

Chapter 6: Motor Vehicles

Introduction

Motor vehicles remain the primary mode for transporting goods and people within the BMPO planning area. The physical roadway infrastructure and the motor vehicles it supports play a vital role in the BMPO planning area's social and economic livelihood. Efficient movement of motor vehicles supports the economic vitality of the region and maintains the mobility of its residents. Identifying needs and deficiencies in the roadway system is an important step in maintaining and improving the flow of motor vehicles. Most new motor vehicle projects also have provisions for bicycles and pedestrians facilities that enhance the multi-modal transportation system.

This chapter outlines the basic assumptions through the future year (2040), including forecasts of future population and employment and the resulting demand on the regional arterial and collector roadway network. Two different future transportation network scenarios were evaluated:

- 2040 Committed Improvements
- 2040 Preferred Alternative

The Metropolitan Transportation Plan (MTP) is a financially constrained plan; the Preferred Scenario includes projects recommended for implementation that can be financed with existing and anticipated funding resources over the planning period. The Preferred Scenario identifies regionally significant projects, primarily on arterial road segments and generally excludes local and collector streets. Some collector street projects have been included due to their impacts on the regional transportation system, while other collector street deficiencies that were identified and corresponding improvement projects are addressed in the Bend Transportation System Plan (TSP).

As part of this MTP update, the future network scenarios were evaluated with a link-based system analysis (demand-to-capacity). Previous MTP analysis and other local agency efforts identified system deficiencies at both the link and intersection level. The 2040 model results were used to identify the system link deficiencies and to select projects for the Preferred Scenario. Key intersection improvement projects identified in the previous MTP Preferred Scenario or other local agency planning efforts were also included.

Although the majority of projects included within this plan have funding sources, some additional projects are identified that go beyond the immediate availability of known funding trends. These projects ("Illustrative Plan") address capacity and connectivity issues that were not addressed in the Preferred Scenario. The designation and inclusion of these extra projects are important to future planning efforts, as they allow right-of-way needs to be preserved and allow opportunities for new funding that becomes available to be applied to projects that have been already been identified as

addressing future deficiencies in the regional transportation network. These extra roadway projects are included in an “Illustrative” list near the end of the chapter.

Several other planning studies are underway that will influence the expected transportation conditions in the greater Bend Planning Area. These studies include:

- US 97 Bend North Corridor Project
- Bend Urban Growth Boundary (UGB) Expansion
- Bend Westside Integrated Land Use and Transportation Plan
- Bend Central Multimodal Mixed-Use Area (MMA) Plan

Findings and recommendations that result from these ongoing planning efforts will be amended into the Bend MTP and incorporated into future MTP. A more rigorous alternatives analysis will also be conducted after the Urban Growth Boundary process is complete as part of subsequent MTP and TSP updates.

Goals and Policies

The goals and policies of the Bend MTP were developed based on a review of the existing goals outlined in other regional and local plans. The Oregon Highway Plan provides guidance on the standards of performance necessary for motor vehicles on the state highway facilities. The region also has specific goals and policies outlined within the local transportation plans (Deschutes County Comprehensive Plan, Deschutes County Transportation System Plan, and the City of Bend Transportation System Plan) that are specifically related to motor vehicles. The goals that were created and adopted will help guide the future development of the roadway network and select specific projects for implementation. The motor-vehicle goals are included in Chapter 4 of this plan.

Performance Standards

A variety of performance measures have been developed and adopted by governing jurisdictions to evaluate how well the transportation system operates under existing and future conditions. This plan focuses on link demand/capacity (d/c) ratios at the corridor level. For future MTP Updates, further model refinement and post-processing may be used to incorporate intersection level of service measures into the analysis.

Forecasts and Needs

The existing conditions analysis is summarized in Chapter 3 of this plan and identified a series of transportation needs and existing deficiencies. These needs, along with the adopted goals and policies developed for the future direction of the transportation network, provide the starting point for the future year analysis.

Forecasted Land Use

Land use is a key factor in developing a functional transportation system. The amount of land that is planned to be developed, the type of land uses and how the land uses are mixed together have a direct relationship to expected demands on the transportation system. Understanding the amount and type of land use is critical to taking actions to maintain or enhance transportation system operation.

The Bend MPO travel demand model was developed by the Transportation Planning Analysis Unit (TPAU) at ODOT (Oregon Department of Transportation). The travel demand model was used to determine future traffic volumes within the study area. Complete land use data sets were developed by MPO, City, and County staff and TPAU for the following conditions.

- Existing 2010 Conditions (base travel forecast for the region)
- Future 2040 Conditions

For transportation forecasting, the land use data is stratified into geographical areas called transportation analysis zones (TAZs), which represent the sources of vehicle trip generation. There are 463 TAZs within the BMPO planning area model; each TAZ represents land use and the access to the transportation system within the planning area. This land use database includes the population, the number of residential dwelling units (households), and employees within specific TAZs. The totals that were assumed for each category in the Bend MPO travel demand model for the base (2010) and future year (2040) are summarized in Table 6-1.

Table 6-1: Land Use Summary

Land Use	2010	2040	Increase	Percent Increase
Population	92,343	164,082	71,739	78%
Households	37,852	65,168	27,316	72%
Employees	40,763	80,783	40,020	98%

* Note: The Bend MPO model extends significantly beyond the BMPO boundary. The land use totals shown in Table 6-1 are for the entire model area.

In Table 6-1, the employee category only includes the total number of employees, though the travel demand model utilizes a range of employment types (retail, service, industrial, and other). All employment category areas exhibit significant growth during the planning horizon. This growth was converted to forecasted travel demand and then applied to the existing transportation network to determine the future deficiencies of the motor vehicle system, as explained in the next section.

Forecasted Travel Demand

The determination of future transportation needs in the BMPO planning area requires the ability to accurately forecast travel demand resulting from estimates of future population and employment. The objective of the transportation planning process is to provide the information necessary for making decisions on when and where

improvements should be made to the transportation system to meet the forecasted travel demand.

Traffic forecasting can be divided into several distinct but integrated components that represent the logical sequence of travel behavior. These components and their general order in the traffic forecasting process are as follows:

- **Trip Generation-** The trip generation process translates land use quantities (number of dwelling units, number of employees) into vehicle trip ends (number of vehicles entering or leaving a TAZ).
- **Trip Distribution-** This step estimates how many trips travel from one zone (TAZ) in the model to any other zone. Distribution is based on the number of trip ends generated in each zone pair and on factors that relate the likelihood of travel between any two zones to the travel time between zones.
- **Mode Choice-** This step determines how many trips will be made by various modes (single-occupant vehicle, transit, carpool, etc.).
- **Traffic Assignment-** This step allocates trips between an origin and destination by a particular mode to a route, where each traveler is assigned to the path with the shortest travel time.

The initial roadway network used in the traffic model was the streets and roadways identified in the existing conditions chapter (Chapter 3) of this plan. A future 2040 Committed Scenario was analyzed to identify existing deficiencies and motor vehicle infrastructure needs. The Committed Scenario assumes that the BMPO planning area will experience its projected growth in population and employment and the demand for the transportation facilities will increase accordingly. The Committed street network includes TSP projects identified in the adopted plan, that have committed funding to construct, either through the City’s Capital Improvement Program (CIP), the Oregon Statewide Transportation Improvement Plan (STIP), or other privately funded road improvements. The transportation improvements assumed for this scenario are listed in Tables 6-2 and 6-3. This scenario serves as the basis of comparison for the other future year (2040) scenario that will be evaluated.

