**

**Colorado Division**

12300 W. Dakota Ave., Suite 180
Lakewood, Colorado 80228
720-963-3000
Fax 720-963-3001

April 5, 2011

Mr. Don Hunt
Executive Director
Colorado Department of Transportation
4201 E. Arkansas Ave.
Denver, Colorado 80222

SUBJECT: Determination of Need for Supplemental Environmental Impact Statement (SEIS), US Highway 160 from Durango to Bayfield, La Plata County, Colorado

Dear Mr. Hunt:

On March 22, 2011 the FHWA approved the Draft Section 4(f) Evaluation for the US 550 Connection to US 160 at Farmington Hill. This evaluation was prepared because a reassessment of environmental conditions during the design process for the US 160, Durango to Bayfield project discovered a previously unidentified eligible historic property that would be impacted.

Based on this evaluation the FHWA has determined that the proposed action would result in significant environmental impacts to historic and Section 4(f) resources which were not evaluated in the Final Environmental Impact Statement (FEIS) and Record of Decision (ROD). According to 23 CFR 771.130(a)(2) this determination requires the preparation of a Supplemental Environmental Impact Statement (SEIS).

The significant environmental impacts which were not evaluated in the FEIS/ROD have been determined to be confined to a limited portion of the overall project consisting of the US 550 Connection to US 160 at Farmington Hill. As such, the SEIS may be limited to only this portion of the project in order to supplement the existing FEIS/ROD. Per 23 CFR 771.130(f) the preparation of this supplement shall not: (1) Prevent the granting of new approvals; (2) Require the withdrawal of previous approvals; or (3) Require the suspension of project activities; for any activity not directly affected by the supplement.

If there are any questions regarding this project, please contact Ms. Stephanie Gibson, Environmental Program Manager, at 720-963-3013.

Sincerely yours,

for John M. Cater
Division Administrator

RECOVERY.GOV

cc: Richard Reynolds, CDOT Region 5
Kerrie Neet, CDOT Region 5
William Hanson, FHWA Colorado Division
Stephanie Gibson, FHWA Colorado Division

# Appendix A

## No Action Alternative

Evaluation Worksheets

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | West of US 550 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2660 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 700 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1505 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1505 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 25.1 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | US 550 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2880 | veh/h |
| Peak-hour factor, PHF | 0.96 | |
| Peak 15-min volume, v15 | 750 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1075 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1075 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 17.9 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp a
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2880 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 555 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2880 | | 555 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 758 | | 146 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3259 | | 602 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 0.651$ Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2331$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 3259 | 6900 | No |
| $v_{12}$ | 2331 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2657 | 6900 | No |
| $v_R$ | 602 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 15.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.417$

Space mean speed in ramp influence area, $S_R = 52.5$ mph

Space mean speed in outer lanes, $S_0 = 65.8$ mph

Space mean speed for all vehicles, $S = 55.7$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview Ramp A to Ramp B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2325 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 612 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 877 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 877 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 14.6 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp B
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2325 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 115 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2325 | | 115 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 612 | | 30 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2631 | | 125 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 0.619 Using Equation 1

$v_{12} = v_F (P_{FM}) =$ 1628 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2756 | 6900 | No |
| $v_{R12}$ | 1753 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 9.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

Intermediate speed variable, $M_S$ = 0.226

Space mean speed in ramp influence area, $S_R$ = 55.9 mph

Space mean speed in outer lanes, $S_0$ = 58.2 mph

Space mean speed for all vehicles, $S$ = 56.7 mph

HCS2000: Basic Freeway Segments Release 4.1f

Nick Samuelson
SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp C and Ramp D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2435 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 641 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 918 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 918 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 15.3 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview to CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2435 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 641 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 918 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 918 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 15.3 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2435 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1090 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2435 | | 1090 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 641 | | 287 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2755 | | 1182 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 0.637 Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2184 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2755 | 6900 | No |
| $v_{12}$ | 2184 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 1573 | 6900 | No |
| $v_R$ | 1182 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 14.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S$ = 0.469

Space mean speed in ramp influence area, $S_R$ = 51.6 mph

Space mean speed in outer lanes, $S_0$ = 65.8 mph

Space mean speed for all vehicles, $S$ = 54.0 mph

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SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1345 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 354 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 761 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 761 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 12.7 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 223 On Ramp
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1345 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 195 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 1345 | | 195 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 354 | | 51 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 1522 | | 211 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_F (P_{FM}) = 1522$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 1733 | 4600 | No |
| $v_{R12}$ | 1733 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A = 9.7$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

Intermediate speed variable, $M_S = 0.225$

Space mean speed in ramp influence area, $S_R = 55.9$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 55.9$ mph

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1790 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 290 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 1790 | | 290 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 471 | | 76 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2026 | | 314 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2026$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2026 | 4600 | No |
| $v_{12}$ | 2026 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 1712 | 4600 | No |
| $v_R$ | 314 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D = 12.7$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.391$

Space mean speed in ramp influence area, $S_R = 53.0$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 53.0$ mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1500 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 395 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 849 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 849 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 14.1 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Freeway Weaving Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency/Co.:
Date Performed: 5/2/11
Analysis Time Period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Weaving Location: Grandview Off/Three Springs On
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Inputs

| | | |
|---|---|---|
| Freeway free-flow speed, SFF | 60 | mph |
| Weaving number of lanes, N | 4 | |
| Weaving segment length, L | 2070 | ft |
| Terrain type | Rolling | |
| Grade | | % |
| Length | | mi |
| Weaving type | A | Multilane or C-D |
| Volume ratio, VR | 0.39 | |
| Weaving ratio, R | 0.16 | |

## Conversion to pc/h Under Base Conditions

| | Non-Weaving V A-C | Non-Weaving V B-D | Weaving V A-D | Weaving V B-C | |
|---|---|---|---|---|---|
| Volume, V | 1355 | 0 | 145 | 735 | veh/h |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | |
| Peak 15-min volume, v15 | 357 | 0 | 38 | 193 | v |
| Trucks and buses | 5 | 5 | 5 | 5 | % |
| Recreational vehicles | 0 | 0 | 0 | 0 | % |
| Trucks and buses PCE, ET | 2.5 | 2.5 | 2.5 | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | 2.0 | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.930 | 0.930 | 0.930 | |
| Driver population adjustment, fP | 1.00 | 1.00 | 1.00 | 1.00 | |
| Flow rate, v | 1533 | 0 | 164 | 831 | pc/h |

## Weaving and Non-Weaving Speeds

| | Weaving | Non-Weaving |
|---|---|---|
| a (Exhibit 24-6) | 0.15 | 0.00 |
| b (Exhibit 24-6) | 2.20 | 4.00 |
| c (Exhibit 24-6) | 0.97 | 1.30 |
| d (Exhibit 24-6) | 0.80 | 0.75 |
| Weaving intensity factor, Wi | 0.84 | 0.11 |
| Weaving and non-weaving speeds, Si | 42.15 | 60.15 |
| Number of lanes required for unconstrained operation, Nw (Exhibit 24-7) | | 1.84 |
| Maximum number of lanes, Nw (max) (Exhibit 24-7) | | 1.40 |
| Type of operation is | | Constrained |

## Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 51.49 mph

| | | |
|---|---|---|
| Weaving segment density, D | 12.27 | pc/mi/ln |
| Level of service, LOS | B | |
| Capacity of base condition, cb | 7176 | pc/h |
| Capacity as a 15-minute flow rate, c | 6675 | pc/h |
| Capacity as a full-hour volume, ch | 6341 | pc/h |

## Limitations on Weaving Segments

| | Analyzed | If Max Exceeded See Note Maximum | Note |
|---|---|---|---|
| Weaving flow rate, Vw | 995 | 2800 | a |
| Average flow rate (pcphpl) | 632 | 2300 | b |
| Volume ratio, VR | 0.39 | 0.35 | c |
| Weaving ratio, R | 0.16 | N/A | d |
| Weaving length (ft) | 2070 | 2500 | e |

Notes:

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.

d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).

g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

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SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | CR 233 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2235 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 588 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Grade | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 1.5 | |
| Recreational vehicle PCE, ER | 1.2 | |
| Heavy vehicle adjustment, fHV | 0.976 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 804 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 804 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 13.4 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between Ramp C and Ramp D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2090 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 550 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 788 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 788 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 13.1 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: Grandview Ramp C
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2090 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 385 | vph |
| Length of first accel/decel lane | 1900 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2090 | | 385 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 550 | | 101 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2365 | | 417 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 0.631 Using Equation 1

$v_{12} = v_F (P_{FM})$ = 1492 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2782 | 6900 | No |
| $v_{R12}$ | 1909 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 8.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

| | | |
|---|---|---|
| Intermediate speed variable, | $M_S$ = 0.195 | |
| Space mean speed in ramp influence area, | $S_R$ = 56.5 | mph |
| Space mean speed in outer lanes, | $S_0$ = 58.7 | mph |
| Space mean speed for all vehicles, | $S$ = 57.1 | mph |

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Granview Ramp A to Ramp B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2475 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 651 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 934 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 934 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 15.6 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | US 550 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2475 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 651 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 934 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 934 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 15.6 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | West of US 550 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3125 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 822 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1768 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1768 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 59.8 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 29.6 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

| Movement | EBT | EBR | WBL | WBT | NBL | NBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (vph) | 2385 | 275 | 205 | 2270 | 855 | 495 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 5.0 |
| Lane Util. Factor | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Frt | 1.00 | 0.85 | 1.00 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 |
| Satd. Flow (prot) | 3438 | 1538 | 1719 | 3438 | 1719 | 1538 |
| Flt Permitted | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 |
| Satd. Flow (perm) | 3438 | 1538 | 1719 | 3438 | 1719 | 1538 |
| Peak-hour factor, PHF | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Adj. Flow (vph) | 2385 | 275 | 205 | 2270 | 855 | 495 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 1 |
| Lane Group Flow (vph) | 2385 | 275 | 205 | 2270 | 855 | 494 |
| Turn Type | | Free | Prot | | | pt+ov |
| Protected Phases | 2 | | 1 | 6 | 8 | 8 1 |
| Permitted Phases | | Free | | | | |
| Actuated Green, G (s) | 68.0 | 150.0 | 14.0 | 87.0 | 53.0 | 72.0 |
| Effective Green, g (s) | 69.0 | 150.0 | 15.0 | 88.0 | 54.0 | 72.0 |
| Actuated g/C Ratio | 0.46 | 1.00 | 0.10 | 0.59 | 0.36 | 0.48 |
| Clearance Time (s) | 5.0 | | 5.0 | 5.0 | 5.0 | |
| Vehicle Extension (s) | 3.0 | | 3.0 | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 1581 | 1538 | 172 | 2017 | 619 | 738 |
| v/s Ratio Prot | c0.69 | | 0.12 | c0.66 | c0.50 | 0.32 |
| v/s Ratio Perm | | 0.18 | | | | |
| v/c Ratio | 1.51 | 0.18 | 1.19 | 1.13 | 1.38 | 0.67 |
| Uniform Delay, d1 | 40.5 | 0.0 | 67.5 | 31.0 | 48.0 | 29.9 |
| Progression Factor | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 918.7 | 0.3 | 401.3 | 233.5 | 696.6 | 2.4 |
| Delay (s) | 959.2 | 0.3 | 468.8 | 264.5 | 744.6 | 32.3 |
| Level of Service | F | A | F | F | F | C |
| Approach Delay (s) | 860.1 | | | 281.4 | 483.5 | |
| Approach LOS | F | | | F | F | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 560.8 | HCM Level of Service | F |
| HCM Volume to Capacity ratio | 1.43 | | |
| Actuated Cycle Length (s) | 150.0 | Sum of lost time (s) | 12.0 |
| Intersection Capacity Utilization | 134.7% | ICU Level of Service | H |
| Analysis Period (min) | 60 | | |
| c Critical Lane Group | | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 735 | 0 | 355 | 95 | 0 | 195 | 180 | 60 | 50 | 145 | 60 | 555 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 1.00 | 1.00 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 774 | 0 | 374 | 100 | 0 | 205 | 189 | 63 | 53 | 153 | 63 | 584 |
| RTOR Reduction (vph) | 0 | 0 | 289 | 0 | 0 | 71 | 0 | 0 | 32 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 774 | 0 | 85 | 100 | 0 | 134 | 189 | 63 | 21 | 153 | 63 | 584 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 | | | 5 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 21.7 | | 16.1 | 21.7 | | 16.1 | 16.1 | 6.6 | 36.8 | 16.1 | 6.6 | 70.9 |
| Effective Green, g (s) | 21.7 | | 16.1 | 21.7 | | 16.1 | 16.1 | 6.6 | 28.3 | 16.1 | 6.6 | 62.4 |
| Actuated g/C Ratio | 0.31 | | 0.23 | 0.31 | | 0.23 | 0.23 | 0.09 | 0.40 | 0.23 | 0.09 | 0.88 |
| Clearance Time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | 3.0 | 3.0 | | 3.0 | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 1051 | | 359 | 542 | | 359 | 780 | 173 | 632 | 780 | 173 | 1393 |
| v/s Ratio Prot | c0.23 | | | 0.06 | | | 0.06 | 0.03 | | 0.04 | 0.03 | |
| v/s Ratio Perm | | | 0.05 | | | 0.08 | | | 0.01 | | | c0.37 |
| v/c Ratio | 0.74 | | 0.24 | 0.18 | | 0.37 | 0.24 | 0.36 | 0.03 | 0.20 | 0.36 | 0.42 |
| Uniform Delay, d1 | 22.0 | | 22.4 | 18.1 | | 23.1 | 22.4 | 30.2 | 13.0 | 22.2 | 30.2 | 0.8 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 2.7 | | 0.3 | 0.2 | | 0.7 | 0.2 | 5.8 | 0.0 | 0.1 | 5.8 | 0.2 |
| Delay (s) | 24.8 | | 22.7 | 18.3 | | 23.8 | 22.6 | 36.0 | 13.0 | 22.3 | 36.0 | 1.0 |
| Level of Service | C | | C | B | | C | C | D | B | C | D | A |
| Approach Delay (s) | | 24.1 | | | 22.0 | | | 23.7 | | | 7.8 | |
| Approach LOS | | C | | | C | | | C | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 18.7 | HCM Level of Service | B |
| HCM Volume to Capacity ratio | 0.49 | | |
| Actuated Cycle Length (s) | 70.9 | Sum of lost time (s) | 9.0 |
| Intersection Capacity Utilization | 59.3% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency or Company:
Date Performed: 5/2/11
Analysis Time Period: PM Peak
Freeway/Direction: Eastbound
From/To: West of US 550
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4250 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1118 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 2405 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 2405 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | | mi/h |
| Number of lanes, N | 2 | |
| Density, D | | pc/mi/ln |
| Level of service, LOS | F | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | US 550 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3665 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 964 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1382 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1382 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 23.0 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp A
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3665 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 555 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3665 | | 555 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 964 | | 146 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 4147 | | 602 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 0.629 Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2831 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 4147 | 6900 | No |
| $v_{12}$ | 2831 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 3545 | 6900 | No |
| $v_R$ | 602 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 19.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

| | | |
|---|---|---|
| Intermediate speed variable, | $D_S$ = 0.417 | |
| Space mean speed in ramp influence area, | $S_R$ = 52.5 | mph |
| Space mean speed in outer lanes, | $S_0$ = 64.6 | mph |
| Space mean speed for all vehicles, | $S$ = 55.8 | mph |

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency or Company:
Date Performed: 5/2/11
Analysis Time Period: PM Peak
Freeway/Direction: Eastbound
From/To: Grandview Ramp A to Ramp B
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3110 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 818 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1173 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1173 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 19.5 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp B
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3110 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 170 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3110 | | 170 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 818 | | 45 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3519 | | 184 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 0.619$ Using Equation 1

$v_{12} = v_F (P_{FM}) = 2177$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 3703 | 6900 | No |
| $v_{R12}$ | 2361 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 14.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.245$

Space mean speed in ramp influence area, $S_R = 55.6$ mph

Space mean speed in outer lanes, $S_0 = 57.0$ mph

Space mean speed for all vehicles, $S = 56.1$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp C and Ramp D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3280 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 863 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1237 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1237 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 20.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview to CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3280 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 863 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1237 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1237 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 20.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3280 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1065 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3280 | | 1065 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 863 | | 280 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3712 | | 1155 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 0.614$ Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2725$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 3712 | 6900 | No |
| $v_{12}$ | 2725 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2557 | 6900 | No |
| $v_R$ | 1155 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D = 18.7$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.467$

Space mean speed in ramp influence area, $S_R = 51.6$ mph

Space mean speed in outer lanes, $S_0 = 65.8$ mph

Space mean speed for all vehicles, $S = 54.7$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2215 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 583 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1253 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1253 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 20.9 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 223 On Ramp
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2215 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 400 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 2215 | 400 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 583 | 105 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 2506 | 434 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_F (P_{FM}) = 2506$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2940 | 4600 | No |
| $v_{R12}$ | 2940 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A = 19.0$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.277$

Space mean speed in ramp influence area, $S_R = 55.0$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 55.0$ mph

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 No Action
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2370 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 280 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2370 | | 280 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 624 | | 74 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2682 | | 304 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2682$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2682 | 4600 | No |
| $v_{12}$ | 2682 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2378 | 4600 | No |
| $v_R$ | 304 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D = 18.3$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.390$

Space mean speed in ramp influence area, $S_R = 53.0$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 53.0$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2090 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 550 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1182 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1182 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 19.7 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Freeway Weaving Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Dir of Travel: | US 160 Westbound |
| Weaving Location: | Grandview Off/Three Springs On |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Inputs

| | | |
|---|---|---|
| Freeway free-flow speed, SFF | 60 | mph |
| Weaving number of lanes, N | 4 | |
| Weaving segment length, L | 2070 | ft |
| Terrain type | Rolling | |
| Grade | | % |
| Length | | mi |
| Weaving type | A | Multilane or C-D |
| Volume ratio, VR | 0.46 | |
| Weaving ratio, R | 0.09 | |

## Conversion to pc/h Under Base Conditions

| | Non-Weaving | | Weaving | | |
|---|---|---|---|---|---|
| | V A-C | V B-D | V A-D | V B-C | |
| Volume, V | 1950 | 0 | 140 | 1500 | veh/h |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | |
| Peak 15-min volume, v15 | 513 | 0 | 37 | 395 | v |
| Trucks and buses | 5 | 5 | 5 | 5 | % |
| Recreational vehicles | 0 | 0 | 0 | 0 | % |
| Trucks and buses PCE, ET | 2.5 | 2.5 | 2.5 | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | 2.0 | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.930 | 0.930 | 0.930 | |
| Driver population adjustment, fP | 1.00 | 1.00 | 1.00 | 1.00 | |
| Flow rate, v | 2206 | 0 | 158 | 1697 | pc/h |

## Weaving and Non-Weaving Speeds

| | Weaving | Non-Weaving |
|---|---|---|
| a (Exhibit 24-6) | 0.15 | 0.00 |
| b (Exhibit 24-6) | 2.20 | 4.00 |
| c (Exhibit 24-6) | 0.97 | 1.30 |
| d (Exhibit 24-6) | 0.80 | 0.75 |
| Weaving intensity factor, Wi | 1.47 | 0.24 |
| Weaving and non-weaving speeds, Si | 35.25 | 55.39 |
| Number of lanes required for unconstrained operation, Nw (Exhibit 24-7) | | 2.12 |
| Maximum number of lanes, Nw (max) (Exhibit 24-7) | | 1.40 |
| Type of operation is | | Constrained |

## Weaving Segment Speed, Density, Level of Service and Capacity

| | | |
|---|---|---|
| Weaving segment speed, S | 43.93 | mph |

| | | |
|---|---|---|
| Weaving segment density, D | 23.11 | pc/mi/ln |
| Level of service, LOS | B | |
| Capacity of base condition, cb | 7176 | pc/h |
| Capacity as a 15-minute flow rate, c | 6675 | pc/h |
| Capacity as a full-hour volume, ch | 6341 | pc/h |

## Limitations on Weaving Segments

| | Analyzed | If Max Exceeded See Note<br>Maximum | Note |
|---|---|---|---|
| Weaving flow rate, Vw | 1855 | 2800 | a |
| Average flow rate (pcphpl) | 1015 | 2300 | b |
| Volume ratio, VR | 0.46 | 0.35 | c |
| Weaving ratio, R | 0.09 | N/A | d |
| Weaving length (ft) | 2070 | 2500 | e |

Notes:

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.

d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).

g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | CR 233 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3590 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 945 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1354 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1354 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 22.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between Ramp C and Ramp D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3450 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 908 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1301 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1301 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 21.7 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date performed: | 5/2/11 |
| Analysis time period: | PM Peak |
| Freeway/Dir of Travel: | US 160 Westbound |
| Junction: | Grandview Ramp C |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3450 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 590 | vph |
| Length of first accel/decel lane | 1900 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3450 | | 590 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 908 | | 155 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3904 | | 640 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 0.631$ Using Equation 1

$v_{12} = v_F (P_{FM}) = 2462$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 4544 | 6900 | No |
| $v_{R12}$ | 3102 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 17.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.256$

Space mean speed in ramp influence area, $S_R = 55.4$ mph

Space mean speed in outer lanes, $S_0 = 56.6$ mph

Space mean speed for all vehicles, $S = 55.8$ mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: | Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Grandview Ramp A to Ramp B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4040 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1063 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1524 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1524 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 25.4 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | US 550 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4040 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1063 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1524 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1524 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 25.4 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | West of US 550 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 No Action |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4340 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1142 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 2456 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 2456 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | | mi/h |
| Number of lanes, N | 2 | |
| Density, D | | pc/mi/ln |
| Level of service, LOS | F | |

Overall results are not computed when free-flow speed is less than 55 mph.

| Movement | EBT | EBR | WBL | WBT | NBL | NBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (vph) | 3335 | 915 | 205 | 3835 | 505 | 330 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 5.0 |
| Lane Util. Factor | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Frt | 1.00 | 0.85 | 1.00 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 |
| Satd. Flow (prot) | 3438 | 1538 | 1719 | 3438 | 1719 | 1538 |
| Flt Permitted | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 |
| Satd. Flow (perm) | 3438 | 1538 | 1719 | 3438 | 1719 | 1538 |
| Peak-hour factor, PHF | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Adj. Flow (vph) | 3335 | 915 | 205 | 3835 | 505 | 330 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 3335 | 915 | 205 | 3835 | 505 | 330 |
| Turn Type | | Free | Prot | | | pt+ov |
| Protected Phases | 2 | | 1 | 6 | 8 | 8 1 |
| Permitted Phases | | Free | | | | |
| Actuated Green, G (s) | 89.0 | 150.0 | 14.0 | 108.0 | 32.0 | 51.0 |
| Effective Green, g (s) | 90.0 | 150.0 | 15.0 | 109.0 | 33.0 | 51.0 |
| Actuated g/C Ratio | 0.60 | 1.00 | 0.10 | 0.73 | 0.22 | 0.34 |
| Clearance Time (s) | 5.0 | | 5.0 | 5.0 | 5.0 | |
| Vehicle Extension (s) | 3.0 | | 3.0 | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 2063 | 1538 | 172 | 2498 | 378 | 523 |
| v/s Ratio Prot | c0.97 | | 0.12 | c1.12 | c0.29 | 0.21 |
| v/s Ratio Perm | | 0.59 | | | | |
| v/c Ratio | 1.62 | 0.59 | 1.19 | 1.54 | 1.34 | 0.63 |
| Uniform Delay, d1 | 30.0 | 0.0 | 67.5 | 20.5 | 58.5 | 41.6 |
| Progression Factor | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 1112.1 | 1.7 | 401.3 | 965.5 | 623.1 | 2.5 |
| Delay (s) | 1142.1 | 1.7 | 468.8 | 986.0 | 681.6 | 44.1 |
| Level of Service | F | A | F | F | F | D |
| Approach Delay (s) | 896.6 | | | 959.7 | 429.7 | |
| Approach LOS | F | | | F | F | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 881.8 | HCM Level of Service | F |
| HCM Volume to Capacity ratio | 1.56 | | |
| Actuated Cycle Length (s) | 150.0 | Sum of lost time (s) | 12.0 |
| Intersection Capacity Utilization | 141.5% | ICU Level of Service | H |
| Analysis Period (min) | 60 | | |
| c Critical Lane Group | | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 720 | 0 | 345 | 90 | 0 | 190 | 570 | 65 | 150 | 250 | 85 | 930 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 1.00 | 1.00 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 758 | 0 | 363 | 95 | 0 | 200 | 600 | 68 | 158 | 263 | 89 | 979 |
| RTOR Reduction (vph) | 0 | 0 | 237 | 0 | 0 | 56 | 0 | 0 | 105 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 758 | 0 | 126 | 95 | 0 | 144 | 600 | 68 | 53 | 263 | 89 | 979 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 | | | 5 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 21.2 | | 28.9 | 21.2 | | 28.9 | 28.9 | 6.6 | 36.3 | 28.9 | 6.6 | 83.2 |
| Effective Green, g (s) | 21.2 | | 28.9 | 21.2 | | 28.9 | 28.9 | 6.6 | 27.8 | 28.9 | 6.6 | 74.7 |
| Actuated g/C Ratio | 0.25 | | 0.35 | 0.25 | | 0.35 | 0.35 | 0.08 | 0.33 | 0.35 | 0.08 | 0.90 |
| Clearance Time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | 3.0 | 3.0 | | 3.0 | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 875 | | 550 | 451 | | 550 | 1192 | 148 | 529 | 1192 | 148 | 1421 |
| v/s Ratio Prot | 0.22 | | | 0.05 | | | 0.17 | 0.04 | | 0.08 | 0.05 | |
| v/s Ratio Perm | | | 0.08 | | | 0.09 | | | 0.03 | | | c0.62 |
| v/c Ratio | 0.87 | | 0.23 | 0.21 | | 0.26 | 0.50 | 0.46 | 0.10 | 0.22 | 0.60 | 0.69 |
| Uniform Delay, d1 | 29.6 | | 19.3 | 24.4 | | 19.5 | 21.5 | 36.6 | 19.1 | 19.2 | 37.0 | 1.1 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 9.0 | | 0.2 | 0.2 | | 0.3 | 0.3 | 9.9 | 0.1 | 0.1 | 16.8 | 1.4 |
| Delay (s) | 38.6 | | 19.5 | 24.6 | | 19.7 | 21.8 | 46.5 | 19.2 | 19.3 | 53.8 | 2.5 |
| Level of Service | D | | B | C | | B | C | D | B | B | D | A |
| Approach Delay (s) | | 32.4 | | | 21.3 | | | 23.3 | | | 9.3 | |
| Approach LOS | | C | | | C | | | C | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 20.8 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.69 | | |
| Actuated Cycle Length (s) | 83.2 | Sum of lost time (s) | 9.0 |
| Intersection Capacity Utilization | 88.4% | ICU Level of Service | E |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

# Appendix B

## Revised G Modified Alternative

Evaluation Worksheets

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2660 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 700 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1003 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1003 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 16.7 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: US 550 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2660 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 755 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2660 | | 755 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 700 | | 199 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3010 | | 819 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 0.647$ Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2237$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 3010 | 6900 | No |
| $v_{12}$ | 2237 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2191 | 6900 | No |
| $v_R$ | 819 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D = 14.5$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.437$

Space mean speed in ramp influence area, $S_R = 52.1$ mph

Space mean speed in outer lanes, $S_0 = 65.8$ mph

Space mean speed for all vehicles, $S = 55.1$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp A & B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1905 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 501 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 719 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 719 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 12.0 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp B
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1905 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 530 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 1905 | | 530 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 501 | | 139 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2156 | | 575 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 0.619$ Using Equation 1

$v_{12} = v_F (P_{FM}) = 1334$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2731 | 6900 | No |
| $v_{R12}$ | 1909 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 10.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.230$

Space mean speed in ramp influence area, $S_R = 55.9$ mph

Space mean speed in outer lanes, $S_0 = 58.8$ mph

Space mean speed for all vehicles, $S = 56.7$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp A & B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2435 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 641 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 918 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 918 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 15.3 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview to CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2435 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 641 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 918 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 918 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 15.3 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2435 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1090 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2435 | | 1090 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 641 | | 287 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | % | |
| Length | 0.00 | mi | 0.00 | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2755 | | 1182 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 0.637$ Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2184$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2755 | 6900 | No |
| $v_{12}$ | 2184 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 1573 | 6900 | No |
| $v_R$ | 1182 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D = 14.0$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.469$

Space mean speed in ramp influence area, $S_R = 51.6$ mph

Space mean speed in outer lanes, $S_0 = 65.8$ mph

Space mean speed for all vehicles, $S = 54.0$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1345 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 354 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 761 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 761 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 12.7 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 223 On Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1345 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 195 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 1345 | 195 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 354 | 51 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 1522 | 211 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM}) =$ 1522 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 1733 | 4600 | No |
| $v_{R12}$ | 1733 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 9.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

Intermediate speed variable, $M_S$ = 0.225

Space mean speed in ramp influence area, $S_R$ = 55.9 mph

Space mean speed in outer lanes, $S_0$ = N/A mph

Space mean speed for all vehicles, $S$ = 55.9 mph

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Ramp G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1790 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 290 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 1790 | | 290 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 471 | | 76 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2026 | | 314 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 2026 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2026 | 4600 | No |
| $v_{12}$ | 2026 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 1712 | 4600 | No |
| $v_R$ | 314 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 12.7 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S$ = 0.391

Space mean speed in ramp influence area, $S_R$ = 53.0 mph

Space mean speed in outer lanes, $S_0$ = N/A mph

Space mean speed for all vehicles, $S$ = 53.0 mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1500 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 395 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 849 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 849 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 14.1 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Freeway Weaving Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency/Co.:
Date Performed: 5/2/11
Analysis Time Period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Weaving Location: CR 233 On/Grandview Off
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Inputs

| | | |
|---|---|---|
| Freeway free-flow speed, SFF | 60 | mph |
| Weaving number of lanes, N | 4 | |
| Weaving segment length, L | 2070 | ft |
| Terrain type | Rolling | |
| Grade | | % |
| Length | | mi |
| Weaving type | A | Multilane or C-D |
| Volume ratio, VR | 0.49 | |
| Weaving ratio, R | 0.32 | |

## Conversion to pc/h Under Base Conditions

| | Non-Weaving | | Weaving | | |
|---|---|---|---|---|---|
| | V A-C | V B-D | V A-D | V B-C | |
| Volume, V | 1150 | 0 | 350 | 735 | veh/h |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | |
| Peak 15-min volume, v15 | 303 | 0 | 92 | 193 | v |
| Trucks and buses | 5 | 5 | 5 | 5 | % |
| Recreational vehicles | 0 | 0 | 0 | 0 | % |
| Trucks and buses PCE, ET | 2.5 | 2.5 | 2.5 | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | 2.0 | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.930 | 0.930 | 0.930 | |
| Driver population adjustment, fP | 1.00 | 1.00 | 1.00 | 1.00 | |
| Flow rate, v | 1301 | 0 | 396 | 831 | pc/h |

## Weaving and Non-Weaving Speeds

| | Weaving | Non-Weaving |
|---|---|---|
| a (Exhibit 24-6) | 0.15 | 0.00 |
| b (Exhibit 24-6) | 2.20 | 4.00 |
| c (Exhibit 24-6) | 0.97 | 1.30 |
| d (Exhibit 24-6) | 0.80 | 0.75 |
| Weaving intensity factor, Wi | 0.97 | 0.14 |
| Weaving and non-weaving speeds, Si | 40.40 | 58.91 |
| Number of lanes required for unconstrained operation, Nw (Exhibit 24-7) | | 2.10 |
| Maximum number of lanes, Nw (max) (Exhibit 24-7) | | 1.40 |
| Type of operation is | | Constrained |

## Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 48.19 mph

| | | |
|---|---|---|
| Weaving segment density, D | 13.11 | pc/mi/ln |
| Level of service, LOS | B | |
| Capacity of base condition, cb | 7176 | pc/h |
| Capacity as a 15-minute flow rate, c | 6675 | pc/h |
| Capacity as a full-hour volume, ch | 6341 | pc/h |

## Limitations on Weaving Segments

| | Analyzed | If Max Exceeded See Note<br>Maximum | Note |
|---|---|---|---|
| Weaving flow rate, Vw | 1227 | 2800 | a |
| Average flow rate (pcphpl) | 632 | 2300 | b |
| Volume ratio, VR | 0.49 | 0.35 | c |
| Weaving ratio, R | 0.32 | N/A | d |
| Weaving length (ft) | 2070 | 2500 | e |

Notes:

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.

d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).

g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone:                                                Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | CR 233 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2235 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 588 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 843 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 843 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 14.1 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone:                                        Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1835 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 483 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 692 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 692 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 11.5 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

Jon E. Larson
SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: Grandview Ramp C
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1885 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1240 | vph |
| Length of first accel/decel lane | 1900 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 1885 | 1240 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 496 | 326 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 2133 | 1344 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 0.631$  Using Equation 1

$v_{12} = v_F (P_{FM}) = 1345$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 3477 | 6900 | No |
| $v_{R12}$ | 2689 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A = 13.9$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.226$

