Interchange Modification Justification Report

I-229 Exit 9 (Benson Road)

I-229 Benson Road Interchange Modification Study
Project # IM2292(98)67N, PCN 04XK

Sioux Falls, South Dakota
January, 2019
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## Abbreviations

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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AASHTO</td>
<td>American Association of State Highway Transportation Officials</td>
</tr>
<tr>
<td>CATEX</td>
<td>Categorical Exclusion</td>
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<tr>
<td>CMF</td>
<td>Crash Modification Factor</td>
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<td>CRM</td>
<td>Critical Rate Factor</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>Highway Capacity Software</td>
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<td>HOT</td>
<td>High Occupancy Transit</td>
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<td>High Occupancy Vehicle</td>
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<td>Highway Safety Manual</td>
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<td>IMJR</td>
<td>Interchange Modification Justification Report</td>
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<tr>
<td>LOS</td>
<td>Level of Service</td>
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<td>MRM</td>
<td>Mileage Reference Marker</td>
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<td>MPO</td>
<td>Metropolitan Planning Organization</td>
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<td>MSA</td>
<td>Metropolitan Statistical Area</td>
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<td>South Dakota Department of Transportation</td>
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<td>STIP</td>
<td>Statewide Transportation Improvement Program</td>
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<td>Traffic Analysis Zone</td>
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1.0 Executive Summary

This Interchange Modification Justification Report (IMJR) provides technical analysis related to proposed changes to the existing Benson Road interchange (Exit 9) on Interstate 229 (I-229) in Sioux Falls, SD.

The proposed action is a reconfiguration of the existing Benson Road Interchange on I-229 in Sioux Falls, SD. The action is proposed to bring the existing interchange up to current design standards and provide appropriate operational capacity for future traffic demand. No adverse impacts to the Interstate highway system are forecast due to the proposed change.

The Federal policy considerations and requirements have been addressed in the Recommendations section of this report and summary responses to the requirements associated with the Policy on Access to the Interstate System, dated May 22, 2017 are provided below.

The proposed change is a reconfiguration of an existing interchange and improvements to the existing crossroad facility (Benson Road). The changes will address current and future capacity needs of the Benson Road Interchange and along the Benson Road Corridor, as well as improve accessibility for non-automobile transportation modes along Benson Road. The proposed change does not result in any new access points on the Interstate Highway System.

The concept alternatives involve changes to the geometric design of an existing diamond interchange and changes to the crossroad arterial street (Benson Road) to meet the transportation needs in the study area. Mass transit reaches a limited market in South Dakota and HOV facilities are currently not in use because they have not been shown to be economically feasible. Neither mass transit nor HOV facilities will provide sufficient relief to future travel demand within the study planning horizon.

The operation and safety analysis contained in this study shows that the proposed build alternatives are not expected to adversely affect the safety or efficiency of the Interstate system. The build alternatives are also expected to improve access management on the crossroad in the vicinity of the interchange.

Conceptual signing plans were prepared for each interchange alternative and for the Benson Road arterial corridor on each side of I-229.

The proposed access is a reconfiguration of an existing interchange with full access to an arterial city street and includes all movements. The conceptual drawings have been prepared using current standards and further design using current standards is anticipated and will receive additional reviews throughout the next steps of the design.

This proposal is the result of land use and transportation plans prepared within the MPO process, including the Sioux Falls MPO Long Range Transportation Plan, the SDDOT 2010 Decennial Interstate Corridor Study, the I-229 Major Investment Corridor Study, and the I-229 Exit 9 Crossroad Corridor Study. The Benson Road Interchange project PE is programmed in the Statewide Transportation Improvement Program (STIP) for 2022 with construction in the 2023-2025 timeframe.
Analysis techniques included an evaluation of operational capacity using Highway Capacity Manual 2010 techniques via HCS 2010. Highway Safety Manual techniques were used to the extent possible in this report. Other techniques and reference materials are detailed in a Methods and Assumptions document prepared for this study and signed by the South Dakota Department of Transportation and Federal Highway Administration participants in February 2018 and modified as necessary throughout the study. The Methods and Assumptions document is included in Appendix 2.
2.0 Introduction

2.1 Background and Project Need

The I-229 Exit 9 interchange (Benson Road) is located in northeast Sioux Falls, SD and serves as one of the primary access points to the Sioux Falls Regional Airport and one of the region’s largest industrial areas. The interchange currently experiences high peak-hour demand as drivers commute to and from industrial-area jobs. This high peak-hour use and continued job growth around the interchange have driven demands for interchange improvements.

The South Dakota Department of Transportation (SDDOT), the City of Sioux Falls, the Sioux Falls MPO, and the Federal Highway Administration (FHWA) conducted a Major Investment Study for the I-229 corridor which was finished in 2017. That study, which included a sub-study component for Exit 9, recommended improvements at the Exit 9 interchange and identified two alternatives for further consideration:

- A modified diamond interchange with a northbound-to-westbound loop in the northeast quadrant
- A diverging diamond interchange

The Major Investment Study identified several specific issues/needs for Exit 9:

- Congestion at the Benson Road/I-229 interchange
- Future growth along Benson Road east of I-229
- Need for improved pedestrian connectivity
- Need for a possible connection to the Veterans Parkway corridor

This Interchange Modification Justification Report seeks to provide the necessary analysis for approval of the interchange modification action. A companion environmental document will provide environmental analysis and determine a recommended alternative.

The primary need of this project is to improve traffic operations and safety and to enhance mobility for other modes of transportation at the Benson Road Interchange and along the Benson Road Corridor. The Purpose and Need statement is included in Appendix 1.

The 2017 Benson Road Corridor Study concluded that improvements were necessary along Benson Road and at the Benson Road Interchange to address existing congestion issues and to accommodate planned growth which are expected to worsen traffic operations at the interchange along Benson Road.

The study continues the previous planning work and provides the necessary analysis for consideration by SDDOT and FHWA.

2.2 Study Area

The study area is shown in Figure 1. It includes I-229 from Rice Street (Exit 7) to Interstate 90 (Exit 10), including the interchanges at Exit 7, Exit 9 and Exit 10. The crossing arterial street at Exit 9, Benson Road, is included from its intersection with Cliff Avenue on the west to its intersection with Sycamore Avenue on the east. The crossing arterial street at Exit 7, Rice Street, is included from its intersection with Cliff Avenue on the west to its intersection with Bahnson Avenue on the east.

The following arterial street intersections were included in the study analysis:

- Benson Road/Cliff Avenue
- Benson Road/Lewis Avenue
• Benson Road/Potsdam Avenue
• Benson Road/I-229 southbound
• Benson Road/I-229 northbound
• Benson Road/Hall Avenue
• Rice Street/Cliff Avenue
• Rice Street/Wayland Avenue
• Rice Street/I-229 southbound
• Rice Street/I-229 northbound
• Rice Street/Bahnson Avenue

2.3 Methods and Assumptions

Preparation of this report included the following work tasks:

• Data Gathering
• Review previous Interstate studies and coordinate with preparation of the environmental studies, including feasible alternatives and the recommended alternative.
• Determine existing and future operational characteristics of Interstate and local street facilities.
• Prepare a deliverable report.

Traffic forecasts were prepared using output from the regional travel demand model maintained by the City of Sioux Falls and the Sioux Falls MPO. Traffic operations were analyzed using the Highway Capacity Manual techniques using HCS 2010 software modules and Highway Safety Manual techniques.

This IMJR Document is organized in accordance with FHWA’s Policy on Access to the Interstate System – May 22, 2017.

The analysis methods and assumptions used in this study are documented in a separate Methods and Assumptions document that was negotiated between the supervising agencies and the consultant. A copy of the Methods and Assumptions document is provided in Appendix 2.
3.0 Operational and Safety Analysis

3.1 Existing Conditions Analysis

Demographics

The Sioux Falls metropolitan area enjoys a robust economy and sustained population growth. During the period 1980 – 2000 the population grew at a steady rate of 2% - 3% per year. Even in the face of the recent recession, the population continued to grow at an annual rate of 1%-2% per year and the 2010 Census shows the city with a population of 153,888, while the Metropolitan Statistical Area (MSA) had a population of 228,261 and the market area had a population of 1,043,450 (market area is a term used in economics and human geography describing the area surrounding a central place, from which people are attracted to use the place’s goods or services).

Generally, employment for the Sioux Falls area has grown at approximately the same rate as the population and unemployment is currently near 2% in Sioux Falls, compared with a statewide rate of 2.7%, regional rate of 3.0%, and a national unemployment rate of 5.0%.

Existing Land Use

Land use around the Exit 9 interchange and along Benson Road is a mix of agriculture, industrial, office, and commercial development. The study area Traffic Analysis Zones (TAZ’s) currently reflect the existing population and employment inputs. The area is in transition, in particular east of I-229 which has been designated as a growth area. The future year TAZ’s show infill of uses similar to those currently existing in the study area.

The future land use plan for Sioux Falls shows continued development of light industrial land uses for this portion of the urban area.

Existing Roadway Network

As previously identified, the existing major corridors within the study area include:

- I-229 – from Interstate 90 to Exit 7 (Rice Street)
- Benson Road – from Cliff Avenue to Bahnson Avenue/Hall Avenue
- Rice Street – from Cliff Avenue to Bahnson Avenue

The following major intersections were analyzed:

- Benson Road/Cliff Avenue
- Benson Road/Lewis Avenue
- Benson Road/Potsdam Avenue
- Benson Road/I-229 SB Ramp Terminal
- Benson Road/I-229 NB Ramp Terminal
- Benson Road/Hall Avenue
- Rice Street/Cliff Avenue
- Rice Street/Wayland Place
- Rice Street/I-229 SB Ramp Terminal
- Rice Street/I-229 NB Ramp Terminal
- Rice Street/Bahnson Avenue
Alternative Travel Modes

Travel within the study area is primarily by automobile. The 2017 Benson Road Corridor Study recommended building sidewalks along Benson Road to provide pedestrian access for the planned growth along the corridor. Multimodal level of service (LOS) analysis was completed for the build alternatives for pedestrian, bicycle and transit modes along Benson Road and discussed in the report.

Interchanges

Interchanges in the study area include:

- I-90/I-229 Interchange (I-90 Exit 400) – Partial Cloverleaf Interchange
- I-229/Benson Road (Exit 9) – Diamond Interchange with signalized control at NB ramp terminal.
- I-229/Rice Street (Exit 7) – Folded Diamond Interchange with signalized control at both ramp termini.

Existing Data

Traffic counts on the Interstate roadway segments were gathered by SDDOT in 2017. Traffic counts on the arterial street system were obtained from the City of Sioux Falls and HDR counts from 2015 and 2017. Count data were assembled and balanced to produce a representation of peak hour traffic flows through the study area. Peak hour traffic volumes are shown in Figures 2, 3 and 6.

Operational Performance

Operational performance of highways is evaluated in terms of the quality of service, which describes how well a transportation facility operates from the traveler’s perspective. Quality of service is usually measured with “Level of Service”, a letter grade similar to those used in school. Level of service “A” refers to uncongested traffic conditions, with level of service “B” through “E” describing increasingly more congested conditions and level of service “F” describing the highest congestion or saturation. Level of service is determined in different ways for different roadway facilities, with Interstate highway facilities evaluated in terms of vehicle density, urban intersections evaluated in terms of vehicle delay, and other facilities evaluated using other measures of roadway dynamics. All quality of service is determined using techniques developed for the Highway Capacity Manual (HCM), published by the Transportation Research Board.

