US 97 Parkway Plan Phase 2

Facility Plan

February 26, 2021

Revised Draft

Prepared for:

Oregon Department of Transportation

Prepared by:

WSP DKS

TABLE OF CONTENTS

FIGURES

TABLES

ABBREVIATIONS

AADT ..... Annual Average Daily Traffic
AMT ..... Alternative Mobility Targets
ATR ..... Automatic Traffic Recorder
BMPO ..... Bend Metropolitan Planning Organization
BRM ..... Bend-Redmond Model
CTAC ..... Citywide Transportation Advisory Committee
FEIS ..... Final Environmental Impact Statement
HSM ..... Highway Safety Manual
IAMP ..... Interchange Area Management Plan
INFRA ..... Infrastructure for Rebuilding America
ITS ..... Intelligent Transportation Systems
LOS ..... Level-of-service
LTS ..... Level of Traffic Stress
MPO ..... Metropolitan Planning Organization
MTP ..... Metropolitan Transportation Plan
NCHRP ..... National Cooperative Highway Research Program
ODOT ..... Oregon Department of Transportation
OHP ..... Oregon Highway Plan
OTC ..... Oregon Transportation Commission
PHF ..... Peak-Hour Factor
PMT ..... Project Management Team
RIRO ..... Right-In-Right-Out
ROW ..... Right-of-Way
SPIS ..... Safety Priority Index System
TAC ..... Technical Advisory Committee
TSMO ..... Transportation Systems Management and Operations
TSP ..... Transportation System Plan
VMT ..... Vehicle Miles Traveled

1.0 BACKGROUND AND INTRODUCTION

1.1 STUDY BACKGROUND AND PURPOSE

The Bend Metropolitan Planning Organization (BMPO) completed an update to the regional long-range transportation plan in 2014, which identified future traffic congestion on US 97 through Bend and predicts that US 97 is unlikely to meet mobility targets in the future. US 97 serves a significant volume of freight, regional, local, and recreational traffic. Adding traditional lane capacity is unlikely due to financial and physical constraints, and is incompatible with the City of Bend's economic, land use, and livability goals, which form the basis for alternative mobility targets (AMTs) in the City of Bend's Transportation System Plan (TSP).

The US 97 Parkway Plan is a multi-phase planning process to improve safety, mobility, and active transportation and transit use on the US 97 Parkway between Tumalo Road and Baker Road, most of which is within the Bend, Oregon. The first phase focused on developing goals and objectives and understanding existing conditions and plans.

The second phase commenced with the development of a project vision and analysis of future conditions. Alternatives were then developed to address the identified needs and evaluated against project goals, objectives and criteria. The final task leading up to this facility plan was the investment strategy, which further prioritized projects based on technical analysis and the evaluation scoring, the interrelationship with other projects, the severity of the need and the type of solution, and opportunities for funding.

1.2 PROJECT PHASING

The project took place in two phases:

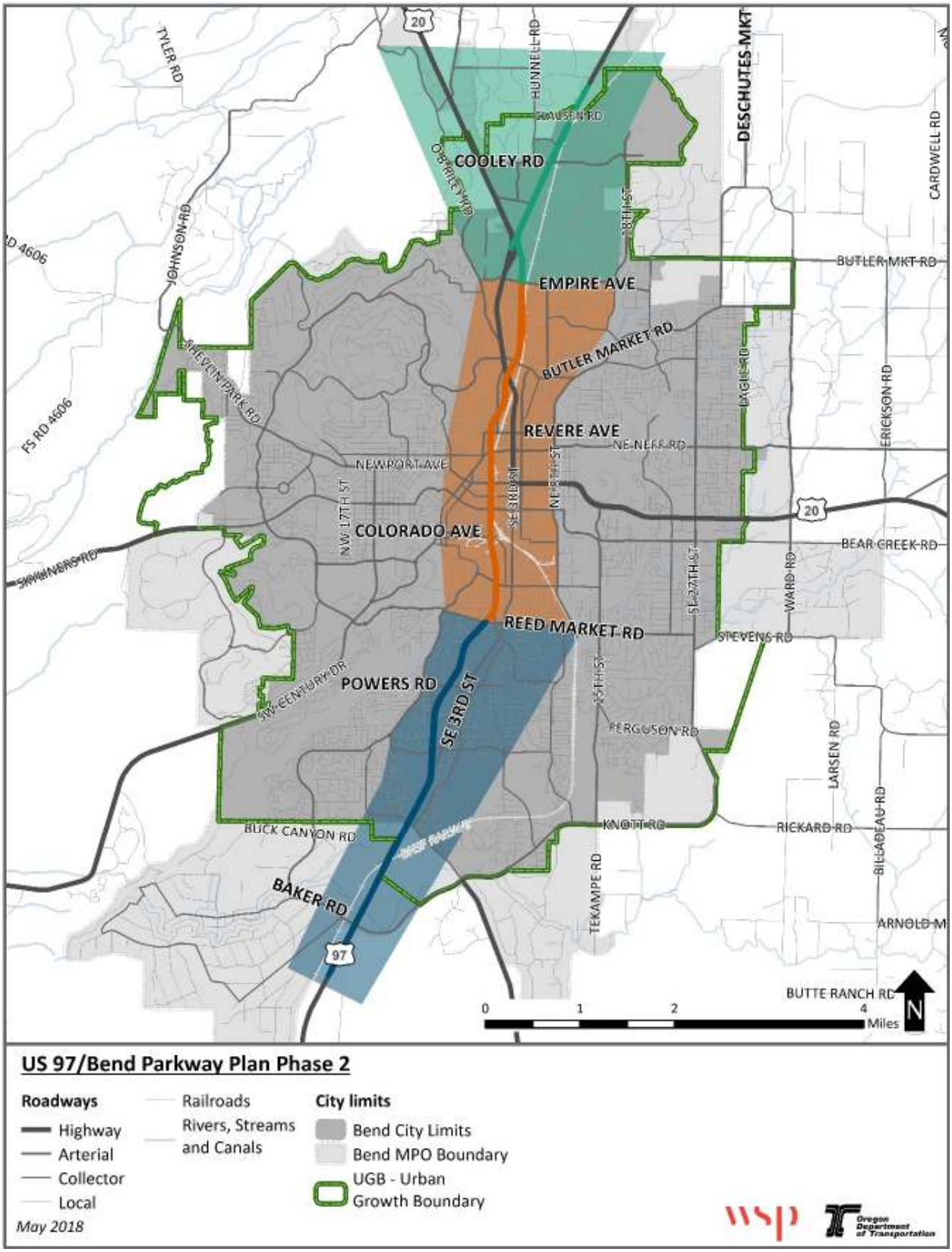
- **Phase 1** included a summary of existing plans and agreements, existing conditions analysis, future traffic forecast and future conditions analysis, and description of preliminary alternatives.
- **Phase 2** included two levels of alternatives analysis: the investment strategy and the facility plan. Phase 2 had a larger budget that allowed for the kind of detailed travel analysis that was needed for public involvement, among other things. Some Phase 1 memos were updated with additional information in Phase 2.

1.3 PROJECT AREA AND STUDY AREAS

The project area follows the US 97 corridor between the northern terminus at Bend's northern city limits at Clausen Road and the southern terminus at Baker Road.

The project area is divided into three subareas, or "study areas," for reporting outcomes of projects that are not corridor-wide. Figure 1 shows the north, central, and south study areas. The north study area (shown in green) is between the project's northern terminus at Bend's northern city limits at Clausen Road and Empire Avenue. The central study area (shown in orange) is between Empire Avenue and Reed Market Road. The south study area (shown in blue) is between Reed Market Road and the project's southern terminus at Baker Road.

Figure 1: Study Areas



1.4 THE US 97 PARKWAY PLAN

The US 97 Parkway Plan summarizes and attaches all study technical memorandums and the investment strategy into a single document. While this plan includes efforts from Phase 1, it focuses primarily on Phase 2 of the project.

This plan is to be adopted as a facility plan by the Oregon Transportation Commission (OTC). A facility plan is a transportation plan for a facility such as a highway corridor or an airport master plan, and can be multimodal or focus on one transportation mode. Facility plans determine the function as well as existing and future needs for a transportation facility, and include strategies for managing the existing transportation facilities and for improving the facilities to keep them operating at acceptable levels for twenty years. Facility plans further refine policies and investment priorities identified in the OTP and mode and topic plans. Findings of compatibility with city and county comprehensive plans, compliance with applicable statewide planning goals, and consistency with statewide plans and plans adopted by the OTC are attached to this plan as Attachment B.

2.0 PUBLIC INVOLVEMENT AND LOCAL GOVERNMENT PARTICIPATION

2.1 PROJECT ADVISORY AND DECISION-MAKING STRUCTURE

Project Management Team

The project was overseen by a Project Management Team (PMT) that included the sponsoring agency (ODOT), the BMPO, the City of Bend, and the project consultant team. The PMT used the existing BPMO Technical Advisory (TAC) and BMPO Policy Board (the Policy Board) as committees throughout both phases of the project. These committees were intended to represent a range of community and agency interests related to the project.

BMPO Technical Advisory Committee

The TAC was charged with reviewing project materials for technical accuracy, providing feedback to the PMT, and recommending policy actions to the Policy Board. The TAC comprises professional staff members, staff from local governments, area and regional transportation agencies and other public agencies.

BMPO Policy Board

The Policy Board was ultimately responsible for decision-making guidance on project outcomes, recommendations to ODOT (as sponsor), and for making any applicable adoptions to the Metropolitan Transportation Plan (MTP). The Policy Board adopted the facility plan as a component of the MTP. The plan establishes MTP policy and project priorities.

Oregon Transportation Commission

The OTC will meet to consider adoption of the final US 97 Parkway Facility Plan as a component of the Oregon Highway Plan. Adoption by the OTC establishes policies and priorities for the corridor that guide management of the facility by ODOT and local governments.

Bicycle and Pedestrian Working Group

A Bicycle and Pedestrian Working Group comprising ODOT and City of Bend staff provided supplemental analysis focused on the need for more high-quality crossing opportunities along US 97 for people walking and biking.

Joint TAC and Policy Board Meetings

The following five 2-hour meetings including TAC and Policy Board members took place during Phase 2:

- November 29, 2018
- March 11, 2019
- November 19, 2019
- April 20, 2020
- August 13,2020

Sounding Board

The PMT recommended, and the Policy Board approved, membership for a Sounding Board that provided project and process feedback to the Policy Board. The group met twice during Phase 2. Membership includes representatives from neighborhood associations, the Chamber of Commerce and local business groups, economic development groups, the freight industry, environmental justice and community organizations, and advocates for local tourism.

2.2 PUBLIC INVOLVEMENT OPPORTUNITIES

Visioning Process

A visioning process took place in fall 2018, which included a visioning workshop during the Policy Board and TAC joint meeting. The vision was shaped by feedback from the Policy Board, the TAC, and the project Sounding Board, as well as an online open house that elicited information and feedback from the larger Bend community.

The vision statement adopted by the Policy Board in December 2018 states the following:

> In 2040, the Parkway is a key part of the larger US 97 highway corridor, which has a primary function of providing safe and reliable travel between communities and connections to recreation areas and economic centers with minimal interruptions, including travel to and from Bend as a major regional destination given its many major employment and commercial areas. The Parkway continues to support statewide, regional, and local interests as a critical asset in support of communities and economies, relative to the hierarchy of US 97's national, statewide, and regional designations.

Major elements, which are more fully detailed in the adopted document, include the following:

- US 97 Bend Parkway is part of a significant statewide route.
- US 97 Bend Parkway is a significant local route.

- US 97 Bend Parkway is facilitating through travel.
- The US 97 Bend Parkway is fully integrated into the overall Bend multimodal transportation system with strategic on-/off-ramps, overcrossings/undercrossings, and a strong parallel system that accommodates the community's transportation needs.
- Local traffic growth is primarily accommodated on the local roadway system.
- The US 97 Bend Parkway corridor is safer for all users and more efficient due to access changes.
- The US 97 Bend Parkway corridor is part of a transportation system that supports active transportation modes such as walking, biking and taking public transportation.

Evaluation of Projects

A joint meeting of the Policy Board and the TAC was convened in spring 2019 to review and provide input to the First Level Alternatives Evaluation. Another joint meeting was held on November 19, 2019, regarding the Second Level Alternatives Evaluation. At that meeting, members heard presentations on both the Second Level Alternatives Evaluation and the Murphy Road/Powers Road Improvement Concepts.

The Policy Board and TAC members expressed a variety of questions and comments following the presentation by project staff and consultants. Areas of emphasis for the Policy Board and TAC included the following:

- Impacts of potential right-in-right-out (RIRO) closures and whether right-ins and right-outs could be evaluated separately
- Coordination of US 97 Parkway Plan recommendations with projects already included in the Bend's Capital Improvement Plan
- Distance between active transportation crossings of the Parkway

A public outreach update to the Policy Board and TAC members discussed strategies used to obtain input on vision and needs, results of Bend's demographic profile, and outreach contacts.

The second meeting of the Sounding Board was held on November 20, 2019. At that meeting, the group reviewed the alternatives evaluation and provided input on the investment strategy. Feedback included the following:

- Questions regarding the RIRO recommendations and potential cumulative impacts of widespread RIRO closure
- Concerns about whether ramp meters would lead to queuing and gridlock on city streets
- Interest in coordination of US 97 Parkway Plan improvements with Bend TSP projects

Online Open House

An online open house was hosted to share information about possible solutions and gather feedback from the general public. The online open house differed from a conventional survey in that it contained more

details, images, and links to other information intended to help create informed feedback. Survey details and results are outlined in the US 97 Parkway Phase 2: Online Open House Survey Summary.[1]

A Title VI report and demographic analysis did not identify a prominent Title VI population but did recommend additional focus on reaching low-income populations based on their lower participation in a 2018 online survey. During the outreach period, the project team provided project information to local food pantries and social service organizations and hosted two tabling events at discount grocery stores where they engaged with 90 shoppers and referred them to the online survey.

The online survey was available from November 26 to December 15, 2019, and received 1,122 responses, including 455 long-form open-ended comments. Emails and handwritten letters received during the survey period were incorporated into the summary.

The first 13 questions were multiple choice and asked respondents about the relative urgency of proposed solutions and strategies to problems on the US 97 Parkway, selecting from "*Very urgent*," "*Somewhat urgent*," "*Less urgent*," "*Not needed*," "*I have concerns*," or "*Not sure*." These rating options were selected to help ODOT prioritize timing of future investments and to identify the need for further refinement or clarification.

Question 14 asked the open-ended question: *"Is there anything else you want to tell us about the project or the proposed solutions? (Please explain below.)"* Congestion was the most commonly identified general problem (61 individuals), followed by Safety (33), Speed (18), and Traffic Signals (19). The most common comment was keeping RIRO exits open (104), followed by adding new ramps or merge lanes (47) and better enforcing the speed limit on the Parkway (36). The most popular locations mentioned were Hawthorne Avenue (106), Lafayette Avenue (90), Reed Market Road (46), Empire Avenue (33), Murphy Road (30), and Powers Road (29).

Respondents were asked questions on their demographics and usage of the Parkway. More specifically, these were questions of zip code, modes of transportation used in general and on the Parkway, frequency of Parkway usage, age, gender, household income, race/ethnicity, and languages spoken at home. Most of the collected feedback came from Bend residents (88 percent) who use the Parkway once a week or more (87 percent) with 30 percent saying that they live or work adjacent to the Parkway. While 87 percent of respondents said that they usually get around by driving a car, roughly 25 percent said that they also usually bike or walk.

Most respondents identified as white/Caucasian (95 percent), which is overrepresented compared to 2016 census data (86 percent). Despite additional efforts to engage lower-income groups, this survey had a slightly lower response rate than the 2018 survey among respondents who reported earning under the Bend median income (14 percent vs. 16 percent) while participation from respondents earning $100,000 or more increased slightly. Compared with the 2018 survey, respondents over 65 years old were significantly overrepresented, constituting over one-third of all respondents (twice the actual 65+ population). Respondents identifying as male were also overrepresented by about 8 percent, outnumbering female respondents by 13 percent.

[1] US 97 Parkway Phase 2: Online Open House Summary DRAFT, January 2020

The qualitative feedback from the public about the urgency of the needs and concerns about solutions was used along with the results of the technical work to inform the timing of the need and next steps for implementation as part of the investment strategy. The prioritization process and criteria are described in more detail in the next chapter.

3.0 EXISTING CONDITIONS

3.1 SUMMARIES OF EXISTING PLANS AND AGREEMENTS

Summaries of existing plans and agreements were produced in Phase 1 and Phase 2 as Technical Memorandum #1.[2, 3] The Phase 1 Summary of Existing Plans & Agreements report provides an extensive overview of key plans, studies, and management agreements that influence the Parkway Plan study area. The Phase 2 Summary of Existing Plans & Agreements report overviews five additional studies that were not included in the Phase 1 report but were relevant to the Parkway Plan. The Findings attachment to this Facility Plan outlines how the Parkway Plan is compatible and consistent with existing plans and complies with applicable statewide planning goals.

3.2 EXISTING TRANSPORTATION FACILITIES

Analysis of existing transportation facilities in Technical Memorandum #2[4] examined typical cross section, access management standards and access spacing, shoulder widths, and the transit system. The following key findings are in that memorandum:

- US 97 through the study corridor is classified as a Statewide Highway and has been designated as a part of the national highway system, a federally designated truck route, a state freight route and reduction review route, and an expressway. The segment south of Robal Road to south of the Murphy Road interchange has also been designated as a bypass.
- Sidewalk coverage is sparse, but bicycle facilities are present along most of the corridor.
- Speed limits range between 45 and 65 mph.
- The northbound and southbound travel lanes are physically separated through most of the study corridor. The approximately 3.4-mile segment of highway between Tumalo Place and Grandview Drive includes only a striped median of about 10 feet in width.
- From Empire Avenue to Reed Market Road, the average interchange spacing is approximately 1 mile, which is significantly less than ODOT's 1.9-mile interchange spacing standard for urban expressways.
- Approximately two-thirds of the highway corridor has substandard shoulder widths.

[2] US 97 Parkway Plan Phase 1: Technical Memorandum #1, Summary of Existing Plans and Agreements, March 3, 2017
[3] US 97 Parkway Plan Phase 2: Technical Memorandum #1, Summary of Existing Plans and Agreements, June 19, 2018
[4] US 97 Parkway Plan Phase 2: Technical Memorandum #2, Existing Conditions, December 13, 2017

- Approximately 30 regional transit buses travel along US 97 every weekday.

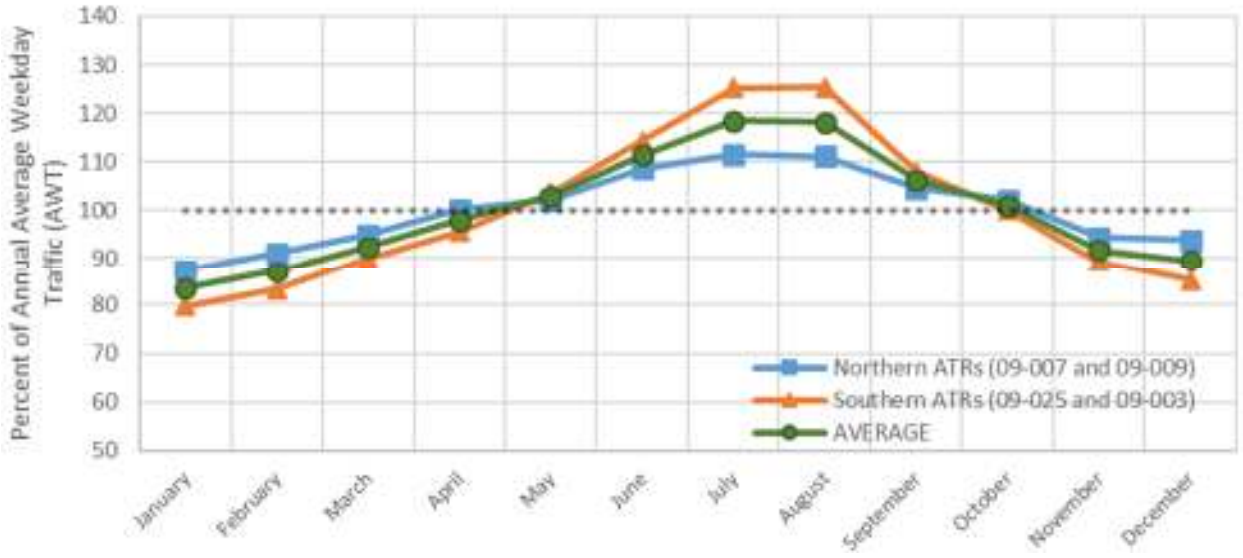
3.3 TRAFFIC VOLUME

Analysis of existing traffic volume characteristics examined seasonal variability, peak-hour traffic volumes, and regional travel patterns. The methodical approach to this analysis and other analyses is described in detail in the Methodology Memorandum.[5]

Seasonal Variability

The 30th highest annual hour traffic volumes (30 HV) were used for analysis. Four automatic traffic recorder stations (ATRs) within the project area collected traffic volume data continuously throughout the year and revealed key trends pertaining to traffic composition and seasonal trends. As shown in Figure 2, all four ATRs show increased traffic volumes during summer months. Traffic volumes in the southern half of the corridor have more seasonal variability with a steeper increase in traffic during the summer, which may indicate a higher proportion of recreational traffic compared to the more commuter-oriented traffic profile in the north half of the corridor.