Space mean speed in ramp influence area, $S_R = 55.9$ mph

Space mean speed in outer lanes, $S_0 = 59.0$ mph

Space mean speed for all vehicles, $S = 56.6$ mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone:                                                Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and E |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3125 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 822 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1179 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1179 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 19.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3125 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 822 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1179 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1179 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 19.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

| Movement | WBL | WBR | NBT | NBR | SBL | SBT |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (veh/h) | 0 | 0 | 930 | 420 | 110 | 535 |
| Sign Control | Stop | | Free | | | Free |
| Grade | 0% | | 0% | | | 0% |
| Peak Hour Factor | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Hourly flow rate (vph) | 0 | 0 | 979 | 442 | 116 | 563 |
| Pedestrians | | | | | | |
| Lane Width (ft) | | | | | | |
| Walking Speed (ft/s) | | | | | | |
| Percent Blockage | | | | | | |
| Right turn flare (veh) | | | | | | |
| Median type | | | None | | | None |
| Median storage veh) | | | | | | |
| Upstream signal (ft) | | | | | | |
| pX, platoon unblocked | | | | | | |
| vC, conflicting volume | 1492 | 489 | | | 1421 | |
| vC1, stage 1 conf vol | | | | | | |
| vC2, stage 2 conf vol | | | | | | |
| vCu, unblocked vol | 1492 | 489 | | | 1421 | |
| tC, single (s) | 6.8 | 6.9 | | | 4.1 | |
| tC, 2 stage (s) | | | | | | |
| tF (s) | 3.5 | 3.3 | | | 2.2 | |
| p0 queue free % | 100 | 100 | | | 76 | |
| cM capacity (veh/h) | 86 | 524 | | | 475 | |

| Direction, Lane # | NB 1 | NB 2 | NB 3 | SB 1 | SB 2 | SB 3 |
|---|---|---|---|---|---|---|
| Volume Total | 489 | 489 | 442 | 116 | 282 | 282 |
| Volume Left | 0 | 0 | 0 | 116 | 0 | 0 |
| Volume Right | 0 | 0 | 442 | 0 | 0 | 0 |
| cSH | 1700 | 1700 | 1700 | 475 | 1700 | 1700 |
| Volume to Capacity | 0.29 | 0.29 | 0.26 | 0.24 | 0.17 | 0.17 |
| Queue Length 95th (ft) | 0 | 0 | 0 | 24 | 0 | 0 |
| Control Delay (s) | 0.0 | 0.0 | 0.0 | 15.0 | 0.0 | 0.0 |
| Lane LOS | | | | C | | |
| Approach Delay (s) | 0.0 | | | 2.6 | | |
| Approach LOS | | | | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | 0.8 | | |
| Intersection Capacity Utilization | 38.8% | ICU Level of Service | A |
| Analysis Period (min) | 15 | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 735 | 0 | 355 | 95 | 0 | 195 | 180 | 60 | 50 | 145 | 60 | 555 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 1.00 | 1.00 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 774 | 0 | 374 | 100 | 0 | 205 | 189 | 63 | 53 | 153 | 63 | 584 |
| RTOR Reduction (vph) | 0 | 0 | 289 | 0 | 0 | 71 | 0 | 0 | 32 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 774 | 0 | 85 | 100 | 0 | 134 | 189 | 63 | 21 | 153 | 63 | 584 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 | | | 5 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 21.7 | | 16.1 | 21.7 | | 16.1 | 16.1 | 6.6 | 36.8 | 16.1 | 6.6 | 70.9 |
| Effective Green, g (s) | 21.7 | | 16.1 | 21.7 | | 16.1 | 16.1 | 6.6 | 28.3 | 16.1 | 6.6 | 62.4 |
| Actuated g/C Ratio | 0.31 | | 0.23 | 0.31 | | 0.23 | 0.23 | 0.09 | 0.40 | 0.23 | 0.09 | 0.88 |
| Clearance Time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | 3.0 | 3.0 | | 3.0 | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 1051 | | 359 | 542 | | 359 | 780 | 173 | 632 | 780 | 173 | 1393 |
| v/s Ratio Prot | c0.23 | | | 0.06 | | | 0.06 | 0.03 | | 0.04 | 0.03 | |
| v/s Ratio Perm | | | 0.05 | | | 0.08 | | | 0.01 | | | c0.37 |
| v/c Ratio | 0.74 | | 0.24 | 0.18 | | 0.37 | 0.24 | 0.36 | 0.03 | 0.20 | 0.36 | 0.42 |
| Uniform Delay, d1 | 22.0 | | 22.4 | 18.1 | | 23.1 | 22.4 | 30.2 | 13.0 | 22.2 | 30.2 | 0.8 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 2.7 | | 0.3 | 0.2 | | 0.7 | 0.2 | 5.8 | 0.0 | 0.1 | 5.8 | 0.2 |
| Delay (s) | 24.8 | | 22.7 | 18.3 | | 23.8 | 22.6 | 36.0 | 13.0 | 22.3 | 36.0 | 1.0 |
| Level of Service | C | | C | B | | C | C | D | B | C | D | A |
| Approach Delay (s) | | 24.1 | | | 22.0 | | | 23.7 | | | 7.8 | |
| Approach LOS | | C | | | C | | | C | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 18.7 | HCM Level of Service | B |
| HCM Volume to Capacity ratio | 0.49 | | |
| Actuated Cycle Length (s) | 70.9 | Sum of lost time (s) | 9.0 |
| Intersection Capacity Utilization | 59.3% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4250 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1118 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1603 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1603 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 26.7 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp A
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 4250 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1395 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 4250 | | 1395 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 1118 | | 367 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 4809 | | 1512 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 0.570 Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3392 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 4809 | 6900 | No |
| $v_{12}$ | 3392 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 3297 | 6900 | No |
| $v_R$ | 1512 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 24.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

## Speed Estimation

Intermediate speed variable, $D_S$ = 0.499

Space mean speed in ramp influence area, $S_R$ = 51.0 mph

Space mean speed in outer lanes, $S_0$ = 64.2 mph

Space mean speed for all vehicles, $S$ = 54.3 mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp A & B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2855 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 751 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1077 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1077 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 18.0- | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date performed: | 5/2/11 |
| Analysis time period: | PM Peak |
| Freeway/Dir of Travel: | US 160 Eastbound |
| Junction: | Grandview Ramp B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2855 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 425 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2855 | | 425 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 751 | | 112 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | % | |
| Length | | mi | | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3231 | | 461 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 0.619 Using Equation 1

$v_{12} = v_F (P_{FM})$ = 1999 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 3692 | 6900 | No |
| $v_{R12}$ | 2460 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 15.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S$ = 0.249

Space mean speed in ramp influence area, $S_R$ = 55.5 mph

Space mean speed in outer lanes, $S_0$ = 57.4 mph

Space mean speed for all vehicles, $S$ = 56.1 mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp A & B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3280 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 863 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1237 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1237 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 20.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview to CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3280 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 863 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1237 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1237 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 20.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3280 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1065 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3280 | | 1065 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 863 | | 280 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3712 | | 1155 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 0.614$ Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2725$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 3712 | 6900 | No |
| $v_{12}$ | 2725 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2557 | 6900 | No |
| $v_R$ | 1155 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D = 18.7$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.467$

Space mean speed in ramp influence area, $S_R = 51.6$ mph

Space mean speed in outer lanes, $S_0 = 65.8$ mph

Space mean speed for all vehicles, $S = 54.7$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2215 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 583 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1253 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1253 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 20.9 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: CR 223 On Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2215 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 400 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2215 | | 400 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 583 | | 105 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | % | |
| Length | | mi | | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2506 | | 434 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM}) =$ 2506 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2940 | 4600 | No |
| $v_{R12}$ | 2940 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 19.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S$ = 0.277

Space mean speed in ramp influence area, $S_R$ = 55.0 mph

Space mean speed in outer lanes, $S_0$ = N/A mph

Space mean speed for all vehicles, $S$ = 55.0 mph

HCS2000: Ramps and Ramp Junctions Release 4.1f

Nick Samuelson
SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date performed: | 5/2/11 |
| Analysis time period: | PM Peak |
| Freeway/Dir of Travel: | US 160 Westbound |
| Junction: | CR 233 Off Ramp |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2370 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 280 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2370 | | 280 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 624 | | 74 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | % | |
| Length | 0.00 | mi | 0.00 | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2682 | | 304 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2682$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2682 | 4600 | No |
| $v_{12}$ | 2682 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2378 | 4600 | No |
| $v_R$ | 304 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D = 18.3$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.390$

Space mean speed in ramp influence area, $S_R = 53.0$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 53.0$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2090 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 550 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1182 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1182 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 19.7 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Freeway Weaving Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency/Co.:
Date Performed: 5/2/11
Analysis Time Period: PM Peak
Freeway/Dir of Travel: US 160 Westbound
Weaving Location: CR 233 On/Grandview Off
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Inputs

| | | |
|---|---|---|
| Freeway free-flow speed, SFF | 60 | mph |
| Weaving number of lanes, N | 4 | |
| Weaving segment length, L | 2070 | ft |
| Terrain type | Rolling | |
| Grade | | % |
| Length | | mi |
| Weaving type | A | Multilane or C-D |
| Volume ratio, VR | 0.51 | |
| Weaving ratio, R | 0.19 | |

## Conversion to pc/h Under Base Conditions

| | Non-Weaving | | Weaving | | |
|---|---|---|---|---|---|
| | V A-C | V B-D | V A-D | V B-C | |
| Volume, V | 1745 | 0 | 345 | 1500 | veh/h |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | |
| Peak 15-min volume, v15 | 459 | 0 | 91 | 395 | v |
| Trucks and buses | 5 | 5 | 5 | 5 | % |
| Recreational vehicles | 0 | 0 | 0 | 0 | % |
| Trucks and buses PCE, ET | 2.5 | 2.5 | 2.5 | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | 2.0 | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.930 | 0.930 | 0.930 | |
| Driver population adjustment, fP | 1.00 | 1.00 | 1.00 | 1.00 | |
| Flow rate, v | 1974 | 0 | 390 | 1697 | pc/h |

## Weaving and Non-Weaving Speeds

| | Weaving | Non-Weaving |
|---|---|---|
| a (Exhibit 24-6) | 0.15 | 0.00 |
| b (Exhibit 24-6) | 2.20 | 4.00 |
| c (Exhibit 24-6) | 0.97 | 1.30 |
| d (Exhibit 24-6) | 0.80 | 0.75 |
| Weaving intensity factor, Wi | 1.60 | 0.28 |
| Weaving and non-weaving speeds, Si | 34.24 | 54.14 |
| Number of lanes required for unconstrained operation, Nw (Exhibit 24-7) | | 2.29 |
| Maximum number of lanes, Nw (max) (Exhibit 24-7) | | 1.40 |
| Type of operation is | | Constrained |

## Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 41.69 mph

| | | |
|---|---|---|
| Weaving segment density, D | 24.35 | pc/mi/ln |
| Level of service, LOS | C | |
| Capacity of base condition, cb | 7176 | pc/h |
| Capacity as a 15-minute flow rate, c | 6675 | pc/h |
| Capacity as a full-hour volume, ch | 6341 | pc/h |

## Limitations on Weaving Segments

| | Analyzed | Maximum | If Max Exceeded See Note<br>Note |
|---|---|---|---|
| Weaving flow rate, Vw | 2087 | 2800 | a |
| Average flow rate (pcphpl) | 1015 | 2300 | b |
| Volume ratio, VR | 0.51 | 0.35 | c |
| Weaving ratio, R | 0.19 | N/A | d |
| Weaving length (ft) | 2070 | 2500 | e |

Notes:

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.

d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).

g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | CR 233 to Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3590 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 945 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1354 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1354 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 22.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3245 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 854 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1224 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1224 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 20.4 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: Grandview Ramp C
Jurisdiction:
Analysis Year: Year 2030 Rev Alt G Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3245 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1095 | vph |
| Length of first accel/decel lane | 1900 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 3245 | 1095 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 854 | 288 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 3672 | 1187 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 0.631 Using Equation 1

$v_{12} = v_F (P_{FM})$ = 2316 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 4859 | 6900 | No |
| $v_{R12}$ | 3503 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 20.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

## Speed Estimation

Intermediate speed variable, $M_S$ = 0.299

Space mean speed in ramp influence area, $S_R$ = 54.6 mph

Space mean speed in outer lanes, $S_0$ = 56.9 mph

Space mean speed for all vehicles, $S$ = 55.2 mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and E |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4340 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1142 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1637 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1637 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 27.3 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt G Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4340 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1142 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1637 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1637 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 27.3 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

| Movement | WBL | WBR | NBT | NBR | SBL | SBT |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (veh/h) | 0 | 0 | 580 | 255 | 170 | 1205 |
| Sign Control | Stop | | Free | | | Free |
| Grade | 0% | | 0% | | | 0% |
| Peak Hour Factor | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Hourly flow rate (vph) | 0 | 0 | 611 | 268 | 179 | 1268 |
| Pedestrians | | | | | | |
| Lane Width (ft) | | | | | | |
| Walking Speed (ft/s) | | | | | | |
| Percent Blockage | | | | | | |
| Right turn flare (veh) | | | | | | |
| Median type | | | None | | | None |
| Median storage veh) | | | | | | |
| Upstream signal (ft) | | | | | | |
| pX, platoon unblocked | | | | | | |
| vC, conflicting volume | 1603 | 305 | | | 879 | |
| vC1, stage 1 conf vol | | | | | | |
| vC2, stage 2 conf vol | | | | | | |
| vCu, unblocked vol | 1603 | 305 | | | 879 | |
| tC, single (s) | 6.8 | 6.9 | | | 4.1 | |
| tC, 2 stage (s) | | | | | | |
| tF (s) | 3.5 | 3.3 | | | 2.2 | |
| p0 queue free % | 100 | 100 | | | 77 | |
| cM capacity (veh/h) | 74 | 691 | | | 764 | |

| Direction, Lane # | NB 1 | NB 2 | NB 3 | SB 1 | SB 2 | SB 3 |
|---|---|---|---|---|---|---|
| Volume Total | 305 | 305 | 268 | 179 | 634 | 634 |
| Volume Left | 0 | 0 | 0 | 179 | 0 | 0 |
| Volume Right | 0 | 0 | 268 | 0 | 0 | 0 |
| cSH | 1700 | 1700 | 1700 | 764 | 1700 | 1700 |
| Volume to Capacity | 0.18 | 0.18 | 0.16 | 0.23 | 0.37 | 0.37 |
| Queue Length 95th (ft) | 0 | 0 | 0 | 23 | 0 | 0 |
| Control Delay (s) | 0.0 | 0.0 | 0.0 | 11.1 | 0.0 | 0.0 |
| Lane LOS | | | | B | | |
| Approach Delay (s) | 0.0 | | | 1.4 | | |
| Approach LOS | | | | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | 0.9 | | |
| Intersection Capacity Utilization | 36.6% | ICU Level of Service | A |
| Analysis Period (min) | 15 | | |

# HCM Signalized Intersection Capacity Analysis
## 3: US 160 & Three Springs

5/4/2011

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 720 | 0 | 345 | 90 | 0 | 190 | 570 | 65 | 150 | 250 | 85 | 930 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 1.00 | 1.00 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 1583 | 1770 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 758 | 0 | 363 | 95 | 0 | 200 | 600 | 68 | 158 | 263 | 89 | 979 |
| RTOR Reduction (vph) | 0 | 0 | 237 | 0 | 0 | 56 | 0 | 0 | 105 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 758 | 0 | 126 | 95 | 0 | 144 | 600 | 68 | 53 | 263 | 89 | 979 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 | | | 5 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 21.2 | | 28.9 | 21.2 | | 28.9 | 28.9 | 6.6 | 36.3 | 28.9 | 6.6 | 83.2 |
| Effective Green, g (s) | 21.2 | | 28.9 | 21.2 | | 28.9 | 28.9 | 6.6 | 27.8 | 28.9 | 6.6 | 74.7 |
| Actuated g/C Ratio | 0.25 | | 0.35 | 0.25 | | 0.35 | 0.35 | 0.08 | 0.33 | 0.35 | 0.08 | 0.90 |
| Clearance Time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | 3.0 | 3.0 | | 3.0 | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 875 | | 550 | 451 | | 550 | 1192 | 148 | 529 | 1192 | 148 | 1421 |
| v/s Ratio Prot | 0.22 | | | 0.05 | | | 0.17 | 0.04 | | 0.08 | 0.05 | |
| v/s Ratio Perm | | | 0.08 | | | 0.09 | | | 0.03 | | | c0.62 |
| v/c Ratio | 0.87 | | 0.23 | 0.21 | | 0.26 | 0.50 | 0.46 | 0.10 | 0.22 | 0.60 | 0.69 |
| Uniform Delay, d1 | 29.6 | | 19.3 | 24.4 | | 19.5 | 21.5 | 36.6 | 19.1 | 19.2 | 37.0 | 1.1 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 9.0 | | 0.2 | 0.2 | | 0.3 | 0.3 | 9.9 | 0.1 | 0.1 | 16.8 | 1.4 |
| Delay (s) | 38.6 | | 19.5 | 24.6 | | 19.7 | 21.8 | 46.5 | 19.2 | 19.3 | 53.8 | 2.5 |
| Level of Service | D | | B | C | | B | C | D | B | B | D | A |
| Approach Delay (s) | | 32.4 | | | 21.3 | | | 23.3 | | | 9.3 | |
| Approach LOS | | C | | | C | | | C | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 20.8 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.69 | | |
| Actuated Cycle Length (s) | 83.2 | Sum of lost time (s) | 9.0 |
| Intersection Capacity Utilization | 88.4% | ICU Level of Service | E |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

# Appendix C

## Revised F Modified & Eastern Realignment Alternative

Evaluation Worksheets

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2660 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 700 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1003 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1003 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 16.7 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: US 550 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2660 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 485 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2660 | | 485 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 700 | | 128 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | % | |
| Length | 0.00 | mi | 0.00 | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 3010 | | 526 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 0.661$ Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2167$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 3010 | 6900 | No |
| $v_{12}$ | 2167 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2484 | 6900 | No |
| $v_R$ | 526 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D = 13.9$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.410$

Space mean speed in ramp influence area, $S_R = 52.6$ mph

Space mean speed in outer lanes, $S_0 = 65.8$ mph

Space mean speed for all vehicles, $S = 55.7$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp A & B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2175 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 572 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 820 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 820 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 13.7 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date performed: | 5/2/11 |
| Analysis time period: | AM Peak |
| Freeway/Dir of Travel: | US 160 Eastbound |
| Junction: | Grandview Ramp B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2175 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 115 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2175 | | 115 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 572 | | 30 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2461 | | 125 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$$P_{FM}^{EQ} = 0.619 \quad \text{Using Equation 1}$$

$$v_{12} = v_F (P_{FM}) = 1523 \text{ pc/h}$$

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2586 | 6900 | No |
| $v_{R12}$ | 1648 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A = 9.1$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

| | | |
|---|---|---|
| Intermediate speed variable, | $M_S = 0.224$ | |
| Space mean speed in ramp influence area, | $S_R = 56.0$ | mph |
| Space mean speed in outer lanes, | $S_0 = 58.4$ | mph |
| Space mean speed for all vehicles, | $S = 56.8$ | mph |

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp B & D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2285 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 601 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 862 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 862 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 14.4 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview to US 550/CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2285 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 601 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 862 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 862 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 14.4 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: US 550/CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2285 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 2 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1365 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | 500 | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2285 | | 1365 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 601 | | 359 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2586 | | 1480 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 0.450 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1978 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2586 | 6900 | No |
| $v_{12}$ | 1978 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 1106 | 6900 | No |
| $v_R$ | 1480 | 4100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = -1.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

Intermediate speed variable, $D_S$ = 0.496

Space mean speed in ramp influence area, $S_R$ = 51.1 mph

Space mean speed in outer lanes, $S_0$ = 65.8 mph

Space mean speed for all vehicles, S = 53.9 mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between CR 233/US 550 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 920 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 242 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 521 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 521 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 8.7 | pc/mi/ln |
| Level of service, LOS | A | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date performed: | 5/2/11 |
| Analysis time period: | AM Peak |
| Freeway/Dir of Travel: | US 160 Eastbound |
| Junction: | US 550/CR 223 On Ramp |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 920 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 615 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 920 | 615 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 242 | 162 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 1041 | 667 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_F (P_{FM}) = 1041$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 1708 | 4600 | No |
| $v_{R12}$ | 1708 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 9.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

Intermediate speed variable, $M_S = 0.225$

Space mean speed in ramp influence area, $S_R = 56.0$ mph

Space mean speed in outer lanes, $S_0$ = N/A mph

Space mean speed for all vehicles, $S = 56.0$ mph

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: US 500/CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1790 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 495 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 1790 | | 495 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 471 | | 130 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | % | |
| Length | 0.00 | mi | 0.00 | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2026 | | 537 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2026$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2026 | 4600 | No |
| $v_{12}$ | 2026 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 1489 | 4600 | No |
| $v_R$ | 537 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D = 12.7$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.411$

Space mean speed in ramp influence area, $S_R = 52.6$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 52.6$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1295 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 341 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 733 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 733 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 12.2 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Freeway Weaving Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency/Co.:
Date Performed: 5/2/11
Analysis Time Period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Weaving Location: US 550 On/Grandview Off
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Inputs

| | | |
|---|---|---|
| Freeway free-flow speed, SFF | 60 | mph |
| Weaving number of lanes, N | 4 | |
| Weaving segment length, L | 2070 | ft |
| Terrain type | Rolling | |
| Grade | | % |
| Length | | mi |
| Weaving type | A | Multilane or C-D |
| Volume ratio, VR | 0.60 | |
| Weaving ratio, R | 0.08 | |

## Conversion to pc/h Under Base Conditions

| | Non-Weaving V A-C | Non-Weaving V B-D | Weaving V A-D | Weaving V B-C | |
|---|---|---|---|---|---|
| Volume, V | 1150 | 0 | 145 | 1590 | veh/h |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | |
| Peak 15-min volume, v15 | 303 | 0 | 38 | 418 | v |
| Trucks and buses | 5 | 5 | 5 | 5 | % |
| Recreational vehicles | 0 | 0 | 0 | 0 | % |
| Trucks and buses PCE, ET | 2.5 | 2.5 | 2.5 | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | 2.0 | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.930 | 0.930 | 0.930 | |
| Driver population adjustment, fP | 1.00 | 1.00 | 1.00 | 1.00 | |
| Flow rate, v | 1301 | 0 | 164 | 1799 | pc/h |

## Weaving and Non-Weaving Speeds

| | Weaving | Non-Weaving |
|---|---|---|
| a (Exhibit 24-6) | 0.15 | 0.00 |
| b (Exhibit 24-6) | 2.20 | 4.00 |
| c (Exhibit 24-6) | 0.97 | 1.30 |
| d (Exhibit 24-6) | 0.80 | 0.75 |
| Weaving intensity factor, Wi | 1.46 | 0.26 |
| Weaving and non-weaving speeds, Si | 35.29 | 54.64 |
| Number of lanes required for unconstrained operation, Nw (Exhibit 24-7) | | 2.48 |
| Maximum number of lanes, Nw (max) (Exhibit 24-7) | | 1.40 |
| Type of operation is | | Constrained |

## Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 41.09 mph

| | | |
|---|---|---|
| Weaving segment density, D | 19.86 | pc/mi/ln |
| Level of service, LOS | B | |
| Capacity of base condition, cb | 7176 | pc/h |
| Capacity as a 15-minute flow rate, c | 6675 | pc/h |
| Capacity as a full-hour volume, ch | 6341 | pc/h |

## Limitations on Weaving Segments

| | Analyzed | Maximum | If Max Exceeded See Note<br>Note |
|---|---|---|---|
| Weaving flow rate, Vw | 1963 | 2800 | a |
| Average flow rate (pcphpl) | 816 | 2300 | b |
| Volume ratio, VR | 0.60 | 0.35 | c |
| Weaving ratio, R | 0.08 | N/A | d |
| Weaving length (ft) | 2070 | 2500 | e |

Notes:

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.

d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).

g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Grandview to US 550/CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2885 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 759 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1088 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1088 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 18.1 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 2740 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 721 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1034 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1034 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 17.2 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: AM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: Grandview Ramp C
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2740 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 385 | vph |
| Length of first accel/decel lane | 1900 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 2740 | 385 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 721 | 101 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 3101 | 417 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ}$ = 0.631 Using Equation 1

$v_{12} = v_F (P_{FM})$ = 1956 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 3518 | 6900 | No |
| $v_{R12}$ | 2373 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 11.9 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S$ = 0.211

Space mean speed in ramp influence area, $S_R$ = 56.2 mph

Space mean speed in outer lanes, $S_0$ = 57.7 mph

Space mean speed for all vehicles, $S$ = 56.7 mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH Inc.

Phone:                                        Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and E |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3125 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 822 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1179 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1179 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 19.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

Analyst: SEH Inc.
Agency or Company:
Date Performed: 5/2/11
Analysis Time Period: AM Peak
Freeway/Direction: Westbound
From/To: West of Grandview
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3125 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 822 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1179 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1179 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 19.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 735 | 0 | 630 | 300 | 0 | 195 | 1035 | 135 | 470 | 145 | 60 | 555 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | | 5.0 | 5.0 | | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Lane Util. Factor | 0.97 | | 0.88 | 0.97 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 774 | 0 | 663 | 316 | 0 | 205 | 1089 | 142 | 495 | 153 | 63 | 584 |
| RTOR Reduction (vph) | 0 | 0 | 229 | 0 | 0 | 18 | 0 | 0 | 244 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 774 | 0 | 434 | 316 | 0 | 187 | 1089 | 142 | 251 | 153 | 63 | 584 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 6 | | | 5 6 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 27.1 | | 49.9 | 27.1 | | 49.9 | 32.8 | 12.1 | 44.2 | 32.8 | 12.1 | 87.0 |
| Effective Green, g (s) | 27.1 | | 49.9 | 27.1 | | 49.9 | 32.8 | 12.1 | 44.2 | 32.8 | 12.1 | 87.0 |
| Actuated g/C Ratio | 0.31 | | 0.57 | 0.31 | | 0.57 | 0.38 | 0.14 | 0.51 | 0.38 | 0.14 | 1.00 |
| Clearance Time (s) | 5.0 | | | 5.0 | | | 5.0 | 5.0 | | 5.0 | 5.0 | |
| Vehicle Extension (s) | 3.0 | | | 3.0 | | | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 1069 | | 1599 | 1069 | | 908 | 1294 | 259 | 804 | 1294 | 259 | 1583 |
| v/s Ratio Prot | c0.23 | | | 0.09 | | | c0.32 | c0.08 | | 0.04 | 0.03 | |
| v/s Ratio Perm | | | 0.16 | | | 0.12 | | | 0.16 | | | 0.37 |
| v/c Ratio | 0.72 | | 0.27 | 0.30 | | 0.21 | 0.84 | 0.55 | 0.31 | 0.12 | 0.24 | 0.37 |
| Uniform Delay, d1 | 26.6 | | 9.4 | 22.7 | | 9.0 | 24.7 | 34.9 | 12.5 | 17.7 | 33.4 | 0.0 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 2.5 | | 0.1 | 0.2 | | 0.1 | 5.1 | 8.1 | 0.2 | 0.0 | 2.2 | 0.1 |
| Delay (s) | 29.1 | | 9.5 | 22.9 | | 9.1 | 29.9 | 43.0 | 12.7 | 17.7 | 35.6 | 0.1 |
| Level of Service | C | | A | C | | A | C | D | B | B | D | A |
| Approach Delay (s) | | 20.0 | | | 17.4 | | | 26.0 | | | 6.3 | |
| Approach LOS | | C | | | B | | | C | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 19.6 | HCM Level of Service | B |
| HCM Volume to Capacity ratio | 0.75 | | |
| Actuated Cycle Length (s) | 87.0 | Sum of lost time (s) | 15.0 |
| Intersection Capacity Utilization | 72.2% | ICU Level of Service | C |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4250 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1118 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1603 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1603 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 26.7 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp A
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 4250 | vph |

Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 485 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 4250 | | 485 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 1118 | | 128 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | % | |
| Length | 0.00 | mi | 0.00 | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 4809 | | 526 | | | pcph |

Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 0.616 Using Equation 5

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3163 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 4809 | 6900 | No |
| $v_{12}$ | 3163 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 4283 | 6900 | No |
| $v_R$ | 526 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 22.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

## Speed Estimation

Intermediate speed variable, $D_S$ = 0.410

Space mean speed in ramp influence area, $S_R$ = 52.6 mph

Space mean speed in outer lanes, $S_0$ = 63.3 mph

Space mean speed for all vehicles, $S$ = 55.8 mph

HCS2000:  Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone:                                            Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp A & B |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description:  Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3765 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 991 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1420 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1420 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 23.7 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: Grandview Ramp B
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3765 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 175 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 3765 | 175 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 991 | 46 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 4260 | 190 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 0.619$ Using Equation 1

$v_{12} = v_F (P_{FM}) = 2635$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 4450 | 6900 | No |
| $v_{R12}$ | 2825 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734 v_R + 0.0078 v_{12} - 0.00627 L_A$ = 18.2 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.269$

Space mean speed in ramp influence area, $S_R = 55.2$ mph

Space mean speed in outer lanes, $S_0 = 56.0$ mph

Space mean speed for all vehicles, $S = 55.4$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | AM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between Ramp B & D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3935 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1036 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1484 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1484 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 24.7 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Grandview to US 550/CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3935 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1036 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1484 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1484 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 24.7 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: US 550/CR 233 Off Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3935 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 2 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 1980 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | 500 | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3935 | | 1980 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 1036 | | 521 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 4453 | | 2147 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ}$ = 0.450 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3185 pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 4453 | 6900 | No |
| $v_{12}$ | 3185 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2306 | 6900 | No |
| $v_R$ | 2147 | 4100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 9.1 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

## Speed Estimation

Intermediate speed variable, $D_S$ = 0.556

Space mean speed in ramp influence area, $S_R$ = 50.0 mph

Space mean speed in outer lanes, $S_0$ = 64.8 mph

Space mean speed for all vehicles, $S$ = 53.5 mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Eastbound |
| From/To: | Between CR 233/US 550 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1955 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 514 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1106 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1106 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 18.4 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Eastbound
Junction: US 550/CR 223 On Ramp
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 1955 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 655 | vph |
| Length of first accel/decel lane | 1470 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | Ramp | Adjacent Ramp | |
|---|---|---|---|---|
| Volume, V (vph) | 1955 | 655 | | vph |
| Peak-hour factor, PHF | 0.95 | 0.95 | | |
| Peak 15-min volume, v15 | 514 | 172 | | v |
| Trucks and buses | 5 | 2 | | % |
| Recreational vehicles | 0 | 0 | | % |
| Terrain type: | Rolling | Rolling | | |
| Grade | % | % | % | |
| Length | mi | mi | mi | |
| Trucks and buses PCE, ET | 2.5 | 2.5 | | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.971 | | |
| Driver population factor, fP | 1.00 | 1.00 | | |
| Flow rate, vp | 2212 | 710 | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_F (P_{FM}) = 2212$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 2922 | 4600 | No |
| $v_{R12}$ | 2922 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A = 18.7$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.276$

Space mean speed in ramp influence area, $S_R = 55.0$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 55.0$ mph

HCS2000: Ramps and Ramp Junctions Release 4.1f

Jon E. Larson
SEH, Inc.

Phone: Fax:
E-mail:

## Diverge Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date performed: | 5/2/11 |
| Analysis time period: | PM Peak |
| Freeway/Dir of Travel: | US 160 Westbound |
| Junction: | US 550/CR 233 Off Ramp |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Diverge | |
| Number of lanes in freeway | 2 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 2370 | vph |

## Off Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-Flow speed on ramp | 40.0 | mph |
| Volume on ramp | 485 | vph |
| Length of first accel/decel lane | 1000 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent ramp | | vph |
| Position of adjacent ramp | | |
| Type of adjacent ramp | | |
| Distance to adjacent ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 2370 | | 485 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 624 | | 128 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | 0.00 | % | 0.00 | % | | % |
| Length | 0.00 | mi | 0.00 | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 2682 | | 526 | | | pcph |

## Estimation of V12 Diverge Areas

L = (Equation 25-8 or 25-9)

$P_{FD}^{EQ} = 1.000$ Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD} = 2682$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{Fi} = v_F$ | 2682 | 4600 | No |
| $v_{12}$ | 2682 | 4400 | No |
| $v_{FO} = v_F - v_R$ | 2156 | 4600 | No |
| $v_R$ | 526 | 2100 | No |

## Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D = 18.3$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $D_S = 0.410$

Space mean speed in ramp influence area, $S_R = 52.6$ mph

Space mean speed in outer lanes, $S_0 =$ N/A mph

Space mean speed for all vehicles, $S = 52.6$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between CR 233 Ramps |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 1885 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 496 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1067 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 2 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 4.5 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1067 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 2 | |
| Density, D | 17.8 | pc/mi/ln |
| Level of service, LOS | B | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Freeway Weaving Release 4.1f

Jon E. Larson
SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency/Co.: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Dir of Travel: | US 160 Westbound |
| Weaving Location: | US 550 On/Grandview Off |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Inputs

| | | |
|---|---|---|
| Freeway free-flow speed, SFF | 60 | mph |
| Weaving number of lanes, N | 4 | |
| Weaving segment length, L | 2070 | ft |
| Terrain type | Rolling | |
| Grade | | % |
| Length | | mi |
| Weaving type | A | Multilane or C-D |
| Volume ratio, VR | 0.55 | |
| Weaving ratio, R | 0.07 | |

## Conversion to pc/h Under Base Conditions

| | Non-Weaving | | Weaving | | |
|---|---|---|---|---|---|
| | V A-C | V B-D | V A-D | V B-C | |
| Volume, V | 1745 | 0 | 140 | 2005 | veh/h |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | |
| Peak 15-min volume, v15 | 459 | 0 | 37 | 528 | v |
| Trucks and buses | 5 | 5 | 5 | 5 | % |
| Recreational vehicles | 0 | 0 | 0 | 0 | % |
| Trucks and buses PCE, ET | 2.5 | 2.5 | 2.5 | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | 2.0 | 2.0 | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | 0.930 | 0.930 | 0.930 | |
| Driver population adjustment, fP | 1.00 | 1.00 | 1.00 | 1.00 | |
| Flow rate, v | 1974 | 0 | 158 | 2268 | pc/h |

## Weaving and Non-Weaving Speeds

| | Weaving | Non-Weaving |
|---|---|---|
| a (Exhibit 24-6) | 0.15 | 0.00 |
| b (Exhibit 24-6) | 2.20 | 4.00 |
| c (Exhibit 24-6) | 0.97 | 1.30 |
| d (Exhibit 24-6) | 0.80 | 0.75 |
| Weaving intensity factor, Wi | 1.82 | 0.34 |
| Weaving and non-weaving speeds, Si | 32.71 | 52.33 |
| Number of lanes required for unconstrained operation, Nw (Exhibit 24-7) | | 2.42 |
| Maximum number of lanes, Nw (max) (Exhibit 24-7) | | 1.40 |
| Type of operation is | | Constrained |

## Weaving Segment Speed, Density, Level of Service and Capacity

Weaving segment speed, S 39.32 mph

| | | |
|---|---|---|
| Weaving segment density, D | 27.97 | pc/mi/ln |
| Level of service, LOS | C | |
| Capacity of base condition, cb | 7176 | pc/h |
| Capacity as a 15-minute flow rate, c | 6675 | pc/h |
| Capacity as a full-hour volume, ch | 6341 | pc/h |

## Limitations on Weaving Segments

| | Analyzed | Maximum | If Max Exceeded See Note<br>Note |
|---|---|---|---|
| Weaving flow rate, Vw | 2426 | 2800 | a |
| Average flow rate (pcphpl) | 1100 | 2300 | b |
| Volume ratio, VR | 0.55 | 0.35 | c |
| Weaving ratio, R | 0.07 | N/A | d |
| Weaving length (ft) | 2070 | 2500 | e |

Notes:

a. Weaving segments longer than 2500 ft. are treated as isolated merge and diverge areas using the procedures of Chapter 25, "Ramps and Ramp Junctions".

b. Capacity constrained by basic freeway capacity.

c. Capacity occurs under constrained operating conditions.

d. Three-lane Type A segments do not operate well at volume ratios greater than 0.45. Poor operations and some local queuing are expected in such cases.

e. Four-lane Type A segments do not operate well at volume ratios greater than 0.35. Poor operations and some local queuing are expected in such cases.

f. Capacity constrained by maximum allowable weaving flow rate: 2,800 pc/h (Type A), 4,000 (Type B), 3,500 (Type C).

g. Five-lane Type A segments do not operate well at volume ratios greater than 0.20. Poor operations and some local queuing are expected in such cases.

h. Type B weaving segments do not operate well at volume ratios greater than 0.80. Poor operations and some local queuing are expected in such cases.

i. Type C weaving segments do not operate well at volume ratios greater than 0.50. Poor operations and some local queuing are expected in such cases.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Grandview to US 550/CR 233 |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3890 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1024 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1467 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1467 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 24.5 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

Nick Samuelson
SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and D |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 3750 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 987 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1414 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1414 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 23.6 | pc/mi/ln |
| Level of service, LOS | C | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Ramps and Ramp Junctions Release 4.1f

SEH Inc.