Table 6-2: Highway and Arterial Projects (Committed)

Location	From	To	Improvement	Jurisdiction	Construction Status
Reed Market Rd	15 th Street	27 th Street	3-lane collector modernization with bike lanes and sidewalks	Bend	Complete
Reed Market Rd	15 th Street		Intersection Improvement – will convert from signal to partial multi-lane roundabout	Bend	Under Construction
Reed Market Rd	American Lane		Re-align American Lane (straighten road and add traffic signal at Reed Market intersection)	Bend	Under Construction

Location	From	To	Improvement	Jurisdiction	Construction Status
Reed Market Rd	4 th Street	15 th Street	3-lane collector modernization with bike lanes and sidewalks	Bend	Under Construction
Murphy Rd Phase 1			Re-align Murphy Rd, Murphy Rd overcrossing of US 97, hwy access modifications, roundabout at Murphy/3rd	Bend/ODOT	Under Construction

Table 6-3: Collector Roadway Improvements (Committed)*

Location	From	To	Improvement	Construction Status
New E-W Collector	Brosterhous Rd	American Lane	New 2-lane road	Future date (TBD)

Note: * This list of improvements is intended to focus on regionally-significant improvements and there may be other committed local City projects that are not listed here.

The Bend MPO travel demand model is a useful tool for determining future deficiencies in the transportation network. The model was created using average annual weekday daily traffic volumes. These volumes reflect average conditions, but neglect the seasonal variations that are characteristic of the area. Typically, adjustments for the 30th Highest Hour or other correctional factors are applied to traffic counts on state highways (US 20 and US 97) to reflect the higher traffic volumes that are exhibited during the summer months. The counts are adjusted based on data from Automatic Traffic Recording (ATR) devices maintained on state facilities. The travel demand model does not account for these adjustments. Based on the travel characteristics within and through the BMPO planning area, seasonal variation has a significant impact on the existing and future traffic operations and it should be noted that the model generally underestimates the future forecast traffic volumes for certain peak months throughout the year.

Future Corridor Deficiencies

The Committed Scenario represented the base case for the forecasted 2040 growth. This scenario included transportation system improvements within the BMPO planning area that can be constructed and implemented with the current programmed funding and are identified in the Capital Improvement Plan (CIP) or the Statewide Transportation Improvement Plan (STIP). Figure 6-1 shows the forecasted demand to capacity ratio on roadways within the planning area for the 2040 Committed Scenario. The demand-to-capacity ratios illustrated here are based on raw model outputs that serve as a general guide to identify needs and differ from the volume/capacity (v/c) ratios that are calculated using post-processed traffic volumes and the *Highway Capacity Manual Methodology*¹. As shown, the Committed Scenario transportation system does not have adequate roadway capacity to serve the expected future travel needs. Red roadway segments in Figure 6-1 indicate roadway segments that are over-

¹ 2000 *Highway Capacity Manual*, Transportation Research Board, 2000, Chapter 27.

capacity and do not meet the City or ODOT (0.85 in most of the MPO area) traffic operating standards. The demand-to-capacity ratios exceed 1.0 on multiple key corridors in the study area including:

- Cooley Road (between Boyd Acres Road and 18th Street)
- Reed Market Road
 - between Brookwood Boulevard and Bend Parkway
 - between American Lane and Pettigrew Road²
- US 20
 - between Cooley Road and Empire Avenue
 - between 3rd Street and 15th Street
- US 97
 - between Cooley Road and Butler Market Road
 - between Revere Avenue and Truman Avenue
- 27th Street (between Bear Creek Road and Ferguson Road)
- OB Riley Road (between Mathers Drive and Archie Briggs Road)
- Colorado Avenue (between Simpson Avenue and Broadway Street)
- Neff Road (between 8th Street and Purcell Boulevard)
- 15th Street
 - between Bear Creek Road and Wilson Avenue
 - between Reed Market Road and Desert Wood Drive
- Empire Avenue (Boyd Acres Road and US 20)
 - between US20 and Bend Parkway
 - between 18th Street and Purcell Boulevard
- 18th Street (between Egypt Drive and Empire Avenue)
- Wilson Avenue (between Bond Street and 15th Street)
- Brookwood Boulevard (between Powers Road and Porcupine Road)
- Wall Street (from Revere Avenue to Lafayette Avenue)

² City of Bend TSP street policy #19 prohibits widening Reed Market Road from Century Drive to Bond Street.

