

# US16 / US16B / Catron Boulevard Intersection Alternatives Report

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US16 / US16B / Catron Boulevard Intersection  
Study

*Rapid City, South Dakota*  
December 23, 2016

Prepared for and in coordination with



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# 1. Introduction

## 1.1 Study Purpose

Recent development on the south side of Rapid City has created a need for defining and preserving the study corridor. A detailed traffic analysis of the US16 and US16B / Catron Boulevard corridors, and more specifically the US16 & US16B / Catron Boulevard intersection, will aid in determining current and future needs for the intersection and provide a framework for future development. The study will also address access along the corridor and evaluate the peripheral street network. An environmental overview was performed to identify any potential conflicts and provide guidance as the project moves forward.

A previous study with a similar scope was conducted in 2007. The 2007 study was driven largely by development, including a proposed Walmart facility. The study was terminated abruptly when Walmart decided to build further east, near the 5<sup>th</sup> Street area. At the same time, development dropped off with the nationwide economic downturn. This study evaluates several of the intersection alternatives for US16 & US16B / Catron Boulevard that were considered in 2007. Prior to this, a US16 Corridor Study was completed in 2004. The purpose of the 2004 Study was to help the City and the State improve the safety and efficiency of the corridor for the traveling public, through the implementation of good access management. The 2004 report assumed a future interchange would be needed at the US16 & US16B / Catron Boulevard intersection. With the recent advancement in alternative intersection and interchange designs, additional options were included and evaluated with the current study. See Appendix A for the Methods and Assumptions Documentation.

## 1.2 Location of Study

The study area is located at the southern limits of the City of Rapid City in western South Dakota as shown in Figure 1. The focal point of the study is the intersection of US16 & US16B / Catron Boulevard. The traffic analysis area spans the US16 corridor between Promise Road on the north and Sammis Trail on the south. Traffic was also evaluated along US16B / Catron Boulevard between 5<sup>th</sup> Street and US16, and along Catron Boulevard extending west from 5<sup>th</sup> Street to Sheridan Lake Road. Options for the west rearage road and peripheral street network are also evaluated.

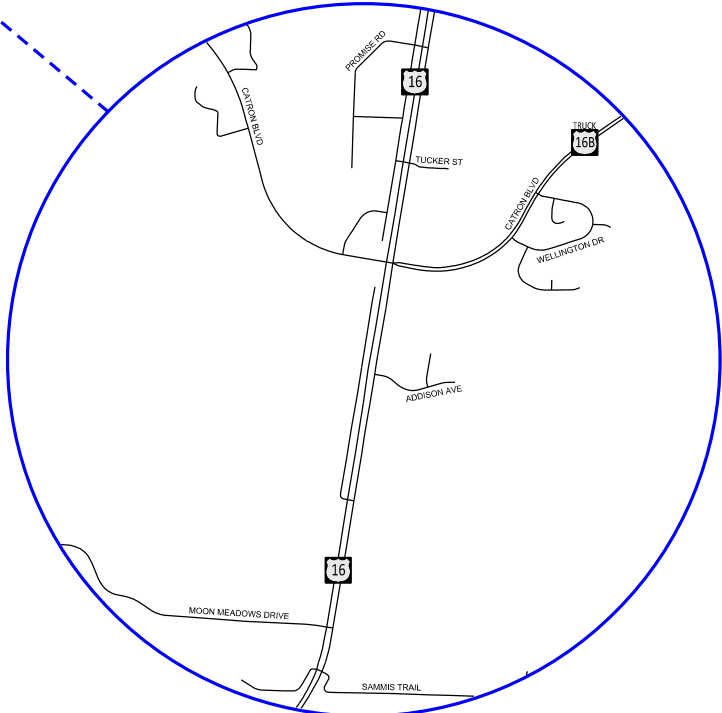
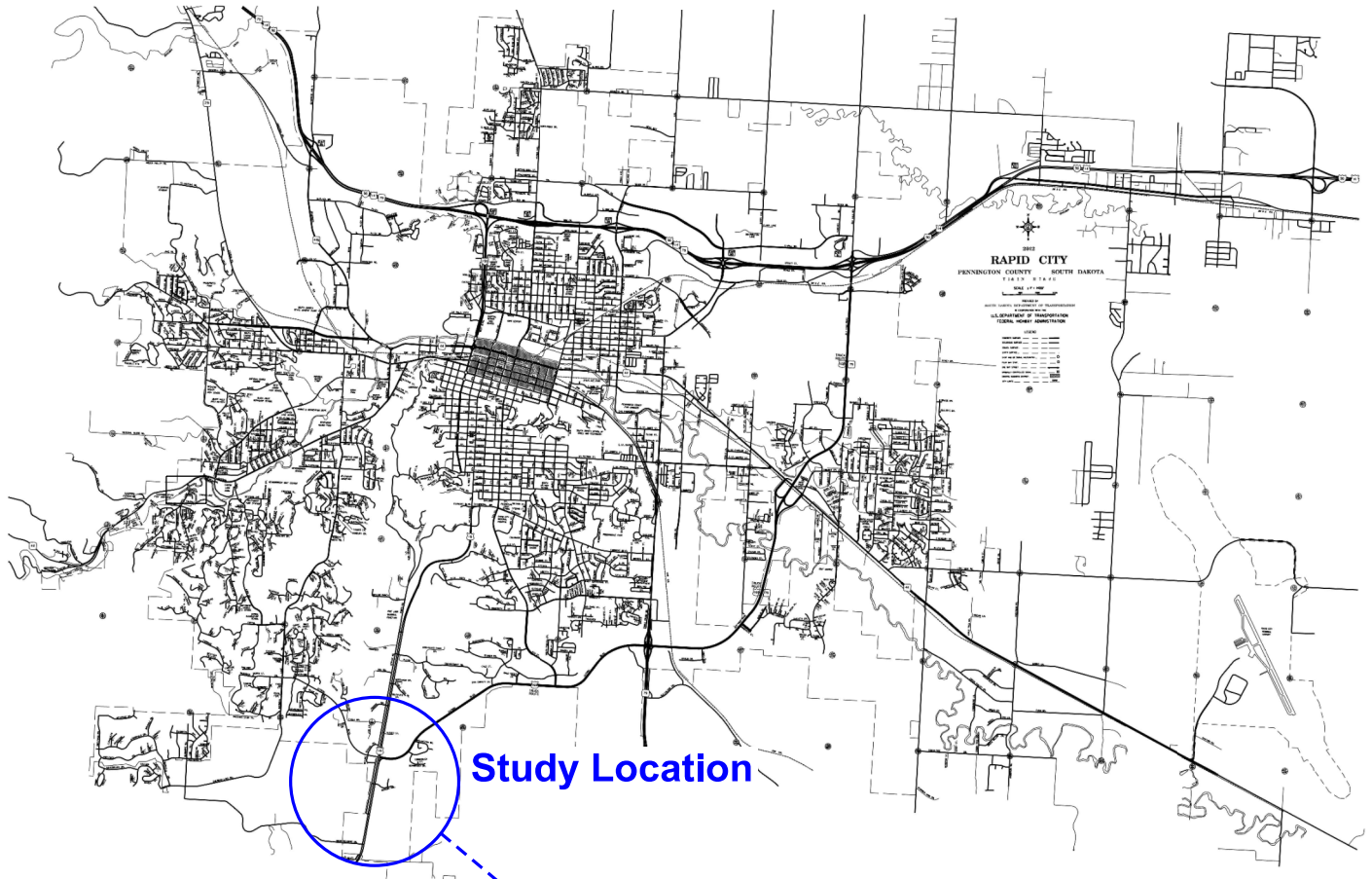
## 1.3 Neighborhood Development

The Rapid City Comprehensive Plan (2014) was reviewed for anticipated future land use. The study area falls within the US Highway 16 Neighborhood Area as identified in the Comprehensive Plan. Based on the plan, the US16 corridor within the study area and the US16 & US16B / Catron Boulevard intersection will be generally bounded by Mixed Use Commercial development. There is a block of land classified as Urban Neighborhood on the west side of US16, which has been shown as commercial land use in previous planning efforts. US16B / Catron Boulevard is generally bounded by commercial development within the intersection project limits and residential use outside the project limits. An excerpt from the Comprehensive Plan is shown in Figure 2.

Several recent development plans submitted to the City of Rapid City have implications for the study:

- Black Hills Corporation Traffic Impact Analysis (June 2015)
- Buffalo Crossing Traffic Impact Analysis (August 2015)
- Moon Meadows Development Traffic Impact Analysis, Fourth Edition (July 2014)
- Skyline Village Apartments Traffic Impact Study (April 2012) & Copper Ridge Subdivision (April 2015)

# RAPID CITY



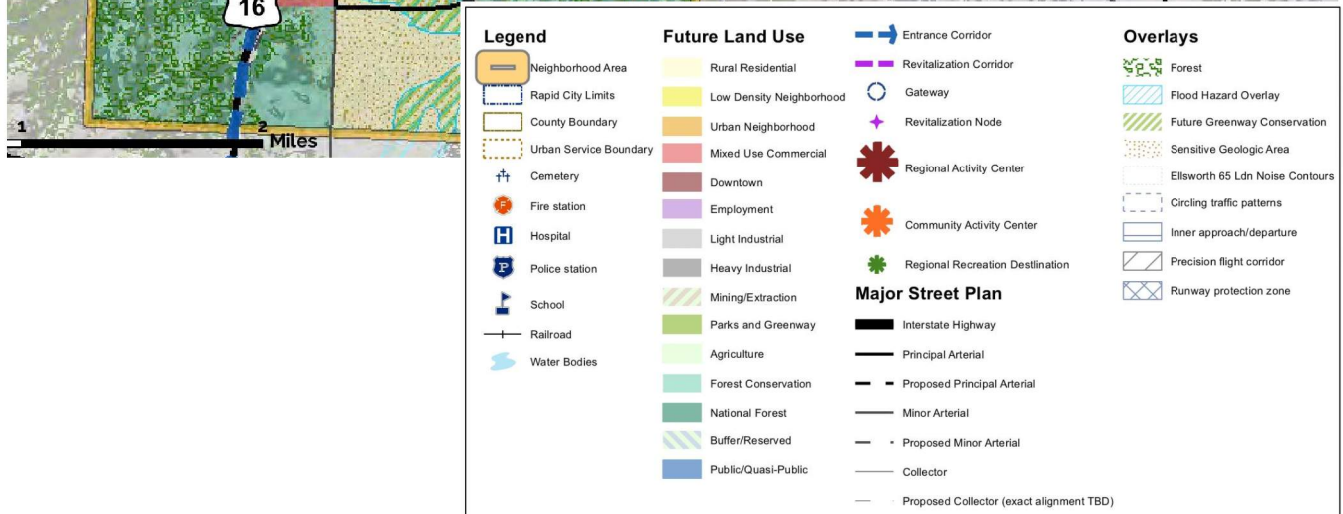
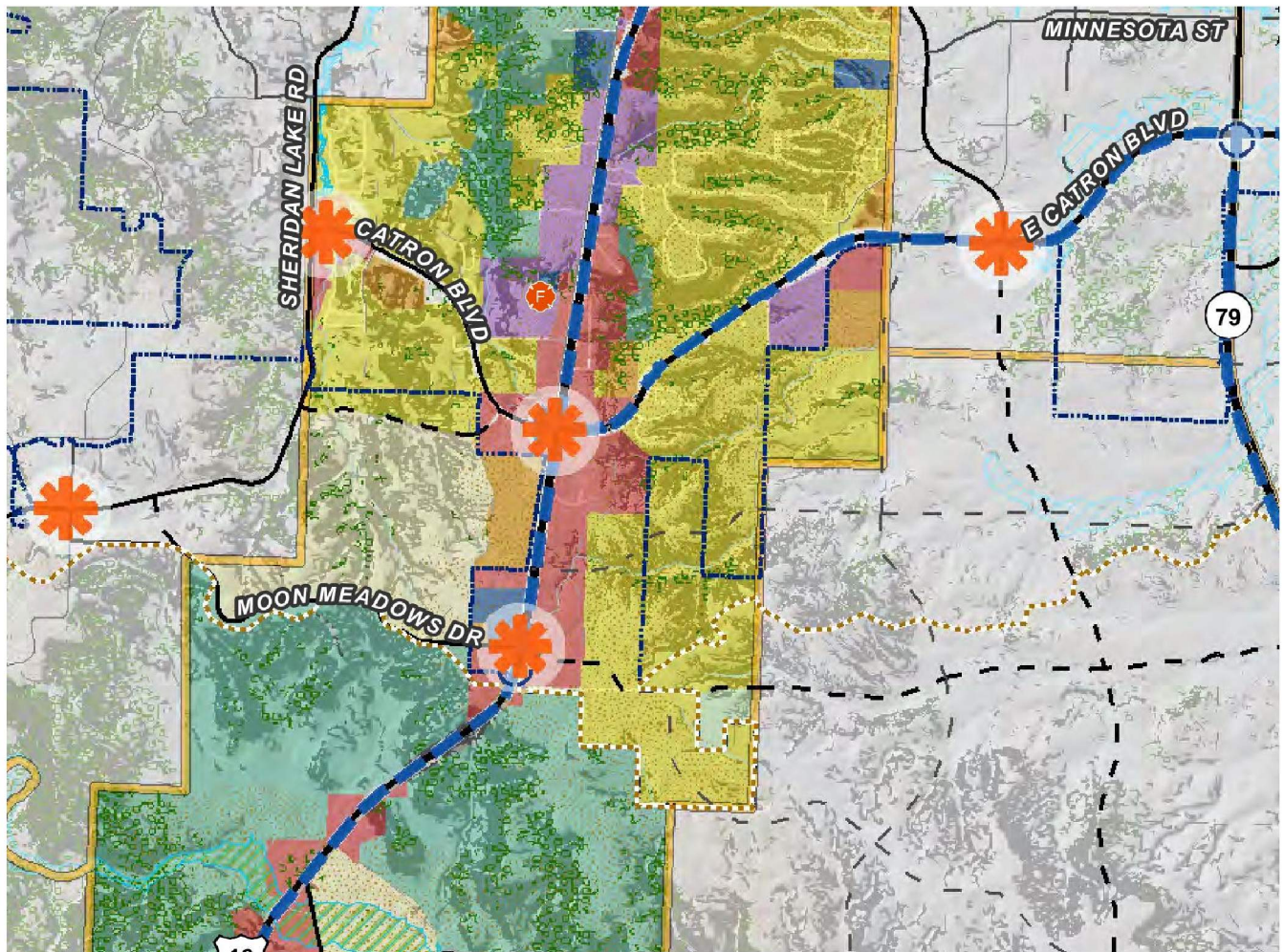
**Study Location**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

1





**Future Land Use**

From Rapid City Comprehensive Plan (2014)

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

2



The Black Hills Corporation site is located in the southwest quadrant of the US16 & US16B / Catron Boulevard intersection. At the time of this report, a significant amount of grading had been completed and construction of the buildings had commenced. The Traffic Impact Analysis (TIA) indicated that a traffic signal would be required at the proposed Les Hollers Way & Catron Boulevard intersection.

