Final Report - Main Volume

Billings I-90 Interchanges Project

Prepared for Montana Department of Transportation

1.0 INTRODUCTION

1.1 Report Format

This Main Volume is organized into the following sections:

- **Introduction** – This section describes the report format, project background and purpose, and study area description.
- **Traffic Volumes** – This section summarizes project count data collection results, existing and future projected traffic volumes, and the methodology of estimating these volumes.
- **Deficiency Analysis** – This section presents the analysis performed to identify existing (2003), short term (2008) and long term (2023) deficiencies. This section is arranged to analyze each interchange with respect to six categories: geometric elements, safety, capacity, traffic control, bicycle and pedestrian, and street and highway lighting. At the end of this section is a comprehensive summary of deficiencies by category and time period. Potential "critical failures", which involve deficiencies that may require reconstruction of an interchange bridge structure, are highlighted and discussed.
- **Potential Solutions** – This section summarizes analysis of various potential solutions to mitigate major deficiencies (such as corridor and intersection capacity failures and those potentially requiring interchange reconfiguration and bridge widening.)

- **Recommended Improvements** – This section provides recommended projects which most effectively address the deficiencies, based on the evaluation of potential solutions. A discussion of the timing of each improvement, along with planning-level cost estimates and potential funding sources, is included. The improvements are identified as either "O&M" or "Project/STIP" improvements depending upon the nature and extent of the improvements.

- **Appendices** – These appendices contain tables and aerial based graphics to support the analysis and findings.

This main volume is accompanied by separately bound *Data* and *Worksheets* volumes which contain raw count data results and analysis worksheets respectively.

1.2 Project Background and Purpose

The City of Billings is the hub of eastern Montana, and Interstate 90 provides local and regional access for Billings and the surrounding area. Much traffic growth in Billings has occurred on or near I-90, and future growth is expected to continue along this corridor.

In order to insure that these I-90 interchanges can adequately accommodate existing and future traffic, MDT requested a traffic engineering study of five interchange areas along I-90 near Billings. The primary goals of this study are:

1. Evaluate existing and future projected traffic
2. Identify existing, short term and long term deficiencies at these interchanges areas, including "critical failures" that require interchange reconfiguration or bridge structure widening.
3. Evaluate and recommend improvements to address these deficiencies
4. Provide cost estimates and identify potential funding sources for these improvements
5. Prioritize projects by timing and project type (safety related or capacity related)

The target years for this analysis are existing (2003), short term (2008) and long term (2023). Anticipated timing for Project/STIP improvement recommendations are provided in 5 or 10 year increments (0-5 years, 5-10 years, 10-20 years, etc.) based on our analysis of traffic growth and when such projects will be needed. The sorted list of improvements can then be utilized by MDT for future nomination of projects.

This study is not intended to provide a "systems" analysis of interchanges serving the Billings urban area, although critical failures of the existing interchange structures have been identified for the short and long-term. This study is also not intended to provide an evaluation of mainline I-90 operations such as merge, weave, through capacity, etc. The only mainline I-90 evaluation performed in this study is Highway Capacity Manual (HCM) based LOS evaluation at ramp merge/diverge areas and platoon impacts to on-ramp merge operation due to future signalization at ramp intersections.

1.3 Project Location and Limits

This project evaluates five of the seven interchanges along I-90 within the City of Billings urban boundary. Primary emphasis is placed on the interstate on / off ramps and the crossroad at each interchange. At a minimum, each interchange study area includes the ramp intersections and the adjacent intersection on each side of the interchange. Specific interchange study areas include:

- Shiloh Road Interchange @ Zoo Drive (Exit 443), and Zoo Drive between South Frontage Road and Shiloh Road
- South Billings Boulevard Interchange @ U-1033 / U-1013 (Exit 447), and South Billings Boulevard between South Frontage Road and King Avenue East
- 27th Street Interchange @ P-53 (Exit 450), and 27th Street between Garden Avenue and State Avenue / Belknap Avenue
- US 87 / Lockwood Interchange @ P-16 (Exit 452), and US 87 between Coburn Road and North Frontage Road / Lockwood Road intersection,
- Johnson Lane Interchange @ U-1032 (Exit 455), and Johnson Lane between Old Hardin Road and North Frontage Road.

Figure 1 identifies these interchange study area boundaries.

The West Billings interchange (milepost 446) and the I-90/I-94 system interchange (milepost 456) are not included in this study.

