Highway Safety Analysis for Potential Safety Improvements

Updated US 97 Safety Assessment

Deschutes County, Oregon

Final Report

August 2018

Highway Safety Analysis for Potential Safety Improvements

Updated US 97 Safety Assessment

Deschutes County, Oregon

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Executive Summary

EXECUTIVE SUMMARY

Kittelson & Associates, Inc. (Kittelson) analyzed crash history and evaluated potential crash countermeasures on a 9-mile section of US 97 from the south Redmond city limits (milepost 124.40) to the north Bend city limits (milepost 133.39). This report, completed in 2018, is an update to the *2015 US 97 Safety Assessment.* This analysis includes the most recent, complete five-year ODOT reported crash data (2011-2015).

This study identified near- and medium-term countermeasures that would cost less than a series of frontage roads that have been identified by Oregon Department of Transportation (ODOT) as long-term alternatives. Kittelson applied quantitative safety evaluation methods to evaluate a range of countermeasures to improve safety along the corridor. The findings and recommendations of the study are summarized below.

FINDINGS

Roadway Characteristics

US 97 is a four-lane rural highway with a posted speed limit of 65 miles per hour (mph). The posted speed limit increased from 55 mph to 65 mph in March 2016. The crash data used in this report reflects a posted speed limit of 55 mph. The two travel lanes in each direction are separated by a 10-foot paved median. The study area is shown in **Figure 1**. The typical cross-section consists of two travel lanes in each direction (12 feet in width), shoulders of 8 to 10 feet in width, and a paved center median of 10 feet in width. The roadway is straight with only a few large horizontal curves in the study area. Driveway density is highest within 0.50-mile of the City of Bend and City of Redmond limits, in the transition sections from rural to urban areas. One grade-separated crossing is provided at Deschutes Junction; all other public and private accesses are at-grade.

Historical Crash Analysis

Over the five-year study period (2011-2015), 130 crashes were reported on the US 97 study corridor from milepost (MP) 124.40 to 133.39. A summary of the most-relevant crash trends is provided below.

- Crash types varied throughout the corridor. The three most common crash types were rear-end (32 crashes), run off the road (25 crashes), and sideswipe-meeting (18 crashes).
- 11 reported crashes were fatal or severe injury (injury A) crashes. 48 crashes resulted in a moderate or minor injury (injury B or C), and 71 crashes resulted in property damage only.
- Of the 11 fatal or injury A crashes,
    - Forty-five percent (5 of 11) were head-on crashes, sideswipe meeting crashes, or turning movement crashes – crash types that could be corrected by a median.
    - Forty-five percent (5 of 11) occurred during dark, dawn, or dusk light conditions.

- The most commonly-reported crash cause was "speed too fast for conditions."
- Approximately 53 percent of all reported crashes (69 of 130) involved snow, ice, or wet roadways.

Field Observations

Field observations were conducted in December 2014 during daylight and dark light conditions. A team consisting of ODOT, Deschutes County, Oregon State Police, and consultants participated in the field visit. Observations from this field visit are summarized below.

- Traffic volumes were higher during the peak hours, making it difficult to find gaps in both directions of traffic to complete a left-turn from the minor street approach to US 97.
- Vehicles were observed using the 10-foot striped median to complete two-stage left turns from minor-street approaches onto US 97.
- During night-time conditions, it was difficult to see approaching intersections.
- The team discussed that right-turn deceleration lanes and right-turn acceleration lanes would be beneficial at key intersections due to the high traffic volumes and speeds.
- One bicyclist was observed riding along US 97.
- Rock outcroppings were located along the corridor, approximately 30 feet from the edge of the roadway shoulder.
- Driveways are located throughout the corridor, with higher density within 0.50-mile of the City of Bend and City of Redmond limits.

CONCLUSIONS

Kittelson prioritized projects aimed at reducing fatal and Injury A crashes as Short-term, Medium-term, or Median-related projects. Median-related projects were phased separately from other countermeasures due to the impacts to public and private accesses along the corridor; i.e., resulting in access points becoming right-in/right-out only. If a median is carried forward for implementation, ODOT will develop an outreach plan and document key access management principles, as defined in OAR 734-051-7010 and 734-051-1065.

The Median-related projects include U-turn treatments to maintain access to driveways along the corridor that would otherwise be restricted by a median. This report discusses a J-turn concept to provide u-turning maneuvers. More information on design of unsignalized J-turn intersections on state highways is provided in National Cooperative Highway Research Program (NCHRP) Report 745: *Left-Turn Accommodations at Unsignalized Intersections*. Additional information on the safety and operational effect of U-turns at unsignalized median openings is provided in NCHRP Report 524: Safety of U-Turns at Unsignalized Median Openings. NCHRP 524 analyzed crashes at unsignalized median openings and found the crashes involving U-turn and left-turn movements at unsignalized median openings were infrequent. The report states that "results indicate that access management strategies that increase U-turn volumes at unsignalized median openings can be used safely and efficiently."

Each group of projects and their estimated benefit-cost (B/C) ratios are summarized in **Table 1**, **Table 2**, and **Table 3**, respectively. While the magnitude of these B/C ratios may change upon refining the cost estimates, the priority for implementation is not expected to change. In addition to the projects summarized in the tables, Kittelson also suggests consideration of Variable Speed Limit (VSL) to reduce speeds during inclement weather and poor road conditions.

Table 1 Short-Term Projects

Location	Annual Observed Crash Frequency	Annual Predicted Crash Frequency	Annual Expected Crash Frequency	Short-Term Project Countermeasures	Project CMF^	20-Year Crash Reduction	Preliminary 20-Yr Cost Estimate**	Expected Annual Comprehensive Crash Cost Reduction (Benefit)	Benefit / Cost Ratio*
Redmond City Limits to Quarry Ln	4.2	7.2	5.9	▪ Inlaid Raised Pavement Markers	92%	9.4	$ 14,000	$ 94,100	83.7
Quarry Ln	0.4	0.6	0.5	▪ Increase sight distance^^	86%	1.4	$1,000	$14,000	173.9
				▪ Median on minor street approach	75%	2.5	$7,000	$24,900	44.4
				▪ Intersection lighting^^	83%	1.7	$63,000	$17,000	3.4
Quarry Ln to 61st Street	5.4	10.2	8.0	▪ Inlaid Raised Pavement Markers	92%	12.8	$ 18,000	$ 128,000	88.6
61st Street	1.6	0.9	1.1	▪ Intersection lighting^^	83%	3.7	$63,000	$37,000	7.4
				▪ Median on minor street approach	75%	5.5	$7,000	$55,000	97.6
61st Street to Deschutes Jct.	2.4	6.7	4.8	▪ Inlaid Raised Pavement Markers	92%	7.6	$ 12,000	$ 75,800	78.7
Deschutes Jct.	1.0	0.6	0.8	▪ Restripe merge	98%	0.3	$ 10,000	$3,000	3.7
Deschutes Jct. to Ft Thompson Ln	7.4	7.2	7.3	▪ Inlaid Raised Pavement Markers;	92%	11.7	$ 17,000	$ 116,500	85.4
Ft Thompson Ln	1.0	0.8	0.9	▪ None	N/A	N/A	$ -	$ -	--
Ft Thompson Ln to Bend City Limits	2.6	3.2	2.9	▪ Inlaid Raised Pavement Markers	92%	4.7	$ 7,000	$47,000	83.5
Total	***26.0***	***37.4***	***32.2***			**61.3**	**$ 219,000**	**$ 612,000**	**34.8**

**B/C Ratios reflect a uniform series present worth factor of 12.46 for a 20-year life span. B/C Ratio = (Annual Benefits X Present Worth Factor)/(Estimated Project Cost)*
Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
***Cost estimates exclude any right-of-way impacts or costs.*
^Project CMF accounts for the proportion of crashes that the CMF applies to within the corridor.
^^Indicates project is complete or in-progress as of August 2018. (Signage upgrades are also in progress at the intersections of US 97/61st Street and US 97/Quarry Avenue.)

Table 2 Medium-Term Projects

Location	Annual Observed Crash Frequency	Annual Predicted Crash Frequency	Annual Expected Crash Frequency	Medium-Term Project Countermeasures	Project CMF^	20-Year Crash Reduction	Preliminary 20-Yr Cost Estimate**	Expected Annual Comprehensive Crash Cost Reduction (Benefit)	Benefit / Cost Ratio
Redmond City Limits to Quarry Ln	4.2	7.2	5.9	▪ Segment Lighting	92%	9.4	$1,080,000	$94,100	1.1
				▪ Increase clear zone (Reduce Roadside Hazard Rating (RHR))	94%	7.1	$ 329,000	$ 70,500	2.7
Quarry Ln	0.4	0.6	0.5	▪ Deceleration Lane	93%	0.8	$ 170,000	$ 7,500	0.6
Quarry Ln to 61st Street	5.4	10.2	8.0	▪ Segment Lighting	92%	12.8	$1,466,000	$128,000	1.1
				▪ Increase clear zone (Reduce RHR)	94%	9.6	$576,000	$96,000	2.1
61st Street	1.6	0.9	1.1	▪ Acceleration Lane	89%	2.4	$463,000	$24,000	0.6
				▪ Deceleration Lane	93%	1.5	$160,000	$15,000	1.2
61st Street to Deschutes Jct.	2.4	6.7	4.8	▪ None	N/A	N/A	N/A	$ -	N/A
Deschutes Jct.	1.0	0.6	0.8	▪ None	N/A	N/A	N/A	$ -	N/A
Deschutes Jct. to Ft Thompson Ln	7.4	7.2	7.3	▪ Increase clear zone (Reduce RHR)	94%	8.8	$ 1,164,000	$ 87,300	0.9
Ft Thompson Ln	1.0	0.8	0.9	• Private street intersection (no recommendations)	N/A	N/A	N/A	N/A	N/A
Ft Thompson Ln to Bend City Limits	2.6	3.2	2.9	▪ Segment Lighting	92%	4.6	$579,000	$46,000	1.0
				▪ Increase clear zone (Reduce RHR)	94%	3.5	$482,000	$35,000	0.9
Total	*26.0*	*37.4*	*32.2*			60.5	$6,469,000	$ 603,400	1.2

**B/C Ratios reflect a uniform series present worth factor of 12.46 for a 20-year life span. B/C Ratio = (Annual Benefits X Present Worth Factor)/(Estimated Project Cost)*
Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
***Cost estimates exclude any right-of-way impacts or costs.*
^Project CMF accounts for the proportion of crashes that the CMF applies to within the corridor.

Table 3 Median-Related Alternatives and Phasing

Phase	Start and End MP	Number of U-Turns Included	Project Cost ($)**	Project Benefit ($)	B/C Ratio
Phase 1	130.181 – 132.04 (MP 132.04 to Deschutes Junction)	One	$2.0 million	$2.1 million	1.1
Phase 2	128.578 – 130.181 (Deschutes Junction to 61st Street)	One	$1.9 million	$2.5 million	1.4
Phase 3	124.40 – 128.578 (61st Street to Redmond City Limits)	Two	$4.3 million	$5.0 million	1.1
Phase 4	132.04 – 133.39 (Phase 1 Median to Bend City Limits)	Two	$2.8 million	$1.9 million	0.7

Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
***Cost estimates assume a concrete barrier median type and J-turn treatment for a conservative analysis. Cost estimates exclude any right-of-way impacts or costs.*

Details of each countermeasure by location and project category are provided in the Project Prioritization section of this report. When implementing the proposed countermeasures, Kittelson suggests:

- Consider implementation of Short-term projects first. They are the most cost-effective and generally do not require additional right-of-way or impact to adjacent properties.
- Consider implementing the Median-related projects in phases. Phases 1 and 2 could be implemented with two U-turn treatments, when funding becomes available. Phases 1 and 2 address high-crash locations while also minimizing the number of access points impacted by the median. Precede implementation of median and U-turn treatments with a public education campaign, and provide signage to educate drivers how to safely use the U-turn treatment.
- Medium-term projects are cost-effective, but require greater investment than short-term projects. They have potential to impact right-of-way, which would delay implementation.
- Pending successful implementation of Median-related Phases 1 and 2, Phases 3 and 4 could be implemented, when funding becomes available.

Section 2
Introduction

INTRODUCTION

The Oregon Department of Transportation (ODOT) has requested Kittelson & Associates, Inc. (Kittelson) to conduct a safety assessment of a 9-mile section of US 97, from the south Redmond city limits (milepost 124.40) to the north Bend city limits (milepost 133.39).

PROJECT DESCRIPTION

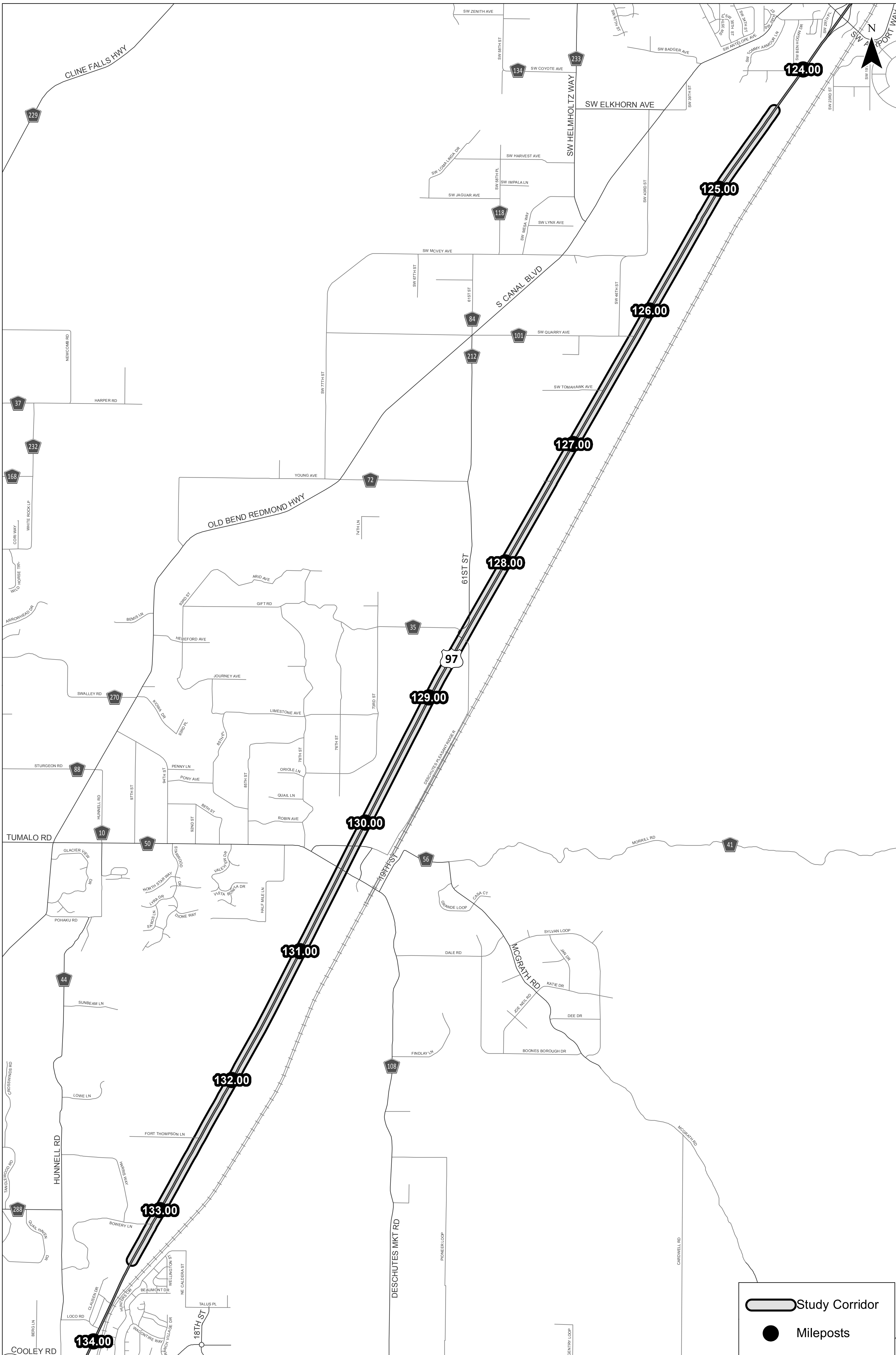
The goals of the US 97 Safety Assessment are to:

- Improve public safety through an evaluation of crash trends and contributing factors,
- Identify effective safety countermeasures, and
- Prioritize projects through a benefit-cost analysis.

This assessment focused on identifying low- and medium-cost countermeasures that could be implemented in the near-term (within approximately 5 years) and medium-term (within approximately 5-15 years). This analysis considers five years of the corridor's historical crash data and applies Highway Safety Manual (HSM) crash prediction methods on the roadway segments and at the major intersections. These methods remove statistical bias often inherent in crash analysis, due to the random nature of crashes. Kittelson identified a range of crash countermeasures (low-to-medium cost) and used their documented effectiveness to compare the benefits (expected reduction in crash severity and frequency) to the estimated construction cost (dollars) in a benefit-cost analysis. Based on this analysis, Kittelson made suggestions for a series of potential corridor safety improvements.

STUDY AREA

The study corridor is a rural four-lane principal arterial running from the south Redmond city limits (MP 124.40) to the north Bend city limits (MP 133.39). The limits of the study are depicted in **Figure 1**.



Study Corridor
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure 1

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Section 3
Existing Conditions

EXISTING CONDITIONS

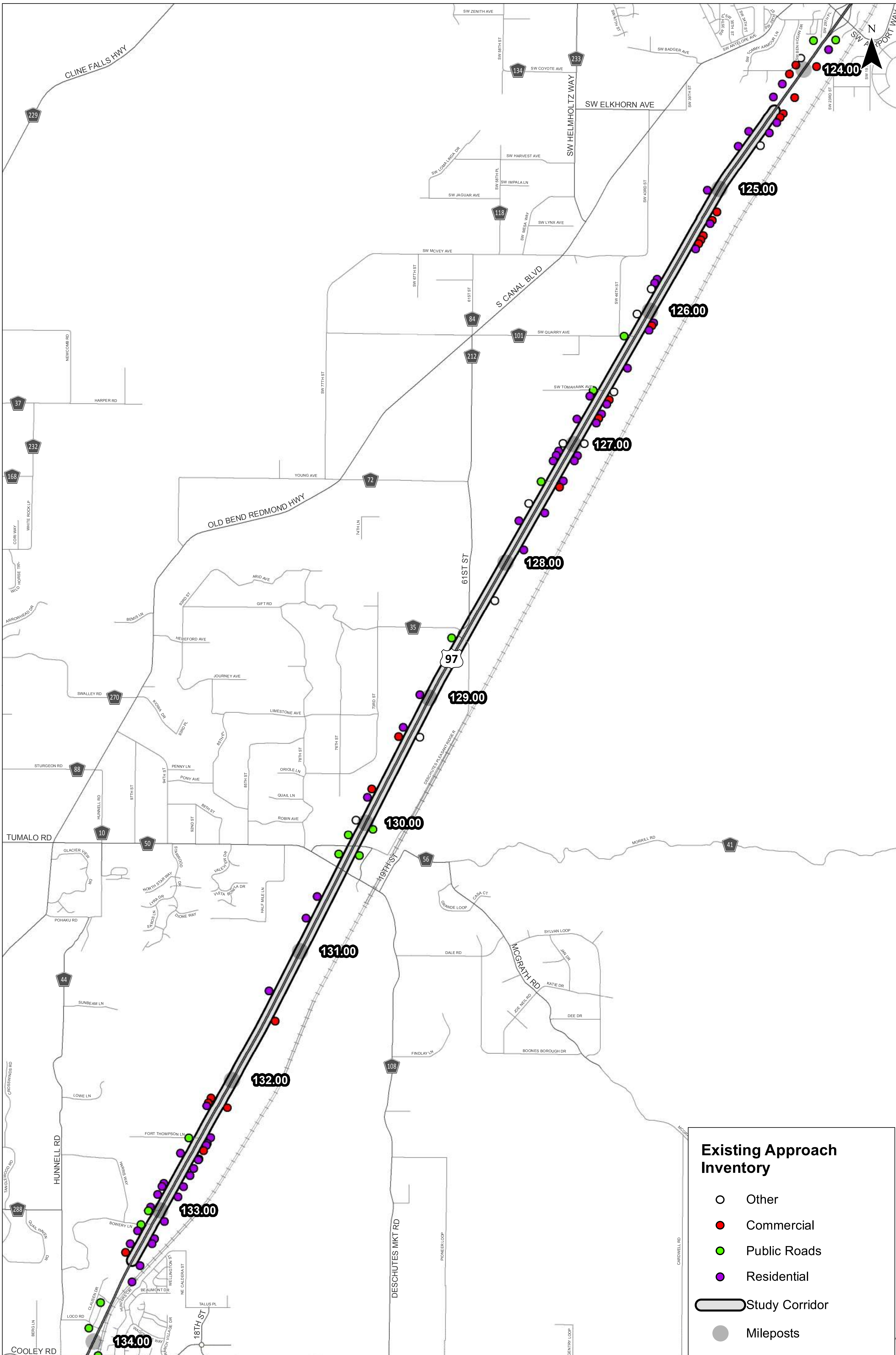
The existing conditions analysis identifies factors influencing crash potential, including: traffic characteristics, historical crash analysis, and field observations.

ROADWAY CHARACTERISTICS

US 97 is a rural four-lane principal arterial running north-south within the study area. US 97 serves as a major statewide and regional connection. The highway runs from California to Washington through Central Oregon, with trucks accounting for approximately nine percent of the annual average daily traffic. The study corridor serves as the primary connection between Bend and Redmond, carrying commuter traffic between the cities daily. There are limited alternatives to the north-south corridor.

US 97 provides access to residential, commercial, and industrial properties (including several owned by Central Oregon Irrigation District (COID). **Figure 2** shows the locations of the approaches on US 97, based on ODOT's records. Additional properties may have the rights to access even if no access currently exists. The highest functionally-classified roads that intersect US 97 are Deschutes Market Road, 61st Street (Gift Road), and Quarry Avenue. All public and private accesses are at-grade, except the rural grade-separated interchange at Deschutes Market Road. Deschutes Market Road is a Rural Arterial east of the highway and a Rural Collector west of the highway. Deschutes County is currently considering intersection improvements at the intersection of Tumalo Road/Tumalo Place (the southbound ramp terminal with US 97). 61st Street is a Rural Collector, and Quarry Avenue is a Local Street.

As shown in **Figure 3**, the typical cross-section of US 97 in the study area includes two 12-foot travel lanes in each direction, separated by a 10-foot wide striped median. Shoulder widths average approximately 8-feet throughout the corridor. Centerline and shoulder rumble strips are provided throughout the study corridor. The pavement widens slightly at the intersection with 61st Street to accommodate a northbound left-turn lane.



