Attachment E: Detailed Technical Analysis

Scenario Evaluation Detailed Technical Analysis

PREPARED FOR: Citywide Transportation Advisory Committee
PREPARED BY: DKS Associates
City of Bend Staff
DATE: November 23, 2018

Introduction

The purpose of this memorandum is to document the analysis and findings from a comparative analysis of three aspirational future scenarios for the Bend Transportation System Plan (TSP) and Bend Metropolitan Planning Organization (MPO) Transportation Plan. The findings learned from this analysis will be used to guide the development of a hybrid scenario representing a Citywide framework for the Bend transportation network. The Citywide framework represents the regionally significant facilities (e.g., arterial and collector level corridors) that serve mobility needs throughout the City of Bend (area within the urban growth boundary) and Bend MPO area (area within the MPO boundary).

The document is organized into three overall topics: defining the scenarios and the evaluation tools, scenario evaluation, and findings and recommendations.

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Defining Scenarios and Evaluation Tools

The following sections describe the context that was used to help develop the scenarios, the measures and tools that were used to evaluate them and describes the scenarios themselves.

Legal and Planning Guideline Context

The key State of Oregon regulatory drivers for the scenario evaluation portion of this planning process are described in Oregon Administration Rule (OAR) 660-012-035.[1] The rule requires the evaluation of scenarios to consider the following as components of system alternatives:

- Improvements to existing facilities or services
- New facilities or services, including different modes or combinations of modes that could reasonably meet identified transportation needs
- Transportation system management measures
- Demand management measures
- A no-build alternative

These components have been included in the scenarios evaluated in the document, as described in the following sections. OAR 660-012-035 also includes a performance measure requirement for transportation plans within MPOs for reducing vehicle miles travelled (VMT) per capita, aimed at achieving the goal of increasing transportation choices and reducing reliance on automobile trips. The City of Bend addressed the VMT per capita requirement in the adopted Integrated Land Use and Transportation Plan (ILUTP, 2016), which includes strategies, programs, and measures that are integrated into this scenario evaluation. VMT per capita is included as a performance measure in the scenario evaluation.

In addition to State of Oregon planning requirements, there are Federal requirements for Performance Measures that the Bend MPO must address as part of this scenario evaluation for the Metropolitan Transportation Plan (MTP). These requirements are described in Chapter 23 of the Federal Register, part 490.[2] The Performance Measures in the Federal requirements includes measures for on-going system monitoring/reporting as well as scenario evaluation, so those relevant for this scenario evaluation process were identified.

Plan Goals and Corresponding Performance Measures

The Citywide Transportation Advisory Committee (CTAC) and the Steering Committee approved seven draft goals that provide guidance for shaping the Citywide transportation framework. In addition, CTAC recommended and the Steering Committee approved Performance Measures to help understand how different transportation scenarios could meet those Goals.

[1] Land Conservation and Development Department Chapter 660 Division 12 Transportation Planning, accessed on November 9, 2018.

[2] National Performance Management Measures; Assessing Performance of the National Highway System, Freight Movement on the Interstate System, and Congestion Mitigation and Air Quality Improvement Program, access on November 9, 2018.

Goal 1: Increase System Capacity, Quality and Connectivity for All Users

- Demand-to-Capacity Ratio
- Sidewalk System Completeness
- Bicycle System Level of Traffic Stress
- Completeness of Low-Stress Network

Goal 2: Ensure Safety for All Users

- Qualitative Assessment of Predicted Crashes

Goal 3: –Facilitate Housing Supply, Job Creating, and Economic Development to Meet Demand/Growth

- Vehicle Hours of Delay
- Peak Hour VMT on Rural Facilities
- Travel Time Reliability

Goal 4: Protect Livability and Ensure Equity and Access

- Transportation Equity
- Transit Accessibility for Vulnerable Populations
- Employment Accessibility
- Percent of Collector Roads with an average daily traffic (ADT) above 4,000 vehicles

Goal 5: Steward the Environment

- Vehicle Miles Traveled Per Capita

Goal 6: Have a Regional Outlook and Future Focus

- Arterial Roadway Miles with Demand-to-Capacity Ratio Deficiencies
- Potential for Alternative Funding
- Mode Split

Goal 7: Implement a Comprehensive Funding and Implementation Plan

- Cost
- Roadway Lane Miles

Evaluation Tools

The evaluations described in this memorandum were completed using the following tools:

- **ArcGIS mapping software.** This tool was used to provide mapping resources, including identifying key pedestrian and bicycle facilities, manage data inputs into other key evaluation tools, and create map figures for presentation.
  - *Tool Strengths:* spatial analysis for quantifying the amounts of different facility types and understanding the proximity relationships between transportation facilities and land use.
  - *Tool Limitations:* does not predict use of transportation facilities or the operational performance of those facilities.
- **Bend-Redmond Regional Travel Demand Model**. This tool is used to forecast future transportation growth and needs in Bend for the year 2040. The project team coordinated with Bend MPO staff and the Oregon Department of Transportation's (ODOT's) Transportation Planning Analysis Unit, who manages the model, to prepare model scenarios

that could be used to measure transportation system impacts for each growth configuration. Key assumptions used in the transportation modeling:

- *Tool Strengths:* links land use and the transportation network to forecast/predict how much people will travel, by which mode, and by which route, including sensitivity to system operational factors such as travel time due to congestion and pricing strategies.
- *Tool Limitations:* focuses on Citywide or regional mobility, so does not integrate some local street level facilities, the nuances of intersection controls or crossing limitations and their effect on routes people may take to avoid congestion, or the differences between the qualities of various pedestrian or bicycle facilities (limiting mode-split evaluation for walking and biking). This tool predicts what people will do based on current behavior, which is uncertain when considering 20-year timeframes. Travel patterns and modes are changing because of technology. With new mobility solutions and autonomous vehicles on the horizon, it is difficult to exactly predict what mobility will look like many years from now and account for this change in any currently available model for the Bend area.

- **Conveyal Analysis Tool.** An open-source software tool developed by Conveyal[3] was utilized for accessibility analysis. It uses land use data and transportation networks to determine what can be reached from a given point in the transportation network based on different modes of travel. A summary of key assumptions for this tool are included under Goal 4: Protect Livability and Ensure Equity and Access.
  - *Tool Strengths:* considers more refined details of route completeness to determine how far people can reasonably travel to reach a destination.
  - *Tool Limitations:* does not predict travel demand or facility usage and is not sensitive to varying levels of congestion in determining the distance a person can travel.

Key Travel Demand Model Assumptions

The Bend-Redmond Regional Travel Demand Model is a tool that utilizes an evaluation of supply (the transportation network) and demand (trip making generated from land use) to forecast the movement of people throughout the City. The model provides outputs that help assess network performance such as roadway volume and congestion at a regional scale, meaning that the network is limited primarily to arterials and collectors, not local streets. The regional modeling process includes an iterative feedback loop linking forecasted congestion (where motor vehicle demand is reaching and possibly exceeding facility capacities) to mode-choice and trip-distribution, which helps estimate when transportation network improvements can result in an increased number motor vehicle trips (also known as “induced demand”). However, note that in a regional area the size of Bend, induced demand effects tend to be limited compared to large regional areas like Los Angeles, California, or Seattle, Washington, where congestion lasting many hours of the day significantly alters how people choose to travel.

Key inputs developed for the travel demand model evaluation, as described in the following sub-sections, include land use, transit service, regional growth, and transportation network.

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[3] Visit www.conveyal.com for more information

Land Use

The land use inputs are aggregations of population and employment in transportation analysis zones for all areas in the Bend MPO boundary. Population and the corresponding demographic data is represented by the number of households, their size, income level, and the average age of the head of household. In 2040, the projected population in Bend is 143,600 and the projected employment is 81,000. The methodology for population, employment and land use assumptions are documented in the Proposed Land Use Assumptions for Bend's Transportation Plan Technical Memorandum.[4]

Transit Service

The public transit system routes and frequency are an important factor for determining mode-split in the travel forecasts. The baseline public transit system in 2040 was based off the transit system from the Integrated Land Use and Transportation Plan.[5]

Regional Growth

The Bend Redmond Regional Travel Demand Model includes roadways and traffic volumes that enter/exit the Bend urban area via major roadways such as US 97 and US 20. Traffic growth on these corridors considers regional growth (i.e., growth in surrounding cities or other parts of the state) that would travel to or through Bend. The Bend Redmond 2040 model was estimated by a newer technique that integrates with the statewide travel demand model (developed and managed by ODOT) to enhance predictions of growth on major regional corridors.

Transportation Network

The travel demand model transportation network for the scenarios was based on the existing MTP financially constrained planned improvements. This is a subset of the City, County, and State planned improvements that is reasonably likely to be constructed, given anticipated funding sources. Current 5-year Capital Improvement Program (CIP) and improvements required from the 2016 Bend Urban Growth Boundary expansion were also included as a baseline assumption. Specific projects in the Baseline are discussed in the following sections.

Key Conveyal Analysis Tool Assumptions

The Conveyal Analysis Tool was used to analyze accessibility within Bend, using a 100- by 100-meter grid. To evaluate accessibility across the whole community, the Conveyal Analysis Tool utilized key inputs including land use, transit service and the transportation network.

Land Use

Land use data developed for the City of Bend's 2016 Urban Growth Boundary expansion was utilized. This data contained 2040 estimates of employment and population for each land parcel. It was calculated using Envision Tomorrow and was updated to include the proposed future land use assumption forecast totals described to CTAC and approved by the Steering Committee.[6]

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[4] Proposed Land Use Assumptions for Bend's Transportation Plan, February 12, 2018.

[5] Integrated Land Use and Transportation Plan. 2016.

[6] Proposed Land Use Assumptions for Bend's Transportation Plan, February 2018.

Transit Service

The baseline transit network used bus stops, routes, and schedules that existed as of October 6, 2018. The data were prepared in General Transit Feed Specification (GTFS) format by Trillium Solutions on behalf of Cascades East Transit. For future scenarios, additional bus routes, mobility hubs, and higher frequencies for certain routes were coded into the GTFS, according to the projects identified by CTAC.

Transportation Network

The baseline roadway network was based on the current network as well as assumptions from the MTP Financially Constrained Projects, the 2016 TSP projects for UGB expansion areas, the City of Bend five-year CIP projects, and the City of Bend CIP Citywide Safety Improvement project. Routable GIS data for this road network was taken from OpenStreetMap,[7] which was updated to reflect Deschutes County's roadway data, with additional links added for assumed future projects, as described previously .

The baseline bicycle network used the baseline roadway network, bike paths and multiuse trails (sourced from Bend Park and Recreation District's GIS data as well as OpenStreetMap), and data regarding the Level of Traffic Stress (LTS) of each roadway linkage.[8] The baseline pedestrian network used the baseline roadway network, pedestrian paths and multiuse trails (sourced from Bend Park and Recreation District's GIS data as well as aerial imagery and OpenStreetMap), and data regarding sidewalk completeness.

Baseline: MTP and CIP

This Baseline serves as a comparative condition for the analysis. The projects included in this Baseline are mapped in Figures 1 through 3 and summarized in Table 1.

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[7] www.OpenStreetMap.com

[8] The LTS analysis from the Existing Conditions Technical Memorandum was updated to reflect changes to the baseline transportation system and for each scenario.

Figure 1: Baseline (Bend MTP Financially Constrained and CIP) Projects

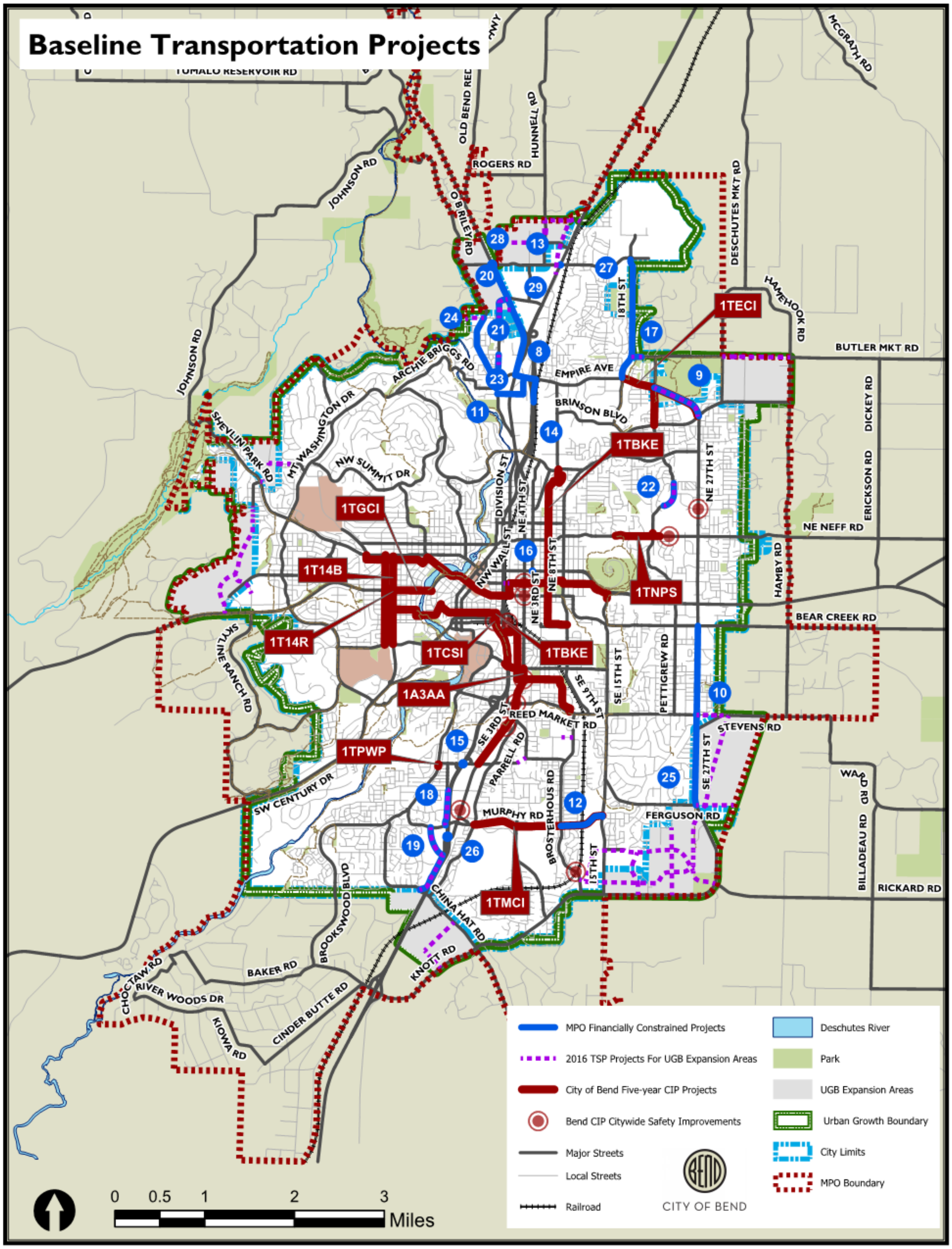

Figure 2: Baseline (Bend Urban Area Transportation Systems Plan Rural Road Network Upgrade) Projects

