US 97 Parkway Plan
TECH MEMO #2: EXISTING CONDITIONS

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DATE: December 13, 2017

TO: US 97 Parkway Plan Project Team

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P17008-000

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The purpose of this memorandum is to describe existing transportation conditions for US 97 and the US 97 Bend Parkway through the city of Bend. This includes a description of the geometric characteristics, frequencies and types of access provided, traffic controls, modes of travel served, traffic volume characteristics, conditions for walking and biking, safety conditions, levels of congestion, and the reliability of travel times through the corridor. A summary of the key findings from this memorandum is provided below, with further information included in the subsequent sections.

SUMMARY OF KEY FINDINGS

Existing Transportation Facilities

- US 97 through the study corridor is classified as a Statewide Highway and has been designated as a part of the National Highway System, a Federally Designated Truck Route, a State Freight Route and Reduction Review Route, and an Expressway. The segment south of Robal Road to south of the Murphy Road interchange has also been designated as a Bypass.
- Sidewalk coverage is sparse, but bicycle facilities are present along most of the corridor.
- Speed limits range between 45 and 65 mph.
- The northbound and southbound travel lanes are physically separated through most of the study corridor. The approximately 3.4-mile segment of highway between Tumalo Place and Grandview Drive includes only a striped median of about 10 feet in width.
- From Empire Avenue to Reed Market Road, the average interchange spacing is approximately one mile, which is significantly shorter than ODOT's 1.9-mile interchange spacing standard for urban expressways.
- Approximately two-thirds of the highway corridor has substandard shoulder widths.
- Approximately 30 regional transit buses travel along US 97 every weekday.

Traffic Volume

- Traffic volumes in the south half of the corridor have more seasonal variability with a steeper increase in traffic during the summer. This likely indicates a higher recreational proportion of traffic compared to the more commuter-oriented traffic profile in the north half of the corridor.
- During a typical weekday, traffic volumes peak sharply in the morning around 7:00 AM, decrease until about 10:00 AM, then gradually increase and peak again around 5:00 PM.
- PM peak traffic volumes are significantly higher than those in the AM peak.
- The Central Study Area experiences the greatest traffic volumes (nearly 49,000 vehicles per day), while the South Study Area experiences the lowest (about 19,000 vehicles per day).

Multimodal Analysis

- The at-grade pedestrian crossings at Reed Lane, Badger Road, and Pinebrook Boulevard appear to be appropriately controlled (Rectangular Rapid Flashing Beacons) for the low measured pedestrian

demand. However, if even a modest increase in pedestrian demand were realized, a higher level of protection would be warranted, such as a signal or beacon with red indication. Since one of the project goals is to "Facilitate the use of multimodal travel options"[1], this should be considered in the future.

- The distances on US 97 between pedestrian and bicycle crossing opportunities range from 900 to 4,500 feet, with an average of 2,000 feet. Crossings in the North Study Area are most widely spaced. From Butler Market Road to Murphy Road, where crossing demand is likely highest, the average distance between crossings is approximately 1,650 feet (about 1/3 mile). In urban areas, the desired spacing for pedestrian and bicycle accessways commonly ranges from 500-800 feet, where practical.
- Bicycle crossings at interchange ramps are difficult to complete, especially at off-ramps where exiting vehicles can often be difficult to recognize from through vehicles due to late activation of turn signals.
- For northbound bicycles, the crossing at the northbound US 20 to Sisters loop ramp does not have sufficient sight distance, requiring the cyclist to estimate vehicle proximity by sound.

Safety Analysis

- Most crashes occur in the 12:00 PM to 6:00 PM period, which corresponds with the peak in traffic volumes.
- Weekdays experience more crashes than weekend days.
- November and December experience significantly more crashes than the other months.
- Approximately 58 percent of all crashes resulted in only property damage.
- Most crashes for a road condition of either wet, snow, or ice occur in the months of November, December, and February. These account for half of the total crashes during those months.
- From 2011-2015 there were two fatal crashes, five severe injury (level 'A') crashes, four bicycle-involved crashes, and two pedestrian-involved crashes.
- The segments of US 97 between the north city limits and Robal Road and between Powers Road and the Murphy Road interchange have recently experienced crash rates higher than the statewide average. The removal of the traffic signal at the Pinebrook Boulevard intersection and the Murphy Road interchange construction project may have influenced the crash rate in the latter segment.
- 19 of the 29 study intersections were flagged as safety focus locations, including the three top 10 percent SPIS sites at Cooley Road, Powers Road, and Pinebrook Boulevard (may have been recently mitigated). Table 1 shows which study intersections were flagged as safety focus areas and why.

[1] US 97 Parkway Plan Goals and Objectives, May 9, 2017 Final

Table 1: Intersections Flagged as Safety Focus Areas

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

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

Corridor Operations Analysis

- There is a significant amount of congestion at study intersections during the PM peak hour, with eight of the 17 unsignalized intersections and eight of the 11 signalized intersections failing to meet adopted mobility targets (i.e., they experience a V/C ratio greater than 0.85).
- Aggressive driver behavior at many unsignalized intersections during the peak hour was noted in the field, resulting in short gap acceptance.
- Southbound queues at US 97/Robal Road extend through Cooley Road during the PM peak hour, and both the Cooley Road and Robal Road intersections appear to operate at or near capacity.
- Southbound traffic at the Bend Parkway Southbound On-Ramp/Division Street & 3rd Street intersection queues significantly, impacting upstream queues at the Mt Washington and OB Riley intersections.
- Recent improvements to the US 97/Murphy Road interchange removed one of the southbound to eastbound movements from the Parkway. This appears to have increased the southbound jug-handle volume at the Parkway/Powers Road intersection. During the PM peak hour, the southbound jug-handle movement was observed to queue back around the loop ramp and occasionally back up the Parkway to Powers Road. Southbound traffic on the Parkway would then queue back to near Reed Lane. This condition should be solved in the long-term following the completion of the rest of the ramps at Murphy Road.
- Many interchange ramp connections to the Parkway are estimated to be operating near capacity during the summer peak hours. This is specifically true in the southbound direction between Division Street and Colorado Avenue and in the northbound direction between 3rd Street and Empire Avenue.
- There is poor travel time reliability (i.e., travel times vary and can be difficult to predict) on US 97 near Cooley Road/Robal Road and near Powers Road.
- The AM and PM peak hours tend to have less reliable travel times, especially in the North Study Area.
- Even during the peak hours, travel time reliability remains relatively good in the Central Study Area.

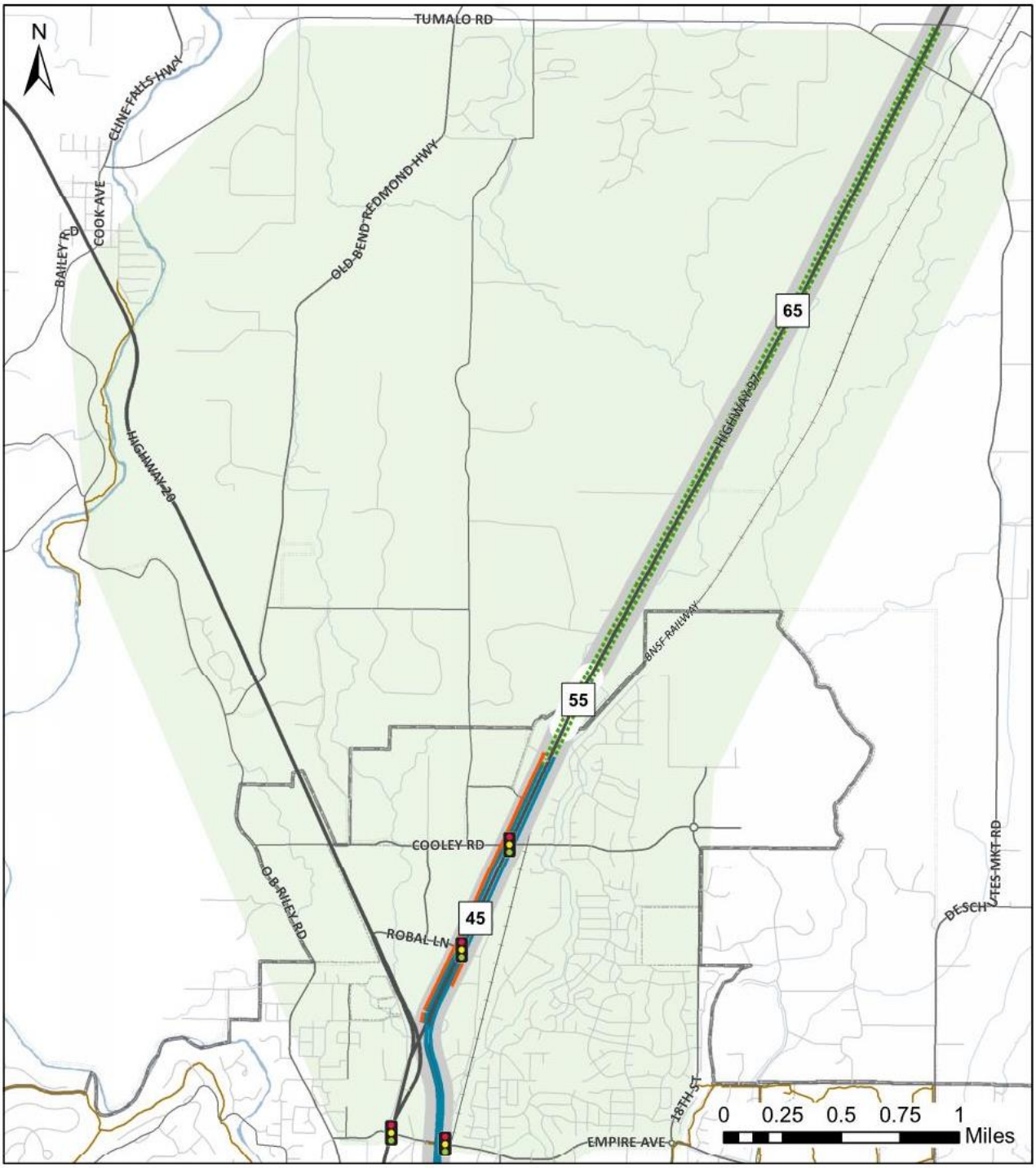
EXISTING TRANSPORTATION FACILITIES

US 97 is the key north-south connection for Central Oregon. It provides connections between California and Washington and is the primary route between regional destinations from The Dalles to Klamath Falls. The segment of US 97 addressed by this study spans from Tumalo Place (Milepoint 130.18) to Baker Road (Milepoint 143.69). This segment of US 97 is classified by the Oregon Department of Transportation (ODOT) as a Statewide Highway and has been designated as a part of the National Highway System, a Federally Designated Truck Route, a State Freight Route and Reduction Review Route, and an Expressway. The segment from Milepoint 134.67 to 141.91 (south of Robal Road to south of the Murphy Road interchange) has also been designated as a Bypass.[3] Within the bypassed area, US 97 is known as the Bend Parkway. Once US 97 becomes the Bend Parkway, 3rd Street, which runs parallel to the Parkway, becomes the US 20 (north of Greenwood Avenue)/US 97 Business Route.

The study corridor has been divided into three study areas: North, Central, and South. Figures 1 through 3 show the study area limits along with the existing motor vehicle, bicycle, and pedestrian facilities. Sidewalk coverage is sparse, but bicycle facilities are present along most of the corridor. Speed limits within the study area range between 45 and 65 mph, as shown in the figures.

[3] A short segment from Milepoint 141.12 to 141.86 does not appear to be designated as a Bypass.

Figure 1



Existing Transportation Facilities - North Study Area

Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Posted Speed (xx)
- Railroads
- Traffic Signal

Bike & Pedestrian Facilities
- Striped Bike Lane
- Bikes Allowed on Shoulder
- Sidewalk
- Trails

Parkway Study Area
- North Study Area

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

Figure 2

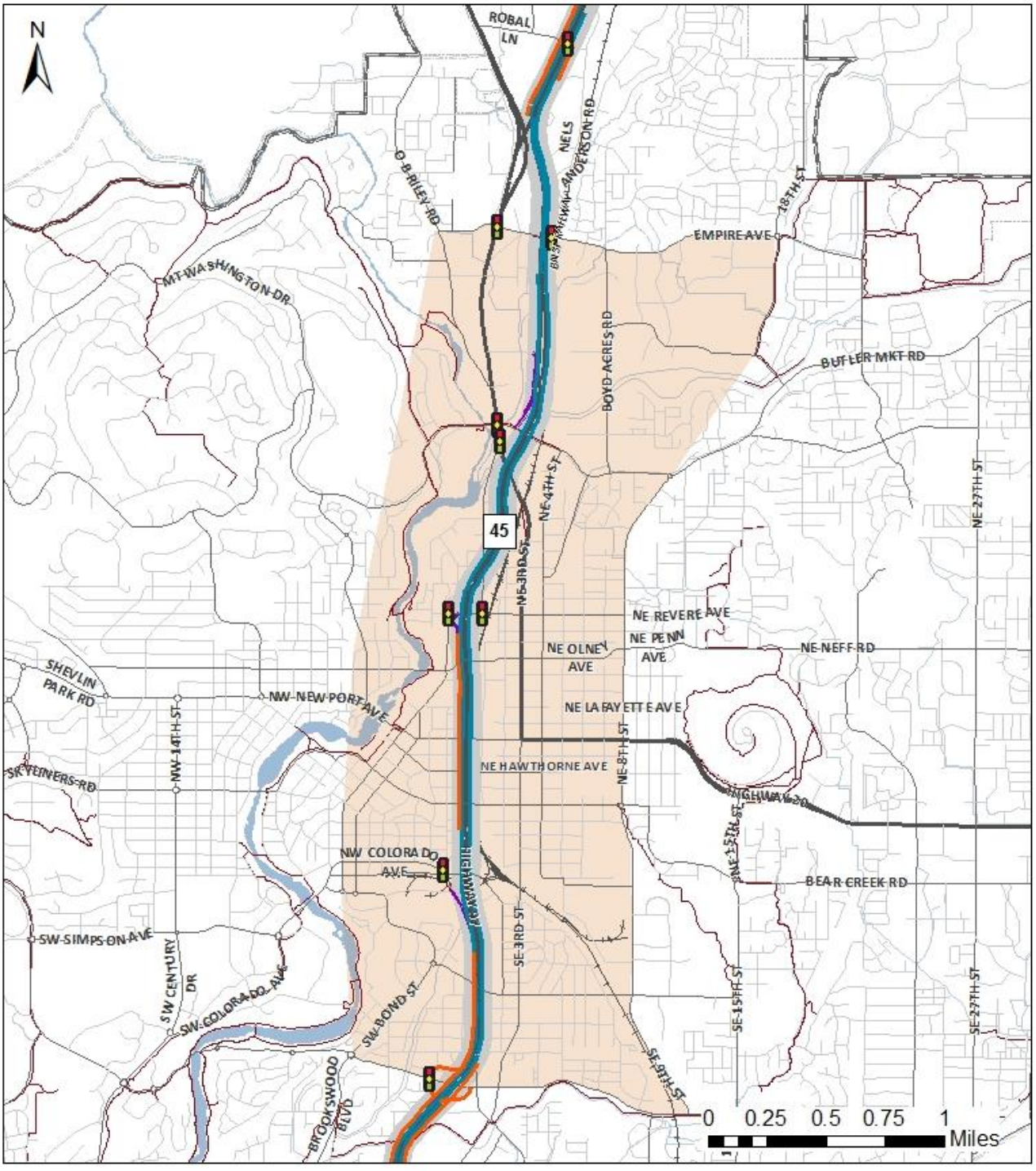
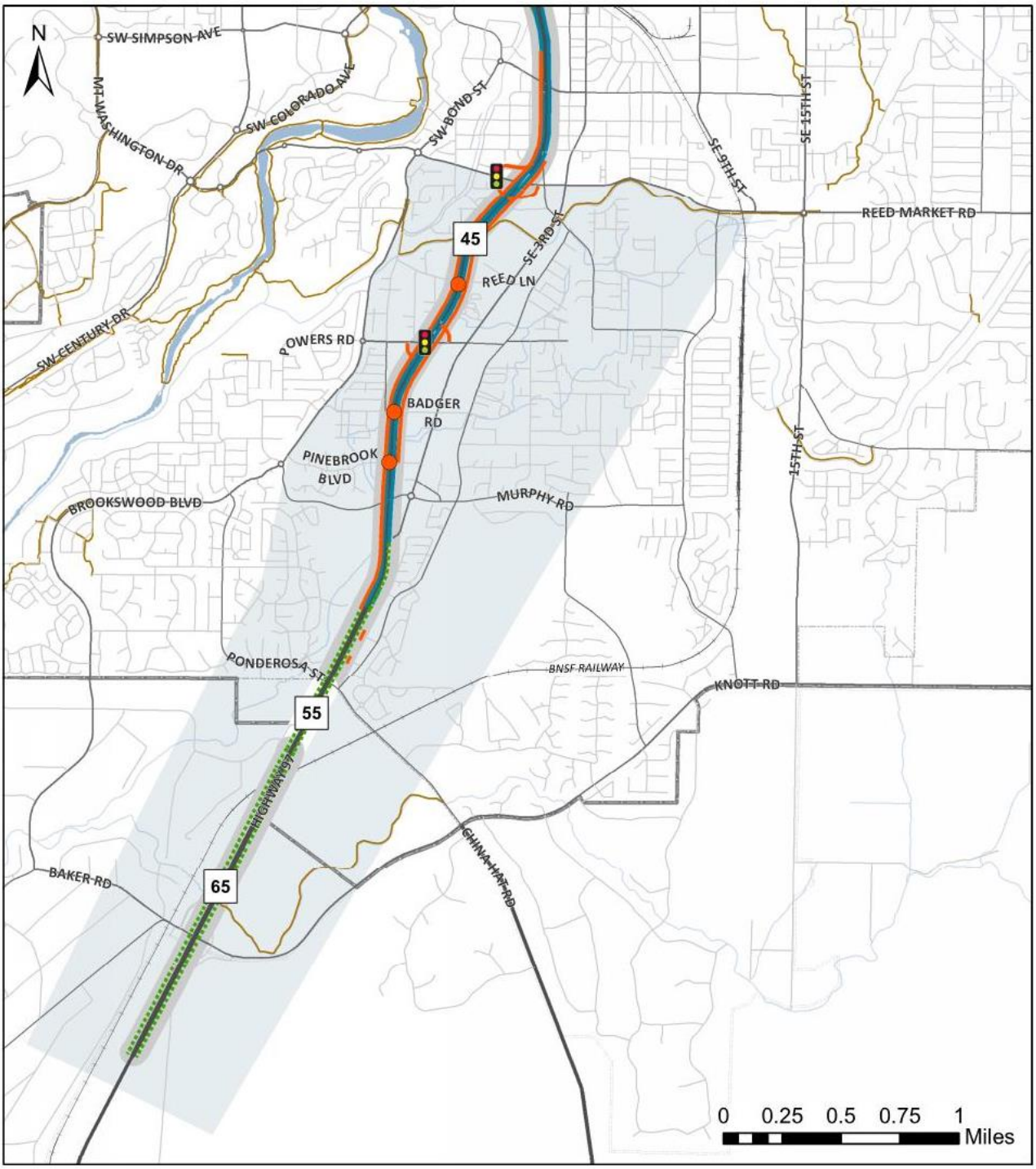

N
ROBAL LN
O B RILEY RD
NELS ANDERSON RD
EMPIRE AVE
18TH ST
MT WASHINGTON DR
BOYD ACRES RD
BUTLER MKT RD
NE 27TH ST
NE 4TH ST
45
NE 3RD ST
NE REVERE AVE
NE PENN AVE
NE OLNEY AVE
NE NEFF RD
SHEVLIN PARK RD
NW NEWPORT AVE
NW 14TH ST
NE LAFAYETTE AVE
NE 8TH ST
SKYLINERS RD
NE HAWTHORNE AVE
HIGHWAY 20
NW COLORADO AVE
HIGHWAY 97
BEAR CREEK RD
SW SIMPSON AVE
SW CENTURY DR
SW COLORADO AVE
SW BOND ST
SE 3RD ST
SE 15TH ST
SE 27TH ST
SE 9TH ST
BROOKSWOOD BLVD
0 0.25 0.5 0.75 1
Miles
Existing Transportation Facilities - Central Study Area
Roads
Highway
Arterial
Collector
Local
Infrastructure
Posted Speed
Railroads
Traffic Signal
Bike & Pedestrian Facilities
Striped Bike Lane
Sidewalk
Trails
Shared Use Path
Parkway Study Area
Central Study Area
Boundaries & Misc.
Bend City Limits
Bend MPO Boundary
UGB - Urban Growth Boundary
Waterways

Figure 3



Existing Transportation Facilities - South Study Area

Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Posted Speed (XX)
- Railroads
- Traffic Signal

Bike & Pedestrian Facilities
- Striped Bike Lane
- Bikes Allowed on Shoulder
- Flashing Beacon Pedestrian Crossing
- Sidewalk
- Trails

Parkway Study Area
- South Study Area

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

Typical Cross-Section and Access

The highway is comprised of a four-lane typical cross-section (two lanes each direction; 12-foot-wide lanes) throughout the study area. The level of access provided varies throughout the corridor, with a mix of painted and barrier median treatments, two-way left turn lanes (TWLTL), at-grade intersections, and grade-separated interchanges. Figures 4-7 illustrate the level of access provided along the corridor and the spacing between intersections and interchanges.

The northbound and southbound travel lanes are physically separated through most of the study corridor. The approximately 2.4-mile segment of highway from Tumalo Place to just south of Fort Thompson Lane/Beechcraft Lane includes only a striped median of about 10 feet in width. ODOT's standard design[4] for a striped median requires a minimum width of 16 feet. The striped median was not designed for use as a left turn lane but is commonly used as one. The standard design for a left turn lane requires a minimum width of 20 feet. In addition to the public street connections shown in this segment, there are also many private accesses to US 97, which create opportunities for vehicular conflicts in this high-speed corridor. Lastly, a TWLTL exists for approximately one mile between Grandview Drive and just south of Fort Thompson Lane/Beechcraft Lane.

Within the approximately 3.7 miles from Empire Avenue to Reed Market Road, there are five interchanges and three at-grade, right-in/right-out intersections. The average interchange spacing (disregarding the at-grade intersections) is approximately one mile, which is not uncommon in heavily urbanized areas but is significantly shorter than ODOT's interchange spacing standard for urban expressways of 1.9 miles. ODOT's access spacing standards applicable to US 97 vary throughout the corridor. Table 2 compares those spacing standards for segments of the corridor to the actual frequency of access points, showing that there are far more direct connections to US 97 than desired for the safe and efficient operation of the expressway.

[4] ODOT Highway Design Manual, 2012, Table 7-1: ODOT 4R/New Rural Standards – Expressway.

Table 2: Access Management Standards and Average Access Spacing along the US 97

Segment	Rural/Urban Expressway	Speed (mph)	Access Management Spacing Standard (mi)	Average Access Spacing NB (mi)	Average Access Spacing SB (mi)
Tumalo Pl to MP 132.19 (0.27 mi north of Fort Thompson Ln)	Rural	65	1.0 [B]	0.65	0.49
MP 132.19 to MP 133.32 (700 ft north of Fort Thompson Ln)	Urban	65	0.5 [B]	0.04	0.03
MP 133.32 to MP 133.56 (740 ft north of Grandview Dr)	Urban	55	0.5 [B]	0.10	0.08
MP 133.56 to Nels Anderson Pl	Urban	45	0.5 [B]	0.28	0.15
Nels Anderson to Sisters Loop	Urban	45	1.0 [C]	0.21	0.21
Sisters Loop to Revere Ave	Urban	45	1.9 [A]	0.72	0.72
Revere Ave to Lafayette Ave	Urban	45	1.0 [CD]	NA	0.29
Lafayette Ave to Hawthorne Ave	Urban	45	0.5 [B]	NA	0.27
Hawthorne Ave to Truman Ave	Urban	45	1.0 [C]	NA	0.32
Truman Ave to Reed Market	Urban	45	1.0 [C]	NA	0.25
Reed Market to Reed Ln	Urban	45	1.0 [C]	0.32	NA
Reed Ln to Pinebrook Blvd	Urban	45	0.5 [B]	0.28	0.28
Murphy Rd to Ponderosa St	Urban	45	1.0 [C]	0.41	0.40
Ponderosa St to Rocking Horse Ct.	Urban	55	0.5 [B]	NA	0.22
Rocking Horse Ct. to Baker Rd	Urban	65	1.0 [C]	0.73	0.73

[A] Oregon Highway Plan, Appendix C Access Management Standards, Table 12: Interchange Spacing

[B] Oregon Highway Plan, Appendix C Access Management Standards, Table 14: Access Management Spacing Standards for Statewide Highways with AADT of More than 5,000 Vehicles

[C] Oregon Highway Plan, Appendix C Access Management Standards, Table 19: Minimum Spacing Standards Applicable to Non-Freeway Interchanges with Two-Lane Crossroads

[D] Oregon Highway Plan, Appendix C Access Management Standards, Table 20: Minimum Spacing Standards Applicable to Non-Freeway Interchanges with Multi-Lane Crossroads