Study Corridor & Approaches
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
2

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Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

Figure 3 US 97 Typical Section

TRAFFIC CHARACTERISTICS

Traffic data was inventoried from the Oregon Transportation Management System (OTMS), ODOT's TransGIS website, and the Deschutes County Transportation System Plan. New data was not obtained for the purposes of this study. The most-recent traffic count data is summarized in **Table 4**.[1]

Table 4 Study Area Available Traffic Volumes

Location	Date	AADT	Truck AADT	Source
US 97, at Deschutes Junction	2016	26,900	2,400	OTMS*
US 97, at Quarry Avenue	2016	32,000	2,900	OTMS
Deschutes Junction, East Leg	2015	4,200	N/A	TransGIS^
Deschutes Junction, West Leg	2015	4,000	N/A	TransGIS^

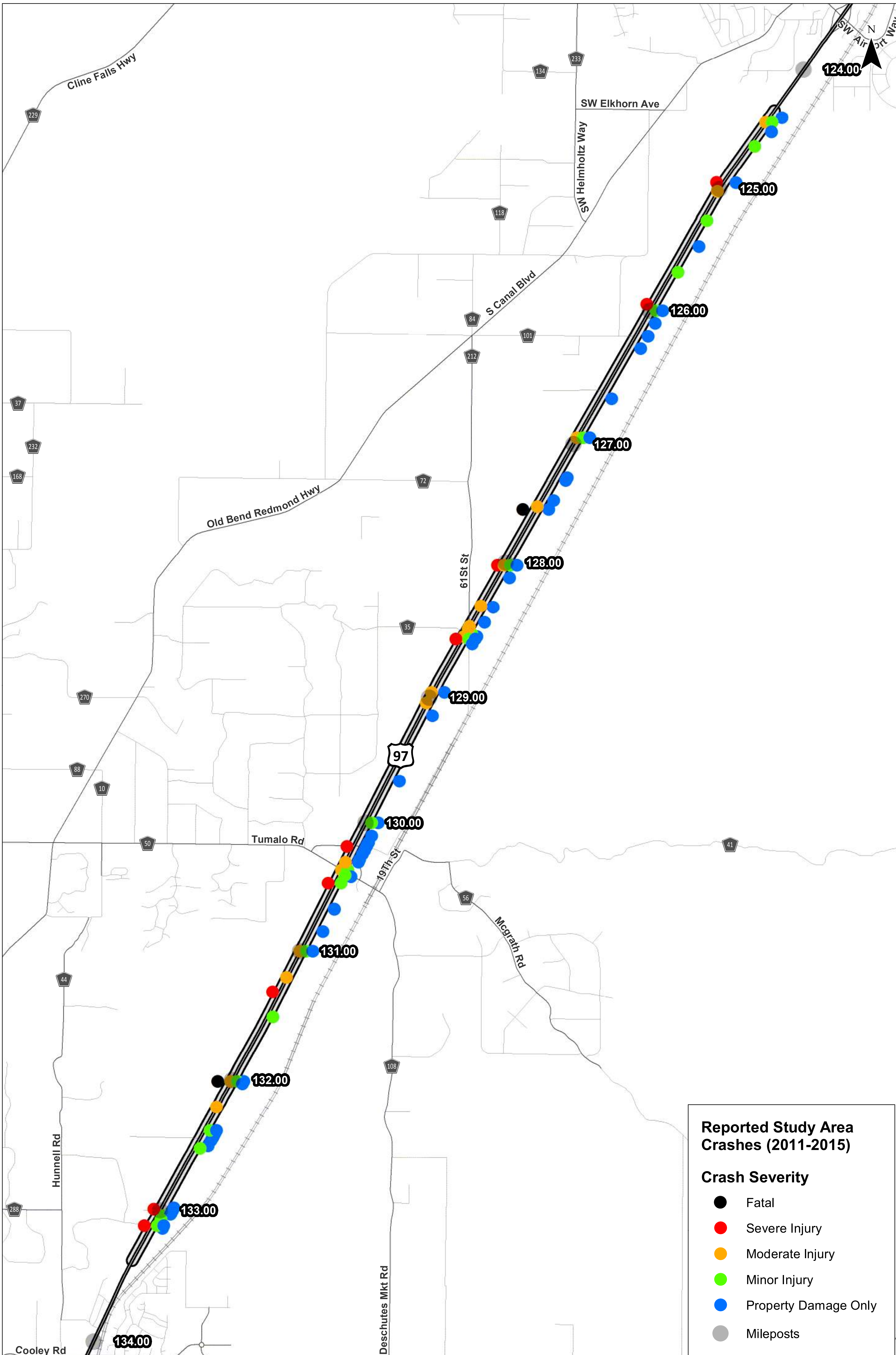
*Oregon Transportation Management System
^Volumes obtained from TransGIS online portal in August 2018.

Traffic volumes were not available for the majority of the intersections along the corridor. Field observations indicated that volumes of turning vehicles at intersections were highest at Deschutes Junction, followed by 61st Street and then by Quarry Avenue. In the absence of available hourly volumes, field observations also confirmed the peaking characteristics of the traffic during the weekday a.m. and p.m. peak hours when drivers are commuting between Bend and Redmond.

HISTORICAL CRASH ANALYSIS

Kittelson conducted a review of the crash history over a 5-year study period, from 2011 through 2015. Crash data and crash reports were provided by ODOT. A summary table of all reported crashes over the study period is provided in **Appendix A**. Over the study period (2011 through 2015), 130 crashes were reported on the US 97 study corridor from MP 124.40 to 133.39. A corridor crash map showing the location and severity of each crash is provided in **Figure 4**.

[1] Traffic volumes used in the safety analysis correspond to the years of the crash data used in the analysis.



Crash Severity
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
4

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KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

Over the five-year study period, 130 crashes were reported on the US 97 study corridor. The crashes were spread throughout the corridor, with the highest frequency occurring at intersections and full milepost numbers. The high frequency at full milepost numbers is likely associated with rounding during the reporting of each crash as there are no geometric changes at each full milepost.

Crash data from the year 2016 was considered preliminary at the time of analysis and was therefore not included in the analysis. The speed limit within the study area increased from 55 mph to 65 mph in March 2016. Kittelson reviewed the 2016 crash data and identified the following key points from the year 2016:

- A total of 38 crashes were reported in 2016.
- One fatal crash and one serious injury crash were reported in the study area in 2016.
  - The serious injury crash was a rear-end crash that occurred in daylight in June and was associated with careless driving and excessive speed.
  - The fatal crash was a sideswipe-meeting crash that occurred in dark conditions in December. The reported cause on the crash report indicated “drove left of center on two-way road” and “improper overtaking.”
- The most common crash types in 2016 were rear-end crashes (10 crashes), fixed object crashes (8 crashes), sideswipe overtaking crashes (6 crashes), and sideswipe meeting or head-on crashes (5 crashes).

Frequency and Severity

The crash severity distribution of the US 97 study corridor crashes is summarized in **Table 5. Table 6** compares the average annual crash rates for the last five years to the statewide average crash rate for rural principal arterials. **Table 6** also summarizes how the crash rates of individual study segments within the study corridor compare to similar roads. Compared to the typical crash rates of similar roads in Oregon, the study section of US 97 had lower crash rates. Although the crash rates were not above statewide averages, there are opportunities to reduce the frequency of fatal and severe-injury crashes.

Table 5 Crash Severity Distribution

<table>
<tr><th>Corridor / Class</th><th>Property Damage Only</th><th>Minor Injury</th><th>Moderate Injury</th><th>Severe Injury</th><th>Fatality</th></tr>
<tr><td rowspan="2">US 97 Crashes (2011-2015)</td><td>71
54.6%</td><td>28
21.6%</td><td>20
15.4%</td><td>9
6.9%</td><td>2
1.5%</td></tr>
<tr><td>71
54.6%</td><td colspan="3">57
43.9%</td><td>2
1.5%</td></tr>
</table>

Table 6 Crash Rate Comparison

Crash Rate Type*	Study Corridor Average Crash Rate	Statewide Average Crash Rate for Rural Principal Arterials (2015)
Overall Average Crash Rate (crashes per million VMT)	**0.30**	**0.80**
Redmond City Limits to Quarry Lane	0.24	0.80
South of Quarry Lane to 61st Street	0.28	
South of 61st Street to Deschutes Junction	0.21	
South of Deschutes Junction to Ft. Thompson Lane	0.42	
South of Ft. Thompson Lane to Bend City Limits	0.31	
Fatal and Severe Injury Crash Rate (Crashes per 100 million VMT)	**2.54**	**5.38**
Redmond City Limits to Quarry Lane	2.09	5.38
South of Quarry Lane to 61st Street	2.40	
South of 61st Street to Deschutes Junction	1.22	
South of Deschutes Junction to Ft. Thompson Lane	3.02	
South of Ft. Thompson Lane to Bend City Limits	4.83	
Fatal Crash Rate (Crashes per 100 million VMT)	**0.46**	**2.05**
Redmond City Limits to Quarry Lane	0.00	2.05
South of Quarry Lane to 61st Street	0.80	
South of 61st Street to Deschutes Junction	0.00	
South of Deschutes Junction to Ft. Thompson Lane	1.01	
South of Ft. Thompson Lane to Bend City Limits	0.00	

Note: *Oregon crash rates obtained from 2015 Oregon Crash Rate Book.*
**Crash rate calculations for the corridor are based on an average AADT of 27,600 for the 9-mile US 97 study corridor or the nearest AADT estimate.*

Time

The crash frequency and severity are depicted by year and by month in **Figure 5** and **Figure 6**, respectively. Reported crash frequency ranged between 16 and 45 per year over the study period. Crash frequency was highest in 2014; a high frequency of snow and ice related crashes were reported that year. Severe crashes – crashes resulting in a severe injury or fatality – typically ranged between two and four per year, with the exception of zero severe crashes in 2013. Crash frequency is highest during winter months.

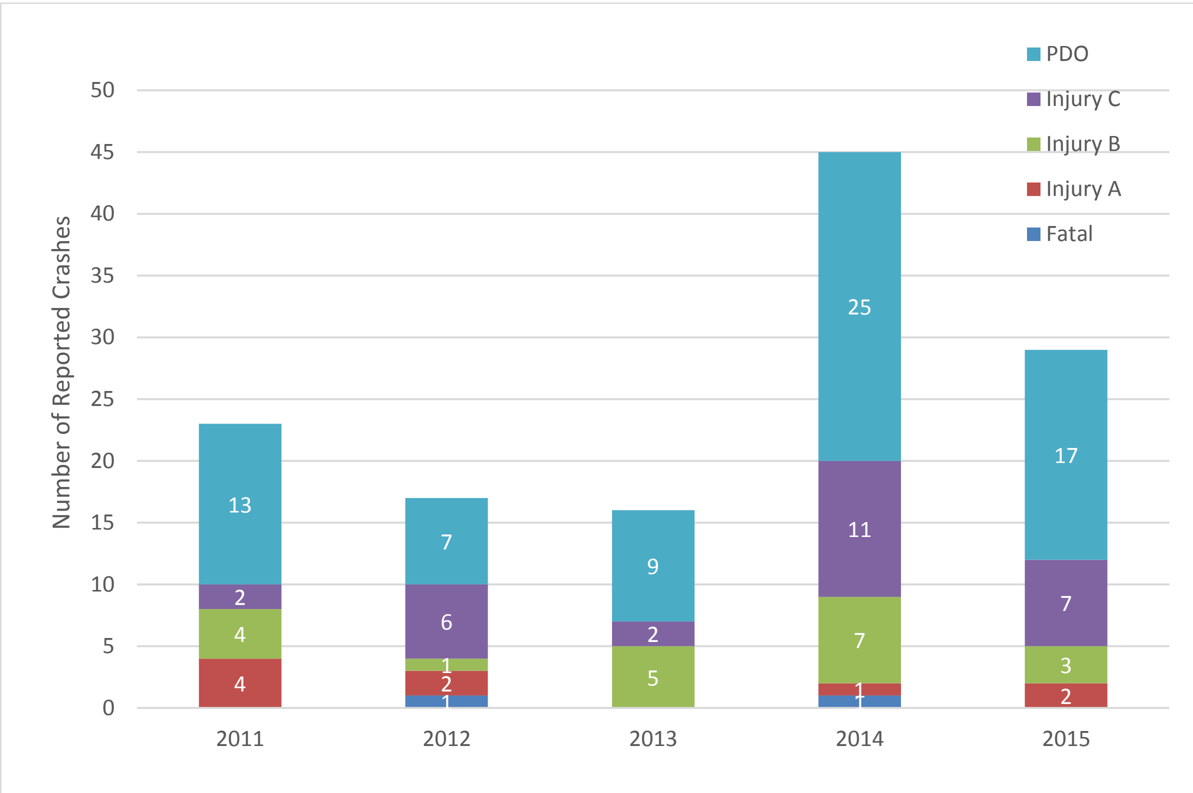


Figure 5 Crash Frequency and Severity by Year (2011 – 2015)

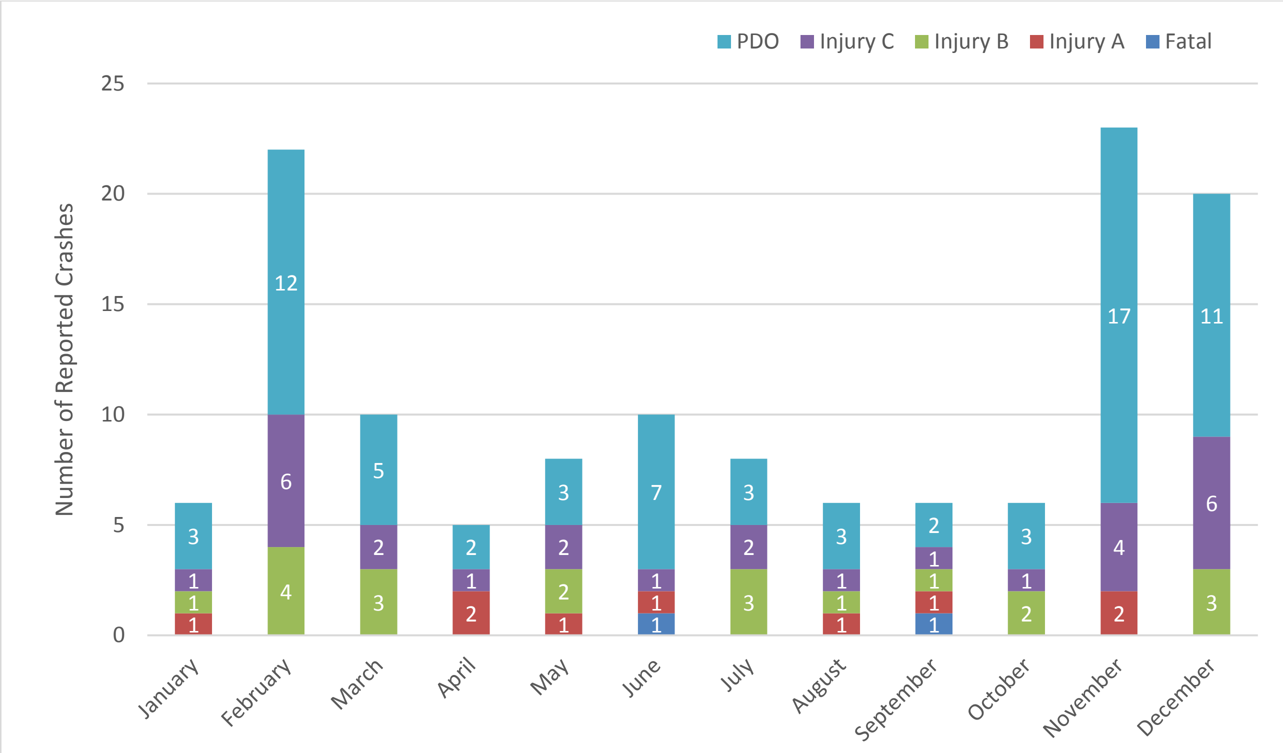


Figure 6 Crash Frequency and Severity by Month (2011 – 2015)

Collision Type

Table 7 summarizes the collision types over the study corridor. Crash frequency and severity by collision type is depicted in **Figure 7**. The crash type by corridor location is summarized in **Figure 8**. Although classified as different crash types in the table, overturn and animal crashes may also involve vehicles that run off the road. These three crash types combined account for 51 crashes, or 39 percent of all crashes in the corridor. Similarly, sideswipe meeting and head-on crashes are similar crash types addressed by similar countermeasures. These two crash types account for 29 crashes in the corridor, or 22 percent of all crashes. Head on and sideswipe crashes accounted for 27 percent of fatal and severe crashes in the corridor. Lane departure crashes include run off the road and head on crashes. Lane departure crashes were the most common crash type, accounting for 61 percent of all crashes in the corridor and 54 percent of fatal and severe crashes in the corridor.

Figure 9 shows the location of fixed object, non-collision, and overturn crashes along with the object involved in the crash. Crash clusters at round milepost numbers may be due to how the crashes were reported and may not indicate the exact location of crashes.

Table 7 Collision Type (2011 – 2015)

Collision Type	Total Crashes		Fatal and Severe Injury Crashes	
	Frequency	Percent	Frequency	Percent
Run off the Road	25	19.2	3	27.3
Turning Movement or Angle	10	7.7	2	18.2
Head On	11	8.5	2	18.2
Sideswipe, Meeting	18	13.8	1	9.1
Sideswipe, Overtaking	6	4.6	--	--
Rear End	32	24.7	2	18.2
Overturned	10	7.7	--	--
Animal	16	12.3	--	--
Pedestrian	2	1.5	1	9.1
Total Crashes	**130**	**100%**	**11**	**100%**

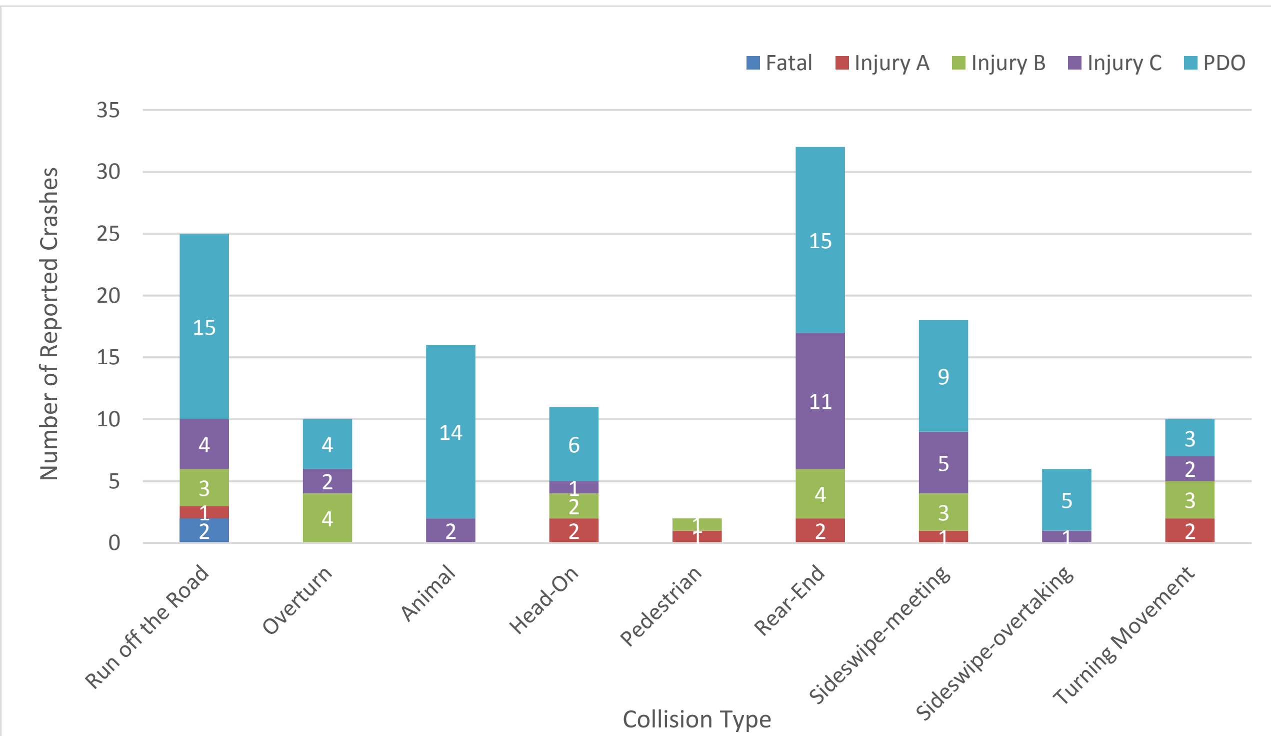
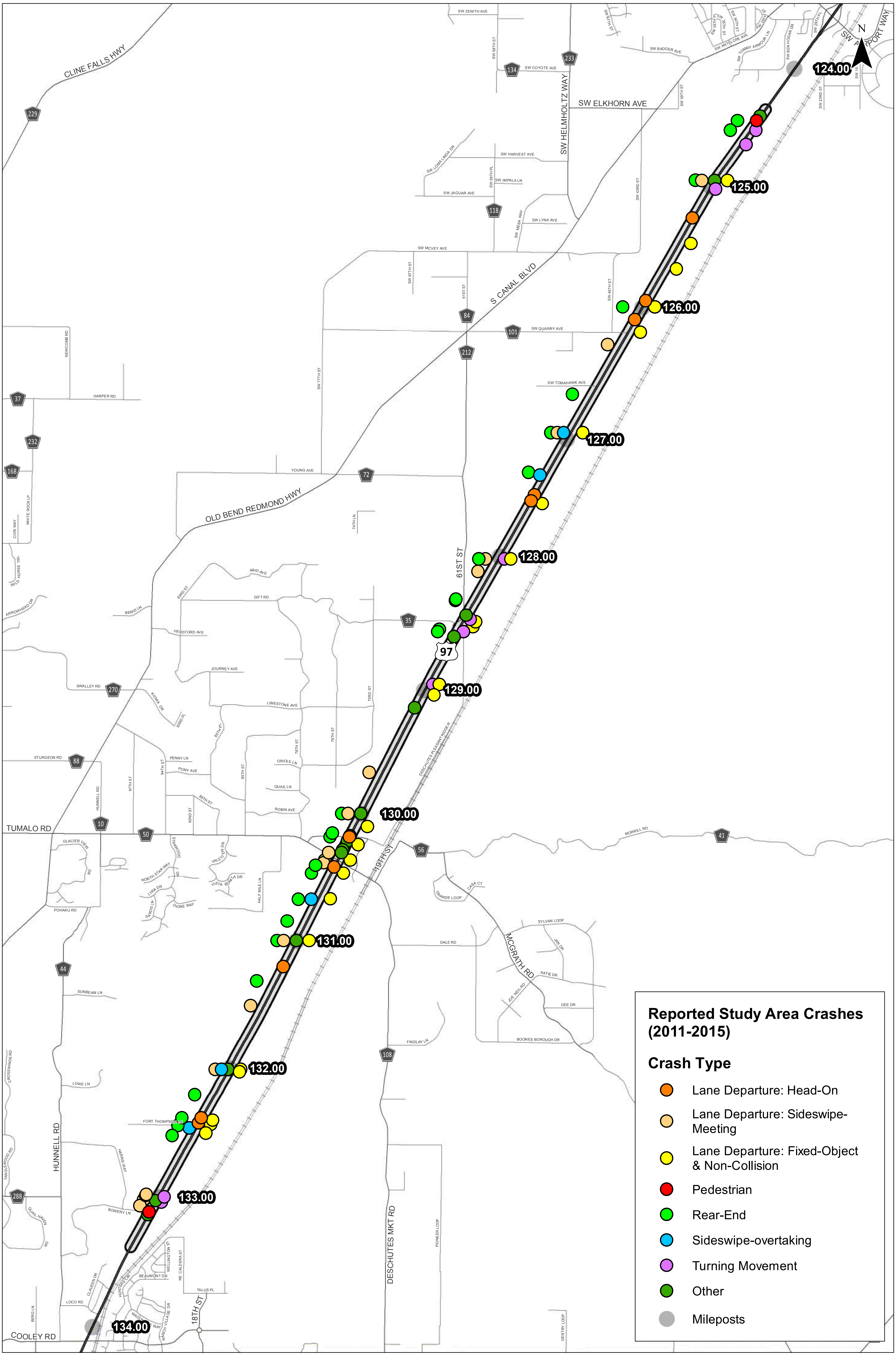