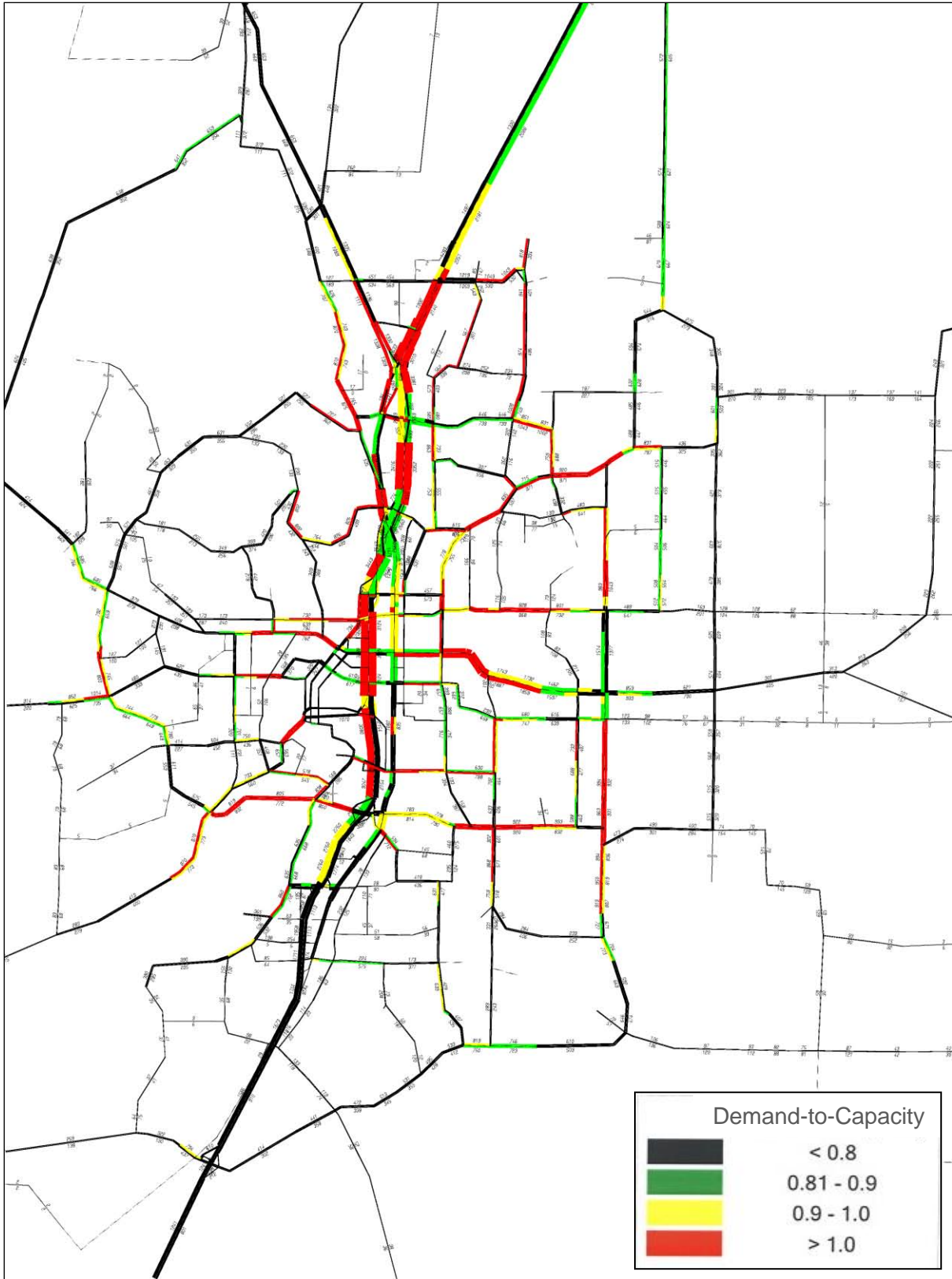


Figure 6-1: 2040 Committed Scenario System Performance Plot

Within the planning area, US 97 and US 20 generally have an operational v/c standard of 0.85. This standard is more stringent than the City's standard. In addition to the red segments shown in Figure 6-1, the green and yellow segments of US 97 and US 20 also fall below the jurisdictional standards. The most congested area on US 20 is generally concentrated between 3rd Street and Purcell Boulevard and does not meet operational standards for a significant portion of the corridor. US 97 also exhibits high congestion levels and does not meet jurisdictional standards for the majority of the corridor between Tumalo Road and Reed Market Road under the 2040 Committed Scenario.

Peak Hour Travel Speeds

PM peak hour travel speeds were also extracted from the future year (2040) model for the Committed Scenario along four corridors including:

- Reed Market Road (Colorado Avenue to Pettigrew Road)
- 27th Street (Butler Market Road to Rickard Road)
- 3rd Street (Greenwood Avenue to Murphy Road)
- US 20 (Old Bend-Redmond Highway to Empire Avenue)
- Greenwood Avenue/US 20 (3rd Street to Providence Drive)

The model output provided average travel speeds by direction of travel. The comparison of travel speeds for existing and future years indicate general deficiencies in the roadway network; reduced travel speeds are attributed to increases in traffic flow. Table 6-4 summarizes the existing travel speeds extracted from the 2010 base model and the future 2040 Committed Scenario for the PM peak hour. Note that while these travel speeds are not post-processed, they still provide an indication of congestion. As shown in the table, the model forecasts travel speeds along the key roadways to decrease by as much as 40% in the future year (2040).

Table 6-4: Corridor Raw Model Travel Speeds³ (PM Peak Hour)

Corridor	2010 (Existing)	2040 (Committed)	% Change
Reed Market Road (eastbound)	37.8 mph	29.5 mph	-22%
Reed Market Road (westbound)	37.8 mph	28.9 mph	-24%
27 th Street (northbound)	42.6 mph	41.1 mph	-4%
27 th Street (southbound)	43.9 mph	37.3 mph	-15%
3 rd Street (northbound)	38.7 mph	38.1 mph	-2%
3 rd Street (southbound)	38.6 mph	33.8 mph	-12%
US 20 (southbound)	49.0 mph	29.4 mph	-40%
US 20 (northbound)	49.3 mph	40.7 mph	-17%

³ Corridor model travel speeds were extracted directly from the MPO travel model and reported without post-processing.

Corridor	2010 (Existing)	2040 (Committed)	% Change
Greenwood (US 20) Avenue (eastbound)	45.5 mph	36.1 mph	-21%
Greenwood (US 20) Avenue (westbound)	46.0 mph	41.5 mph	-10%

Roadway System Improvements

The projected roadway directional volumes were reviewed to identify locations where capacity improvements might be required between intersections. The seven locations identified were:

US 97 from Colorado Avenue to US 20 – through volumes are too high for conventional 4-lane expressway service and a separate refinement plan is needed to examine local capacity improvements and congestion management measures.

Reed Market from Parkway to 27th Street—through volumes are too high for conventional 2-lane arterial service. Currently funded projects (included in the Committed Network) include capacity and intersection improvements along the corridor that should be adequate to handle the demand as a high-capacity 3-lane arterial.

US 97 from US 20 to Cooley Road – through volumes are too high for conventional 4-lane arterial service. The US 97 North Bend Corridor Project is currently underway and will identify a long term solution for this section of US 97. Interim improvements may be possible at the intersections of Cooley Road and Robal Road.

27th Street from Butler Market Road to Rickard Road – through volumes are too high for conventional 2-lane arterial service. Possible capacity improvements include upgrading the arterial to 3-lanes.

Empire Avenue from 3rd Street to Parkway Ramps – through volumes are too high for conventional 3-lane arterial service. Proposed capacity improvements include upgrading to 5-lanes.

18th Street from Empire Boulevard to Cooley Road – through volumes are too high for conventional 2-lane arterial service. Completing the 3-lane arterial improvements should be adequate.

O.B. Riley Road from Glen Vista Road to Archie Briggs Road – through volumes are too high for conventional 2-lane major collector service. Possible improvements include upgrading O.B. Riley Road to a 3-lane, high-capacity collector.

Future Capacity Analysis

The current analysis focuses on applying the travel model to extract system measures such as link capacity and demand. The previous MTP, the Bend TSP, and the Bend SDC analyzed future demand at study intersections within the MPO and provided the guidance for developing an intersection improvement project list. These projects have an estimated cost of \$65 million, are funded by a variety of City sources, and are not included in the current MTP analysis of regionally significant corridors.

Scenario Development

As summarized in the previous section, the Committed Scenario has significant roadway system capacity deficiencies in the future year (2040). Addressing the system deficiencies requires both direct upgrades to roadways and other measures (transit, bicycle/pedestrian improvements, and traffic demand management policies) that are not completely captured in the travel demand model. Future MTP updates may provide more comprehensive motor vehicle analysis including transit, bicycle/pedestrian, and traffic demand management policy impacts.

One preferred build scenario was developed for this MTP Update. The scenario is based on the project list of the previous MTP Preferred 2030 scenario with several refinements to address new system deficiencies caused by updated 2040 land uses and traffic growth. In future MTP Updates, projects will be added and removed from the preferred list based on the evaluation process outlined in the next section. Qualitative measures of effectiveness will be captured by the updated travel model. The result will be financially constrained Preferred Scenario addressing the most important system deficiencies.

A funding analysis⁴ was conducted to determine the available funding resources for transportation capital projects and public transportation operations in the Bend MPO area over the planning period for the MTP (2014-2040). Several road-related funding sources were identified at the federal, state, and local level for the planning period. Total available transportation revenue is \$252.6 million, with \$156.6 million available for roadway projects.

Evaluation Process

Evaluation criteria help guide the selection of future roadway projects within the BMPO planning area and provide qualitative and quantitative measures for each goal category developed at the onset of the planning process. The evaluation criteria are categorized into two levels; the first level of evaluation includes criteria that can be used for general screening purposes and evaluates how well potential projects meet the established goals and policies. The second level of evaluation includes a more detailed system-wide analysis that evaluates specific projects included in the travel demand model. Table 6-5 outlines the first level of recommended evaluation criteria categorized by goal category.

⁴ Bend MTP Revenue Analysis, *ECONorthwest*. August 2014.

The table includes both quantitative and qualitative measures of effectiveness that were considered while developing the future (2040) scenario roadway improvement projects for inclusion in the Preferred Scenario.