Figure 4

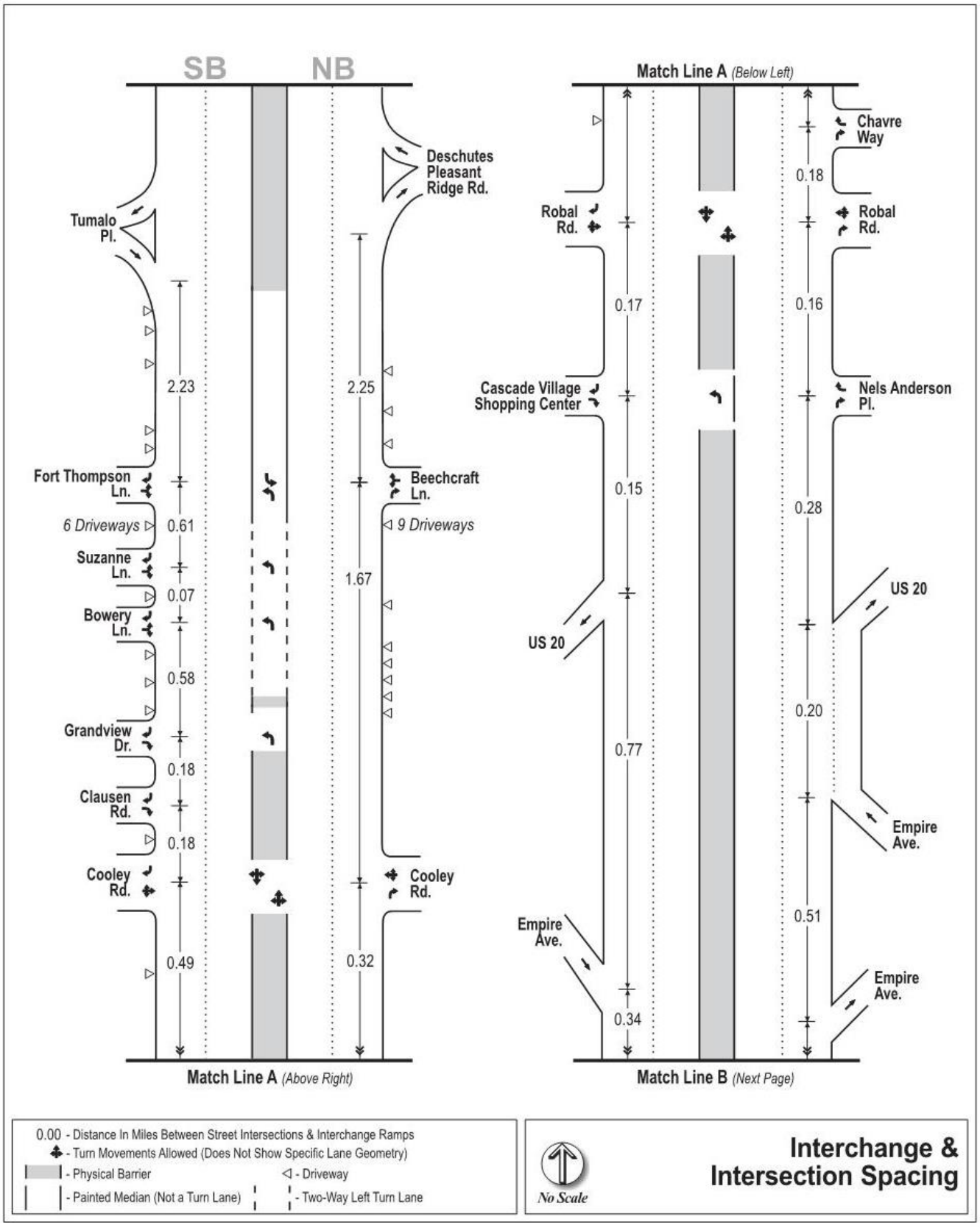

SB
NB
Match Line A (Below Left)
Deschutes Pleasant Ridge Rd.
Tumalo Pl.
Chavre Way
Robal Rd.
Robal Rd.
0.18
0.17
0.16
2.23
2.25
Cascade Village Shopping Center
Nels Anderson Pl.
Fort Thompson Ln.
Beechcraft Ln.
0.15
0.28
6 Driveways
0.61
9 Driveways
Suzanne Ln.
1.67
US 20
US 20
0.07
Bowery Ln.
0.58
0.20
Grandview Dr.
0.77
0.18
Clausen Rd.
Empire Ave.
0.18
Cooley Rd.
Cooley Rd.
0.51
Empire Ave.
0.49
0.32
Empire Ave.
0.34
Match Line A (Above Right)
Match Line B (Next Page)
0.00 - Distance In Miles Between Street Intersections & Interchange Ramps
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Driveway
- Painted Median (Not a Turn Lane)
- Two-Way Left Turn Lane
No Scale
Interchange & Intersection Spacing

Figure 5

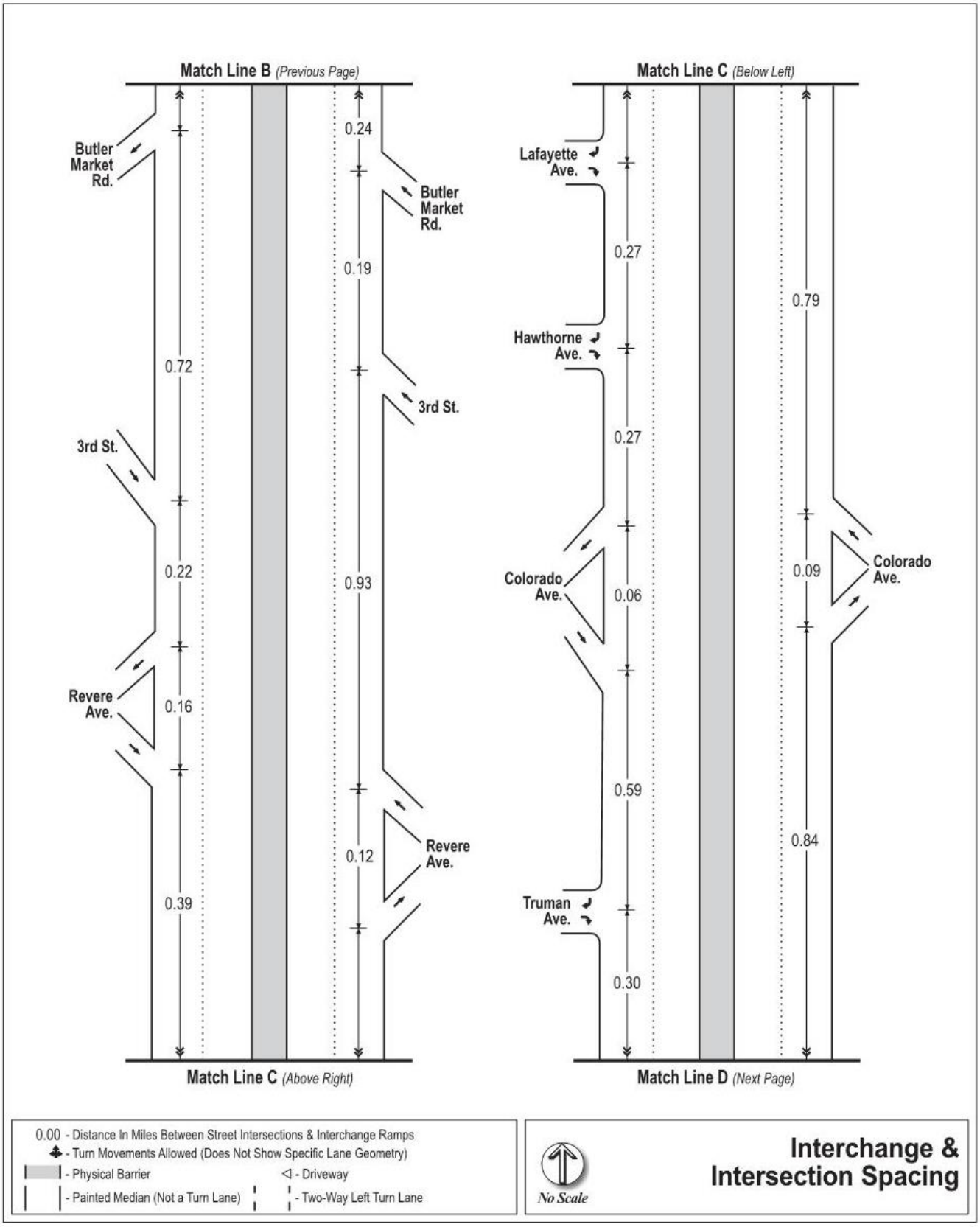

Match Line B (Previous Page)
Butler Market Rd.
3rd St.
Revere Ave.
0.72
0.22
0.16
0.39
0.24
0.19
0.93
0.12
Butler Market Rd.
3rd St.
Revere Ave.
Match Line C (Above Right)
Match Line C (Below Left)
Lafayette Ave.
Hawthorne Ave.
Colorado Ave.
Truman Ave.
0.27
0.27
0.06
0.59
0.30
0.79
0.09
0.84
Colorado Ave.
Match Line D (Next Page)
0.00 - Distance In Miles Between Street Intersections & Interchange Ramps
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Driveway
- Painted Median (Not a Turn Lane)
- Two-Way Left Turn Lane
No Scale
Interchange & Intersection Spacing

Figure 6

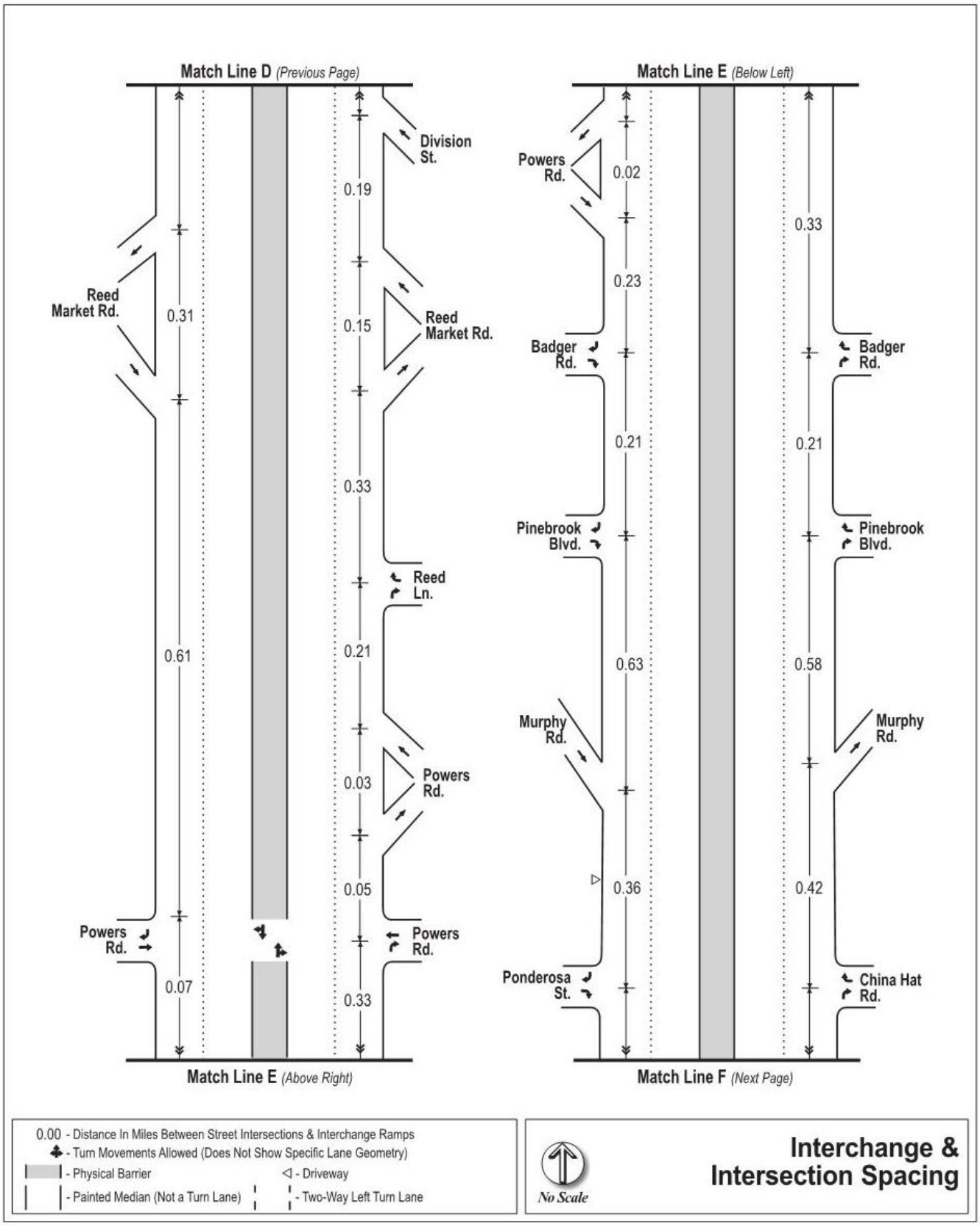
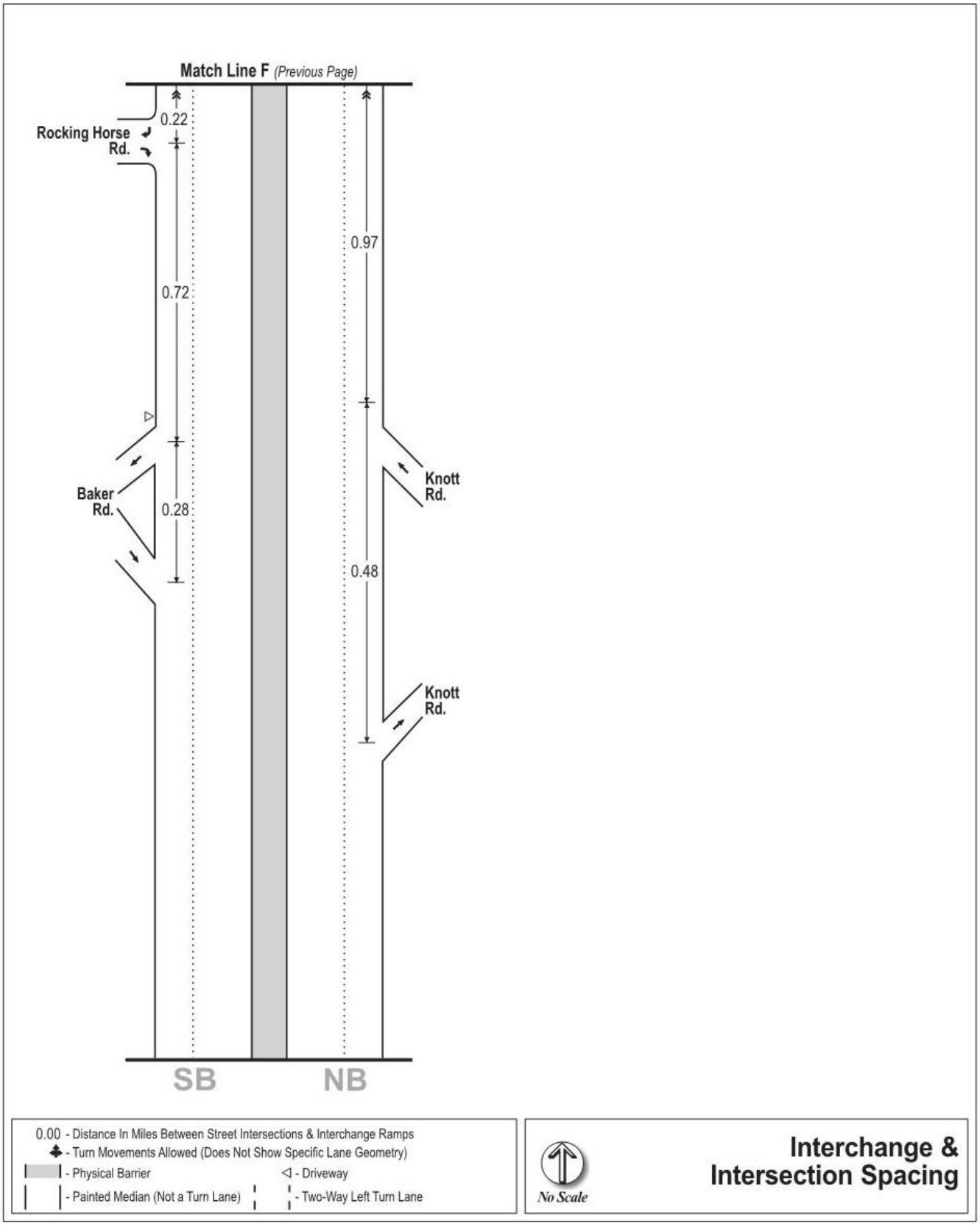

Match Line D (Previous Page)
Division St.
Reed Market Rd.
Reed Market Rd.
Reed Ln.
Powers Rd.
Powers Rd.
Powers Rd.
0.19
0.31
0.15
0.33
0.61
0.21
0.03
0.05
0.07
0.33
Match Line E (Above Right)
Match Line E (Below Left)
Powers Rd.
Badger Rd.
Pinebrook Blvd.
Murphy Rd.
Ponderosa St.
Badger Rd.
Pinebrook Blvd.
Murphy Rd.
China Hat Rd.
0.02
0.23
0.21
0.63
0.36
0.33
0.21
0.58
0.42
Match Line F (Next Page)
0.00 - Distance In Miles Between Street Intersections & Interchange Ramps
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Driveway
- Painted Median (Not a Turn Lane)
- Two-Way Left Turn Lane
No Scale
Interchange & Intersection Spacing

Figure 7


Match Line F (Previous Page)
Rocking Horse Rd.
0.22
0.72
0.28
0.97
0.48
Baker Rd.
Knott Rd.
Knott Rd.
SB
NB
0.00 - Distance In Miles Between Street Intersections & Interchange Ramps
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Driveway
- Painted Median (Not a Turn Lane)
- Two-Way Left Turn Lane
No Scale
Interchange & Intersection Spacing

Shoulder Widths

In addition to providing needed lateral support for the pavement, highway shoulders serve many safety and operational functions. They provide space for law enforcement activity, disabled vehicles to pull over, bicycle travel, passage around incidents blocking travel lanes, and partial storage for snow removal.

Shoulder widths vary throughout the study area. ODOT's Highway Design Manual (Urban and Rural Non-Freeway)[5] shoulder widths standards for expressways are eight feet for the outer/right shoulder and four feet for the inside/left shoulder. Approximately two-thirds of the highway corridor does not meet this standard, as shown in Figures 8-11. This includes the roughly eight-mile segment from Grandview Drive to Murphy Road where most of the shoulder is no greater than six feet wide, which is typically not sufficient to store a disabled vehicle away from moving traffic without disrupting the flow of traffic. The figure also shows the degree to which the segment fails to meet standards.

ODOT's standard design for bike lanes requires only six feet of width. Where the highway shoulder is used for bicycle travel (which may be referred to as a shoulder bikeway), a six-foot width would be considered to meet the minimum need. However, if this space is also used for other purposes (e.g., disabled vehicles, law enforcement activity, etc.) it would not be functional for bicycle travel.

[5] Highway Design Manual, Chapters 6 and 7, ODOT, 2012.

Figure 8

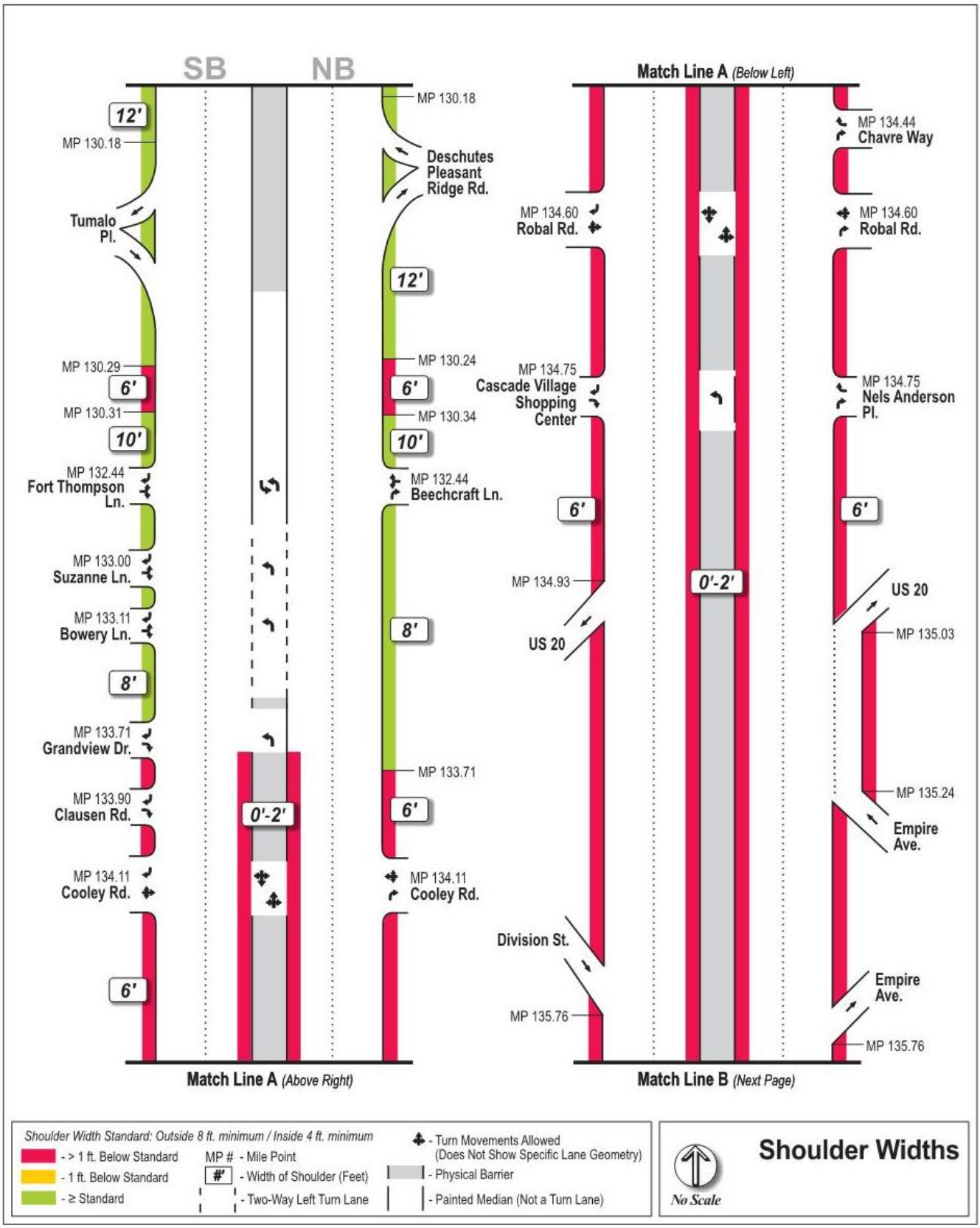

SB
NB
Match Line A (Below Left)
MP 130.18
12'
MP 130.18
Deschutes Pleasant Ridge Rd.
Tumalo Pl.
12'
MP 130.24
MP 130.29
6'
6'
MP 130.31
MP 130.34
10'
10'
MP 132.44
Fort Thompson Ln.
MP 132.44
Beechcraft Ln.
MP 133.00
Suzanne Ln.
MP 133.11
Bowery Ln.
8'
8'
MP 133.71
Grandview Dr.
MP 133.71
MP 133.90
Clausen Rd.
0'-2'
6'
MP 134.11
Cooley Rd.
MP 134.11
Cooley Rd.
6'
Match Line A (Above Right)
MP 134.60
Robal Rd.
MP 134.44
Chavre Way
MP 134.60
Robal Rd.
MP 134.75
Cascade Village Shopping Center
MP 134.75
Nels Anderson Pl.
6'
6'
MP 134.93
0'-2'
US 20
US 20
MP 135.03
MP 135.24
Empire Ave.
Division St.
Empire Ave.
MP 135.76
MP 135.76
Match Line B (Next Page)
Shoulder Width Standard: Outside 8 ft. minimum / Inside 4 ft. minimum
- > 1 ft. Below Standard
- 1 ft. Below Standard
- ≥ Standard
MP # - Mile Point
- Width of Shoulder (Feet)
- Two-Way Left Turn Lane
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Painted Median (Not a Turn Lane)
No Scale
Shoulder Widths

Figure 9

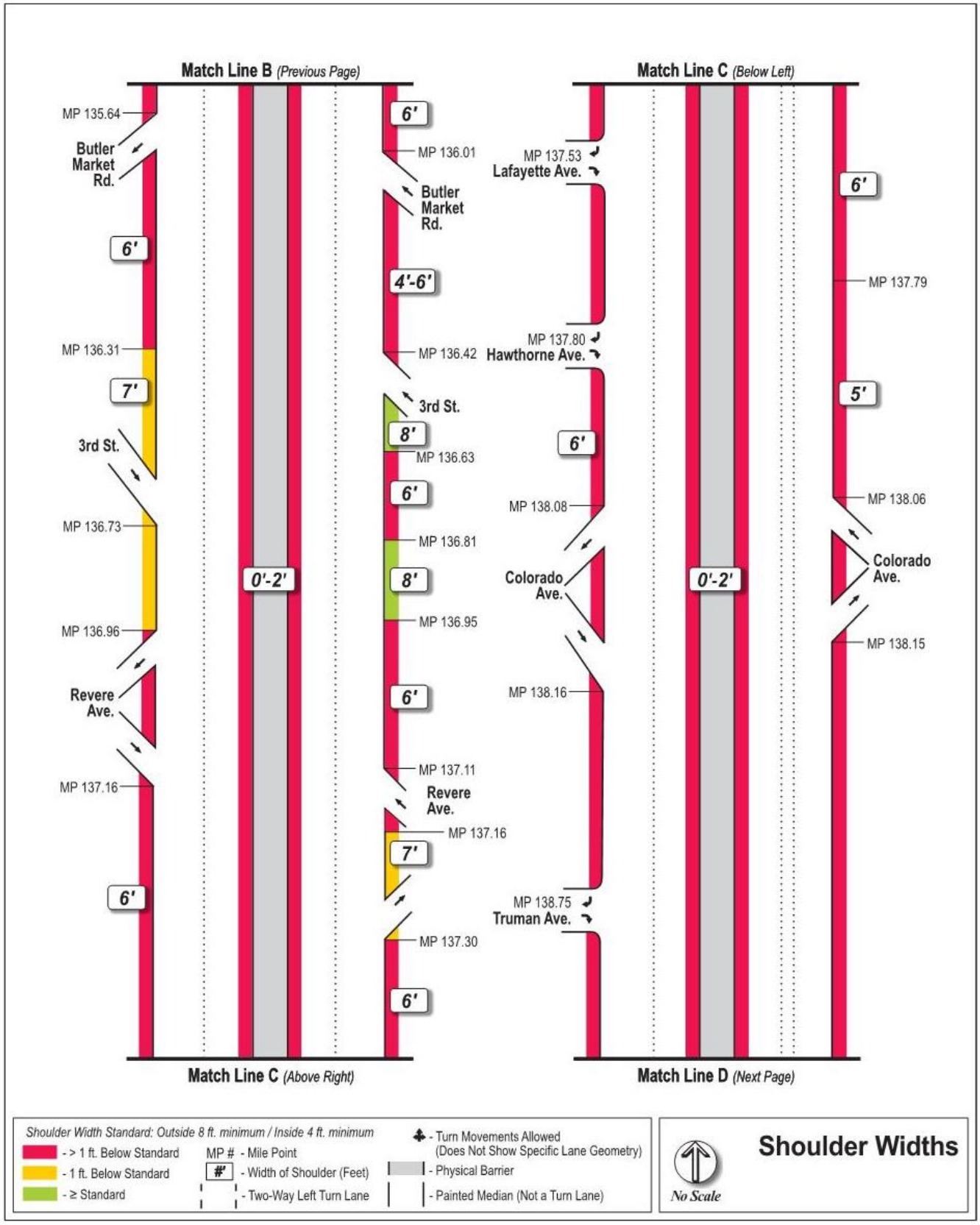

Match Line B (Previous Page)
Match Line C (Below Left)
MP 135.64
Butler Market Rd.
6'
MP 136.01
Butler Market Rd.
4'-6'
MP 136.31
7'
MP 136.42
3rd St.
8'
3rd St.
MP 136.63
6'
MP 136.73
MP 136.81
8'
0'-2'
MP 136.95
MP 136.96
6'
Revere Ave.
MP 137.11
Revere Ave.
MP 137.16
7'
MP 137.16
6'
MP 137.30
6'
Match Line C (Above Right)
MP 137.53
Lafayette Ave.
6'
MP 137.79
MP 137.80
Hawthorne Ave.
5'
6'
MP 138.06
MP 138.08
Colorado Ave.
0'-2'
Colorado Ave.
MP 138.15
MP 138.16
MP 138.75
Truman Ave.
Match Line D (Next Page)
Shoulder Width Standard: Outside 8 ft. minimum / Inside 4 ft. minimum
- > 1 ft. Below Standard
- 1 ft. Below Standard
- ≥ Standard
MP # - Mile Point
- Width of Shoulder (Feet)
- Two-Way Left Turn Lane
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Painted Median (Not a Turn Lane)
No Scale
Shoulder Widths