Figure 7 Crash Severity by Collision Type (2011 – 2015)

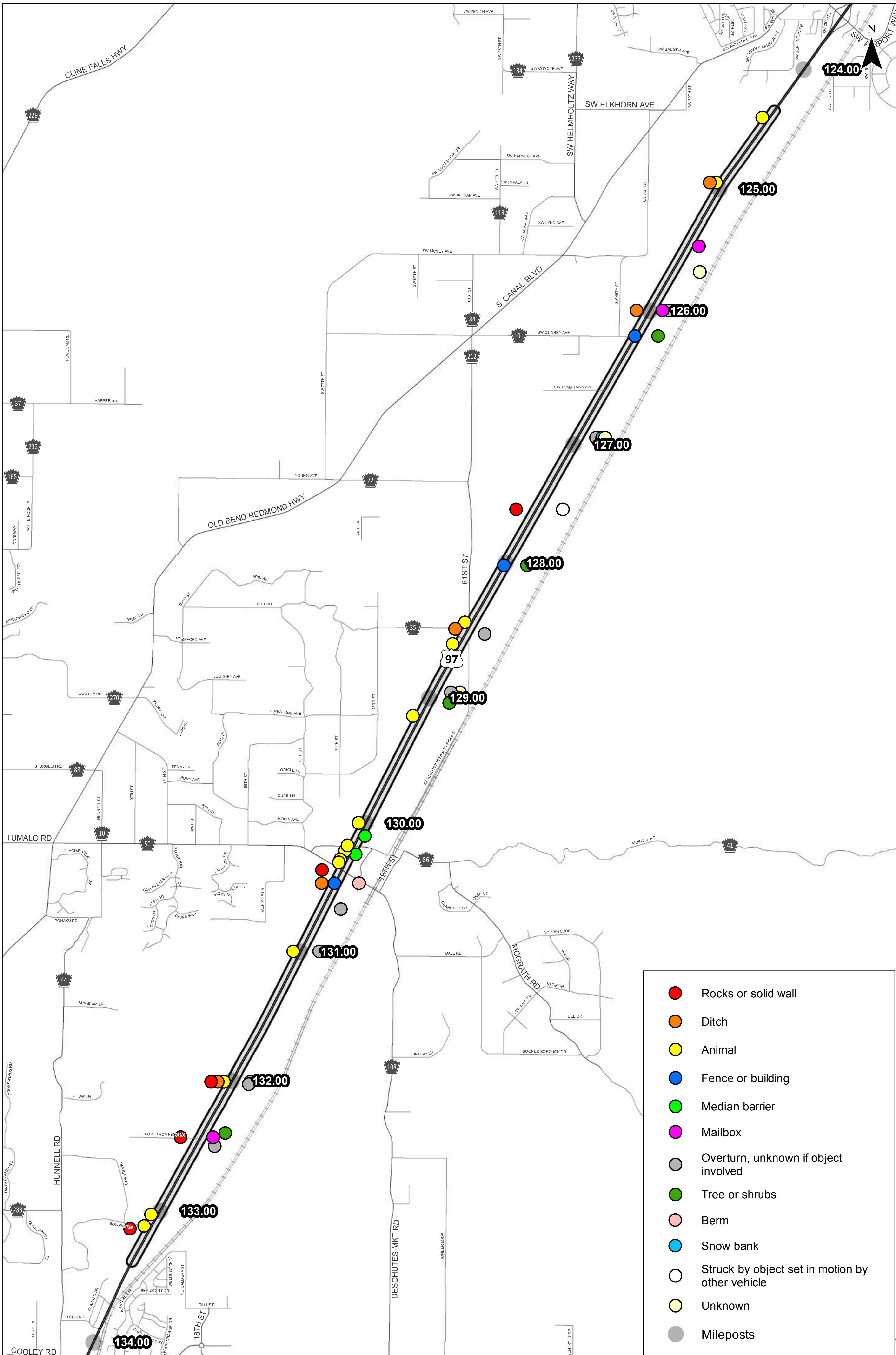


Crash Types
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
8

KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation



Objects Involved in Fixed Object, Non-Collision, and Overturn Crashes
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
9

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KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

Lighting

Figure 10 displays the distribution of crash lighting conditions relative to crash severity, and **Figure 11** displays the distribution of lighting conditions across the corridor. Forty-two percent of the reported crashes (55 of 130) occurred in non-daylight conditions (dusk, dawn, or dark). Forty-five percent of fatal and severe injury crashes(X of y) occurred during non-daylight conditions.

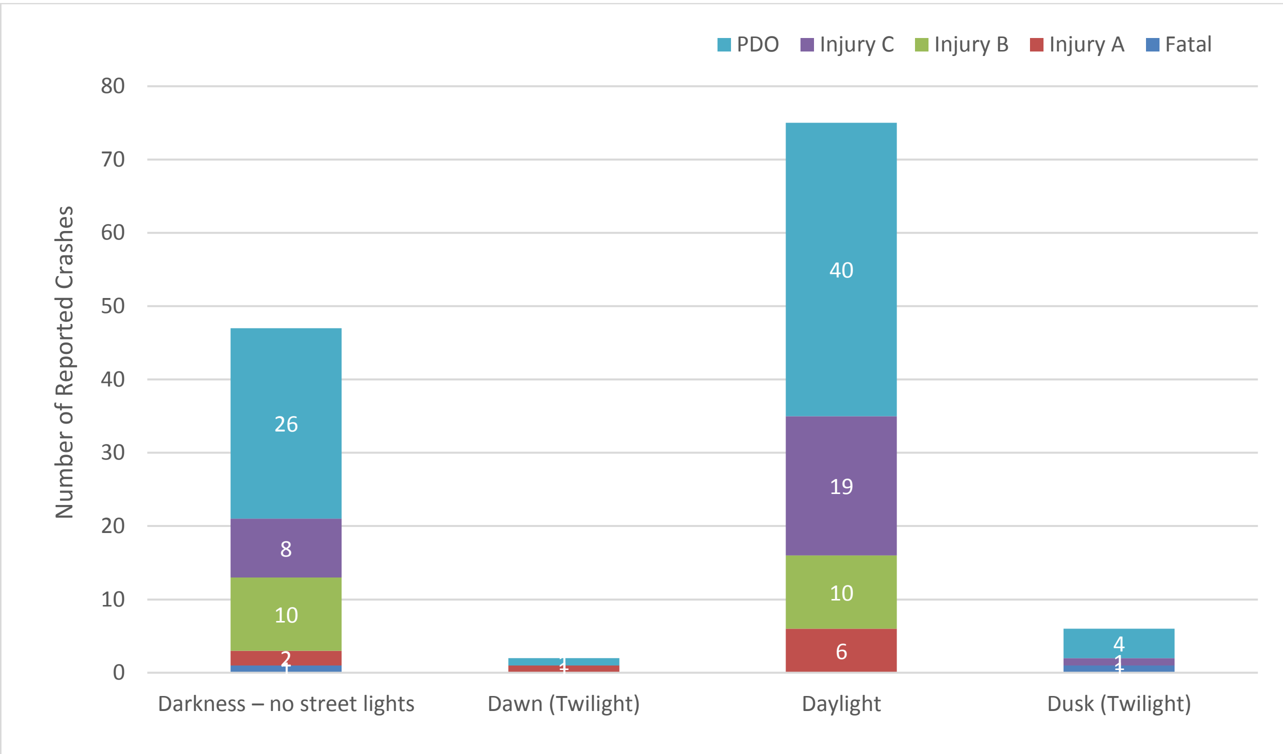
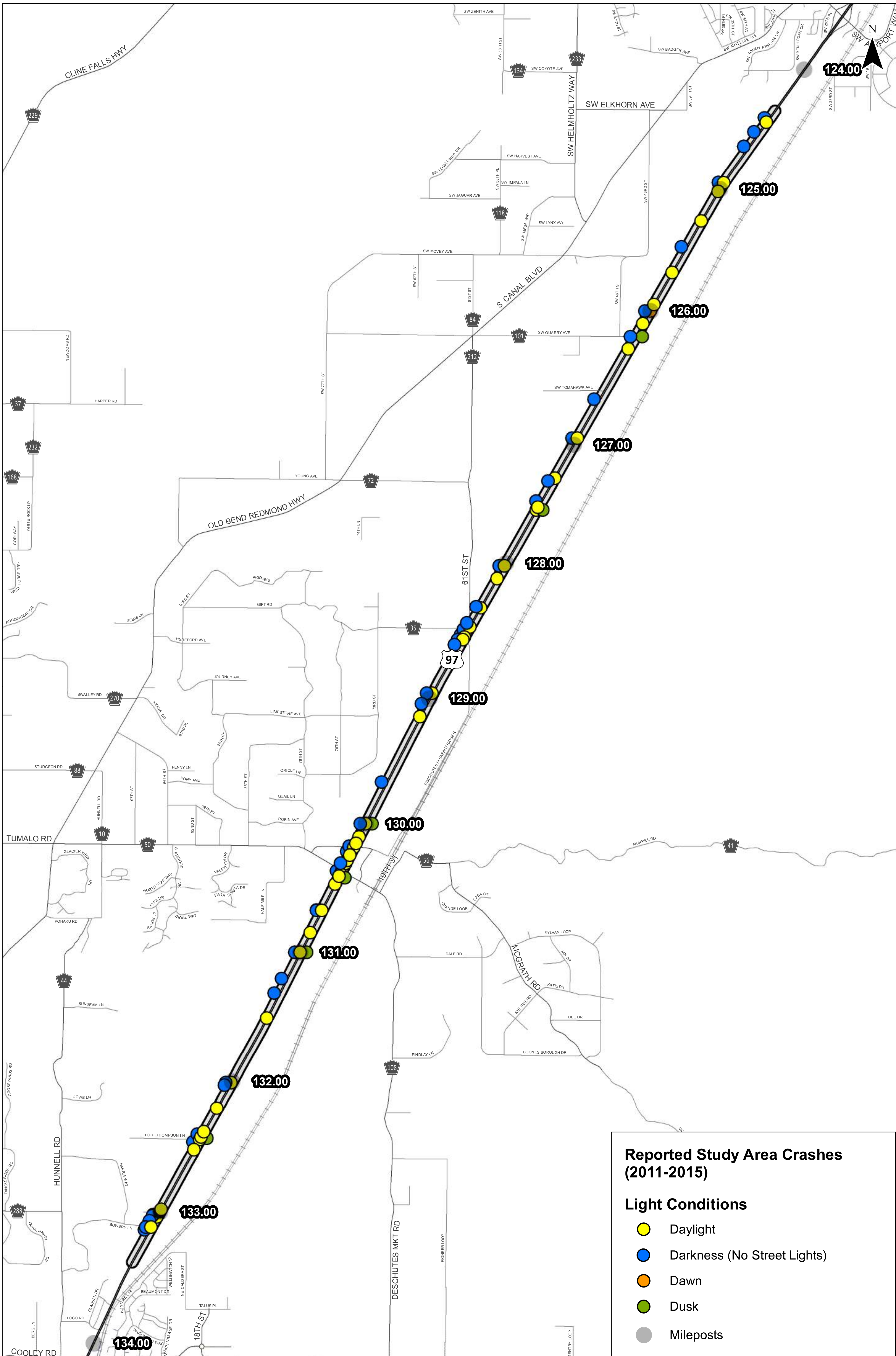


Figure 10 Lighting Conditions and Crash Severity (2011 – 2015)



Light Conditions
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
11

KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

Roadway Conditions

Figure 12 shows the distribution of roadway conditions at the time of the crash and the severity of the crashes. Sixty-nine crashes (53 percent) occurred on roadways categorized as snow, ice, wet, or unknown. However, 73 percent (x of y) of fatal and severe injury crashes occurred on dry roadways. **Figure 13** shows that the snow, ice, and wet roadway crashes occurred throughout the corridor.

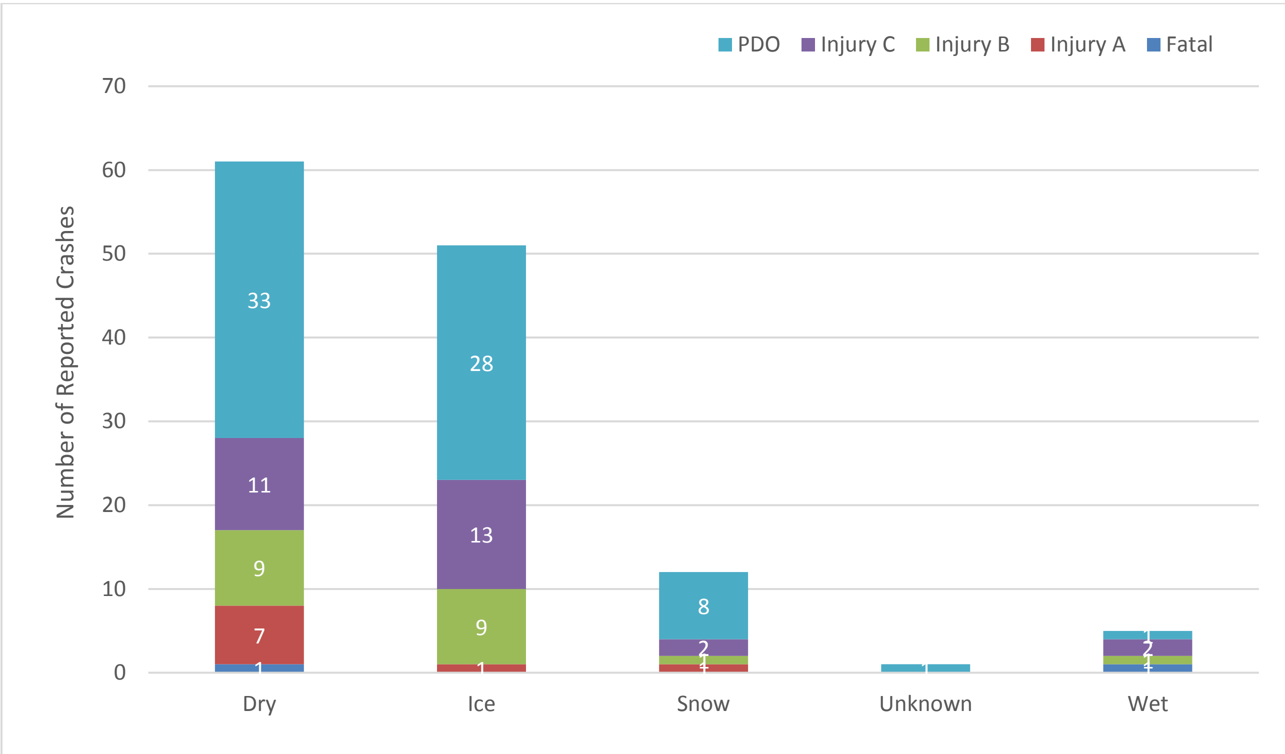
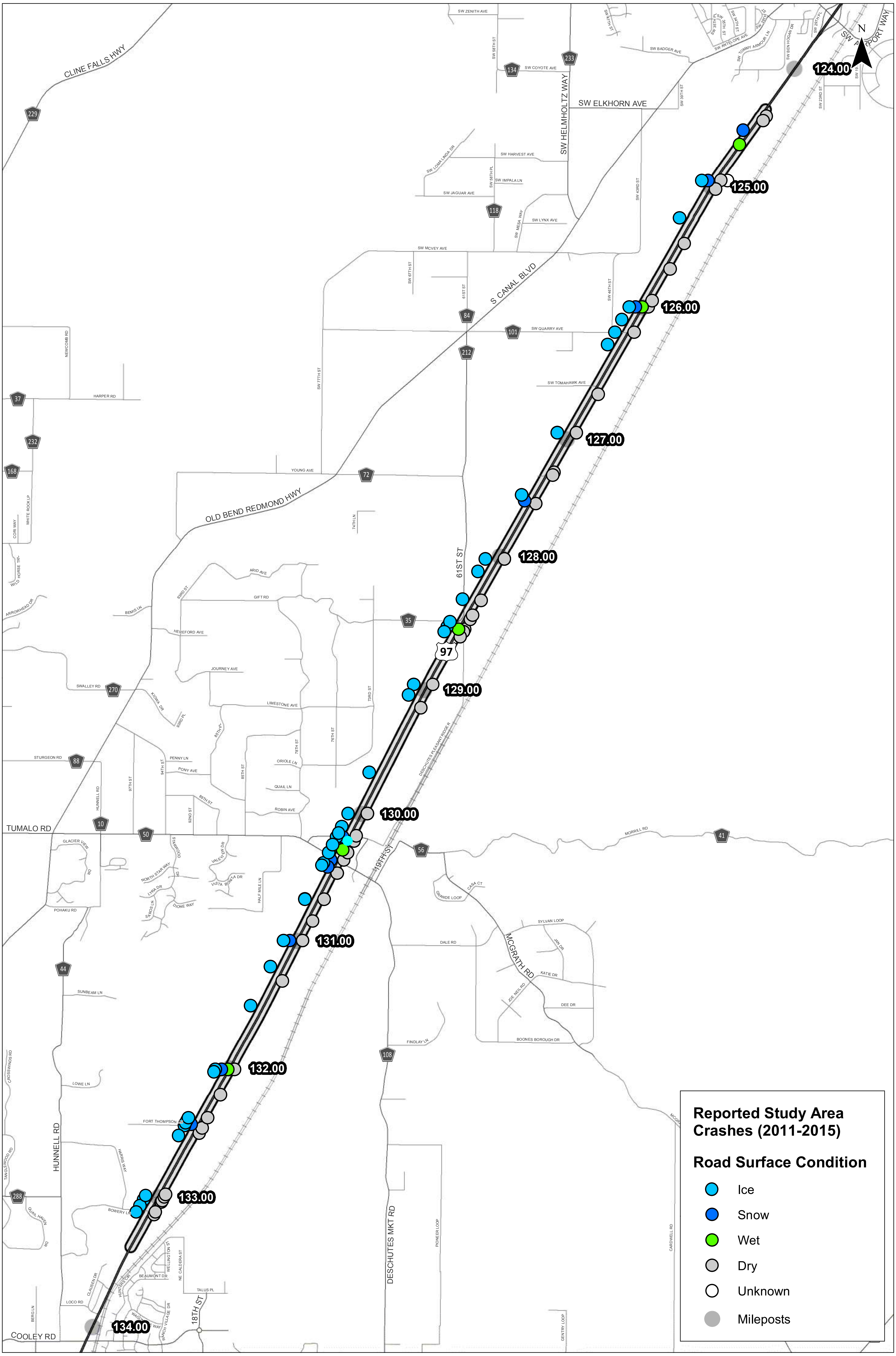


Figure 12 Roadway Conditions and Crash Severity (2011 – 2015)



Roadway Conditions for Reported Crashes (2011-2015)
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
13

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KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

Other Factors

Other factors noted in the crash data included excess speed and alcohol use. These factors were found to occur in the following proportion of reported crashes over the study period:

- Excess Speed – "Too fast for conditions" was the most commonly reported crash cause in the crash reports. Not all crash reports included a crash cause, and crash reports can indicate multiple crash causes. Fifty-two crashes indicated speed was a factor. The second most commonly reported crash cause was "Other," with 17 crashes, and "Followed too closely," with 17 crashes. Speed "too fast for conditions" does not necessarily indicate drivers exceeding the posted speed limit; conditions may create a situation in which vehicles need to travel below the speed limit in some cases such as inclement weather.
- Alcohol Use – Crash reports indicate alcohol was involved in 6 of the reported crashes.

FIELD OBSERVATIONS

Kittelson, ODOT, and Deschutes County conducted a field review of the corridor on December 18, 2014 and December 19, 2014. Team members reviewed the crash history prior to the field visit and drove the corridor several times in daylight and dark conditions. Participants stopped to observe the key intersections along the corridor including Bowery Lane, Deschutes Junction, 61st Street, and Quarry Lane. The purpose of the field review was to identify and document the presence and condition of existing facilities and make observations regarding traffic and safety issues. The following provides the findings of the field review.

Observations related to geometric design elements are summarized below.

- Bicycles
    - One bicyclist was observed riding along the study corridor during the visit.
- Roadway Segment Observations
    - It was difficult to find a gap in major-street traffic to complete a left-turn from the minor street. Vehicles were observed using the 10-foot wide striped median to complete two-stage left-turns.
    - Rock outcroppings are located throughout the corridor approximately 30 feet from the edge of the roadway shoulder.
- Intersection Observations
    - One tree restricts intersection sight distance at the intersection of US 97/Quarry Lane.

- Traffic turning onto US 97 at Deschutes Market Road has an acceleration lane with a merge, but many vehicles continue to stop rather than making the turn and then merging onto US 97 from the east.
- During dark lighting conditions it is difficult to identify intersections in advance – there are limited visual cues to identify intersections.
- 61st Street has a northbound left-turn lane from US 97; no other major-street left-turn lanes are provided on the study segment.

