

**US97 BEND NORTH CORRIDOR
SOLUTIONS**

The Dalles - California #4 (US97)

**TRAFFIC ANALYSIS
MP 130.00 to 136.50**

December 2010



Transportation Planning Analysis Unit

Transportation Development Division, Salem, Oregon

US97 BEND NORTH CORRIDOR SOLUTIONS

TRAFFIC ANALYSIS THE DALLES - CALIFORNIA #4 (US97) MP 130.00 to MP 136.50

**Oregon Department of Transportation
Transportation Development Division
Planning Section
Transportation Planning Analysis Unit
555 13th Street NE, Suite 2
Salem, Oregon 97301-4178**

Prepared by: Peter L. Schuytema, P.E.

Reviewed by: Dorothy J. Upton, P.E.

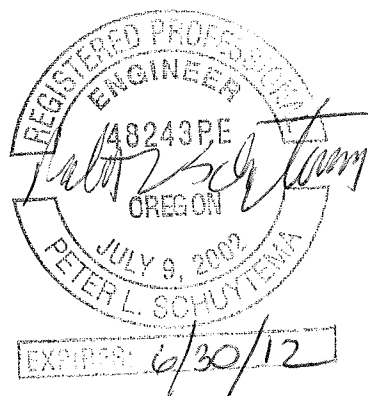


Table of Contents

Executive Summary	1
Background Information	6
Operational Standards	10
Year 2007 No-Build Existing Conditions	11
Crash Analysis	11
Crash Types	11
Crash Analysis Summary	12
State Highways	12
Local Roads	17
Traffic Development	22
Analysis Results	23
Mainline & Merge/Diverge/Weave Segments	23
Preliminary Signal Warrants	23
Unsignalized Intersections	25
Signalized Intersections	27
Queuing	27
Other Operational Performance Measures	29
Spacing Standards	30
Year 2015 & 2035 No-Build Future Conditions	33
Future Travel Trends	33
Traffic Development	34
Analysis Results	35
Mainline & Merge/Diverge/Weave Segments	35
Preliminary Signal Warrants	36
Unsignalized Intersections	38
Signalized Intersections	43
Queuing	44
Other Operational Performance Measures	49
Build Alternative Descriptions	51
Cooley Road to South Project Limits – Common for Both Alternatives	51
North of Cooley Road – East DS-1	53
North of Cooley Road – East DS-2	56
Alternative Analysis	57
Traffic Development	57
East DS-1 Analysis Results	57
Mainline & Merge/Diverge/Weave Segments	57
Preliminary Signal Warrants	60
Unsignalized Intersections	62

Signalized Intersections	66
Queuing.....	67
Other Operational Performance Measures.....	70
Spacing Standards.....	71
East DS-2 Analysis Results	73
Mainline & Merge/Diverge/Weave Segments.....	73
Preliminary Signal Warrants.....	75
Unsignalized Intersections.....	77
Signalized Intersections	81
Queuing.....	82
Other Operational Performance Measures.....	86
Spacing Standards.....	87
Alternative Summary & Comparison	89
Conclusions.....	91

Table of Figures

Figure 1: Vicinity Map..... 7

Figure 2: Project Area..... 8

Figure 3: Alternative East DS-1 54

Figure 4: Alternative East DS-2..... 55

Table of Tables

Table 1: US 97 Crash Type and Year Table	13
Table 2: US20 Crash Type and Year Table	15
Table 3: 2010 (2007-2009 data) Top 5 % and 10% SPIS Sites	16
Table 4: Cooley Road Crash Type and Year Table	17
Table 5: Empire Avenue Crash Type and Year Table	19
Table 6: O.B. Riley Road Crash Type and Year Table	20
Table 7: Year 2007 US20 & US97 Mainline Segment and Merge/Diverge/Weave V/C Ratios	23
Table 8: Year 2007 Preliminary Signal Warrants.....	24
Table 9: Year 2007 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	25
Table 10: Year 2007 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	26
Table 11: Year 2007 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	26
Table 12: Year 2007 State Highway Signalized Intersection Operations.....	27
Table 13: Year 2007 City Street Signalized Intersection Operations	27
Table 14: Year 2007 No-build Significant Queue Blocking	29
Table 15: Year 2007 No-build Overall Simulation Measures of Effectiveness	30
Table 16: Year 2007 No-build Segment Travel Time and Speed.....	30
Table 17: Spacing Standards Comparison	32
Table 18: Year 2015 and 2035 No-build US97 Mainline and Merge/Diverge/Weave V/C Ratios	35
Table 19: Year 2015 & 2035 No-Build Preliminary Signal Warrants.....	37
Table 20: Year 2015 State Highway No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	39
Table 21: Year 2015 City Street No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	40
Table 22: Year 2015 County Road No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	40
Table 23: Year 2035 State Highway No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	41

Table 24: Year 2035 City Street No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches	42
Table 25: Year 2035 County Road No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches	42
Table 26: Year 2015 & 2035 State Highway No-build Signalized Intersection Operations	43
Table 27: Year 2015 & 2035 City Street No-build Signalized Intersection Operations ..	44
Table 28: Year 2015 No-build Significant Queue Blocking	46
Table 29: Year 2035 No-build Significant Queue Blocking	47
Table 30: Year 2015 & 2035 No-build Overall Simulation Measures of Effectiveness ..	50
Table 31: Year 2015 & 2035 No-build Segment Travel Time and Speed.....	50
Table 32: Year 2015 and 2035 East DS-1 US97 Mainline and Merge/Diverge/Weave V/C Ratios	58
Table 33: Year 2015 and 2035 East DS-1 US20/3rd St Connections V/C Ratios.....	59
Table 34: Year 2015 & 2035 East DS-1 Preliminary Signal Warrants	61
Table 35: Year 2015 East DS-1 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches	62
Table 36: Year 2015 East DS-1 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches	63
Table 37: Year 2015 East DS-1 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches	64
Table 38: Year 2035 East DS-1 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches	64
Table 39: Year 2035 East DS-1 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches	65
Table 40: Year 2035 East DS-1 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches	66
Table 41: Year 2015 & 2035 State Highway East DS-1 Signalized Intersection V/C Ratios	67
Table 42: Year 2015 & 2035 City Street East DS-1 Signalized Intersection V/C Ratios	67
Table 43: Year 2015 East DS-1 Significant Queue Blocking.....	68
Table 44: Year 2035 East DS-1 Significant Queue Blocking.....	69
Table 45: Year 2015 & 2035 East DS-1 Overall Simulation Measures of Effectiveness	70
Table 46: Year 2015 & 2035 East DS-1 Segment Travel Time and Speed.....	71
Table 47: Spacing Standards Comparison	72

Table 48: Year 2015 and 2035 East DS-2 US97 Mainline and Merge/Diverge/Weave V/C Ratios	74
Table 49: Year 2015 and 2035 East DS-2 US20/3rd St Connections V/C Ratios.....	74
Table 50: Year 2015 & 2035 East DS-2 Preliminary Signal Warrants	76
Table 51: Year 2015 East DS-2 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	77
Table 52: Year 2015 East DS-2 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	78
Table 53: Year 2015 East DS-2 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	78
Table 54: Year 2035 East DS-2 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	79
Table 55: Year 2035 East DS-2 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	80
Table 56: Year 2035 East DS-2 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches.....	81
Table 57: Year 2015 & 2035 State Highway East DS-2 Signalized Intersection V/C Ratios	81
Table 58: Year 2015 & 2035 City Street East DS-2 Signalized Intersection V/C Ratios ¹	82
Table 59: Year 2015 East DS-2 Significant Queue Blocking.....	83
Table 60: Year 2035 East DS-2 Significant Queue Blocking.....	84
Table 61: Year 2015 & 2035 East DS-2 Overall Simulation Measures of Effectiveness	86
Table 62: Year 2015 & 2035 East DS-2 Segment Travel Time and Speed.....	86
Table 63: Spacing Standards Comparison	88
Table 64: Alternative Comparison for 2035 Results	89

EXECUTIVE SUMMARY

The purpose of the proposed action is to improve safety and freight mobility for trucks and autos on US97 by implementing a practical design solution that is affordable within the 20-year funding opportunities and that meets the following medium-term and long-term objectives:

- Reduces delay, congestion, and the number and severity of crashes at the US97/Cooley Road and US97/Robal Road intersections within the medium-term planning period as defined by the Bend Metropolitan Planning Organization's 2007-2030 Metropolitan Transportation Plan, and
- Reduces delay, congestion, and improves safety on US97 between the Deschutes Market Road/Tumalo Junction interchange and Empire Avenue interchange within the long-term planning period as defined by the Bend Metropolitan Planning Organization's 2007-2030 Metropolitan Transportation Plan.

This project is located on the northern edge of the City of Bend in Deschutes County in Central Oregon. With a population over 77,000, Bend includes a federally designated Metropolitan Planning Organization (MPO) which coordinates planning between member jurisdictions through a regional transportation plan. Two-thirds of the project area is within the Bend city limits and the MPO boundary while the northern third is in rural Deschutes County. The southern portion of the project area includes a regional mall and big-box commercial west of US97 and light industrial with some retail east of US97. Residential uses border the study area on the west, north, and east sides. Based on the overall range of project alternatives, the traffic analysis study area includes US97 from just north of the Deschutes Market Road Interchange to just south of the Butler Market Road Interchange ramps and US20 from north of Old Bend-Redmond Highway to just south of Empire Avenue. The study area also covers significant local facilities from O.B. Riley Road on the west to Boyd Acres Road on the east.

US97 is the regionally significant north-south four-lane major arterial through central Oregon and the project area currently carrying about 42,200 vehicles a day north of Robal Road. The facility is classified as a statewide expressway, a freight route, and is part of the National Highway System. US97 south of Nels Anderson Place is also a bypass as defined by the Oregon Highway Plan. US20 is a two-lane major arterial and a statewide expressway from the project limits to the junction with 3rd Street. The 2007 (2009 equivalent) average daily traffic (ADT) on US20 is about 27,500 northwest of Robal Road. US20 (a.k.a. US97 Business or 3rd Street) is a north-south five-lane major arterial with a statewide non-freight level of importance.

Within the southern section of the project area, US97 and US20 intersect within a partial interchange with Empire Avenue serving as the link between them. Expressways are meant to favor through traffic with access provided at wide-spaced intersections or

interchanges with private accesses discouraged. However, because of increasing congestion, slowing traffic flow, and crashes on US97 (and US20) in the project area, the highways are no longer meeting the intent of the expressway designation.

Over the past six years most crashes within the project area are rear-end and turning collisions (typical for an urban area) at intersections typically occurring in dry, daylight conditions. On US97, while the number of crashes has generally remained constant over time from 2004 to 2009, the number of severe injury or fatal crashes has increased. The US97 crash data for the past six years yields an average segment crash rate of 30-70% below comparable statewide facilities. On US20, the number of crashes has increased over time from 2004 to 2009. The average segment crash rates exceed statewide comparable rates only west of Cooley Road. There are four 2010 Top 5% or 10% SPIS (Safety Priority Index System) sites on US97 and one on US20 in the study area. Top 5% SPIS sites require investigation and plans for correction.

The 2007 30th Highest Hour Volumes used in this analysis were developed mostly using a combination of classification and turning movement intersection counts taken in 2007. The raw counts were seasonally adjusted to obtain the 30th Highest Hour Volumes. The 30th Highest Hour Volume occurs on a Friday in August around 4:00 to 5:00 PM. Because of recent economic events, employment and population losses have caused current traffic volumes to fall at least 10% from 2007 levels. Because of little or no growth in the traffic volumes since 2007, the 2007 counts are functionally equivalent to 2010 counts.

In 2007, all of the free-flow mainline segments of US97 are under the volume-to-capacity standards except for the northbound section between the Butler Market Road on-ramp and the Empire Avenue off-ramp. The signalized US97 intersections of Cooley and Robal Roads are at or approaching capacity. Along US20, most of the unsignalized intersections along US20 west of the US97/3rd Street connections are at or over capacity for the stopped side-street approaches. The high traffic volumes on US20 (3rd Street) and Empire Avenue have the US20 & Empire Avenue intersection over standard. In addition, the volumes along Empire Avenue between US20 (3rd Street) and US97 are high enough that turning from unsignalized intersections is difficult with high levels of delay.

Queuing problems are mainly left turn lanes being blocked by adjacent through queues. Most of the long-lasting queuing problems are on US97 between Cooley Road and Butler Market Road and along Empire Avenue. Many closely spaced intersections along Empire Avenue show significant blocking times such as between US20 (3rd St) and Jamison Street on the west and Industrial Park Boulevard on the east; between the ramp terminals at the Empire Avenue interchange; and between the closely spaced US20 and Butler Market on-ramps on northbound US97. The effects of the congestion and signals on US97 and the 3rd Street portion of US20 are illustrated with a 10 mph reduction in average speed from the posted 45 mph.

On US97, the existing street, ramp and interchange spacing is substantially under the applicable standards. The interchange spacing is only about a third of the 1.9 mile standard with interchanges spaced approximately one-half mile apart from Empire Avenue to Butler Market Road. Interchange ramp-to-ramp spacing is generally only about a quarter-mile

apart instead of the one mile standard which will likely lead to congestion issues with higher volumes.

On US20, the street spacing is just under the standard between Cooley and Robal Roads but is less than a third of the required spacing between at-grade intersections and the US97/US20/3rd Street interchange connections. The ramp terminal spacing standard is not met at the US97/Empire Avenue interchange as there are full access intersections 300' away on the west and about 800' on the east. The signalized US20 (3rd Street) & Empire Avenue intersection is only about 850' away from the southbound ramp terminal, so meeting the spacing standard is unlikely even under ideal conditions.

To create future year 2015 and 2035 volumes, the Bend Metropolitan Planning Organization (BMPO) travel demand model was used. The model is based on the current comprehensive land use plans of Deschutes County and the City of Bend. The Metropolitan Transportation Plan (MTP) financially constrained model scenario was used to develop the future volumes. The volumes were post-processed using procedures from the National Cooperative Highway Research Council (NCHRP) Report 255 to create the future no-build and alternative design hour volumes.

In 2035, the rural sections of US 97 are at or over the v/c standards. In the urban sections, northbound mainline US97 is over or near capacity from south of Butler Market Road to north of Empire Avenue. The southbound direction is over or near the v/c standard from the Empire Avenue interchange south to the project limits.

Most intersections on US97 and US20 are at or over capacity by 2035, leading to extensive queuing and delays on the north end of US97 and US20 likely spreading across multiple hours. The worst signalized bottlenecks in the project area are the US97 & Cooley Road and the US20 & Empire Avenue intersections. The US97 & Nels Anderson Place/Cascade Village Mall intersection is the worst unsignalized bottleneck. The northbound left has no safe gaps in southbound traffic, so vehicles attempting this risk a serious crash. Exiting the mall will be difficult because gaps are limited, so long delays and queues are expected.

By 2035, the queuing is extensive throughout the project area. The US97 & Cooley Road intersection has queues that extend north of Bowery Lane southbound and almost back to Robal Road northbound. Queuing on Cooley Road from this intersection backs into US20 on the west and to Boyd Acres on the east. The queues from the US20 (3rd St) & Empire Avenue intersection extends almost all the way to Cooley Road and over 1000' south of the intersection for the northbound direction. Cooley Road, Robal Road, and Empire Avenue have extensive queuing over their entire length in the project area. Long queues exist on most side-street approaches. The effect of the increasing future congestion can be seen as speeds continue to drop as the overall network speed operates at a crawl speed.

Twenty alternatives and many more concepts were considered in the alternative development phase. These alternatives and concepts were tested first on the purpose and need criteria and then later against the goals and objectives. These alternatives and concepts considered alignments to the west of US97 and the commercial area, along

existing US97 (3rd Street), and to the east of US97 adjacent to the railroad tracks. Near the end of the alternative refinement process, the alternatives were “down-scaled” using a practical design approach, resulting in alternatives with reduced scope and complexity to better address future funding and phasing. The final build alternatives are known as East DS-1 and DS-2.

Both East DS-1 and DS-2 realign US97 to the east of the current alignment next to the railroad tracks. The current US97 would become an extension of 3rd Street from the US20 connections to a new US97 interchange north of Grandview Drive. Both build alternatives share a common design from Cooley Road south, but have different northern interchange types and local road connections.

Both alternatives generally do not affect the existing pedestrian, bike or transit facilities. The largest change will be the extension of Robal Road west to O.B. Riley Road. This allows for easier and quicker pedestrian and biking access from local neighborhoods along Britta Street or O.B. Riley Road to the commercial area east of US20. Pedestrian and bike travel on 3rd Street may be more attractive since traffic volumes dropped with the highway through traffic removed.

In the East DS-1 alternative, north of Cooley Road, US97 returns to its current alignment. US97 has a full diamond service interchange with the extension of 3rd Street located just north of Bowery Lane. Between the 3rd Street interchange and the south project limits, US97 is completely access-controlled. North of Cooley Road, 3rd Street is built on a new four/five lane alignment west of the current alignment. North of Grandview Drive, 3rd Street narrows to a two/three-lane cross-section. Third Street continues east as a two-lane roadway to a new north-south frontage road adjacent to the railroad tracks. This frontage road will serve residences and businesses that used to access US97 directly in this section.

In the East DS-2 alternative, north of Cooley Road, US97 returns to its current alignment. US97 has a system-type partial interchange with the extension of 3rd Street located just north of Grandview Drive. Movements would only be allowed to US97 from 3rd Street northbound and from US97 to 3rd Street southbound. Between the 3rd Street interchange and the south project limits, US97 is completely access-controlled. Third Street north of Cooley is a five-lane cross-section generally on the current alignment. With no direct connection to the west side of US97, Hunnell Road (north section) will be improved north of Loco Road to Fort Thompson Road. Bowery Lane will be improved, formally connected to Hunnell Road, and extended over US97 to a frontage road adjacent to the railroad tracks that serves residences and businesses that had direct US97 access in this section.

Overall, East DS-1 and DS-2 have similar volumes and results and both are substantially better than the no-build in all respects. The number of locations over standard or over capacity is only a third to a half of the no-build. Overall, network and US97 segment speeds and US97 speeds are double the no-build values. By eliminating the Cooley and Robal Road signals and other accesses, the future US97 travel times are about 75% of the 2007 existing condition values. Both of the alternatives have peak operating speeds

reasonably close to the posted speeds, and have improved the access spacing on US97 to exceed spacing standards north of the US20 connections.

US97 is free of congestion in both alternatives except for localized slowing in the weaving section south of Empire Avenue. This section is a “transition” section between the improved new alignment north of Empire Avenue and the unchanged near-capacity section south of Butler Market Road. In this transition section, the improvements are primarily to improve and smooth the traffic flows and not attract additional traffic which would result in a more severe bottleneck south of Butler Market. On the northern side of the project area, the alternatives will preserve the good operations and the overall feel that drivers are used to on the north side of Bend.

There are a number of US20 or local street intersections at or over the v/c standards with some still over capacity with reasonable improvements (US20 intersections represent 80% of the locations over capacity). The US20 improvements offer some capacity enhancements by keeping congestion at a manageable level which keeps operations consistent and balanced with the rest of surrounding system. Otherwise, without separating the highway and local street functions, the project area would have much worse operations than the rest of the system as the local road network is not very well developed.

Overall, the alternatives create a good match or balance between the existing and project areas unlike early more comprehensive alternatives which attracted so much additional local traffic onto US97 that the congestion problem became unmanageable. The alternatives have lower system capacities and less connection points than previous alternatives which will keep most of the short local trips off US97.

Both alternatives function much better than the no-build alternative and will allow free-flow operations on US97 through the 2035 design year. The alternatives will allow US97 to operate consistently with its expressway and freight route designations by maximizing the flow of long distance and regional trips while minimizing access points. Both alternatives meet the project purpose of improving safety and freight mobility on US97. Both alternatives are consistent and balanced in size and operations with the existing facility north and south of the project area while keeping local traffic (short trips) on the local system. Because East DS-1 and DS-2 have very similar networks and a small difference in volumes, either of these are viable based on traffic operations. Although East DS-2 seems to operate much poorer on a system basis, the actual volume difference between East DS-1 and DS-2 is very small and well within the typical 10% weekly volume fluctuations, so both alternatives will function similarly.

BACKGROUND INFORMATION

The purpose of the proposed action is to improve safety and freight mobility for trucks and autos on US97 by implementing a practical design solution that is affordable within the 20-year funding opportunities and that meets the following medium-term and long-term objectives:

- Reduces delay, congestion, and the number and severity of crashes at the US97/Cooley Road and US97/Robal Road intersections within the medium-term planning period as defined by the Bend Metropolitan Planning Organization's 2007-2030 Metropolitan Transportation Plan, and
- Reduces delay, congestion, and improves safety on US97 between the Deschutes Market Road/Tumalo Junction interchange and Empire Avenue interchange within the long-term planning period as defined by the Bend Metropolitan Planning Organization's 2007-2030 Metropolitan Transportation Plan.

This project is located on the northern edge of the City of Bend in Deschutes County in Central Oregon (Figure 1). With a population over 77,000, Bend includes a federally designated Metropolitan Planning Organization (MPO) which coordinates planning between member jurisdictions through a RTP. Two-thirds of the project area is within the Bend city limits and the MPO boundary while the northern third is in rural Deschutes County. The southern portion of the project area includes a regional mall and big-box commercial west of US97 and light industrial with some retail east of US97. Residential uses border the study area on the west, north, and east sides. Because of the overall range of the project alternatives, the study area for traffic analysis purposes includes US97 from just north of the Deschutes Market Road Interchange to just south of the Butler Market Road Interchange ramps and US20 from north of Old Bend-Redmond Highway to just south of Empire Avenue. The study area also covers local facilities from O.B. Riley Road on the west to Boyd Acres Road on the east (Figure 2).

US97 is the regionally significant north-south four-lane major arterial through central Oregon and the project area carrying about 42,200 vehicles a day northwest of Robal Road. The facility is classified as a statewide expressway, a freight route, and is part of the National Highway System. US97 south of Nels Anderson Place is also a bypass as defined by the Oregon Highway Plan. US20 is a two-lane major arterial and a statewide expressway from the project limits to the junction with 3rd Street. The average daily traffic (ADT) on US20 is about 27,500 west of Robal Road. From the start of 3rd Street south through the project area, US20 (a.k.a. US97 Business or 3rd Street) is a north-south five-lane major arterial with a statewide non-freight level of importance.

Figure 1: Vicinity Map

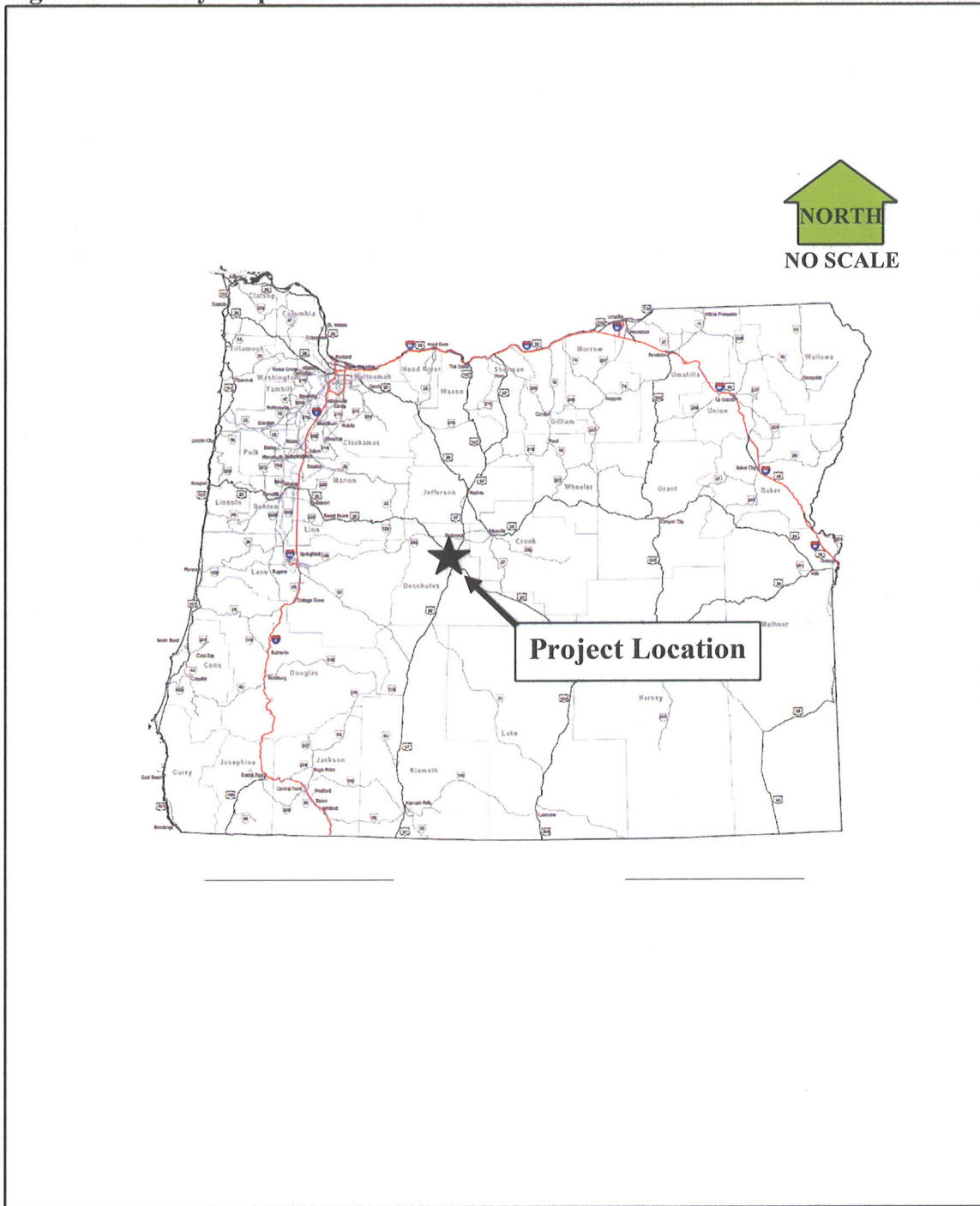
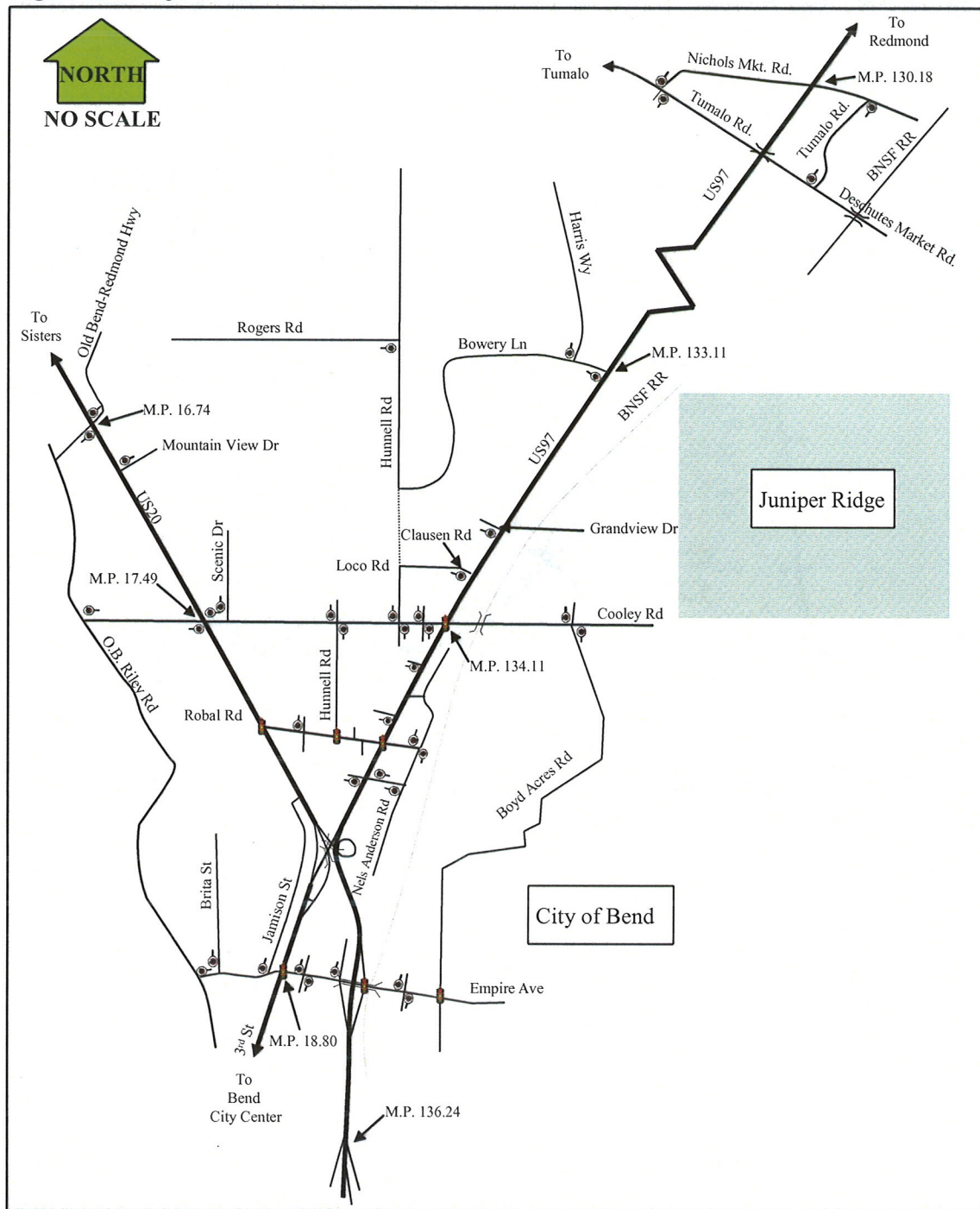


Figure 2: Project Area



Within the southern section of the project area, US97 and US20 intersect together in a partial interchange with Empire Avenue serving as the link between them. Expressways are meant to favor through traffic with access provided at wide-spaced intersections or interchanges with private accesses discouraged. However, because of increasing congestion, slowing traffic flow, and crashes on US97 (and US20) in the project area, the highway is no longer meeting the intent of the expressway designation.