Table 6-5: Recommended Evaluation Criteria

Goal Category	Measure of Effectiveness	Type of Criteria
Project Level Criteria		
Mobility and Balance	<ul style="list-style-type: none"> ▪ Demand-to-capacity ratio ▪ Travel speeds ▪ Provides balance of modes of travel 	<ul style="list-style-type: none"> ● ● ○
Safety and Efficiency	<ul style="list-style-type: none"> ▪ Ability to address existing safety issues ▪ Ability to support TSM measures ▪ Supports ITS corridor 	<ul style="list-style-type: none"> ○ ○ ○
Environment and Livability	<ul style="list-style-type: none"> ▪ Impact to environmentally sensitive land ▪ Impact to resource land 	<ul style="list-style-type: none"> ○ ○
Economic Development	<ul style="list-style-type: none"> ▪ Provision for economic revitalization ▪ Supports freight mobility ▪ Supports ITS corridor 	<ul style="list-style-type: none"> ○ ○ ○
Program Level Criteria		
Accessibility and Equity	<ul style="list-style-type: none"> ▪ Ability to provide Transportation Demand Management (TDM) ▪ Connectivity of travel modes 	<ul style="list-style-type: none"> ○ ○
Land Use	<ul style="list-style-type: none"> ▪ Ability to support multi-modal transportation development ▪ Improve street connectivity ▪ Provide alternatives to state route system for local travel 	<ul style="list-style-type: none"> ○ ○ ○
Financially Responsible	<ul style="list-style-type: none"> ▪ Capital cost of alternatives ▪ Opportunity to promote public / private partnership 	<ul style="list-style-type: none"> ● ○

- Notes**
- = Quantitative (Absolute value from technical methods)
 - = Qualitative (Relative value based on judgment)

The previous MTP update used similar evaluation criteria to identify Preferred Scenario projects. The majority of the projects selected for the current Preferred Scenario were identified and evaluated for priority in the previous MTP update.

The Bend MPO travel demand model (developed by TPAU) was used to analyze several quantitative measures. This section describes the system performance measures used to evaluate the different scenarios and presents the results of the overall system wide performance evaluation.

Preferred Scenario

The preferred scenario includes the recommendations for the Bend Metropolitan Transportation Plan for the future year (2040). The Preferred Scenario for the future year was selected based on the system-wide system performance evaluation, the adopted goals and policies and the results of the financial analysis. The Preferred Scenario includes a list of projects that have been prioritized based on the established

evaluation criteria outlined above and the financial constraints of the existing and future budget. The project list includes projects from the previous MTP Preferred Scenario that are still needed to address the future capacity issues throughout the Bend MPO planning area, as well as new projects that were identified to meet system needs. As mentioned previously, the project list only includes projects that have regional significance. All other projects are the responsibility of the City and County for implementation and they are not included in the Bend MTP list of preferred projects.

Some of the collector roadway system deficiencies identified in each of the future scenarios were not addressed in the project lists due to limited minimal impacts to the regional transportation system. The financial analysis that was developed in coordination with the Bend MTP examined revenues for the arterial and collector systems. For the purpose of this regional analysis, a total cost for the collector project list over the MTP time period is included in Table 6-6, though several of the individual projects are not identified.

Table 6-6 summarizes the recommended roadway improvement projects under three jurisdictions: City of Bend, Deschutes County or ODOT. For most projects, the location includes a street segment defined by the street name with the project limits. This list is preliminary and the specific limits and location may be refined as further analysis is conducted and more information is obtained before construction occurs. The projects identified are at the planning level and many of the details were assumed based on the time-frame of construction and may be modified prior to construction. All of the projects identified in the preferred scenario have a project number that is mapped on Figures 6-3 and 6-4. Roadway expansion and extension projects are illustrated in Figure 6-3; intersection improvements and roundabouts are illustrated in Figure 6-4.

The projects were selected and prioritized based on funding availability, the established evaluation criteria, and the impact of the projects within the BMPO planning area. The evaluation criteria were introduced in the previous section and include a series of quantitative and qualitative project level criteria. These criteria are used to prioritize and select projects for the Preferred Scenario.

Table 6-6 outlines the prioritized projects into two categories, short-term and long term. The short-term projects include committed projects that are already funded (including GO Bond) to address needs identified through previous planning and analysis and are expected to occur within the next five years. The long-term projects include projects that will occur more than five years after the plan has been adopted. Prioritization of the projects will be refined through Stage 2 of the MTP Update.

These potential roadway improvement projects are needed to comply with adopted policies and standards within the BMPO area. The project priority listed in the table serves only as a guide for implementation. Changes in development patterns, funding availability and other factors may influence the order that projects are constructed throughout the BMPO planning area.

Table 6-6: Financially Constrained / Preferred Scenario-Project List

Project #	Location (Jurisdiction)	From	To	Improvement	Project Priority	Planning Level Cost (\$1,000s)
1	Reed Market Rd	15 th Street	27 th Street	3 lane collector modernization with bike lanes and sidewalks	Short	Funded
2	Reed Market Rd	15 th Street		Intersection Improvement – will convert from signal to partial multi-lane roundabout	Short	Funded
3	Reed Market Rd	American Lane		Re-align American Lane (straighten road and add traffic signal at Reed Market intersection)	Short	Funded
4	Reed Market Rd	4 th Street	15 th Street	3 lane collector modernization with bike lanes and sidewalks	Short	Funded
5	Murphy Rd Phase 1			Re-align Murphy Rd, Murphy overcrossing US 97, hwy access modifications, Murphy/3 rd roundabout	Short	Funded (under construction)
6	New E-W Collector	Brosterhous Rd	American Lane	New 2 lane road	Short	Funded
Total Short-Term Project Cost (projects 1-6): Funded						
7	Empire Avenue	3 rd Street	US 97 NB ramps	Widen to 5 lanes and install signal at SB ramps	Long	\$3,900
8	Empire Avenue	Purcell Boulevard	27 th Street	Construct 2 lane extension	Long	\$6,700
9	Reed Market Road (Bend)	27 th Street Intersection		Re-align Stevens Road to connect directly to Reed Market Road	Long	\$4,700
10	O.B. Riley Road	Empire Avenue Intersection		Construct intersection control improvements	Long	\$1,900
11	Murphy Road	Brosterhous Road	15 th Street	Construct 2 lane extension	Long	\$11,375
12	US 97/Cooley Road area improvements	Cooley Road		Various intersection and lane upgrade improvements	Long	\$30,000
13	Empire Ave (Bend)	US 97 NB off-ramp		Widen existing ramp to 2 lanes	Long	\$3,000
14	US 97	Powers Road Intersection		Preliminary engineering and ROW acquisition for overcrossing or interchange	Long	\$6,500
15	US 20 (Greenwood Avenue)	4 th Street Intersection		Install traffic signal	Long	\$413

Project #	Location (Jurisdiction)	From	To	Improvement	Project Priority	Planning Level Cost (\$1,000s)
16	Yeoman Road	18 th Street	Existing section	Construct 2 lane extension	Long	\$1,009
17	North frontage road	Murphy Road	Powers Road	New 2 lane road	Long	\$5,400
18	South frontage road	Murphy Road	Parkway off-ramp	New 2 lane road	Long	\$13,800
19	Britta Street (north section)	Robal Road	Empire Avenue	New 2 lane road extension	Long	\$1,000
20	Britta Street	Ellie Lane	Halfway Road	New 2 lane road extension	Long	\$2,000
21	Purcell Boulevard	Holiday Ave (south)	Holida Avenue (north)	New 2 lane road extension	Long	\$2,288
22	Mervin Samples Road – Sherman Road	O.B. Riley Road	Empire Avenue	Upgrade to 2 lane collector roadway and install traffic signal at US 20	Long	\$6,100
23	O.B. Riley Road	Glen Vista Road	Archie Briggs Road	Upgrade to 3 lane arterial	Long	\$6,700
24	27 th Street	Bear Creek Road	Ferguson Road	Upgrade to 3 lane arterial	Long	\$11,500
25	US 97	Murphy Road		Construct northbound on and southbound off ramps	Long	\$6,100
26	18 th Street	Cooley Road	Empire Avenue	Complete 3 lane arterial corridor	Long	\$6,100
42	US 20	Cooley Road		Construct intersection control improvements	Long	\$1,600
45	US 20	Cooley Road	3 rd Street	Add second southbound through lane	Long	\$4,800
46				Other future local transportation projects	Long	\$19,678
Total Long-Term Project Cost (projects 7-26, 42, 45, and 46):						\$156,563
TOTAL COST:						\$156,563

**The project cost estimates include right-of-way costs.*

Scenario Model Evaluation

Each model scenario was used to evaluate the impacts of the scenarios on the regional transportation system. These criteria are most relevant during the initial stages of project development for general screening purposes and planning purposes. The criteria have been refined by the BMPO and are used to determine the projects to be selected for inclusion in the plan.