Figure 10

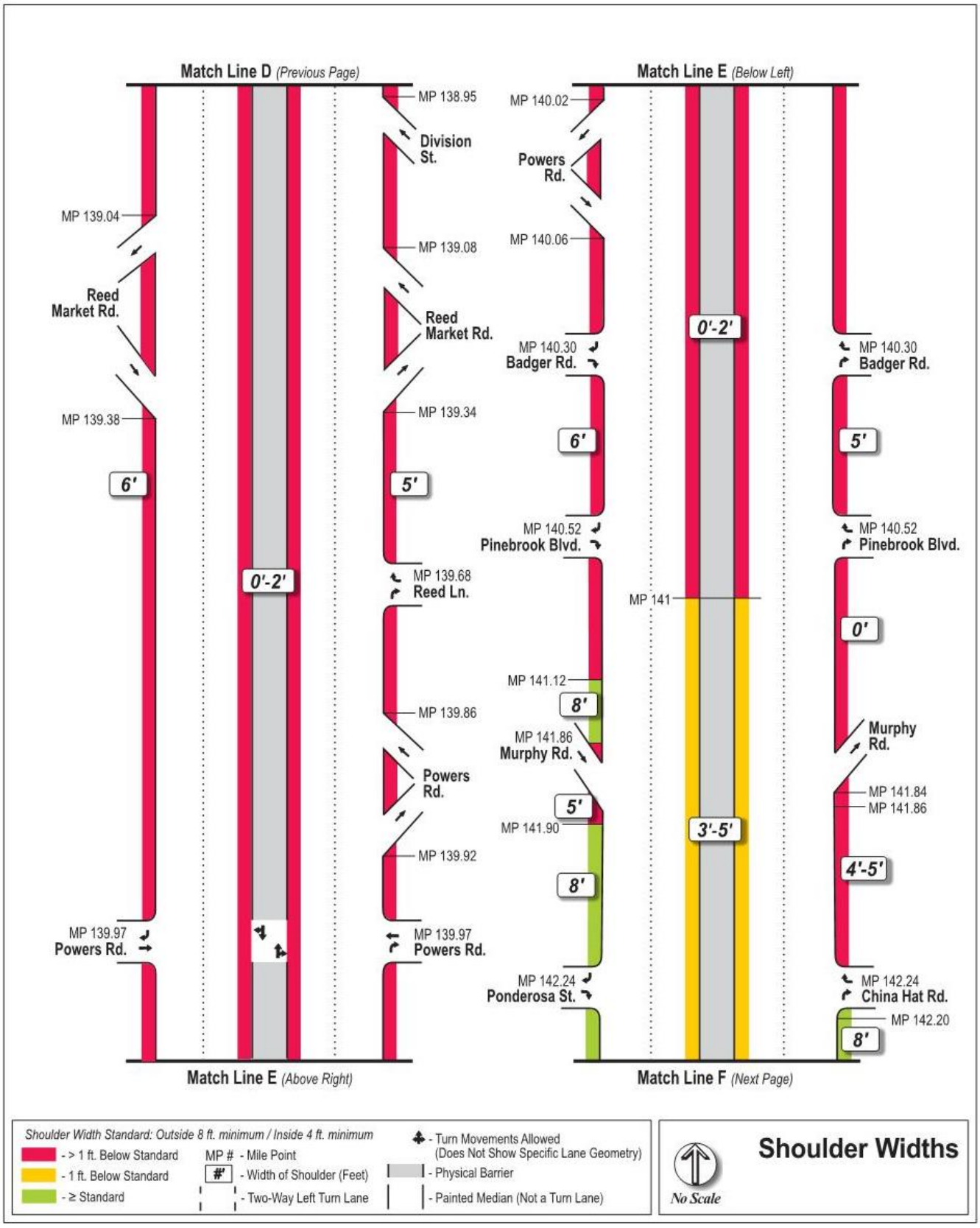
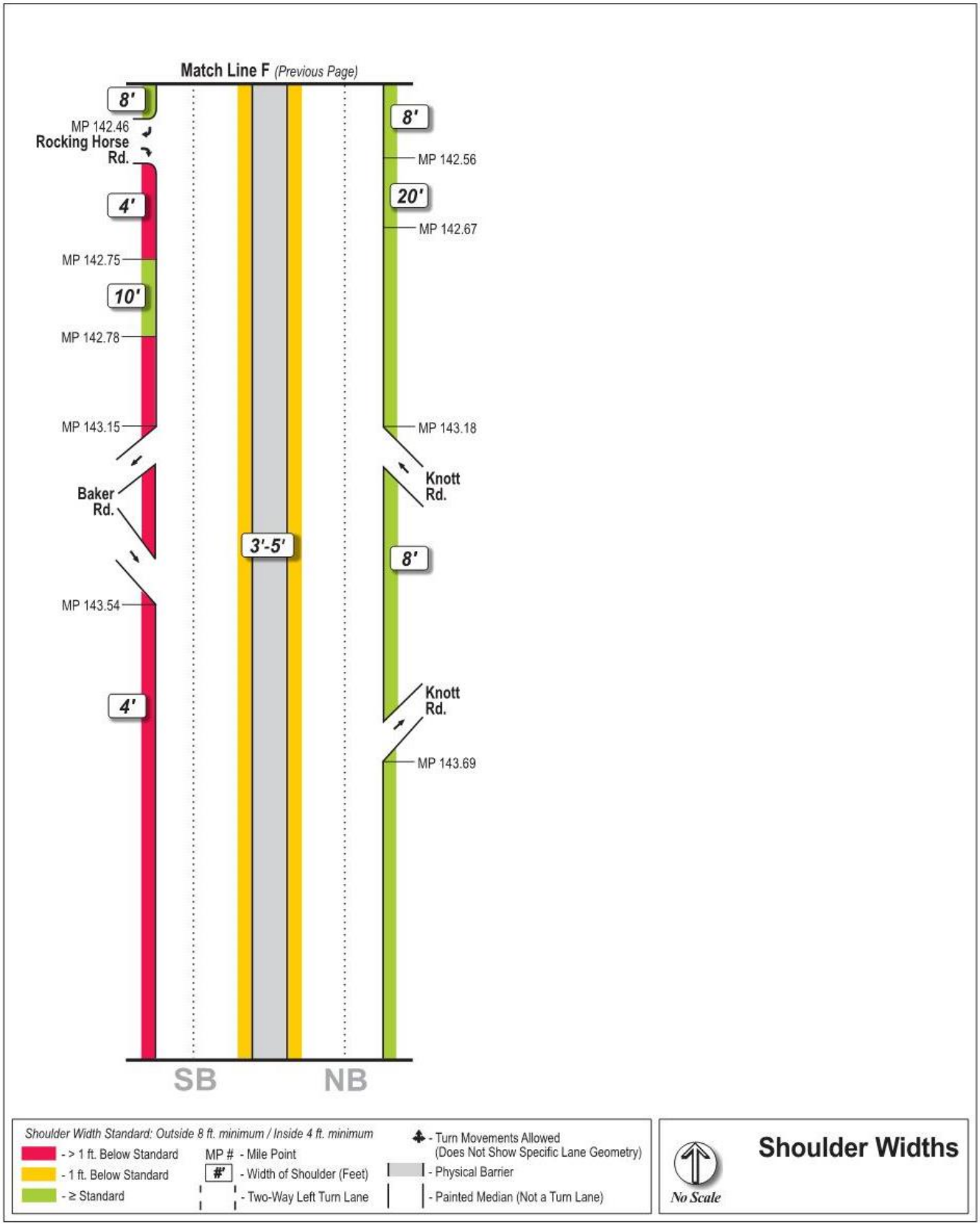

Match Line D (Previous Page)
MP 138.95
Division St.
MP 139.04
MP 139.08
Reed Market Rd.
Reed Market Rd.
MP 139.34
MP 139.38
6'
5'
0'-2'
MP 139.68
Reed Ln.
MP 139.86
Powers Rd.
MP 139.92
MP 139.97
Powers Rd.
MP 139.97
Powers Rd.
Match Line E (Above Right)
Match Line E (Below Left)
MP 140.02
Powers Rd.
MP 140.06
0'-2'
MP 140.30
Badger Rd.
MP 140.30
Badger Rd.
6'
5'
MP 140.52
Pinebrook Blvd.
MP 140.52
Pinebrook Blvd.
MP 141
0'
MP 141.12
8'
MP 141.86
Murphy Rd.
Murphy Rd.
MP 141.84
MP 141.86
5'
MP 141.90
3'-5'
4'-5'
8'
MP 142.24
Ponderosa St.
MP 142.24
China Hat Rd.
MP 142.20
8'
Match Line F (Next Page)
Shoulder Width Standard: Outside 8 ft. minimum / Inside 4 ft. minimum
- > 1 ft. Below Standard
- 1 ft. Below Standard
- ≥ Standard
MP # - Mile Point
#' - Width of Shoulder (Feet)
- Two-Way Left Turn Lane
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Painted Median (Not a Turn Lane)
No Scale
Shoulder Widths

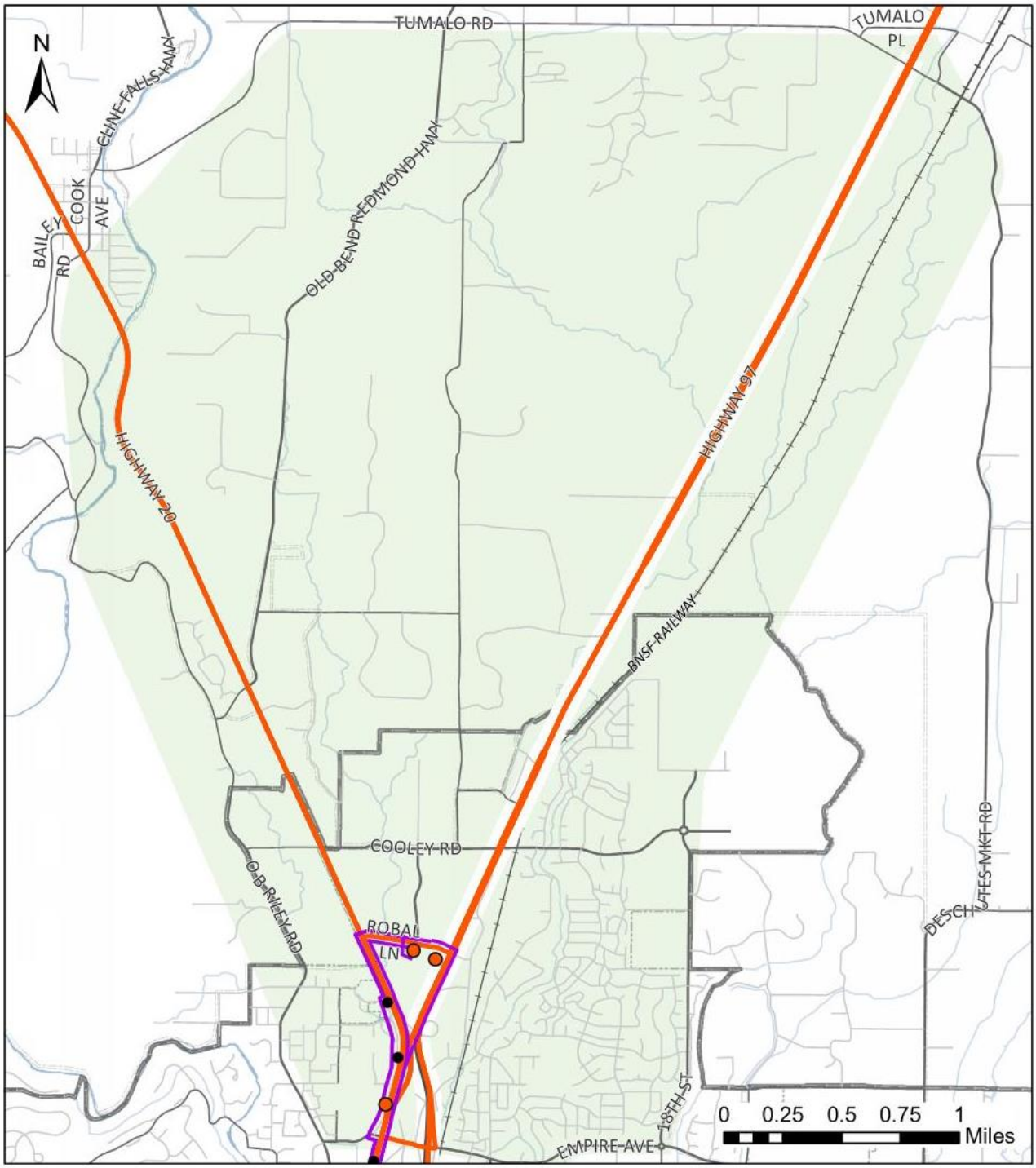
Figure 11


Match Line F (Previous Page)
8'
MP 142.46
Rocking Horse Rd.
4'
MP 142.75
10'
MP 142.78
MP 143.15
Baker Rd.
MP 143.54
4'
3'-5'
8'
MP 142.56
20'
MP 142.67
MP 143.18
Knott Rd.
8'
Knott Rd.
MP 143.69
SB
NB
Shoulder Width Standard: Outside 8 ft. minimum / Inside 4 ft. minimum
- > 1 ft. Below Standard
- 1 ft. Below Standard
- ≥ Standard
MP # - Mile Point
- Width of Shoulder (Feet)
- Two-Way Left Turn Lane
- Turn Movements Allowed (Does Not Show Specific Lane Geometry)
- Physical Barrier
- Painted Median (Not a Turn Lane)
No Scale
Shoulder Widths

Transit System

Figures 12-14 show the relationship between existing transit routes and the US 97 study corridor. Regional transit routes provide connecting service between regional destinations, such as the cities of Redmond, La Pine, Madras and Portland, while local routes serve the city of Bend. Approximately 30 regional transit buses travel along US 97 every weekday. There is one stop on US 97, just south of Robal Road, that serves about eight buses per weekday.

Figure 12



Transit Facilities - North Study Area

Regional
- Regional Stop
- Regional Route

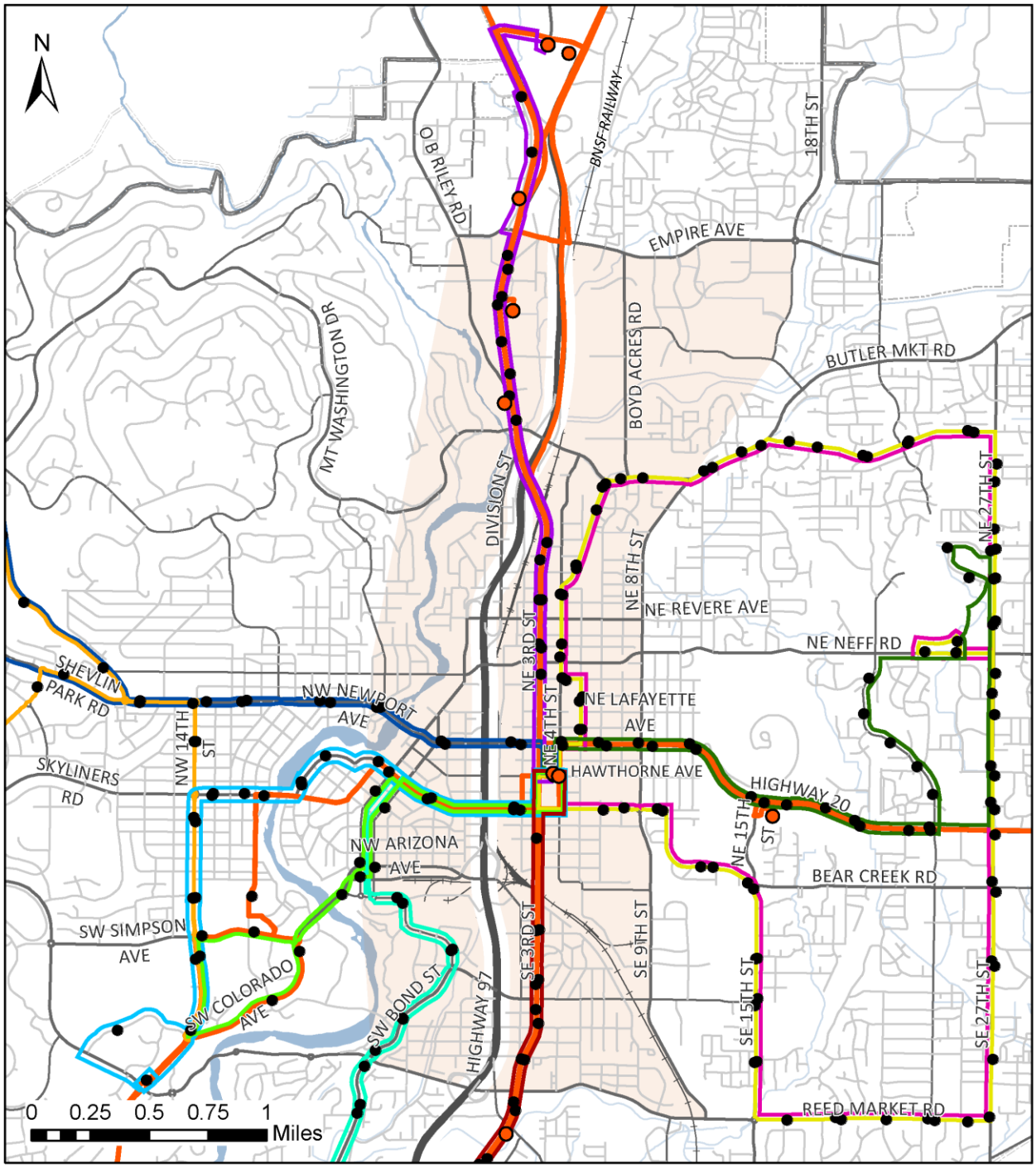
Local
- Local Stop
- Route 4

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

Parkway Study Area
- North Study Area

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

Figure 13



Transit Facilities - Central Study Area

Regional
- Regional Stop
- Regional Route

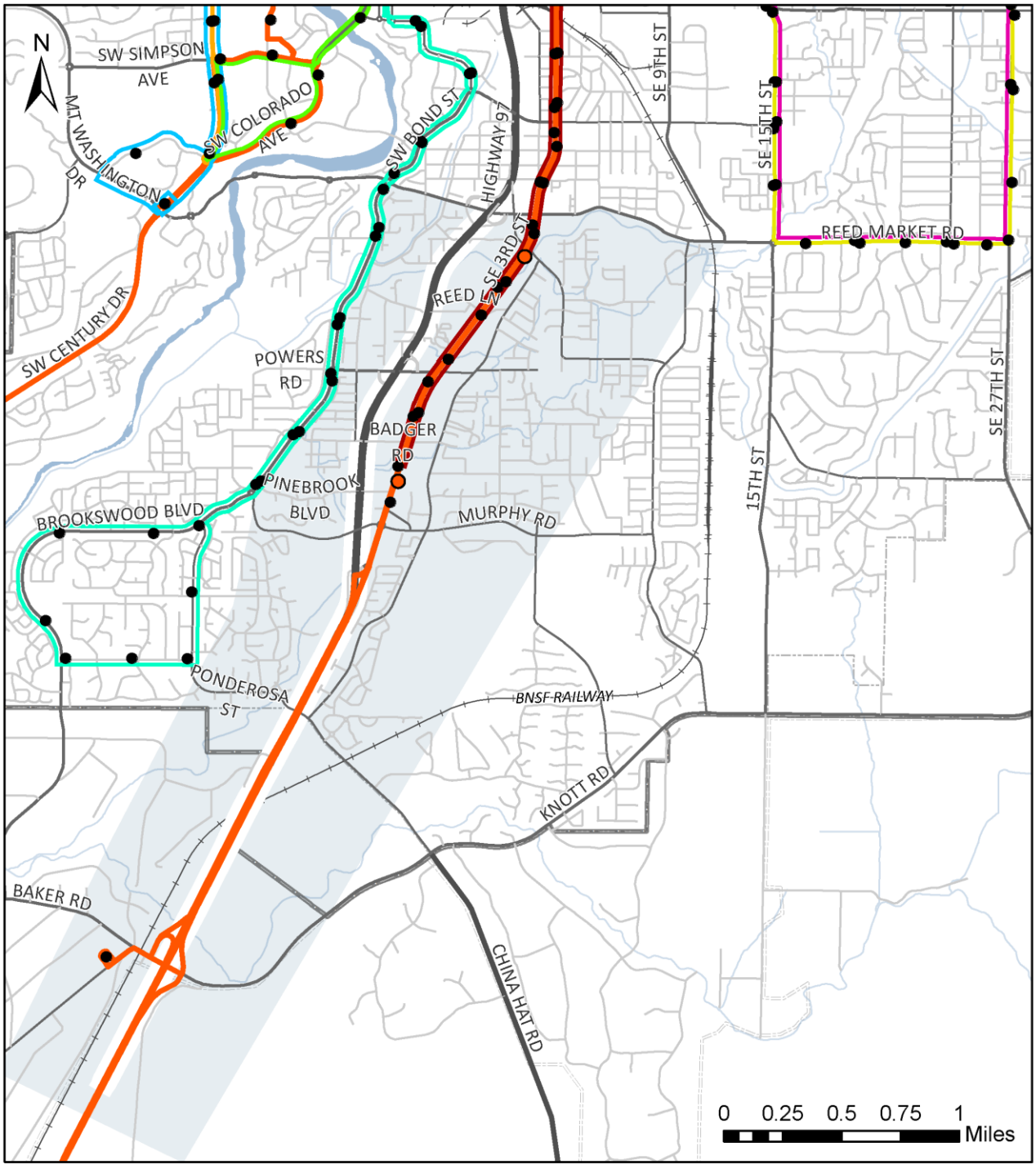
Local
- Local Stop
- Route 1
- Route 2
- Route 3
- Route 4
- Route 5
- Route 6
- Route 7
- Route 10
- Route 11
- Route 12

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

Parkway Study Area
- Central Study Area

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

Figure 14



Transit Facilities - South Study Area

Regional
- Regional Stop
- Regional Route

Local
- Local Stop
- Route 1
- Route 2
- Route 5
- Route 6
- Route 10
- Route 11
- Route 12

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

Parkway Study Area
- South Study Area

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

TRAFFIC VOLUME

This section describes motor vehicle traffic volume characteristics along US 97 under existing conditions (2017).

Seasonal Variability

Seasonal adjustments to measured traffic volumes help account for the variation in traffic during the year. The 30th highest annual hour traffic volumes (30 HV) will be used for analysis and design purposes. To estimate conditions for the 30 HV period, seasonal adjustments to obtained traffic counts were made using the methodology from ODOT's Analysis Procedures Manual (APM)[6], as detailed in the Traffic Analysis Methodology Memorandum for this project.[7]

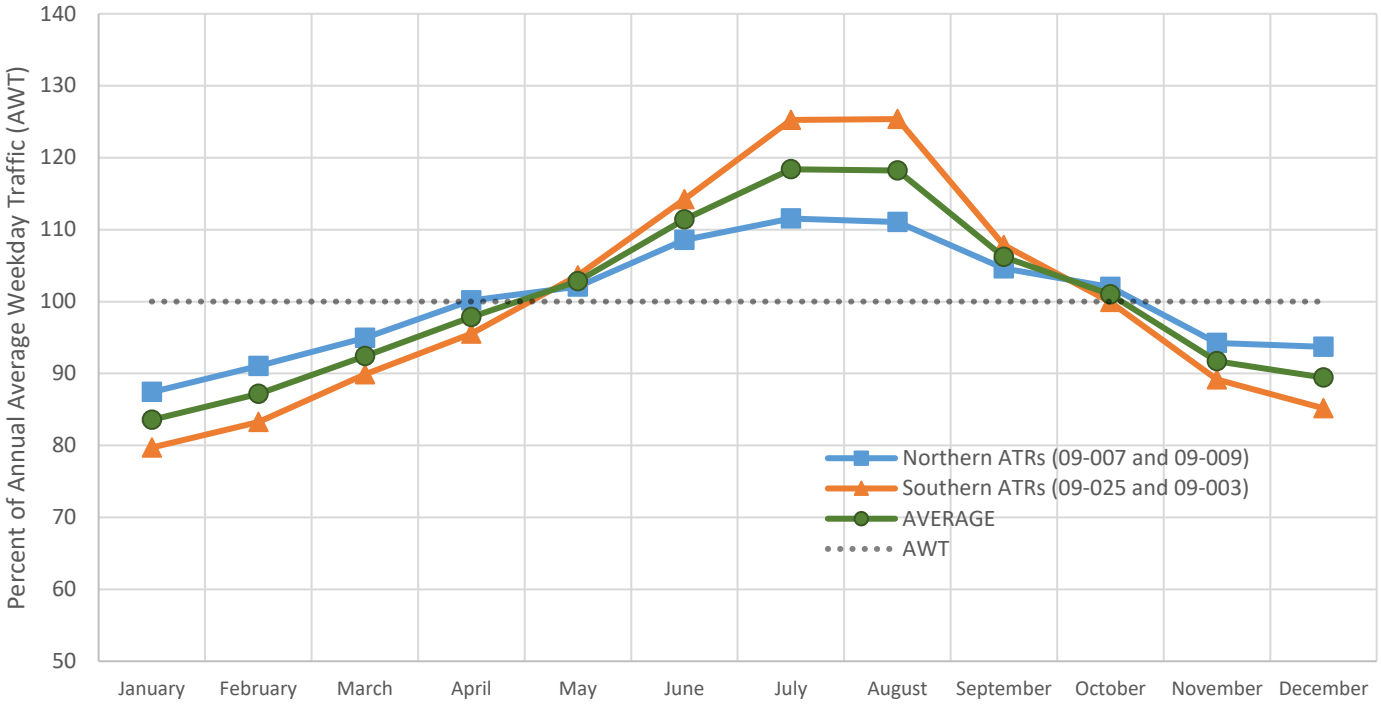
There are four Automatic Traffic Recorder stations (ATRs) within the project study area; two north of US 20 (at Empire Boulevard and at Revere Avenue) and two south of US 20 (at Pinebrook Boulevard and at China Hat Rd). These ATRs collect traffic volume data continuously throughout the year and reveal some key trends pertaining to traffic composition on US 97. Both northern ATRs (09-007 and 09-009) have closely correlated seasonal trends. The two southern ATRs are also closely correlated to each other but have significantly more seasonal variability with a steeper summer peak than the northern ATRs, as shown in Figure 15.