1.4 Functional Classification / National Highway System

All five of these interchanges are diamond interchanges. I-90 and the ramps are classified as *Interstate – Primary Arterial.* MDT classifies the interchange crossroads as follows:

- Zoo Drive – *Minor Arterial*
- South Billings Boulevard – *Minor Arterial*
- 27th Street – *Principal Arterial*

- US 87 – *Principal Arterial* (north and between ramps), *Minor Arterial* (south)
- Johnson Lane – *Local* (north), *Minor Arterial* (between ramps and south)

Figure 2 schematically illustrates the functional classification of all roadways within each interchange study area.

27th Street and US 87 are designated as part of the *National Highway System* (NHS) north/west toward the City of Billings from their respective I-90 interchanges.

2.0 TRAFFIC VOLUMES

SEH collected 24 hour tube count data and 8 hour turning movement count data at all five interchange study areas. Most of this data was collected in July, 2003, while the remaining counts were collected in August and December, 2003.

The following count data was also compiled:

- 2003 24 hour permanent count station data from two MDT permanent count stations.
- 2003 ADT tube count data at the Shiloh and South Billings Boulevard interchanges from MDT.
- Historic ADT count data from the City of Billings
- ADT and PM peak hour turning movement count data at the Shiloh interchange from the 2001 *Transportation Master Plan for Shiloh Interchange – North Side Properties* report
- ADT and PM peak hour turning movement count data at the South Billings interchange from the 2003 *Traffic Accessibility Study for Billings Operations Center Subdivision* report.

All count data was factored by MDT 2003 monthly factors provided by MDT. These factors did not include axle correction factors (ACF). It was assumed that count data in other traffic study reports and City of Billings historic data was already factored.

2.1 Existing 2003 ADT Volumes

24 hour vehicle classification tube counts were collected on all roadway segments within the five interchange study areas except along I-90 mainline. These raw tube counts are summarized in **Tables A-1 thru A-5** in Appendix A. Raw count data printouts are contained in the *Data* volume of this report.

MDT provided permanent count station 24 hour data on I-90 immediately west of the Shiloh interchange and between the South Billings – 27th Street interchanges. These two sets of I-90 interchange raw counts are included in **Appendix N** (*Data* volume) and summarized in **Table A-6**.

MDT monthly factors shown in **Table A-7** were applied to these raw daily counts to estimate 2003 ADT volumes. **Tables A-8 thru A-12** contains these ADT calculation tables for each interchange. **Table A-13** shows these ADT calculations for the two MDT permanent count stations on I-90.

Daily volumes along remaining I-90 sections were estimated by adding or subtracting ramp ADT volumes from these two I-90 permanent count station volumes. **Table A-14** summarizes these I-90 mainline 2003 ADT volumes.

Figures A-1 thru A-5 illustrate these 2003 ADT volumes at these five project interchanges.

2.2 Existing 2003 Turning Movement Volumes

Turning movement counts were collected at major intersections within the five interchange study areas. These turning movement counts were collected during the following times of the day:

- AM peak (7:00 am - 9:00 am)
- Noon Peak (10:00 am – 2:00 pm)
- PM peak (4:00 pm – 6:00 pm)

Raw turning movement count data printouts are contained in **Appendices I thru M** in the *Data* volume of this report.

MDT monthly factors shown in **Table A-7** were applied to these raw turning movement counts to estimate 2003 factored turning movement volumes. **Figures A-6 thru A-10** illustrate 2003 factored peak hour turning movement volumes.

2.3 Vehicle Classification and Peak Percent of Daily

ADT volume summary tables in **Appendix A** also include count data calculations related to vehicle classification and peak hour percent of daily traffic.

Vehicle Classification - Tube count data collected during this project is stratified by the standard MDT / FHWA 13 vehicle types. The raw tube count data in the *Data* volume of this report show these raw tube count data results by 13 vehicle types. These 13 vehicle types were

then compressed into *passenger vehicles* (types 1-4), *light trucks* (types 5-7), and *heavy trucks* (types 8-13). **Tables A-1 thru A-5** summarize the percent of these three vehicle groups.

This vehicle classification count data confirms that trucks comprise a significant portion of traffic at these five interchanges. The Johnson Lane interchange has the highest percentage of large vehicles, with up to 16% heavy trucks and 14% light trucks on some roadway sections. The Johnson Lane ramps have 7-16% heavy trucks and 4-12% light trucks. The other four interchanges have up to 6% heavy trucks on their ramps.