Figure 6-2 shows the forecasted demand to capacity ratio on roadways within the planning area for the 2040 Preferred Scenario.

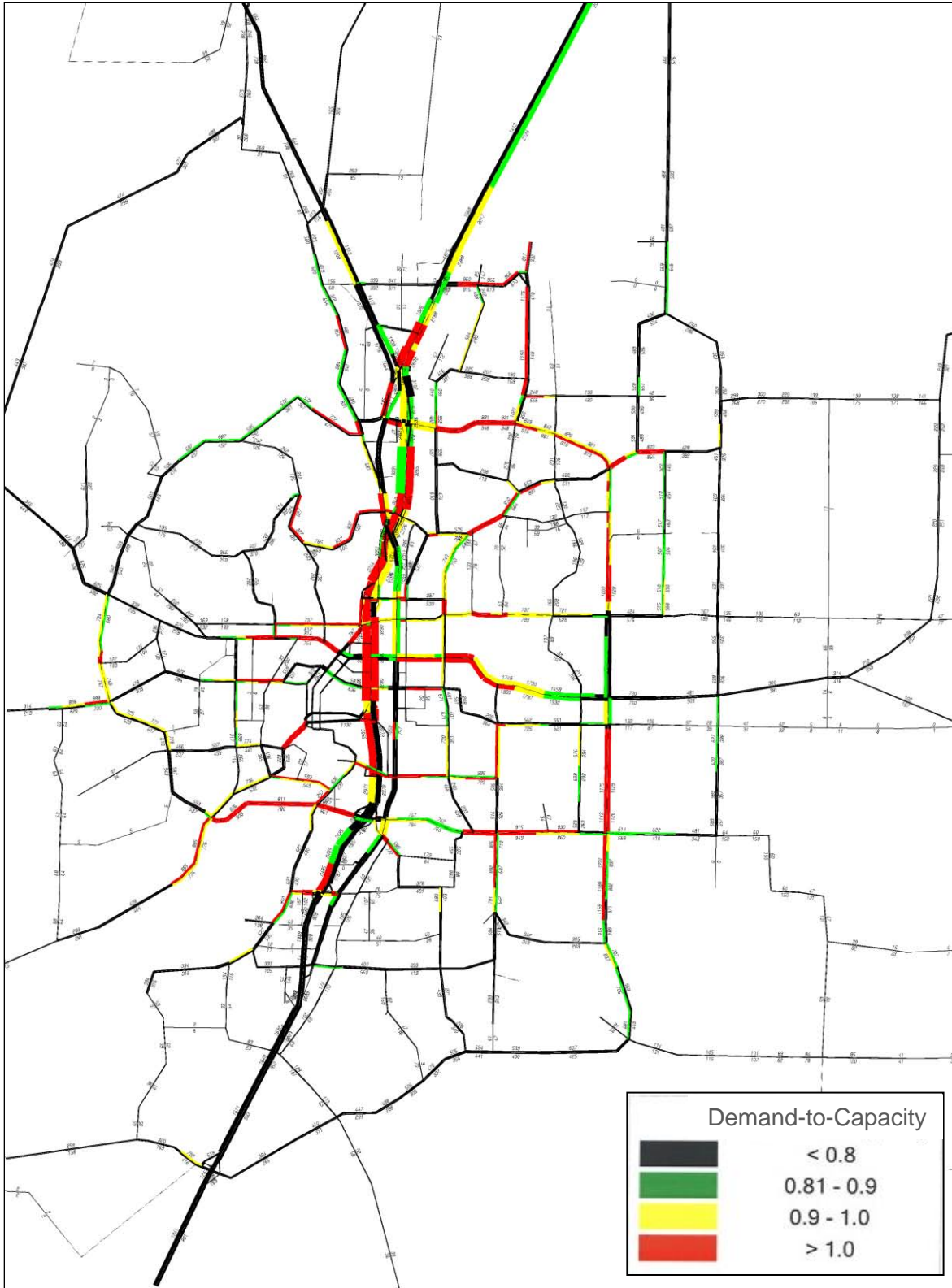


Figure 6-2: 2040 Preferred Scenario System Performance Plot

A system-wide evaluation for the future year (2040) of the BMPO planning area was conducted on the model data. The evaluation criteria and results are discussed below.

- **Vehicle Miles Traveled (VMT) during the PM peak hour** -- This measure evaluates the total miles traveled by all vehicles over a selected transportation corridor or over the entire system within the predicted future MPO boundary during the PM peak hour.
- **Vehicle Hours Traveled (VHT) during the PM peak hour** -- This measure evaluates the total hours traveled by all vehicles over a selected transportation corridor or over the entire system within the predicted future MPO boundary during the PM peak hour.
- **Total Lane Miles** -- This measure evaluates the length of driving lanes multiplied by the number of driving lanes for the total transportation roadway network within the predicted future MPO boundary.
- **Demand/Capacity Ratio** -- The measure of congestion can be measured by the demand/capacity ratio which determines the ratio of vehicles over the capacity of a roadway. The travel demand model has the capacity of evaluating the overall flow of traffic over the length of a specified corridor. D/C ratios that are higher than 0.80 affect driving decisions due to the presence of other vehicles. A D/C ratio of 1.0 indicates significant congestion.
- **Number/Percentage of Congested Lane Miles during the PM peak hour** -- Congestion on the roadway network is defined by a threshold of the demand over capacity ratio. The number and percentage of lane miles that operate with a D/C ratio over 0.80 are characterized by “congested conditions”. The level of congestion can also be determined by a scale of D/C ratios that include free flow, moderately congested, and congested.
- **Travel times during the PM peak hour** -- Traffic flow can be measured by computing the time it takes to complete a trip during the PM peak hour (which is typically the most congested period of the day). The measure can be determined for specific corridors or the average for the entire planning area transportation system

The following tables (Table 6-7 thru Table 6-10) compare numerous evaluation measures that were calculated from the base year (2010) and future year (2040) model output. The evaluation of the scenarios refined the selection of the Preferred Scenario. Note that all measures are calculated for the roadway system within the predicted future MPO boundary, with the exception average travel time. Average travel time is calculated over the entire system for all trips beginning and/or ending within the predicted future MPO boundary.

