

Traffic Signals

There is an existing traffic signal along 27th Street at State Avenue. **Table 3** summarizes signal warrant analyses at the remaining unsignalized intersections along 27th Street.

Using project forecasts, traffic signal warrants will be met at the I-90 westbound ramps by 2023. However, most of the ramp “side street” traffic are right turns onto 27th Street. Traffic volumes are adequate to satisfy warrants in only five of the necessary eight hours under existing and short term conditions.

Using project traffic projections at the I-90 eastbound ramps, four hour volume signal warrants will be met in the long term. Interestingly, eight hour long term signal warrants will not be met with these long term volumes, as the eight hour main street volumes are not adequate (but the four hour main street curve threshold volumes are met). Most of these ramp “side street” volumes are left turns onto 27th Street.

The signal warrant analysis at 27th Street / Garden Avenue are based on eight hour turning movement count data obtained during this project, and based on signal warrants will not be met by 2023.

The two ramp intersections are about 475’ apart, and the westbound ramp is about 1,200 feet from the existing traffic signal at State Avenue. Signal coordination along 27th Street would be beneficial to traffic flow.

The following traffic signal deficiencies have been identified:

- New traffic signal or adequate capacity for off-ramp right turns at 27th Street / I-90 westbound ramps [long term]
- New traffic signal at 27th Street / I-90 eastbound ramps [long term]
- Coordinate new traffic signals when installed [long term]

C. 27th Street Interchange Capacity

27th Street interchange study area has a relatively low level of traffic growth.

The current signal timing at 27th Street / State Avenue was used for existing 2003, and current phasing was maintained with phase optimization for short term 2008. With two ramp signals assumed in long term 2023, network optimization was performed with Synchro software. 2023 cycle lengths were 60 seconds or less during all three peak periods.

Intersection Capacity

Table 9 summarizes the HCM-2000 LOS analyses for intersections in this interchange study area. **Appendix Q** (*Worksheets* volume) contains these LOS analysis worksheets.

At 27th Street / State Avenue, the overall signalized intersection currently operates at LOS C during all peak periods. Many movements currently operate at LOS D. There are similar LOS results in 2008 and 2023, with the overall signalized intersection continuing to operate at LOS C during all peak periods. Phase optimization in 2008 and network optimization in 2023 allowed this intersection to maintain a fairly consistent LOS during this 20 year period. However, by 2023 the southbound 27th Street left turn movement will operate at LOS E.

At 27th Street / I-90 WB ramps, daily traffic forecasts suggest that this intersection will meet signal warrants by the year 2023, so this future traffic signal was assumed in this capacity analysis. The stop controlled ramp approach at this unsignalized intersection currently operates at LOS B during all peak periods. In 2008, the stop controlled ramp approach will continue to operate at LOS B during all peak periods. In 2023, the overall signalized intersection will operate at LOS A during all peak periods.

At 27th Street / I-90 EB ramps, daily traffic forecasts suggest that this intersection will meet signal warrants by the year 2023, so this future traffic signal was assumed in this capacity analysis. The stop controlled ramp approach at this unsignalized intersection currently operates at LOS D / C / E during the AM / Noon / PM peak periods. In 2008, the stop controlled ramp approach will operate at LOS D / C / F during the AM / Noon / PM peak periods. In 2023, the overall signalized intersection will operate at LOS B during all peak periods.

At 27th Street / Garden Avenue, the 27th Street approach under stop control currently operate at LOS B / A / A during the AM / Noon / PM peak periods. In 2008, the 27th Street approach under stop control will continue to operate at LOS B / A / A during the AM / Noon / PM peak periods. In 2023, the 27th Street approach under stop control will operate at LOS B / B / A during the AM / Noon / PM peak periods.

The following intersection capacity deficiencies have been identified within the 27th Street interchange study area:

- Potential inadequate capacity and signal operation updates at 27th Street / State Avenue [long term]

- Consider adding short left turn lane on off-ramp at 27th Street / I-90 westbound ramps [long term]
- Consider separating 27th Street left turns from thru movement with signalization at 27th Street / I-90 westbound ramps [long term]
- Inadequate capacity for stop controlled off-ramp left turns without signalization at 27th Street / I-90 eastbound ramps [short term]
- Consider adding short right turn lane on off-ramp at 27th Street / I-90 eastbound ramps [long term]
- Consider separating 27th Street left turns from thru movement with signalization at 27th Street / I-90 eastbound ramps [long term]

Ramp Capacity

Table 6 summarizes the HCM-2000 LOS analyses for I-90 ramp merge / diverge operation with estimated 2023 traffic forecasts. All ramps will merge and diverge at HCM-2000 LOS A or B with 2023 traffic forecasts.

The 27th Street interchange on-ramps will have moderate volumes by the year 2023. Based on project 2023 forecasts, the westbound and eastbound on-ramps will have up to 370 vph and 273 vph respectively. Almost all of these year 2023 on-ramp volumes will be from the downtown Billings direction. At the eastbound on-ramp, the highest left turn volume onto the eastbound on-ramp is projected to be 248 vph in 2023, so a double left turn lane will probably not be needed.

Both on-ramps were identified as having a potential ramp merge deficiency related to a new traffic signal.