Phone: Fax:
E-mail:

## Merge Analysis

Analyst: SEH Inc.
Agency/Co.:
Date performed: 5/2/11
Analysis time period: PM Peak
Freeway/Dir of Travel: US 160 Westbound
Junction: Grandview Ramp C
Jurisdiction:
Analysis Year: Year 2030 Rev Alt F Mod
Description: US 160 Supplemental EIS

## Freeway Data

| | | |
|---|---|---|
| Type of analysis | Merge | |
| Number of lanes in freeway | 3 | |
| Free-flow speed on freeway | 60.0 | mph |
| Volume on freeway | 3750 | vph |

## On Ramp Data

| | | |
|---|---|---|
| Side of freeway | Right | |
| Number of lanes in ramp | 1 | |
| Free-flow speed on ramp | 40.0 | mph |
| Volume on ramp | 590 | vph |
| Length of first accel/decel lane | 1900 | ft |
| Length of second accel/decel lane | | ft |

## Adjacent Ramp Data (if one exists)

| | | |
|---|---|---|
| Does adjacent ramp exist? | No | |
| Volume on adjacent Ramp | | vph |
| Position of adjacent Ramp | | |
| Type of adjacent Ramp | | |
| Distance to adjacent Ramp | | ft |

## Conversion to pc/h Under Base Conditions

| Junction Components | Freeway | | Ramp | | Adjacent Ramp | |
|---|---|---|---|---|---|---|
| Volume, V (vph) | 3750 | | 590 | | | vph |
| Peak-hour factor, PHF | 0.95 | | 0.95 | | | |
| Peak 15-min volume, v15 | 987 | | 155 | | | v |
| Trucks and buses | 5 | | 2 | | | % |
| Recreational vehicles | 0 | | 0 | | | % |
| Terrain type: | Rolling | | Rolling | | | |
| Grade | | % | | % | | % |
| Length | | mi | | mi | | mi |
| Trucks and buses PCE, ET | 2.5 | | 2.5 | | | |
| Recreational vehicle PCE, ER | 2.0 | | 2.0 | | | |
| Heavy vehicle adjustment, fHV | 0.930 | | 0.971 | | | |
| Driver population factor, fP | 1.00 | | 1.00 | | | |
| Flow rate, vp | 4243 | | 640 | | | pcph |

## Estimation of V12 Merge Areas

L = (Equation 25-2 or 25-3)

$P_{FM}^{EQ} = 0.631$ Using Equation 1

$v_{12} = v_F (P_{FM}) = 2676$ pc/h

## Capacity Checks

| | Actual | Maximum | LOS F? |
|---|---|---|---|
| $v_{FO}$ | 4883 | 6900 | No |
| $v_{R12}$ | 3316 | 4600 | No |

## Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A = 19.1$ pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

## Speed Estimation

Intermediate speed variable, $M_S = 0.276$

Space mean speed in ramp influence area, $S_R = 55.0$ mph

Space mean speed in outer lanes, $S_0 = 56.2$ mph

Space mean speed for all vehicles, $S = 55.4$ mph

HCS2000: Basic Freeway Segments Release 4.1f

SEH Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | Between ramp C and E |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4340 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1142 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1637 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1637 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 27.3 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

SEH, Inc.

Phone: Fax:
E-mail:

## Operational Analysis

| | |
|---|---|
| Analyst: | SEH Inc. |
| Agency or Company: | |
| Date Performed: | 5/2/11 |
| Analysis Time Period: | PM Peak |
| Freeway/Direction: | Westbound |
| From/To: | West of Grandview |
| Jurisdiction: | |
| Analysis Year: | Year 2030 Rev Alt F Mod |

Description: Traffic Operations Analysis for the US 160 Supplemental EIS

## Flow Inputs and Adjustments

| | | |
|---|---|---|
| Volume, V | 4340 | veh/h |
| Peak-hour factor, PHF | 0.95 | |
| Peak 15-min volume, v15 | 1142 | v |
| Trucks and buses | 5 | % |
| Recreational vehicles | 0 | % |
| Terrain type: | Rolling | |
| Grade | 0.00 | % |
| Segment length | 0.00 | mi |
| Trucks and buses PCE, ET | 2.5 | |
| Recreational vehicle PCE, ER | 2.0 | |
| Heavy vehicle adjustment, fHV | 0.930 | |
| Driver population factor, fp | 1.00 | |
| Flow rate, vp | 1637 | pc/h/ln |

## Speed Inputs and Adjustments

| | | |
|---|---|---|
| Lane width | 12.0 | ft |
| Right-shoulder lateral clearance | 6.0 | ft |
| Interchange density | 0.50 | interchange/mi |
| Number of lanes, N | 3 | |
| Free-flow speed: | Measured | |
| FFS or BFFS | 60.0 | mi/h |
| Lane width adjustment, fLW | 0.0 | mi/h |
| Lateral clearance adjustment, fLC | 0.0 | mi/h |
| Interchange density adjustment, fID | 0.0 | mi/h |
| Number of lanes adjustment, fN | 3.0 | mi/h |
| Free-flow speed, FFS | 60.0 | mi/h |
| | Urban Freeway | |

## LOS and Performance Measures

| | | |
|---|---|---|
| Flow rate, vp | 1637 | pc/h/ln |
| Free-flow speed, FFS | 60.0 | mi/h |
| Average passenger-car speed, S | 60.0 | mi/h |
| Number of lanes, N | 3 | |
| Density, D | 27.3 | pc/mi/ln |
| Level of service, LOS | D | |

Overall results are not computed when free-flow speed is less than 55 mph.

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 720 | 0 | 1260 | 295 | 0 | 190 | 1075 | 160 | 405 | 250 | 85 | 930 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 9.0 | | 9.0 | 9.0 | | 9.0 | 9.0 | 8.5 | 9.0 | 9.0 | 8.5 | 9.0 |
| Lane Util. Factor | 0.97 | | 0.88 | 0.97 | | 1.00 | 0.97 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 |
| Frt | 1.00 | | 0.85 | 1.00 | | 0.85 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 |
| Flt Protected | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (prot) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Flt Permitted | 0.95 | | 1.00 | 0.95 | | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 |
| Satd. Flow (perm) | 3433 | | 2787 | 3433 | | 1583 | 3433 | 1863 | 1583 | 3433 | 1863 | 1583 |
| Peak-hour factor, PHF | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| Adj. Flow (vph) | 758 | 0 | 1326 | 311 | 0 | 200 | 1132 | 168 | 426 | 263 | 89 | 979 |
| RTOR Reduction (vph) | 0 | 0 | 161 | 0 | 0 | 8 | 0 | 0 | 249 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 758 | 0 | 1165 | 311 | 0 | 192 | 1132 | 168 | 177 | 263 | 89 | 979 |
| Turn Type | Prot | | custom | Prot | | custom | Prot | | custom | Prot | | custom |
| Protected Phases | 1 | | | 1 | | | 5 | 6 | | 5 | 6 | |
| Permitted Phases | | | 5 6 | | | 5 6 | | | 1 6 | | | 1 5 6 |
| Actuated Green, G (s) | 28.0 | | 64.5 | 28.0 | | 64.5 | 39.0 | 16.5 | 53.0 | 39.0 | 16.5 | 110.0 |
| Effective Green, g (s) | 28.0 | | 64.5 | 28.0 | | 64.5 | 39.0 | 16.5 | 44.5 | 39.0 | 16.5 | 101.5 |
| Actuated g/C Ratio | 0.25 | | 0.59 | 0.25 | | 0.59 | 0.35 | 0.15 | 0.40 | 0.35 | 0.15 | 0.92 |
| Clearance Time (s) | 9.0 | | | 9.0 | | | 9.0 | 8.5 | | 9.0 | 8.5 | |
| Vehicle Extension (s) | 3.0 | | | 3.0 | | | 3.0 | 3.0 | | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 874 | | 1634 | 874 | | 928 | 1217 | 279 | 640 | 1217 | 279 | 1461 |
| v/s Ratio Prot | c0.22 | | | 0.09 | | | c0.33 | 0.09 | | 0.08 | 0.05 | |
| v/s Ratio Perm | | | c0.42 | | | 0.12 | | | 0.11 | | | 0.62 |
| v/c Ratio | 0.87 | | 0.71 | 0.36 | | 0.21 | 0.93 | 0.60 | 0.28 | 0.22 | 0.32 | 0.67 |
| Uniform Delay, d1 | 39.2 | | 16.2 | 33.6 | | 10.7 | 34.2 | 43.7 | 22.0 | 24.8 | 41.7 | 0.9 |
| Progression Factor | 1.00 | | 1.00 | 1.00 | | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Incremental Delay, d2 | 9.1 | | 1.5 | 0.3 | | 0.1 | 12.5 | 3.6 | 0.2 | 0.1 | 0.7 | 1.2 |
| Delay (s) | 48.3 | | 17.7 | 33.9 | | 10.8 | 46.7 | 47.3 | 22.2 | 24.9 | 42.4 | 2.1 |
| Level of Service | D | | B | C | | B | D | D | C | C | D | A |
| Approach Delay (s) | | 28.8 | | | 24.8 | | | 40.7 | | | 9.3 | |
| Approach LOS | | C | | | C | | | D | | | A | |

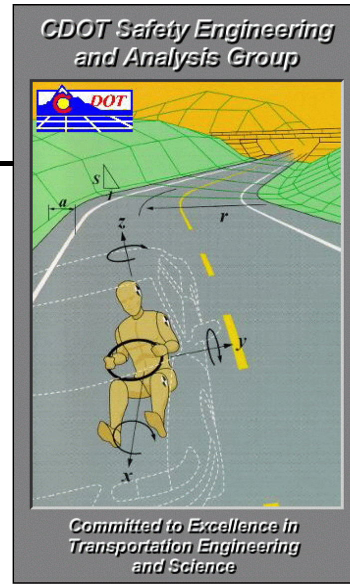
| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 27.5 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.81 | | |
| Actuated Cycle Length (s) | 110.0 | Sum of lost time (s) | 18.0 |
| Intersection Capacity Utilization | 102.8% | ICU Level of Service | G |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

# CDOT MEMORANDUM

# US 550 Connection to US 160 in Grandview SEIS—Safety Review of Alternative Connection Options

# June 27, 2011

# STATE OF COLORADO




**DEPARTMENT OF TRANSPORTATION**
HQ Safety and Traffic Engineering Branch
Safety Engineering and Analysis Group
4201 East Arkansas Avenue
Denver, Colorado 80222-3400
303.757.9654 Voice
303.757.9219 Fax

DATE: June 27, 2011

TO: Mike McVaugh, R-5 Traffic & Safety Engineer

FROM: Bryan K. Allery, HQ Safety and Traffic Engineering

SUBJECT: **US 550 Connection to US 160 in Grandview SEIS**
**Safety Review of Alternative Connection Options**

Attached for your review is a copy of the draft Safety Review for the above referenced location in Region 5. The observations in this report are based on Traffic & Safety analyses and Volume studies made by SEH, Inc. and the analysis of five years of accident history and review of Visidata images. The Region is advised to verify through field surveys and other available sources, the observations made in this report regarding physical features, roadside characteristics and traffic control devices in the study area.

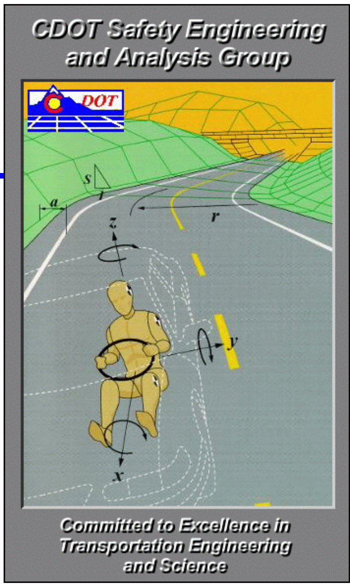
If you have any comments on the content or format of this report, please provide them to us by July 29. If we do not hear from you by this date, we will assume that the report has met with your approval.

Should any questions arise concerning this report, or if further assistance is needed, please do not hesitate to contact me at 303.757.9967 or Ron Nelson at 303.512.5101.

attachment

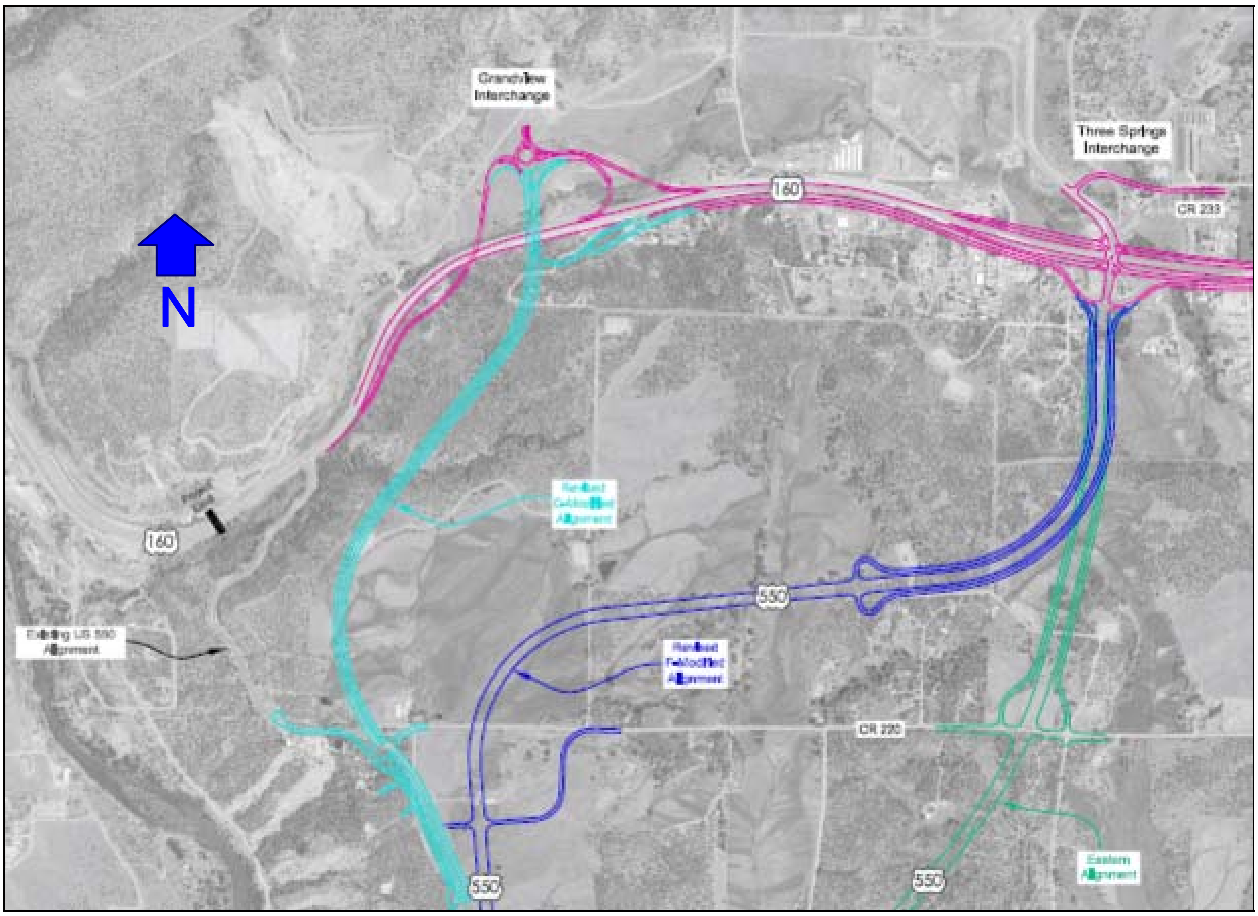
c: K C Matthews, HQ Safety and Traffic Engineering, R-5 Group RE
San Lee, HQ Safety and Traffic Engineering, R-5 Group

File




# Abbreviated Safety Review

**Review of Alternatives:**
**US 550 Connection to US 160**
**US 160 Corridor SEIS, Region 5**
**June 2011**

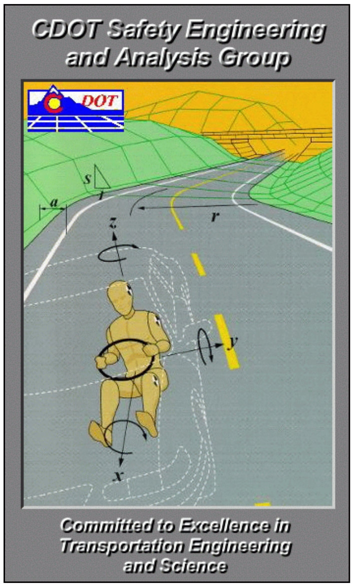



**Prepared by:** **The Colorado Department of Transportation**
Safety and Traffic Engineering Branch
Safety Engineering and Analysis Group
4201 E. Arkansas Ave.
Denver, CO 80222

This report is prepared solely for the purpose of identifying, evaluating and planning safety improvements on public roads. It is subject to the provisions of 23 U.S.C.A. 409, and therefore is not subject to discovery and is excluded from evidence. Applicable provisions of 23 U.S.C.A. 409 are cited below:

> *Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 152 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists or data.*

Any intentional or inadvertent release of this report, or any data derived from its use shall not constitute a waiver of privilege pursuant to 23 U.S.C.A. 409.




## *A Statement of Philosophy*

The efficient and responsible investment of resources in addressing safety problems is a difficult task. Since crashes occur on all highways in use, it is inappropriate to say of any highway that it is safe. However, it is correct to say that highways can be built to be safer or less safe. Road safety is a matter of degree. When making decisions effecting road safety it is critical to understand that expenditure of limited available funds on improvements in places where it prevents few injuries and saves few lives can mean that injuries will occur and lives will be lost by not spending them in places where more accidents could have been prevented[1]. It is CDOT's objective to maximize accident reduction within the limitations of available budgets by making road safety improvements at locations where it does the most good or prevents the most accidents.

# INTRODUCTION

This abbreviated safety review examines the potential safety outlook for the alternative connections of US 550 to US 160 as outlined in the US highway 160, Durango to Bayfield Environmental Impact statement (EIS). Estimations and comments provided in this review are based on projected traffic volumes, capacity analysis and traffic operations formulated by SEH, Inc. and provided in the two SEH, Inc. memorandums to Mike McVaugh, Region 5 Traffic & Safety Engineer. The memorandums, both dated May 5, 2011, are: No. COTO5 - 112456, Traffic & Safety Analysis and No. 112456-COTO5, Year 2030 Traffic Volume Verification and Existing Conditions at Farmington Hill.

Four options for the new connection were reviewed:

1. No action alternative: Leaves the existing US 160 to US 550 intersection at its current location and the current alignment of US 550 immediately south of US 160 is maintained.

2. Revised G Modified alternative: Realigns a segment of US 550 to connect with US 160 at the new Grandview interchange utilizing a roundabout for traffic distribution to the US 160 ramps. This option also reconstructs a short segment of US 550 on a four lane cross-section. For reference, the Grandview interchange is constructed at approximately milepost (MP) 89.0 on US 160.

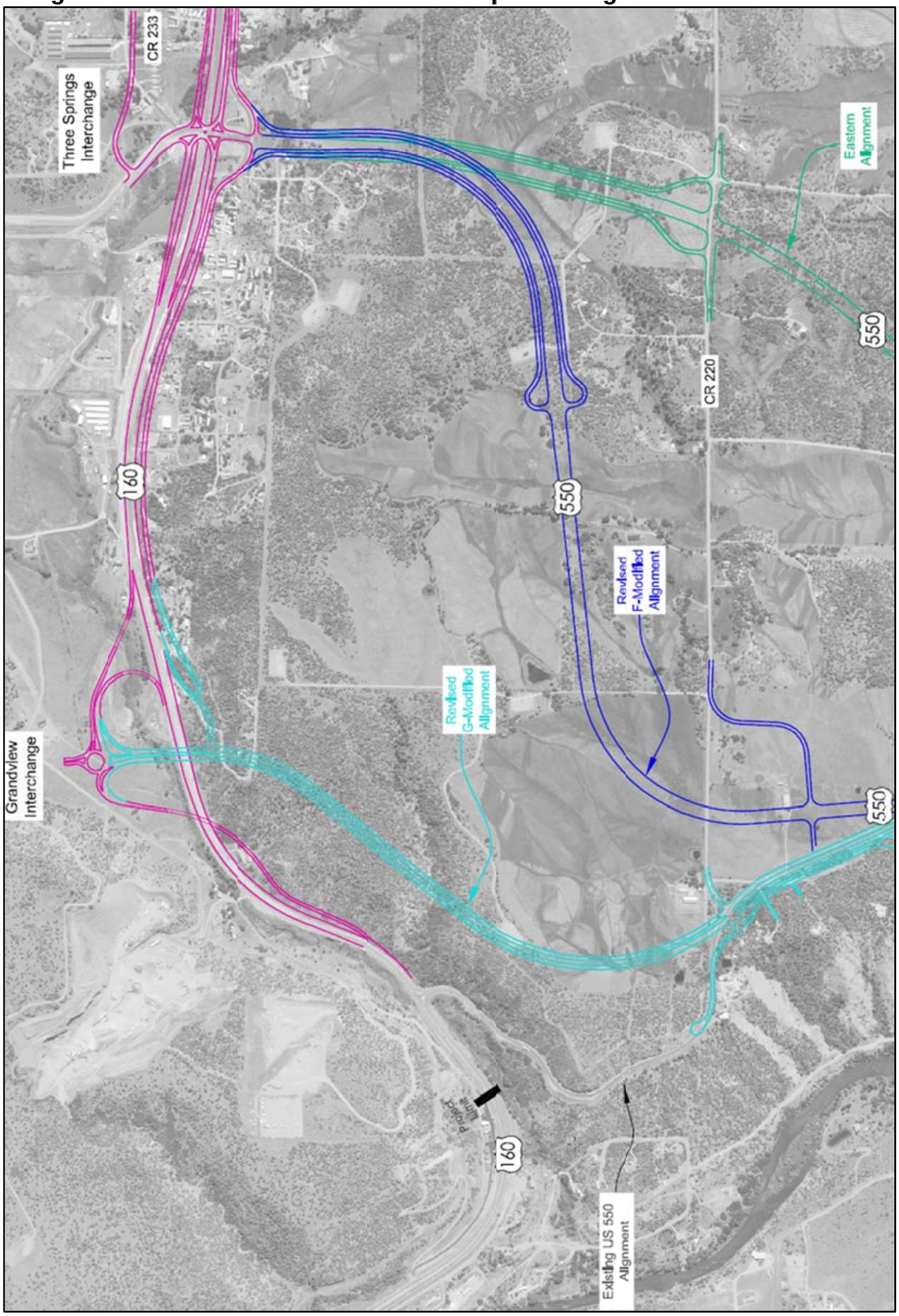
3. Revised F Modified alternative: Realigns and widens an alternate segment of US 550 to connect with US 160 at the proposed Three Springs (County Rd. or CR 233) single point urban interchange (SPUI) at MP 90.10 on US 160.

4. Eastern Realignment alternative: Also connects US 550 to US 160 at the Three Springs SPUI, however it includes a third realignment of US 550 south of the interchange but still widens the new section of US 550 to four lanes.

[1] Hauer, E., (1999) *Safety Review of Highway 407: Confronting Two Myths*. TRB

**Figure 1**, copied from the above memorandum, shows the four alternatives.

**Figure 1** **Area Map Showing the Four Alternatives**



Based on the memo's summary description of the alternatives, the following three assumptions are made:

- The US 160/Grandview Interchange is constructed and includes a roundabout ramp intersection and similar ramp configuration for all four alternatives.

- The US 160/Three Springs interchange will be constructed as a SPUI for all four alternatives.

- A continuous frontage road on the south side of US 160 between the new interchanges will be built for all four alternatives.

## RECENT CRASH EXPERIENCE

The Western Grandview segment of US 160 together with the intersection of US 550 and US 160 and the US 160/Three Springs intersection are shown in the satellite photo of **Figure 2**. Crash experience for the recent study period of 1/1/2005 through 12/31/2009 along this segment of US 160 is reviewed in the following report sections.

**Figure 2** **Grandview Segment of US 160**

## Crash Distribution in the Western Grandview Segment of US 160

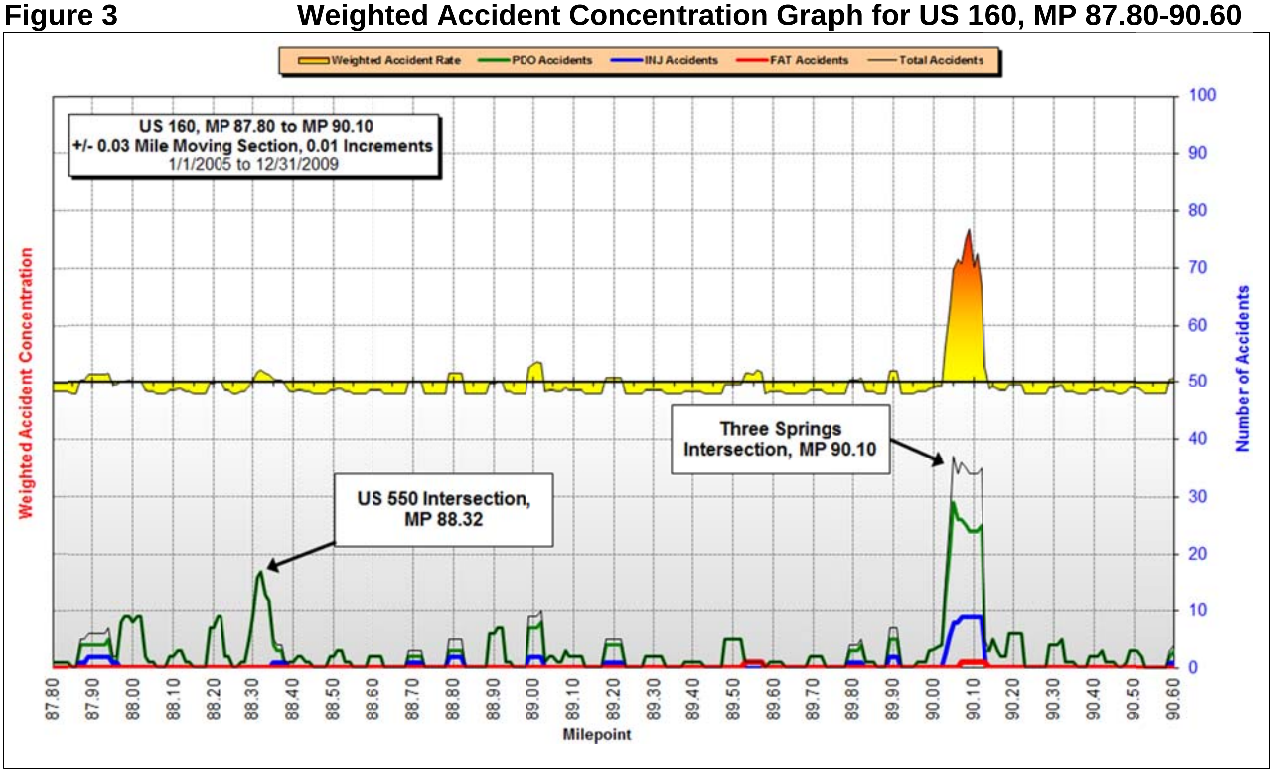
The location where crashes occurred through the Grandview section of US 160 is displayed in the weighted accident concentration graph (WAC) shown in **Figure 3**. This graphical depiction of crash location on US 160 extends from just west of the intersection with US 550 to just east of the Three Springs intersection.

The WAC graph helps to identify where crash clusters formed or locations where multiple crashes were reported. These appear as higher points or spikes in the graph line on the lower axis. These lines are also separated by crash severity through their color: PDO or property damage only crashes are green, INJ or injury crashes are blue and FAT or fatal crashes are red. The upper graph uses weighting factors for the fatal and injury crashes to emphasize the locations where these more severe crashes were reported.

As shown in **Figure 3**, the Three Springs intersection (MP 90.10) exhibits the largest crash cluster in the corridor. Over 30 accidents were reported in the area immediately around the intersection. Near the US 550 intersection (MP 88.32), just under 20 crashes were reported.

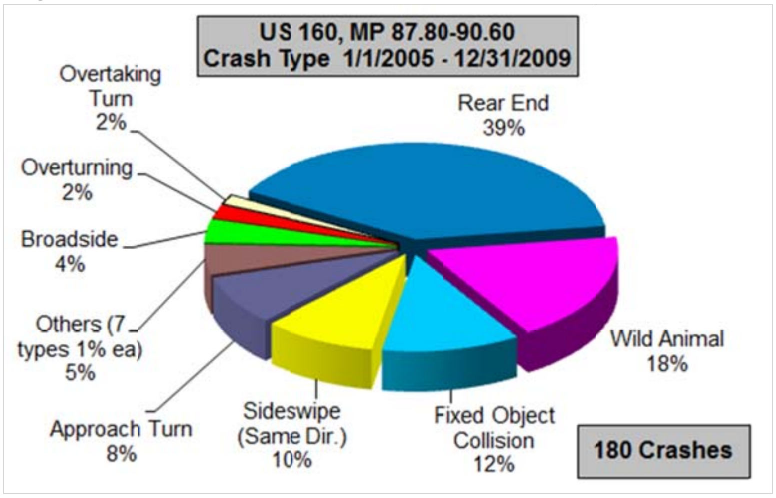
Individual crashes and minor crash clusters shown in **Figure 3** between the US 550 intersection and the Three Springs intersection typically involve deer collisions, driveway-related accidents and rear-end collisions associated with numerous private and public accesses to the highway and congestion backups from the Three Springs intersection.

**Figure 3** **Weighted Accident Concentration Graph for US 160, MP 87.80-90.60**



The types of crashes and crash severity detected in the Grandview segment of US 160 are presented in the charts of **Figures 4** & **5**. Rear end collisions were most common, accounting for 39% of the total 180 crashes. Rear end crashes exhibited increased frequency during morning and afternoon rush hour periods. Rear end crashes in the westbound lanes displayed higher frequency between 6 am and 8 am while eastbound rear end collisions were more prevalent in the afternoon between 3 and 6pm.

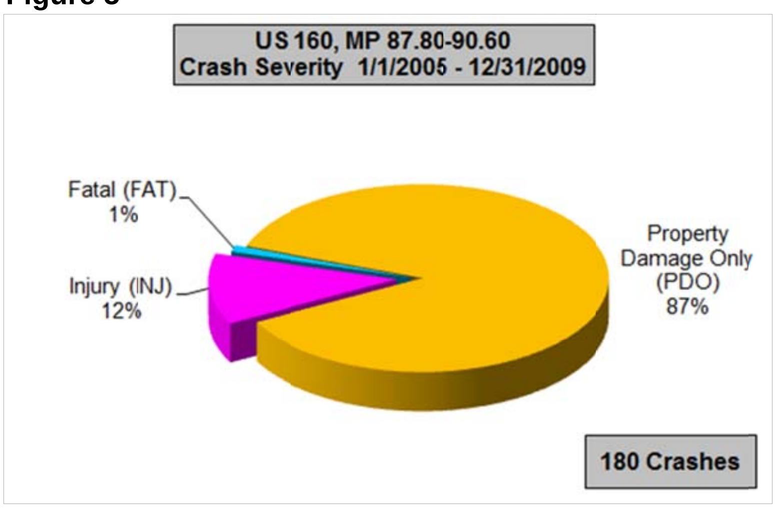
**Figure 4**




There were 33 collisions with deer representing 18% of the total and collisions with roadside fixed objects accounted for 12% of the total.

The crash severity chart of **Figure 5** indicates that most of the crashes on this segment of US 160 were low severity, property damage only (PDO) accidents. Overall, there were 2 fatal (FAT) crashes, 22 injury (INJ) crashes and 156 PDO crashes.