Section 4
Potential Crash Countermeasures

POTENTIAL CRASH COUNTERMEASURES

Potential crash countermeasures were considered to reduce crash potential on the corridor, based on field observations and crash analysis.

The previous US 97 Safety Assessment recommended speed feedback signs in transition areas between urban and rural areas. ODOT installed speed feedback signs on US 97 at transition locations as drivers enter Bend and Redmond. ODOT is also in the process of designing illumination and signing plans at the US 97/61st Street and US 97/Quarry Avenue intersections; however, these improvements have not yet been constructed and are therefore still referenced in this report.

COUNTERMEASURE TOOLBOX

Prior to identifying improvements for specific locations along the corridor, a variety of potential crash countermeasure improvements were defined being appropriate to the context of this corridor. This Toolbox of Countermeasures was identified from the Federal Highway Administration (FHWA) Crash Modification Factor (CMF) Clearinghouse, the *Highway Safety Manual* (HSM), FHWA's *Two Low-Cost Safety Concepts for Two-Way Stop-Controlled, Rural Intersection on High-Speed Two-Lane, Two-Way Roadways* (FHWA-HRT-08-063), and ODOT's Approved CMF list, among others. The countermeasures are described within the following categories: roadway, roadside, signage, intersection, and lighting.

Roadway Improvements – the roadway category consists of improvements implemented within the roadway's traveled cross-section effecting roadway segment driver behavior and/or traffic operations. The countermeasures identified are designed to reduce roadway/lane departures through increased driver awareness and pavement marking retroreflectivity. One example roadway improvement is inlaid raised pavement markers (RPM), an example of which is provided in **Figure 14**. The spacing of RPMs can be decreased on approaches to intersections to provide visual warning to drivers. Another example is a raised median, which may take the form of a concrete barrier or a cable median barrier.

Figure 14 Example of Inlaid (Recessed) Raised Pavement Markers
(Source: http://safety.fhwa.dot.gov/roadwaysafetyawards/2013/)

Roadside Improvements – the roadside category consists of improvements implemented within the right-of-way, but outside the normal traveled cross-section. These improvements include improving the roadside design by removing fixed objects in the clear zone and widening the clear zone. Roadside improvements are intended to improve the recoverability of roadway departures and/or reduce the severity of roadway departure crashes.

Signage Improvements – the proposed signage improvements involve installing advanced warning signs prior to key intersections, installing signs with higher grade retroreflectivity, and installing larger signs.

Intersection Improvements – the intersection category consists of various improvements at specific intersections primarily intended to improve the safety of intersection maneuvers and to increase driver awareness at and on approach to intersections. Intersection improvements include enhanced signage and markings such as larger stop signs, additional stop signs, and a median on the minor street; increasing sight distance at an intersection; installing left-turn lanes; installing or lengthening right-turn deceleration lanes; and installing or lengthening right-turn acceleration lanes. **Figure 15** shows an example of a median on a minor street approach.

Figure 15 Example of Median on Minor Street Approach (Source:https://www.columbus.gov/uploadedfiles%5CPublic_Service%5CTransportation%5CMobility%5CEstimated%20Costs%20FINAL.pdf)

Lighting – the lighting category consists of additional illumination at intersections and on some segments identified by the crash analysis. The segments are based on locations with the highest percentages of crashes that occurred during dark lighting conditions. The additional lighting would help improve the visibility of the roadway and key intersections at night. These improvements are intended to reduce the number of roadway departure crashes and intersection crashes in dark and dusk lighting conditions. Lighting may also help reduce the risk for pedestrian crashes by making pedestrians more visible at key intersections and along segments at the transition to the city limits.

Table 8 summarizes all countermeasures identified for consideration on the corridor.

Table 8 US 97 Corridor Toolbox of Crash Countermeasures

Countermeasure Category	Common Crash Types	Crash Countermeasures
Roadway	• Run-Off Road • Fixed Object • Overturned Vehicle • Head-On • Non-Daylight Conditions	• Install Inlaid Raised Pavement Markers • Install Raised Median and or barrier with U-turn to Provide Access to Driveways
Roadside	• Run-Off Road • Fixed Object • Overturned Vehicle	• Improve Roadside Design by Increasing Clear Zone Width
Signage	• Intersection Crashes • Speed-Involved Crashes	• Install Intersection Ahead Warning Signs • Replace Signs with Higher Retroreflectivity or Larger Signs
Intersection	• Rear-End • Left-Turning • Angle	• Increase Intersection Sight Distance • Install Low-Cost Signing and Marking Treatments, including Minor Street Median • Install Right-Turn Deceleration Lane • Install Left-Turn Lane • Install Right-Turn Acceleration Lane • Restripe Merge
Lighting	• Run-Off Road • Fixed Object • Animal Crashes • Non-Daylight Conditions	• Install Intersection Lighting • Illumination along Key Segments

CRASH MODIFICATION FACTORS

Kittelson identified crash modification factors (CMFs) for each countermeasure, where available. CMFs were identified from the ODOT Approved List[2], from the HSM, or the FHWA CMF Clearinghouse database. The FHWA CMF Clearinghouse is maintained by the University of North Carolina Highway Safety Research Center at the following web address: http://www.cmfclearinghouse.org/. A CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. CMFs have been developed for a variety of countermeasures through decades of safety research; however, CMFs are not available for all countermeasures.

The ODOT list of approved CMFs is intended to provide consistency among projects; it does not prohibit other countermeasures and CMFs from being evaluated. The supporting information provides details

[2] ODOT references Crash Reduction Factors, instead of Crash Modification Factors. CRFs are related to CMFs by the following equation: CRF=1-CMF.

about the area(s) a CMF applies to, applicable crash type(s), applicable severity type(s), standard error (if available), and a star rating. The star rating system is managed by the FHWA and denotes the CMF's quality on a one-to-five scale, where five indicates the highest or most reliable rating. CMFs with the highest star ratings were prioritized for use in this analysis, when possible. CMFs with lower star-ratings were used for several countermeasures where no other information was available. These lower-rated CMFs are generally more indicative of a crash reduction trend and should not be heavily relied on for specific crash reduction approximation.

A CMF having a standard error indicates a statistical level of confidence in that countermeasure's effectiveness to reduce crashes. However, standard errors are not included with all CMFs in the CMF Clearinghouse. Therefore, for consistency in this analysis, the average CMF is used for each countermeasure, but it is recognized that each countermeasure's effectiveness to reduce crashes may vary among different locations.

A detailed list of countermeasures and applicable CMFs is provided in **Appendix B**. More information on the development and application of CMFs is available in Part D of the HSM.

COUNTERMEASURE APPLICATION

The potential improvements within the Countermeasure Toolbox were applied to specific locations taking into consideration the context of the corridor, crash types reported over the 5-year study period, and contributing factors identified by crash analysis and field reviews. The result was a collection of location-based projects ranging in cost and expected effectiveness. **Table 9** summarizes the potential improvements for the specific locations discussed above. As shown, a comprehensive range of countermeasures was identified to address the reported crashes and reduce the potential for future crashes. The following section describes the evaluation process applied to prioritize projects based on expected cost-effectiveness.

Table 9 Potential Countermeasure Improvements by Location

Location	Potential Countermeasures
Redmond City Limits to Quarry Ln	▪ Inlaid Raised Pavement Markers ▪ Raised Median ▪ Segment lighting
Quarry Ln	▪ Increase Sight Distance; ▪ Median on minor street approach ▪ Intersection lighting ▪ Right turn Deceleration Lane
Quarry Ln to 61st Street	▪ Inlaid Raised Pavement Markers ▪ Segment Lighting ▪ Increase clear zone (Reduce Roadside Hazard Rating) ▪ Raised Median
61st Street	▪ Intersection lighting ▪ Median on minor street approach ▪ Right turn Deceleration Lane ▪ Acceleration Lane
61st Street to Deschutes Jct.	▪ Inlaid Raised Pavement Markers ▪ Raised Median
Deschutes Jct.	▪ Restripe Merge
Deschutes Jct. to Ft Thompson Ln	▪ Inlaid Raised Pavement Markers ▪ Increase clear zone (Reduce RHR from 2 to 1) ▪ Raised Median
Ft Thompson Ln	▪ Private street intersection (no recommendations).
Ft Thompson Ln to Bend City Limits	▪ Inlaid Raised Pavement Markers ▪ Segment Lighting ▪ Raised Median

*Note: The shading is used to help differentiate between locations (shaded – intersections; non-shaded – roadway segments)

ADDITIONAL COUNTERMEASURE CONSIDERATIONS

Due to the prevalence of speed-related crashes occurring in winter months, Kittelson also suggests a Variable Speed Limit (VSL) be considered for the US 97 corridor. The VSL could not be analyzed in the analysis in this report because a CMF is not available for the rural context. However, installations of VSL throughout several states have shown a reduction in crashes and speed. ODOT is currently planning a VSL system for US 97 south of the City of Bend.

Wyoming, Utah, Washington, and Oregon have implemented variable speed limits. Washington and Wyoming have implemented VSL for safety reasons on rural sections of interstate. Wyoming DOT saw a reduction in crashes and speed after implementation of the VSL.

The CMF Clearinghouse includes CMFs for variable speed limits. The CMFs range from 0.71 to 0.92 and have 4-start quality ratings. However, the CMFs are only applicable to urban areas and therefore not appropriate to apply to this section of US 97. The studies that developed the CMFs were conducted on interstates in urban areas of Seattle and St. Louis and do not likely reflect the winter weather issues of US 97.

Although this report does not analyze the B/C associated with installation of VSL, Kittelson suggests it be considered as an option to reduce speeds and crashes during winter months and inclement weather conditions.

Section 5
Improvement Alternatives Analysis

IMPROVEMENT ALTERNATIVES ANALYSIS

Countermeasures identified in Section 4 were grouped into projects at each intersection and within each segment. The expected crash reduction potential of countermeasures (as indicated by CMFs described in Section 4 and provided in **Appendix B**) was used to establish initial project groups. Crash prediction methods from the HSM were applied to conduct benefit-cost analysis and to establish a prioritized list of projects based on expected cost-effectiveness. The result is a list of Short- and Medium-term projects, with the most cost-effective treatments included in the Short-term project group.

This analysis is intended to identify and prioritize alternative safety projects through a planning-level analysis. Therefore, this analysis reflects planning-level cost estimates that are used to inform a relative comparison of benefit-cost between alternatives. The findings of this analysis will identify relative priorities for implementation; the prioritized projects should be scoped and more detailed cost estimates should be prepared to revise the B/C ratios prior to making final funding decisions.

BENEFIT

The benefit of the countermeasures is quantified in terms of the annual cost savings to society associated with a reduction in crashes after implementation. The benefit is calculated by estimating the number of crashes reduced by a proposed countermeasure (or group of countermeasures) and associating a societal cost to those reduced crashes. The methods applied to estimate and quantify the benefits of countermeasures at intersections and segments along the study corridor are described below.

Crash Prediction

Crash prediction tools and methods from the HSM were applied to estimate the expected crash frequency within the study corridor, with and without countermeasures. The fundamental purpose for using the HSM crash prediction method is to compensate for the randomness in crash occurrence. Crashes include a human component not directly related to geometry or presence of certain roadway features. Any given set of crash data for a period of time will reflect randomness in crash frequency not related to changes to the roadway. The HSM method for predicting the expected average annual crash frequency applies the Empirical Bayes (EB) method to remove statistical bias.

Method

Crash frequency and severity is predicted using safety performance functions (SPFs). SPFs are regression equations estimating the frequency and severity of crashes based on multiple factors, including intersection geometry, lane configuration, and traffic volume. SPFs are based on national research and are intended to reflect a range of driver and roadway characteristics. The SPFs were calibrated to reflect variations between conditions in Oregon and other states studied to develop the SPFs. Variations could include driver characteristics, roadway design, terrain, and other factors associated with geometry, human factors, and driving environment. Calibration factors were obtained from *Calibrating the Highway Safety Manual Predictive Methods for Oregon Highways,* Final Report SPR 684 OTREC-RR-12-02.

Predicting crashes for a No-Build scenario (existing and future) estimates the expected number of crashes assuming only traffic volume varies between years. The expected number of crashes serves as a baseline crash estimate for comparison with the project alternatives.

SPFs for rural multilane undivided highways were obtained from Chapter 11 of the HSM and applied to determine existing crash prediction estimates for roadway segments and intersections. The rural multilane undivided highways model was the most appropriate because the divided highway model does not account for a flush median that exists on US 97. For the purpose of this study, it was assumed the traffic volumes will not change with implementation of safety improvements.

Predicted average crash frequency was computed using ODOT-calibrated spreadsheet tools designed to implement the HSM crash prediction methodology. The tools implement the EB procedure to establish an “expected” average crash frequency based on observed crash history and “predicted” average crash frequency. The application of the EB procedure produces the most reliable long-term expected average number of crashes.

Intersections were analyzed using the methodology from Chapter 11 of the HSM, with the exception of Deschutes Junction. Because this intersection functions as an interchange, it was evaluated using ISATe software, which applies the methodology developed in NCHRP 17-45, *Safety Prediction Methodology and Analysis Tool for Freeways and Interchanges*.

No-Build Crash Prediction Results

The expected number of crashes is summarized in **Table 10** by intersection and segment.

Table 10 No-Build Annual Crash History and Prediction Estimates

Location	Observed Annual Number of Crashes	Predicted Number of Crashes per Year	Expected Number of Crashes per Year*
Redmond City Limits to Quarry Ln	4.2	7.2	5.9
Quarry Ln / US 97	0.4	0.6	0.5
Quarry Ln to 61st Street	5.4	10.2	8.0
61st Street / US 97	1.6	0.9	1.1
61st Street to Deschutes Jct.	2.4	6.7	4.8
Deschutes Jct. / US 97	1.0	0.6	0.8
Deschutes Jct. to Ft Thompson Ln	7.4	7.2	7.3
Ft Thompson Ln / US 97	1.0	0.8	0.9
Ft Thompson Ln to Bend City Limits	2.6	3.2	2.9
Total	***26.0***	***37.4***	***32.2***

*The expected number of crashes are used in the benefit/cost calculations discussed below.

As shown in **Table 10**, if no changes are made to the existing roadway and volumes remain similar to those recorded in 2016, approximately 32.2 crashes are expected per year. This indicates approximately 6.2 crashes more crashes are expected per year for similar facilities in Oregon than were observed over the study period. Detailed spreadsheets documenting the existing crash prediction analyses are provided in **Appendix C**.

Build Crash Prediction Results

The No-Build expected crash frequency was used as the baseline for comparison of multiple projects. The expected number of crashes over the 20-year analysis period was multiplied by the project CMF (i.e., the expected change in crashes associated with each project).

The purpose of this report is to provide a relative comparison in crash reduction between various alternatives; therefore, 2016 volumes are consistently applied to predict crashes for all build alternatives.

CMFs are multiplicative, indicating that when more than one countermeasure is applied at a location, the combined project CMF is the product of the individual countermeasure CMFs. The combined project CMF was applied to the expected No-Build number of crashes to predict the number of crashes estimated to occur if the project is implemented. This method assumes traffic volumes are equal to those in the No-Build scenario and that no significant changes, other than the proposed countermeasures, are made to US 97 that would substantially impact the number of crashes.

Some CMFs only apply to specific crash types. For example, the CMF for installing intersection lighting applies only to non-daylight crashes. These CMFs were only applied to the ratio of observed crashes of the designated type relative to the total crashes observed on the corridor.

Where countermeasures do not have quantifiable estimates of effectiveness, no quantitative reductions were applied. Therefore, the benefit-cost ratios may be considered conservative estimates.

Cost of Crashes

The benefit of each alternative was calculated by applying a cost to the crashes reduced. The cost per crash reduced was developed based on the crash severity breakdown of the corridor and the economic value per crash by severity from ODOT's Benefit/Cost spreadsheet tool. Based on that tool, the following economic values were assumed for each crash severity:

- Fatal Crash: $1,850,000
- Injury A Crash: $1,850,000
- Injury B Crash: $85,800
- Injury C Crash: $85,800
- Property Damage Only Crash: $20,400

The weighted average cost based on the crash severity distribution of the five-year crash history for the study corridor resulted in an average cost of $199,360 per crash reduced. After the CMFs are applied to estimate the number of crashes reduced per year, the 20-year present value cost of crashes is calculated using a uniform series present worth factor of 12.46, as instructed by the *ODOT Highway Safety Projects Benefit/Cost Analysis Worksheet*. The safety "benefit" of the countermeasures is calculated as the difference in present value crash costs between No-Build and Build scenarios.

COST OF IMPROVEMENTS

Planning-level cost estimates were calculated for the potential countermeasures identified in **Table 9**. Cost estimates were based on costs listed in the ODOT CMF list and unit costs developed from the ODOT bid items when possible. Several soft cost factors were applied to the unit cost of each estimate. These include mobilization (10%), traffic control (8%), erosion control (3%), construction survey (2%), drainage (20%), clearing (2%), and engineering and administration (25%). Additionally, a contingency of 40 percent was applied to each estimate. The cost estimates do not include any assumptions or cost for right-of-way impacts. The cost estimates will be revised through ODOT's project scoping process. A summary table of the potential countermeasures and planning-level cost estimates is provided in **Appendix D.**

The proposed countermeasures have varying design life. For example, most roadway construction projects will have a 20-year design life. However, a shorter design life was assumed for treatments such as pavement markings (10 years), raised pavement markers (10 years), and signage (10 years). Countermeasures with a shorter design life were assumed to be replaced as-needed over the 20-year analysis period. The following assumptions were used for the service life of the countermeasures (all others assume a 20-year lifespan):

- Inlaid raised pavement markers (10 years);
- Signing and striping improvements, including median on minor street approach (10 years); and
- Restriping merge area (5 years).

PROJECT PRIORITIZATION

Projects were grouped into three categories such that the projects with the relatively highest effectiveness (i.e., greatest crash reduction per dollar spent) are included in the higher priority categories. The project categories are described as follows:

- Short-term projects are the most cost-effective and do not require additional right-of-way or public outreach.
- Medium-term projects are generally higher cost than short-term projects and tend to involve a greater degree of construction activity.
- Median-related projects are presented as a separate category because these projects involve the construction of a median along the highway and a U-Turn treatment to accommodate access to driveways and intersections. These projects involve higher costs and are more likely to impact right-of-way than short- or medium-term projects. These projects may require additional steps prior to implementation.

Some countermeasures may be included in both short- and medium-term categories, depending on its effectiveness at specific locations. Benefit-cost ratios were provided for each group of projects.

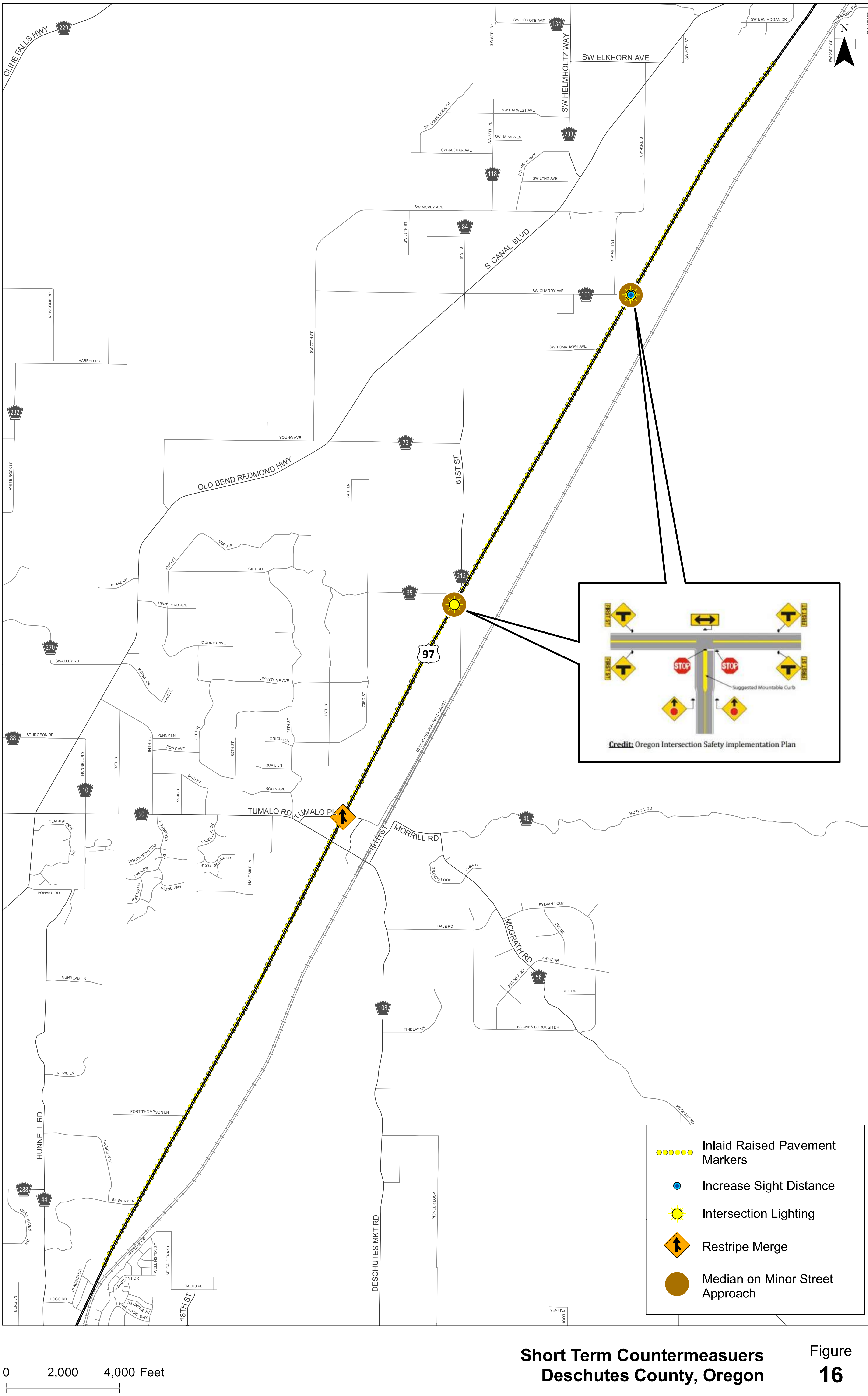
Short-Term Projects

Short-term projects are highly effective safety countermeasures implemented within the next five years at a relatively low cost. These include inlaid raised pavement markers, improving sight distance, intersection lighting, and enhanced signing and striping, including a median, on the minor street approach. **Table 11** summarizes the benefit-cost analysis for the short-term projects. **Figure 16** illustrates the proposed locations of the short-term, low-cost projects along the corridor.