The existing study area roadways were evaluated using the HCM methodologies for Interstate highways and urban streets. SDDOT has established a minimum level of service standard of “C” for interstate facilities, including ramp terminal intersections. The City of Sioux Falls has established minimum level of service standard of “D” for arterial signalized intersections.

Level of service on I-229 was calculated for mainline, ramp merge-diverge, and weave areas for peak hours under 2017 conditions. The level of service results are shown in Figure 6. Note that several Interstate mainline segments were analyzed both as regular mainline segments and weaving segments. If it was determined that the segment satisfied the conditions for weaving, the weaving level of service was reported and indicated by an asterisk (*) next to the level of service result.
The Interstate system operates at acceptable levels of service within the study area.

Intersection turning volumes and level of service for peak hours under 2018 conditions are shown in Figures 2 and 3 for the Benson Road and Rice Street arterial corridors. Multimodal levels of service for the Benson Road and Rice Street arterial corridors are shown in Figures 4 and 5. The Existing Conditions Traffic Memo is included for reference in Appendix 3.

The arterial street system experiences peak hour congestion at the following locations:

- Benson Road/Potsdam Avenue
- Benson Road/I-229 Southbound Ramp Terminal
- Benson Road/I-229 Northbound Ramp Terminal
- Rice Street/I-229 Southbound Ramp Terminal
- Rice Street/I-229 Northbound Ramp Terminal

Certain movements experienced low levels of service or queues that exceeded the length of the available storage during particular peak hours. The southbound left turn at Rice Street/Cliff Avenue is an example of this characteristic, with the left turn queue extending through the Bennett Street/Cliff Avenue intersection at times.

Multi-modal level of service varies widely throughout the Benson Road and Rice Street corridors. The lowest levels of service are related to locations with the absence of specific facilities for pedestrians and bicyclists in these corridors.
Figure 4 (Benson Road)
Figure 5 (Rice).png

EXISTING MULTIMODAL PEAK HOUR LEVEL OF SERVICE

EB = Eastbound
WB = Westbound

SCALE IN FEET

750
1500

EB = Car Level of Service
WB = Car Level of Service
B = Bicycle Level of Service
C = Transit Level of Service

Plotting Date: 2/20/2018
Date: 2/20/2018
Revision:

Rice Street
Existing Multimodal Peak Hour Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Figure 6 ( Interstate Vol).dg n

Existing Peak Hour Balanced Traffic Volumes and Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Existing Safety Conditions

An analysis of existing safety conditions was conducted based on crash records provided by SDDOT. The analysis was conducted using the Critical Rate Method, as described in the Highway Safety Manual (HSM), published by the American Association of State Highway and Transportation Officials (AASHTO).

**Highway Safety Manual definition:**

- **Critical Rate Method (CRM):** a method in which the observed crash rate at each site is compared to a calculated critical crash rate that is unique to each site.

Crash data for the years 2013 through 2017 were provided by SDDOT and reviewed to identify any existing crash concentrations/crash trends and develop potential crash mitigation measures. Analysis were conducted for the following roadway facilities:

- Arterial street intersections
- Arterial street segments
- Interstate mainline segments
- Interstate ramp segments

Critical crash rates were calculated for each segment, ramp, or intersection and used to identify portions of the study area that displayed crash rates higher than the critical rate. Each of the above-critical locations is discussed in subsequent sections of this report.

**Segment, Ramp and Intersection Crash Rates**

The study area was divided into segments representing:

- Interstate mainline segments (Figure 7, Table 1)
- Interstate ramp segments (Figure 8, Table 2)
- Arterial street intersections (Figures 9 & 10, Table 3)
- Arterial street segments (Figures 11 & 12, Table 4)

Mainline and ramp sections were each analyzed separately to allow calculation of representative crash rates and critical rates for each type of Interstate feature.

The study arterial street intersections and intervening arterial street segments were each grouped for calculation of crash rates and critical rates.

Details of the crash records for each segment and intersection are contained in Appendix 4.

**Segment and Intersection Critical Crash Rates:**

Critical crash rates were calculated based on the statistical populations in each spreadsheet, using the methods shown in the Highway Safety Manual (American Association of State Highway and Transportation Officials (AASHTO), 2010). Those segments and intersections that lay outside the critical rates are shown in red coloration in the last column of each spreadsheet. All the segments and intersections that lay within the critical limits are shown in green. The locations of non-critical or critical crash rates are also illustrated on the figures.

**Crash Trends:**

Review of the crash summaries for each Interstate and arterial street section revealed a few crash trends:
• Slightly elevated incidence of single vehicle crashes on southbound I-229 at I-90 during inclement weather events.
• A short-term concentration of crashes on southbound I-229 at Rice Street, likely during construction activities.
• Single-vehicle run-off crashes on the northbound Rice Street off-ramp during inclement weather (only 5 in the 5-year period, but enough to appear outside the critical rate boundary).
• Concentrations of angle crashes at the Benson/Cliff and Rice/Cliff intersections.
• A concentration of crashes involving parked cars on Rice between Wayland and I-229 SB.

Potential Mitigation Measures:
The general crash trends identified above suggest several potential strategies for reducing crash rates with the study area:

• Consider ITS-related means of communicating slippery roadway conditions to drivers and continue aggressive winter maintenance.
• Addition of high-friction surface courses on bridges, curves, and weaving areas may help reduce crashes that occur during inclement weather.
• Consider work zone traffic control that doesn’t require drivers to enter high speed traffic from a stop condition.
• Conduct road safety audits of the Benson/Cliff and Rice/Cliff intersections to consider ways to reduce angle crashes.
• Consider a wider edge line to delineate the parking lane along Rice Street.
## TABLE 1 - INTERSTATE SEGMENT CRASH RATES (2013-2017)

**I-229/BENSON INTERSTATE ACCESS STUDY**

<table>
<thead>
<tr>
<th>TRAVEL DIRECTION</th>
<th>SEGMENT</th>
<th>NUMBER CRASHES</th>
<th>SEGMENT LENGTH</th>
<th>DAILY VOLUME</th>
<th>MVMT$^1$</th>
<th>CRASH RATE</th>
<th>TEV$^*$$^2$ RATE</th>
<th>CRITICAL RATE</th>
<th>CRASH/CRITICAL RATIO</th>
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<tr>
<td>SB</td>
<td>I-90 INTERCHANGE AREA</td>
<td>11</td>
<td>0.331</td>
<td>4265</td>
<td>2.58</td>
<td>4.27</td>
<td>18209.66</td>
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<td>I-90 TO BENSON</td>
<td>16</td>
<td>0.686</td>
<td>7900</td>
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<td>22</td>
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<td><strong>WEIGHTED AVERAGE RATE</strong></td>
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<td><strong>1.46</strong></td>
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$^1$MVMT = MILLION VEHICLE MILES TRAVELED  
$^2$TEV$^*$$^2$ = TOTAL ENTERING VEHICLES PER DAY, TIMES OBSERVED CRASH RATE  

SOURCE: HIGHWAY SAFETY MANUAL, FIRST EDITION, 2010, AASHTO
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<th>NUMBER CRASHES</th>
<th>SEGMENT LENGTH</th>
<th>DAILY VOLUME</th>
<th>MVMT(^1)</th>
<th>CRASH RATE</th>
<th>TEV*(^2) RATE</th>
<th>CRITICAL RATE</th>
<th>CRASH/CRITICAL RATIO</th>
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<td>I-90 WB ON RAMP</td>
<td>4</td>
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<td>2840</td>
<td>1.21</td>
<td>3.00</td>
<td>9366.58</td>
<td>4.91</td>
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<td>SB</td>
<td>I-90 EB ON RAMP</td>
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<td>0.367</td>
<td>3635</td>
<td>2.43</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>SB</td>
<td>BENSON OFF RAMP</td>
<td>2</td>
<td>0.371</td>
<td>730</td>
<td>0.49</td>
<td>4.05</td>
<td>2953.88</td>
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<td>SB</td>
<td>BENSON ON RAMP</td>
<td>4</td>
<td>0.283</td>
<td>5140</td>
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<td>1.51</td>
<td>7744.81</td>
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<td>SB</td>
<td>RICE OFF RAMP</td>
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<td>0.270</td>
<td>1505</td>
<td>0.74</td>
<td>1.35</td>
<td>2029.43</td>
<td>5.79</td>
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<td>SB</td>
<td>RICE ON RAMP</td>
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<td>0.173</td>
<td>2735</td>
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<td>1.16</td>
<td>3367.31</td>
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<td>NB</td>
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<td>0.152</td>
<td>2835</td>
<td>0.79</td>
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<td>6.88</td>
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<tr>
<td>NB</td>
<td>RICE ON RAMP</td>
<td>4</td>
<td>0.235</td>
<td>1585</td>
<td>0.68</td>
<td>5.88</td>
<td>9326.73</td>
<td>5.98</td>
<td>0.98</td>
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<tr>
<td>NB</td>
<td>BENSON OFF RAMP</td>
<td>8</td>
<td>0.360</td>
<td>5035</td>
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<td>2.42</td>
<td>12176.56</td>
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<td>NB</td>
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<td>0.264</td>
<td>970</td>
<td>0.47</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>NB</td>
<td>I-90 EB OFF RAMP</td>
<td>3</td>
<td>0.425</td>
<td>3155</td>
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<td>1.23</td>
<td>3867.85</td>
<td>4.03</td>
<td>0.30</td>
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<td>NB</td>
<td>I-90 WB OFF RAMP</td>
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<td>2.00</td>
<td>5798.36</td>
<td>5.22</td>
<td>0.38</td>
</tr>
</tbody>
</table>

**COLUMN TOTAL**

33060  74456.03  2.25

**WEIGHTED AVERAGE RATE**

MVMT = MILLION VEHICLE MILES TRAVELED

\(^2\)TEV* = TOTAL ENTERING VEHICLES TIMES CRASH RATE

SOURCE: HIGHWAY SAFETY MANUAL, FIRST EDITION, 2010, AASHTO
Intersection Crash Summary (See Table 3)

Benson Road

I-229 Exit 9 (Benson Road) Interchange Modification Study

Note:
The crash types shown in the figure represent the predominant types of intersection crashes. Other crash types exist at most intersections.

Legend
- Direction of Vehicle
- Crash Severity (property damage only unless otherwise noted)
- Critical Crash Rate Intersection (2013 to 2017 Data)
- Non-Critical Crash Rate Intersection (2013 to 2017 Data)

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Injuries</th>
<th>Critical Crashes</th>
<th>Non-Critical Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benson Road</td>
<td>22</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Lewis Avenue</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Freedom Avenue</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hall Avenue</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

St. Michaels Cemetery
Sycamore Avenue
Benson Avenue

SCALE IN FEET
0 750 1500

FILE:
INTERSTATE 2/28/2018
2/28/2018

Note: (2013 to 2017 Data)
Figure 10

Rice Street
Intersection Crash Summary (See Table 3)
I-229 Exit 9 (Benson Road) Interchange Modification Study

Legend
- Direction of Vehicle
- Crash Severity (property damage only unless otherwise noted)
- Critical Crash Rate Intersection (2013 to 2017 Data)
- Non-Critical Crash Rate Intersection (2013 to 2017 Data)

Note:
The crash types shown in the figure represent the predominant types of intersection crashes. Other crash types exist at most intersections.