Figure 2: US 97 ATR Average Weekday Traffic Seasonal Trends through Bend



Average Weekday Traffic Volume Profile

Changes in traffic volumes on US 97 throughout an average weekday were studied by creating a daily traffic volume profile using 24-hour counts collected in April 2017 at the following four locations representing the north, central, and south study areas:

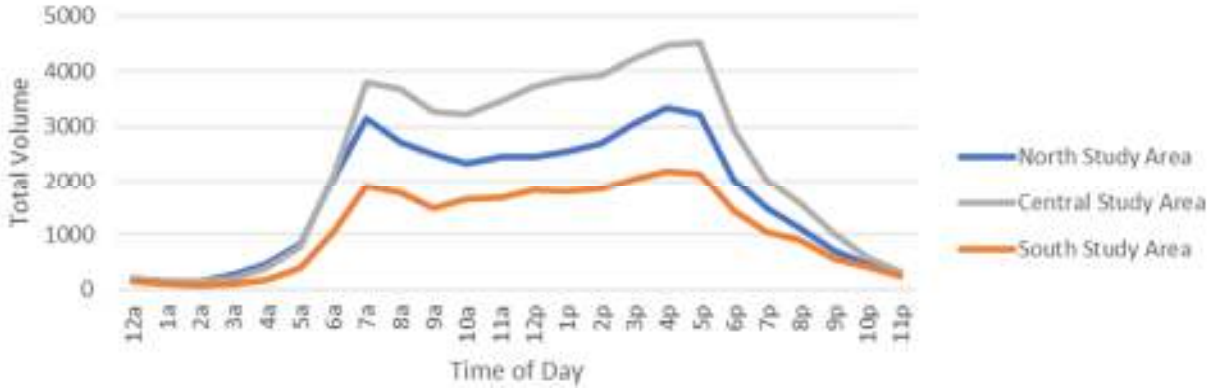
- North of Clausen Road (north study area)
- Between Butler Market Road and Empire Avenue (central study area)
- Between Reed Market Road and Truman Avenue (central study area)

[5] US 97 Parkway Plan Phase 2: Methodology Memorandum, July 17, 2018

- Between Knott Road and China Hat Road (south study area)

As shown in Figure 3, traffic peaks sharply in the morning around 7:00 AM, decreases until about 10:00 AM, then gradually increases and peaks again at around 5:00 p.m. The PM peak traffic volumes are greater than AM peak-hour volumes for the entire corridor and for each study area.

Figure 3: Average Weekday Traffic Volume Profile by Study Area



Peak-Hour Traffic Volumes

Motor vehicle turning movement counts were collected at each of the 29 intersections flagged as safety focus areas during the weekday evening peak period (4:00 p.m. to 6:00 p.m.). All traffic counts were collected in the same week. The peak hour of traffic occurs from about 4:30 p.m. to 5:30 p.m.

Average daily traffic volumes range from nearly 49,000 vehicles per day in the central study area to about 19,000 vehicles per day in the south study area. Heavy vehicle percentages vary only slightly and average around 9 percent.

Regional Travel Patterns

An analysis was performed to determine what percentage of trips using US 97 originate and terminate locally and regionally. The 2010 Bend-Redmond travel demand model was used to estimate the distribution of trips using US 97 at four locations along the corridor. Table 1 breaks down the corridor usage by trips that begin and end in Bend, trips that either begin or end in Bend, and trips that begin and end outside of Bend.

Table 1: US 97 Corridor Travel Patterns

LOCATION	BEGIN AND END IN BEND	BEGIN OR END IN BEND	BEGIN AND END OUTSIDE BEND
US 97/Bend Parkway Southbound			
South of US 20 Interchange	40%	50%	10%
South of Revere Ave Interchange	53%	38%	9%
South of Truman Ave	54%	37%	9%
South of Badger Rd	21%	60%	19%
US 97/Bend Parkway Northbound			
South of US 20 Interchange	27%	65%	8%
South of Revere Ave Interchange	55%	36%	9%
South of Truman Ave	52%	36%	12%

South of Badger Rd	21%	59%	20%

On average, 40 percent of trips on US 97 in Bend are local trips within Bend and 50 percent of trips using US 97 have either an origin or destination in Bend. On average, only 10 percent of trips on US 97 are through trips that start and end outside of Bend. Thus, vehicles on US 97 exit and enter the Parkway frequently throughout the corridor to complete local trips.

3.4 MULTIMODAL ANALYSIS

Analysis of existing multimodal conditions examined pedestrian crossings, bicycle and pedestrian spacing, bicycle facilities, and level of traffic stress (LTS) assessment for both bicyclists and pedestrians.

Pedestrian Crossings

The following four at-grade crossings of the Parkway were analyzed using the National Cooperative Highway Research Program (NCHRP) Report 562, "Improving Pedestrian Safety at Unsignalized Crossings":[6]

- Reed Lane
- Powers Road
- Badger Road
- Pinebrook Boulevard

NCHRP Report 562 grouped pedestrian crossing treatments into three categories: passive (e.g., a crosswalk); enhanced/active (vehicles are warned but not required to stop, often with a flashing yellow light), and; red signal or beacon (vehicles are required to stop, often with a red light).

The crossings at Reed Lane, Badger Road, and Pinebrook Boulevard are currently controlled by rectangular rapid flashing beacons, which are categorized as active. The crossing at Powers Road is signal-controlled and thus categorized as a signal treatment. The inputs for this analysis included major road volume, posted speed limit, crossing distance, and pedestrian volume.

The at-grade pedestrian crossings at Reed Lane, Badger Road, and Pinebrook Boulevard appear to be appropriately controlled (rectangular rapid flashing beacons) for the low measured pedestrian demand. However, if even a modest increase in pedestrian demand were realized, a higher level of protection would be warranted, such as a signal or beacon with red indication. Despite the NCHRP report recommendation, the enhanced crossing treatments may not be safe enough in the long term. Therefore, these existing pedestrian crossings should be considered as candidates for grade separation. Since one of the project goals is to "Facilitate the use of multimodal travel options," this should be considered in the future.

Bicycle and Pedestrian Spacing

An analysis of spacing between bicycle and pedestrian crossings in the project area showed that spacing distances range from 900 to 4,500 feet, with an average of 2,000 feet. Crossings in the north study area are most widely spaced. From Cooley Road to Empire Avenue, east-west access is further limited by the railroad tracks that run parallel and adjacent to the highway. Other constraints such as existing development and

[6] NCHRP Report 562: "Improving Pedestrian Safety at Unsignalized Crossings," Transportation Research Board, 2006

topography further limit east-west access along the corridor. From Butler Market Road to Murphy Road, where crossing demand is likely highest, the average distance between crossings is approximately 1,650 feet (about 1/3 mile). In urban areas, the desired spacing for pedestrian and bicycle access commonly ranges from 500 to 800 feet where practical.

Bicycle Facilities

US 97 includes a bike lane in each direction from the Murphy Road interchange to the northern urban growth boundary. The bike lanes are demarcated with standard bike lane striping (6-inch shoulder stripe plus bike symbol stencil) and colored pavement and have typical widths of 5 to 6 feet.

The north and central segments of the study corridor contain multiple interchanges. Bulb-outs with bicycle signage are used at some locations to align bicycles for optimal visibility at off-ramp crossings. Note that there are no bulb-outs at the southbound Revere Avenue, southbound/northbound Colorado Avenue, and southbound Reed Market Road off-ramps. Bicycles are required to yield to motor vehicles at all ramp crossings.

The quality of bicycle facilities was evaluated both qualitatively and quantitatively. The following field observations related to biking comfort and safety were made by a moderately experienced cyclist. Key findings for further consideration include the following:

- Bicycle ramp crossing are difficult to safely complete, especially at off-ramps where exiting vehicles can be difficult to recognize from through vehicles due to late activation of turn signals.
- For northbound cyclists, the crossing at the northbound US 20 to Sisters loop ramp has limited sight distance.
- Both the bicycle and pedestrian facilities are affected by the heavy right-turn movements at the intersection of Powers Road and the Parkway, as well as the associated jug-handle off- and on-ramps.

Based on the qualitative field observations, the cycling conditions along the US 97 study corridor could be perceived as very stressful due to the multiple ramp crossings and proximity to higher speed vehicles.

Bicycle Level of Traffic Stress Assessment

A Bicycle LTS analysis was also conducted to characterize the bicycling experience on US 97. This methodology broke road segments into four classifications for measuring the effects of traffic-based stress on bicycle riders: Lowest (LTS 1), Low (LTS 2), Medium (LTS 3), or LTS 4 (High) where LTS 1 indicates the least stressful environment and LTS 4 indicates the most stressful. The measure of traffic stress quantifies the perceived safety issue of being in close proximity to vehicles, primarily considering the physical distance to traffic and the speed of traffic. The methodology did not include explicit consideration of traffic volume because it is assumed that the stress caused by proximity is present regardless of the amount of traffic. The analysis included the mainline of the US 97 corridor as well as key crossing locations. The speed of adjacent traffic was a major factor in this analysis, so corridors with posted speeds below 35 mph tend to have more favorable ratings. Portions of US 97 currently have bike lanes, but the LTS is still very high because riders are adjacent to high-speed traffic. Physical separation between people biking and motorized traffic would be required to make US 97 a comfortable place to ride a bike.

The Bicycle LTS analysis also considered the difficulty of crossing streets (at intersections between collectors and arterials only). The crossing criteria included a number of motor vehicle travel lanes and speed of motorized traffic. The intersections identified as having a medium level (highest identified) of stress for bicyclists are located at unsignalized intersections. These intersections include the following:

- 3rd Street and US 97 northbound ramp terminal
- Reed Market Road and US 97 northbound ramp terminal
- Baker Road and US 97 southbound ramp terminal

Pedestrian Level of Traffic Stress Assessment

A Pedestrian LTS assessment was completed for the US 97 mainline and key crossing locations to characterize the quality of the pedestrian environment. The LTS experienced by pedestrians was assessed by considering various roadway characteristics and applying a context-based, subjective stress rating of Lowest (LTS 1), Low (LTS 2), Medium (LTS 3), or High (LTS 4) where LTS 1 indicates the least stressful environment and LTS 4 indicates the most stressful. The assessment methodology followed guidelines set forth by ODOT.

Roadway characteristics that were considered to affect the comfort and safety of pedestrian travel included the presence and width of buffers from traffic (landscaped or others), the condition and width of sidewalks or paths, lighting, number of travel lanes, and the speed of motorized traffic.

The entire corridor was rated Medium (LTS 3) to High (LTS 4). High stress environments are present where no sidewalks exist or where sidewalks are curb-tight with no buffer from high-speed traffic. Where planter strips were present, the pedestrian stress was reduced to Medium (LTS 3) because of the added buffer the planter strips provide separating people walking from motor vehicles.

The Pedestrian LTS analysis also considered the difficulty of crossing streets (at intersections between collectors and arterials only). Crossing characteristics that affect the comfort and safety of pedestrian travel include the presence of a median (at least 6 feet wide), minimal Americans with Disabilities Act features, lighting, pavement markings, number of travel lanes, motor vehicle volume and the speed of motorized traffic. Unsignalized crossings of higher speed roadways (45 mph or greater) resulted in the LTS 4 (High). These include the following:

- Empire Avenue and US 97 southbound ramp terminal
- 3rd Street and US 97 northbound ramp terminal
- Baker Road and US 97 southbound ramp terminal
- Knott Road and US 97 northbound ramp terminal

3.5 SAFETY ANALYSIS

Analysis of existing safety conditions utilized crash calendars and patterns, crash-rate analysis, geometric safety risk assessment, pedestrian and bicycle safety risk assessment, and a predictive method.

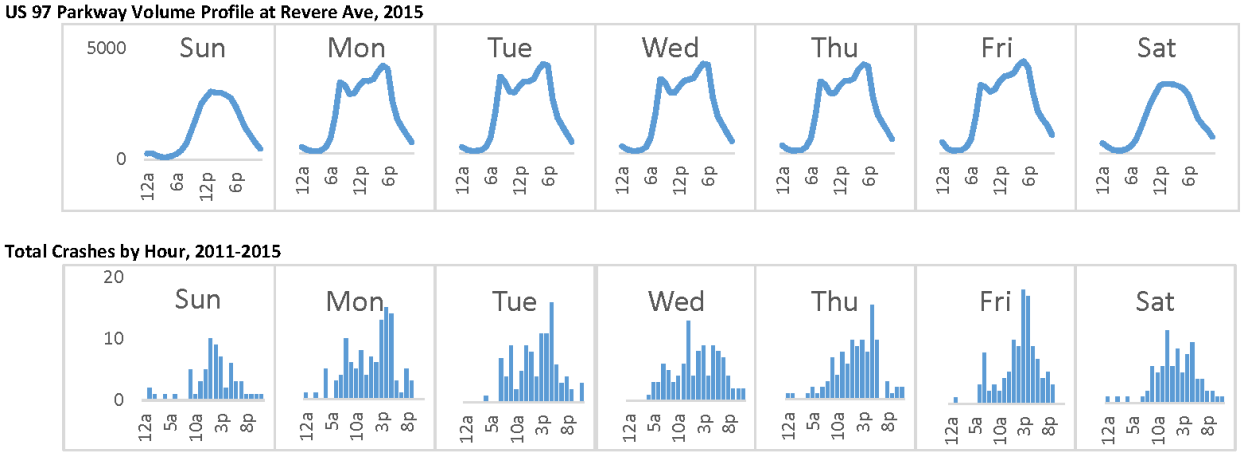
Crash data from 2011 to 2015 was obtained from ODOT's Crash Analysis and Reporting Unit for study segments and intersections and was supplemented by crash data from the City of Bend. Details on location,

crash type, severity, and other crash characteristics were used to identify crash patterns. Critical crash rates were calculated and used to flag intersections and segments along the corridor as safety focus locations.

Crash Calendar and Patterns

Crash calendars were developed to illustrate the pattern of crashes from 2011 to 2015, by month, day, and periods within each day. Figure 4 shows these trends for total crashes. Two other calendars (not shown here) display these trends for severity of crashes and for road conditions and selected causes, respectively.

Figure 4: Crash Calendar – Total Crashes



Total Crashes

	Total	Sun				Mon				Tue				Wed				Thu				Fri				Sat			
		12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	689	4	10	39	10	7	36	59	12	1	27	59	18	4	27	47	25	5	25	59	18	1	22	68	19	3	20	50	14
Jan	43	1	1				2	3	2		2	2	2		3	4	2	1	1	7	1			2				6	1
Feb	49			4		2	2	3	1		1	1		1	8	2	1		1	1	1		1	8	2		3	5	1
Mar	44			3	3	1	4	6			2	2			2	2	5	2		3			1	3	1	1	2	1	
Apr	37						3	1	1		2	6	1			5	1		1	3	1		3	4	3			2	
May	58		1	4	1	1	2	8			2	7	1		2	4	3			10	3		3	1				4	1
Jun	66	1	3	3	2	2	7	5			4	5	2	1		3	3		2	6	1		2	6	1			5	2
Jul	47	1		1	1		3	7			1	5	2			5	3		5	2	2		2	5		1		1	
Aug	61		1	6			3	8	2		4	3			3	4	2		2	5	2		2	4	3		1	3	3
Sep	58		2				5	3	2			7	1		3	4	1	1	3	5	3		1	8	3		1	4	1
Oct	55		1	2			2	5	1		1	3			1	5	1		2	3	3		5	6	2		2	8	2
Nov	98	1		8	2	1		8	1	1	5	8	5	1	1	6	2		5	11	1		2	15	3	1	8	1	1
Dec	73		1	8	1		3	2	2		3	10	4	1	4	3	1	1	3	3		1		6	1		3	10	2

The crash calendar for total crashes shows that most crashes occur in the 12:00 p.m. to 6:00 p.m. period, which corresponds with the peak on the corridor volume histogram. Weekdays experience more crashes than weekend days and the months of November and December experience significantly more crashes than the other months.

Overall, approximately 58 percent of all crashes result in only property damage. Fridays have the greatest number of property damage crashes, while midweek days like Monday, Tuesday, and Thursday tend to have higher numbers of crashes that result in injuries.

Per the crash calendar, most crashes for a road condition of either wet, snow, or ice occur in the months of November, December, and February. These road condition crashes account for half of the total crashes during those months.

Crashes with speed as a contributing cause most often occur in the winter months of February, November, and December. This could indicate motorists driving too fast for conditions when the road is wet, snowy, or icy. Conversely, the compliance-related crashes (failing to yield, disregarding traffic signal, passing stop sign) are more spread out throughout the year and have their highest occurrence during summer months of June and August, when the population may have a higher percentage of visitors unfamiliar with the roadways.

Over the study period of 2011-2015 there were two fatal crashes, five severe injury (level 'A') crashes, four bicycle-involved crashes, and two pedestrian-involved crashes. There were 27 animal-related crashes and 26 alcohol-involved crashes out of a total of 689 crashes over the five-year period.

Crash-Rate Analysis

Crash-rate analysis was conducted for each study intersection and segment along the US 97 study corridor and compared against respective statewide rates. Intersections and segments were flagged as safety focus locations if observed crash rates surpassed the accepted rates described below.

Intersection Crash-Rate Analysis

The observed crash rate for intersections is a function of the number of crashes and the annual average daily traffic (AADT). Each intersection was grouped into a reference population based on intersection control and urban or rural area classification. The crash rates (per million entering vehicles) for each intersection were compared to two different standards:

- **Critical crash rate** compares performance to other similar intersections being studied.
- **90th percentile crash rate** is based on similar intersections throughout the state.

Five intersections that had observed crash rates greater than either the critical or 90th percentile crash rate were flagged as safety focus areas for further consideration.

The intersections at US 20/Butler Market Road and Bend Parkway northbound ramps/Revere Avenue had crash rates only slightly greater than the critical crash rate, but still lower than the 90th percentile crash rate. In contrast, the intersections at Bend Parkway northbound ramps/Reed Market Road, Bend Parkway/Pinebrook Boulevard, and US 97 southbound ramps/Baker Road had crash rates much greater than the critical and 90th percentile crash rates. The intersection of Bend Parkway/Pinebrook Boulevard was reconstructed to an unsignalized intersection allowing only right-in/right-out turning movements, which may have mitigated the high crash rate. Although it was not flagged as a safety focus area, the intersection of US 97 northbound ramps and Knott Road has a guardrail that drivers hit frequently while making a left turn onto the northbound ramp, possibly due to a tight turning radius.

The excess proportion of specific crash types analysis examined the proportion of crash types (i.e., rear-end, backing, angle, etc.) to determine if certain types of crashes are more prevalent at each intersection than should be expected. Crash types with a crash rate at least 10 percent higher than the reference population

were flagged as safety focus areas. Sixteen of the 29 study intersections were flagged, with rear-end and turning crashes as the most commonly overrepresented crash types at study intersections

The Safety Priority Index System (SPIS) is a method developed by ODOT for identifying potential safety problems on state highways. This method considers the rate, frequency, and severity of crashes to produce a rating, with the highest rated sites statewide being considered for potential safety improvements. The 2015 SPIS ratings for US 97 were obtained from ODOT to screen for locations with SPIS ratings among the state's top 10 percent. Three study intersections on US 97 that had already been flagged in previously mentioned analysis were flagged again. In total, 19 of the 29 study intersections were flagged as safety focus locations, including the three top 10 percent SPIS sites at Cooley Road, Powers Road, and Pinebrook Boulevard (may have been recently mitigated). Table 2 shows which study intersections were flagged as safety focus areas and why.

Segment Crash-Rate Analysis

In addition to individual intersections, crash rates for segments of the US 97 study corridor were analyzed to identify potential problem areas of the corridor. Along the study corridor, 13 segments and their crash rates were obtained from the 2014 ODOT Crash Book. The average crash-rate experience between 2010 and 2014 was compared against the statewide average.

Two segments were flagged as safety focus areas for having five-year average observed crash rates that exceeded the statewide average rate. These were City Limits to Robal Road and Powers Road to 3rd Street (now replaced by the Murphy Road interchange). It should be noted that both segments have at-grade signalized intersections. A region-wide safety assessment was recently completed for the ODOT All Roads Transportation Safety Program, which does not identify the US 97 study corridor as being among the top safety concerns in Region 4 taken as a whole.

Crash maps were developed to show observed segment crash rates compared to statewide average crash rates. Figure 5, Figure 6, and Figure 7 presents these maps. They also identify clusters of study intersections (shown as "areas"), for which more detailed crash maps are provided in Technical Memorandum #2, Existing Conditions These detailed maps show the number of crashes by severity and crash type trends for each intersection, and whether the intersection is flagged as a safety focus area.

Bicycle and Pedestrian-Involved Crashes

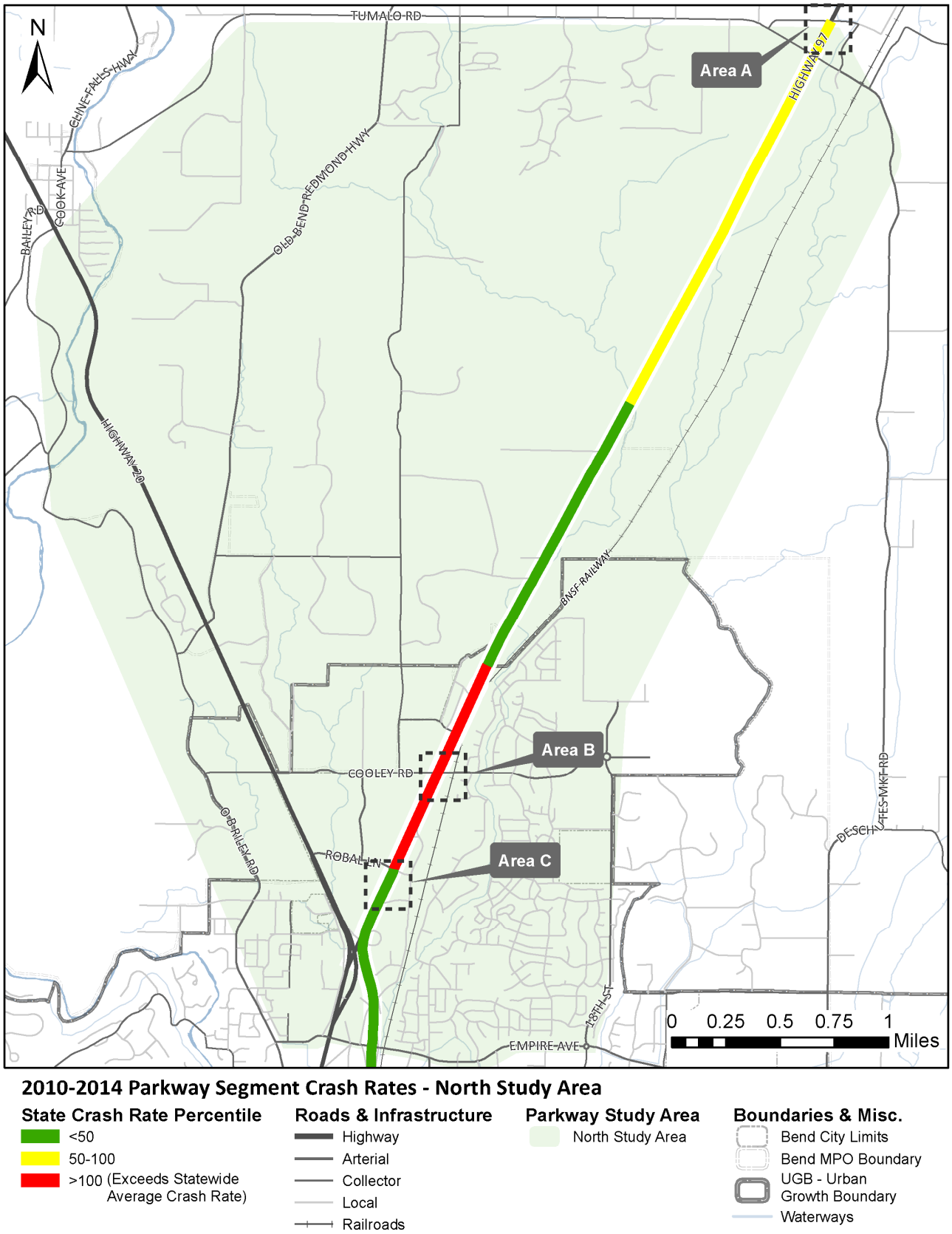
Bicycle- and pedestrian-involved crashes along the corridor were mapped. Four crashes involved people on bicycles and two crashes involved people walking. Pedestrian-involved crashes included one major injury on US 97 just outside the northern city limits and one fatality at the intersection of Bend Parkway southbound on-ramp/Division Street and 3rd Street. The severity of crashes involving people on bicycles ranged from minor to major injury, with two crashes occurring at intersections in the central study area and two occurring along US 97 in the south study area. Three of the bicycle and pedestrian crashes occurred when it was dark and visibility was low. Only one crash occurred during cloudy weather, which indicates that weather generally was not a significant factor in these crashes.