The following ramp capacity deficiencies have been identified within the 27th Street interchange study area:

- Potential platoon deficiency due to new traffic signal at 27th Street / I-90 westbound ramps [long term]
- Potential platoon deficiency due to new traffic signal at 27th Street / I-90 eastbound ramps [long term]

D. 27th Street Interchange Safety

27th Street Interchange Safety Deficiencies

- No deficiencies identified

E. 27th Street Interchange Bicycles & Pedestrians

27th Street Interchange Bicycle and Pedestrian Facilities



No connections to sidewalks on I-90 bridge on 27th St.

The 27th Street interchange does not have any sidewalks within the interchange study area with the exception of the intersection at State Avenue and along the I-90 bridge structure (separated by a concrete divider). Pedestrians currently utilize the wide shoulders along 27th Street between these sidewalk sections. There are no crosswalks marked at either ramp terminal intersection. The intersection at State Avenue is equipped with pedestrian push buttons, signal indications, and marked crosswalks.

The BikeNet plan identifies 27th Street as a Principal Vehicular Arterial on which bike usage is not encouraged. State Avenue is designated as an Arterial District Connector west of 27th Street and as a Primary District Connector east of 27th Street (Belknap Avenue).

27th Street Interchange Bicycle and Pedestrian Deficiencies

- Lack of sidewalks (and supporting crosswalk markings) along 27th Street through the study area with the exception of the I-90 bridge [existing]
- No bicycle deficiencies

F. 27th Street Interchange Street and Highway Lighting

27th Street Interchange Lighting Deficiencies

- No deficiencies identified



Partial Interchange Lighting (PIL) at 27th St. EB off-ramp gore area

3.4 US 87 LOCKWOOD INTERCHANGE

A. US 87 Lockwood Interchange Geometric Elements

US 87 is a designated NHS (National Highway System) route and truck route north from I-90, and further north becomes Main Street in the Heights. There are industrial uses along State Avenue (sugar refinery) and Belknap Drive. Garden Avenue serves residential neighborhoods and two campgrounds.

Intersection configurations

There are several geometric deficiencies at the US 87 / North Frontage Road intersection. The North Frontage Road realigns but still has about a 30 degree skew angle relative to the opposite approach serving the gas station at the intersection. This North Frontage Road realignment occurs in a 200' radius horizontal curve. There are also grades along the North Frontage Road between Steffes Road and



Inadequate lighting (only one light) at EB ramps / 27th St. intersection

US 87. At this intersection, US 87 has about a 700' radius horizontal curve.

Relative to US 87, the I-90 westbound off-ramp has about a 35 degree skew, the I-90 westbound on-ramp has about a 20 degree skew, the I-90 eastbound on-ramp has about a 20 degree skew, and the I-90 eastbound off-ramp has about a 35 degree skew angle.



North Frontage Road approach at US 87

Coburn Road realigns near US 87 to reduce its skew angle to about 12 degrees.

Otherwise, there were no other configuration deficiencies identified.

Lane widths / taper lengths

Figure C-4 (Appendix C) shows lane widths, taper lengths, and shoulder widths. Most lane widths range from 11' to 12', though there are a few lane sections that are only 10' wide.

There are adequate paved shoulders along US 87, the ramps, and all public street approaches. At the North Frontage Road intersection, the gas station entrance has curb and gutter.

Auxiliary lane taper lengths along US 87 meet MDT standards

Truck turns

US 87 is a designated truck route.

Figure D-4 (Appendix D) illustrates truck turn movements at study area intersections along US 87. At the US 87 / North Frontage Road intersection, only North Frontage Road approach provides adequate

room for trucks to make turning movements. Left and right turns from both US 87 approaches and the gas station approach cannot be made without crossing a centerline or otherwise traveling outside an appropriate path for WB-20 truck turn movements. Opposing left turns overlap in both the east-west and north-south directions. Visual observation and guardrail / jersey barrier damage confirm that truck turns are difficult at this intersection.

Truck turn movements at the private gas station entrances along the north side of US 87 north of the US 90 westbound ramps are adequate. The right-in / right-out entrance along the south side of US 87 north of the US 90 westbound ramps are not adequate for two way truck traffic.

WB-20 truck turns onto the westbound on-ramp are tight. There are no guardrail or other roadside objects and a small unpaved shoulder area provides additional space. However, this has been identified as an existing deficiency.

The eastbound ramp intersection also has somewhat tight truck turns due to the guardrail along the ramp, and there is some evidence of guardrail / jersey barrier damage along the on-ramp.

There is currently adequate room for trucks at Coburn Road, but some turning movements are somewhat tight. If a traffic signal is installed at Coburn Road (signal warrants are met in future), the tight truck turns will become a deficiency. Relatively low volumes on Coburn Road and the full frontage entrance into the gas station allow trucks to easily enter / exit this gas station.

Intersection sight distance

No sight distance deficiencies were identified.

Vertical clearance

There are no vertical clearance issues.

Access Management

US 87 has three private entrances between the North Frontage Road and Coburn Road. These entrances serve the two gas stations between the North Frontage Road and the I-90 westbound ramps. A raised median on US 87 restricts left turn movements at these entrances. Along northbound US 87, the two entrances are about 320' north of the I-90 westbound ramps and about 300' south of the North Frontage Road respectively. Along southbound US 87, the single gas station entrance is about 210' south of the North Frontage Road and about 500' north of the I-90 westbound ramps. There is another entrance along southbound US 87 about 280' north of the North Frontage Road

which also serves this gas station; left turn movements at this entrance are also restricted by a raised median along US 87.