The Buffalo Crossing site is located on the southeast quadrant of the US16 & US16B / Catron Boulevard intersection, where an outdoor water park used to be located. The proposed development includes a gas station, hotel, and health care facility. Some of the grading has been completed for the future rearage road, Healing Way, which will provide access to the property.

The Moon Meadows Development is located east of US16 and north of Sammis Trail. At the time of the study, Moon Meadows Drive had been extended east of US16 and the east leg of the Sammis Trail intersection was closed and re-routed to Moon Meadows Drive. The TIA indicated that a traffic signal would be required at the US16 & Moon Meadows Drive intersection once the site develops.

The Skyline Village Apartments Traffic Impact Study (TIS) addresses the area that is currently known as Copper Ridge Subdivision. The development includes an apartment complex located west of Promise Road (northwest of the US16 & US16B / Catron Boulevard intersection). Several new buildings have been constructed and are available for leasing. This site is far enough away that it will have little implication on the intersection alternatives, but it will be a consideration for the peripheral street network.

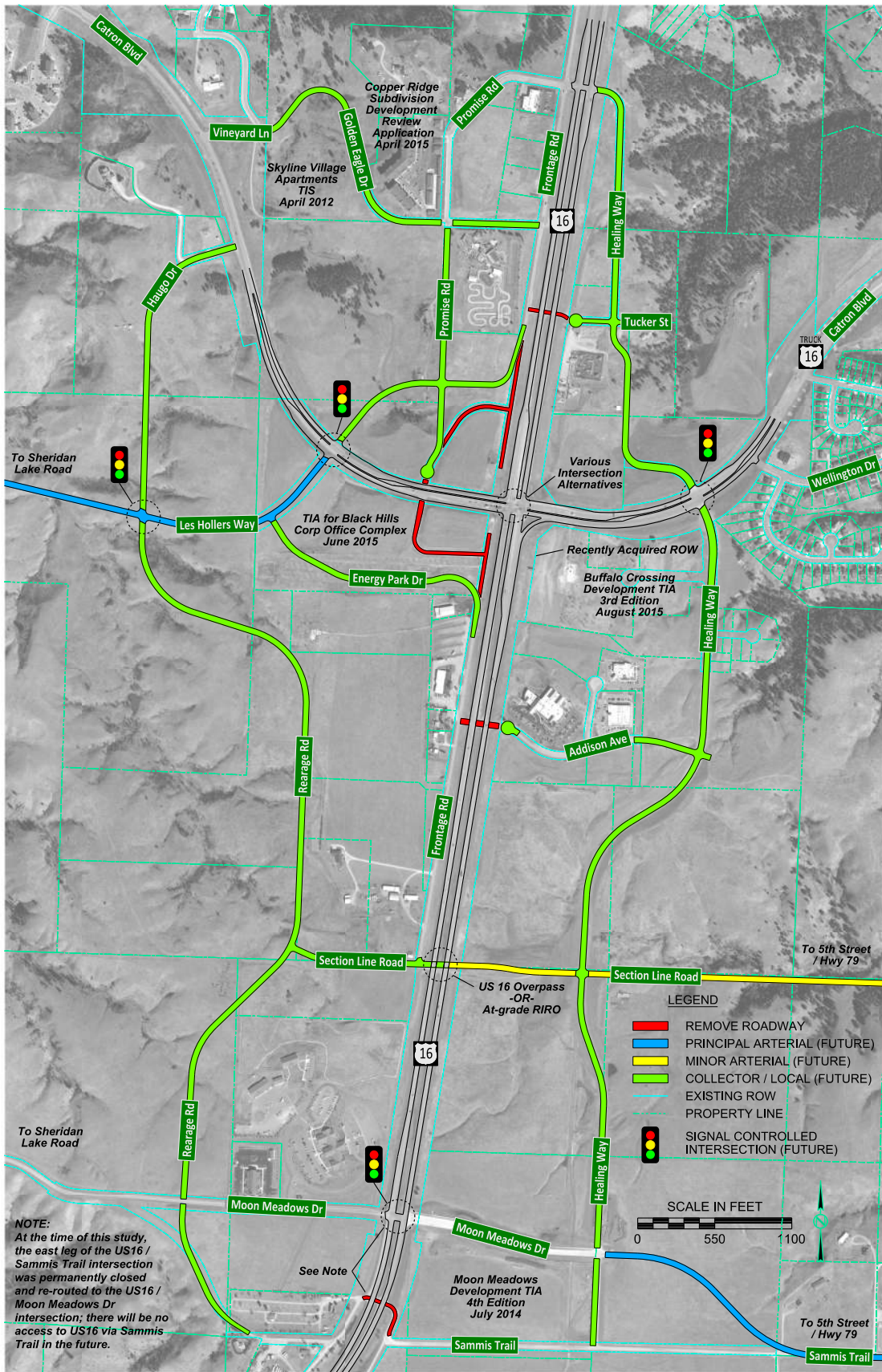
Development plans discussed in this section and associated documentation are included in Appendix L.

## 1.4 Peripheral Street Network

The study scope includes an evaluation of the west rearage road layout. The City of Rapid City Major Street Plan (2015) was used as a reference point for developing two options for the peripheral road network. The Major Street Plan shows Healing Way (the east rearage road) as a future collector and Section Line Road east of US16 is classified as a future minor arterial. US16, US16B / Catron Boulevard, and Moon Meadows Drive are classified as principal arterials. Additionally, Les Hollers Way is considered to be a future principal arterial that continues west to Sheridan Lake Road.

Two layouts for the peripheral street network were developed and are shown in Figures 3 and 4. Options for the west rearage road are limited when accounting for the Copper Ridge and Black Hills Corporation Development Plans. Figure 3 (Option 1) attempts to honor the existing development plans and Major Street Plan. Figure 4 (Option 2) attempts to provide better traffic flow through the northwest quadrant by connecting Promise Road directly to Les Hollers Way at Catron Boulevard. Similarly, the Copper Ridge area is connected directly to Haugo Drive at Catron Boulevard, which continues south becoming the west rearage road.

If warranted due to development, another signalized intersection could be installed on Les Hollers Way at the Haugo Drive intersection. A traffic signal at Les Hollers Way & Energy Park Drive would not meet City standards for intersection spacing requirements (minimum spacing of 1,200 feet is required between a signalized access and signalized intersection). Option 2 includes an extension between the Black Hills Corporation site and the west rearage road providing a route to the potentially signalized intersection. Option 2 includes other slight modifications to the rearage road at it continues south. Option 1 utilizes more of the existing right-of-way (ROW) at Sammis Trail, while Option 2 hugs the property line. The Section Line Road and west rearage road were shifted in some locations to avoid potential cultural sites.



### Peripheral Street Network - Option 1

Based on Development and Major Street Plans  
 US16 / US16B / Catron Blvd Study Rapid City, SD

Figure





## 2. Existing Conditions

### 2.1 Existing Conditions Traffic

The traffic study area includes the US16 corridor between Promise Road and Sammis Trail, the US16B / Catron Boulevard corridor between 5<sup>th</sup> Street and US16, and the Catron Boulevard corridor between US16 and Sheridan Lake Road. Intersections that were included in the traffic analysis are shown in Figure 5. Several of the intersections do not currently exist and were not included in the existing conditions analysis. Peak hour turning volumes were obtained from traffic counts collected in 2015.

Figure 6 shows the existing lane configuration at the study intersections. The US16 & US16B / Catron Boulevard intersection is currently controlled by a traffic signal and has the following intersection configuration:

- Eastbound – 1 left turn lane, 1 thru lane, 1 combination thru/right turn lane
- Westbound – 1 left turn lane, 2 thru lanes, 1 right turn lane
- Northbound – 1 left turn lane, 2 thru lanes, 1 separated right turn bay
- Southbound – 1 left turn lane, 2 thru lanes, 1 right turn lane

The analysis indicated that the existing intersection is functioning at level of service D for both AM and PM peak hour traffic volumes. Low levels of service were also found during the PM peak hour at Catron Boulevard & Sheridan Lake Road and US16B / Catron Boulevard & 5<sup>th</sup> Street. The summary memo “Existing Conditions Traffic Volumes and Level of Service” is included as Appendix B. See Figure 7 “Existing Peak Hour Volumes & LOS” for a summary of the results.

### 2.2 Existing Conditions Safety

A safety analysis was conducted within the traffic study area for existing conditions. The US16 & US16B / Catron Boulevard and the US16 & Promise Road intersections were identified as needing safety improvements based on a critical crash rate analysis.

For the signal-controlled US16 & US16B / Catron Boulevard intersection, crashes were attributed to the mix of high speeds and high traffic volumes. High speeds can be contributing to the fixed object crashes, merge area crashes and disregard signals crashes. It was recommended that SDDOT conduct a speed study after project improvements are made to determine appropriate speed limits within the corridor due to increased urbanization and increased turning and crossing traffic.

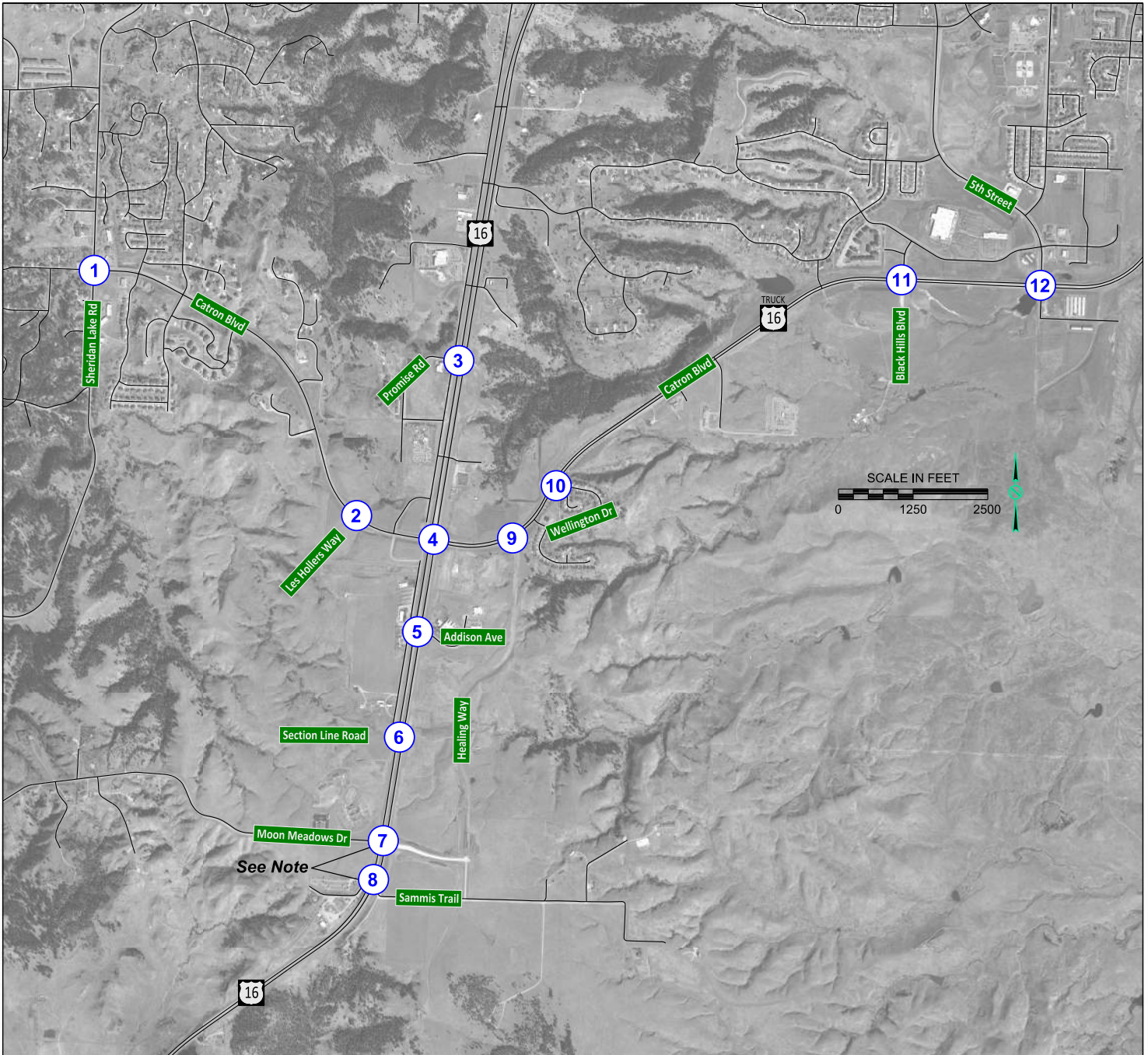
The stop-controlled US16 & Promise Road intersection had a relatively small crash sample size and future monitoring was recommended.

The Rapid City Arterial Safety Study (2012) was also reviewed for safety recommendations. There were no safety issues identified for any of the roadway segments or intersections within the project area.

The existing conditions safety analysis is summarized in the memo “Preliminary Safety Analysis” which is included as an Appendix C.

A safety assessment was also conducted for the build alternatives and is discussed in Section 4. The analysis of alternatives is summarized in the memo “Safety Assessment for Proposed Alternatives” which is included as Appendix E.





**NOTE:**

At the time of this study, the east leg of the US16 & Sammis Trail intersection (8) was permanently closed and re-routed to the US16 & Moon Meadows Dr intersection (7); there will be no access to US16 via Sammis Trail in the future.