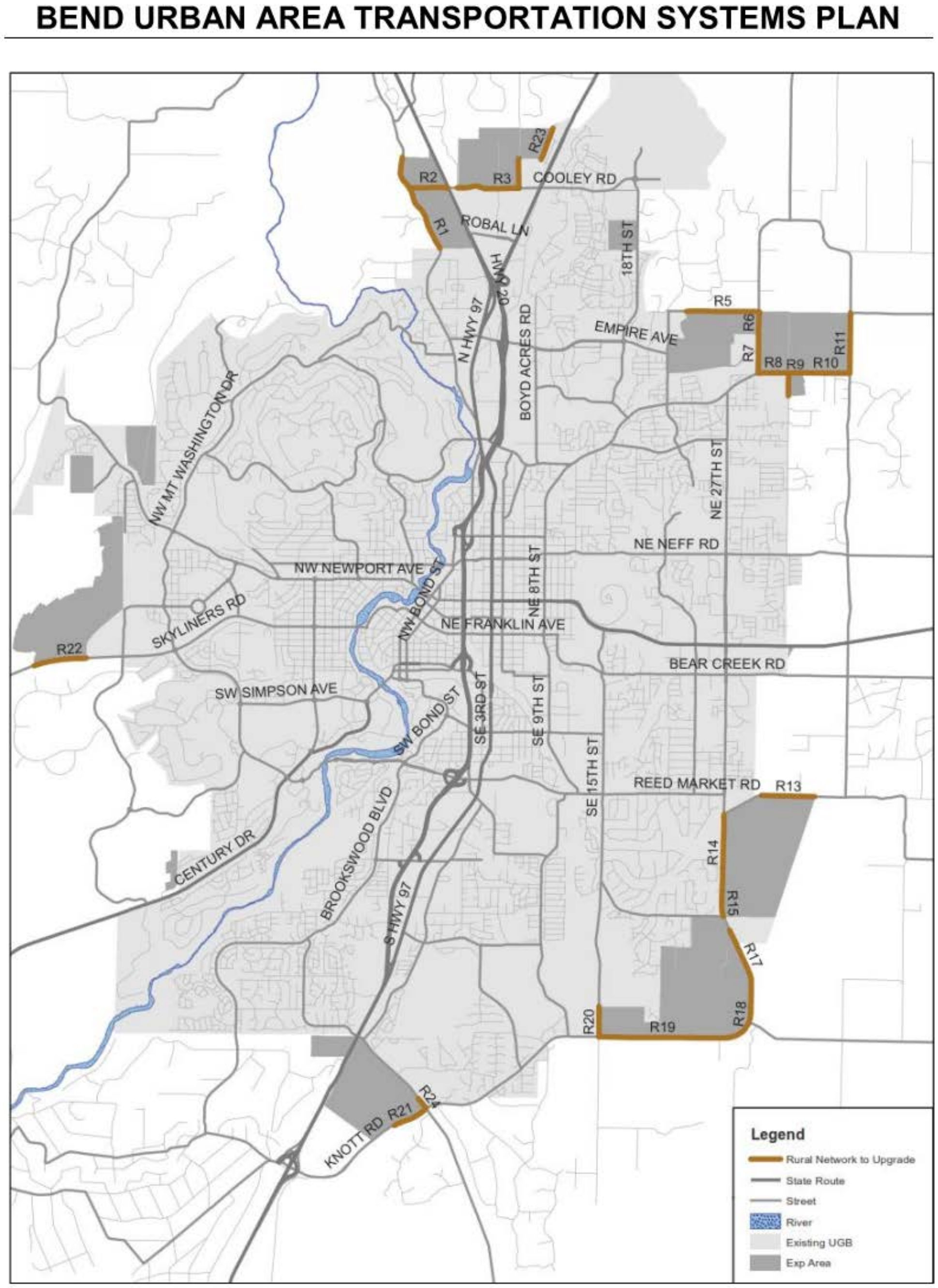

Figure 3: Baseline (Bend Urban Area Transportation Systems Plan New Roadway, Corridor and Intersection) Projects

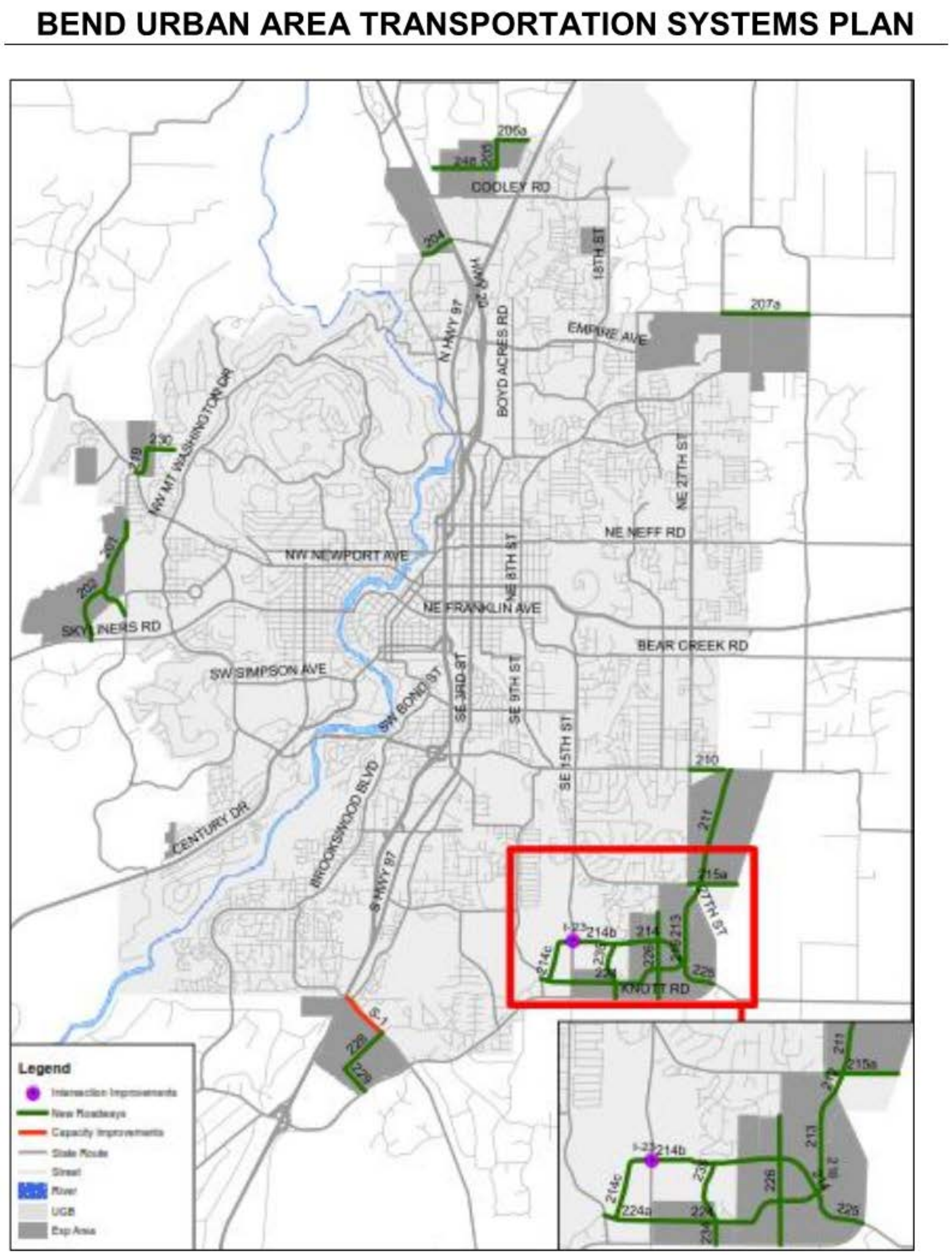

Table 1: Baseline (Financially Constrained) Project List

NUMBER	PROJECT	SOURCE
8	Empire Avenue: Widen to 5 lanes and install signal at Southbound ramps	Bend MTP Financially Constrained Projects
9	Empire Avenue: Construct 2-lane extension	Bend MTP Financially Constrained Projects
10	Realign Stevens Road to connect directly to Reed Market Road	Bend MTP Financially Constrained Projects
11	O.B. Riley Road: Construct intersection control improvements	Bend MTP Financially Constrained Projects
12	Murphy Road: Construct 2-lane extension	Bend MTP Financially Constrained Projects
13	US 97/Cooley Road area intersection and lane upgrade improvements	Bend MTP Financially Constrained Projects
14	Empire Ave: Widen existing ramp to 2 lanes	Bend MTP Financially Constrained Projects
15	US 97 Preliminary engineering and right-of-way acquisition for overcrossing or interchange	Bend MTP Financially Constrained Projects
17	Yeoman Road: Construct 2-lane extension	Bend MTP Financially Constrained Projects
18	New 2-lane north frontage road	Bend MTP Financially Constrained Projects
19	New 2-lane south frontage road	Bend MTP Financially Constrained Projects
20	Britta Street (north section): 2-lane road extension	Bend MTP Financially Constrained Projects
21	Britta Street: New 2-lane road extension	Bend MTP Financially Constrained Projects
22	Purcell Boulevard: New 2 lane road extension	Bend MTP Financially Constrained Projects
23	Mervin Samples Road to Sherman Road: Upgrade to 2-lane collector roadway and install traffic signal at US 20	Bend MTP Financially Constrained Projects
24	O.B. Riley Road: Upgrade to 3-lane arterial	Bend MTP Financially Constrained Projects
25	27th Street: Upgrade to 3-lane arterial	Bend MTP Financially Constrained Projects
26	US 97: Construct northbound on-ramps and southbound off-ramps	Bend MTP Financially Constrained Projects
27	18th Street: Complete 3-lane arterial corridor	Bend MTP Financially Constrained Projects
28	US 20: Construct intersection control improvements	Bend MTP Financially Constrained Projects
29	Add second southbound through lane on US 20	Bend MTP Financially Constrained Projects
1TMCI	Murphy Corridor Improvements	City of Bend Five-year CIP Projects
1TECI	Empire Corridor Improvements	City of Bend 2018-2023 CIP Projects
1TBKE	Bicycle Greenways	City of Bend 2018-2023 CIP Projects
1A3AA	South 3rd Street Pedestrian Improvements	City of Bend 2018-2023 CIP Projects
1TNPS	Neff and Purcell Intersection (Formerly Neff and Purcell Sidewalk)	City of Bend 2018-2023 CIP Projects
1TPWP	Powers and Brookswood Roundabout Phase II	City of Bend 2018-2023 CIP Projects
1TGCI	Galveston Corridor Improvements	City of Bend 2018-2023 CIP Projects
1T14B	14th Street Reconstruction Schedule B	City of Bend 2018-2023 CIP Projects

NUMBER	PROJECT	SOURCE
1T14R	14th Street Reconstruction	City of Bend 2018-2023 CIP Projects
1TCSI	Citywide Safety Improvements	City of Bend 2018-2023 CIP Projects
R1	O.B. Riley Road: Curb and sidewalk on east side, bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R2	Cooley Road: Curbs, sidewalks and bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R3	Cooley Road: Curbs and sidewalk on north side, bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R4	Hunnell Road: Sidewalk on west side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R5	Yeoman Road: Curbs, sidewalks and bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R6	Deschutes Market Road: Curb and sidewalk on east side, bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R7	Deschutes Market Road: Curb and sidewalk on east side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R8	Butler Market Road: Curb and sidewalk on north side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R9	Butler Market Road: Curbs, sidewalks and bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R10	Butler Market Road: Curb and sidewalk on north side, bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R11	Butler Market Road: Curbs and sidewalks on both sides	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R12	Eagle Road: Curb, sidewalk, and bike lane on east side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R13	Stevens Road: Curbs, sidewalks, and bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R14	Southeast 27th Street: Curb, sidewalk, and bike lane on east side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R15	Southeast 27th Street: Curb and sidewalk on east side, bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R16	Southeast 27th Street: Curb and sidewalk on east side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R17	Southeast 27th Street: Curb and sidewalk on both sides	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R18	Southeast 27th Street: Curbs, sidewalks, and bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R19	Knott Road: Curbs, sidewalks, and bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R20	15th Street: Curb and sidewalk on east side, bike lanes both directions	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R21	Knott Road: Curb and sidewalk on north side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R22	Skyliners Road: Curb and sidewalk on north side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades

NUMBER	PROJECT	SOURCE
R23	Clausen Drive: Sidewalk on west side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R24	China Hat Road: Sidewalks on both sides	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R25	China Hat Road: Widen bridge to include sidewalks on both sides	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
R26	Deschutes Market Road: Widen bridge to include sidewalk on west side	Bend Urban Area Transportation Systems Plan, Rural Road Network Upgrades
201	Skyline Ranch Road Extension	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
202	Crossing Drive Extension	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
204	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
205	Hunnell Road Extension	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
206A	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
207A	Yeoman Road Extension	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
210	New collector roadway to Stevens	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
211	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
212	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
213	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
214	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
214B	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
214C	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections

NUMBER	PROJECT	SOURCE
215A	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
216	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
219	Skyline Ranch Road	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
224	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
224A	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
225	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
226	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
228	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
229	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
230	New collector roadway	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
234	Raintree Court Extension	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
235	Raintree Court Extension North	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
248	Loco Road Extension	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
S-1	Corridor improvement, China Hat, widen from 2 to 3 lanes	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections
I-23	Roundabout at Murphy Road/Southeast 15th Street	Bend Urban Area Transportation Systems Plan, New Roadway, Corridor, and Intersections

Scenarios for Evaluation

Several options for addressing future needs and shaping the BMPO area were discussed, ranging from improving safety, to creating vibrant centers, to adding regional corridor capacity. Each scenario tests a different investment strategy. The scenarios were constructed to learn which types or combinations of projects and programs could potentially meet the needs of the community in 2040.

Scenario A: Build New Corridors

Scenario B: Widen and Enhance Existing Corridors

Scenario C: Maximize the Existing Transportation System

All three scenarios include the Baseline (current City of Bend 5-year CIP projects and MTP financially-constrained projects[9]). Additional “aspirational” projects or programs (projects or programs without identified funding based on current revenue projections) were added to each scenario, based on the theme. All scenarios were analyzed with a future year of 2040. For scenario comparison, the Baseline Projects were also evaluated. The three scenarios are discussed in further detail in the following sections.

Scenario A: Build New Corridors

The Scenario A theme focuses on building new corridors to improve connectivity. This scenario includes a new river crossing at Powers Road, the improvements from the US 97 North Parkway Extension Final Environmental Impact Statement (FEIS),[10] and several pedestrian and bicycle projects. The projects included in this scenario are shown in Figure 4 and summarized in Table 2.

[9] Projects on the Transportation System Development Charge (TSDC) project list were not included in the baseline. This is because their construction depends on development. In addition, the recent TSDC project cost update means that the current TSDC fee would not generate enough revenue to fully fund the TSDC project list. Therefore, it isn’t possible at this time to determine which projects would be built.

[10] U.S. 97: Bend North Corridor Planning Phase. Planning study to improve the safety of U.S. 97 north of Bend.