Portions of O.B. Riley, Cooley, Deschutes Market, Nichols Market and Tumalo Roads and Old Bend-Redmond Highway in the study area are Deschutes County two-lane rural major collectors. Empire Avenue is a City of Bend two and four-lane major arterial from 3rd Street east (18,300 ADT) and a two-lane minor arterial from O.B. Riley Road to 3rd Street. Other City two-lane minor arterials include Cooley, Robal, O.B. Riley, and Boyd Acres Roads. Hunnell Road is a minor arterial south of Cooley Road and a City collector north of Cooley Road. All other roads like Nels Anderson Place and Grandview Drive are City local streets.

Sidewalks on US97 are generally limited to the west side of the highway from Grandview Drive south to the US20/US97 interchange. There is partial sidewalk section on the east side of US97 that starts at Cooley Road, then jogs eastward a bit and travels along the east side of Nels Anderson Road south to Robal Road. This sidewalk continues about two-thirds of the way to Nels Anderson Place and then connects to a commercial parking lot. South of the US97/US20 interchange, US97 is a grade-separated facility with no pedestrian facilities. There is a six-foot colored bike lane available for bicyclists.

US20 has no pedestrian facilities west of the US20/US97 interchange. At the interchange, the US97 west-side sidewalk crosses the US20 eastbound ramp to 3rd Street and leads to Jamison Street. Jamison Street only has a west side sidewalk for half the distance to Empire Avenue. South of Empire Avenue, sidewalks are limited to the west side of the roadway. On US20, there are no marked bicycle lanes from the project limits to Empire Avenue, but there are wide paved shoulders available. South of Empire Avenue there are marked bicycle lanes in both directions.

For the City street network in the study area, sidewalks are generally limited to between Hunnell Road and US97 on Robal and Cooley Roads and Clausen Drive. Empire Avenue only has a sidewalk and a paved shoulder on the north side of the street between O.B. Riley Road and US20 (3rd St). Sidewalk and marked bicycle lanes are discontinuous east of 3rd to Boyd Acres Road.

Transit service in the project area is limited to a single route (#4 North 3rd St) that uses US20 (3rd St) to Robal Road then turns around at the Cascade Village Mall and travels back south to downtown. Service is at 40 minute intervals on the weekdays and 80 min on Saturday (no Sunday service). The only stops in the project area are the ODOT park-n-ride south of Empire Avenue, on the US20 connection to 3rd Street (for the Jamison Street industrial area), and the Cascade Village Mall.

Operational Standards

When evaluating maximum acceptable Volume to Capacity (v/c) Ratios for the existing and future no-build conditions, the 1999 Oregon Highway Plan (OHP) mobility standards for a Metropolitan Planning Organization (MPO) area were used. The maximum acceptable v/c ratio for the expressway portions of US97 and US20 is 0.80. The rural sections north of Grandview Drive on US97 and Cooley Road on US20 have a v/c ratio of 0.70. The section of US20 from the US97/US20 interchange south to the southern study area boundary has a maximum v/c ratio of 0.85. The v/c ratio at the ramp terminals on Empire Avenue should not exceed 0.85. For unsignalized intersections, stopped approaches should have a maximum v/c ratio of 0.80 for rural areas and 0.90 in urban areas (based from District-level highways in a MPO area). A v/c ratio of 1.0 represents an intersection that is at capacity.

For the alternatives, the 2003 Highway Design Manual (HDM) v/c's for a MPO are used. Unlike the OHP v/c's the HDM values are not standards, but design guidelines. Design exceptions can be obtained where it is not practical to achieve the HDM v/c's. The design v/c's for US97 and US20 are 0.75 except for 0.60 outside of the MPO boundary. Ramp terminal v/c's are the same as the mainline roadway at 0.75. Because of the differences between the OHP and the HDM v/c's, there may be un-changed areas in the alternatives that meet OHP but do not meet the HDM v/c's. These areas will need design exceptions, however, they should be easily obtainable.

The City of Bend has a three-hour v/c standard in which the v/c must be less than or equal to 1.0 in the shoulder hours on each side of the peak hour for two-way stop-controlled, roundabouts, and signalized intersections. Three separate analysis hours were outside the scope of this project, however, the 4-5 PM and 5-6 PM peak hours are within 10% of each other, so the 4-5 PM peak hour (30th highest hour) will be used to approximate the City standard. Additionally, unsignalized two-way stop-controlled intersections must have less than or equal to 50 seconds of average delay for the critical lane group on approaches with more than 100 peak hour trips and signalized intersections must have no more than 80 seconds of total delay. Deschutes County uses Level of Service (LOS) D for existing facilities and LOS C for new facilities.

In addition to v/c ratios, 95th percentile queue lengths were also obtained to better understand the operation of the system. The v/c calculation methods do not generally take the full impact of adjacent intersections into account, so it is possible to have queues that back through upstream intersections without having reported high v/c ratios. Excessively long queues are often seen in areas where v/c ratios exceed standards. ODOT does not have a queuing standard, but areas in which the 95th percentile queue exists for more than 5% of the 30th highest hour will likely negatively impact operations and are noted in the results. The City of Bend stipulates that the 95th percentile queue needs to be less or equal to the storage provided for unsignalized and signalized intersections.

YEAR 2007 NO-BUILD EXISTING CONDITIONS

Crash Analysis

The purpose of the crash analysis is to document existing safety issues in the project area that might be further impacted by project traffic. Crash deficiencies should be addressed within the build alternatives. The crash analysis is based off on official reported crashes submitted to ODOT's Crash Analysis and Reporting Unit for the study area roadways from 2004 to 2009. The full crash table for the project area are is summarized in Appendix A with the state highway crash characteristic summary listings in Appendix B and the local roadway crash characteristic summary listings shown in Appendix C.

Crash Types

The crashes in the project area are typical for an urban area with most being rear-end, turning (from streets or accesses) or angle types. Rear-end collisions are generally caused by motorists following too close or traveling too fast for conditions, or being inattentive and often colliding into the last vehicle in the queue stopped at an intersection. Limiting street and/or access spacing, adding turn lanes, or constructing medians might reduce these collisions. Turning and angle collisions are caused by motorists taking improper gaps in traffic and failing to yield the right-of-way. Many times the traffic main street volume is high enough so that there are a limited number of available gaps, so the motorist ends up taking a smaller gap which has a higher crash risk.

Increasing sight distance, lowering speed limits, adding illumination, and improving intersection controls (adding all-way stops, roundabouts, signals, grade separation, etc.) may reduce these kinds of crashes.

Higher speed roadways such as US97, US20 and O.B. Riley Road have a high number of head-on, fixed object and sideswipe collisions. Head-on collisions and fixed object collisions are generally caused by motorists driving too fast for conditions, losing control of the vehicle and either hitting another vehicle or object (tree, abutment, ditch, etc). Driving under the influence or fatigue can be a factor in these kinds of collisions and these also have the greatest chance of a fatality or Injury A (internal injuries) severity because of the high speeds. There is generally no pattern for the fixed object collisions, so the only options are to keep the roadways shoulders (clear zone) free of objects or provide protective guardrails or other measures. Head-on collisions are mitigated with median barriers to prevent cross-over type movements. Sideswipe collisions are caused by driver error and result from improper passing movements (sideswipe-meeting) or trying to avoid a stopped vehicle (sideswipe-overtaking) in the roadway. Adding no-passing zones or turn lanes may reduce these collisions.

Crash Analysis Summary

The following sections show the summarized crash analysis statistics for US97, US20 and significant roadways in the study area for the period between January 1, 2004 and December 31, 2009. There were 292 crashes on US97 and 79 on US20 highway segments in the project area. Typically over two-thirds of crashes occurred in dry, daylight conditions. The crash types are typical for the urban and rural portions of this project with numerous intersection crashes in the urban segments. Along US97 the segment crash rates are lower than comparable statewide rates although there are two 2010 SPIS top five percent sites identified on this roadway. The rural segment along US20 (north of Cooley Road) has experienced segment crash rates higher than comparable statewide rates for the last three years. The urban section of US20 is well below the comparable statewide rates. There were no reported top five percent 2010 SPIS sites on US20.

The lower volume local streets (Boyd Acres, Deschutes Market Road, Hunnell Road (south), Nels Anderson Road, Old-Bend Redmond Highway, and Tumalo Road) typically have property damage only crashes that occur in daylight conditions. The typical crash types were turning and angle movements at the local street intersections. Cooley Road and O.B. Riley Road both had about two-thirds of their crashes being fatal or injury crashes. They were typically daylight crashes involving turning and angle movements. An unusual occurrence that shows up in the crash summary is that most every local street had at least one motorcycle crash listed. Boyd Acres and O.B. Riley Roads are parallel facilities to US97 and US20 and serve as alternate routes.

State Highways

US97

The majority of the crashes were rear end collisions at intersections. Table 1 shows the crash and year summary for US97 between 2004 and 2009. The crashes on US 97 were mainly rear-end, turning or fixed object type. These crashes mainly occurred in dry, daytime conditions. About 43% of the crashes occurred at one of three intersections: Cooley Road (MP 134.07 to MP 134.39), Robal Road (MP 134.48 to MP 134.70) and Empire Avenue (MP 135.03 to 135.76). Crashes were highest on this roadway in 2005 with 63 being reported. The six year average is 49 crashes per year.

Table 1: US 97 Crash Type and Year Table

Crash Type	2004	2005	2006	2007	2008	2009	Total
Angle	1	4	2	0	1	0	8
Backing	2	0	2	0	0	1	5
Fixed Object	2	6	12	6	3	3	32
Head-on	0	5	1	0	6	0	12
Misc. / Other	1	5	1	2	2	2	13
Non-Collision	0	0	1	1	2	2	6
Rear-end	22	32	26	24	21	23	148
Sideswipe-Meeting	0	2	0	0	1	3	6
Sideswipe-Overtaking	3	5	7	1	3	4	23
Turning	8	4	2	8	12	5	39
Total	39	63	54	42	51	43	292
Fatal - Injury A Crashes ¹	0	0	1	7	2	10	20
Intersection / Related	16	19	13	13	24	16	101

¹ Injury A is an incapacitating non-fatal injury (i.e. broken bones, severe/internal bleeding, unconsciousness, etc) that prevents a person from continuing normal activities that they were capable of before the injury.

There were a total of 292 crashes in this area between 2004 and 2009:

- Four fatal crashes
- 5% (15) Injury A crashes
- 50% (147) injury crashes (including A)
- 48% (141) Property Damage Only (PDO) crashes
- 74% (215) occurred in daylight conditions
- 51% (148) were rear-end collisions
- 13% (39) were turn movement related
- 11% (32) were fixed object collisions
- 10% (29) were side-swipe collisions
- 19% (56) were located at or near Cooley Road
- 18% (52) were located at or near Robal Road
- 5% (16) were located at or near Empire Avenue

There were four fatal crashes in this section during the six year period. In October 2006, there was a fatal rear-end collision located at the US97 and Robal Road traffic signal. The crash occurred in clear dry illuminated conditions in the early evening. A southbound vehicle was traveling too fast for conditions (but not exceeding the posted speed) and failed to avoid a vehicle stopped in a queue at the light. The second vehicle was forced into a third vehicle in front of it. The driver of the errant vehicle was the fatality. There were two fatal crashes in December 2008. The first was a southbound vehicle that was speeding and over the centerline just after noon on a clear dry Monday. This errant vehicle struck another vehicle head-on killing both the driver and passenger of the second vehicle. The second crash about three weeks later about 8 AM on a snowy day when a southbound vehicle, exceeding the posted speed, failed to stay in the lane. It ended up overturning and skidding down the pavement. The driver died attempting to escape from the vehicle. The

last crash happened in 2009 a few days before Thanksgiving on a clear, dry Tuesday afternoon. A southbound vehicle failed to stay in the lane on a straightaway, side-swiped a northbound vehicle and then overturned. The fatality was a passenger in the struck vehicle.

The number of crashes has generally remained constant over time from 2004 to 2009 with a spike in 2005 because of an increase in angle, head-on, and rear-end collisions. The number of severe injury or fatal crashes has increased over the past six years. The crash rates were reviewed based on three segments. The first which runs from Deschutes Market Road near milepoint 130.00 to the Bend north urban growth boundary (UGB) at 132.19, has a 2009 crash rate of 0.35 crashes per million vehicle miles (MVM) compared to the statewide rate for rural expressways and rural principal arterials of 0.68 crashes per MVM. The second segment, from the UGB to Robal Road has an overall 2009 crash rate of 0.88 crashes per million vehicle miles as compared to the comparable statewide rate of 2.02 for urban principal arterials. The last segment from Robal Road to the south end of the project has a 2009 segment crash rate of 0.38 crashes per million vehicle miles compared to 0.61 for comparable urban expressways statewide. A review of the past six years of crash data show that the average crash rates for the three segments are 30-70% less than rates for statewide comparable rates.

The 2009 intersection crash rates at Cooley Road and Robal Road are 0.39 and 0.31 crashes per million entering vehicles respectively. These intersections are substantially below the 1.0 crashes per million entering vehicles rule of thumb for indicating a need for further investigation. However, a rule of thumb is just that and depending on the individual intersection crash patterns or severity a safety issue may be indicated without meeting the 1.0 value. Both of these intersections have had enough crashes in past years to put them in the top 5% of the most serious crash locations in Region 4, so cost-effective safety improvements still need to be identified for these intersections.

US20

Rear-end and turning crashes accounted for 59% of the crashes on US20. Table 2 shows the crash type and year summary from 2004 to 2009. These crashes mainly occurred in dry, daytime conditions. There were concentrations of crashes at four intersections within the project area: Cooley Road (MP 17.48-17.49), Robal Road (MP 17.86-18.16), Empire Avenue (MP 18.30 – 18.82), and Nels Anderson Road (MP 19.01- 19.03).

There were two fatal crashes on this roadway segment in the study period. The first crash was an angle collision located at the stop-controlled Cooley Road intersection in November 2006. A westbound vehicle ran the stop sign striking a northbound vehicle killing its driver on a cloudy dry mid-afternoon on a Friday. The second fatal crash occurred early on a Thursday morning in May 2007. An eastbound vehicle failed to maintain its lane, crashing and killing the passenger.

The one pedestrian crash in this section occurred in November 2004 late one afternoon. The collision was near the US20 /Nels Anderson Road intersection (MP 19.01) under dark,

but lighted conditions. The driver was traveling northbound, in fog, on wet pavement. The driver tried to avoid the pedestrian, but the pedestrian was standing or lying in the roadway. The pedestrian suffered a severe injury (Injury A).

Table 2: US20 Crash Type and Year Table

Crash Type	2004	2005	2006	2007	2008	2009	Total
Angle	2	1	3	2	0	0	8
Fixed Object	0	1	1	1	3	1	7
Head-on	2	0	0	0	0	1	3
Misc. / Other	0	0	1	3	2	2	8
Pedestrian	1	0	0	0	0	0	1
Parking	0	0	0	0	1	0	1
Rear-end	3	4	6	4	5	4	26
Sideswipe-Meeting	0	0	1	1	0	0	2
Sideswipe-Overtaking	0	0	0	2	0	0	2
Turning	1	3	4	4	4	5	21
Total	9	9	16	17	15	13	79
Fatal - Injury A Crashes ¹	1	1	2	1	2	0	7
Intersection / Related	4	6	11	5	11	9	46

¹Injury A is an incapacitating non-fatal injury (i.e. broken bones, severe/internal bleeding, unconsciousness, etc) that prevents a person from continuing normal activities that they were capable of before the injury.

There were a total of 79 crashes in this area between 2004 and 2009:

- Two fatal crashes
- One pedestrian crash
- 6% (5) Injury A crashes
- 53% (42) injury crashes (including A)
- 44% (35) Property Damage Only (PDO) crashes
- 80% (63) occurred in daylight conditions
- 33% (26) were rear-end collisions
- 27% (21) were turn movement related
- 10% (8) were angle collisions
- 52% (41) were located at or near Empire Avenue, Robal Road and Cooley Road

The number of crashes has increased over time from 2004 to 2009. Crashes were highest on this roadway in 2007 with a six year average of about 13 crashes per year.

The crash rates were reviewed based on two segments, The first segment from Old Bend-Redmond Highway to Cooley Road (MP 17.48) has a 2009 crash rate of 0.89 crashes per million vehicle miles compared to the statewide rate of 0.68 crashes per MVM for rural other principal arterials. This is highest crash rate in the project area. This section has a number of intersection related crashes such as angle, turning, and rear-ends. Very few crashes are the typical rural crashes (i.e. fixed-object, sideswipe, and head-on). This section is transitioning from an urban to a rural character, or has an urban crash pattern with a rural crash rate comparison. This section would not have an issue if it was classified as urban.

The second segment, from Cooley Road to Empire Avenue has an overall crash rate of 0.77 crashes per million vehicle miles as compared to the comparable statewide rate of 2.08 for urban other principal arterials. A review of the past six years of crash rates shows that the average crash rate is comparable to other rural principal arterials at 0.68 crashes per million vehicle miles. The segment rate has been trending higher since 2007 with the last three years more than 15% higher than the average.

The 2009 intersection crash rates at Cooley Road, Robal Road and Empire Avenue are 0.10, 0.35, and 0.18 crashes per million entering vehicle, respectively. These intersections are substantially below the 1.0 crashes per million entering vehicles rule of thumb for indicating a safety issue. However, a rule of thumb is just that and depending on the individual intersection crash patterns or severity, a safety issue may be indicated without meeting the 1.0 value. The Empire Avenue intersection has experienced enough crashes in past years to put it in the top 10% of the most serious crash locations in Region 4 even with the low intersection crash rate. Cost-effective safety improvements should still be identified for these intersections even though the crash rates are below statewide averages.

SPIS Reporting

There are several 2010 SPIS (Safety Priority Index System) sites in the study area. Table 3 lists the top five and ten percent of the 2010 SPIS sites located within the study area on US97 from Cooley Road to Robal Road and US20 from O.B. Riley Road to Empire Avenue. The data in Table 3 is based on a three-year average of the recorded SPIS sites. Every year the top 10% of SPIS sites are listed and the top 5% require investigations. The 2010 5% SPIS cutoff value is 53.30 therefore only two of the sites listed in Table 3 are Top 5% SPIS sites, both of which are on US97. One location is at Cooley Road and the other is at Robal Road.

Table 3: 2010 (2007-2009 data) Top 5 % and 10% SPIS Sites

Route No.	BMP	EMP	Intersection (if appropriate)	# of Crashes	Fatal Crashes	SPIS Value
US97	130.10	130.27	Deschutes Market Road	7	1	51.69
	134.02	134.20	Cooley Road	22	0	54.78 ¹
	134.47	134.57	n/a	5	0	45.86
	134.51	134.65	Robal Road	19	0	54.81 ¹
US20	18.71	18.89	Empire Avenue	13	0	46.36

¹Top 5% SPIS site

Local Roads

Boyd Acres Road

There have been a total of 26 crashes on this road segment between 2004 and 2009 with the majority being turning, angle, and rear-end. These crashes mainly occurred in dry, daytime conditions. Less than one-third have been injury crashes. The number of crashes per year has remained moderately constant with the last three years averaging only three crashes per year with no fatal or severe injury crashes. The crash rate for this roadway was not calculated since the short section would skew the calculation.

Half of the collisions are at or near the Empire Avenue intersection. The Empire Avenue intersection was signalized in late 2007, so a number of the earlier related Empire Avenue crashes may be mitigated.

Cooley Road

The majority crash types were angle collisions (Table 4). These crashes mainly occurred in dry, daytime conditions. There were two crashes with either a fatality or severe injury (Injury A). Almost all crashes on this roadway are intersection related.

The number of crashes per year has been relatively low, and has declined over the last three years. The crash rate for this roadway was 0.36 crashes per million vehicle miles which is about half the 2009 statewide crash rate for urban other principal arterials at 0.68 crashes per million vehicle miles.

Table 4: Cooley Road Crash Type and Year Table

Crash Type	2004	2005	2006	2007	2008	2009	Total
Angle	1	4	2	0	0	0	7
Fixed Object	2	0	0	0	1	0	3
Non-Collision/Miscellaneous	0	0	0	1	0	0	1
Rear-end	1	0	1	0	1	0	3
Turning	0	0	0	0	0	1	1
Total	4	4	3	1	2	1	15
Fatal – Injury A Crashes ¹	1	0	1	0	0	0	2
Intersection / Related	4	4	2	0	1	1	12

¹Injury A is an incapacitating non-fatal injury (i.e. broken bones, severe/internal bleeding, unconsciousness, etc) that prevents a person from continuing normal activities that they were capable of before the injury.

There were a total of 15 crashes in this area between 2004 and 2009:

- There was 1 fatal crash
- 53% (8) injury crashes
- 40% (6) Property Damage Only (PDO) crashes
- 73% (11) occurred in clear weather conditions
- 67% (10) occurred in daylight conditions
- All but one occurred on dry pavement
- 53% (8) were turning or angle collisions
- 47% (7) were located at or near the Bend Parkway

There was one fatal crash on Cooley Road during the six year reported period. It occurred on the Veteran's Day holiday in 2006 Friday at about 3 pm. A northbound vehicle ran a stop sign in cloudy but dry conditions, striking a westbound vehicle. The driver and two passengers were injured in the errant vehicle, while the elder driver of the struck vehicle was the fatality.

There was also one crash that incurred a severe injury (Injury A) was a rear end collision at the US97 intersection. The southbound driver was following too close and failed to stop in time, striking a vehicle stopped but not waiting to turn. The severe injury was in the stopped vehicle. The crash occurred on a Monday evening in July 2004 in clear, dry conditions.

Deschutes Market Road

There have been 14 crashes on this road segment between 2004 and 2009. The major types were non-collision crashes as almost half have involved striking an animal. These crashes mainly occurred in dry, daytime conditions. Less than one-third are injury crashes. For the past six years, crashes average about two per year with a high of six in 2006 and a low of none in 2007. The crash rate for this roadway was not calculated since the short section would skew the calculation.

Empire Avenue

The majority of the 32 crashes that occurred in the six year period were turning or rear end collisions, occurring at intersections (Table 5). These crashes mainly occurred in dry, daytime conditions.

The number of crashes has been increasing between 2004 and 2009, with a spike in 2008. The 2009 crash rate for this roadway was 1.08 crashes per million vehicle miles compared to a statewide crash rate of 0.68 for urban other principal arterials. The segment rate is somewhat inflated since this is a short section, however the trend is increasing as the last three years are almost twice the six year average of crashes.