Peak Percent of Daily – Peak hour shares of daily traffic are typical at these five interchanges. The AM / Noon / PM peak hour share of daily traffic ranges from 4-11% / 5-10% / 6-11% at all count locations (see **Tables A-1 thru A-5**). The PM peak generally has the highest traffic levels, but there are also many links where the AM or Noon peak is the highest. Commuter characteristics of inbound morning and outbound afternoon traffic are evident at many interchange ramps.

Along I-90 mainline, the PM peak has the highest volumes in each direction between the South Billings Boulevard and 27th Street interchanges (**see Table A-6**). At the Pre-pass station west of Shiloh interchange, commuter patterns are again evident as the eastbound (entering Billings) direction is heaviest in the AM peak hour and westbound (leaving Billings) traffic is heaviest in the PM peak hour.

2.4 MDT QRS Forecasts

MDT maintains a Quick Response System II (QRS-II) travel demand model for the Billings urban area. This model was recently updated by the MDT planning division for another Billings project at the end of November, 2003. These current model forecasts were utilized as the basis for projected traffic growth at these five interchanges.

Figures B-1 thru B-5 show these QRS-II model volumes for existing 2002 conditions at these five interchanges. **Figures B-6 thru B-10** show QRS-II model forecasts for future 2027 projected conditions.

Tables B-1 thru B-5 summarize these QRS model results by roadway section at the five interchanges. These tables also calculate growth rates and interpolate to estimate existing 2003 and future 2023 volumes based on these model results. These growth factors were then compared with City of Billings historic count data and forecasts from other relevant traffic studies as described below.

2.5 Other Data and Traffic Studies

Traffic count and forecast data was obtained from the following sources:

- Historic Count Data for City of Billings / Yellowstone County, 1975 through 2002
- Traffic Accessibility Study for Billings Operations Center Subdivision, Engineering, Inc., April, 2003
- Transportation Master Plan for Shiloh Interchange – North Side Properties, Engineering, Inc., January, 2001

Historic count data for roadways throughout the City of Billings was obtained from MDT. This count data spreadsheet contained historic counts from 1975 thru 2002, and about 24 of these locations were project roadway sections. A trendline analysis of all historic count data was performed to estimate historic growth rates on all of these roadway sections.

These two recent traffic studies evaluated existing and future traffic conditions at the South Billings Boulevard and Shiloh interchanges respectively. **Tables B-6 thru B-10** summarize this data for the five project interchanges. This data was used to verify and supplement project data collection and forecasts.

The Shiloh Master Plan study and discussions with local consultant and agency staff indicated that there may be substantial development growth south of the South Frontage Road / Zoo Drive intersection near the Shiloh interchange. This development was included in the long term 2023 forecast scenario for the Shiloh interchange. The potential development south of the South Frontage Road and west of Shiloh Road at Zoo Drive was not included in the current MDT QRS-II model.

At the Johnson Lane interchange, the potential exists for commercial development along the North Frontage Road near Johnson Lane. For the purposes of this analysis, it was assumed that a truck stop and additional commercial uses will be developed for the short and long term scenarios north of I-90 in this vicinity.

2.6 Adjusted and Final Traffic Growth Rates

The following steps were performed to estimate future traffic growth rates on roadway sections at all five interchanges.

- Calculate difference between existing QRS-II model results and existing project ground count data
- Estimate *adjusted* QRS-II growth rates
- Compare adjusted QRS-II growth rates to historic growth or projections in other traffic studies
- Estimate *final* growth rates

Tables B-11 thru B-15 summarize this process and the *final* growth rates for roadway sections at project each interchange.

Adjusted Growth Rates – All travel demand models have some discrepancies between their validated existing volumes and actual ground counts. These differences are theoretically extended into model forecasts. In an attempt to remove these discrepancies, existing model volumes were compared with existing ground counts and their 1) mathematical difference and 2) mathematical ratio were calculated. With equal weighting to each, this mathematical difference and ratio was applied to the QRS-II model forecasts to estimate *adjusted* QRS-II traffic forecasts and resulting *adjusted* QRS-II annual growth rates for each roadway section.

Final Growth Rates – These *adjusted* QRS-II forecasts and growth rates were compared with historic growth rates and forecasts in City of Billings count data and other traffic studies. Most of the *adjusted* QRS-II growth rates were consistent with this other data and were maintained as *final* growth rates. However, *adjusted* growth rates on all I-90 mainline sections, six ramps, and twelve crossroad or local roadway sections were modified as described in the following paragraphs to produce *final* growth rates and forecasts.