Table 11 Short-Term Projects Benefit-Cost Summary

Location	Annual Observed Crash Frequency	Annual Predicted Crash Frequency	Annual Expected Crash Frequency	Short-Term Project Countermeasures	Project CMF^	20-Year Crash Reduction	Preliminary 20-Yr Cost Estimate**	Expected Annual Comprehensive Crash Cost Reduction (Benefit)	Benefit / Cost Ratio*
Redmond City Limits to Quarry Ln	4.2	7.2	5.9	▪ Inlaid Raised Pavement Markers	92%	9.4	$ 14,000	$ 94,100	83.7
Quarry Ln	0.4	0.6	0.5	▪ Increase sight distance^^	86%	1.4	$1,000	$14,000	173.9
				▪ Median on minor street approach	75%	2.5	$7,000	$24,900	44.4
				▪ Intersection lighting^^	83%	1.7	$63,000	$17,000	3.4
Quarry Ln to 61st Street	5.4	10.2	8.0	▪ Inlaid Raised Pavement Markers	92%	12.8	$ 18,000	$ 128,000	88.6
61st Street	1.6	0.9	1.1	▪ Intersection lighting^^	83%	3.7	$63,000	$37,000	7.4
				▪ Median on minor street approach	75%	5.5	$7,000	$55,000	97.6
61st Street to Deschutes Jct.	2.4	6.7	4.8	▪ Inlaid Raised Pavement Markers	92%	7.6	$ 12,000	$ 75,800	78.7
Deschutes Jct.	1.0	0.6	0.8	▪ Restripe merge	98%	0.3	$ 10,000	$3,000	3.7
Deschutes Jct. to Ft Thompson Ln	7.4	7.2	7.3	▪ Inlaid Raised Pavement Markers;	92%	11.7	$ 17,000	$ 116,500	85.4
Ft Thompson Ln	1.0	0.8	0.9	▪ None	N/A	N/A	$ -	$ -	--
Ft Thompson Ln to Bend City Limits	2.6	3.2	2.9	▪ Inlaid Raised Pavement Markers	92%	4.7	$ 7,000	$47,000	83.5
Total	***26.0***	***37.4***	***32.2***			**61.3**	**$ 219,000**	**$ 612,000**	**34.8**

**B/C Ratios reflect a uniform series present worth factor of 12.46 for a 20-year life span. B/C Ratio = (Annual Benefits X Present Worth Factor)/(Estimated Project Cost)*
***Cost estimates exclude any right-of-way impacts or costs.*
^Project CMF accounts for the proportion of crashes that the CMF applies to within the corridor.
^^Indicates project is complete or in-progress as of August 2018. (Signage upgrades are also in progress at the intersections of US 97/61st Street and US 97/Quarry Avenue.)



Short Term Countermeasuers
Deschutes County, Oregon

Figure 16

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Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

As shown in **Table 11** and **Figure 16**, the short-term projects may be implemented for approximately $219,000 and have a cumulative benefit-cost ratio of 34.8.

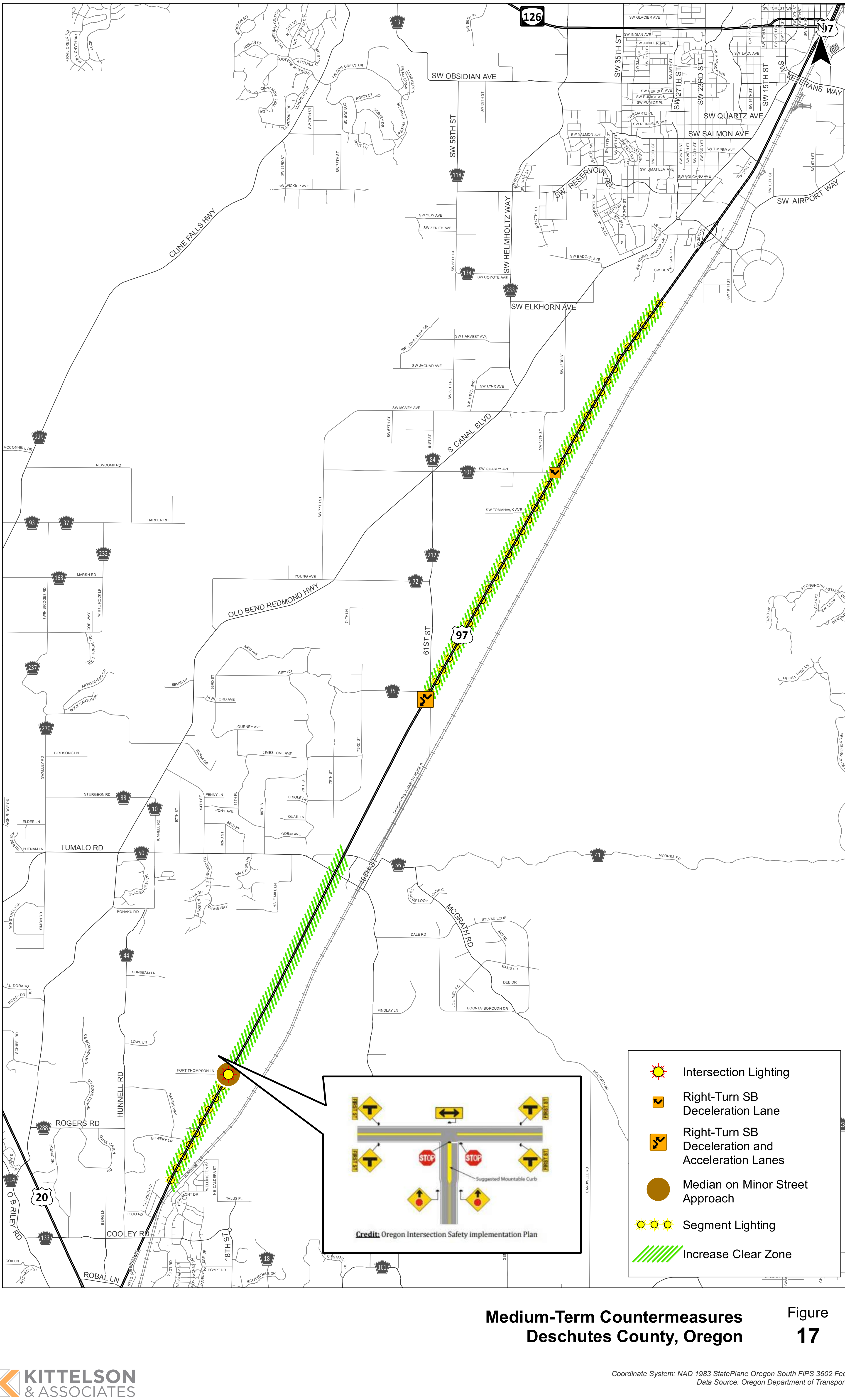
Medium-term Projects

Medium-term projects are generally higher cost and tend to involve a greater degree of construction activity than short-term projects. Segment lighting, clear zone improvements projects, acceleration lanes, and deceleration lanes were classified as medium-term projects for this corridor. **Table 12** summarizes benefit-cost analysis for the medium-term projects. **Figure 17** illustrates the proposed locations of the medium-term projects along the corridor.

Table 12 Medium-Term Projects Benefit-Cost Summary

Location	Annual Observed Crash Frequency	Annual Predicted Crash Frequency	Annual Expected Crash Frequency	Medium-Term Project Countermeasures	Project CMF^	20-Year Crash Reduction	Preliminary 20-Yr Cost Estimate**	Expected Annual Comprehensive Crash Cost Reduction (Benefit)	Benefit / Cost Ratio
Redmond City Limits to Quarry Ln	4.2	7.2	5.9	▪ Segment Lighting	92%	9.4	$1,080,000	$94,100	1.1
				▪ Increase clear zone (Reduce Roadside Hazard Rating (RHR))	94%	7.1	$ 329,000	$ 70,500	2.7
Quarry Ln	0.4	0.6	0.5	▪ Deceleration Lane	93%	0.8	$ 170,000	$ 7,500	0.6
Quarry Ln to 61st Street	5.4	10.2	8.0	▪ Segment Lighting	92%	12.8	$1,466,000	$128,000	1.1
				▪ Increase clear zone (Reduce RHR)	94%	9.6	$576,000	$96,000	2.1
61st Street	1.6	0.9	1.1	▪ Acceleration Lane	89%	2.4	$463,000	$24,000	0.6
				▪ Deceleration Lane	93%	1.5	$160,000	$15,000	1.2
61st Street to Deschutes Jct.	2.4	6.7	4.8	▪ None	N/A	N/A	N/A	$ -	N/A
Deschutes Jct.	1.0	0.6	0.8	▪ None	N/A	N/A	N/A	$ -	N/A
Deschutes Jct. to Ft Thompson Ln	7.4	7.2	7.3	▪ Increase clear zone (Reduce RHR)	94%	8.8	$ 1,164,000	$ 87,300	0.9
Ft Thompson Ln	1.0	0.8	0.9	• Private street intersection (no recommendations)	N/A	N/A	N/A	N/A	N/A
Ft Thompson Ln to Bend City Limits	2.6	3.2	2.9	▪ Segment Lighting	92%	4.6	$579,000	$46,000	1.0
				▪ Increase clear zone (Reduce RHR)	94%	3.5	$482,000	$35,000	0.9
Total	***26.0***	***37.4***	***32.2***			**60.5**	**$6,469,000**	**$ 603,400**	**1.2**

**B/C Ratios reflect a uniform series present worth factor of 12.46 for a 20-year life span. B/C Ratio = (Annual Benefits X Present Worth Factor)/(Estimated Project Cost)*
***Cost estimates exclude any right-of-way impacts or costs.*
^Project CMF accounts for the proportion of crashes that the CMF applies to within the corridor.



Medium-Term Countermeasures
Deschutes County, Oregon

Figure
17

Median-Related Projects and Alternatives

In order to address the median cross-over crashes, a raised median was evaluated. Forty-five percent of all fatal and severe injury crashes (x of y) in the study corridor were median cross-over or turning movement crashes. The median installation would restrict access at driveways and intersections to right-in/right-out only for the length of the median. Therefore, this project includes U-turn treatments at median openings.

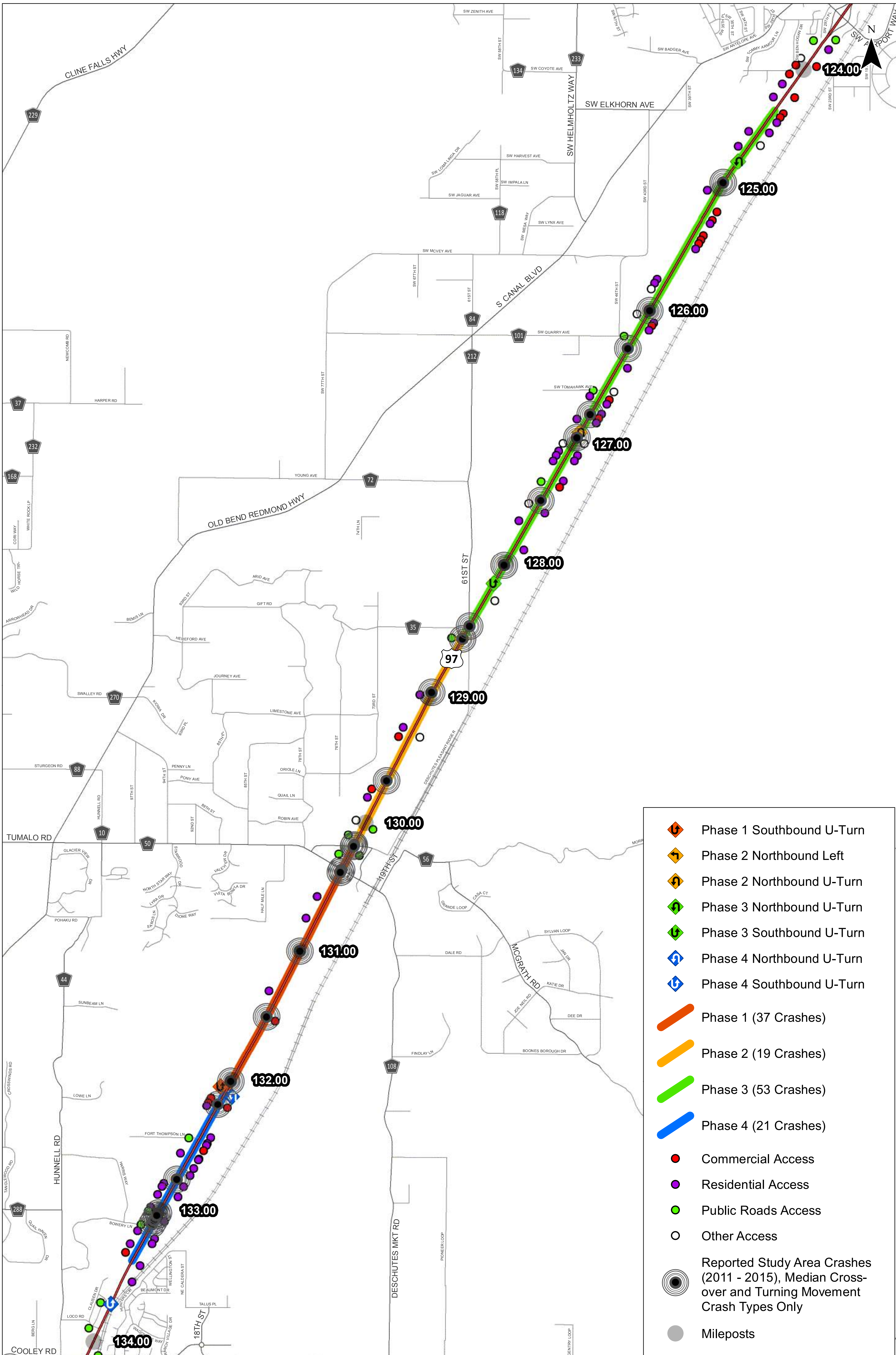
This analysis and report assume that a J-turn concept will be used to accommodate the u-turn maneuvers. J-turns have been shown to be effective at reducing crashes by consolidating turning movements at multiple locations at one location and enhancing the crossing location to raise awareness of the conflict point. A Missouri study found J-turns in conjunction with median turn restrictions resulted in a decrease of 34.8 percent in all crashes and 53.7 percent in fatal and injury crashes.[3] For the purpose of this analysis, the cost estimates for each J-turn assumes the location will be illuminated to increase visibility during dark lighting conditions. **Appendix E** illustrates a conceptual design of a J-turn concept along US 97.

There were no sections of the study corridor where a substantial length of median could be installed without impacting driveways at a reasonable cost. Therefore, phased implementation is recommended to prioritize implementation along segments of the study corridor where median installation provides the greatest reduction in crash frequency while minimizing impacts to existing accesses. **Figure 18**illustrates the location of each median phase and the U-turns associated with each phase. The figure also illustrates the location of driveways along the corridor and the locations of target crash types (head-on, sideswipe meeting, and turning movement crashes between 2011 and 2015).

As shown in **Figure 18**, phased implementation of median could begin near Deschutes Junction where there is the lowest driveway density. In general, driveway density is lower in the mid-section of the study corridor and increases towards the City limits. Further study is needed to design each U-turn treatment, which will need to account for distance to driveways, ability to accommodate acceleration lanes, and available right-of-way.

The following sections describe the four phases proposed for the median-related alternative. The analysis presented in this section provides the benefit/cost analysis using cost estimates for the concrete barrier median type. The concrete barrier is expected to have a higher cost than a cable barrier and is presented here to provide a conservative analysis. ODOT will conduct additional analysis of median types before selecting a preferred barrier type.

[3] Edara, et al. *Evaluation of J-turn Intersection Design Performance in Missouri*. December 2013.



Median Phasing Concept
US 97, MP 124.40 - 133.39
Deschutes County, Oregon

Figure
18

H:\18\18175 - US 97 Safety Planning\GIS\report figures\18175_fig18_median_phases.mxd - aludwig - 5:11 PM 8/11/2018

KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Oregon Department of Transportation

Phase I Median-related Alternative

The Phase 1 median-related alternative includes approximately 1.86 miles of median extending from approximately MP 130.18 to Deschutes Junction. One J-turn near the southern end of the segment (near MP 130.18), or alternate U-turn treatment, is recommended to serve southbound traffic. Deschutes Junction will serve as the U-turn opportunity for northbound traffic.

The benefit-cost analysis for Phase 1 is summarized in **Table 13**. Phase 1 has the highest benefit-cost ratio of all four phases.

Table 13 Median-related Phase 1 Benefit-Cost Summary

Countermeasures	Project Cost ($)*	Project Benefit ($)	B/C Ratio
Median and J-Turn	$2,000,000	$2,100,000	1.1

Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
**Cost estimates assume a concrete barrier median type and J-turn treatment for a conservative analysis. Cost estimates exclude any right-of-way impacts or costs.*

Phase 2 Median-related Alternative

Phase 2 of the median-related alternative includes approximately 1.60 miles of median extending from Deschutes Junction north to the intersection at 61st Street. One J-turn, or alternate U-turn treatment, will serve northbound traffic on the northern end of the segment. The J-turn at this location should be further evaluated to determine if an alternative treatment could be installed off of the highway on 61st Street in place of a J-turn. An aerial image of the intersection of US 97/61st Street is shown in **Figure 19**. The existing northbound left-turn from US 97 onto 61st Street should be maintained to accommodate the left-turning traffic at this location.

The benefit-cost analysis for Phase 2 is summarized in **Table 14.**

Figure 19 Aerial Image of US 97/61st Street

Table 14 Median-related Phase 2 Benefit-Cost Summary

Countermeasures	Project Cost ($)*	Project Benefit ($)	B/C Ratio
Median and J-Turn	$1,900,000	$2,500,000	1.4

Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
***Cost estimates assume a concrete barrier median type and J-turn treatment for a conservative analysis. Cost estimates exclude any right-of-way impacts or costs.*

Phase 3 Median-related Alternative

Phase 3 of the median-related alternative includes approximately 4.18 miles of median extending from 61st Street north to the Redmond City Limits. One U-turn opportunity should be provided for northbound traffic, and one should be provided for southbound traffic. The design of Phase 3 should further evaluate the placement of the U-turns. The northbound U-turn may need to be located south of the end of the median in order to fit the U-turn between driveways. If needed, the interchange at Yew Avenue can provide an alternate U-turn opportunity for residents and businesses located north of the last U-turn treatment.

The benefit-cost analysis for Phase 3 is summarized in **Table 15.**

Table 15 Median-related Phase 3 Benefit-Cost Summary

Countermeasures	Project Cost ($)*	Project Benefit ($)	B/C Ratio
Median and J-Turns	$4,300,000	$5,000,000	1.1

Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
***Cost estimates assume a concrete barrier median type and J-turn treatment for a conservative analysis. Cost estimates exclude any right-of-way impacts or costs.*

Phase 4 Median-related Alternative

Phase 4 of the median-related alternative includes approximately 1.35 miles of median extending from the Bend City Limits to approximately MP 132.04. One U-turn opportunity should be provided for northbound traffic, and one should be provided for southbound traffic. The design of the Phase 4 project should further evaluate the placement of the U-turns.

The benefit-cost analysis for Phase 4 is summarized in **Table 16.** The cost estimates include two J-turns, although future analysis may be needed to finalize the appropriate treatment.

Table 16 Median-related Phase 4 Benefit-Cost Summary

Countermeasures	Project Cost ($)*	Project Benefit ($)	B/C Ratio
Median and U-turns	$2,800,000	$1,900,000	0.7

Note: All costs presented are Present Value Costs ($) over the 20-year analysis period.
***Cost estimates assume a concrete barrier median type and J-turn treatment for a conservative analysis. Cost estimates exclude any right-of-way impacts or costs.*

Median-related Suggestions

Based on the four phases of median-related projects presented in this section, Phase 1 has the highest benefit-cost ratio and the smallest number of driveways impacted by the median. Phase 2 also has a small number of driveways impacted. Therefore, Phases 1 and 2 could be implemented together to minimize construction costs and the number of attenuators needed if a concrete barrier is installed. Kittelson recommends that this project be monitored by ODOT to determine the success of the project at reducing crashes, the reception of the project by the community, and the usage of the U-turn treatments by the public. Implementation of J-turns or other U-turn treatments should be accompanied with an educational campaign and signage to promote driver understanding and improve driver expectation.