	TRAFFIC STUDY INTERSECTIONS	EXISTING CONTROL	FUTURE CONTROL
1	Catron Blvd & Sheridan Lake Rd	Signalized	Signalized
2	Catron Blvd & Les Hollers Way	Does not Exist	Signalized (Black Hills Corp TIS)
3	US16 & Promise Rd	Stop	Stop
4	US16 & US16B / Catron Blvd	Signalized	Signalized
5	US16 & Addison Ave	Stop	Stop (access may be eliminated)
6	US16 & Section Line Rd	Does not Exist	Stop
7	US16 & Moon Meadows Dr	Stop	Signalized (Moon Meadows TIA)
8	US16 & Sammis Trail	Stop	Stop (access will be eliminated)
9	US16B / Catron Blvd & Healing Way	Does not Exist	Signalized (Buffalo Crossing TIS)
10	US16B / Catron Blvd & Wellington Dr	Stop	Stop
11	US16B / Catron Blvd & Black Hills Blvd	Signalized	Signalized
12	US16B / Catron Blvd & 5th Street	Signalized	Signalized



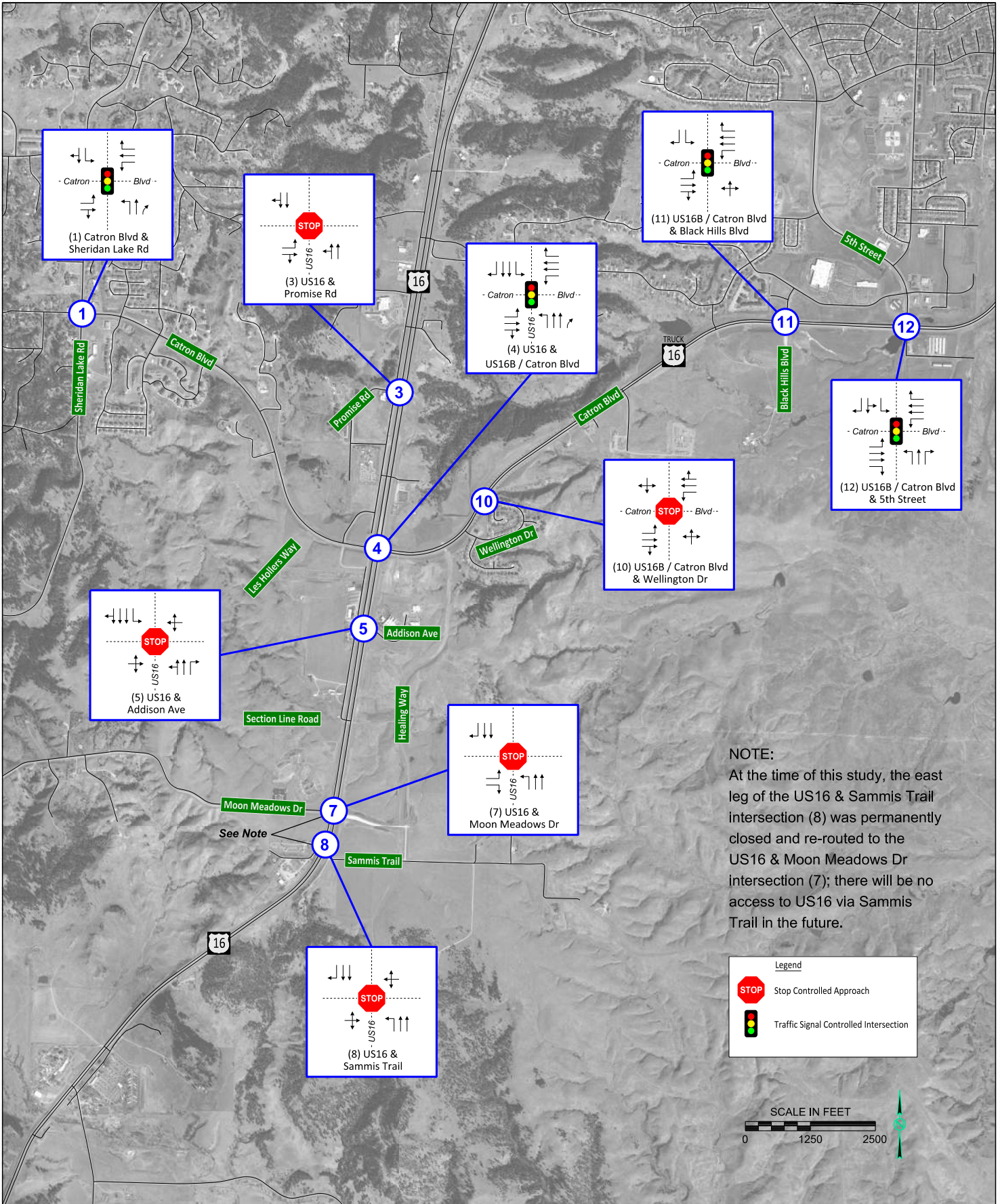
**Traffic Study Intersections**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure



**5**





**NOTE:**  
 At the time of this study, the east leg of the US16 & Sammis Trail intersection (8) was permanently closed and re-routed to the US16 & Moon Meadows Dr intersection (7); there will be no access to US16 via Sammis Trail in the future.

**Legend**

-  Stop Controlled Approach
-  Traffic Signal Controlled Intersection

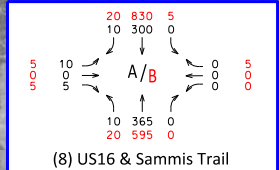
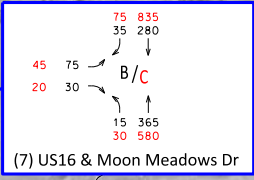
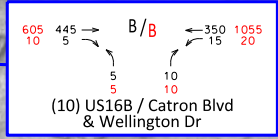
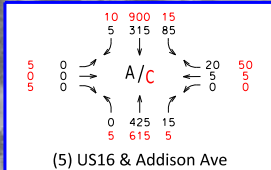
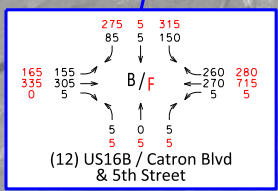
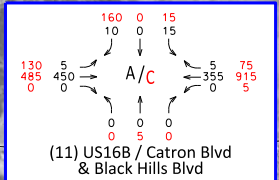
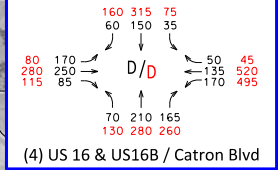
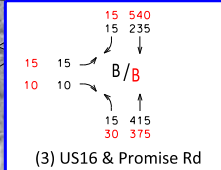
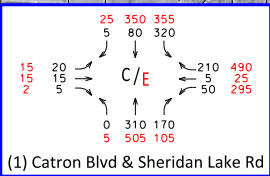
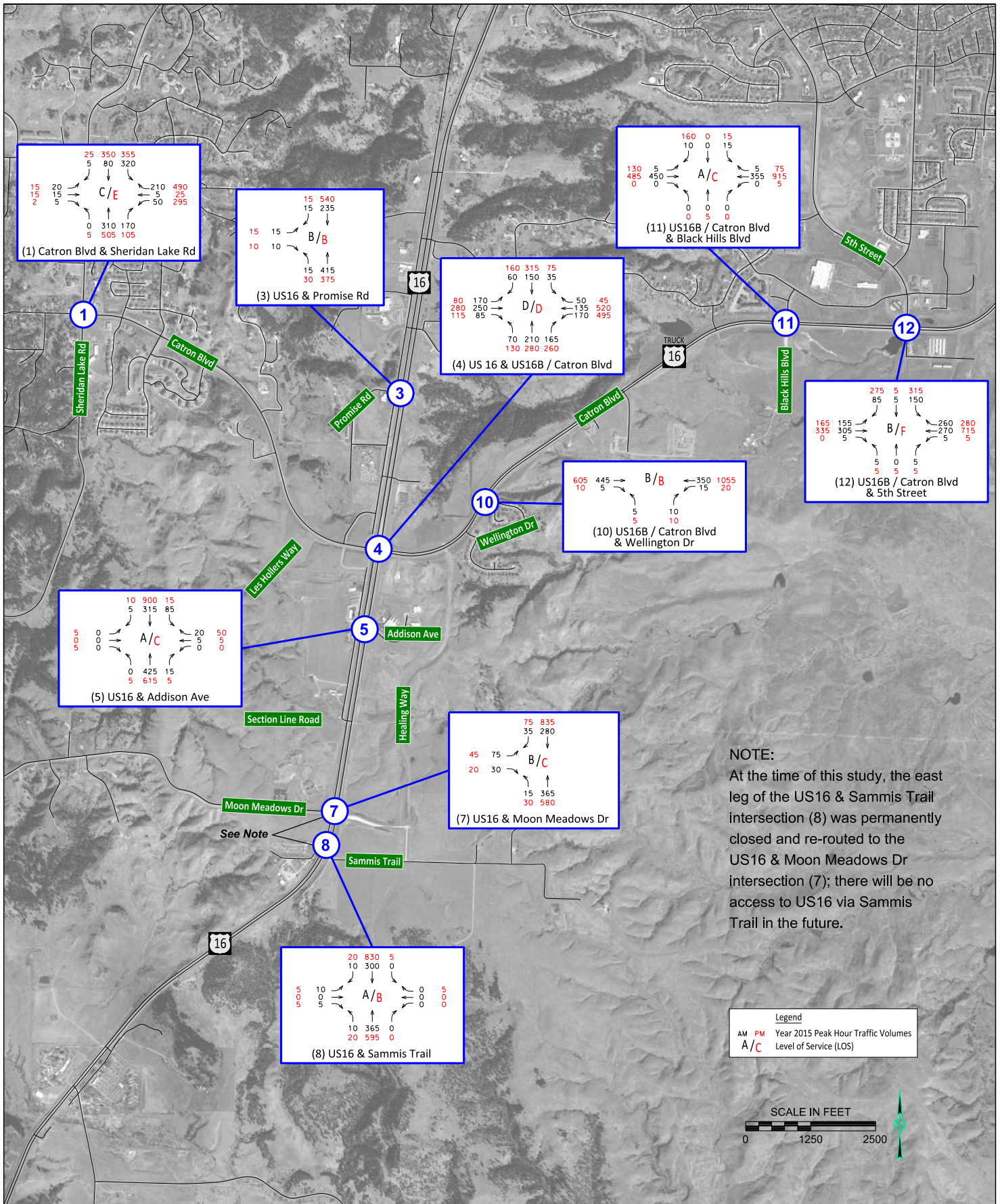


**Existing Intersection Lane Configurations**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure  
**6**





**Existing Peak Hour Volumes & LOS**  
 US16 / US16B / Catron Blvd Study Rapid City, SD

Figure  
**7**

### 3. Traffic Projections

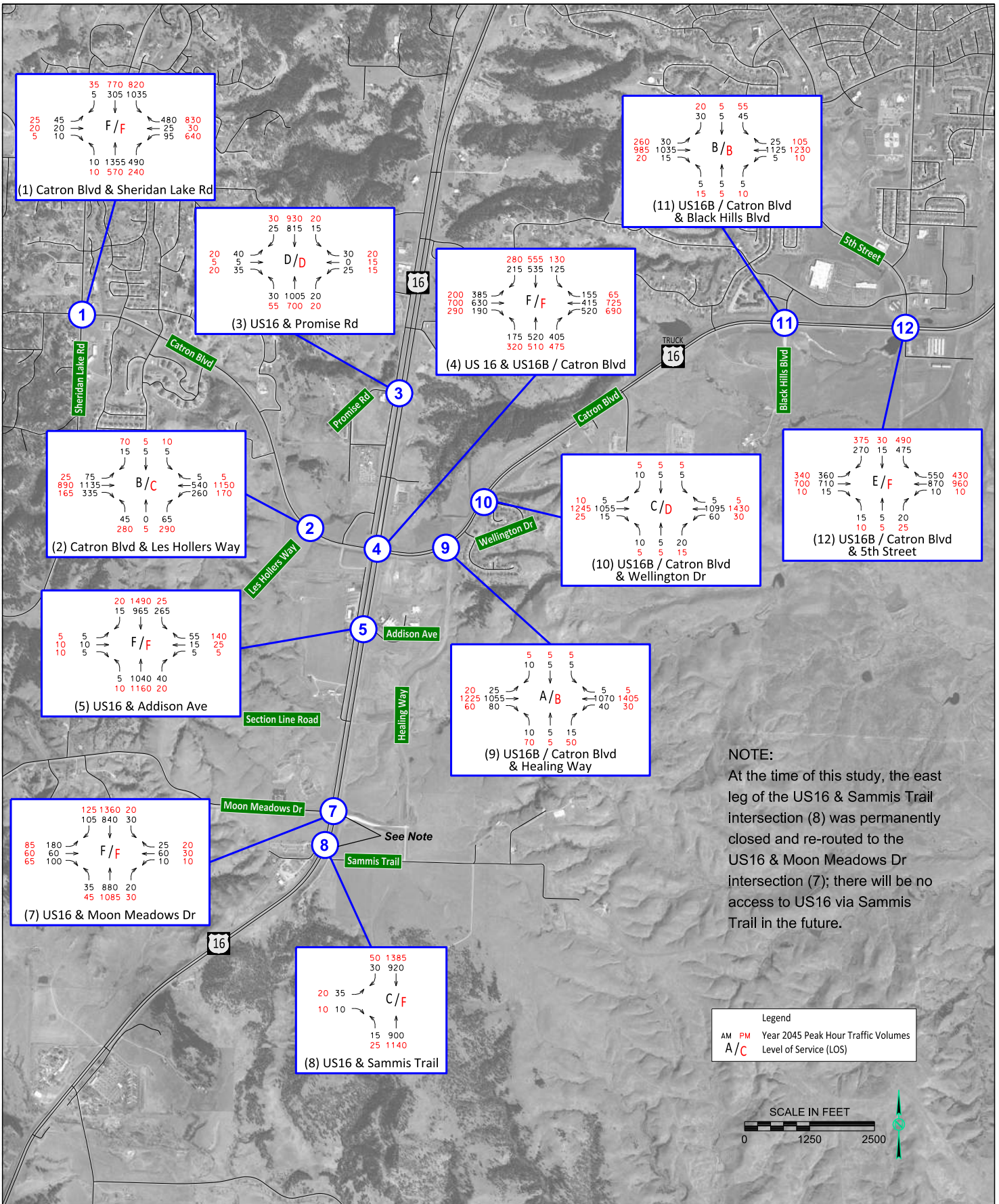
A future no-build traffic analysis was conducted to evaluate how the existing facilities will operate under projected future traffic conditions. The Rapid City MPO / City of Rapid City provided link average daily traffic (ADT) values for year 2045 using the regional travel demand model. The link volumes were used to develop AM and PM peak hour turning movement volumes for each intersection in the study area. The 2045 analysis includes the planned future intersections of Catron Boulevard & Les Hollers Way and US16B / Catron Boulevard & Healing Way. The existing intersection at US16 & Addison Avenue is included in the analysis. However, the access to US16 at Addison Avenue may be eliminated in the future with traffic redirected to the intersection at US16B / Catron Boulevard & Healing Way.