The gas station at US 87 / Coburn Road has a full movement entrance on US 87 about 270' south of Coburn Road and a full frontage entrance along Coburn Road between US 87 and Rosebud Lane. As volumes grow on US 87, left turns at this full movement private access on US 87 will become more difficult. Also, the full frontage gas station entrance on Coburn Road may present problems after a traffic signal is installed at US 87 / Coburn Road (meets signal warrants in future).

US 87 Lockwood Interchange Geometric Deficiencies

- Intersection configuration at US 87 / North Frontage Road [Existing]
- I-90 westbound off-ramp skew angle [Existing]
- I-90 eastbound off-ramp skew angles [Existing]
- Lane widths along US 87 [Existing]
- Truck turns at US 87 / North Frontage Road [Existing]
- Truck turns at south side gas station entrance next to US 87 / North Frontage Road intersection [Existing]
- Truck turns at US 87 / I-90 westbound on-ramp [Existing]
- Truck turns at US 87 / I-90 eastbound on-ramp [Existing]
- Truck turns at US 87 / Coburn Road [Long term with traffic signal]
- Access management along US 87 and Coburn Road near gas station at US 87 / Coburn Road [Long term with traffic signal]

B. US 87 Lockwood Interchange Traffic Control

Signs and Pavement Markings



Figure F-4 (Appendix F) illustrates existing traffic control signs and pavement markings.

Following are sign and pavement marking deficiencies within this interchange study area:

No lane control signs along US 87 at I-90 WB off-ramp

- There is a Jct I-90 advance guide sign on southbound US 87 north of the signalized North Frontage Road intersection [existing]



No lane control on gas station approach at US 87 / North Frontage Road

- There are no intersection lane control signs on traffic signal mast arms for US 87 approaches at I-90 eastbound ramps, I-90 westbound ramps, and North Frontage Road [existing]
- US 87 and US 212 guide signs facing I-90 westbound off-ramp have advance turn arrow (M5) rather than directional arrow (M6) auxiliary signs [existing]
- The gas station’s two lane approach at the US 87 / North Frontage Road intersection has no intersection lane control signs or pavement markings describing lane use (faded “only” in right lane suggests thru/left and right is intended lane control) [existing]

Traffic Signals

There are existing traffic signals along US 87 at the North Frontage Road, I-90 westbound ramps, and I-90 eastbound ramps. **Table 4** summarizes signal warrant analyses at the US 87 / Coburn Road unsignalized intersection.

Using project forecasts and assuming the posted 45 mph speed limit on US 87, Coburn Road will meet all volume warrants in 2023, will meet the four hour and peak hour volume warrant in 2008, and currently meets the peak hour volume warrant (and almost meets other volume warrants) in 2003. If the speed limit were reduced to 40 mph or lower along US 87, Coburn Road will meet four hour and peak hour warrants and almost meet eight hour volume warrants (meets warrants in six hours) in 2023. This need for a traffic signal has been identified as a long term deficiency.

The existing traffic signals along US 87 have spacing of about 730’ (between the North Frontage Road and I-90 westbound ramps) and 570’ between the I-90 westbound and eastbound ramps). The two I-90 ramp intersection traffic signals are controlled by one controller so they are currently coordinated. It would be beneficial to also coordinate the North Frontage Road intersection with these ramp signals.

The following traffic signal deficiencies have been identified:

- New traffic signal at US 87 / Coburn Road [Long term]
- Coordinate the North Frontage Road signal timing with the two ramp intersections along US 87 [Short term]
- Coordinate new Coburn Road traffic signal when installed [Long term]

C. US 87 Lockwood Interchange Capacity

Most of the US 87 Lockwood interchange study area has a relatively low level of traffic growth; the exception is traffic growth on the North Frontage Road east of US 87.

The current signal timing at 27th Street / State Avenue was used for existing 2003, and current phasing was maintained with phase optimization for short term 2008. With two ramp signals assumed in long term 2023, long term network optimization was performed with Synchro software. 2023 cycle lengths ranged from 62 to 80 seconds during the three peak periods.

Intersection Capacity

Table 10 summarizes the HCM-2000 LOS analyses for intersections in this interchange study area. **Appendix R** (*Worksheets* volume) contains these LOS analysis worksheets.

At US 87 / North Frontage Road, the overall signalized intersection currently operates at LOS A / A / B during the AM / Noon / PM peak periods. In 2008, the overall signalized intersection operates at LOS A / B / B during the AM / Noon / PM peak periods. In 2023, the overall signalized intersection operates at LOS A / B / C during the AM / Noon / PM peak periods. The southbound right turn lane will need to be extended in the future to operate as an effective right turn lane.

At US 87 / I-90 WB ramps, the overall signalized currently operates at LOS B / B / C during the AM / Noon / PM peak periods. In 2008, the overall signalized intersection will operate at LOS B / B / D during the AM / Noon / PM peak periods. In 2023, the overall signalized intersection will operate at LOS C / B / D during the AM / Noon / PM peak periods; signal timing updates will be needed to minimize degradation of intersection LOS.