Table 2: Study Intersections and those Flagged as Safety Focus Areas

INT. NO.	INTERSECTION NAME	REASON INTERSECTION WAS FLAGGED AS SAFETY FOCUS AREA			
		High Intersection Crash Rate	Overrepresentation of a Crash Type	Top 10% SPIS Site	High Segment Crash Rate
1	US 97 and Tumalo Pl	Not Flagged			
2	US 97 and Cooley Rd		Rear-end	x	x
3	US 97 and Robal Rd		Rear-end		x
4	US 97 and Nels Anderson Pl		Rear-end		
5	Bend Pkwy SB On-Ramp and Empire Ave		Turn		
6	Bend Pkwy NB Ramps and Empire Ave	Not Flagged			
7	US 20 and Empire Ave	Not Flagged			
8	US 20 and Butler Market Rd	X			
9	Bend Pkwy SB Off-Ramp and Butler Market Rd		Turn		
10	Bend Pkwy NB On-Ramp and Butler Market Rd	Not Flagged			
11	Bend Pkwy SB On-Ramp/Division St and 3rd St	Not Flagged			
12	Bend Pkwy SB Ramps and Revere Ave		Turn		
13	Bend Pkwy NB Ramps and Revere Ave	X	Turn		
14	Bend Pkwy and Lafayette Ave		Rear-end		
15	Bend Pkwy and Hawthorne Ave		Rear-end		
16	Bend Pkwy SB Ramps and Colorado Ave		Angle and Turn		
18	Bend Pkwy and Truman Ave	Not Flagged			
19	Bend Pkwy SB Ramps and Reed Market Rd	Not Flagged			
20	Bend Pkwy NB Ramps and Reed Market Rd	X	Angle and Turn		
21	Bend Pkwy and Reed Ln	Not Flagged			
22	Bend Pkwy SB Ramps and Powers Rd		Rear-end		x
23	Bend Pkwy and Powers Rd		Rear-end	x	x
24	Bend Pkwy NB Ramps and Powers Rd		Turn		x
25	Bend Pkwy and Badger Rd		Rear-end		x
26	Bend Pkwy and Pinebrook Blvd[7]	X		x	x
27	US 97 and Ponderosa St		SS-O		
28	US 97 SB Ramps and Baker Rd	X			
29	US 97 NB Ramps and Knott Rd	Not Flagged			

[7] In 2015, this intersection was reconstructed to allow only right-in and right-out turning movements, which may have mitigated the high crash rate.

Figure 5: 2010-2014 Parkway Segment Crash Rates – North Study Area



2010-2014 Parkway Segment Crash Rates - North Study Area

State Crash Rate Percentile
- <50
- 50-100
- >100 (Exceeds Statewide Average Crash Rate)

Roads & Infrastructure
- Highway
- Arterial
- Collector
- Local
- Railroads

Parkway Study Area
- North Study Area

Boundaries & Misc.
- Bend City Limits
- Bend MPO Boundary
- UGB - Urban Growth Boundary
- Waterways

Figure 6: 2010-2014 Parkway Segment Crash Rates – Central Study Area

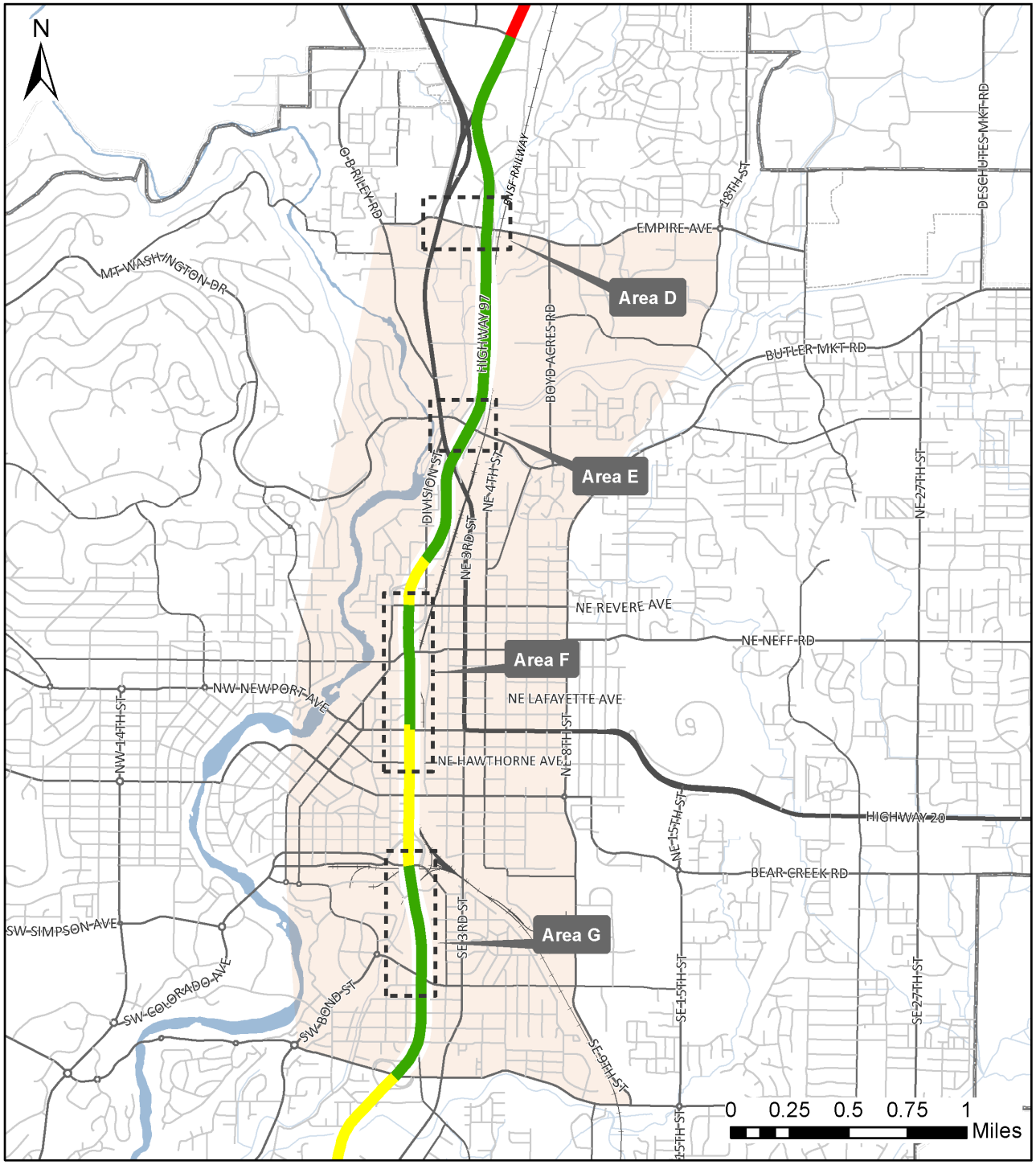
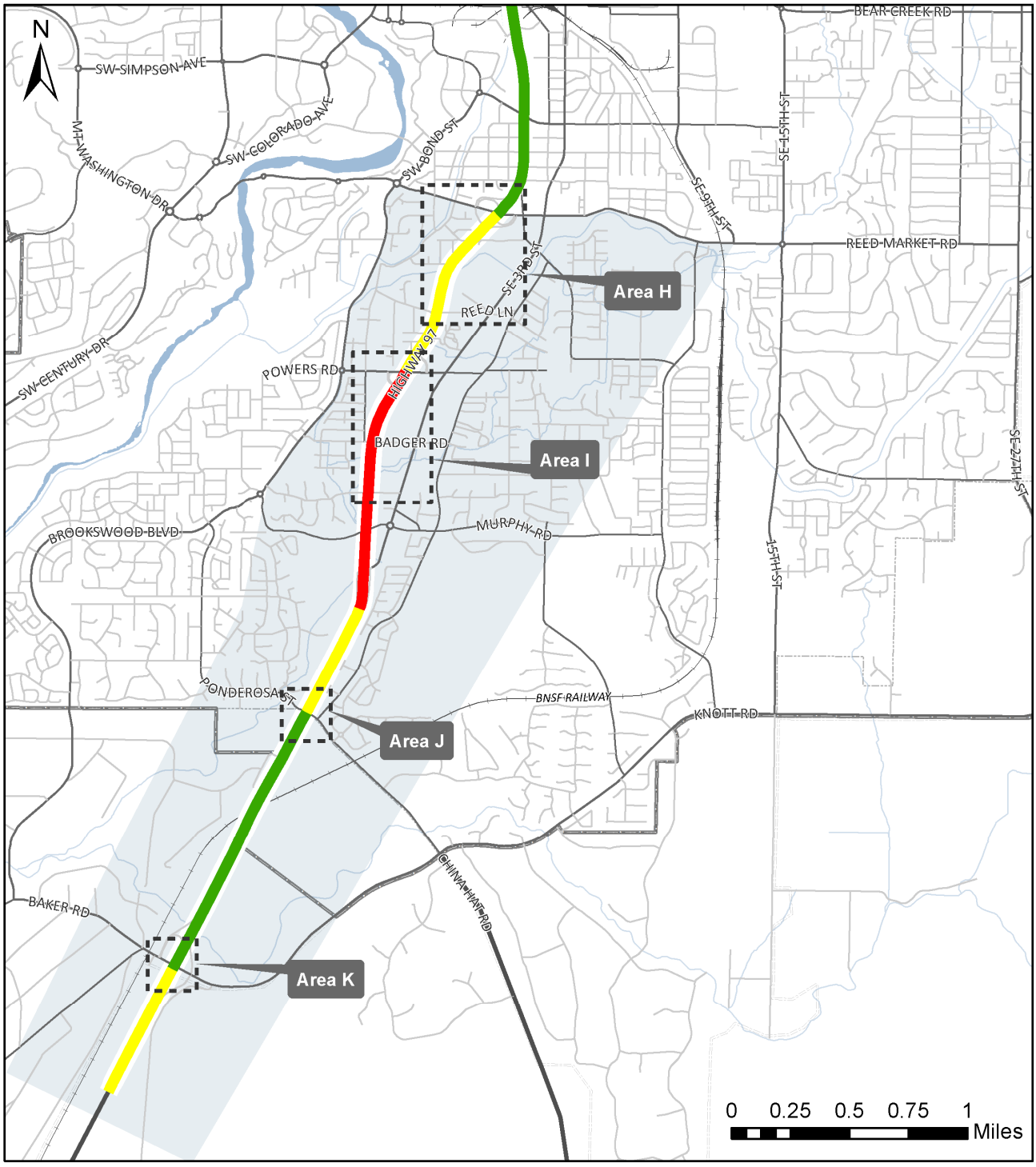


Figure 7: 2010-2014 Parkway Segment Crash Rates – South Study Area



2010-2014 Parkway Segment Crash Rates - South Study Area

State Crash Rate Percentile
- <50
- 50-100
- >100 (Exceeds Statewide Average Crash Rate)

Roads & Infrastructure
- Highway
- Arterial
- Collector
- Local
- Railroads

Parkway Study Area
- South Study Area

Boundaries & Misc.
- Bend City Limits
- Bend MPO Boundary
- UGB - Urban Growth Boundary
- Waterways

Geometric Safety Risk Assessment

Locations along the limited access Parkway segment of the corridor (US 20 to Murphy Road) were identified where geometric conditions may represent safety risks due to limited lengths of acceleration or deceleration lanes, which can affect the ability to safely enter or exit the highway. The identification of locations with higher risk factors included a comparison of existing conditions to ODOT's design standards. The existing lane lengths were compiled based on measurements from aerial photographs and were rounded to the nearest 25 feet.

Of the four locations where existing deceleration lane lengths are shorter than the standard at the posted travel speed, two include the at-grade intersections with Powers Road. The at-grade intersections of southbound US 97 to Lafayette Avenue and southbound US 97 to Hawthorne Avenue have deceleration lane lengths that are sufficient at 45 mph, but not for 55 mph. The at-grade intersections of southbound US 97 to Truman Avenue, southbound US 97 to Badger Road, northbound US 97 to Badger Road, and northbound US 97 to Reed Lane do not have deceleration lanes.

Acceleration lanes are not frequently constructed for at-grade intersections and ODOT design standards are not available for design speeds less than 50 mph. However, the difficulty of getting up to mainline speeds and safely merging from at-grade intersections on the Parkway is a commonly expressed concern. Therefore, existing at-grade intersections on the Parkway were compared against design standards for acceleration lane lengths to show how long acceleration lanes should be if provided. If acceleration lanes were provided at at-grade intersections to help merging traffic get up to speed, lengths up to 960 feet would be desired. Most interchanges have adequate acceleration lane lengths with the exceptions of northbound US 97 at Division Street, Colorado Avenue, and Revere Avenue.

Pedestrian and Bicycle Safety Risk Assessment

Locations along the corridor were identified where geometric conditions may represent safety risks to people walking and biking. These locations include areas where people walking and biking experience high exposure to high-speed traffic.

Most of the corridor was rated as having high exposure for pedestrians due to lack of sidewalks or other pedestrian facilities. Short segments of southbound US 97 that have sidewalks are in the vicinity of Nels Anderson Place, Revere Avenue, Wilson Avenue, and Pinebrook Boulevard. Both sides of US 97 have sidewalks from around Reed Market Road to Pinebrook Boulevard.

Bicycle high exposure locations include locations where bicycle facilities are not physically separated from motor vehicle traffic or are not present at all. Except for a small segment of a separated shared-use path on southbound US 97 from Murphy Road to Romaine Village Way, the entire US 97 corridor is rated as high exposure for people riding bicycles due to the lack of separated facilities on this high-speed facility.

Predictive Method

A Highway Safety Manual (HSM) predictive analysis was performed to determine a baseline collision rate for comparison with future safety improvement alternatives. This predictive method was used again in future conditions analysis to establish a 2040 baseline from which to compare the effectiveness of alternatives.

3.6 CORRIDOR OPERATIONS ANALYSIS

The corridor operations analysis examined the efficiency of travel under existing (2017) conditions by identifying locations of congestion and using crowdsourced speed data to describe the variability in travel times.

Field observations were performed in April 2017 in conjunction with the count data collection. During field observations, capacity issues were noted mainly at the Cooley Road and Robal Road intersections. Most of the unsignalized intersections also had some queuing issues, and aggressive driver behavior. Southbound queues at US 97/Robal Road extend through Cooley Road during the PM peak hour, and both the Cooley Road and Robal Road intersections appear to operate at or near capacity. Southbound traffic at the US 97 southbound on-ramp/Division Street and 3rd Street intersection also queues significantly, affecting upstream queues at the Mt. Washington and O.B. Riley intersections.

Recent improvements to the Murphy Road interchange removed one of the southbound to eastbound movements from the Parkway, which may have increased the southbound jug-handle volume at the Powers Road intersection. During the PM peak hour, the southbound jug-handle movement was observed to queue back around the loop ramp and occasionally back up the Parkway to Powers Road. Southbound traffic on the Parkway would then queue back to near Reed Lane. This issue was exacerbated by detrimental weather conditions (hail) during the PM peak-hour field observations, indicating sensitivity of traffic operations on the Parkway to changes in weather.

Intersection Operations Analysis

Analysis of intersection traffic operations was conducted at all study intersections using the seasonally factored 30 HV traffic volumes for the year 2017. Performance measures used for this analysis included volume-to-capacity (V/C) ratio, seconds of control delay, level-of-service (LOS), and 95th Percentile Queue lengths.

A significant amount of congestion at study intersections occurs during the PM peak hour, with 8 of the 17 unsignalized intersections and 8 of the 11 signalized intersections on the US 97 corridor failing to meet adopted mobility targets (i.e., a V/C ratio greater than 0.85). Of the intersections paralleling the corridor, 4 of the 11 unsignalized intersections and 1 of the 5 signalized intersections also fail to meet adopted mobility targets.

Northern Subarea Refined Operations Analysis

To better analyze the operational performance of the intersections on US 97 north of US 20, a SimTraffic model was developed for a select portion of the project area centering around the Cooley Road and Robal Road area on US 97. Queuing results at three locations informed operations analysis:

- **US 97 and Cooley Road** - Under peak summer conditions the intersection operates near capacity and fails to achieve the ODOT mobility target. Operations at this intersection are heavily influenced by commuter and recreational travel between Bend and Redmond. Queuing issues were observed for the southbound, eastbound, and westbound approaches.

- **US 97 and Robal Road** - Capacity deficiencies were found, with southbound queues sometimes extending to Cooley Road and northbound queues extending south of the US 20 interchange. The northbound left-turn movement exceeds storage capacity.
- **US 97 and Nels Anderson Place** operates at capacity during the PM peak hour. Queue storage is an issue for eastbound right traffic attempting to turn onto southbound US 97.

US 97/Bend Parkway Refined Intersection Operations Analysis

To better analyze the operational performance of the US 97 corridor, including the origin-destination interactions between regional and local trips, a Vissim microsimulation model was developed for US 97 and several intersections on parallel local facilities. Key US 97 findings from the model include the following:

- Both the Division Street and Butler Market Road intersections with US 20 (3rd Street) fail to meet mobility targets. Simulation analysis shows queuing issues at these locations:
  - Southbound through and on-ramp movements at US 20/Division Street/US 97 southbound on-ramp
  - Westbound left and through movements at US 20/Butler Market Road
  - Eastbound right turn at US 20/Butler Market Road
- At US 97 northbound and southbound ramps and Colorado Avenue the conflict between the high-demand unsignalized eastbound left turn from Colorado Avenue and the westbound right-turn and through movements on Colorado Avenue causes queuing issues that extend nearly half a mile on Colorado Avenue.
- The high volumes at the US 97 southbound ramps and Reed Market Road intersection result in southbound right turns spilling back into the mainline ramp. However, the back of the ramp queue remains more than a safe stopping distance from the gore point of the off-ramp.
- The high volumes at the US 97 northbound ramps and Reed Market Road intersection result in northbound right-turn vehicles spilling back into the safe sight distance part of the ramp gore.
- The eastbound queue spillback at US 97 and Powers Road extends west, blocking through the US 97 southbound off-ramp onto Powers Road.
- US 97 and Baker Road/Knott Road ramp terminals and US 97 at Truman, Lafayette, and Hawthorne all experience aggressive driver gap selection behavior, which minimizes the queue spillback impacts and keeps the queues within storage areas. However, aggressive gap selection is also a sign of drivers accepting a greater crash risk.

Parallel route intersection operations findings include the following:

- 4th Avenue and Butler Market Road experiences significant westbound queues, indicating that the intersection is operating at or near capacity.
- 4th Avenue and Revere Avenue operates near capacity, with queue storage deficiencies at southbound right, eastbound through, and westbound left-turn movements.

- The Brookswood Road/Bond Street/Reed Market Road roundabout appeared to be operating at capacity under average weekday conditions but operates at capacity under peak summer conditions. The two critical movements are eastbound and southbound.
- 3rd Street and Reed Market Road experiences heavy east-west traffic during the PM peak, with Reed Market Road serving as one of the primary east-west connections across the city. The most significant queuing issues are for the northbound left and through, southbound left, and eastbound through movements.
- The Brookswood Boulevard and Powers Road roundabout experiences some brief but heavy queuing on the southbound approach during the peak 15 minutes of the peak hour but operates well below capacity for the remainder of the PM peak hour.

Parkway Merging/Diverging Operations Analysis

Operations analysis was performed for select interchange ramp merging, diverging, and weaving segments on the Parkway using Highway Capacity Manual methodologies. The select segments included the following:

- Revere-Butler Market-Empire-Sister's loop ramp in the northbound direction
- Southbound Division on-ramp and southbound Revere off-ramp in the southbound direction
- Eastbound Reed Market to the northbound US 97 on-ramp and westbound Reed Market to northbound US 97 in the northbound direction
- Revere to Colorado in both directions

Congestion in the southbound direction is more prevalent during the PM peak hour, with all analysis locations failing to meet the mobility target. Congestion in the northbound direction steadily increased from Reed Market Road to Revere Avenue, with performance failing to meet the mobility target from 3rd Street to Empire Avenue. Field observations were also performed.

Travel Time Reliability Analysis

Travel time reliability analysis was performed using the most recent three years of available HERE data, which included crowdsourced travel time information from mobile devices on a selected corridor. A planning time index was used for the study segments along the US 97 and US 20/US 97 Business/SE 3rd Street. The planning time index represents the total travel time that should be planned for, including both typical and unexpected delays. Findings include the following

- There is poor travel time reliability (i.e., travel times vary and can be difficult to predict) on US 97 near Cooley Road/Robal Road and near Powers Road.
- The AM and PM peak hours tend to have less reliable travel times, especially in the north study area.
- Even during the peak hours, travel time reliability remains relatively good in the central study area.

Travel Time Correlation Analysis

Travel time data used in the travel time reliability analysis was compared with historic collision, incident, and weather data to identify correlations between those occurrences and impacts to travel time reliability. The

study period used for this analysis was the weekday PM peak hour (4:30-5:30 p.m.) for May 2015 to April 2017. Travel times were flagged if an incident occurred along the US 97 corridor in the study period. These incident-related travel times were averaged by segment for comparison with the baseline average travel time. For the collision data comparison, a similar procedure was used to flag collision-related travel times along the corridor during the study period. For the weather data comparison, daily precipitation totals were used as an indicator of poor weather that could affect travel times. A travel time was considered weather-related if the daily precipitation totaled 0.1 inch or greater. Average travel times related to collision, incident, and weather-related factors are summarized along with the baseline travel times by segment in Table 3, with travel times exceeding the baseline shown in red.