The analysis indicates that a low level of service is expected in 2045 at all the existing intersections, except US16B / Catron Boulevard & Black Hills Boulevard (LOS B/B). The future intersections at Catron Boulevard & Les Hollers Way (LOS B/C) and US16B / Catron Boulevard & Healing Way (LOS A/B) are shown at good levels of service with the planned intersection configurations and signal control. The US16 & US16B / Catron Boulevard intersection is expected to operate at LOS F for AM and PM peak hour traffic volumes.

The intersections that currently operate with stop sign control may be considered for future signalization based on future signal warrant studies and consideration of overall corridor operations and safety. It should be recognized that low levels of service for stop-controlled approaches at arterial roadways is a common condition and not necessarily a reason for intersection improvements. Continued corridor planning will be instrumental in determining the future roadway network and locations where future improvements will be needed.

The 2045 No-Build analysis memo "Future No-Build Traffic Volumes and Level of Service" is included in Appendix D. See Figure 8 "2045 No-Build Peak Hour Volumes & LOS" for a summary of the findings.





**2045 No-Build Peak Hour Volumes & LOS**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

**8**

## 4. Alternatives Analysis

### 4.1 Methodology

Eight build alternatives for the US16 & US16B / Catron Boulevard intersection were developed and evaluated as part of the study. All of the intersection alternatives will provide a minimum LOS C. Alternatives that include entrance and exit ramps (Tight Diamond Urban Interchange, Single Point Urban Interchange, and Diverging Diamond Interchange) were oriented so the ramps lie in the north / south direction. This was primarily due to the ramps potentially interfering with the Les Hollers Way and Healing Way intersections. There is also limited right-of-way on US16B / Catron Boulevard if the ramps were oriented in the east / west direction.

#### 4.1.1 Typical Sections

A rural surfacing section was generally assumed for build alternatives due to the existing location and characteristics of the project setting. The project is located in an undeveloped area and characterized by relatively higher / rural speed limits. Typical sections specific to the various alternatives have been included in the following discussion. The final layouts for the Single Point Urban Interchange and Continuous Flow Intersection utilize an urban section with curb and gutter and sidewalks.

#### 4.1.2 Right-of-Way (ROW) and Control of Access

ROW impacts were estimated assuming a 34' offset from the edge of pavement. This assumption allows space for a standard ditch section. ROW impacts adjacent to ramps were estimated by offsetting the ramp alignment a standard distance of 75'. ROW impacts can be mitigated to some extent by using an urban section along US16B / Catron Boulevard and eliminating the adjacent ditches. This would result in additional storm sewer costs. Existing and proposed ROW is shown on the Alternative Layouts. The existing Control of Access is shown in Figure 10. Existing regulations will provide the framework for proper access management as development occurs within the corridor and acquisition of additional Control of Access is not anticipated at this time.

#### 4.1.3 Posted Speed Limits and Design Speed

Posted speed limits are relatively high in the project area with US16B / Catron Boulevard posted at 45 mph, US16 southbound posted at 50 mph, and US16 northbound posted at 60 mph. The design speeds assumed for developing the layouts are shown below.

US16	65 mph
Catron Blvd	50 mph
Arterial	50 mph
Collector	35 mph

#### 4.1.4 Pedestrian and Bicycle Facilities

The Rapid City Area Bicycle and Pedestrian Master Plan (2011) was reviewed for applicability to this study. Both Catron Boulevard and US16 were identified for future bicycle and pedestrian needs. Figure 9 summarizes the plan as it pertains to the project area.

In the Master Plan, US16B / Catron Boulevard is characterized as having an existing shoulder bikeway. No future needs were identified for US16B / Catron Boulevard or US16. A future shared bike lane was also shown for the west US16 frontage road, north of Catron Boulevard. This may have implications for some alternatives if the frontage road is relocated due to conflicts with proposed exit ramps. US16 and



US16B / Catron Boulevard were also identified for future sidewalk projects; both roadways are categorized as Low Priority.

A rural section with an 8' outside shoulder was assumed when developing the alternative layouts for both US16B / Catron Boulevard and US16. Depending on the timing of the project in relation to the adjacent development, an urban section with sidewalk may be considered in the future. Currently, the area is generally undeveloped with little connectivity for pedestrian facilities to residential areas. The final layouts for the Single Point Urban Interchange and Continuous Flow Intersection utilize an urban section with curb and gutter and sidewalks on both sides of the roadway corridor.

Bicycle and Pedestrian Use was included in the Alternative Comparison Matrix and alternatives were scored based on the opportunity for signal protected crossings and the length of the crossing distances.

#### **4.1.5 Section Line Road**

The distance between the US16 & US16B / Catron Boulevard intersection and US16 & Moon Meadows Drive intersection is slightly less than one mile. An intersection on US16 at Section Line Road would be approximately 1,800' from the Moon Meadows intersection. Since US16 is classified as an Expressway, a minimum access spacing of ½ mile is required per South Dakota Access Management Rules. Providing a grade separated crossing at that location maintains traffic flow and facilitates movement between the east and west sides of US 16.

Two options were identified for the Section Line Road intersection at US16:

- At-grade right-in-right-out
- US16 overpass of Section Line Road

The at-grade right-in-right-out is the cheapest option from a construction cost perspective. However, it would not meet requirements for access spacing and would not provide connectivity between the east and west sides of US16.

The US16 overpass would require construction of two bridge structures for the northbound and southbound directions which would cross over Section Line Road. This option would be in compliance with access requirements and it would provide east / west connectivity. The main drawback with the overpass option is the expense of the bridge structures. Local access to US16 would also be eliminated.

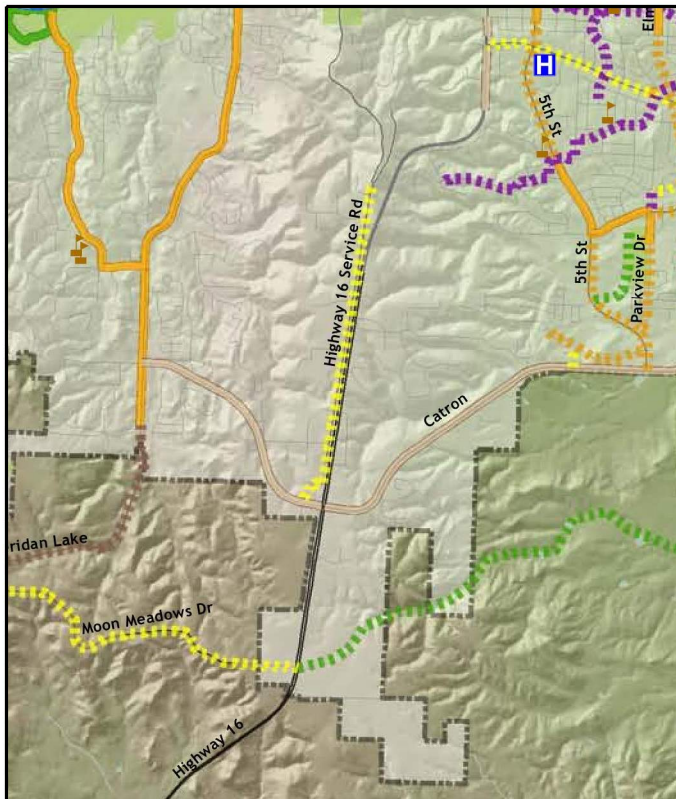
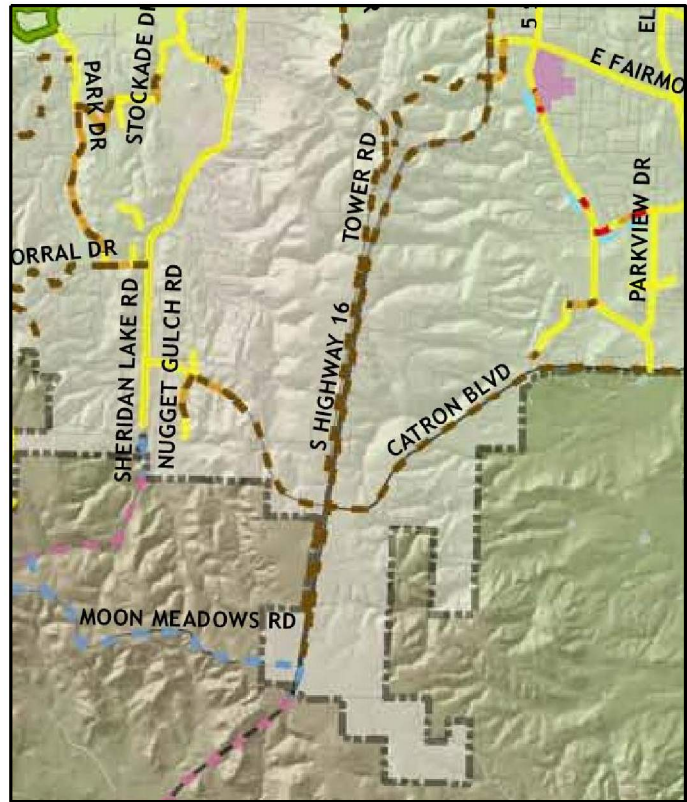
There is some flexibility with how the US16 overpass could be constructed. The US16 roadway could be elevated with an embankment or maintained at natural grade. Due to the significant drop in elevation east of US16, Section Line Road could be excavated down below natural grade at the crossing location. The excavation could provide borrow material for the US16 & US16B / Catron Boulevard intersection.

## Prioritized Sidewalk Projects

- |                           |                                 |
|---------------------------|---------------------------------|
| <b>Within City Limits</b> | <b>Three-Mile Planning Area</b> |
| High Priority             | High Priority                   |
| Medium Priority           | Medium Priority                 |
| Low Priority              | Low Priority                    |
| Shared-Use Path           | Special Generators              |
| Sidewalks Both Sides      | City of Rapid City              |
| Sidewalk One Side         | Box Elder                       |
| Desire Paths              | Three-Mile Planning Area        |
| Railroads                 |                                 |

Note: The sidewalk inventory evaluated sidewalks on collector and arterial roadways only. Sidewalks should be provided on both sides of local streets when development or street construction occurs.

0 1 2 Miles



## Recommended Bikeways

- |                                      |                     |
|--------------------------------------|---------------------|
| Shoulder Bikeway, Existing/Proposed  |                     |
| Bike Lane, Planned/Proposed          |                     |
| Shared Lane, Planned/Proposed        |                     |
| Signed Shared Roadway, Proposed      |                     |
| Cycle Track, Existing                |                     |
| Shared-Use Path, Existing/Proposed   |                     |
| Side Path, Existing/Planned/Proposed |                     |
| Intersection Improvements            |                     |
| Hospital                             | Mountain Bike Areas |
| Civic Destination                    | Parks               |
| Recreational Destination             | Railroads           |
| School                               | City of Rapid City  |

0 1.25 2.5 Miles



### Bicycle and Pedestrian Plan

From Bicycle and Pedestrian Master Plan (2011)  
US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

9

#### 4.1.6 Eastbound Catron Boulevard Acceleration Lane

US16 is currently configured with a northbound separated right turn lane that becomes an acceleration lane as it continues on eastbound US16B / Catron Boulevard (See Figure 10, No-Build Alternative). All of the basic alternative layouts maintained this configuration generally using a design speed of 25 mph for the right turn. Based on SDDOT design standards, the required distance for an acceleration lane would be 1150' (550' for acceleration plus the merging taper distance of 600'). Depending on the alternative, the available length for an acceleration lane on US16B / Catron Boulevard between US16 and Healing Way ranges from 1100' to 600'.

In addition to the acceleration lane, a right turn lane is also proposed on eastbound US16B / Catron Boulevard at the Healing Way intersection. According to the Buffalo Crossing TIA (2015), the eastbound right turn lane on US16B / Catron Boulevard at Healing Way should be 600' in length (120' taper plus 480' storage and deceleration). The acceleration lane and right turn lane on US16B / Catron Boulevard were generally portrayed as a continuous auxiliary lane between US16 and Healing Way in the basic alternative layouts. However, this configuration was further evaluated due to the potential weaving conflicts between accelerating and decelerating eastbound traffic.

As the alternatives were refined and evaluated, the Single Point Urban Interchange (SPUI) and the Continuous Flow Intersection (CFI) were carried forward for further refinement. Three additional SPUI options were developed to address the weaving conflict. The first option (Alternative 2.1) is shown in Figure 13. This option eliminated the acceleration lane and converted the northbound to eastbound right turn to a yield controlled movement. The yield condition had negative impacts on the overall intersection operation as well as safety concerns and is not recommended. The second option (Alternative 2.2) that was evaluated included a dual right turn lane from eastbound US16B / Catron Boulevard to southbound Healing Way. This option is shown in Figure 14. Option 2 provides enough room on US16B / Catron Boulevard to include an acceleration lane that is equal in length to the existing acceleration lane. Although the existing acceleration lane is geometrically substandard, it would provide better flow for the northbound to eastbound movement. However, there would still be the potential for weaving conflicts between the two intersections. The third option (Alternative 2.3) included dual northbound to eastbound right turn lanes (See Figure 15). The right turn lanes would be signal controlled and will function efficiently with the proposed SPUI traffic signal phasing. This option addresses the safety concern associated with weaving, but it is a significant change from the existing traffic flow patterns.

A simple traffic simulation was also conducted to better understand the effects of weaving on eastbound US16B / Catron Boulevard between the US16 and Healing Way intersections. The simulation revealed eastbound traffic was generally dispersed enough to allow calm weaving operations. The auxiliary lane was also extended to the east, beyond Healing Way, to allow adequate distance for acceleration after the intersection. This is the recommended approach for the northbound to eastbound movement and is shown in Figures 12 (SPUI) and 18 (CFI).

#### 4.1.7 Constructability and Construction Sequencing

The proposed roadway alignments generally coincide with the existing roadways. Since the existing intersection operates at LOS D for peak hour traffic, this configuration may be required during construction. This would consist of 6 lanes on each leg (2 through lanes in each direction, right turn lane, and left turn lane).