Appendix A
Historical Crash Analysis

Project Name:	US 97 Bend-Redmond
Project Number:	22183
Query Information:	US 97 MP 124.4 - 133.39
Date queried:	2011-2016 (2016 preliminary)
Data Provider:	ODOT Crash Analysis Reporting Unit
Analyst:	AJG
Current Date:	5/17/2018
Text File Name:	

General Crash Information

Crash ID	Crash Month	Crash Day	Crash Year	Week Day Code	Crash Hour (Hour Starting)	County	Functional Class Code	Highway Number	Latitude Degrees	Longitude Degrees	Milepoint	Collision Type	Crash Severity	Weather Condition	Road Surface Condition	Light Condition	Highest_Severity
1409818	January	20	2011	Thursday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15626111	-121.2616972	130.48	Object or Other	Non-fatal injury crash	Clear	Dry	Daylight	Injury A
1410331	February	19	2011	Saturday	8:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12349167	-121.2854972	133.02	deswipe-meetir	Property damage only crash (PDO)	Snow	Ice	ness – no street	PDO
1410340	February	19	2011	Saturday	12:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656111	-121.2757167	132	eswipe-overtak	Property damage only crash (PDO)	Snow	Snow	Daylight	PDO
1410345	February	19	2011	Saturday	5:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13105278	-121.27985	132.43	Object or Other	Property damage only crash (PDO)	Snow	Snow	Dusk (Twilight)	PDO
1410347	February	19	2011	Saturday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656111	-121.2757167	132	Non-collision	Non-fatal injury crash	Snow	Ice	Daylight	Injury B
1410416	February	23	2011	Wednesday	9:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.194275	-121.2338597	127.49	Head-On	Property damage only crash (PDO)	Clear	Ice	ness – no street	PDO
1412860	March	30	2011	Wednesday	8:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16225278	-121.2575778	130	Rear-End	Non-fatal injury crash	Clear	Dry	Dusk (Twilight)	Injury C
1412883	March	30	2011	Wednesday	7:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15756389	-121.2607917	130.38	deswipe-meetir	Non-fatal injury crash	Cloudy	Dry	ness – no street	Injury B
1412892	March	30	2011	Wednesday	8:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14948889	-121.2664	131	Rear-End	Property damage only crash (PDO)	Clear	Dry	Dusk (Twilight)	PDO
1416755	April	20	2011	Wednesday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18785	-121.2388556	128	urning Moveme	Non-fatal injury crash	Clear	Dry	Dawn (Twilight)	Injury A
1420375	April	25	2011	Monday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15990833	-121.2591611	130.18	Head-On	Non-fatal injury crash	Cloudy	Snow	Daylight	Injury A
1422337	May	30	2011	Monday	1:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656111	-121.2757167	132	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1422433	May	2	2011	Monday	1:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12323333	-121.2856972	133.04	urning Moveme	Non-fatal injury crash	Clear	Dry	Daylight	Injury C
1426990	June	28	2011	Tuesday	11:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22587222	-121.2092167	125	Miscellaneous	Property damage only crash (PDO)	Unknown	Unknown	Daylight	PDO
1427596	June	9	2011	Thursday	6:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12220556	-121.2864917	133.12	Pedestrian	Non-fatal injury crash	Clear	Dry	Daylight	Injury A
1427861	June	11	2011	Saturday	Jnknown Tim	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15951667	-121.2594333	130.23	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1428227	June	10	2011	Friday	4:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18076389	-121.2442722	128.56	Rear-End	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1433092	July	7	2011	Thursday	1:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18368	-121.2420583	128.33	Rear-End	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1440822	August	12	2011	Friday	9:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16003889	-121.2590722	130.17	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1441779	September	22	2011	Thursday	8:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13400389	-121.2776472	132.2	Rear-End	Non-fatal injury crash	Clear	Dry	Daylight	Injury B
1441842	September	27	2011	Tuesday	9:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.20437222	-121.2260194	126.7	Rear-End	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1442522	October	30	2011	Sunday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18785	-121.2388556	128	Rear-End	Non-fatal injury crash	Clear	Dry	ness – no street	Injury B
1443463	November	28	2011	Monday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656111	-121.2757167	132	Animal	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1456758	February	27	2012	Monday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.2005275	-121.2289917	127	Rear-End	Non-fatal injury crash	Clear	Ice	Daylight	Injury C
1457984	February	27	2012	Monday	11:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14296667	-121.2709056	131.5	deswipe-meetir	Non-fatal injury crash	Snow	Ice	Daylight	Injury C
1457998	February	29	2012	Wednesday	7:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15756944	-121.2607889	130.38	Object or Other	Non-fatal injury crash	Cloudy	Snow	Daylight	Injury C
1458069	February	29	2012	Wednesday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15368056	-121.2634917	130.68	Non-collision	Property damage only crash (PDO)	Cloudy	Ice	ness – no street	PDO
1458079	February	29	2012	Wednesday	7:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15731389	-121.2609639	130.4	deswipe-meetir	Non-fatal injury crash	Snow	Ice	Daylight	Injury C
1465764	March	22	2012	Thursday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656667	-121.2757139	132	deswipe-meetir	Non-fatal injury crash	Clear	Ice	ness – no street	Injury B
1465826	March	22	2012	Thursday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16641111	-121.2547194	129.68	deswipe-meetir	Property damage only crash (PDO)	Clear	Ice	ness – no street	PDO
1467626	April	4	2012	Wednesday	Jnknown Tim	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18101667	-121.2440778	128.54	Non-collision	Non-fatal injury crash	Cloudy	Ice	ness – no street	Injury C
1469492	May	7	2012	Monday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14949167	-121.2664	131	Rear-End	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1475437	June	4	2012	Monday	2:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656944	-121.2757111	132	Object or Other	Fatal crash	Rain	Wet	ness – no street	Fatal
1476997	July	21	2012	Saturday	4:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12195	-121.2866861	133.14	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1481688	September	20	2012	Thursday	8:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14543889	-121.2691881	131.31	Rear-End	Non-fatal injury crash	Clear	Dry	ness – no street	Injury A
1484308	July	22	2012	Sunday	9:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21952778	-121.2142139	125.5	Object or Other	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1493590	November	11	2012	Sunday	6:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21061111	-121.221125	126.2	Object or Other	Property damage only crash (PDO)	Cloudy	Dry	Dusk (Twilight)	PDO
1493854	November	16	2012	Friday	11:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22587778	-121.2092111	125	Rear-End	Non-fatal injury crash	Cloudy	Dry	ness – no street	Injury A
1495437	December	16	2012	Sunday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18785	-121.2388528	128	Object or Other	Non-fatal injury crash	Cloudy	Ice	Daylight	Injury C
1495730	December	26	2012	Wednesday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18785	-121.2388528	128	deswipe-meetir	Property damage only crash (PDO)	Cloudy	Ice	Daylight	PDO
1512290	March	8	2013	Friday	6:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.20936944	-121.2221	126.3	deswipe-meetir	Property damage only crash (PDO)	Snow	Ice	Daylight	PDO
1512574	March	22	2013	Friday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.181525	-121.2436944	128.5	Object or Other	Non-fatal injury crash	Snow	Ice	ness – no street	Injury B
1520622	May	18	2013	Saturday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18177778	-121.2435	128.48	urning Moveme	Non-fatal injury crash	Clear	Dry	Daylight	Injury B
1521039	May	29	2013	Wednesday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16225278	-121.2575778	130	Rear-End	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1523131	June	10	2013	Monday	12:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.19652778	-121.2320361	127.31	Rear-End	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1528780	July	9	2013	Tuesday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.23186389	-121.2034389	124.5	Pedestrian	Non-fatal injury crash	Clear	Dry	Daylight	Injury B
1531824	July	24	2013	Wednesday	6:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.175225	-121.2486389	129	urning Moveme	Non-fatal injury crash	Clear	Dry	Daylight	Injury B
1537832	October	2	2013	Wednesday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21315833	-121.2191514	126	Object or Other	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1537836	October	5	2013	Saturday	5:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13015556	-121.2805139	132.5	Non-collision	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1537840	October	26	2013	Saturday	1:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.2005275	-121.2289917	127	Non-collision	Non-fatal injury crash	Clear	Dry	ness – no street	Injury B
1540467	November	8	2013	Friday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.23234167	-121.2029722	124.46	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1540483	November	19	2013	Tuesday	4:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12336111	-121.2855975	133.03	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1540590	October	18	2013	Friday	7:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21315833	-121.2191514	126	Rear-End	Non-fatal injury crash	Clear	Dry	ness – no street	Injury C
1540928	November	27	2013	Wednesday	5:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13066667	-121.2801361	132.46	eswipe-overtak	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1541291	December	2	2013	Monday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21315833	-121.2191514	126	Non-collision	Non-fatal injury crash	Rain	Wet	Daylight	Injury C
1541306	December	3	2013	Tuesday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656667	-121.2757111	132	Miscellaneous	Property damage only crash (PDO)	Cloudy	Snow	Daylight	PDO
1550500	January	23	2014	Thursday	4:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13143889	-121.2795639	132.4	Object or Other	Property damage only crash (PDO)	Fog	Ice	ness – no street	PDO
1550558	January	28	2014	Tuesday	6:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22948056	-121.205775	124.7	urning Moveme	Non-fatal injury crash	Rain	Wet	ness – no street	Injury C
1550560	January	28	2014	Tuesday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16225278	-121.2575778	130	deswipe-meetir	Property damage only crash (PDO)	Rain	Ice	Daylight	PDO
1553187	February	4	2014	Tuesday	4:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21061111	-121.221125	126.2	Object or Other	Property damage only crash (PDO)	Cloudy	Ice	ness – no street	PDO
1553189	February	4	2014	Tuesday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22587222	-121.2092167	125	Object or Other	Property damage only crash (PDO)	Snow	Snow	Daylight	PDO
1553233	February	14	2014	Friday	2:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18076389	-121.2442722	128.56	Rear-End	Non-fatal injury crash	Rain	Wet	Daylight	Injury B
1553424	February	3	2014	Monday	4:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14948889	-121.2664	131	Non-collision	Non-fatal injury crash	Cloudy	Ice	ness – no street	Injury B
1553426	February	3	2014	Monday	6:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21315833	-121.2191508	126	Object or Other	Property damage only crash (PDO)	Snow	Snow	Dawn (Twilight)	PDO

1553455	February	3	2014	Monday	4:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656111	-121.2757167	132	Object or Other-	Property damage only crash (PDO)	Snow	Ice	ness – no street	PDO
1553461	February	7	2014	Friday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.175225	-121.2486389	129	Object or Other-	Property damage only crash (PDO)	Snow	Ice	Daylight	PDO
1553632	February	9	2014	Sunday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16225278	-121.2575778	130	deswipe-meetin	Property damage only crash (PDO)	Clear	Ice	Daylight	PDO
1553666	February	9	2014	Sunday	12:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14948889	-121.2664	131	deswipe-meetin	Non-fatal injury crash	Clear	Snow	Daylight	Injury C
1553669	February	7	2014	Friday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15834444	-121.2602472	130.32	deswipe-meetin	Non-fatal injury crash	Snow	Ice	Daylight	Injury B
1553671	February	7	2014	Friday	4:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15990833	-121.2591611	130.18	Rear-End	Property damage only crash (PDO)	Snow	Ice	Daylight	PDO
1559871	March	8	2014	Saturday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.19339167	-121.2345447	127.56	Non-collision	Property damage only crash (PDO)	Cloudy	Dry	Daylight	PDO
1559901	March	11	2014	Tuesday	12:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.23186667	-121.2034389	124.5	Rear-End	Non-fatal injury crash	Clear	Dry	Daylight	Injury C
1560009	February	7	2014	Friday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.2005225	-121.2289972	127	Object or Other-	Non-fatal injury crash	Snow	Ice	Daylight	Injury C
1562061	April	2	2014	Wednesday	2:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21315833	-121.2191508	126	Non-collision	Property damage only crash (PDO)	Rain	Ice	ness – no street	PDO
1562165	April	11	2014	Friday	4:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.2005225	-121.2289972	127	Rear-End	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1566561	May	16	2014	Friday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18051389	-121.2444639	128.58	urning Moveme	Non-fatal injury crash	Clear	Dry	Daylight	Injury A
1573472	June	6	2014	Friday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14948889	-121.2664028	131	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1580206	July	25	2014	Friday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18785	-121.2388556	128	Rear-End	Non-fatal injury crash	Clear	Dry	Daylight	Injury C
1580219	July	27	2014	Sunday	10:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16225278	-121.2575778	130	Miscellaneous	Non-fatal injury crash	Clear	Dry	ness – no street	Injury C
1580934	September	26	2014	Friday	7:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.19339444	-121.2345444	127.56	Object or Other-	Fatal crash	Clear	Dry	Dusk (Twilight)	Fatal
1585186	July	25	2014	Friday	1:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.20052222	-121.2289972	127	Object or Other-	Non-fatal injury crash	Clear	Dry	Daylight	Injury B
1585486	August	14	2014	Thursday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18785	-121.2388556	128	Rear-End	Property damage only crash (PDO)	Cloudy	Dry	Daylight	PDO
1597205	October	27	2014	Monday	9:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15365833	-121.2635111	130.68	eswipe-overtak	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1598287	November	3	2014	Monday	4:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12375	-121.2852972	133	urning Moveme	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1598681	November	13	2014	Thursday	4:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15691389	-121.2612444	130.43	Head-On	Property damage only crash (PDO)	Snow	Snow	Dusk (Twilight)	PDO
1598758	November	15	2014	Saturday	10:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.130925	-121.2799472	132.44	Rear-End	Property damage only crash (PDO)	Sleet	Ice	Daylight	PDO
1598768	November	15	2014	Saturday	11:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13118333	-121.2797556	132.42	Head-On	Property damage only crash (PDO)	Sleet	Ice	Daylight	PDO
1598869	November	18	2014	Tuesday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18051389	-121.2444639	128.55	Rear-End	Non-fatal injury crash	Clear	Ice	ness – no street	Injury C
1599255	December	1	2014	Monday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.20052222	-121.2289972	127	deswipe-meetin	Non-fatal injury crash	Sleet	Ice	Daylight	Injury C
1599270	December	1	2014	Monday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.20052222	-121.2289972	127	eswipe-overtak	Property damage only crash (PDO)	Rain	Ice	Daylight	PDO
1599317	December	3	2014	Wednesday	6:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.175225	-121.2486417	129	Non-collision	Non-fatal injury crash	Rain	Ice	ness – no street	Injury B
1599598	December	15	2014	Monday	6:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13656389	-121.2757167	132	eswipe-overtak	Non-fatal injury crash	Cloudy	Ice	ness – no street	Injury C
1599710	November	27	2014	Thursday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15860833	-121.2600667	130.3	Miscellaneous	Property damage only crash (PDO)	Rain	Wet	Daylight	PDO
1599874	December	24	2014	Wednesday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14948889	-121.2664028	131	Object or Other-	Property damage only crash (PDO)	Snow	Ice	Daylight	PDO
1599893	December	24	2014	Wednesday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.14688056	-121.2681972	131.2	Head-On	Non-fatal injury crash	Clear	Ice	ness – no street	Injury B
1599910	December	25	2014	Thursday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18380556	-121.2419611	128.32	Rear-End	Non-fatal injury crash	Cloudy	Ice	ness – no street	Injury B
1599990	December	16	2014	Tuesday	5:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15834722	-121.26025	130.32	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1600050	December	29	2014	Monday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22587222	-121.2092167	125	deswipe-meetin	Property damage only crash (PDO)	Snow	Ice	Daylight	PDO
1600060	December	29	2014	Monday	1:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22207778	-121.2122389	125.3	Head-On	Non-fatal injury crash	Clear	Ice	Daylight	Injury C
1600062	December	29	2014	Monday	4:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18659167	-121.2398389	128.1	deswipe-meetin	Property damage only crash (PDO)	Snow	Ice	Daylight	PDO
1600075	December	29	2014	Monday	6:00 AM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12285	-121.2859972	133.07	deswipe-meetin	Non-fatal injury crash	Snow	Ice	ness – no street	Injury C
1607197	January	1	2015	Thursday	2:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.17418889	-121.2493611	129.08	Object or Other-	Non-fatal injury crash	Clear	Ice	ness – no street	Injury B
1616429	May	6	2015	Wednesday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.19364722	-121.23435	127.54	Head-On	Non-fatal injury crash	Sleet	Snow	Daylight	Injury B
1616434	May	6	2015	Wednesday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15626389	-121.2617	130.48	Rear-End	Non-fatal injury crash	Cloudy	Dry	Daylight	Injury C
1619026	June	30	2015	Tuesday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21698333	-121.2161889	125.7	Object or Other-	Non-fatal injury crash	Clear	Dry	Daylight	Injury C
1620485	August	4	2015	Tuesday	4:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21379722	-121.2186583	125.95	Head-On	Non-fatal injury crash	Clear	Dry	Daylight	Injury A
1620538	August	4	2015	Tuesday	10:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.22500556	-121.2099639	125.07	urning Moveme	Non-fatal injury crash	Clear	Dry	Daylight	Injury B
1624972	September	22	2015	Tuesday	2:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18051389	-121.2444639	128.58	Rear-End	Non-fatal injury crash	Clear	Dry	Daylight	Injury C
1626489	November	16	2015	Monday	5:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12220556	-121.2864944	133.12	Miscellaneous	Non-fatal injury crash	Clear	Dry	ness – no street	Injury C
1626945	November	29	2015	Sunday	1:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12387778	-121.2852028	132.99	deswipe-meetin	Non-fatal injury crash	Snow	Ice	Daylight	Injury A
1626951	November	29	2015	Sunday	1:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.1299	-121.2807083	132.52	Rear-End	Non-fatal injury crash	Clear	Ice	Daylight	Injury C
1626953	November	29	2015	Sunday	2:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15704444	-121.2611556	130.42	Rear-End	Non-fatal injury crash	Clear	Ice	Daylight	Injury C
1627208	August	24	2015	Monday	4:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13169722	-121.2793722	132.38	Rear-End	Non-fatal injury crash	Clear	Dry	Daylight	Injury C
1631406	January	21	2015	Wednesday	3:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12400556	-121.2851111	132.98	deswipe-meetin	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1632824	March	29	2015	Sunday	8:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18216111	-121.2432139	128.45	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1639418	June	26	2015	Friday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15144444	-121.2650472	130.85	Rear-End	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1639423	June	26	2015	Friday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18051389	-121.2444639	128.58	urning Moveme	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1641100	August	27	2015	Thursday	8:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.17289167	-121.25025	129.18	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	Daylight	PDO
1641306	September	12	2015	Saturday	5:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.19627222	-121.2322361	127.33	eswipe-overtak	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1642919	November	27	2015	Friday	3:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.12220556	-121.2864944	133.12	Head-On	Property damage only crash (PDO)	Cloudy	Ice	Daylight	PDO
1642965	November	26	2015	Thursday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.21188611	-121.2201389	126.1	Head-On	Property damage only crash (PDO)	Clear	Ice	Daylight	PDO
1642988	November	27	2015	Friday	1:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15912778	-121.2597056	130.26	Object or Other-	Property damage only crash (PDO)	Clear	Ice	Daylight	PDO
1642994	November	27	2015	Friday	3:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.13169722	-121.2793722	132.38	Head-On	Property damage only crash (PDO)	Clear	Ice	Daylight	PDO
1643142	November	28	2015	Saturday	9:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.16095	-121.2584583	130.1	Object or Other-	Property damage only crash (PDO)	Clear	Ice	Daylight	PDO
1643217	November	29	2015	Sunday	2:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.15365833	-121.2635111	130.68	Rear-End	Property damage only crash (PDO)	Clear	Ice	Daylight	PDO
1643310	November	29	2015	Sunday	3:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.1603	-121.2588972	130.15	Rear-End	Property damage only crash (PDO)	Cloudy	Ice	Daylight	PDO
1643464	December	9	2015	Wednesday	11:00 PM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.18001389	-121.2448722	128.62	Miscellaneous	Property damage only crash (PDO)	Clear	Dry	ness – no street	PDO
1644030	December	31	2015	Thursday	6:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.23091389	-121.204375	124.58	urning Moveme	Property damage only crash (PDO)	Cloudy	Snow	ness – no street	PDO
1644032	December	31	2015	Thursday	6:00 PM	Deschutes	Urban Principal Arterial – Other	he Dalles - Californ	44.23091389	-121.204375	124.58	Rear-End	Property damage only crash (PDO)	Cloudy	Snow	ness – no street	PDO
1644037	December	30	2015	Wednesday	6:00 AM	Deschutes	Rural Principal Arterial – Other	he Dalles - Californ	44.13630833	-121.2759111	132.02	Non-collision	Property damage only crash (PDO)	Snow	Ice	ness – no street	PDO

Appendix B
Countermeasure Crash Modification Factors (CMFs)

Reference ID	Project ID	Site	Future No Build Expected Crashes (Total Crashes/Year)	Alternative	Countermeasures	Proportion of CMF Target Crash Type	CMF Average
S1	1.02	Redmond City Limits to Quarry Ln	5.90	1	Inlaid Raised Pavement Markers	55%	92%
S1	1.03	Redmond City Limits to Quarry Ln	5.90	M3	Median	100%	87%
S1	1.04	Redmond City Limits to Quarry Ln	5.90	4	Increase clear zone (Reduce RHR from 2 to 1)	100%	94%
I1	2.01	Quarry Ln	0.54	1	Increase Sight Distance	30%	86%
I1	2.02	Quarry Ln	0.54	1	Intersection lighting	45%	83%
I1	2.03	Quarry Ln	0.54	4	Deceleration Lane	100%	93%
I1	2.04	Quarry Ln	0.54	M3	Restrict left turns, provide J-Turn for NB & SB	100%	65%
I1	2.05	Quarry Ln	0.54	1	Median on minor street approach	100%	75%
S2	3.00	Quarry Ln to 61st Street	8.02	1	Inlaid Raised Pavement Markers	55%	92%
S2	3.01	Quarry Ln to 61st Street	8.02	M3	Median - Jersey Barrier	100%	87%
S2	3.03	Quarry Ln to 61st Street	8.02	4	Segment Lighting	30%	92%
S2	3.04	Quarry Ln to 61st Street	8.02	4	Increase clear zone (Reduce RHR from 2 to 1)	100%	94%
I2	4.00	61st Street	1.12	4	Accel Lane(s)	100%	89%
I2	4.01	61st Street	1.12	4	Decel Lane(s)	100%	93%
I2	4.02	61st Street	1.12	1	Intersection lighting	45%	83%
I2	4.03	61st Street	1.12	1	Median on minor street approach	100%	75%
I2	4.04	61st Street	1.12	M2	Restrict left turns, provide J-Turn for NB	100%	65%
S3	5.00	61st Street to Deschutes Jct.	4.75	1	Inlaid Raised Pavement Markers	55%	92%
S3	5.01	61st Street to Deschutes Jct.	4.75	M2	Median - Jersey Barrier	100%	87%
S3	5.03	61st Street to Deschutes Jct.	4.75	4	Increase clear zone (Reduce RHR from 2 to 1)	100%	94%
I3	6.02	Deschutes Jct.	0.75	1	Restripe Merge	100%	98%
S4	7.00	Deschutes Jct. to Ft Thompson Ln	7.30	1	Inlaid Raised Pavement Markers	55%	92%
S4-ph1	7.04	Deschutes Jct. to Ft Thompson Ln - PHASE 1 (MP 130.23 - 132.04)	6.54	M1	Median - Jersey Barrier	100%	87%
S4-ph4	7.06	Deschutes Jct. to Ft Thompson Ln - PHASE 4 (MP 132.29 - 132.04)	0.55	M4	Median - Jersey Barrier	100%	87%
S4	7.03	Deschutes Jct. to Ft Thompson Ln	7.30	4	Increase clear zone (Reduce RHR from 2 to 1)	100%	94%
I4	8.00	Ft Thompson Ln	0.86	4	Intersection lighting	45%	83%
I4	8.01	Ft Thompson Ln	0.86	4	Median on minor street approach	100%	75%
I4	8.02	Ft Thompson Ln	0.86	M4	Restrict left turns, provide J-Turn for SB & NB	100%	65%
S5	9.01	Ft Thompson Ln to Bend City Limits	2.94	1	Inlaid Raised Pavement Markers	55%	92%
S5	9.02	Ft Thompson Ln to Bend City Limits	2.94	M4	Median - Jersey Barrier	100%	87%
S5	9.03	Ft Thompson Ln to Bend City Limits	2.94	4	Segment Lighting	30%	92%
S5	9.04	Ft Thompson Ln to Bend City Limits	2.94	4	Increase clear zone (Reduce RHR from 2 to 1)	100%	94%

Appendix C
No-Build
Crash Prediction Analyses

Worksheet 2A -- General Information and Input Data for Rural Multilane Highway Intersections			
General Information		**Location Information**	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Intersection	Intersection at MP 126.2 (Quarry)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		**Base Conditions**	**Site Conditions**
Intersection type (3ST, 4ST, 4SG)		--	3ST
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ = 78,300 (veh/day)	--	30,000
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ = 23,000 (veh/day)	--	350
Intersection skew angle (degrees)		0	29
Number of non-STOP-controlled approaches with left-turn lanes (0, 1, 2)		0	0
Number of non-STOP-controlled approaches with right-turn lanes (0, 1, 2, 3, or 4)		0	0
Intersection lighting (present/not present)		Not Present	Not Present
Calibration Factor, C_i		1.00	0.15

Worksheet 2B -- Crash Modification Factors for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)
Crash Severity Level	CMF for Intersection Skew Angle (CMF_{1i}) from Equations 11-18 or 11-20 and 11-19 or 11-21	CMF for Left-Turn Lanes (CMF_{2i}) from Table 11-22	CMF for Right-Turn Lanes (CMF_{3i}) from Table 11-23	CMF for Lighting (CMF_{4i}) from Equation 11-22	Combined CMF (CMF_{COMB}) (2)*(3)*(4)*(5)
Total	1.08	1.00	1.00	1.00	1.08
Fatal and Injury (FI)	1.09	1.00	1.00	1.00	1.09

Note: The 4-leg Signalized Intersection (4SG) models do not have base conditions and so can only be used for estimation purposes. As a result, there are not CMFs provided for the 4SG condition.