Table 3: Average Travel Time Comparison

SEGMENT	FROM	TO	AVERAGE TRAVEL TIME (MIN)			
			Baseline	Incident	Collision	Weather
US 97/Bend Parkway Southbound						
S2	Clausen Rd	US 20 Interchange	2.58	**2.94**	**2.82**	2.53
S3	US 20 Interchange	SE 3rd St Interchange	1.92	**2.02**	1.91	1.91
S5	SE 3rd St Interchange	Colorado Ave	2.4	**2.84**	**2.43**	**2.45**
S7	Colorado Ave	Reed Market Rd	1.26	**1.35**	**1.3**	**1.33**
S9	Reed Market Rd	Murphy Rd Interchange	2.79	2.75	**2.93**	2.71
S11	Murphy Rd Interchange	China Hat Rd	0.96	**1**	**1.04**	0.95
US 97/Bend Parkway Northbound						
N11	China Hat Rd	Murphy Rd Interchange	0.96	0.95	**0.98**	0.94
N9	Murphy Rd Interchange	Reed Market Rd	2.5	**2.51**	**2.61**	2.48
N7	Reed Market Rd	Colorado Ave	1.18	**1.34**	**1.21**	**1.23**
N5	Colorado Ave	SE 3rd St Interchange	2.31	**3.03**	**2.91**	**2.91**
N3	SE 3rd St Interchange	US 20 Interchange	2	**2.58**	**2.75**	**2.38**
N2	US 20 Interchange	Clausen Rd	3.15	**4.07**	**4**	**4.15**

The comparison above indicates a strong correlation between incidents or collisions and an increased travel time average. Most of the corridor shows a higher average travel time compared to the baseline when an incident or collision occurs in the PM peak hour. The weather data comparison was less conclusive, as only half of segments show higher travel times when precipitation was recorded on that day. Further investigation into specific precipitation types (such as snow, rain, or ice) is needed to determine if any strong correlations exist between weather patterns and travel time reliability.

4.0 FUTURE CONDITIONS

Technical Memorandum #4[8] describes the "No-Build" transportation conditions in the year 2040. It applies many of the same analysis methods used to describe existing conditions in Technical Memorandum #2 to the traffic volumes for the year 2040 in Technical Memorandum #3.[9]

[8] US 97 Parkway Plan Phase 2: Technical Memorandum #4, Future Conditions, November 9, 2018
[9] US 97 Parkway Plan Phase 2: Technical Memorandum #3. Future Traffic Forecast, October 30, 2018

4.1 FUTURE TRAFFIC FORECAST – BEND-REDMOND TRAVEL DEMAND MODEL

The Oregon Department of Transportation (ODOT) developed and maintains a travel demand model that estimates daily and PM peak-hour demand for the existing year (2010) and future year (2040) transportation system. The travel demand model includes the surrounding communities of Bend and Redmond and is called the Bend-Redmond Model (BRM). Two key structures help estimate future traffic: transportation analysis zones and a network of links, which includes projects from the Bend MTP and Bend Urban Growth Boundary expansion. Future traffic forecasting is detailed in Technical Memorandum #3.

Projected Land Use Changes and Growth

Projected land uses were developed for the model area with the general development patterns based on the Comprehensive Plan designations for Bend. The projected household and employment growth between 2010 and 2040 within the Bend Metropolitan Planning Office (MPO) area was incorporated into the forecast. Note that this growth is identical to the growth assumed for the Bend MTP/TSP update that was adopted in fall 2020.

Post Processing and Model Application

Model application and methodology for post-processing model outputs is discussed in Technical Memorandum #3. Key findings from application of the Bend-Redmond Travel Demand Model include the following:

- The regional travel demand model indicates high growth throughout the project limits, with especially high growth at the north and south ends of the analysis area.
- High-level travel demand model analysis indicates that the 2040 travel demand on US 97 will exceed the peak-hour capacity, while all major east-west connections within the project limits will also operate near or over capacity.
- Daily demand to peak-hour capacity analysis indicates likely trip diversion due to congestion on US 97, Empire Avenue, and Reed Market Road.
- Travel pattern analysis using the Bend-Redmond travel demand model shows that on average 43 percent of trips on US 97 in Bend in 2040 are local trips (begin and end in Bend) within the city and another 47 percent of trips using US 97 have either an origin or destination in Bend. This is generally consistent with findings for existing conditions, except for the segment south of Badger Road where the percentage of local trips on US 97 increases dramatically (21 to 41 percent) due to future growth in the southeast UGB expansion area. On average, only 10 percent of trips on US 97 are through trips, meaning they start and end outside of Bend.

4.2 FUTURE TRANSPORTATION NETWORK

The 2040 No-Build transportation network includes several planned improvement projects within and surrounding the study area. These projects were taken from recent planning studies and combined to create a “Financially Constrained” transportation network, which will be the baseline from which to compare improvement alternatives.

4.3 MULTIMODAL ANALYSIS

Future multimodal analysis methods, detailed in Technical Memorandum #4, were consistent with those performed for the existing conditions analysis for ease of comparison.

Bicycle Level of Stress Assessment

In the future 2040 No-Build scenario, the only planned improvement that would significantly change the Bicycle LTS findings from existing conditions is the new traffic signal on Empire Avenue at the US 97 southbound ramp terminal. Signalization of Empire Avenue at the US 97 southbound ramp terminal would improve the estimated LTS at this location from Low (LTS 2) to Lowest (LTS 1).

There are no physically separate bicycle facilities planned for the US 97 mainline and travel speeds are assumed to remain high. Therefore, the mainline Bicycle LTS will continue to be High (LTS 4).

Pedestrian Level of Stress Assessment

As with the Bicycle LTS analysis, the only planned improvement by 2040 is the new traffic signal on Empire Avenue at the US 97 southbound ramp terminal. This crossing was rated as having a High LTS (LTS 4) under existing conditions but improves to a Low LTS (LTS 1) with signalized control. The other three intersections found to have a High LTS (LTS 4) under existing conditions will continue to have High LTS (LTS 4) under the 2040 No-Build condition:

- 3rd Street / US 97 northbound ramp
- Baker Road / US 97 southbound ramps
- Knott Road / US 97 northbound ramps

Additionally, the Pedestrian LTS worsens from Medium (LTS 3) to High (LTS 4) at the intersection of Colorado Avenue/US 97 northbound ramps due to an increase in traffic volumes at this unsignalized crossing.

Under existing conditions, the US 97 mainline was categorized as a Medium (LTS 3) to High (LTS 4) stress pedestrian environment. There are no planned improvements along the US 97 mainline that would lessen levels of traffic stress experienced by people walking and the Pedestrian LTS analysis methodology for street segments is unaffected by traffic volume. Therefore, the 2040 No-Build assessment of Pedestrian LTS on the US 97 mainline is unchanged from existing conditions.

Pedestrian and Bicycle Crossing Improvement Priorities

A separate Bicycle and Pedestrian Working Group comprising ODOT and City of Bend staff provided supplemental analysis focused on the need for more high-quality crossing opportunities along US 97 for people walking and biking. This analysis included factors such as the current quality of crossings, distance between crossing opportunities, potential demand resulting from adjacent land uses, crash history, and alignment with Bend's low-stress network.

Locations for enhancements to existing crossings and addition of new crossings were categorized into two tier levels: Tier 1 locations were considered higher priority and Tier 2 projects, while still important, were considered lower priority. All new crossings were assumed to be grade-separated (i.e., they would cross over or under US 97).

The analysis identified a number of strategic locations for improvements that would provide low-stress crossings in the corridor at an average spacing of less than ½-mile. The proposed investments in existing and new pedestrian and bicycle crossing improvements at the time of the future conditions analysis would result in the low-stress crossing spacing detailed in Table 4.

Table 4: Pedestrian and Bicycle Low-Stress Crossing Spacing on US 97 Resulting from Investments in Existing and New Crossing Improvements*

STUDY AREA	CROSS STREET 1	CROSS STREET 2	DISTANCE (FT)	DISTANCE (MI)
North	Cooley Rd	Robal Rd	2,620	0.50
	Robal Rd	Empire Ave	4,545	0.86
Central	Empire Ave	Butler Market Rd	4,510	0.85
	Butler Market Rd	Underwood Ave	3,170	0.60
	Underwood Ave	Revere Ave	1,170	0.22
	Revere Ave	Olney Ave	1,045	0.20
	Olney Ave	Greenwood Ave	1,775	0.34
	Greenwood Ave	Hawthorne Ave	735	0.14
	Hawthorne Ave	Franklin Ave	730	0.14
	Franklin Ave	Colorado Ave	1,610	0.30
	Colorado Ave	Aune Rd	590	0.11
	Aune Rd	Wilson Ave	1,980	0.38
	Wilson Ave	Reed Market Rd	2,380	0.45
South	Reed Market Rd	Canal/ Garfield Ave	1,630	0.31
	Canal/Garfield Ave	Powers Rd	2,820	0.53
	Powers Rd	Badger Rd/Pinebrook Blvd	2,275	0.43
	Badger Rd/Pinebrook Blvd	Murphy Rd	1,480	0.28
	Murphy Rd	China Hat Rd	4,380	0.83
	China Hat Rd	Baker Rd/Knott Rd	6,410	1.21

*The crossings listed here are representative of what was considered at the time of the future conditions analysis and do not reflect final recommendations for existing and new crossing improvements.

4.4 SAFETY ANALYSIS

To establish a future 2040 baseline from which to compare the effectiveness of alternatives, the same predictive crash analysis performed under existing conditions was performed for the 2040 No-Build condition. Predictive methods were used to assess safety performance at the intersection, segment, or interchange level and are effective for a comparison of future alternatives. "Predicted" crash frequency was calculated for all locations, including those where additional geometry changes were assumed under the 2040 No-Build conditions. "Expected" crash frequency was calculated at locations where the only change under 2040 No-Build conditions is traffic volumes.[10]

Overall, about 246 crashes per year were predicted for US 97 through Bend (88 fatal or injury, 158 property damage only). Note that the expected crash frequencies for existing conditions presented in Technical

[10] At locations where the AADT volume exceeds the maximum value in the HSM Calculation spreadsheet for urban arterials, the maximum AADT value was used instead. The locations where this occurred and the actual AADT are noted in the appendix to Technical Memorandum #4, Future Conditions.

Memorandum #2, Existing Conditions, should not be compared to the 2040 No-Build predicted crashes, as they are based on different methodologies.

2040 No-Build conditions were compared back to existing conditions for some locations where only traffic volumes are assumed to change (i.e., no infrastructure improvements are made) using the "excess expected crash frequency" measure. This metric compares the difference between expected (uses historical crash data) and predicted (uses predictive model only) crash frequency for a study site under specific conditions This comparison indicates a growth in crash frequencies by 20 percent for locations where the only change between existing and future conditions is traffic volumes. The only locations to have a higher (positive) excess expected crash frequency are US 97 at Hawthorne Avenue and Lafayette Avenue.

4.5 CORRIDOR OPERATIONS ANALYSIS

The corridor operations analysis examined the efficiency of travel under 2040 No-Build conditions by identifying locations of congestion and using crowdsourced speed data to describe the variability in travel times.

Existing capacity issues were confirmed in the 2040 No-Build operations analysis. Furthermore, the forecast demand exceeds the capacity at a majority of the study intersections.

Intersection Operations Analysis

Intersection traffic operations were analyzed using the same tools and methodology applied for existing conditions. The analysis was conducted at all study intersections using the forecast seasonally factored 30 HV traffic volumes for the year 2040. At all but one of the study intersections (US 97 and Cooley Road) turn movements fail to meet mobility targets under future conditions. The only unsignalized intersections meeting mobility targets are both northbound ramp terminals at Powers Road and Butler Market Road. Off the Parkway, several key local intersections also fail to meet mobility targets.

A vehicle queuing analysis, following the ODOT APM methodology (with SimTraffic 10 and Vissim 10), was used to estimate 95th percentile queues for each dedicated turn lane at the designated study intersections in both the Vissim and SimTraffic analyses.

Northern Subarea Refined Operations Analysis

The SimTraffic model developed during the existing conditions analysis was used to measure the 95th percentile queues for the year 2025. These queuing results informed the operations analysis findings presented below:

- **US 97 and Cooley Road** - The Cooley Road Interim Improvements at US 97 identified in the 2014 MTP Update meet mobility targets through 2025 and provide sufficient capacity to serve the forecast demand through 2035. A southbound right-turn lane at the northern Cooley Road and US 97 intersection would likely allow the Interim Improvements to serve the 2040 No-Build demand.
- **US 97 and Robal Road** – This intersection provides less than 70 percent of the capacity needed to serve the 2040 No-Build demand.

- **US 97 and Nels Anderson Place** – This intersection remains over capacity in the future. The forecast demand for both the northbound left-turn and eastbound right-turn movements decreases from existing, due to the over 30 percent increase southbound through demand on US 97.

US 97/Bend Parkway Refined Intersection Operations Analysis

The Vissim model developed as part of the existing conditions analysis was updated with origin-destination (O-D) data from the 2040 No-Build BRM and volumes from the 2040 No-Build design-hour forecasts. Most of the study intersections are expected to experience demand well above their capacity under forecast 2040 No-Build design-hour conditions. Therefore, the Vissim model generated unserved demand over the 4:00 p.m. to 6:00 p.m. analysis interval. Averaged over all the model simulation runs, more than 13,000 vehicles (approximately 17 percent of the total 4:00 p.m. to 6:00 p.m. demand) were unable to enter the network. Due to the excess levels of demand in the model, it should be noted that the simulation may not be showing all the impacts on a spatial or temporal basis because conditions are worse than shown. Furthermore, when future alternatives are evaluated, capacity issues may not necessarily be resolved due to the latent demand finally being served.

Delay plots were developed, showing the relative delay throughout the model, giving an indication of the extents of queues throughout the model every 15 minutes). The data from the queue plots show the capacity breakdown of the throughout the 4:00 p.m. to 6:00 p.m. analysis.

US 97 Corridor Intersections Operations

Key findings from the operations analysis include the following:

- The US 97/Empire Avenue/US 20/3rd Street area experiences large volume growth, and the improvements for this area included in the 2014 MTP update do not provide nearly enough capacity for the forecast demand.
- The portions of the Parkway south of Empire Avenue are only able to serve approximately 83 percent of the forecast seasonal demand, based on simulation results.
- The capacity failures at the Reed Market interchange ramp terminals appear to cause the largest bottleneck in the system, generating long queues for both northbound and southbound US 97. The capacity failures at the ramp terminals are accelerated by capacity constraints at the 3rd Street and Reed Market intersection.
- The Powers Road intersection fails to provide sufficient capacity for the northbound and southbound movements on US 97.
- All right-in/right-out intersections queue extensively on the minor street approaches.

Parallel Route Intersection Operations

Based on the operations analysis from the Synchro model and the analysis results from the Vissim simulations, the following findings were made at study intersections on the parallel state and local systems:

- 4th Street and Butler Market Road – The westbound queues at this intersection extend out of the model by 4:15 p.m. and continue to build unserved demand until the end of the analysis time period.

- 3rd Street and 4th Street and Revere Avenue – Increased growth (approximately 60 percent) for eastbound Revere Avenue due to limited options for east-west travel causes queue spillback from the 4th Street intersection to create northbound and southbound queues on 3rd Street, which also experiences demand beyond the intersection's capacity. Westbound demand on Revere Avenue increases as well. The 3rd Street intersection does not provide sufficient capacity for the increased demand, leading to westbound queues that extend out of the model by 5:00 p.m.
- Brookswood Road/Bond Street/Reed Market Road – The roundabout continues to experience demand that exceeds the intersection capacity under Future No-Build conditions, with the northbound and southbound Brookswood Boulevard and Reed Market eastbound approaches queuing out of the model by 4:15 p.m.
- 3rd Street and Reed Market Road – This intersection experiences increased east-west demand, with the northbound approach queuing out of the model at 4:00 p.m., the eastbound approach queues through the US 97 ramps also by 4:00 p.m., and the southbound Reed Market approach queuing out of the model by 5:00 p.m.

Parkway Merging/Diverging Ramp Operations Analysis

Operations analysis was performed for select interchange ramp merging, diverging, and weaving segments on the Parkway using Highway Capacity Manual methodologies, consistent with the existing conditions analysis. Key findings from this analysis follow:

- Congestion at all interchange ramp merging, diverging, and weaving areas on the Parkway will worsen by 2040. In fact, 10 of the 15 mainline/ramp junctions analyzed are projected to have insufficient capacity to serve the traffic demand. This could result in more bottleneck locations on the Parkway mainline, diversion of traffic to adjacent city streets, and an increased duration of congestion.
- In the northbound direction, the stretch of interchange ramp merging and diverging areas on the Parkway mainline failing to meet the adopted mobility target will extend from the Colorado Avenue on-ramp to the Empire Avenue off-ramp.
- In the southbound direction, all analyzed interchange ramp merging and diverging areas on the Parkway mainline from Division Street to Colorado Avenue will fail to meet the adopted mobility target.

4.6 TRAVEL TIME RELIABILITY ANALYSIS

Travel time reliability analysis was performed using the HERS-ST analysis tool. Travel time reliability was analyzed by using a planning time index for the study segments along the US 97 corridor. The planning time index represents the total travel time that should be planned for, including both typical and unexpected delay.

All the segments except for one showed an increased planning time index, which indicates decreased travel time reliability. This is likely due to an increase in peak-hour congestion, which degrades the daily travel time reliability. Key locations that show significant deterioration in the future include Clausen Road to Cooley Road, Robal Road to the US 20 interchange, and Hawthorne Avenue to the Colorado Avenue interchange. These changes are due to new traffic control (at Cooley Road) and increases in demand along the corridor.

Pinebrook Boulevard to Murphy Road was the only segment to improve in reliability, due to the removal of traffic control and closure of the Pinebrook Boulevard intersection under 2040 No-Build conditions.

Average daily speed and average travel time support the travel time reliability trends and indicate an increase in congestion where speeds decrease and travel times increase. Corridor travel times on US 97 are projected to increase by as much as 25 minutes throughout the PM peak period by the year 2040. The entire corridor shows a total travel time increase of just under two minutes.

5.0 ALTERNATIVES EVALUATION

5.1 FIRST LEVEL EVALUATION

Preliminary alternatives identified for the project were described at the conceptual level in Technical Memorandum #5.[11] Alternatives were developed from plans, community feedback, the PMT, and the consultant team intended to address deficiencies in operations and safety identified in the Technical Memorandum #2, Existing Conditions, and Technical Memorandum #4, Future Conditions.

First Level Evaluation Criteria

The First Level Evaluation began the process of evaluating and screening of projects using a simple qualitative version of the project evaluation criteria. Technical Memorandum #6[12] outlines this process and provides a high-level view of each alternative type, listing source plans (if any), typical cost ranges, applicable locations, and which goals they potentially address.

Project goals, objectives and evaluation criteria are defined in the Methodology Memorandum. Many of the evaluation criteria presented in the Methodology Memorandum are quantitative and require a more detailed analysis, and were used in Second Level Evaluation instead.

Since the First Level Evaluation is qualitative, the original evaluation criteria were modified for use in a high-level qualitative screening. For example, a First Level Evaluation criteria might be “potential to reduce crashes” (qualitative) instead of the Second Level Evaluation criteria of “reduction in crash frequency” (quantitative). For comparison purposes, Table 5 presents goals and objectives alongside the First Level Evaluation criteria and Second Level Evaluation criteria.

[11] US 97 Parkway Plan Phase 2: Technical Memorandum #5, Preliminary Alternatives, February 25, 2019
[12] US 97 Parkway Plan Phase 2: Technical Memorandum #6, First Level Alternatives Evaluation, July 9, 2019

Table 5: First and Second Level Screening Evaluation Criteria

GOAL	OBJECTIVES	QUALITATIVE EVALUATION CRITERIA (FIRST LEVEL)	EVALUATION CRITERIA (SECOND LEVEL)
1. Improve safety for all modes	Reduce the frequency and severity of crashes for all modes with an emphasis on severe and fatal injuries	Potential to reduce crashes	Reduction in crash frequency (all modes)
		N/A	Reduction in crash severity (all modes)
2. Support economic development throughout the region and state	Support efficient movement of people, goods and services, and recreational traffic to, within and through the City of Bend	Ability to improve travel time reliability on US 97	Travel Time Reliability measures on the Bend Parkway (planning time index)
		N/A	Percent through traffic on congested segments (modeled demand/capacity ratio $\geq$ 1.0) of the Bend Parkway
	Develop strategies to accommodate planned growth through provision of transportation options now, and into the future	Enhances travel for multiple modes	Degree to which the alternative enhances travel for multiple modes (qualitative assessment)
3. Manage transportation mobility into the future	Evaluate the ability to achieve ODOT volume/capacity (V/C) targets and develop alternative mobility measures and targets, where appropriate	Would reduce congestion on US 97	Ability to meet ODOT v/c targets
	Assess impacts on local system	Would reduce congestion on city streets	Ability to meet Bend mobility standards (v/c ratios and LOS)
4. Consider accessibility to key destinations now and in the future	Evaluate and assess reliable travel times between key destinations during peak periods	N/A	Travel Time Reliability measures (planning time index) for specific routes during PM peak hour
5. Facilitate the use of multimodal travel options	Enhance transit, bicycle and pedestrian facilities along, parallel to, and across, US 97	Supports implementation of low-stress pedestrian and bicycle crossings of US 97	Number of bike and pedestrian crossing locations on the Bend Parkway with low Level of Traffic Stress (LTS 2 or lower)
		Supports implementation of a parallel low-stress walking and biking network along the US 97 corridor	Miles of north-south bike and pedestrian facilities with low Level of Traffic Stress within 0.25 mile of the Bend Parkway
	Look for transportation demand management opportunities	Supports travel demand management strategies (or supports the transit system)	Does the alternative allow for transportation demand management strategies?