Construction sequencing for the interchange alternatives that include a US16 overpass (Alternatives 1, 2, 3, and 6) will generally require the following:

- Construct the ramps while maintaining traffic through the existing intersection
- Crossover US16 traffic and construct the northbound bridge
- Crossover US16 traffic and construct the opposite / southbound bridge

US16B / Catron Boulevard would also be constructed in three general phases:

- Construct westbound lanes
- Construct eastbound lanes
- Construct center median

An alternative to the US16 crossovers would be to maintain traffic on the proposed ramps with two temporary signalized intersections at US16B / Catron Boulevard. The intersections would function as a diamond or tight diamond interchange while the embankment and bridge structures are constructed.

Construction sequencing for the alternatives that include at-grade intersections (Alternatives 4, 5, and 8) will generally require the following:

- Crossover US16 traffic to northbound or southbound lanes
- Divert Catron Boulevard traffic to westbound or eastbound lanes
- Construct intersection in quadrants

The Echelon Interchange (Alternative 7) would require construction of the at-grade portions first, then construction of the elevated sections and bridge structures.

The flyover ramps would add an additional phase of construction for the bridges sections. In general, the bridge structures would require special time/construction constraints so the beams can be set in an expedited manner during low traffic volume periods and construction can proceed with US16B / Catron Boulevard traffic passing under the new structure. Temporary traffic signals and temporary surfacing would be expected with all alternatives.

The alternatives with at-grade intersections provide the lowest level of construction complexity and will be easier than the overpass options for construction sequencing.

#### 4.1.8 Environmental Impacts

The proposed alternatives have very little anticipated environmental impacts based on information known at this time. The South Dakota State Historic Preservation Office has indicated there are a handful of known cultural sites within the study area. These include an historic farmstead, Native American site, euroamerican artifacts, and roads. The known features are not in the immediate vicinity of US16 or US16B / Catron Boulevard. Portions of the study area, specifically associated with the west rearage road, have not been inventoried for cultural resources. While the project does not impact any known cultural resources, there is potential for more resources to be identified in the future when field inventories are completed. The primary known environmental impact is the need for additional ROW which is tabulated in the Alternative Comparison Matrix. There is also a small wetland area in the southeast quadrant of the

US16 & US16B / Catron Boulevard intersection that may be encroached upon by the alternatives. A noise evaluation was conducted and concluded that the project is not anticipated to generate noise impacts at the noise sensitive receptors along the project corridor. The environmental impacts are discussed further in the Environmental Screening document which has been included as Appendix J.

#### **4.1.9 Safety Assessment for Proposed Alternatives**

A safety assessment was conducted to evaluate the proposed build alternatives. The proposed alternatives include several concepts that are relatively new and have been used in a limited number of locations nationwide. Safety performance information, including crash modification factors (CMFs), was collected from resources such as the Highway Safety Manual (HSM), Crash Modification Factor (CMF) Clearinghouse, Federal Highway Administration (FHWA) references and state research reports as available. This information was used to develop a relative safety ranking for each alternative using a scale ranging from 1 to 5. A value of 1 represents the lowest anticipated safety benefit based on reduction in crash frequency while a value of 5 represents the highest anticipated safety benefit based on reduction in crash frequency. These rankings were included directly in the Alternative Comparison Matrix in Section 7. In general, the Single Point Urban Interchange and Diverging Diamond Interchange scored the highest (best) safety ranking, while the Alternatives with typical at-grade intersections ranked lowest.

The complete analysis of alternatives is summarized in the memo “Safety Assessment for Proposed Alternatives” which is included as Appendix E.

#### **4.1.10 Northwest Quadrant Access Evaluation**

An existing frontage road access point located on the north side of Catron Boulevard between US16 and Les Hollers Way was evaluated for potential conflicts with the Single Point Urban Interchange (SPUI) and the Continuous Flow Intersection (CFI) alternatives described in the following sections. For the SPUI, the existing access would be located in the influence area of both adjacent intersections on Catron Boulevard (Les Hollers Way and US16). Maintaining the access with the implementation of the SPUI is not recommended from a safety perspective. However, maintaining the access is not expected to affect the level of service or other operational parameters of the interchange.

For the CIF, the access lies within the footprint of the west crossover intersection. Maintaining the access could attract drivers to attempt unsafe left turns out of the eastbound crossover flow or unexpected right turns out of the westbound through flow. Access at this location is not recommended with the CFI for safety reasons. Additional discussion can be found in Appendix K.



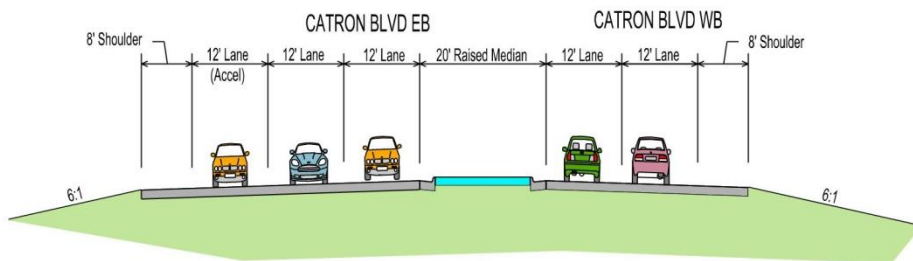
## 4.2 No-Build Alternative

The No-Build Alternative is shown in Figure 10. It assumes the intersections of Catron Boulevard & Les Hollers Way and US16B / Catron Boulevard & Healing Way have been implemented with traffic signal control.

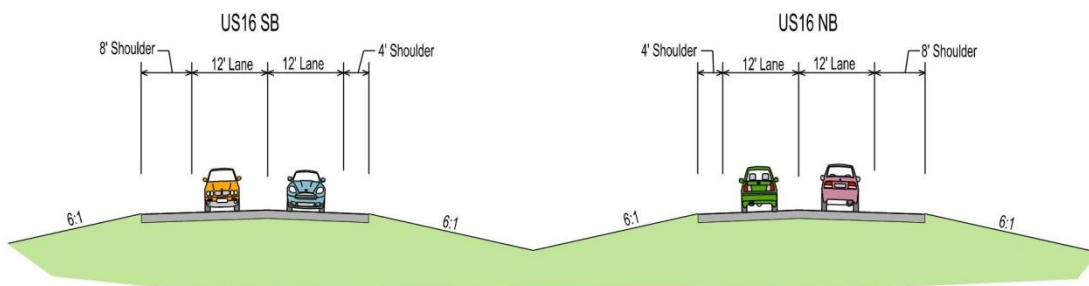
As previously discussed, the existing intersection does not provide an adequate level of service for existing or future traffic volumes (LOS F/F). The existing typical sections for US16 and US16B / Catron Boulevard are shown below.

The existing ROW for US16 is approximately 330' through the study area. The US16B / Catron Boulevard ROW is 150' wide at the study intersection, but varies greatly to the east. Based on the SDDOT Road Design Manual, an Expressway would have 300' ROW for a divided section and 200' ROW for an undivided section. Existing Control of Access is shown in Figure 10 as well.

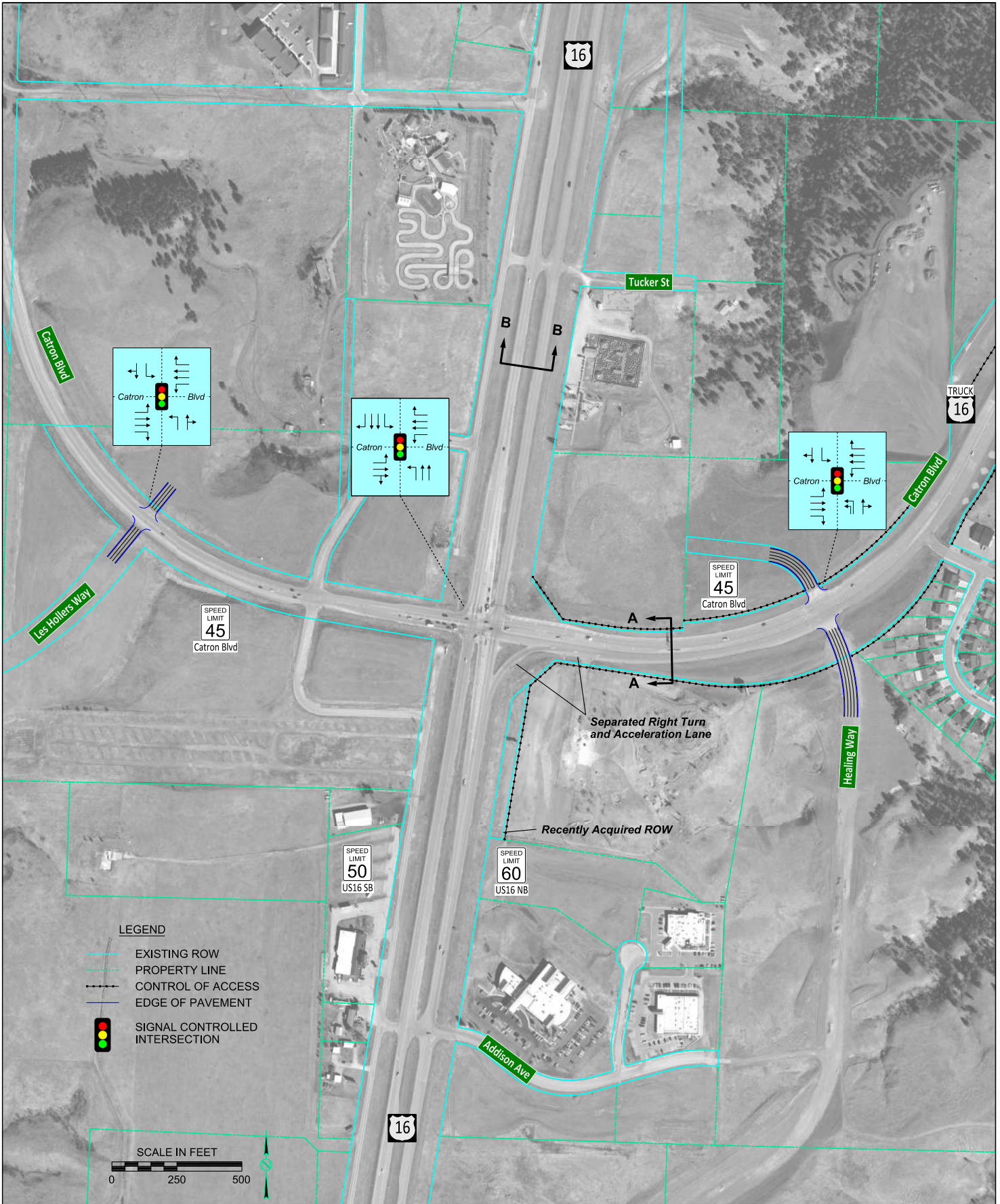
Pedestrian access can be accommodated at the intersection since all movements are signal controlled, except the northbound separated right turn.



**Typical Section – US16B / Catron Boulevard Existing (Figure 10, Section A-A)**



**Typical Section – US16 Existing (Figure 10, Section B-B)**



**No-Build Alternative**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure  
**10**

### 4.3 Build Alternatives

Eight build alternatives are discussed in the following section. An evaluation matrix is included in the Section 7, Summary and Recommendations. The HCS traffic model reports are included in Appendix I.

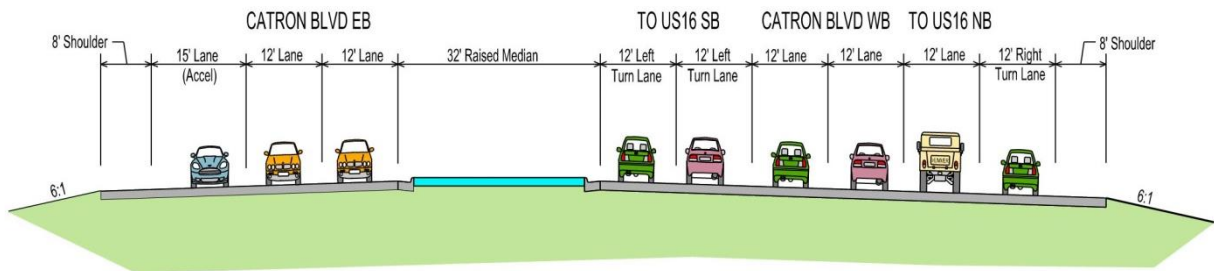
#### 4.3.1 Alternative 1: Tight Diamond Urban Interchange (TDUI)

A TDUI is similar to the traditional diamond interchange except it utilizes two closely spaced, signalized intersections located where the ramps intersect the crossing street. The two intersection signals are coordinated. Left turn lane stacking on the crossing street occurs in advance of the first intersection. The Alternative 1 layout is shown in Figure 11. The proposed TDUI intersections are spaced 300' apart. US16 through traffic has been accommodated with an overpass. All legs consist of a right turn lane, two left turn lanes, and at least two through lanes. Three eastbound through lanes were required for this alternative in order to handle the projected future traffic. Typical sections are shown below.

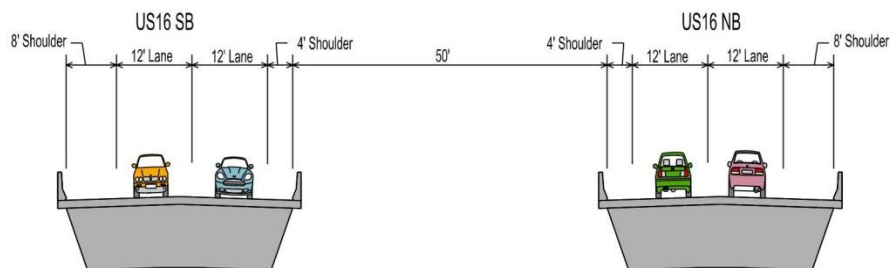
The Highway Capacity Software (HCS) used for the build traffic analysis has limited capability regarding TDUI modeling. The Alternative 1 TDUI was modeled using both one and two intersection configurations. The two intersection configuration indicates the TDUI will provide LOS C. However, the single intersection analysis indicates there may be additional delays associated with the limited storage within the interchange and the high turning demand.

The twin bridges that cross over US16B / Catron Boulevard are anticipated to have a roadway width of 36 feet and an overall out-out length of 200 feet. It is anticipated that these structures would be single span girder bridges with concrete decks.

Since the TDUI is composed of typical signalized intersections, it will have normal driver expectations. It will also be able to accommodate pedestrian and bicycle access through the traffic signals.