At US 87 / I-90 EB ramps, the overall signalized currently operates at LOS B / B / C during the AM / Noon / PM peak periods. In 2008, the overall signalized intersection will continue to operate at LOS B / B / C during the AM / Noon / PM peak periods. In 2023, the overall signalized intersection will operate at LOS C / C / F during the AM / Noon / PM peak periods; signal timing updates will be needed to minimize degradation of intersection LOS.

At US 87 Street / Coburn Road, daily traffic forecasts suggest that this intersection will meet signal warrants by the year 2023, so this future traffic signal was assumed in this capacity analysis. The Coburn Road approach under stop control currently operates at LOS C / B / C during the AM / Noon / PM peak periods. In 2008, the Coburn Road approach under stop control will operate at LOS C during all peak

periods. In 2023, the overall signalized intersection will operate at LOS A during all peak periods. Future signalization may necessitate evaluation of several geometric design features near this intersection, including access management along gas station frontage, lack of left turn lane on US 87, and length of four lane section to east (or south) of Coburn Road.

The following *intersection capacity* deficiencies have been identified within the US 87 Lockwood interchange study area:

- Signal timing updates at all three signalized intersections [short term]
- Inadequate southbound right turn storage length on North Frontage Road, at US 87 / North Frontage Road [long term]
- Consider separating US 87 left turns from thru movement with signalization at US 87 / Coburn Road [long term]
- Consider future signal impacts on US 87 through lane drop about 1200' beyond Coburn Road [long term]
- Consider future signal impacts on US 87 through lane addition about 150' before Coburn Road [long term]

Ramp Capacity

Table 6 summarizes the HCM-2000 LOS analyses for I-90 ramp merge / diverge operation with estimated 2023 traffic forecasts. All ramps will merge and diverge at HCM-2000 LOS A or B with 2023 traffic forecasts.

The US 87 Lockwood interchange on-ramps will have moderate volumes by the year 2023. Based on project 2023 forecasts, the westbound and eastbound on-ramps will have up to 576 vph and 441 vph respectively. About 60 to 70 percent of year 2023 westbound on-ramp volumes and almost all year 2023 eastbound on-ramp volumes will be from the north (Billings) direction. The highest year 2023 left turn volumes onto these on-ramps are projected to be 182 vph and 438 vph at the westbound and eastbound ramps respectively, so a double left turn lane may be needed at the eastbound ramp intersection. There are up to 390 vph making the right turn movement onto the westbound on-ramp in 2023.

The following *ramp capacity* deficiencies have been identified within the US 87 Lockwood interchange study area:

- Potential platoon deficiency due to signalized double left turn at US 87 / I-90 eastbound ramps [long term]

D. US 87 Lockwood Interchange Safety

US 87 Lockwood Road Interchange Safety Deficiencies

- The relatively high number of left-turn accidents (east/west on US 87) at the US 87 / N Frontage Road intersection suggests that signal phasing modifications (or other mitigation measures) may be needed [existing]
- The relatively high number of left-turn accidents at the intersection of US 87 / I-90 eastbound ramps (southbound-to-eastbound) suggests that signal phasing modifications (or other mitigation measures) may be needed [existing]

E. US 87 Lockwood Interchange Bicycles & Pedestrians

The US 87 Lockwood interchange provides for sidewalks only along the I-90 bridge structure (separated by a concrete divider). There is also a section of attached sidewalk that begins on the northwest corner of US 87 / N Frontage Road and extends westward. No other pedestrian facilities exist within the interchange study area. Pedestrians currently utilize the wide shoulders along US 87. There are no pedestrian push buttons, signal indications, or crosswalks marked at any of the three study area intersections. There is a pedestrian crossing sign on the south leg of the US 87 / N Frontage Road intersection (this entrance bisects a gas station), although there are no crosswalk markings and the crossing location is not defined nor obvious.

The BikeNet plan identifies US 87 as an Arterial District Connector. Wide paved shoulders on US 87 currently service bicycle traffic per Arterial District Connector standards, except along the I-90 bridge where the shoulder and outside lane narrows significantly. The presence of a concrete barrier along the roadway edge (creating a shy distance issue) further magnifies this deficiency. Although bicyclists can utilize the 4' wide sidewalk as they cross the bridge, if pedestrians are present this may create a conflict. N Frontage Road is identified as a Secondary Connector. A potential future off-street bicycle path is shown along the existing railroad corridor paralleling I-90 on the north side through the study area.



No sidewalks along US 87 south of Lockwood Road

US 87 Lockwood Interchange Bicycle and Pedestrian Deficiencies

- Lack of sidewalks (and supporting crosswalk markings) along US 87 through the study area with the exception of the I-90 bridge [existing]
- Lack of pedestrian push buttons / signal indications at all signalized intersections [existing]

- Lack of crosswalk markings at pedestrian crossing sign for private gas station (south leg) at US 87 / N Frontage Road intersection [existing]
- Inadequate shoulder / outside lane width to accommodate bicycles across the I-90 bridge [existing]

F. US 87 Lockwood Interchange Street and Highway Lighting

US 87 Lockwood Road Interchange Lighting Deficiencies

- Crossroad and ramp lighting does not meet CIL standards [existing]
- I-90 mainline highway lighting does not meet CIL standards [long term]

3.5 JOHNSON LANE INTERCHANGE

A. Johnson Lane Interchange Geometric Elements

The Johnson Lane interchange was funded by the Lockwood Transportation District. Traffic growth and traffic related issues have increased recently in this study area. Industrial uses are along the North Frontage Road. The Flying J truck stop is a large truck traffic generator, and other commercial uses exist near the Johnson Lane / Old Hardin Road intersection. Emerald Hills continues to develop to the east on Old Hardin Road, and significant turning movements occur at Becraft Lane.