GOAL	OBJECTIVES	QUALITATIVE EVALUATION CRITERIA (FIRST LEVEL)	EVALUATION CRITERIA (SECOND LEVEL)
6. Enhance the environment	Reduce emissions through reduction of vehicular delay, improved connections in the local system, and the use of alternative modes	N/A	Total PM peak-hour vehicle delay (vehicle hours)
		Potential to reduce vehicle miles traveled	Total PM peak-hour vehicle miles traveled (regional measure)
	Minimize right-of-way impacts	Would impact property	Approximate degree of right-of-way impacts (order of magnitude costs)
	Design projects to avoid, mitigate and minimize impacts	Would impact the environment	
7. Identify cost effective solutions	Prioritize low cost, high benefit solutions	Order of magnitude cost	Total cost
	Prioritize solutions that that leverage existing planned projects and programs	N/A	Does alternative leverage existing planned projects and programs?
8. Develop an implementation plan	Consider available funding sources and existing planned project and programs	Ability to construct in reasonably affordable phases	Can the alternative be separated into reasonably fundable and constructible phases?
	Recommend potential future funding sources	N/A	
	Include partner commitments to short-term actions	N/A	Does the alternative have local agency support?
Additional Criteria (from Scope of Work)		Can be constructed to comply with design standards (geometric feasibility)	
		Would impact freight movement	
		Substantial conflicts with ODOT, City, or County policies and regulations	

Corridor-wide projects evaluated included the following:

- Ramp meters at on-ramps throughout the corridor
- Full closure of RIRO accesses, or right-in closures with right-out modification
- On- and off-ramps improved to standard lengths and geometry
- Active transportation grade-separated crossing improvements
- Transportation systems management and operations (TSMO) projects:
  - Weather warning system
  - Variable speed signs and roadside traveler information dissemination
  - Incident management program
  - Shoulders built to standard widths
  - Enhanced traffic signal operations at ramp terminals and traveler information signing
  - Traffic signal priority for transit and freight at signalized intersections on US 97

Projects that are not corridor-wide are organized by three study areas: north, central, and south. Types of location-specific projects include auxiliary lanes, frontage roads, lane reconfigurations, roundabouts or signals, intersection and interchange improvements, and overcrossings.

Transit improvements were not proposed because, while several intercity bus routes operate on the Parkway, there is only one transit stop on the Parkway (in the north study area) and that stop will be moved to Third Street as part of the US 97 Bend North Corridor Final Environmental Impact Statement (North Corridor FEIS). Additionally, while buses will continue to operate on the Parkway, the 2040 Cascades East Transit Master Plan that is in development does not propose specific improvements to the Parkway.

Each candidate project was scored on each criterion to assess its positive, negative, or neutral impacts compared to the No-Build scenario, unless otherwise indicated. This assessment is qualitative and high level since the full impacts of each project are unknown at this point in the process. To represent this qualitative evaluation, a value of +1, 0 or -1 was applied, as appropriate. Total evaluation scores for each project are the sum of its scores for each criterion.

First Level Evaluation Conclusion

After the First Level Evaluation, the list of alternatives was narrowed and combined into two bundles of projects to be further analyzed through modeling in the Second Level Evaluation. Projects that competed or conflicted were put in separate bundles for comparison with each other. Technical Memorandum #6 summarizes the two project bundles (A and B).

5.2 SECOND LEVEL EVALUATION

Second Level Evaluation Process

The Second Level Evaluation process applied a more comprehensive assessment of the alternatives using a combination of qualitative and quantitative analysis and evaluation criteria. Technical Memorandum #7

details this process.[13] Further analysis of RIRO closure and modification projects is outlined in the RIRO Closure/Modification Alternatives Analysis, an appendix of Technical Memorandum #7.

Many of the evaluation criteria presented in the Methodology Memorandum are quantitative and required a more detailed analysis than was conducted during First Level Evaluation. Table 6 summarizes the goals, objectives and evaluation criteria applied for the Second Level Evaluation. Note that while the evaluation criteria focused mostly on Parkway performance, some network and local system measures were also considered and provided input into project implementation recommendations.

Table 6: Second Level Evaluation Criteria and Method

GOAL	OBJECTIVES	EVALUATION CRITERIA	EVALUATION METHOD
1. Improve safety for all modes	Reduce the frequency and severity of crashes for all modes with an emphasis on severe and fatal injuries	Reduction in crash frequency (all modes)	HSM Part C / TOPS BC / Crash Modification Factors (CMF)
		Reduction in crash severity (all modes)	HSM Part C / TOPS BC / CMF
2. Support economic development throughout the region and state	Support efficient movement of people, goods and services, and recreational traffic to, within and through the city of Bend	Travel Time Reliability measures on the Bend Parkway (planning time index)	HERS-ST / TOPS BC
		Percent through traffic on congested segments (modeled demand/capacity ratio $\geq$ 1.0) of the Bend Parkway	Travel Demand Model
	Develop strategies to accommodate planned growth through provision of transportation options now, and into the future	Degree to which the alternative enhances travel for multiple modes (qualitative assessment)	Qualitative Assessment
3. Manage transportation mobility into the future	Evaluate the ability to achieve ODOT volume/capacity (v/c) targets and develop alternative mobility measures and targets, where appropriate	Ability to meet ODOT v/c targets	Synchro/Vistro/ HCS Analysis
	Assess impacts on local system	Ability to meet Bend mobility standards (v/c ratios and LOS)	Synchro/Vistro
4. Consider accessibility to key destinations now and in the future	Evaluate and assess reliable travel times between key destinations during peak periods	Travel Time Reliability measures (planning time index) for specific routes during PM peak hour	HERS-ST / TOPS BC
		Peak-hour vehicle miles travelled by street classification	Travel Demand Model

[13] US 97 Parkway Plan Phase 2: Technical Memorandum #7, Second Level Alternatives Evaluation, November 6, 2019

GOAL	OBJECTIVES	EVALUATION CRITERIA	EVALUATION METHOD
5. Facilitate the use of multimodal travel options	Enhance transit, bicycle and pedestrian facilities along, parallel to, and across, US 97	Number of bike and pedestrian crossing locations on the Bend Parkway with low Level of Traffic Stress (LTS 2 or lower)	Bike/Ped LTS Analysis
		Miles of north-south bike and pedestrian facilities with low Level of Traffic Stress within 0.25 mile of the Bend Parkway	Bike/Ped LTS Analysis
	Look for transportation demand management opportunities	Does the alternative allow for transportation demand management strategies?	Qualitative Assessment
6. Enhance the environment	Reduce emissions through reduction of vehicular delay, improved connections in the local system, and the use of alternative modes	Total PM peak-hour vehicle delay (vehicle hours)	Synchro/Vistro Analysis
		Total PM peak-hour vehicle miles traveled (regional measure)	Travel Demand Model
	Minimize right-of-way impacts	Approximate degree of right-of-way impacts (order of magnitude costs)	Conceptual Layout/ Qualitative Assessment
	Design projects to avoid, mitigate and minimize impacts	Not applicable (design criteria; applies to all projects)	N/A
7. Identify cost effective solutions	Prioritize low cost, high benefit solutions	Total cost	Unit Cost/Planning Level Cost Estimates
		Reduction in delay and crashes	Synchro/Vistro Analysis and HSM Part C/ TOPS BC
	Prioritize solutions that leverage existing planned projects and programs	Does alternative leverage existing planned projects and programs?	Yes/No Assessment
8. Develop an implementation plan	Consider available funding sources and existing planned project and programs	Can the alternative be separated into reasonably fundable and constructible phases?	Qualitative Assessment
	Recommend potential future funding sources	Not applicable (funding sources to be recommended in implementation plan)	Qualitative Assessment
	Include partner commitments to short-term actions	Does the alternative have local agency support?	Is included in an adopted or in-process plan demonstrating local support. However, local agencies will need to confirm support through this process.

Based on input from the TAC, each goal was weighted equally, except for safety, which was weighted twice as high as the others. Within each goal, performance measures were scored equally.

The results of the evaluation were organized into scoring bins to simplify comparing outcomes across goal areas. Each candidate project was scored to assess its positive, negative, or neutral impacts relative to the No-Build scenario, unless otherwise indicated. A five-step scoring system was used by assigning a value according to the scale presented in Table 7.

Table 7: Second Level Evaluation Scoring Scale

	EVALUATION SCORE				
	+2	+1	0	-1	-2
Level of support for goals and objectives	Strongly supports	Moderately supports	No significant change	Moderately conflicts	Strongly conflicts

Groups of similar projects, or projects that address the same problem, were identified in Technical Memorandum #6. Projects were scored within each group against the No-Build scenario and compared to each another.

For most of the quantitative measures, the range of values reported were analyzed to determine the averages within the project groups. Outcomes that exceeded the averages (whether positively or negatively) were assigned the maximum score, either a +2 or a -2. Outcomes that were numerically below average were assigned either a +1 or a -1. Where no change was expected, a value of 0 was assigned. The exception was Goal 1 (Safety), which was weighted double based on direction from the Policy Board (+4, +2, 0, -2, -4).

Murphy Road and Powers Road Improvement Concepts

Technical Memorandum #8[14] provides more detailed design and analysis of options at two locations: where US 97 intersects both Powers Road and Murphy Road. The work in this memorandum builds off the analysis already performed in Technical Memorandum #7 by developing conceptual interchange/overcrossing designs at these locations, as well as providing additional sensitivity analysis related to the traffic interaction between them.

Technical Memorandum #8 assessed the following concepts:

- Powers Road tight diamond interchange
- Powers Road overcrossing
- Murphy Road tight diamond interchange
- Associated frontage road connections (north, south, and western loops)

Based on the analysis and findings from the memorandum, the following implementation recommendations are made related to the Murphy Road and Powers Road interchanges:

1. The highest priority should be the Murphy Road tight diamond interchange. The costs of the tight diamond concept would make this improvement relatively feasible, and this connection should help to relieve some of the existing operational issues at the Powers Road/US 97 intersection. Also, closure of the Badger Road and Pinebrook Boulevard RIRO access would only increase traffic at Powers Road/US 97 in absence of a full interchange at Murphy Road. This interchange would likely be needed to serve both the Murphy Crossing Urban Renewal District and the SE Area, both of which are likely to develop in the short term. In addition, if the Powers Road interchange needs to be phased for funding purposes, the full access Murphy Road tight diamond interchange would be critical to serve short-term demand while Powers Road access to the Parkway is limited.

[14] US 97 Parkway Plan Phase 2: Technical Memorandum #8, Murphy Road / Powers Road Improvement Concepts, October 26, 2019

2. The next highest priority should be the Powers Road interchange, as this location is already under heavy traffic demand. An overcrossing is not the ultimate solution at this location due to negative operational impacts both south at Murphy Road and north at Reed Market. However, an overcrossing could be implemented in the short term as an initial phase of a full interchange, provided the Murphy Road tight diamond interchange is already full access. A tight diamond interchange at Powers Road would provide connections that could ultimately be connected to a southern river crossing. The final tight diamond interchange solution at Powers Road should include consideration of the travel demand impacts of a southern river crossing.
3. The north frontage road priority is predicated on the access and circulation strategy that would be implemented with the closure of the Badger Road and Pinebrook Boulevard RIRO access locations. This concept is recommended to be included with the Powers Road tight diamond interchange at the latest, as that concept requires the closure of the Badger Road RIRO access.
4. The south frontage road is recommended to be implemented when the Murphy Crossing Urban Renewal District begins to develop, or when the "Thumb" develops, or when the China Hat overcrossing is constructed.
5. The west loop frontage road is recommended to be implemented as soon as possible after the construction of the Murphy Road tight diamond interchange, preferably while the first commercial developments west of the interchange are under construction.

Recommended Projects

The Second Level Evaluation recommends 11 corridor-wide projects, 8 projects specific to the south study area, 4 projects specific to the central study area,[15] and only North Corridor FEIS projects specific to the north study area. Table 8 provides the complete list of recommended projects, broken down by area. The results were later discussed with project stakeholders, leading to a refinement into a final list of recommended projects. Figure 8, Figure 9, and Figure 10 show the location of recommended projects in each of the three study areas, differentiated by color according to project type. Full descriptions, cost estimates, and evaluation score results are summarized in Technical Memorandums #7 and #8. Brief project descriptions are given in the Recommended Investment Strategy section of this plan.

[15] Some central study area projects were consolidated during the investment strategy, reducing the number of central study area projects from eight to four.

Table 8: Recommended Improvement Projects for the US 97 Corridor

PROJECT CATEGORY	PROJECTS RECOMMENDED FOR IMPLEMENTATION[1]	PROJECT NUMBER(S)
Corridor-Wide Projects	Install ramp meters	C1
	Right-in-right-out	C2a - C2h
	Extend acceleration and deceleration lanes	C3a - C3d
	Active transportation crossing improvements	C4a - C4r
	Shoulder-width improvements	C5
	Weather Warning System	C6
	Variable speed signs	C7
	Incident management	C8
	Enhanced signal operations at ramp terminals	C9
	Traveler information signing	C10
	Roadside traveler information dissemination	C11
North Study Area	FEIS projects	N1
Central Study Area	Butler Market interchange improvements	M1
	Revere Avenue lane reconfiguration	M2
	Colorado Avenue signal (or roundabout) at NB ramp	M3
	Colorado Avenue improvement to SB ramp intersection	M4
South Study Area	Reed Market refinement study from Bond Street to 3rd Street	S1
	Dedicated left-turn lane Reed Market Road and 3rd Street	S2
	Powers Road interchange	S3
	China Hat overcrossing	S4
	Interchange Area Management Plan at Baker Road/Knott Road interchange	S5
	Murphy tight diamond interchange	S6
	Murphy north frontage road	S7
	Murphy south frontage road	S8

[1]Following the Second Level Evaluation. Projects are further prioritized for short, medium, and long terms in the investment strategy.

Figure 8: Locations of Recommended Projects from Second Level Evaluation – North Study Area

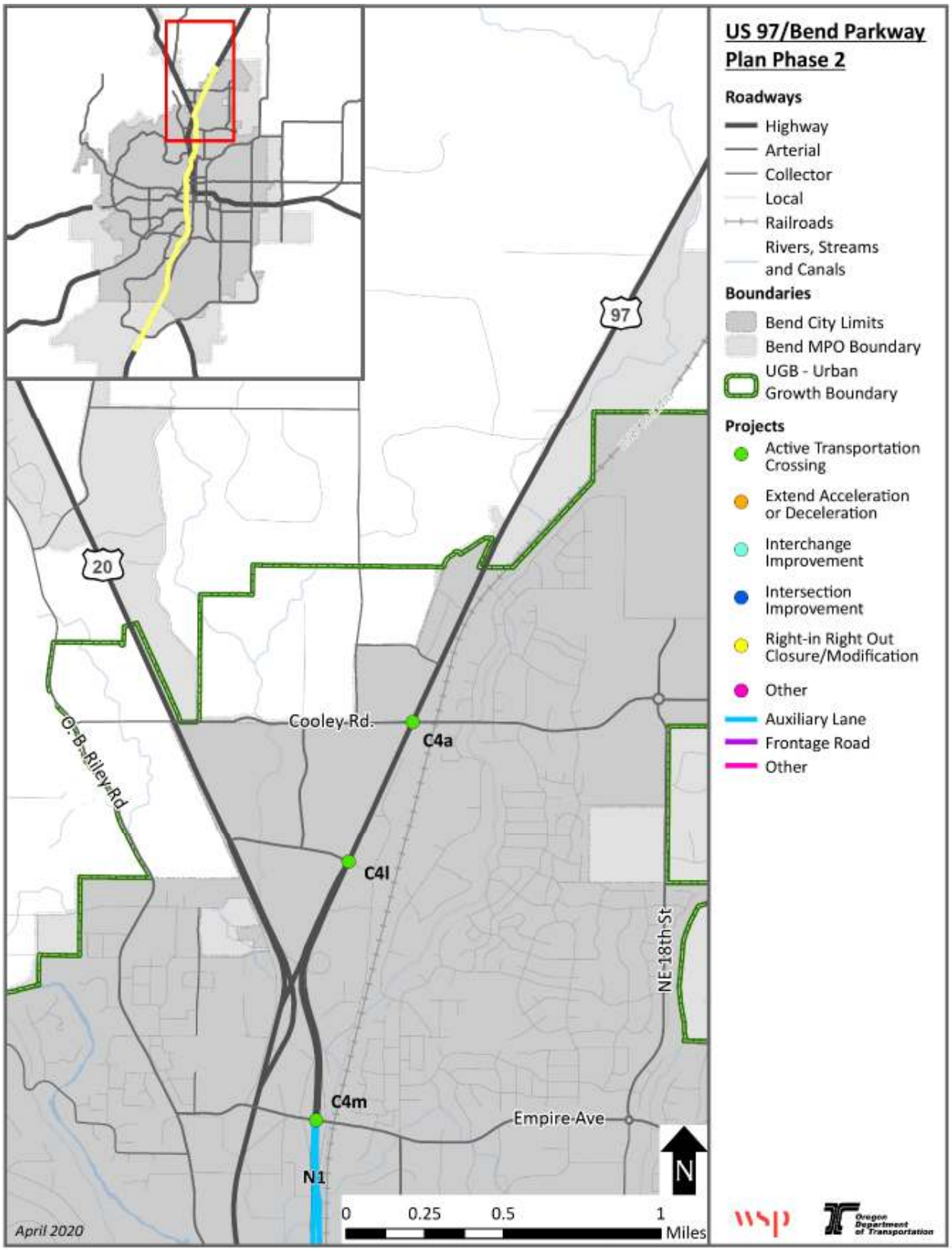


Figure 9: Locations of Recommended Projects from Second Level Evaluation – Central Study Area

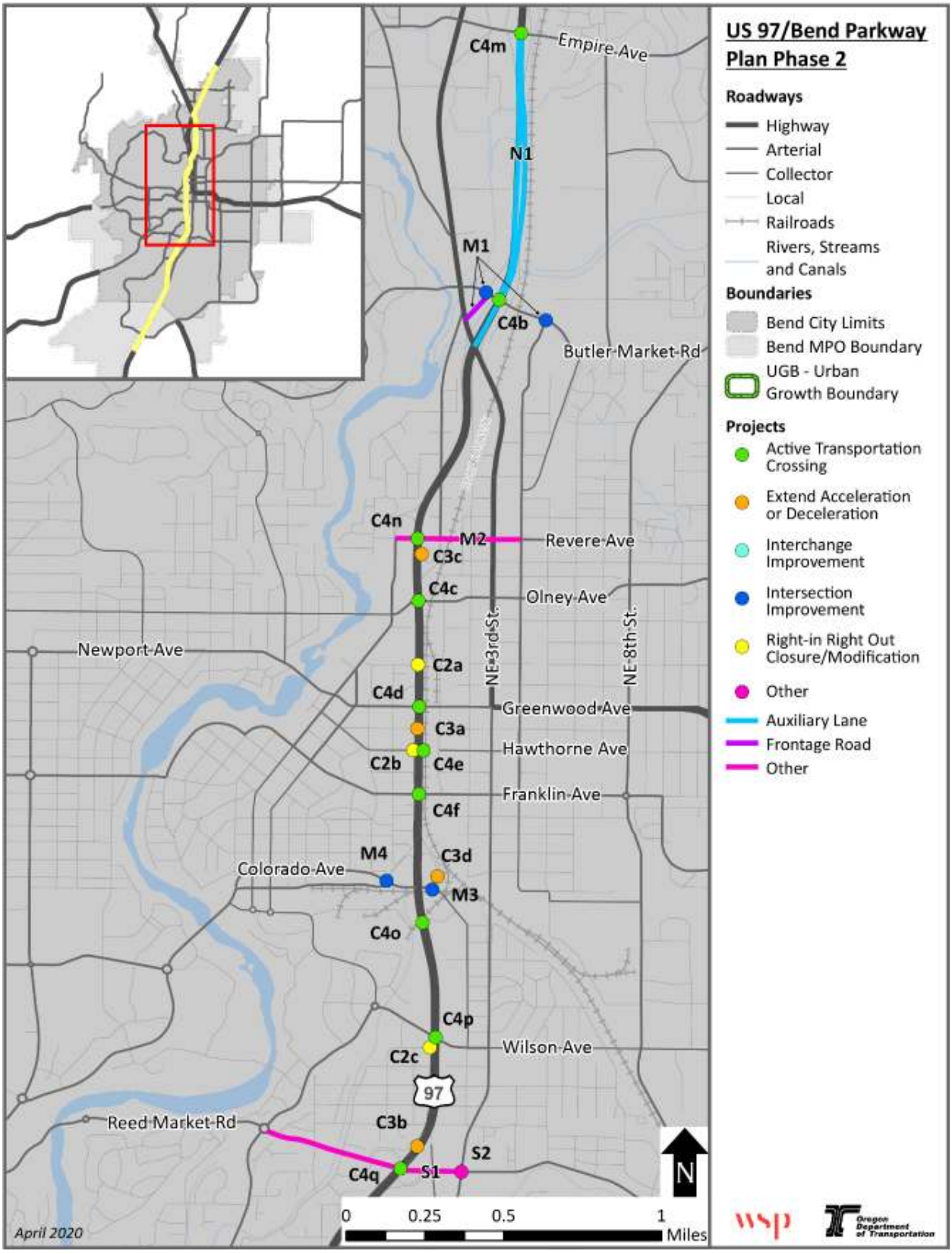
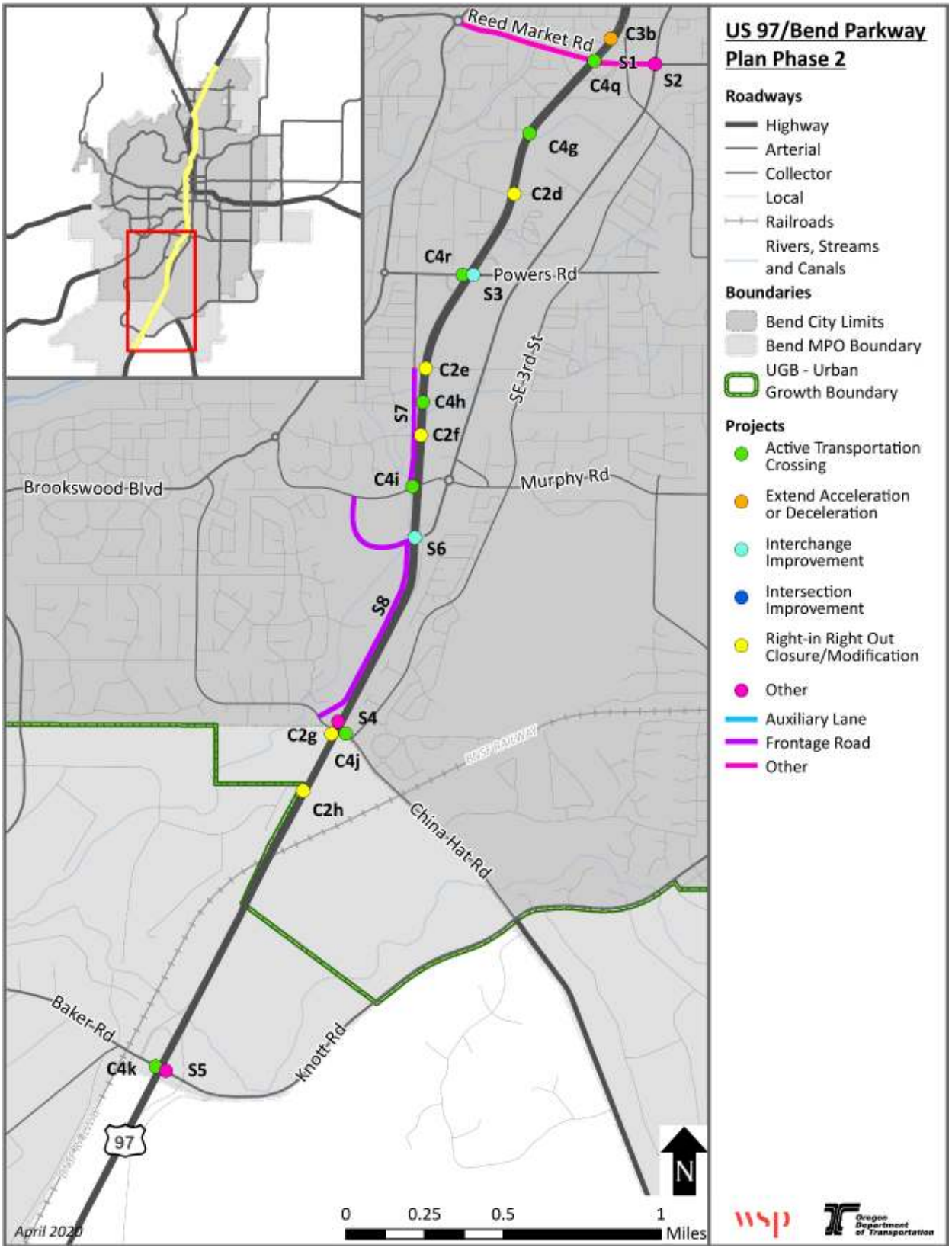


Figure 10: Locations of Recommended Projects from Second Level Evaluation – South Study Area



6.0 RECOMMENDED INVESTMENT STRATEGY

This section first describes the prioritization of projects for implementation and recommendations, followed by project descriptions and investment strategy recommendations grouped by location, starting with corridor-wide projects and followed by projects in the north study area, central study area, and south study area. (Projects are described in further detail in the Technical Memorandums #7 and #8).