The steeper increase in summer traffic volumes compared to winter at the southern ATRs likely indicates a higher recreational proportion of traffic compared to the more commuter-oriented traffic profile of the northern ATRs. All four ATR counts indicated that July conditions best represent the 30 HV. However, the traffic counts for the study area were collected the week of April 10. To adjust these counts to represent July conditions, two different seasonal factors were applied to the north and south ends of the corridor. As a result, all counts collected from Truman Road to the north were increased by 11 percent. All counts collected south of Pinebrook Boulevard were increased by 31 percent. Counts between Truman Road and Pinebrook Boulevard were gradually increased by 11 to 31 percent, maintaining balanced volumes along the corridor.

[6] ODOT Analysis Procedures Manual, Version 2.

[7] US 97 Parkway Plan [Traffic Analysis] Methodology Memorandum, March 7, 2017.

Figure 15: US 97 ATR Average Weekday Traffic Seasonal Trends through Bend



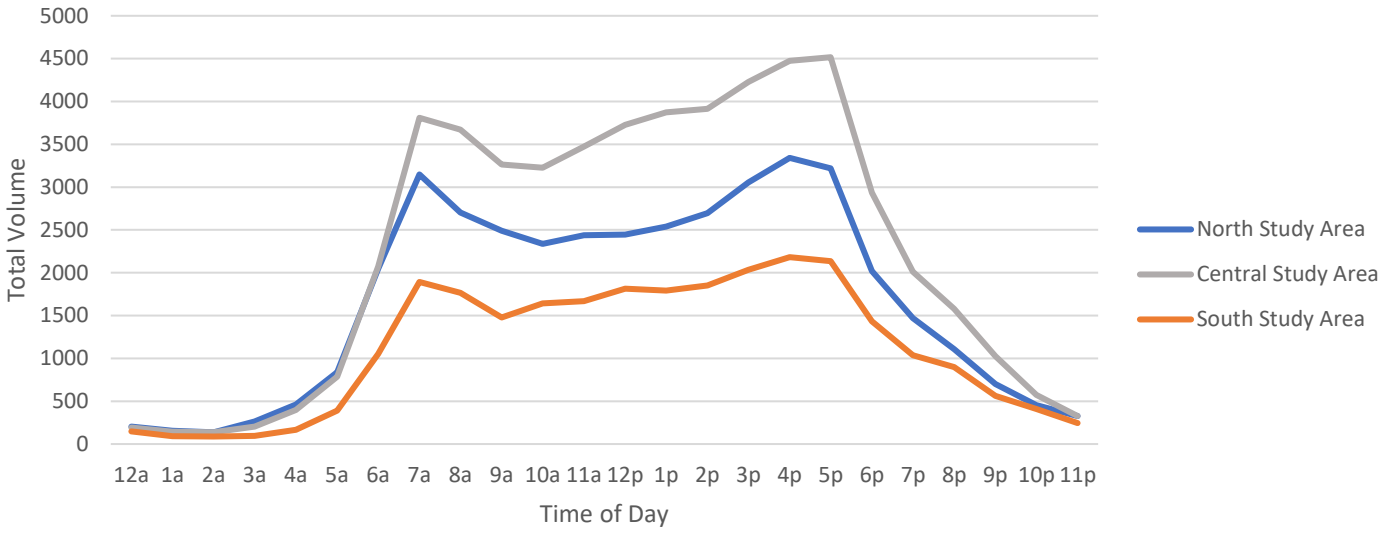
Average Weekday Traffic Volume Profile

Changes in traffic volumes on US 97 throughout an average weekday were studied by creating a daily traffic volume profile using 24-hour counts collected in April 2017 at the following four locations.

- North of Clausen Road
- Between Butler Market Road and Empire Avenue
- Between Reed Market Road and Truman Avenue
- Between Knott Road and China Hat Road

These locations represent the North, Central, and South Study Areas. For the profile presented below, the second and third locations were averaged to create the Central Study Area profile.

Figure 16: Average Weekday Traffic Volume Profile by Study Area



As shown in, Figure 16 traffic peaks sharply in the morning around 7:00 AM, decreases until about 10:00 AM, then gradually increases and peaks again around 5:00 PM. PM peak traffic volumes are significantly higher than those in the AM peak. The Central Study Area experiences the greatest traffic volumes, while the South Study Area experiences the lowest. Though the magnitude varies along the corridor, the pattern over the day is similar for each study area. These trends informed the selection of a single system peak hour for use in the analysis.

Peak Hour Traffic Volumes

Motor vehicle turning movement counts were collected at each of the 29 study intersections during the weekday evening peak period[8] (4:00 PM to 6:00 PM). All traffic counts were collected in the same week. The peak hour of traffic occurs from about 4:30 PM to 5:30 PM.

Figures 17-19 summarize existing lane configurations, traffic control, and weekday PM peak hour turning movement traffic volumes for each study intersection, as well as Average Daily Traffic (ADT) volumes with heavy vehicle (e.g., trucks, RVs) percentages at select locations on US 97. Detailed traffic count data, including PM peak period turn movement counts at the study intersections and 24-hour vehicle classification counts, are attached to this memorandum. As shown, average daily traffic volumes range from nearly 49,000 vehicles per day in the Central Study Area to about 19,000 vehicles per day in the South Study Area. Heavy vehicle percentages vary only slightly and average around nine percent.

[8] Count data collected on Tuesday, April 11th, 2017; Wednesday, April 12th, 2017; and Thursday, April 13th, 2017.

Figure 17

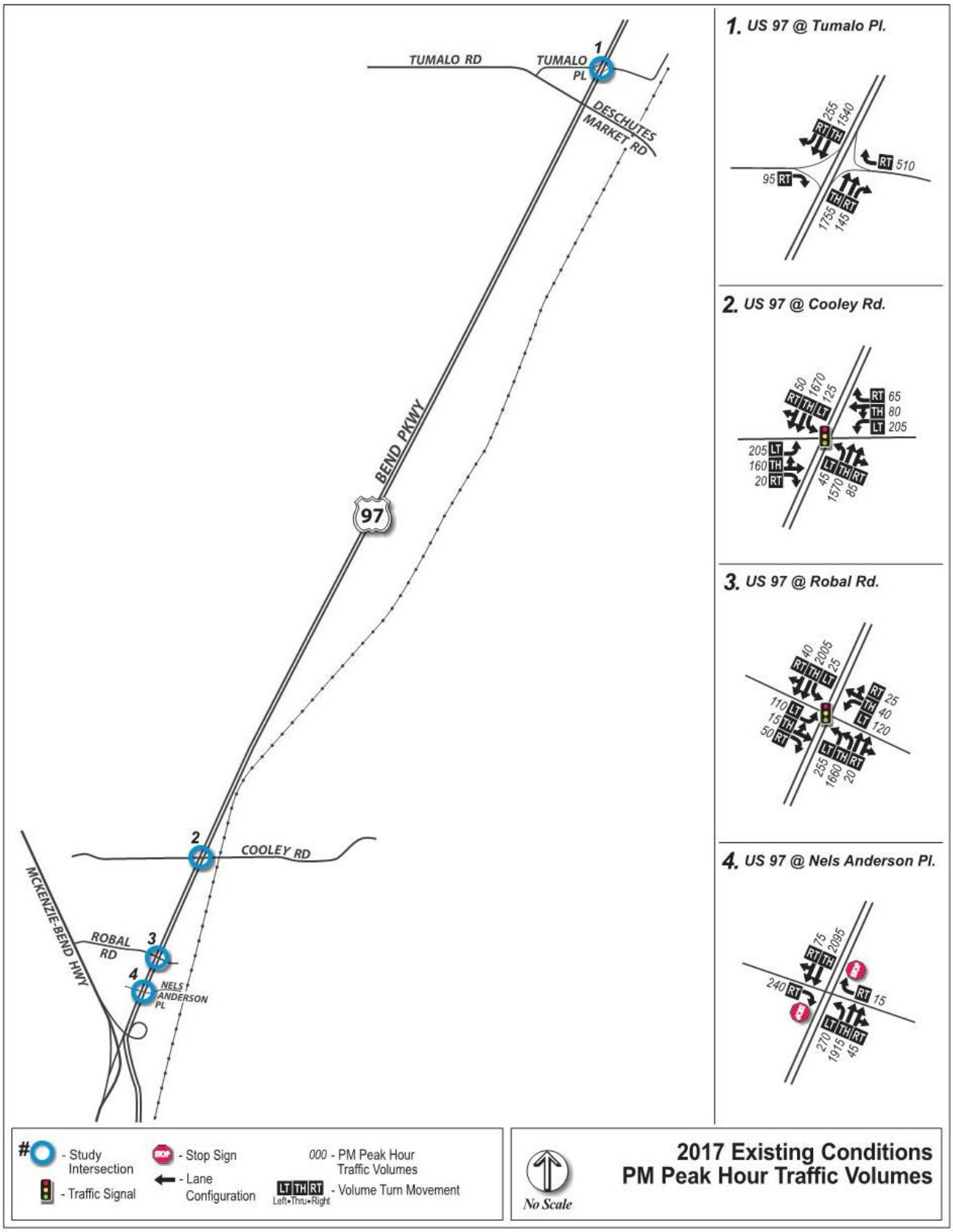

TUMALO RD
TUMALO PL
DESCHUTES MARKET RD
BEND PKWY
97
COOLEY RD
MCKENZIE-BEND HWY
ROBAL RD
NELS ANDERSON PL
1. US 97 @ Tumalo Pl.
2. US 97 @ Cooley Rd.
3. US 97 @ Robal Rd.
4. US 97 @ Nels Anderson Pl.
- Study Intersection
- Traffic Signal
- Stop Sign
- Lane Configuration
000 - PM Peak Hour Traffic Volumes
- Volume Turn Movement
Left•Thru•Right
No Scale
2017 Existing Conditions
PM Peak Hour Traffic Volumes

Figure 18

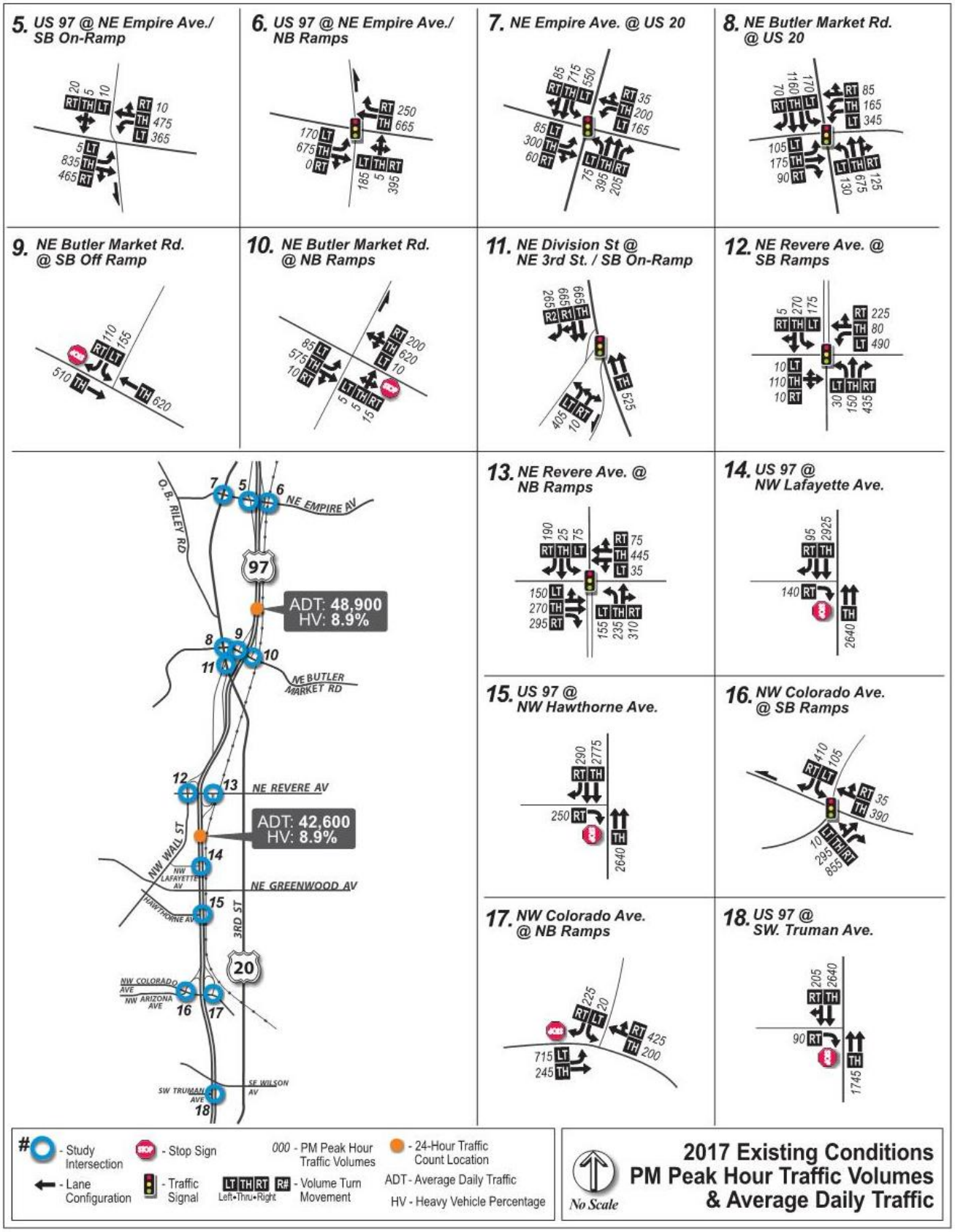
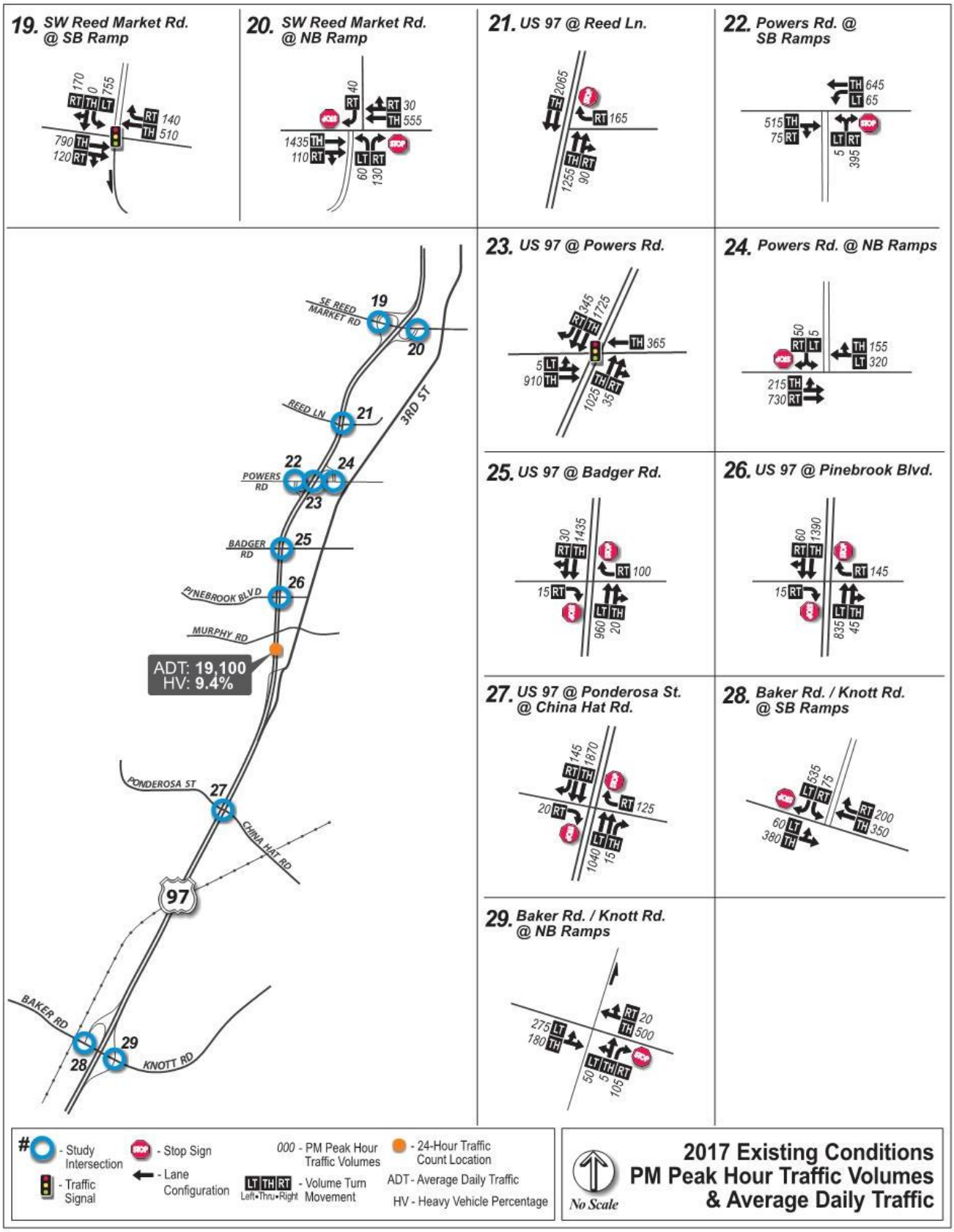

5. US 97 @ NE Empire Ave./ SB On-Ramp
6. US 97 @ NE Empire Ave./ NB Ramps
7. NE Empire Ave. @ US 20
8. NE Butler Market Rd. @ US 20
9. NE Butler Market Rd. @ SB Off Ramp
10. NE Butler Market Rd. @ NB Ramps
11. NE Division St @ NE 3rd St. / SB On-Ramp
12. NE Revere Ave. @ SB Ramps
13. NE Revere Ave. @ NB Ramps
14. US 97 @ NW Lafayette Ave.
15. US 97 @ NW Hawthorne Ave.
16. NW Colorado Ave. @ SB Ramps
17. NW Colorado Ave. @ NB Ramps
18. US 97 @ SW. Truman Ave.
O.B. RILEY RD
NE EMPIRE AV
NE BUTLER MARKET RD
NE REVERE AV
NW WALL ST
NW LAFAYETTE AV
NE GREENWOOD AV
HAWTHORNE AV
3RD ST
NW COLORADO AVE
NW ARIZONA AVE
SW TRUMAN AVE
SE WILSON AV
97
20
ADT: 48,900
HV: 8.9%
ADT: 42,600
HV: 8.9%
- Study Intersection
- Stop Sign
000 - PM Peak Hour Traffic Volumes
- 24-Hour Traffic Count Location
- Lane Configuration
- Traffic Signal
LT TH RT - Volume Turn Movement
Left-Thru-Right
ADT - Average Daily Traffic
HV - Heavy Vehicle Percentage
No Scale
2017 Existing Conditions
PM Peak Hour Traffic Volumes
& Average Daily Traffic

Figure 19


19. SW Reed Market Rd. @ SB Ramp
20. SW Reed Market Rd. @ NB Ramp
21. US 97 @ Reed Ln.
22. Powers Rd. @ SB Ramps
23. US 97 @ Powers Rd.
24. Powers Rd. @ NB Ramps
25. US 97 @ Badger Rd.
26. US 97 @ Pinebrook Blvd.
27. US 97 @ Ponderosa St. @ China Hat Rd.
28. Baker Rd. / Knott Rd. @ SB Ramps
29. Baker Rd. / Knott Rd. @ NB Ramps
SE REED MARKET RD
REED LN
3RD ST
POWERS RD
BADGER RD
PINEBROOK BLVD
MURPHY RD
PONDEROSA ST
CHINA HAT RD
BAKER RD
KNOTT RD
97
ADT: 19,100
HV: 9.4%
- Study Intersection
- Traffic Signal
- Stop Sign
- Lane Configuration
000 - PM Peak Hour Traffic Volumes
LT TH RT - Volume Turn Movement Left•Thru•Right
- 24-Hour Traffic Count Location
ADT - Average Daily Traffic
HV - Heavy Vehicle Percentage
No Scale
2017 Existing Conditions
PM Peak Hour Traffic Volumes
& Average Daily Traffic

MULTIMODAL ANALYSIS

This section includes an overview of the existing state of the bicycle and pedestrian facilities along the study corridor. For this phase of the study, the multimodal analysis has been limited to consideration of the frequency of pedestrian and bicycle crossing opportunities as well as the quality of the at-grade pedestrian crossings.

Pedestrian Crossing Analysis

The following four at-grade crossings of the Parkway were analyzed using the National Cooperative Highway Research Program (NCHRP) Report 562, "Improving Pedestrian Safety at Unsignalized Crossings"[9]:

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

The NCHRP report groups pedestrian crossing treatments into three categories: passive (e.g., a crosswalk), enhanced/active (vehicles are warned but not required to stop, often with a flashing yellow light), and red signal or beacon (vehicles are required to stop, often with a red light). The crossings at Reed Lane, Badger Road, and Pinebrook Boulevard are currently controlled by rectangular rapid flashing beacons (RRFBs), which are categorized as active. The crossing at Powers Road is signal-controlled and thus categorized as a signal treatment. Pedestrian crossing treatments are shown on Figures 20-22.

The inputs for this analysis include major road volume, posted speed limit, crossing distance, and pedestrian volume. The measured pedestrian volumes during the PM peak hour were low (less than five pedestrians per hour) for all four crossings, which leads to a recommendation that passive treatments such as raised median islands, curb extensions and other measures to slow traffic and shorten crossing distances may be adequate[10]. If peak pedestrian crossing volumes are actually greater than measured or if demand grows to be greater than 14 pedestrians per hour, then the recommendation changes to implement red signal/beacon devices at all four crossings. This category includes devices that show a red indication (such as a signal or beacon) to motorists at the crossing location, requiring them to stop. Further details on this analysis can be found in the Appendix.

At-grade intersections have been progressively removed from the Parkway. The plan for the future is to continue doing so, replacing at-grade access points with interchanges. As this occurs, speeds will increase and drivers may not expect to encounter an at-grade pedestrian crossing. Despite the NCHRP report recommendation, enhanced/active or red signal/beacon pedestrian crossing treatments may not be safe in the long-term. Therefore, these existing pedestrian crossings should be considered as candidates for grade separation (e.g., and overcrossing bridge).

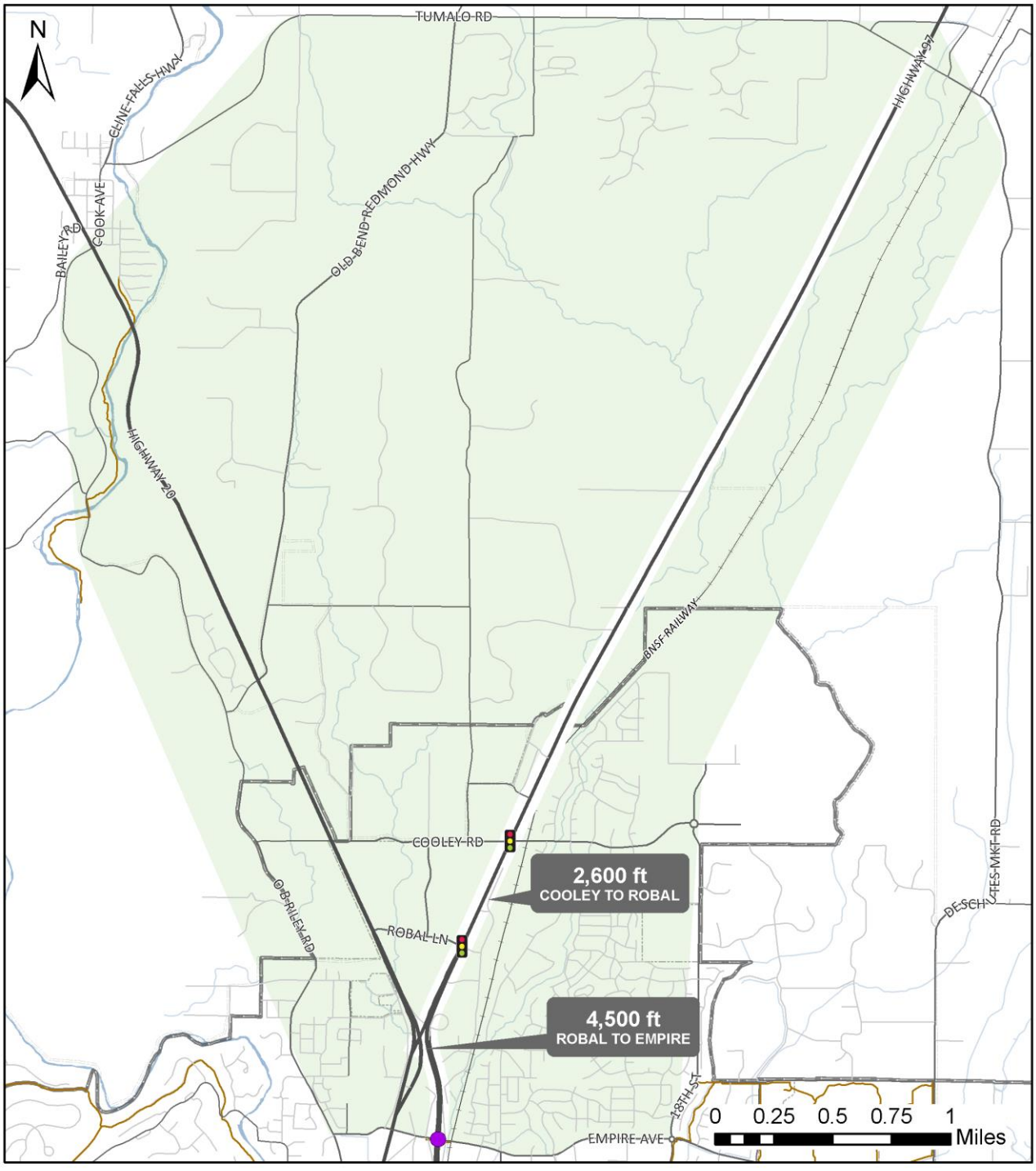
---

[9] *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings*, Transportation Research Board, 2006.
[10] Freight route mobility statue OR 366.215 may preempt some treatments.

Bicycle and Pedestrian Spacing Analysis

Figures 20-22 identify the spacing of pedestrian and bicycle crossings on US 97. Along the entire study area corridor, spacing distances range from 900 to 4,500 feet, with an average of 2,000 feet. Crossings in the North Study Area are most widely spaced. From Cooley Road to Empire Avenue, east-west access is further limited by the railroad tracks that run parallel and adjacent to the highway. Other constraints such as existing development and topography further limit east-west access along the corridor. From Butler Market Road to Murphy Road, where crossing demand is likely highest, the average distance between crossings is approximately 1,650 feet (about 1/3 mile). In urban areas, the desired spacing for pedestrian and bicycle access commonly ranges from 500-800 feet where practical.