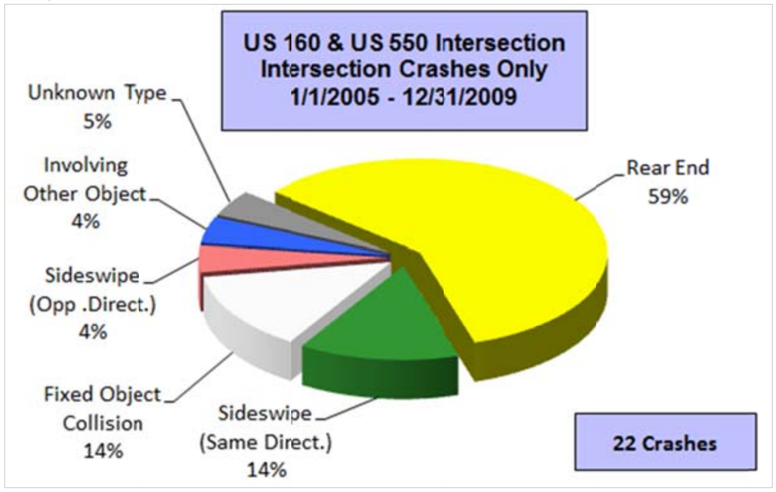
**Figure 5**



**Crash Experience at the Existing US 160/US 550 (Farmington Hill) Intersection**

Crashes occurring at the intersection of US 160 & US 550 (MP 88.32 on US 160) during the period 1/1/2005 - 12/31/2009 were reviewed. The chart in **Figure 6** shows the breakdown of crash types detected.

**Figure 6**

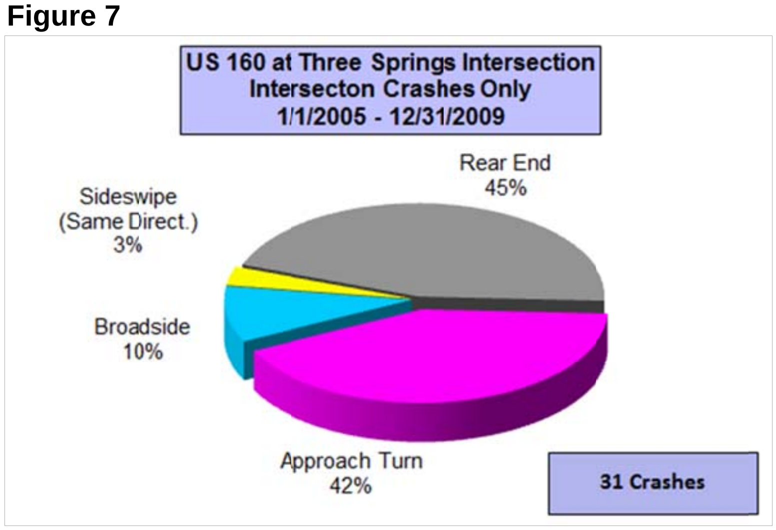



Rear-end collisions were most frequent at this intersection, primarily involving eastbound vehicles on US 160 approaching the traffic signal during afternoon periods.

**Crash Experience at the Existing US 160/Three Springs Intersection**

During the review period of 1/1/2005 through 12/31/2009, 31 crashes were noted at the US 160/Three Springs intersection. The chart in **Figure 7** shows the type of crashes reported. Rear end collisions and approach turn crashes were most common, accounting for nearly 90 percent of the total. Westbound vehicles on US 160 were at fault in nearly all of the rear-end accidents (12 of 14) while eastbound vehicles on 160 turning left in front of westbound through vehicles were at fault in 8 of 13 approach turn crashes.

**Figure 7**



### Crash Distribution on the Existing Alignment of US 550 from MP 14.00-16.56

The satellite photo of **Figure 8** depicts the segment of US 550 between MP 14.00 and the US 160 intersection at MP 16.56. This segment of US 550 is characterized by rolling terrain and modestly curvilinear alignment between MP 14.00 and MP 15.8 which is near the County Rd. 220 intersection. Between MP 15.8 and MP 16.56, US 550 descends steeply along sharper curves toward the US 160 intersection.

**Figure 8** **US 550, MP 14.00 – 16.56**

The location where crashes occurred along the segment of US 550 from MP 14.00 to 16.56, is displayed in the weighted accident concentration graph or WAC graph shown in **Figure 9**. This graph, extends from the intersection with US 160 at MP 16.56 south to MP 14.00. This segment includes both the rolling terrain on Florida Mesa and the steeper grades of Farmington Hill approaching the US 160 intersection at MP 16.56.

The WAC graph helps to identify where crash clusters formed or locations where multiple crashes were reported. These appear as points or spikes in the graph lines. The graphed accident data on the lower axis are segregated by crash severity through their color: PDO or property damage only crashes are green, INJ or injury crashes are blue and FAT or fatal crashes are red. The upper graph uses weighting factors for the injury and fatal crashes to emphasize the locations where these more severe crashes were reported.

In addition to the WAC graph, **Figure 9** shows the crash types and crash severity for the crashes that make up the WAC graph.

**Figure 9 Weighted Accident Concentration Graph for US 550, MP 14.00-16.56**

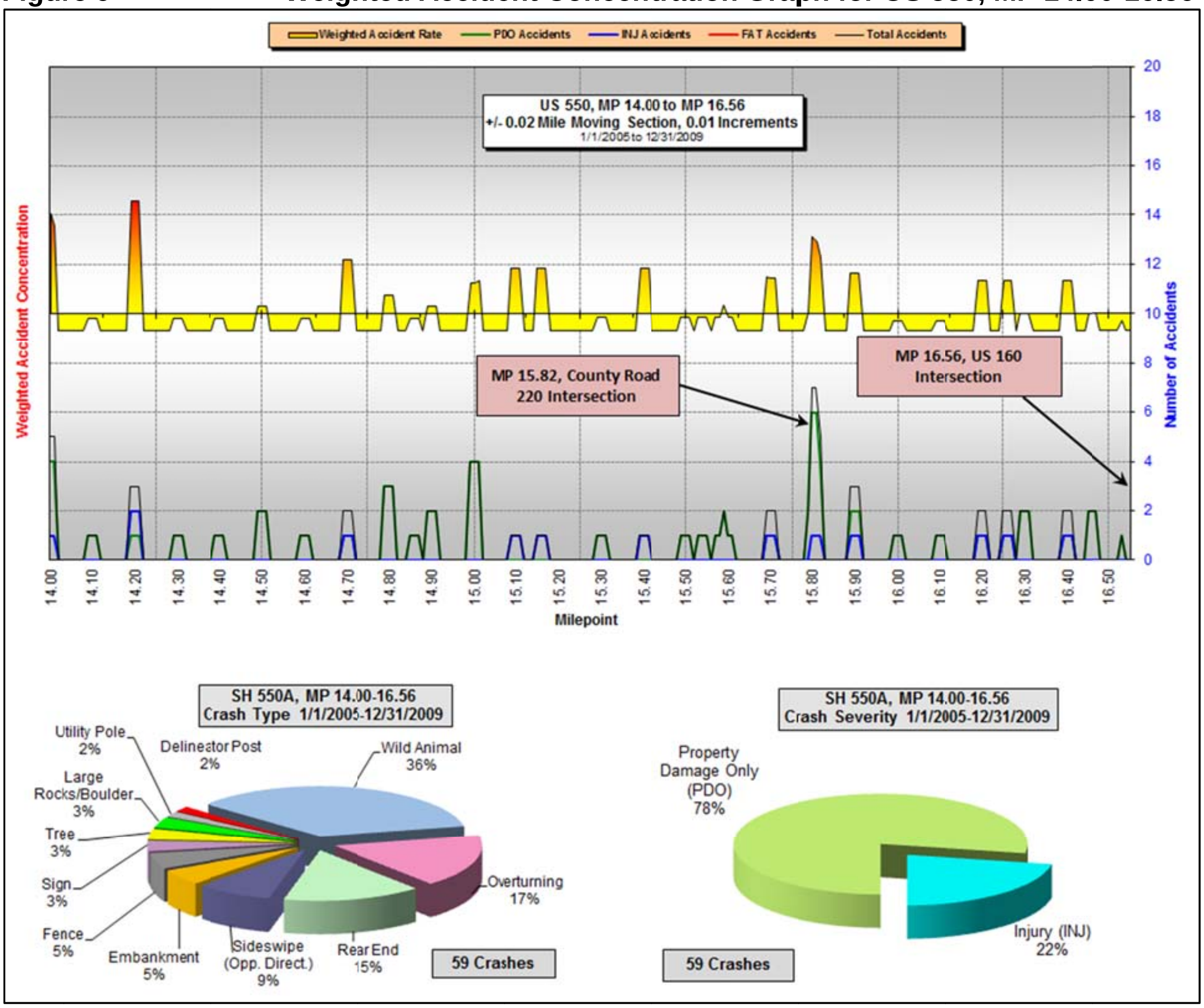


**Figure 9** The crashes depicted in the WAC graph are generally distributed evenly throughout this segment of US 550. Slightly increased crash density may be indicated between MP 16.20 and the US 160 intersection. A cluster of seven crashes appears at MP 15.82 which is the County Road 220 intersection. Crashes occurring at the intersection of US 550 and US 160 are assigned to the crash history of US 160 by convention and are shown on the previous WAC chart for US 160.

Among the more frequent crash types, collisions with deer or other wild animals were most common on the overall segment from MP 14.00-16.35. Deer involved crashes, however, occurred with more frequency in the southern portion of this segment of US 550, between MP 14.00 & 15.00.

The 10 overturning crashes were next in frequency of occurrence, making up 17% of the total. These were most prevalent between MP 15.00 and the US 160 intersection.

Rear end collisions accounted for 15% of the 59 crashes. Most of the rear end collisions occurred at the CR 220 intersection at MP 15.82.

Run-off-road type of crashes that typically involve colliding with roadside fixed objects and overturning occurred more frequently between MP 15.8 and the US 160 intersection.

There was a higher percentage of injury producing crashes along US 550 than on US 160. The frequency of injury crashes was highest between MP 15.7 and the US 160 intersection.

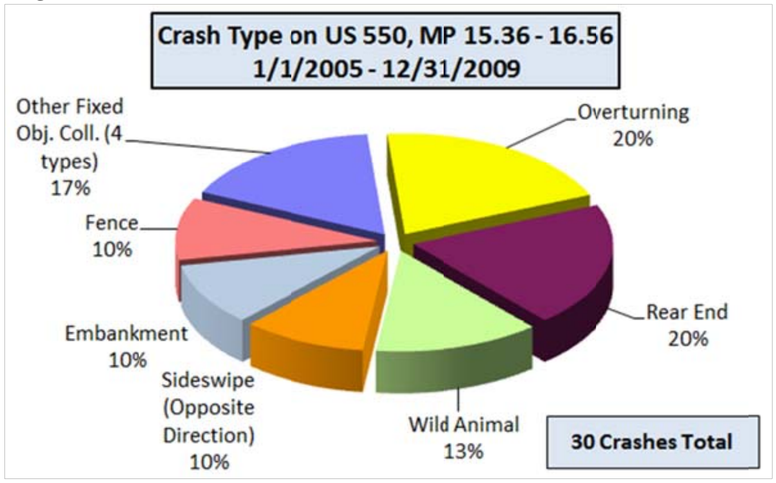
**Crash Experience on the Existing section of US 550 proposed for potential realignment**

According to the US 160 Final Environmental Impact Statement (FEIS), approximately 1.2 miles of existing US 550 could be realigned as part of the proposed improvements to the US 160 corridor. This segment on US 550 extends roughly from MP 15.36 to the intersection with US 160 at MP 16.56. Again, the annotated aerial photo in **Figure 8** helps to identify the location of MP 15.36 and the US 160 intersection.

Although this segment of US 550 is included in the previous, discussion, a specific examination of crash history along this reduced segment that is slated for potential realignment is helpful.

The types of crashes detected on the existing section of US 550 from MP 15.36 to the US 160 intersection are shown in **Figure 10**. Overturning accidents, rear-end collisions and collisions with various roadside fixed objects such as embankments, fencing and trees were most numerous. Along this roadway segment, the overturning crashes and fixed object collisions all involved drivers losing control and running off the road.

**Figure 10**




The number of run-off-road crashes, icy road crashes and roadside fixed object crashes is higher than expected along this segment of US 550 based on statewide averages. Many of these crashes occurred within the section characterized by steeper grades and a curvilinear alignment descending from the Mesa to the intersection with US 160 (MP 15.71 - MP 16.56).

As noted in the FEIS, the adverse environment of US 550's present location including steep terrain, north facing aspect and limited road shoulders are factors in the type and severity of the crashes experienced. Also, the driver's sight distance along this segment of US 550 is reduced by the sharp horizontal curves. In some cases the sight distance does not meet current design standards for horizontal alignment.

## ESTIMATED 2030 CRASH FREQUENCY AT THE ALTERNATIVE CONNECTIONS

The future safety of proposed highway facilities is difficult to estimate. Safety Performance Function (SPF) methodologies can be employed to provide general, expected or average crash frequency based on the type of highway facility and the traffic volume using the facility.

The Safety Performance Function reflects the complex relationship between traffic exposure measured in average daily traffic (ADT), and accident count for a highway segment or intersection measured in accidents per mile per year (apmpy) or accidents per year (Acc/Yr). The SPF models provide an estimate of the normal or expected accident frequency for a range of ADT among similar facilities.

The SPF lends itself well to the conceptual formulation of the Level of Service of Safety (LOSS). The concept of level of service uses qualitative measures that characterize safety of a roadway feature in reference to its expected performance. If the level of safety predicted by the SPF will represent a normal or expected number of accidents at a specific level of ADT, then the degree of deviation of observed crash experience from the norm can be stratified to represent specific levels of safety.

LOSS-I - Indicates low potential for accident reduction
LOSS-II- Indicates better than expected safety performance
LOSS-III - Indicates less than expected safety performance
LOSS-IV - Indicates high potential for accident reduction

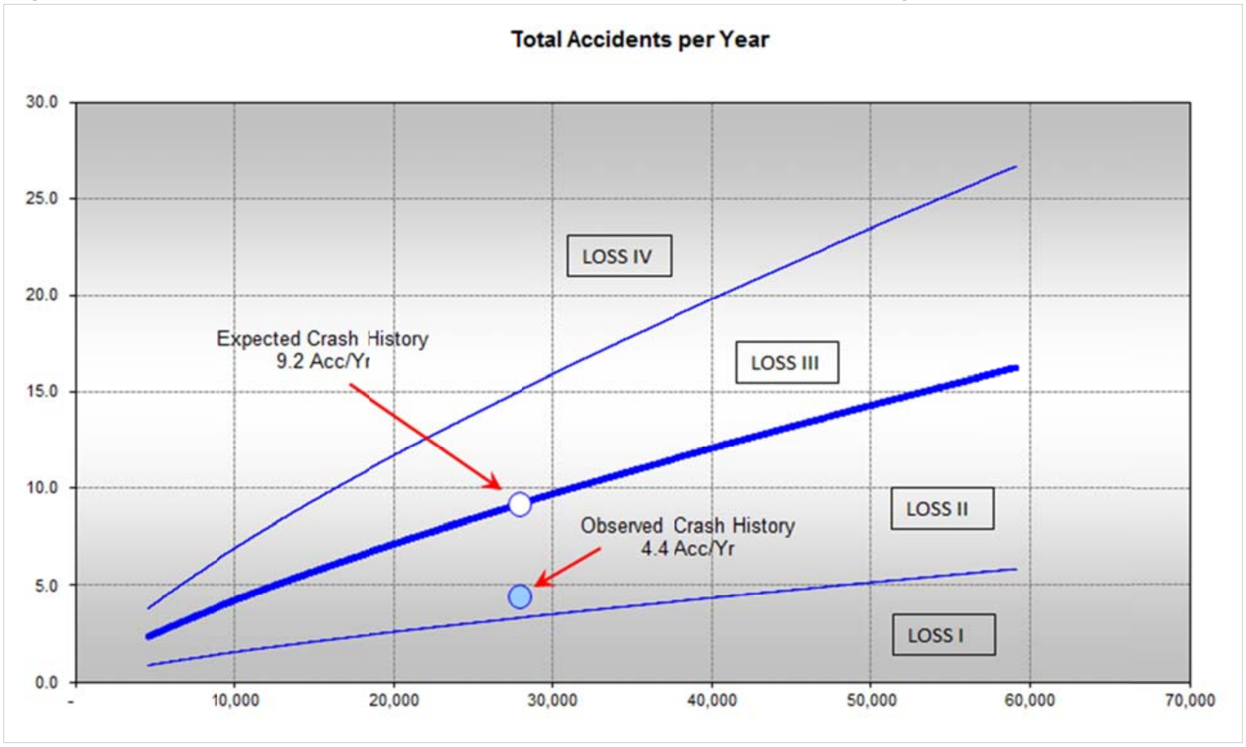
LOSS reflects how the roadway segment is performing relative to its expected accident frequency at a specific level of ADT. It only provides an accident frequency comparison with the expected norm for the type of facility.

### No Action Alternative

The safety performance function (SPF) for the existing US 160/US 550 intersection is shown on the 3-leg, divided, signalized T-intersection SPF model in **Figure 11**. The graph shows the recent or observed 5-year accident history based on average daily traffic volumes (ADT) of approximately 27,870 ADT on US 160 and 9,950 ADT on US 550. The plotted, observed accident frequency of 4.4 accidents per year (22 crashes/5 years) is currently lower than the expected frequency of 9.2 crashes per year for this type of intersection at the present traffic volume. This existing crash frequency can be considered to be in the LOSS II envelope and that it is performing at a better than expected level.

This agrees with the relatively low delay and congestion suggested by a LOS B operational finding by SEH in their memorandum: Existing Conditions at Farmington Hill.

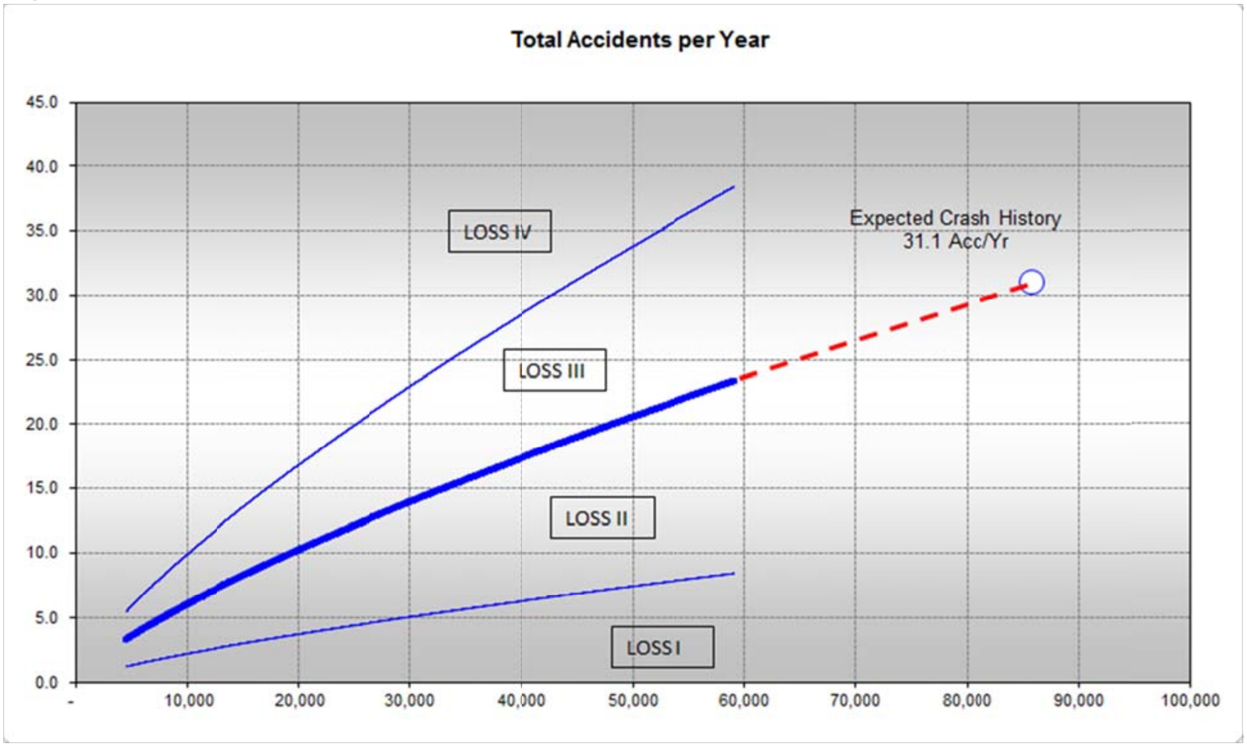
**Figure 11** **US 160/US 550 Existing Intersection SPF**




In **Figure 12**, a similar 3-leg, divided, signalized T-intersection safety performance function model is used to estimate the potential 2030 accident frequency utilizing the forecast 2030 traffic volumes (approximately 85,900 ADT on US 160 and 19,500 ADT on US 550). Although these future, estimated traffic volumes are in excess of those currently experienced on similar T intersections in Colorado and therefore, substantially beyond the model's current range, a potential expected crash frequency of 31 accidents per year may be estimated for the No Action alternative in which the 3-leg, divided, signalized T-intersection is maintained. For use in crash prediction analysis, it is reasonable to suggest that this T intersection will perform in an expected or average manner. Therefore we suggest that at the future, estimated traffic volumes, 31 crashes per year could be experienced.

*For the No Action Alternative, the US 160/US 550 intersection by itself may exhibit 31 crashes per year based on the estimated future traffic volumes at this location and current statewide crash frequency averages for similar T intersections. This is well in excess of the current 4.4 crashes/year observation at this location. It can also be assumed that under the No Action Alternative, there may be no potential for crash reduction because the intersection configuration will not change.*

**Figure 12** US 160/US 550 No Action SPF for Year 2030 Forecast Volume




## Revised G Modified Alternative

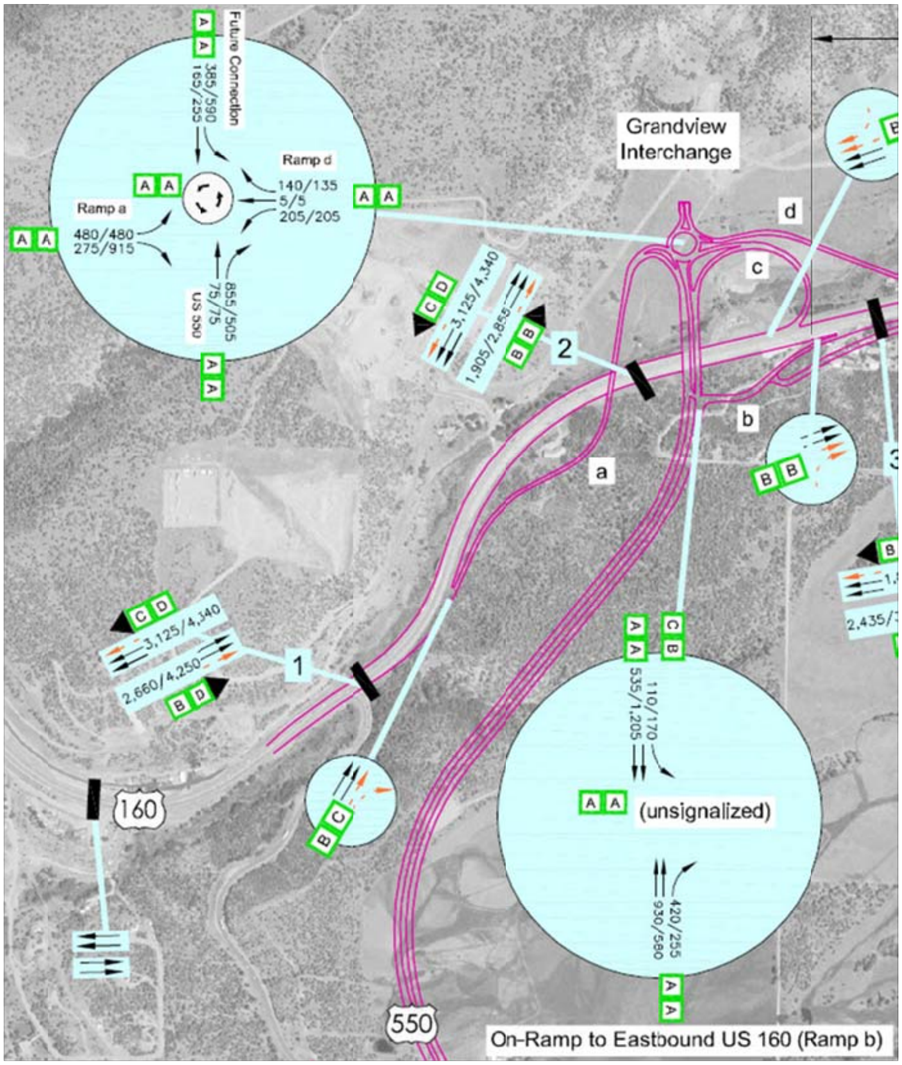
To estimate the potential future crash frequency for the Revised G Modified Alternative alignment connection, the year 2030 traffic volumes, including peak hour individual traffic movements provided by SEH, were used. The afternoon or pm peak hour directional volumes were generally highest. These peak hour volumes, which include traffic introduced by the realignment of US 550, were converted to ADT using a 10% factor in this analysis. **Figure 13** shows a portion of the SEH project drawing and the traffic counts that were used. We do not have Colorado-specific crash prediction models for roundabout ramp intersections. Because of this, the roundabout ramp facility was modeled as a complex, signalized, 4-lane ramp intersection to which was applied a crash reduction factor (CRF) of 70% for conversion to expected crashes at the proposed roundabout.

The estimated ADT for the ramp intersection approaches were 3,400 and 13,900 vehicles per day which yields 11.6 crashes per year as an expected crash frequency for a conventional ramp intersection based on available SPF models. Application of the roundabout's crash reduction factor results in an expected crash frequency of 3.5 crashes per year at the roundabout ramp intersection including US 550 traffic.

Additionally, the eastbound US 160 on-ramp intersection with US 550, (south of the interchange bridge) was examined for potential future crash frequency using SPF methods. Based on available 2030 traffic volumes, this intersection is expected to experience 2 crashes per year. When combined with potential accidents occurring at the roundabout, this analysis suggests a total of 5.5 (3.5 + 2) accidents per year for this connection option.

*Based on available 2030 traffic volumes and ramp intersection safety models, the Revised G Modified Alternative is expected to experience an overall crash frequency of 5.5 crashes per year at the US 550/160 connection. In comparison with the No Action alternative for 2030, the safety for the Revised G Modified alternative in 2030 will be better.*

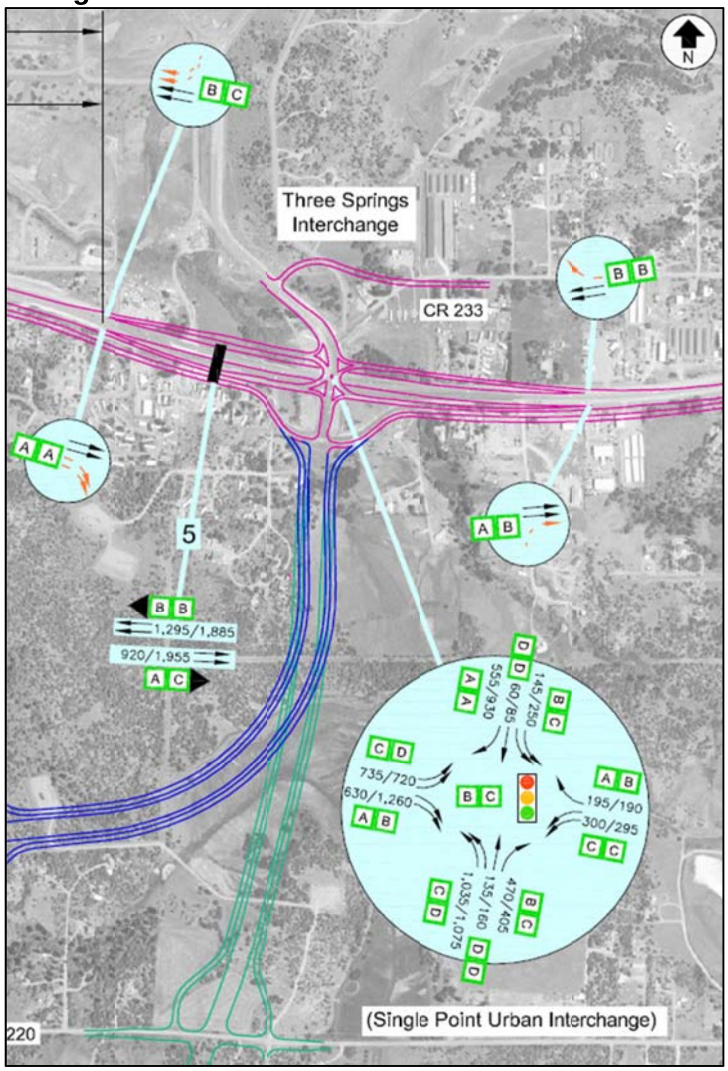
**Figure 13 Revised G Modified Alternative Traffic Movements for 2030**




## Revised F Modified Alternative and Eastern Realignment Alternative

Crash frequency for the US 160/US 550 connection associated with the proposed Three Springs interchange was estimated using year 2030 traffic volumes, again developed from available pm peak hour traffic movements. **Figure 14** identifies the interchange area and forecast 2030 traffic movement counts for the interchange.

**Figure 14 Revised F Modified Alternative and Eastern Realignment Alternative Traffic Movements for 2030**




Without observation-based crash prediction models for single point urban interchanges (SPUIs), the US 550 connection at Three Springs was modeled as a diamond-type interchange using conventional ramp intersection SPFs with a subsequent 20% crash reduction factor applied to account for the SPUI configuration's improved safety aspects.

This analysis suggests that approximately 8 accidents per year can be expected with year 2030 traffic volume (including the traffic introduced by US 550).

In addition, the frontage road intersection with US 550 to the south of the interchange may experience 5.8 crashes per year if configured as a stop-controlled, 4-leg intersection. Combined, the expected crash frequency at the SPUI connection may be 13.8 (8 + 5.8) crashes per year.

The roundabout configuration of the Revised G Modified alternative exhibits 5.5 crashes per year versus the SPUI configuration of the Revised F Modified and Eastern Realignment alternatives which exhibit 13.8 crashes per year. This confirms SEH's contention that roundabouts are safer than the signalized intersections at SPUI ramp terminals.

*The US 160/US 550 connection of the Revised F Modified Alternative and the Eastern Realignment Alternative may experience a crash frequency of 13.8 accidents per year. This safety performance is better than the No Action alternative but worse than the Revised G Modified Alternative.*

**Relative Safety of the Alternatives Associated with future Capacity**

From a different perspective, a measure of future safety for US 550 users may parallel the operational level-of-service forecasts for year 2030 developed by SEH. Between the Revised G Modified and Revised F Modified/Eastern Alignment alternatives, the additional connection of US 550 at the roundabout specified under Revised G Modified still exhibits excess or reserve capacity at 2030 volumes when compared to the US 550 connection at the signalized SPUI intersection of the Revised F Modified/Eastern Alignment alternative which approaches capacity earlier than the roundabout. Better safety performance for an intersection often exists when that intersection has additional future capacity as exhibited by the Revised Alternative G Modified intersection connection.

## SAFETY BENEFITS OF IMPROVING US 550 TO A 4-LANE CROSS SECTION

Under the No Action alternative, US 550 will remain as a 2-Lane highway south of US 160. The other three alternatives will improve US 550 to a 4-lane, divided cross section from the US 160 connection to the construction limit south of US 160.

Currently, on the segment of US 550 from MP 15.36 to MP 16.56 the observed crash frequency is 3.7 accidents per mile per year based on the present ADT of 9,950 vehicles per day. This safety performance function is plotted on the 2-lane mountainous highway SPF model shown in **Figure 15**. At present, this segment of US 550 is performing in the LOSS II region or slightly better than expected safety performance.

At the forecast 2030 traffic volumes however, definite safety benefits are achieved by upgrading US 550 to a 4-lane cross section, as indicated with the SPF analysis shown in **Figures 16** and **17** which use the SPF models for 2-lane and 4-lane Colorado highways.