Figure 4: Scenario A (Build New Corridors) Projects

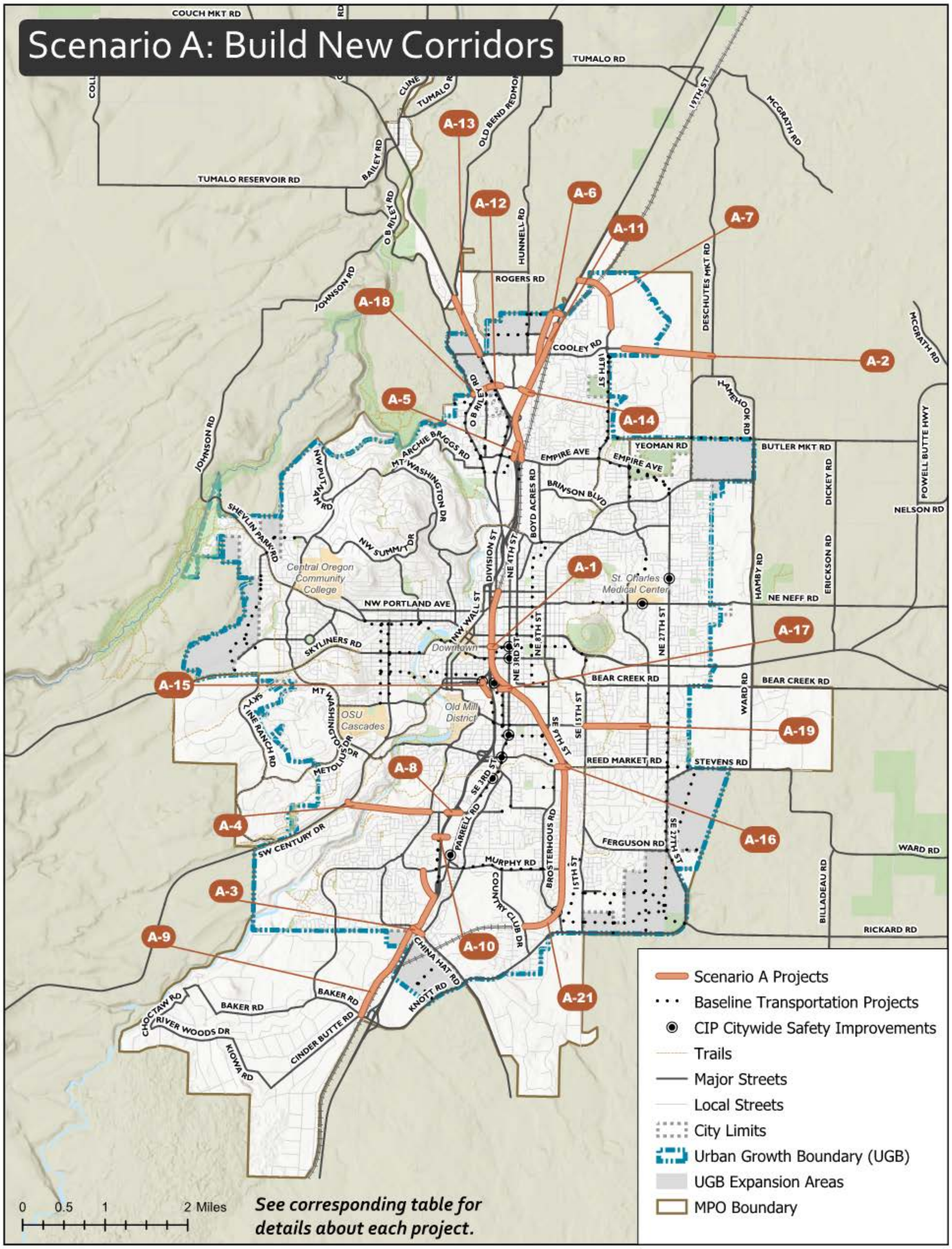

Table 2: Scenario A (Build New Corridors) Project List

NUMBER	PROJECT	NEED
A-1	Hawthorne Avenue Grade-separated Crossing at US 97/Railroad	Barriers for bicyclists and pedestrians through central Bend
A-2	Cooley Road Extension (between 18th St and Deschutes Market Rd)	East-West Corridor Congestion
A-3	Ponderosa Street/China Hat Road Overcrossing of US 97	East-West Corridor Congestion
A-4	Powers River Crossing (between Century Drive and US 97), note that the Scenic River Boundary is approximately 1 mile north of the southern UGB limits	East-West Corridor Congestion
A-5	US 97/Empire Avenue Southbound off-ramp	US 97 Corridor Capacity/Safety (Empire to Cooley)
A-6	US 97 North Parkway Extension (from Grandview Drive to US 97), including all improvements in the FEIS	US 97 Corridor Capacity/Safety (Empire to Cooley)
A-7	US 97 North Interchange with connection to 18th Street	US 97 Corridor Capacity/Safety (Empire to Cooley)
A-8	Powers Road/US 97 Interchange	US 97 Corridor Capacity/Safety (Murphy to Empire)
A-9	US 97/Murphy Road Frontage Road	US 97 Corridor Capacity/Safety (Murphy to Empire)
A-10	US 97 Pedestrian Overcrossing at Badger Road	US 97 Corridor Capacity/Safety (Murphy to Empire)
A-11	3rd Street Multi-Use Path (between Empire Avenue and Grandview Drive)	US 97-Hwy 20 Triangle Pedestrian and Bicyclist Access
A-12	Pedestrian/Bicycle Overcrossing of US 20 near Robal Road	US 97-Hwy 20 Triangle Pedestrian and Bicyclist Access
A-13	US 20 Multi-Use Path (between Cooley Road and Old Bend-Redmond Highway)	US 97-Hwy 20 Triangle Pedestrian and Bicyclist Access
A-14	Pedestrian/Bicycle Overcrossing of US 97 near Robal Road	US 97-Hwy 20 Triangle Pedestrian and Bicyclist Access
A-15	Trail connection from Colorado Avenue towards Division Street	Colorado Interchange Area Capacity and Ped/Bike Access
A-16	Reed Market Road Railroad Overcrossing	Reed Market Congestion and Safe Crossings (4th to 27th)
A-17	Aune Road extension to 3rd Street	Colorado Interchange Area Capacity and Ped/Bike Access
A-19	Extend Wilson from 15th to Pettigrew	East Connectivity
A-21	Grade separate rail crossings at Revere, Wilson, Reed Market, Country Club	East-West Corridor Congestion

Scenario B: Widen and Enhance Existing Corridors

The Scenario B theme focuses on using a variety of improvements to widen and enhance existing corridors increase capacity. Some of the widening projects in this scenario include Reed Market Road, Empire Boulevard, Butler Market Road, 27th Street, and Knott Road. All widening projects are assumed to include pedestrian and bicycle facilities, including protected bicycle facilities where appropriate. The projects included in this scenario are shown in Figure 5 and summarized in Table 4.

Figure 5: Scenario B (Widen and Enhance Existing Corridors) Projects

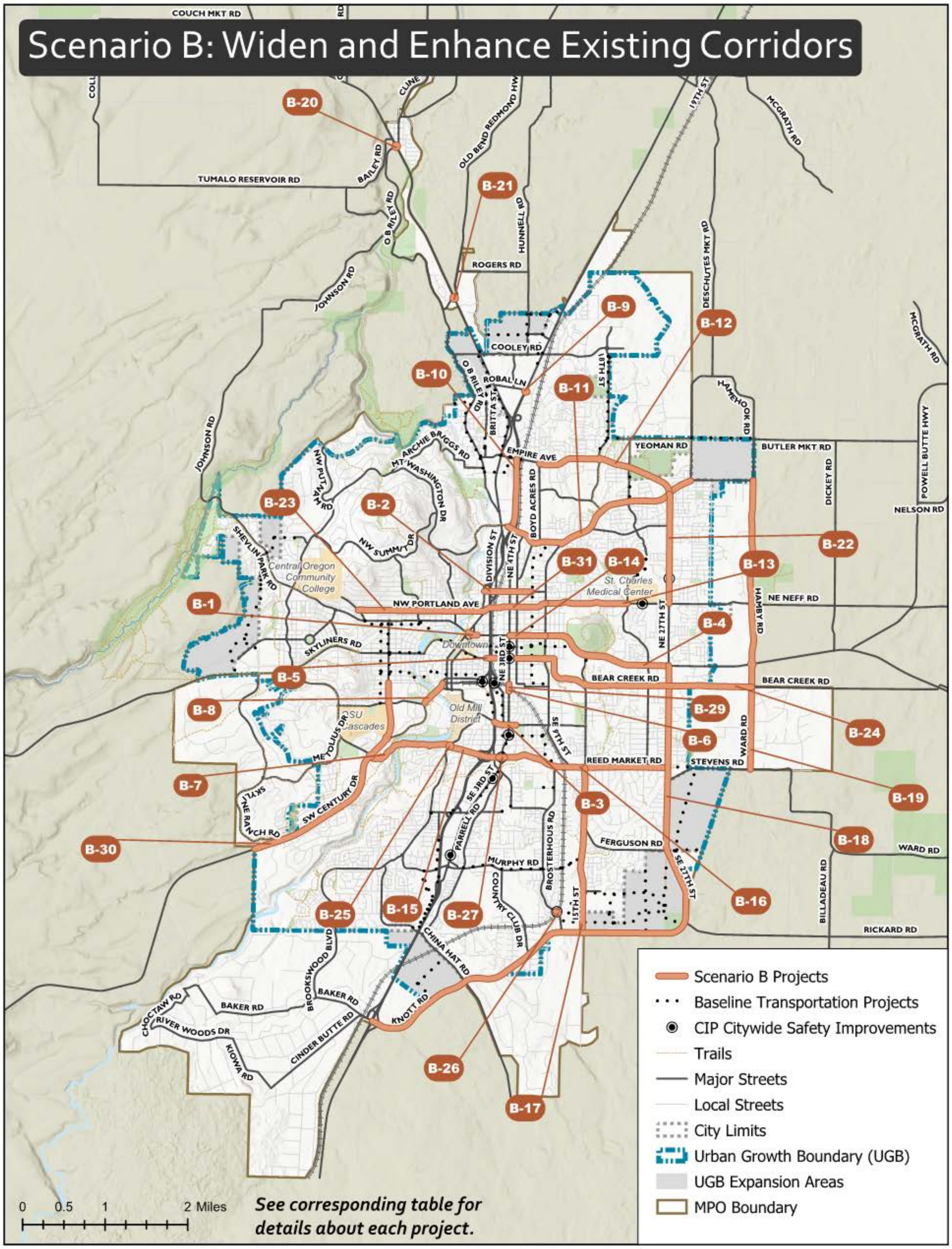

Table 3: Scenario B (Widen and Enhance Existing Corridors) Project List

NUMBER	PROJECT	NEED
B-1	Greenwood Ave protected bicycle facilities (between Wall St and Hill St)	Barriers for bicyclists and pedestrians through central Bend
B-2	Revere Ave bicycle facilities (between Wall St and 6th St)	Barriers for bicyclists and pedestrians through central Bend
B-3	Wilson Ave protected bicycle facilities (between 4th St and US 97)	Barriers for bicyclists and pedestrians through central Bend
B-4	US 20 protected bicycle facilities (from 3rd Street to 27th Street)	Barriers for bicyclists and pedestrians through central Bend
B-5	Protected bicycle undercrossing of US 97 at Franklin Avenue	Barriers for bicyclists and pedestrians through central Bend
B-6	Protected bicycle undercrossing of railroad at 3rd St	Barriers for bicyclists and pedestrians through central Bend
B-7	Reed Market Road widening (from Century Drive to Bond Street)	East-west Corridor Congestion
B-8	Colorado Ave widening (from Simpson Ave to Arizona Ave)	East-west Corridor Congestion
B-9	US 97/Robal Road intersection capacity improvements	US 97 Corridor Capacity/Safety (Empire Boulevard to Cooley Road)
B-10	US 97 southbound auxiliary lane (from Empire Boulevard to Butler Market Road)	US 97 Corridor Capacity/Safety (Murphy to Empire Boulevard)
B-11	Butler Market Road widening (from US 97 to Deschutes Market Road) with roundabout at Wells Acre Road	Butler Market Corridor Capacity and Safety Needs (US 97 to 27th)
B-12	Empire Boulevard widening (from Boyd Acres Road to Butler Market Road)	Butler Market Corridor Capacity and Safety Needs (US 97 to 27th)
B-13	Neff Road protected bicycle facilities and enhanced crossings (from 8th Street to Purcell Boulevard	Neff Corridor Safety (8th to Purcell)
B-14	Greenwood Ave enhanced crossings (from 3rd Street to 8th Street)	Greenwood Corridor Pedestrian/Bicyclist Safety)
B-15	Reed Market Road widening and enhanced pedestrian and bicyclist facilities (from Bond Street to 3rd Street)	Reed Market Congestion (Bond to 4th)
B-16	Reed Market Road widening and enhanced pedestrian and bicyclist facilities (from 3rd St to 27th St)	Reed Market Congestion and Safe Crossings (4th to 27th)
B-17	Corridor Improvements to 15th St between US 20 and Knott Road, including protected bike/pedestrian facilities and roundabouts at key intersections	15th St Capacity and Safety at major intersections (Knott Road to Wilson)

NUMBER	PROJECT	NEED
B-18	27th Street/Knott Road widening to 5 lanes (from US 97 to US 20)	15th Street Capacity and Safety at major intersections (Knott to Wilson), East-West Corridor Congestion
B-19	Hamby Road widening (from Stevens Road to Butler Market Road), including a roundabout at US 20	27th Street/US 20 and Hamby/US 20 Capacity and Safety
B-20	US 20 roundabout at Cook/Tumalo	US 20 West Rural Crossing Capacity and Safety
B-21	US 20 roundabout at Old Bend-Redmond Highway	US 20 West Rural Crossing Capacity and Safety
B-22	27th Street widening (from Neff Road to Butler Market Road)	27th Street capacity
B-23	Portland Ave intersection improvements	Congestion and traffic operations
B-24	Protected bicycle facility on Bear Creek Road	Safety and capacity
B-25	Widen Bond/Reed Market roundabout (partial two lane)	Bond/Reed Mkt roundabout capacity
B-26	Widen railroad undercrossing on Brosterhous	Bicycle and pedestrian access on Brosterhous
B-27	Provide dedicated left turn lanes on Reed Market at 3rd Street, possibly through widening or a road diet	Capacity on Reed Market Road
B-29	Widen 3rd Street to 4 lanes under the railroad, including complete street design	3rd Street Capacity (Greenwood to Wilson)
B-30	Protected bike/pedestrian routes on Century Drive	Safety and Capacity
B-31	Portland Ave-Olney Ave protected bicycle facilities (College Way to 8th Street)	Barriers for bicyclists and pedestrians through central Bend

Scenario C: Maximize the Existing Transportation System

The Scenario C theme focuses on using a variety of improvements to maximize the efficiency of the existing transportation system. These include mobility hubs at key locations along transit lines, high capacity transit routes, demand management and access management tools, and implementing new signal technologies. The projects included in this scenario are shown in Figure 6 and summarized in Tables 4A and 4B.