Figure 20



Spacing Analysis - North Study Area

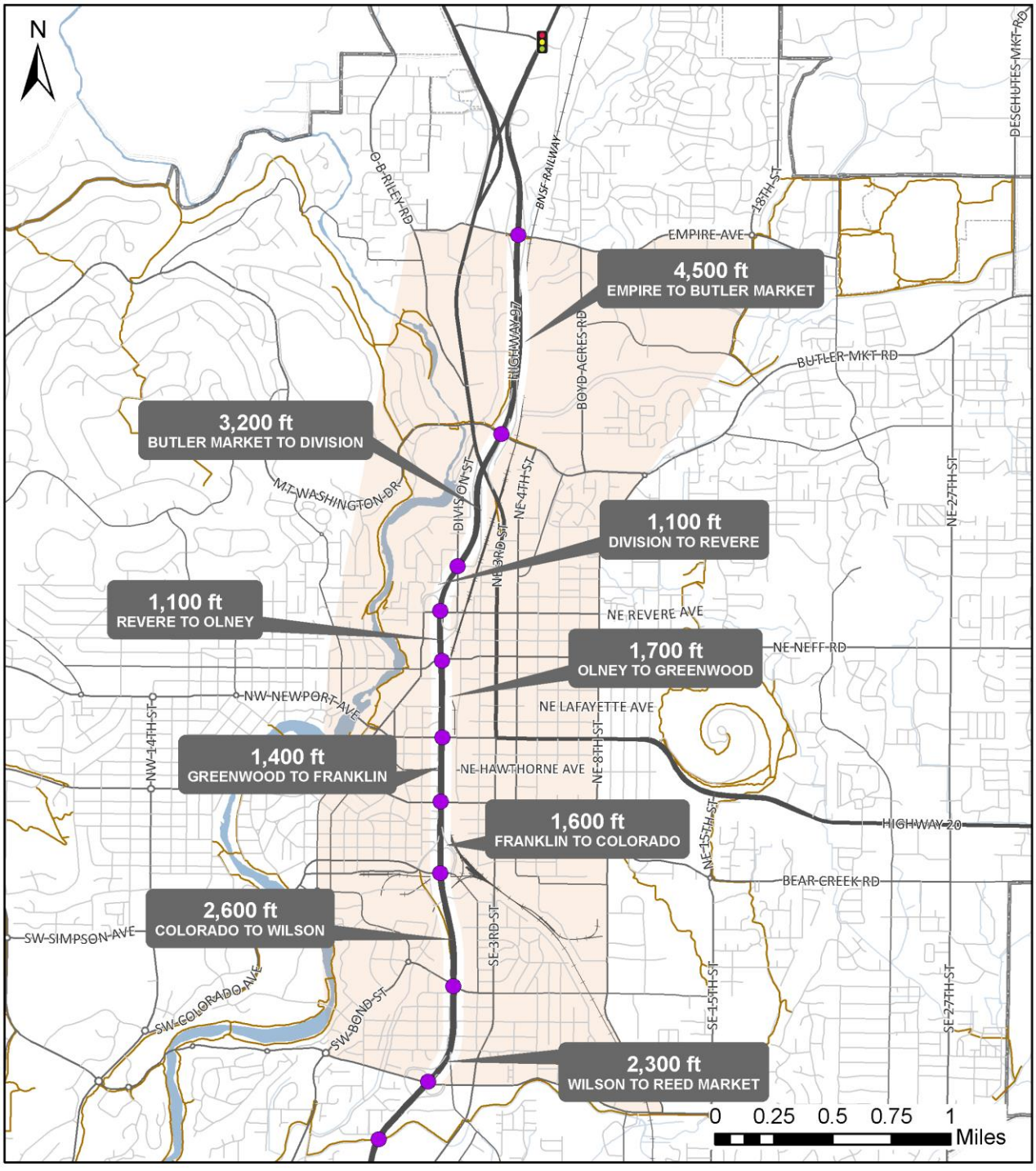
Crossings
- Traffic Signal
- Grade-separated Crossing

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

Parkway Study Area
- North Study Area

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

Figure 21



Spacing Analysis - Central Study Area

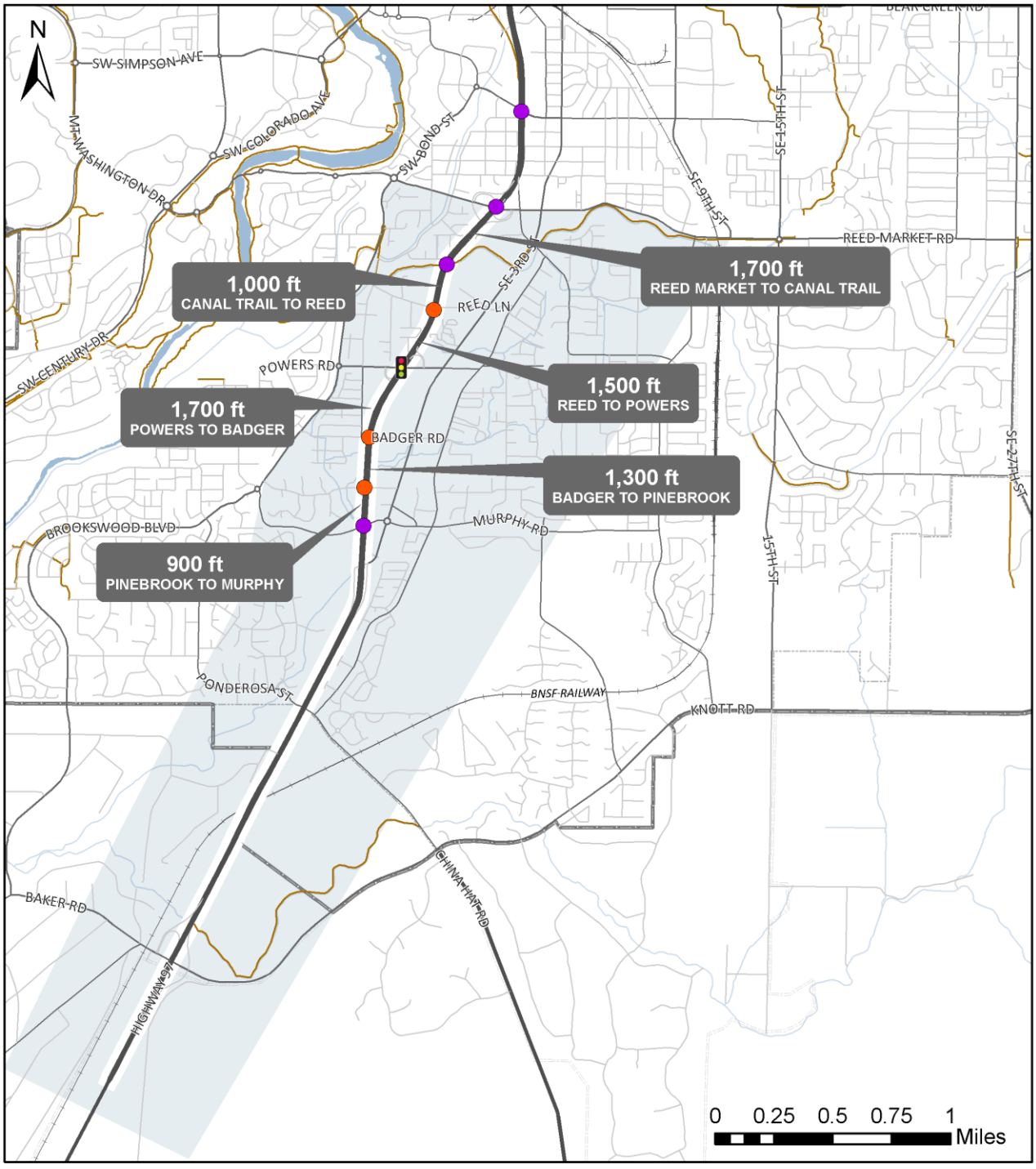
Crossings
- Traffic Signal
- Grade-separated Crossing

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

Parkway Study Area
- Central Study Area

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

Figure 22



Spacing Analysis - South Study Area

Crossings
- Traffic Signal
- Flashing Beacon Pedestrian Crossing
- Grade-separated Crossing

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

Parkway Study Area
- South Study Area

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

Bicycle Facilities

US 97 includes a bike lane in each direction from the Murphy Road interchange to the northern urban growth boundary. The bike lanes are demarcated with standard bike lane striping (6-inch shoulder stripe plus bike symbol stencil) and colored pavement as shown in Figure 23, and have typical widths of five to six feet.

The North and Central segments of the study corridor contain multiple interchanges. Bulb-outs with bicycle signage, as shown in Figure 23 are used at some locations to align bicycles for optimal visibility at off-ramp crossings. Note there are no bulb-outs at the SB Revere Avenue, SB/NB Colorado Avenue, and SB Reed Market Road off-ramps. Bicycles are required to yield to motor vehicles at all ramp crossings.

The quality of bicycle facilities was not evaluated in detail for this phase of the study. Instead, field observations related to biking comfort and safety were made by a moderately experienced cyclist. Key findings for further consideration include:

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

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

Figure 23: Bike Facility Examples

SAFETY ANALYSIS

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

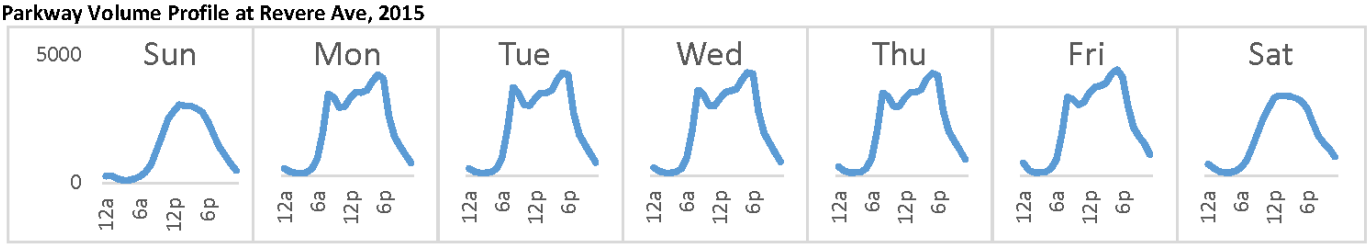
severity, and other crash characteristics were used to identify crash patterns. Critical crash rates were calculated and used to flag intersections and segments along the corridor as safety-focus locations.

Crash Calendar and Patterns

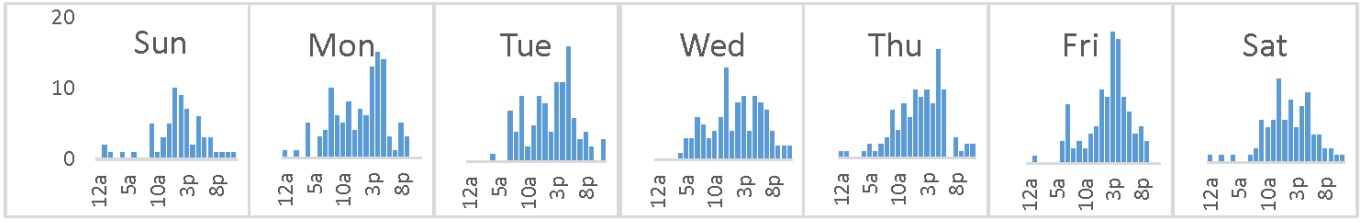
Crash calendars were developed to illustrate the pattern of crashes over the five-year period, 2011-2015, by month, day, and periods within each day. The calendars display these trends for total crashes (Figure 24), for severity of crashes (Figure 25), and for road condition and selected causes (Figure 26).

Figure 24: Crash Calendar – Total Crashes[11]

US 97 Parkway Volume Profile at Revere Ave, 2015



Total Crashes by Hour, 2011-2015

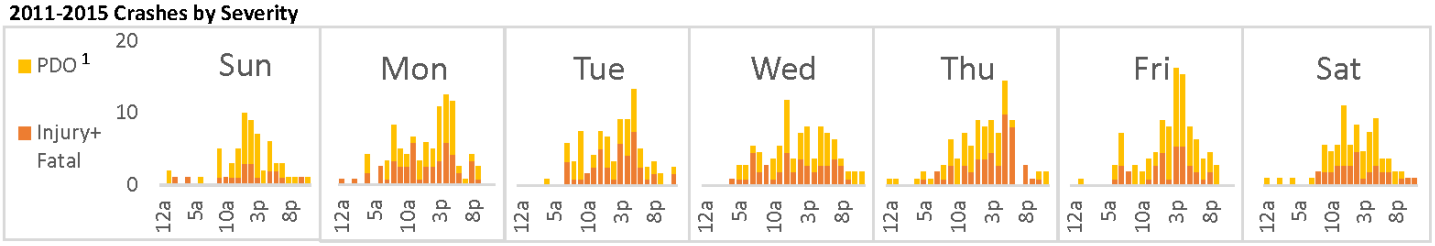


Total Crashes		Sun				Mon				Tue				Wed				Thu				Fri				Sat			
	Total	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	689	4	10	39	10	7	36	59	12	1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

[11] Calendar cells are shaded based on the local minima and maxima. Totals are shaded on a separate scale.

Figure 25: Crash Calendar – Severity

2011-2015 Crashes by Severity



Severity: Fatality and Injury Crashes

		Sun				Mon				Tue				Wed				Thu				Fri				Sat			
	Total	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	292	2	3	10	4	4	21	23	7	0	11	31	8	2	14	19	11	1	9	29	14	0	7	24	5	0	9	17	7
Jan	16						1	2	2		1		1			1	2			2				2				2	
Feb	22			1		1	2	2			1				4		1			1				4	2		2	1	
Mar	21			1	1		2	5				2			2	1	3	1					1	1	1				
Apr	19						2	1	1		1	5				2	1			1	1		1	2				1	
May	29			1	1	1		3			1	5	1		1	1				9	3							2	
Jun	25	1		1		2	4				1	3	2	1			1			3	1			3				2	
Jul	19				1		2	3				3	1			2			2	1	2		1	1					
Aug	26		1	1			2	1	1		2	2			2	2	2		1	2	1		1	1			1	1	2
Sep	30		2				3		2			3			3	1	1		3	3	3			3	1			1	1
Oct	25			1				1			1	2				3				1	2		3	4	1		2	2	2
Nov	35	1		3	1			4			1	4	1		1	4			2	6	1			2			3		1
Dec	25			1			3	1	1		2	2	2	1	1	2			1					1			1	5	1

Severity: Property Damage Only Crashes

		Sun				Mon				Tue				Wed				Thu				Fri				Sat			
	Total	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	397	2	7	29	6	3	15	36	5	1	16	28	10	2	13	28	14	4	16	30	4	1	15	44	14	3	11	33	7
Jan	27	1	1				1	1			1	2	1		3	3		1	1	5	1							4	1
Feb	27			3		1		1	1			1		1	4	2			1		1		1	4			1	4	1
Mar	23			2	2	1	2	1			2					1	2	1		3				2		1	2	1	
Apr	18						1				1	1	1			3			1	2			2	2	3			1	
May	29		1	3			2	5			1	2			1	3	3			1			3	1				2	1
Jun	41		3	2	2		3	5			3	2				3	2		2	3			2	3	1			3	2
Jul	28	1		1			1	4			1	2	1			3	3		3	1			1	4		1		1	
Aug	35			5			1	7	1		2	1			1	2			1	3	1		1	3	3			2	1
Sep	28						2	3				4	1			3		1		2			1	5	2		1	3	
Oct	30		1	1			2	4	1			1			1	2	1		2	2	1		2	2	1			6	
Nov	63			5	1	1		4	1	1	4	4	4	1		2	2		3	5			2	13	3	1	5	1	
Dec	48		1	7	1			1	1		1	8	2		3	1	1	1	2	3		1		5	1		2	5	1

[1]Property Damage Only

Figure 26: Crash Calendar – Road Condition and Selected Causes

Road Condition: Wet/Snow/Ice Crashes

		Sun				Mon				Tue				Wed				Thu				Fri				Sat			
	Total	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	162	0	1	13	5	5	10	5	2	0	3	12	7	2	12	5	5	4	8	7	3	1	4	17	1	2	12	12	4
Jan	9										1	1	1					1	1	1	1							1	1
Feb	26			2		2	2							1	6								1	4	1		2	4	1
Mar	12				3	1	3											2								1	2		
Apr	2						1																1						
May	7			1				2				1								1	2								
Jun	6				1	1										1	1							1				1	
Jul	3							1					1			1													
Aug	1			1																									
Sep	3														1				2										
Oct	5						1	1									1						2						
Nov	48			6	1	1		1	1			4	4		1	1	2		3	4				10		1	6	1	1
Dec	40		1	3			3		1		2	6	1	1	4	2	1	1	2	1		1		2			2	5	1

Cause: Speed Related Crashes[2]

		Sun				Mon				Tue				Wed				Thu				Fri				Sat			
	Total	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	80	1	1	9	0	4	9	1	1	0	1	1	0	2	6	1	6	2	2	3	1	0	1	9	0	2	5	8	4
Jan	6								1		1							1		1								1	1
Feb	18			2		2	1							1	2		1							3			2	3	1
Mar	6					1	3											1								1			
Apr	0																												
May	5			2			1								1													1	
Jun	6					1	2										2												1
Jul	1	1																											
Aug	2							1				1																	
Sep	2																				1							1	
Oct	4																1		1				1					1	
Nov	17			4													2		1	2				5		1	2		
Dec	13		1	1			2							1	3	1								1			1	1	1

Cause: Compliance Related Crashes[3]

		Sun				Mon				Tue				Wed				Thu				Fri				Sat			
	Total	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a	12a-6a	6a-12p	12p-6p	6p-12a
Total	124	0	2	5	5	1	7	10	4	0	7	9	7	0	4	4	5	0	2	13	8	0	3	9	5	1	1	9	3
Jan	6						1		1							1				2								1	
Feb	10			2								1			3							1	2					1	
Mar	10			1	2			3			1	1					1			1									
Apr	8						1				1	1								1			1	1	2				
May	10				1	1		2				1	1			1	1			1	1								
Jun	15				1		3	1			1	1	2							2	1			1				2	
Jul	6						1	1				1	1			1				1									
Aug	14		1	2				1							1	1	2		1	1	1			1	1				1
Sep	9						1										1		1	1	2		1		1				1
Oct	11		1					1			1										3			1	1			2	1
Nov	12				1			1	1		3	1	1							1				1		1	1		
Dec	13								2			2	2							2				2				3	

[2]Includes causes: Speeding, Too Fast for Conditions

[3]Includes causes: No Yield, Disregarded Traffic Signal, Passed Stop Sign

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

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

When looking at road condition, the impact of weather is very apparent. Per the crash calendar, most crashes for a road condition of either wet, snow, or ice occur in the months of November, December, and February. These road condition crashes account for half of the total crashes during those months.

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

Some crash characteristics, such as bicycle or pedestrian-involved crashes, alcohol-involved crashes, high severity, or animal-involved crashes, did not have enough data points for analysis in the crash calendar. Over the study period of 2011-2015 there were two fatal crashes, five severe injury (level ‘A’) crashes, four bicycle-involved crashes, and two pedestrian-involved crashes. There were 27 animal-related crashes and 26 alcohol-involved crashes out of a total of 689 crashes over the five-year period. Additional details on the crash data can be found in the Appendix.

Crash Rate Analysis

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

Intersection Crash Rate Analysis

The observed crash rate for intersections is a function of the number of crashes and the annual average daily traffic (AADT). Each intersection is grouped into a reference population based on intersection control and urban or rural area classification. The crash rates (crashes per million entering vehicles) for each intersection were compared to two different standards: a critical crash rate which compares performance to other similar intersections being studied, and a 90th percentile crash rate which is based on similar intersections throughout the state (obtained from ODOT's Analysis Procedures Manual Exhibit 4-1). Full calculations are provided in the Appendix. The table below (Table 3) shows these crash rates for study intersections where crashes were documented. Intersections that had observed crash rates greater than either the critical or 90th percentile crash rate were flagged as safety focus areas for further consideration.

Table 3: Intersection Crash Rates* (2011-2015)

Int. No.	Intersection Name	Flagged	Observed Crash Rate	Critical Crash Rate	90th Percentile Rate
1	US 97 & Tumalo Pl		0.08	0.58	1.08
2	US 97 & Cooley Rd		0.63	0.68	0.86
3	US 97 & Robal Rd		0.66	0.68	0.86
4	US 97 & Nels Anderson Pl		0.07	0.35	0.41
5	Bend Pkwy SB On-Ramp & Empire Blvd		0.15	0.39	0.41
6	Bend Pkwy NB Ramps & Empire Blvd		0.54	0.73	0.86
7	US 20 & Empire Blvd		0.48	0.71	0.86
8	US 20 & Butler Market Rd	Yes	0.74	0.70	0.86
9	Bend Pkwy SB Off-Ramp & Butler Market Rd		0.27	0.39	0.29
10	Bend Pkwy NB On-Ramp & Butler Market Rd		0.04	0.43	0.41
11	Bend Pkwy SB On-Ramp/Division St & 3rd St		0.10	0.72	0.86
12	Bend Pkwy SB Ramps & Revere Ave		0.48	0.76	0.86
13	Bend Pkwy NB Ramps & Revere Ave	Yes	0.76	0.74	0.86
14	Bend Pkwy & Lafayette Ave		0.13	0.30	0.29
15	Bend Pkwy & Hawthorne Ave		0.26	0.29	0.29
16	Bend Pkwy SB Ramps & Colorado Ave		0.26	0.79	0.86
18	Bend Pkwy & Truman Ave		0.04	0.31	0.29
19	Bend Pkwy SB Ramps & Reed Market Rd		0.11	0.73	0.86
20	Bend Pkwy NB Ramps & Reed Market Rd	Yes	0.62	0.35	0.29
21	Bend Pkwy & Reed Ln		0.19	0.32	0.29
22	Bend Pkwy SB Ramps & Powers Rd		0.27	0.38	0.29
23	Bend Pkwy & Powers Rd		0.61	0.68	0.86
24	Bend Pkwy NB Ramps & Powers Rd		0.13	0.39	0.29
25	Bend Pkwy & Badger Rd		0.11	0.39	0.41
26	Bend Pkwy & Pinebrook Blvd	Yes	1.03	0.40	0.41
27	US 97 & Ponderosa St		0.19	0.38	0.41
28	US 97 SB Ramps & Baker Rd	Yes	0.68	0.36	0.48
29	US 97 NB Ramps & Knott Rd		0.56	0.72	1.08

*Crash rates are crashes per million vehicles entering the intersection.

Five intersections were flagged as safety focus areas. The intersections at US 20/Butler Market Road and Bend Parkway Northbound Ramps/Revere Avenue had crash rates only slightly greater than the critical crash rate, but still lower than the 90th percentile crash rate. In contrast, the intersections at Bend Parkway Northbound Ramps/Reed Market Road, Bend Parkway/Pinebrook Boulevard, and US 97 Southbound Ramps/Baker Road had crash rates much greater than the critical and 90th percentile crash rates. It should be noted that in 2015, the intersection of Bend Parkway/Pinebrook Boulevard was reconstructed from a full-movement signalized intersection to an unsignalized intersection allowing only right-in/right-out turning movements, which may have mitigated the high crash rate. Although it was not flagged as a safety focus area the intersection of US 97 Northbound Ramps and Knott Road has a guardrail that gets hit frequently by drivers making a left turn onto the northbound ramp, possibly due to a tight turning radius.

The excess proportion of specific crash types analysis looks at the proportion of crash types (i.e., rear-end, backing, angle, etc.) for each intersection and compares it with the average for the reference population (i.e., similar intersections within the study area) to determine if certain types of crashes are more prevalent than should be expected. A reference population must contain at least five intersections to be valid and at least two crashes of the same type are necessary to calculate the excess proportion for that intersection. Crash types with a crash rate at least 10% higher than the reference population were flagged as safety focus areas. The following table (Table 4) presents only the flagged intersections and shows that rear-end and turning crashes are the most commonly overrepresented crash types at study intersections.

Table 4: Excess Proportion of Crashes (2011-2015)

Int. No.	Intersection Name	Flagged	Crash Type	Excess Proportion	Crash Type	Excess Proportion
2	US 97 & Cooley Rd	Yes	Rear-end	0.17		
3	US 97 & Robal Rd	Yes	Rear-end	0.13		
4	US 97 & Nels Anderson Pl	Yes	Rear-end	0.21		
5	Bend Pkwy SB On-Ramp & Empire Blvd	Yes	Turn	0.19		
9	Bend Pkwy SB Off-Ramp & Butler Market Rd	Yes	Turn	0.59		
12	Bend Pkwy SB Ramps & Revere Ave	Yes	Turn	0.59		
13	Bend Pkwy NB Ramps & Revere Ave	Yes	Turn	0.16		
14	Bend Pkwy & Lafayette Ave	Yes	Rear-end	0.18		
15	Bend Pkwy & Hawthorne Ave	Yes	Rear-end	0.30		
16	Bend Pkwy SB Ramps & Colorado Ave	Yes	Angle	0.24	Turn	0.14
20	Bend Pkwy NB Ramps & Reed Market Rd	Yes	Angle	0.10	Turn	0.30
22	Bend Pkwy SB Ramps & Powers Rd	Yes	Rear-end	0.34		
23	Bend Pkwy & Powers Rd	Yes	Rear-end	0.17		
24	Bend Pkwy NB Ramps & Powers Rd	Yes	Turn	0.43		
25	Bend Pkwy & Badger Rd	Yes	Rear-end	0.16		
27	US 97 & Ponderosa St	Yes	SS-O*	0.18		

*SS-O = Sideswipe crash that occurred while overtaking another vehicle

The Safety Priority Index System (SPIS) provides another method for identifying crash hot spots. The SPIS is a method developed by ODOT for identifying potential safety problems on state highways. This method

considers the rate, frequency, and severity of crashes to produce a rating, with the highest rated sites statewide being considered for potential safety improvements.

The 2015 SPIS ratings for US 97 were obtained from ODOT to screen for locations with SPIS ratings among the state's top 10 percent. Three study intersections on US 97 were flagged, as shown in Table 5. These intersections were already flagged as safety focus areas in the above crash rate analyses. In total, 19 intersections were flagged through the three methodologies described above as safety focus locations.

Table 5: Intersections with SPIS Ratings among the Top 10 Percent (2015)

Int. No.	Intersection Name	Flagged
2	US 97 & Cooley Rd	Yes
23	Bend Pkwy & Powers Rd	Yes
26	Bend Pkwy & Pinebrook Blvd	Yes

Segment Crash Rate Analysis

In addition to individual intersections, crash rates for segments of the US 97 study corridor were analyzed to identify potential problem areas of the corridor. Thirteen segments along the corridor and their crash rates were obtained from the 2014 ODOT Crash Book (2015 data was not yet available). The average crash rate experience between 2010-2014 was compared against the statewide average (Crash Rate Table II in the Crash Book). Segments were flagged as safety focus areas if their five-year average observed crash rate exceeded the statewide average rate. As seen in Table 6, two segments were flagged: City Limits to Robal Road and Powers Road to 3rd Street (now replaced by the Murphy Road interchange). It should be noted that both segments have at-grade signalized intersections. A region wide safety assessment was recently completed for the ODOT All Roads Transportation Safety (ARTS) Program[12], which identified regional hot spots for further safety focus. This assessment did not show the US 97 study corridor as being among the top safety concerns in Region 4.