There is a planned MDT safety improvement at the Johnson Lane / Old Hardin Road intersection which will provide protected only westbound left turn phasing.

Intersection configurations

All cross streets and ramps approaches Johnson Lane at skewed angles. The North Frontage Road and the I-90 ramps realign to reduce this skew angle. The North Frontage Road has a 15 to 20 degree skew, the I-90 westbound ramps have about a 20 degree skew, and the I-90 eastbound ramps have about 20 degree (off-ramp) and 35 degree (on-ramp) skew angles respectively.

Old Hardin Road approaches have a 25 to 30 degree skew angle. While realignment would be a beneficial improvement, it appears unrealistic with adjacent development.

Lane widths / taper lengths

Figure C-5 (Appendix C) shows lane widths, taper lengths, and shoulder widths. Most lane widths range from 11' to 14'. The center

median area on Johnson Lane under I-90 is about 9' wide, but this center median area widens to 12' - 13' as the center lane converts to Johnson Lane left turn lanes at the I-90 ramps

There is about 37' total pavement width under the I-90 bridge structure between the jersey barriers which protect the bridge columns.

Except near and under the I-90 bridge structure, there are adequate paved shoulders along Johnson Lane. Under the I-90 bridge structure, Johnson Lane has 13' to 14' travel lanes with no shoulder between the jersey barriers. Old Harden Road has curb and gutter.

Auxiliary lane taper lengths along Johnson Lane meet MDT standards except for the 50' taper at the northbound left turn lane at the I-90 westbound ramp intersection. This taper length should be 72' for 8:1 ratio and 9' wide median area.



Difficult truck turns at Johnson Lane / Old Hardin Road

Truck turns

Figure D-5 (Appendix D) illustrates truck turn movements at study area intersections along Johnson Lane. At the North Frontage Road intersection, some WB-20 truck turns cross the painted centerline and the remainder are very tight. Opposing truck left turns overlap badly for the North Frontage Road approaches.

Some turning movements at the I-90 ramps are tight, but there is additional unpaved shoulder area available as there are no guardrails or other roadside obstacles except for a few streetlight poles.

Most WB-20 truck turning movements are not accommodated at Johnson Lane / Old Hardin Road intersection. The southbound to westbound right turn requires full use of the painted channelization island, and we commonly observed trucks starting this right turn from the southbound thru lane. Though less frequently used by trucks, perhaps the most difficult truck turn movements are the southbound to eastbound movement and the opposite westbound to northbound movement. These movements are restricted by curb and we observed trucks driving over curbs and, for the southbound to eastbound movement, backing up in the middle of the intersection to complete this movement. The northbound and southbound left turn movements from Johnson Lane overlap.

Much of the truck traffic at the Johnson Lane / Old Hardin Road intersection is destined for the Flying J gas station on the northwest corner. It was observed that trucks occasionally wait in westbound Old Hardin Road until internal site congestion cleared. Most large trucks utilize the western two entrances where the diesel pumps and truck parking exists, but recreational vehicles use the eastern entrance.

Figure D-5 shows that truck turns can be made at the western pair of

entrances as long as they operate as one-way entrances. The eastern passenger vehicle entrance cannot accommodate WB-20 trucks, but these trucks do not normally use this entrance.

Truck turns are also difficult at the adjacent Old Hardin Road / Becraft Lane intersection. However, these truck turns are restricted by painted lane lines, and large truck traffic is relatively light at this intersection.



I-90 columns limit ramp sight distance along Johnson Lane

Intersection sight distance

Figure E-2 in Appendix E illustrates sight distance triangles for the I-90 off-ramps at Johnson Lane. Assuming the posted speed limit of 35 mph is the design speed, the intersection sight distance (ISD) when looking left at the nearest lane should be 415' / 515' / 620' for passenger cars / single unit trucks / combination trucks crossing two lanes (AASHTO Green Book). Using the MDT / AASHTO methodology of the driver being 14.4' (4.4 meters) behind the edge of the nearest travel lane, the I-90 bridge columns restrict intersection sight distance for the off-ramps to about 385' (117 meters) for the westbound off-ramp and about 600' (183 meters) for the eastbound off-ramp. The westbound off-ramp has adequate sight distance for passenger cars and single unit trucks, but is just below the suggested ISD length for combination trucks. The 385' available sight distance for the eastbound off-ramp does not provide the suggested ISD length for any vehicle type, though it is just below the suggested length for passenger cars with 35 mph speed along Johnson Lane.

Note that these sight distance estimates were estimated from the aerial photos. Also, AASHTO states that 4.4 meters (14.4 feet) from the edge of the major-road traveled way “represents the typical position of the minor-road driver’s eye when a vehicle is stopped relatively close to the major road. Field observations of vehicle stopping positions found that, where necessary, drivers will stop with the front of their vehicle 2.0 meters (6.5’) or less from the edge of the major-road traveled way.” With the relatively low volumes on Johnson Lane, it is not difficult for trucks to edge out closer to the travel lane. However, this sight distance limitation has been identified as an existing deficiency for both ramps.