Table 5: Empire Avenue Crash Type and Year Table

Crash Type	2004	2005	2006	2007	2008	2009	Total
Angle	0	0	1	3	1	0	5
Fixed Object	0	0	0	0	0	1	1
Non-Collision/Miscellaneous	0	0	0	0	1	0	1
Rear-end	0	3	1	1	3	1	9
Turning	2	2	0	4	5	3	16
Total	2	5	2	8	10	5	32
Fatal –Injury A Crashes ¹	0	1	0	0	1	0	2
Intersection / Related	2	5	2	8	7	4	28

¹Injury A is an incapacitating non-fatal injury (i.e. broken bones, severe/internal bleeding, unconsciousness, etc) that prevents a person from continuing normal activities that they were capable of before the injury.

There were a total of 32 crashes in this area between 2004 and 2009:

- 44% (14) injury crashes (including two Injury A)
- 56% (18) Property Damage Only (PDO) crashes
- 88% (28) occurred in daylight conditions
- 50% (16) were turn movement related
- 28% (9) were rear-end collisions
- 88% (28) were intersection related crashes

Two crashes incurred a severe injury (Injury A) in this reporting period. The first occurred on a cloudy, dry Thursday afternoon in May 2005. It involved a motorcycle making an improper lane change, driving in the wrong lane to pass a second vehicle which was turning left. The second crash occurred on a clear, dry April morning in 2008. A vehicle turning left did not yield right of way to a motorcycle.

Hunnell Road (South)

The six year crash listing (2004-2009) only reports one crash on this roadway segment. It was a property damage only (PDO) backing accident on a Thursday afternoon in April 2005. A northbound vehicle backed into a southbound vehicle in clear dry conditions.

Nels Anderson Road

The majority crash types were turning or angle collisions and rear-end crashes. These crashes mainly occurred in dry, daytime conditions. Three of the five crashes that have occurred on this road between 2004 and 2009 are at or near the Empire Avenue intersection. The number of crashes per year has remained moderately constant with no crashes in 2009 therefore no crash rate was calculated for this roadway.

O.B. Riley Road

The 24 crashes reported during the study period were almost equally split between angle, fixed object, rear-end, and turning collisions (Table 6). Three separate fatal crashes occurred during this period. Just over half of these crashes occurred in the daytime, a larger majority in dry conditions.

The number of crashes per year has remained moderately constant averaging about six per year. The crash rate for this roadway was 0.58 crashes per million vehicle miles which is almost half the comparable 2009 statewide crash rate for rural major collector at 1.11 crashes per million vehicle miles.

Table 6: O.B. Riley Road Crash Type and Year Table

Crash Type	2004	2005	2006	2007	2008	2009	Total
Angle	1	0	1	1	2	0	5
Fixed Object	0	2	2	0	2	1	7
Miscellaneous / Other	0	0	1	0	0	0	1
Rear-end	2	0	1	1	1	0	5
Turning	0	0	2	1	1	2	6
Total	3	2	7	3	6	3	24
Fatal – Injury A Crashes ¹	0	1	1	0	1	1	4
Intersection / Related	3	0	4	2	5	3	17

¹Injury A is an incapacitating non-fatal injury (i.e. broken bones, severe/internal bleeding, unconsciousness, etc) that prevents a person from continuing normal activities that they were capable of before the injury.

There were a total of 24 crashes on this road segment between 2004 and 2009:

- Three fatal crashes
- 50% (12) injury crashes (including 1 severe Injury A)
- 38% (9) Property Damage Only (PDO) crashes
- 63% (15) occurred in daylight conditions or in clear weather conditions
- 46% (11) were turning or angle related
- 29% (7) were fixed object collisions
- 21% (5) were rear-end collisions

The first fatality was a fixed object collision which occurred on a Monday evening in April 2005 on a cloudy but dry evening located at the signalized US 20 intersection. The driver failed to maintain his lane and ran off the road a struck a tree.

A second fatality was also a fixed object collision on a Thursday evening in March 2008. A southbound motorcycle that was driving too fast for conditions failed to stay in his lane. The cyclist lost control hitting the ditch, fell off, and struck a fixed object. The crash occurred on a clear dry night.

The third fatality occurred on a Monday evening in July 2009 in unknown conditions. A northbound motorcycle struck a westbound moped that did not yield right of way and was obscured from view.

The crash that resulted in a severe injury (Injury A) occurred on a Friday in July 2006. A southbound motorcycle struck a left turning vehicle that did not yield right-of-way. The crash occurred in the afternoon of a clear, dry day.

Old Bend-Redmond Highway

There were ten crashes in the six year reporting period on the Old Bend-Redmond Highway, seven of which were turn movement related. These crashes are occurring generally at or near Rickard Road, but in clear, dry daylight conditions. Half of the crashes are injury crashes although none are severe (Injury A). The number of crashes per year has remained moderately constant at about two per year. The crash rate for this roadway was not calculated since the short section would skew the calculation.

Robal Road

The majority of the 16 crashes on this road segment between 2004 and 2009 were turning, angle, or rear-end collisions. These crashes mainly occurred in dry, daytime conditions. Almost two-thirds of the crashes are injury crashes. Over two-thirds of the collisions occurred at or near the Hunnell Road intersection. The number of crashes per year has remained moderately constant except for 2007 with about three crashes per year. The crash rate for this roadway was not calculated since the short section would skew the calculation.

Tumalo Road

There have been five crashes reported on this road segment between 2004 and 2009 which were rear end, turning and other (animal). The crashes were all property damage only and occurred in clear, dry conditions. The number of crashes per year has remained moderately constant with only one or so non-fatal or severe injury crashes. The crash rate for this roadway was not calculated since the short section would skew the calculation.

Other Roadways

There have not been any crashes reported in the six years covered in this analysis on the following roadway segments:

- Chavre Way from US97 to Nels Anderson Road,
- Hunnell Road (north) from Cooley Road to Loco Road
- Nels Anderson Place from US97 to Nels Anderson Road
- Nichols Market Road east from Tumalo Road to US97
- Rogers Road from Old Bend-Redmond Hwy to Hunnell Rd

Traffic Development

The 2007 30th Highest Hour Volumes used in this analysis were developed mostly using a combination of 16-hour classification and 3-hour turning movement intersection counts and 48-hour hose tube counts taken in 2007. A peak hour count was obtained to determine lane flows within the northbound weaving section between the Empire Avenue on-ramp and the US20 loop off-ramp (commonly known as the Sister's Loop). Potential alternative impacts necessitated obtaining 3-hour classification counts at certain local street intersections in 2009. Table D1 in Appendix D shows the location, duration, and time obtained for each count. The peak hour for the study area was found to be 4:00 to 5:00 pm. The 30th Highest Hour Volume occurs on a Friday in August.

The counts were seasonally adjusted to 30th Highest Hour Volumes using three local Automatic Traffic Recorders (ATR). ATR's #09-007 Bend-Empire and #09-009 Bend-Revere were averaged together for the Bend Parkway portion of US97. ATR #09-007 Bend-Empire and #09-020 Redmond were averaged together for the rest of US97.

There were no matches in the ATR Characteristic Table for US20 because the subject site volumes were more than 10% of the values shown in the table, so the Seasonal Trends Table was used. The average of the Commuter and Summer trends were used for the expressway portion of US20. Third Street and other local roads used the Commuter trend. Interchange ramps used an average of the Bend Parkway seasonal factors and the local road seasonal factors as ramps are a hybrid between the crossroad and the mainline. The 2007 30th highest hour volumes and lane configurations are shown in Appendix E.

Because of the elapsed time between the traffic counts and the current year, the volumes were reviewed to address concerns that they were out-of-date. Current traffic counts were reviewed and found that the 2007 counts are at least 10% higher than 2009 or 2010 values. In addition, economic events since 2008 have caused employment to drop about 20%, and population has leveled out or decreased in the study area. Because of little or no growth in the traffic volumes beyond 2007, the 2007 counts are functionally equivalent to 2010 counts.

Analysis Results

Mainline & Merge/Diverge/Weave Segments

In 2007, all of the free-flow mainline segments of US97 are under the OHP 0.70 v/c rural standard or the 0.80 v/c urban standard except for the northbound section between the Butler Market Road on-ramp and the Empire Avenue off-ramp (Table 7). The v/c is relatively high on US97 between Butler Market Road and the US20 loop ramp connection to US20 which likely indicates a future congested area.

Table 7: Year 2007 US20 & US97 Mainline Segment and Merge/Diverge/Weave V/C Ratios¹

Section ²	OHP v/c Std.	Direction	
		NB	SB
Mainline north of Deschutes Market Rd	0.70	0.52	0.37
Nichols Market Rd/Deschutes Market Rd Off-ramp diverges	0.70	0.49	0.36
Nichols Market Rd/Deschutes Market Rd On-ramp merges	0.70	0.49	0.35
Mainline south of Deschutes Market Rd	0.70	0.49	0.37
US97 Business Off-ramp diverge	0.80		0.53
Mainline US20 NB Flyover ramp from 3 rd St	0.85	0.34	
Mainline US20 SB ramp to 3 rd St	0.85		0.53
Sister's Loop ramp to US20	0.85	0.33	
Mainline north of Empire Ave ³	0.80	0.70	0.39
Mainline between Empire Ave ramps	0.80	0.68	0.39
Empire Ave On-ramp merge	0.80		0.54
Empire Ave Off-ramp diverge	0.80	0.72	
Mainline south of Empire Ave	0.80	0.81	0.62
Butler Market Rd Off-ramp diverge	0.80		0.55
Butler Market Rd On-ramp merge	0.80	0.70	
Mainline south of Butler Market Rd ramps	0.80	0.72	0.52
US20 (3 rd St) NB On-Ramp to US97 merge	0.80	0.62	

¹Blackened cells indicate that the applicable OHP v/c standard has been exceeded.

²NB= Northbound, SB= Southbound

³The northbound mainline segment is a weaving section, so the weaving v/c ratio controls the operation of the segment.

Preliminary Signal Warrants

Preliminary Signal Warrant (PSW) criteria were analyzed for all of the unsignalized intersections included in the study area. PSW's are from the Manual of Uniform Traffic Control Devices (MUTCD) Warrant #1 Case A and B. Case A and B deal primarily with high volumes on the minor street and high volumes on the major street respectively.

Meeting PSW's does not guarantee that a traffic signal will be installed. Region Traffic staff will need to perform a intersection traffic control study in which the Region Traffic Engineer will forward the recommendation to the State Traffic Engineer's office. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal will be installed on a state highway.

Table 8 shows the 2007 PSW status for the unsignalized intersections in the project area. All of the unsignalized intersections in the project area do not meet PSW's except for the US20 & Old Bend-Redmond Highway intersection. This intersection is outside of the urban growth boundary and has a rural nature, so signalizing is not desirable. In addition, Region 4 Traffic does not support a signal at this location.

Table 8: Year 2007 Preliminary Signal Warrants¹

Intersection	PSW Met?
Tumalo Rd & Nichols Market Rd	No
Tumalo Road & Deschutes Market Rd	No
US97 & Grandview Dr	No
US97 & Clausen Rd	No
Old Bend-Redmond Hwy & O.B. Riley Rd	No
US20 & Old Bend-Redmond Hwy	Yes
Cooley Rd & O.B. Riley Rd	No
US20 & Cooley Rd	No
Cooley Rd & Hunnell Rd (south)	No
Cooley Rd & Hunnell Rd (north)	No
Cooley Rd & Boyd Acres Rd	No
US20 & Jamison St	No
Robal Rd & Nels Anderson Dr	No
Nels Anderson Dr & Nels Anderson Pl	No
US97 & Nels Anderson Pl/Cascade Village	No
O.B. Riley Rd & Empire Ave	No
Empire Ave & Britta St	No
Empire Ave & Jamison St	No
Empire Ave & Sherman Rd/Industrial Park Blvd	No
Empire Ave & Nels Anderson Rd/SB US 97 Ramp Terminal	No

¹Black shaded cells indicate that preliminary signal warrants (PSW's) have been met. Meeting PSW's does not guarantee that a traffic signal will be installed. Region Traffic staff will need to perform an intersection traffic control study in which the Region Traffic Engineer will forward the recommendation to the State Traffic Engineer's office. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal will be installed on a state highway.

Unsignalized Intersections

In 2007, congestion problems at unsignalized intersections are concentrated in a few areas. Volume to capacity ratios, level of service, and approach delay are well under standards in most of the project area. Table 9 shows the state-jurisdiction unsignalized intersections, while Table 10 and Table 11 show the city and county locations, respectively.

Most of the unsignalized intersections along US20 west of the US97/3rd Street connections are at or over capacity for the stopped side-street approaches. Volume-to-capacity ratios in excess of 1.0 indicate that sufficient gaps in traffic are limited. Ratios in excess of 2.0 indicate that no sufficient gaps are available and vehicles must use a shorter gap to turn onto or travel across a roadway, risking a crash.

Table 9: Year 2007 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	OHP v/c Std.	v/c Ratio ¹	Critical Movement ²
US97 & Bowery Ln	0.70/0.80	0.58/0.03	NBT/EBLR
US97 & Grandview Dr	0.80/0.90	0.55/0.31	SBTR/EBLR
US97 & Clausen Rd	0.80/0.90	0.59/0.09	SBTR/EBR
US97 & Lowe's Dwy	0.80/0.90	0.44/0.12	SBTR/EBR
US97 & Chavre Wy	0.80/0.90	0.59/0.04	NBTR/WBR
US97 & Target Dwy	0.80/0.90	0.42/0.59	SBTR/EBR
US20 & Old Bend-Redmond Hwy	0.70/0.80	0.32/1.0+	NBT/WBLTR
US20 & Mountainview Dr	0.70/0.80	0.39/0.11	NBT/WBLR
US20 & Cooley Rd	0.80/0.90	0.57/1.0+	SBT/WBTR
US20 & Jamison St	0.80/0.90	0.59/0.92	SBTR/EBLR
US97 & Nels Anderson Pl/ Cascade Village Dwy	0.80/0.90	0.79/0.48	NBTR/EBR
Empire Ave & Nels Anderson Rd/ SB US 97 Ramp Terminal	0.85/0.90	0.66/1.0+	EBTR/SBLTR

¹Black shaded cells indicate the applicable OHP mainline/stopped approach v/c standard has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Other problem areas include Empire Avenue from US20 to the northbound US97 (Bend Parkway) ramp terminal. Volumes are high enough along Empire Avenue to make turns from unsignalized intersections difficult with high levels of delay. The Nels Anderson approach at the SB US97 ramp terminal is at capacity, however the eastbound through-right and westbound left movements onto the ramp are significantly under standard at 0.66 and 0.54, respectively.

Table 10: Year 2007 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	v/c Ratio ¹	Delay (s)	Critical Movement ²
Cooley Rd & Scenic Dr	0.13/0.01	0.0/10.8	WBTR/SBLR
Cooley Rd & Hunnell Rd (south)	0.10/0.01	0.0/13.3	WBTR/SBLTR
Cooley Rd & Hunnell Rd (north)	0.22/0.19	0.0/16.9	EBTR/SBLTR
Cooley Rd & Loop Rd/Lowe's Dwy	0.22/0.04	0.0/11.3	EBTR/NBLTR
Cooley Rd & Boyd Acres Rd	0.01/0.20	0.3/16.5	EBLTR/NBLTR
Robal Rd & Auto Mall Dwy	0.22/0.07	0.0/12.0	EBTR/NBLTR
Robal Rd & Target Dwy	0.14/0.14	0.0/10.2	WBT/SBR
Robal Rd & Cascade Village Dwy	0.22/0.13	0.0/11.6	EBTR/NBR
Robal Rd & Nels Anderson Dr	0.38/0.17	10.5/8.4	NBLT/EBLR
Nels Anderson Dr & Chavre Wy	0.06/0.0	9.4/5.2	NBLT/EBLR
Nels Anderson Dr & Nels Anderson Pl	0.07/0.11	0.0/11.4	SBTR/EBLR
O.B. Riley Rd & Empire Ave	0.10/0.31	5.5/16.6	SBLTR/WBLT
Empire Ave & Britta St	0.13/0.13	0.0/12.2	WBT/SBL
Empire Ave & Jamison St	0.24/0.54	0.0/22.2	WBTR/SBLR
Empire Ave & Sherman Rd/Industrial Park Blvd	0.60/1.0+	0.0/120+	EBTR/SBLTR
Empire Ave & Blenheim/Corporate Pl	0.31/0.27	0.0/27.2	WBTR/NBLTR

¹Black shaded cells indicate the City v/c of 1.0 and/or the 50 second delay standard for unsignalized intersection has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Table 11: Year 2007 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches¹

Intersection	LOS	Critical Movement ²
Tumalo Rd & Nichols Market Rd	A/B	EBL/SBLTR
Tumalo Road & Deschutes Market Rd	A/B	WBTL/NBLR
Old Bend-Redmond Hwy & O.B. Riley Rd	A/A	SBTL/WBLR
Cooley Rd & O.B. Riley Rd	A/A	SBTL/WBLR
Rogers Rd & Hunnell Rd	A/A	NBTL/EBLR
Bowery Ln & Harris Wy	A/A	EBTL/SBLR

¹County operational standards are LOS D for existing facilities.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Signalized Intersections

The signalized intersections along US97 are at or approaching capacity. Like with the unsignalized intersections, the high volumes of traffic on US20 (3rd Street) and Empire Avenue have the US20 & Empire Avenue intersection over standard (Table 12). The City-controlled signalized intersections on Empire and Robal shown in Table 13 are well under standards.

Table 12: Year 2007 State Highway Signalized Intersection Operations

Intersection	OHP v/c Std.	v/c Ratio ¹
US97 & Cooley Rd	0.80	1.10
US97 & Robal Rd	0.80	0.91
US20 & Robal Rd	0.80	0.70
US20 (3 rd St) & Empire Ave	0.85	0.89
Empire Ave & NB US97 Ramp Terminal	0.85	0.74

¹Black shaded cells indicate the applicable OHP v/c has been exceeded.

Table 13: Year 2007 City Street Signalized Intersection Operations¹

Intersection	v/c Ratio	Delay (s)
Robal Rd & Hunnell Rd	0.38	20.2
Empire Avenue & Boyd Acres Rd	0.54	26.8

¹City operational standards are a v/c of 1.0 and/or 80 seconds of intersection delay.

Queuing

The queues and other measures of effectiveness (MOE) were created by averaging at least five random SimTraffic micro-simulation runs together. Field collected headway, driver reaction time, turning speeds, and spot speed data in addition to visual observation and Region 4 local knowledge was used to calibrate the SimTraffic model as best as possible to 30th highest hour conditions. Appendix P gives more detail on the simulation calibration. Queues shown on the figures are a combination of stopped vehicles and vehicles traveling at seven or less miles per hour.

Appendix F shows the 95th percentile queues for the 2007 existing conditions. Along US97, the high level of commuter through traffic between Redmond and Bend is causing the majority of the queuing as vehicles bunch up between relatively free-flow sections north and south of the Cooley-Robal area.

In 2007, there is significant queuing on US97 between Clausen Road and Nels Anderson Place, on Cooley and Robal Roads around the US97 intersections, and along Empire Avenue from Jamison Street to the US97 interchange. Closely spaced intersection and commercial driveway approaches are being blocked by the queues radiating from the US97

intersections with Cooley and Robal Roads. In addition, northbound US97 traffic slows substantially north of Butler Market Road because of high through volumes mixing with traffic coming and going on closely spaced on and off ramps in this section. The slowdown section tapers out as vehicles accelerate away from the Empire Avenue area. Some of this congestion is caused by the Empire Avenue northbound off-ramp backing into the US97 mainline.

An additional measure for queuing is the percent time blocked for turn storage bays and intersections. The queuing figures show the extent of the queuing and the percent time blocked shows how much of the peak hour that these queues block significant transportation elements. Blocking percentages of five percent or greater are considered significant as these levels can have a measurable effect on an intersection's operation.

Table 14 shows the percent time a turn lane or an intersection is blocked for the 2007 existing conditions. Significant queue blocking is substantial throughout the study area with most problems being left turn lanes blocked by adjacent through queues from 10% to 50% of the peak hour. Most of the long-lasting queuing problems are on US97 between Cooley Road to Butler Market Road and along Empire Avenue. Many closely spaced intersections also are showing significant blocking times such as between US20 (3rd St) and Jamison Street on the west and Industrial Park Boulevard on the east on Empire Avenue; between the ramp terminals at the Empire Avenue interchange; and between the closely spaced US20 and Butler Market on-ramps on northbound US97. In addition, queues are filling up the northbound Empire Avenue off-ramp and affecting northbound US97 traffic over a quarter of the peak hour.

Table 14: Year 2007 No-build Significant Queue Blocking¹

Intersection	Approach ¹	Blocked Lane	Blocked Intersection	Average Percent Time Blocked
US97 & Cooley Rd	EB	L		35
			Loop Rd/ Lowe's Dwy	13
	WB	L		11
	NB	L		12
	SB	L		18
			Clausen Dr	8
US97 & Robal Rd	WB	TR		32
	NB	L		14
	SB	L		18
			Target Dwy	28
US97 & Butler Market Rd NB On-ramp	NB		US20 (3 rd St) NB On-ramp	13
US20 & Cooley Rd	WB	L		23
US20 & Robal Rd	WB	L		8
US20 (3 rd St) & Empire Ave	EB		Jamison St	51
	WB	L		28
			Industrial Park Blvd/Sherman Rd	9
	NB	L		36
	SB	L		17
Robal Rd & Hunnell Rd S	SB	L		13
Empire Ave & Industrial Park Blvd/Sherman Rd	WB	L		6
Empire Ave & Nels Anderson Rd/US97 SB On-ramp	WB	L		54
			US97 NB Ramps	17
Empire Ave & US97 NB Ramps	WB		Corporate Pl/Blenhiem Pl	21
	NB		US97	28
Empire Ave & Boyd Acres Rd	NB	L		12

¹NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, TR = shared through-left-right lane.

Other Operational Performance Measures

Tables 15 and 16 show additional MOE's for the project area which includes all modeled roadways (see Appendix E). The micro-simulation runs used for the queuing analysis were also used so the results would be consistent. MOE's allow comparisons to be made on a

system-wide basis. Generally, lower delays, lower number of stops, lower travel time and higher average speed show a more efficient system.

Table 15 shows the system-level MOE's. The Average Speed MOE is the speed of all vehicles completely or partially traveling this path averaged over each segment between intersections. The Total Stops MOE shows how many times, on the average, the total number of vehicles would stop either at an intersection or substantially slowed down enough in a queue. The Delay MOE is the total delay for all of the vehicles in the project roadway network for the peak hour whether stopped or not. The Travel Time MOE is accumulated travel time of all vehicles completely or partially the project area roadways in the design hour.

Table 15: Year 2007 No-build Overall Simulation Measures of Effectiveness

Measure of Effectiveness
Average Speed = 22 mph
Total Stops ¹ = 25,800
Delay = 740 hr
Travel Time = 1,485 hr

¹A stop is recorded every time a vehicle drops below 7 mph (crawl speed). A vehicle might have multiple stops on a single intersection approach.

Table 16 shows specific per-vehicle MOE's for travel time and average speed for specific roadway segments. The effects of the congestion and signals on US97 and the 3rd Street portion of US20 can be seen with a 10 mph reduction in average speed from the posted 45 mph. The congestion on city roadways is evident because of the low average speeds (less than half of the posted speed limit). An exception is O.B. Riley Road as it is substantially unaffected with a 43 mph average speed compared to its 45 mph posted speed.

Table 16: Year 2007 No-build Segment Travel Time and Speed

Segment	Travel Time per vehicle (min:s)	Average Speed (mph)
US97 (Deschutes Pleasant Ridge Rd – Butler Market Rd)	11:15	32
US20 (Old Bend-Redmond Hwy – Empire Ave)	3:30	35
O.B. Riley Rd (Old Bend-Redmond Hwy – Empire Ave)	2:25	43
Empire Ave (O.B. Riley Rd – Boyd Acres Rd)	3:20	14
Cooley Rd (O.B. Riley Rd – Boyd Acres Rd)	5:00	15
Robal Rd (US20 – Nels Anderson Rd)	2:20	12

Spacing Standards

Appendix C in the OHP has spacing standards for public road approaches and private accesses to be used in the planning process. The following spacing standards apply to the US 97 Bend North Corridor Solutions project:

- Interchange-to-interchange: three miles for a rural expressway and 1.9 miles for an urban expressway or statewide highway based on cross-road spacing. This standard is for the planning of new interchanges on the state system.
- Ramp-to-ramp/intersection: one mile between two interchanges in access-controlled freeway sections or between an interchange and an at-grade intersection.
- Ramp-to-Ramp: one-half mile between the taper sections of intersections or adjacent on and off-ramps.
- Next intersection adjacent to ramp terminal: 1320 feet for a two or multi-lane crossroad in an urban area to the next full or right-in/right-out intersection.
- Street spacing: One mile at 55 mph for a rural expressway; 2640 feet for streets at 45 mph on a urban expressway; and 990 feet for a urban statewide highway. There is no standard for private accesses as they are discouraged on statewide highways and expressways.

Table 17 shows the comparison between major road segments and their appropriate spacing standard. On US97, the existing street, ramp and interchange spacing is substantially under the applicable standards. The interchange spacing is only about a third of the 1.9 mile standard with interchanges spaced approximately one-half mile apart from Empire Avenue to Butler Market Road. Interchange ramp-to ramp spacing is generally only about a quarter-mile apart instead of the one mile standard which will likely lead to congestion issues with higher volumes. Street spacing is also a third to half of the required levels.

On US20, the street spacing is just under the standard between Cooley and Robal Roads but is less than a third of the required spacing between at-grade intersections and the US97/US20/3rd Street interchange connections. Along Empire Avenue at the US97 interchange, the ramp terminal spacing standard is not met as there are nearby full access intersections 300' away on the west and about 800' on the east. The signalized US20 (3rd Street) & Empire Avenue intersection is only about 850' away from the southbound ramp terminal, so meeting the spacing standard will not be possible even under the best conditions.

There are relatively few private accesses on US97 north of Cooley Road, with only the Lowe's, Target, and Cascade Village Mall right-in/right-out driveways between Cooley and the US97 Business Southbound off-ramp. US97 from the Cascade Village Mall access south through Butler Market Road is access-controlled with the only connections being interchanges. Like US97, the northern section of US20 has very few accesses north of Empire Avenue. From Empire Avenue south, US20 is an uncontrolled five-lane section with many driveways.