[12] *ODOT All Roads Transportation Safety (ARTS) Program – Hot Spot Report,* Prepared by DKS Associates, May 2015.

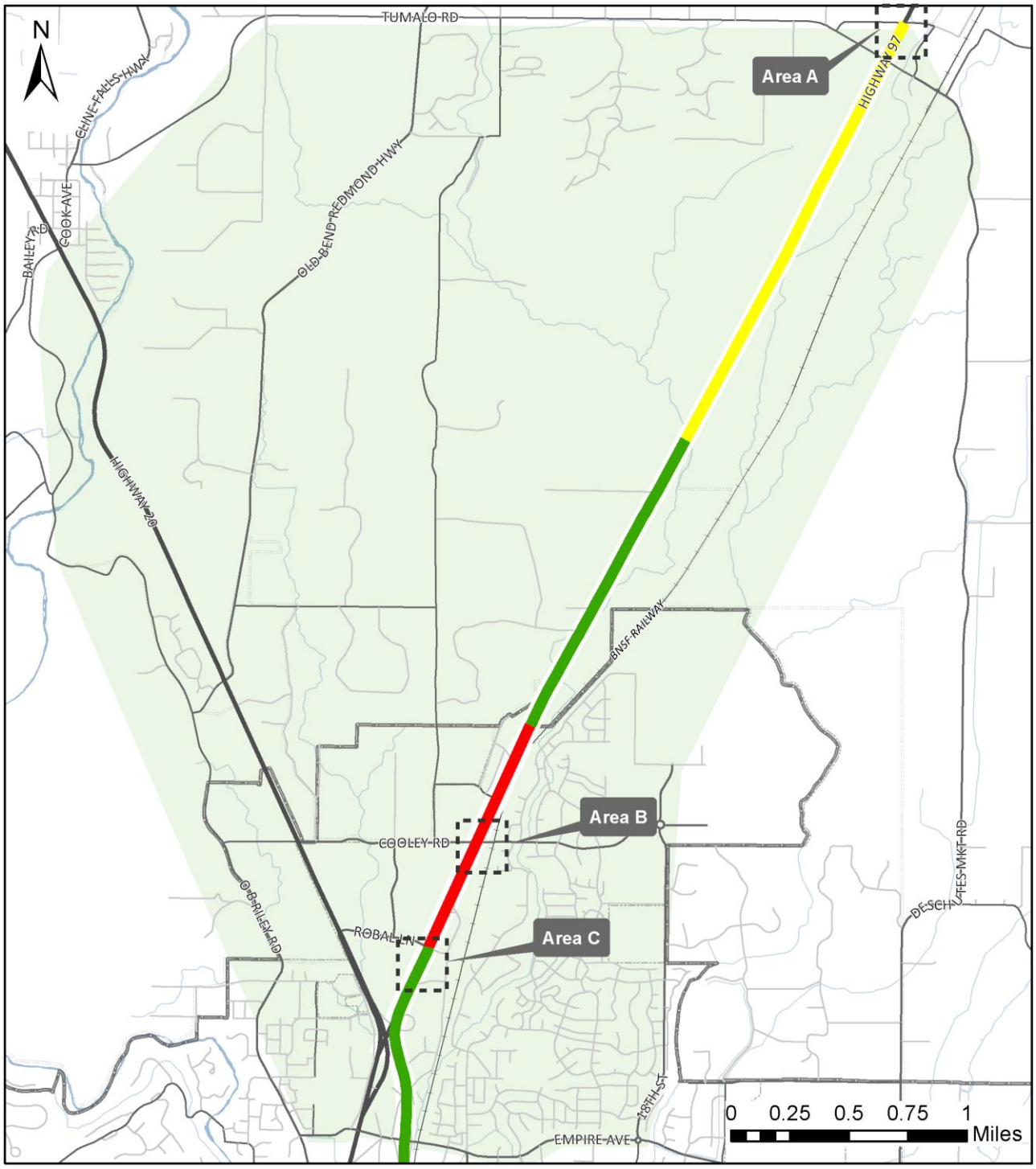
Table 6: US 97 Study Corridor Segment Crash Rates

Start MP	End MP	Segment Name	Flagged	Area Type	Observed Crash Rate	Statewide Average Rate
130.18	132.19	Bend-Deschutes Market Rd to Bend UA		Rural Area	0.41	0.73
132.19	133.56	Bend UA to City Limits		Suburban Area	0.29	0.99
133.56	134.60	City Limits to Robal Rd	Yes	Urban City	1.10	0.86
134.60	136.48	Robal Rd to Hwy 17/3rd Street Crossing		Urban City	0.40	0.86
136.48	136.92	US 97/3rd Street Crossing to Division St		Urban City	0.06	0.86
136.92	137.13	Division St to Revere Ave		Urban City	0.48	0.86
137.13	137.66	Revere Ave to Greenwood Ave		Urban City	0.30	0.86
137.66	138.24	Greenwood Ave to Colorado Ave		Urban City	0.46	0.86
138.24	139.17	Colorado Ave to Reed Market Rd		Urban City	0.21	0.86
139.17	139.97	Reed Market Rd to Powers Rd		Urban City	0.76	0.86
139.97	141.01	Powers Rd to 3rd St	Yes	Urban City	2.40	0.86
141.01	142.24	3rd St to Ponderosa Dr/China Hat Rd		Urban City	0.44	0.86
142.24	143.47	Ponderosa Dr to Baker Rd/Knott Rd		Suburban Area	0.33	0.99

Crash Maps

Figures 27-29 illustrate the findings from Table 6, showing observed segment crash rates compared to statewide average crash rates. They also identify clusters of study intersections (shown as “Areas”), for which more detailed crash maps are provided in Figures 30-32. These maps show the number of crashes by severity and crash type trends for each intersection, and whether the intersection is flagged as a safety focus area.

Figure 27



2010-2014 Parkway Segment Crash Rates - North Study Area

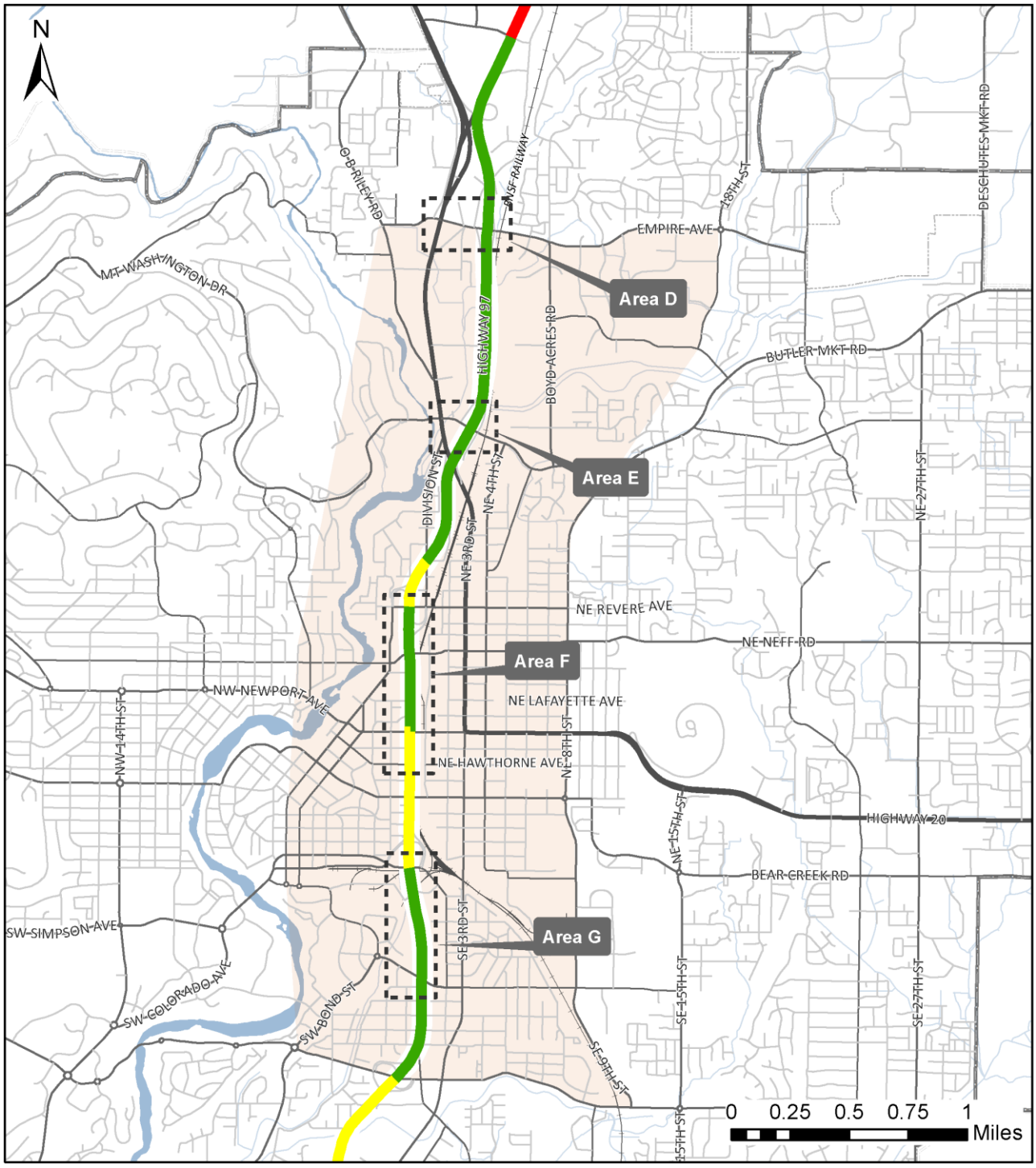
State Crash Rate Percentile
- <50
- 50-100
- >100 (Exceeds Statewide Average Crash Rate)

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

Parkway Study Area
- North Study Area

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

Figure 28



2010-2014 Parkway Segment Crash Rates - Central Study Area

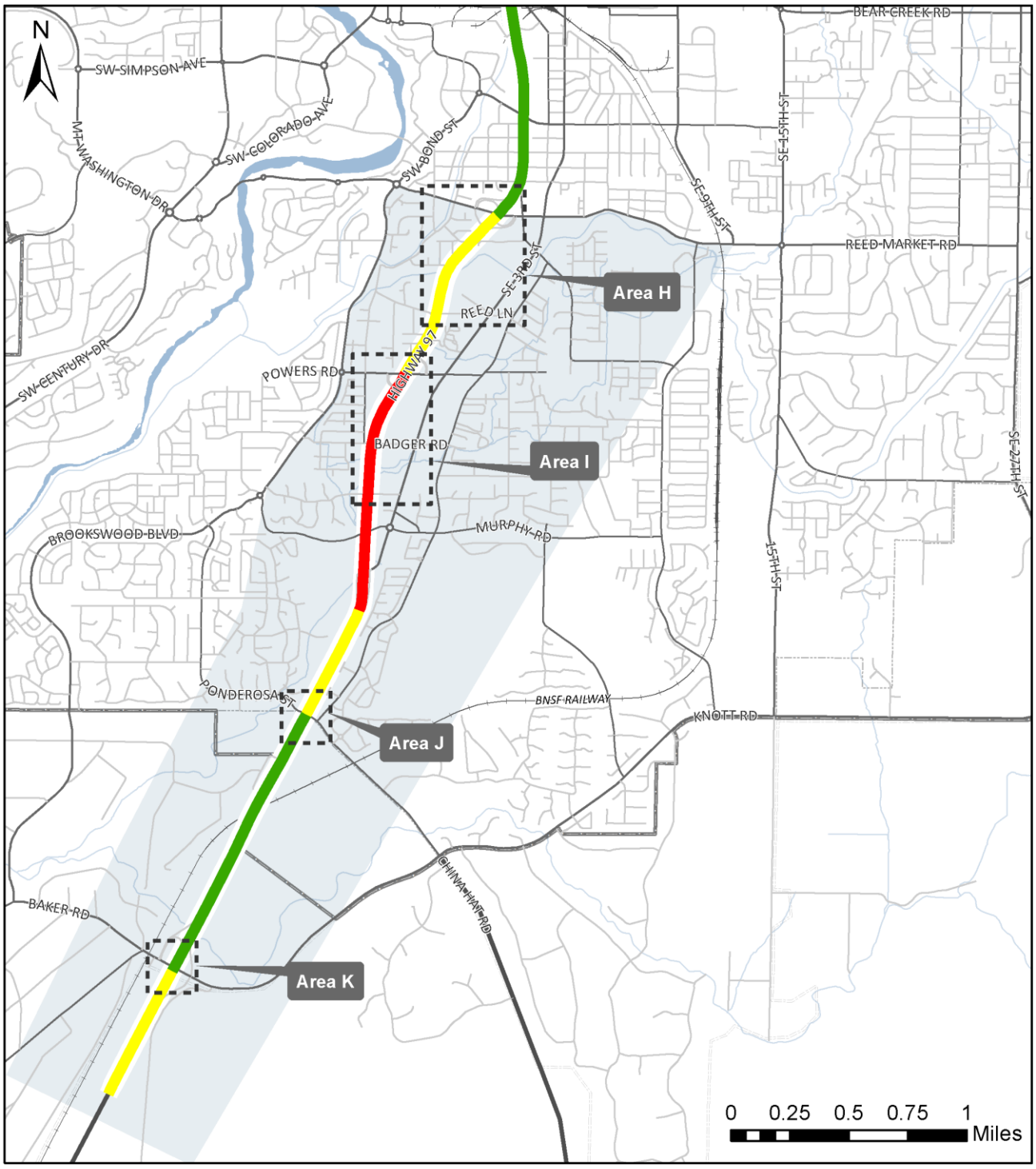
State Crash Rate Percentile
- <50
- 50-100
- >100 (Exceeds Statewide Average Crash Rate)

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

Parkway Study Area
- Central Study Area

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

Figure 29



2010-2014 Parkway Segment Crash Rates - South Study Area

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

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

Parkway Study Area
- South Study Area

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

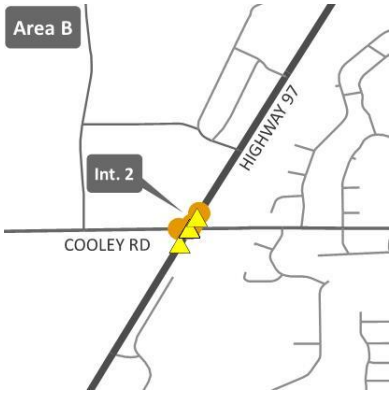
Figure 30: Intersection Crashes – North Study Area

Crash Severity ● Property Damage Only △ Injury ■ Fatality

Int. 1: US 97 & Tumalo Pl

Crash Severity
1 Serious Injury Crash (Injury A)
4 Property Damage Only Crashes

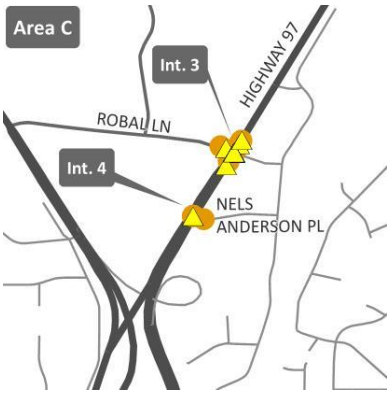
Crash Type
2 Rear-end Crashes
3 Other Crashes



Int. 2: US 97 & Cooley Rd
Flagged as Safety Focus Area

Crash Severity
14 Injury Crashes (Injury B & C)
26 Property Damage Only Crashes

Crash Type
4 Angle Crashes
2 Sideswipe Crashes
32 Rear-end Crashes
2 Other Crashes



Int. 3: US 97 & Robal Rd
Flagged as Safety Focus Area

Crash Severity
1 Serious Injury Crashes (Injury A)
19 Injury Crashes (Injury B & C)
22 Property Damage Only Crashes

Crash Type
2 Sideswipe Crashes
3 Turn Crashes
32 Rear-end Crashes
5 Other Crashes

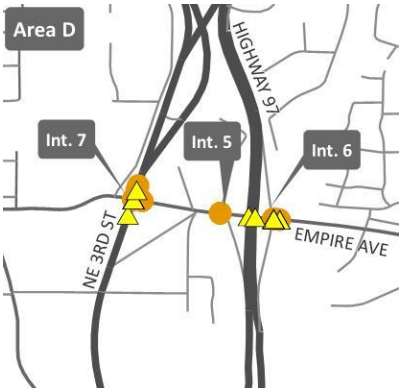
Int. 4: US 97 & Nels Anderson Pl
Flagged as Safety Focus Area

Crash Severity
1 Non-serious Injury Crashes (Injury B & C)
4 Property Damage Only Crashes

Crash Type
4 Rear-end Crashes
1 Other Crash

Figure 31: Intersection Crashes – Central Study Area

Crash Severity ● Property Damage Only △ Injury ■ Fatality



Int. 5: Bend Pkwy SB On-Ramp & Empire Blvd
Flagged as Safety Focus Area

Crash Severity
1 Non-serious Injury Crashes (Injury B & C)
4 Property Damage Only Crashes

Crash Type
2 Turn Crashes
3 Rear-end Crashes

Int. 6: Bend Pkwy NB Ramps & Empire Blvd

Crash Severity
11 Non-serious Injury Crashes (Injury B & C)
9 Property Damage Only Crashes

Crash Type
2 Angle Crashes
5 Turn Crashes
12 Rear-end Crashes
1 Other Crash

Int. 7: US 20 & Empire Blvd

Crash Severity
9 Non-serious Injury Crashes (Injury B & C)
13 Property Damage Only Crashes

Crash Type
2 Angle Crashes
1 Bicycle Crash
6 Turn Crashes
12 Rear-end Crashes
1 Other Crash

Int. 8: US 20 & Butler Market Rd
Flagged as Safety Focus Area

Crash Severity
20 Non-serious Injury Crashes (Injury B & C)
18 Property Damage Only Crashes

Crash Type
4 Angle Crashes
10 Turn Crashes
22 Rear-end Crashes
2 Other Crashes

Int. 9: Bend Pkwy SB Off-Ramp & Butler Market Rd
Flagged as Safety Focus Area

Crash Severity
1 Non-serious Injury Crashes (Injury B & C)
5 Property Damage Only Crashes

Crash Type
5 Turn Crashes
1 Rear Crash

Int. 10: Bend Pkwy NB On-Ramp & Butler Market Rd

Crash Severity
1 Property Damage Only Crash

Crash Type
1 Rear-end Crash

Int. 11: Bend Pkwy SB On-Ramp/Division St & 3rd St

Crash Severity
1 Fatal Crash
2 Non-serious Injury Crashes (Injury B & C)
1 Property Damage Only Crashes

Crash Type
1 Pedestrian Crash
1 Turn Crash
1 Rear-end Crash
1 Other Crash

Int. 12: Bend Pkwy SB Ramps & Revere Ave
Flagged as Safety Focus Area

Crash Severity
1 Serious Injury Crash (Injury A)
5 Non-serious Injury Crashes (Injury B & C)
8 Property Damage Only Crashes

Crash Type
11 Turn Crashes
3 Rear-end Crashes

Int. 13: Bend Pkwy NB Ramps & Revere Ave
Flagged as Safety Focus Area

Crash Severity
1 Serious Injury Crash (Injury A)
7 Non-serious Injury Crashes (Injury B & C)
19 Property Damage Only Crashes

Crash Type
3 Angle Crashes
1 Bicycle Crash
10 Turn Crashes
13 Rear-end Crashes

Int. 14: Bend Pkwy & Lafayette Ave
Flagged as Safety Focus Area

Crash Severity
4 Non-serious Injury Crashes (Injury B & C)
8 Property Damage Only Crashes

Crash Type
10 Rear-end Crashes
2 Other Crashes

Int. 15: Bend Pkwy & Hawthorne Ave
Flagged as Safety Focus Area

Crash Severity
11 Non-serious Injury Crashes (Injury B & C)
13 Property Damage Only Crashes

Crash Type
23 Rear-end Crashes
1 Other Crash

Int. 16: Bend Pkwy SB Ramps & Colorado Ave
Flagged as Safety Focus Area

Crash Severity
1 Non-serious Injury Crashes (Injury B & C)
5 Property Damage Only Crashes

Crash Type
2 Angle Crashes
2 Turn Crashes
2 Rear-end Crashes

Int. 17: Bend Pkwy NB Ramps & Colorado Ave

No crashes reported at this site

Int. 18: Bend Pkwy & Truman Ave

Crash Severity
3 Property Damage Only Crashes

Crash Type
2 Rear-end Crashes
1 Other Crash

Figure 32: Intersection Crashes – South Study Area

Crash Severity ● Property Damage Only △ Injury ■ Fatality

Int. 19: Bend Pkwy SB Ramps & Reed Market Rd

Crash Severity
1 Non-serious Injury Crashes (Injury B & C)
3 Property Damage Only Crashes

Crash Type
1 Angle Crash
1 Turn Crash
1 Rear-end Crash
1 Other Crash

Int. 20: Bend Pkwy NB Ramps & Reed Market Rd
Flagged as Safety Focus Area

Crash Severity
11 Non-serious Injury Crashes (Injury B & C)
11 Property Damage Only Crashes

Crash Type
3 Angle Crashes
1 Sideswipe
12 Turn Crashes
6 Rear-end Crashes

Int. 21: Bend Pkwy & Reed Ln

Crash Severity
5 Non-serious Injury Crashes (Injury B & C)
5 Property Damage Only Crashes

Crash Type
1 Sideswipe Crash
2 Turn Crashes
7 Rear-end Crashes

Int. 22: Bend Pkwy SB Ramps & Powers Rd
Flagged as Safety Focus Area

Crash Severity
3 Non-serious Injury Crashes (Injury B & C)
4 Property Damage Only Crashes

Crash Type
7 Rear-end Crashes

Int. 23: Bend Pkwy & Powers Rd
Flagged as Safety Focus Area

Crash Severity
23 Non-serious Injury Crashes (Injury B & C)
16 Property Damage Only Crashes

Crash Type
5 Angle Crashes
1 Sideswipe Crash
1 Turn Crash
31 Rear-end Crashes
1 Other Crash

Int. 24: Bend Pkwy NB Ramps/Powers Rd
Flagged as Safety Focus Area

Crash Severity
2 Non-serious Injury Crashes (Injury B & C)
1 Property Damage Only Crash

Crash Type
2 Turn Crashes
1 Rear-end Crash

Int. 25: Bend Pkwy & Badger Rd
Flagged as Safety Focus Area

Crash Severity
2 Non-serious Injury Crashes (Injury B & C)
2 Property Damage Only Crashes

Crash Type
1 Turn Crash
3 Rear-end Crashes

Int. 26: Bend Pkwy & Pinebrook Blvd
Flagged as Safety Focus Area

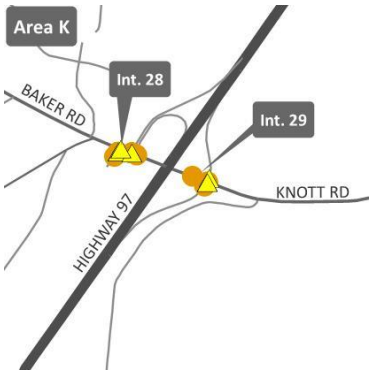
Crash Severity
18 Non-serious Injury Crashes (Injury B & C)
16 Property Damage Only Crashes

Crash Type
5 Angle Crashes
1 Bicycle Crash
2 Sideswipe Crashes
8 Turn Crashes
18 Rear-end Crashes

Int. 27: US 97 & Ponderosa St
Flagged as Safety Focus Area

Crash Severity
2 Non-serious Injury Crashes (Injury B & C)
6 Property Damage Only Crashes

Crash Type
2 Sideswipe Crashes
1 Turn Crash
5 Rear-end Crashes



Int. 28: US 97 SB Ramps & Baker Rd
Flagged as Safety Focus Area

Crash Severity
7 Non-serious Injury Crashes (Injury B & C)
10 Property Damage Only Crashes

Crash Type
9 Turn Crashes
8 Rear-end Crashes

Int. 29: US 97 NB Ramps & Knott Rd

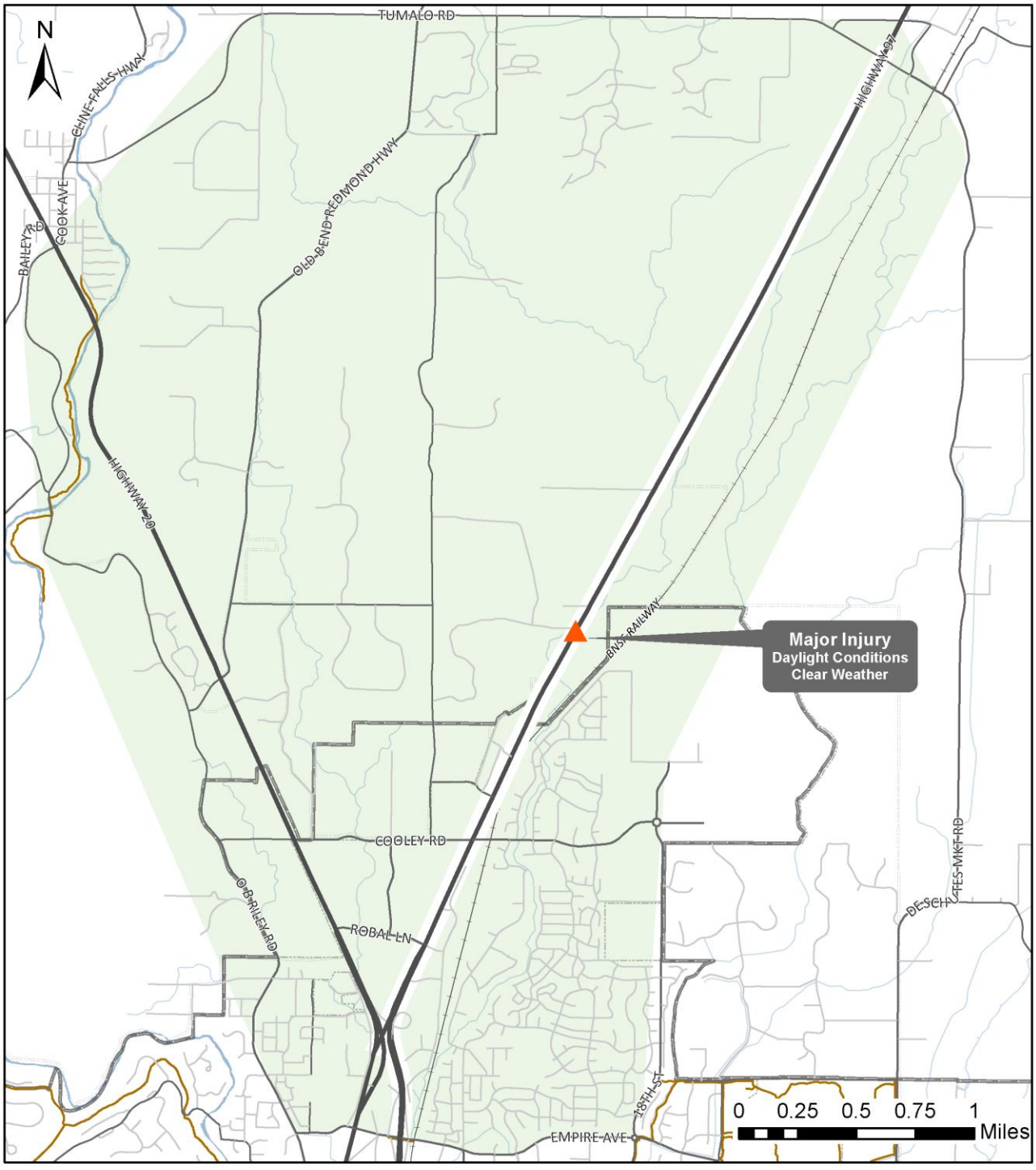
Crash Severity
3 Non-serious Injury Crashes (Injury B & C)
7 Property Damage Only Crashes

Crash Type
4 Turn Crashes
3 Rear-end Crashes
3 Other Crashes

Bicycle and Pedestrian-Involved Crashes

Bicycle and pedestrian-involved crashes along the corridor are shown on Figures 33-35. There were four crashes involving people on bicycles and two crashes involving people walking. Pedestrian-involved crashes included one major injury on US 97 just outside the northern city limits and one fatality at the intersection of Bend Parkway Southbound On-Ramp/Division Street and 3rd Street. The severity of crashes involving people on bicycles ranged from minor to major injury, with two crashes occurring at intersections in the Central Study Area and two occurring along US 97 in the South Study Area. Three of the bicycle and pedestrian crashes occurred when it was dark and visibility was low. Only one crash occurred during cloudy weather, which indicates that weather generally was not a significant factor in these crashes.