Table 6-7: MPO System-wide Performance Measures (PM Peak Hour)

PM Peak Hour Performance Measures	EXISTING	FUTURE	
	Base Year (2010)*	Committed (2040)	Preferred (2040)
City of Bend Facilities			
Vehicle Miles Traveled (VMT)	59,256	112,017	111,703
Vehicle Hours Traveled (VHT)	1,162	3,419	3,342
Deschutes County Facilities			
Vehicle Miles Traveled (VMT)	4,587	13,241	13,356
Vehicle Hours Traveled (VHT)	107	299	299
ODOT Facilities			
Vehicle Miles Traveled (VMT)	44,353	69,391	71,210
Vehicle Hours Traveled (VHT)	941	1,814	1,698
Total (All Facilities)			
Average Travel Time (minutes)	7.20	8.65	8.35
Vehicle Miles Traveled (VMT)	108,196	194,649	196,269
Vehicle Hours Traveled (VHT)	2,660	5,532	5,339

*For the base year, all measures were calculated based on the existing MPO boundary.

Table 6-7 outlines critical evaluation measures such as the peak hour average travel time, vehicle miles traveled and vehicle hours traveled for City of Bend, Deschutes County and ODOT facilities. These measures are quantitative measures that are typically used to evaluate the transportation network and effectively indicate future travel patterns compared to the base year (2010) and future year Committed Scenario (2040) and the Preferred Scenario (2040). The Preferred Scenario improves system-wide operations by improving (decreasing) VHT by over 3% from the Committed Scenario while maintaining approximately the peak VMT (<1% difference). The average travel times for the PM peak hour increase by 20% from the Base Scenario to Committed Scenario, while the Preferred Scenario provides a 3% improvement over the Committed Scenario.

Table 6-8: Percentage of Congested Lane-Miles (PM Peak Hour)

	EXISTING	FUTURE	
	Base Year (2010)	Committed (2040)	Preferred (2040)
City of Bend Facilities			
Total Lane Miles	246	267	272
Congested Lane Miles	15	80	72
% of Congested Lane Miles	6%	30%	26%
Deschutes County Facilities			
Total Lane Miles	42	49	47
Congested Lane Miles	0	3	4
% of Congested Lane Miles	0%	6%	9%
ODOT Facilities			
Total Lane Miles	68	75	83
Congested Lane Miles	11	41	34
% of Congested Lane Miles	16%	55%	41%

Note: Congestion defined as model links with demand/capacity ratio ≥ 0.80
 ODOT operational standard: $v/c = 0.80$

Table 6-8 illustrates a similar trend of evaluation results; the Preferred Scenario has the most significant effects on the future roadway network. There are more total lane miles due to the number of roadway extension and expansion projects, but the percentage of congested lane miles decreases by 4% for City of Bend and 14% for ODOT facilities with the Preferred Scenario improvements.

Table 6-9 and Table 6-10 provide a summary of future year (2040) congested conditions. D/C ratios that are greater than 1.0 indicate congested conditions on the roadway network. The City of Bend maintains the highest percentage of roadway facilities within the BMPO planning area.

Table 6-9: Percentage of Total Lane Miles by Demand/Capacity Ratio (PM Peak Hour)

Demand/ Capacity Ratio	EXISTING		FUTURE			
	Base Year (2010)		Committed (2040)		Preferred (2040)	
	Lane Miles	%	Lane Miles	%	Lane Miles	%
City of Bend Facilities						
0.0-0.59	207	84%	146	55%	156	57%
0.60-0.69	12	5%	19	7%	22	8%
0.70-0.79	12	5%	22	8%	22	8%
0.80-0.89	7	3%	24	9%	20	7%
0.90-0.99	6	2%	22	8%	23	8%
≥1.0	2	1%	34	13%	29	11%
Total	246	100%	267	100%	272	100%
Deschutes County Facilities						
0.0-0.59	42	100%	38	78%	35	74%
0.60-0.69	0	0%	4	8%	5	11%
0.70-0.79	0	0%	4	8%	3	6%
0.80-0.89	0	0%	1	2%	3	6%
0.90-0.99	0	0%	1	2%	0	0%
≥1.0	0	0%	1	2%	1	2%
Total	42	100%	49	100%	47	100%
ODOT Facilities						
0.0-0.59	40	59%	22	29%	30	36%
0.60-0.69	11	16%	8	11%	10	12%
0.70-0.79	6	9%	4	5%	9	11%
0.80-0.89	9	13%	12	16%	9	11%
0.90-0.99	1	1%	10	13%	12	14%
≥1.0	1	1%	19	25%	13	16%
Total	68	100%	75	100%	83	100%

As shown in Table 6-9, ODOT facilities exhibit a higher percentage of congested roadway conditions for the PM peak hour for each of the future year (2040) scenarios (indicated by D/C ratios greater than 0.80). According to the model analysis, the Preferred Scenario provides congestion improvement over the Committed Scenario on both City and State facilities. The Preferred Scenario congestion mitigations are especially effective on State facilities, increasing uncongested lane-miles from 29% to 37% while decreasing congested lane-mile from 25% to 16%. Preferred Scenario capacity improvements to parallel routes (e.g., O.B. Riley Road) allow state facility traffic to shift to other routes, decreasing state highway congestion.

Table 6-10: Percentage of VMT by Demand/Capacity Ratio (PM Peak Hour)

Demand/ Capacity Ratio	Existing		Future			
	Base Year (2003)		Committed (2040)		TSP (2040)	
	VMT	%	VMT	%	VMT	%
City of Bend Facilities						
0.0-0.59	35,029	59%	28,247	25%	30,592	27%
0.60-0.69	6,045	10%	9,906	9%	11,159	10%
0.70-0.79	7,061	12%	12,622	11%	13,075	12%
0.80-0.89	5,099	9%	16,155	14%	13,695	12%
0.90-0.99	4,680	8%	16,136	14%	17,357	16%
≥1.0	1,342	2%	28,951	26%	25,825	23%
Total	59256	100%	112017	100%	111703	100%
Deschutes County Facilities						
0.0-0.59	4,401	96%	6,864	52%	5,877	44%
0.60-0.69	0	0%	1,736	13%	2,451	18%
0.70-0.79	0	0%	2,285	17%	2,014	15%
0.80-0.89	0	0%	1,025	8%	1,937	15%
0.90-0.99	0	0%	844	6%	261	2%
≥1.0	186	4%	486	4%	816	6%
Total	4587	100%	13240	100%	13356	100%
ODOT Facilities						
0.0-0.59	18,969	43%	11,031	16%	24,781	35%
0.60-0.69	8,449	19%	6,907	10%	9,930	14%
0.70-0.79	5,236	12%	3,396	5%	7,422	10%
0.80-0.89	8,891	20%	12,327	18%	8,013	11%
0.90-0.99	1,887	4%	10,860	16%	10,668	15%
≥1.0	921	2%	24,870	36%	10,396	15%
Total	44,353	100%	69,391	100%	71,210	100%

As noted previously, the Preferred Scenario has a higher number of total lane miles due to a number of roadway projects modeled in the scenario, but it still yields a lower percentage of congested vehicle miles traveled compared to the Committed Scenario.

Another system-wide performance measure that was evaluated includes link speeds through the transportation network. PM peak hour speeds were extracted from the future year (2040) model for the Committed and Preferred Scenarios along three select corridors including:

- 27th Street (Butler Market Road to Rickard Road)
- US 20 (Old Bend-Redmond US to Empire Avenue)
- Greenwood Avenue/US 20 (3rd Street to Providence Drive)

Table 6-11 summarizes the PM peak hour speeds along these corridors. Compared to the Committed Scenario, the speeds along the corridors increase for the Preferred Scenario and indicate that the roadway improvement projects improve the operations on these specific corridors. Travel speeds represent one system-wide measure of evaluating the changes to the roadway network and comparing differences between each scenario.