6.1 PRIORITIZATION OF PROJECTS FOR IMPLEMENTATION

The Investment Strategy Memorandum[16] further prioritizes the identified projects with an eye toward implementation. The process starts with the timing of the need based on technical analysis and the evaluation scoring, the interrelationship with other projects, the severity of the need, and the type of solution. The timing of the need is then considered against the potential for phasing and opportunities for funding. Project costs were developed in coordination with ODOT.

Proposed Tiers

The proposed tiers for projects were assigned not only by technical need or work, but also by opportunities for phasing or funding.

- **Tier 1 projects** are intended for implementation in the short term (0–10 years). There are 27 Tier 1 projects. Most Tier 1 projects address needs identified for the short term, and others are included due to linkages with other projects or funding. All but two RIRO projects and the majority of active transportation crossing projects fall under this category. No Tier 1 projects are development driven.
- **Tier 2 projects** are intended for implementation in the medium term (11–15 years). There are 21 Tier 2 projects. Tier 2 projects may be needed in the short, medium, or long terms but fall under this timeline due to phasing or funding limitations. All development driven projects are Tier 2.
- **Tier 3 projects** are designated for implementation in the long term (16–20 years). Only one project is proposed as Tier 3: Active Transportation Crossing at Wilson Avenue (C4p).

Table 9 presents a summary of the projects, their tiers, and next steps for implementation for each. A more detailed table with project triggers and dependencies, cost estimates, funding opportunities, and other considerations appears in the appendix of the Investment Strategy Memorandum. Projects without specific funding opportunities described in the Investment Strategy Memorandum or in the detailed table in its appendix will need to compete for limited local, state, and federal funding in the TSP and STIP.

[16] US 97 Parkway Plan Phase 2: Investment Strategy, April 15, 2020

Table 9: Project Tiers and Next Steps

PROJECT NUMBER	PROJECT NAME	PROPOSED TIER	NEXT STEPS
C1	Install ramp meters	Tier 2	Concept of Operations (Cost is approximately $50K). Would operate most effectively if implemented together rather than ramp by ramp.
C2a	Close Lafayette Avenue right turn onto Parkway and extend the deceleration lane for the right turn off the Parkway.	Tier 1	Advance scoping to consider how to bundle RIROs. Consider moving forward with top locations (Lafayette, Hawthorne, Reed Lane and Truman) first. Consider whether they could be done in phases, without final mitigation, and whether all should be done together or broken up. The scoping study could also include the strategy for the corridor.
C2b	Close Hawthorne Avenue right turn onto Parkway.	Tier 1	
C2c	Close Truman Avenue RIRO intersection with Parkway	Tier 1	
C2d	Close Reed Lane RIRO intersection with Parkway	Tier 1	
C2e	Close Badger Road RIRO intersections with Parkway	Tier 1	
C2f	Close Pinebrook Boulevard RIRO intersections with Parkway	Tier 1	
C2g	Close China Hat Road and Ponderosa Street RIRO intersections with Parkway	Tier 2	S4 (China Hat overcrossing) would likely require closure. Development Driven.
C2h	Close Rocking Horse Road RIRO intersections with Parkway	Tier 2	Consider timing for closure in S5 (Baker/Knott Interchange Area Management Plan) and S6 (Murphy interchange.
C3a	Extend Southbound right-turn deceleration lane at Hawthorne Avenue	Tier 1	
C3b	Extend southbound deceleration lane to Reed Market Road	Tier 1	
C3c	Extend Revere Avenue northbound on-ramp acceleration lane	Tier 2	
C3d	Extend acceleration lane for Colorado Avenue northbound on-ramp	Tier 2	
C4a	Active transportation crossing improvements: Cooley Road	Tier 1	Coordinate with INFRA grant design.
C4b	Active transportation crossing improvements: Butler Market Road	Tier 1	Coordinate with TSP improvements.
C4c	Active transportation crossing improvements: Olney Avenue	Tier 1	Coordinate with TSP improvements.
C4d	Active transportation crossing improvements: Greenwood Avenue	Tier 1	Conceptual design and analysis
C4e	Active transportation crossing improvements: Hawthorne Crossing	Tier 1	Develop feasible design.
C4f	Active transportation crossing improvements: Franklin Avenue	Tier 1	Conceptual design and analysis
C4g	Active transportation crossing improvements: Canal/Garfield undercrossing	Tier 2	Conceptual design
C4h	Active transportation crossing improvements: Badger/Pinebrook Overcrossing	Tier 2	Conceptual design to determine optimal location (Badger vs Pinebrook)
C4i	Active transportation crossing improvements: Murphy Road	Tier 1	Conceptual design

PROJECT NUMBER	PROJECT NAME	PROPOSED TIER	NEXT STEPS
C4j	Active transportation crossing improvements: China Hat Road Overcrossing	Tier 2	Conceptual design for S4
C4k	Active transportation crossing improvements: Baker Road/Knott Road	Tier 2	Coordinate with outcomes from Interchange Area Management Plan.
C4l	Active transportation crossing improvements: Robal Road	Tier 1	Coordinate with INFRA grant design
C4m	Active transportation crossing improvements: Empire Avenue	Tier 2	Identify Empire Ave project (3rd to SB Ramp terminal)
C4n	Active transportation crossing improvements: Revere Avenue	Tier 2	Refine M1 conceptual design
C4o	Active transportation crossing improvements: Aune Avenue	Tier 1	Develop Aune Extension conceptual design
C4p	Active transportation crossing improvements: Wilson Avenue	Tier 3	Conceptual design
C4q	Active transportation crossing improvements: Reed Market Road	Tier 2	Complete S1
C4r	Active transportation crossing improvements: Powers Road	Tier 1	Refine Conceptual design for S3
C5	Shoulder-width improvements at strategic locations in corridor	Tier 2	Study corridor to determine which locations this should be completed based on operational issues/needs and available right-of-way. This could be bundled with RIRO study.
C6	Weather warning system	Tier 2	Concept of Operations. ODOT should coordinate with the County and MPO as this is also part of the Deschutes County ITS Plan.
C7	Variable speed signs	Tier 2	
C8	Incident management	Tier 2	
C9	Enhanced signal operations at ramp terminals	Tier 1	Complete ATC conversion plan and obtain additional radar funding.
C10	Traveler information signing	Tier 1	Incorporate into the near-term INFRA Grant project in the Cooley – Empire area, which may change local circulation.
C11	Roadside traveler information dissemination	Tier 1	ODOT should coordinate with the County and MPO as this is also part of the Deschutes County ITS Plan.
N1	FEIS projects	Tier 1	INFRA grant is Phase 1
M1	Butler Market interchange improvements	Tier 1	
M2	Revere Avenue lane reconfiguration	Tier 2	
M3	Colorado Avenue Signal (or roundabout) at NB ramp	Tier 1	
M4	Colorado Avenue improvement to SB ramp intersection	Tier 2	Conduct Study
S1	Reed Market refinement study from Bond Street to 3rd Street	Tier 1	Complete Refinement Study.
S2	Dedicated left-turn lane Reed Market Road and 3rd St (through the TSP)	Tier 1	
S3	Powers Road interchange	Tier 1	Refine preliminary design and begin ROW acquisition.

PROJECT NUMBER	PROJECT NAME	PROPOSED TIER	NEXT STEPS
S4	China Hat overcrossing	Tier 2	
S5	Interchange Area Management Plan at Baker Road/Knott Road interchange	Tier 1	
S6	Murphy tight diamond interchange	Tier 1	ODOT and City of Bend to develop a detailed coordination plan for implementation of Powers and Murphy Road Interchange projects
S7	Murphy north frontage road	Tier 2	
S8	Murphy south frontage road	Tier 2	Could be built in phases based on development

6.2 CORRIDOR-WIDE PROJECTS

Ramp Meters (ITS/TSMO)

This project set would apply metering traffic signals for all on-ramps to the US 97 Bend Parkway between the Empire Avenue and Baker Road-Knott Road interchanges. On-ramp volumes were analyzed to determine which locations would need dual lane ramp meters. Table 10 summarizes the range of forecast year 2040 volumes (from average weekday to 30 HV across all analyzed No-Build and Build conditions) at each on-ramp and includes recommendations for locations of dual lane meters.

Table 10: Ramp Meter Configuration Recommendations

ON-RAMP	VOLUME RANGE	RECOMMENDED RAMP METER CONFIGURATION
Empire Avenue SB	870–1,235	Multi-Lane Metering
Division Street/3rd Street SB	440–825	Single-Lane Metering
Revere Avenue SB	430–530	Single-Lane Metering
Colorado Avenue SB	430–490	Single-Lane Metering
Reed Market Road SB	135–460	Single-Lane Metering
Powers Road SB	50–235	Single-Lane Metering
Murphy Road SB	580–845	Single-Lane Metering
Murphy Road NB	160–425	Single-Lane Metering
Powers Road NB	290–500	Single-Lane Metering
Reed Market Road (EB Reed Market)	220–730	Single-Lane Metering
Reed Market Road (Division)	545–845	Single-Lane Metering
Colorado Avenue NB	1,035–1,500	Multi-Lane Metering
Revere Avenue NB	330–445	Single-Lane Metering
3rd Street NB	475–550	Single-Lane Metering
Butler Market Road NB	240–310	Single-Lane Metering

Installation of ramp meters is proposed as a Tier 2 project, since they are expected to provide benefits to traffic operations but may not be needed in the short term. Additionally, RIROs need to be closed first for ramp meters to function effectively and further study is needed to develop operational details.

The Concept of Operations is proposed for development in the short term and implementation would take place in the medium term. There is potential for phasing, with ramps north of Powers Road implemented as Phase 1 because the interchange projects at Powers Road and Murphy Road would need to be completed prior to metering due to changes in flow and operations.

The Concept of Operations would include an assessment of all other ramps that are substandard to determine whether other roadway improvements are required to accommodate ramp meters. Ramps would likely operate most effectively if implemented together rather than ramp by ramp. Specific triggers for installation of ramp meters would be identified in the Concept of Operations; however, merge failures at some locations on the Parkway would likely occur in the next 10 to 15 years or sooner, depending on development, changing trends in travel demand, and other projects.

Right-In-Right-Out Closures/Modifications (Operations)

RIRO projects close either both a right turn onto the Parkway (right-out) and right turn from the Parkway onto a local road (right-in), or one or the other with modifications to extend the remaining acceleration or deceleration lane. These are intended to address deficiencies in operations and safety on the Parkway.

Triggers for RIRO projects include existing safety and operational issues, geometric deficiencies, needs of other projects for closure, and development. Six of eight RIRO projects are Tier 1 projects and are needed in the short term to address existing safety, operational, and geometric problems, or are needed for projects that are not development driven. China Hat Road and Ponderosa Street (C2g), and Rocking Horse Road (C2h) RIRO closures are Tier 2 projects because their need is development driven.

Completion of all RIRO projects north of Powers Road (C2a though C2d) is needed for installation of ramp meters (C1) to operate effectively. Thus, the need for RIRO closure or modification is triggered by the need for ramp metering.

Most RIRO projects are anticipated to be completed with minimal ROW impacts. However, the Lafayette Avenue project (C2a) would require ROW for the deceleration lane extension.

The closures of China Hat Road and Ponderosa Street RIRO intersections with the Parkway (C2g) may be completed separately, but full closure at this location would be necessary for the China Hat overcrossing project (S4).

The Powers Interchange (S3) and Murphy Road tight diamond (S6) projects would trigger the need for closure of Badger Road RIRO (C2e) and Pinebrook Boulevard RIRO (C2f), respectively. Both RIRO projects would also be necessary for the Murphy north frontage road (S7) to operate effectively. While these two RIRO projects may be phased where each side is closed separately, full closures would be required for projects S3, S6 and S7.

The need for the Rocking Horse Road RIRO closure is driven by development buildout south of Ponderosa Street within the urban growth boundary. An Interchange Area Management Plan (IAMP) at Baker Road and Knott Road Interchange (S5) would be needed to determine access plans for this location. The Murphy tight diamond interchange (S6) and south frontage road (S8) would also be needed prior to this RIRO closure.

The next step is to advance scoping to consider:

- Bundling
- Needed mitigation
- Whether they could be done in phases, without final mitigation

One possibility may be to move forward with the highest-priority locations first (including Lafayette Avenue, Hawthorne Avenue, Truman Avenue, and Reed Lane) with others following later. A RIRO study can be bundled with a study on shoulder-width improvements.

Ramps Improved to Standard Lengths (Operations)

Acceleration and deceleration lanes on US 97 provide drivers with an opportunity to adjust their speeds to match the traffic stream while entering or exiting the mainline facility. Locations for analysis were identified where geometric conditions represented a safety risk due to substandard acceleration/deceleration lane lengths. Four ramp-extension projects were recommended for implementation following the alternatives evaluation process:

- Two deceleration lane extension projects: Hawthorne Avenue southbound (C3a) and Reed Market Road southbound (C3b). Both are proposed as Tier 1 projects.
- Two acceleration lane extension projects: from Revere Avenue northbound (C3c) and from Colorado Avenue northbound (C3d). Both are proposed as Tier 2 projects.

All four ramp-extension projects are triggered by existing geometric deficiency. Safety issues are also a concern, particularly at Hawthorne Avenue. The Colorado Avenue northbound project (C3d) is the only one with likely ROW impacts, where some space on the Franklin Avenue overcrossing could be repurposed to fit in the extended acceleration lane.

The southbound deceleration lane at Hawthorne Avenue southbound (C3a) is needed to maintain Parkway exit access to downtown. It should be considered for pairing with nearby overcrossing projects, but has independent safety issues and needs to be addressed in the short term.

Active Transportation Crossing Improvements (Active Transportation)

ODOT and the City of Bend have agreed that the preferred approach to providing low-stress active transportation facilities in the Parkway corridor is to develop parallel routes using city streets and paths supplemented with enhanced crossings along US 97 to improve connectivity. The identification of connections to parallel low-stress routes was a joint City of Bend/ODOT effort completed in coordination with the broader low-stress network that was being developed as part of the City of Bend's Transportation System Plan update. There are 18 active transportation crossing improvement projects:

- 10 as Tier 1
- 7 as Tier 2]
- 1 (at Wilson Avenue) as Tier 3

These projects are all triggered by existing gaps in the high priority low-stress bicycle and pedestrian network. Table 11 lists priority locations for improving existing and creating new US 97 Pedestrian and Bicycle Crossings, with tier priority and improvement type and sorted by study area.

Table 11: Priority Locations for Improving Existing and Creating New US 97 Pedestrian and Bicycle Crossings

STUDY AREA	PROJECT	CROSSING INVESTMENT LOCATIONS	TIER 1 PRIORITY	TIER 2 PRIORITY	TIER 3 PRIORITY	IMPROVE EXISTING OR CREATE NEW CROSSING?*
North	C4a	Cooley Road	X			Improve existing (at-grade signal)
	C4l	Robal Road	X			Improve existing (at-grade signal)
	C4m	Empire Avenue		X		Improve existing (overcrossing unsignalized/signalized)
Central	C4b	Butler Market Road	X			Improve existing (overcrossing unsignalized)
	C4n	Revere Avenue		X		Improve existing (overcrossing signalized)
	C4c	Olney Avenue	X			Improve existing (undercrossing)
	C4d	Greenwood Avenue	X			Improve existing (undercrossing)
	C4e	Hawthorne Avenue	X			Create new crossing
	C4f	Franklin Avenue	X			Improve existing (undercrossing)
	C4o	Aune Avenue	X			Improve existing (undercrossing)
	C4p	Wilson Avenue			X	Improve existing (overcrossing)
	C4q	Reed Market Road		X		Improve existing (overcrossing unsignalized/signalized)
South	C4g	Canal/Garfield Avenue		X		Improve existing (undercrossing)
	C4h	Badger Road/ Pinebrook Blvd		X		Improve existing (at-grade rectangular rapid flashing beacons)
	C4r	Powers Road	X			Improve existing (at-grade signal)
	C4i	Murphy Road	X			Improve existing (overcrossing)
	C4j	China Hat Road		X		Create new crossing
	C4k	Baker Road/Knott Road		X		Improve existing (overcrossing unsignalized)

* All pedestrian and bicycle crossings of the US 97 Parkway are assumed to be grade-separated in the future (i.e., overcrossings or undercrossings).

Funding opportunities vary for these projects. At least two projects could be funded through Infrastructure for Rebuilding America (INFRA) grants (C4a, C4l), and at least six could be part of potential bond projects (C4b, C4c, C4d, C4e, C4f, C4o). The active transportation crossing improvement does not appear to be included in the bond project for Reed Market Road improvements, though active transportation improvements would be part of any ultimate solution at this location. A crossing improvement at China Hat Road, triggered by development of the "Thumb" area, would likely be developer or city funded.

Next steps for certain active transportation crossing improvement projects include coordination with INFRA grant design (C4a, C4l), coordination with TSP improvements, coordination with (or completion of) other projects, and analysis and/or conceptual design. Individual projects could be implemented separately or grouped together. Cost estimates for these projects will be developed on a case-by-case basis as part of stand-alone scoping efforts or integrated as part of larger interchange or corridor projects.

Transportation Systems Management and Operations Projects

TSMO projects include a set of strategies that focus on operational improvements and maintenance that could restore or possibly increase the performance of existing facilities. These projects generally do not conflict with one another and multiple strategies may be included

Weather Warning System, Variable Speed Signs, and Roadside Traveler Information Dissemination

The weather warning system[17] project (C6) and variable speed signs[18] project (C7) are both Tier 2. The roadside traveler information dissemination[19] project (C11) is not assigned a tier but could be bundled with C6 and C7. All TSMO projects could be bundled together, or each in combination with other TSMO projects.

Of these three projects (C6, C7 and C11), phasing would be considered for the weather warning system project (C6), because signs do not need to be installed all at once, and costs for these projects would be per sign.

The needs for the three projects are all triggered by existing travel time reliability impacts. Namely, seasonal crash trends affect the need for a weather warning system, seasonal weather impacts affect the need for variable speed signs, and special events affect the need for roadside traveler information.

The recommended next step for all three projects is that ODOT coordinate with current County or MPO ITS planning efforts and explore previous funding sources for ITS projects as well as communications infrastructure needs

[17] A **weather warning system** includes a variety of applications that activate warnings regarding weather (e.g., roadway flooding, fog, snow, or ice) to inform drivers of potentially hazardous conditions.
[18] **Variable speed signs** are used to manage congested corridors, and/or events caused by incidents or weather by displaying advisory speeds according to the conditions ahead.
[19] **Roadside traveler information dissemination** uses variable message signs on roadways or highway advisory radio to disseminate traveler information. This system could also be used to help guide travelers during special events such as festivals or concerts.

Incident Management (ITS/TSMO)

The incident management[20] project (C8) is Tier 2 and is triggered by travel time reliability impacts from crashes. It could be bundled with the roadside traveler information dissemination project (C11). It would be more effective if implemented with the shoulders built to standard widths project (C5). The recommended next step is that ODOT coordinate with current County or MPO ITS planning effort and explore previous funding sources for ITS projects. The estimated cost would be $50,000 to $500,000 per year.

Shoulder-Width Improvements at Strategic Locations in the Corridor (Operations)

The shoulder-width improvements at strategic locations in the corridor project[21] (C5) is proposed as Tier 2, and the project need is triggered by existing geometric deficiencies and travel time reliability issues. This project would increase the benefit of the incident management project (C8) and could support traffic enforcement.

Right-of-way (ROW) space needed to widen shoulders would be either purchased or repurposed by modifying medians where the ROW) is tight.

Phasing could be implemented by segment. The next step would be to study and identify priority locations based on operational issues and needs and available ROW. This study could be bundled with a RIRO study.

Enhanced Traffic Signal Operations at Ramp Terminals and Traveler Information Signing (Operations)

The enhanced traffic signal operations at ramp terminals project[22] (C9) is Tier 1, the need for which is triggered by queuing, particularly at Powers Road. It should be coordinated with ODOT's ongoing ATC conversion plan. This could include freight and transit signal priority as interim solutions. Phasing would be possible following the implementation of ATC controllers. The next step would be to complete the ATC conversion plan and obtain additional radar funding.