Figure 33



2011-2015 Bicycle & Pedestrian Crashes - North Study Area

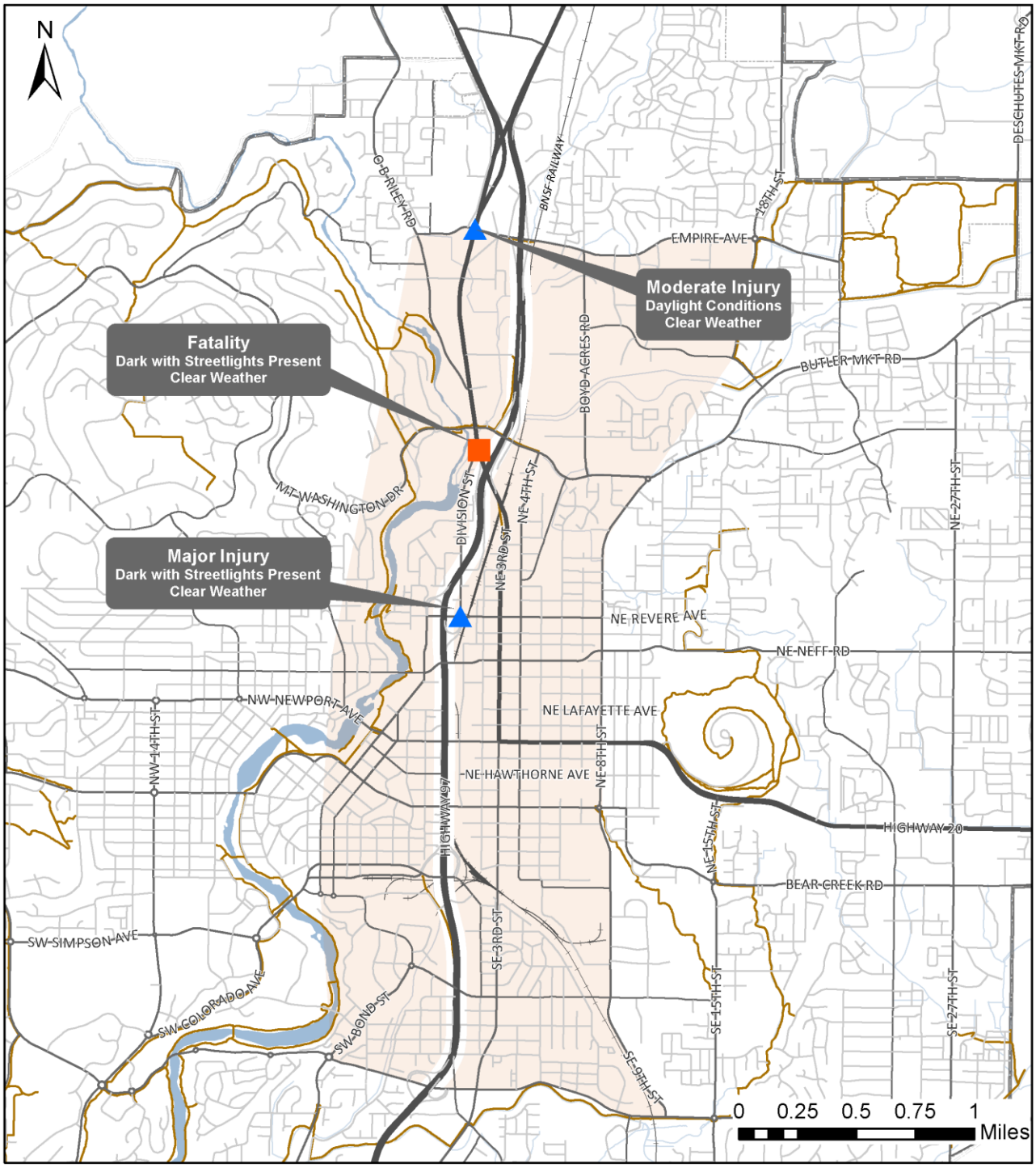
Crash Type
- Ped, Injury

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

Parkway Study Area
- North Study Area

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

Figure 34



2011-2015 Bicycle & Pedestrian Crashes - Central Study Area

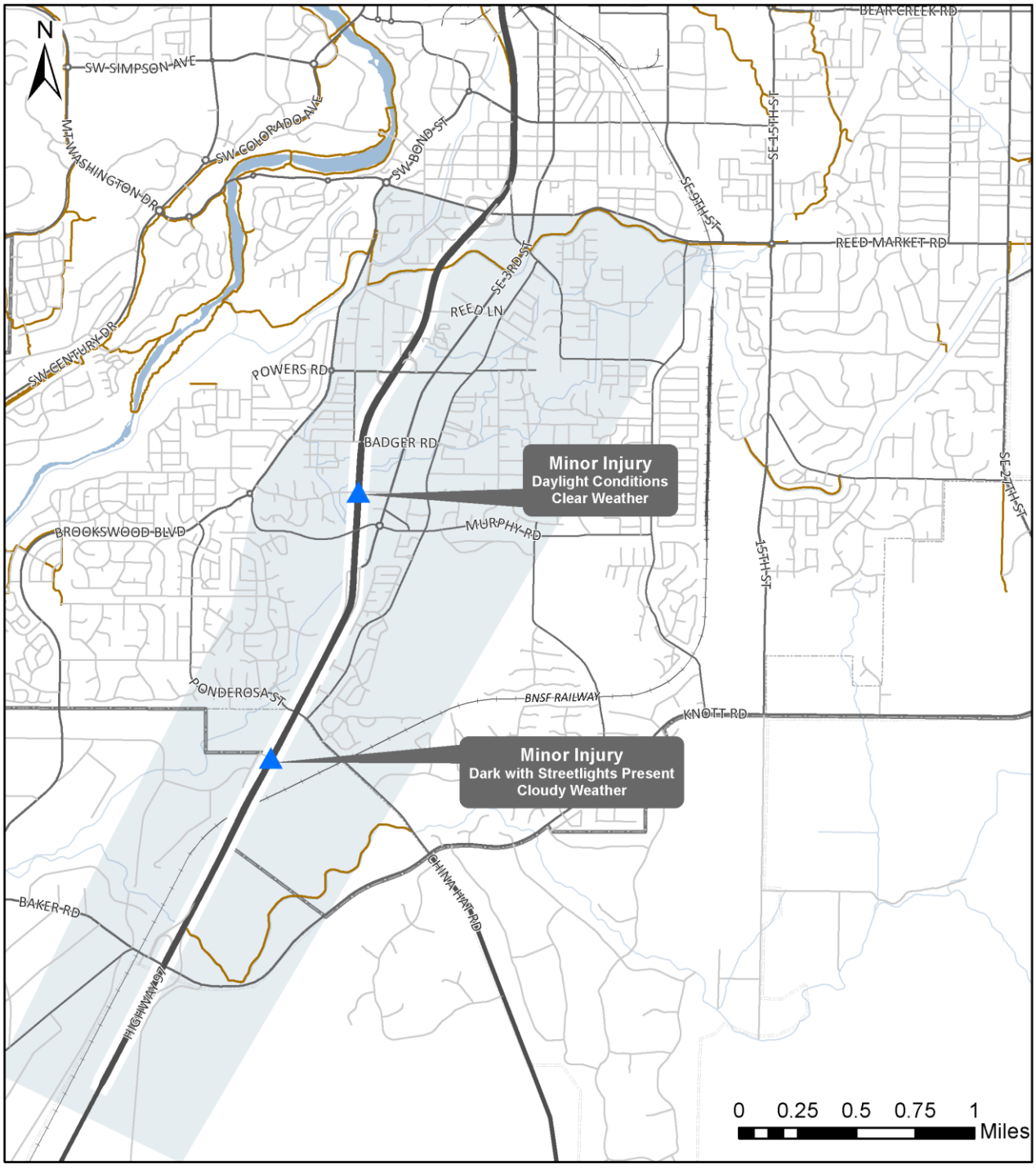
Crash Type
- Bike, Injury
- Ped, Fatality

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

Parkway Study Area
- Central Study Area

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

Figure 35



2011-2015 Bicycle & Pedestrian Crashes - South Study Area

Crash Type
- Bike, Injury

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

Parkway Study Area
- South Study Area

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

CORRIDOR OPERATIONS ANALYSIS

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

Intersection Operations Analysis

Intersection traffic operations were analyzed using Synchro software and the Highway Capacity Manual (HCM)[13] methodologies (HCM 2010[14] at unsignalized intersections, HCM 2000 at signalized intersections). The analysis was conducted at all study intersections using the 30 HV traffic volumes for the year 2017. Performance measures used for this analysis include volume-to-capacity (V/C) ratio, seconds of control delay, and level of service (LOS). Table 7 summarizes the results of this analysis, with each intersection's performance compared to the adopted mobility target.[15] Locations where the V/C ratio exceeds the mobility target are bolded for ease of reference.

Table 7: Existing 30th Highest Annual Hour Traffic Operations at Study Intersections (2017)

				Mobility Target	Performance		
Int. No.	Intersection	Jurisdiction	Control [D]	V/C	V/C [A]	LOS [B]	Delay (sec) [C]
1	US 97 & Tumalo Pl	ODOT/ County	Free	≤ 0.70 (major) ≤ 0.95 (minor)	0.51(0.46)/ 0.30	B/B	NA
2	US 97 & Cooley Rd	ODOT/ City	Signalized	≤ 0.85	**0.95**	D	54.8
3	US 97 & Robal Rd	ODOT/ City	Signalized	≤ 0.85	**1.02** [F]	E	78.6
4	US 97 & Nels Anderson Pl/Cascade Village	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	**1.29/1.29** [E]	F/F	>100/ >100
5	Bend Pkwy SB On-Ramp & Empire Blvd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Empire Blvd)	0.72/0.71	D/F	27.7/>100
6	Bend Pkwy NB Ramps & Empire Blvd	ODOT/ City	Signalized	≤ 0.85	**0.87**	E	58.1
7	US 20 & Empire Blvd	ODOT/ City	Signalized	≤ 0.85	**0.96**	E	68.5
8	US 20 & Butler Market Rd	ODOT/ City	Signalized	≤ 0.85	**0.90**	D	40.5
9	Bend Pkwy SB Off-Ramp & Butler Market Rd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Butler	NA/0.76	NA/E	NA/39.9

[13] *2000 Highway Capacity Manual*, Transportation Research Board, Washington, D.C., 2000.
[14] *2010 Highway Capacity Manual*, Transportation Research Board, Washington, D.C., 2010.
[15] Mobility targets for ODOT facilities obtained from the 1999 Oregon Highway Plan.

Int. No.	Intersection	Jurisdiction	Control [D]	Mobility Target V/C	Performance V/C [A]	LOS [B]	Delay (sec) [C]
				Market Rd)			
10	Bend Pkwy NB On-Ramp & Butler Market Rd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Butler Market Rd)	0.12/0.04	B/C	10.4/15.0
11	Bend Pkwy SB On-Ramp/Division St & 3rd St	ODOT/ City	Signalized	≤ 0.85	**0.97**	D	38.7
12	Bend Pkwy SB Ramps & Revere Ave	ODOT/ City	Signalized	≤ 0.85	0.69	C	22.0
13	Bend Pkwy NB Ramps & Revere Ave	ODOT/ City	Signalized	≤ 0.85	0.62	B	10.9
14	Bend Pkwy & Lafayette Ave	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	0.83(**0.95**)/ **1.53** [E]	NA/F	NA/>100
15	Bend Pkwy & Hawthorne Ave	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	0.83(**0.96**)/ >**2.00** [E]	NA/F	NA/>100
16	Bend Pkwy SB Ramps & Colorado Ave	ODOT/ City	Signalized	≤ 0.85	0.79	C	28.5
17	Bend Pkwy NB Ramps & Colorado Ave	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Colorado Ave)	**0.88/> 2.00** [E]	D/F	29.3/>100
18	Bend Pkwy & Truman Ave	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	0.56(**0.91**)/ **1.00** [E]	NA/F	NA/>100
19	Bend Pkwy SB Ramps & Reed Market Rd	ODOT/ City	Signalized	≤ 0.85	**0.95**	C	34.0
20	Bend Pkwy NB Ramps & Reed Market Rd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Reed Market Rd)	NA/**1.53** [E]	NA/F	NA/>100
21	Bend Pkwy & Reed Ln	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	0.41(0.62)/ 0.44	NA/C	NA/21.6
22	Bend Pkwy SB Ramps & Powers Rd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Powers Rd)	0.07/0.83	A/E	9.0/37.8
23	Bend Pkwy & Powers Rd	ODOT/ City	Signalized	≤ 0.85	**1.12** [F]	E	63.5
24	Bend Pkwy NB Ramps & Powers Rd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Powers Rd)	0.21/0.09	A/B	9.3/11.7
25	Bend Pkwy & Badger Rd	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	0.30(0.44)/ 0.20	NA/C	NA/16.9
26	Bend Pkwy & Pinebrook Blvd	ODOT/ City	TWSC	≤ 0.85	0.27(0.44)/ 0.27	NA/C	NA/15.5
27	US 97 & Ponderosa St	ODOT/ City	TWSC	≤ 0.85 (major) ≤ 0.95 (minor)	0.33(0.62)/ 0.26	NA/C	NA/21.4
28	US 97 SB Ramps & Baker Rd	ODOT/ City	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Knott Rd)	0.34/**0.87** [E]	A/E	27.9/35.7

Int. No.	Intersection	Jurisdiction	Control [D]	Mobility Target V/C	Performance V/C [A]	Performance LOS [B]	Performance Delay (sec) [C]
29	US 97 NB Ramps & Knott Rd	ODOT/ County	TWSC	≤ 0.85 (ramp) ≤ 0.95 (Knott Rd)	0.31/**1.76** [E]	B/F	10.3/>100

A Overall intersection V/C ratio at signalized intersection and V/C ratio for Major Street/Minor Street at two-way stop-controlled intersection. Major Street NB(SB)/Minor Street at two-way stop-controlled intersections where HCS Multilane Highway Analysis was used.

B Major street LOS/minor street LOS for two-way stop-controlled intersections. Overall intersection LOS for signalized intersections.

C Control delay for Major Street/Minor Street for two-way stop-controlled intersections. Overall intersection delay for signalized intersections.

D TWSC stands for Two-Way Stop-Controlled.

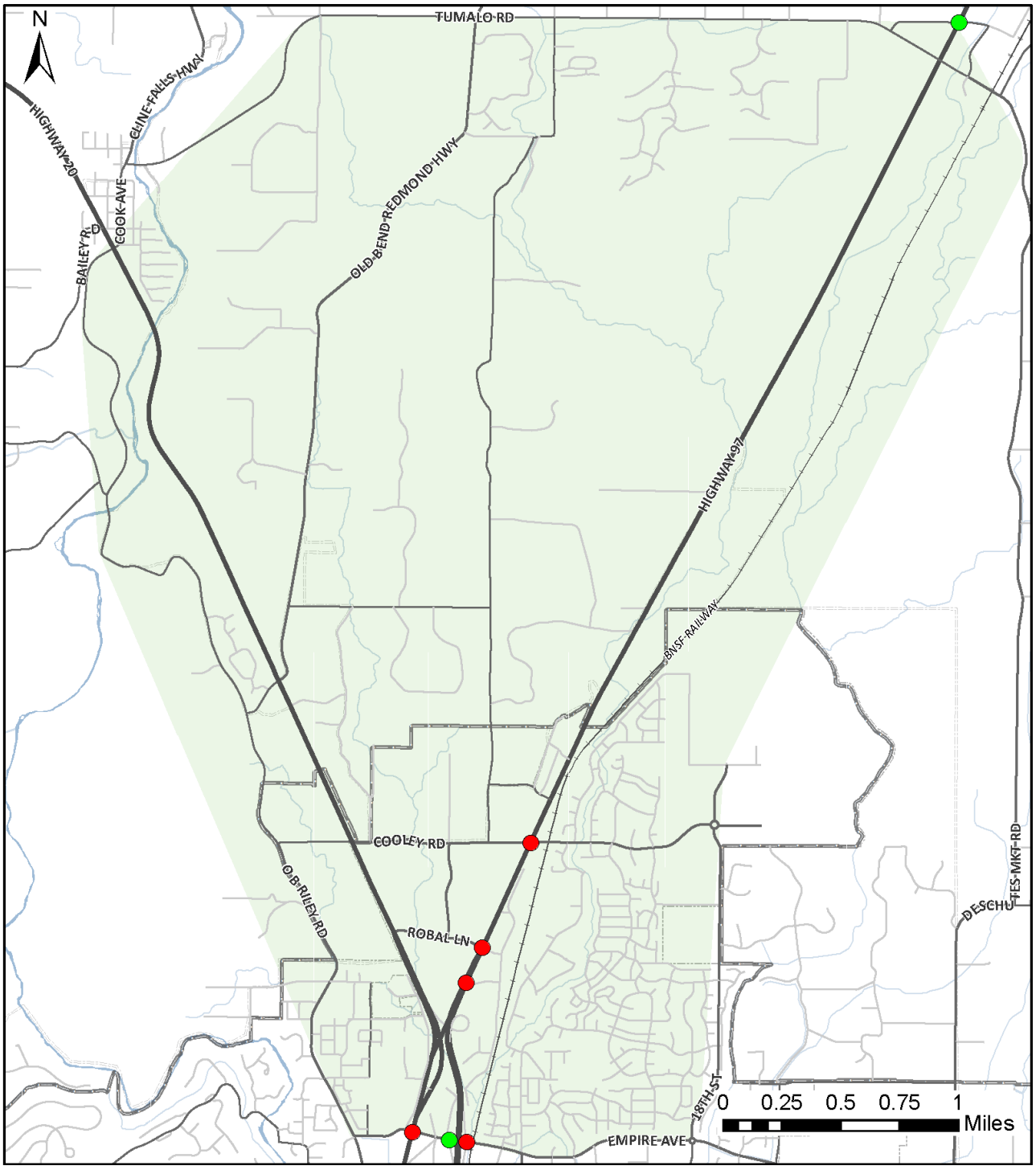
E Gap Acceptance of seven seconds was used per the HCM default value. However, field observations revealed a more aggressive gap acceptance of approximately five seconds.

F Some signalized intersections are shown having V/C ratios greater than 1.00. While theoretically impossible, these values appear to the result of the seasonal factoring applied to actual count data to replicate 30 HV conditions and, in some cases, the use of default saturation flow rates.

Bold values indicate performance measures failing to meet adopted mobility targets.

Eight of the 17 unsignalized intersections and eight of the 11 signalized intersections fail to meet adopted mobility targets. This indicates that there is a significant amount of congestion at study intersections throughout the corridor during the peak hour. Figures 36-38 summarize intersection performance for the North, Central, and South study areas.

Figure 36



Intersection Operations Analysis - North Study Area

Intersection Operations
- V/C Meets Target
- V/C Fails to Meet Target

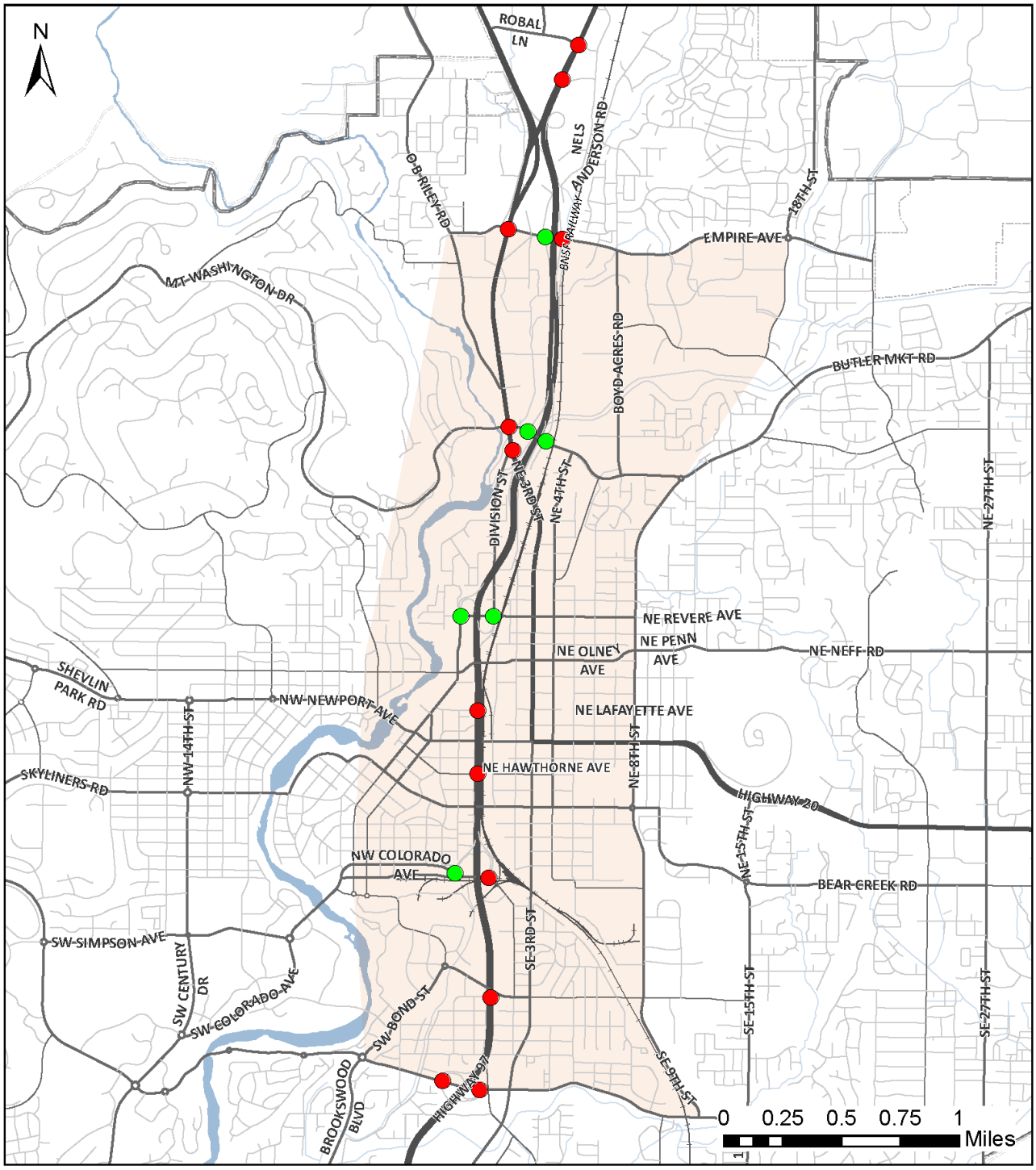
Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Railroads

Parkway Study Area
- North Study Area

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

Figure 37



Intersection Operations Analysis - Central Study Area

Intersection Operations
- V/C Meets Target
- V/C Fails to Meet Target

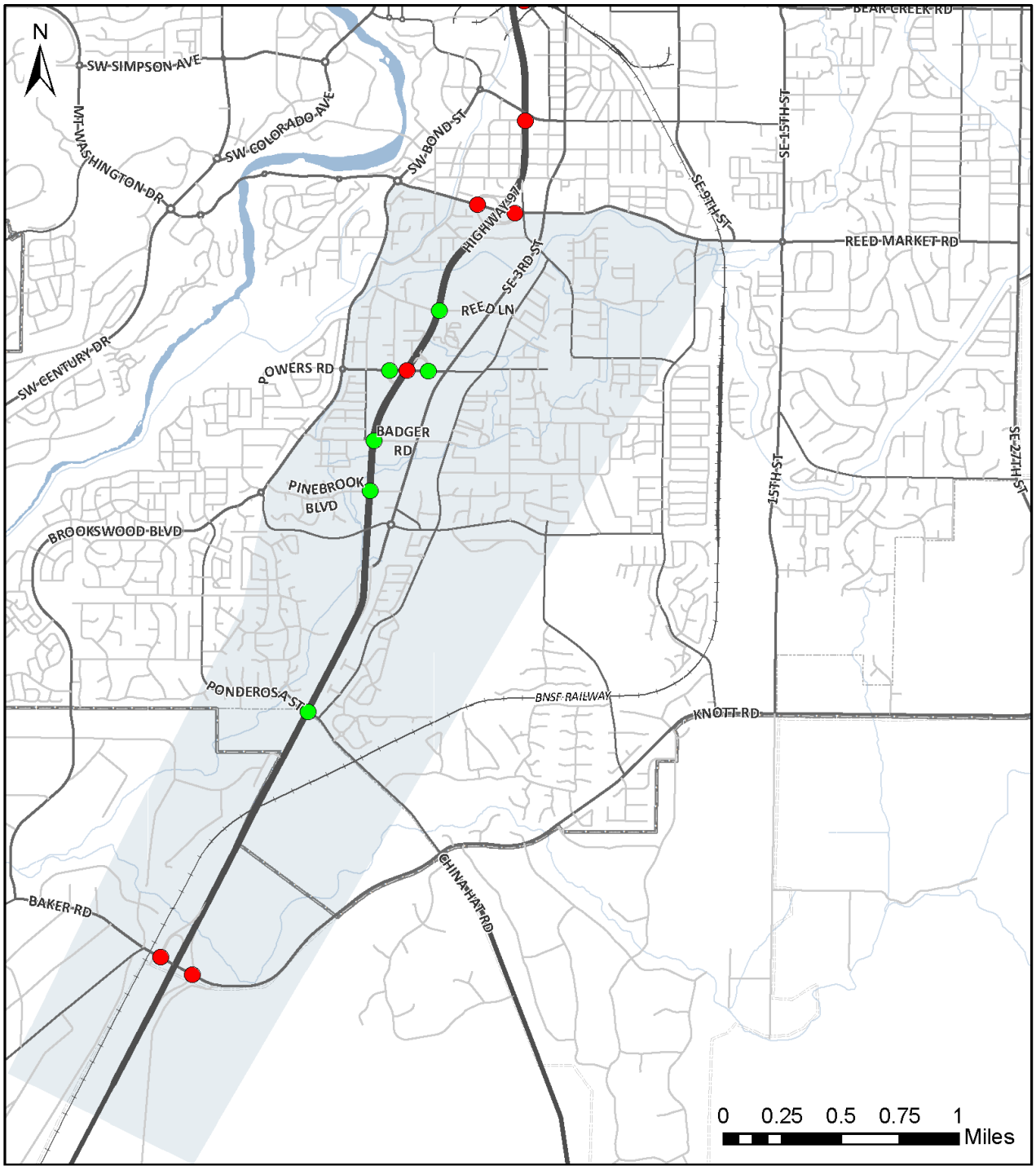
Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Railroads

Parkway Study Area
- Central Study Area

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

Figure 38



Intersection Operations Analysis - South Study Area

Intersection Operations
- V/C Meets Target
- V/C Fails to Meet Target

Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Railroads

Parkway Study Area
- South Study Area

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

Field observations indicated capacity issues mainly at the Cooley Road and Robal Road intersections. Most of the unsignalized intersections also had some queueing issues, and aggressive driver behavior (short gap acceptance of around 5 seconds compared to Highway Capacity Manual default value of 6.9 seconds) during the peak hour. This shows the impact of long-term demand exceeding capacity where there are very little normal "acceptable" gaps. When this occurs the potential for crashes is greatly increased. Therefore, this shows a risk factor for a future crash location. Southbound queues at US 97/Robal Road extend through Cooley Road during the PM peak hour, and both the Cooley Road and Robal Road intersections appear to operate at or near capacity. Southbound traffic at the Bend Parkway Southbound On-Ramp/Division Street & 3rd Street intersection also queues significantly, impacting upstream queues at the Mt Washington and OB Riley intersections.