**Figure 15** **Current 2-Lane Highway Safety Performance Function**

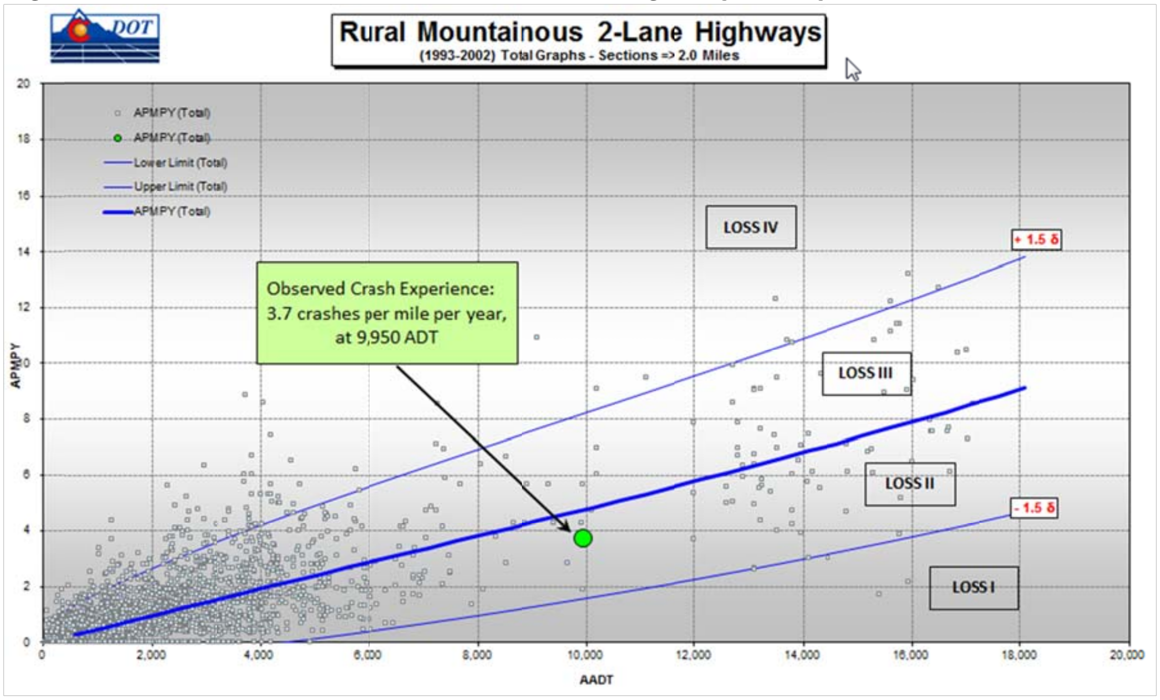



**Figure 16** **2-Lane Highway Safety Performance Function**

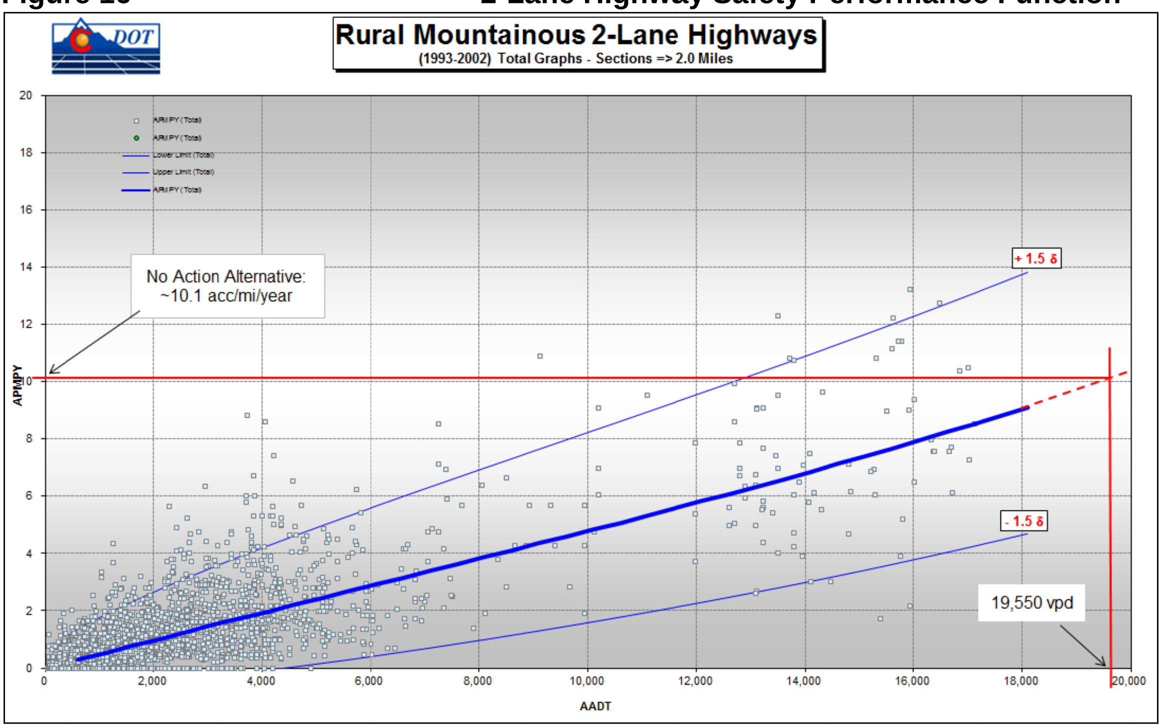
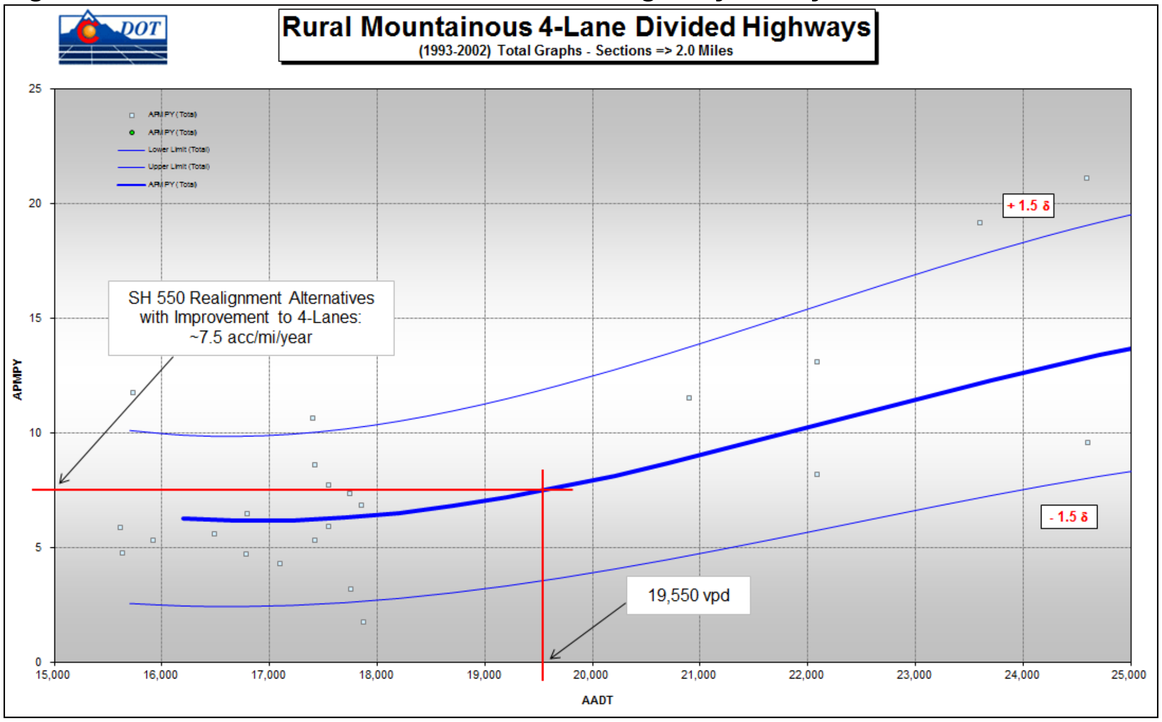


**Figure 17** **4-Lane, Divided Highway Safety Performance Function**




If US 550 remains as a 2-lane highway in mountainous terrain carrying the year 2030 volume of 19,550 vehicles per day, it may experience approximately 10.1 crashes per mile per year. In contrast, if US 550 is improved to a 4-lane, divided cross section, the expected accident frequency can be reduced by over 25% to 7.5 crashes per mile per year. Again, this improvement in safety is expected to accompany the cross-sectional improvement only. Realignment of the highway to moderate the adverse horizontal and vertical curve aspects at Farmington Hill would provide further safety benefits.

*Based on year 2030 forecast traffic volumes and statewide safety performance models for 2-lane and 4-lane, divided highways, redesign of US 550 to a 4-lane, divided cross section is expected reduce crash frequency and improve safety. The Revised G Modified Alternative and Revised F Modified and Eastern Realignment alternatives both include a 4-lane, divided cross section. The improvement to a 4-lane section, together with a safer alignment as US 550 descends from Florida Mesa is expected to be an effective safety improvement option versus maintaining the No Action alignment.*

## ESTIMATED FUTURE CRASH FREQUENCY ON US 160

A comparison among alternatives was also made based on relative crash frequency along the mainline (non-intersection) of US 160. For this analysis, the year 2030 peak hour traffic volumes provided by SEH were used together with a 4-lane freeway safety performance function model to estimate expected crash frequencies along US 160 for each alternative. The forecast pm peak hour volumes at several locations along the Grandview section of US 160 were converted to approximate ADTs using a 10% conversion factor. The converted traffic volumes, which varied from 30,200 vehicles per day (vpd) to 80,000 vpd depending on alternative and specific location along US 160, were then applied to the 4-lane urban freeway SPF model. The resulting average, potential crash frequencies for US 160 were:

No Action Alternative – 20 accidents per mile per year*.
Revised G Modified Alternative – 18 accidents per mile per year.
Revised F Modified and Eastern Realignment – 22 accidents per mile per year.

*Note that under the No Action alternative, the severe congestion and delay experienced by drivers at the US 160/550 intersection may reduce peak hour flow on US 160 which tends to moderate crash frequency but at the expense of mobility along the corridor.

*From the perspective of future potential accident frequency along the mainline (non-intersection crashes) of US 160, the Revised G Modified Alternative appears to offer lower potential crash occurrence and safer operation for users of SH 160 as compared to the Revised F Modified/Eastern Alignment and No Action options.*

## CONCLUSION

It is difficult to estimate reliable future crash frequency on proposed, innovative highway facilities. Based on our available crash prediction tools and volume forecasts, we agree with SEH in their finding that the Revised G Modified alternative has a greater potential for future safety improvement when compared to the No Action and Revised F Modified and Eastern Realignment alternatives.

**Table 1** consolidates some of our findings and helps to rank the four Alternatives based on potential safety comparisons determined in this review. **Again, note that these rankings are based solely on geometric factors of the four alternatives. The adverse terrain and environmental factors associated with the No Action Alternative should be strongly considered by the reader due to the inherent safety issues this alternative has.**

**Table 1**

| Type of Comparison | No Action Alternative | Revised G Modified Alternative | Revised F Modified Alternative | Eastern Realignment Alternative |
|---|---|---|---|---|
| Estimated Intersection Crash Frequency at Year 2030 Traffic Volume | 31 crashes per year | 5.5 crashes per year | 13.8 crashes per year | 13.8 crashes per year |
| Relative Safety Rank | 4 | 1 | 2 | 2 |
| | | | | |
| Estimated Crash Frequency on US 550 at Proposed Width (2-lane or 4-lane) and 2030 Traffic Volume | 10.1 crashes per mile per year | 7.5 crashes per mile per year | 7.5 crashes per mile per year | 7.5 crashes per mile per year |
| Relative Safety Rank | 4 | 1 | 1 | 1 |
| | | | | |
| Estimated Crash Frequency on US 160 at Year 2030 Traffic Volume | 20 crashes per mile per year | 18 crashes per mile per year | 22 crashes per mile per year | 22 crashes per mile per year |
| Relative Safety Rank | 2 | 1 | 3 | 3 |
| | | | | |
| Total of Relative Safety Rankings | 10 | 3 | 6 | 6 |
| | | | | |
| **Overall Rank for Potential Safety Benefit** | **4** | **1** | **2** | **2** |

# APPENDIX

- 5-Year Detailed Summary of Traffic Crashes at Current Intersection of US 160 & US 550
- 5-Year Detailed Summary of Traffic Crashes at the Current Three Springs Intersection (intersection of US 160 and La Plata County Road 233)
- 5-Year Detailed Summary of Traffic Crashes on US 550, MP 15.26-16.56
- 5-Year Crash Listing for US 550, MP 15.26-16.56
- US 550 Stripmap of the Current Traffic Control Devices

# Colorado Department of Transportation
## Safety and Traffic Engineering
## Detailed Accident Summary Report

Job #: 20110519135156

**Highway:** 160A **Begin:** 88.12 **End:** 88.52 **From:** 01/01/2005 **To:** 12/31/2009

### Severity

| | | | |
|---|---|---|---|
| PDO: | 22 | | |
| INJ: | 0 | 0 | :Injured |
| FAT: | 0 | 0 | :Killed |
| **Total:** | **22** | | |

### Multi-Vehicle

| | |
|---|---|
| One Vehicle: | 4 |
| Two Vehicles: | 16 |
| Three or More: | 2 |
| Unknown: | 0 |
| **Total:** | **22** |

### Location

| | | | |
|---|---|---|---|
| On Road: | 20 | Off in Median: | 0 |
| Off Road Left: | 1 | Private Property: | 0 |
| Off Road Right: | 1 | Unknown: | 0 |
| Off Road at Tee: | 0 | **Total:** | **22** |

### Accident Type

| | | | | | |
|---|---|---|---|---|---|
| Overturning: | 0 | Road Maintenance Equipment: | 0 | Fence: | 0 |
| Other Non Collision: | 0 | Domestic Animal: | 0 | Tree: | 0 |
| School Age Peds: | 0 | Wild Animal: | 0 | Large Rocks or Boulder: | 0 |
| Ped on Toy Motorized Vehicle: | 0 | Light/Utility Pole: | 0 | Railroad Crossing Equipment: | 0 |
| Other Pedestrians: | 0 | Traffic Signal Pole: | 0 | Barricade: | 0 |
| Head On: | 0 | Sign: | 2 | Wall/Building: | 0 |
| Rear End: | 13 | Guard Rail: | 0 | Crash Cushion/Traffic Barrel: | 0 |
| Broadside: | 0 | Cable Rail: | 0 | Mailbox: | 0 |
| Approach Turn: | 0 | Concrete Highway Barrier: | 0 | Other Fixed Object: | 0 |
| Overtaking Turn: | 0 | Bridge Structure: | 0 | Involving Other Object: | 1 |
| Sideswipe (Same): | 3 | Vehicle Debris/Cargo: | 0 | Unknown: | 1 |
| Sideswipe (Opposite): | 1 | Culvert/Headwall: | 0 | **Total:** | **22** |
| Parked Motor Vehicle: | 0 | Embankment: | 1 | | |
| Railway Vehicle: | 0 | Curb: | 0 | Total Fixed Objects: | 3 |
| Bicycle: | 0 | Delineator Post: | 0 | Total Other Objects: | 1 |

### Lighting Conditions

| | |
|---|---|
| Daylight: | 18 |
| Dawn or Dusk: | 2 |
| Dark - Lighted: | 2 |
| Dark - Unlighted: | 0 |
| Unknown: | 0 |
| **Total:** | **22** |

### Weather Conditions

| | | | |
|---|---|---|---|
| None: | 17 | Dust: | 0 |
| Rain: | 1 | Wind: | 2 |
| Snow/Sleet/Hail: | 2 | Unknown: | 0 |
| Fog: | 0 | **Total:** | **22** |

### Road Description

| | |
|---|---|
| At Intersection: | 8 |
| At Driveway Access: | 0 |
| Intersection Related: | 14 |
| Non Intersection: | 0 |
| Alley Related: | 0 |
| Roundabout: | 0 |
| Ramp: | 0 |
| Parking Lot: | 0 |
| Unknown: | 0 |
| **Total:** | **22** |

### Road Conditions

| | |
|---|---|
| Dry: | 17 |
| Wet: | 2 |
| Muddy: | 0 |
| Snowy: | 1 |
| Icy: | 1 |
| Slushy: | 1 |
| Foreign Material: | 0 |
| Dry w/Icy Road Treatment: | 0 |
| Wet w/Icy Road Treatment: | 0 |
| Snowy w/Icy Road Treatment: | 0 |
| Icy w/Icy Road Treatment: | 0 |
| Slushy w/Icy Road Treatment: | 0 |
| Unknown: | 0 |
| **Total:** | **22** |

### Mainline/Ramps/Frontage Rds

| | |
|---|---|
| Mainline: | 22 |
| Crossroad (Ramp A): | 0 |
| Frontage Rd: | 0 |

#### Ramps

| | | | |
|---|---|---|---|
| B: | 0 | H: | 0 |
| C: | 0 | I: | 0 |
| D: | 0 | J: | 0 |
| E: | 0 | K: | 0 |
| F: | 0 | T: | 0 |
| G: | 0 | | |

#### Intsx Frontage/Ramps

| | | | |
|---|---|---|---|
| M: | 0 | N: | 0 |
| O: | 0 | P: | 0 |

| | |
|---|---|
| HOV Lanes: | 0 |
| Uknwn: | 0 |
| **Total:** | **22** |

### Accident Rates

| | | | | |
|---|---|---|---|---|
| PDO: | 0.47 | MVMT | Total: | 0.47 MVMT |
| Injury: | 0.00 | MVMT | | |
| Fatal: | 0.00 | 100 MVMT | | |

**ADT:** 25,447 **Length:** 1.00 **Coris File:** tcoris2009.dbf

**Highway:** 160A **Begin:** 88.12 **End:** 88.52 **From:** 01/01/2005 **To:** 12/31/2009

| Vehicle Types | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| Vehicle/Vehicle Combo (> 10k Lbs): | 3 | 1 | 0 |
| School Bus (All School Busses): | 0 | 0 | 0 |
| Non-School Bus (> 8) in Commerce: | 0 | 0 | 0 |
| Transit Bus: | 0 | 0 | 0 |
| Passenger Car/Van: | 11 | 11 | 1 |
| Passenger Car/Van w/Trailer: | 0 | 0 | 0 |
| Pickup Truck/Utility Van: | 6 | 4 | 0 |
| Pickup Truck/Utility Van w/Trailer: | 0 | 0 | 0 |
| SUV: | 2 | 2 | 0 |
| SUV w/Trailer: | 0 | 0 | 0 |
| Motor Home: | 0 | 0 | 1 |
| Motorcycle: | 0 | 0 | 0 |
| Bicycle: | 0 | 0 | 0 |
| Motorized Bicycle: | 0 | 0 | 0 |
| Farm Equipment: | 0 | 0 | 0 |
| Hit and Run - Unknown: | 0 | 0 | 0 |
| Light Rail: | 0 | 0 | 0 |
| Other: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **22** | **18** | **2** |

Commercial Vehicle

| Direction | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| North: | 0 | 0 | 0 |
| Northeast: | 0 | 0 | 0 |
| East: | 15 | 11 | 1 |
| Southeast: | 0 | 0 | 0 |
| South: | 1 | 1 | 0 |
| Southwest: | 0 | 0 | 0 |
| West: | 6 | 6 | 1 |
| Northwest: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **22** | **18** | **2** |

| Contributing Factor | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Apparent Contributing Factor: | 15 | 17 | 2 |
| Asleep at the Wheel: | 0 | 0 | 0 |
| Driver Fatigue: | 0 | 0 | 0 |
| Illness/Medical: | 2 | 0 | 0 |
| Driver Inexperience: | 0 | 0 | 0 |
| Agressive Driving: | 2 | 0 | 0 |
| Driver Unfamilar with Area: | 0 | 1 | 0 |
| Driver Emotionally Upset: | 0 | 0 | 0 |
| Evading Law Enforcement Officier: | 0 | 0 | 0 |
| Physical Disability: | 0 | 0 | 0 |
| DUI, DWAI, DUID: | 0 | 0 | 0 |
| Distracted/Passenger: | 0 | 0 | 0 |
| Distracted/Cell Phone: | 0 | 0 | 0 |
| Distracted/Radio: | 0 | 0 | 0 |
| Distracted/Other: | 3 | 0 | 0 |
| Other Factor: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **22** | **18** | **2** |

| Vehicle Movement | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| Going Straight: | 12 | 5 | 0 |
| Slowing: | 4 | 2 | 0 |
| Stopped in Traffic: | 0 | 11 | 1 |
| Making Right Turn: | 1 | 0 | 0 |
| Making Left Turn: | 2 | 0 | 1 |
| Making U-Turn: | 1 | 0 | 0 |
| Passing: | 0 | 0 | 0 |
| Backing: | 0 | 0 | 0 |
| Enter/Leave Parked Pos: | 1 | 0 | 0 |
| Parked: | 0 | 0 | 0 |
| Changing Lanes: | 1 | 0 | 0 |
| Avoiding Object in Road: | 0 | 0 | 0 |
| Weaving: | 0 | 0 | 0 |
| Spun Out of Control: | 0 | 0 | 0 |
| Drove Wrong Way: | 0 | 0 | 0 |
| Other: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **22** | **18** | **2** |

| Driver Condition (Alcohol) | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Alcohol Suspected: | 20 | 18 | 2 |
| Alcohol Suspected: | 2 | 0 | 0 |
| Unknown Alcohol: | 0 | 0 | 0 |
| **Alcohol Sub-Total:** | **22** | **18** | **2** |

| Driver Condition (Drugs) | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Drugs Suspected: | 22 | 18 | 2 |
| Drugs Suspected: | 0 | 0 | 0 |
| Unknown Drugs: | 0 | 0 | 0 |
| **Drugs Sub-Total:** | **22** | **18** | **2** |

**ADT:** 25,447 **Length:** 1.00 **Coris File:** tcoris2009.dbf

# Colorado Department of Transportation
## Safety and Traffic Engineering
## Detailed Accident Summary Report

Job #: 20110519142028

**Highway:** 160A **Begin:** 90.10 **End:** 90.14 **From:** 01/01/2005 **To:** 12/31/2009

3 Springs Intersection

### Severity

| | | | |
|---|---|---|---|
| PDO: | 22 | | |
| INJ: | 9 | 46 | :Injured |
| FAT: | 0 | 0 | :Killed |
| **Total:** | **31** | | |

### Multi-Vehicle

| | |
|---|---|
| One Vehicle: | 0 |
| Two Vehicles: | 30 |
| Three or More: | 1 |
| Unknown: | 0 |
| **Total:** | **31** |

### Location

| | | | |
|---|---|---|---|
| On Road: | 31 | Off in Median: | 0 |
| Off Road Left: | 0 | Private Property: | 0 |
| Off Road Right: | 0 | Unknown: | 0 |
| Off Road at Tee: | 0 | **Total:** | **31** |

### Accident Type

| | | | | | |
|---|---|---|---|---|---|
| Overturning: | 0 | Road Maintenance Equipment: | 0 | Fence: | 0 |
| Other Non Collision: | 0 | Domestic Animal: | 0 | Tree: | 0 |
| School Age Peds: | 0 | Wild Animal: | 0 | Large Rocks or Boulder: | 0 |
| Ped on Toy Motorized Vehicle: | 0 | Light/Utility Pole: | 0 | Railroad Crossing Equipment: | 0 |
| Other Pedestrians: | 0 | Traffic Signal Pole: | 0 | Barricade: | 0 |
| Head On: | 0 | Sign: | 0 | Wall/Building: | 0 |
| Rear End: | 14 | Guard Rail: | 0 | Crash Cushion/Traffic Barrel: | 0 |
| Broadside: | 3 | Cable Rail: | 0 | Mailbox: | 0 |
| Approach Turn: | 13 | Concrete Highway Barrier: | 0 | Other Fixed Object: | 0 |
| Overtaking Turn: | 0 | Bridge Structure: | 0 | Involving Other Object: | 0 |
| Sideswipe (Same): | 1 | Vehicle Debris/Cargo: | 0 | Unknown: | 0 |
| Sideswipe (Opposite): | 0 | Culvert/Headwall: | 0 | **Total:** | **31** |
| Parked Motor Vehicle: | 0 | Embankment: | 0 | | |
| Railway Vehicle: | 0 | Curb: | 0 | Total Fixed Objects: | 0 |
| Bicycle: | 0 | Delineator Post: | 0 | Total Other Objects: | 0 |

### Lighting Conditions

| | |
|---|---|
| Daylight: | 27 |
| Dawn or Dusk: | 3 |
| Dark - Lighted: | 1 |
| Dark - Unlighted: | 0 |
| Unknown: | 0 |
| **Total:** | **31** |

### Weather Conditions

| | | | |
|---|---|---|---|
| None: | 30 | Dust: | 0 |
| Rain: | 1 | Wind: | 0 |
| Snow/Sleet/Hail: | 0 | Unknown: | 0 |
| Fog: | 0 | **Total:** | **31** |

### Road Description

| | |
|---|---|
| At Intersection: | 23 |
| At Driveway Access: | 0 |
| Intersection Related: | 8 |
| Non Intersection: | 0 |
| Alley Related: | 0 |
| Roundabout: | 0 |
| Ramp: | 0 |
| Parking Lot: | 0 |
| Unknown: | 0 |
| **Total:** | **31** |

### Road Conditions

| | |
|---|---|
| Dry: | 29 |
| Wet: | 1 |
| Muddy: | 0 |
| Snowy: | 0 |
| Icy: | 1 |
| Slushy: | 0 |
| Foreign Material: | 0 |
| Dry w/Icy Road Treatment: | 0 |
| Wet w/Icy Road Treatment: | 0 |
| Snowy w/Icy Road Treatment: | 0 |
| Icy w/Icy Road Treatment: | 0 |
| Slushy w/Icy Road Treatment: | 0 |
| Unknown: | 0 |
| **Total:** | **31** |

### Mainline/Ramps/Frontage Rds

| | |
|---|---|
| Mainline: | 31 |
| Crossroad (Ramp A): | 0 |
| Frontage Rd: | 0 |

#### Ramps

| | | | |
|---|---|---|---|
| B: | 0 | H: | 0 |
| C: | 0 | I: | 0 |
| D: | 0 | J: | 0 |
| E: | 0 | K: | 0 |
| F: | 0 | T: | 0 |
| G: | 0 | | |

#### Intsx Frontage/Ramps

| | | | |
|---|---|---|---|
| M: | 0 | N: | 0 |
| O: | 0 | P: | 0 |

| | |
|---|---|
| HOV Lanes: | 0 |
| Uknwn: | 0 |
| **Total:** | **31** |

### Accident Rates

| | | | | | |
|---|---|---|---|---|---|
| PDO: | 0.54 | MVMT | Total: | 0.76 | MVMT |
| Injury: | 0.22 | MVMT | | | |
| Fatal: | 0.00 | 100 MVMT | | | |

**ADT:** 22,300 **Length:** 1.00 **Coris File:** tcoris2009.dbf

**Highway:** 160A **Begin:** 90.10 **End:** 90.14 **From:** 01/01/2005 **To:** 12/31/2009

3 Springs Intersection

| Vehicle Types | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| Vehicle/Vehicle Combo (> 10k Lbs): | 2 | 2 | 0 |
| School Bus (All School Busses): | 0 | 0 | 0 |
| Non-School Bus (> 8) in Commerce: | 0 | 0 | 0 |
| Transit Bus: | 0 | 0 | 0 |
| Passenger Car/Van: | 11 | 16 | 1 |
| Passenger Car/Van w/Trailer: | 0 | 0 | 0 |
| Pickup Truck/Utility Van: | 14 | 7 | 0 |
| Pickup Truck/Utility Van w/Trailer: | 0 | 1 | 0 |
| SUV: | 3 | 5 | 0 |
| SUV w/Trailer: | 0 | 0 | 0 |
| Motor Home: | 0 | 0 | 0 |
| Motorcycle: | 1 | 0 | 0 |
| Bicycle: | 0 | 0 | 0 |
| Motorized Bicycle: | 0 | 0 | 0 |
| Farm Equipment: | 0 | 0 | 0 |
| Hit and Run - Unknown: | 0 | 0 | 0 |
| Light Rail: | 0 | 0 | 0 |
| Other: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **31** | **31** | **1** |

Commercial Vehicle

| Direction | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| North: | 0 | 1 | 0 |
| Northeast: | 0 | 0 | 0 |
| East: | 13 | 7 | 0 |
| Southeast: | 0 | 0 | 0 |
| South: | 0 | 2 | 0 |
| Southwest: | 0 | 0 | 0 |
| West: | 18 | 21 | 1 |
| Northwest: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **31** | **31** | **1** |

| Contributing Factor | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Apparent Contributing Factor: | 23 | 31 | 1 |
| Asleep at the Wheel: | 0 | 0 | 0 |
| Driver Fatigue: | 0 | 0 | 0 |
| Illness/Medical: | 0 | 0 | 0 |
| Driver Inexperience: | 1 | 0 | 0 |
| Agressive Driving: | 0 | 0 | 0 |
| Driver Unfamilar with Area: | 0 | 0 | 0 |
| Driver Emotionally Upset: | 0 | 0 | 0 |
| Evading Law Enforcement Officier: | 0 | 0 | 0 |
| Physical Disability: | 0 | 0 | 0 |
| DUI, DWAI, DUID: | 1 | 0 | 0 |
| Distracted/Passenger: | 0 | 0 | 0 |
| Distracted/Cell Phone: | 0 | 0 | 0 |
| Distracted/Radio: | 1 | 0 | 0 |
| Distracted/Other: | 4 | 0 | 0 |
| Other Factor: | 1 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **31** | **31** | **1** |

| Vehicle Movement | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| Going Straight: | 17 | 11 | 0 |
| Slowing: | 3 | 6 | 0 |
| Stopped in Traffic: | 0 | 9 | 1 |
| Making Right Turn: | 0 | 0 | 0 |
| Making Left Turn: | 10 | 4 | 0 |
| Making U-Turn: | 0 | 0 | 0 |
| Passing: | 0 | 0 | 0 |
| Backing: | 0 | 0 | 0 |
| Enter/Leave Parked Pos: | 1 | 0 | 0 |
| Parked: | 0 | 0 | 0 |
| Changing Lanes: | 0 | 1 | 0 |
| Avoiding Object in Road: | 0 | 0 | 0 |
| Weaving: | 0 | 0 | 0 |
| Spun Out of Control: | 0 | 0 | 0 |
| Drove Wrong Way: | 0 | 0 | 0 |
| Other: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **31** | **31** | **1** |

| Driver Condition (Alcohol) | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Alcohol Suspected: | 29 | 30 | 1 |
| Alcohol Suspected: | 1 | 0 | 0 |
| Unknown Alcohol: | 1 | 1 | 0 |
| **Alcohol Sub-Total:** | **31** | **31** | **1** |

| Driver Condition (Drugs) | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Drugs Suspected: | 30 | 30 | 1 |
| Drugs Suspected: | 0 | 0 | 0 |
| Unknown Drugs: | 1 | 1 | 0 |
| **Drugs Sub-Total:** | **31** | **31** | **1** |

**ADT:** 22,300 **Length:** 1.00 **Coris File:** tcoris2009.dbf

**Highway:** 550A **Begin:** 15.36 **End:** 16.56 **From:** 01/01/2005 **To:** 12/31/2009

## Severity

| | | | |
|---|---|---|---|
| PDO: | 23 | | |
| INJ: | 7 | 10 | :Injured |
| FAT: | 0 | 0 | :Killed |
| **Total:** | **30** | | |

## Multi-Vehicle

| | |
|---|---|
| One Vehicle: | 20 |
| Two Vehicles: | 10 |
| Three or More: | 0 |
| Unknown: | 0 |
| **Total:** | **30** |

## Location

| | | | |
|---|---|---|---|
| On Road: | 13 | Off in Median: | 0 |
| Off Road Left: | 8 | Private Property: | 0 |
| Off Road Right: | 8 | Unknown: | 0 |
| Off Road at Tee: | 1 | **Total:** | **30** |

## Accident Type

| | | | | | |
|---|---|---|---|---|---|
| Overturning: | 6 | Road Maintenance Equipment: | 0 | Fence: | 3 |
| Other Non Collision: | 0 | Domestic Animal: | 0 | Tree: | 2 |
| School Age Peds: | 0 | Wild Animal: | 4 | Large Rocks or Boulder: | 1 |
| Ped on Toy Motorized Vehicle: | 0 | Light/Utility Pole: | 1 | Railroad Crossing Equipment: | 0 |
| Other Pedestrians: | 0 | Traffic Signal Pole: | 0 | Barricade: | 0 |
| Head On: | 0 | Sign: | 1 | Wall/Building: | 0 |
| Rear End: | 6 | Guard Rail: | 0 | Crash Cushion/Traffic Barrel: | 0 |
| Broadside: | 0 | Cable Rail: | 0 | Mailbox: | 0 |
| Approach Turn: | 0 | Concrete Highway Barrier: | 0 | Other Fixed Object: | 0 |
| Overtaking Turn: | 0 | Bridge Structure: | 0 | Involving Other Object: | 0 |
| Sideswipe (Same): | 0 | Vehicle Debris/Cargo: | 0 | Unknown: | 0 |
| Sideswipe (Opposite): | 3 | Culvert/Headwall: | 0 | **Total:** | **30** |
| Parked Motor Vehicle: | 0 | Embankment: | 3 | | |
| Railway Vehicle: | 0 | Curb: | 0 | Total Fixed Objects: | 10 |
| Bicycle: | 0 | Delineator Post: | 0 | Total Other Objects: | 1 |

## Lighting Conditions

| | |
|---|---|
| Daylight: | 14 |
| Dawn or Dusk: | 3 |
| Dark - Lighted: | 2 |
| Dark - Unlighted: | 11 |
| Unknown: | 0 |
| **Total:** | **30** |

## Weather Conditions

| | | | |
|---|---|---|---|
| None: | 25 | Dust: | 0 |
| Rain: | 1 | Wind: | 0 |
| Snow/Sleet/Hail: | 4 | Unknown: | 0 |
| Fog: | 0 | **Total:** | **30** |

## Road Description

| | |
|---|---|
| At Intersection: | 2 |
| At Driveway Access: | 0 |
| Intersection Related: | 6 |
| Non Intersection: | 22 |
| Alley Related: | 0 |
| Roundabout: | 0 |
| Ramp: | 0 |
| Parking Lot: | 0 |
| Unknown: | 0 |
| **Total:** | **30** |

## Road Conditions

| | |
|---|---|
| Dry: | 21 |
| Wet: | 2 |
| Muddy: | 0 |
| Snowy: | 0 |
| Icy: | 6 |
| Slushy: | 1 |
| Foreign Material: | 0 |
| Dry w/Icy Road Treatment: | 0 |
| Wet w/Icy Road Treatment: | 0 |
| Snowy w/Icy Road Treatment: | 0 |
| Icy w/Icy Road Treatment: | 0 |
| Slushy w/Icy Road Treatment: | 0 |
| Unknown: | 0 |
| **Total:** | **30** |

## Mainline/Ramps/Frontage Rds

| | |
|---|---|
| Mainline: | 30 |
| Crossroad (Ramp A): | 0 |
| Frontage Rd: | 0 |

### Ramps

| | | | |
|---|---|---|---|
| B: | 0 | H: | 0 |
| C: | 0 | I: | 0 |
| D: | 0 | J: | 0 |
| E: | 0 | K: | 0 |
| F: | 0 | T: | 0 |
| G: | 0 | | |