Worksheet 2C -- Intersection Crashes for Rural Multilane Highway Intersections

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-7 or 11-8			**$N_{spf\ int}$**	**Overdispersion Parameter, k**	**Combined CMFs** from (6) of Worksheet 2B	**Calibration Factor, C_i**	**Predicted average crash frequency, $N_{predicted\ int}$**
	a	b	c or d (4SG)	from Equation 11-11 or 11-12	from Table 11-7 or 11-8			(3)*(5)*(6)
Total	-12.526	1.204	0.236	3.555	0.460	1.08	0.15	0.577
Fatal and Injury (FI)	-12.664	1.107	0.272	1.407	0.569	1.09	0.15	0.230
Fatal and Injury[a] (FI[a])	-11.989	1.013	0.228	0.810	0.566	1.09	0.15	0.133
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 0.347

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2D -- Crashes by Severity Level and Collision Type for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision Type$_{(TOTAL)}$**	**$N_{predicted\ int\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision Type$_{(FI)}$**	**$N_{predicted\ int\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ int}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ int\ (PDO)}$ (crashes/year)**
	from Table 11-9	$(7)_{TOTAL}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}$[a] from Worksheet 2C	from Table 11-9	$(7)_{PDO}$ from Worksheet 2C
Total	0.999	0.577	1.000	0.230	1.001	0.133	1.001	0.347
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$ [a]		$(8)*(9)_{PDO}$
Head-on collision	0.007	0.004	0.009	0.002	0.014	0.002	0.004	0.001
Sideswipe collision	0.010	0.006	0.009	0.002	0.010	0.001	0.013	0.005
Rear-end collision	0.245	0.141	0.264	0.061	0.167	0.022	0.217	0.075
Angle collision	0.045	0.026	0.070	0.016	0.076	0.010	0.017	0.006
Single-vehicle collision	0.119	0.069	0.117	0.027	0.129	0.017	0.121	0.042
Other collision	0.573	0.331	0.531	0.122	0.605	0.080	0.629	0.218

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2E -- Summary Results for Rural Multilane Highway Intersections

(1)	(2)
Crash severity level	**Predicted average crash frequency (crashes / year)**
	(7) from Worksheet 2C
Total	0.6
Fatal and Injury (FI)	0.2
Fatal and Injury[a] (FI[a])	0.1
Property Damage Only (PDO)	0.3

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2A -- General Information and Input Data for Rural Multilane Highway Intersections

General Information		Location Information	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Intersection	Intersection at MP 128.58 (61st/Gift)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Intersection type (3ST, 4ST, 4SG)		--	3ST
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ = 78,300 (veh/day)	--	30,000
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ = 23,000 (veh/day)	--	3,100
Intersection skew angle (degrees)		0	3
Number of non-STOP-controlled approaches with left-turn lanes (0, 1, 2)		0	0
Number of non-STOP-controlled approaches with right-turn lanes (0, 1, 2, 3, or 4)		0	0
Intersection lighting (present/not present)		Not Present	Not Present
Calibration Factor, C_i		1.00	0.15

Worksheet 2B -- Crash Modification Factors for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)
Crash Severity Level	CMF for Intersection Skew Angle (CMF_{1i}) from Equations 11-18 or 11-20 and 11-19 or 11-21	CMF for Left-Turn Lanes (CMF_{2i}) from Table 11-22	CMF for Right-Turn Lanes (CMF_{3i}) from Table 11-23	CMF for Lighting (CMF_{4i}) from Equation 11-22	Combined CMF (CMF_{COMB}) (2)*(3)*(4)*(5)
Total	1.03	1.00	1.00	1.00	1.03
Fatal and Injury (FI)	1.05	1.00	1.00	1.00	1.05

Note: The 4-leg Signalized Intersection (4SG) models do not have base conditions and so can only be used for estimation purposes. As a result, there are not CMFs provided for the 4SG condition.

Worksheet 2C -- Intersection Crashes for Rural Multilane Highway Intersections

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-7 or 11-8			**$N_{spf\ int}$**	**Overdispersion Parameter, k**	**Combined CMFs**	**Calibration Factor, C_i**	**Predicted average crash frequency, $N_{predicted\ int}$**
	a	b	c or d (4SG)	from Equation 11-11 or 11-12	from Table 11-7 or 11-8	from (6) of Worksheet 2B		(3)*(5)*(6)
Total	-12.526	1.204	0.236	5.949	0.460	1.03	0.15	0.922
Fatal and Injury (FI)	-12.664	1.107	0.272	2.546	0.569	1.05	0.15	0.401
Fatal and Injury[a] (FI[a])	-11.989	1.013	0.228	1.332	0.566	1.05	0.15	0.210
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 0.521

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2D -- Crashes by Severity Level and Collision Type for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision Type$_{(TOTAL)}$**	**$N_{predicted\ int\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision Type$_{(FI)}$**	**$N_{predicted\ int\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ int}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ int\ (PDO)}$ (crashes/year)**
	from Table 11-9	$(7)_{TOTAL}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}$[a] from Worksheet 2C	from Table 11-9	$(7)_{PDO}$ from Worksheet 2C
Total	0.999	0.922	1.000	0.401	1.001	0.210	1.001	0.521
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$[a]		$(8)*(9)_{PDO}$
Head-on collision	0.007	0.006	0.009	0.004	0.014	0.003	0.004	0.002
Sideswipe collision	0.010	0.009	0.009	0.004	0.010	0.002	0.013	0.007
Rear-end collision	0.245	0.226	0.264	0.106	0.167	0.035	0.217	0.113
Angle collision	0.045	0.041	0.070	0.028	0.076	0.016	0.017	0.009
Single-vehicle collision	0.119	0.110	0.117	0.047	0.129	0.027	0.121	0.063
Other collision	0.573	0.528	0.531	0.213	0.605	0.127	0.629	0.328

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2E -- Summary Results for Rural Multilane Highway Intersections

(1)	(2)
Crash severity level	**Predicted average crash frequency (crashes / year)** (7) from Worksheet 2C
Total	0.9
Fatal and Injury (FI)	0.4
Fatal and Injury[a] (FI[a])	0.2
Property Damage Only (PDO)	0.5

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2A -- General Information and Input Data for Rural Multilane Highway Intersections

General Information		Location Information	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Intersection	Intersection at MP 130.18 (Deschutes Jct)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Intersection type (3ST, 4ST, 4SG)		--	3ST
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ = 78,300 (veh/day)	--	25,200
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ = 23,000 (veh/day)	--	4,000
Intersection skew angle (degrees)		0	23
Number of non-STOP-controlled approaches with left-turn lanes (0, 1, 2)		0	0
Number of non-STOP-controlled approaches with right-turn lanes (0, 1, 2, 3, or 4)		0	0
Intersection lighting (present/not present)		Not Present	Not Present
Calibration Factor, C_i		1.00	0.15

Worksheet 2B -- Crash Modification Factors for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)
Crash Severity Level	CMF for Intersection Skew Angle (CMF_{1i}) from Equations 11-18 or 11-20 and 11-19 or 11-21	CMF for Left-Turn Lanes (CMF_{2i}) from Table 11-22	CMF for Right-Turn Lanes (CMF_{3i}) from Table 11-23	CMF for Lighting (CMF_{4i}) from Equation 11-22	Combined CMF (CMF_{COMB}) (2)*(3)*(4)*(5)
Total	1.08	1.00	1.00	1.00	1.08
Fatal and Injury (FI)	1.09	1.00	1.00	1.00	1.09

Note: The 4-leg Signalized Intersection (4SG) models do not have base conditions and so can only be used for estimation purposes. As a result, there are not CMFs provided for the 4SG condition.

Worksheet 2C -- Intersection Crashes for Rural Multilane Highway Intersections

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-7 or 11-8			**$N_{spf\ int}$**	**Overdispersion Parameter, k**	**Combined CMFs** from (6) of Worksheet 2B	**Calibration Factor, C_i**	**Predicted average crash frequency, $N_{predicted\ int}$**
	a	b	c or d (4SG)	from Equation 11-11 or 11-12	from Table 11-7 or 11-8			(3)*(5)*(6)
Total	-12.526	1.204	0.236	5.122	0.460	1.08	0.15	0.829
Fatal and Injury (FI)	-12.664	1.107	0.272	2.250	0.569	1.09	0.15	0.367
Fatal and Injury[a] (FI^a)	-11.989	1.013	0.228	1.183	0.566	1.09	0.15	0.193
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 0.462

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2D -- Crashes by Severity Level and Collision Type for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision Type$_{(TOTAL)}$**	**$N_{predicted\ int\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision Type$_{(FI)}$**	**$N_{predicted\ int\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI^a)**	**$N_{predicted\ int}$ (FI^a) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ int\ (PDO)}$ (crashes/year)**
	from Table 11-9	$(7)_{TOTAL}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}^{a}$ from Worksheet 2C	from Table 11-9	$(7)_{PDO}$ from Worksheet 2C
Total	0.999	0.829	1.000	0.367	1.001	0.193	1.001	0.462
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}^{a}$		$(8)*(9)_{PDO}$
Head-on collision	0.007	0.006	0.009	0.003	0.014	0.003	0.004	0.002
Sideswipe collision	0.010	0.008	0.009	0.003	0.010	0.002	0.013	0.006
Rear-end collision	0.245	0.203	0.264	0.097	0.167	0.032	0.217	0.100
Angle collision	0.045	0.037	0.070	0.026	0.076	0.015	0.017	0.008
Single-vehicle collision	0.119	0.099	0.117	0.043	0.129	0.025	0.121	0.056
Other collision	0.573	0.475	0.531	0.195	0.605	0.117	0.629	0.290

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2E -- Summary Results for Rural Multilane Highway Intersections

(1)	(2)
Crash severity level	**Predicted average crash frequency (crashes / year)**
	(7) from Worksheet 2C
Total	0.8
Fatal and Injury (FI)	0.4
Fatal and Injury[a] (FI^a)	0.2
Property Damage Only (PDO)	0.5

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2A -- General Information and Input Data for Rural Multilane Highway Intersections			
General Information		**Location Information**	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Intersection	Intersection at MP 132.44 (Ft Thompson)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		**Base Conditions**	**Site Conditions**
Intersection type (3ST, 4ST, 4SG)		--	4ST
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ = 78,300 (veh/day)	--	25,200
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ = 7,400 (veh/day)	--	100
Intersection skew angle (degrees)		0	12
Number of non-STOP-controlled approaches with left-turn lanes (0, 1, 2)		0	0
Number of non-STOP-controlled approaches with right-turn lanes (0, 1, 2, 3, or 4)		0	0
Intersection lighting (present/not present)		Not Present	Not Present
Calibration Factor, C_i		1.00	0.39

Worksheet 2B -- Crash Modification Factors for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)
Crash Severity Level	CMF for Intersection Skew Angle (CMF_{1i}) from Equations 11-18 or 11-20 and 11-19 or 11-21	CMF for Left-Turn Lanes (CMF_{2i}) from Table 11-22	CMF for Right-Turn Lanes (CMF_{3i}) from Table 11-23	CMF for Lighting (CMF_{4i}) from Equation 11-22	Combined CMF (CMF_{COMB}) (2)*(3)*(4)*(5)
Total	1.08	1.00	1.00	1.00	1.08
Fatal and Injury (FI)	1.09	1.00	1.00	1.00	1.09

Note: The 4-leg Signalized Intersection (4SG) models do not have base conditions and so can only be used for estimation purposes. As a result, there are not CMFs provided for the 4SG condition.

Worksheet 2C -- Intersection Crashes for Rural Multilane Highway Intersections

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-7 or 11-8			**$N_{spf\ int}$**	**Overdispersion Parameter, k**	**Combined CMFs** from (6) of Worksheet 2B	**Calibration Factor, C_i**	**Predicted average crash frequency, $N_{predicted\ int}$**
	a	b	c or d (4SG)	from Equation 11-11 or 11-12	from Table 11-7 or 11-8			(3)*(5)*(6)
Total	-10.008	0.848	0.448	1.914	0.494	1.08	0.39	0.807
Fatal and Injury (FI)	-11.554	0.888	0.525	0.872	0.742	1.09	0.39	0.370
Fatal and Injury[a] (FI^a)	-10.734	0.828	0.412	0.641	0.655	1.09	0.39	0.272
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 0.437

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2D -- Crashes by Severity Level and Collision Type for Rural Multilane Highway Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision Type$_{(TOTAL)}$**	**$N_{predicted\ int\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision Type$_{(FI)}$**	**$N_{predicted\ int\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI^a)**	**$N_{predicted\ int}$ (FI^a) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ int\ (PDO)}$ (crashes/year)**
	from Table 11-9	$(7)_{TOTAL}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}$ from Worksheet 2C	from Table 11-9	$(7)_{FI}^{a}$ from Worksheet 2C	from Table 11-9	$(7)_{PDO}$ from Worksheet 2C
Total	1.000	0.807	1.000	0.370	1.001	0.272	1.001	0.437
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}^{a}$		$(8)*(9)_{PDO}$
Head-on collision	0.005	0.004	0.008	0.003	0.014	0.004	0.000	0.000
Sideswipe collision	0.009	0.007	0.006	0.002	0.005	0.001	0.015	0.007
Rear-end collision	0.149	0.120	0.152	0.056	0.086	0.023	0.146	0.064
Angle collision	0.380	0.307	0.427	0.158	0.466	0.127	0.318	0.139
Single-vehicle collision	0.055	0.044	0.052	0.019	0.054	0.015	0.058	0.025
Other collision	0.402	0.325	0.355	0.131	0.376	0.102	0.464	0.203

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 2E -- Summary Results for Rural Multilane Highway Intersections

(1)	(2)
Crash severity level	**Predicted average crash frequency (crashes / year)**
	(7) from Worksheet 2C
Total	0.8
Fatal and Injury (FI)	0.4
Fatal and Injury[a] (FI^a)	0.3
Property Damage Only (PDO)	0.4

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1A -- General Information and Input Data for Rural Multilane Roadway Segments			
General Information		**Location Information**	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Roadway Section	MP 124.4 to 126.15 (Redmond to Quarry)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Roadway type (divided / undivided)		Undivided	Undivided
Length of segment, L (mi)		--	1.75
AADT (veh/day)	$AADT_{MAX}$ = 33,200 (veh/day)	--	30,000
Lane width (ft)		12	12
Shoulder width (ft) - right shoulder width for divided		6	8
Shoulder type - right shoulder type for divided		Paved	Paved
Median width (ft) - for divided only		30	Not Applicable
Side Slopes - for undivided only		1:7 or flatter	1:7 or Flatter
Lighting (present/not present)		Not Present	Not Present
Auto speed enforcement (present/not present)		Not Present	Not Present
Calibration Factor, Cr		1.00	0.37

Worksheet 1B (b) -- Crash Modification Factors for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)
CMF for Lane Width	CMF for Shoulder Width	CMF for Side Slopes	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1ru	*CMF 2ru*	*CMF 3ru*	*CMF 4ru*	*CMF 5ru*	*CMF comb*
from Equation 11-13	from Equation 11-14	from Table 11-14	from Equation 11-15	from Section 11.7.1	(1)*(2)*(3)*(4)*(5)
1.00	0.94	1.00	1.00	1.00	0.94

Worksheet 1C (b) -- Roadway Segment Crashes for Rural Multilane Undivided Roadway Segments

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients**			**N spf rs(u)**	**Overdispersion Parameter, k**	**Combined CMFs**	**Calibration Factor, Cr**	**Predicted average crash frequency, $N_{predicted\ rs(u)}$**
	from Table 11-3					(6) from Worksheet 1B (b)		
	a	b	c	from Equation 11-7	from Equation 11-8			(3)*(5)*(6)
Total	-9.653	1.176	1.675	20.696	0.107	0.94	0.37	7.202
Fatal and Injury (FI)	-9.410	1.094	1.796	11.332	0.095	0.94	0.37	3.943
Fatal and Injury[a] (FI[a])	-8.577	0.938	2.003	5.220	0.077	0.94	0.37	1.816
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 3.259

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1D (b) -- Crashes by Severity Level and Collision Type for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision $Type_{(TOTAL)}$**	**$N_{predicted\ rs(u)\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision $Type_{(FI)}$**	**$N_{predicted\ rs(u)\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ rs(u)}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ rs(u)\ (PDO)}$ (crashes/year)**
	from Table 11-4	$(7)_{TOTAL}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$[a] from Worksheet 1C (b)	from Table 11-4	$(7)_{PDO}$ from Worksheet 1C (b)
Total	1.000	7.202	0.999	3.943	1.000	1.816	1.000	3.259
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$ [a]		$(8)*(9)_{PDO}$
Head-on collision	0.040	0.288	0.083	0.327	0.118	0.214	0.012	0.039
Sideswipe collision	0.148	1.066	0.101	0.398	0.097	0.176	0.178	0.580
Rear-end collision	0.305	2.196	0.339	1.337	0.194	0.352	0.283	0.922
Angle collision	0.014	0.101	0.024	0.095	0.032	0.058	0.008	0.026
Single-vehicle collision	0.390	2.809	0.375	1.479	0.473	0.859	0.399	1.300
Other collision	0.103	0.742	0.077	0.304	0.086	0.156	0.120	0.391

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1E -- Summary Results for Rural Multilane Roadway Segments

(1)	(2)	(3)	(4)
Crash severity level	**Predicted average crash frequency (crashes/year)**	**Roadway segment length (mi)**	**Crash rate (crashes/mi/year)**
	(7) from Worksheet 1C (a) or (b)		(2)/(3)
Total	7.2	1.8	4.1
Fatal and Injury (FI)	3.9	1.8	2.3
Fatal and Injury[a] (FI[a])	1.8	1.8	1.0
Property Damage Only (PDO)	3.3	1.8	1.9

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1A -- General Information and Input Data for Rural Multilane Roadway Segments

General Information		Location Information	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Roadway Section	MP 126.25 to 128.53 (Quarry to 61st)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Roadway type (divided / undivided)		Undivided	Undivided
Length of segment, L (mi)		--	2.28
AADT (veh/day)	$AADT_{MAX}$ = 33,200 (veh/day)	--	30,000
Lane width (ft)		12	12
Shoulder width (ft) - right shoulder width for divided		6	8
Shoulder type - right shoulder type for divided		Paved	Paved
Median width (ft) - for divided only		30	Not Applicable
Side Slopes - for undivided only		1:7 or flatter	1:5
Lighting (present/not present)		Not Present	Not Present
Auto speed enforcement (present/not present)		Not Present	Not Present
Calibration Factor, Cr		1.00	0.37

Worksheet 1B (b) -- Crash Modification Factors for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)
CMF for Lane Width	CMF for Shoulder Width	CMF for Side Slopes	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1ru	*CMF 2ru*	*CMF 3ru*	*CMF 4ru*	*CMF 5ru*	*CMF comb*
from Equation 11-13	from Equation 11-14	from Table 11-14	from Equation 11-15	from Section 11.7.1	(1)*(2)*(3)*(4)*(5)
1.00	0.94	1.09	1.00	1.00	1.03

Worksheet 1C (b) -- Roadway Segment Crashes for Rural Multilane Undivided Roadway Segments

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-3			**N spf rs(u)**	**Overdispersion Parameter, k**	**Combined CMFs** (6) from Worksheet 1B (b)	**Calibration Factor, Cr**	**Predicted average crash frequency, $N_{predicted\ rs(u)}$**
	a	b	c	from Equation 11-7	from Equation 11-8			(3)*(5)*(6)
Total	-9.653	1.176	1.675	26.964	0.082	1.03	0.37	10.227
Fatal and Injury (FI)	-9.410	1.094	1.796	14.764	0.073	1.03	0.37	5.600
Fatal and Injury[a] (FI[a])	-8.577	0.938	2.003	6.800	0.059	1.03	0.37	2.579
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 4.627

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1D (b) -- Crashes by Severity Level and Collision Type for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision $Type_{(TOTAL)}$**	**$N_{predicted\ rs(u)\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision $Type_{(FI)}$**	**$N_{predicted\ rs(u)\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ rs(u)}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ rs(u)\ (PDO)}$ (crashes/year)**
	from Table 11-4	$(7)_{TOTAL}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$[a] from Worksheet 1C (b)	from Table 11-4	$(7)_{PDO}$ from Worksheet 1C (b)
Total	1.000	10.227	0.999	5.600	1.000	2.579	1.000	4.627
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$[a]		$(8)*(9)_{PDO}$
Head-on collision	0.040	0.409	0.083	0.465	0.118	0.304	0.012	0.056
Sideswipe collision	0.148	1.514	0.101	0.566	0.097	0.250	0.178	0.824
Rear-end collision	0.305	3.119	0.339	1.898	0.194	0.500	0.283	1.310
Angle collision	0.014	0.143	0.024	0.134	0.032	0.083	0.008	0.037
Single-vehicle collision	0.390	3.989	0.375	2.100	0.473	1.220	0.399	1.846
Other collision	0.103	1.053	0.077	0.431	0.086	0.222	0.120	0.555

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1E -- Summary Results for Rural Multilane Roadway Segments

(1)	(2)	(3)	(4)
Crash severity level	**Predicted average crash frequency (crashes/year)**	**Roadway segment length (mi)**	**Crash rate (crashes/mi/year)**
	(7) from Worksheet 1C (a) or (b)		(2)/(3)
Total	10.2	2.3	4.5
Fatal and Injury (FI)	5.6	2.3	2.5
Fatal and Injury[a] (FI[a])	2.6	2.3	1.1
Property Damage Only (PDO)	4.6	2.3	2.0