Vertical clearance

There are advance warning signs along Johnson Lane indicating that there is 14’-4” vertical clearance under the I-90 bridge structure provides. MDT standards indicate that the minimum vertical clearance for an arterial or collector under a bridge (or other obstruction) is 16’-6” (5.05 meters).

There are no other vertical clearance issues.

Access Management

There are no private entrances along Johnson Lane between the North Frontage Road and Old Hardin Road. There is one private residential entrance along Johnson Lane about 400' north of the North Frontage Road.

There are numerous commercial entrances near the Johnson Lane / Old Hardin Road intersection. The three entrances serving the Flying J service station are about 250', 400' and 500' west of Johnson Lane respectively. The eastern entrance is full movement which mostly serves passenger vehicles, though a few large trucks use this entrance. The western two entrances service most large truck traffic, and primarily operate as one way entrances. The proximity of these three full movement intersections to the Johnson Road / Old Hardin Road intersection impacts intersection operation. These unprotected left turn movements will become more difficult in future years as traffic continues to grow along Old Hardin Road. Internal circulation is limited at the Flying J site, as there is no internal connection between the eastern passenger vehicle side and the western truck side. There is good access management on the south side of Old Hardin Road, as the shared entrance is about 600' west of Johnson Lane.

There are two service station entrances on Johnson Lane about 150' and 290' south of Old Hardin Road. There is also a power substation service entrance on Johnson Lane about 140' south of Old Hardin Road; this entrance also serves a drive thru coffee house. However, this coffee shop entrance and the nearest gas station entrance are only about 50' and 75' south of the northbound Johnson Lane stop bar respectively. Minimal queues on this approach can block left turn movements at these two entrances.

On Old Hardin Road, the gas station entrance and Becraft Lane are about 220' and 380' east of Johnson Lane respectively. This gas station entrance is about 140' east of the Old Hardin Road westbound stop bar.

Johnson Lane Interchange Geometric Deficiencies

- Skew angle at Johnson Lane / I-90 eastbound on-ramp [Existing]
- Skew angle at Johnson Lane / Old Hardin Road [Existing]
- Cross section (lane and paved shoulder widths) along Johnson Lane under and near the I-90 bridge structure [Existing]
- Taper length for northbound Johnson Lane left turn lane at I-90 westbound ramp intersection [Existing]

- Truck turns at US 87 / North Frontage Road [Existing]
- Truck turns at US 87 / I-90 westbound ramps [Existing]
- Truck turns at US 87 / I-90 eastbound ramps [Existing]
- Truck turns at US 87 / Old Hardin Road [Existing]
- I-90 westbound off-ramp sight distance [Existing]
- I-90 eastbound off-ramp sight distance [Existing]
- I-90 bridge structure vertical clearance over Johnson Lane [Existing]
- Access management at Flying J service station entrances on Old Hardin Road west of Johnson Lane [Short term]
- Access management on Johnson Lane south of Old Hardin Road [Long term]
- Access management on Old Hardin Road east of Johnson Lane [Long term]

B. Johnson Lane Interchange Traffic Control

Signs and Pavement Markings

Figure F-5 (Appendix F) illustrates existing traffic control signs and pavement markings.

Following are some sign and pavement marking deficiencies within this interchange study area:

- There is less advance I-90 guide signing on Johnson Road than other interchange cross streets in this project [existing]
- There are no intersection lane control signs for left turn lanes along Johnson Lane at North Frontage Road, I-90 westbound ramps, and I-90 eastbound ramps [existing]
- There is no posted speed limit sign on southbound Johnson Lane under I-90 when approaching I-90 eastbound off-ramp which has restricted sight distance [existing]
- There is no object marker on guardrail along Johnson Lane between I-90 ramp intersections [existing]



No object marker on guardrail along Johnson Lane under I-90

Traffic Signals

There is an existing traffic signal along Johnson Lane at Old Hardin Road. **Table 5** summarizes signal warrant analyses at the remaining

unsignalized intersections along Johnson Lane and at the Old Hardin Road / Becraft Lane intersection.

Traffic forecasts for the Johnson Lane / North Frontage Road intersection will not meet traffic signal warrants by 2023. However, the westbound approach will operate at a poor level of service in 2023.

Traffic forecasts at the I-90 westbound ramp intersection will meet signal warrants by 2023.

At the eastbound ramp intersection, eight hour turning movement count data for ramp volumes was used with 24 hour count data on Johnson Lane for the signal warrant analysis, as ramp tube count data appeared incorrect for several hours. Using only these eight hours of data, this eastbound ramp intersection meets the peak hour warrant in 2003 and 2008, and also meets the four hour warrant in 2008. In 2003 and 2008, the eight hour volume warrant is met for six of needed hours; analysis of these eight hour side street volumes suggests that if 24 hours of ramp count data were available, this eight hour volume warrant would be met. However, about 85 to 96 percent of these ramp volumes are right turns toward Old Hardin Road, and all intersection approaches operate at an adequate level of service (LOS C or better) in 2003 and 2008.. Therefore, this eastbound ramp intersection traffic signal deficiency was identified as long term.