Table 6-11: Future (2040) Corridor Speed Summary (by direction)

Corridor	Committed	Preferred	Change
	<i>Speed (mph)</i>	<i>Speed (mph)</i>	<i>(%)</i>
27 th Street (northbound)	41.1	42.8	4%
27 th Street (southbound)	37.3	38.7	4%
US 20 (southbound)	29.4	41.6	41%
US 20 (northbound)	40.7	48.8	20%
Greenwood Avenue (eastbound)	36.1	38.0	5%
Greenwood Avenue (westbound)	41.5	42.3	2%

Illustrative Project List

Although the majority of projects included within this plan have reasonable funding, most of the projects identified were of regional significance but did not address many deficiencies on the state systems. The long-term facility needs for several sections along both US 97 and US 20 have been a focus of past and ongoing planning studies. Outcomes from these studies include projects (not yet funded) to improve highway operations on the state systems within the Bend MPO.

In 2007, ODOT and FHWA began the Environmental Impact Statement (EIS) for the US 97 Bend North Corridor Project to provide and plan for a safe, affordable, long term traffic solution for US 97 at the north end of Bend. Project improvements in the vicinity of Empire Avenue have identified funding and are currently listed in Table 6-6. Other improvements associated with the US 97 Bend North Corridor Project, including the extension of 3rd Street, do not have identified funding and are included in the Illustrative Project List, Table 6-13.

Given current funding trends for state facility improvements, any new state projects would require a fundamental change in funding opportunities and priorities to achieve many of them. The cost of these added improvements on state facilities are very significant and it is expected that they will require a local match to implement. Moving projects to the fiscally constrained list over time and the impact on the MTP budget will need to be addressed through future plan amendments.

An illustrative list of potential new state facility projects was developed, as summarized in Table 6-12, that will serve as placeholders until the various planning studies and environmental reviews have been completed to provide better definition of the scope and scale of anticipated projects. As more funding becomes available, the Bend MPO would consider the implementation of these projects.

Table 6-12: Illustrative Project List for State Facilities

Project Description	Limits	Estimated Cost
US 97 Bend North Corridor Improvements	Bend Northern UGB to Empire Avenue	\$120-\$180 million
US 97 Corridor Improvements	Empire Avenue to Colorado Avenue	Unknown
US 20 Corridor Improvements	3rd Street to 27th Street	Unknown
US 20 North Corridor Improvements	Tumalo Road to Empire Avenue	Unknown
US 20 grade separated improvements	At Cook Avenue/O.B. Riley Road	Unknown

Additional projects from the previous MTP Preferred Scenario or other local agency planning efforts were not included in the Preferred Scenario due to funding constraints. Some of these projects still provide regional connectivity and in some cases congestion relief either by adding lanes or providing alternate routes. Therefore, the project list provided in Table 6-13 summarizes these projects, providing additional guidance to the MPO should more funding become available over the next 25 years. Note that as these projects are not part of the Preferred Scenario they are not included on the project maps (Figures 6-3 and 6-4), nor the model system measures.

Table 6-13: Additional Illustrative Projects

Project #	Location (Jurisdiction)	From	To	Improvement	Estimated Cost (\$1,000s)
27	Cooley Road	18 th Street	Deschutes Market Road	Construct 3 lane road extension	\$11,867
28	Hunnell Road	Cooley Road	Rodgers Road	Construct new 2 lane road	\$8,000
29	Yeoman Road	Deschutes Market Road	Butler Market Road	Construct 2 lane road extension	\$1,688
30	South frontage road	Ponderosa Street	Baker Road	Construct new 2 lane road	Unknown

Project #	Location (Jurisdiction)	From	To	Improvement	Estimated Cost (\$1,000s)
31	Murphy Road	15 th Street	Rickard Road	Construct new 2 lane road extension	Unknown
32	Cooley Road	O.B. Riley Road	O.B. Riley Road	New 2 lane road loop extension	\$10,863
33	Putnam Road/Tumalo Road	City UGB	Johnson Market Road	Construct new 2 lane road	Unknown
34	Skyline Ranch Road	Shevlin Park Road	Skyliners Road	Construct new 2 lane road	\$11,000
35	Summit Drive	Mt Washington Drive	Skyline Ranch Road	Construct new 2 lane road	\$5,000
39	New E-W collector	27 th Street	Hamby Road	Construct new 2 lane road	Unknown
40	Central Area MMA Improvements			Intersection control improvements and local street network enhancements	Unknown
41	Colorado	US 97 Parkway NB Ramps		Construct intersection control improvements	\$3,400
43	Purcell Boulevard	Cooley Road	Yeoman Road	Construct 2 lane road extension	\$4,731
44	Robal Road	US 97 (Parkway) intersection		High capacity intersection improvement	\$4,800
47	US 97	Powers Road Intersection		Complete construction of interchange or overcrossing	\$13,500

Further Study/Additional Analysis

The projects listed in Table 6-6 address many of the corridor deficiencies that were identified for the future year (2040) within the Bend MPO planning area. Some of the identified deficiencies (based on ODOT's, City of Bend's and Deschutes County operational standards) were either not addressed or not completely resolved with the Preferred Scenario project list. The following corridors still contain highly congested ($D/C > 1.0$) segments in the Preferred Scenario that exceed the likely peak hour capacity on those corridors.

- US 20 – partially improved
- US 97 – partially improved

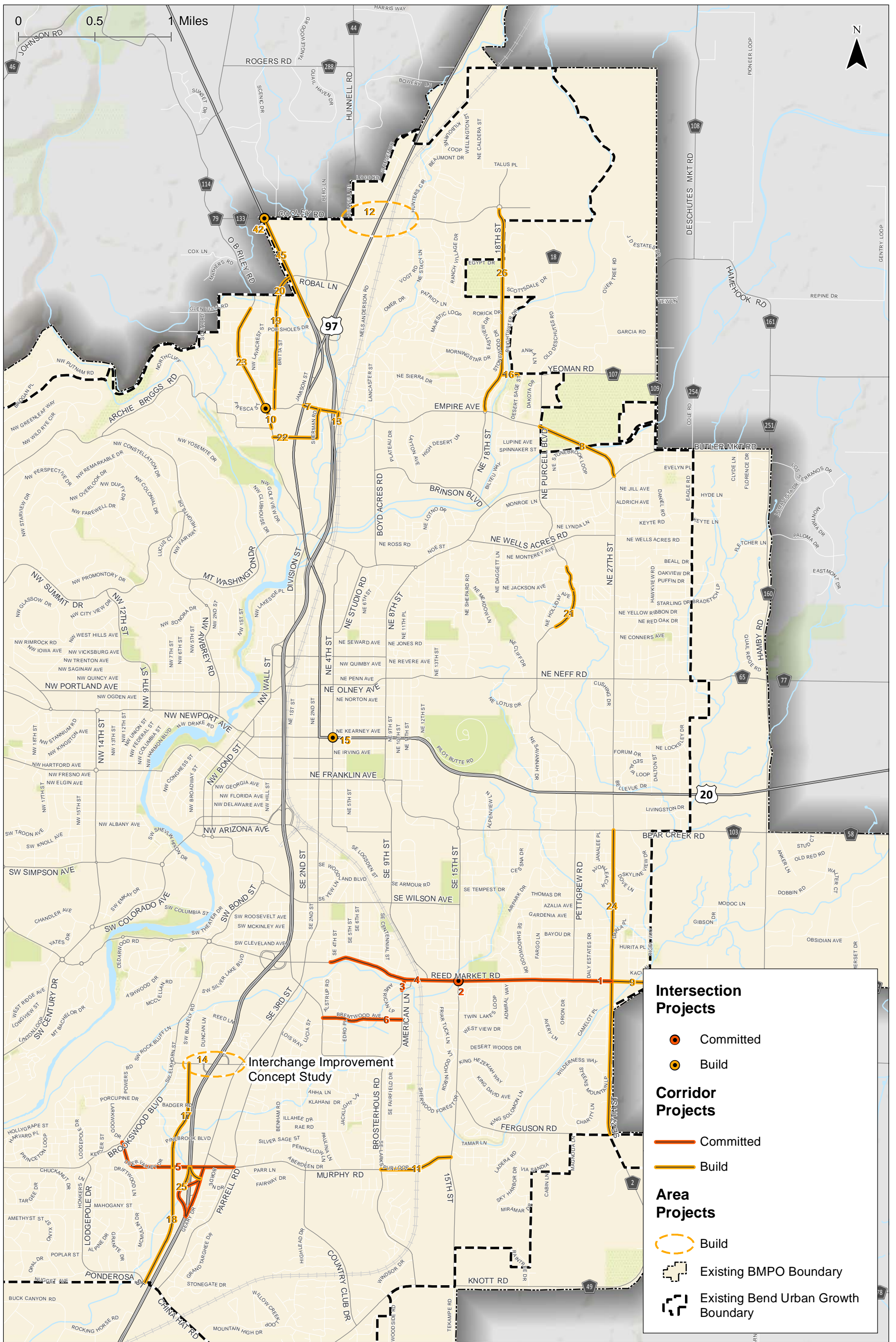
Several of the illustrative projects address the issues on these corridors, either by moving demand to alternate routes or improving capacity on existing routes. Future updates to the MTP may refine the corridor analysis, using intersection operational