Figure 6: Scenario C (Maximize the Existing Transportation Systems) Projects

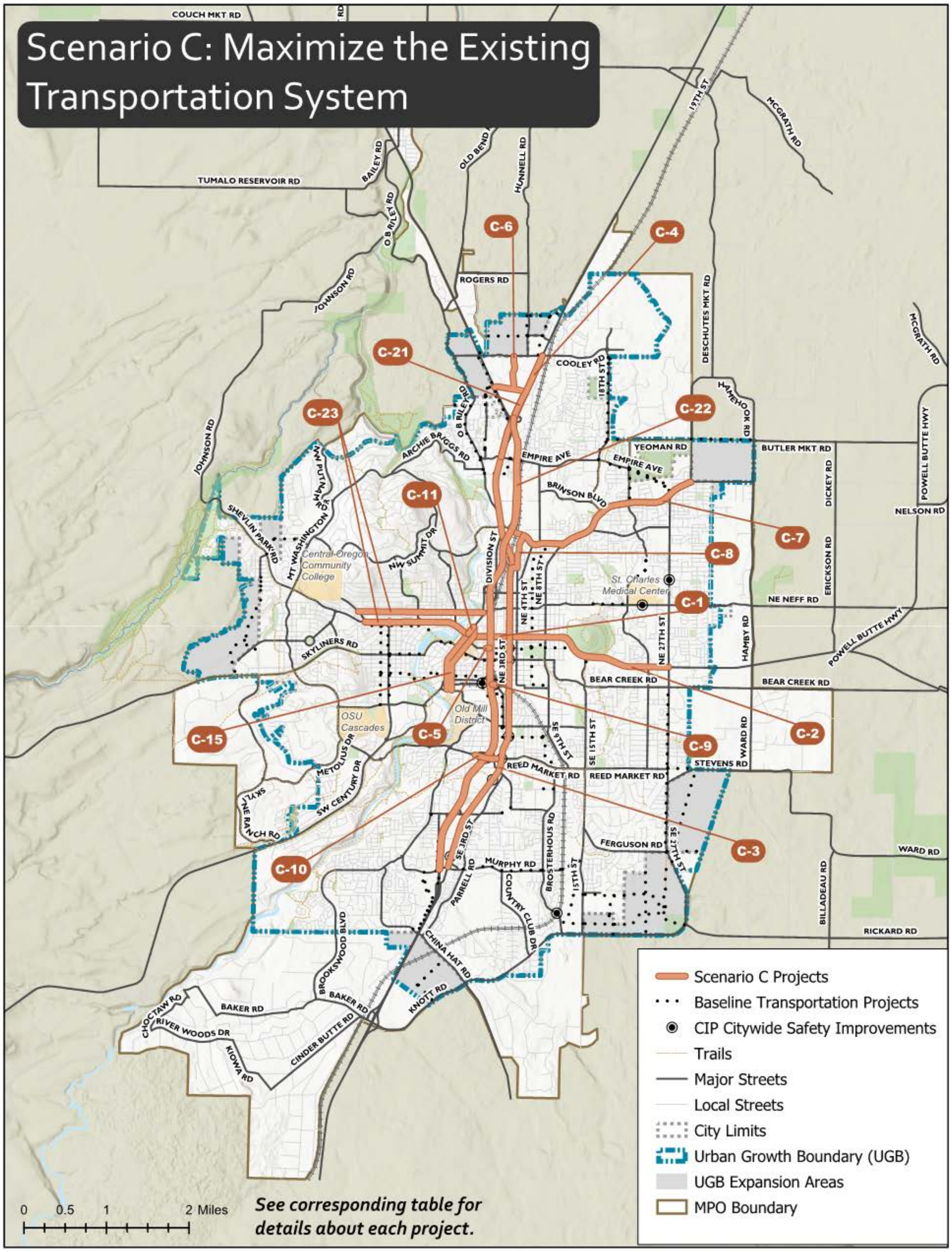

Table 4A: Scenario C (Maximize the Existing Transportation Systems) Project List

NUMBER	PROJECT	NEED
C-1	Greenwood Avenue road diet (from Bond Street to 3rd Street)	Barriers for bicyclists and pedestrians through central Bend
C-2	High-capacity transit on the Newport-Greenwood corridor, with mobility hubs at COCC, downtown, and St. Charles, including improved transit connections from neighborhoods to high capacity transit stops	East-West Corridor Congestion
C-3	3rd Street high-capacity transit with mobility hubs near Robal Road, downtown Bend, and Murphy Road	US 97 Corridor Capacity/Safety (Empire Boulevard to Cooley Road)
C-4	US 97 access management (from Cooley Road to US 20)	US 97 Corridor Capacity/Safety (Empire Boulevard to Cooley Road)
C-5	US 97 access at Hawthorne Ave closure	US 97 Corridor Capacity/Safety (Murphy Road to Empire Boulevard)
C-6	Enhance bicycle and pedestrian facilities: Robal and Hunnel corridor	US 97 - US 20 Triangle Ped/Bike Access
C-7	Butler Market Road intersection capacity improvements	Butler Market Corridor Capacity and Safety Needs (US 97 to 27th)
C-8	Implement transit service options along Butler Market from downtown into the Northeast UGB expansion area	Butler Market Corridor Capacity and Safety Needs (US 97 to 27th)
C-9	US 97 northbound/Colorado Avenue traffic signal	Colorado Interchange Area Capacity and Pedestrian/Bike Access
C-10	Reduce turn movements at the Reed Market Road/US 97 northbound ramps	Reed Market Congestion and Safety (Bond to 4th)
C-11	Convert Wall St to a southbound one-way between Bond and Newport with free right-turn at Wall/Bond and roundabout at Wall and Lafayette*	Congestion and traffic operations
C-15	Road diet on Wall and Bond with parking protected bicycle facilities	Bike access to downtown
C-21	Traffic signal priority for freight and transit at signalized intersections on US 97	US 97 Corridor Capacity/Safety (Empire to Cooley)
C-22	Close at-grade US 97 connections and install on-ramp metering	US 97 Corridor Capacity/Safety (Murphy to Empire Boulevard)
C-23	Evaluate one-way streets on Newport and Portland	General System Capacity
C-24	Relocate the BNSF railroad switch yard from near Reed Market Road to outside of Bend	East-West Corridor Congestion

Table 4B. Programs and projects that are not mapped

NUMBER	PROJECT	NEED
C-12	Sign the route from US 20 to US 97 to continue on 3rd St to Division ramp instead of Empire or provide traveler info.	Congestion and traffic operations
C-13	Mobility Hubs (access to transit, bike share, car share, etc.) at key gateways and activity centers	Transit Service to Outlying Areas
C-14	Enhanced transit service to Sunriver/La Pine, Tumalo/Sisters, and Redmond, connecting to Mobility Hubs	Transit Service to Outlying Areas
C-16	TDM program for major employers and institutions	Manage Congestion
C-17	Reduce speed limit to 20 miles per hour on key routes leading to and within downtown to improve safety for all users	Barriers for bicyclists and pedestrians through central Bend
C-18	Increase transit service frequency to 10-minute headways on major corridors	East-West Corridor Congestion
C-19	Improved traffic signal coordination on signalized corridors, including freight and transit signal priority on designated corridors	East-West Corridor Congestion
C-20	Parking pricing in Downtown Bend	Demand management

Scenario Comparison

The project team used both quantitative and qualitative assessments to help compare the impacts of the three different themes represented by the scenarios. The Performance Measures were grouped into categories based on their related draft TSP goals. The following sections describe performance measure indicators for each of the seven goals and provides the analysis output for each indicator by scenario.

Goal 1: Increase System Capacity, Quality and Connectivity for All Users

A reliable and effective transportation system with capacity and quality to accommodate all transportation needs and which is connected to destinations is vital to a well-functioning city. Expanding the connectivity and quality allows people to choose the transportation mode that works best for them, which may minimize congestion and provide reliable travel times.

The following indicators were used to compare system capacity, quality and connectivity across the analyzed scenarios:

- Demand-to-capacity ratio
- Sidewalk system completeness
- Bicycle system level of traffic stress
- Completeness of low-stress network

Demand-to-Capacity Ratio

Purpose and Overview

The level of congestion for motorists is one indicator of the quality of the transportation system for drivers. Increasing levels of congestion may result in more time spent in a vehicle and can divert trips to less congested local roads. If trips are diverted to local roads or collectors that travel through neighborhoods, quality of life may be affected. There may also be economic impacts due to delayed freight delivery and transit impacts due to less reliable transit schedules. This measure identifies potential future congestion issues and evaluates solutions. A related measure is Travel Time Reliability, discussed under Goal 3.

Demand-to-capacity ratio is predicted using a travel demand model. It is expressed as a decimal representation, with 1.0 representing a saturated, or "full" condition. The number describes the proportion of available capacity that is forecasted to be used along a roadway segment. A demand-to-capacity ratio is determined by dividing the forecasted traffic volume along a segment by the capacity of a given roadway segment. A lower ratio indicates smoother operations and minimal delays. As the ratio approaches 1.0, congestion increases, and performance is reduced. A ratio of greater than 1.0 means that the roadway is oversaturated and can result in increased queueing and delays.

Data Sources and Methods

The Bend-Redmond Regional Travel Demand Model was used to measure demand-to-capacity ratios for each scenario. The baseline roadway network was based on assumptions from the Bend MPO's Metropolitan Transportation Plan Financially Constrained Projects, the 2016 TSP projects for Urban Growth Boundary (UBG) expansion areas, the City of Bend 5-year CIP projects, and the City of Bend CIP Citywide Safety Improvements. Additional road and transit links were coded into the model by the project team for each scenario.

Baseline Conditions in 2040

The figures shown in Appendix A map the projected demand-to-capacity ratios on roadways across Bend under the baseline conditions in 2040. Dark red indicates a roadway that the model shows would be over capacity, while green shows that the model indicates no expected congestion issues. Model results indicate that congestion during the baseline 2040 PM peak hour would be pervasive throughout Bend. The model shows that many roadway segments may be over capacity or nearing capacity by 2040. Some notable roadways that the model shows as over capacity in the Baseline by 2040 include:

- Reed Market Road from Century Drive to 15th Street
- Colorado Avenue, from Simpson to the US 97 interchange
- Newport Avenue and Portland Avenue, from Wall Street to 9th Street
- US 97, in the triangle area
- US 97 south of Empire Boulevard and north of Butler Market Road
- US 97 south of Olney Avenue and north of Colorado Avenue
- 27th Street from Reed Market Road to US 20/Greenwood Avenue
- 27th Street from Neff Road to Empire Boulevard

Scenario A

In comparison to the Baseline, the model indicates that projects included in Scenario A would make some notable improvements in congestion. Scenario A was run in the Bend-Redmond Regional Travel Demand Model to provide inputs for this comparative analysis. In Scenario A, the North Parkway Extension (A-6) (including all improvements in the final environmental impact statement (FEIS) is obviously visible, as volume would shift from 3rd Street to the new US 97 alignment. The model also shows an increase in volume along the new 18th Street connection (A-18) to US 97, which would utilize the new Cooley Road extension (A-2). The new river crossing at Powers Road (A-4) would draw trips away from Reed Market Road. The model shows that the China Hat Road/Ponderosa Street overcrossing would change the distribution of trips in the nearby area, with more trips using Parrell to access the Murphy Road/US 97 Interchange. The model also shows that there would be a decrease in trips on Reed Market Road, Greenwood/US 20 and Neff Road near the Wilson Extension.

The model shows large differences between the Baseline Scenario and Scenario A in the area of the North Parkway Extension (A-6). Under the Baseline Scenario, large sections of US 97 would be significantly over capacity in northern Bend, as well as portions of US 20 in the triangle area. With the North Parkway Extension projects (A-6), the model shows that congestion improvements would extend to Butler Market Road before falling back to similar levels of congestion as the Baseline. The US 97 North Interchange connection to 18th Street (A-7) combined with the Cooley Road extension to Deschutes Market Road (A-2) would provide additional connectivity to the northeast area of Bend, possibly removing some congestion from 18th Street south of Cooley Road and from Empire Boulevard.

The model shows that a new bridge over the Deschutes River in the southern part of the City, called the Powers River Crossing (A-4), would significantly improve congestion on Reed Market Road west of US 97. However, even with the new river crossing, Reed Market Road near the US 97 interchange would still be over capacity.

The model shows improvements on Reed Market Road east of US 97 that are due to the Wilson Road Extension (A-19). This extension would provide another parallel east-west route, which could move trips off of Reed Market Road, Bear Creek Road and US 20.

While the model shows that the Powers River Crossing would be over capacity as a two-lane bridge, a test of a four-lane bridge shows that the bridge would be *under* capacity and that more trips would divert to the Powers River Crossing instead of using Reed Market Road. The Powers Road/US 97 Interchange (A-8) would decrease congestion along US 97 at Powers Road. The combination of the Powers River Crossing and an interchange at Powers Road and US 97 would be important to relieving the congestion at Reed Market Road.

The model shows that the China Hat Road/Ponderosa Street overcrossing (A-3) would shift trips to Parrell Road and to the Knott Road/Baker Street interchange. Overall, the system would still be able to handle the volume shift.

Scenario B

The Bend-Redmond Regional Travel Demand Model shows that Scenario B would make the most improvements over Baseline for demand-to-capacity because of the significant widening of several roadways. Many of the roadways would double their capacity, leading to a reduction in their demand-to-capacity ratios.

In Scenario B, the model shows that significantly more traffic would use the Reed Market Road, Empire Boulevard and 27th Street corridors than in the Baseline. Fewer trips would use Neff Road, US 20/Greenwood and Wilson Avenue. More trips would take the bridge on Colorado Avenue while slightly fewer trips would occur on Galveston Avenue, Portland Avenue and Newport Avenue.

With the additional widening in Scenario B, the model shows that Empire Boulevard and long stretches of 27th Street would be under capacity. This would allow those areas to act as an alternate route to access eastern Bend, instead of utilizing one of the congested east-west corridors, shifting volume from Neff Road, Greenwood Avenue, and Bear Creek Road to 27th Street. The model shows that widening of Empire Boulevard (B-12) would add some minimal congestion along US 97 at the Empire Interchange. The widening of Empire would mean that Butler Market Road would not see a significant shift in trips, leaving it significantly under capacity and potentially oversized.

The model shows that capacity issues along Reed Market Road would be minimalized with the extensive widening (B-7, B-15, B-16). This would shift a significant number of trips to this corridor, as it would be a major five lane east-west route through Bend. Widening of 27th Street/Knott road (B-18) south of Reed Market Road would not be beneficial since these corridors were uncongested in the Baseline and would not divert new trips to these facilities.

The model shows that widening the bridge at Colorado Avenue (B-8) would help relieve some stress along Franklin Avenue and Galveston Avenue. There would also be a reduction in trips along Newport Avenue and Greenwood Avenue; however, these roadways would remain slightly over capacity in 2040. The Colorado Avenue Bridge would be at capacity in 2040 in the eastbound direction but would be under capacity in the westbound direction.

Scenario C

The Bend-Redmond travel demand model shows that Scenario C would also make demand-to-capacity ratio improvements when compared to the Baseline. Modeling Scenario C shows a reduction in trips on the Parkway, in large part due to the ramp metering and closure of right-in right-out (RIRO) access (C-22). Some trips would divert to Brookswood Boulevard and 3rd Street. There would also a reduction in trips along Greenwood Avenue/US 20 and Neff Road. The model shows that Portland Avenue and Newport Avenue appear to have a large difference in traffic, but this shift is because Scenario C shows those two streets converted to a couplet (C-23) (a pair of one-way streets). There would also be a shift in demand along Robal Road and Hunnel Road, due to access management along US 97 near the triangle area (C-4).

The model shows that the most significant improvement in congestion under Scenario C would occur along US 97. With ramp metering (C-22), the Parkway would be under capacity from the US 20 connection to the Knott Road/Baker Road interchange. Ramp metering would shift some local trips from US 97 to Brookswood Boulevard and 3rd Street, but both of those roadways would remain under capacity. North of the US 20 connection, US 97 would be just over capacity, an improvement over the Baseline.

The model shows that modifying Newport Avenue and Portland Avenue to a couplet (C-23) would cause more traffic to use Franklin Avenue and the Galveston Avenue Bridge, adding congestion to Galveston Avenue. Newport Avenue approaching the bridge would be slightly under capacity, but Portland Avenue would remain over capacity. The model shows that parking pricing in the downtown area (C-20) would decrease congestion, as fewer driving trips would be expected to access the downtown area, at least in single occupant motor vehicles.

The model shows that there would be slightly lower congestion along Greenwood Avenue/US 20 and Neff Road, with less peak hour demand on both corridors. Some of these trips would utilize the high-capacity transit corridor along Greenwood Avenue instead.

Summary

Overall, all three scenarios perform better than the Baseline for the Demand-to-Capacity Ratio (Congestion) Performance Measure. Table 5 shows the qualitative rating of each project with regards to demand-to-capacity ratios (in comparison to the Baseline). The models show that each scenario has significant projects which would make major improvements in this congestion measure.

- In Scenario A, the North Parkway Extension, with all improvements from the FEIS (A-6) would make some major capacity improvements on US 97, as would the Powers River Crossing (A-4) combined with the Powers Interchange (A-8) and the Wilson Road Extension (A-19).
- In Scenario B, Empire Boulevard widening (B-12), Reed Market Road widening (B-7, B-15, B-16) and 27th Street widening (B-18) would significantly improve capacity and reduce demand-to-capacity ratios.
- Scenario C shows that major improvements would happen along the Parkway with ramp metering and closure of the at-grade intersections (C-22).

Table 5: Qualitative Demand-to-Capacity Rating

Scenario	Demand-to-Capacity Rating
Scenario A	
Scenario B	
Scenario C	

Sidewalk System Completeness

Purpose and Overview

Providing transportation options for various modes of travel supports a balanced transportation system. Pedestrian activity is supported by providing safe and well-connected networks that link together various origins and destinations. If people do not feel safe or do not have adequate facilities to walk, they are more likely to drive or limit trips, leading to less balanced usage of the transportation system, higher vehicle-miles traveled, greater environmental impacts, or reduced opportunities.

Sidewalk system completeness is expressed as the percentage of Bend's arterial and collector roadways that have sidewalks on one or both sides of the road. This measure calculates the extent to which the sidewalk network is complete and to which Bend's built environment supports pedestrian activity. Note that this measure only considers whether or not a sidewalk is present; it does not consider the condition of the sidewalk. It also does not include local streets, where a large percentage of walking trips originate, and which can be of particular importance to those with mobility impairments or young children and which will be addressed in Phase 2 of the Transportation Plan update.

Sidewalk System Completeness can be used to indicate sidewalk completeness for the Baseline, and to compare between the alternative scenarios. An additional key evaluation of pedestrian connectivity is under Goal 4: Employment Accessibility.