### Intsx Frontage/Ramps

| | | | |
|---|---|---|---|
| M: | 0 | N: | 0 |
| O: | 0 | P: | 0 |

| | |
|---|---|
| HOV Lanes: | 0 |
| Uknwn: | 0 |
| **Total:** | **30** |

## Accident Rates

| | | | | |
|---|---|---|---|---|
| PDO: | 1.38 | MVMT | Total: | 1.80 MVMT |
| Injury: | 0.42 | MVMT | | |
| Fatal: | 0.00 | 100 MVMT | | |

**ADT:** 7,715 **Length:** 1.18 **Coris File:** tcoris2009.dbf

# Colorado Department of Transportation
# Safety and Traffic Engineering
# Detailed Accident Summary Report

Job #: 20110519143432

**Highway:** 550A **Begin:** 15.36 **End:** 16.56 **From:** 01/01/2005 **To:** 12/31/2009

| Vehicle Types | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| Vehicle/Vehicle Combo (> 10k Lbs): | 0 | 0 | 0 |
| School Bus (All School Busses): | 0 | 0 | 0 |
| Non-School Bus (> 8) in Commerce: | 0 | 0 | 0 |
| Transit Bus: | 0 | 0 | 0 |
| Passenger Car/Van: | 14 | 4 | 0 |
| Passenger Car/Van w/Trailer: | 0 | 0 | 0 |
| Pickup Truck/Utility Van: | 9 | 2 | 0 |
| Pickup Truck/Utility Van w/Trailer: | 1 | 0 | 0 |
| SUV: | 4 | 3 | 0 |
| SUV w/Trailer: | 0 | 0 | 0 |
| Motor Home: | 0 | 0 | 0 |
| Motorcycle: | 2 | 0 | 0 |
| Bicycle: | 0 | 0 | 0 |
| Motorized Bicycle: | 0 | 0 | 0 |
| Farm Equipment: | 0 | 0 | 0 |
| Hit and Run - Unknown: | 0 | 1 | 0 |
| Light Rail: | 0 | 0 | 0 |
| Other: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **30** | **10** | **0** |

Commercial Vehicle

| Direction | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| North: | 11 | 0 | 0 |
| Northeast: | 0 | 0 | 0 |
| East: | 7 | 2 | 0 |
| Southeast: | 0 | 0 | 0 |
| South: | 3 | 3 | 0 |
| Southwest: | 0 | 0 | 0 |
| West: | 9 | 5 | 0 |
| Northwest: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **30** | **10** | **0** |

| Contributing Factor | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Apparent Contributing Factor: | 19 | 10 | 0 |
| Asleep at the Wheel: | 0 | 0 | 0 |
| Driver Fatigue: | 1 | 0 | 0 |
| Illness/Medical: | 0 | 0 | 0 |
| Driver Inexperience: | 4 | 0 | 0 |
| Agressive Driving: | 0 | 0 | 0 |
| Driver Unfamilar with Area: | 3 | 0 | 0 |
| Driver Emotionally Upset: | 1 | 0 | 0 |
| Evading Law Enforcement Officier: | 0 | 0 | 0 |
| Physical Disability: | 0 | 0 | 0 |
| DUI, DWAI, DUID: | 2 | 0 | 0 |
| Distracted/Passenger: | 0 | 0 | 0 |
| Distracted/Cell Phone: | 0 | 0 | 0 |
| Distracted/Radio: | 0 | 0 | 0 |
| Distracted/Other: | 0 | 0 | 0 |
| Other Factor: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **30** | **10** | **0** |

| Vehicle Movement | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| Going Straight: | 21 | 3 | 0 |
| Slowing: | 2 | 0 | 0 |
| Stopped in Traffic: | 0 | 7 | 0 |
| Making Right Turn: | 0 | 0 | 0 |
| Making Left Turn: | 0 | 0 | 0 |
| Making U-Turn: | 0 | 0 | 0 |
| Passing: | 0 | 0 | 0 |
| Backing: | 2 | 0 | 0 |
| Enter/Leave Parked Pos: | 1 | 0 | 0 |
| Parked: | 0 | 0 | 0 |
| Changing Lanes: | 0 | 0 | 0 |
| Avoiding Object in Road: | 2 | 0 | 0 |
| Weaving: | 0 | 0 | 0 |
| Spun Out of Control: | 1 | 0 | 0 |
| Drove Wrong Way: | 1 | 0 | 0 |
| Other: | 0 | 0 | 0 |
| Unknown: | 0 | 0 | 0 |
| **Total:** | **30** | **10** | **0** |

| Driver Condition (Alcohol) | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Alcohol Suspected: | 26 | 9 | 0 |
| Alcohol Suspected: | 3 | 0 | 0 |
| Unknown Alcohol: | 1 | 1 | 0 |
| **Alcohol Sub-Total:** | **30** | **10** | **0** |

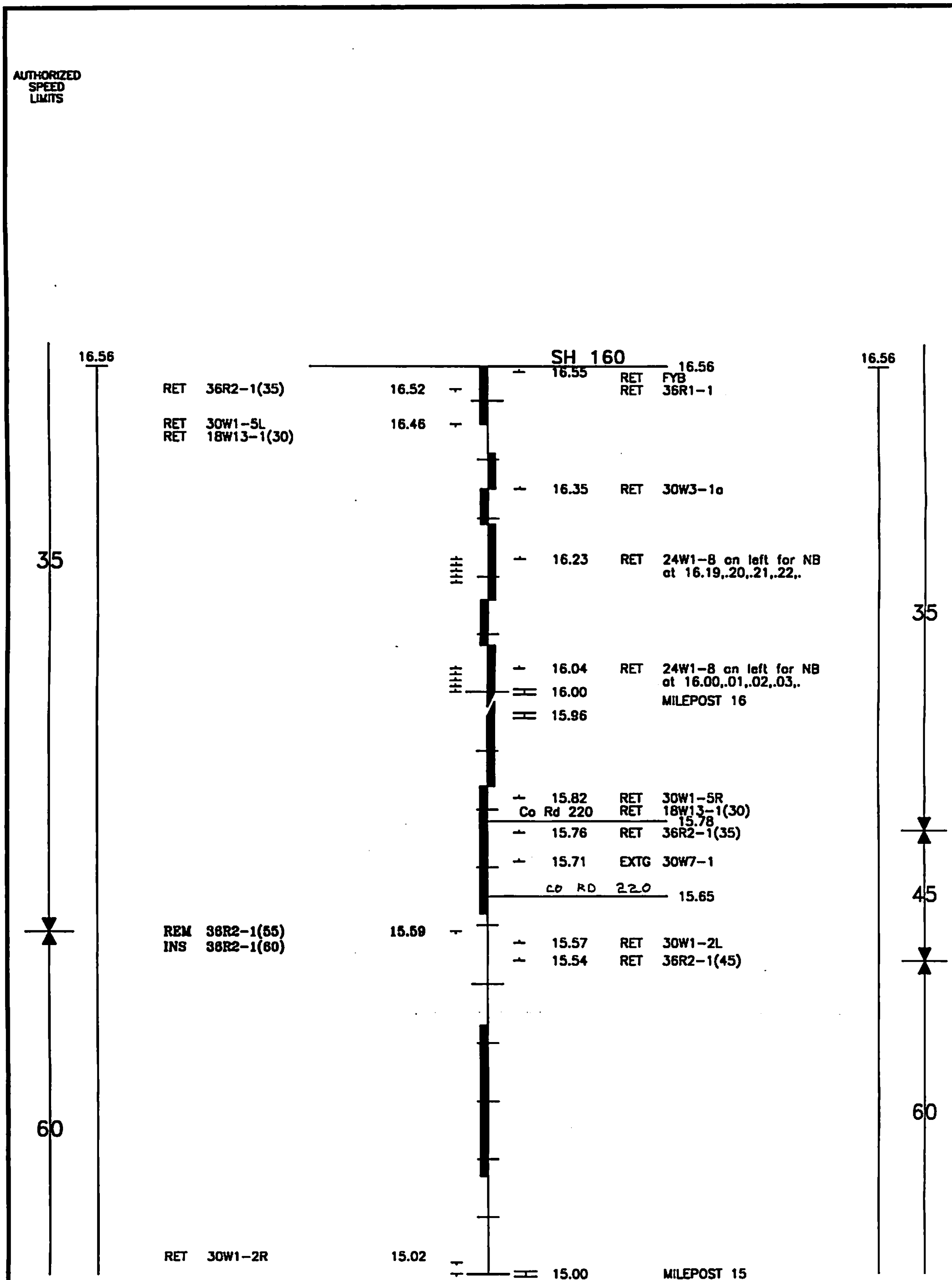
| Driver Condition (Drugs) | Veh 1 | Veh 2 | Veh 3 |
|---|---|---|---|
| No Drugs Suspected: | 27 | 8 | 0 |
| Drugs Suspected: | 2 | 1 | 0 |
| Unknown Drugs: | 1 | 1 | 0 |
| **Drugs Sub-Total:** | **30** | **10** | **0** |

**ADT:** 7,715 **Length:** 1.18 **Coris File:** tcoris2009.dbf

| | hwy | mp | date | time | sev | location | road_desc | vehicles | contour | condition | lighting | weather | acctype | dir_1 | vehicle_1 | factor_1 | limit_1 | speed_1 | veh_move_1 | dir_2 | veh_move_2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 550A | 15.4 | 6/16/2009 | 0830 | INJ | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-LEVEL | DRY | DAYLIGHT | NONE | OVERTURNING | E | PICKUP TRUCK/UTILITY VAN | NONE APPARENT | 60 | 55 | AVOIDING OBJECT IN ROAD | | |
| 2 | 550A | 15.5 | 12/13/2009 | 2045 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | CURVE ON-LEVEL | ICY | DARK-UNLIGHTE | NONE | OVERTURNING | E | SUV | DRIVER INEXPERIENCE | 60 | 45 | SPUN OUT OF CONTROL | | |
| 3 | 550A | 15.54 | 4/1/2008 | 2004 | PDO | ON | NON-INTERSECTION | 1 | CURVE ON-LEVEL | DRY | DARK-UNLIGHTE | NONE | WILD ANIMAL | N | PASSENGER CAR/VAN | NONE APPARENT | 50 | 50 | GOING STRAIGHT | | |
| 4 | 550A | 15.58 | 8/12/2008 | 1530 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | CURVE ON-LEVEL | DRY | DAYLIGHT | NONE | FENCE | S | PASSENGER CAR/VAN | DRIVER EMOTIONALLY UPS | 35 | 25 | BACKING | | |
| 5 | 550A | 15.6 | 8/9/2008 | 0617 | PDO | ON | NON-INTERSECTION | 1 | STRAIGHT ON-LEVEL | DRY | DARK-UNLIGHTE | NONE | WILD ANIMAL | W | SUV | NONE APPARENT | 45 | 45 | GOING STRAIGHT | | |
| 6 | 550A | 15.7 | 4/12/2009 | 0045 | INJ | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-LEVEL | WET | DARK-LIGHTED | NONE | FENCE | E | PICKUP TRUCK/UTILITY VAN | DRIVER UNFAMILIAR W/ARI | 45 | 60 | GOING STRAIGHT | | |
| 7 | 550A | 15.7 | 1/31/2009 | 1956 | PDO | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-LEVEL | DRY | DARK-UNLIGHTE | NONE | TREE | E | PASSENGER CAR/VAN | DUI, DWAI, DUID | 45 | 50 | GOING STRAIGHT | | |
| 8 | 550A | 15.8 | 8/12/2009 | 2140 | PDO | OFF AT TEE | INTERSECTION RELATED | 1 | STRAIGHT ON-LEVEL | DRY | DARK-UNLIGHTE | NONE | FENCE | W | SUV | NONE APPARENT | 35 | 15 | GOING STRAIGHT | | |
| 9 | 550A | 15.8 | 4/9/2009 | 2025 | PDO | ON | NON-INTERSECTION | 1 | STRAIGHT ON-LEVEL | DRY | DARK-UNLIGHTE | NONE | WILD ANIMAL | E | PICKUP TRUCK/UTILITY VAN | NONE APPARENT | 55 | 55 | GOING STRAIGHT | | |
| 10 | 550A | 15.81 | 12/5/2007 | 0750 | PDO | ON | INTERSECTION RELATED | 2 | CURVE ON-LEVEL | DRY | DAYLIGHT | NONE | REAR END | W | PICKUP TRUCK/UTILITY VAN | NONE APPARENT | 35 | 10 | ENTERING/LEAVING PARKEI | W | STOPPED IN TRAFFIC |
| 11 | 550A | 15.81 | 1/15/2008 | 0755 | PDO | ON | INTERSECTION RELATED | 2 | CURVE ON-LEVEL | DRY | DAWN OR DUSK | NONE | REAR END | W | PASSENGER CAR/VAN | NONE APPARENT | 35 | 03 | GOING STRAIGHT | W | STOPPED IN TRAFFIC |
| 12 | 550A | 15.81 | 3/2/2009 | 0735 | PDO | ON | INTERSECTION RELATED | 2 | STRAIGHT ON-LEVEL | DRY | DAYLIGHT | NONE | REAR END | W | PICKUP TRUCK/UTILITY VAN | NONE APPARENT | 35 | 15 | GOING STRAIGHT | W | STOPPED IN TRAFFIC |
| 13 | 550A | 15.81 | 4/2/2009 | 1615 | INJ | ON | AT INTERSECTION | 2 | CURVE ON-GRADE | DRY | DAYLIGHT | NONE | REAR END | W | PICKUP TRUCK/UTILITY VAN | DRIVER FATIGUE | 35 | 35 | GOING STRAIGHT | W | STOPPED IN TRAFFIC |
| 14 | 550A | 15.81 | 6/22/2009 | 1030 | PDO | ON | INTERSECTION RELATED | 2 | STRAIGHT ON-LEVEL | DRY | DAYLIGHT | NONE | REAR END | W | PASSENGER CAR/VAN | NONE APPARENT | 35 | 15 | GOING STRAIGHT | W | STOPPED IN TRAFFIC |
| 15 | 550A | 15.9 | 1/8/2005 | 0915 | PDO | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-GRADE | ICY | DAYLIGHT | SNOW/SLEE | TREE | N | PICKUP TRUCK/UTILITY VAN | DRIVER INEXPERIENCE | 35 | 35 | GOING STRAIGHT | | |
| 16 | 550A | 15.9 | 2/24/2007 | 0500 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | STRAIGHT ON-GRADE | ICY | DARK-UNLIGHTE | NONE | OVERTURNING | N | PASSENGER CAR/VAN | NONE APPARENT | 35 | 35 | GOING STRAIGHT | | |
| 17 | 550A | 15.9 | 10/2/2006 | 0155 | INJ | OFF RIGHT | AT INTERSECTION | 2 | CURVE ON-GRADE | DRY | DARK-UNLIGHTE | NONE | OVERTURNING | N | PASSENGER CAR/VAN | NONE APPARENT | 45 | 44 | GOING STRAIGHT | S | GOING STRAIGHT |
| 18 | 550A | 16 | 9/17/2005 | 1620 | PDO | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-GRADE | DRY | DAYLIGHT | NONE | LARGE ROCKS/BOULDER | S | PASSENGER CAR/VAN | NONE APPARENT | 35 | 35 | GOING STRAIGHT | | |
| 19 | 550A | 16.1 | 1/18/2007 | 0726 | PDO | ON | NON-INTERSECTION | 1 | CURVE ON-GRADE | DRY | DAWN OR DUSK | NONE | WILD ANIMAL | N | SUV | NONE APPARENT | 35 | 35 | GOING STRAIGHT | | |
| 20 | 550A | 16.2 | 5/26/2007 | 1330 | INJ | ON | NON-INTERSECTION | 2 | CURVE ON-GRADE | WET | DAYLIGHT | RAIN | SIDESWIPE (OPPOSITE DIRECTI | N | MOTORCYCLE | NONE APPARENT | 35 | 35 | GOING STRAIGHT | S | GOING STRAIGHT |
| 21 | 550A | 16.2 | 5/2/2008 | 0816 | PDO | ON | INTERSECTION RELATED | 2 | STRAIGHT ON-LEVEL | DRY | DAYLIGHT | NONE | SIDESWIPE (OPPOSITE DIRECTI | W | PASSENGER CAR/VAN | DRIVER UNFAMILIAR W/ARI | 35 | 01 | BACKING | E | STOPPED IN TRAFFIC |
| 22 | 550A | 16.26 | 6/12/2006 | 2025 | INJ | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-GRADE | DRY | DAWN OR DUSK | NONE | OVERTURNING | S | MOTORCYCLE | NONE APPARENT | 35 | 35 | GOING STRAIGHT | | |
| 23 | 550A | 16.26 | 8/5/2009 | 0930 | PDO | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-GRADE | DRY | DAYLIGHT | NONE | SIGN | W | PASSENGER CAR/VAN | DUI, DWAI, DUID | 50 | 50 | DROVE WRONG WAY | | |
| 24 | 550A | 16.3 | 11/6/2008 | 0754 | PDO | ON | NON-INTERSECTION | 2 | CURVE ON-GRADE | DRY | DAYLIGHT | NONE | REAR END | E | PASSENGER CAR/VAN | DRIVER INEXPERIENCE | 35 | 10 | GOING STRAIGHT | E | STOPPED IN TRAFFIC |
| 25 | 550A | 16.3 | 12/13/2005 | 1158 | PDO | ON | NON-INTERSECTION | 2 | CURVE ON-GRADE | ICY | DAYLIGHT | NONE | SIDESWIPE (OPPOSITE DIRECTI | N | PASSENGER CAR/VAN | NONE APPARENT | 35 | 20 | GOING STRAIGHT | S | GOING STRAIGHT |
| 26 | 550A | 16.4 | 12/29/2005 | 0430 | INJ | OFF LEFT | NON-INTERSECTION | 1 | CURVE ON-GRADE | ICY | DARK-UNLIGHTE | SNOW/SLEE | OVERTURNING | N | PICKUP TRUCK/UTILITY VAN | DRIVER UNFAMILIAR W/ARI | 35 | 20 | GOING STRAIGHT | | |
| 27 | 550A | 16.4 | 7/21/2008 | 1950 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | CURVE ON-GRADE | DRY | DARK-UNLIGHTE | NONE | EMBANKMENT | E | PICKUP TRUCK/UTILITY VAN | DRIVER INEXPERIENCE | 35 | 35 | AVOIDING OBJECT IN ROAD | | |
| 28 | 550A | 16.46 | 9/15/2006 | 1700 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | CURVE ON-GRADE | DRY | DAYLIGHT | NONE | EMBANKMENT | N | PASSENGER CAR/VAN | NONE APPARENT | 35 | 20 | SLOWING | | |
| 29 | 550A | 16.46 | 1/2/2005 | 2310 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | CURVE ON-GRADE | SLUSHY | DARK-LIGHTED | SNOW/SLEE | LIGHT/UTILITY POLE | N | PASSENGER CAR/VAN | NONE APPARENT | 35 | 35 | SLOWING | | |
| 30 | 550A | 16.54 | 1/30/2005 | 0600 | PDO | OFF RIGHT | NON-INTERSECTION | 1 | CURVE ON-GRADE | ICY | DARK-UNLIGHTE | SNOW/SLEE | EMBANKMENT | N | PICKUP TRUCK/UTILITY VAN | NONE APPARENT | 35 | 30 | GOING STRAIGHT | | |

COLORADO DEPARTMENT OF TRANSPORTATION

# AUTHORIZED SPEED LIMITS AND RECOMMENDED TRAFFIC CONTROL DEVICES




Signed By: Matthew Rega

Matthew Rega

Staff Traffic Engineer

Date: 12/12/96

S

= EXTG NO-PASSING ZONE

N

SIGNLOG ON 08-20-96

| | FILE | MEMO | SHEET | Implemented with changes as marked |
|---|---|---|---|---|
| | 880.550.01 | 5937 | 5 | Date: By: |

SH 550 FROM NEW MEXICO STATE LINE TO SH 160 S/O DURANGO

SUPERSEDES SHEET 5, MEMO 5738, 01-11-94

Version 96.11.1 Drawn By: CKA

# SEH MEMORANDUM

# US 550 Connection to US 160 Draft Supplemental EIS—Alternative R Analysis

# February 7, 2012

MEMORANDUM


TO: Mike McVaugh, PE - CDOT Region 5

FROM: Phil Weisbach, PE
Jon E. Larson, PE

Philip J. Weisbach
Jon E. Larson


DATE: February 7, 2012

RE: US 550 Connection to US 160 Draft Supplemental EIS – Alternative R Analysis
SEH No. STOLF - 116527

## Executive Summary

Based on your direction, we have analyzed the Alternative R interchange submitted as part of the Webb Ranch Report. The year 2030 traffic volumes used were referenced from the previously analyzed Alternative A, which is contained in Appendix A for reference. Additionally, there is potential that an additional leg to the interchange will be required north from the westbound ramp intersection to accommodate the existing La Plata County Gravel Pit Operation (quarry) or future public use when the quarry is vacated. Therefore, the analyses evaluate the 3-legged US 550 / US 160 interchange (T-interchange) as shown in the Web Ranch Report as well as with a $4^{th}$ leg extending north from the westbound ramp terminal intersection as a future access to the quarry site. The following is a summary description of the alternatives and the intersections are labeled on Figure 1:

1. **Alternative R: 3-legged Interchange.**

   The <u>eastbound US 160 ramp terminal intersection</u> includes the following laneage configuration:

   - One eastbound free right turn to southbound US 550 with an exclusive climbing lane;
   - One northbound free right turn lane from US 550 to eastbound US 160; and
   - One through lane in both the northbound and southbound directions on the overpass structure above US 160.

   The <u>westbound US 160 ramp terminal intersection</u> includes the following laneage configuration:

   - One westbound left turn lane to southbound US 550 on the off-ramp; and
   - One northbound left turn lane from US 550 to westbound US 160.

   In the stop-controlled condition, the westbound left turn at the westbound ramp is assumed as stopped approach. Because there are no conflicting movements at the eastbound ramp, each movement operates as a free condition in both the stop-controlled and signalized scenarios.

2. **Alternative R: 4-legged Interchange.**

   The <u>eastbound US 160 ramp terminal intersection</u> includes the following laneage configuration:

   - One eastbound free right turn from US 160 to southbound US 550 with an exclusive climbing lane;

- One eastbound left turn lane from US 160 to northbound US 550 to provide access to the quarry;
- One free right turn lane from northbound US 550 to eastbound US 160;
- One southbound left turn lane to eastbound US 160; and
- One through lane in both the northbound and southbound directions.

The westbound US 160 ramp terminal intersection includes the following laneage configuration:

- One westbound left turn lane from US 160 to southbound US 550;
- One westbound right turn lane from US 160 to northbound US 550 to provide access to the quarry;
- One northbound left turn lane for the westbound US 160 on-ramp;
- One southbound right turn lane for the westbound US 160 on-ramp; and
- One lane each for the northbound and southbound through movements.

Because the of the tight-diamond configuration of the interchange, the ramp terminal intersections will be close together. Therefore, the overpass structure will require the left turn lanes to be side by side to accommodate the 1,000 vehicles per hour performing the northbound left turn movement in the morning peak period. Therefore, the bridge is assumed to be four lanes wide.

---

The technical results and supporting data of these analyses are included Appendix B of this memo.

The fundamental questions these analyses are intended to answer:

1. **In the year 2030, will the Alternative R interchange meet the purpose and need for capacity for the following conditions:**
   - **With a 3-legged ramp terminal intersection on the westbound ramp?**
   - **With a 4-legged ramp terminal intersection on the westbound ramp?**

**Summary of Results:** The results of the analysis performed are summarized below:

| Alternative R Interchange | Purpose and Need for Capacity | | | |
|---|---|---|---|---|
| | Stop-Control | | Signalization | |
| | Met | Not Met | Met | Not Met |
| 3-legged Interchange | | ✓ | ✓ | |
| 4-legged Interchange | | ✓ | | ✓ |

---

## Background and History

Alternatives for the US 550 connection to the US 160 corridor were evaluated in the 2011 US 550 Draft Supplemental EIS. The US 160 draft SEIS selected the Grandview Alternative G Modified as the Preferred Alternative which included an interchange connecting US 160 with US 550 approximately 0.6 miles east of the current Farmington Hill signalized intersection.

Representatives of Webb Ranch submitted the *Webb Ranch Report & Comments Concerning: US 550 South Connection to US 160 Supplemental Draft EIS* (November 28, 2011). The report takes issue with the conclusion of the US 160 draft SEIS due to its impact on the historical properties including the Webb Ranch property and provides alternative alignments that avoid these properties. The report provides four "R" Alternatives that generally follow the existing US 550 alignment with all alternatives intersecting US 160 in a grade-separated, tight diamond T-interchange configuration at the existing US 550 / US 160 location. Refer to Appendix C for a conceptual layout of Alternative R.

This memo analyzes whether the interchange at US 550 / US 160 for the R Alternative would meet the traffic capacity requirements of the purpose and need in the year 2030. The traffic analysis in this document focuses solely on the connection of US 550 to US 160 at Farmington Hill (See Figure 1). The merge, diverge and weave sections associated with interchange location were previously analyzed as part of the Alternative A, the findings of which met the purpose and need for capacity. Additionally, due to the substandard weave length for vehicles entering eastbound US 160 from northbound US 550, Alternative R proposes to tie into Ramp A at the Grandview interchange instead of directly onto US 160.

## Evaluation Criteria for Capacity

Alternative R was evaluated to determine if it met operational level of service requirements as described in the Executive Summary of the 2006 US 160 EIS, capacity analysis performed according to the methods described in the Highway Capacity Manual[1] (HCS). This memorandum focuses on traffic capacity analysis and not design. Traffic volumes used in the analysis are year 2030 seasonal peak hour volumes that were projected using year 2009 traffic count data, growth factors from the CDOT website, and trip generation estimates from the Grandview development. Additionally, we obtained traffic data from La Plata County regarding trip generation estimates from the quarry. The 2030 background traffic volumes were projected based on the background annual growth rates in the accepted methodology in the *US 160 and US 550 Year 2030 Traffic Volume Verification* memo dated June 23, 2011 to calculate the year 2030 background scenario. The trips generated by the Grandview development were combined with the year 2030 background volumes to generate the year 2030 total seasonal peak hour volumes used in the analysis.

For the purposes of this analysis, US 160 is assumed to be east/west and US 550 is assumed to be north/south.

**Purpose and Need for Capacity**

The capacity requirement for the purpose and need is as follows:

- A Level of Service (LOS) D or better for an urban signalized intersection and its individual legs or movements during the peak hour in year 2030.

[1] Highway Capacity Manual - Special Report 209. Transportation Research Board. National Research Council. 2000.

LOS is a measure used to describe operational conditions at an intersection. LOS categories ranging from A to F are assigned based on the predicted delay in seconds per vehicle for the intersection as a whole and for individual turning movements. LOS A indicates very good operations, and LOS F indicates poor, congested operations. Anything worse than LOS D for any intersection, leg, or individual movement is considered "failing," and not meeting the purpose and need. These criteria were applied to the analysis of Alternative R in this memorandum.

## Alternative R - 3-legged Interchange – Figure 1

The US 160 **eastbound ramp terminals** includes an eastbound free right turn to US 550 with an exclusive southbound climbing lane, a free right turn lane on northbound US 550 to eastbound US 160.

The US 160 **westbound ramp terminals** includes one westbound left turn lane on the off-ramp and one northbound left turn lane for the on-ramp from the northbound direction. In the stop-controlled condition, the westbound to southbound left turn at the westbound ramp is assumed to be a stop approach.

There are no conflicting movements at the eastbound ramp, each movement operates as a free condition in both the stop-controlled and signalized scenarios. Therefore, there is no intersection capacity analysis to be performed at the eastbound ramp. The analysis worksheets are contained in Appendix B for reference.

### Westbound Ramp Terminal – Stop Control on Off-Ramp

The analysis of the Alternative R interchange (Figure 1) shows that the side-street stop-controlled intersection and the westbound left turn movement are expected to operate at LOS F in the morning and evening peak periods.

### Westbound Ramp Terminal – Traffic Signal Control

The analysis of the Alternative R interchange (Figure 1) shows that the signalized intersection is expected to operate at LOS C during the morning peak period and LOS B during the evening peak period. Additionally, the individual movements are expected to operate at LOS D or better during the morning and evening peak periods. The significant northbound left turn volume is shown to be accommodated adequately due to the limited number of phases these two movements require to operate the signal.

### Conclusion

The analysis shows that this alternative satisfies the capacity requirements of the purpose and need in the year 2030 because this alternative accommodates the projected year 2030 volumes at LOS D or better.

## Alternative R - 4-legged Interchange – Figure 1

The **eastbound ramp terminal** includes an eastbound free right turn to southbound US 550 with an exclusive climbing lane, an eastbound left turn lane, a free right turn lane on northbound US 550 to eastbound US 160, one southbound left turn lane and one through lane in both the northbound and southbound directions.

The **westbound ramp terminal** includes one westbound left turn lane and one right turn lane on the off-ramp, one northbound left turn lane for the on-ramp, one northbound through lane, and one lane for each the southbound right turn and through movements.

**Trip Generation**

Depending upon impacts of Alternative R to the quarry access road on the north side of US 160, there may be necessity to utilize the US 550 / US 160 interchange to accommodate access to the quarry to the north of the westbound ramp terminal intersection. The parcel of land to the north is currently utilized by La Plata County as a gravel quarry. In order to estimate the number of vehicles that would use the north leg of the westbound ramp intersection, trips were based on the current land use at this site, the quarry, from information provided by La Plata County. Trips were estimated during the summer peak season to correspond with the US 160 Draft SEIS which evaluates traffic operations using year 2030 projected summer peak season traffic volumes.

According to Jim Davis, La Plata County Engineer, “On average we haul 50,000 tons of gravel per year out of the County's gravel pit ("Crader Pit") opposite Farmington Hill. The gravel is typically hauled during the months of May through August. Typically, 5 loads a day are hauled using 6 to 9 trucks, which is approximately 30 to 45 loads per day. The access road to north of US 160 is the only legal access to this property.”

Assuming 45 loads per day, the quarry would generate approximately 90 vehicle trips per day (45 inbound / 45 outbound). It was assumed that one round of trucks would occur during the morning peak period and one round of trucks would occur during the evening peak period. Based on this assumption, the quarry would generate 18 trips in the morning peak period and 18 trips during the evening peak period.

The trips were distributed equally to US 160 westbound, US 160 eastbound and US 550 southbound. The traffic operations analysis assumes 100% trucks utilizing the movements exclusive to the quarry access on the north leg of the US 160 / US 550 westbound ramp.

## Westbound Ramp Terminal

**Stop Control on Off-Ramp**

The analysis of the Alternative R interchange (Figure 1) shows that the side-street stop-controlled intersection and the eastbound and westbound ramp left turn movements are expected to operate at LOS F in the morning and evening peak periods.

**Traffic Signal Control**

Based on the methodologies contained in the Highway Capacity Manual, the analysis of the Alternative R interchange (Figure 1) shows that the signalized intersection is expected to operate at LOS E during the morning peak period and LOS B during the evening peak period. Additionally, the westbound left turn and northbound left turn movements are expected to operate at LOS E during the morning peak period. With the additional north leg, the significant northbound left turn volume does not have enough green time to clear adequately due to the increased number of phases at a 4-legged intersection.

## Eastbound Ramp Terminal

**Stop Control on Off-Ramp**

The analysis of the Alternative R interchange (Figure 1) shows that the side-street stop-controlled intersection and the eastbound left turn movement are expected to operate at LOS F in the morning and evening peak periods.

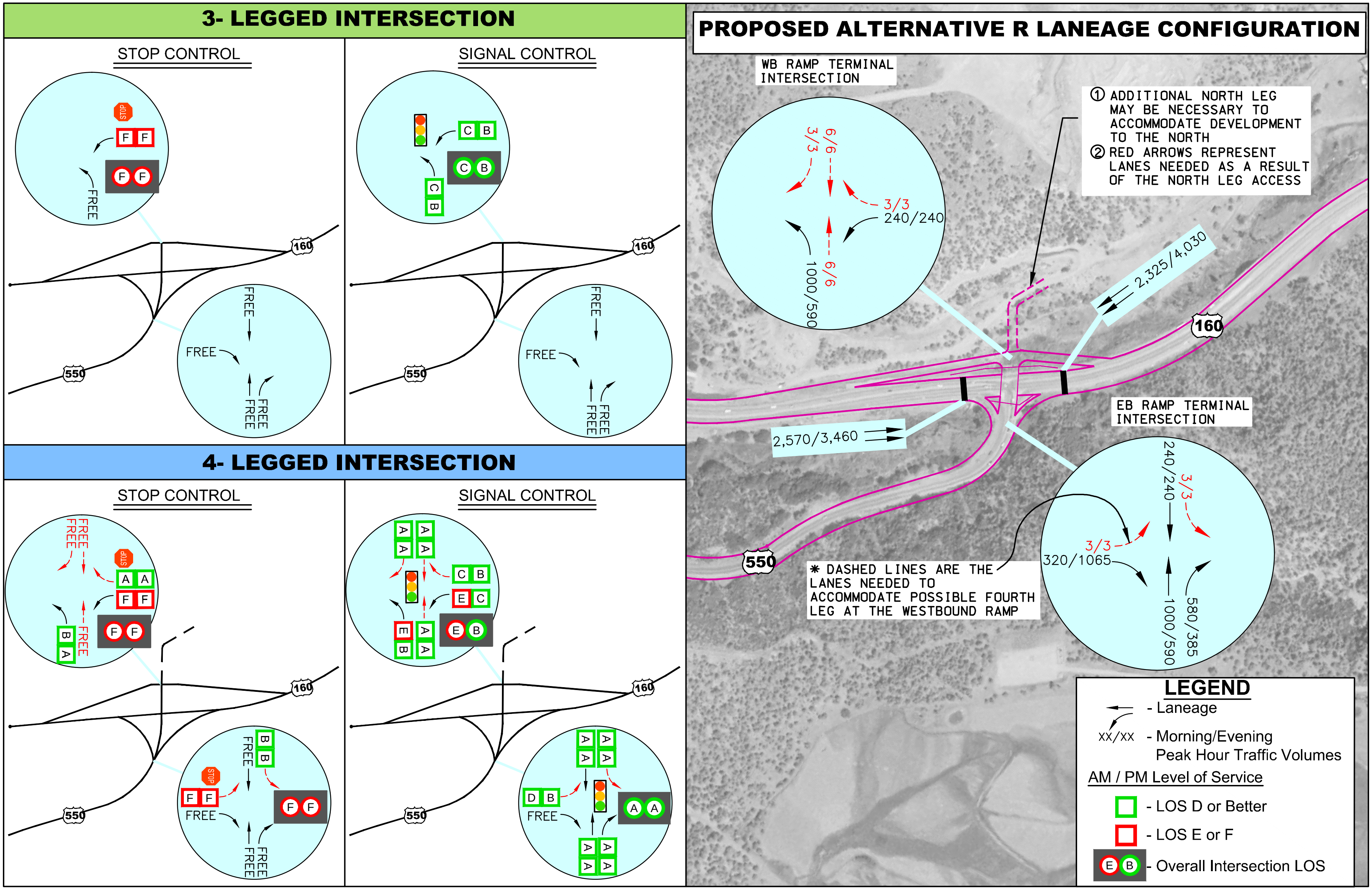
**Traffic Signal Control**

The analysis of the Alternative R interchange (Figure 1) shows that the signalized intersection is expected to operate at LOS A during the morning and evening peak periods. Additionally, the individual movements are expected to operate at LOS D or better during the morning and evening peak periods.