St. Michaels Cemetery

Sioux Falls, SD
## TABLE 3 - INTERSECTION CRASH RATES (2013-2017)
### I-229/BENSON INTERSTATE ACCESS STUDY

<table>
<thead>
<tr>
<th>INTERSECTION</th>
<th>NUMBER CRASHES</th>
<th>DAILY VOLUME</th>
<th>MEV(^1)</th>
<th>CRASH RATE</th>
<th>TEV*R(^2)</th>
<th>CRITICAL RATE</th>
<th>CRASH/CRITICAL RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENSON/CLIFF</td>
<td>64</td>
<td>25700</td>
<td>46.90</td>
<td>1.36</td>
<td>35068.49</td>
<td>1.10</td>
<td>1.24</td>
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<tr>
<td>BENSON/LEWIS</td>
<td>39</td>
<td>19600</td>
<td>35.77</td>
<td>1.09</td>
<td>21369.86</td>
<td>1.13</td>
<td>0.96</td>
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<tr>
<td>BENSON/POTSDAM</td>
<td>15</td>
<td>16000</td>
<td>29.20</td>
<td>0.51</td>
<td>8219.18</td>
<td>1.16</td>
<td>0.44</td>
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<tr>
<td>BENSON/I-229 SB</td>
<td>9</td>
<td>15600</td>
<td>28.47</td>
<td>0.32</td>
<td>4931.51</td>
<td>1.17</td>
<td>0.27</td>
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<td>BENSON/I-229 NB</td>
<td>10</td>
<td>6000</td>
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<td>5479.45</td>
<td>1.37</td>
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<td>BENSON/HALL</td>
<td>2</td>
<td>1000</td>
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<td>1.10</td>
<td>1095.89</td>
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<td>0.48</td>
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<tr>
<td>RICE/CLIFF</td>
<td>77</td>
<td>27000</td>
<td>49.28</td>
<td>1.56</td>
<td>42191.78</td>
<td>1.09</td>
<td>1.43</td>
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<tr>
<td>RICE/WAYLAND</td>
<td>5</td>
<td>13700</td>
<td>25.00</td>
<td>0.20</td>
<td>2739.73</td>
<td>1.19</td>
<td>0.17</td>
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<td>RICE/I-229 SB</td>
<td>7</td>
<td>15400</td>
<td>28.11</td>
<td>0.25</td>
<td>3835.62</td>
<td>1.17</td>
<td>0.21</td>
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<td>RICE/I-229 NB</td>
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<td>21700</td>
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<td>1.06</td>
<td>23013.70</td>
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<td>0.95</td>
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<td>RICE/BAHNSON</td>
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<td>20.08</td>
<td>0.10</td>
<td>1095.89</td>
<td>1.23</td>
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<td>COLUMN TOTAL</td>
<td>172700</td>
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<tr>
<td>WEIGHTED AVERAGE RATE</td>
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<td></td>
<td></td>
<td></td>
<td>0.86</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) MEV = MILLION ENTERING VEHICLES  
\(^2\) TEV*R = TOTAL ENTERING VEHICLES TIMES CRASH RATE  
SOURCE: HIGHWAY SAFETY MANUAL, FIRST EDITION, 2010, AASHTO
Figure 11 (Benson Crash).dg

10 -09 -2018

P L O T T I N G  D A T E :

FILE :

INTERSTATE

2/28/2018

2/28/2018

Benson Road

Legend

\( \square_{xx} \) injured

Direction of Vehicle

Crash Severity (property damage only unless otherwise noted)

Critical Crash Rate Segment (2013 to 2017 Data)

Non-Critical Crash Rate Segment (2013 to 2017 Data)

Note:
The crash types shown in the figure represent the predominant types of intersection crashes. Other crash types exist at most intersections.

Arterial Street Segment Crash Summary (See Table 4)

Benson Road

I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD
Rice Street Arterial Street Segment Crash Summary (See Table 4)

I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD

Figure 12

Legend

Direction of Vehicle
Crash Severity (property damage only unless otherwise noted)

Critical Crash Rate Segment (2013 to 2017 Data)

Non-Critical Crash Rate Segment (2013 to 2017 Data)

Note:
The crash types shown in the figure represent the predominant types of intersection crashes. Other crash types exist at most intersections.
### TABLE 4 - ARTERIAL SEGMENT CRASH RATES (2013-2017)

I-229/BENSON RD IMJR

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>NUMBER CRASHES</th>
<th>SEGMENT LENGTH</th>
<th>DAILY VOLUME</th>
<th>MVMT(^1)</th>
<th>CRASH RATE</th>
<th>TEV*R (^2)</th>
<th>CRITICAL RATE</th>
<th>CRASH/CRITICAL RATIO</th>
</tr>
</thead>
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<tr>
<td>BENSON: CLIFF TO LEWIS</td>
<td>19</td>
<td>0.501</td>
<td>12,200</td>
<td>11.15</td>
<td>1.70</td>
<td>20780.36</td>
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<td>0.76</td>
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<tr>
<td>BENSON: LEWIS TO POTSDAM</td>
<td>15</td>
<td>0.267</td>
<td>14,900</td>
<td>7.26</td>
<td>2.07</td>
<td>30783.44</td>
<td>2.40</td>
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<td>BENSON: POTSDAM TO I-229 SB</td>
<td>3</td>
<td>0.093</td>
<td>14,900</td>
<td>2.53</td>
<td>1.19</td>
<td>17675.65</td>
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<td>0.39</td>
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<td>3</td>
<td>0.200</td>
<td>14,900</td>
<td>5.44</td>
<td>0.55</td>
<td>8219.18</td>
<td>2.55</td>
<td>0.22</td>
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<td>BENSON: I-229 NB TO HAL</td>
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<td>1.01</td>
<td>0.99</td>
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<td>RICE: CLIFF TO WAYLAND</td>
<td>5</td>
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<td>12,700</td>
<td>4.47</td>
<td>1.12</td>
<td>14195.47</td>
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<td>11,600</td>
<td>13.87</td>
<td>3.32</td>
<td>38481.65</td>
<td>2.16</td>
<td>1.54</td>
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<td>RICE: I-229 SB TO I-229 NB</td>
<td>12</td>
<td>0.192</td>
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<td>2.46</td>
<td>34246.58</td>
<td>2.61</td>
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<td>0.429</td>
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<td>0.24</td>
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<td></td>
</tr>
</tbody>
</table>

\(^1\) MVMT = MILLION VEHICLE MILES TRAVELED  
\(^2\) TEV*R = TOTAL ENTERING VEHICLES PER DAY, TIMES OBSERVED CRASH RATE  

**Weighted Average Rate**: 1.57
3.2 Alternatives

Previous studies have identified improvements at the Benson Road Interchange and crossroad to provide adequate roadway capacity and improve safety. The following improvement concepts were developed to address the interchange area needs:

- No-Build
- 2-Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp
- 2-Lane Northeast Quadrant Loop with 2-Lane SB On-Ramp
- 2-Lane Collector-Distributor (CD) Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp
- 2-Lane Partial Cloverleaf Northeast Quadrant with 2-Lane SB On-Ramp
- 2-Lane Partial Cloverleaf Northeast Quadrant with CD lane and 2-Lane SB On-Ramp
- Diverging Diamond Interchange with 3-Lane SB On-Ramp – Add to Existing Overpass (WB Lanes)
- Diverging Diamond Interchange with 3-Lane SB On-Ramp – Separate Structure (EB Lanes)
- Benson Road – WB 3rd Lane from Lewis Avenue to I-229
- Benson Road – 4-Lane Divided Section from I-229 east to Hall Avenue

The interchange alternatives are shown in Figures I-1 - I-7 and Benson Road crossroad alternatives are shown in Figures A-1 and A-2 on the following pages. Each option was evaluated under forecast traffic conditions to determine future traffic operations.
Benson 1a Option Features:
- Dual right turn lane and free right-turn movement for EB Benson Road to SB I-229 traffic.
- 30 mph 2-lane ramp loop for NB I-229 to WB Benson Road traffic.
- Pedestrian underpass for NB off-ramp / NB on-ramp loop.
- Realign I-229 NB off-ramp, EB on Benson Road yield movement.
- 3rd WB lane on Benson Road from I-229 to the west.
- 3rd EB lane on Benson Road from Lewis Avenue to I-229.
- Widen existing Benson Road bridge.
- Raised median Benson Road with left turn lanes.
- Retaining walls necessary for power poles and pedestrian underpass.

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.
Alternative Scenario 1b
2-Lane Northeast Quadrant Loop with 2-Lane SB On-Ramp

I-229 Exit 9 (Benson Road) IMJR

Retaining walls necessary for power poles and pedestrian underpass.

10/8/2018

Benson 1b Option Features:
- Single right turn lane and four right turn movement for EB Benson Road to SB I-229 traffic.
- Significant queuing for EB on Benson Road to SB on I-229 traffic.
- 30 mph 2-lane ramp loop for NB I-229 to WB Benson Road traffic.
- Pedestrian underpass for NB off-ramp / WB on-ramp loop.
- Realign I-229 NB off ramp, EB on Benson Road yield movement.
- 3rd WB lane on Benson Road from I-229 to the west.
- 3rd EB lane on Benson Road from Lewis Avenue to I-229.
- Widen existing Benson Road bridge.
- Raised median Benson Road with left turn lanes.
- Retaining walls necessary for power poles and pedestrian underpass.

Note:
Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.
Alternative Scenario 1c
2-Lane Collector - Distributor (CD) Lane Northeast Quadrant Loop
with 3-Lane SB On-Ramp
I-229 Exit 9 (Benson Road) IMJR

100' Radius
V = 30 mph

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.

Benson 1c Option Features:
- Collector-Distributor (CD) lane for NB off-ramp connection.
- Dual right turn lane and free right turn movement for EB Benson Road to SB I-229 traffic.
- 30 mph 2-lane ramp loop for NB I-229 to Wll Benson Road traffic.
- Pedestrian underpass for NB off-ramp / NB on-ramp loop.
- Realign I-229 NB off-ramp, EB on Benson Road yield movement.
- 3rd WB lane on Benson Road from I-229 to the west.
- 3rd EB lane on Benson Road from Lewis Avenue to I-229.
- Wider existing Benson Road bridge.
- Raised median Benson Road with left turn lanes.
- Retaining walls necessary for power poles and pedestrian underpass.