Recent improvements to the Murphy Road/US 97 interchange removed one of the southbound to eastbound movements from the Parkway. This may have increased the southbound jug-handle volume at the Parkway/Powers Road intersection. During the PM peak hour, the southbound jug-handle movement was observed to queue back around the loop ramp and occasionally back up the Parkway to Powers Road. Southbound traffic on the Parkway would then queue back to near Reed Lane.

Parkway Merging/Diverging Ramp Operations Analysis

Operations analysis was performed for select interchange ramp merging, diverging, and weaving segments on the Parkway using HCM methodologies.[16] The select segments included:

- Revere-Butler Market-Empire-Sister's Loop Ramp in northbound direction
- Southbound Division on-ramp & Southbound Revere off-ramp in southbound direction
- Eastbound Reed Market to Northbound US 97 on-ramp and Westbound Reed Market to Northbound US 97 in northbound direction
- Revere to Colorado in both directions

Table 8 summarizes the results of this analysis for the 30 HV condition. The adopted mobility target for these movements on the Parkway is at a V/C ratio no greater than 0.85. V/C ratios exceeding 0.85 exceed the target. Locations where the V/C mobility standard was exceeded are shown in boldface.

[16] Highway Capacity Software (HCS) 7 software and the HCM 6 methodology were used.

Table 8: Existing 30th Highest Annual Hour Merging/Diverging/Weaving Operations (2017)

Location	Segment Type	V/C
US 97/Bend Parkway Southbound		
SB Division Street Ramp	Merge	**0.94**
SB Revere Avenue Ramp	Diverge	**0.94**
SB Revere Avenue Ramp	Merge	**0.94**
SB Colorado Avenue Ramp	Diverge	**0.94**
SB Colorado Avenue Ramp	Merge	**0.90**
US 97/Bend Parkway Northbound		
NB Reed Market Road Ramp	Merge	0.42
NB Division Street Ramp (Reed Market)	Merge	0.54
NB Colorado Avenue Ramp	Diverge	0.54
NB Colorado Avenue Ramp	Merge	0.84
NB Revere Avenue Ramp	Diverge	0.83
NB Revere Avenue Ramp	Merge	0.72
NB 3rd Street Ramp	Merge	**0.88**
NB Butler Market Road Ramp	Merge	**0.97**
NB Empire Avenue Ramp	Diverge	**0.95**
NB Empire Avenue Ramp - Sisters Loop	Weaving	0.61

Bold values indicate performance fails to meet adopted mobility target.

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

Field observations, which were performed during traffic conditions closer to average annual conditions than the 30 HV, noted no congestion around these merge/diverge/weave areas. The difference between observed and calculated conditions is likely due to the seasonal factoring applied to the actual traffic counts, with the volumes analyzed in HCS being significantly higher (10-30%) than the field observed volumes. Also, given the mix of expressway and arterial highway type designs on the Parkway, the HCS analysis used capacity reduction factors associated with frontage and collector-distributor roads, which may be underestimating the amount of available capacity.

Travel Time Reliability Analysis

Travel time reliability is a measure of the consistency in travel times over a corridor. Even in a congested corridor, if travel times can be confidently predicted drivers can plan their trips to arrive on time. However, where consistent travel times are less reliable, unexpected delays can make trip planning a frustrating experience.

Travel time reliability analysis was performed using the most recent three years of available HERE data for US 97. HERE data includes crowdsourced travel time information from mobile devices on a selected corridor.

DKS analyzed travel time reliability using a planning time index for the study segments along the US 97 and US 20/US 97 Business/SE 3rd Street. The Federal Highway Administration (FHWA) defines the planning time index 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 percent 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 planning time index 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.

Table 9 summarizes the results of the travel time reliability analysis for the PM peak hour (4:30 PM to 5:30 PM), showing average speeds, average travel times, and the planning time index for each segment of the corridors. The planning time indices for each segment are also illustrated in Figures 39-41, where red indicates a high planning time index and green indicates a lower planning time index.

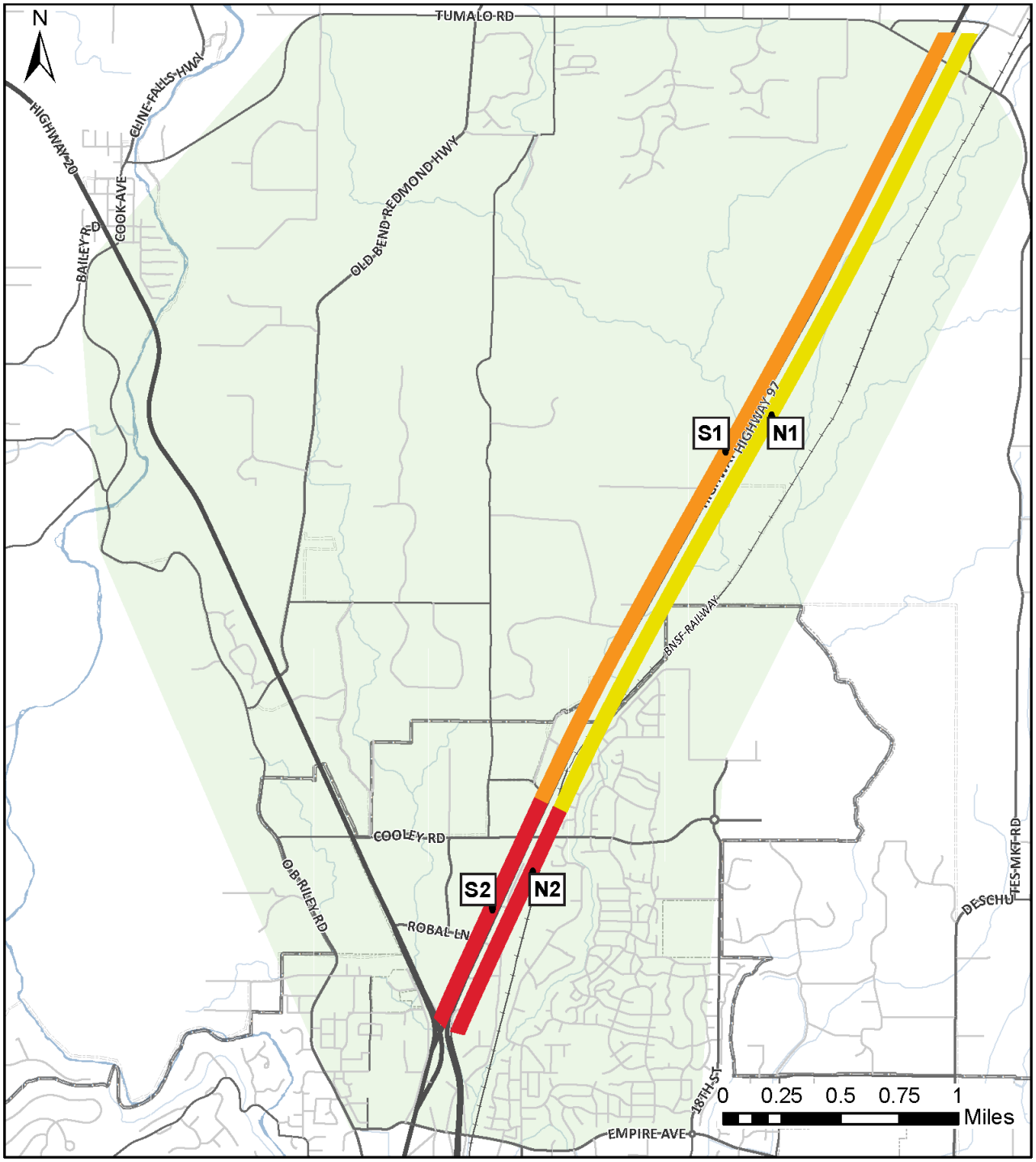
As expected, higher planning time indices on the US 97 study corridor occur in the north study area due to the congested nature of the peak periods at the at-grade intersections, mainly Cooley Road and Robal Road. The southern study area likely experiences higher planning indices on US 97 due to both the at-grade intersection at Powers Road and the construction that has taken place over the past three years (e.g., Murphy Road interchange) from which the HERE data was sourced. US 20/US 97 Business/SE 3rd Street generally experiences worse travel time reliability than the Parkway, which is likely due to the frequency of driveways and intersections along that corridor.

Table 10 shows how travel times for larger segments of the study corridor change between free flow (i.e., a time when no congestion is experienced) conditions and the PM peak hour. A trip through the corridor during the PM peak hour takes an extra three minutes on average compared to non-congested times. Most of that congestion occurs north of Colorado Avenue.

Table 9: Weekday PM Peak Hour Travel Time Reliability

Seg. No./ Name	From	To	Posted Speed (mph)	Avg. Speed (mph)	Average Travel Time (min)	Planning Time Index
US 97/Bend Parkway Southbound						
S1	Tumalo Pl	Clausen Rd	45-65	48	4.74	1.34
S2	Clausen Rd	US 20 Interchange	45	24	2.58	3.14
S3	US 20 Interchange	SE 3rd St Interchange	45	48	1.92	1.14
S5	SE 3rd St Interchange	Colorado Ave	45	45	2.40	1.15
S7	Colorado Ave	Reed Market Rd	45	44	1.26	1.22
S9	Reed Market Rd	Murphy Rd Interchange	45	37	2.79	1.80
S11	Murphy Rd Interchange	China Hat Rd	45	41	0.96	1.41
US 97/Bend Parkway Northbound						
N11	China Hat Rd	Murphy Rd Interchange	45	42	0.96	1.27
N9	Murphy Rd Interchange	Reed Market Rd	45	40	2.50	1.43
N7	Reed Market Rd	Colorado Ave	45	47	1.18	1.08
N5	Colorado Ave	SE 3rd St Interchange	45	46	2.31	1.13
N3	SE 3rd St Interchange	US 20 Interchange	45	45	2.00	1.06
N2	US 20 Interchange	Clausen Rd	45	20	3.15	4.24
N1	Clausen Rd	Tumalo Pl.	45-65	54	4.12	1.26
US 20/US 97 Business/SE 3rd Street Southbound						
S4	US 20 Interchange	SE 3rd St Interchange	35-45	23	3.78	2.28
S6	Bend Pkwy Interchange	US 20 (Greenwood Ave)	35-45	19	3.78	2.69
S8	US 20 (Greenwood Ave)	Reed Market Rd	35	16	5.56	2.56
S10	Reed Market Rd	Murphy Rd Interchange	35*45	22	3.96	2.34
US 97 Business/SE 3rd Street Northbound						
N10	Murphy Rd Interchange	Reed Market Rd	35-45	20	4.4	2.68
N8	Reed Market Rd	US 20 (Greenwood Ave)	35	18	5.16	2.90
N6	US 20 (Greenwood Ave)	Bend Pkwy Interchange	35-45	19	3.73	3.15
N4	Bend Pkwy Interchange	US 20 Interchange	35-45	26	3.97	2.09

Figure 39



Travel Time Reliability - North Study Area

Planning Time Index
- 1.0 – 1.2
- 1.2 – 2.0
- 2.0 – 3.0
- 3.0 – 4.0

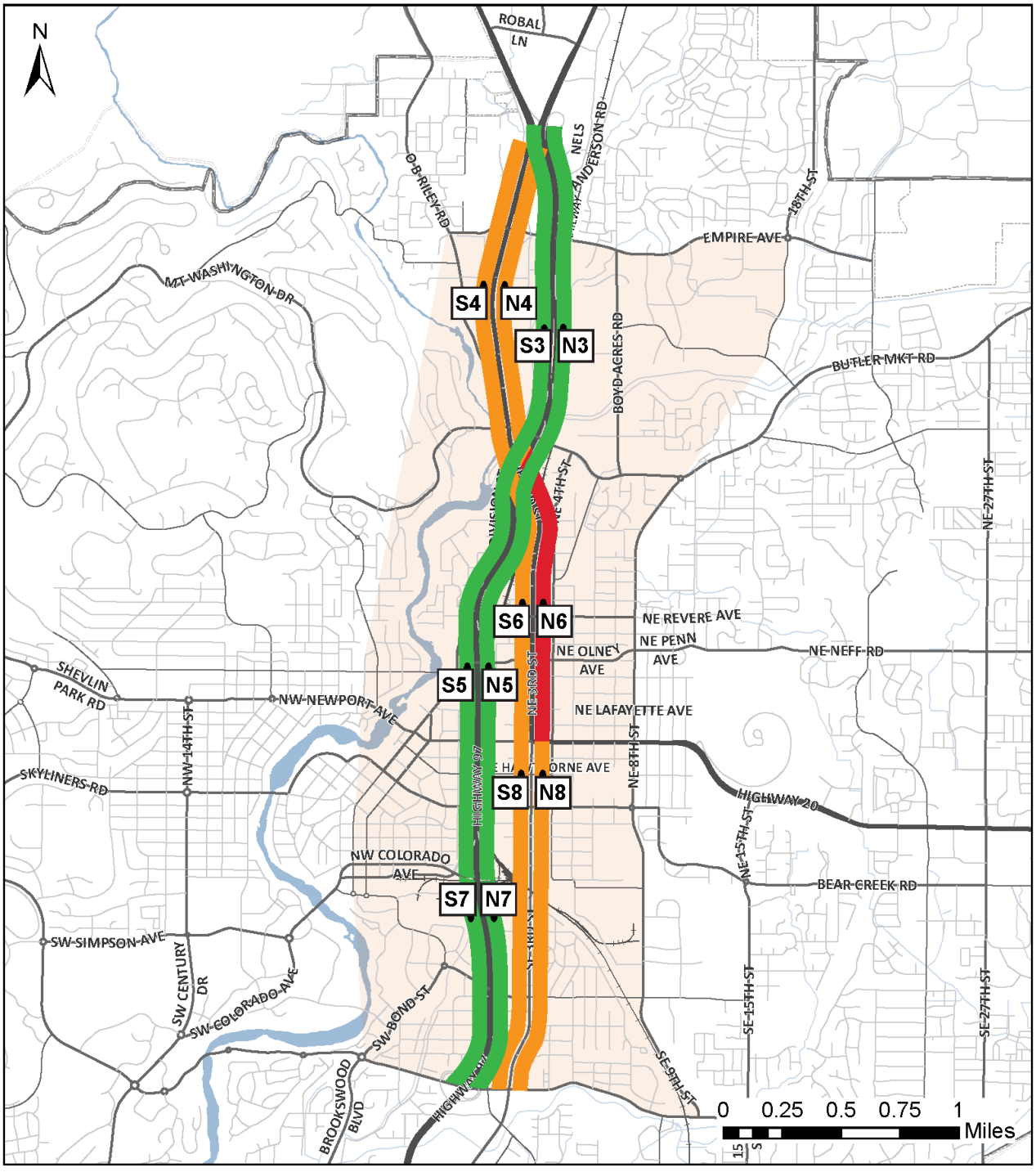
Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Railroads

Parkway Study Area
- North Study Area

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

Figure 40



Travel Time Reliability - Central Study Area

Planning Time Index
- 1.0 – 1.2
- 1.2 – 2.0
- 2.0 – 3.0
- 3.0 – 4.0

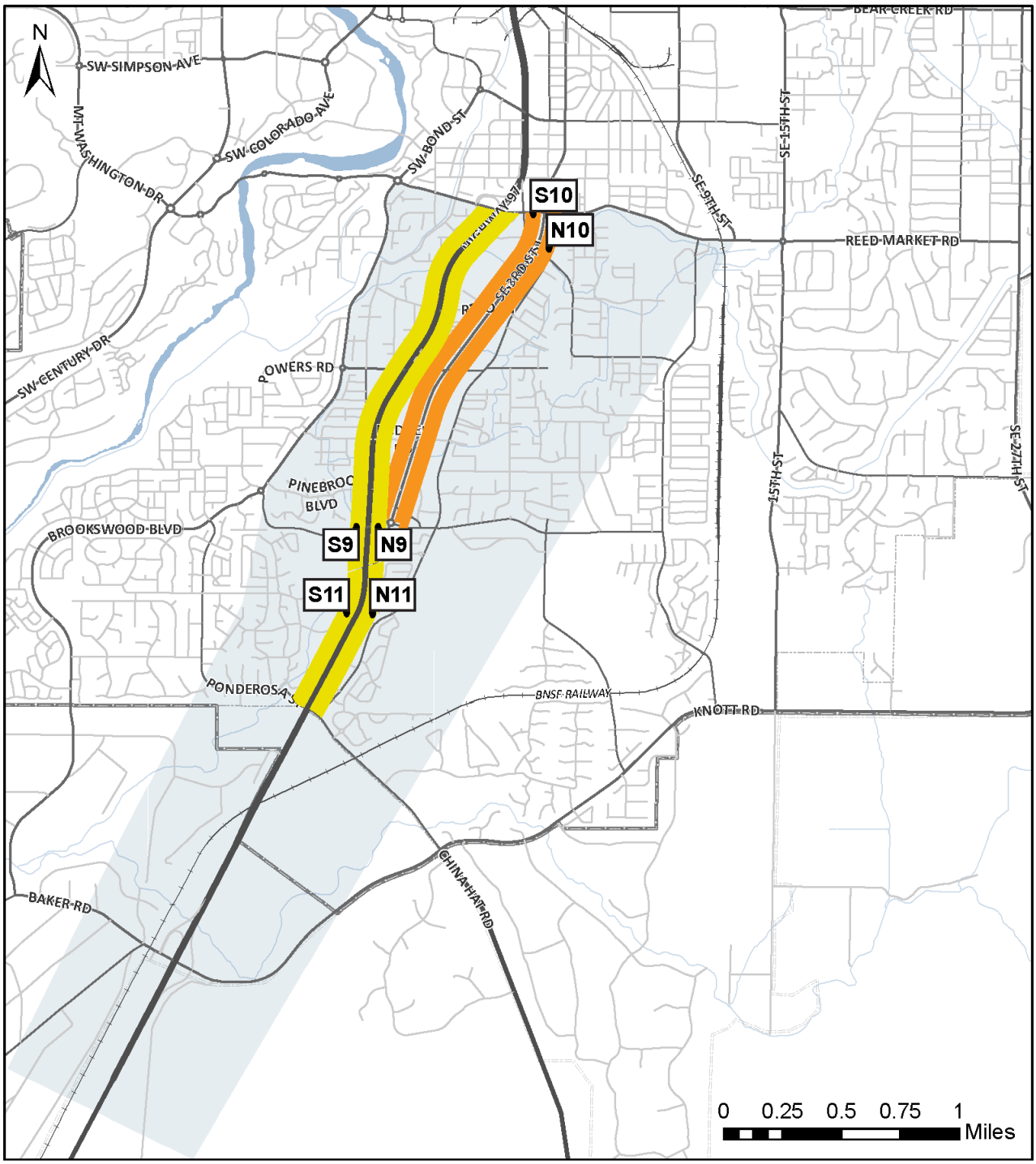
Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Railroads

Parkway Study Area
- Central Study Area

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

Figure 41



Travel Time Reliability - South Study Area

Planning Time Index
- 1.0 – 1.2
- 1.2 – 2.0
- 2.0 – 3.0
- 3.0 – 4.0

Roads
- Highway
- Arterial
- Collector
- Local

Infrastructure
- Railroads

Parkway Study Area
- South Study Area

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

Table 10: Weekday PM Peak Hour Travel Time Summary

US 97 Segment/Direction	From	To	Free Flow Travel Time (min)	Average Travel Time (min)
US 97/Bend Parkway Southbound	Clausen Rd	Colorado Ave	5.00	6.90
US 97/Bend Parkway Southbound	Colorado Ave	China Hat Rd	4.00	5.01
US 97/Bend Parkway Northbound	China Hat Rd	Colorado Ave	4.00	4.64
US 97/Bend Parkway Northbound	Colorado Ave	Clausen Rd	5.00	7.46

Figures 42-44 show 24-hour travel time reliability measures for southbound and northbound directions. The AM and PM peak hours tend to have less reliable travel times. Due to the congestion and crashes associated with the peak hours, travel time is more variable, especially at the at-grade intersections. This effect is more pronounced in the North Study Area. However, even during the peak hours, travel time reliability remains relatively good in the Central Study Area.

Figure 42: Travel Time Reliability - North Study Area

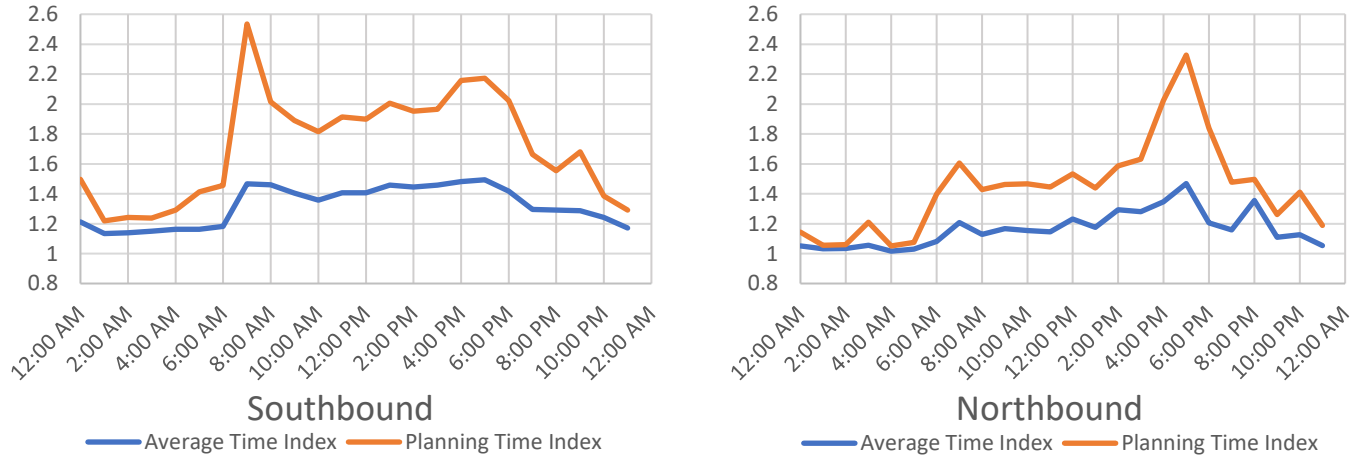


Figure 43: Travel Time Reliability - Central Study Area

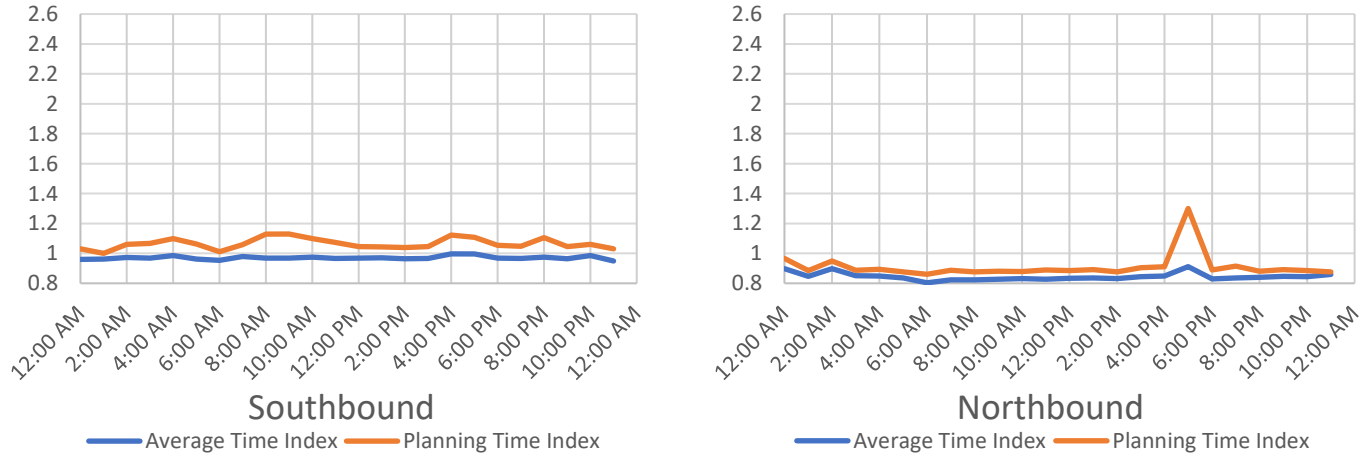


Figure 44: Travel Time Reliability - South Study Area