Table 17: Spacing Standards Comparison

Roadway	Segment	Spacing Standard	Existing Conditions¹
	Deschutes Market Rd – Fort Thompson Ln	1 mi	<2500 ft ²
US97	Fort Thompson Ln – Grandview Dr	1 mi	200- 600 ft ²
	Grandview Dr – Clausen Rd	2640 ft	1000 ft
	Clausen Rd – Cooley Rd	2640 ft	1110 ft
	Cooley Rd - Robal Road	2640 ft	400 - 600 ft ²
	Robal Road – Nels Anderson Pl	2640 ft	800 ft
	Nels Anderson Pl – US97 BUS/US20 Ramps	1 mi	950 ft
	US97 BUS/US20 Ramps – Empire Ave Ramps	1 mi	1060 ft
	US97 BUS/US20 Overcrossing – Empire Ave Overcrossing	1.9 mi	2590 ft
	Empire Avenue Ramps – Butler Market Rd Ramps	1 mi	1270 ft
	Empire Ave Overcrossing – Butler Market Rd Undercrossing	1.9 mi	4490 ft
US20	Old Bend-Redmond Highway – Cooley Rd	1 mi	300 - 1700 ft ²
	Cooley Rd – Robal Rd	2640 ft	2220 ft
	Robal Rd – Jamison St	2640 ft	1530 ft
	Jamison St – 3 rd St Connections	1 mi	1640 ft
	3 rd St Connections – Empire Ave	1 mi	1530 ft
	Empire Ave – project limits	990 ft	<300 ft ²
Empire Ave	Sherman Rd – Nels Anderson Rd/SB US97 On-ramp	1320 ft	300 ft
	US97 NB Off-ramp – Corporate/Blenhiem Pl	1320 ft	780 ft

¹Black-shaded cells mean that the interchange/ramp/street spacing is less than the corresponding standard.

²Approximate approach (road or driveway) spacing over segment

YEAR 2015 & 2035 NO-BUILD FUTURE CONDITIONS

Future Travel Trends

An analysis was undertaken to determine the future general travel trends throughout the project area using the Bend MPO travel demand model. These travel trends illustrate the traffic patterns on a regional scale both in distribution across areas in Bend as well as identifying the longer distance through trips versus the short local trips.

The 2030 Metropolitan Transportation Plan (MTP) fiscally constrained model scenario was not completed at the time of this analysis, so the 2030 Committed (No-build) scenario was used in combination with the 2003 existing road network which created a true future no-build scenario. Given no changes to the road system, this is what is projected. The major findings are shown below and more detailed travel patterns and results are in Appendix G.

- Through the project study area, 10% of trips on US 20 and 25% on US 97 are through trips. This low through trip percentage indicates that there will be a high amount of trip ends in the project area which may cause intersection/interchange design issues regardless of alternative.
- Around 33% of the local trips are “short hops” on the Parkway (US97) between one or two interchanges.
- At least 50% of the trips on US 97 between Empire Avenue and Cooley Road are “short-hop” (local) trips.
- Over 50% of the trips using Empire Avenue are local trips beginning or ending in adjacent neighborhoods that do not access the Parkway.
- Trips using US 97 are much more likely to originate or terminate in Bend as they are primarily local or commuter-based, while trips that use US 20 are more likely to be long-distance trips.

A large portion of trips use US97 for short distances mainly because US97 is the most attractive route given the overall time savings when compared to the local system. These short-hops cause significant congestion issues at intersections and interchanges with US97. Generally, if capacity was never an issue, traffic would favor the major routes in the project area: US97, US20, 3rd Street, and Empire Avenue. Traffic congestion causes bottlenecks and traffic flows respond by diverting to longer, slower routes. The need to restrict access to US97 to the most important connections and to have sufficient parallel local facilities was determined in part from this trend information. These trends/patterns are also implicitly included in all of the future traffic development as the MTP model scenario will have similar results.

Traffic Development

To create future year 2015 and 2035 volumes, the Bend Metropolitan Planning Organization (BMPO) travel demand model was used. Travel demand models are a combination of mathematical equations and relationships using locally-provided existing and future housing and employment information to project future traffic conditions. These future conditions are placed on a network which is similar to the actual roadway network. The model is based on the current comprehensive land use plans of Deschutes County and the City of Bend. Growth beyond the current comprehensive plans will result in higher impacts than what is shown here.

Significant approved developments were reviewed to see if the population and employment assumptions were consistent with the model assumptions. The only significant approved development in the area is the Les Schwab headquarters development which is part of the first phase of the Juniper Ridge area northeast of the US97 & Cooley Road intersection. The development is consistent with the future model assumptions so no new trips are needed to be added to the network. There is a potential Wal-Mart development in the northwest quadrant of the US 97 & Cooley Road intersection; however, that development is also consistent with the model, so if that development gets approved in the short-term, the future volumes will not need to be revised.

The model application effort used the MTP scenario to develop the future no-build volumes. The MTP scenario is financially constrained which means that all the city, county and state projects (outside of the US97 Bend North Corridor Solutions project) in and around the Bend metropolitan area that can be funded within the next 20 years are included. These projects are assumed to occur regardless of what happens in the US97 Bend North Corridor project area. The Bend Comprehensive (General) Plan map and the MTP project list are included in Appendix D.

The volumes were post-processed using procedures from the National Cooperative Highway Research Council (NCHRP) Report 255. Model base and future year volumes are compared to develop a relative difference between scenarios. This difference was applied to the existing 2007 30th highest hour volumes to arrive at the 2035 no-build volumes used in the analysis. The 2015 no-build volumes were interpolated using straight-line growth from the 2007 existing conditions and the 2035 no-build volumes. Appendix D details the future volumes development. The 2015 Future No-build volumes are shown in Appendix H and the 2035 Future No-Build Volumes are shown in Appendix I.

There is a very large amount of new employment and housing in and around the Cooley Road area (not including any new Juniper Ridge urban growth boundary expansions). The amount of projected growth in the study area is reflected by the large change in volumes. US97 north of Robal Road jumps 32% from 44,500 ADT in 2007 to 58,700 ADT in 2035. Average daily traffic approaching 60,000 on US97 will likely spread the peak period across multiple hours. A 50% increase occurs on US20 west of Robal Road where it increases from 27,500 in 2007 to 41,200 ADT in 2035.

Cooley Road and Empire Avenue are carrying a much larger share of the east-west traffic in 2035 as the volume demand shifts north over time as significant road improvements are completed. Cooley Road is extended to Deschutes Market Road while Empire Avenue is completed and widened to 27th Street. The volumes on Cooley Road on both sides of US97 increase about three times over the 2007 existing conditions which will overwhelm the existing two-lane roadway. Cooley Road west of US97 goes from 7,100 ADT in 2007 to 23,800 in 2035. Similarly, Cooley Road east of US97 increases from 8,200 ADT in 2007 to 23,100 ADT in 2035. Volumes on Empire Avenue also increase substantially resulting in a potentially congested corridor by 2035. For example, Empire Avenue ADT between the US97 ramp terminals almost doubles from 18,200 to 35,900.

Analysis Results

Mainline & Merge/Diverge/Weave Segments

Table 18 shows the volume-capacity ratios for the mainline free-flow segments, ramps, and merge/diverge/weave sections in the study area. In 2015, all sections of US 97 are operating acceptably except for the northbound section between the Butler Market Road on-ramp and the Empire Avenue off-ramp. The section from US20 to Butler Market Road is just below the OHP 0.80 v/c standard as well.

In 2035, the rural sections of US 97 in the Deschutes Market Road area are acceptable in the southbound direction. Higher outbound (northbound) commuter flows in the afternoon push the section north of Deschutes Market Road to over the OHP 0.70 v/c standard and the rest of the section is at the standard. In the urban sections, northbound US97 is over or near capacity from the south of Butler Market Road to north of Empire Avenue. The southbound direction is over or near the OHP standard from the Empire Avenue interchange south.

The over standard mainline sections of US97, especially south of the project limits, will increase congestion for traffic entering and leaving the project area. Any substantial improvements within the project results in traffic reaching the limits faster, thus increasing congestion at these points until subsequent no-build mainline sections are improved. The section south of Empire Avenue would act as a transition section between the at-capacity sections south of Butler Market Road and the improved sections north of Empire Avenue.

Table 18: Year 2015 and 2035 No-build US97 Mainline and Merge/Diverge/Weave V/C Ratios^{1,2}

Section	OHP v/c Std.	Direction			
		2015		2035	
		NB	SB	NB	SB
Mainline north of Deschutes Market Rd	0.70	0.57	0.40	0.72	0.50
Nichols Market Rd/ Deschutes Market Rd Off-ramp diverges	0.70	0.53	0.39	0.67	0.43
Nichols Market Rd/ Deschutes Market Rd On-ramp merges	0.70	0.53	0.37	0.69	0.46
Mainline south of Deschutes Market Rd	0.70	0.54	0.39	0.69	0.49
US97 Business Off-ramp diverge	0.80		0.54		0.61
Mainline US20 NB Flyover ramp from 3 rd St	0.85	0.37		0.97	
Mainline US20 SB ramp to 3 rd St	0.85		0.59		0.83
Sister's Loop ramp to US20	0.85	0.37		0.49	
Mainline north of Empire Ave ³	0.80	0.76	0.40	0.93	0.50
Mainline between Empire Ave ramps	0.80	0.72	0.40	0.92	0.50
Empire Ave On-ramp merge	0.80		0.58		0.77
Empire Ave Off-ramp diverge	0.80	0.78		1.02	
Mainline south of Empire Ave	0.80	0.88	0.67	1.16	0.88
Butler Market Rd Off-ramp diverge	0.80		0.59		0.78
Butler Market Rd On-ramp merge	0.80	0.76		1.00	
Mainline south of Butler Market Rd ramps	0.80	0.79	0.56	1.06	0.78
US20 (3 rd St) NB On-Ramp (on US97) merge	0.80	0.68	0.67	0.93	

¹Blackened cells indicate that the v/c standard has been exceeded.

²NB=Northbound, SB=Southbound

³The northbound mainline segment is a weaving section, so the weaving v/c ratio controls the operation of the segment. Because of the high weaving flows, the operation of the weaving section will likely be worse than predicted.

Preliminary Signal Warrants

Table 19 shows the results from the 2015 and 2035 preliminary signal warrant (PSW) analysis. In 2015, three intersections meet the PSW criteria: US20 & Old Redmond-Bend Hwy, US20 & Cooley Road, and O.B. Riley Road & Empire Avenue. Although the US20 & Old Bend-Redmond Highway intersection is over the OHP v/c standard, its rural location makes it an undesirable for a signal because of safety concerns with the potential for high-speed crashes. In addition, Region 4 is not supportive of a signal at this intersection.

The US20 & Cooley Road intersection is likely still too rural in character to be signalized until development changes the surrounding area. Region 4 is supportive of a signal here combined with speed and access changes (for example, closing the south side of the Old Bend-Redmond intersection) along US20 as part of future development mitigation. Development is likely to occur before 2015 in the Cooley Road vicinity and is part of the overall future growth assumptions, so this intersection was assumed to be signalized for 2015 and 2035. Without this assumption, the intersection v/c and delays are too high which

causes unrealistic analysis and simulation results along Cooley Road and the northern project area.

Additional development after 2015 will likely drive the O.B. Riley Road & Empire Avenue intersection signalization, so this likely improvement (signalization) is shown in the 2015 and 2035 analyses. The future volumes here are too high for a single lane roundabout. Assuming widening would occur here in the project horizon (not in the MTP) to accommodate a multiple-lane roundabout is not likely, so only a traffic signal was assumed. The City does have future plans to improve this intersection. Northbound and southbound left turn lanes were added to O.B Riley Road in both 2015 and 2035 with permissive-protected phasing as a companion improvement with signalization.

Table 19: Year 2015 & 2035 No-Build Preliminary Signal Warrants¹

Intersection	PSW Met?	
	2015	2035
Tumalo Rd & Nichols Market Rd	No	No
Tumalo Road & Deschutes Market Rd	No	No
US97 & Grandview Dr	No	No
US97 & Clausen Rd	No	No
Old Bend-Redmond Hwy & O.B. Riley Rd	No	Yes
US20 & Old Bend-Redmond Hwy	Yes	Yes
Cooley Rd & O.B. Riley Rd	No	Yes
US20 & Cooley Rd	Yes	Yes
Cooley Rd & Hunnell Rd (south)	No	Yes
Cooley Rd & Hunnell Rd (north)	No	Yes
Cooley Rd & Boyd Acres Rd	No	No
US20 & Jamison St	No	Yes
Robal Rd & Nels Anderson Dr	No	No
Nels Anderson Dr & Nels Anderson Pl	No	No
US97 & Nels Anderson Pl/Cascade Village	No	No
O.B. Riley Rd & Empire Ave	Yes	n/a ²
Empire Ave & Britta St	No	No
Empire Ave & Jamison St	No	Yes
Empire Ave & Sherman Rd/Industrial Park Blvd	No	Yes
Empire Ave & Nels Anderson Rd/SB US 97 Ramp Terminal	No	No

¹Black shaded cells indicate that preliminary signal warrants (PSW's) have been met. Region Traffic staff will need to perform a intersection traffic control study in which the Region Traffic Engineer will forward the recommendation to the State Traffic Engineer's office. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal will be installed on a state highway.

²This intersection will be signalized (or a roundabout installed) before 2035.

By 2035, many of the high volume corridors such as Empire Avenue and Cooley Road cause the significant unsignalized intersections to meet PSW's. Many of these intersections are in urban enough areas to be signalized. However, too many signals on a given roadway lowers the progression bandwidth (makes it harder to progress traffic through the system

quickly), increases travel time and decreases capacity (throughput) of the main roadway. Seven additional intersections met PSW's for 2035.

The US20 & Jamison Street intersection is not a desirable location because its close proximity to the US97/US20/3rd Street interchange connections. This intersection was originally built for emergency services access, never intending to act as a full intersection. The build alternatives will modify the roadways in this area and will close this approach.

Improving the Cooley Road intersections with the north and south portions of Hunnell Road will be driven by development. By 2035, this area is projected to be well developed, so signals were assumed at these two locations by then. If the Cooley Road intersection with Loop Rd/Lowe's is closed anytime in the future, development agreements state that the Cooley Road & Hunnell Road N/Lowe's intersection will be signalized.

The intersections of Old Bend-Redmond Highway and Cooley Road with O.B. Riley Road also are projected to meet PSW's. For 2035, a roundabout was assumed for the Old Bend-Redmond location as operations can affect the adjacent US20 intersection; while the Cooley Road location was left unchanged. The Jamison Street and Industrial Boulevard intersections on Empire were assumed to be unsignalized in the analysis as they are too close to the US20 (3rd Street) intersection, are directly affected by the project, and would not be a good choice for signalization.

Unsignalized Intersections

In 2015, the unsignalized minor roadway and private approaches along US97 operate well under standards (Table 20). Along US20, the mainline unsignalized approaches are under standards, but limited gaps in traffic for turning vehicles cause the intersections with Old Bend-Redmond Hwy and Jamison Street to exceed capacity. Vehicles may use much smaller gaps than standard, risking a crash by doing so.

Congestion of the city intersections (Table 21) is limited to Empire Avenue from Jamison Street to the US97 interchange. Delays exceed two minutes at many approaches and some movements have a v/c of greater than 2.0 (no safe gaps available). Long queues extending through most of the peak hour block nearby intersections increasing the congestion. Most of this congestion radiates from the US20 (3rd Street) & Empire Avenue intersection which is over capacity. Outside of the urban growth boundary, no congestion issues exist (Table 22).

Table 20: Year 2015 State Highway No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	OHP v/c Std.	v/c Ratio ¹	Critical Movement ²
US97 & Bowery Ln	0.70	0.61/0.03	NBT/EBLR
US97 & Grandview Dr	0.80	0.62/0.34/	NBT/EBLR
US97 & Clausen Rd	0.80	0.62/0.10	SBTR/EBR
US97 & Lowe's Dwy	0.80	0.47/0.12	SBT/EBR
US97 & Chavre Wy	0.80	0.63/0.05	NBTR/WBR
US97 & Target Dwy	0.80	0.63/0.43	EBR/GBT
US20 & Old Bend-Redmond Hwy	0.70	0.31/2.0+	NBT/WBLTR
US20 & Mountainview Dr	0.70	0.44/0.15	NBT/WBLR
US20 & Jamison St	0.80	0.66/1.43	SBTR/EBLR
US97 & Nels Anderson Pl/Cascade Village Dwy	0.80	0.84/0.55	NBTR/EBR
Empire Ave & Nels Anderson Rd/ SB US 97 Ramp Terminal	0.85	0.88/2.0+	WBL/SBLTR

¹Black shaded cells indicate the applicable OHP v/c standard has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

By 2035, US97 volumes have increased enough to have the unsignalized intersection mainline approaches reach or exceed the OHP v/c standards (Table 23). These minor intersections start exceeding standards in 2026. The US97 & Nels Anderson Place/Cascade Village Mall intersection is the worst unsignalized bottleneck. The northbound left has no safe gaps in southbound traffic, so vehicles that try it will be risking a serious crash. Exiting the mall will be difficult because of limited gaps; so long delays and queues are expected. Most of the intersections along US20 are approaching or over capacity, so poor side-street operation will be expected.

Table 21: Year 2015 City Street No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	v/c Ratio ¹	Delay (s)	Critical Movement ²
Cooley Rd & Scenic Dr	0.20/0.02	0.0/12.6	WBTR/SBLR
Cooley Rd & Hunnell Rd (north)	0.23/0.63	0.0/27.0	EBTR/SBLTR
Cooley Rd & Hunnell Rd (south)	0.18/0.36	0.0/22.8	WBTR/NBTR
Cooley Rd & Loop Rd/Lowe's Dwy	0.28/0.16	0.0/19.9	EBTR/SBLTR
Cooley Rd & Boyd Acres Rd	0.04/0.36	1.2/29.9	WBLTR/NBLTR
Robal Rd & Auto Mall Dwy	0.27/0.08	0.0/13.2	EBTR/WBL
Robal Rd & Target Dwy	0.15/0.15	0.0/10.4	WBT/SBR
Robal Rd & Cascade Village Dwy	0.24/0.14	0.0/11.6	EBTR/NBR
Robal Rd & Nels Anderson Dr	0.18/0.42	8.6/11.3	EBLT/NBLT
Nels Anderson Dr & Chavre Wy	0.07/0.00	9.4/5.2	NBLT/EBLR
Nels Anderson Dr & Nels Anderson Pl	0.07/0.20	0.0/12.4	SBTR/EBLR
Empire Ave & Britta St	0.16/0.20	0.0/14.1	WBT/SBL
Empire Ave & Jamison St	0.27/0.72	0.0/120+	WBTR/SBLR
Empire Ave & Sherman Rd/Industrial Park Blvd	0.68/2.0+	0.0/120+	EBTR/SBLTR
Empire Ave & Blenheim/Corporate Pl	0.36/0.30	0.0/29.9	WBTR/NBLTR

¹Black shaded cells indicate the applicable City v/c of 1.0 and/or the 50 second delay standard for unsignalized intersection has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Table 22: Year 2015 County Road No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	LOS ¹	Critical Movement ²
Tumalo Rd & Nichols Market Rd	A/B	EBL/SBLTR
Tumalo Rd & Deschutes Pleasant Ridge Rd	A/B	WBLT/NBLR
Tumalo Road & Deschutes Market Rd	A/C	EBL/NBLR
Old Bend-Redmond Hwy & O.B. Riley Rd	A/B	SBLT/WBLR
Cooley Rd & O.B. Riley Rd	A/B	SBLT/WBLR
Rogers Rd & Hunnell Rd	A/A	NBLT/EBLR
Bowery Ln & Harris Wy	A/A	EBLT/SBLR

¹County operational standards are LOS D for existing facilities.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Table 23: Year 2035 State Highway No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	OHP v/c Std.	v/c Ratio ¹	Critical Movement	Year Exceeded	
				Std.	Cap.
US97 & Bowery Ln	0.70	0.78/0.07	SBTR/EBLR	2026	2040+
US97 & Grandview Dr	0.80	0.77/0.43	SBTR/EBLR	2040+	2040+
US97 & Clausen Rd	0.80	0.82/0.19	SBTR/EBR	2034	2040+
US97 & Lowe's Dwy	0.80	0.60/0.12	SBT/EBR	2040+	2040+
US97 & Chavre Wy	0.80	0.80/0.09	NBTR	2036	2040+
US97 & Target Dwy	0.80	0.53/0.91	SBT/EBR	2035	2040+
US20 & Old Bend-Redmond Hwy	0.70	0.49/2.0+	NBL/WBLTR	<2007	<2007
US20 & Mountainview Dr	0.70	0.61/0.62	NBT/WBLR	2040+	2040+
US20 & Jamison St	0.80	0.93/2.0+	SBTR/EBLR	<2007	2009
US97 & Nels Anderson Pl/ Cascade Village	0.80	2.0+/1.06	NBL/EBR	2017	2020
Empire Ave & Nels Anderson Rd/SB US 97 Ramp Terminal	0.85	2.0+/2.0+	WBL/SBLTR	<2007	<2007

¹Black shaded cells indicate the OHP 0.70 rural or 0.80 urban v/c for expressways, the 0.80 rural or 0.90 urban v/c for unsignalized stopped approaches or 0.85 for 3rd Street/US20 and ramp terminals has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

The Cooley Road intersections with Boyd Acres Road and Loop Road (Lowe's) experience minor approach delays over two minutes by 2018 depending on development (Table 24). Empire Avenue through the study area exceeds the delay and capacity City operational standards by 2015. Long delays and queues are expected around the US97 Empire interchange area. There is a need for Empire Avenue traffic control and lane capacity improvements before 2015 and Cooley Road improvements before 2020.

The County road system is under standard in 2035 with good operations predicted beyond 2040 (Table 25), except at the O.B. Riley Road & Cooley Road intersection. This intersection is predicted to reach LOS E by 2017 and LOS F by 2018 depending on development in the Cooley Road area.

Table 24: Year 2035 City Street No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	v/c Ratio ¹	Delay (s)	Critical Movement	Year Std. Exceeded
Cooley Rd & Scenic Dr	0.42/0.05	0.0/26.5	WBTR/SBLR	2040+
Cooley Rd & Loop Rd/Lowe's Dwy	0.54/2.0+	0.0/120+	EBTR/SBLTR	2021
Cooley Rd & Boyd Acres Rd	0.27/2.0+	8.3/120+	WBLTR/NBLTR	2018
Robal Rd & Auto Mall Dwy	0.43/0.26	0.0/22.9	EBTR/SBLTR	2040+
Robal Rd & Target Dwy	0.19/0.18	0.0/11.2	WBT/SBR	2040+
Robal Rd & Cascade Village Dwy	0.16/0.17	0.0/12.9	EBTR/NBR	2040+
Robal Rd & Nels Anderson Dr	0.27/0.64	10.1/16.2	EBLR/NBLT	2040+
Nels Anderson Dr & Chavre Way	0.10/0.00	9.7/3.7	NBLT/EBLR	2040+
Nels Anderson Dr & Nels Anderson Pl	0.08/0.64	0.0/22.0	SBTR/EBLR	2040+
Empire Ave & Britta St	0.29/0.90	0.0/80.0	WBT/SBL	2026
Empire Ave & Jamison St	0.44/2.0+	0.0/120+	WBTR/SBLR	2013
Empire Ave & Sherman Rd/Industrial Park Blvd	1.03/2.0+	0.0/120+	EBTR/SBLTR	<2007
Empire Ave & Blenheim/Corporate Pl	0.64/1.96	0.0/120+	WBTR/NBLTR	2016

¹Black shaded cells indicate the applicable City v/c of 1.0 and/or the 50 second delay standard for unsignalized intersection has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Table 25: Year 2035 County Road No-Build Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	LOS ¹	Critical Movement ²	Year Exceeded	
			Std.	Cap.
Tumalo Rd & Nichols Market Rd	A/B	EBL/SBLTR	2040+	2040+
Tumalo Rd & Deschutes Pleasant Ridge Rd	A/B	WBLT/NBLR	2040+	2040+
Tumalo Road & Deschutes Market Rd	A/C	EBL/NBLR	2040+	2040+
Old Bend-Redmond Hwy & O.B. Riley Rd	C/A ³	NBTR/WBLR	2040+	2040+
Cooley Rd & O.B. Riley Rd	A/F	SBLT/WBLR	2017	2018
Roger Rd & Hunnell Rd	A/A	NBLT/EBLR	2040+	2040+
Bowery Ln & Harris Wy	A/A	EBLT/SBLR	2040+	2040+

¹Black shaded cells indicate that the County LOS D standard for existing intersections has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

³Single-lane roundabout

Signalized Intersections

Tables 26 and 27 present signalized intersection operations for the future no-build conditions for state and city facilities. The signalized analysis is based on fully optimized signal timing including cycle lengths. Region 4 has indicated that protected left turns will be added in the near future to the Empire Avenue approaches at the US20 & Empire Avenue intersection, so this is included in the 2015 and 2035 results.

Most of the signalized intersections on US97 and US20 are over standard in 2015 and all are over capacity by 2034 (Table 26). This will lead to extensive queuing and delays on the north end of the Bend Parkway and US20 likely spreading across multiple hours. The worst bottlenecks in the project area are the US97 & Cooley Road and the US20 & Empire Avenue intersections which have v/c's around 1.80. The northbound Empire Avenue off-ramp reaches capacity around 2022 and is substantially over capacity in 2035. This level of congestion at the ramp terminal will cause ramp queues to block the right northbound US97 (mainline) lane.

Table 26: Year 2015 & 2035 State Highway No-build Signalized Intersection Operations

Intersection	OHP v/c Std.	v/c Ratio ¹		Year Exceeded	
		2015	2035	Std.	Cap.
US97 & Cooley Rd	0.80	1.14	1.79	<2007	<2007
US97 & Robal Rd	0.80	0.97	1.23	<2007	2018
US20 & Cooley Rd	0.80	0.81	1.28	2015	2023
US20 & Robal Rd	0.80	0.75	1.02	2019	2034
US20 & Empire Ave	0.85	1.14	1.85	<2007	2011
Empire Ave & NB US97 Ramp Terminal	0.85	0.85	1.33	2016	2022

¹Black shaded cells indicate that the OHP v/c has been exceeded.