Data Sources and Methods

Existing sidewalk location data were provided by the City of Bend Utility Department as GIS data. Additionally, aerial imagery was analyzed to identify and verify the locations of sidewalks on all public roadway corridors within Bend. The results were used to populate a presence/absence attribute on the Deschutes County Street centerline GIS dataset. All proposed roadway enhancements and new roadway corridors in the scenarios were assumed to provide sidewalks on both sides of the roadway unless otherwise specified. The improvements were coded into GIS. This enabled the team to compare the differences between the sidewalk system in the future scenarios. The sidewalk system completeness measure specifically measures the arterial and collector sidewalk system completeness since the scenario evaluation process focuses on regional level impacts.

Results

Table 6 shows the percent of sidewalk system completeness for each scenario. There is not a significant difference between the Baseline, Scenario A or Scenario C. Based on the assumption that all projects provide sidewalks on both sides of the roadway, Scenario B makes the largest improvement on the Baseline, in large part because Scenario B impacts the most roadway miles of the scenarios.

Table 6: Sidewalk System Completeness on Arterial and Collector Roadways

Scenario	Sidewalk System Completeness (Arterials and Collectors)
Baseline	74%
Scenario A	75%
Scenario B	84%
Scenario C	75%

Bicycle System Level of Traffic Stress

Purpose and Overview

Providing transportation options for various modes of travel supports a balanced transportation system. Bicycle activity is encouraged by providing safe, comfortable, and well-connected networks that link together various origins and destinations. If potential bicycle users do not feel safe or do not have adequate facilities, they are more likely to rely on driving or limit trips, leading to less balanced usage of the transportation system, higher vehicle-miles traveled, greater environmental impacts, or reduced opportunities.

Safety and comfort are extremely important factors for bicyclists. While these perceptions are specific to each individual, the bicycle system Level of Traffic Stress (LTS)[11] provides a standardized method to identify whether roadways or bike facilities would feel safe and comfortable to different types of potential cyclists. In brief, LTS is calculated based on the physical infrastructure and design of a roadway, coupled with traffic speeds and volumes, and other relevant information. LTS is expressed on a scale from 1 to 4:

- Level 1: riders of most ages and abilities, including children as young as 10 years old
- Level 2: most adult cyclists,
- Level 3: experienced bicyclists, or
- Level 4: strong and fearless bicyclists.

This performance measure calculates, for each scenario, the number of lane miles of arterial and collector roadways that would have an LTS of 1 or 2. It is important to note that this measure does not include trails and separate bike facilities, such as multi-use paths, which are almost always LTS 1.

Total miles of LTS 1 or 2 facilities is one measure of the bicycle network, but it does not indicate whether low-stress facilities form an effective *network* throughout the area, nor does it include routes that are not located on roadways. The low-stress network and employment accessibility Performance Measures provide additional context for considering bicycle connectivity. These metrics are documented in the sections that follow.

[11] Oregon Department of Transportation, Analysis Procedures Manual, Version 2, Chapter 14, Multimodal Analysis

Data Sources and Methods

GIS data provided by City of Bend and Deschutes County, as well as aerial photography, were used to identify roadway corridor features relating to the bicycle facilities.

For this performance measure, all new roadway projects or corridor widening projects were assumed to be complete streets[12] unless otherwise stated, with bicycle facilities that provide an LTS 1 or LTS 2 experience. Project improvements associated with each scenario were coded into the GIS roadway centerline data to provide a quantitative assessment of the change in bicycle level of traffic stress between scenarios. This was calculated only for collectors and arterials since the scenario evaluation process focuses on regional level impacts.

Results

Scenario A, Scenario B and Scenario C would all make improvements over the Baseline, as shown in Table 7. Scenario B would see the largest gain in miles of low LTS facilities due to the number of miles of roadway that Scenario B would impact. By introducing low-stress bicycle facilities as part of the widening of Reed Market Road, Empire Boulevard and 27th Street, there would be a significant increase in miles of LTS bicycle facilities. Scenario A includes multi-use paths that do not factor into this analysis.

Table 7: Miles of LTS 1 or LTS 2 facilities on collector or arterial roadways

Scenario	Miles of LTS 1 or LTS 2 Bicycle Facilities	Change from 2040 Baseline (%)
Baseline	32.3	-
Scenario A	34.0	5%
Scenario B	47.4	47%
Scenario C	34.9	8%

Completeness of Low-Stress Network

Purpose and Overview

Well-connected bicycle networks provide more opportunity for multimodal travel and increase options available to people making trips. This performance measure calculates the percentage of the low-stress bicycle network which would be completed (i.e. have an LTS of 1 or 2) by the Baseline and Scenarios A, B and C. It can be used to compare bicycle connectivity between various future states.

Because this measure considers key routes for bicyclists, it is more refined than simply measuring the change in the LTS of the entire transportation network or counting new lane miles that are accessible for bicyclists. Certain routes and linkages are more important than others for developing connectivity across Bend. By measuring the completeness of the low-stress bicycle network, this measure helps indicate whether the Baseline and future scenarios would impact the bicycle network in the places where connectivity is needed most.

Data Sources and Methods

The City of Bend has identified key corridors and linkages that would be necessary to develop a Citywide network of low-stress bike routes to provide connectivity across Bend. Based on this

[12] “Complete streets” means including pedestrian, bicycle, and appropriate transit facilities.

analysis, staff and consultants identified priority roadways and intersections that would act as key corridors and connections in a future-state “Low-Stress Bicycle Network”.

To calculate the completion of the low-stress bicycle network for each scenario, the bicycle LTS from existing conditions was updated to reflect expected changes from the baseline projects and the scenario projects. All new roadway projects or corridor widening projects were assumed to be complete streets[13] unless otherwise stated, with bicycle facilities that provide an LTS 1 or LTS 2 bicycle route, either on-street or off-street. Project improvements were coded into the GIS roadway centerline data to provide a quantitative assessment of the change in bicycle level of traffic stress between scenarios.

The resulting data was used to identify which linkages in the low-stress bicycle network were completed under the Baseline and each alternative. The level of completeness was calculated according to the number of lane miles completed and reported as a percentage of the total lane miles in the low-stress network.

Results

Scenario B performed best in this analysis, again due to the number of lane miles that would be impacted in this scenario. Scenario A and Scenario C each showed a small increase; they included fewer projects that often were not part of the low-stress network and not reachable for most people on bicycles. To increase bicycle connectivity, it would be helpful to use a network-focused approach, considering the LTS and which routes are needed for the overall system.

The employment accessibility metric (included under Goal 4) provides additional context for analyzing bicycle connectivity.

Table 8: Miles of Projects on the Low-Stress Bicycle Network

Scenario	Miles of Projects on the Low-Stress Bicycle Network	Low-Stress Network Completed by Each Scenario (%)
Scenario A	3.6	2%
Scenario B	21.4	13%
Scenario C	1.3	1%

Goal 2: Ensure Safety for All Users

Safety is one of the most important aspects of a well-functioning transportation system. Goal 2 seeks to reduce speeding, serious injury and fatal crashes, and maximize safe routes for all modes throughout the City, especially for people walking and biking. The safety measures help to answer the question “does the scenario improve the safety of transportation facilities and systems?”

A qualitative assessment of predicted crash rates was conducted to compare safety for all users across the analyzed scenarios. Two additional Performance Measures (reported fatal and injury crashes, reported crashes by mode) were identified as Performance Measures for monitoring programs.

[13] “Complete streets” means that streets are designed to include motor vehicle travel lanes, sidewalks, appropriate bicycle facilities, and transit facilities.

Qualitative Assessment of Predicted Crash Rates

Purpose and Overview

This performance measure seeks to identify the expected safety effects of each scenario. Specific project types, such as converting a two-way stop-controlled intersection to a roundabout or widening a roadway, have historical trends of observed safety impact that have been measured, analyzed, and documented in various studies. Information about these impacts can help quantitatively assess the relative safety effects of each scenario.

Data Sources and Methods

Existing safety data, including top 10% ODOT Safety Priority Index System (SPIS) locations, were examined for this performance measure. The SPIS network screening process utilizes crash rate, frequency, and severity data from the previous three years to help identify sites with a higher potential safety need. The top 10% SPIS sites were identified in the Existing Conditions Memorandum. Demand model volumes from the Bend-Redmond Regional Travel Demand Model were also used to guide the qualitative assessment. The Federal Highway Administration's Crash Modification Factors (CMF) Clearinghouse was used to research the potential safety implications of various projects.[14]

A qualitative safety assessment of the proposed projects was conducted for each scenario. Project types were compared to CMFs of relatively similar improvement types (i.e., roundabouts, protected bicycle facilities, three-lane versus five-lane roadway cross sections etc.) to estimate if, in general, crashes would likely increase or decrease for each scenario. This methodology is limited to trends and is not intended to predict future crash rates. The assessment also considered increases or decreases in forecasted traffic volume to the high crash rate locations identified in the existing conditions memo.

Results

Scenario A

Across Scenario A, one of the largest safety impacts would come from grade separation projects. Along US 97 and US 20 in Bend, there are numerous high-speed at-grade crossings, which can present a significant safety hazard. There are a several projects in Scenario A that would separate conflicting vehicle traffic and bicycle and pedestrian volumes along these routes, such as Ponderosa Street/China Hat Road overcrossing (A-3), Hawthorne Avenue grade separated crossing (A-1), US 97 pedestrian and bicycle overcrossing at Badger (A-10), and North Parkway Extension FEIS improvements (A-6). Grade separation would also occur at several of the at-grade railroad crossings in Bend in Scenario A (A-16, A-21).

In particular, the intersection of US 97 and Powers Road was identified in existing conditions as a top 10% SPIS site. The Powers Road Interchange project (A-6) would help address many of the safety issues associated with this location by grade separating the crossing of US 97 and building the on-ramps and off-ramps to current ODOT standards. The improvements at Powers Road combined with the grade separation of Ponderosa Street/China Hat Road (A-3) would add more trips to the intersection of Powers Road and Parrell Road, which may lead to safety impacts at this top 10% SPIS site.

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[14] Federal Highway Administration Crash Modification Factor Clearinghouse, www.cmfclearinghouse.org Accessed October 2018

Scenario A also includes projects that would add multi-use paths for pedestrians and bicyclists, such as the 3rd Street multi-use path (A-11), the US 20 multi-use path (A-13) and the trail connection from Colorado Avenue (A-15). Separating vehicular and bicycle/pedestrian traffic would provide bicyclists and pedestrians with safer routes, which can increase active transportation travel. However, these projects should be considered with respect to how they relate to the broader bicycle and pedestrian network across Bend, as there are other critical pedestrian and bicycle needs in the core area that were not addressed in Scenario A.

An additional safety benefit that would be associated with Scenario A is a reduction in overall VMT and a slight decrease in VMT on rural facilities. With a reduction in VMT, especially on rural facilities that may not be built to current urban standards, the expected total number of crashes in Bend could be reduced. While VMT would be reduced in Scenario A, there would be an increase in the total miles of collectors with an average daily traffic above 4,000 vehicles per day. This could be an indicator of traffic diversion to lower facility types, such as local streets. With more vehicles using facilities that were designed for lower traffic volumes, the potential for crashes could increase.

Scenario B

Scenario B would provide large multimodal safety impacts. In this scenario, there would be significant improvements to bicycle facilities throughout Bend, with many facilities being upgraded to protected bicycle facilities, such as Greenwood Avenue (B-1), Revere Avenue (B-2), Wilson Avenue (B-3), US 20/Greenwood Avenue (B-4), Neff Road (B-13), 15th Street (B-17), Bear Creek Road (B-24), Century Drive (B-30), and Portland Avenue/Olney Avenue (B-31). Additionally, roadway widening projects were assumed to include a low-stress bicycle route, either on- or off-street. These provide safer routes for bicyclists to travel. There would also be protected pedestrian facilities and enhanced pedestrian crossings in this scenario, including along Greenwood Avenue (B-14) and Neff Road (B-13). Greenwood Avenue between 3rd and 9th street was identified as a top 10% SPIS site, with both pedestrian and bicyclist involved crashes reported along this stretch of roadway in the most recent SPIS crash data. Protected bicycle facilities and enhanced crossings along Greenwood Avenue in this location could have a high impact on safety outcomes.

Another known safety improvement is implementing a roundabout in place of a two-way or four-way stop-controlled intersection. Roundabouts help reduce speeds and reduce the severity of collisions, leading to an improvement in safety outcomes. Scenario B would provide roundabouts along US 20 at Cook/Tumalo (B-20) and Old Bend Redmond Highway (B-21) in the north area of Bend, along with a roundabout at US 20 and Hamby Road (B-19) in eastern Bend. The US 20/Hamby Road intersection is a current top 10% SPIS site in ODOT, meaning there could be a significant benefit from implementing a roundabout at this location. Roundabouts would be located along 15th Street (B-17) and Butler Market Road (in Scenario B as well.

Along Hamby Road from Stevens Road to Butler Market Road (B-19), the widening project would change the roadway from a two-lane road to a three-lane road. By providing a median with a turn lane, a reduction in rear-end collisions could be expected. However, many of the other roadway widening projects would be expected to worsen safety outcomes. Widening a roadway from a three-lane roadway to a five-lane roadway would lead to an increase in traffic volumes along the corridor (i.e. Reed Market Road (B-7, B-15, B-16), Butler Market Road (B-11), Empire Boulevard (B-12), 27th Street/Knott Road (B-18)). National crash modification factors indicate these corridors would likely see an increase in crashes in the future compared to three-lane roadways. Particular care would need to be given to the design of the US 20/27th Street intersection with the widening of 27th Street (B-18). This is a current top 10% SPIS site, and more traffic demand at this location could negatively impact safety.

Many of the projects in Scenario B would affect current top 10% SPIS sites. The addition of protected bicycle facilities along Neff Road near Purcell (B-13) and significantly lower volumes along Neff Road near Purcell could lead to a reduction in crashes at this location. There could be less traffic demand along 3rd Street near Roosevelt Avenue and Wilson Avenue between 2nd and 3rd Street, in part due to the widening on Reed Market Road.

In Scenario B, there could be a slight increase in VMT. With an increase in VMT, the number of expected crashes could also increase in Bend. There is slightly more vehicular demand along 3rd Street near Franklin Avenue (another SPIS site) which could negatively impact safety.

Scenario C

The safety impacts in Scenario C are similar to the impacts discussed in Scenario A and Scenario B. Ramp metering (C-22) in Scenario C would necessitate at-grade access closures along US 97, which would reduce the potential for vehicle conflicts on the high-speed corridor. Access management near the triangle area along US 97 (C-4) would also reduce conflicts. Scenario C identifies enhanced pedestrian and bicycle facilities along Robal Road/Hunnel Road (C-6) and Wall Street/Bond Street (C-15), improving safety for active transportation users. Scenario C also identifies a road diet along Greenwood Avenue (C-1) in downtown Bend, which would reduce vehicle speeds and improve pedestrian and bicycle facilities along this segment. Reducing the speed limit on Franklin Avenue (C-17) could have a positive impact on safety, but the Newport/Portland couplet (C-23) would add demand to Franklin Avenue, potentially negating the safety impact. Overall, these projects make site-specific improvements to safety but should be considered in the context of the broader bicycle and pedestrian system.

Scenario C would have limited safety improvement for current top 10% SPIS sites. Along 3rd Street near Roosevelt Avenue, there would be slightly more traffic demand than in the Baseline, which could impact safety outcomes. However, there would be a slight decrease in traffic demand at Reed Market Road near 3rd Street and a reduction in turn movements (C-10), which could lead to fewer crashes.

Summary

To summarize the qualitative analysis discussed for each scenario above, a general safety rating was given for each scenario when compared to the Baseline. Overall, each of the scenarios would be expected to improve safety over the Baseline. Grade separated crossings and access management on high speed routes would significantly improve vehicular safety, while protected bicycle lanes and enhanced pedestrian facilities and crossings are expected to greatly improve safety for active transportation users. However, out of the three scenarios, both Scenario A and C are expected to have the highest positive safety impact, as shown in Table 9.