**Conclusion**

The analysis shows that this alternative does not meet capacity requirements for the purpose and need because the westbound ramp intersection is not adequate to maintain LOS D in the morning and evening peak periods with either stop-control or signalization.

jel
Attachments
p:\ae\c\codot\105181\to #3 - us 160 interchange analysis\project___supplemental eis\116527\us 160 seis_2030 alt r analysis_2-7-2012.docx




SEH

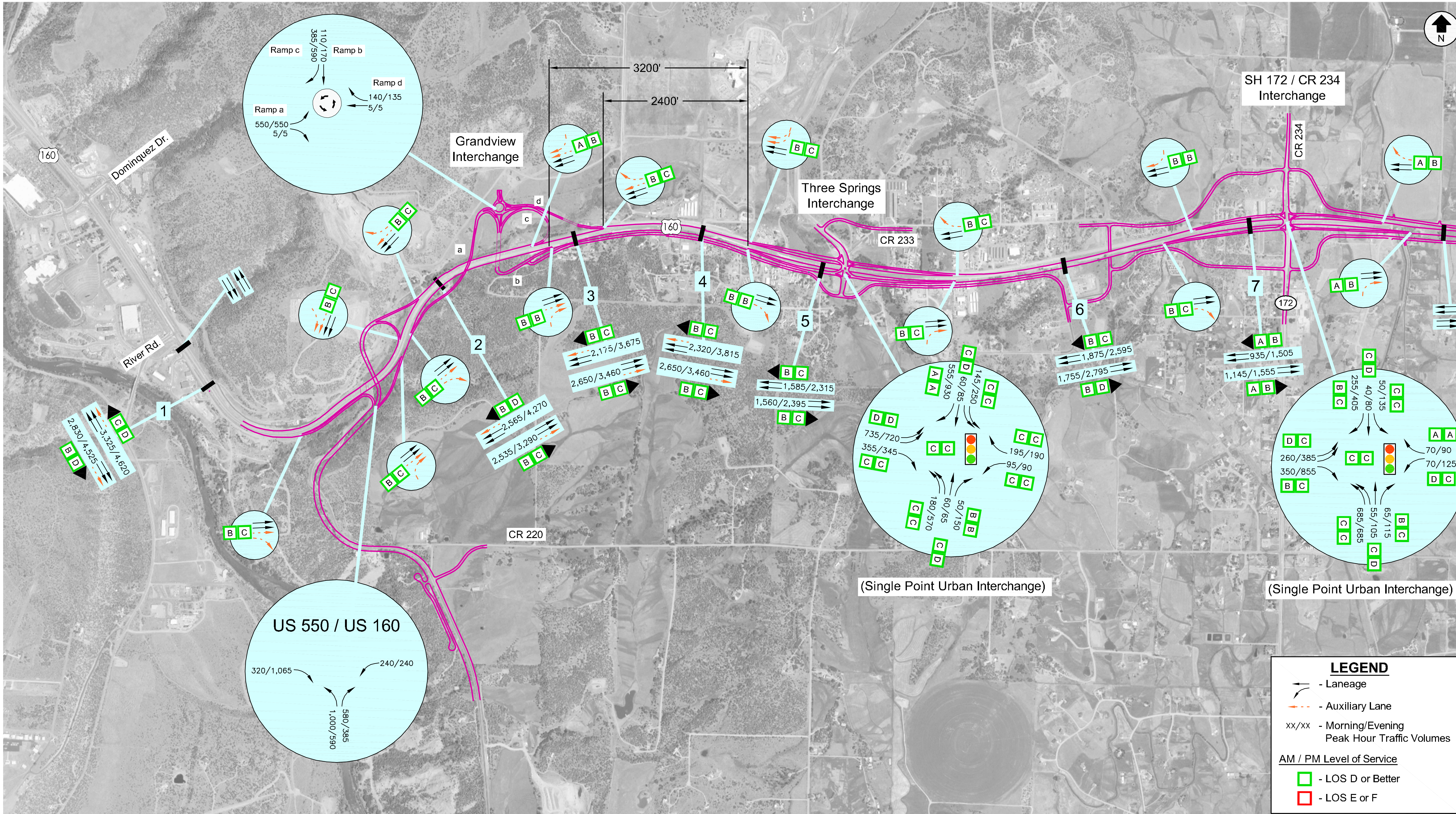
US 550 AT US 160 SUPPLEMENTAL EIS

US 550 /US 160 INTERCHANGE - ALTERNATIVE R

| Scale | 1"=500' | Date | 02/07/12 | Drawn by | KLH | Job # | 116527 | Figure | 1 |
|---|---|---|---|---|---|---|---|---|---|

# Appendix A

Revised Preliminary Alternative A




# Year 2030 Traffic Volumes

Year 2030 Traffic Operation Analysis for the US 550 at US 160 Section 4(f) Alternatives
Revised Preliminary Alternative A

| Scale | 1"=1500' | Date | 4/28/10 | Drawn by | NWS | Job # | 105181 | Figure | 3 |
|---|---|---|---|---|---|---|---|---|---|

# Appendix B

Level of Service Worksheets

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (veh/h) | 0 | 0 | 0 | 240 | 0 | 0 | 1000 | 0 | 0 | 0 | 0 | 0 |
| Sign Control | | Stop | | | Stop | | | Free | | | Free | |
| Grade | | 0% | | | 0% | | | 0% | | | 0% | |
| Peak Hour Factor | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Hourly flow rate (vph) | 0 | 0 | 0 | 261 | 0 | 0 | 1087 | 0 | 0 | 0 | 0 | 0 |
| Pedestrians | | | | | | | | | | | | |
| Lane Width (ft) | | | | | | | | | | | | |
| Walking Speed (ft/s) | | | | | | | | | | | | |
| Percent Blockage | | | | | | | | | | | | |
| Right turn flare (veh) | | | | | | | | | | | | |
| Median type | | | | | | | | None | | | None | |
| Median storage veh) | | | | | | | | | | | | |
| Upstream signal (ft) | | | | | | | | | | | | |
| pX, platoon unblocked | | | | | | | | | | | | |
| vC, conflicting volume | 2174 | 2174 | 0 | 2174 | 2174 | 0 | 0 | | | 0 | | |
| vC1, stage 1 conf vol | | | | | | | | | | | | |
| vC2, stage 2 conf vol | | | | | | | | | | | | |
| vCu, unblocked vol | 2174 | 2174 | 0 | 2174 | 2174 | 0 | 0 | | | 0 | | |
| tC, single (s) | 7.1 | 6.5 | 6.2 | 7.1 | 6.5 | 6.2 | 4.1 | | | 4.1 | | |
| tC, 2 stage (s) | | | | | | | | | | | | |
| tF (s) | 3.5 | 4.0 | 3.3 | 3.5 | 4.0 | 3.3 | 2.2 | | | 2.2 | | |
| p0 queue free % | 100 | 100 | 100 | 0 | 100 | 100 | 33 | | | 100 | | |
| cM capacity (veh/h) | 15 | 15 | 1085 | 15 | 15 | 1085 | 1623 | | | 1623 | | |

| Direction, Lane # | WB 1 | NB 1 | SB 1 | SB 2 |
|---|---|---|---|---|
| Volume Total | 261 | 1087 | 0 | 0 |
| Volume Left | 261 | 1087 | 0 | 0 |
| Volume Right | 0 | 0 | 0 | 0 |
| cSH | 15 | 1623 | 1700 | 1700 |
| Volume to Capacity | 16.91 | 0.67 | 0.00 | 0.00 |
| Queue Length 95th (ft) | Err | 140 | 0 | 0 |
| Control Delay (s) | Err | 11.6 | 0.0 | 0.0 |
| Lane LOS | F | B | | |
| Approach Delay (s) | Err | 11.6 | 0.0 | |
| Approach LOS | F | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | 1944.6 | | |
| Intersection Capacity Utilization | 82.0% | ICU Level of Service | E |
| Analysis Period (min) | 15 | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (veh/h) | 0 | 0 | 0 | 240 | 0 | 0 | 590 | 0 | 0 | 0 | 0 | 0 |
| Sign Control | | Stop | | | Stop | | | Free | | | Free | |
| Grade | | 0% | | | 0% | | | 0% | | | 0% | |
| Peak Hour Factor | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Hourly flow rate (vph) | 0 | 0 | 0 | 261 | 0 | 0 | 641 | 0 | 0 | 0 | 0 | 0 |
| Pedestrians | | | | | | | | | | | | |
| Lane Width (ft) | | | | | | | | | | | | |
| Walking Speed (ft/s) | | | | | | | | | | | | |
| Percent Blockage | | | | | | | | | | | | |
| Right turn flare (veh) | | | | | | | | | | | | |
| Median type | | | | | | | | None | | | None | |
| Median storage veh) | | | | | | | | | | | | |
| Upstream signal (ft) | | | | | | | | | | | | |
| pX, platoon unblocked | | | | | | | | | | | | |
| vC, conflicting volume | 1283 | 1283 | 0 | 1283 | 1283 | 0 | 0 | | | 0 | | |
| vC1, stage 1 conf vol | | | | | | | | | | | | |
| vC2, stage 2 conf vol | | | | | | | | | | | | |
| vCu, unblocked vol | 1283 | 1283 | 0 | 1283 | 1283 | 0 | 0 | | | 0 | | |
| tC, single (s) | 7.1 | 6.5 | 6.2 | 7.1 | 6.5 | 6.2 | 4.1 | | | 4.1 | | |
| tC, 2 stage (s) | | | | | | | | | | | | |
| tF (s) | 3.5 | 4.0 | 3.3 | 3.5 | 4.0 | 3.3 | 2.2 | | | 2.2 | | |
| p0 queue free % | 100 | 100 | 100 | 0 | 100 | 100 | 60 | | | 100 | | |
| cM capacity (veh/h) | 98 | 100 | 1085 | 98 | 100 | 1085 | 1623 | | | 1623 | | |

| Direction, Lane # | WB 1 | NB 1 | SB 1 | SB 2 |
|---|---|---|---|---|
| Volume Total | 261 | 641 | 0 | 0 |
| Volume Left | 261 | 641 | 0 | 0 |
| Volume Right | 0 | 0 | 0 | 0 |
| cSH | 98 | 1623 | 1700 | 1700 |
| Volume to Capacity | 2.65 | 0.40 | 0.00 | 0.00 |
| Queue Length 95th (ft) | 609 | 48 | 0 | 0 |
| Control Delay (s) | 840.6 | 8.7 | 0.0 | 0.0 |
| Lane LOS | F | A | | |
| Approach Delay (s) | 840.6 | 8.7 | 0.0 | |
| Approach LOS | F | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | 249.2 | | |
| Intersection Capacity Utilization | 59.3% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |

| Movement | EBT | EBR | WBL | WBT | NBL | NBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (vph) | 0 | 0 | 240 | 0 | 1000 | 0 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | | | 5.0 | | 5.0 | |
| Lane Util. Factor | | | 1.00 | | 1.00 | |
| Frt | | | 1.00 | | 1.00 | |
| Flt Protected | | | 0.95 | | 0.95 | |
| Satd. Flow (prot) | | | 1770 | | 1770 | |
| Flt Permitted | | | 0.95 | | 0.95 | |
| Satd. Flow (perm) | | | 1770 | | 1770 | |
| Peak-hour factor, PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Adj. Flow (vph) | 0 | 0 | 261 | 0 | 1087 | 0 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 0 | 0 | 261 | 0 | 1087 | 0 |
| Turn Type | | | Prot | | | |
| Protected Phases | | | 3 | | | |
| Permitted Phases | | | | | 2 | |
| Actuated Green, G (s) | | | 15.1 | | 51.4 | |
| Effective Green, g (s) | | | 15.1 | | 51.4 | |
| Actuated g/C Ratio | | | 0.20 | | 0.67 | |
| Clearance Time (s) | | | 5.0 | | 5.0 | |
| Vehicle Extension (s) | | | 3.0 | | 3.0 | |
| Lane Grp Cap (vph) | | | 349 | | 1189 | |
| v/s Ratio Prot | | | c0.15 | | | |
| v/s Ratio Perm | | | | | c0.61 | |
| v/c Ratio | | | 0.75 | | 0.91 | |
| Uniform Delay, d1 | | | 28.9 | | 10.7 | |
| Progression Factor | | | 1.00 | | 1.00 | |
| Incremental Delay, d2 | | | 8.5 | | 10.8 | |
| Delay (s) | | | 37.4 | | 21.5 | |
| Level of Service | | | D | | C | |
| Approach Delay (s) | 0.0 | | | 37.4 | 21.5 | |
| Approach LOS | A | | | D | C | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 24.6 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.88 | | |
| Actuated Cycle Length (s) | 76.5 | Sum of lost time (s) | 10.0 |
| Intersection Capacity Utilization | 80.9% | ICU Level of Service | D |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

| Movement | EBT | EBR | WBL | WBT | NBL | NBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (vph) | 0 | 0 | 240 | 0 | 590 | 0 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | | | 5.0 | | 5.0 | |
| Lane Util. Factor | | | 1.00 | | 1.00 | |
| Frt | | | 1.00 | | 1.00 | |
| Flt Protected | | | 0.95 | | 0.95 | |
| Satd. Flow (prot) | | | 1770 | | 1770 | |
| Flt Permitted | | | 0.95 | | 0.95 | |
| Satd. Flow (perm) | | | 1770 | | 1770 | |
| Peak-hour factor, PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Adj. Flow (vph) | 0 | 0 | 261 | 0 | 641 | 0 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 0 | 0 | 261 | 0 | 641 | 0 |
| Turn Type | | | Prot | | | |
| Protected Phases | | | 3 | | | |
| Permitted Phases | | | | | 2 | |
| Actuated Green, G (s) | | | 12.5 | | 22.5 | |
| Effective Green, g (s) | | | 12.5 | | 22.5 | |
| Actuated g/C Ratio | | | 0.28 | | 0.50 | |
| Clearance Time (s) | | | 5.0 | | 5.0 | |
| Vehicle Extension (s) | | | 3.0 | | 3.0 | |
| Lane Grp Cap (vph) | | | 492 | | 885 | |
| v/s Ratio Prot | | | c0.15 | | | |
| v/s Ratio Perm | | | | | c0.36 | |
| v/c Ratio | | | 0.53 | | 0.72 | |
| Uniform Delay, d1 | | | 13.8 | | 8.8 | |
| Progression Factor | | | 1.00 | | 1.00 | |
| Incremental Delay, d2 | | | 1.1 | | 3.0 | |
| Delay (s) | | | 14.9 | | 11.8 | |
| Level of Service | | | B | | B | |
| Approach Delay (s) | 0.0 | | | 14.9 | 11.8 | |
| Approach LOS | A | | | B | B | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 12.7 | HCM Level of Service | B |
| HCM Volume to Capacity ratio | 0.66 | | |
| Actuated Cycle Length (s) | 45.0 | Sum of lost time (s) | 10.0 |
| Intersection Capacity Utilization | 80.9% | ICU Level of Service | D |
| Analysis Period (min) | 15 | | |
| c Critical Lane Group | | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (veh/h) | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 580 | 3 | 240 | 0 |
| Sign Control | | Stop | | | Stop | | | Free | | | Free | |
| Grade | | 0% | | | 0% | | | 0% | | | 0% | |
| Peak Hour Factor | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Hourly flow rate (vph) | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1087 | 630 | 3 | 261 | 0 |
| Pedestrians | | | | | | | | | | | | |
| Lane Width (ft) | | | | | | | | | | | | |
| Walking Speed (ft/s) | | | | | | | | | | | | |
| Percent Blockage | | | | | | | | | | | | |
| Right turn flare (veh) | | | 20 | | | | | | | | | |
| Median type | | | | | | | | None | | | None | |
| Median storage veh) | | | | | | | | | | | | |
| Upstream signal (ft) | | | | | | | | | | | | |
| pX, platoon unblocked | | | | | | | | | | | | |
| vC, conflicting volume | 1354 | 1354 | 261 | 1354 | 1354 | 1087 | 261 | | | 1087 | | |
| vC1, stage 1 conf vol | | | | | | | | | | | | |
| vC2, stage 2 conf vol | | | | | | | | | | | | |
| vCu, unblocked vol | 1354 | 1354 | 261 | 1354 | 1354 | 1087 | 261 | | | 1087 | | |
| tC, single (s) | 8.1 | 6.5 | 6.2 | 7.1 | 6.5 | 6.2 | 4.1 | | | 5.1 | | |
| tC, 2 stage (s) | | | | | | | | | | | | |
| tF (s) | 4.4 | 4.0 | 3.3 | 3.5 | 4.0 | 3.3 | 2.2 | | | 3.1 | | |
| p0 queue free % | 96 | 100 | 100 | 100 | 100 | 100 | 100 | | | 99 | | |
| cM capacity (veh/h) | 79 | 150 | 778 | 126 | 148 | 263 | 1304 | | | 383 | | |

| Direction, Lane # | EB 1 | NB 1 | NB 2 | SB 1 | SB 2 |
|---|---|---|---|---|---|
| Volume Total | 3 | 1087 | 630 | 3 | 261 |
| Volume Left | 3 | 0 | 0 | 3 | 0 |
| Volume Right | 0 | 0 | 630 | 0 | 0 |
| cSH | 0 | 1700 | 1700 | 383 | 1700 |
| Volume to Capacity | Err | 0.64 | 0.37 | 0.01 | 0.15 |
| Queue Length 95th (ft) | Err | 0 | 0 | 1 | 0 |
| Control Delay (s) | Err | 0.0 | 0.0 | 14.5 | 0.0 |
| Lane LOS | F | | | B | |
| Approach Delay (s) | Err | 0.0 | | 0.2 | |
| Approach LOS | F | | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | Err | | |
| Intersection Capacity Utilization | 79.9% | ICU Level of Service | D |
| Analysis Period (min) | 15 | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (veh/h) | 0 | 0 | 0 | 240 | 0 | 3 | 1000 | 6 | 0 | 0 | 6 | 3 |
| Sign Control | | Stop | | | Stop | | | Free | | | Free | |
| Grade | | 0% | | | 0% | | | 0% | | | 0% | |
| Peak Hour Factor | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Hourly flow rate (vph) | 0 | 0 | 0 | 261 | 0 | 3 | 1087 | 7 | 0 | 0 | 7 | 3 |
| Pedestrians | | | | | | | | | | | | |
| Lane Width (ft) | | | | | | | | | | | | |
| Walking Speed (ft/s) | | | | | | | | | | | | |
| Percent Blockage | | | | | | | | | | | | |
| Right turn flare (veh) | | | | | | | | | | | | |
| Median type | | | | | | | | None | | | None | |
| Median storage veh) | | | | | | | | | | | | |
| Upstream signal (ft) | | | | | | | | | | | | |
| pX, platoon unblocked | | | | | | | | | | | | |
| vC, conflicting volume | 2190 | 2187 | 7 | 2187 | 2190 | 7 | 10 | | | 7 | | |
| vC1, stage 1 conf vol | | | | | | | | | | | | |
| vC2, stage 2 conf vol | | | | | | | | | | | | |
| vCu, unblocked vol | 2190 | 2187 | 7 | 2187 | 2190 | 7 | 10 | | | 7 | | |
| tC, single (s) | 7.1 | 6.5 | 6.2 | 7.1 | 6.5 | 7.2 | 4.1 | | | 4.1 | | |
| tC, 2 stage (s) | | | | | | | | | | | | |
| tF (s) | 3.5 | 4.0 | 3.3 | 3.5 | 4.0 | 4.2 | 2.2 | | | 2.2 | | |
| p0 queue free % | 100 | 100 | 100 | 0 | 100 | 100 | 32 | | | 100 | | |
| cM capacity (veh/h) | 15 | 15 | 1076 | 15 | 15 | 849 | 1610 | | | 1614 | | |

| Direction, Lane # | WB 1 | WB 2 | NB 1 | NB 2 | SB 1 | SB 2 |
|---|---|---|---|---|---|---|
| Volume Total | 261 | 3 | 1087 | 7 | 7 | 3 |
| Volume Left | 261 | 0 | 1087 | 0 | 0 | 0 |
| Volume Right | 0 | 3 | 0 | 0 | 0 | 3 |
| cSH | 15 | 849 | 1610 | 1700 | 1700 | 1700 |
| Volume to Capacity | 17.46 | 0.00 | 0.68 | 0.00 | 0.00 | 0.00 |
| Queue Length 95th (ft) | Err | 0 | 143 | 0 | 0 | 0 |
| Control Delay (s) | Err | 9.3 | 11.7 | 0.0 | 0.0 | 0.0 |
| Lane LOS | F | A | B | | | |
| Approach Delay (s) | 9875.7 | | 11.7 | | 0.0 | |
| Approach LOS | F | | | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | 1917.0 | | |
| Intersection Capacity Utilization | 79.9% | ICU Level of Service | D |
| Analysis Period (min) | 15 | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (veh/h) | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 590 | 385 | 3 | 240 | 0 |
| Sign Control | | Stop | | | Stop | | | Free | | | Free | |
| Grade | | 0% | | | 0% | | | 0% | | | 0% | |
| Peak Hour Factor | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Hourly flow rate (vph) | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 641 | 418 | 3 | 261 | 0 |
| Pedestrians | | | | | | | | | | | | |
| Lane Width (ft) | | | | | | | | | | | | |
| Walking Speed (ft/s) | | | | | | | | | | | | |
| Percent Blockage | | | | | | | | | | | | |
| Right turn flare (veh) | | | 20 | | | | | | | | | |
| Median type | | | | | | | | None | | | None | |
| Median storage veh) | | | | | | | | | | | | |
| Upstream signal (ft) | | | | | | | | | | | | |
| pX, platoon unblocked | | | | | | | | | | | | |
| vC, conflicting volume | 909 | 909 | 261 | 909 | 909 | 641 | 261 | | | 641 | | |
| vC1, stage 1 conf vol | | | | | | | | | | | | |
| vC2, stage 2 conf vol | | | | | | | | | | | | |
| vCu, unblocked vol | 909 | 909 | 261 | 909 | 909 | 641 | 261 | | | 641 | | |
| tC, single (s) | 8.1 | 6.5 | 6.2 | 7.1 | 6.5 | 6.2 | 4.1 | | | 5.1 | | |
| tC, 2 stage (s) | | | | | | | | | | | | |
| tF (s) | 4.4 | 4.0 | 3.3 | 3.5 | 4.0 | 3.3 | 2.2 | | | 3.1 | | |
| p0 queue free % | 98 | 100 | 100 | 100 | 100 | 100 | 100 | | | 99 | | |
| cM capacity (veh/h) | 175 | 276 | 778 | 255 | 274 | 475 | 1304 | | | 609 | | |

| Direction, Lane # | EB 1 | NB 1 | NB 2 | SB 1 | SB 2 |
|---|---|---|---|---|---|
| Volume Total | 3 | 641 | 418 | 3 | 261 |
| Volume Left | 3 | 0 | 0 | 3 | 0 |
| Volume Right | 0 | 0 | 418 | 0 | 0 |
| cSH | 0 | 1700 | 1700 | 609 | 1700 |
| Volume to Capacity | Err | 0.38 | 0.25 | 0.01 | 0.15 |
| Queue Length 95th (ft) | Err | 0 | 0 | 0 | 0 |
| Control Delay (s) | Err | 0.0 | 0.0 | 10.9 | 0.0 |
| Lane LOS | F | | | B | |
| Approach Delay (s) | Err | 0.0 | | 0.1 | |
| Approach LOS | F | | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | Err | | |
| Intersection Capacity Utilization | 58.3% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (veh/h) | 0 | 0 | 0 | 240 | 0 | 2 | 590 | 6 | 0 | 0 | 6 | 3 |
| Sign Control | | Stop | | | Stop | | | Free | | | Free | |
| Grade | | 0% | | | 0% | | | 0% | | | 0% | |
| Peak Hour Factor | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Hourly flow rate (vph) | 0 | 0 | 0 | 261 | 0 | 2 | 641 | 7 | 0 | 0 | 7 | 3 |
| Pedestrians | | | | | | | | | | | | |
| Lane Width (ft) | | | | | | | | | | | | |
| Walking Speed (ft/s) | | | | | | | | | | | | |
| Percent Blockage | | | | | | | | | | | | |
| Right turn flare (veh) | | | | | | | | | | | | |
| Median type | | | | | | | | None | | | None | |
| Median storage veh) | | | | | | | | | | | | |
| Upstream signal (ft) | | | | | | | | | | | | |
| pX, platoon unblocked | | | | | | | | | | | | |
| vC, conflicting volume | 1298 | 1296 | 7 | 1296 | 1299 | 7 | 10 | | | 7 | | |
| vC1, stage 1 conf vol | | | | | | | | | | | | |
| vC2, stage 2 conf vol | | | | | | | | | | | | |
| vCu, unblocked vol | 1298 | 1296 | 7 | 1296 | 1299 | 7 | 10 | | | 7 | | |
| tC, single (s) | 7.1 | 6.5 | 6.2 | 7.1 | 6.5 | 7.2 | 4.1 | | | 4.1 | | |
| tC, 2 stage (s) | | | | | | | | | | | | |
| tF (s) | 3.5 | 4.0 | 3.3 | 3.5 | 4.0 | 4.2 | 2.2 | | | 2.2 | | |
| p0 queue free % | 100 | 100 | 100 | 0 | 100 | 100 | 60 | | | 100 | | |
| cM capacity (veh/h) | 95 | 98 | 1076 | 96 | 97 | 849 | 1610 | | | 1614 | | |

| Direction, Lane # | WB 1 | WB 2 | NB 1 | NB 2 | SB 1 | SB 2 |
|---|---|---|---|---|---|---|
| Volume Total | 261 | 2 | 641 | 7 | 7 | 3 |
| Volume Left | 261 | 0 | 641 | 0 | 0 | 0 |
| Volume Right | 0 | 2 | 0 | 0 | 0 | 3 |
| cSH | 96 | 849 | 1610 | 1700 | 1700 | 1700 |
| Volume to Capacity | 2.72 | 0.00 | 0.40 | 0.00 | 0.00 | 0.00 |
| Queue Length 95th (ft) | 615 | 0 | 49 | 0 | 0 | 0 |
| Control Delay (s) | 871.8 | 9.2 | 8.7 | 0.0 | 0.0 | 0.0 |
| Lane LOS | F | A | A | | | |
| Approach Delay (s) | 864.6 | | 8.6 | | 0.0 | |
| Approach LOS | F | | | | | |

| Intersection Summary | | | |
|---|---|---|---|
| Average Delay | 253.1 | | |
| Intersection Capacity Utilization | 58.3% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 3 | 0 | 320 | 0 | 0 | 0 | 0 | 1000 | 580 | 3 | 240 | 0 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | | 4.0 | | | | | 5.0 | 5.0 | 5.0 | 5.0 | |
| Lane Util. Factor | 1.00 | | 1.00 | | | | | 1.00 | 1.00 | 1.00 | 1.00 | |
| Frt | 1.00 | | 0.85 | | | | | 1.00 | 0.85 | 1.00 | 1.00 | |
| Flt Protected | 0.95 | | 1.00 | | | | | 1.00 | 1.00 | 0.95 | 1.00 | |
| Satd. Flow (prot) | 902 | | 1583 | | | | | 1863 | 1583 | 902 | 1863 | |
| Flt Permitted | 0.95 | | 1.00 | | | | | 1.00 | 1.00 | 0.20 | 1.00 | |
| Satd. Flow (perm) | 902 | | 1583 | | | | | 1863 | 1583 | 189 | 1863 | |
| Peak-hour factor, PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Adj. Flow (vph) | 3 | 0 | 348 | 0 | 0 | 0 | 0 | 1087 | 630 | 3 | 261 | 0 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 133 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 3 | 0 | 348 | 0 | 0 | 0 | 0 | 1087 | 497 | 3 | 261 | 0 |
| Heavy Vehicles (%) | 100% | 0% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 100% | 2% | 2% |
| Turn Type | Prot | | Free | | | | | | Perm | Perm | | |
| Protected Phases | 7 | | | | | | | 2 | | | 6 | |
| Permitted Phases | | | Free | | | | | | 2 | 6 | | |
| Actuated Green, G (s) | 0.7 | | 50.8 | | | | | 40.1 | 40.1 | 40.1 | 40.1 | |
| Effective Green, g (s) | 0.7 | | 50.8 | | | | | 40.1 | 40.1 | 40.1 | 40.1 | |
| Actuated g/C Ratio | 0.01 | | 1.00 | | | | | 0.79 | 0.79 | 0.79 | 0.79 | |
| Clearance Time (s) | 5.0 | | | | | | | 5.0 | 5.0 | 5.0 | 5.0 | |
| Vehicle Extension (s) | 3.0 | | | | | | | 3.0 | 3.0 | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 12 | | 1583 | | | | | 1471 | 1250 | 149 | 1471 | |
| v/s Ratio Prot | 0.00 | | | | | | | c0.58 | | | 0.14 | |
| v/s Ratio Perm | | | c0.22 | | | | | | 0.31 | 0.02 | | |
| v/c Ratio | 0.25 | | 0.22 | | | | | 0.74 | 0.40 | 0.02 | 0.18 | |
| Uniform Delay, d1 | 24.8 | | 0.0 | | | | | 2.7 | 1.6 | 1.1 | 1.3 | |
| Progression Factor | 1.00 | | 1.00 | | | | | 1.00 | 1.00 | 1.00 | 1.00 | |
| Incremental Delay, d2 | 10.7 | | 0.3 | | | | | 2.0 | 0.2 | 0.1 | 0.1 | |
| Delay (s) | 35.5 | | 0.3 | | | | | 4.7 | 1.9 | 1.2 | 1.4 | |
| Level of Service | D | | A | | | | | A | A | A | A | |
| Approach Delay (s) | | 0.6 | | | 0.0 | | | 3.6 | | | 1.4 | |
| Approach LOS | | A | | | A | | | A | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 2.9 | HCM Level of Service | A |
| HCM Volume to Capacity ratio | 0.67 | | |
| Actuated Cycle Length (s) | 50.8 | Sum of lost time (s) | 5.0 |
| Intersection Capacity Utilization | 83.3% | ICU Level of Service | E |
| Analysis Period (min) | 15 | | |

c Critical Lane Group

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 0 | 0 | 0 | 240 | 0 | 3 | 1000 | 6 | 0 | 0 | 6 | 3 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | | | | 5.0 | | 5.0 | 5.0 | 5.0 | | | 5.0 | 5.0 |
| Lane Util. Factor | | | | 1.00 | | 1.00 | 1.00 | 1.00 | | | 1.00 | 1.00 |
| Frt | | | | 1.00 | | 0.85 | 1.00 | 1.00 | | | 1.00 | 0.85 |
| Flt Protected | | | | 0.95 | | 1.00 | 0.95 | 1.00 | | | 1.00 | 1.00 |
| Satd. Flow (prot) | | | | 1770 | | 808 | 1770 | 950 | | | 950 | 808 |
| Flt Permitted | | | | 0.95 | | 1.00 | 0.75 | 1.00 | | | 1.00 | 1.00 |
| Satd. Flow (perm) | | | | 1770 | | 808 | 1403 | 950 | | | 950 | 808 |
| Peak-hour factor, PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Adj. Flow (vph) | 0 | 0 | 0 | 261 | 0 | 3 | 1087 | 7 | 0 | 0 | 7 | 3 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| Lane Group Flow (vph) | 0 | 0 | 0 | 261 | 0 | 1 | 1087 | 7 | 0 | 0 | 7 | 2 |
| Heavy Vehicles (%) | 2% | 2% | 2% | 2% | 2% | 100% | 2% | 100% | 2% | 2% | 100% | 100% |
| Turn Type | | | | Prot | | custom | Perm | | | | | Perm |
| Protected Phases | | | | 3 | | | | 2 | | | 6 | |
| Permitted Phases | | | | | | 8 | 2 | | | | | 6 |
| Actuated Green, G (s) | | | | 15.4 | | 15.4 | 64.0 | 64.0 | | | 64.0 | 64.0 |
| Effective Green, g (s) | | | | 15.4 | | 15.4 | 64.0 | 64.0 | | | 64.0 | 64.0 |
| Actuated g/C Ratio | | | | 0.17 | | 0.17 | 0.72 | 0.72 | | | 0.72 | 0.72 |
| Clearance Time (s) | | | | 5.0 | | 5.0 | 5.0 | 5.0 | | | 5.0 | 5.0 |
| Vehicle Extension (s) | | | | 3.0 | | 3.0 | 3.0 | 3.0 | | | 3.0 | 3.0 |
| Lane Grp Cap (vph) | | | | 305 | | 139 | 1004 | 680 | | | 680 | 578 |
| v/s Ratio Prot | | | | c0.15 | | | | 0.01 | | | 0.01 | |
| v/s Ratio Perm | | | | | | 0.00 | c0.77 | | | | | 0.00 |
| v/c Ratio | | | | 0.86 | | 0.00 | 1.08 | 0.01 | | | 0.01 | 0.00 |
| Uniform Delay, d1 | | | | 35.9 | | 30.6 | 12.7 | 3.6 | | | 3.6 | 3.6 |
| Progression Factor | | | | 1.00 | | 1.00 | 1.00 | 1.00 | | | 1.00 | 1.00 |
| Incremental Delay, d2 | | | | 20.3 | | 0.0 | 53.5 | 0.0 | | | 0.0 | 0.0 |
| Delay (s) | | | | 56.2 | | 30.7 | 66.2 | 3.6 | | | 3.6 | 3.6 |
| Level of Service | | | | E | | C | E | A | | | A | A |
| Approach Delay (s) | | 0.0 | | | 55.9 | | | 65.8 | | | 3.6 | |
| Approach LOS | | A | | | E | | | E | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 63.5 | HCM Level of Service | E |
| HCM Volume to Capacity ratio | 1.04 | | |
| Actuated Cycle Length (s) | 89.4 | Sum of lost time (s) | 10.0 |
| Intersection Capacity Utilization | 83.3% | ICU Level of Service | E |
| Analysis Period (min) | 15 | | |