Signalized intersections on the City facilities (Table 27) are all under standard in 2015. In 2027, the Cooley Road & Hunnell (north) intersection is projected to reach capacity and will be substantially over capacity by 2035 without any additional lanes. All other City signalized intersections are under standards, but the intersections of the south leg of Hunnell Road with Cooley Avenue and Empire Avenue at Boyd Acres Rd are approaching capacity.

Table 27: Year 2015 & 2035 City Street No-build Signalized Intersection Operations

Intersection	v/c Ratio ¹ / Delay (s)		Year Std. Exceeded
	2015	2035	
Cooley Rd & Hunnell Rd S	n/a	0.90/41.4	2039
Cooley Rd & Hunnell Rd N	n/a	1.34/120+	2027
Robal Rd & Hunnell Rd	0.55/15.9	0.83/38.3	2040+
O.B. Riley Rd & Empire Ave	0.34/10.6	0.86/23.5	2040+
Empire Avenue & Boyd Acres Rd	0.64/24.7	0.96/61.8	2038

¹Black shaded cells indicate the City v/c of 1.0 and/or the 80 second overall delay standard has been exceeded.

Queuing

Appendix I contains the 2015 and 2035 95th percentile queuing figures for the project area. The 2015 and 2035 queues were created by averaging at least five random SimTraffic micro-simulations together. Because of the extreme congestion on the road network in 2035, the simulation was only run for 30 minutes instead of the normal 60 minutes for all other scenarios and years. Beyond 30 minutes, the queuing backs into adjacent intersections blocking turn bays in a cascading fashion which causes the simulation to eventually report unrealistic results (actual drivers would reroute instead of sitting at a left turn bay for 20 minutes). The 2035 queues are presented as approximate values as the actual 2035 values would be much longer than the 2015. Queues shown on the figures are a combination of stopped vehicles and vehicles traveling at seven or less miles per hour.

By 2015, congestion on US97 northbound extends from the south project limits at Butler Market all the way to Grandview Drive. Southbound, queuing starts at Grandview Drive and continues until the US97 Business exit (to 3rd St). The Cooley and Robal intersections have long queues that radiate out in all directions. Many minor intersections such as Nels Anderson Place, Chavre Way, and Clausen Road are blocked. The US97 northbound ramp terminal backs onto US97 creating congestion between Butler Market Road and the Sister's Loop (US20) exit ramp.

On US20, the Empire Avenue intersection backs up traffic almost to Robal Road and onto the US97 mainline south of the Cascade Village Mall access. Long queues (over 500') exist for southbound approaches at the Cooley and Robal Road intersections.

On the local system, queuing is limited to spots on Cooley and Robal Roads. However, both direction of Empire Avenue are congested entirely within the project area. Long queues exist for almost all side-street approaches.

By 2035, the queuing is extensive project-area wide. The US97 & Cooley Road intersection has queues that extend north of Bowery Lane southbound and almost to Robal Road northbound. Queuing along Cooley Road from this intersection backs west into US20 and east to Boyd Acres Road. The queues from the US20 (3rd St) & Empire Avenue

intersection has queues extending almost to Cooley Road and over 1000' for the northbound direction. Cooley Road, Robal Road, and Empire Avenue have extensive queuing over their entire length in the project area. Long queues exist on most side-street approaches.

Table 28 shows the significant queue blocking sites and percentages in the project area in 2015. Many turn bays on US97 are blocked for over 33% of the peak hour with many smaller intersections blocked up to almost 25% of the hour. Ramp blockages on US97 south of Empire Avenue extend to about 35% of the peak hour. On US20, blocking is limited to turn bays around 15-20% of the peak hour. At Empire Avenue, the southbound left turn bay is blocked almost 69% of the peak hour, the northbound left over 50%, and the closely spaced intersection of Jamison Street is at 70%.

Most turn bays along Empire Avenue are blocked during some of the peak hour from 5% to 70%. The largest times are around the US97 interchange. The westbound left onto the southbound on-ramp is blocked almost 70% of the time, the southbound ramp queues block the northbound ramp terminal over 30% of the time, and the northbound ramp queues backs onto the US97 mainline over 40% of the time.

Table 29 shows the significant queue blocking sites and percentages in the project area in 2035. By 2035, the queue blocking areas have spread from the major arterials and intersections to most routes. Because of the shorter 30 minute run times for the 2035 simulations, these times are likely underestimated in Table 29 and are presented as approximate values. Many turn bays and intersections are blocked on US97 from 20% to over 80% of the peak hour. Ramp blockages on US97 south of Empire Avenue extend to at least 75% of the peak hour. On US20, blocking occurs at all intersections up to almost 50% of the peak hour. At Empire Avenue, the southbound and northbound left turn bays are blocked about 75% of the peak hour and the closely spaced intersection of Jamison Street is almost 65%.

Table 28: Year 2015 No-build Significant Queue Blocking¹

Intersection	Approach	Blocked Lane	Blocked Intersection	Average Percent Time Blocked
US97 & Cooley Rd	EB	L		28
			Loop Rd/ Lowe's Dwy	5
	WB	L		37
	NB	L		18
	SB	L		37
			Clausen Dr	22
US97 & Chavre Wy	WB		Nels Anderson Rd	17
US97 & Robal Rd	EB	L		7
			CV Mall Dwy	7
	WB	L		37
	NB	L		26
	SB	L		10
			Target Dwy	17
US97 & CV Mall Dwy /Nels Anderson Pl	NB	L		32
US97 & Sister's Loop (US20 Conn)	NB		Empire Ave NB On-ramp	9
US97 & Empire Ave NB Off-ramp	NB		Butler Market Rd NB On-ramp	24
US97 & Butler Market Rd NB On-ramp	NB		US20 (3 rd St) NB On-ramp	35
US20 & Cooley Rd	WB	L		16
	NB	R		13
	SB	L		14
US20 & Robal Rd	WB	L		21
	SB	L		5
US20 (3 rd St) & Empire Ave	EB		Jamison St	70
	WB	L		15
	NB	L		51
		R		15
	SB	L		65
Robal Rd & Hunnell Rd S	SB	L		8
Empire Ave & OB Riley Rd	NB	L		6
	SB	L		5
Empire Ave & Britta St	EB		OB Riley Rd	8
Empire Ave &	EB		Britta St	9

Jamison St	WB		US20 (3 rd St)	14
Empire Ave & Industrial Park Blvd/Sherman Rd	WB	L		9
Empire Ave & Nels Anderson Rd/US97 SB On-ramp	EB	L		6
	WB	L		69
			US97 NB Ramps	31
Empire Ave & US97 NB Ramps	WB		Corporate Pl/Blenhiem Pl	51
	NB		US97	43
Empire Ave & Corporate Pl/Blenhiem Pl	WB	L		50
			Boyd Acres Rd	34
Empire Ave & Boyd Acres Rd	EB	L		6
	WB	L		48
	NB	L		42

¹NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, R = exclusive right turn lane.

Table 29: Year 2035 No-build Significant Queue Blocking^{1, 2}

Intersection	Approach	Blocked Lane	Blocked Intersection	Average Percent Time Blocked
US97 & Cooley Rd	EB	L		63
			Loop Rd/Lowe's Dwy	46
	WB	L		84
			Boyd Acres Rd	35
	NB	L		25
	SB	L		70
			Clausen Dr	56
US97 & Chavre Wy	WB		Nels Anderson Rd	>20
US97 & Robal Rd	EB	L		19
			CV Mall Dwy	19
	WB	L		55
			Nels Anderson Rd	56
	NB	L		>30
	SB	L		>10
			Target Dwy	>20
US97 & CV Mall Dwy /Nels Anderson Pl	NB	L		>35
US97 & Sister's Loop (US20 Conn)	NB		Empire Ave NB On-ramp	>10
US97 & Empire Ave NB Off-ramp	NB		Butler Market Rd NB On-ramp	35

US97 & Butler Market Rd NB On-ramp	NB		US20 (3 rd St) NB On-ramp	45
US20 & Old Bend-Redmond Hwy	NB	L		12
	SB	L		45
US20 & Cooley Rd	WB	L		46
			OB Riley Rd	24
	NB	L		15
		R		26
	SB	L		33
			Mountainview Dr	30
US20 & Mountainview Dr	SB	L		39
US20 & Robal Rd	WB	L		67
			CV Mall Dwy	18
	SB	L		22
			Cooley Rd	5
US20 (3 rd St) & Empire Ave	EB		Jamison St	>70
	WB	L		17
			Industrial Park Blvd/Sherman Rd	12
	NB	L		75
		R		16
	SB	L		79
Cooley Rd & Scenic Dr	EB		US20	40
Cooley Rd & Hunnell Rd S	EB		Scenic Dr	43
	WB	L		62
			Hunnell Rd N	14
	NB	L		61
Cooley Rd & Hunnell Rd N	EB	L		79
			Hunnell Rd S	49
	WB	L		17
Cooley Rd & Loop Rd/Lowe's Dwy	EB	L		46
			Hunnell Rd N	25
	NB	R		79
Robal Rd & CV Mall Dwy (at old AutoMall site)	EB	L		24
			US20	7
	WB	L		45
			Hunnell Rd S	11
Robal Rd & Hunnell Rd S	EB	L		18
			CV Mall Dwy	7
	SB	L		69
Robal Rd & Nels Anderson Rd	NB		Nels Anderson Pl	24

Empire Ave & OB Riley Rd	NB	L		15
	SB	L		19
Empire Ave & Britta St	EB		OB Riley Rd	37
	SB	L		95
Empire Ave & Jamison St	EB		Britta St	62
	WB		US20 (3 rd St)	>15
Empire Ave & Industrial Park Blvd/Sherman Rd	WB	L		10
Empire Ave & Nels Anderson Rd/US97 SB On-ramp	WB	L		77
			US97 NB Ramps	>35
Empire Ave & US97 NB Ramps	WB		Corporate Pl/Blenhiem Pl	57
	NB		US97	75
Empire Ave & Corporate Pl/Blenhiem Pl	WB	L		70
			Boyd Acres Rd	50
Empire Ave & Boyd Acres Rd	EB	L		21
			Corporate Pl/Blenhiem Pl	5
	WB	L		73
	NB	L		83

¹NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, R = exclusive right turn lane.

²The 2035 values in this table are based on a 30-minute simulation run which was the longest reportable time before the network completely filled up because of congestion and other metering effects from bottlenecks. The 2035 values are shown as approximations and actual values are likely much higher than shown.

Most turn bays along Empire Avenue are blocked at least some period in the peak hour from 5% to 95%. The largest times are around the US97 interchange. The westbound left onto the southbound on-ramp is blocked over 75% of the time, the southbound ramp queues block the northbound ramp terminal over 30% of the time, and the northbound ramp queues backs onto the US97 mainline over 75% of the time. Queue blocking along other local roads is significant in 2035. All of the intersections along Cooley Road and Robal Road have turn bays and adjacent intersections and approaches blocked around 75% of the hour.

Other Operational Performance Measures

Tables 30 and 31 show additional operational MOE's for the project area. Compared to the 2007 values, the 2015 speeds have fallen from 22 to 14 mph (33%), the total stops have increased about 60%, the delay has increased 105%, and the overall network travel time increased about 33%. The overall average speed in 2035 has been reduced to a crawl speed. Because of extreme congestion from bottlenecks and other metering effects, the 2035 no-

build simulation could only be run for 30 minutes. Speeds are relatively unaffected, but other values such as delay and number of stops are showed 2035 values equal to or less than 2015 values which is not intuitive. In actuality, the 2035 values would be much higher than 2015, but the actual difference cannot be measured. Based on the 57% reduction in average travel speed, the other network MOE's will increase by at least that much.

Table 30: Year 2015 & 2035 No-build Overall Simulation Measures of Effectiveness

Measure of Effectiveness	Year	
	2015	2035 ²
Average Speed (mph)	14	8
Total Stops ¹	42,000	>66,000
Delay (hr)	1,525	>2,400
Travel Time (hr)	2,290	~3,600

¹ A stop is recorded every time a vehicle drops below 7 mph (crawl speed). A vehicle might have multiple stops on an intersection approach.

²The 2035 values are based on a 30-minute simulation run which was the longest reportable time before the network completely filled up because of the congestion and metering effects from bottlenecks. Other than speed, the 2035 values are approximated and actual values are likely much higher than shown.

Table 31 shows some specific per-vehicle MOE's for travel time and average speed for specific roadway segments. The effect of the congestion can be seen as speeds continue to drop on the study area roadways. Empire Avenue is operating at crawl speed conditions from 2015 forward. The queues spreading onto the local system can be seen as travel time and speeds on Cooley and Robal Roads significantly decrease in speed and correspondingly increase in travel times. Other than O.B. Riley Road, the local system is traveling at a crawl speed.

Table 31: Year 2015 & 2035 No-build Segment Travel Time and Speed

Segment	Travel Time per vehicle (min:s)		Average Speed (mph)	
	2015	2035	2015	2035 ¹
US97 (Deschutes Pleasant Ridge Rd – Butler Market Rd)	14:05	18:05	27	20
US20 (Old Bend-Redmond Hwy – Empire Ave)	5:25	11:20	26	17
O.B. Riley Rd (Old Bend-Redmond Hwy – Empire Ave)	2:40	3:40	40	31
Empire Ave (O.B. Riley Rd – Boyd Acres Rd)	6:00	7:25	9	7
Cooley Rd (O.B. Riley Rd – Boyd Acres Rd)	4:15	19:10	19	5
Robal Rd (US20 – Nels Anderson Rd)	3:00	6:00	10	5

¹The 2035 values are based on a 30-minute simulation run which was the longest reportable time before the network completely filled up.

BUILD ALTERNATIVE DESCRIPTIONS

Twenty alternatives and many more concepts were considered in the alternative development phase. These alternatives and concepts were tested first on the purpose and need criteria and then later against goals and objectives. These alternatives and concepts considered alignments to the west of US97 and the commercial area, along existing US97 (3rd Street), and to the east of US97 adjacent to the railroad tracks. Near the end of the alternative refinement process, the alternatives were “down-scaled” using a practical design approach, resulting in alternatives with reduced scope and complexity to better address future funding and phasing. The final build alternatives are known as East DS-1 and DS-2. For additional detail on the considered alternatives, please refer to Appendix J and the Alternatives Development Report. Appendix K contains the detailed lane configurations for segments, interchanges and intersections for the two alternatives. Appendix O contains the design storage lengths for the two alternatives.

Both build alternatives realign US97 east of the current alignment next to the railroad tracks. The current alignment would become an extension of 3rd Street from the US20 connections north to a new US97 interchange. The East DS-1 and DS-2 alternatives share a common design from Cooley Road south. The two alternatives have different northern interchange types and local road connections (see Figures 3 and 4).

Both alternatives generally do not affect the existing pedestrian, bike or transit facilities. The largest change will be the extension of Robal Road west from US20 to O.B. Riley Road. This will allow for easier, quicker pedestrian and bicycle access from local neighborhoods along Britta Street or O.B. Riley Road to the commercial area east of US20. Because the highway through traffic has been removed from 3rd Street, volumes are less, making pedestrian and bike travel on 3rd Street more attractive.

The new or modified roadways will match into the existing facilities. On US97, the six foot bike lane will be continued while on US20, the six foot shoulders will be extended. No sidewalks will be built for either roadway. Project segments on County facilities will match into the current roadway. Segments on City facilities will have sidewalks and bike lanes as appropriate. The alternatives do not affect the current transit route in the project area other than the 3rd Street ODOT Region 4 Headquarters driveway will be closed. Vehicles will need to use Mervin Samples Road on the south edge of the ODOT Region 4 campus to access the park and ride lot.

Cooley Road to South Project Limits – Common for Both Alternatives

US97 would be a four-lane access-controlled facility through the project area. At the south project limits (Butler Market Road), the northbound ramp connection from 3rd Street would add a third northbound lane. The northbound on-ramp connection from Butler Market Road would merge into it. The northbound three lanes would continue past the single-lane Empire Avenue northbound off-ramp then split into two two-lane roadways via a left exit

(a 3-2-2 split). The western two-lane connection would have one lane connecting through the existing US20 loop ramp to US20 westbound and one lane connecting to northbound 3rd Street. The eastern two lane roadway is the US97 mainline lanes. US97 southbound would have no connections to US20 or 3rd Street at this location and simply “flyover” the westerly connections. The Empire Avenue southbound on-ramp creates a weaving section with a single auxiliary lane which would drop at the Butler Market off-ramp.

US20 is four lanes through the project area with signalized intersections at Cooley Road, Robal Road and Empire Avenue. At 3rd Street, the two eastbound lanes turn south and create a four-lane section with the two southbound 3rd Street lanes. The inside two lanes become eastbound dual left turn lanes onto Empire Avenue and the other two lanes continue south to the project limits. In the northbound direction, the two 3rd Street northbound lanes are joined at Empire Avenue by a third lane from the westbound to northbound right turn at Empire Avenue. The right lane drops at the ramp to northbound 3rd Street and the two remaining US20 lanes continue west.

Third Street remains in its five-lane cross-section north to Cooley Road. The Cascade Village Mall/Nels Anderson Place intersection is restricted to a right-in-right-out configuration.. The eastern Lowe’s driveway is closed because of the 3rd Street & Cooley Road intersection being realigned to the west to accommodate the new US97 alignment. All other approaches and intersections remain.

O.B. Riley Road is relatively unchanged other than a new single-lane roundabout at the extended Robal Road intersection and a signal at Empire Avenue. For 2035, a roundabout at Old Bend-Redmond Highway was assumed in the future no-build. Cooley Road is unchanged from O.B. Riley Road to US20. From US20 to east of Boyd Acres Road, Cooley Road has a four/five lane cross-section with signals at both the Hunnell Road north and south intersections.

Robal Road has been extended west from the existing signal at US20 to O.B. Riley Road. Britta Street is extended north to connect to Robal Road to allow for quicker access to the state system for the emergency services complex located between Britta Street and US20. Robal Road is a two/three lane cross-section from O.B. Riley Road to Hunnell Road with extended storage bays and single/dual turn lanes as needed. Because of the need for dual left turn lanes at the Robal Road & Hunnell Road intersection, Robal is expanded to a four-lane cross-section to 3rd Street. Robal Road east of 3rd Street is unchanged as are the commercial accesses along Robal Road into Target, the old AutoMall site, and into the Cascade Village Mall. Hunnell Road is expanded to four-lanes to the north of Robal Road to allow for the development of the south to east dual left turn and to allow run-out room for the west to north dual left turn.

Empire Avenue has a signal added at O.B. Riley Road as part of the project. Empire Avenue is a three lane cross-section from O.B. Riley Road west to the business park access west of Jamison Street. From the business park access east, Empire Avenue is widened to two travel lanes in each direction to match into the existing five-lane section

at the US97 northbound ramp terminal. The Jamison Street approach is restricted to a right-in-right-out. At US20 (3rd Street), dual left and right turn lanes are provided for the westbound direction. Industrial Park Boulevard is a right-in-right-out with the opposite Sherman Avenue/Nels Anderson Road approach closed. The Nels Anderson/US97 southbound ramp terminal is signalized and coordinated with the existing US20 and southbound US97 ramp terminal signals.

North of Cooley Road – East DS-1

In the East DS-1 alternative, north of Cooley Road, US97 returns to its current alignment. US97 has a full diamond service interchange with the extension of 3rd Street located just north of Bowery Lane. US97 between the 3rd Street interchange and the southern project limits is completely access-controlled. North of the 3rd Street interchange, a median barrier may be added in a future phase or as part of a future safety project to the Deschutes Junction interchange.

Third Street north of Cooley is built on a new four/five lane alignment west of the current alignment. Clausen Drive/Loco Road and Grandview Drive will have full-movement, stop-controlled intersections with 3rd Street. North of Grandview Drive, 3rd Street narrows to a two/three-lane cross-section with new intersections and connections to Bowery Lane and Harris Way. At the US97 interchange, the bridge structure will have a single lane in each direction plus left turn lanes at the ramp terminals. Third Street will continue east as a two-lane roadway to a new north-south frontage road adjacent to the railroad tracks which will serve residences and businesses that used to access US97 directly in this section.

Other local street improvements would include connecting Fort Thompson Lane directly to Harris Way and Hunnell Road. Hunnell Road would also be improved from Loco Road north to Fort Thompson Lane. Additional road/access connections would also be built for any properties currently only served by US97.

Figure 3: Alternative East DS-1

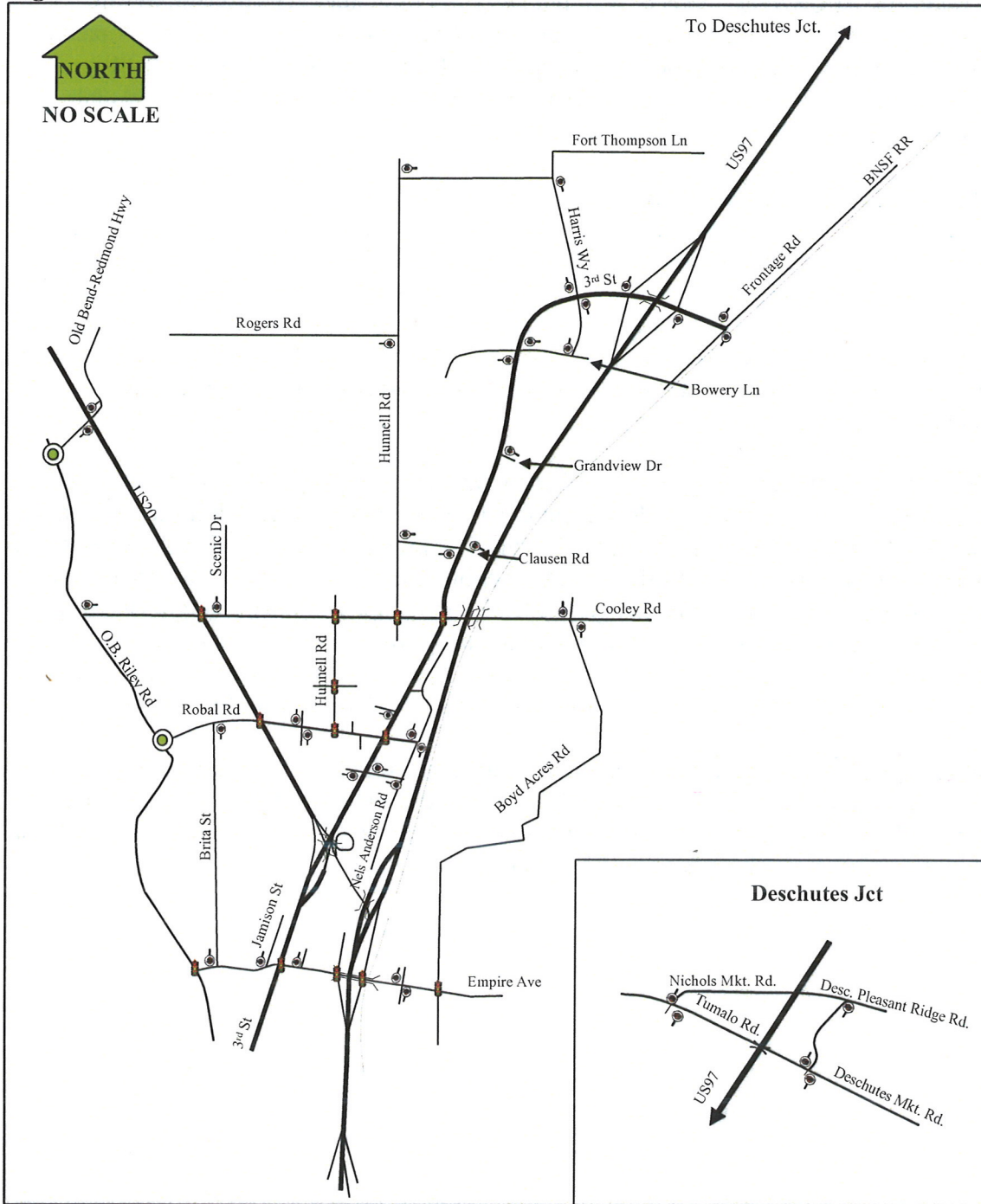
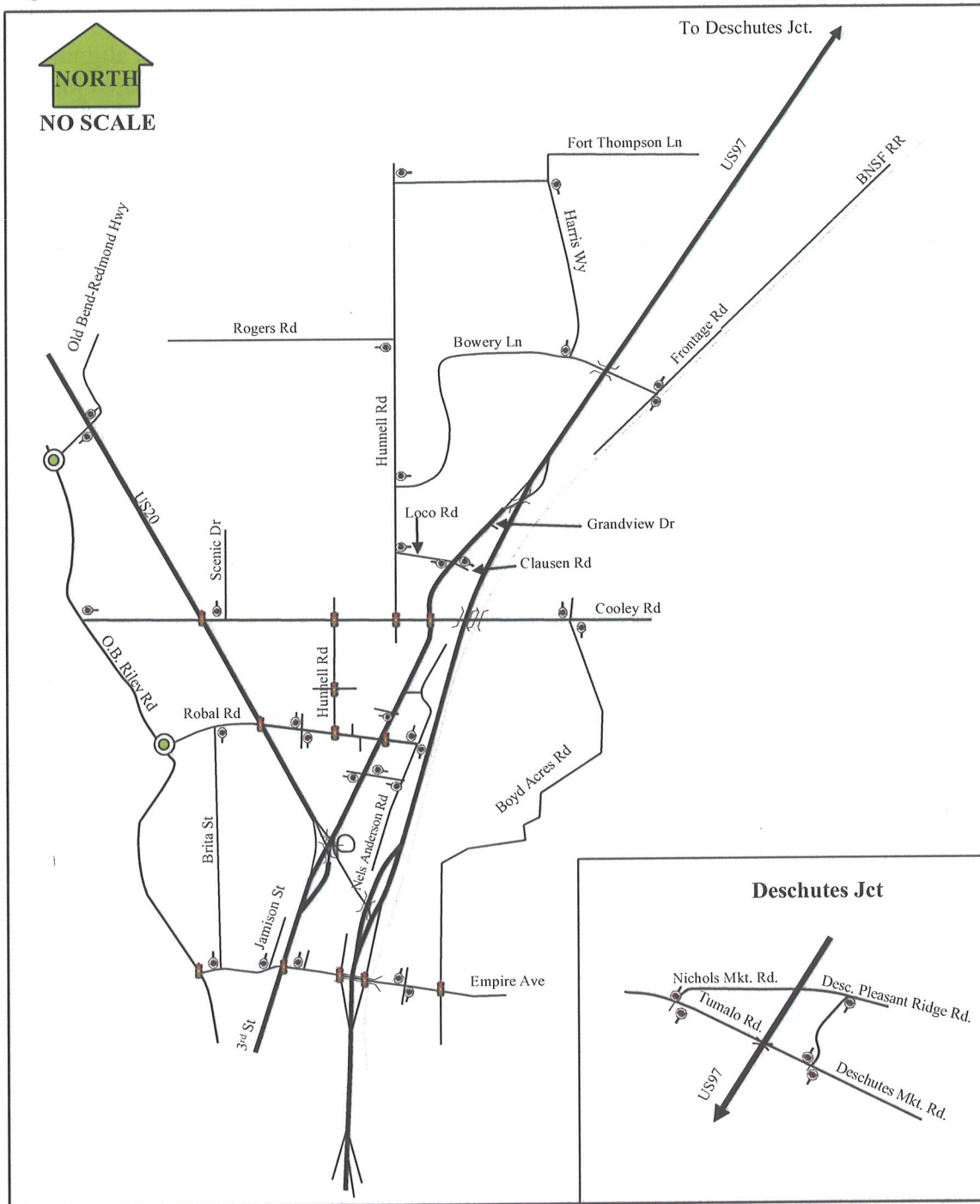


Figure 4: Alternative East DS-2



North of Cooley Road – East DS-2

In the East DS-2 alternative, north of Cooley Road, US97 returns to its current alignment. US97 has a system-type partial interchange with the extension of 3rd Street located just north of Grandview Drive. Movements would only be allowed to US97 from 3rd Street northbound and from US97 to 3rd Street southbound. “Turnaround” movements would need to be performed at the Deschutes Junction interchange on the north edge of the project area and at the Butler Market Road interchange on the south edge of the project area (no southbound off-ramp at Empire Avenue). US97 between the 3rd Street interchange and the southern project limits is completely access-controlled. North of the 3rd Street interchange, a median barrier may be added in a future phase or as part of a future safety project to the Deschutes Junction interchange.