Table 9: Qualitative Safety Rating

Scenario	Qualitative Safety Rating
Scenario A	
Scenario B	
Scenario C	

Goal 3: Facilitate Housing Supply, Job Creation, and Economic Development to Meet Demand/Growth

Bend is a rapidly growing city, and the transportation system needs to grow with it to make sure its residents can access jobs, shopping areas, and housing. Commercial users such as freight need to be able to move goods reliably through and around the city.

The following indicators were used to compare economic development across the analyzed scenarios:

- Vehicle hours of delay
- Peak hour VMT on rural facilities (diversion)
- Travel time reliability

Vehicle Hours of Delay

Purpose and Overview

Vehicle hours of delay is a measure of total system congestion forecasted across all roadways the during the afternoon (PM) peak hour, typically between 5 PM and 6 PM. Essentially, this performance measure involves predicting how many minutes of delay that each vehicle would encounter during the peak hour of the day. Individual delays are then summed up for every vehicle on the roadway network. The result is the total hours of delay experienced by all vehicles during the afternoon peak hour. Vehicle hours of delay is an aggregate measure that can be used to consider the impacts to automobile travelers and the economy (value of lost time). It is a measure that is a part of MPO planning requirements.

Data Sources and Methods

The Bend-Redmond Regional Travel Demand Model was used to model vehicle hours of delay for each scenario, using 2040 land use assumptions. Inputs for the travel demand model are described in previous Performance Measures, such as the demand-to-capacity ratio.

Vehicle hours of delay were modeled for all trips beginning and ending within the MPO boundary (technically termed internal-internal). The origin-destination (O-D) delay was calculated for each O-D pair by subtracting the free-flow travel time from the model PM peak travel time. This delay was multiplied by the number of vehicle trips between the O-D pair to produce the vehicle delay. This measure was compiled for each scenario.

Results

Table 10 shows the vehicle hours of delay for each scenario. The model shows that Scenarios A, B, and C all would make improvements in vehicle hours of delay when compared to the

Baseline. Scenario B would have the lowest total vehicle hours of delay during the PM peak period. By widening many of the major corridors in Bend, congestion would significantly decrease, leading to a delay savings under Scenario B. Scenario A also would see a large reduction in vehicle delay. This is because increased connectivity leads to a reduction in delay as more trips utilize alternate routes to the most highly congested corridors. Scenario C shows a slight improvement in vehicle hours of delay. For a more detailed discussion of the impacts of individual projects on congestion, see the demand-to-capacity ratio section above.

Table 10: 2040 PM Peak Vehicle Hours of Delay

Scenario	Vehicle Hours of Delay (hours)	Change from 2040 Baseline (%)
Baseline	1053	Not applicable
Scenario A	874	-17
Scenario B	826	-22
Scenario C	1008	-4

Peak Hour Vehicle Miles Traveled on Rural Facilities

Purpose and Overview

Rural facilities are not typically designed for urban levels of traffic demand. An increase of diversion onto rural facilities (avoiding urban area congestion) could impact safety outcomes. By modeling the total number vehicle miles traveled on rural facilities, the scenarios can be compared to the Baseline to determine if the improvement scenarios are reducing diversion to surrounding rural facilities.

Data Sources and Methods

The Bend-Redmond Travel Demand Model was used to model the PM peak hour vehicle miles traveled on rural facilities for each scenario. Inputs for the travel demand model are described in previous Performance Measures, such as the demand-to-capacity ratio.

A rural facility was assumed to be any roadway within one mile outside of the UGB. The UGB was used for this performance measure with the assumption that by 2040, many of the roadways within the UGB expansion area would have been upgraded to urban standards. The forecasted peak hour volume on these facilities was multiplied by the length of the facility to determine the total peak hour vehicle miles traveled for each scenario.

Results

Table 11 shows the PM peak VMT on rural facilities in Bend. None of the scenarios would significantly change from Baseline. Both Scenario A and Scenario C would decrease rural VMT less than 2% over the Baseline, while Scenario B would increase rural VMT by less than 0.5%.

Within each scenario, the magnitude of change in peak hour VMT on rural roadways was relatively small. No individual project significantly impacted this performance measure for any of the scenarios.

Table 11: 2040 PM Peak VMT on Rural Facilities

Scenario	Vehicle Miles Traveled	Change from 2040 Baseline (%)
Baseline	36,040	Not applicable
Scenario A	35,464	-1.6%
Scenario B	36,224	+0.5%
Scenario C	35,473	-1.6%

Travel Time Reliability

Purpose and Overview

Travel time reliability is a measure of the consistency in travel times for automobiles over a corridor. Essentially, it predicts the extent of unexpected delays. If travel times can be confidently predicted, then drivers can plan their trips to arrive on time. However, where travel times are less reliable, unexpected delays can make trip planning a frustrating experience.

Travel time reliability is a measure that is a part of MPO planning requirements. It can be measured as the difference in trip times from day-to-day, and/or across different time periods of the same day. In this case, reliability from day-to-day was modeled.

Because the input data are not calibrated to Bend's local conditions, the results of this metric are useful for comparing the impacts of scenarios but they are not intended to be accurate measures of the system in Bend as a whole. The reported results are relative differences between scenarios, rather than as an overall result.

Data Sources and Methods

Travel time reliability analysis was performed using the Oregon Department of Transportation's HERS-ST analysis tool.[15] This complex modeling tool is used by state agencies to analyze major roadway deficiencies for programming and planning purposes. The tool captures probabilities and impacts from various delay events or causes, which makes it an effective tool for travel time reliability analysis of future conditions. The HERS-ST tool uses facility characteristics such as geometry, traffic control, and volume profile components to produce several delay measurements that can be used to calculate travel time reliability measures. These measures are not calibrated to local conditions; thus, only the relative difference is reported for evaluation of alternatives.

Travel time reliability was analyzed by using a planning time index (PTI) for specific corridors throughout Bend. The Federal Highway Administration (FHWA) defines PTI as 95th percentile travel time divided by the free-flow travel time, indicating the time a driver should allow to traverse the corridor segment while remaining on schedule 95% of the time. The planning time index represents the total travel time that should be planned for, including both typical and unexpected delay. For example, a PTI of 1.50 means that for a trip that takes 20 minutes in light traffic, a traveler should budget a total of 30 minutes to ensure on-time arrival 95 percent of the time. The higher the index, the less reliable the segment.

The travel time reliability was calculated for each scenario to compare to the Baseline.

[15] Oregon Department of Transportation Analysis Tools, Accessed October 2018

Results

The difference in travel time reliability was mapped across the different corridors in Bend, shown in Appendix B. For each scenario, the total miles of roadway with a high planning time index is shown in Table 12. A high PTI indicates a less reliable travel time. Under the Baseline, there would be over 37 miles of roadway with a PTI greater than 1.5. Sixteen of those miles would be highly unreliable corridors, with a PTI greater than 2.0.

Table 12: Miles of Roadway with a high planning time index

Scenario	PTI of 1.5-2.0 (miles)	PTI of 2.0+ (miles)
Baseline	21.5	16.3
Scenario A	20.9	13.4
Scenario B	14.2	15.3
Scenario C	19.4	16.4

In Scenario A, the travel demand model shows an overall reduction in unreliable corridors, with a total of approximately 34 miles. While Scenario B has the fewest miles of unreliable corridors overall, Scenario A sees the largest reduction in highly unreliable corridors (those with a PTI greater than 2.0). Reliability would be improved on US 97 with the addition of the North Parkway FEIS improvements (A-6). The North Parkway FEIS, the 18th Street Connection (A-17), and the Cooley Road Extension (A-2) also help improve travel time reliability on segments of Empire Boulevard. Reliability would be improved on US 97 near Powers Road due to the Powers Road Interchange (A-8). The Wilson Extension (A-19) would help improve travel time reliability on Reed Market Road and US 20/Greenwood Avenue by reducing volumes along those corridors.

Scenario B performs best overall on this measure. There would be a sharp decrease in miles with a planning time index over 1.5. With the proposed increased capacity along many of the arterial corridors, large stretches of Reed Market Road, Empire Boulevard and 27th Street would see significant improvements in travel time reliability. 3rd Street south of the railroad would also see improvements in travel time reliability, part of which can be attributed to the widening of the railroad undercrossing (B-29).

There would be a slight improvement in travel time reliability with Scenario C compared to the Baseline. This improvement largely comes from ramp metering and access management on the Parkway (C-22, C-4), with large segments of roadway having a PTI less than 1.5.

Goal 4: Protect Livability and Ensure Equity and Access

As Bend grows, it is important that the City retains its livability and is accessible to all residents regardless of income level or ability. The indicators to compare livability, equity and access are listed as follows:

- Employment accessibility
- Vulnerable populations within 0.25 mile of sidewalks, low-stress bicycle facilities, and transit
- Transportation equity
- Percentage of collector roads with an ADT above 4,000

Employment Accessibility

Purpose and Overview

In this context, accessibility measures the ease of reaching destinations – how well infrastructure and services enable people to get from Point A to Point B. There are many destinations that a person may wish to reach: jobs, schools, parks, shopping, and healthcare are a few examples. To simplify this analysis, this measure focused on employment, since it is a common type of destination.

This performance measure calculates how many jobs the average Bend resident could reach within 30 minutes if traveling by car, transit,[16] bicycle, (using low-stress bicycle routes), or on foot. It considers system completeness for each mode and measures how that impacts people's ability to travel between their homes and workplaces. This metric also specifically considers transit schedules and routes to measure not just whether people are located near transit, but whether transit enables them to reach key destinations in a reasonable amount of time.

Data Sources and Methods

Data sources used to calculate results are listed in the key assumptions for the Conveyal tool. For each scenario, additional links were added for proposed roadway, bicycle and pedestrian projects. Projects were assumed to be built to complete-streets standards; any roadway that was constructed or modified in a scenario was assumed to include a low-stress (LTS 1 or 2) bicycle facility and a pedestrian facility. For Scenario C, additional bus routes, mobility hubs, and higher frequencies for certain transit routes were coded to account for the projects identified by CTAC.

To calculate employment accessibility for each mode in each scenario, the Conveyal Analysis Tool was used to calculate how many jobs are reachable from a given point. The result is the number of jobs reachable for the average (50th percentile) 2040 Bend resident within 30 minutes of leaving home.

Transit was also analyzed as a 60-minute scenario in order to learn more about network connectivity. Thirty minutes was not felt to be a realistic time to walk to a bus stop, catch the bus, possibly transfer to another bus, and walk to the final destination.

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[16] For transit, we measured employment accessibility for jobs within 30 minutes as well as jobs within 60 minutes.

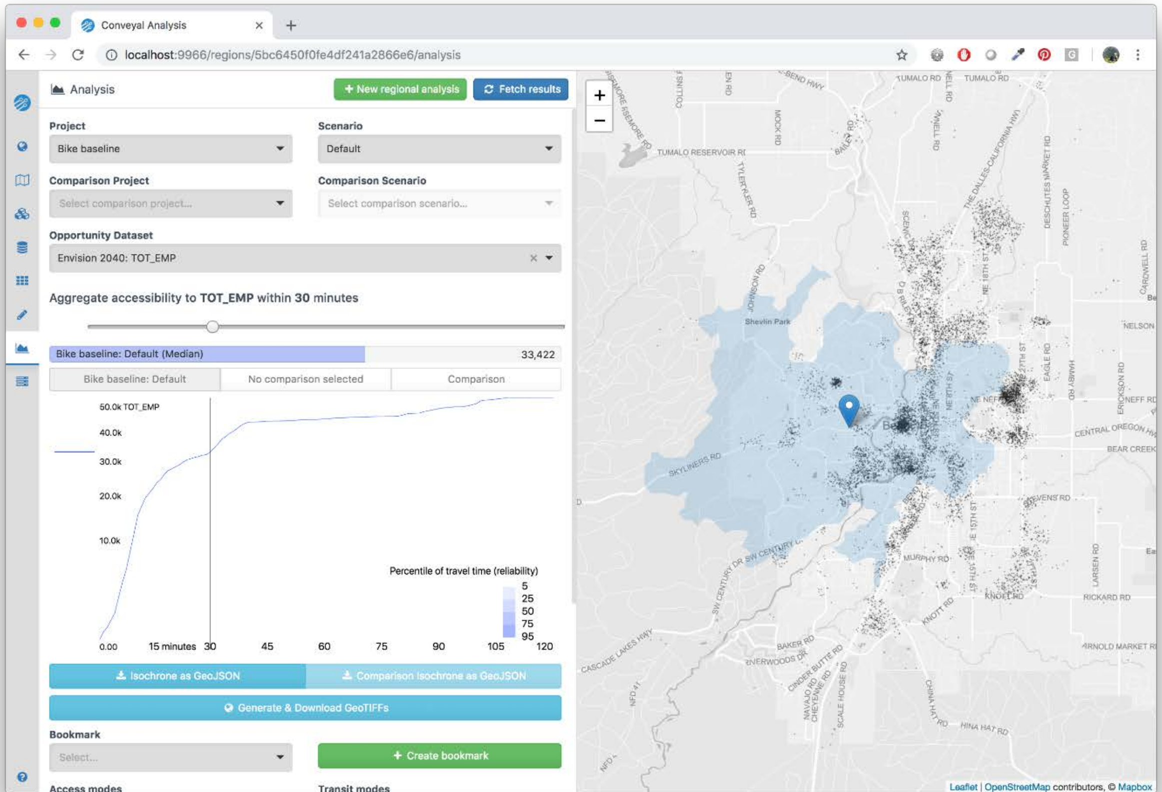
Since the viability of the bicycle network is so dependent upon user comfort and perceptions of safety, employment accessibility was measured using only low-stress connections (roadways with LTS 1 or 2). This measures how well an individual on a bicycle could reach destinations using roads and paths that would feel safe and comfortable to the average person.

An additional scenario was calculated to determine accessibility with an ideal bicycle network, if the whole roadway network were LTS 1 or 2. This measures the upper limit of what accessibility could be if the entire road network were reasonable for the average person on a bicycle. A low-stress bicycle network would generate results between these two bookends, depending on which roadway connections were included.

The pedestrian network is also dependent upon users' comfort and safety. Pedestrian accessibility was modeled for the entire road network and did not restrict the analysis only to road segments with sidewalks. Therefore, actual access may be lower depending on the geographic location, presence, and condition of sidewalks, and a person's physical abilities and comfort level with non-sidewalk routes. The sidewalk system completeness performance measure gives a sense of how complete the network is and should be considered alongside pedestrian accessibility.

Figure 7 shows a visualization of the regional accessibility results. Areas shaded in darker blue indicate areas where residents have access to a greater number of jobs within 30 minutes, using only low-stress bike routes. Locations of jobs are shown as clusters of dots, and the dark blue boundary line indicates the UGB area plus some additional areas (e.g. Gopher Gulch) that were assumed to develop, based on the future land use assumptions. The bar graph on the left indicates the number of jobs accessible to the n^{th} percentile. In this case, accessibility was calculated for the median, or 50th percentile, 2040 resident.

Figure 7: Example of Regional Accessibility Analysis



Results

Results for each scenario, by mode, are included in Table 13.

Table 13: Jobs accessible to the median[17] person in 30 minutes, by mode

Scenario	Auto	Pedestrian	Bicycle (low-stress facilities only)	Bicycle (all facilities)	Transit	Transit (60 mins)
Baseline	100%	7%	29%	64%	5%	40%
Scenario A	100%	7%	31%	77%	5%	40%
Scenario B	100%	7%	41%	64%	5%	40%
Scenario C	100%	7%	30%	63%	12%	67%

For every scenario, the median resident would have access to all jobs in Bend within 30 minutes. For transit, employment accessibility is lower than any other mode (5 to 12% of all jobs) when considering a 30-minute timeframe. This is important to keep in mind when considering how people make decisions about their mode choice. As thirty minutes does not allow much time to walk to a bus stop, catch a bus, possibly transfer, and then walk to a final destination, employment accessibility was also modeled for a 60-minute timeframe, which had much higher results (40 to 67% of all jobs). For both time periods, accessibility was

17 50th percentile

considerably higher in Scenario C, since this scenario featured improved transit service (higher frequency routes, additional routes, and higher mobility around three "mobility hubs"). The other scenarios did not include changes to transit service.