Traffic forecasts for the Old Hardin Road / Becraft Lane intersection will not meet traffic signal warrants by 2023. However, 2023 forecasts meet warrants for 5 of necessary 8 hours and 3 of necessary 4 hours, so this intersection may be close to meeting warrants by 2023. Since most turning movements from Becraft Lane are left turns out, these side street turning movements will become difficult as traffic volumes grow on Old Hardin Road. This intersection is only about 400' east of the Johnson Lane / Old Hardin Road signalized intersection.

Future traffic signal spacing along Johnson Lane will be about 750' (between the I-90 westbound and eastbound ramp intersections) and 500' (between I-90 eastbound ramps and Old Hardin Road). New traffic signals should be coordinated with the Old Hardin Road traffic signal when they are installed.

The following *traffic signal* deficiencies have been identified:

- Monitor need for traffic signal at Johnson Lane / North Frontage Road [long term]
- New traffic signal at Johnson Lane / I-90 westbound ramps [long term]

- New traffic signal at Johnson Lane / I-90 eastbound ramps [long term]
- Monitor need for traffic signal at Old Hardin Road / Becraft Lane [long term]
- Coordinate new traffic signals along Johnson Lane [long term]

C. Johnson Lane Interchange Capacity

The Johnson Lane interchange study area is projected to have a relatively high traffic growth throughout the study area, except for low growth north of the North Frontage Road.

The current signal timing at Johnson Lane / Old Hardin Road was used for existing 2003. MDT plans to add a protected left turn phase in 2004, so this new phase was added for short term 2008 and long term 2023 signal timing. The 2008 signal timings were optimized for short term 2008 with Synchro software. With two ramp signals assumed in long term 2023, long term network optimization was performed with Synchro software. 2023 cycle lengths ranged from 54 to 90 seconds during the three peak periods.

Intersection Capacity

Table 11 summarizes the HCM-2000 LOS analyses for intersections in this interchange study area. **Appendix S** (*Worksheets* volume) contains these LOS analysis worksheets.

At Johnson Lane / North Frontage Road, daily traffic forecasts suggest that this intersection will meet signal warrants by the year 2023, so a future traffic signal was assumed in this capacity analysis. The westbound approach under stop control currently operates at LOS C / B / B during the AM / Noon / PM peak periods. In 2008, this westbound approach operates at LOS D / C / D during the AM / Noon / PM peak periods. In 2023, this westbound approach will operate at LOS F in all peak periods with a traffic signal (and no further improvements).

In 2003, the eastbound approach under stop control operates at LOS A during all peak periods. Most of this eastbound approach traffic makes right turns at Johnson Lane. In 2008, this eastbound approach will operate at LOS B during all peak periods. In 2023, this eastbound approach will operate at LOS E / D / E during the AM / Noon / PM peak periods with a traffic signal (and no further improvements).

At Johnson Lane / I-90 WB ramps, daily traffic forecasts suggest that this intersection will meet signal warrants by the year 2023, so a future traffic signal was assumed in this capacity analysis. The westbound ramp under stop control currently operates at LOS F / C / D during the

AM / Noon / PM peak periods. In 2008, this westbound ramp will operate at LOS F / D / F during the AM / Noon / PM peak periods. Almost all of this westbound ramp traffic makes a left turn onto Johnson Lane. The northbound left turn movement operates at LOS B or better during all peak periods in 2003 and 2008. In 2023, the overall signalized intersection will operate at LOS F / D / F during the AM / Noon / PM peak periods, suggesting the need for additional lane/capacity improvements.

At Johnson Lane / I-90 EB ramps, daily traffic forecasts suggest that this intersection will meet signal warrants by the year 2023, so a future traffic signal was assumed in this capacity analysis. The eastbound ramp under stop control currently operates at LOS B / B / C during the AM / Noon / PM peak periods. In 2008, this eastbound ramp will operate at LOS C / C / D during the AM / Noon / PM peak periods, with the eastbound left turn operating at LOS F. The southbound left turn movement operates at LOS A during all peak periods in 2003 and at LOS C or better 2008. In 2023, the overall signalized intersection will operate at LOS E / C / E during the AM / Noon / PM peak periods with no other improvements in place.

At Johnson Lane / Old Hardin Road, the overall signalized intersection currently operates at LOS B / A / B during the AM / Noon / PM peak periods. In 2008, the overall signalized intersection operates at LOS C / B / C during the AM / Noon / PM peak periods. The protected only eastbound left turn movement will operate at LOS F during the 2008 PM peak period. In 2023, the overall signalized intersection operates at LOS E / C / E during the AM / Noon / PM peak periods. Several movements will operate at LOS E – F in 2023.

At Johnson Lane / Becraft Lane, daily traffic forecasts suggest that this intersection will not meet signal warrants by the year 2023, so the current stop control was always assumed in this capacity analysis. The Becraft Lane approach under stop control currently operate at LOS C / A / A during the AM / Noon / PM peak periods. In 2008, the Becraft Lane approach under stop control will operate at LOS D / B / D during the AM / Noon / PM peak periods. In 2023, the Becraft Lane approach under stop control will operate at LOS F / C / F during the AM / Noon / PM peak periods.