Sioux Falls, SD

Figure I-3

Legend
- Interchanges/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Retaining Wall
- Existing ROW / Property Line
- Existing Control of Access
- Proposed Control of Access
- ROW Acquisition
- Road Closure
- Signalized Intersection
- Number of Traffic Lanes
Benson 1d Option Features:
- 30 mph 2-lane for NB I-229 to WB Benson Road traffic controlled at signal.
- Pedestrians allowed to cross off-ramp traffic at the signalized WB Benson Road.
- Inside / outside lanes will have the ability to turn right on red (assumed).
- Realign I-229 NB off-ramp, EB on Benson Road yield movement.
- 3rd WB lane on Benson Road from I-229 to the west.
- 3rd EB lane on Benson Road from Lewis Avenue to I-229.
- Widen existing Benson Road bridge.
- Retaining wall necessary for power poles and pedestrian underpass.

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.
Benson 1e Option Features:
- Collector-Distributor (CD) lane for NB off-ramp loop.
- 30 mph 2-lane for NB I-229 to WB Benson Road traffic controlled at signal.
- Pedestrians allowed to cross the WB Benson Road traffic at the signalized off-ramp.
- Inside / outside lane will have the ability to turn right on red (assumed).
- Relocate I-229 NB off ramp, EB on Benson Road yield movement.
- 3rd EB lane on Benson Road from Lewis Avenue to I-229.
- Widen existing Benson Road bridge.
- Raised median Benson Road with left turn lanes.
- Retaining walls necessary for power poles and pedestrian underpass.
- Dual right turn lane and free right turn movement for EB Benson Road to SB I-229 traffic.

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.
Alternative Scenario 4a
Diverging Diamond Interchange with 3-Lane SB On-Ramp
Add 2 WB Lanes to Existing Overpass.
I-229 Exit 9 (Benson Road) IMJR

Benson 4a Option Features:
- Diverging Diamond interchange configuration.
- Widen existing Benson Road bridge.
- Realign west I-229 ramps to maximize separation distance to Potsdam Avenue.
- 2-lane free right turn movement for EB Benson Road to SB I-229 traffic.

Note:
Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.

Note:
Control of Access to be provided on east side of interchange. Minimum length to be 660’. Final Control of Access to be determined during final design.

Legend
- Interchanges/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Retaining Wall
- Existing ROW / Property Line
- Existing Control of Access
- Proposed Control of Access
- ROW Acquisition
- Road Closure
- Signalized Intersection
- Number of Traffic Lanes

Scale in Feet
0 375 750

Note:
Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.

Note:
Control of Access to be provided on east side of interchange. Minimum length to be 660’. Final Control of Access to be determined during final design.

Legend:
- Interchanges/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Retaining Wall
- Existing ROW / Property Line
- Existing Control of Access
- Proposed Control of Access
- ROW Acquisition
- Road Closure
- Signalized Intersection
- Number of Traffic Lanes

Scale in Feet
0 375 750

Note:
Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.

Note:
Control of Access to be provided on east side of interchange. Minimum length to be 660’. Final Control of Access to be determined during final design.
Alternative Scenario 4b
Diverging Diamond Interchange with 3-Lane SB On-Ramp
Add a Separate Structure for 2 EB Lanes
I-229 Exit 9 (Benson Road) IMJR

Benson 4b Option Features:
- Diverging Diamond Interchange configuration.
- Existing Benson Road bridge will be used for WB traffic only. EB traffic will be on proposed on separate bridge to the north of the existing.
- Realign west I-229 ramps to maximize separation distance to Benson Avenue.
- 2-lane free right turn movement for EB Benson Road to SB I-229 traffic.

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.

Note: Control of Access to be provided on east side of interchange. Minimum length to be 660'. Final Control of Access to be determined during final design.

Legend
- Interchanges/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Retaining Wall
- Existing ROW / Property Line
- Existing Control of Access
- Proposed Control of Access
- ROW Acquisition
- Road Closure
- Signalized Intersection
- Number of Traffic Lanes

Scale in Feet
0 375 750
Westbound 3rd Lane from Lewis Avenue to I-229

Alternative Scenario Benson Road

Benson C1a Option Features:
- WB 3rd lane from Lewis Avenue to I-229.
- EB 3rd lane from Casco Avenue to I-229.
- Raised center median with left turn lanes.
- Widen Lewis Avenue intersection on south side of Benson Road.
- WB and EB 3/4 access at Potsdam Avenue.

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.
**Alternative Scenario Benson Road**

4-Lane Divided Section to Hall Avenue east of I-229

**I-229 Exit 9 (Benson Road) IMJR**

Sioux Falls, SD

**Note:**

Control of Access to be provided on east side of interchange. Minimum length to be 660'. Final Control of Access to be determined during final design.

**Legend**
- Interchange/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Retaining Wall
- Existing ROW / Property Line
- Existing Control of Access
- Proposed Control of Access
- ROW Acquisition
- Road Closure
- Signalized Intersection
- Number of Traffic Lanes

**Benson C1 Option Features:**
- Future Benson Road extension across the Big Sioux River.
- 2 lanes in each direction with raised median and left turn lane on Benson Road from I-229 to Sycamore Avenue.
3.3 Future Year Traffic

Traffic forecasts for 2023 and 2045 were prepared using the regional travel demand model maintained by the City of Sioux Falls and the Sioux Falls Metropolitan Planning Organization. The forecasts were based on the latest land development information and modeling updated from the 2040 model used in the I-229 Major Investment Study. Future year traffic demand reflects planned improvements. It is assumed in the 2023 volume projections that a Benson Road extension, east to Rice Street, will not occur prior to 2023. Also, as a result of the build condition with a raised median on Benson Road, the through movements and left turns at Potsdam Avenue were re-routed to the Lewis Avenue intersection and the left turns for the HSBC driveway were also re-routed through the Lewis Avenue intersection.

Operational Performance

Level of service on I-229 was calculated for ramp merge-diverge, and weave areas for peak hours under 2023 and 2045 conditions in the immediate vicinity of the Benson Road interchange. The level of service results for the No-Build scenario are shown in Figures 13 - 22. Note that ramp merge-diverge segments for the I-229 SB Benson merge and I-229 NB Benson diverge are reported as part of the weaving segment between Benson Road and Rice Street. If it was determined that the segment satisfied the conditions for weaving, the weaving level of service was reported and indicated by an asterisk (*) next to the level of service result.

Interstate volumes and level of service for peak hours under 2023 and 2045 Build conditions are shown in Figures 23 - 29. Intersection peak hour turning volumes and level of service for 2023 and 2045 are shown in Figures 30-36 and 44-50 respectively for Benson Road. Multimodal levels of service for the Benson Road arterial corridor are shown in Figures 37 - 43 and 51 – 57, respectively for 2023 and 2045 Build conditions.

The 2023 operational analysis revealed the following findings:

- Interstate facilities within the Benson Road interchange area continue to operate at an acceptable level of service, LOS C or better for all build conditions scenarios analyzed.
- Arterial Street system performs at acceptable level of service for all build conditions scenarios analyzed, with the exception of Alternate 1D and 1E at the I-229 ramp terminals. This is a result of the northbound loop ramp traffic being controlled by the traffic signal at the I-229 northbound ramp terminal and negatively impacts signal timing at the downstream intersection (I-229 southbound ramp terminal). Allowing right on red for the dual southbound rights at the I-229 northbound ramp terminal may improve operations associated with Alternatives 1D and 1E. Alternatives 1A, 1B, and 1C address this deficiency by allowing free right turn movements for the southbound right turn at the I-229 northbound ramp terminal.
- Peak hour congestion (LOS E) or worse is experienced on the arterial network at the following locations:
  - Benson Road/Potsdam Avenue (PM) – STOP controlled intersection
  - Benson Road/Hall Avenue (PM) – STOP controlled intersection

2023 Intersection levels of service for the interchange build alternatives are summarized in Table 5.
Certain movements experienced low levels of service or queues that exceeded the length of the available storage during particular peak hours. The southbound left turn during the PM peak hour at Benson Road/Lewis Avenue is an example of this characteristic. Queues however do not impact adjacent streets or accesses and the overall intersection level of service achieves the minimum requirement for LOS D with a specific movement no worse than LOS E. The existing left turn storage could likely be extended over the existing pavement surface by striping modifications.

A northbound right turn lane is necessary at the Benson Road and Lewis Avenue intersection in order to address low levels of service in the PM peak hour. The Benson Road/Hall Avenue intersection low level of service is addressed by the installation of a traffic signal in the 2045 scenario.

Multimodal level of service continues to vary throughout the Benson Road corridor.

The 2045 operational analysis revealed the following findings:

- Interstate facilities within the Benson Road interchange area continue to operate at an acceptable level of service, LOS C or better for all build conditions scenarios analyzed
- The arterial street system performs at acceptable level of service for all build conditions scenarios analyzed, with the exception of Alternatives 1D and 1E at the I-229 ramp terminals. This is a result of the northbound loop ramp traffic being controlled by the traffic signal at the I-229 northbound ramp terminal and negatively impacts signal timing at the downstream intersection (I-229 southbound ramp terminal). Allowing right on red for the dual southbound rights at the I-229 northbound ramp terminal may improve operations associated with Alternatives 1D and 1E. Alternatives 1A, B, and C address this deficiency by allowing free right turn movements for the southbound right turn at the I-229 northbound ramp terminal.

2045 Intersection levels of service under each interchange build alternatives are summarized in Table 6.

### Table 5: 2023 Build Alternatives Intersection Level of Service

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Existing</th>
<th>No Build</th>
<th>Alt. 1A</th>
<th>Alt. 1B</th>
<th>Alt. 1C</th>
<th>Alt. 1D</th>
<th>Alt. 1E</th>
<th>Alt. 4A</th>
<th>Alt. 4B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benson/Cliff</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
</tr>
<tr>
<td>Benson/Lewis</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
</tr>
<tr>
<td>Benson/Potsdam</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
</tr>
<tr>
<td>Benson/I-229 SB Ramp</td>
<td>D A F C</td>
<td>B A B A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
</tr>
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</table>

### Table 6: 2045 Build Alternatives Intersection Level of Service

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Existing</th>
<th>No Build</th>
<th>Alt. 1A</th>
<th>Alt. 1B</th>
<th>Alt. 1C</th>
<th>Alt. 1D</th>
<th>Alt. 1E</th>
<th>Alt. 4A</th>
<th>Alt. 4B</th>
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</thead>
<tbody>
<tr>
<td>Benson/Cliff</td>
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<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
<td>AM PM</td>
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<td>AM PM</td>
</tr>
<tr>
<td>Benson/Lewis</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
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<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
<td>B C</td>
</tr>
<tr>
<td>Benson/Potsdam</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
<td>F F</td>
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</tr>
<tr>
<td>Benson/I-229 SB Ramp</td>
<td>D A F C</td>
<td>B A B A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
<td>A A A</td>
</tr>
</tbody>
</table>
The analysis for the 2045 traffic forecast conditions requires similar improvements at the Benson Road and Lewis Avenue intersection as under 2023 traffic forecast conditions. The improvements include re-striping of Lewis Avenue to provide additional southbound left turn storage and providing a northbound right turn lane on Lewis Avenue. Additionally, a traffic signal will likely be warranted at the Benson Road and Hall Avenue intersection based upon 2045 forecast traffic volumes.
Figure 13 (Benson 2023).png

Note:
The northbound left turn queues at Benson Road / I-229 off-ramp exceed available storage and extend onto interstate during PM peak hour.