The traveler information signing project (C10) would guide travelers along a certain path using static signing. It is also Tier 1, the need for which is triggered by the confusion of drivers, particularly those less familiar with the regional road network. It could be included as part of the INFRA grant for improved wayfinding from

[20] Incident management is the coordination of responses to clear incidents that affect safe and efficient travel. Strategies include dedicated incident response programs and strategies, incident response vehicles, and staged/dry-run towing.

[21] Widened shoulders provide space for law enforcement activity, disabled vehicles to pull over, bicycle travel, passage around incidents, opportunities for improved freight operations, potential transit use, and partial storage for snow removal. Standard width shoulders for the Parkway would be 8 feet wide for the outer/right shoulder and 4 feet wide for the inner/left shoulder, although further study would determine the specific locations and amounts of additions, if any.

[22] Enhanced traffic signal operations at ramp terminals includes improving existing signals through re-timing/optimization, adaptive systems, or better/increased detection. Enhanced traffic signal operations could be combined with geometric and lane utilization improvements to be fully effective. Many of these improvements could be realized through the upcoming ODOT ATC conversion plan. Furthermore, upgrading ramp signals to new technology would help to future-proof the network for potential future connected and autonomous vehicle applications.

Robal Road to Division Street. The recommended next step is that ODOT coordinate with current County or MPO ITS planning effort and explore previous funding sources for ITS projects. Cost to implement is estimated at $2,000 to $30,000 per location.

6.3 NORTH STUDY AREA

FEIS Projects

FEIS projects[23] (N1) are not assigned a tier. Instead, timing depends on the larger North Corridor process and availability of funding to address existing operational and safety issues. The INFRA grant-funded portion is the short-term first phase, and the full FEIS is long term.

6.4 CENTRAL STUDY AREA

US 97 Mainline Projects (Modification)

The auxiliary lanes on southbound US 97 between Empire Avenue and Butler Market Road and on northbound US 97 between 3rd Street and Empire Avenue are part of FEIS projects (N1). They do not serve an existing need, but it is anticipated they will when traffic volumes are well over capacity 20 years out. They are part of the ultimate build out of FEIS projects (N1) and should be re-assessed after the completion of the INFRA grant phase.

Butler Market Road Projects

Interchange Improvements (Modification)

The Butler Market Road interchange improvements project (M1) is Tier 1 and would involve a southbound frontage road to the interchange and roundabouts (or signals) at the southbound off-ramp and at Butler Market Road and 4th Avenue.

The options considered at the southbound off-ramp terminal with Butler Market Road are a traffic signal or a roundabout. The existing off-ramp terminal fails to meet the existing mobility target. The control type (roundabout or signal) should match what is installed at Butler Market Road and 4th Street. The project could be a part of a bond. Unlike the frontage road to the interchange, there would be no likely significant ROW impacts.

The new frontage road concept would extend the southbound off-ramp to connect directly to US 20 (Business 97). The existing southbound frontage road to interchange ramp terminal fails to meet the existing mobility target and westbound Butler Market queuing issues exist. Exact project trigger needs to be determined through a more detailed study. This project would require signal upgrades at 3rd Street and Butler Market Road, access refinement between the ramp terminal and 3rd Street, re-alignment of the west

[23] The project analyzed for the Parkway Study is in the FEIS, which to date is only partially funded. The ongoing North Corridor Study will identify the funded interim phases of the FEIS Preferred Option; therefore, that analysis will provide different results than those presented for the north study area in this study. This project was identified as its own group because it will affect only the north portion of the corridor and is compatible with all other projects.

leg at Division Street and 3rd Street, and completion of the roundabout or signal at the Butler Market southbound off-ramp. The project could be part of a bond. ROW impacts would be minimal.

The intersection of Butler Market Road and 4th Street is within the influence area of the interchange and its performance can affect operations at the ramp terminals. The two traffic control options considered here are a traffic signal or a roundabout. Today, this location has all-way stop controls. The trigger for traffic control options at Butler Market Road and 4th Street is to address existing operational need. The control type (roundabout or signal) should match what is installed at the Butler Market Road southbound off-ramp. A roundabout scored higher than a signal in the Second Level Evaluation.

Revere Avenue Projects (Modification)

To improve bicycle and pedestrian facilities on Revere Avenue, going from four vehicular travel lanes to three is proposed from 4th Street to Wall Street, to reallocate the ROW width and this safer design benefits bicyclists and pedestrians. This change would allow for better sidewalks and buffered bike lanes within the existing ROW. Furthermore, the project would also include the following elements, which could improve safety and operations:

- Dedicated left-turn lanes at Division Street and Revere Avenue
- The ability to separate left-turn phases at Division Street and Revere Avenue during railroad closures to the east

The Revere Avenue lane reconfiguration project (M2) is Tier 2 and would address existing geometric and active transportation needs. It could be combined with a larger "Z" project that extends to Portland Avenue/Wall Street.

Colorado Avenue Projects (Modification)

The US 97 northbound and southbound ramps at Colorado Avenue will not provide enough capacity to serve the forecast demand. In addition, the northbound ramp intersection at Colorado Avenue was flagged for safety issues. Two projects besides the northbound on-ramp acceleration lane extension are proposed for Colorado Avenue:

- The signal or roundabout at the northbound ramp project (M3) is Tier 1 and would address existing operational needs. There are potential impacts to rail properties due to a westbound right-turn lane.
- The improvement to the southbound ramp intersection project (M4) is Tier 2. A study should occur in the short term to prevent core area solutions from precluding interchange solutions. This study can happen at any time, because there are no project dependencies and TSP findings are sufficient to support a study at this location. The TSP includes Colorado Avenue/US 97 safety improvements in its near-term investment priorities. The cost estimate is unknown.

6.5 SOUTH STUDY AREA

Reed Market Road (Modification)

The Reed Market refinement study project (S1) from Bond Street to 3rd Street is Tier 1 and is triggered by existing operational needs on Reed Market Road. Solutions would likely require some ROW acquisition,

particularly north of the northbound ramp terminal. The next step is to complete a refinement study, which can happen at any time, because TSP findings are sufficient to support a study at this location. The TSP includes Reed Market Road/US 97 interchange improvement study in its near-term investment priorities. Implementation of study recommendations should start in the short term. Outcomes from the study are potential bond projects.

The dedicated left-turn lane at Reed Market Road and 3rd Street project (S2) is Tier 1 and is triggered by existing operation needs on Reed Market Road. Ultimate solutions will be identified by the refinement study and would also likely require some ROW acquisition. This project is already funded through the City of Bend five-year CIP.

Murphy Road and Powers Road Improvement Concepts

The recommended Murphy Road and Powers Road projects are outlined in the Alternatives Evaluation section of this plan and detailed in Technical Memorandum #8.

Powers Road (Modification)

The Powers Road interchange project (S3) is Tier 1. This project is recommended after completion of the Murphy Road tight diamond interchange project (S6), which can partially address existing needs. The Badger Road RIRO project (C2e) is required prior to the S6 project. Potential phasing would be to construct an overcrossing before the interchange, but only after the Murphy Road tight diamond (S6) project is completed. Next steps are to refine preliminary design and begin ROW acquisition in the short term, followed by construction in the mid-term.

Murphy Road (Modification)

The Murphy Road tight diamond interchange (S6) is Tier 1. It is triggered by the need for development of the Urban Renewal District around Murphy Road and to provide some relief to existing operations issues at Powers Road. It requires a RIRO closure at the Pinebrook Boulevard project (C2f), and likely requires some ROW acquisition. Potential funding sources are a bond or urban renewal funding. The recommended next step is for ODOT to develop a detailed project coordination plan with the City of Bend regarding the implementation of Murphy and Powers Road Interchange projects.

Both frontage road projects are development driven Tier 2 projects, triggered by growth south of Murphy Road related to future buildout of the Murphy Road crossing area and the “thumb” area, the undeveloped UGB land bounded by China Hat Road, Knott Road, and US 97.

The north frontage road project depends on the Pinebrook Boulevard and China Hat Road/Ponderosa Street RIRO closures projects (C2f, C2g). There is potential for phasing, with improvements to Blakely Road first, followed by new construction south of Pinebrook. Some ROW acquisition would be required. The project is likely to be partially developer funded.

The south frontage road project would depend on the Murphy tight diamond (S6), China Hat Road overcrossing (S4), and Rocking Horse Road closure (C2h) projects to function effectively. There is potential for phasing with connection from the tight diamond to Murphy Road first, followed by the extension to Ponderosa Street as development increases. It is likely the south frontage road project would require minimal

ROW acquisition. The south frontage road project is a City of Bend responsibility and would likely be partially developer funded through properties in the Murphy crossing area.

China Hat Road (Modification)

The China Hat Road overcrossing project would address an issue related to future development access to the Parkway between Baker Road/Knott Road and Murphy Road. The China Hat Road overcrossing project (S4) is Tier 2, would be triggered by build out of the "thumb," and would depend on the RIRO closure at the China Hat Road and Ponderosa Street project (C2g) and the Murphy tight diamond interchange project (S6). The overcrossing would likely require some ROW acquisition. The project would likely be developer or City of Bend funded.

Baker Road/Knott Road (Modification)

The Baker Road/Knott Road options consider either signals or roundabouts at the existing two-way stop-controlled ramp terminals. The IAMP at Baker Road/Knott Road Interchange project (S5) is Tier 1. Improvements are needed now to accommodate growth near this interchange. The Baker/Knott IAMP is anticipated to start this summer (2020) and may identify a phased set of solutions.

7.0 ALTERNATIVE MOBILITY TARGETS

7.1 BACKGROUND

The Oregon Highway Plan (OHP) identifies highway mobility targets for maintaining acceptable and reliable levels of mobility on the state highway system, consistent with expectations for each facility type, location, and functional objectives.[24] The adopted mobility targets are the initial tool for identifying deficiencies and considering solutions for vehicular mobility on the state system. However, consistent with OHP Policy 1F, the ability to meet OHP mobility targets may not be compatible with a community's adopted land use plan, financial capacity, or goals. In these cases, alternative mobility targets can be explored for a facility to adjust long-term roadway performance expectations.

It is important for a highway facility plan to identify a broad range of transportation system projects and services to address the deficiencies that would exist at the end of a 20-year planning horizon if the community grows in accordance with its adopted land use plan. However, it is also important to realistically identify which transportation projects and services are reasonably likely to be implemented over the 20-year planning horizon, based on financial or other constraints. This exercise enables the community and the state to establish realistic expectations for how that transportation system will likely operate at the end of the 20-year planning horizon.

Because of the financial constraints that have been faced by state and local governments over the last 20 years and which are expected to continue into the foreseeable future, it is often the case that the local and/or state roadways will not be able to meet local LOS standards or, in the case of ODOT, roadway v/c ratio-based mobility targets, at the end of the 20-year planning horizon if the community grows in

[24] *1999 Oregon Highway Plan, as amended May 2015*, Policy 1F: Highway Mobility Policy, Oregon Department of Transportation

accordance with its land use plan. This is particularly common in larger communities or in those with roadways that experience higher travel demands. In these cases, it is appropriate to adjust roadway performance expectations, as expressed through local LOS standards or state mobility targets, to match the performance that is actually forecast to exist at the end of the 20-year planning horizon, through the adoption of alternative standards or mobility targets.

In these situations, adopting alternative standards or mobility targets means adjusting roadway performance expectations to match realistic expectations for how the roadways are forecasted to operate, taking into account financial and other constraints. In addition to establishing realistic expectations for future system performance, this process will help reduce the need to list state and local investment needs that both parties acknowledge are unlikely to be achieved.

7.2 NEED FOR ALTERNATIVE MOBILITY TARGETS ON US 97 PARKWAY

Continued growth in regional travel along US 97 coupled with a significant amount of population and employment growth projected in Bend will increase daily trips on the US 97 Parkway from about 50,000 today to about 80,000 by 2040. Even with the transportation improvements identified as reasonably likely to be funded in the US 97 Parkway Plan and the City's TSP (approximately $1 billion of projects and programs), transportation analysis forecasts many intersections along the US 97/Bend Parkway corridor will not comply with ODOT's current mobility targets by the end of the 20-year planning horizon.

An evaluation of the differences between the current targets and forecasted traffic operations (discussed in more detail below) confirmed the need for assessing the potential to mitigate conditions through other means, while balancing the goals established as part of the US 97 Parkway Plan and Bend TSP. The findings of that evaluation are described below.

Current Mobility Targets

Currently, all ODOT intersections within the Bend MPO area must comply with the v/c ratio-based mobility targets in Table 6 of the OHP. ODOT v/c ratio mobility targets are based on highway classification and area type. Within Bend, US 97 is classified as a Statewide Highway and Expressway within an MPO. Therefore, the v/c target is a maximum of 0.85 for intersections on US 97 and its ramp terminals.

The mobility targets in the OHP are based on conditions present during the 30th highest annual hour of traffic (30 HV). Within Bend, the 30 HV typically occurs during the summer months, when traffic volumes increase due to an influx of vacationers and visitors, leading to a significant increase in traffic over average weekday conditions (from an 11 percent to 31 percent increase in some areas).

Projected 2040 Operations in the US 97 Corridor

During the development of Bend's TSP, an alternative mobility targets technical memorandum[25] was prepared that analyzed the need for alternative mobility targets on state highways. This analysis assumed that all of the reasonably likely to be funded projects in the Bend MPO area would be constructed in the 20-year planning horizon, including many projects from the US 97 Parkway Plan. Based on this analysis, Table 12 lists the future year 2040 peak hour (30 HV) intersection operations without and with the reasonably likely to

[25] *2020 Bend's Transportation Plan, Appendix I – Alternative Mobility Target Memorandum,* City of Bend

be funded projects (referred to as the "No Build"[26] and "Mitigated" scenarios, respectively). Given the increased growth in Bend over the 20-year planning horizon, traffic demand is forecast to exceed capacity at many intersections by 2040. As shown in Table 12, 13 study intersections would continue to fail to comply with existing mobility targets even under the mitigated scenario.

Table 12: Intersection Operations in the US 97 Parkway Corridor without and with Reasonably Likely to be Funded Improvements (2040 PM Peak Hour, 30 HV)

INT. NO.	INTERSECTION	CONTROL [A]	EXISTING OHP MOBILITY TARGET	NO BUILD V/C [C]	MITIGATED V/C	US 97 PARKWAY PLAN/TSP PROJECT
1	US 97 & Tumalo Pl	*(removed from study area after existing conditions analysis was completed)*				
2	US 97 & Cooley Rd	Signalized	< 0.85	**1.07**	**0.89**	US 97 North Corridor Project
3	US 97 & Robal Rd	Signalized	< 0.85	**1.41**	0.73	US 97 North Corridor Project
4	US 97 & Nels Anderson Pl/Cascade Village	TWSC	< 0.85 (major) < 0.95 (minor)	**>2.00 / >2.00**	–[D]	US 97 North Corridor Project
5	US 97 Bend Pkwy SB On-Ramp & Empire Blvd	Signalized [B]	< 0.85	**1.28**	**0.99**	Empire Blvd widening (C-13)
6	US 97 Bend Pkwy NB Ramps & Empire Blvd	Signalized	< 0.85	**1.33**	**1.10**	Empire Blvd widening (C-13)
7	US 20 & Empire Blvd	Signalized	< 0.85	**1.32**	**1.25**	US 97 North Parkway Extension Phase 2 (C-40)
8	US 20 & Butler Market Rd	Signalized	< 0.85	**1.27**	**1.04**	Butler Market Rd/US 20/US 97 improvement (C-21)
9	US 97 Bend Pkwy SB Off-Ramp & Butler Market Rd	TWSC/RAB [B]	< 0.85	NA[E] / **1.30**	0.55	Butler Market Rd/US 20/US 97 improvement (C-21)
10	US 97 Bend Pkwy NB On-Ramp & Butler Market Rd	TWSC	< 0.85 (ramp) < 0.95 (Butler Market Rd)	0.11 / 0.04	0.11 / 0.13	-
11	US 97 Bend Pkwy SB On-Ramp/Division St & 3rd St	Signalized	< 0.85	**1.37**	**0.88**	Butler Market Rd/US 20/US 97 improvement (C-21)
12	US 97 Bend Pkwy SB Ramps & Revere Ave	Signalized	< 0.85	**0.99**	0.84	Revere Ave interchange improvements (C-9)
13	US 97 Bend Pkwy NB Ramps & Revere Ave	Signalized	< 0.85	**0.94**	**0.92**	Revere Ave interchange improvements (C-9)
14	US 97 Bend Pkwy & Lafayette Ave	TWSC/Free [B]	NA	NA[E] / **>2.00**	NA	US 97 right-off only (C-42)
15	US 97 Bend Pkwy & Hawthorne Ave	TWSC/Free [B]	NA	NA[E] / **>2.00**	NA	US 97 right-off only (C-42)
16	US 97 Bend Pkwy SB Ramps & Colorado Ave	Signalized	< 0.85	**1.17**	**0.98**	-
17	US 97 Bend Pkwy NB Ramps & Colorado Ave	TWSC/ Signalized [B]	< 0.85	0.52 / **1.29**	**0.90**	US 97/Colorado Ave NB ramp capacity improvement (C-7)
18	US 97 Bend Pkwy & Truman Ave	TWSC/ Closed [B]	-	NA[E] / **>2.00**	-	US 97 right-on, right-off closure (C-42)
19	US 97 Bend Pkwy SB Ramps & Reed Market Rd	Signalized	< 0.85	**1.29**	**0.89**	US 97/Reed Market Rd interchange (C-19,C-20)

[26] For more details on the No Build scenario results, see the US 97 Parkway Plan Phase 2, Technical Memorandum #4 – Future Conditions, November 2018

INT. NO.	INTERSECTION	CONTROL [A]	EXISTING OHP MOBILITY TARGET	NO BUILD V/C [C]	MITIGATED V/C	US 97 PARKWAY PLAN/TSP PROJECT
20	US 97 Bend Pkwy NB Ramps & Reed Market Rd	TWSC/ Signalized [B]	< 0.85	NA[E] / **>2.00**	0.80	US 97/Reed Market Rd interchange (C-19,C-20)
21	US 97 Bend Pkwy & Reed Ln	TWSC/ Closed [B]	–	NA[E] / **1.05**	–	US 97 right-on, right-off closure (C-42)
22	US 97 Bend Pkwy SB Ramps & Powers Rd	Signalized [B]	< 0.85	0.08 / **1.24**	0.81	Powers Rd interchange (C-41)
23	US 97 Bend Pkwy & Powers Rd	Signalized/ Closed [B]	–	**1.45**	–	Powers Rd interchange (C-41)
24	US 97 Bend Pkwy NB Ramps & Powers Rd	Signalized [B]	< 0.85	0.28 / 0.09	0.70	Powers Rd interchange (C-41)
25	US 97 Bend Pkwy & Badger Rd	Closed [B]	–	–	–	US 97 right-on, right-off closure (C-42)
26	US 97 Bend Pkwy & Pinebrook Blvd	Closed [B]	–	–	–	US 97 right-on, right-off closure (C-42)
27	US 97 & Ponderosa St	TWSC/ Closed [B]	–	NA[E] / **>2.00**	–	US 97 right-on, right-off closure (C-42)
28	US 97 SB Ramps & Baker Rd	TWSC	< 0.85 (ramp) < 0.95 (Knott Rd)	0.02 / **1.26**	0.06 / **0.86**	-
29	US 97 NB Ramps & Knott Rd	TWSC	< 0.85 (ramp) < 0.95 (Knott Rd)	0.41 / **>2.00**	0.38 / **>2.00**	-
40	US 20 & O.B. Riley Rd	Signalized	< 0.85	**0.91**	0.82	-
46	Revere Ave & 3rd St (US 97)	Signalized	< 0.85	**1.17**	**1.10**	-
Study intersections meeting targets				**2 / 28**	**10 / 23**	

A TWSC stands for two-way stop-controlled. RAB stands for roundabout.
B Traffic control change due to US 97 Parkway Plan/TSP project.
C Signalized intersection volume-to-capacity (v/c) results are reported for the overall intersection. RAB results are reported for the worst leg. TWSC intersection results are reported for the worst major approach/ worst minor approach.
D This intersection was not analyzed as part of the TSP. The design of the US 97 North Corridor project would directly affect this intersection, and any alternative mobility targets should be identified as part of that process.
E Major street movement operates under free-flow conditions; movement v/c results are not applicable.
Bold and Red values indicate the adopted mobility target would not be met.

It should be noted that while the US 97 at Cooley Road intersection is forecast as failing to meet mobility targets in the 2040 mitigated scenario, the actual design of this intersection has not yet been finalized. The ultimate design of Phase 1 of the US 97 North Corridor project may significantly change the performance of this intersection as well as US 97 at Robal Road and US 97 at Nels Anderson Place. In addition, the ongoing US 97 Baker Road IAMP will likely identify improvements to the US 97 ramp terminal intersections at Baker Road and Knott Road. Any alternative mobility targets needed at those intersections should be recommended as part of those respective efforts.

It should also be noted that the environmental impact statement for the US 97 North Corridor project included additional improvements at the US 20 and Empire Boulevard intersection. However, during the Bend TSP process, it was determined that these improvements would not be included in the financially constrained project list. Therefore, no improvements were assumed to be in place for the purpose of this analysis.

Factors Limiting the Ability to Meet Existing Mobility Targets

The following several factors combine to make compliance with the current mobility targets within Bend difficult.

Projected multimodal travel needs

The importance of US 20 and US 97 to statewide, regional, and local travel creates significant multimodal demands for both short and long trip users along the corridor. These users include the following:

- People driving taking advantage of the higher speeds and grade-separated intersections to make local trips to homes, work, and shopping
- People driving making regional trips between cities (including between Redmond, Sisters, Sunriver, La Pine and other Central and Eastern Oregon destinations)
- Freight traveling to and through Bend
- Transit traveling along the main state facility or crossing at a local street
- People biking and walking along and across US 20 and US 97

Balancing the needs of each of these various users was a key factor in the discussions and decisions of both the Bend MPO Policy Board and Bend Citywide Transportation Advisory Committee related to evaluating scenarios and identifying projects and programs for the US 97 Parkway Plan and Bend TSP.

Existing and planned development patterns

In many areas along US 20 and US 97, adjacent existing development and planned urban form promoting increased density and mixed land use constrain the ability to widen the highway ROW or provide parallel alternate routes. Obtaining needed ROW for highway widening would require acquisition and removal of such development, which would be very expensive and counter to the goals and objectives of the community.