Along I-90 mainline, *adjusted* QRS-II growth rates ranged from almost no growth to 1.8 percent annual growth. Historic count data from the City of Billings indicate that historic growth rates along I-90 have ranged from 1.9% west of Shiloh interchange to 3.1% near the US 87 Lockwood interchange. In order to be more conservative and consistent with historic growth rates, *final* growth rates at the two I-90 permanent count station sections were increased to 2.0 percent at the pre-pass station west of Shiloh interchange and 2.5 percent between South Billings Boulevard and 27th Street interchanges. Growth rates at other I-90 mainline sections were estimated by adding or subtracting ramp *final* forecast volumes; I-90 *final* annual growth rates ranged from 1.5% to 3.4%.

Adjusted growth rates on three I-90 ramps were less than 1.0%, resulting in a negative growth rate. These were increased to 0.2% - 0.5% annual growth. The other three ramp growth rates were slightly

modified upward or downward to better balance I-90 directional volumes.

Four roadway sections on crossroad or other roadway sections were not included in the QRS-II model, so forecasts were estimated based on other traffic studies (Gabel Road, Pierce Parkway and Midland Boulevard) or the estimated buildout of undeveloped land (Southgate Drive). The *adjusted* QRS-II growth rate for Zoo Drive between Gabel Road and I-90 westbound ramps was increased to more closely match forecasts in the Shiloh traffic study. The *adjusted* QRS-II growth rate for 27th Street east of I-90 was negative, so it was increased by 1 percent to achieve a positive growth rate; both Garden Avenue approaches which feed 27th Street were given the same growth rate. The *adjusted* QRS-II growth rate on the North Frontage Road west of Johnson Lane was reduced from 6% to 5% annually because it appeared the QRS-II model assigned too much traffic to the North Frontage Road and not enough to eastbound I-90 (the eastbound I-90 off ramp had a negative growth rate in the model). Finally, several *adjusted* QRS-II growth rates were modified to more closely match historic growth rates and produce more balanced forecasts.

Forecasts at Shiloh interchange - At the Shiloh interchange, the MDT QRS-II model includes significant development growth north of I-90 but did not include much development growth south of the South Frontage Road. This potential development may have multiple entrances along the South Frontage Road, including direct access on the south leg of the Zoo Drive / South Frontage Road intersection. If this occurs, it would have significant impacts throughout the Shiloh interchange study area.

The forecasts at the Shiloh interchange represent very high growth rates which are typically very difficult to maintain over a twenty year period. These forecasts should be viewed as either the "worst case" scenario for 2023 or, more likely, traffic growth which may occur over a longer time frame than 20 years. Either way, it's helpful to be aware of the potential long term impacts and related needs at the Shiloh interchange due to significant development potential south of I-90.

2.7 Short and Long Term Forecasts

The *final* annual growth rates shown in **Tables B-11 thru B-15** were applied to existing 2003 ADT volumes and factored 2003 turning movement volumes to estimate short term (2008) and long term (2023) traffic forecasts.

ADT Forecasts – **Figures B1 thru B-10** show the short term 2008 and long term 2023 ADT forecasts at each interchange. At the two I-90 permanent count stations (west of Shiloh and between South Billings

Boulevard – 27th Street), ADT volumes are anticipated to grow from 23,000 – 24,000 vehicles per day (vpd) in 2003 to about 35,000 - 40,000 vpd in 2023.

Turning Movement Forecasts – **Figures B-11 thru B-15** show the short term 2008 peak hour turning movement forecasts at each interchange.

Turning movement projections from recent traffic studies were also utilized along Zoo Drive and South Billings Boulevard. Along Zoo Drive, projections from the *Shiloh Interchange - North Side Properties* traffic study (Engineering Inc., January, 2001) were used to project peak hour turning movements at Gabel Road and project additional peak hour traffic.

Projected PM peak hour turning movements from the *Billings Operations Center Subdivision* traffic study (Engineering Inc., April, 2003) provided forecasts associated with the Midland Road connection to South Billings Boulevard. This study only provided PM forecasts, so these PM turning movements were assumed to occur during all three peak periods. This Midland Road traffic was assumed to be distributed equally to / from I-90 east, I-90 west, and South Billings Boulevard north of King Avenue.

Figures B-16 thru B-20 show the long term 2023 peak hour turning movement forecasts at each interchange.