Legend

AM PM
2023 Peak Hour
Traffic Volumes

Signalized Intersection

Stop Controlled
Intersection

LOS Avg. Delay

A XX sec. A.M.

A XX sec. P.M.

St. Michaels Cemetery

Benson Road

60th Street N

LEGEND

SCALE IN FEET

0 750 1500

Interstate

40 5 110 5

1805 625 45 135

385 165

1450 320

F 117.2 sec.

C 20.7 sec.

365 60

1640 110

315 210 395

365

160 110

165 100

395

2023 No-Build Traffic Volumes and Peak Hour Intersection LOS

Benson Road

I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD
Note: The southbound left turn queues at Rice Street / I-229 off-ramp exceed available storage and extend onto interstate during PM peak hour.
Figure 15 (Benson 2023).dg

I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD
Figure 18 (Benson 2045).png

I-229 Exit 9 (Benson Road) Interchange Modification Study

2045 No-Build Traffic Volumes and Peak Hour Intersection LOS

**Legend**
- Signalized Intersection
- Stop Controlled Intersection
- 2045 Peak Hour Traffic Volumes

**Note:**
The northbound left turn queues at Benson Road / I-229 off-ramp exceed available storage and extend onto interstate during PM peak hour.

**Traffic Volumes**
2045 Peak Hour

**On-onto interstate during PM peak hour.**

**LOS**
- A: XX sec. (A.M.)
- A: XX sec. (P.M.)

**Avg. Delay**

**SCALE IN FEET**

<table>
<thead>
<tr>
<th>A.M.</th>
<th>P.M.</th>
</tr>
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<tbody>
<tr>
<td>XX sec.</td>
<td>XX sec.</td>
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</table>

**Plotting Date:** 3/15/2018
The southbound left turn queues at Rice Street / I-229 off-ramp exceed available storage and extend onto interstate during PM peak hour.
Figure 20 (Benson 2045).dg

10-09-2018

PLOTTING DATE:

FILE:

INTERSTATE

3/15/2018

3/15/2018

LEVEL OF SERVICE

EB = Eastbound
WB = Westbound

LEVEL OF SERVICE

AUTO

LEVEL OF SERVICE

PEDESTRIAN

LEVEL OF SERVICE

BICYCLE

LEVEL OF SERVICE

TRANSIT

LEVEL OF SERVICE

SCALE IN FEET

0 750 1500

EB = Eastbound
WB = Westbound

LEVEL OF SERVICE

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TRANSIT

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AUTO

LEVEL OF SERVICE

PEDESTRIAN
Figure 23 (Alternative Scenario 1a)

- Year 2023 AM/PM Ramp Level of Service
- Year 2023 Weaving Analysis
- Year 2045 AM/PM Ramp Level of Service
- Year 2045 Weaving Analysis

2-Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp.

I-229 exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD
Alternative Scenario 1b
2-Lane Northeast Quadrant Loop with 2-Lane SB On-Ramp.
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD

Legend
- Year 2023 AM/PM Ramp Level of Service
- Year 2023 Weaving Analysis
- Year 2045 AM/PM Ramp Level of Service
- Year 2045 Weaving Analysis
Figure 25 (Alternative Scenario 1c -- 2-Lane Collector-Distributor (CD) Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp.

Legend:
- Year 2023 AM/PM Ramp Level of Service
- Year 2023 Weaving Analysis
- Year 2045 AM/PM Ramp Level of Service
- Year 2045 Weaving Analysis

Alternative Scenario 1c -- 2-Lane Collector-Distributor (CD) Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp.

I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Alternative Scenario 1d -- 2-Lane Partial Clover Leaf Northeast Quadrant Loop with 2-Lane SB On-Ramp.

I-29 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Alternative Scenario 1e -- 2-Lane Partial Clover Leaf Northeast Quadrant with CD Lane and 2-Lane SB On-Ramp.

I-29 exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD

Legend
- Year 2023 AM/PM Ramp Level of Service
- Year 2023 Weaving Analysis
- Year 2045 AM/PM Ramp Level of Service
- Year 2045 Weaving Analysis
Figure 28

Alternative Scenario 4a -- Diverging Diamond Interchange with 3-Lane SB On-Ramp. Add 2 WB Lanes to Existing Overpass.

Legend:
- Year 2023 AM/PM Ramp Level of Service
- Year 2023 Weaving Analysis
- Year 2045 AM/PM Ramp Level of Service
- Year 2045 Weaving Analysis
Figure I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD

3-Lane SB On-Ramp. Add a Separate Structure for 2 EB Lanes.

Alternative Scenario 4b -- Diverging Diamond Interchange with 3-Lane SB On-Ramp. Add a Separate Structure for 2 EB Lanes.

Legend
- Year 2023 AM/PM Ramp Level of Service
- Year 2023 Weaving Analysis
- Year 2045 AM/PM Ramp Level of Service
- Year 2045 Weaving Analysis
Benson Road Alternative 1e
2023 Build Traffic Volumes and Peak Hour Intersection LOS
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Figure 35 (2023).dg

Benson Road Alternative 4a
2023 Build Traffic Volumes and Peak Hour Intersection LOS
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Figure 36 (2023). Design

Legend

2023 Peak Hour Traffic Volumes

Signalized Intersection

Stop Controlled Intersection

LOS Avg. Delay

A XX sec. A.M.

A XX sec. P.M.

Traffic Volumes

2023 Build Traffic Volumes and Peak Hour Intersection LOS

Benson Road Alternative 4b

2023 Build Traffic Volumes and Peak Hour Intersection LOS

I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD
Figure 38 (MM 2023). 

1-229 Exit 9 (Benson Road) Interchange Modification Study

**Benson Road Alternative 1b**
2023 Build Multimodal Peak Hour Level of Service
Figure 40 (MM 2023). Benson Road Alternative 1d
2023 Build Multimodal Peak Hour Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD
Figure 41 (MM 2023). Benson Road Alternative 1e
2023 Build Multimodal Peak Hour Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD

June 9, 2023
Figure 42 (MM 2023).

Benson Road Alternative 4a
2023 Build Multimodal Peak Hour Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study

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Benson Road Alternative 4b
2023 Build Multimodal Peak Hour Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD

Figure 43 (MM 2023).dg

PLOTTING DATE: 10/09/2018

EB = Eastbound
WB = Westbound
### Benson Road Alternative 1a

**2045 Build Traffic Volumes and Peak Hour Intersection LOS**

I-229 Exit 9 (Benson Road) Interchange Modification Study

Sioux Falls, SD

**Legend**

<table>
<thead>
<tr>
<th>AM</th>
<th>PM</th>
</tr>
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<tbody>
<tr>
<td>2045 Peak Hour Traffic Volumes</td>
<td></td>
</tr>
</tbody>
</table>

**Traffic Volumes**

2045 Peak Hour

Benson Road Alternative 1a

**Signalized Intersection**

**Stop Controlled Intersection**

**LOS**

<table>
<thead>
<tr>
<th>Traffic Volumes</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>Benson Road</td>
<td>100 300 205</td>
<td>155 275 120</td>
<td>370 160</td>
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<tr>
<td>65 105 45</td>
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<td>40 0 0</td>
<td>40 55</td>
<td>365 45</td>
<td>1875 335</td>
<td></td>
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<tr>
<td>0 0 110</td>
<td>0 0 85</td>
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**Plotting Date:** 6/1/2018

**File:** 44
<table>
<thead>
<tr>
<th>Traffic Volumes 2045 Peak Hour</th>
<th>Benson Road Alternative 1b</th>
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<tbody>
<tr>
<td><strong>2045 Build Traffic Volumes and Peak Hour Intersection LOS</strong></td>
<td><strong>Benson Road Alternative 1b</strong></td>
</tr>
<tr>
<td><strong>Cessna Air Center</strong></td>
<td><strong>I-229 Exit 9 (Benson Road) Interchange Modification Study</strong></td>
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<td><strong>Sioux Falls, SD</strong></td>
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<tr>
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<tr>
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<tr>
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<td><strong>Drawn By:</strong> BRM</td>
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<td><strong>Revision:</strong> 8/23/2018</td>
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Figure 47 (2045). Design Considerations:

- **Benson Road Alternative 1d**
- **2045 Build Traffic Volumes and Peak Hour Intersection LOS**

**Legend**
- **Signalized Intersection**
- **Stop Controlled Intersection**

**Traffic Volumes**
- **2045 Peak Hour Traffic Volumes**

**LOS and Avg. Delay**
- **A.M.**
- **P.M.**

**Traffic Volume Breakdown**
- **Benson Road**
- **Lewin Avenue**
- **Pondson Avenue**
- **Hall Avenue**
- **Sycamore Avenue**
- **60th Street North**
- **St. Michaels Cemetery**

**6th Street South**

**Scale in Feet**
0 750 1500
**Legend**

- **Signalized Intersection**
- **Stop Controlled Intersection**

**2045 Peak Hour Traffic Volumes**

**Traffic Volumes**

2045 Peak Hour

**Benson Road Alternative 1e**

**2045 Build Traffic Volumes and Peak Hour Intersection LOS**

**I-229 Exit 9 (Benson Road) Interchange Modification Study**

Sioux Falls, SD

**Plotting Date:** 10/9/2018

**Drawn By:** BRM

**Date:** 6/1/2018

**Chked By:** DUH

**Date:** 6/1/2018

**Revision:**
Benson Road Alternative 4a
2045 Build Traffic Volumes and Peak Hour Intersection LOS
I-229 Exit 9 (Benson Road) Interchange Modification Study
Sioux Falls, SD
Figure 56 (MM 2045). Benson Road Alternative 4a
2045 Build Multimodal Peak Hour Level of Service
I-229 Exit 9 (Benson Road) Interchange Modification Study
Safety

The build alternatives are a modified diamond interchange containing a dual-lane loop ramp (DLLR) in the northeast quadrant and a Diverging Diamond Interchange (DDI), which would replace the existing diamond interchange.

The analysis limits for the predictive safety analysis are focused on the immediate interchange area as shown in Figure 58. On I-229, the limits extend from the interchange of I-229 / Rice Street to the interchange of I-229 / I-90, for a total distance of 2.3 miles. In addition to the freeway, the four interchange ramps and the two ramp terminals were analyzed.

Three alternatives were evaluated with this predictive safety analysis. The “No-Build” alternative maintains the existing diamond interchange layout. The second alternative adds a dual-lane loop ramp in the northeast quadrant to serve northbound I-229 traffic turning west onto Benson Road. This alternative would also reconfigure the alignments and lane layouts for other ramps, but they would still maintain the traditional diamond interchange layout. The third alternative would convert the interchange to a diverging diamond interchange. Within these general configurations, the IMJR includes review of several variations of the DLLR and DDI. However, the crash prediction analysis herein is based on the DLLR concept numbered 1a and the DDI concept denoted 4a.