The following *intersection capacity* deficiencies have been identified within the Johnson Lane interchange study area:

- Inadequate capacity for stop controlled westbound North Frontage Road approach or possible need for intersection signal at Johnson Lane / North Frontage Road [long term]

- Inadequate capacity for stop controlled westbound I-90 ramp approach or possible need for intersection signal prior to long term at Johnson Lane / I-90 westbound ramp or possible need for intersection signal prior to long term [existing]
- Potential inadequate storage length for northbound left turn after traffic signal is installed at Johnson Lane / I-90 westbound ramp [long term]
- Potential inadequate capacity at Johnson Lane / I-90 eastbound ramp [long term]
- Potential inadequate capacity at Johnson Lane / Old Hardin Road [short term]
- Inadequate capacity at Johnson Lane / Old Hardin Road [long term]
- Inadequate capacity for stop controlled northbound Becraft Lane approach or possible need for intersection signal at Old Hardin Road / Becraft Lane [long term]

Ramp Capacity

Table 6 summarizes the HCM-2000 LOS analyses for I-90 ramp merge / diverge operation with estimated 2023 traffic forecasts. All ramps will merge and diverge at HCM-2000 LOS A or B with 2023 traffic forecasts.

The Johnson Lane interchange on-ramps will have moderate volumes by the year 2023. Based on project 2023 forecasts, the westbound and eastbound on-ramps will have up to 844 vph and 471 vph in the westbound and eastbound directions respectively. The highest year 2023 left turn volumes onto these on-ramps are projected to be 639 vph and 227 vph at the westbound and eastbound ramps respectively, so a double left turn lane may be needed at the westbound ramp intersection. There are up to 242 vph making the right turn movement onto the eastbound on-ramp in 2023.

Both ramp intersections are identified as having a potential future signal. The westbound on-ramp was identified as having a potential ramp merge deficiency related to a signalized double left turn.

The following ramp capacity deficiencies have been identified within the Johnson Lane interchange study area:

- Potential platoon deficiency due to new traffic signal at Johnson Lane / I-90 westbound ramps [long term]

- Potential platoon deficiency due to signalized double left turn at Johnson Lane / I-90 westbound ramps [long term]
- Potential platoon deficiency due to new traffic signal at Johnson Lane / I-90 eastbound ramps [long term]

D. Johnson Lane Interchange Safety Deficiencies

- No deficiencies identified

E. Johnson Lane Interchange Bicycles & Pedestrians



No ped/bike facilities at I-90 underpass on Johnson Lane

The Johnson Lane interchange study area does not have any pedestrian facilities, with the exception of sidewalks at the Old Hardin Road intersection. At this location there also exists marked crosswalks on three approaches, with pedestrian push buttons / signal indications. Pedestrians currently use the shoulders for travel north of Old Hardin Road within the interchange study area, and must either climb over a guardrail and walk on uneven ground, or walk in the vehicular travel lane when crossing under I-90 on Johnson Lane.

The BikeNet plan identifies Johnson Lane and Old Hardin Road as Arterial District Connectors. There is adequate shoulder width to meet the standard for this facility, with the exception of the I-90 underpass on Johnson Lane where bikes have to merge with vehicular traffic and insufficient lane width exists. The North Frontage Road is classified as a Secondary Connector through the interchange study area.

Johnson Lane Interchange Bicycle and Pedestrian Deficiencies

- Lack of sidewalks (and supporting crosswalk markings) along Johnson Lane through the study area, including the I-90 underpass [existing]
- Lack of crosswalk and pedestrian push buttons/signal indications on the north leg of the Old Hardin Road / Johnson Lane intersection [existing]
- Inadequate shoulder width for bicycles on Johnson Lane under/near I-90 bridge [existing]

F. Johnson Lane Interchange Street and Highway Lighting

Johnson Lane Interchange Lighting Deficiencies

- WB I-90 ramp terminal intersection has only one light pole. MDT guidelines for PIL show two lights per ramp terminal intersection. [existing]
- Crossroad and ramp lighting does not meet CIL standards [long term]

- I-90 mainline highway lighting does not meet CIL standards [long term]

3.6 Summary of Deficiencies

All deficiencies identified in the above sections are schematically shown on aerial based **Figures 3 thru 7**. These deficiencies are also summarized in **Tables 14 thru 18**.

3.7 Potential Critical Failures

Interchange deficiencies that may require reconstruction of the interchange bridge structures or interchange reconfiguration are highlighted on **Figures 3 thru 7** and in **Tables 14 thru 18**. These are considered potential “critical failures”, and represent major reconstruction efforts. The majority of critical failures are capacity related. These critical failures are considered “potential” since there may be options available (discussed in later sections in the analysis of alternative improvements) that alleviate the need for structure widening and/or intersection reconfiguration. However, the intent of this section was to identify areas of concern. Since all of the analysis in this report is based on forecast volumes which are speculative in nature, it is important to understand where the potential for problems exists in case growth occurs at higher rates than anticipated.

Descriptions of the potential critical failures identified, along with the anticipated timeframe for failure, are as follows:

Shiloh Road Interchange Potential Critical Failures

- Inadequate capacity @ Zoo Drive / I-90 ramps, requiring bridge widening for additional turn lanes [long term]

South Billings Boulevard Interchange Potential Critical Failures

- Potential inadequate capacity @ S. Billings Boulevard / I-90 ramps, requiring bridge widening for additional turn lanes [long term]

27th Street Interchange Potential Critical Failures

- No critical failures identified in the short or long term

US 87 Lockwood Road Interchange Potential Critical Failures

- Inadequate capacity @ US 87 / I-90 EB ramps, requiring bridge widening for additional turn lanes [long term]