Third Street north of Cooley Road is a five-lane cross-section generally on the current alignment. Clausen Drive/Loco Road and Grandview Drive will have full-movement, stop-controlled intersections with 3rd Street. At the US97 interchange, the bridge structure and ramps will be single lanes.

Since there is no direct connection to the west side of US97, Hunnell Road will be improved north of Loco Road to Fort Thompson Lane. Bowery Lane will be improved, formally connected to Hunnell Road, and extended over US97 to a frontage road adjacent to the railroad tracks. This frontage road will serve residences and businesses that used to access US97 directly in this section. Other local street improvements would include connecting Fort Thompson Lane directly to Harris Way and Hunnell Road. Additional road/access connections would be built for any properties currently only served by US97.

ALTERNATIVE ANALYSIS

Traffic Development

To create the build year (2015) and the design year (2035) volumes, the Bend Metropolitan Planning Organization (BMPO) travel demand model was used. The build alternatives used the Metro Transportation Plan (MTP) scenario to develop the future alternative volumes. The MTP scenario is financially constrained which means that all the city, county and state projects (outside of the US97 North Corridor project) that can be funded within the next 20 years in and around the Bend metropolitan area are included. These projects are assumed to occur regardless of what happens in the US 97 Bend North Corridor project area. The Bend Comprehensive (General) Plan map and the MTP project list is included in Appendix D. The alternative scenarios assumed ramp metering on US97 from the 3rd Street to the Butler Market interchanges by limiting capacities on the ramps to mimic a metered flow.

The volumes were post-processed using procedures from the National Cooperative Highway Research Council (NCHRP) Report 255. The 2035 future year no-build volumes and the 2035 alternative volumes were compared to develop relative differences (link-based ratios) between scenarios. These differences were applied to the 2035 no-build design year volumes to determine the 2035 design year volumes for each alternative. Then the 2015 alternative model scenarios were compared to the 2035 alternative model scenarios to determine another set of differences. This second set of differences was used adjust the 2035 design year volumes down to the 2015 build year volumes. Appendix D gives more details on the future volume development. The East DS-1 alternative 2015 and 2035 volumes are shown in Appendix K and East DS-2 alternative 2015 and 2035 volumes are shown in Appendix M.

East DS-1 Analysis Results

Mainline & Merge/Diverge/Weave Segments

Tables 31 and 32 show the v/c ratio results for the free-flow highway mainline, ramp connections, interchange merge/diverges and weaving sections. In 2015, all sections operate well under the 0.60 rural and the 0.75 urban Highway Design Manual (HDM) v/c's. By 2035, the only problems on East DS-1 are on northbound US97 at the project's edges. The higher commuter flows in the afternoon peak hour are northbound (outbound toward Redmond), so it is more critical than the southbound. Other than the northbound weaving section between Butler Market Road and Empire Avenue, the sections are unchanged from the no-build and represent conditions north and south of the project area.

The section between the Empire Avenue and Butler Market Road interchanges can act as a transition section between the improved new alignment north of Empire and the unchanged near-capacity section south of Butler Market. In this transition, the improvements are primarily limited to improving the traffic flow rather than capacity. Because of high volumes and weaving movements, speeds will be less than the section north of Empire Avenue but greater than south of Butler Market Road. This allows southbound traffic traveling at relatively high speeds to slow down without coming immediately into near-capacity flows. It also allows traffic from Empire Avenue the maximum distance to merge into US97 traffic. Northbound traffic can increase speeds north of Butler Market Road but not too fast allowing room for vehicles to maneuver. This creates the geometric lane and operational balance (three lanes are needed south of the diverge) required at the major diverge to US20 and northbound 3rd Street.

Table 32: Year 2015 and 2035 East DS-1 US97 Mainline and Merge/Diverge/Weave V/C Ratios¹

Section	HDM v/c	Direction ²			
		2015		2035	
		NB	SB	NB	SB
Mainline north of Deschutes Market Rd	0.60	0.54	0.37	0.72	0.50
Nichols Market Rd/ Deschutes Market Rd Off-ramp diverges	0.60	0.47	0.36	0.59	0.49
Nichols Market Rd/ Deschutes Market Rd On-ramp merges	0.60	0.51	0.31	0.69	0.42
Mainline south of Deschutes Market Rd	0.60	0.47	0.32	0.58	0.44
3 rd St Off-ramp diverges	0.75	0.43	0.33	0.50	0.45
3 rd St On-ramp merges	0.75	0.46	0.27	0.56	0.36
Mainline between 3 rd St ramps	0.75	0.41	0.27	0.47	0.36
Mainline south of 3 rd St	0.75	0.42	0.27	0.49	0.37
Empire Ave NB On-ramp merge	0.75	0.42		0.48	
NB Mainline south of Empire Ave NB On-ramp	0.75	0.34		0.41	
3 rd St/US20 NB diverge	0.75	0.50		0.64	
Mainline south of NB ramp to 3 rd St/US20	0.75	0.50	0.30	0.64	0.42
Empire Ave – Butler Market Rd SB weaving section ³	0.75		0.54		0.65
US20 Connection – Empire Ave NB weaving section ³	0.75	0.67		0.84	
Butler Market Rd NB On-ramp merge	0.75	0.55		0.68	
Mainline south of Butler Market Rd (SB) and US20 (NB) ramps	0.75	0.71	0.34	0.93	0.43

¹Blackened cells indicate that the HDM design v/c guideline has been exceeded.

²NB=Northbound, SB = Southbound

³This mainline segment is a weaving section, so the weaving v/c ratio controls the operation of the segment. Because of the high weaving flows, the operation of the weaving section will likely be worse than predicted.

Table 33: Year 2015 and 2035 East DS-1 US20/3rd St Connections V/C Ratios

Section ¹	HDM v/c	2015	2035
US20 Connection to NB 3 rd St	0.75	0.34	0.37
Connection to WB US20 & NB 3 rd St	0.75	0.45	0.58
US97 (Sister's Loop) Connection & WB US20 On-ramp merge	0.75	0.31	0.51

¹NB=Northbound, WB = Westbound

Auxiliary lanes will be needed before 2015 in the northbound direction and by 2027 in the southbound direction between the Empire Avenue and Butler Market Road interchanges. Auxiliary lanes allow vehicles to easily merge or diverge out of high traffic flows. They also allow local traffic traveling between interchanges to stay out the mainline lanes. With the limited on-ramp to off-ramp traffic between these two interchanges, the primary function of the auxiliary lanes will be to smooth out conflicting mainline and ramp flows.

The closely-spaced successive US20 and Butler Market Road on-ramps plus a relatively short weaving section can make northbound weaving problematic. The best combination between geometry and operations was to make this a Type B weaving section where vehicles in the right lane can either exit at Empire Avenue or continue north on US97. The auxiliary lane would originate with the higher volume US20 on-ramp and have the Butler Market Road on-ramp merge into it thus keeping the majority of the on-off movements out of the through lanes. This also keeps the northbound cross-section to three total lanes. The v/c for the northbound weaving section is 0.84 which is over the HDM v/c of 0.75 but the distance between the ramps is too short to have a lower v/c four-lane section with a two-lane off ramp at Empire Avenue. Some local congestion/slowing between weaving vehicles is possible in this section.

The southbound Empire Avenue- Butler Market Road is a Type A weaving section where vehicles in the right auxiliary lane must exit at Butler Market if a lane change is not made and forces US97 traffic to make a lane change to exit at Butler Market. This weaving section is not over the HDM v/c; however, because of the high weaving volumes operations will be subject to slowdowns and localized congestion. A Type B weave would be preferable, but the additional length beyond the Butler Market off-ramp would interfere with the Butler Market Road overcrossing and a nearby canal.

The two lanes in each direction on US20 between 3rd Street and the project limits east of the Old Bend-Redmond Highway is driven by the intersections on the project. Widening of US20 between the project limits and Robal Road will be necessary once the US20 & Cooley intersection is signalized (approximately 2020). Stopping previously free traffic on the mainline will approximately cut the capacity in half so additional lanes are necessary to keep the same flow of traffic constant.

Between the Robal Road and Empire Avenue the project need is trying to keep congestion at a practical level without clogging up a good portion of the nearby system. Around 2019, the Robal Road intersection will exceed the OHP v/c which indicates a need for an improvement. Robal Road improvements such as adding a dual left turn lane on Robal will

require two eastbound lanes or adding the westerly extension will take signal phase time away from the mainline thus accelerating the need for widening if done before 2019. By 2019, the v/c at the Empire Avenue intersection is predicted to be around 1.20 without any improvements. The 1.20 v/c level is well over capacity. Long queues in all directions can be expected especially through the 3rd/US20 section making it difficult to maneuver with long travel times and delays.

Preliminary Signal Warrants

Table 34 shows the preliminary signal warrant (PSW) results. Meeting a preliminary signal warrant does not mean an improvement will be installed. The region will have to do a intersection traffic control study and get approval of the State Traffic Engineer's office before a signal will be approved on state highways.

In 2015, only the US20 & Old Bend-Redmond Highway and the O.B. Riley Road & Empire Avenue intersections meet PSW's. The US20 & Old Bend-Redmond Highway intersection is a poor location for a signal as it is located in a rural high-speed area and Region 4 does not support a signal at this location. Since this intersection has the same operation with or without this project, it was removed to limit the scope of the alternatives to mainly focus on US97 issues. The East DS-1 alternative adds significantly more traffic to O.B. Riley Road and Empire Avenue which makes the O.B. Riley Road & Empire Avenue intersection part of the project improvements, so this intersection is assumed to be signalized in the analysis. The intersection has too much traffic for a roundabout to work properly so a signal is shown as the most practical option.

Depending on timing of project elements many other intersections were assumed to have improved traffic control in 2015. The intersections along Cooley Road at US20, Hunnell Road S and Hunnell Road N intersections were signalized assuming development growth in the Cooley Road area by then. This assumption smoothed out the simulation results by removing the queue from an over-capacity Cooley Road, especially from the US20 intersection that jams up the system unrealistically. Around 2020, PSW's start being met at these intersections from assumed traffic growth. Also, because of existing development agreements, when the Loop Road/Lowe's driveway is closed to accommodate the new 3rd Street alignment, the Cooley Road & Hunnell Road N intersection will be signalized. This 3rd Street realignment will likely be in one of the first constructed phases in order to gain measureable capacity relief and to allow development in the immediate area.

The additional traffic along O.B. Riley Road triggers a PSW in 2022 at the new Robal Road intersection. The analysis assumed that the intersection would be constructed as a single-lane roundabout when the western Robal Road extension is built since it works well and fits the suburban character of the area.

Table 34: Year 2015 & 2035 East DS-1 Preliminary Signal Warrants¹

Intersection	PSW Met?		Year Met
	2015	2035	
Tumalo Rd & Nichols Market Rd	No	No	
Tumalo Road & Deschutes Market Rd	No	No	
3 rd St & US97 NB Ramps	No	No	
3 rd St & US97 SB Ramps	No	No	
3 rd St & Grandview Dr	No	No	
3 rd St & Clausen Rd	No	No	
3 rd St & Nels Anderson Pl/Cascade Village	No	No	
Old Bend-Redmond Hwy & O.B. Riley Rd	No	Yes	2030
Old Bend-Redmond Hwy & US20	Yes	Yes	Now
Cooley Rd & O.B. Riley Rd	No	No	
Cooley Rd & US20	No ²	Yes	2020
Cooley Rd & Hunnell Rd (south)	No ²	Yes	2025
Cooley Rd & Hunnell Rd (north)	No ²	Yes	2035
Cooley Rd & Boyd Acres Rd	No	No	
Robal Rd & O.B. Riley Rd	No ³	Yes	2022
Robal Rd & Britta St	No	No	
Robal Rd & Nels Anderson Dr	No	No	
Nels Anderson Dr & Nels Anderson Pl	No	No	
Empire Ave & O.B. Riley Rd	Yes	Yes	Now
Empire Ave & Britta St	No	No	
Empire Ave & Jamison St	No	No	
Empire Ave & Industrial Park Blvd	No	No	
Empire Ave & Nels Anderson Rd/SB US97 Ramp Terminal	No ⁴	Yes	2035
Empire Ave & Corporate/Blenhiem Pl	No	No	
Hunnell Rd & Shopping Center Access	No	No	

¹Black shaded cells indicate that preliminary signal warrants (PSW's) have been met. Region Traffic staff will need to perform an intersection traffic control study in which the Region Traffic Engineer will forward the recommendation to the State Traffic Engineer's office. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal will be installed on a state highway.

²The 2015 analysis assumed signals at these locations as these are likely mitigations for near-term developments along Cooley Road.

³This intersection when constructed as part of the project will likely be a roundabout regardless of when the PSW is met.

⁴This intersection will be substantially widened as part of the project and would need to be signalized for Empire Avenue to operate efficiently.

Technically, the Empire Avenue & US97 Southbound Ramp Terminal/ Nels Anderson Road intersection does not meet PSW's until at or beyond the design year, since the Nels Anderson approach volume is relatively low and the on-ramp has traffic moving away from the intersection. However, for the southbound left turn movement, the interchange and this section of Empire Avenue between US97 and US20 (3rd Street) to work acceptably, this intersection needs to be signalized. Otherwise, queues from this intersection will affect the adjacent one and will severely limit exits from the relatively isolated Nels Anderson industrial area. With the above assumptions, the only additional intersection to meet PSW's

by 2035 is the O.B. Riley Road & Old Bend-Redmond Highway in 2030 because of increased traffic flows on O. B. Riley Road (some from new development and some from diverting US20 traffic). This intersection is in rural Deschutes County and was assumed to be a single-lane roundabout.

Unsignalized Intersections

In 2015, all unsignalized intersections in the project area are under standards except for the US20 & Old Bend-Redmond Highway intersection (Tables 35 – 37). The US20 & Old Bend-Redmond Highway intersection has a v/c of over 2.0 indicating that there are no safe gaps available to turn into. Vehicles will select smaller gaps which creates more risk for a crash.

Table 35: Year 2015 East DS-1 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	HDM v/c	v/c Ratio ¹	Critical Movement ²
3 rd St & NB Ramps	0.75	0.17/0.16	EBL/NBL
3 rd St & SB Ramps	0.75	0.18/0.21	EBTL/SBL
US20 & Old Bend-Redmond Hwy	0.75	0.28/2.0+	WBL/NBL

¹Blackened cells means that the HDM v/c design guideline has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Table 36: Year 2015 East DS-1 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	v/c Ratio	Delay (s)	Critical Movement¹
3 rd St & Frontage Rd	0.00/0.02	7.3/8.9	EBL/NBTL
3 rd St & Grandview Dr	0.01/0.02	8.0/12.9	SBL/WBL
3 rd St & Clausen Rd	0.16/0.05	8.4/44.2	NBL/WBL
3 rd St & Chavre Wy	0.28/0.03	0.0/9.4	NBT/WBR
3 rd St & Target Dwy	0.20/0.38	0.0/14.0	SBT/EBR
3 rd St & Nels Anderson Pl/Cascade Village	0.47/0.37	0.0/15.1	NBT/WBR
Cooley Rd & Scenic Dr	0.10/0.02	0.5/10.6	EBTL/SBLR
Cooley Rd & Boyd Acres Rd	0.03/0.46	9.5/45.7	WBL/NBTR
O.B. Riley Rd & Robal Rd ²	0.33/0.30	6.3/5.0	SBTL/WBLR
Robal Rd & Britta St	0.02/0.15	1.0/9.6	WBTL/NBLR
Robal Rd & Auto Mall Dwy	0.02/0.08	8.5/17.5	EBL/NBTL
Robal Rd & Target Dwy	0.10/0.10	0.0/9.9	WBT/SBR
Robal Rd & Cascade Village Dwy	0.04/0.06	0.0/9.1	EBT/NBR
Robal Rd & Nels Anderson Dr	0.37/0.03	12.9/2.3	NBTL/EBLR
Nels Anderson Dr & Chavre Wy	0.01/0.01	2.3/8.9	NBTL/EBLR
Nels Anderson Dr & Nels Anderson Pl	0.01/0.13	0.4/11.1	NBTL/EBLR
Empire Ave & Britta St	0.01/0.01	8.2/12.5	EBL/SBL
Empire Ave & Jamison St	0.15/0.06	0.0/10.1	WBT/SBR
Empire Ave & Industrial Park Blvd	0.36/0.07	0.0/10.2	WBT/SBR
Empire Ave & Corporate/Blenhiem Pl	0.02/0.42	10.4/52.9	EBL/NBLTR
Hunnell Rd & Loco Rd	0.00/0.17	1.3/10.4	SBTL/WBLR

¹This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

²Intersection is a roundabout.

Table 37: Year 2015 East DS-1 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	LOS	Critical Movement ¹
Tumalo Rd & Deschutes Pleasant Ridge Rd	A/B	WBTL/NBLR
Tumalo Road & Nichols Market Rd	A/B	EBL/SBLTR
Tumalo Rd & Deschutes Market Rd	A/C	EBL/NBLTR
3 rd St & Harris Wy	A/B	WBL/NBLTR
3 rd St & Bowery Ln	A/B	SBL/EBLTR
O.B. Riley Rd & Old Bend-Redmond Hwy	A/B	SBTL/WBLR
O.B. Riley Rd & Cooley Rd	A/B	SBL/WBL
Hunnell Rd & Rogers Rd	A/A	NBTL/EBLR
Hunnell Rd & Fort Thompson Ln	A/A	SBTL/WBLR
Fort Thompson Ln & Harris Wy	A/A	WBTL/NBLR
Bowery Ln & Harris Wy	A/A	EBTL/SBLR

¹This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

By 2035 the mainline left turns are having difficulty finding gaps as the US20 v/c ratio is over standards at the US20 & Old Bend-Redmond intersection (Table 38). Traffic diversion to other local facilities such as Robal and Cooley Roads is likely in the peak periods of the day. On the local system, only the Cooley Road & Boyd Acres Road intersection exceeds standard (Tables 39-40) around 2016 which likely indicates a traffic control improvement.

Table 38: Year 2035 East DS-1 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	HDM v/c	v/c Ratio ¹	Critical Movement ²	Year Exceeded	
				Std.	Cap.
3 rd St & NB Ramps	0.75	0.30/0.36	EBL/NBL	2040+	2040+
3 rd St & SB Ramps	0.75	0.33/0.36	EBTR/SBTR	2040+	2040+
US20 & Old Bend-Redmond Hwy	0.75	0.81/2.0+	WBL/NBL	<2007	<2007

¹Blackened cells means that the HDM design v/c guideline has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

Table 39: Year 2035 East DS-1 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	v/c Ratio	Delay ¹ (s)	Critical Movement ²	Year Std. Exceeded
3 rd St & Frontage Rd	0.02/0.04	7.3/9.4	EBL/NBTL	2040+
3 rd St & Grandview Dr	0.01/0.11	8.8/17.7	SBL/WBL	2040+
3 rd St & Clausen Rd	0.26/0.77	9.4/120+	NBL/EBL	2017
3 rd St & Chavre Wy	0.36/0.05	0.0/9.9	NBT/WBR	2040+
3 rd St & Target Dwy	0.22/0.41	0.0/15.9	SBT/EBR	2040+
3 rd St & Nels Anderson Pl/Cascade Village	0.37/0.15	0.0/19.9	NBT/WBR	2040+
Cooley Rd & Scenic Dr	0.25/0.03	0.3/17.3	EBTL/SBLR	2040+
Cooley Rd & Boyd Acres Rd	0.21/2.0+	1.7/120+	WBL/NBL	2016
O.B. Riley Rd & Robal Rd ³	0.89/0.53	29.8/9.6	SBTL/WBLR	2039
Robal Rd & Britta St	0.05/0.30	1.9/11.2	WBTL/NBLR	2040+
Robal Rd & Auto Mall Dwy	0.04/0.36	9.9/47.3	EBL/NBTL	2040+
Robal Rd & Target Dwy	0.13/0.17	0.0/10.7	WBT/SBR	2040+
Robal Rd & Cascade Village Dwy	0.00/0.12	0.0/9.7	EBT/NBR	2040+
Robal Rd & Nels Anderson Dr	0.42/0.04	14.9/2.4	NBTL/EBLR	2040+
Nels Anderson Dr & Chavre Wy	0.02/0.01	3.1/9.2	NBTL/EBLR	2040+
Nels Anderson Dr & Nels Anderson Pl	0.02/0.16	0.9/11.3	NBT/EBLR	2040+
Empire Ave & Britta St	0.01/0.04	9.2/20.3	EBL/SBL	2040+
Empire Ave & Jamison St	0.25/0.10	0.0/11.6	WBT/SBR	2040+
Empire Ave & Industrial Park Blvd	0.55/0.10	0.0/10.2	WBT/SBR	2040+
Empire Ave & Corporate/Pl	0.03/0.72	13.1/120+	EBL/NBLTR	2040+
Hunnell Rd & Loco Rd	0.00/0.02	0.6/11.2	SBTL/WBLR	2040+

¹Blackened cells mean that the City 50 second delay standard for unsignalized intersections with the subject approach having more than 100 peak hour trips or the v/c of 1.0 standard has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

³Intersection is a roundabout.

Table 40: Year 2035 East DS-1 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	LOS	Critical Movement ¹	Year Std. Exceeded
Tumalo Rd & Deschutes Pleasant Ridge Rd	A/C	WBTL/NBLR	2040+
Tumalo Road & Nichols Market Rd	A/D	EBL/SBLTR	2040+
Tumalo Rd & Deschutes Market Rd	A/C	EBL/SBLTR	2040+
3 rd St & Harris Wy	A/C	WBL/SBLTR	2040+
3 rd St & Bowery Ln	A/C	NBL/EBLTR	2040+
O.B. Riley Rd & Old Bend-Redmond Hwy ¹	B/C	SBTL/WBLR	2038
O.B. Riley Rd & Cooley Rd	A/D	SBL/WBLR	2040+
Hunnell Rd & Rogers Rd	A/A	SBTR/EBLR	2040+
Hunnell Rd & Fort Thompson Ln	A/A	SBTR/WBLR	2040+
Fort Thompson Ln & Harris Wy	A/A	WBTL/NBLR	2040+
Bowery Ln & Harris Wy	A/A	EBTL/SBLR	2040+

¹This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR= shared left-through-right turn lane.

²Intersection is a roundabout.

Signalized Intersections

Most of the state highway signalized intersections exceed the HDM v/c's and are approaching or exceeding capacity by the design year (Table 41). Even with two lanes in each direction on US20 with dual turn lanes as appropriate, the US20 intersections at Cooley and Robal Roads are about at capacity with 0.93 and 1.0 v/c respectively. The US20 (3rd Street) & Empire Avenue intersection is substantially over capacity at a v/c of 1.10. Four southbound lanes (two through and long dual left turns) are needed to allow for lane changing along 3rd Street between the US20 connection and Empire Avenue. The large volume at this intersection would typically be handled with a grade separation rather than at-grade. However, because of the close proximity to US97, grade separations are not practical.

Table 41: Year 2015 & 2035 State Highway East DS-1 Signalized Intersection V/C Ratios

Intersection ¹	HDM v/c	v/c Ratio ²		Year Exceeded	
		2015	2035	Std.	Cap.
US20 & Cooley Rd	0.75	0.50	0.93	2027	2039
US20 & Robal Rd	0.75	0.61	1.00	2022	2035
US20 & Empire Ave	0.75	0.83	1.10	2015	2028
Empire Ave & NB US97 Ramps	0.75	0.57	0.79	2032	2040+
Empire Ave & SB US97 On-ramp	0.75	0.48	0.68	2040+	2040+

¹NB = Northbound, SB = Southbound

²Black shaded cells indicate the HDM design v/c guideline has been exceeded.

All City signalized intersections are under standards in 2015. All meet standards in 2035 except for the O.B. Riley Road & Empire Avenue intersection (Table 42). This intersection is over the City standards (and the highest in the project area) mainly because of high northbound and southbound through movements from the increased volumes. This shows the need to widen O.B. Riley Road to two travel lanes in each direction by 2027.

Table 42: Year 2015 & 2035 City Street East DS-1 Signalized Intersection V/C Ratios

Intersection	v/c Ratio ¹		Delay (s)		Year Std. Exceeded
	2015	2035	2015	2035	
3 rd St & Cooley Rd	0.44	0.84	47.2	59.2	2040+
3 rd St & Robal Rd	0.65	0.73	42.3	44.1	2040+
Cooley Rd & Hunnell Rd S	0.12	0.38	12.3	16.3	2040+
Cooley Rd & Hunnell Rd N	0.19	0.41	17.9	18.8	2040+
Robal Rd & Hunnell Rd	0.33	0.56	16.7	21.9	2040+
O.B. Riley Rd & Empire Ave	0.62	1.26	20.4	106.9	2027
Empire Avenue & Boyd Acres Rd	0.64	0.93	26.3	47.1	2040+

¹Black shaded cells indicate the City v/c of 1.0 and 80 second delay standard for signalized intersections has been exceeded.