The predictive crash analysis presented in this memorandum is based on the principles and methods of the Highway Safety Manual (HSM) 2010 edition with 2014 supplement published by AASHTO as discussed in detail below. It presents a comparative analysis of the predicted crashes anticipated within the interchange area for the “No-Build” future condition (maintain diamond interchange) and the planned build alternatives (DLLR and DDI). The results are intended to verify the assumption that the construction of a DLLR or DDI at this location will not result in a decrease in overall safety performance in the interchange area.
Figure 58 – IHSDM Analysis Limits

Source: Google Earth, April 2018
Safety Methodology

This predictive safety analysis was completed using the American Association of State Highway and Transportation Officials (AASHTO) HSM method, including the National Cooperative Highway Research Program (NCHRP) Report 17-45 method for evaluating freeways and interchanges, which is now part of the HSM as a supplemental volume published in 2014.

FHWA supports, and in many cases now requires, the use of the method for the evaluation of proposed freeway facility improvements, including new or modified Interstate access. According to the HSM preface: “The focus of the HSM is to provide quantitative information for decision making. The HSM assembles currently available information and methodologies on measuring, estimating, and evaluating roadways in terms of crash frequency (number of crashes per year) and crash severity (level of injuries due to crashes). The HSM presents tools and methodologies for consideration of ‘safety’ across the range of highway activities …”

For this study, the HSM predictive method was used. “The predictive method provides a quantitative measure of expected crash frequency under both existing conditions and conditions which have not yet occurred. This allows proposed roadway conditions to be quantitatively assessed …” (HSM, 2010)

The HSM method crash prediction estimates are developed using safety performance functions (SPFs) for specific facility types. The SPFs take into account the daily traffic volume information, but they assume that other geometric and traffic control features match a theoretical base condition for that facility type. Therefore, crash modification factors (CMFs) are used to make adjustments to the initial SPF results, to account for differences between the actual analysis condition and the theoretical base condition. A CMF of 1 means the analysis condition and the theoretical base condition will predict the same number of crashes. Thus, if a CMF is greater than 1, that will increase the number of predicted crashes, while if it is less than 1, it will decrease the number of predicted crashes. For example, if a depressed freeway median is narrower than the assumed 60-foot base condition, then a CMF greater than 1 is applied to adjust the SPF results for the segment.

The HSM methodology has been in development for many years and is rapidly advancing; however, there are still many limitations where the available tools do not yet offer SPFs and/or CMFs for certain conditions. Where this is the case, recent research and crash data were also considered to refine the results as described later in this section.

Facilities, Segmentation and Data Inputs:

In keeping with the site based HSM analysis approach, each type of facility was examined separately. This involved segmenting the I-229 mainline and the I-229 ramps into functional elements. The Interactive Highway Safety Design Model (IHSDM) software automatically segments highways (including freeway segments, ramps and C-D roads) following HSM guidance. The ramp terminal intersections were also considered individually. IHSDM reports provided in Appendix 6 list all freeway, ramp, and ramp terminal intersection sites that were reviewed.

The HSM method requires several geometric and operational inputs to accurately compute the SPFs and apply the correct CMFs. This includes information such as segment length, daily traffic volume, ramp locations, merge distances, and horizontal curvature. The geometric inputs were primarily obtained from the conceptual design files and aerial photography. The traffic volume data was based on data and design year volume forecasts from the 2040 Sioux Falls Travel Demand Model.
I-229 Mainline Segments

The I-229 mainline segments were evaluated using HSM methods implemented using the Interactive Highway Safety Design Model (IHSDM) version 13.1.0 software provided by FHWA.

I-229 Entrance and Exit Ramps

The I-229 entrance and exit ramps were also evaluated using HSM methods in the IHSDM software. Consistent with this method, each ramp was evaluated as one or more specific ramp segments, taking into account the ramp geometry. Some of the ramps were subdivided into multiple segments to account for changes in number of lanes or shoulder widths.

In the DLLR alternative, the I-229 Northbound exit ramp traverses a portion of two-lane ramp alignment with a tight curve radius before intersecting Benson Road. The condition is uncommon in practice and was very likely unobserved or under-sampled in the development of the HSM crash prediction models. Past research for SDDOT on this gap in the crash prediction methodology led to the “Crash Prediction Analysis Procedures for Diverging Diamond Interchange (DDI) and Two-Lane Loop Ramp” memo dated November 4th, 2015. In the memo, it is recommended to analyze the two-lane loop ramp, now called DLLR, with standard HSM procedures with greater scrutiny unless the research results of NCHRP 03-105 should develop enhanced models / guidance. The referenced research project was published in 2017 as NCHRP Web-Only Document 227: Design of Interchange Loop Ramps and Pavement/Shoulder Cross-Slope Breaks. The report includes a chapter reviewing the HSM procedure for loop ramps against directional ramps, but does not make recommendations on the specific DLLR geometry. The report’s most poignant comment on loop ramp crash prediction is that “HSM prediction models for ramp crashes do a better job of predicting diamond ramp crashes than predicting loop ramp crashes”, which the researchers arrived at through advanced statistical analysis of geometry and crash data.

Benson Road Ramp Terminals

For the No-Build and Build options, the ramps connect to Benson Road at signalized and non-signalized intersections. Interchange ramp terminals are evaluated using the HSM ramp terminal procedure in IHSDM. The IHSDM ramp terminal method does not, however, address DDIs. It only predicts crashes for a variety of more typical diamond and partial cloverleaf interchange ramp terminals. Therefore, it was necessary to develop an estimate for an “operationally-similar” diamond interchange design and then use CMFs from HDR’s “Crash Prediction Analysis Procedures for Diverging Diamond Interchange (DDI) and Two-Lane Loop Ramp” memo dated November 4th, 2015 to modify the results to estimate the predictions for a DDI design. Based on research done in Missouri on safety evaluations of DDIs, the preliminary CMF for conversion of a traditional diamond interchange to a DDI is 0.37 for Fatal + Injury (F+I) crashes at ramp terminal intersections and 0.49 for Property Damage Only (PDO) crashes at ramp terminal intersections.

Benson Road Segments

Crash prediction for an interchange study area within a typical urban footprint can be almost entirely described by evaluating the crashes from the freeway, freeway ramps, and ramp terminal intersections due to how the HSM defines the influence area for those types of sites. For that reason, this analysis does not report urban arterial crashes outside of those estimated directly through ramp terminal analysis. Given the emerging nature of both the DLLR and DDI configurations in crash prediction practice, it is likely that the base HSM models would struggle
to replicate the crash patterns for the proposed Benson Road configuration between the interchange ramp terminals.

**Calibration Factors:**

According to the HSM, “the predictive models were developed from the most complete and consistent data sets available.” However, the report also recommends that the equations be calibrated for each jurisdiction because “the general level of crash frequencies may vary substantially from one jurisdiction to another.” However, SDDOT has not yet conducted the extensive analyses required to develop a complete set of HSM related calibration factors. Therefore, using the national HSM equations is proposed as the best approach for this current analysis.

**Empirical Bayes Approach: Considering Historical Crash Data:**

The HSM method includes an optional step called the Empirical Bayes (EB) approach, which combines “the estimate from a predictive model with observed crash data to obtain a more reliable estimate of the expected average crash frequency.” (HSM, 2010) Essentially, the historical crash data is used to adjust the future crash prediction. Typically, the EB method is only used when it can be applied equally to all of the alternatives under consideration. Thus the improvements being considered must be moderate, so that the historical crash data is reasonable to consider for the No-Build and Build conditions. When major alignment or traffic control changes are proposed (such as the proposed DLLR or DDI), it is not used because “there is typically a small difference in the results obtained from the predictive method when it is used with and without the EB Method.” Therefore, “if the EB Method is not applied consistently, such differences will likely introduce a small bias in the comparison of expected crash frequency among alternatives.” (HSM Supplement, 2014) Therefore, the results are presented without the EB method adjustment.

**Safety Analysis Results**

The No-Build and Build interchange alternatives were evaluated and the predicted number of crashes was compared for the 2023 to 2045 analysis period. As mentioned previously, the required inputs were derived from design plans, aerial photography, and traffic volume data from the 2040 Sioux Falls Travel Demand Model. The following sections present the details of the analyses.

**Build and No-Build Crash Frequency Comparison:**

The predicted annual crash frequencies for the No-Build and Build scenarios (2023 to 2045) are presented in Table 7 including a breakdown of Fatal + Injury (F+I) and Property Damage Only (PDO) crashes. The resulting total number of annual predicted crashes is 26.0 for the DLLR concept, 17.2 for the DDI concept, and 22.9 predicted crashes for the No-Build condition. The No-Build and Build detailed IHSDM results sheets are provided in Appendix 6.
Table 7: 2023 to 2045 Predicted Build and No-Build Annual Crash Frequencies

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<th>Ramps F+I</th>
<th>Ramps PDO</th>
<th>Ramp Terminals F+I</th>
<th>Ramp Terminals PDO</th>
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As shown, the majority of predicted crashes for all scenarios occur on the freeway and at the ramp terminal intersections. The freeway crashes for the Build scenarios introduce small changes in the predicted number of crashes versus the No-Build. The ramp crashes are expected to increase due to added lanes and additional length on some of the ramps.

Focusing on the ramp terminals, the DLLR ramp terminal crashes are expected to increase by 8% and the DDI ramp terminal crashes are expected to be reduced by 56%. The reduction for the DDI is consistent with what would be expected from eliminating left-turns with the DDI concept. The DLLR findings are more surprising given that the loop ramp re-aligns a significant amount of traffic from a left turn movement to a right turn movement at the northbound ramp terminal. A more in-depth review of this site does show that the DLLR reduces total crashes from 7 crashes per year to 2.5 crashes per year, consistent with the significant amount of traffic that has moved to the loop ramp and no longer would be in conflict with cross street traffic. This means the net increase in ramp terminal crashes is projected to happen entirely at the southbound ramp terminal. The primary consideration in this increase is the traffic control device at the intersection as the No-Build assumes a continuation of the stop-controlled condition where the DLLR alternative recommends a traffic signal to improve traffic operations. Since there is not a traffic signal planned for the southbound ramp terminal, it was not considered for the No-Build scenario, even though operations would degrade to a failing level of service condition if volumes increased to the 2045 forecasted levels.

Considering predicted crash severity, the DDI concept may decrease the number of F+I crashes at the ramp terminals by 63% while the DLLR concept may increase F+I crashes by 17%. In addition, the DDI concept may decrease the number of PDO crashes at the ramp terminals by 51% while the DLLR concept may increase by 2%. This result took into account the significant reduction in F+I crashes observed at DDIs compared to standard diamond interchanges in the Missouri research (63% reduction).

**Safety Conclusions**

Based on the preceding HSM analysis, it is concluded that the DDI interchange is likely to exhibit significantly less overall crash frequencies than the existing diamond interchange. The DLLR would likely result in an increase in crashes, but this is due to a longer northbound ramp, and the southbound terminal being signalized instead of stop-controlled. The northbound terminal, in this scenario, would be expected to have a decrease in crashes compared to the No-Build. The freeway crashes for the Build scenarios introduce small changes in the predicted number of crashes versus the No-Build. The ramp crashes are expected to increase due to added lanes and additional length on some of the ramps. The ramp terminal crashes are expected to be reduced by 56% for the DDI and increased by 8% for the DLLR. The DDI has an even better crash benefit when looking at F+I crashes. The DDI reduces F+I crashes at the ramp terminals by 63%, compared to an increase of 19% for the DLLR. The PDO crashes at the ramp terminals are reduced by 51% for the DDI and an increase of 2% for the DLLR. The DDI
alternative would be expected to provide significant safety benefits compared to the No-Build, but the DLLR alternative would likely result in an increase of crashes compared to the No-Build.