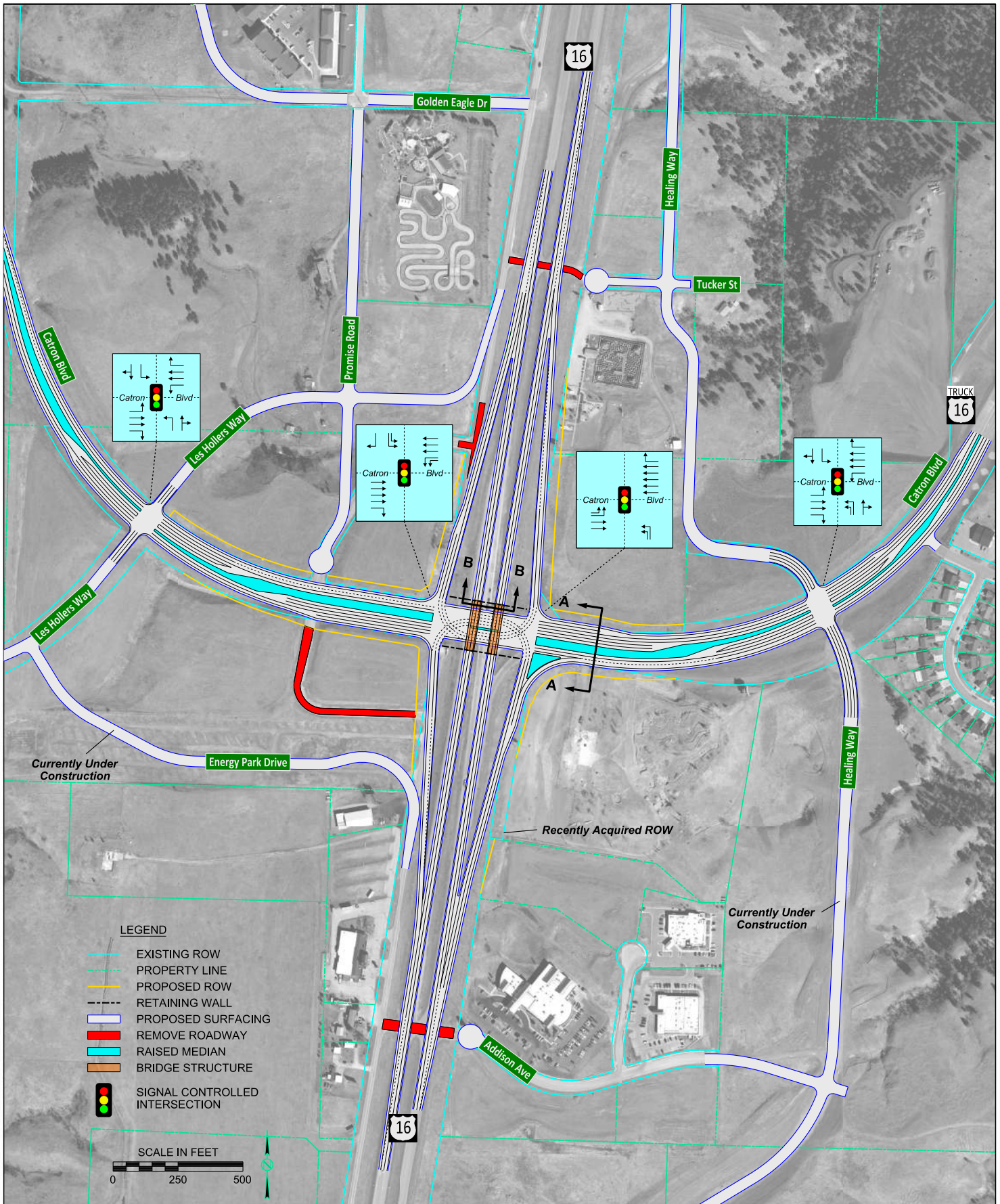


**Typical Section – US16B / Catron Boulevard (Figure 11, Section A-A)**

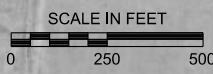


**Typical Section – US16 Bridge (Figure 11, Section B-B)**





- LEGEND**
- EXISTING ROW
  - PROPERTY LINE
  - PROPOSED ROW
  - RETAINING WALL
  - PROPOSED SURFACING
  - REMOVE ROADWAY
  - RAISED MEDIAN
  - BRIDGE STRUCTURE
  - SIGNAL CONTROLLED INTERSECTION



**Alternative 1 - Tight Diamond Urban Interchange**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

**11**

### 4.3.2 Alternative 2: Single Point Urban Interchange (SPUI)

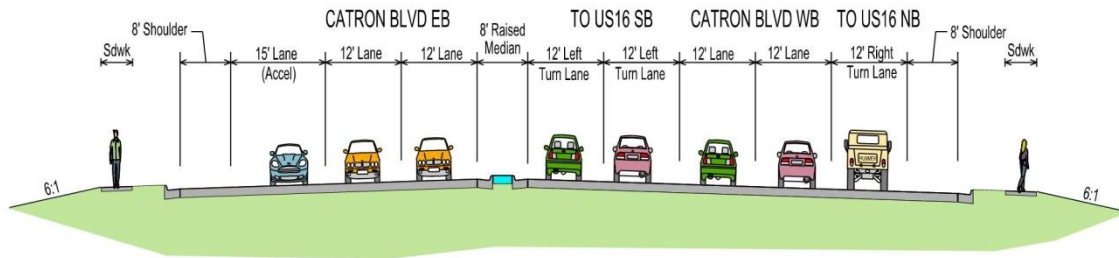
As shown in Figure 12, the SPUI is composed of an elevated US16 bridge overpass and a single at-grade intersection below the bridge structures. The single intersection is characterized by the opposing left movements through the intersection. There are numerous SPUIs currently located in Rapid City. Alternative 2 will provide a future LOS C.

The SPUI will require a longer bridge length and includes more retaining wall than other alternatives. The twin bridges that cross over US16B / Catron Boulevard are anticipated to have a roadway width of 36 feet and an overall out-out length of 375 feet. It is anticipated these structures would be 3-span girder bridges with concrete decks. The bridges in this option would be similar to the I-90 bridges that cross over Haines Avenue.

The SPUI will meet the demands of future traffic with the three phase signal system. The main drawback of the SPUI is the overall cost. The SPUI is also less friendly than other options for pedestrian crossings, in that pedestrians cannot cross US16B / Catron Boulevard at the interchange.

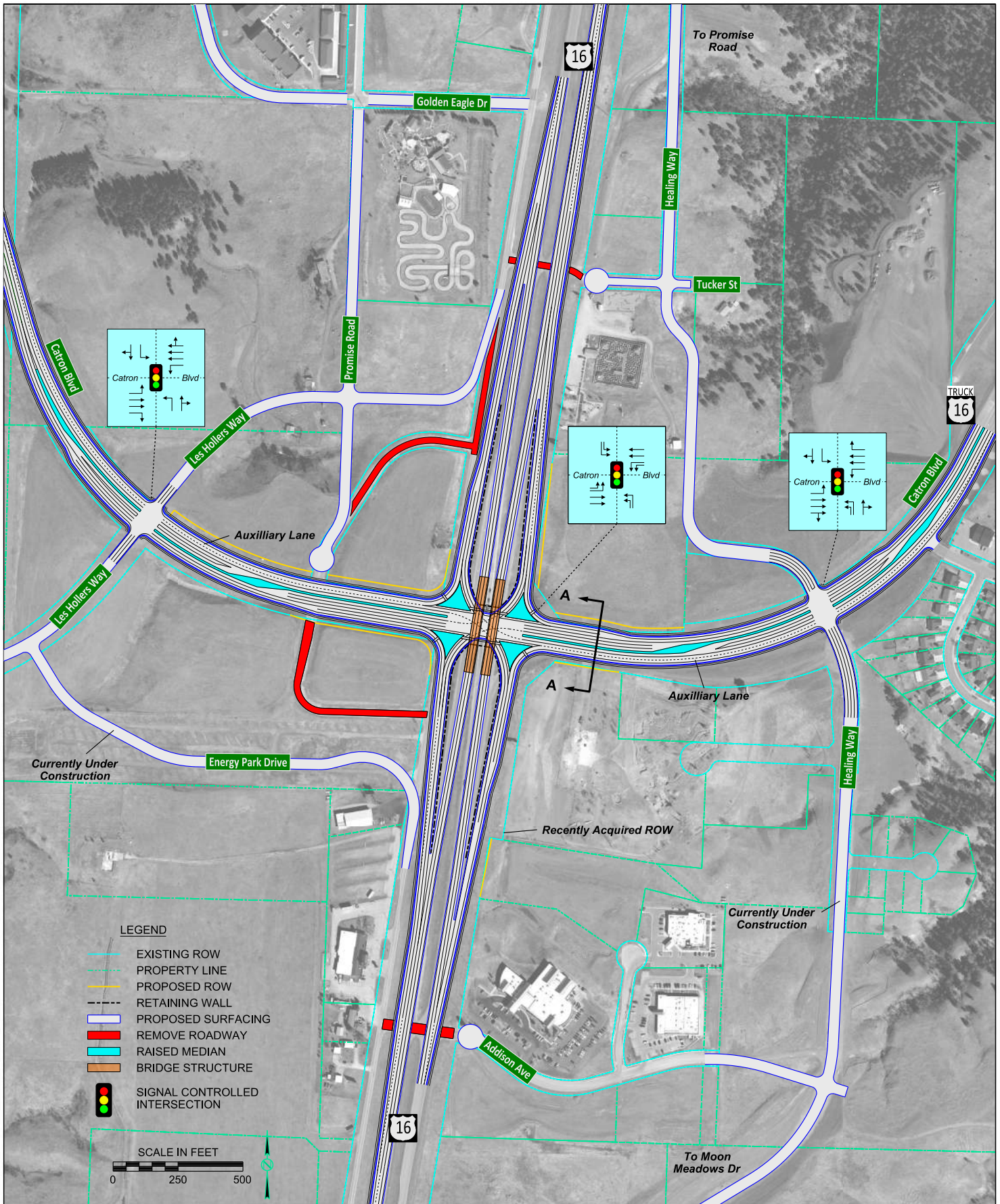
As shown in the layout and typical section, the SPUI consists of two through lanes, two left turn lanes, and a right turn lane on all legs of the intersection. The typical section for the bridge is the same as that proposed for Alternative 1.

As the alternatives were refined and evaluated, the Single Point Urban Interchange and Continuous Flow Intersection emerged as the highest ranked options. The SPUI alternative was further modified, providing three additional options to address the potential weaving conflict on US16B / Catron Boulevard between the eastbound acceleration lane and right turn lane at Healing Way as described in Section 4. Layouts of the additional options were developed as Alternatives 2.1, 2.2, and 2.3 and are included as Figures 13, 14, and 15. Of all four SPUI options (2, 2.1, 2.2 and 2.3), Alternative 2 is the recommended approach for addressing the merging conflict on eastbound US16B / Catron Boulevard between US16 and Healing Way. See Section 4 for additional discussion.



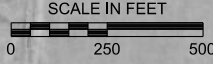
Typical Section – US16B / Catron Boulevard (Figure 12, Section A-A)





**LEGEND**

- EXISTING ROW
- PROPERTY LINE
- PROPOSED ROW
- RETAINING WALL
- PROPOSED SURFACING
- REMOVE ROADWAY
- RAISED MEDIAN
- BRIDGE STRUCTURE
- SIGNAL CONTROLLED INTERSECTION