For pedestrians, accessibility remained almost the same (7%) in all scenarios. The main reason why these results are low is because walking is the slowest mode being considered; there are limits to how far a person can walk in thirty minutes, even with a very well-connected system. Scenario A had a slightly higher result since it includes several new connections and removed barriers to connectivity. This would have a more noticeable impact for residents near these new connections. However, the new connections would not significantly improve accessibility for the *median* person. It should be noted that this analysis does not consider sidewalk completeness; actual accessibility would be lower in areas that do not have sidewalks along collectors and arterials, where pedestrians may feel unsafe walking along a roadway shoulder. These needs can be considered as part of the neighborhood level process in Phase 2.

For bicyclists, using only low-stress roadways and paths, accessibility would increase in all scenarios, compared to the Baseline (29%). Scenario A (31%) and Scenario C (30%) each showed a small increase, and Scenario B (41%) showed a more substantial increase. The reason for this is because Scenario A includes new connections, such as highway overpasses (A-1, A-10), that removed some barriers to bicyclists; however, there was often a high-stress roadway link after the overpass, meaning that the new connections were not enough to provide a safe and comfortable route for people on bikes. Scenario B performed better because it includes significantly more roadway miles than either of the other scenarios. As a result, bicycle connectivity would increase, due to the assumption that new projects would be built to complete streets standards, with an LTS 1 or 2 bike facility. The accessibility improvements are not due to the roadway widening that features prominently in this scenario. Rather, the improvements are due to the inclusion of a lower-stress bike facility along new and modified corridors.

If the entire roadway network (besides Highway 97) were usable for bicyclists, then employment accessibility would be doubled (to 64%) compared to the Baseline. This remained constant (64%) in Scenario B. Accessibility would increase significantly in Scenario A due to the new roadway connections; these projects would now be accessible and usable to people on bikes, so they would provide significantly higher benefits. Accessibility would drop very slightly in Scenario C (63%) due to Newport/Portland becoming one-way roads (C-23).

The two bicycle results provide a set of bookends for considering bicycle-based accessibility on the current roadway network, versus a network where comfortable bike facilities are ubiquitous. Completing the low-stress bicycle network would provide results between these two bookends, depending on the exact connections and roadways that were included.

Vulnerable populations within 0.25 mile of sidewalks, low-stress bicycle facilities, and transit

Purpose and Overview

The purpose of this measure is to measure the proximity of vulnerable populations to multimodal facilities, including sidewalks, bicycle facilities and transit. This measure is intended as another means to consider equity, with a focus on all modes. After considering this performance measure more closely, the project team chose to analyze a more detailed metric for transit. For sidewalks and bike facilities, the team recommends shifting this type of analysis into the neighborhood-level process in Phase 2 and refining the metric being used.

As written, this performance measure involves calculating the percentage of vulnerable populations that live within a quarter-mile of a sidewalk on a collector or arterial road. (This analysis would be replicated with a focus on low-stress bike facilities, and on transit lines). For sidewalks, this metric would not provide meaningful input into the scenario evaluation process; there is not a clear connection between living in proximity to a new sidewalk and being able to reach it or derive a benefit from it. The same is true for bike facilities and transit lines; there may be many barriers between a person's home and the new infrastructure or services, so the metric would not provide a meaningful indication of whether vulnerable populations would benefit from new scenario projects.

To develop more meaningful insight, the project team recommends that the intent of this performance measure be explored in detail as one component of the neighborhood-level process in Phase 2. For pedestrians, the project team could calculate sidewalk completeness (as a percentage and as a total length) for each neighborhood, considering how sidewalk completeness varies between total populations and vulnerable populations (based on ACS census data). This would give some insight regarding which neighborhoods were most lacking in pedestrian infrastructure, and whether this was correlated with other equity concerns. Moreover, this analysis would enable the project team to better estimate the need for sidewalks (in terms of length and cost), discuss whether certain areas seemed to be especially high priorities, and discuss how different levels of investment in a sidewalk completeness program would address the need.

The same approach could be considered for bike facilities. At the neighborhood level, this analysis would focus on identifying barriers to connectivity that cause neighborhoods to act as isolated "islands", where high-stress collector and arterial roadways prevent many people from accessing surrounding areas. The project team could consider barriers to connectivity for different neighborhoods, whether vulnerable populations tend to face more barriers than the general population, and which areas may be most important to improve connectivity.

For transit, the project team determined that accessibility analysis would show more meaningful results than simply considering populations living in a quarter-mile proximity to transit, since routes and schedules are very important for using transit. The team analyzed employment accessibility, by transit, for jobs earning close to, or below, median wage. This analysis was done for transit, since individuals earning lower incomes may gain the most from the ability to reach their job without the expense of car ownership. Essentially, this performance measure models how many low- or average-paying jobs in Bend would be reachable for the average person using public transit.

Data Sources and Methodology

Methods used for the transit employment accessibility analysis were the same as those used for employment accessibility overall. However, the analysis for this metric did not consider 2040 employment and land use forecasts, since future forecasts do not consider levels of future wages or where these types of jobs would be clustered. Instead, census data were used from the 2015 Longitudinal Employer-Household Dynamics' Origin-Destination Employment Statistics (LODES). These data were used to calculate employment accessibility to jobs earning at or below $3,333 per month. This wage level was chosen because it was what the LODES data included, and also because it includes jobs which pay close to, or below, median wage for Bend in this timeframe (roughly $2,650 per month). Census data were provided at the 2010 block-group level.

Results

Results for each scenario, for transit, are included in Table 14.

Table 14: Accessibility to 2015 jobs earning less than $3333 per month, for the average[18] person

Scenario	Transit (30 minute access)	Transit (60 minute access)
Baseline	6%	58%
Scenario A	6%	58%
Scenario B	6%	58%
Scenario C	15%	87%

For both the 30- and the 60-minute timeframe, the results in this table are significantly higher in Scenario C than in the Baseline or Scenario A or Scenario B. This indicates that the transit projects in Scenario C could connect Bend residents to lower-wage jobs, offering benefits to those who rely on transit to commute to work. Again, this analysis is only one type of consideration, but does provide some additional context for considering equity.

Table 15 includes a summary of overall results for this performance measure for transit, with the understanding that pedestrians and bicyclists would be considered during the neighborhood process in Phase 2

Table 15: Qualitative Transit Accessibility Rating

Scenario	Transit Accessibility Rating
Scenario A	
Scenario B	
Scenario C	

Transportation Equity

Purpose and Overview

The transportation equity performance measure seeks to identify scenario performance based on how the transportation system investment impacts different areas considering poverty, age, disabilities, and race. This measure can provide a qualitative assessment to consider whether the costs and benefits of the transportation solutions identified in the scenarios appear to be distributed equitably.

Data Sources and Methods

The US Census Bureau's American Community Survey 5-year (2011 through 2016) data were used to create a series of maps of Bend (Appendix C). There are four maps for each scenario. Each map shows census block groups that are colored according to the proportion of people in

18 50th percentile

each block group that may be particularly vulnerable according the ACS data. Each of the four maps captures a different type of vulnerability; they show the proportion of the population that has been identified as:

- Limited English proficiency
- Persons with disabilities
- Senior citizens
- Low income[19]

The projects associated with each scenario were overlaid on each population map. Roadway projects are shown in violet. Transit improvements are shown as black and red lines. These maps were assessed to qualitatively consider whether some populations were either better served or more greatly impacted by the scenarios

Results

A visual examination of the twelve maps did not reveal significant findings for Scenario A. This scenario includes fewer projects than the others, and there does not appear to be a clear link or general trend (either positive or negative) between the locations of vulnerable populations and the location of projects. Improving connectivity across Bend would likely be beneficial for the whole city, not just particular areas. For specific projects, extending Wilson Avenue (A-19) could potentially impact low income populations since property would need to be acquired for this project.

Scenario B had similar overall results; projects included key corridors across the city and there was not a general trend between the locations of vulnerable populations and the location of projects. Considering specific projects, Scenario B could potentially impact low income populations through the core of the City if property needs to be acquired for the roadway widening projects.

Scenario C includes several transit improvements (new or higher frequency routes) that are located in areas with higher populations of people with low incomes and/or disabilities, particularly those around St. Charles Hospital and the south and east portions of Bend (C-2, C-3). These projects could provide benefits to vulnerable populations.

This examination provides an initial foundation for discussing equity at the regional level, but the results were limited and gave only preliminary insight. Additional discussions should be had as part of the neighborhood outreach process (Phase 2) to learn more about equity concerns, particularly in neighborhoods whose populations may be especially vulnerable.

Percent of Collector Roads with an ADT above 4,000 vehicles

Purpose and Overview

As congestion increases on the regional system, drivers begin to look for alternate routes. This shifts volume away from higher classification roadways to collectors. Modeling the traffic shifts on collector roadways can serve as a proxy for diversion onto local streets. This can also serve as an indicator of increased traffic on roadways that were not designed for high volume traffic.

[19] Percent of People with Income 50 to 130% of Federal Poverty Level. Source: ACS 2016 5-year estimate data

This measure seeks to quantify the change in demand volume on collector routes between scenarios to identify the potential for traffic volume increase on adjacent local streets.

Data Sources and Methods

The Bend-Redmond Travel Demand Model was used to forecast link-level traffic demands for average weekday conditions. Input data for the model are described earlier in this document.

The travel demand model identifies which roadways are collector roadways. For the purpose of this measure, the Powers River Crossing (A-4) was assumed to be an arterial roadway. The miles of collectors which would have an ADT above 4,000 was compared to the total miles of collectors for each scenario.

Results

Table 16 shows the percent of collector roads with an ADT above 4,000 vehicles per day. Scenario A would increase the number of collector roads with an ADT over 4,000 vehicles per day. By building new roads and improving connectivity on the local street system, more trips would divert to collector roads and help disperse vehicles. In particular, the Wilson Road Extension (A-19) (which is coded in the travel demand model as a collector) would draw a significant number of trips to the collector road system. Scenario B would improve congestion on many of the arterial roadways in Bend, helping reduce travel times on these routes. In turn, this draws more trips to the arterial network and away from collector roadways. On this measure for Scenario C, there would be no change from the Baseline.

Table 16: Collector roads with ADT above 4,000 vehicles per day

Scenario	Percent of collector roads with ADT greater than 4,000 vehicles/day
Baseline	20
Scenario A	22
Scenario B	17
Scenario C	20

Goal 5: Steward the Environment

A transportation system that stewards the environment is vital to promoting a healthy, livable community for its residents. Minimizing the impacts of the transportation system on natural features and air and water quality will allow for the plan to steward the environment.

Vehicle Miles Traveled Per Capita

Purpose and Overview

VMT per capita is a recommended performance measure as part of the City's state mandated planning requirements. VMT per capita generally demonstrates the combination of reliance on the automobile, proximity between land uses, and efficiency of the transportation system. Lower VMT can result from short auto trips and/or trips made by other modes such as walking, biking, or transit. Lower VMT values can indicate that the population has access to other travel modes or that the desired destinations (such as school, work, or shopping) are close to home or well-connected. These causes for VMT reduction are generally seen as improvements to quality of life.

Data Sources and Methods

The Bend-Redmond Travel Demand Model was used to measure the daily VMT for each scenario. Inputs for the model are described earlier in this document.

VMT were calculated for all daily trips beginning and ending within the BMPO boundary (technically termed internal to internal trips). Each internal to internal trip was multiplied by the length of each trip to determine the total VMT, which is divided by the projected 2040 population.

Results

Table 17 shows the vehicle miles traveled per capita for each of the scenarios. In 2040, the daily VMT is expected to be 9.95 miles per person under the Baseline.

Table 17: Daily VMT per capita

Scenario	VMT/Capita	Change from 2040 Baseline
Baseline	9.95	Not applicable
Scenario A	9.89	-0.53%
Scenario B	10.00	+0.58%
Scenario C	9.69	-2.60%

Under Scenario A, VMT would decrease to 9.89 miles per person. With increased connectivity, more trips would occur over a shorter distance. Transportation analysis zones near the Powers River Crossing (A-4) would see a reduction in average trip length, as would zones near the northeast UGB expansion area (Appendix D contains maps of the average trip length by zone). There would also be a small reduction in average trip length near the Wilson Road Extension (A-19). These reductions in average trip length from the zones near the edge of the UBG boundary would help drive down VMT per capita.

Under Scenario B, there would be an increase in VMT over the Baseline. In Scenario B, there would be less congestion on many of the major east-west connections in Bend. This would allow people to take longer routes that are quicker than some of the local connections, leading to an increase in VMT per capita. Average trip lengths would increase near Reed Market Road and Empire Boulevard/Butler Market Road, in particular.

While the relative differences of Scenarios A and B compared to the Baseline may seem limited, they are important and potentially significant differences from a regulatory perspective. As documented at length in the Bend UBG Expansion process, VMT per capita is a key measure in State regulations for MPO areas related to reducing reliance on the automobile over time. As found in the UGB Expansion process, VMT/capita in Bend is projected to increase, which triggered the need for the development and adoption of an Integrated Land Use and Transportation Plan (ILUTP) to demonstrate how the increase could be kept below 5%. The Baseline VMT per capita is near the 5% increase threshold, which therefore means a change as small as 0.5% is important.

Under Scenario C, there would be a significant decrease in VMT per capita over the Baseline. This results from a combination of fewer daily vehicle trips and a decrease in average trip length in key areas. There would be large improvements to the transit network under Scenario C (C-2, C-3, C-8, C-13, C-14, C-18), which would help drive down the number of daily vehicle trips. The implementation of a Transportation Demand Management program (C-16) in Scenario C would also decrease the number of single occupancy vehicle trips, which would help lead to a decrease in VMT per capita. The average trip length also would significantly decrease in many of the locations near the mobility hubs (C-13) and where transit improvements occurred. The only mobility hub location where there would not be an obvious decrease in average trip length is near the Portland Avenue/Newport Avenue couplet (C-23). Trips occurring near the couplet would be required to cut through local streets to access the correct direction of travel, leading to longer trips on average in that area.

Goal 6: Have a Regional Outlook and Future Focus

Bend serves as a hub for regional transportation. As the City grows and adapts, it is important to create a system that is designed to test innovative and emerging transportation technologies.

The measures to compare the regional outlook for the BMPO area are:

- Arterial roadway miles with demand to capacity ratio deficiencies
- Potential for alternative funding
- Mode split

Arterial Roadway Miles with Demand to Capacity Ratio Deficiencies

Purpose and Overview

The level of congestion on the transportation system can indicate the quality of the system from a motorist standpoint. Increasing levels of congestion may not only require more time spent in a vehicle but may also affect the time of day that a trip occurs or, ultimately, reduce trips. Particularly for the arterial network, congestion can limit the mobility of regional trips coming to or leaving Bend. These actions can reduce quality of life and may also lead to economic impacts due to delayed goods movement and/or reduced trips to local merchants. This measure estimates the arterial roadway performance for each scenario.

Data Sources and Methods

The Bend-Redmond Travel Demand Model was used to model arterial roadway miles with demand-to-capacity ratios for each scenario. For this analysis, US 97 was included in the arterial roadway system in Bend. In Scenario A, the Powers River Crossing (A-4) and the US 97 North Interchange connection to 18th Street (A-7) were both coded as arterial roadways.

The demand-to-capacity (v/c) ratio for all arterials was calculated for the 2040 PM peak hour. A demand-to-capacity ratio deficiency was defined as any arterial segment with a v/c above 1.0. These roadway segments that the model identifies would be congested, with more demand for trips than can be served by the roadway. The total miles of arterial roadway with a deficiency were calculated for each scenario to compare to the 2040 Baseline.

Results

In Table 18, the miles of arterials with a demand-to-capacity ratio greater than 1.0 during the 2040 PM peak hour is shown. Under the Baseline, there would be 19.2 miles of arterials over capacity during the PM peak hour. In Scenario A, that would be reduced to 13.9 miles (7.1% of arterials), while Scenario B would reduce it further, to 10.5 miles (5.6% of arterials). Scenario C would see a reduction to 14.9 miles of over-capacity arterials (8.0% of arterials).