3.4 Alternatives Analysis

Option 1a: 2 Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp

Option 1a (Figure I-1) proposes a northbound off-ramp with separation of eastbound and westbound traffic on Benson Road. This separation reduces the amount of vehicles queued at the existing signal and the eastbound off ramp skew supports one-way eastbound turning movement. On Benson Road the additional proposed eastbound lane, increased to three total from Lewis Avenue to the east to I-229 and the three lane southbound on-ramp also reduces queuing significantly.

Benefits of Option 1a:

- Free flow northbound I-229 to westbound Benson Road due to loop and no signal.
- Traffic Level of Service (LOS) B is forecast at the interchange for year 2045 conditions.
- Pedestrian underpass reduces conflict with vehicles using the northbound on ramp and the larger volume of traffic on the loop ramp for the westbound Benson Road traffic.
- Free-flow dual rights on Benson Road eastbound to I-229 southbound reduces congestion/queuing on Benson Road between Lewis Avenue and I-229. Free-flow is only interrupted for pedestrian movement.
- Access management treatments considered with installation of raised median.

Drawbacks of Option 1a:

- The construction of the ramps requires substantial right of way acquisition and grading costs associated with constructing a new loop ramp and removal of the existing ramps.
- Option 1a could result in additional crashes compared to the no-build due to added lanes and additional length on some of the ramps.
- Although the pedestrian underpass in this option reduces conflict, the additional cost per pedestrian and bicycle user is high.
- Due to the increased right of way and grading impacts to environmental resources are higher with this option compared to non-loop ramp options.

It is recommended that Option 1a be eliminated from further evaluation for these reasons:

- Total right of way necessary to be acquired.
- High construction cost

Option 1b: 2 Lane Northeast Quadrant Loop with 2-Lane SB On-Ramp

Option 1b (Figure I-2) is very similar to Option 1a. Proposes a northbound off-ramp with separation of eastbound and westbound traffic on Benson Road. This separation reduces the amount of vehicles queued at the existing signal and the eastbound off ramp skew supports one-way eastbound turning movement. The proposed Benson Road eastbound lanes and two
southbound on-ramp lanes from Lewis Avenue to the east to the southbound on-ramp also reduces queuing, however, not as efficient as Option 1a.

Benefits of Option 1b:
- Free flow northbound I-229 to westbound Benson Road due to loop and no signal.
- Traffic Level of Service (LOS) B is forecast at the interchange for year 2045 conditions.
- Pedestrian underpass reduces conflict with vehicles using the northbound on-ramp and the larger volume of traffic on the loop ramp for the westbound Benson Road traffic.
- Single free-flow right turn lane on Benson Road eastbound to I-229 southbound reduces congestion/queuing on Benson between Lewis Avenue and I-229. Free-flow is only interrupted for pedestrian movement.
- Access management treatments considered with installation of raised median.

Drawbacks of Option 1b:
The construction of the ramps requires a substantial amount of right of way acquisition and grading costs associated with constructing a new loop ramp and removal of existing ramps.
- Option 1b is anticipated to create more crashes compared to the no-build due to added lanes and additional length on some of the ramps.
- Although the pedestrian underpass in this option reduces conflict, the additional cost per pedestrian and bicycle user is high.

It is recommended that Option 1b be eliminated from further evaluation for these reasons:
- Total right of way necessary to be acquired.
- High construction cost.

Option 1c: 2-Lane Collector – Distributor (CD) Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp

Option 1c (Figure I-3) proposes a northbound off-ramp with separation of eastbound and westbound traffic on Benson Road while reducing the grading and right of way necessary by implementing a Collector-Distributor lane. The separation of eastbound and westbound vehicles on Benson Road is similar to Options 1a and 1b. The additional proposed eastbound lanes, totaling three, on Benson Road from Lewis Avenue to the east to the southbound on-ramp also reduces queuing significantly.

Benefits of Option 1c:
- The CD lane reduces the amount of right of way acquisition and grading costs associated with the northbound off-ramp.
- Free flow northbound I-229 to westbound Benson Road due to loop and no signal.
- Traffic Level of Service (LOS) B is forecast at the interchange for year 2045 conditions.
- Pedestrian underpass reduces conflict with vehicles using the northbound on-ramp and the larger volume of traffic on the loop ramp for the westbound Benson Road traffic.
- Dual rights on Benson Road for eastbound to I-229 southbound reduces congestion/queueing on Benson Road eastbound between Lewis Avenue and I-229.
• CD lane enhances safety by allowing more distance and separation for vehicles slowing to exit and remain adjacent to the high-speed mainline.

Drawbacks of Option 1c:
• Option 1c is anticipated to create more crashes compared to the no-build due to added lanes and additional length on some of the ramps.
• Although the pedestrian underpass in this option reduces conflict, the additional cost per pedestrian and bicycle user is high.

It is recommended that Option 1c be eliminated from further evaluation for this reason:
• High construction cost.

Option 1d: 2-Lane Partial Clover Leaf Northeast Quadrant Loop with 2-Lane SB On-Ramp

Option 1d (Figure I-4) proposes a signalized loop at the intersection of Benson Road. Right-turn on red would not be allowed.

Benefits of Option 1d
• Access Management treatments considered with installation of raised median

Drawbacks of Option 1d:
• Does not meet Purpose and Need. The Level of Service falls below the acceptable level C because the right turn on red movements would not be allowed to operate as a free-flow movement.
• The construction of the ramps requires substantial right of way acquisition and grading costs associated with constructing a new loop ramp and removal of the existing ramps.

It is recommended that Option 1d be eliminated from further evaluation for these reasons:
• This option does not meet the acceptable Level of Service.
• Total right of way necessary to be acquired.
• High construction cost

Option 1e: 2-Lane Partial Clover Leaf Northeast Quadrant Loop with CD Lane 2-Lane and 2-SB On-Ramp

Option 1e (Figure I-5) proposes is similar to Option 1d with the exception of the CD lane. Right turn on red will not be allowed at the off-ramp for westbound traffic on Benson Road.

Benefits of Option 1e:
• Access management treatments considered with installation of raised median.
Drawbacks of Option 1e:

- Does not meet Purpose and Need. The Level of Service falls below the acceptable Level C because the right turn on red movements would not be allowed to operate as a free-flow movement.
- The construction of the ramps requires substantial right of way acquisition.

It is recommended that Option 1e be eliminated from further evaluation for these reasons:

- This option does not meet the acceptable Level of Service.
- Total right of way necessary to be acquired.

Option 4a: Diverging Diamond Interchange (DDI) with 3-Lane SB On-Ramp; Add 2 WB Lanes to Existing Overpass

Option 4a (Figure I-6) proposes a diverging diamond interchange with a three lane southbound on-ramp for eastbound traffic on Benson Road. This option proposes adding onto the existing structure and converting it to a DDI. The existing structure would be the four westbound lanes.

Benefits of Option 4a:

- Fewer crashes expected compared to the other build alternatives developed. The predicted annual traffic accidents reduces 25% from the no-build option.
- Traffic Level of Service (LOS) C is worst case forecast at the interchange in the morning for the northbound ramp for year 2045 conditions.
- Cost of construction reasonable due to limited amount of grading and reduced right of way acquisition.
- Requires no additional right of way on I-229.
- Fewer impacts to wildlife habitat, wetlands, and other environmental resources due to less grading and right of way.

Drawbacks of Option 4a:

- Adding onto the existing overpass to accommodate the DDI adds cost compared to a new structure over I-229. Cost of this structure is similar but slightly lower compared to other options.
- Out of the two DDI’s the construction costs for this option are the higher of the two.

It is recommended that Option 4a be carried forward for further evaluation and refinement for these reasons:

- Expected reduction in annual total crash numbers resulting in improved safety
- Lower construction cost than the other options
- Fewer environmental impacts
Option 4b: Diverging Diamond Interchange (DDI) with 3-Lane SB On-Ramp. Add a Separate Structure for 2 EB Lanes.

Option 4b (Figure I-7) proposes a diverging diamond interchange with a three lane southbound on-ramp for eastbound traffic on Benson Road. This option proposes constructing a new and separate structure for the future two eastbound lanes of the DDI and converting the existing structure into the four lanes for the westbound traffic.

Benefits of Option 4b:

- Least amount of crashes expected compared to other build alternatives developed. The predicted annual traffic accidents reduces 25% from the no-build option.
- Traffic Level of Service (LOS) C is worst case forecast at the interchange in the morning for the northbound ramp for year 2045 conditions.
- This option has the lowest estimated construction cost due to limited amount of grading and reduced right of way lower structure costs.
- Requires no additional right of way on I-229.
- Fewer impacts to wildlife habitat, wetlands, and other environmental resources due to less grading and right of way.
- Out of the two DDI’s, using the existing structure for maintenance of traffic creates the least amount of impact.

Drawbacks of Option 4b:

- Adding the proposed structure to the north of the existing structure may require additional coordination with private utilities.

It is recommended that Option 4b be carried forward for further evaluation and refinement for these reasons:

- Reduced number of annual total crashes; increased safety
- Lower construction cost than the other options
- Fewer environmental impacts

The Build Options Evaluation Memo and corresponding evaluation matrix is provided in Appendix 7. A summary of the build option recommendations are provided in Table 8 and Table 9.
Table 8 - Build Options to Carry Forward

Options recommended to be carried forward for further refinement and evaluation

<table>
<thead>
<tr>
<th>Option</th>
<th>Interchange Description</th>
<th>Main reason(s) for carrying forward</th>
</tr>
</thead>
</table>
| 4a     | Diverging Diamond Interchange (DDI) with 3-Lane SB On-Ramp. Add 2 WB Lanes to Existing Overpass | • Minimal cost and impacts compared to other options  
• Increase in safety compared to other options  
• Decrease in traffic accidents compared to no-build by 25%  
• Less impact to environmental resources |
| 4b     | Diverging Diamond Interchange with 3-Lane SB On-Ramp. Add a Separate Structure for 2 EB Lanes | • This option is the least expensive of all the options discussed  
• Increase in safety compared to other options  
• Decrease in traffic accidents compared to no-build by 25%  
• Less impact to environmental resources |

It is recommended that both options be justified within the Interchange Modification Study and final bridge option will be determined during preliminary and final design.