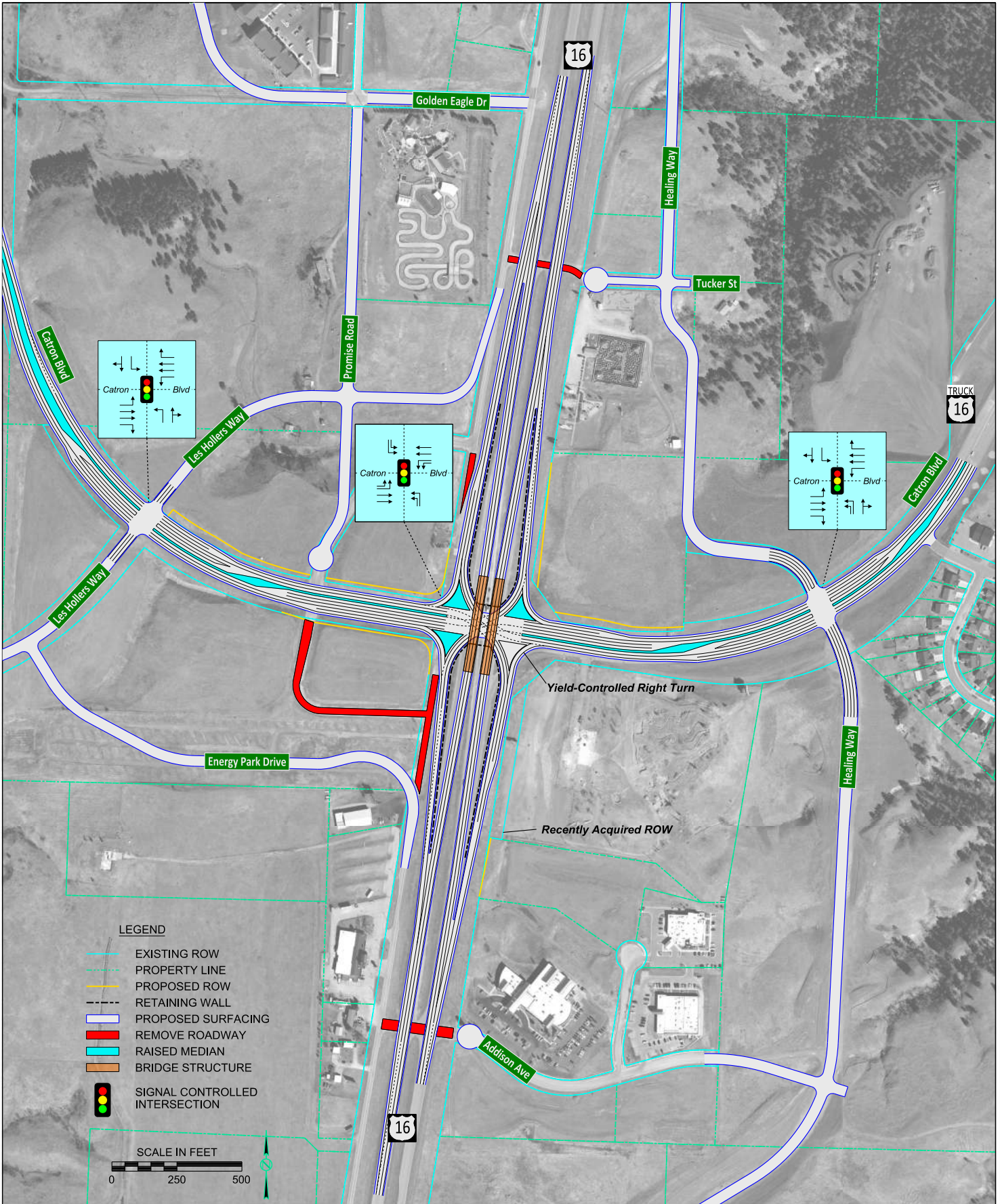


**Alternative 2 - Single Point Urban Interchange**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure  
**12**

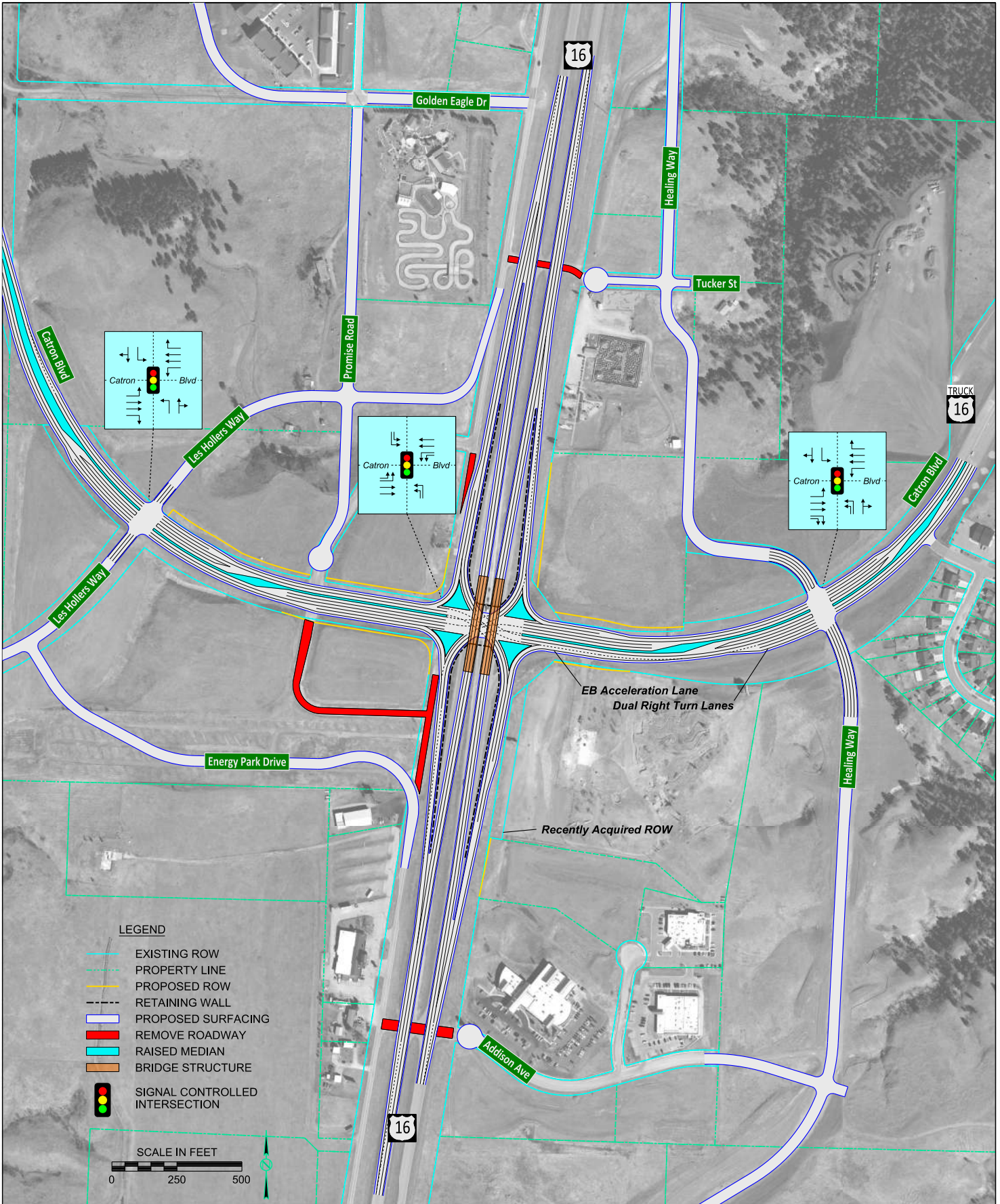




**Alternative 2.1 - Single Point Urban Interchange**  
 with NB to EB Yield-Controlled Right Turn  
 US16 / US16B / Catron Blvd Study Rapid City, SD

Figure  
**13**





**LEGEND**

- EXISTING ROW
- PROPERTY LINE
- PROPOSED ROW
- RETAINING WALL
- PROPOSED SURFACING
- REMOVE ROADWAY
- RAISED MEDIAN
- BRIDGE STRUCTURE
- SIGNAL CONTROLLED INTERSECTION

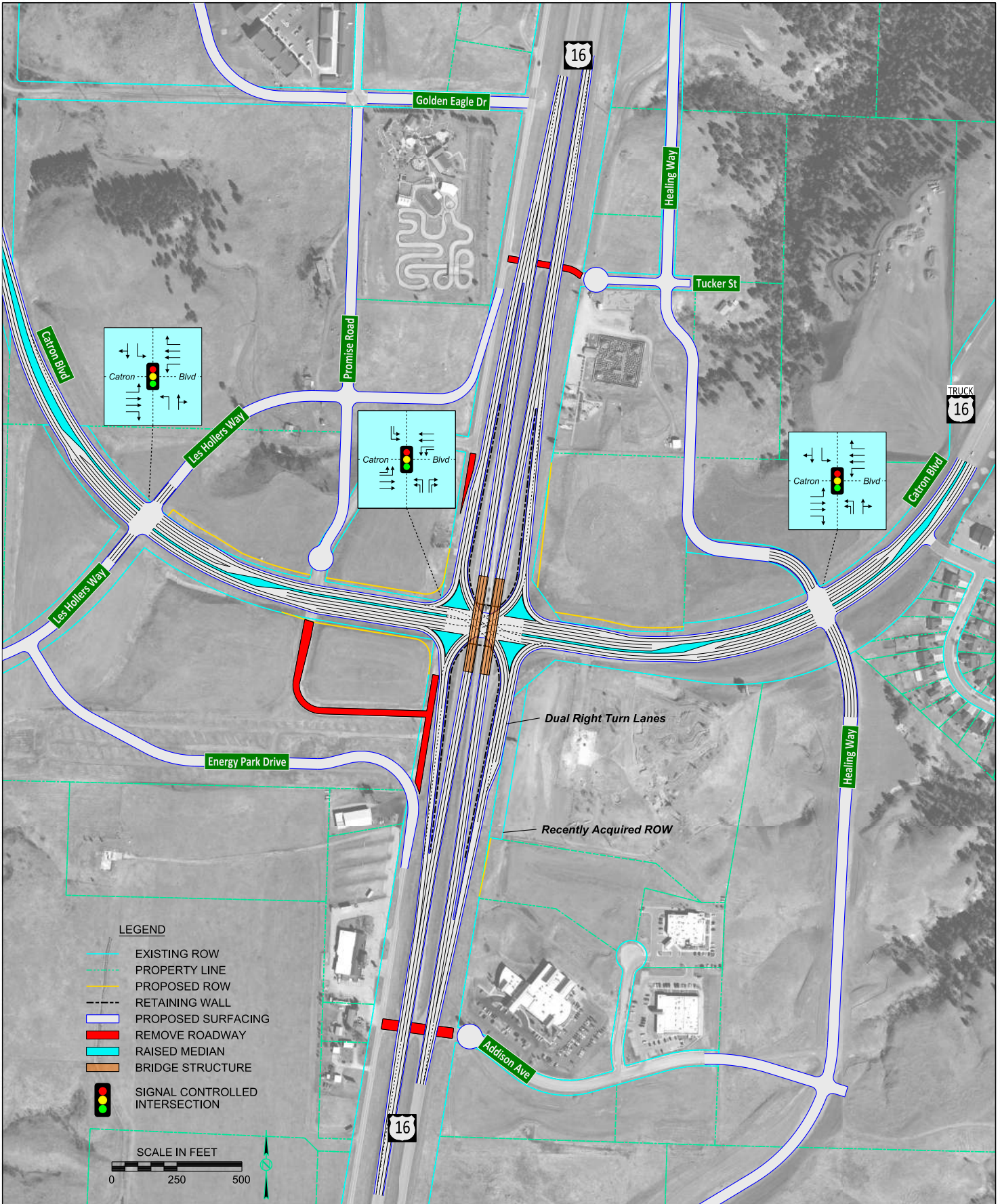
SCALE IN FEET  
 0      250      500



**Alternative 2.2 - Single Point Urban Interchange**  
 with EB to SB Dual Right Turn Lanes at Healing Way  
 US16 / US16B / Catron Blvd Study      Rapid City, SD

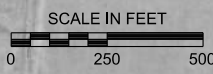
Figure  
**14**





**LEGEND**

- EXISTING ROW
- - - PROPERTY LINE
- PROPOSED ROW
- - - RETAINING WALL
- PROPOSED SURFACING
- REMOVE ROADWAY
- RAISED MEDIAN
- BRIDGE STRUCTURE
- SIGNAL CONTROLLED INTERSECTION



**Alternative 2.3 - Single Point Urban Interchange**  
 with NB to EB Dual Right Turn Lanes  
 US16 / US16B / Catron Blvd Study    Rapid City, SD

Figure  
**15**

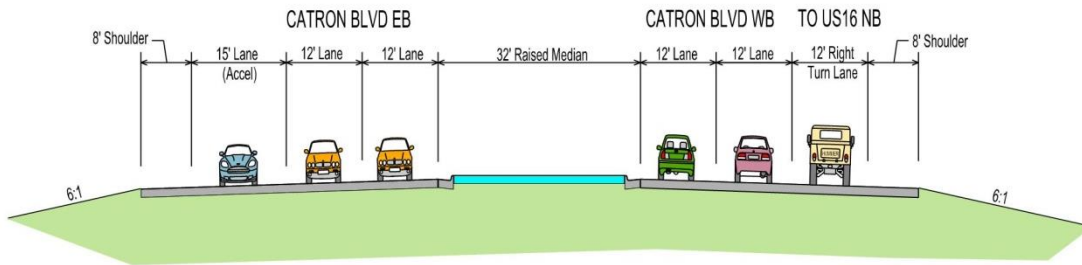
### 4.3.3 Alternative 3: Diverging Diamond Interchange (DDI)

The DDI has a similar configuration to Alternatives 1 and 2 in that the intersection is situated below a proposed US16 overpass. The DDI shifts traffic to the opposite side of the roadway while traveling through the interchange, which results in better traffic operations and reduced conflicts. See Figure 16 for the plan layout of Alternative 3. There are no existing DDIs in South Dakota, although one is planned for the I-90 & LaCrosse Street interchange in Rapid City. Alternative 3 will provide a future LOS B.

The twin bridges that cross over US16B / Catron Boulevard are anticipated to have a roadway width of 36 feet and an overall out-out length of 190 feet. It is anticipated that these structures would be single span girder bridges with concrete decks.

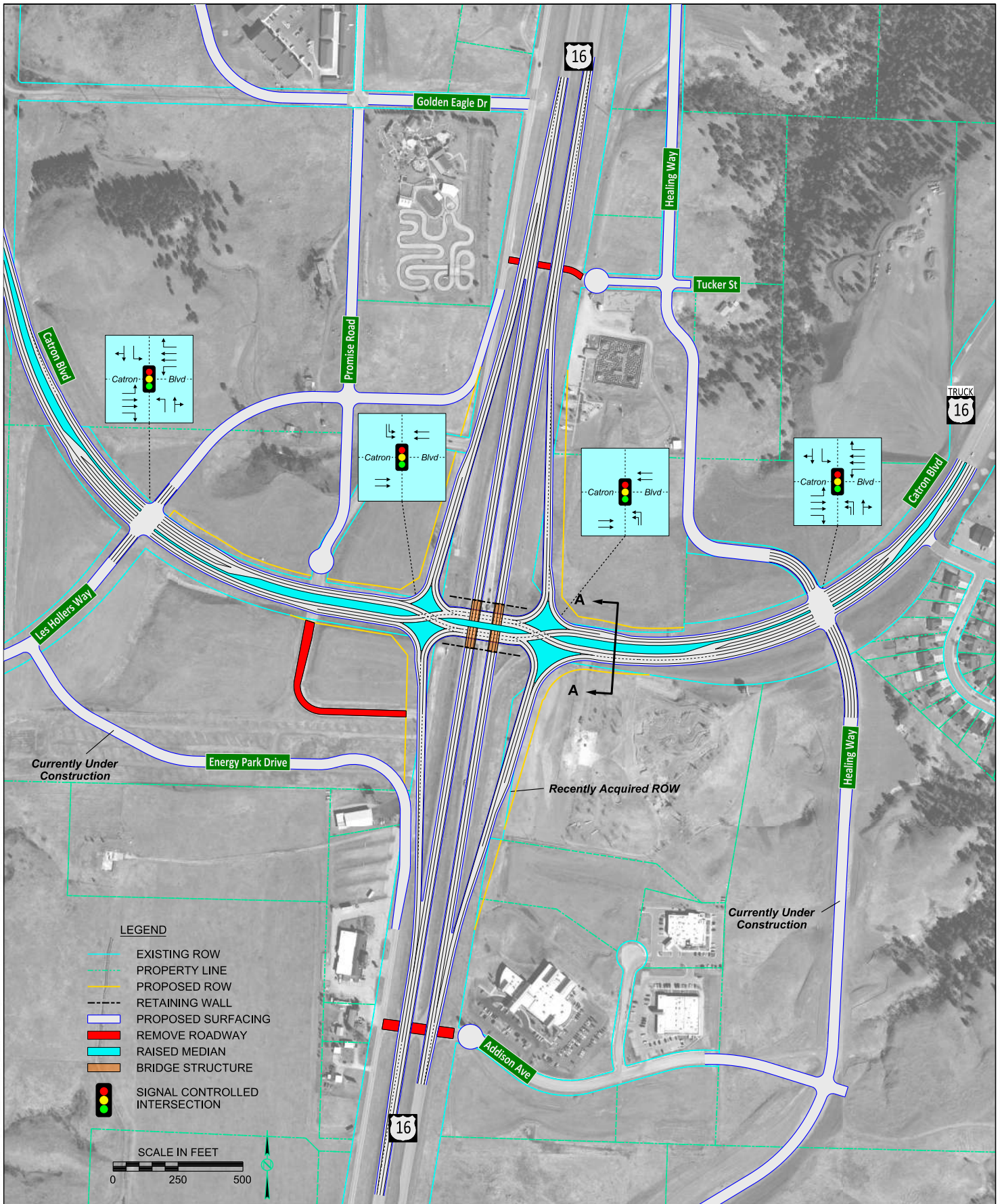
Drawbacks to the DDI include pedestrian access and driver familiarity. Once the LaCrosse Street DDI is in service (currently scheduled for 2020), driver familiarity should be less of an issue. For this particular configuration, the required distance between the intersections causes the ramps to have significant ROW impacts.