measures to better capture project impacts and determine if additional corridor capacity is justified.

Several segments were identified on US 97 that will not meet operational standards in the future year. The Average Daily Traffic (ADT) volumes along this four-lane facility for the future year (2040) are projected to be between 45,000–50,000 vehicles⁵ per day. The high traffic volumes along the Bend Parkway and US 97 were not directly addressed in this MTP Update. Additional north-south capacity, in the form of parallel local improvements, and other management strategies should be considered in a future US 97 Parkway Refinement Study. The on-going Bend Urban Growth Boundary (UGB) Expansion Study also includes the analysis of several different alternative roadway networks, including a network of arterial and collector improvements on the east side of Bend. This network will be evaluated further and included as part of future MTP updates, along with other findings and recommendations from the UGB Expansion study.

There are numerous other highway segments that will not meet ODOT's mobility standards by the MTP's horizon year of 2040, consequently there will need to be additional analysis of options to address these deficiencies. Given the constraints and high costs which would be needed to provide sufficient capacity improvements to meet mobility standards, Transportation System Management (TSM) options such as access management and ramp metering may be considered. Alternate mobility standards may be considered for highway sections, but this will require additional evaluation and approval by ODOT.

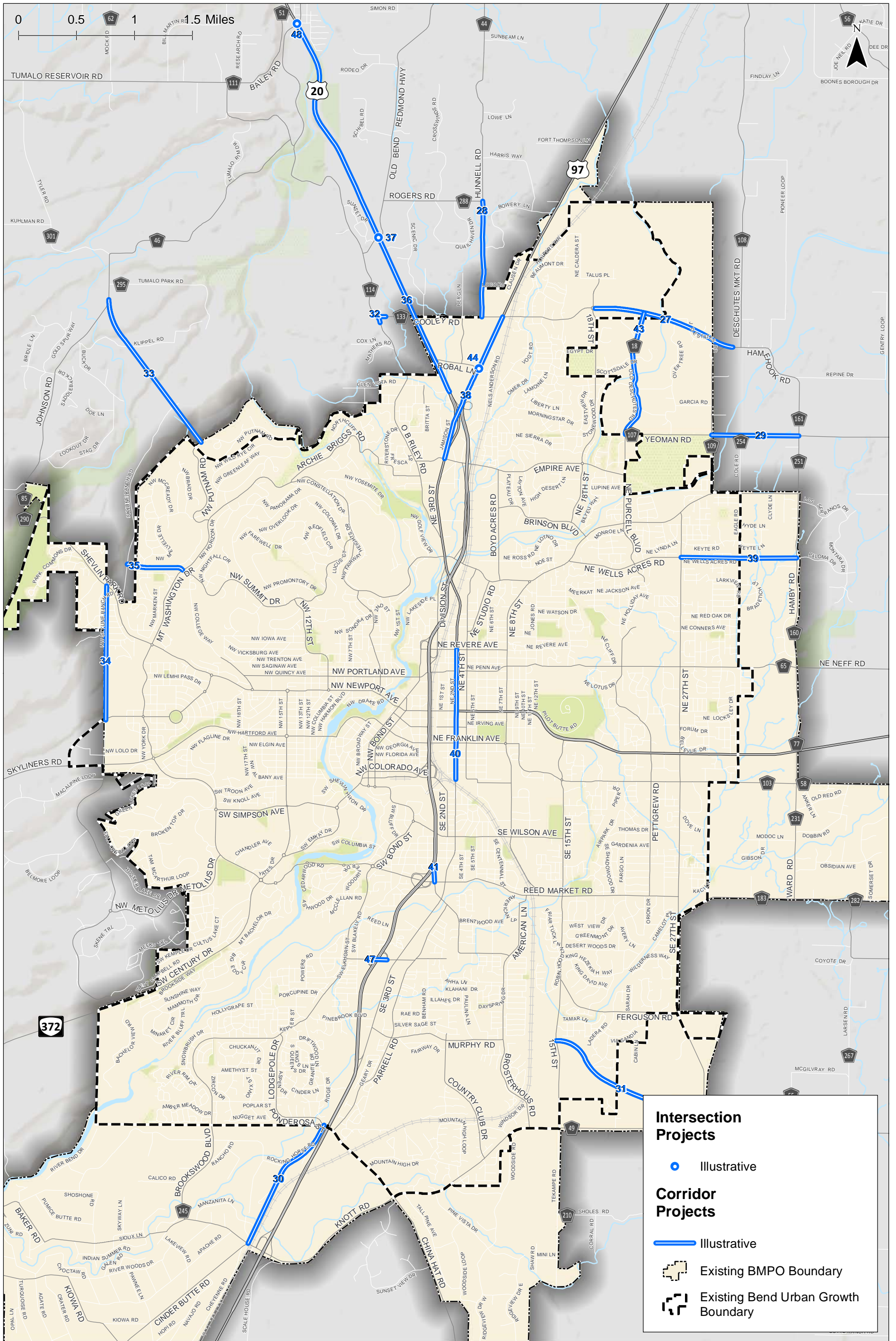
⁵ Based on 2040 travel demand model output.



K:\H_Perlan\proj\file11176 - Bend MPO MTP Updates\6-3 Committed and Build Roadway Improvements - final.mxd - agriffin - 9:47 AM 10/22/2014

Committed and Build Roadway Improvements Bend, Oregon

Figure 6-3



Intersection Projects

- Illustrative

Corridor Projects

- Illustrative

--- Existing BMPO Boundary

— Existing Bend Urban Growth Boundary

Illustrative Roadway Improvements Bend, Oregon

Figure 6-4

K:\H_Performance\11176 - Bend MPO MTP Update\gis\6-4 Aspirational Roadway Improvements final.mxd - agriffin - 10/17 AM 10/22/2014