Table 9 - Build Options to Eliminate

Options recommended to be eliminated from further evaluation

<table>
<thead>
<tr>
<th>Option</th>
<th>Interchange Description</th>
<th>Main reason(s) for not carrying forward</th>
</tr>
</thead>
</table>
| 1a     | 2-Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp | • Additional right of way acquisition  
• High construction cost |
| 1b     | 2-Lane Northeast Quadrant Loop with 2-Lane SB On-Ramp | • Additional right of way acquisition  
• High construction cost |
| 1c     | 2-Lane Collector – Distributor (CD) Lane Northeast Quadrant Loop with 3-Lane SB On-Ramp | • High construction cost  
• Greater impact to environmental resources |
| 1d     | 2-Lane Partial Clover Leaf Northeast Quadrant Loop with 2-Lane SB On-Ramp | • This option does not meet the acceptable Level of Service  
• Additional right of way acquisition  
• High construction cost  
• Greater impact to environmental resources |
| 1e     | 2-Lane Partial Clover Leaf Northeast Quadrant Loop with CD Lane 2-Lane and 2-SB On-Ramp | • This option does not meet the acceptable Level of Service.  
• High construction cost  
• Greater impact to environmental resources |

3.5 Conceptual Signing Plan

A conceptual signing plan for each design alternative is provided in **Appendix 8**.
4.0 Funding Plan

The Benson Road Interchange project PE is programmed in the Statewide Transportation Improvement Program (STIP) for 2022 with construction in the 2023-2025 timeframe. Current SDDOT Budget Estimates for the interchange improvements are shown below.

Table 10 - Anticipated Funding Allocation

<table>
<thead>
<tr>
<th>Project Number</th>
<th>State Funding Category</th>
<th>Federal Funding Category</th>
<th>Federal Funds ($ million)</th>
<th>State Funds ($ million)</th>
<th>Other Funds ($ million)</th>
<th>Total Funds ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM 2292(98)6 P, PCN 04XX</td>
<td>Interstate</td>
<td>National Highway Performance Program (NHPP)</td>
<td>15.036</td>
<td>2.464</td>
<td>0</td>
<td>17.5</td>
</tr>
<tr>
<td>P 1200 ( ) P, PCN 06MM</td>
<td>Local Urban Systems</td>
<td>Surface Transportation Block Grant (STBG)</td>
<td>9.691</td>
<td>2.809</td>
<td>0</td>
<td>12.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>24.727</strong></td>
<td><strong>5.273</strong></td>
<td><strong>0</strong></td>
<td><strong>30.000</strong></td>
</tr>
</tbody>
</table>

Note: As funding is fluid, category breakdown may be different at time of project authorization.

Inflated costs to year of implementation are calculated at $34.0 million.

5.0 Recommendation

The results of this technical analysis indicate that a modified interchange configuration on I-229 at Benson Road in Sioux Falls, SD will provide future operational and safety benefits. Further, the analysis indicates that a diverging diamond interchange configuration is the recommended option and will have fewer environmental impacts than the other build interchange alternatives. The recommended diverging diamond interchange alternatives are displayed in Figure I-6 and Figure I-7 following the considerations and requirements for Interstate access.

The two considerations and requirements for the Interstate access are addressed below:

1. An operational and safety analysis has concluded that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facility (which includes mainline lanes, existing, new, or modified ramps, and ramp intersections with crossroad) or on the local street network based on both the current and the planned future traffic projections. The analysis should, particularly in urbanized areas, include at least the first adjacent existing or proposed interchange on either side of the proposed change in access (Title 23, Code of Federal Regulations (CFR), paragraphs 625.2(a), 655.603(d) and 771.111(f)). The crossroads and the local street network, to at least the first major intersection on either side of the proposed change in access, should be included in this analysis to the extent necessary to fully evaluate the safety and operational impacts that the proposed change in access and
other transportation improvements may have on the local street network (23 CFR 625.2(a) and 655.603(d)). Requests for a proposed change in access should include a description and assessment of the impacts and ability of the proposed changes to safely and efficiently collect, distribute, and accommodate traffic on the interstate facility, ramps, intersection of ramps with crossroad, and local street network (23 CFR 625.2(a) and 655.603(d)). Each request should also include a conceptual plan of the type and location of the signs proposed to support each design alternative (23 U.S.C. 109(d) and 23 CFR 655.603(d)).

The operational and safety analysis contained in this study shows that the proposed Diverging Diamond build scenarios are not expected to adversely affect the safety or efficiency of the Interstate system, including the mainline lanes, modified ramps, ramp intersections with the crossroad, and local street network based upon the current and future traffic projections. The Build and No-build scenarios were evaluated for operational capacity using Highway Capacity Manual 2010 techniques via HCS 2010. All Build scenarios maintain a LOS “C” or better for all Interstate facilities for the build year (2023) and future year (2045) forecast traffic volumes. Additionally, a predictive safety analysis was completed for the Build and No-build scenarios using the AASHTO HSM method, including the NCHRP Report 17-45 method for evaluating freeways and interchanges via the IHSDM version 13.1.0 software. The recommended diverging diamond interchange configuration is likely to exhibit significantly less overall crash frequencies than the existing diamond interchange.

All recommended build alternatives are also expected to improve access management and satisfactorily accommodate design year traffic volumes on the crossroad in the vicinity of the interchange. The crossroad in the vicinity of the interchange (Benson Road) was also evaluated for operational capacity and maintains a minimum LOS “C” at the interchange ramp terminals and meets minimum LOS thresholds as established by the local jurisdiction for signalized intersections on arterial streets under 2045 forecast traffic volumes. Access management on the arterial corridor will be achieved with the installation of a median and limiting left turns to specific street intersections.

The study area included the interchanges north and south of the Benson Road interchange and extends from Exit 7 (Rice Street) to Exit 10 (I-90) on I-229. The adjacent interchange ramps and Interstate segments were analyzed under 2023 and 2045 traffic forecast volumes and are expected to operate at LOS “C” or better.

The conceptual signing plan for the recommended Diverging Diamond alternative is displayed following the considerations and requirements for Interstate access section of this report. A conceptual signing plan has been developed and included in Section 8 of the Appendix for each additional design alternative.

2. The proposed access connects to a public road only and will provide for all traffic movements. Less than "full interchanges" may be considered on a case-by-case basis for applications requiring special access, such as managed lanes (e.g., transit or high occupancy vehicle and high occupancy toll lanes) or park and ride lots. The proposed access will be designed to meet or exceed current standards (23 CFR 625.2(a), 625.4(a)(2), and 655.603(d)). In rare instances where all basic movements are not provided by the proposed design, the report should include a full-interchange option with a comparison of the operational and safety analyses to the partial-interchange option. The report should also include the mitigation proposed to compensate for the missing movements, including wayfinding signage, impacts on local intersections, mitigation of driver expectation leading to wrong-way movements on ramps, etc. The
The proposed access is a reconfiguration of an existing interchange with full access to an arterial city street and includes all movements. The proposed change does not result in any new access points on the Interstate Highway System. The conceptual drawings have been prepared using current standards and further design using current standards is anticipated. Additional refinement will take place during the environmental and design phases of the project.
Alternative Scenario 4a
Diverging Diamond Interchange with 3-Lane SB On-Ramp
Add 2 WB Lanes to Existing Overpass.
I-229 Exit 9 (Benson Road) IMJR

Benson 4a Option Features:
- Diverging Diamond interchange configuration.
- Widen existing Benson Road bridge.
- Realign west I-229 ramps to maximize separation distance to Potsdam Avenue.
- 2-lane free right turn movement for EB Benson Road to SB I-229 traffic.

Note:
- Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.

Note:
- Control of Access to be provided on east side of interchange. Minimum length to be 660'. Final Control of Access to be determined during final design.
Add a Separate Structure for 2 EB Lanes

Diverging Diamond Interchange with 3-Lane SB On-Ramp

Benson 4b Option Features:
- Diverging Diamond Interchange configuration.
- Existing Benson Road bridge will be used for WB traffic only. EB traffic will be on proposed separate bridge to the north of the existing.
- Realign west I-229 ramps to maximize separation distance to Potsdam Avenue.
- 2-lane free right turn movement for EB Benson Road to SB I-229 traffic.

Note:
Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage

Note:
Control of Access to be provided on east side of interchange. Minimum length to be 660'. Final Control of Access to be determined during final design.

Legend:
- Interchanges/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Retaining Wall
- Existing ROW / Property Line
- Existing Control of Access
- Proposed Control of Access
- ROW Acquisition
- Road Closure
- Signalized Intersection
- Number of Traffic Lanes

Scale in Feet

Note:
Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage

Note:
Control of Access to be provided on east side of interchange. Minimum length to be 660'. Final Control of Access to be determined during final design.
Alternative Scenario Benson Road
Westbound 3rd Lane from Lewis Avenue to I-229

I-229 Exit 9 (Benson Road) IMJR
Sioux Falls, SD

Benson C1a Option Features:
- WB 3rd lane from Lewis Avenue to I-229.
- EB 3rd lane from Casco Avenue to I-229.
- Raised center median with left turn lanes.
- Widen Lewis Avenue intersection on south side of Benson Road.
- WB and EB 3/4 access at Potsdam Avenue.

Note: Southbound Lewis Avenue existing section to be restriped to provide additional left turn storage.
Alternate Scenario Benson Road
4-Lane Divided Section to Hall Avenue east of I-229

I-229 Exit 9 (Benson Road) IMJR

Sioux Falls, SD

Note:
Control of Access to be provided on east side of interchange. Minimum length to be 660'. Final Control of Access to be determined during final design.

Benson C1 Option Features:
- Future Benson Road extension across the Big Sioux River.
- 2 lanes in each direction with raised median and left turn lane on Benson Road from I-229 to Sycamore Avenue.
Alternative Scenario 4a
Diverging Diamond Interchange with 3-Lane SB On-Ramp. Add 2 WB Lanes to Existing Overpass.
I-229 Exit 9 (Benson Road) IMJR

Legend
- Interchange/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Road Closure
- Signalized Intersection

The existing ½ mile and 1 mile advance guide signs for I-229 SB Exit 9 to remain.
Alternative Scenario 4b
Diverging Diamond Interchange with 3-Lane SB On-Ramp. Add a Separate Structure for 2 EB Lanes.

I-229 Exit 9 (Benson Road) IMJR

The existing ½ mile and 1 mile advance guide signs for I-229 SB Exit 9 to remain.
Alternative Scenario Benson Road
Westbound 3rd Lane from Lewis Avenue to I-229.
I-229 Exit 9 (Benson Road) IMJR

Legend
- Interchange/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Road Closure
- Signalized Intersection

Figure
S-A-1
Alternative Scenario Benson Road
4-Lane Divided Section to Hall Avenue east of I-229.
I-229 Exit 9 (Benson Road) IMR

Legend
- Interchange/Ramp/Loop Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Bridge Construction
- Road Closure
- Signalized Intersection

Sioux Falls, SD

Figure S-A-2

Page dimensions: 1224.0x792.0

Sioux Falls, SD

Date: Drawn By: Chked By:

Revision: Date:

Figure I-229 Exit 9 (Benson Road) IMJR

P.Sanow
B.Miller
7/30/2018
7/30/2018

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4-Lane Divided Section to Hall Avenue east of I-229.

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Legend
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- Road Closure
- Bridge Construction
- Pedestrian Underpass Construction
- Raised Median Construction
- Interchange/Ramp/Loop Construction

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APPENDIX

1 - Purpose and Need
2 - Methods and Assumptions Document
3 – Technical Memo - Existing Traffic Conditions
4 – Technical Memo - Existing Conditions Crash Analysis
5 – Technical Memo - Future Traffic Conditions
6 – Technical Memo - Predictive Crash Analysis
7 – Technical Memo - Interchange Options Evaluation
8 - Conceptual Signing Plans

Appendices are available upon request, but have been removed from the web version to maintain a reasonable file size for downloading.