c Critical Lane Group

| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 3 | 0 | 1065 | 0 | 0 | 0 | 0 | 590 | 385 | 3 | 240 | 0 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | | 4.0 | | | | | 5.0 | 5.0 | 5.0 | 5.0 | |
| Lane Util. Factor | 1.00 | | 1.00 | | | | | 1.00 | 1.00 | 1.00 | 1.00 | |
| Frt | 1.00 | | 0.85 | | | | | 1.00 | 0.85 | 1.00 | 1.00 | |
| Flt Protected | 0.95 | | 1.00 | | | | | 1.00 | 1.00 | 0.95 | 1.00 | |
| Satd. Flow (prot) | 902 | | 1583 | | | | | 1863 | 1583 | 902 | 1863 | |
| Flt Permitted | 0.95 | | 1.00 | | | | | 1.00 | 1.00 | 0.40 | 1.00 | |
| Satd. Flow (perm) | 902 | | 1583 | | | | | 1863 | 1583 | 381 | 1863 | |
| Peak-hour factor, PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Adj. Flow (vph) | 3 | 0 | 1158 | 0 | 0 | 0 | 0 | 641 | 418 | 3 | 261 | 0 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 155 | 0 | 0 | 0 |
| Lane Group Flow (vph) | 3 | 0 | 1158 | 0 | 0 | 0 | 0 | 641 | 263 | 3 | 261 | 0 |
| Heavy Vehicles (%) | 100% | 0% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 100% | 2% | 2% |
| Turn Type | Prot | | Free | | | | | | Perm | Perm | | |
| Protected Phases | 7 | | | | | | | 2 | | | 6 | |
| Permitted Phases | | | Free | | | | | | 2 | 6 | | |
| Actuated Green, G (s) | 0.6 | | 28.5 | | | | | 17.9 | 17.9 | 17.9 | 17.9 | |
| Effective Green, g (s) | 0.6 | | 28.5 | | | | | 17.9 | 17.9 | 17.9 | 17.9 | |
| Actuated g/C Ratio | 0.02 | | 1.00 | | | | | 0.63 | 0.63 | 0.63 | 0.63 | |
| Clearance Time (s) | 5.0 | | | | | | | 5.0 | 5.0 | 5.0 | 5.0 | |
| Vehicle Extension (s) | 3.0 | | | | | | | 3.0 | 3.0 | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 19 | | 1583 | | | | | 1170 | 994 | 239 | 1170 | |
| v/s Ratio Prot | 0.00 | | | | | | | 0.34 | | | 0.14 | |
| v/s Ratio Perm | | | c0.73 | | | | | | 0.17 | 0.01 | | |
| v/c Ratio | 0.16 | | 0.73 | | | | | 0.55 | 0.26 | 0.01 | 0.22 | |
| Uniform Delay, d1 | 13.7 | | 0.0 | | | | | 3.0 | 2.4 | 2.0 | 2.3 | |
| Progression Factor | 1.00 | | 1.00 | | | | | 1.00 | 1.00 | 1.00 | 1.00 | |
| Incremental Delay, d2 | 3.9 | | 3.0 | | | | | 0.5 | 0.1 | 0.0 | 0.1 | |
| Delay (s) | 17.6 | | 3.0 | | | | | 3.5 | 2.5 | 2.0 | 2.4 | |
| Level of Service | B | | A | | | | | A | A | A | A | |
| Approach Delay (s) | | 3.1 | | | 0.0 | | | 3.1 | | | 2.4 | |
| Approach LOS | | A | | | A | | | A | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 3.0 | HCM Level of Service | A |
| HCM Volume to Capacity ratio | 0.73 | | |
| Actuated Cycle Length (s) | 28.5 | Sum of lost time (s) | 0.0 |
| Intersection Capacity Utilization | 61.7% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |

c Critical Lane Group

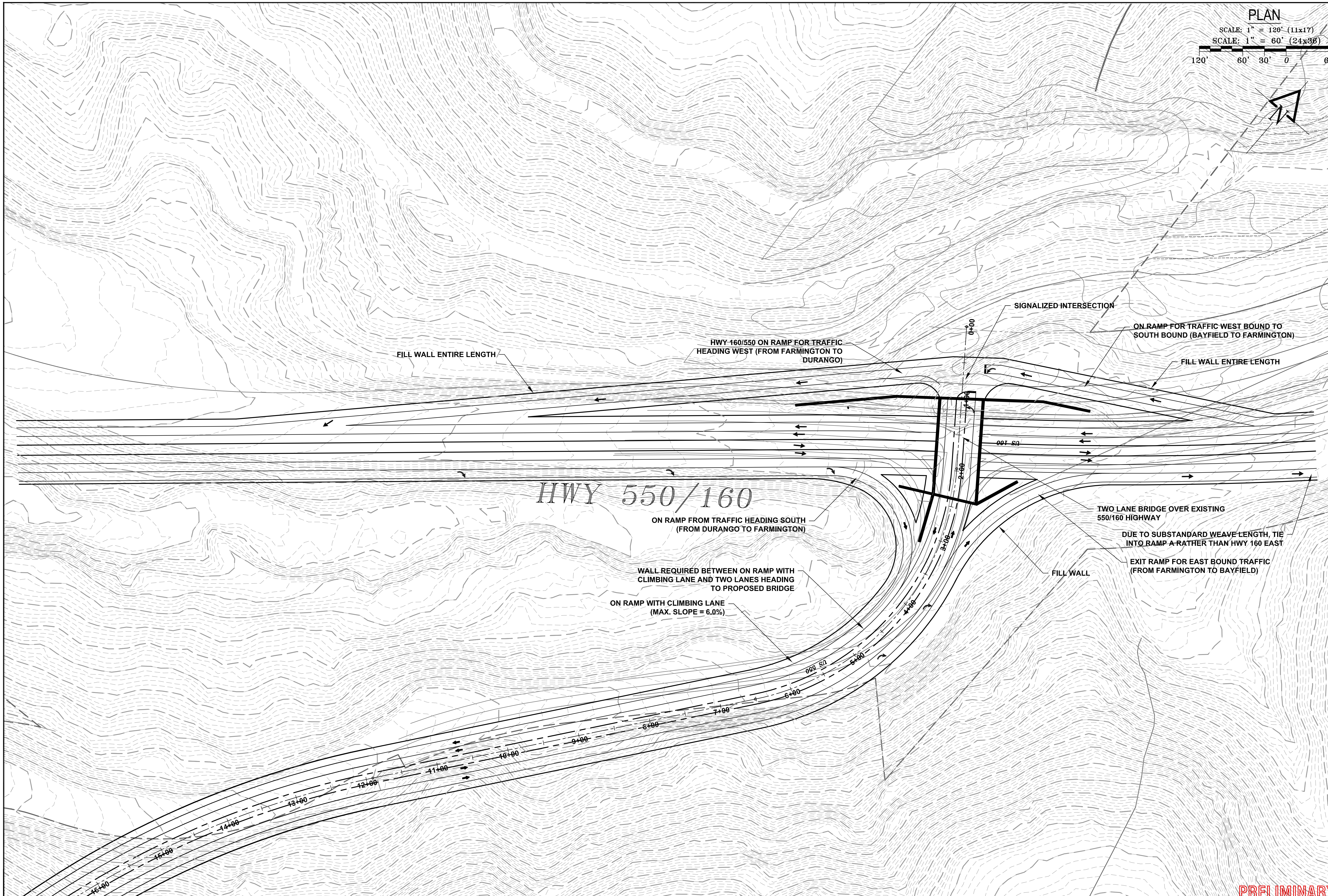
| Movement | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 0 | 0 | 0 | 240 | 0 | 3 | 590 | 6 | 0 | 0 | 6 | 3 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | | | | 5.0 | | 5.0 | 5.0 | 5.0 | | | 5.0 | 5.0 |
| Lane Util. Factor | | | | 1.00 | | 1.00 | 1.00 | 1.00 | | | 1.00 | 1.00 |
| Frt | | | | 1.00 | | 0.85 | 1.00 | 1.00 | | | 1.00 | 0.85 |
| Flt Protected | | | | 0.95 | | 1.00 | 0.95 | 1.00 | | | 1.00 | 1.00 |
| Satd. Flow (prot) | | | | 1770 | | 808 | 1770 | 950 | | | 950 | 808 |
| Flt Permitted | | | | 0.95 | | 1.00 | 0.75 | 1.00 | | | 1.00 | 1.00 |
| Satd. Flow (perm) | | | | 1770 | | 808 | 1403 | 950 | | | 950 | 808 |
| Peak-hour factor, PHF | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| Adj. Flow (vph) | 0 | 0 | 0 | 261 | 0 | 3 | 641 | 7 | 0 | 0 | 7 | 3 |
| RTOR Reduction (vph) | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| Lane Group Flow (vph) | 0 | 0 | 0 | 261 | 0 | 1 | 641 | 7 | 0 | 0 | 7 | 2 |
| Heavy Vehicles (%) | 2% | 2% | 2% | 2% | 2% | 100% | 2% | 100% | 2% | 2% | 100% | 100% |
| Turn Type | | | | Prot | | custom | Perm | | | | | Perm |
| Protected Phases | | | | 3 | | | | 2 | | | 6 | |
| Permitted Phases | | | | | | 8 | 2 | | | | | 6 |
| Actuated Green, G (s) | | | | 14.5 | | 14.5 | 33.7 | 33.7 | | | 33.7 | 33.7 |
| Effective Green, g (s) | | | | 14.5 | | 14.5 | 33.7 | 33.7 | | | 33.7 | 33.7 |
| Actuated g/C Ratio | | | | 0.25 | | 0.25 | 0.58 | 0.58 | | | 0.58 | 0.58 |
| Clearance Time (s) | | | | 5.0 | | 5.0 | 5.0 | 5.0 | | | 5.0 | 5.0 |
| Vehicle Extension (s) | | | | 3.0 | | 3.0 | 3.0 | 3.0 | | | 3.0 | 3.0 |
| Lane Grp Cap (vph) | | | | 441 | | 201 | 812 | 550 | | | 550 | 468 |
| v/s Ratio Prot | | | | c0.15 | | | | 0.01 | | | 0.01 | |
| v/s Ratio Perm | | | | | | 0.00 | c0.46 | | | | | 0.00 |
| v/c Ratio | | | | 0.59 | | 0.00 | 0.79 | 0.01 | | | 0.01 | 0.00 |
| Uniform Delay, d1 | | | | 19.2 | | 16.4 | 9.5 | 5.2 | | | 5.2 | 5.2 |
| Progression Factor | | | | 1.00 | | 1.00 | 1.00 | 1.00 | | | 1.00 | 1.00 |
| Incremental Delay, d2 | | | | 2.1 | | 0.0 | 5.1 | 0.0 | | | 0.0 | 0.0 |
| Delay (s) | | | | 21.4 | | 16.4 | 14.6 | 5.2 | | | 5.2 | 5.2 |
| Level of Service | | | | C | | B | B | A | | | A | A |
| Approach Delay (s) | | 0.0 | | | 21.3 | | | 14.5 | | | 5.2 | |
| Approach LOS | | A | | | C | | | B | | | A | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 16.4 | HCM Level of Service | B |
| HCM Volume to Capacity ratio | 0.73 | | |
| Actuated Cycle Length (s) | 58.2 | Sum of lost time (s) | 10.0 |
| Intersection Capacity Utilization | 61.7% | ICU Level of Service | B |
| Analysis Period (min) | 15 | | |

c Critical Lane Group

# Appendix C

## Alternative R Conceptual Layout

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**Russell Planning & Engineering, Inc.**
Civil Engineering Services
934 Main Avenue, Unit C
Durango, Colorado 81301
Phone: (970) 385-4546
Fax: (970) 385-4502

Drawn: KF
Drafted: KF
Checked: SW

Date of Submittal
11/28/2011

1 OF 1

5

File Name: R:\Current Projects\Land Projects 3\Webb\ACAD\Exhibits\2011121 Interchange Exhibit Plotted: 11/28/2011 11:53 AM Plot Style: HALF.STB Plotted By: TRAVIS MOONEY

# SEH MEMORANDUM

# US 160/US 550 at Farmington Hill—Existing Conditions

# May 17, 2012

**MEMORANDUM**

TO: Mike McVaugh, CDOT Region 5 Traffic and Safety Engineer

FROM: Phil Weisbach, PE, Project Manager Phil J. Weisbach
Jon Larson, PE, Traffic Engineer Jon E. Larson

DATE: May 17, 2012

RE: US 160 / US 550 at Farmington Hill - Existing Conditions
SEH No. 112456-COTO5

Based on your direction, we have analyzed the existing seasonal peak hour traffic volumes at the Farmington Hill intersection. The fundamental question this memo is intended to answer is:

1. What is the existing seasonal traffic operations performance at US 550 / US 160?

**Summary of Results:**

| Existing Seasonal Traffic Operations | Level of Service | |
|---|---|---|
| | AM Peak Hour | PM Peak Hour |
| US 550 / US 160 at Farmington Hill | B | C |

## Existing Seasonal Traffic Operations at Farmington Hill (Figure 1)

The US 550 / US 160 intersection at Farmington Hill is a 3-legged intersection as shown in Figure 1. The intersection has the following configuration:

- **Eastbound Approach (US 160).** Two through lanes and one free right turn lane.
- **Westbound Approach (US 160).** Two through lanes and one exclusive left turn lane.
- **Northbound Approach (US 550).** One exclusive left turn lane and one exclusive right turn lane.

Morning and evening peak hour turning movement counts were collected on Thursday, August 26, 2010. The data collection period represents an average weekday during the seasonal peak period in the Durango area. The seasonal peak period operations were analyzed because it represents the worst case scenario. Figure 1 shows the existing seasonal peak hour traffic volumes, lane configuration and LOS for the US 550 / US 160 intersection. Noon and Saturday peak period volumes were reviewed, however, they are significantly lower than the morning and evening peak periods and were not analyzed.

To evaluate the performance of the intersections within the study area, the Level of Service (LOS) was calculated using Synchro software. This software package utilizes criteria described in the Highway Capacity Manual[1]. LOS is a measure used to describe operational conditions at an intersection. LOS categories ranging from A to F are assigned based on the predicted delay

[1] Highway Capacity Manual - Special Report 209. Transportation Research Board. National Research Council. 2000.

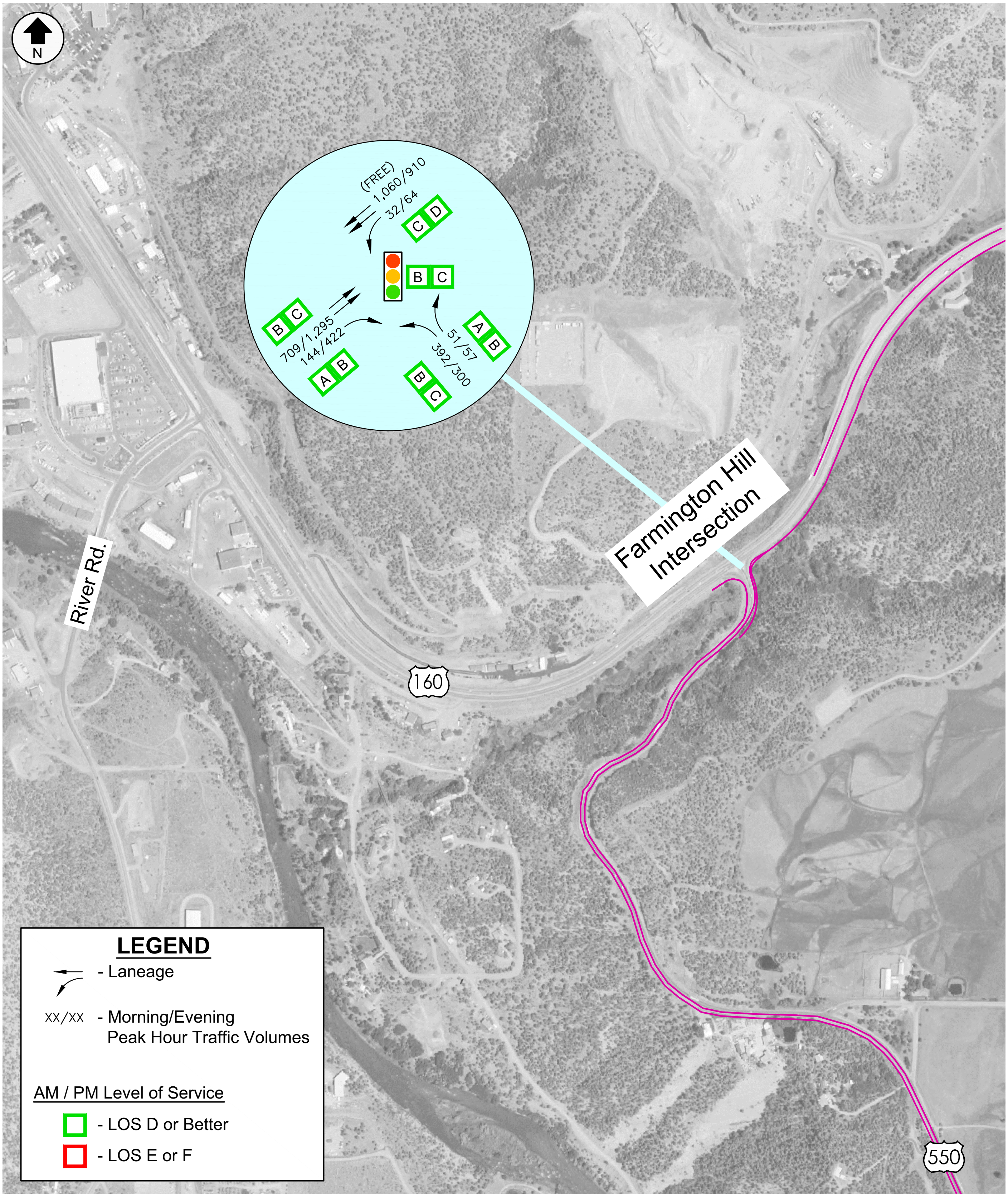
in seconds per vehicle for the intersection as a whole and for individual turning movements. LOS A indicates very good operations, and LOS F indicates poor, congested operations. The operations will be evaluated based on a desired overall operation, LOS D. The LOS analysis assumes the following inputs based on existing data: 5% heavy vehicles, a 110 second cycle length, a free westbound through movement, protected left turn phases and a protected + overlap northbound right turn phase.

The analysis indicates that the US 550 / US 160 intersection at Farmington Hill currently operates at LOS B during the morning and evening peak periods. Individual movements at the intersections are shown to operate at LOS D or better during the morning and evening peak periods as well. The intersection currently exhibits acceptable traffic operations.

Please feel free to contact Jon at 303.441.5417 or Phil at 303.441.5411 with any questions or comments.

jel

p:\ae\c\codot\105181\to #3 - us 160 interchange analysis\project___supplemental eis\may 2011 memos\year 2030 projected traffic volumes_us 550 and us 160\5-11-2011\updated 5-17-12\memo_existing conditions_5-17-2012.docx




US 550 Connection to US 160 in Grandview - Traffic Analysis
Existing Seasonal Traffic Operations (August 2010)

| Scale | 1"=800' | Date | 5/17/12 | Drawn by | JEL | Job # | 105181 | Figure | 1 |
|---|---|---|---|---|---|---|---|---|---|

# Appendix

Peak Hour Traffic Data
Level of Service Worksheets

File Name: E:\NATHAN TMCS\DURANGO TMCS 8-10\15MIN\#17 US550&FRONTAGEAM.ppd
Start Date: 8/26/2010
Start Time: 7:00:00 AM
Site Code: 00000000
Comment 1: Default Comments
Comment 2: Change These in The Preferences Window
Comment 3: Select File/Preference in the Main Scree
Comment 4: Then Click the Comments Tab

| | US 550 Southbound | | | | US 160 Westbound | | | | US 550 Northbound | | | | US 160 Eastbound | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start Time | Left | Thru | Right | Peds | Left | Thru | Right | Peds | Left | Thru | Right | Peds | Left | Thru | Right | Peds |
| 07:00 AM | 0 | 0 | 0 | 0 | 4 | 242 | 0 | 0 | 83 | 0 | 8 | 0 | 0 | 145 | 31 | 0 |
| 07:15 AM | 0 | 0 | 0 | 0 | 3 | 314 | 0 | 0 | 121 | 0 | 11 | 0 | 0 | 142 | 34 | 0 |
| 07:30 AM | 0 | 0 | 0 | 0 | 9 | 371 | 0 | 0 | 141 | 0 | 11 | 0 | 0 | 186 | 39 | 0 |
| 07:45 AM | 0 | 0 | 0 | 0 | 7 | 274 | 0 | 0 | 92 | 0 | 12 | 0 | 0 | 191 | 29 | 0 |
| 08:00 AM | 0 | 0 | 0 | 0 | 8 | 213 | 0 | 0 | 92 | 0 | 15 | 0 | 0 | 163 | 29 | 0 |
| 08:15 AM | 0 | 0 | 0 | 0 | 8 | 202 | 0 | 0 | 67 | 0 | 13 | 0 | 0 | 169 | 47 | 0 |
| 08:30 AM | 0 | 0 | 0 | 0 | 4 | 194 | 0 | 0 | 66 | 0 | 12 | 0 | 0 | 184 | 36 | 0 |
| 08:45 AM | 0 | 0 | 0 | 0 | 4 | 201 | 0 | 0 | 59 | 0 | 12 | 0 | 0 | 150 | 38 | 0 |
| | | | | | | | | | | | | | | | | |
| 07:00 AM | | | | | | | | | | | | | | | | |
| 07:15 AM | | | | | | | | | | | | | | | | |
| 07:30 AM | | | | | | | | | | | | | | | | |
| 07:45 AM | 0 | 0 | 0 | 0 | 23 | 1201 | 0 | 0 | 437 | 0 | 42 | 0 | 0 | 664 | 133 | 0 |
| 08:00 AM | 0 | 0 | 0 | 0 | 27 | 1172 | 0 | 0 | 446 | 0 | 49 | 0 | 0 | 682 | 131 | 0 |
| 08:15 AM | 0 | 0 | 0 | 0 | 32 | 1060 | 0 | 0 | 392 | 0 | 51 | 0 | 0 | 709 | 144 | 0 |
| 08:30 AM | 0 | 0 | 0 | 0 | 27 | 883 | 0 | 0 | 317 | 0 | 52 | 0 | 0 | 707 | 141 | 0 |
| 08:45 AM | 0 | 0 | 0 | 0 | 24 | 810 | 0 | 0 | 284 | 0 | 52 | 0 | 0 | 666 | 150 | 0 |
| | | | | | | | | | | | | | | | | |
| 07:00 AM | | | | | | | | | | | | | | | | |
| 07:15 AM | | | | | | | | | | | | | | | | |
| 07:30 AM | | | | | | | | | | | | | | | | |
| 07:45 AM | 2500 | | | | | | | | | | | | | | | |
| 08:00 AM | 2507 | | | | | | | | | | | | | | | |
| 08:15 AM | 2388 | | | | | | | | | | | | | | | |
| 08:30 AM | 2127 | | | | | | | | | | | | | | | |
| 08:45 AM | 1986 | | | | | | | | | | | | | | | |

File Name: E:\NATHAN TMCS\DURANGO TMCS 8-10\15MIN\#17 US550&FRONTAGEPM.ppd
Start Date: 8/26/2010
Start Time: 4:00:00 PM
Site Code: 00000000
Comment 1: Default Comments
Comment 2: Change These in The Preferences Window
Comment 3: Select File/Preference in the Main Scree
Comment 4: Then Click the Comments Tab

| | US 550 Southbound | | | | US 160 Westbound | | | | US 550 Northbound | | | | US 160 Eastbound | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start Time | Left | Thru | Right | Peds | Left | Thru | Right | Peds | Left | Thru | Right | Peds | Left | Thru | Right | Peds |
| 04:00 PM | 0 | 0 | 0 | 0 | 12 | 236 | 0 | 0 | 72 | 0 | 10 | 0 | 0 | 294 | 101 | 0 |
| 04:15 PM | 0 | 0 | 0 | 0 | 18 | 226 | 0 | 0 | 75 | 0 | 12 | 0 | 0 | 326 | 98 | 0 |
| 04:30 PM | 0 | 0 | 0 | 0 | 11 | 209 | 0 | 0 | 72 | 0 | 14 | 0 | 0 | 322 | 106 | 0 |
| 04:45 PM | 0 | 0 | 0 | 0 | 16 | 233 | 0 | 0 | 70 | 0 | 18 | 0 | 0 | 316 | 117 | 0 |
| 05:00 PM | 0 | 0 | 0 | 0 | 19 | 242 | 0 | 0 | 83 | 0 | 13 | 0 | 0 | 331 | 101 | 0 |
| 05:15 PM | 0 | 0 | 0 | 0 | 15 | 216 | 0 | 0 | 73 | 0 | 10 | 0 | 0 | 317 | 101 | 0 |
| 05:30 PM | 0 | 0 | 0 | 0 | 14 | 211 | 0 | 0 | 75 | 0 | 5 | 0 | 0 | 319 | 100 | 0 |
| 05:45 PM | 0 | 0 | 0 | 0 | 11 | 187 | 0 | 0 | 48 | 0 | 3 | 0 | 0 | 271 | 99 | 0 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04:00 PM | | | | | | | | | | | | | | | | |
| 04:15 PM | | | | | | | | | | | | | | | | |
| 04:30 PM | | | | | | | | | | | | | | | | |
| 04:45 PM | 0 | 0 | 0 | 0 | 57 | 904 | 0 | 0 | 289 | 0 | 54 | 0 | 0 | 1258 | 422 | 0 |
| 05:00 PM | 0 | 0 | 0 | 0 | 64 | 910 | 0 | 0 | 300 | 0 | 57 | 0 | 0 | 1295 | 422 | 0 |
| 05:15 PM | 0 | 0 | 0 | 0 | 61 | 900 | 0 | 0 | 298 | 0 | 55 | 0 | 0 | 1286 | 425 | 0 |
| 05:30 PM | 0 | 0 | 0 | 0 | 64 | 902 | 0 | 0 | 301 | 0 | 46 | 0 | 0 | 1283 | 419 | 0 |
| 05:45 PM | 0 | 0 | 0 | 0 | 59 | 856 | 0 | 0 | 279 | 0 | 31 | 0 | 0 | 1238 | 401 | 0 |

| | |
|---|---|
| 04:00 PM | |
| 04:15 PM | |
| 04:30 PM | |
| 04:45 PM | 2984 |
| 05:00 PM | 3048 |
| 05:15 PM | 3025 |
| 05:30 PM | 3015 |
| 05:45 PM | 2864 |

| Movement | EBT | EBR | WBL | WBT | NBL | NBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (vph) | 709 | 144 | 32 | 0 | 392 | 51 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | 5.0 | 5.0 | | 5.0 | 5.0 |
| Lane Util. Factor | 0.95 | 1.00 | 1.00 | | 1.00 | 1.00 |
| Frt | 1.00 | 0.85 | 1.00 | | 1.00 | 0.85 |
| Flt Protected | 1.00 | 1.00 | 0.95 | | 0.95 | 1.00 |
| Satd. Flow (prot) | 3438 | 1538 | 1719 | | 1719 | 1538 |
| Flt Permitted | 1.00 | 1.00 | 0.95 | | 0.95 | 1.00 |
| Satd. Flow (perm) | 3438 | 1538 | 1719 | | 1719 | 1538 |
| Peak-hour factor, PHF | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Adj. Flow (vph) | 709 | 144 | 32 | 0 | 392 | 51 |
| RTOR Reduction (vph) | 0 | 99 | 0 | 0 | 0 | 18 |
| Lane Group Flow (vph) | 709 | 45 | 32 | 0 | 392 | 33 |
| Turn Type | | Perm | Prot | | | pt+ov |
| Protected Phases | 2 | | 1 | | 8 | 8 1 |
| Permitted Phases | | 2 | | | | |
| Actuated Green, G (s) | 19.2 | 19.2 | 5.8 | | 21.2 | 32.0 |
| Effective Green, g (s) | 19.2 | 19.2 | 5.8 | | 21.2 | 32.0 |
| Actuated g/C Ratio | 0.31 | 0.31 | 0.09 | | 0.35 | 0.52 |
| Clearance Time (s) | 5.0 | 5.0 | 5.0 | | 5.0 | |
| Vehicle Extension (s) | 3.0 | 3.0 | 3.0 | | 3.0 | |
| Lane Grp Cap (vph) | 1079 | 483 | 163 | | 595 | 804 |
| v/s Ratio Prot | c0.21 | | c0.02 | | c0.23 | 0.02 |
| v/s Ratio Perm | | 0.03 | | | | |
| v/c Ratio | 0.66 | 0.09 | 0.20 | | 0.66 | 0.04 |
| Uniform Delay, d1 | 18.2 | 14.8 | 25.6 | | 16.9 | 7.1 |
| Progression Factor | 1.00 | 1.00 | 1.00 | | 1.00 | 1.00 |
| Incremental Delay, d2 | 1.5 | 0.1 | 0.6 | | 2.7 | 0.0 |
| Delay (s) | 19.6 | 14.9 | 26.1 | | 19.6 | 7.1 |
| Level of Service | B | B | C | | B | A |
| Approach Delay (s) | 18.8 | | | 26.1 | 18.2 | |
| Approach LOS | B | | | C | B | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 18.8 | HCM Level of Service | B |
| HCM Volume to Capacity ratio | 0.60 | | |
| Actuated Cycle Length (s) | 61.2 | Sum of lost time (s) | 15.0 |
| Intersection Capacity Utilization | 55.8% | ICU Level of Service | B |
| Analysis Period (min) | 60 | | |
| c Critical Lane Group | | | |

| Movement | EBT | EBR | WBL | WBT | NBL | NBR |
|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | |
| Volume (vph) | 1295 | 422 | 64 | 0 | 300 | 57 |
| Ideal Flow (vphpl) | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Total Lost time (s) | 5.0 | 5.0 | 5.0 | | 5.0 | 5.0 |
| Lane Util. Factor | 0.95 | 1.00 | 1.00 | | 1.00 | 1.00 |
| Frt | 1.00 | 0.85 | 1.00 | | 1.00 | 0.85 |
| Flt Protected | 1.00 | 1.00 | 0.95 | | 0.95 | 1.00 |
| Satd. Flow (prot) | 3438 | 1538 | 1719 | | 1719 | 1538 |
| Flt Permitted | 1.00 | 1.00 | 0.95 | | 0.95 | 1.00 |
| Satd. Flow (perm) | 3438 | 1538 | 1719 | | 1719 | 1538 |
| Peak-hour factor, PHF | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Adj. Flow (vph) | 1295 | 422 | 64 | 0 | 300 | 57 |
| RTOR Reduction (vph) | 0 | 220 | 0 | 0 | 0 | 15 |
| Lane Group Flow (vph) | 1295 | 202 | 64 | 0 | 300 | 42 |
| Turn Type | | Perm | Prot | | | pt+ov |
| Protected Phases | 2 | | 1 | | 8 | 8 1 |
| Permitted Phases | | 2 | | | | |
| Actuated Green, G (s) | 40.0 | 40.0 | 7.8 | | 20.7 | 33.5 |
| Effective Green, g (s) | 40.0 | 40.0 | 7.8 | | 20.7 | 33.5 |
| Actuated g/C Ratio | 0.48 | 0.48 | 0.09 | | 0.25 | 0.40 |
| Clearance Time (s) | 5.0 | 5.0 | 5.0 | | 5.0 | |
| Vehicle Extension (s) | 3.0 | 3.0 | 3.0 | | 3.0 | |
| Lane Grp Cap (vph) | 1647 | 737 | 161 | | 426 | 617 |
| v/s Ratio Prot | c0.38 | | c0.04 | | c0.17 | 0.03 |
| v/s Ratio Perm | | 0.13 | | | | |
| v/c Ratio | 0.79 | 0.27 | 0.40 | | 0.70 | 0.07 |
| Uniform Delay, d1 | 18.2 | 13.0 | 35.6 | | 28.6 | 15.4 |
| Progression Factor | 1.00 | 1.00 | 1.00 | | 1.00 | 1.00 |
| Incremental Delay, d2 | 2.6 | 0.2 | 1.6 | | 5.4 | 0.0 |
| Delay (s) | 20.8 | 13.2 | 37.3 | | 34.0 | 15.4 |
| Level of Service | C | B | D | | C | B |
| Approach Delay (s) | 18.9 | | | 37.3 | 31.0 | |
| Approach LOS | B | | | D | C | |

| Intersection Summary | | | |
|---|---|---|---|
| HCM Average Control Delay | 21.5 | HCM Level of Service | C |
| HCM Volume to Capacity ratio | 0.72 | | |
| Actuated Cycle Length (s) | 83.5 | Sum of lost time (s) | 15.0 |
| Intersection Capacity Utilization | 67.6% | ICU Level of Service | C |
| Analysis Period (min) | 60 | | |
| c Critical Lane Group | | | |