Table 18: Arterial roads with capacity deficiencies

Scenario	Miles of arterials with v/c greater than 1.0	Percent of arterials with v/c greater than 1.0
Baseline	19.2	10.2
Scenario A	13.9	7.1
Scenario B	10.5	5.6
Scenario C	14.9	8.0

The largest improvement on this measure would occur in Scenario B. The widening projects in Scenario B would increase the capacity on many of the arterial roadways in Bend, such as the Empire Boulevard widening (B-12), 27th Street widening (B-18), and Reed Market Road widening (B-7, B-15, B-16).

Scenario A would also decrease the number of arterial roadways with capacity deficiencies. The Wilson Extension (A-19) would help reduce demand below capacity along nearby arterials. The Powers River Crossing (A-4) was coded as a three-lane bridge but expanding that to four or five lanes over the river could further reduce the miles of demand-to-capacity ratio deficiencies on arterials.

Small demand-to-capacity ratio reductions in Scenario C could account for the slight decrease from the Baseline, including less congestion along Newport Avenue with the addition of high-capacity transit (C-2).

Potential for Alternative Funding

Purpose and Overview

As the budget for projects becomes tighter, alternative funding sources (e.g., private industry transportation services) become attractive options for cities to investigate to help finance projects. Potential alternative funding sources may provide extra opportunities for projects that would otherwise be difficult to underwrite.

Data Sources and Methods

A qualitative review of individual project types in each scenario was conducted to determine what additional potential funding sources, if any, may exist. Each scenario details the potential alternative funding sources that may be available to projects within that scenario.

Results

In general, grant funding opportunities do not differentiate between new roadway connections and roadway widening projects, so Scenario A and B would likely have similar potential for alternative funding for roadway projects.

Over the past five years, there has been an increase in grant funding opportunities that focus on active transportation modes, as well as additional funds available for public transit. This may provide additional opportunities for the bicycle, pedestrian, and transit elements of Scenario A, B, and C to secure alternative funding. The mobility hubs (C-13) in Scenario C may be able to attract private partnerships or investment.

This qualitative comparison to the Baseline, as shown in Table 19, is based on information available at this time; trends for grant and other funding opportunities may change over the course of Bend's Transportation Plan 20-year planning horizon.

Table 19: Qualitative Rating for Alternative Funding Potential

Scenario	Alternative Funding Rating
Scenario A	I
Scenario B	I
Scenario C	^

Mode Split

Purpose and Overview

In order to have a future focus when considering the emergence of shared and connected mobility, it is important to identify improvement opportunities for multimodal transportation to enhance access to those services. Mode split provides a quantitative measure of how each project shifts trips between walking, biking, transit, and auto trips. A higher percent of non-single occupancy vehicle (non-SOV) trips also has the potential to reduce congestion, improve air quality and the livability of the BMPO area.

Data Sources and Methods

The Bend-Redmond Travel Demand Model was used to model the daily mode split within the BMPO area during an average weekday.

Mode split was calculated for all daily trips beginning or ending within the BMPO boundary. A non-SOV trip includes walking, biking, and transit. For Scenario C, the transit mode split also encompasses any solutions associated with the mobility hubs, which may include several different smart mobility options.

Results

As shown in Table 20, Scenario A and B would perform similarly to the Baseline. In these scenarios, roughly 46% of all daily internal to intenral trips in the travel demand model would be single occupancy vehicle (SOV) trips. However, Scenario C would make significant improvements on this measure. There is a two percent reduction in SOV daily trips when compared to the Baseline. This is due in large part to the significant increase in transit trips, from 0.8% in the Baseline to 2.5% in Scenario C. The transit trips in Scenario C also include the estimated number of trips using mobility hubs. There is also a reduction in daily SOV trips with the implementation of a TDM program in the Baseline, further reducing SOV trips by 0.4%. The reduction in SOV trips by two percent is a large driver in the reduction of vehicle miles traveled per capita, discussed under Goal 5.

Note that while the relative differences between scenarios for mode-share seem limited (less than a few percent), this level of difference is significant as it relates closely to the VMT per capita performance measure. As described in the section for that performance measure, small variations in VMT per capita for Bend are important relative to meeting State regulations.

Table 20: Percent Daily Bend MPO Mode Share

Scenario	Single Occupancy Vehicle (SOV) (%)	Non-SOV Trips (%)
Baseline	46.7	53.3
Scenario A	46.8	53.2
Scenario B	46.7	53.3
Scenario C	44.7	55.3

Goal 7: Implement a Comprehensive Funding and Implementation Plan

Transportation improvements will be needed to serve growth and maintain and enhance livability in Bend. Stable, equitable and adequate funding for transportation programs and projects will be critical to allow Bend to continue to grow in a sustainable way.

Cost

Purpose and Overview

The funding required to address transportation improvements and maintain and operate the system can be substantial and may be an important factor for selecting a preferred transportation solution. This performance measure focuses on capital costs. Operations and maintenance needs are another important aspect; the magnitude of operation and maintenance funding needs is indicated by the following section, which considers the number of roadway miles.

Data Sources and Methods

Capital cost estimates were based on the general assumptions included in the recently completed Bend Transportation System Development Charge (TSDC) update.[20] These are currently being updated to reflect recent construction bids received by the City. Given the uncertainty of various unit cost assumptions and project specifics, current cost estimates provide a range of expected cost. These ranges will be further refined as specific unit costs are identified and the project moves towards a recommended funding package.

Results

A range of estimated cost is provided for each project in Appendix E. Several projects are subject to ongoing planning and evaluation studies. Estimated project costs will be further refined as the TSP process and other various efforts are advanced. Specifically, the need for additional right-of-way and/or reconstruction of existing curb lines would have a large impact on several project costs. As individual projects are further understood, these project elements can be better estimated.

In Scenario A, the majority of projects would represent relatively modest roadway extensions and planned connections. The largest driver of cost in this scenario are the North Parkway Extension FEIS improvements (A-6) and the Powers River Crossing (A-4). Both projects would require significant capital and right-of-way costs.

Several projects in Scenario B include roadway expansions that would require significant right-of-way acquisition. The widening of key corridors such as Empire Boulevard (B-12), 27th Street

[20] For more information, reference exhibits from the June 2018 Bend City Council meeting that addressed the TSDC cost increases

(B-18), Knott Road (B-18), Butler Market Road (B-12), Reed Market Road (B-6, B-15, B-16), and Colorado Road (B-8) would amount to large infrastructure projects that would require extensive right-of-way and construction costs. In addition, the feasibility of accommodating enhanced bicycle facilities within the existing curb lines of roadways would have a major impact on the actual costs to construct the bicycle facility projects identified in this scenario.

Most projects in Scenario C would not require the magnitude of capital costs of either Scenario A or Scenario B. However, several projects may require significant additional operational and administration costs, such as downtown parking pricing (C-20) or transit system expansions (C-2, C-3, C-8, C-13, C-14, C-18). The magnitude of those costs needs to be further coordinated with agency partners. In addition, the cost for installing ramp metering (C-22) would not be known until further evaluation is completed by the US 97 Parkway Study, which could significantly drive up costs in this scenario. The largest driver of cost in this scenario would be relocating the railroad switchyard (C-24).

Table 21 provides a relative capital cost of each scenario. The ranges for each scenario were developed by applying an average cost for each project based on the estimated cost range shown in Appendix E (e.g., a project cost range of $500,000 to $1,000,000 would add $750,000 to the estimated scenario cost).

Table 21: Relative Capital Cost by Scenario

Scenario	Relative Capital Cost
Scenario A	$$$
Scenario B	$$$
Scenario C	$

$ = less than $200 million, $$ = $200 to 500 million, $$$ = more than 500 million

Roadway Lane Miles

Purpose and Overview

While it is important to identify a range of solutions to potential problems, it is also important to understand the maintenance impacts of different solution packages. Roadway lane miles is intended as an indicator of the future demand for maintenance of the BMPO transportation system.

Data Sources and Methods

The network coded for the Bend-Redmond Travel Demand Model was used to measure roadway lane miles for each scenario. The total number of roadway lane miles was calculated from the travel demand model to compare the differences between scenarios.

Results

As shown in Table 22, Scenario B would have the most lane miles of roadway, followed by Scenario A, while Scenario C would have slightly fewer lane miles than the Baseline. In Scenario A, new connections such as the Powers River Crossing (A-4), the North Parkway Extension FEIS improvements (A-6) and the other roadway extensions would lead to an increase in lane miles. Scenario B widens long stretches of Empire Boulevard (B-12), 27th Street (B-18), Knott Road (B-18) and Reed Market Road (B-7, B-15, B-16), adding nearly 7% more lane miles of roadway over the Baseline. In Scenario C, there would not be a significant change from the Baseline, but access management (C-4) and at-grade access closures along US 97 for ramp metering (C-22) would lead to a slight decrease in the number of lane miles.

Table 22: Lane miles of roadway

Scenario	Lane Miles of Roadway	Change from Baseline (%)
Baseline	464	Not Applicable
Scenario A	478	+2.8
Scenario B	497	+6.9
Scenario C	462	-0.6

Findings and Recommendations

The scenario evaluation described in this document is focused on learning about different investment options to help move towards the identification of a Citywide transportation framework. However, linkage between scenarios, Performance Measures, and individual project choices is complex. To organize the information and work from big-picture lessons to specific project needs, the findings and recommendations are sorted into the following topics and subsequent sections:

- Summary of Scenario Evaluation by Performance (High-Level Findings)
- Summary of Scenario Evaluation by Transportation Need (Area-Specific Findings)

Summary of Scenario Evaluation by Performance Measure

A key takeaway from the scenario evaluation is the lessons learned about how different types of Citywide transportation investment would perform compared to the plan's goals and corresponding Performance Measures. Table 23 shows the scenario evaluation results in a combined matrix of Performance Measures. Lessons learned at the scenario-level include:

- Motor vehicle congestion issues (corridor demand to capacity ratios, vehicle hours of delay, travel time reliability, etc.) forecasted in the future may be improved by either connectivity investments or corridor widening investments. However, each of those investment types have different secondary effects that are be important to consider:
  - Connectivity investments can improve accessibility for walking and biking, improve system safety by overcoming barriers, and reduce vehicle miles traveled by reducing out-of-direction travel. Connectivity investments are also generally costly and may spread motor vehicle travel patterns onto the collector system that must then consider compatibility with neighborhoods.
  - Corridor widening investments may provide opportunities to provide enhanced walking and biking facilities along roadways (both a safety and accessibility benefit) and focus regional traffic patterns onto arterial corridors. Corridor widening investments can also be costly, may significantly increase maintenance costs, may increase miles driven, and can impact safety by creating higher volume/speed corridors that are difficult to cross.
- Improving walking and biking through Bend is not as simple as filling in key gaps in facilities. The accessibility evaluation found that developing complete, connected corridors throughout the city (both along and crossing corridors) are important to improve travel choices.

- Transportation system demand for motor vehicle trips can be reduced by investments in the transit system (providing improved travel choices) and by implementing policies and programs in key areas, such as parking pricing and employer commute options that encourage travel by other modes.
- Looking towards the future of changing technology and shared mobility, concepts such as mobility hubs have the potential to improve mobility by providing first/last mile travel choices that connect to a robust regional transit system. This type of investment may also provide an opportunity to leverage public/private partnerships.
- Managing congestion and safety on US 97 through Bend is challenging with the projected levels of future growth. Corridor operations and access management solutions, including implementing ramp meters and closing at-grade connections, show significant potential to improving safety and operations with limited impacts to the surrounding city transportation network performance.

Overall, these lessons learned point to the pros and cons of various investment types represented in the three scenarios. Applying these to develop a hybrid scenario for the regional transportation framework should consider a balanced investment in demand management, system management, non-vehicular facilities and services, new complete street connections, and selected widening for capacity. The following section advances this concept by looking at investment performance by need area to begin identifying potential projects to advance.

Table 23: Scenario Performance Relative to the Baseline Projects

Project Goals	Performance Measures	Scenarios		
		A	B	C
Increase System Capacity, Quality, and Connectivity for All Users	Demand to Capacity Ratio (congestion)	↑	⇈	↑
	Sidewalk System Completeness	I	↑	I
	Bicycle System Level of Traffic Stress	↑	⇈	↑
	Completeness of low-stress network	I	↑	I
Ensure Safety for All Users	Qualitative Assessment of Predicted Crash Rates	⇈	↑	⇈
Facilitate Housing Supply, Job Creation, and Economic Development to Meet Demand/Growth	Vehicle Hours of Delay	⇈	⇈	↑
	Peak Hour Vehicle Miles Traveled on Rural Facilities (diversion)	I	I	I
	Travel Time Reliability	↑	⇈	I
Protect Livability and Ensure Equity and Access	Transportation Equity	I	I	↑
	Transit Accessibility for Vulnerable Populations	I	I	↑
	Employment accessibility	↑	I	⇈
	Percentage of collector roads with an ADT above 4,000	↓	↑	I
Steward the Environment	Vehicle Miles Traveled Per Capita	↑	↓	⇈
Have a Regional Outlook and Future Focus	Arterial Roadway Miles with Demand to Capacity Ratio Deficiencies	⇈	⇈	↑
	Potential for alternative funding sources	I	I	↑
	Mode Split*	I	I	↑
Implement a Comprehensive Funding and Implementation Plan	Cost	↓	↓	↑
	Roadway lane miles	↓	⇊	I

Summary of Scenario Performance by Transportation Need

As described in an earlier section, transportation needs throughout Bend were identified by technical evaluation, the public, and agency staff. The most common or significant needs were identified as key needs and used to help develop the projects in the three scenarios. Reflecting on how well each scenario may address the needs is a useful way to start understanding what type of improvements or projects perform best for each area.

Table 24 lists the scenario performance by key need. For each need, the scenario performance score considers Performance Measures that best match the need (e.g., a “capacity” need is compared to demand to capacity ratio and travel time reliability, while a “barrier for walking or biking” need is compared to accessibility, sidewalk completeness, safety, and completeness of the low-stress bicycle network).

The results of the scenario performance by needs begins to shape some potential project recommendations for a hybrid scenario or areas for further discussion, which is described in the following section. Sample findings that illustrate this include:

- *Barriers for Bicyclists and Pedestrians through Central Bend* appear to be best addressed with enhanced walking and bicycle facilities such as those in Scenario B.
- *15th Street Capacity and Safety at Key Intersections* appears to be best addressed with the roundabout projects included in Scenario C.
- *Manage Overall System Demand* appears to be best addressed with the transit and travel demand management strategies in Scenario C.
- *East-West Corridor Congestion* does not have a clear top performing investment strategy between new corridor connections or corridor widening and warrants additional discussion.

Table 24: Scenario Performance in Meeting Key Transportation Needs

Transportation Needs	Scenario A	Scenario B	Scenario C
Barriers for bicyclists and pedestrians through central Bend	I	⇈	↑
East-West Corridor Congestion	⇈	⇈	↑
US 97 Corridor Capacity/Safety (Empire to Cooley)	⇈	I	↑
US 97 Corridor Capacity/Safety (Murphy to Empire)	↑	I	⇈
US 97-Hwy 20 Triangle Pedestrian and Bicyclist Access	⇈	I	I
Butler Market Corridor Capacity and Safety Needs (US 97 to 27th)	I	↑	↓
Neff Corridor Safety (8th to Purcell)	I	↑	I
Greenwood Corridor Pedestrian/Bicyclist Safety	I	↑	I
Colorado Interchange Area Capacity and Pedestrian/Bike Access	↑	↓	↓
Reed Market Congestion (Bond to 4th)	⇈	↓	I
Reed Market Congestion and Safe Crossings (4th to 27th)	⇈	↑	↑
15th Street Capacity and Safety at major intersections (Knott to Wilson)	I	↑	I
27th/US 20 and Hamby/US 20 Capacity and Safety	I	↑	I
US 20 West Rural Crossing Capacity and Safety	I	↑	I
3rd Street Capacity (Greenwood to Wilson)	I	↑	I
Transit Service to Outlying Areas	I	I	↑
Manage Overall System Vehicle Demand	↑	↓	⇈
Century Drive Safety	I	↑	I
Safe Railroad Crossings	⇈	I	I
27th Street Corridor Capacity and Safety	I	↑	I