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1A -- General Information and Input Data for Rural Multilane Roadway Segments

General Information		Location Information	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Roadway Section	MP 128.63 to 130.13 (61st to Deschutes Jct)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Roadway type (divided / undivided)		Undivided	Undivided
Length of segment, L (mi)		--	1.5
AADT (veh/day)	$AADT_{MAX}$ = 33,200 (veh/day)	--	30,000
Lane width (ft)		12	12
Shoulder width (ft) - right shoulder width for divided		6	8
Shoulder type - right shoulder type for divided		Paved	Paved
Median width (ft) - for divided only		30	Not Applicable
Side Slopes - for undivided only		1:7 or flatter	1:5
Lighting (present/not present)		Not Present	Not Present
Auto speed enforcement (present/not present)		Not Present	Not Present
Calibration Factor, Cr		1.00	0.37

Worksheet 1B (b) -- Crash Modification Factors for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)
CMF for Lane Width	CMF for Shoulder Width	CMF for Side Slopes	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1ru	*CMF 2ru*	*CMF 3ru*	*CMF 4ru*	*CMF 5ru*	*CMF comb*
from Equation 11-13	from Equation 11-14	from Table 11-14	from Equation 11-15	from Section 11.7.1	(1)*(2)*(3)*(4)*(5)
1.00	0.94	1.09	1.00	1.00	1.03

Worksheet 1C (b) -- Roadway Segment Crashes for Rural Multilane Undivided Roadway Segments

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-3			**N spf rs(u)**	**Overdispersion Parameter, k**	**Combined CMFs** (6) from Worksheet 1B (b)	**Calibration Factor, Cr**	**Predicted average crash frequency, $N_{predicted\ rs(u)}$**
	a	b	c	from Equation 11-7	from Equation 11-8			(3)*(5)*(6)
Total	-9.653	1.176	1.675	17.739	0.125	1.03	0.37	6.728
Fatal and Injury (FI)	-9.410	1.094	1.796	9.713	0.111	1.03	0.37	3.684
Fatal and Injury[a] (FI[a])	-8.577	0.938	2.003	4.474	0.090	1.03	0.37	1.697
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 3.044

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1D (b) -- Crashes by Severity Level and Collision Type for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision Type$_{(TOTAL)}$**	**$N_{predicted\ rs(u)\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision Type$_{(FI)}$**	**$N_{predicted\ rs(u)\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ rs(u)}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ rs(u)\ (PDO)}$ (crashes/year)**
	from Table 11-4	$(7)_{TOTAL}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$[a] from Worksheet 1C (b)	from Table 11-4	$(7)_{PDO}$ from Worksheet 1C (b)
Total	1.000	6.728	0.999	3.684	1.000	1.697	1.000	3.044
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$ [a]		$(8)*(9)_{PDO}$
Head-on collision	0.040	0.269	0.083	0.306	0.118	0.200	0.012	0.037
Sideswipe collision	0.148	0.996	0.101	0.372	0.097	0.165	0.178	0.542
Rear-end collision	0.305	2.052	0.339	1.249	0.194	0.329	0.283	0.862
Angle collision	0.014	0.094	0.024	0.088	0.032	0.054	0.008	0.024
Single-vehicle collision	0.390	2.624	0.375	1.381	0.473	0.803	0.399	1.215
Other collision	0.103	0.693	0.077	0.284	0.086	0.146	0.120	0.365

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1E -- Summary Results for Rural Multilane Roadway Segments

(1)	(2)	(3)	(4)
Crash severity level	**Predicted average crash frequency (crashes/year)**	**Roadway segment length (mi)**	**Crash rate (crashes/mi/year)**
	(7) from Worksheet 1C (a) or (b)		(2)/(3)
Total	6.7	1.5	4.5
Fatal and Injury (FI)	3.7	1.5	2.5
Fatal and Injury[a] (FI[a])	1.7	1.5	1.1
Property Damage Only (PDO)	3.0	1.5	2.0

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1A -- General Information and Input Data for Rural Multilane Roadway Segments

General Information		Location Information	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Roadway Section	MP 130.23 to 132.29 (Deschutes Jct to Ft Thompson)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Roadway type (divided / undivided)		Undivided	Undivided
Length of segment, L (mi)		--	2.16
AADT (veh/day)	$AADT_{MAX}$ = 33,200 (veh/day)	--	25,200
Lane width (ft)		12	12
Shoulder width (ft) - right shoulder width for divided		6	8
Shoulder type - right shoulder type for divided		Paved	Paved
Median width (ft) - for divided only		30	Not Applicable
Side Slopes - for undivided only		1:7 or flatter	1:7 or Flatter
Lighting (present/not present)		Not Present	Not Present
Auto speed enforcement (present/not present)		Not Present	Not Present
Calibration Factor, Cr		1.00	0.37

Worksheet 1B (b) -- Crash Modification Factors for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)
CMF for Lane Width	CMF for Shoulder Width	CMF for Side Slopes	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1ru	*CMF 2ru*	*CMF 3ru*	*CMF 4ru*	*CMF 5ru*	*CMF comb*
from Equation 11-13	from Equation 11-14	from Table 11-14	from Equation 11-15	from Section 11.7.1	(1)*(2)*(3)*(4)*(5)
1.00	0.94	1.00	1.00	1.00	0.94

Worksheet 1C (b) -- Roadway Segment Crashes for Rural Multilane Undivided Roadway Segments

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-3			**N spf rs(u)**	**Overdispersion Parameter, k**	**Combined CMFs**	**Calibration Factor, Cr**	**Predicted average crash frequency, $N_{predicted\ rs(u)}$**
	a	b	c	from Equation 11-7	from Equation 11-8	(6) from Worksheet 1B (b)		(3)*(5)*(6)
Total	-9.653	1.176	1.675	20.809	0.087	0.94	0.37	7.241
Fatal and Injury (FI)	-9.410	1.094	1.796	11.558	0.077	0.94	0.37	4.022
Fatal and Injury[a] (FI[a])	-8.577	0.938	2.003	5.470	0.062	0.94	0.37	1.904
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 3.219

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1D (b) -- Crashes by Severity Level and Collision Type for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision $Type_{(TOTAL)}$**	**$N_{predicted\ rs(u)\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision $Type_{(FI)}$**	**$N_{predicted\ rs(u)\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ rs(u)}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ rs(u)\ (PDO)}$ (crashes/year)**
	from Table 11-4	$(7)_{TOTAL}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$[a] from Worksheet 1C (b)	from Table 11-4	$(7)_{PDO}$ from Worksheet 1C (b)
Total	1.000	7.241	0.999	4.022	1.000	1.904	1.000	3.219
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$ [a]		$(8)*(9)_{PDO}$
Head-on collision	0.040	0.290	0.083	0.334	0.118	0.225	0.012	0.039
Sideswipe collision	0.148	1.072	0.101	0.406	0.097	0.185	0.178	0.573
Rear-end collision	0.305	2.209	0.339	1.363	0.194	0.369	0.283	0.911
Angle collision	0.014	0.101	0.024	0.097	0.032	0.061	0.008	0.026
Single-vehicle collision	0.390	2.824	0.375	1.508	0.473	0.900	0.399	1.284
Other collision	0.103	0.746	0.077	0.310	0.086	0.164	0.120	0.386

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1E -- Summary Results for Rural Multilane Roadway Segments

(1)	(2)	(3)	(4)
Crash severity level	**Predicted average crash frequency (crashes/year)**	**Roadway segment length (mi)**	**Crash rate (crashes/mi/year)**
	(7) from Worksheet 1C (a) or (b)		(2)/(3)
Total	7.2	2.2	3.4
Fatal and Injury (FI)	4.0	2.2	1.9
Fatal and Injury[a] (FI[a])	1.9	2.2	0.9
Property Damage Only (PDO)	3.2	2.2	1.5

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1A -- General Information and Input Data for Rural Multilane Roadway Segments			
General Information		**Location Information**	
Analyst	JXG	Roadway	US 97
Agency or Company	KAI	Roadway Section	MP 132.49 to 133.39 (Ft Thompson to Bend)
Date Performed	04/25/18	Jurisdiction	ODOT
		Analysis Year	2015

Input Data		Base Conditions	Site Conditions
Roadway type (divided / undivided)		Undivided	Undivided
Length of segment, L (mi)		--	0.9
AADT (veh/day)	$AADT_{MAX}$ = 33,200 (veh/day)	--	25,200
Lane width (ft)		12	12
Shoulder width (ft) - right shoulder width for divided		6	8
Shoulder type - right shoulder type for divided		Paved	Paved
Median width (ft) - for divided only		30	Not Applicable
Side Slopes - for undivided only		1:7 or flatter	1:6
Lighting (present/not present)		Not Present	Not Present
Auto speed enforcement (present/not present)		Not Present	Not Present
Calibration Factor, Cr		1.00	0.37

Worksheet 1B (b) -- Crash Modification Factors for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)
CMF for Lane Width	CMF for Shoulder Width	CMF for Side Slopes	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1ru	*CMF 2ru*	*CMF 3ru*	*CMF 4ru*	*CMF 5ru*	*CMF comb*
from Equation 11-13	from Equation 11-14	from Table 11-14	from Equation 11-15	from Section 11.7.1	(1)*(2)*(3)*(4)*(5)
1.00	0.94	1.05	1.00	1.00	0.99

Worksheet 1C (b) -- Roadway Segment Crashes for Rural Multilane Undivided Roadway Segments

(1)	(2)			(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 11-3			**N spf rs(u)**	**Overdispersion Parameter, k**	**Combined CMFs** (6) from Worksheet 1B (b)	**Calibration Factor, Cr**	**Predicted average crash frequency, $N_{predicted\ rs(u)}$**
	a	b	c	from Equation 11-7	from Equation 11-8			(3)*(5)*(6)
Total	-9.653	1.176	1.675	8.671	0.208	0.99	0.37	3.168
Fatal and Injury (FI)	-9.410	1.094	1.796	4.816	0.184	0.99	0.37	1.760
Fatal and Injury[a] (FI[a])	-8.577	0.938	2.003	2.279	0.150	0.99	0.37	0.833
Property Damage Only (PDO)	--	--	--	--	--	--	--	$(7)_{TOTAL} - (7)_{FI}$ 1.408

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1D (b) -- Crashes by Severity Level and Collision Type for Rural Multilane Undivided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Collision Type	**Proportion of Collision Type(TOTAL)**	**$N_{predicted\ rs(u)\ (TOTAL)}$ (crashes/year)**	**Proportion of Collision Type(FI)**	**$N_{predicted\ rs(u)\ (FI)}$ (crashes/year)**	**Proportion of Collision Type (FI[a])**	**$N_{predicted\ rs(u)}$ (FI[a]) (crashes/year)**	**Proportion of Collision Type (PDO)**	**$N_{predicted\ rs(u)\ (PDO)}$ (crashes/year)**
	from Table 11-4	$(7)_{TOTAL}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$ from Worksheet 1C (b)	from Table 11-4	$(7)_{FI}$[a] from Worksheet 1C (b)	from Table 11-4	$(7)_{PDO}$ from Worksheet 1C (b)
Total	1.000	3.168	0.999	1.760	1.000	0.833	1.000	1.408
		$(2)*(3)_{TOTAL}$		$(4)x(5)_{FI}$		$(6)*(7)_{FI}$[a]		$(8)*(9)_{PDO}$
Head-on collision	0.040	0.127	0.083	0.146	0.118	0.098	0.012	0.017
Sideswipe collision	0.148	0.469	0.101	0.178	0.097	0.081	0.178	0.251
Rear-end collision	0.305	0.966	0.339	0.596	0.194	0.162	0.283	0.399
Angle collision	0.014	0.044	0.024	0.042	0.032	0.027	0.008	0.011
Single-vehicle collision	0.390	1.235	0.375	0.660	0.473	0.394	0.399	0.562
Other collision	0.103	0.326	0.077	0.135	0.086	0.072	0.120	0.169

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 1E -- Summary Results for Rural Multilane Roadway Segments

(1)	(2)	(3)	(4)
Crash severity level	**Predicted average crash frequency (crashes/year)**	**Roadway segment length (mi)**	**Crash rate (crashes/mi/year)**
	(7) from Worksheet 1C (a) or (b)		(2)/(3)
Total	3.2	0.9	3.5
Fatal and Injury (FI)	1.8	0.9	2.0
Fatal and Injury[a] (FI[a])	0.8	0.9	0.9
Property Damage Only (PDO)	1.4	0.9	1.6

NOTE: [a] Using the KABCO scale, these include only KAB crashes. Crashes with severity level C (possible injury) are not included.

Worksheet 3A -- Predicted and Observed Crashes by Severity and Site Type Using the Site-Specific EB Method

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$ (crashes/year)**	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency,**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Segment 1	7.202	3.943	3.259	4.2	0.107	0.565	5.895
Segment 2	10.227	5.600	4.627	5.4	0.082	0.543	8.023
Segment 3	6.728	3.684	3.044	2.4	0.125	0.543	4.752
Segment 4 (total)	7.241	4.022	3.219	7.4	0.087	0.614	7.302
Segment 5	3.168	1.760	1.408	2.6	0.208	0.603	2.942
Segment 6						1.000	0.000
Segment 7						1.000	0.000
Segment 8						1.000	0.000
INTERSECTIONS							
Intersection 1	0.577	0.230	0.347	0.4	0.460	0.790	0.540
Intersection 2	0.922	0.401	0.521	1.6	0.460	0.702	1.124
Intersection 3	0.670	0.367	0.462	1	0.460	0.764	0.748
Intersection 4	0.807	0.370	0.437	1	0.494	0.715	0.862
Intersection 5						1.000	0.000
Intersection 6						1.000	0.000
Intersection 7						1.000	0.000
Intersection 8						1.000	0.000
COMBINED (sum of column)	44.448	24.212	20.395	31.8	--	--	38.668

Note: The breakdown of FI and PDO relies on the observed severity distribution of crashes throughout the study corridor.

Note: N predicted relies on ISATe analysis.

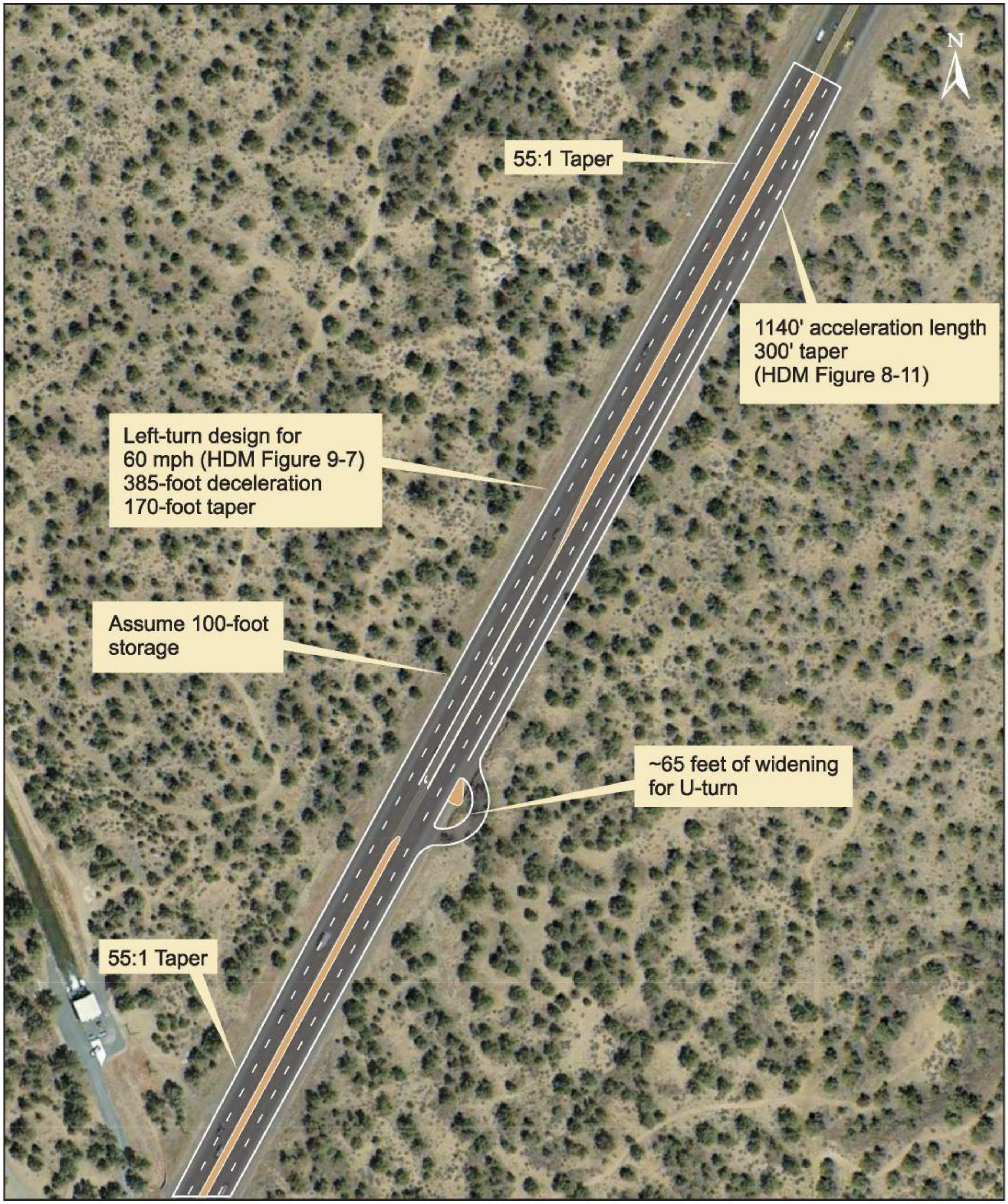
Worksheet 3B -- Site-Specific EB Method Summary Results

(1)	(2)	(3)
Crash severity level	$N_{predicted}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(8)_{COMB}$ from Worksheet 3A
	44.4	38.7
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(3)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$
	24.2	21.1
Property damage only (PDO)	$(4)_{COMB}$ from Worksheet 3A	$(3)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$
	20.4	17.7

Appendix D
Improvement Costs

			Soft Costs								
Items	Unit	Cost per Unit	Mobilization (10%)	Traffic Control (8%)	Erosion Control (3%)	Construction Survey (2%)	Drainage (20%)	Engineering and Administration (25%)	Clearing and Grubbing (2%)	Contingency (40%)	Total Cost
Tree Clearing	tree	$500	$50	$40	$15	$10	$100	$125	$10	$200	**$1,050**
Jersey Barrier	ft	$45	$5	$4	$1	$1	$9	$11	$1	$18	**$95**
Intersection Lighting	pole	$7,500	$750	$600	$225	$150	$1,500	$1,875	$150	$3,000	**$15,750**
New Pavement	sq ft	$7	$1	$1	$0	$0	$1	$2	$0	$3	**$15**
Striping	lin ft	$1	$0	$0	$0	$0	$0	$0	$0	$0	**$2**
Signs - Stop Sign	per sign	$750	$75	$60	$23	$15	$150	$188	$15	$300	**$1,575**
Raised Pavement Markers	per marker	$7	$1	$1	$0	$0	$1	$2	$0	$3	**$15**
Clearing Rock Outcroppings	cubic yard	$70	$7	$6	$2	$1	$14	$18	$1	$28	**$147**
Pavement Removal	sq yd	$5	$1	$0	$0	$0	$1	$1	$0	$2	**$11**
Segment Lighting											
Conduit	lin ft	$20	$2	$2	$1	$0	$4	$5	$0	$8	**$42**
Luminaire, pole, etc.	unit	$9,000	$900	$720	$270	$180	$1,800	$2,250	$180	$3,600	**$18,900**
Total	**per 500'**	**$29,000**	**$2,900**	**$2,320**	**$870**	**$580**	**$5,800**	**$7,250**	**$580**	**$11,600**	**$60,900**
Signing/Markings on Side Street											
Signs: 2 Stop Signs	ea	$750	$75	$60	$23	$15	$150	$188	$15	$300	**$1,575**
Striped Median (Assume 200' striping)	lin ft	$1	$0	$0	$0	$0	$0	$0	$0	$0	**$2**
Total	**per side st ap**	**$1,700**	$170	$136	$51	$34	$340	$425	$34	$680	**$3,570**
Full Decl Lane - assuming speed of 65 mph											
New Pavement	sq ft	$8	$1	$1	$0	$0	$2	$2	$0	$3	**$17**
Striping	lin ft	$1	$0	$0	$0	$0	$0	$0	$0	$0	**$2**
Total		**$81,045**	$8,105	$6,484	$2,431	$1,621	$16,209	$20,261	$1,621	$32,418	**$170,195**
J-Turn Design - WB-67											
New Pavement	sq ft	$8	$1	$1	$0	$0	$2	$2	$0	$3	
Striping	lin ft	$1	$0	$0	$0	$0	$0	$0	$0	$0	
Signage	ea	$750	$75	$60	$23	$15	$150	$188	$15	$300	
Total, including accel lane assumption		**$381,380**	$38,138	$30,510	$11,441	$7,628	$76,276	$95,345	$7,628	$152,552	**$800,898**
lighting at j-turn		$75,000	$7,500	$6,000	$2,250	$1,500	$15,000	$18,750	$1,500	$30,000	
J-Turn Total Cost with Illumination		**$456,380**	$45,638	$36,510	$13,691	$9,128	$91,276	$114,095	$9,128	$182,552	**$958,398**
Concrete Median Barrier											
Concrete Median Barrier	ft	$45	$5	$4	$1	$1	$9	$11	$1	$18	**$95**
Impact Attenuator	ea	$32,850	$3,285	$2,628	$986	$657	$6,570	$8,213	$657	$13,140	**$68,985**
Acel Lane - assuming speed of 65 mph											
New Pavement	sq ft	$8									
Striping	lin ft	$1									
Total		**$220,590**	$22,059	$17,647	$6,618	$4,412	$44,118	$55,148	$4,412	$88,236	**$463,239**
Partial Decl Lane - assuming speed of 65 mph and existing lane (50 ft long)											
New Pavement	sq ft	$8									
Striping	lin ft	$1									
Total		**$76,245**	$7,625	$6,100	$2,287	$1,525	$15,249	$19,061	$1,525	$30,498	**$160,115**

Appendix E Illustration of J-Turn Concept



J-Turn Concept
Deschutes County, Oregon

Figure

E-1

H:\projfile\18175 - US 97 Safety Plan\dwg\figure\18175_figure 01.cdr