Queuing

Appendix L contains the 2015 and 2035 95th percentile queuing figures for the project area. The 2015 and 2035 queues were created by averaging at least five random SimTraffic micro-simulations together. Queues shown on the figures are a combination of stopped vehicles and vehicles traveling at seven or less miles per hour.

In 2015, the main queuing issue on US97 is a significant slowdown section (rolling queue) for northbound US97 from the southern US20 connection north to Empire Avenue because of the extensive weaving. North of Empire Avenue, US97 is free-flow to the northern project limits at the Deschutes Market Interchange. Problems on US20 are generally limited to long northbound and southbound queues at the 3rd Street & Empire Avenue intersection. Queues northbound exceed a quarter-mile while the southbound queue reaches the 3rd Street/US20 interchange. On the local system, long queues exist at the 3rd Street &

Robal Road intersection, but they do not block approaches except for the eastern Cascade Village Mall driveway. Queuing is predominant on Empire Avenue with occasional blockages of minor roads such as Britta Street, Jamison Street, and Industrial Park Boulevard.

Table 43 shows the significant (greater than 5% of the peak hour) blocking areas in 2015 with blocking issues limited to intersection turn bays. The most significant durations occur at the US20 & Old Bend-Redmond Highway intersection mainly from the long delays incurred by side-street traffic trying to cross or turn. Over half of the blocking problems are along Empire Avenue with most taking up almost 10% of the peak hour. Congestion is expected in the highest traveled portions in the peak hour around the US97 interchange.

Table 43: Year 2015 East DS-1 Significant Queue Blocking¹

Intersection	Approach	Blocked Lane	Average Percent Time Blocked
US20 & Old Bend-Redmond Hwy	SB	L	81
	NB	L	66
US20 & Robal Rd	EB	L	10
	WB	T	15
US20 & Empire Ave	NB	R	11
3rd St & Robal Rd	WB	TR	15
	SB	R	7
Empire Ave & Nels Anderson Rd/ US97 SB On-ramp	EB	R	5
Empire Ave & US97 NB Off-ramps	NB	TR	9
Empire Ave & Boyd Acres Rd	EB	T	6
	WB	L	8
	NB	L	33

¹ NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, TR = shared through-right lane.

Through 2035, the constant queuing issue on US97 shows significant slowdown on northbound US97 between the southern US20 connection and the Empire Avenue northbound off-ramp because of extensive weaving. No issues are evident on the rest of US97 in the project area. Long queues exist on US20 approaching Robal Road westbound and significant slowing occurs approaching the Old Bend-Redmond Highway intersection because of left-turning vehicles blocking the westbound through lanes. The northbound queue at the US20 & Empire Avenue exceeds a quarter mile and the southbound queue extends through the 3rd Street/US20 interchange.

Significant queuing occurs on Robal and Empire Avenue with many driveways and streets blocked.

Table 44 shows the significant (greater than 5%) blocking areas in 2035. The queues now have expanded to block turn bays and extend into adjacent intersections and approaches. Most of the blocked roadways are minor except for the eastbound US20 connection to 3rd Street southbound that is blocked 30% of the peak hour. Over 50% of the peak hour

blocking occurs at the US20 & Old Bend-Redmond Highway, US20 & Empire, 3rd Street & Cooley Road, Cooley Road & Boyd Acres Road, and Empire Avenue & O.B Riley Road and Boyd Acres Road intersections.

Table 44: Year 2035 East DS-1 Significant Queue Blocking¹

Intersection	Approach	Blocked Lane	Blocked Intersection	Average Percent Time Blocked
US20 & Old Bend-Redmond Hwy	SB	L		100
	NB	L		100
	WB	L		14
US20 & Cooley Rd	WB	L		5
			Scenic Dr	7
	NB	L		14
		R		14
	SB	L		7
US20 & Robal Rd	EB	L		39
	WB	L		24
		R		30
	NB	L		31
		R		31
US20 & Empire Ave	WB	L		14
			Industrial Park Blvd	14
		R		14
	NB	L		66
		R		69
			Sherman Ave	56
	SB		EB US20/SB 3 rd St	30
3 rd St & Clausen Dr	EB	L		40
	SB	L		7
3 rd St & Cooley Rd	EB	L		17
	WB	L		6
	NB	R		25
	SB	L		66
			Clausen Dr	24
3 rd St & Robal Rd	EB		Cascade Village Dwy	19
	WB	TR		18
			Nels Anderson Dr	5
	NB	T		10
	SB	R		7
Cooley Rd & Hunnell Rd N	NB	L		6
Cooley Rd & Boyd Acres Rd	NB	L		65
	SB	L		72
Robal Rd & Hunnell Rd	WB	R		5

Empire Ave & O.B. Riley Rd	WB	R		58
	NB	L		36
	SB	L		6
Empire Ave & Nels Anderson/US97 SB On-ramp	EB	L		11
		R		11
Empire Ave & US97 NB Ramps	WB	R		6
	NB	TR		8
Empire Ave & Boyd Acres Rd	EB	L		14
		R		11
	WB	L		24
	NB	L		15
		R		62
	SB	R		80

¹NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, TR = shared through-right lane.

Other Operational Performance Measures

Tables 45 and 46 show additional operational MOE's for the project area over the 20-year analysis period. The tables show increasing congestion by dropping overall average speed and increasing delay. However, impacts to US97 are minimal as travel times only increase about 10% from 2015 to 2035. In comparison, on US20 which has numerous over-capacity intersections, travel times more than double. Local system impacts vary from little change on O.B. Riley Road to significant (increase of 40%) on 3rd Street. Roadways with the most affected travel times have the lowest segment speeds. Only US97 and O.B. Riley Road have peak hour speeds close to the posted speeds.

Table 45: Year 2015 & 2035 East DS-1 Overall Simulation Measures of Effectiveness

Measure of Effectiveness	Year	
	2015	2035
Average Speed (mph)	32	18
Total Stops ¹	18,700	47,900
Delay (hr)	330	1,550
Travel Time (hr)	1,130	2,630

¹A stop is recorded every time a vehicle drops below 7 mph (crawl speed). A vehicle might have multiple stops on an intersection approach.

Table 46: Year 2015 & 2035 East DS-1 Segment Travel Time and Speed

Segment	Travel Time per vehicle (min:s)		Average Speed (mph)	
	2015	2035	2015	2035
US97 (Deschutes Market Rd – Butler Market Rd)	7:25	8:10	47	43
US20 (Old Bend-Redmond Hwy – Sherman Ave)	4:20	9:40	29	14
3 rd St (US97 – US20)	5:20	7:40	30	22
O.B. Riley Rd (Old Bend-Redmond Hwy – Empire Ave)	3:15	3:30	35	31
Empire Ave (O.B. Riley Rd – Boyd Acres Rd)	2:30	4:15	17	11
Cooley Rd (O.B. Riley Rd – Boyd Acres Rd)	4:25	4:35	19	18
Robal Rd (O.B. Riley Rd – Nels Anderson Rd)	3:25	4:15	14	11

Spacing Standards

Appendix C in the OHP has spacing standards for public road approaches and private accesses to be used in the planning process. The following spacing standards apply to the US 97 Bend North Corridor Solutions project:

- Interchange-to-interchange: three miles for a rural expressway and 1.9 miles for an urban expressway or statewide highway based on cross-road spacing. This standard is for the planning of new interchanges on the state system.
- Ramp-to-ramp/intersection: one mile between two interchanges in access-controlled freeway sections or between an interchange and an at-grade intersection.
- Ramp-to-Ramp: one-half mile between the taper sections of intersections or adjacent on and off-ramps.
- Next intersection adjacent to ramp terminal: 1320 feet for a two or multi-lane crossroad in an urban area to the next full intersection or right-in-right-out.
- Street spacing: One mile at 55 mph for a rural expressway; 2640 feet for streets at 45 mph on a urban expressway; and 990 feet for a urban statewide highway. There is no standard for private accesses as they are discouraged on statewide highways and expressways.

North of the 3rd Street interchange, US97 has a few accesses up to Deschutes Junction. A future median may be added between the two interchanges to limit conflict points as creating full frontage /backage roads for a few isolated properties was not cost-effective. US97 south of the 3rd Street interchange is access-controlled with the only connections being interchanges. Like US97, the northern section of US20 has very few accesses north of Empire Avenue. From Empire Avenue south, US20 is an uncontrolled five-lane section with many driveways.

Table 47 compares the major road segments and their appropriate spacing standard. On US97 north of the US20 connections to the 3rd Street interchange, the highway exceeds the

interchange and ramp-to-ramp spacing standards. Most existing accesses north of the 3rd Street interchange remain but might be restricted with a future extension of the median barrier north to Deschutes Market Road. The distance from the US20 connections and the Empire Avenue interchange is only about 10% of the standard, however this is only one connection in the northbound direction for a partial interchange. The interchange spacing between Empire Avenue and Butler Market is less than half of the 1.9 mile standard remaining unchanged from the no-build.

On US20, the street spacing is only about a third of the standard north of Cooley Road and Empire Avenue. US20 approaches the standard between 3rd Street and Robal Road northbound and is close to the standards between Cooley and Robal Roads. South of Empire Avenue, the spacing is improved with some driveway closures, but still does not meet the the spacing standards.

Table 47: Spacing Standards Comparison

Roadway	Segment	Spacing Standard	Alternative Spacing ¹
US97	Deschutes Market Rd - 3 rd Street Interchange	1 mi	<2500 ft ²
	3 rd Street Interchange – US20 Connections	1.9 mi	3.2 mi
	US20 Connections – Empire Avenue Interchange	1.9 mi	1030 ft
	Empire Avenue Interchange- Butler Market Interchange	1.9 mi	4490 ft
	3 rd Street Ramps – US20 Connection	2640 ft	1.9 mi NB 3.2 mi SB ³
	US20 Connection – Empire Avenue Ramps	2640 ft	1580 ft ⁴
	Empire Avenue Ramps – Butler Market Ramps	2640 ft	1270 ft
US20	Old Bend-Redmond Highway – Cooley Rd	1 mi	300 - 1700 ft ²
	Cooley Rd – Robal Rd	2640 ft	2220 ft
	Robal Rd – 3 rd St Connections	1 mi	3010 ft EB 4380 ft WB
	3 rd St Connections– Empire Ave	1 mi	1530 ft
	Empire Ave – project limits	990 ft	<400 ft ²
Empire Ave	Industrial Park Blvd – Nels Anderson Rd/SB US97 On-ramp	1320 ft	370 ft ⁵
	US97 NB Off-ramp – Corporate/Blenhiem Pl	1320 ft	780 ft
3 rd Street	US20 Connections – Nels Anderson Rd	1 mi	950 ft
	Harris Way – 3 rd St SB Ramps	1320 ft	1060 ft
	3 rd St NB Ramps – Frontage Road	1320 ft	950 ft

¹Black-shaded cells mean the spacing is less than the corresponding standard.

²Approximate road/driveway spacing over segment

³This is the distance to the next ramp which is the Empire Avenue southbound on-ramp.

⁴Northbound only

⁵Approximately 850 feet to the signalized US20/3rd Street intersection

The ramp terminal spacing standard is not met on Empire Avenue with sections one-third to a half of the requirement. At the 3rd Street interchange, the ramp terminal spacing is about 75% of standard. The interchange has minimized the ramp terminal spread (to limit property impacts) thus maximizing the distance to the next intersection, but existing road geometry at Harris Way and the railroad tracks prevent fully reaching the standards.

East DS-2 Analysis Results

Mainline & Merge/Diverge/Weave Segments

Tables 48 and 49 show the v/c ratio results for the free-flow highway mainline, ramp connections, interchange merge/diverges and weaving sections. In 2015, all sections are operating under the 0.60 rural and the 0.75 urban Highway Design Manual (HDM) v/c's. By 2035, the only problems in East DS-2 are on northbound US97 at the edges of the project. Higher commuter flows in the afternoon peak hour are northbound (outbound toward Redmond), making it more critical than the southbound. Except for the northbound weaving section between Butler Market Road and Empire Avenue, the other sections remain unchanged from the no-build, representing conditions north and south of the project area.

The section between the Empire Avenue and Butler Market Road interchanges is a transition section between the improved new alignment north of Empire and the unchanged near-capacity section south of Butler Market. In this section, the improvements are limited primarily to improving traffic flow rather than improving capacity. Because of high volumes and weaving movements, speeds will be less than north of Empire Avenue but likely greater than south of Butler Market Road. This will allow relatively high speed southbound traffic to slow before reaching near-capacity conditions. Also, it allows traffic from Empire Avenue the maximum room to merge into US97 traffic. Northbound traffic will do the opposite by gradually increasing speed north of Butler Market Road while allowing room for vehicles to maneuver. This creates the geometric lane and operational balance (three lanes are needed south of the diverge) required at the major diverge to US20 and northbound 3rd Street.

Before 2015 in the northbound direction and by 2027 in the southbound direction, auxiliary lanes will be needed between the Empire Avenue and Butler Market Road interchanges. Auxiliary lanes make it easier for vehicles to move into or out of high traffic flows and allow local traffic traveling between interchanges to stay out the mainline lanes. There is limited interchange to interchange traffic so the primary function of the auxiliary lanes here will be to smooth out the conflicting traffic flows.

The short section plus the turbulence between the closely-spaced successive US20 and Butler Market Road on-ramps makes northbound weaving problematic. The best geometric and operational combination is a Type B weaving section where vehicles in the right lane can either exit at Empire Avenue or continue north on US97. The auxiliary lane originates

with the higher volume US20 on-ramp and has the Butler Market Road on-ramp merge into it, keeping most of the on-off movements out of the through lanes. This also keeps the northbound cross-section to three total lanes. The v/c for the northbound weaving section is 0.84 which is over the HDM v/c of 0.75 but the distance between the ramps is too short to have a four-lane section with a two-lane off ramp at Empire Avenue. Some local congestion/slowing between weaving vehicles is possible in this section.

Table 48: Year 2015 and 2035 East DS-2 US97 Mainline and Merge/Diverge/Weave V/C Ratios^{1,2}

Section	Direction				
	HDM	2015		2035	
	v/c	NB	SB	NB	SB
Mainline north of Deschutes Market Rd	0.60	0.54	0.37	0.72	0.50
Nichols Market Rd/ Deschutes Market Rd Off-ramp diverges	0.60	0.47	0.36	0.59	0.49
Nichols Market Rd/ Deschutes Market Rd On-ramp merges	0.60	0.51	0.31	0.69	0.42
Mainline south of Deschutes Market Rd	0.60	0.47	0.32	0.58	0.44
3 rd St NB On-ramp merge/ SB Off-ramp diverge	0.75	0.46	0.33	0.56	0.45
Mainline south of 3 rd St	0.75	0.39	0.27	0.46	0.36
Empire Ave NB On-ramp merge	0.75	0.39		0.45	
NB Mainline south of Empire Ave NB On-ramp	0.75	0.34		0.41	
3 rd St/US20 NB diverge	0.75	0.50		0.64	
Mainline south of NB ramp to 3 rd St/US20	0.75	0.50	0.30	0.64	0.40
Empire Ave – Butler Market Rd SB weaving section	0.75		0.54		0.67
US20 Connection – Empire Ave NB weaving section ³	0.75	0.66		0.84	
Butler Market Rd NB On-ramp merge	0.75	0.51		0.68	
Mainline south of Butler Market Rd (SB) and US20 (NB) ramps	0.75	0.71	0.34	0.93	0.43

¹Blackened cells indicate that HDM design v/c guideline has been exceeded.

²NB = Northbound, SB = Southbound

³This is a weaving section, so the weaving v/c ratio controls the operation of the segment. Because of the high weaving flows, the operation of the weaving section will likely be worse than predicted.

Table 49: Year 2015 and 2035 East DS-2 US20/3rd St Connections V/C Ratios

Section ¹	HDM v/c	2015	2035
US20 Connection to NB 3 rd St	0.75	0.40	0.40
Connection to WB US20 & NB 3 rd St	0.75	0.45	0.58
US97 (Sister's Loop) Connection & WB US20 On-ramp merge	0.75	0.31	0.52

¹NB = Northbound, WB = Westbound

The southbound Empire Avenue- Butler Market Road weaving section is a Type A where vehicles in the right auxiliary lane must exit at Butler Market if a lane change is not made

and forces US97 traffic to make a lane change to exit at Butler Market. This weaving section is not over the HDM v/c, however, because of the high weaving volumes operations will be subject to slowdowns and localized congestion. A Type B weave here would be preferable, but the additional length beyond the Butler Market off-ramp interferes with the Butler Market Road overcrossing and a nearby canal.

The need for two lanes in each direction on US20 between 3rd Street and the project limits east of the Old Bend-Redmond Highway is driven by the intersections on the project. Widening of US20 between the project limits and Robal Road will be necessary once the US20 & Cooley intersection is signalized (approximately 2020) as stopping previously free traffic on the mainline will approximately cut the capacity in half so additional lanes are necessary to keep the same flow of traffic constant.

Between the Robal Road and Empire Avenue intersections of US20 the project need is trying to keep congestion at a practical level without clogging up a good portion of the nearby system. Around 2019, the Robal Road intersection will exceed the OHP v/c which indicates a need for an improvement. Robal Road improvements such as adding a dual left turn lane on Robal needs two eastbound lanes or adding the westerly extension requires taking signal phase time away from the mainline thus accelerating the need for widening if done before 2019. By 2019, the Empire Avenue intersection v/c ratio is predicted to be around 1.20 without any improvements, which is well over capacity. Long queues in all directions can be expected especially through the 3rd/US20 section making it difficult to maneuver with long travel times and delays.

Preliminary Signal Warrants

Table 50 shows the preliminary signal warrant (PSW) results. Meeting a preliminary signal warrant does not mean an improvement will be installed. The region will have to do an intersection traffic control study and get approval of the State Traffic Engineer's office before a signal will be approved on state highways.

In 2015, only the US20 & Old Bend-Redmond Highway and the O.B. Riley Road & Empire Avenue intersections meet PSW's. The US20 & Old Bend-Redmond Highway intersection is a poor location for signal as it is located in a rural high-speed area and Region 4 does not support a signal at this location. Since this intersection has the same operation with or without this project, it was removed from the project to limit the scope to mainly focus on US97 issues. The East DS-2 alternative adds significantly more traffic to O.B. Riley Road and Empire Avenue which makes the O.B. Riley Road & Empire Avenue intersection part of the project improvements, so this intersection is assumed to be signalized in the analysis. The intersection has too much traffic for a roundabout to work properly so a signal is shown as the most practical option.

Table 50: Year 2015 & 2035 East DS-2 Preliminary Signal Warrants¹

Intersection	PSW Met?		Year Met
	2015	2035	
Tumalo Rd & Nichols Market Rd	No	No	
Tumalo Road & Deschutes Market Rd	No	No	
3 rd St & Grandview Dr	No	No	
3 rd St & Clausen Rd	No	No	
3 rd St & Nels Anderson Pl/Cascade Village	No	No	
Old Bend-Redmond Hwy & O.B. Riley Rd	No	Yes	2030
Old Bend-Redmond Hwy & US20	Yes	Yes	
Cooley Rd & O.B. Riley Rd	No	No	
Cooley Rd & US20	No	Yes	2023
Cooley Rd & Hunnell Rd (south)	No ²	Yes	2035
Cooley Rd & Hunnell Rd (north)	No ²	Yes	2021
Cooley Rd & Boyd Acres Rd	No ²	No	
Robal Rd & O.B. Riley Rd ³	No	Yes	2022
Robal Rd & Britta St	No	No	
Robal Rd & Nels Anderson Dr	No	No	
Nels Anderson Dr & Nels Anderson Pl	No	No	
Empire Ave & O.B. Riley Rd	Yes	Yes	
Empire Ave & Britta St	No	No	
Empire Ave & Jamison St	No	No	
Empire Ave & Industrial Park Blvd	No	No	
Empire Ave & Nels Anderson Rd/SB US97 Ramp Terminal	No ⁴	Yes	2040+
Empire Ave & Corporate/Blenhiem Pl	No	No	
Hunnell Rd & Shopping Center Access	No	No	

¹Black shaded cells indicate that preliminary signal warrants (PSW's) have been met. Region Traffic staff will need to perform an intersection traffic control study in which the Region Traffic Engineer will forward the recommendation to the State Traffic Engineer's office. Traffic signal warrants must be met and the State Traffic Engineer's approval obtained before a traffic signal will be installed on a state highway.

²The 2015 analysis assumed signals at these locations as these are likely mitigations for near-term developments along Cooley Road.

³This intersection when constructed as part of the project will likely be a roundabout regardless of when the PSW is met.

⁴This intersection will be substantially widened as part of the project and would need to be signalized for Empire Avenue to operate efficiently.

Depending on timing of project elements numerous other intersections were assumed to have improved traffic control in 2015. The intersections along Cooley Road at US20, Hunnell Road S and Hunnell Road N were signalized assuming development growth in the Cooley Road area by that time. This smoothed out the simulation results, otherwise queuing from an over-capacity Cooley Road, especially from the US20 intersection, would jam the system unrealistically. Around 2021, PSW's start being met at the Cooley Road intersections from assumed traffic growth. Also, because of existing development agreements, when the Loop Road/Lowe's driveway is closed to accommodate the new 3rd Street alignment, the Cooley Road & Hunnell Road N intersection will be signalized. This

3rd Street realignment will likely be in an early construction phase to gain measureable capacity relief and allow development in the immediate area. The Cooley Road & Hunnell Road N intersection also is the primary access to Bowery Lane and the eastside frontage road connections in East DS-2.

The additional traffic along O.B. Riley Road triggers a PSW in 2022 at the new intersection at Robal Road. The analysis assumed that the intersection would be constructed as a single-lane roundabout upon construction of the western Robal Road extension as a single-lane roundabout works well here and fits in with the suburban character of the area.

Technically, the Empire Avenue & US97 Southbound Ramp Terminal/ Nels Anderson Road intersection does not meet PSW's until at or beyond the design year, since the Nels Anderson approach volume is relatively low and the on-ramp has traffic moving away from the intersection. However, for the southbound left turn movement, the interchange and this section of Empire Avenue between US97 and US20 (3rd Street) to work acceptably, this intersection needs to be signalized. Otherwise, queues from this intersection will affect the adjacent one and will severely exits from the relatively isolated Nels Anderson industrial area.

With the above assumptions, the only additional intersection to meet PSW's by 2035 is the O.B. Riley Road & Old Bend-Redmond Highway in 2030 because of increased traffic flows on O. B. Riley Road (some from new development and some from diverting US20 traffic). This intersection is in rural Deschutes County and was assumed to be a single-lane roundabout.

Unsignalized Intersections

In 2015, all unsignalized intersections in the project area are under standards except for the US20 & Old Bend-Redmond Highway intersection (Tables 51-53). This intersection has a v/c of over 2.0 for the side-street indicating that there are no safe gaps available to turn into. Traffic will likely divert to Robal or Cooley Roads to avoid turning left or crossing this intersection in or near the peak hours. Otherwise, vehicles will select smaller gaps in the traffic stream creating more risk for a crash.

Table 51: Year 2015 East DS-2 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	HDM v/c	v/c Ratio ¹	Critical Movement ²
US20 & Old Bend-Redmond Hwy	0.60	0.28/2.0+	WBTR/SBL

¹Blackened cells means that the HDM design v/c guideline has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. SB = Southbound, WB = Westbound, L= exclusive left turn lane, TR = shared left-though lane.

Table 52: Year 2015 East DS-2 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	v/c Ratio	Delay (s)	Critical Movement ¹
3 rd St & Grandview Dr	0.00/0.03	8.2/11.4	SBL/WBLR
3 rd St & Clausen Rd	0.18/0.06	8.2/52.0	NBL/WBL
3 rd St & Chavre Wy	0.33/0.03	0.0/9.6	NBT/WBR
3 rd St & Target Dwy	0.19/0.37	0.0/13.6	SBT/EBR
3 rd St & Nels Anderson Pl/Cascade Village	0.32/0.08	0.0/16.5	NBT/WBR
Cooley Rd & Scenic Dr	0.10/0.02	0.5/10.6	EBTL/SBLR
Cooley Rd & Boyd Acres Rd	0.03/0.56	9.8/63.1	WBL/NBL
O.B. Riley Rd & Robal Rd ¹	0.33/0.30	6.3/5.0	NBTL/WBLR
Robal Rd & Britta St	0.02/0.15	1.0/9.6	WBTL/NBLR
Robal Rd & Auto Mall Dwy	0.02/0.08	8.5/17.5	EBL/NBTL
Robal Rd & Target Dwy	0.10/0.10	0.0/9.9	WBT/SBR
Robal Rd & Cascade Village Dwy	0.04/0.06	0.0/9.1	EBT/NBR
Robal Rd & Nels Anderson Dr	0.35/0.03	12.7/2.3	NBTL/EBLR
Nels Anderson Dr & Chavre Wy	0.01/0.01	2.3/8.9	NBTL/EBLR
Nels Anderson Dr & Nels Anderson Pl	0.01/0.12	0.4/10.6	NBTL/EBLR
Empire Ave & Britta St	0.01/0.01	8.2/13.2	EBL/SBL
Empire Ave & Jamison St	0.15/0.06	0.0/10.1	WBT/SBR
Empire Ave & Industrial Park Blvd	0.40/0.07	0.0/10.1	WBT/SBR
Empire Ave & Corporate/Blenhiem Pl	0.02/0.38	10.4/46.8	EBL/NBLTR
Hunnell Rd & Loco Rd	0.02/0.19	2.2/11.2	SBTL/WBLR
Bowery Ln & Frontage Rd	0.01/0.00	9.0/2.4	NBTL/EBLR

¹This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound, L = exclusive left turn lane, T = through lane, R = exclusive right turn lane, LR = shared left-right lane, TL = shared through-left lane, LTR = shared left-through-right turn lane.

²Intersection is a roundabout.