Financial factors

As is true for most agencies, funding for transportation improvements is limited and constrains the ability of ODOT to fund highway capacity improvements. ODOT and the City of Bend have collaborated on a funding strategy for most major transportation projects in this corridor.

The US 97 Parkway Plan and Bend TSP identified a comprehensive set of transportation solutions resulting in nearly $1 billion of projects and programs deemed reasonably likely to be funded in the 20-year planning horizon, including contributions toward many projects on state highways. However even though the Bend TSP includes a robust transportation funding strategy that enables the projects and programs list to be designated reasonably likely to be funded, remaining facility mobility target performance deficiencies could not be addressed within the funding constraints.

Other Strategies Being Applied to Enhance Mobility

In addition to funding capacity improvements, the US 97 Parkway Plan and Bend's TSP identify funding for programs and policies to improve multimodal conditions and help reduce motor vehicle demand. This

includes a commitment to building a citywide low-stress bicycle and pedestrian network, implementing parking pricing and management in downtown Bend, supporting an expansion of the existing transit network (including mobility hubs and high-capacity transit) and implementing a travel demand management program for major employers and institutions to reduce motor vehicle demand.

7.3 ALTERNATIVE MOBILITY TARGET EVALUATION

Figure 11 shows ODOT's methodology for determining alternative mobility targets.[27] A summary of each step is discussed below, and Table 13 lists the results for each individual intersection.

Figure 11: Alternative Mobility Target Methodology

Step 1: Implement Planned Improvements

Prior to implementing alternative mobility targets, all feasible actions and improvements must be taken to meet the current targets. Even with the implementation of the reasonably likely to be funded improvements in the US 97 Parkway Plan and Bend's TSP, alternative mobility targets will be needed at the following 10 study intersections:[28]

- US 97 Bend Parkway Southbound On-Ramp & Empire Boulevard (v/c = 0.99)
- US 97 Bend Parkway Northbound Ramps & Empire Boulevard (v/c = 1.10)
- US 20 & Empire Boulevard (v/c = 1.25)
- US 20 & Butler Market Road (v/c = 1.04)
- US 97 Bend Parkway Southbound On-Ramp/ Division Street & 3rd Street (v/c = 0.88)
- US 97 Bend Parkway Northbound Ramps & Revere Avenue (v/c = 0.92)
- US 97 Bend Parkway Southbound Ramps & Colorado Avenue (v/c = 0.98)
- US 97 Bend Parkway Northbound Ramps & Colorado Avenue (v/c = 0.90)

[27] Planning Business Line Team Operational Notice PB-02, Oregon Department of Transportation, effective May 2, 2013.

[28] Note: This excludes the intersections on US 97 with Cooley Road and Robal Road, which will be addressed by the North Corridor Project, as well as the US 97 ramp terminals with Baker Road and Knott Road, which will be addressed by the ongoing Interchange Area Management Plan.

- US 97 Bend Parkway Southbound Ramps & Reed Market Road (v/c = 0.89)
- Revere Avenue & 3rd Street (US 97) (v/c = 1.10)

Step 2: Increase v/c targets, Staying Below Capacity

In cases where the v/c is forecast to be greater than the OHP mobility target but less than capacity (v/c = 1.0) during the 30 HV, establish the proposed alternative target consistent with the v/c values used in the OHP. This approach would work for the following six of the 10 intersections needing alternative mobility targets, but not for the remaining four intersections still forecast to operate at v/c greater than 1.0 as listed in Table 13:

- US 97 Bend Parkway Southbound On-Ramp & Empire Boulevard (v/c = 0.99)
- US 97 Bend Parkway Southbound On-Ramp/Division Street & 3rd Street (v/c = 0.88)
- US 97 Bend Parkway Northbound Ramps & Revere Avenue (v/c = 0.92)
- US 97 Bend Parkway Southbound Ramps & Colorado Avenue (v/c = 0.98)
- US 97 Bend Parkway Northbound Ramps & Colorado Avenue (v/c = 0.90)
- US 97 Bend Parkway Southbound Ramps & Reed Market Road (v/c = 0.89)

Step 3: Remove Peaking within the Peak Hour

In cases where v/c is forecast to be greater than or equal to capacity during the 30 HV using the standard analysis procedures, evaluate the actual peak-hour traffic volume for future year 30 HV projections rather than expand the peak 15 minutes to be the 30 HV. If the resulting v/c is less than 1.0, establish the proposed alternative target. Setting the peak-hour factor (PHF) for the 30 HV to 1.0 relaxes the peaking assumptions and allows for analysis of the peak-hour volumes instead of the peak 15-minute volumes. Using this approach would work for the following intersection but not for the remaining three intersections that could not be addressed by Step 2:

- US 20 & Butler Market Road (new v/c = 0.94)

Step 4: Analyze Average Weekday Conditions

In cases where v/c is forecast to be greater than or equal to capacity during the design hour using the actual peak-hour projection of traffic and in areas where design hours are affected by high seasonal traffic volumes, evaluate the annual average weekday PM peak (AWD) as the future-year design hour rather than the 30 HV. If the resulting v/c is less than 1.0, establish the proposed alternative target. Analyzing average weekday conditions instead of the 30 HV gives a more accurate representation of typical conditions instead of peak summer conditions when there is an influx of visitors in Bend. Using AWD volumes with a PHF of 1.0, all study intersections except US 20 at Empire Boulevard (new v/c = 1.07) are forecast to operate with a v/c ratio of 1.0 or less, including the following two intersections that could not be addressed by Step 3:

- US 97 Bend Parkway Northbound Ramps & Empire Boulevard (new v/c = 0.90)
- Revere Avenue & 3rd Street (new v/c = 0.97)

Step 5: Hours of Congestion

In cases where v/c is forecast to be greater than or equal to 1.0 using the Annual Average Weekday PM Peak as the future design hour, determine the duration of the period during which the future Annual Average Weekday PM Peak hour will have a v/c greater than or equal to 1.0. Establish the proposed alternative target by increasing the number of hours that v/c can be greater than or equal to 1.0. An "hours of congestion" analysis assumes that traffic volumes that exceed capacity in the analysis hour are shifted to the "shoulder' hours, iteratively, until all traffic can be accommodated. The calculation of multi-hour conditions with peak spreading is fairly complex and it can be difficult to achieve consistent results. Also, because only the most congested intersections make it to Step 5 when considering alternative mobility targets, it is often found that over-capacity conditions would be present for several hours of the day (in this case, a preliminary estimate for the US 20 at Empire Boulevard intersection is at least 4 hours), making such a target fairly ineffective.

Because of the difficulty with replicating results and managing the system using such a target, and considering an hours-of-congestion-based target would be needed only at one location, it is not recommended that this approach be applied to establish a new target for the US 20 at Empire Boulevard intersection. Instead, the recommended approach (discussed in more detail below) is to apply the average weekday target of a v/c less than or equal to 0.99 as described in Step 4. While this target could not be met through 2040, it could be met for many years (approximately 10 to 15 years). In the meantime, it is recommended that funding for the capacity improvements needed at this location be prioritized. If funding cannot be committed before the average weekday PM peak-hour travel demand begins to exceed the proposed alternative mobility target, an update to the alternative mobility target can be considered at that time.

Table 13: Intersection Operation in the US 97 Parkway Corridor when Applying the Alternative Mobility Target Methodology (2040 PM Peak Hour)

INT. NO.	INTERSECTION	CONTROL [D]	EXISTING OHP MOBILITY TARGET	STEP 1: *30 HV, W/ RECOMMENDED IMPROVEMENTS*	STEP 2: *30 HV, V/C ≤ 1.0*	STEP 3: *30 HV, PHF=1.0,V/C ≤ 1.0*	STEP 4: *AWD, PHF=1.0,V/C ≤ 1.0*
5	Bend Pkwy SB On-Ramp & Empire Blvd	Signalized [B]	< 0.85	**0.99**	0.99	0.96	0.88
6	Bend Pkwy NB Ramps & Empire Blvd	Signalized	< 0.85	**1.10**	**1.10**	**1.01**	0.90
7	US 20 & Empire Blvd	Signalized	< 0.85	**1.25**	**1.25**	**1.18**	**1.07**
8	US 20 & Butler Market Rd	Signalized	< 0.85	**1.04**	**1.04**	0.94	0.86
9	Bend Pkwy SB Off-Ramp & Butler Market Rd	RAB [B]	< 0.85	0.55	0.55	0.51	0.46
10	Bend Pkwy NB On-Ramp & Butler Market Rd	TWSC	< 0.85 (ramp) < 0.95 (Butler Mkt Rd)	0.11 / 0.13	0.11 / 0.13	0.10 / 0.10	0.08 / 0.08
11	Bend Pkwy SB On-Ramp/Division St & 3rd St	Signalized	< 0.85	**0.88**	0.88	0.74	0.68
12	Bend Pkwy SB Ramps & Revere Ave	Signalized	< 0.85	0.84	0.84	0.80	0.74
13	Bend Pkwy NB Ramps & Revere Ave	Signalized	< 0.85	**0.92**	0.92	0.91	0.81
16	Bend Pkwy SB Ramps & Colorado Ave	Signalized	< 0.85	**0.98**	0.98	0.80	0.72
17	Bend Pkwy NB Ramps & Colorado Ave	Signalized [B]	< 0.85	**0.90**	0.90	0.81	0.70
19	Bend Pkwy SB Ramps & Reed Market Rd	Signalized	< 0.85	**0.89**	0.89	0.74	0.66
20	Bend Pkwy NB Ramps & Reed Market Rd	Signalized [B]	< 0.85	0.80	0.80	0.77	0.66
22	Bend Pkwy SB Ramps & Powers Rd	Signalized [B]	< 0.85	0.81	0.81	0.66	0.58
24	Bend Pkwy NB Ramps & Powers Rd	Signalized [B]	< 0.85	0.70	0.70	0.74	0.68
40	US 20 & O.B. Riley Rd	Signalized	< 0.85	0.82	0.82	0.77	0.71
46	Revere Ave & 3rd St	Signalized	< 0.85	**1.10**	**1.10**	**1.02**	0.97
Study intersections meeting targets				**STEP 1:** 7 / 17	**STEP 2:** 13 / 17	**STEP 3:** 14 / 17	**STEP 4:** 16 / 17

A Signalized intersection volume-to-capacity (v/c) results are reported for the overall intersection. Roundabout (RAB) results are reported for the worst leg. Two-way stop control (TWSC) intersection results are reported for the worst major approach/worst minor.

B Control change due to US 97 Parkway Plan/TSP project.

Bold and Red values indicate a v/c ratio greater than the mobility target at that step.

7.4 RECOMMENDED ALTERNATIVE MOBILITY TARGETS

While the major investments recommended through the US 97 Parkway Plan, and identified as reasonably likely to be funded in the Bend TSP, will result in improved intersection performance on ODOT facilities, not all intersections will be able to meet state v/c mobility targets, and there is a need to consider alternative mobility targets in select locations. Alternative mobility targets can help establish realistic expectations for future system performance and create targets that help the community continue to grow in accordance with its adopted land use plan.

The sections below describe the recommended alternative mobility targets, which have been separated into three categories:

- US 97 interchange ramp terminals
- US 20 (3rd Street) intersections
- Empire Boulevard corridor

Figure 12 at the end of this chapter shows the final recommended targets for study area intersections.

US 97 Interchange Ramp Terminals

Seven US 97 interchange ramp terminal intersections will require alternative mobility targets. However, with the exception of the US 97 northbound ramp terminal at Empire Boulevard, all of these can be accommodated through simple increases in the allowable v/c ratio while continuing to use the 30th highest annual hour of traffic as the basis for analysis. Table 14 lists the new recommended v/c ratio targets. Note, that the US 97 southbound ramp terminal/Division Street at 3rd Street will be treated differently (as described in Section 5.2) and the Empire Boulevard ramp terminals will be treated differently (as described in Section 5.3).

Table 14: Recommended Alternative Mobility Targets for US 97 Interchange Ramp Terminal Intersections [A,B,C]

INTERSECTION	MAXIMUM VOLUME TO CAPACITY RATIO TARGET
US 97 Bend Parkway Northbound Ramps at Colorado Avenue	0.90
US 97 Bend Parkway Southbound Ramps at Reed Market Road	
US 97 Bend Parkway Northbound Ramps at Revere Avenue	0.95
US 97 Bend Parkway Southbound Ramps at Colorado Avenue	0.99

Notes:

[A] The peak hour of analysis for applying these alternative mobility targets shall be the 30th highest annual hour.

[B] In addition to meeting the maximum v/c/ ratio target it shall be demonstrated, with a probability equal to or greater than 95 percent, that vehicle queues would not extend onto the US 97 Parkway mainline or into the portion of the ramp needed to safely accommodate deceleration.

[C] Table 15 shows the alternative mobility target for the US 97 interchange ramp terminal intersections on 3rd Street/Division Street. Table 16 shows alternative mobility targets for the US 97 interchange ramp terminal intersections on Empire Boulevard.

Although an interchange serves both mainline traffic and the crossroad to which it connects, it is important that an interchange be managed to avoid the formation of queues on off-ramps that back up into the portions of the ramps needed for safe deceleration from mainline speeds or onto the mainline itself. Therefore, because these alternative mobility targets will allow for more congestion at the ramp terminals, it is recommended that as an additional requirement queuing analysis is conducted to determine that with a probability equal to or greater than 95 percent, vehicle queues would not extend onto the mainline or into the portion of the ramp needed to safely accommodate deceleration.

US 20 (3rd Street) Intersections

Five intersections along US 20 (3rd Street) will require alternative mobility targets. At the two intersections at Empire Boulevard and Revere Avenue, congestion by 2040 is forecast to be significant and would require conversion to an average weekday-based alternative mobility target. (Additional analysis conducted as part of the Bend TSP found this to be true for the intersection at Greenwood Avenue as well.) While it would not be strictly necessary for all intersections along US 20, it is recommended that the alternative mobility targets for US 20 intersections be based on the annual average weekday PM peak hour rather than the 30th highest annual hour for the following reasons:

- The use of an average weekday-based target would be consistent with City of Bend mobility standards.
- US 20 (3rd Street) in Bend functions more similarly to a city arterial compared to the parkway, with numerous at-grade intersections and driveways, slower travel speeds, and more multimodal activity.
- The three most congested intersections along the US 20 corridor that will ultimately require alternative mobility targets set for average weekday conditions will control corridor operations.
- None of the intersections on US 20 involved are directly connected to a US 97 Parkway off-ramp, so the concern related to long ramp queues creating a safety hazard is not a factor.

Table 15 lists the recommended alternative mobility targets for US 20 (3rd Street) intersections. Note, that the recommended alternative mobility target for the US 20 intersection at Empire Boulevard is discussed separately in Section 5.3. Also of note, the 2040 forecast v/c ratio at the US 20/ Butler Market Road intersection is 0.01 greater than the recommended target. However, considering this is a 20-year estimate, it is reasonable to assume the proposed target will be achievable.

Table 15: Recommended Alternative Mobility Targets for US 20 (3rd Street) Intersections [A,B]

INTERSECTION	MAXIMUM VOLUME TO CAPACITY RATIO TARGET
US 20 (3rd Street) at O.B. Riley Road	0.85
US 20 (3rd Street) at Butler Market Road	
US 97 Bend Parkway Southbound On-Ramp/Division St at 3rd Street	
US 20 (3rd Street) at Revere Avenue	0.99

Notes:

[A] The peak hour of analysis for applying these alternative mobility targets shall be the annual average weekday PM peak hour, using a peak-hour factor of 1.0.

[B] Table 16 shows the alternative mobility target for the US 20 (3rd Street) intersection at Empire Boulevard.

Empire Boulevard Corridor

Empire Boulevard is located near the confluence of US 20 and US 97 in Bend and serves a large amount of regional and local traffic, with unique origin-destination patterns given the current design of US 97. Even after implementing the US 97 North Corridor Phase 1 improvements, travel demand on Empire Boulevard near US 20 and US 97 is forecast to significantly exceed capacity. The North Corridor project has identified improvements that would likely address the mobility issues at this location, but the funding for those improvements is not yet identified. Given the unique traffic patterns, separate alternative mobility targets are recommended at the study intersections within this area.

The intersections along Empire Boulevard at US 20 and the US 97 northbound ramps both require an alternative mobility target based on average weekday conditions. While an alternative mobility target is not necessary for the intersection with the US 97 southbound on-ramp, it is recommended that it be treated the same for consistency and because the more congested operations at the other closely spaced intersections will control corridor operations anyway.

Table 16 lists the new recommended v/c ratio targets. For the US 97 northbound ramp terminal, as with other ramp terminals described in section 5.1, it is recommended that additional queuing analysis be required to determine that, with a probability equal to or greater than 95 percent, vehicle queues would not extend onto the mainline or into the portion of the ramp needed to safely accommodate deceleration.

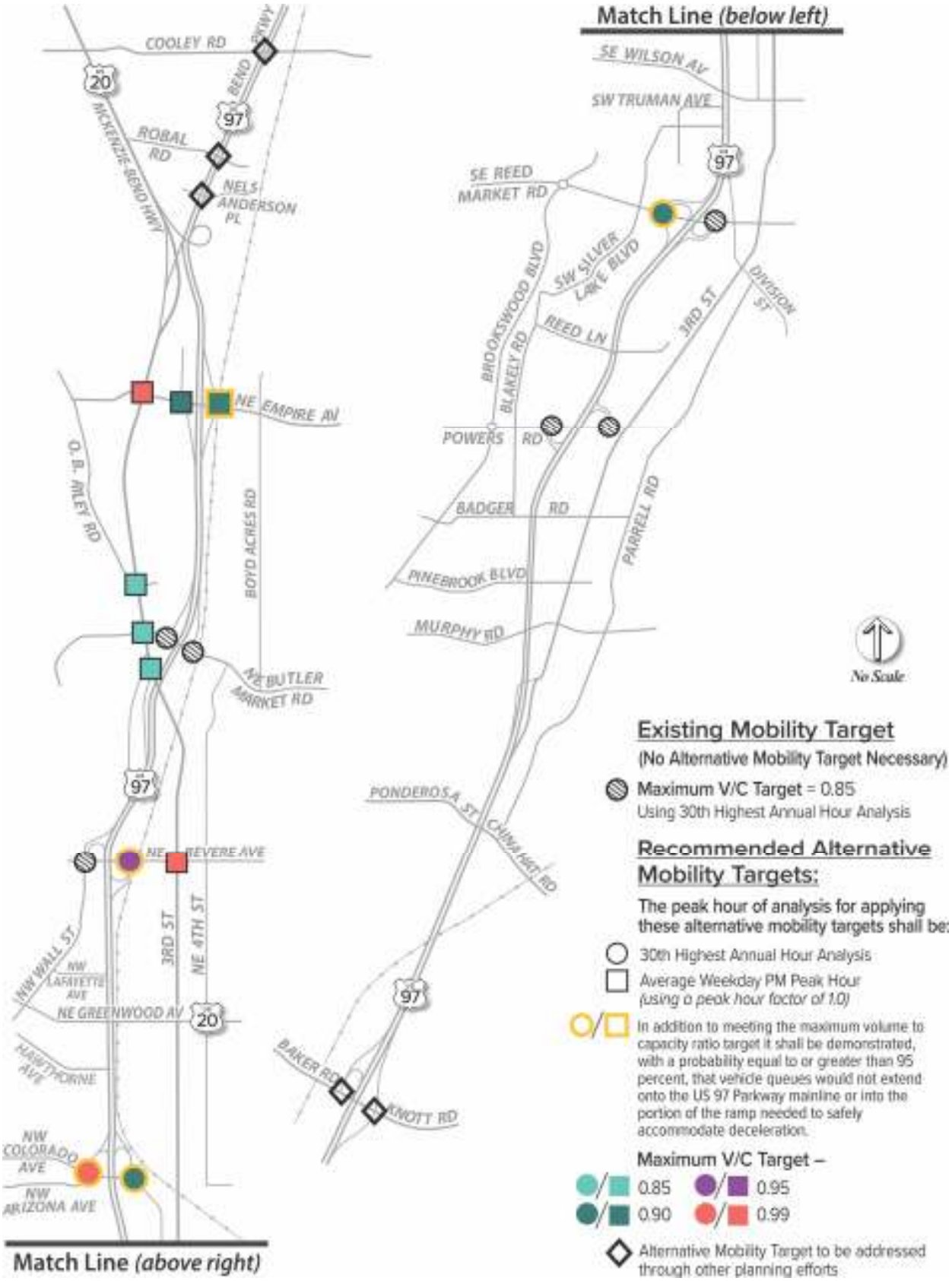
Table 16: Recommended Alternative Mobility Targets for the Empire Boulevard Corridor [A]

INTERSECTION	MAXIMUM VOLUME TO CAPACITY RATIO TARGET
US 97 Bend Parkway Southbound On-Ramp at Empire Boulevard	0.90
US 97 Bend Parkway Northbound Ramps at Empire Boulevard [B]	
US 20 (3rd Street) at Empire Boulevard	0.99

Notes:
[A] The peak hour of analysis for applying these alternative mobility targets shall be the annual average weekday PM peak hour, using a peak-hour factor of 1.0.
[B] In addition to meeting the maximum volume to capacity ratio target it shall be demonstrated, with a probability equal to or greater than 95 percent, that vehicle queues would not extend onto the US 97 Parkway mainline or into the portion of the ramp needed to safely accommodate deceleration.

As noted in Section 4.0, the recommended alternative mobility target for the intersection on US 20 at Empire Boulevard cannot be met through 2040. However, it is expected to be achievable for approximately 10 to 15 years. In the meantime, it is recommended that funding for the capacity improvements needed at this location be prioritized. If funding cannot be committed before the average weekday PM peak-hour travel demand begins to exceed the proposed alternative mobility target, an update to the alternative mobility target can be considered at that time (Figure 12).

Figure 12: US 97 Parkway Corridor Recommended Alternative Mobility Targets



8.0 CONCLUSION

US 97 Parkway Facility Plan provides a roadmap for improvement and management of the US 97 Parkway for the next 20 years. The planning process has included the following:

- Identification of the 20-year project needs
- Public involvement and local government participation at appropriate milestones
- Development and evaluation of project solutions to address the needs
- Proposed project tiers that would establish time frames for implementation based on urgency of the need, interrelation with other projects, phasing, and funding opportunities, among other considerations
- Recommended alternative mobility targets for locations identified as having a need over the next 20 years