Table 53: Year 2015 East DS-2 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	LOS	Critical Movement ¹
Tumalo Rd & Deschutes Pleasant Ridge Rd	A/B	WBTL/NBLR
Tumalo Road & Nichols Market Rd	A/B	EBL/SBLTR
Tumalo Rd & Deschutes Market Rd	A/C	EBL/NBLTR
O.B. Riley Rd & Old Bend-Redmond Hwy	A/B	SBTL/WBLR
O.B. Riley Rd & Cooley Rd	A/B	SBL/WBL
Hunnell Rd & Rogers Rd	A/A	NBTL/EBLR
Hunnell Rd & Bowery Ln	A/A	SBTL/WBLR
Hunnell Rd & Fort Thompson Ln	A/A	NBTR/WBLR
Fort Thompson Ln & Harris Wy	A/A	WBTL/NBLR
Bowery Ln & Harris Wy	A/A	EBTL/SBLR

¹This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB = Eastbound, WB = Westbound, L = exclusive left turn lane, T = through lane, R = exclusive right turn lane, LR = shared left-right lane, LTR = shared left-through-right turn lane.

By 2035, the mainline left turns are having difficulty finding gaps as the US20 v/c ratio is over standards at the US20 & Old Bend-Redmond intersection (Table 54). Traffic diversion to other local facilities such as Robal and Cooley Roads is likely in the peak periods. On the local system, only the Cooley Road & Boyd Acres Road intersection exceeds standard (Tables 55-56) around 2016 which likely indicates a traffic control improvement.

Table 54: Year 2035 East DS-2 State Highway Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	HDM v/c	v/c Ratio ¹	Critical Movement	Year Exceeded	
				Std.	Cap.
US20 & Old Bend-Redmond Hwy	0.60	0.81/2.0+	WBL/NBL	<2007	<2007

¹Blackened cells means that the HDM design v/c guideline has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, WB = Westbound, L= exclusive left turn lane.

Table 55: Year 2035 East DS-2 City Street Unsignalized Intersection Operations for Critical Major and Minor Approaches¹

Intersection	v/c Ratio	Delay (s)	Critical Movement ²	Year Std. Exceeded
3 rd St & Grandview Dr	0.10/0.11	8.8/15.2	SBL/WBLR	2040+
3 rd St & Clausen Rd	0.24/0.62	8.9/80.0	NBL/EBL	2040+
3 rd St & Chavre Wy	0.38/0.05	0.0/10.0	NBT/WBR	2040+
3 rd St & Target Dwy	0.24/0.44	0.0/15.9	SBT/EBR	2040+
3 rd St & Nels Anderson Pl/Cascade Village	0.63/0.15	0.0/20.6	NBT/WBR	2040+
Cooley Rd & Scenic Dr	0.25/0.03	0.3/16.4	EBTL/SBLR	2040+
Cooley Rd & Boyd Acres Rd	0.21/2.0+	15.0/120+	WBL/NBL	2016
O.B. Riley Rd & Robal Rd ²	0.89/0.53	29.8/9.6	SBTL/WBLR	2039
Robal Rd & Britta St	0.06/0.31	2.0/11.3	WBTL/NBLR	2040+
Robal Rd & Auto Mall Dwy	0.04/0.38	9.9/49.7	EBL/NBTL	2040+
Robal Rd & Target Dwy	0.13/0.17	0.0/10.7	WBT/SBR	2040+
Robal Rd & Cascade Village Dwy	0.07/0.12	0.0/9.7	EBT/NBR	2040+
Robal Rd & Nels Anderson Dr	0.42/0.04	14.9/2.4	NBTL/EBLR	2040+
Nels Anderson Dr & Chavre Wy	0.02/0.01	3.1/9.2	NBTL/EBLR	2040+
Nels Anderson Dr & Nels Anderson Pl	0.02/0.16	1.1/11.4	NBTL/EBLR	2040+
Empire Ave & Britta St	0.01/0.04	9.2/20.8	EBL/SBL	2040+
Empire Ave & Jamison St	0.25/0.10	0.0/11.6	WBT/SBR	2040+
Empire Ave & Industrial Park Blvd	0.43/0.10	0.0/10.1	WBT/SBR	2040+
Empire Ave & Corporate/Blenhiem Pl	0.03/0.63	12.7/96.0	EBL/NBLTR	2040+
Hunnell Rd & Loco Rd	0.03/0.48	1.8/18.9	SBTL/WBLR	2040+
Bowery Ln & Frontage Rd	0.04/0.02	9.5/4.1	NBTL/EBLR	2040+

¹Blackened cells mean that the City 50 second delay standard for unsignalized intersections with the subject approach having more than 100 peak hour trips or the v/c of 1.0 standard has been exceeded.

²This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, TL= shared through-left lane, LTR= shared left-through-right turn lane.

³Intersection is a roundabout.

Table 56: Year 2035 East DS-2 County Road Unsignalized Intersection Operations for Critical Major and Minor Approaches

Intersection	LOS	Critical Movement	Year Std. Exceeded
Tumalo Rd & Deschutes Pleasant Ridge Rd	A/C	WBTL/NBLR	2040+
Tumalo Road & Nichols Market Rd	A/C	EBL/SBLTR	2040+
Tumalo Rd & Deschutes Market Rd	A/D	EBL/NBLTR	2040+
O.B. Riley Rd & Old Bend-Redmond Hwy	B/C	SBTL/WBLR	2038
O.B. Riley Rd & Cooley Rd	A/D	SBL/WBL	2040+
Hunnell Rd & Rogers Rd	A/A	NBTL/EBLR	2040+
Hunnell Rd & Bowery Ln	A/B	SBTL/WBLR	2040+
Hunnell Rd & Fort Thompson Ln	A/B	SBTL/WBLR	2040+
Fort Thompson Ln & Harris Wy	A/A	WBTL/NBLR	2040+
Bowery Ln & Harris Wy	A/A	EBTL/SBLR	2040+

¹This is the critical (mainline/side-street) approach by direction and lane configuration for exclusive or shared turn lanes. NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, LR = shared left-right lane, TL= shared through-left lane, LTR= shared left-through-right turn lane.

Signalized Intersections

Most of the state highway signalized intersections exceed the HDM v/c's and are approaching or exceeding capacity by the design year (Table 57). Even with two lanes in each direction on US20 with dual turn lanes as appropriate, the US20 intersections at Cooley and Robal Roads are about at capacity with 0.91 and 1.0 v/c respectively. The US20 (3rd Street) & Empire Avenue intersection is substantially over capacity at a v/c of 1.20. Four southbound lanes (two through and long dual left turn) are needed to allow for lane changing along 3rd Street between the US20 connection and Empire Avenue. The large volume at this intersection would typically be handled with a grade separation rather than at-grade. However, because of the close proximity to US97, grade separations are not practical.

Table 57: Year 2015 & 2035 State Highway East DS-2 Signalized Intersection V/C Ratios

Intersection	HDM v/c	v/c Ratio ¹		Year Exceeded	
		2015	2035	Std.	Cap.
US20 & Cooley Rd	0.75	0.53	0.91	2027	2040
US20 & Robal Rd	0.75	0.63	1.00	2022	2036
US20 & Empire Ave	0.75	0.82	1.20	2015	2025
Empire Ave & NB US97 Ramps	0.75	0.59	0.75	2036	2040+
Empire Ave & SB US97 On-ramp	0.75	0.47	0.66	2040+	2040+

¹Black shaded cells indicate the HDM design v/c guideline has been exceeded.

All City signalized intersections are under standards in 2015 and except for the O.B. Riley Road & Empire Avenue intersection meet standards in 2035 (Table 58). This intersection is just over the City standards mainly because of high southbound through volumes. This shows a likely need to widen O.B. Riley Road to two travel lanes in each direction around the 2035 design year.

Table 58: Year 2015 & 2035 City Street East DS-2 Signalized Intersection V/C Ratios¹

Intersection	v/c Ratio		Delay (s)		Year Std. Exceeded
	2015	2035	2015	2035	
3 rd St & Cooley Rd	0.45	0.78	38.3	50.3	2040+
3 rd St & Robal Rd	0.68	0.81	37.5	51.2	2040+
Cooley Rd & Hunnell Rd S	0.14	0.39	14.6	27.7	2040+
Cooley Rd & Hunnell Rd N	0.29	0.57	20.3	29.8	2040+
Robal Rd & Hunnell Rd	0.35	0.57	16.4	21.6	2040+
O.B. Riley Rd & Empire Ave	0.57	1.01	18.5	60.4	2035
Empire Ave & Boyd Acres Rd	0.65	0.89	26.1	43.8	2040+

¹Black shaded cells indicate the City v/c of 1.0 or 80 second delay standard for signalized intersections has been exceeded.

Queuing

Appendix N contains the 2015 and 2035 95th percentile queuing figures for the project area. The 2015 and 2035 queues were created by averaging at least five random SimTraffic micro-simulations together. Queues shown on the figures are a combination of stopped vehicles and vehicles traveling at seven or less miles per hour.

US97 in 2015 is free-flowing through the project area. Problems on US20 are generally limited to lengthy northbound and southbound queues at the 3rd Street and Empire Avenue intersection. Queues are about 425' northbound and 700' southbound, but no adjacent streets or connections are blocked. On the local system, the longest queues are at the 3rd Street & Robal Road intersection. Only the queues on Robal Road block significant adjacent driveways (Cascade Village Mall) and intersections (Nels Anderson Rd). Empire Avenue queuing does not extend between intersections except with closely spaced ones like 3rd Street and Jamison Street or O.B. Riley Road and Britta Street.

Table 59 shows the significant (greater than 5%) blocking areas in 2015 with blocking issues limited to turn bays. The most significant durations occur at the US20 & Old Bend-Redmond Highway intersection mainly from the long delays incurred by side-street traffic trying to cross or turn. Over half of the blocking problems are along Empire Avenue so congestion is expected in the highest traveled portions during the peak hour around the US97 interchange. The highest blocking in the local system is on the east end of Robal Road where queues block through the Nels Anderson Road intersection almost 10% of the peak hour which will mean localized difficulty for vehicles turning on and off this roadway segment.

By 2035, substantial queuing problems exist within the project area. Significant slowdowns (rolling queues) exist on northbound US97 from the southern US20 connection north to Empire Avenue because of the extensive lane changes (weaving). A second slowdown area exists north of the Empire Avenue northbound off-ramp up to the major diverge area for the connections to US20 and 3rd Street as vehicles position themselves in the proper lanes before the junction.

Congestion on northbound 3rd Street propagates down to the 3rd Street/US20 interchange as significant slowing exists on both the 3rd Street connection from US20 and the connection from US97. Long queues exist on US20 approaching Robal Road westbound and significant slowing occurs approaching the Old Bend-Redmond Highway intersection from intersections at or over capacity in this section. The southbound queue at US20 & Empire Avenue extends into the US20/3rd/US97 connections. Robal Road and Empire Avenue are essentially queued over their entire length because the over-capacity intersections block many accesses and streets.

Table 59: Year 2015 East DS-2 Significant Queue Blocking¹

Intersection	Approach	Blocked Lane	Blocked Intersection	Average Percent Time Blocked
US20 & Old Bend-Redmond Hwy	SB	L		99
	NB	L		50
US20 & Robal Rd	WB	L		18
	NB	R		5
US20 & Empire Ave	NB	L		9
		R		20
3 rd St & Robal Rd	WB	L		38
			Nels Anderson Dr	8
	NB	L		5
Empire Ave & O.B. Riley Rd	WB	R		8
Empire Ave & Nels Anderson/US97 SB On-ramp	EB	L		6
		R		9
Empire Ave & US97 NB Ramps	NB	L		6
Empire Ave & Boyd Acres Rd	EB	L		11
		R		7
	WB	L		14
	NB	R		29

¹NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, R = exclusive right turn lane.

There are over 20 street intersections and significant driveway approaches that have blocking issues (Table 60). Blocking of adjacent streets and intersection turn lanes over half the time occurs at US20 & Old Bend-Redmond Highway, US20 & Empire, 3rd Street

& Robal and Cooley Roads, Cooley Road & Boyd Acres Road, and Empire Avenue & O.B Riley and Boyd Acres Roads.

Table 60: Year 2035 East DS-2 Significant Queue Blocking¹

Intersection	Approach	Blocked Lane	Blocked Intersection	Average Percent Time Blocked
US20 & Old Bend-Redmond Hwy	SB	L		99
	NB	L		91
	WB	L		48
US20 & Cooley Rd	EB	L		13
	WB	L		42
			Scenic Dr	6
	SB	L		12
US20 & Robal Rd	EB	L		25
			Britta St	9
	WB	L		39
		R		49
			AutoMall/CV Dwy	20
	NB	L		25
		R		28
	SB	L		5
US20 & Empire Ave	WB	L		18
			Industrial Park Blvd	18
		R		24
	NB	L		75
		R		76
			Sherman Ave	66
	SB		EB US20/SB 3 rd St	13
3 rd St & Cooley Rd	EB	L		14
		R		14
	WB	L		7
	NB	R		25
	SB	L		55
			Clausen Dr	5
3 rd St & Robal Rd	EB		Cascade Village Dwy	29
	WB	L		68
			Nels Anderson Dr	43
	NB	L		28
	SB	L		18
		R		31
			Target Dwy	15

3 rd St & Nels Anderson Rd/Cascade Village	NB		Connection from US97	13
	SB		Robal Rd	10
Cooley Rd & Hunnell Rd S	EB	L		22
Cooley Rd & Hunnell Rd N	EB	T		8
	NB	L		25
Cooley Rd & Boyd Acres Rd	NB	L		88
	SB	L		68
Robal Rd & AutoMall/ Cascade Village Dwy	EB	L		12
			US20	10
	WB	L		21
			Hunnell Rd S	12
	NB	L		38
Robal Rd & Hunnell Rd	EB	R		17
			AutoMall/ Cascade Village Dwy	13
	WB	L		22
			Target Dwy	10
	NB	L		33
	SB	L		14
Robal Rd & Target Dwy	WB	R		5
			3 rd St	17
Hunnell Rd & Shopping Center Access E-W	SB	L		11
Empire Ave & O.B. Riley Rd	WB	R		58
			Britta St	50
	NB	R		33
	SB	L		16
Empire Ave & Britta St	EB	L		18
			O.B. Riley Rd	13
	WB		Jamison St	14
Empire Ave & Jamison St	WB		3 rd St	7
Empire Ave & Industrial Park Blvd	WB		Nels Anderson/SB US97 SB On-ramp	12
Empire Ave & Nels Anderson/US97 SB On-ramp	EB	L		13
	WB	L		13
			US97 NB Ramps	11
Empire Ave & US97 NB Ramps	WB	R		16
			Corporate/ Blenheim Pl	10
	NB	TR		14
Empire Ave & Corporate/Blenhiem Pl	WB	L		9
			Boyd Acres Rd	6

Empire Ave & Boyd Acres Rd	EB	L		8
		R		18
	WB	L		40
	NB	L		8
		R		46
	SB	R		50

¹NB = Northbound, SB = Southbound, EB= Eastbound, WB = Westbound, L= exclusive left turn lane, T= through lane, R = exclusive right turn lane, TR = shared through-right lane.

Other Operational Performance Measures

Tables 61 and 62 show additional operational MOE's for the project area over the 20-year analysis period. The tables show increasing congestion as overall average speed drops by 50% and delay increases sevenfold. However, impacts to US97 are minimal as travel times only increase about 10% from 2015 to 2035. In comparison, on US20 with its numerous over-capacity intersections, travel times more than double. Impacts from the high amount of queuing on Robal Road and Empire Avenue are reflected in the segment speeds as they drop to crawl speeds. Local system impacts have about a 40% increase in travel time. Only US97 has peak hour speeds close to the posted speeds.

Table 61: Year 2015 & 2035 East DS-2 Overall Simulation Measures of Effectiveness

Measure of Effectiveness	Year	
	2015	2035
Average Speed (mph)	32	15
Total Stops ¹	18,800	56,300
Delay (hr)	320	2,140
Travel Time (hr)	1,140	3,190

¹A stop is recorded every time a vehicle drops below 7 mph (crawl speed). A vehicle might have multiple stops on an intersection approach.

Table 62: Year 2015 & 2035 East DS-2 Segment Travel Time and Speed

Segment	Travel Time per vehicle (min:s)		Average Speed (mph)	
	2015	2035	2015	2035
US97 (Deschutes Market Rd – Butler Market Rd)	7:20	8:15	48	43
US20 (Old Bend-Redmond Hwy – Sherman Ave)	4:25	10:05	31	14
3 rd St (US97 – US20)	3:45	6:55	29	18
O.B. Riley Rd (Old Bend-Redmond Hwy – Empire Ave)	2:50	8:30	36	19
Empire Ave (O.B. Riley Rd – Boyd Acres Rd)	2:40	8:35	16	6
Cooley Rd (O.B. Riley Rd – Boyd Acres Rd)	3:50	5:20	22	16
Robal Rd (O.B. Riley Rd – Nels Anderson Rd)	3:05	5:05	15	10

Spacing Standards

Appendix C in the OHP has spacing standards for public road approaches and private accesses to be used in the planning process. The following spacing standards apply to the US 97 Bend North Corridor Solutions project:

- Interchange-to-interchange: three miles for a rural expressway and 1.9 miles for an urban expressway or statewide highway based on cross-road spacing. This standard is for the planning of new interchanges on the state system.
- Ramp-to-ramp/intersection: one mile between two interchanges in access-controlled freeway sections or between an interchange and an at-grade intersection.
- Ramp-to-Ramp: one-half mile between the taper sections of intersections or adjacent on and off-ramps.
- Next intersection adjacent to ramp terminal: 1320 feet for a two or multi-lane crossroad in an urban area to the next full intersection or right-in-right-out.
- Street spacing: One mile at 55 mph for a rural expressway; 2640 feet for streets at 45 mph on a urban expressway; and 990 feet for a urban statewide highway. There is no standard for private accesses as they are discouraged on statewide highways and expressways.

North of the 3rd Street interchange, US97 has a few accesses up to Deschutes Junction. A future median may be added between the two interchanges to limit conflict points as creating full frontage /backage roads for a few isolated properties was not cost-effective. US97 south of the 3rd Street interchange is access-controlled with the only connections being interchanges. Like US97, the northern section of US20 has very few accesses north of Empire Avenue. From Empire Avenue south, US20 is an uncontrolled five-lane section with many driveways.

Table 63 compares the between major road segments to their appropriate spacing standard. On US97, north of the US20 connections to the 3rd Street interchange, the highway exceeds the interchange and ramp-to-ramp spacing standards. Most existing accesses north of the 3rd Street interchange remain but might be restricted with a future extension of the median barrier north to Deschutes Market Road. The distance from the US20 connections and the Empire Avenue interchange is only about 10% of the standard, however this is only one connection in the northbound direction for a partial interchange. The interchange spacing between Empire Avenue and Butler Market is less than half of the 1.9 mile standard remaining unchanged from the no-build.

Table 63: Spacing Standards Comparison

Roadway	Segment	Spacing Standard	Alternative Spacing¹
US97	Deschutes Market Rd - 3 rd Street Interchange	1 mi	<2500 ft ²
	3 rd Street Interchange – US20 Connections	1.9 mi	2.2 mi
	US20 Connections – Empire Avenue Interchange	1.9 mi	1030 ft
	Empire Avenue Interchange- Butler Market Interchange	1.9 mi	4490 ft
	3 rd Street Ramps – US20 Connection	2640 ft	1.9 mi NB 1.7 mi SB ³
	US20 Connection – Empire Avenue Ramps	2640 ft	1580 ft ⁴
	Empire Avenue Ramps – Butler Market Ramps	2640 ft	1270 ft
US20	Old Bend-Redmond Highway – Cooley Rd	1 mi	300 - 1700 ft ²
	Cooley Rd – Robal Rd	2640 ft	2220 ft
	Robal Rd – 3 rd St Connections	1 mi	3010 ft EB 4380 ft WB
	3 rd St Connections– Empire Ave	1 mi	1530 ft
	Empire Ave – project limits	990 ft	<400 ft ²
Empire Ave	Industrial Park Blvd – Nels Anderson Rd/SB US97 On-ramp	1320 ft	370 ft ⁵
	US97 NB Off-ramp – Corporate/Blenhiem Pl	1320 ft	780 ft
3 rd Street	US20 Connections – Nels Anderson Rd	1 mi	950 ft

¹Black-shaded cells mean the spacing is less than the corresponding standard.

²Approximate road/driveway spacing over segment

³This is the distance to the next ramp which is the Empire Avenue southbound on-ramp.

⁴Northbound only

⁵Approximately 850 feet to the signalized US20/3rd Street intersection

On US20, the street spacing is only about a third of the standard north of Cooley Road and Empire Avenue. US20 approaches the standard between 3rd Street and Robal Road northbound and is close to the standards between Cooley and Robal Roads. South of Empire Avenue, the spacing is improved with some driveway closures, but still does not meet the the spacing standards. The ramp terminal spacing standard is not met on Empire Avenue with sections a third to a half of the required level.

ALTERNATIVE SUMMARY & COMPARISON

Overall, East DS-1 and DS-2 have similar volumes and results. Both are substantially better than the no-build in all respects (Table 64). The number of locations over standard or over capacity is only a third to a half of the no-build. The US97 segment and the overall network speed are double the no-build values. Conversely, alternative travel times are less than half of the no-build. The US97 travel times are about 75% of the 2007 existing condition values because of the elimination of the Cooley and Robal Road signals and other access points. Both of the alternatives have peak operating speeds reasonably close to the posted speeds. Both alternatives improved the access spacing on US97 to exceed spacing standards north of the US20 connections to the new 3rd Street interchange. South of the US20 connections and north of the new 3rd Street interchange on US97 and along US20 the spacing does not meet standards as it is relatively unchanged from the no-build alternative.

Table 64: Alternative Comparison for 2035 Results

Measure	No-build	East DS-1	East DS-2
Number of locations over standards	21	12	11
Number of locations over capacity	15	5	5
Number of turn storage bays blocked more than 50% of the peak hour	17 ¹	10	10
Number of intersections blocked by queues	24 ¹	7	19
Overall average network speed (mph)	8 ¹	18	15
Overall network total stops	>66,000 ¹	47,900	56,300
Overall network delay (hr)	>2,400 ¹	1,550	2,140
Overall network travel time (hr)	~3,600 ¹	2,630	3,190
US97 (Deschutes Jct- Butler Market Rd) Segment Speed (mph)	20 ¹	43	43
US97 (Deschutes Jct- Butler Market Rd) Segment Travel Time (min:sec)	18:05 ¹	8:10	8:15
Sections where spacing standards exceeded or met	0	2	2

¹Data based on a 30-minute simulation run versus 60 minutes for others. Actual 60 minute values are likely much higher or slower than shown.

US97 is free of congestion in both alternatives except for localized slowing in the weaving section south of Empire Avenue. This weaving section is a “transition” section between the improved new alignment north of Empire Avenue and the unchanged near-capacity section south of Butler Market Road. Within this transition section, improvement is limited to smoothing the traffic flows between the old and new sections without attracting additional traffic which would cause a severe bottleneck south of Butler Market. In the north portion of the project area, alternatives preserve the good operations.

There are a number of US20 or local intersections at or over the HDM design v/c guidelines with some still over capacity even with reasonable improvements. Four of the five intersections along US20 from Old Bend-Redmond Highway to Empire Avenue are

over capacity by 2035. The improvements on US20 offer some capacity enhancements to keep congestion at a manageable level but do not keep it free-flowing like on US97 which will keep operations consistent and balanced with the surrounding system because constructing a large amount of capacity improvements would attract too much traffic off the local system to be manageable. Without at least the level of improvements offered in the build alternatives, the project area would be much worse than the rest of the system as the current network is not very well developed (lacks parallel local facilities). Both alternatives degrade the O.B. Riley & Empire Avenue intersection by pushing higher volumes through the intersection than in the future no-build. In addition, queuing is an issue at the westbound approach because the alternatives reduce the US20 (3rd Street) & Empire Avenue bottleneck which allows more traffic to reach O.B. Riley Road.

The alternatives will allow US97 to operate consistently with its expressway and freight route designations by maximizing the flow of long distance and regional trips while minimizing access points. Overall, the alternatives create a good match or balance between the existing and project areas unlike earlier, more comprehensive alternatives which attracted so much additional local traffic onto US97 that congestion became unmanageable. The alternatives have lower system capacities and less connection points than previous alternatives keeping most of the short local trips off US97.

The full interchange in East DS-1 will be more sensitive to future land use changes. Increased growth (i.e. future connection to the Juniper Ridge area east of the railroad tracks) will increase the local traffic on the ramps to/from the south. The success of East DS-1 (and DS-2) relies on having a full parallel city arterial street connection from Empire Avenue to Juniper Ridge in place. This local connection needs to be competitive in travel time with US97 so local users will use it rather than state facilities.

The major difference between the two build alternatives is that East DS-2 does not have the southerly connections from 3rd Street to/from US97. This volume difference is only about 70 vph which results in v/c ratios not varying by more than a few points to a tenth at the most. However, this increase is significant at the system level and East DS-2 acts as a sensitivity analysis for East DS-1. East DS-2 has substantially more total stops (18%) more delay (38%) and more travel time (21%) than DS-1 in 2035 with a very small increase in volumes. Both alternatives are similar for 2015. For most places in East DS-1, an increase of 10% in volume generates results similar to East DS-2. More than 10% causes substantial congestion above and beyond East DS-2 meaning these alternatives are very sensitive to changes in flows. This means that they do represent the maximum flow that can use the alternatives without complete system congestion. In other words, these alternatives represent the minimum level of improvements necessary to handle the expected future volumes. While the volumes used in the analysis are peak 30th highest hour values (Fridays), volumes can easily fluctuate 10% during the week. Because of the numerous intersections at or over capacity this causes significant impacts to the system to the point that East DS1 could easily have results similar to East DS-2 on any given day.

CONCLUSIONS

Both alternatives function much better than the no-build alternative and will allow US97 to achieve free-flow operations through the 2035 design year. The alternatives will allow US97 to operate consistently with its expressway and freight route designations by maximizing the flow of long distance and regional trips while minimizing access points. Both alternatives meet the project purpose of improving safety and freight mobility on US97. Both alternatives are consistent and balanced in size and operations with the existing facility north and south of the project area while keeping local traffic on the local system.

Because East DS-1 and DS-2 have very similar networks and a small difference in volumes, either of these are viable based on traffic operations. Even though East DS-2 seems to operate much poorer for the overall network, the actual volume difference between East DS-1 and DS-2 is very small and well within the typical 10% weekly fluctuations, so either alternative can act similarly to the other on any given day.