As indicated in the layout, the through lanes and left turn lanes are not separated until the exit ramp. The same bridge cross section was assumed for US16 as shown in Alternative 1.



**Typical Section – US16B / Catron Boulevard (Figure 16, Section A-A)**





**Alternative 3 - Diverging Diamond Interchange**  
 US16 / US16B / Catron Blvd Study    Rapid City, SD

Figure  
**16**

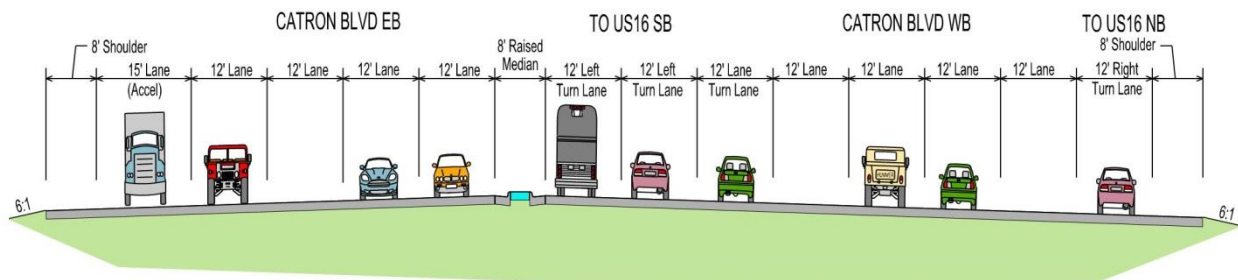
#### 4.3.4 Alternative 4: At-Grade Intersection

Alternative 4 is an expanded at-grade intersection (See Figure 17). In order to meet the demands of future traffic volumes, all approaches at the intersection include four through lanes, three left turn lanes, and separated, yield-controlled, right turn lanes. Although yield-controlled right turns are shown in the layout, acceleration lanes should be considered for these movements if the alternative is carried forward. Alternative 4 will provide a future LOS C.

This option had the second lowest cost, but also extends projected construction limits further than other alternatives in order to accommodate the additional lanes.

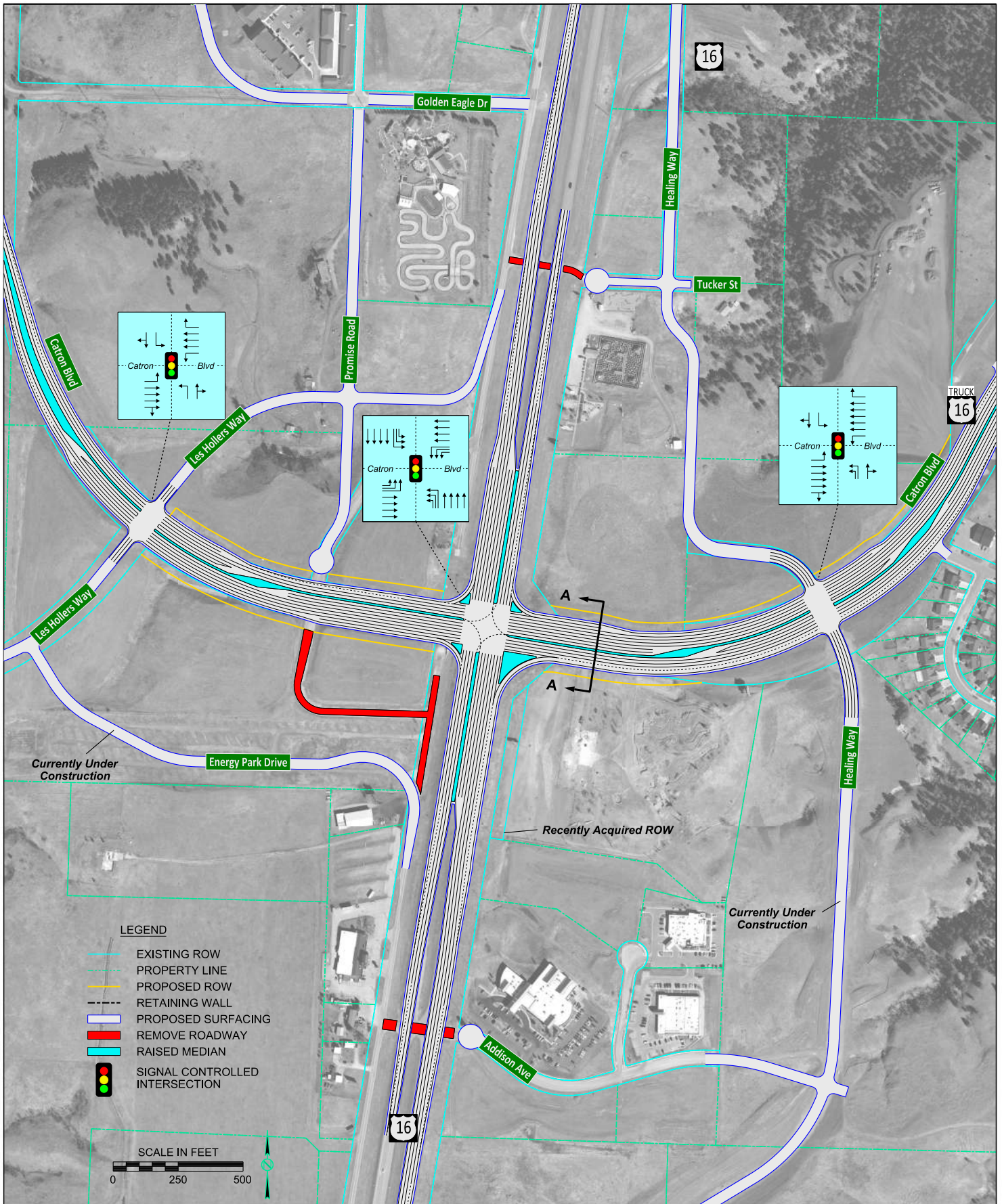
ROW impacts are limited to the US16B / Catron Boulevard corridor. There are no structures included with this alternative.

Although the expanded intersection provides LOS C under future traffic conditions, it does not operate at the efficiency of other alternatives. As expected with an at-grade intersection, it also has many conflict points relative to other alternatives.



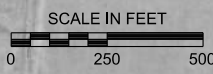
**Typical Section – US16B / Catron Boulevard (Figure 17, Section A-A)**





**LEGEND**

- EXISTING ROW
- PROPERTY LINE
- PROPOSED ROW
- RETAINING WALL
- PROPOSED SURFACING
- REMOVE ROADWAY
- RAISED MEDIAN
- SIGNAL CONTROLLED INTERSECTION



**Alternative 4 - At-Grade Intersection**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

**17**



#### 4.3.5 Alternative 5: Continuous Flow Intersection (CFI)

Alternative 5 includes a CFI as shown in Figure 18. The CFI improves traffic operations by crossing over the left turning vehicles to the other side of oncoming traffic before the main intersection. For Alternative 5, the crossover or left turn displacement is incorporated for only two legs of the intersection on US16B / Catron Boulevard. The CFI consists of two, two phase signalized intersections at the crossover locations and a three phase traffic signal at the main intersection. Alternative 5 will provide a future LOS C.

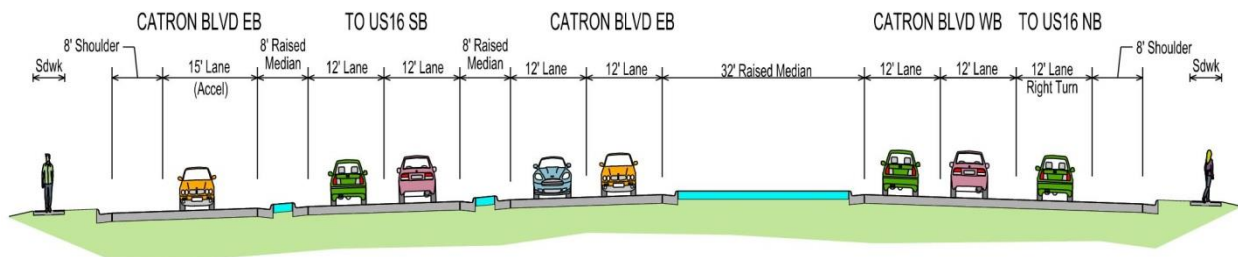
The CFI provides the necessary capacity for efficient future operations. It also has the lowest construction cost. In addition to these benefits, there are no structures required and it is pedestrian friendly.

The CFI had low overall ROW impacts since they are limited to the US16B / Catron Boulevard corridor. However, the ROW impacts extend deeper into private property along the US16B / Catron Boulevard corridor than other alternatives. Another drawback of this option is user familiarity since there are no existing CFIs in South Dakota.

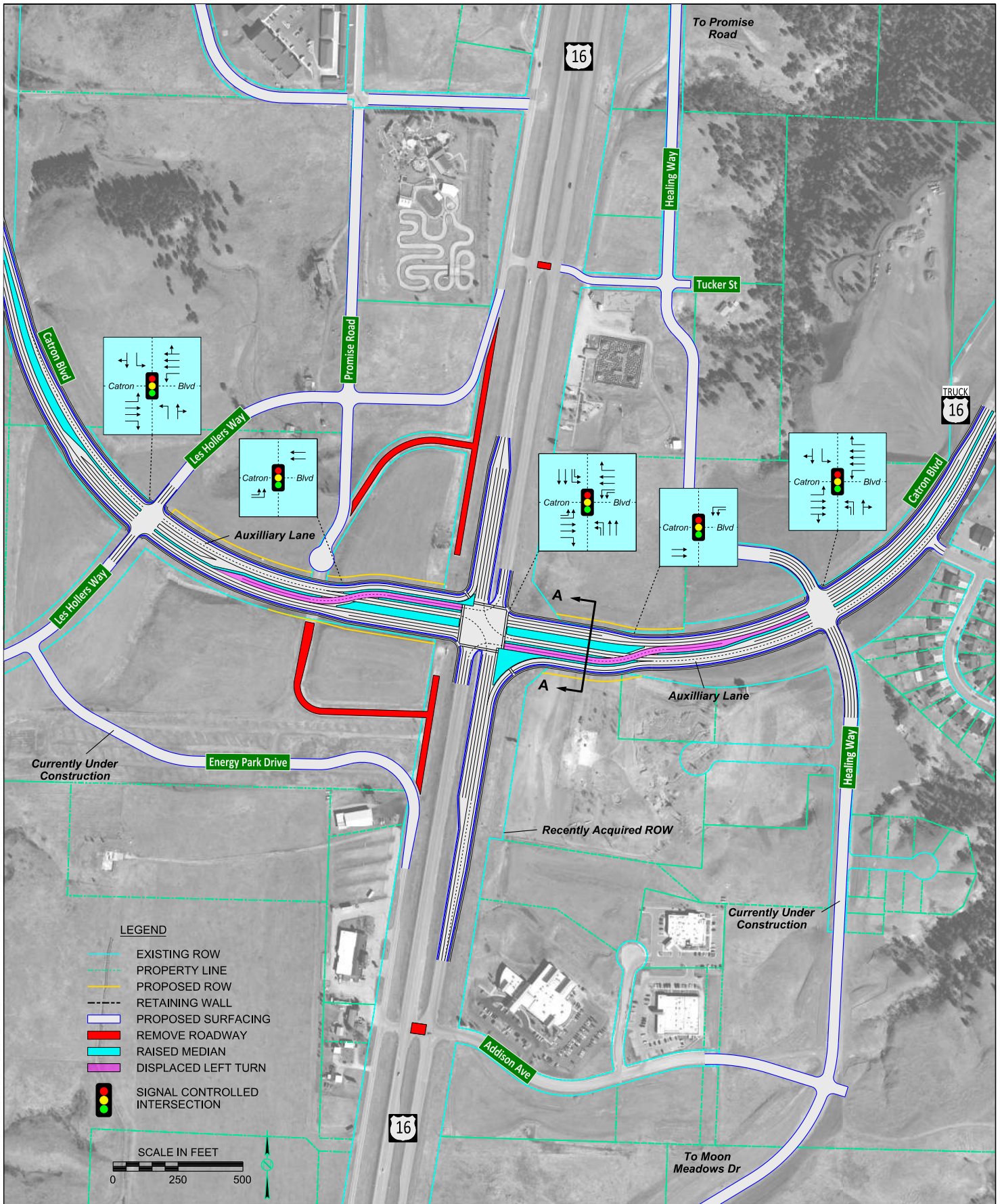
It is also noteworthy that a third westbound lane had to be added on US16B / Catron Boulevard, east of the Healing Way intersection in order to develop the necessary left turn lanes and queue lengths at the CFI. The projected queue for the westbound to southbound left turn lane was evaluated to ensure it would not interfere with the Healing Way intersection.

The CFI layout includes an eastbound auxiliary lane between US16 and Healing Way to address the potential weaving conflict between the eastbound acceleration lane and right turn lane at Healing Way as described in Section 4. The auxiliary lane continues east of Healing Way, similar to SPUI Alternative 2, providing room for acceleration prior to merging into the eastbound lanes.

The three intersections that compose the CFI will require traffic signal coordination. There may be benefit in coordinating all five of the closely spaced signalized intersections on US16B / Catron Boulevard in the future (includes Healing Way and Les Hollers Way intersections). Variations in daily and seasonal traffic demand will likely create the need for regular maintenance of the traffic signal timing patterns. An adaptive traffic signal system would mitigate the need for ongoing maintenance by automating the signal timing adjustments based on live traffic conditions.



Typical Section – US16B / Catron Boulevard (Figure 18, Section A-A)



**Alternative 5 - Continuous Flow Intersection**  
 US16 / US16B / Catron Blvd Study Rapid City, SD

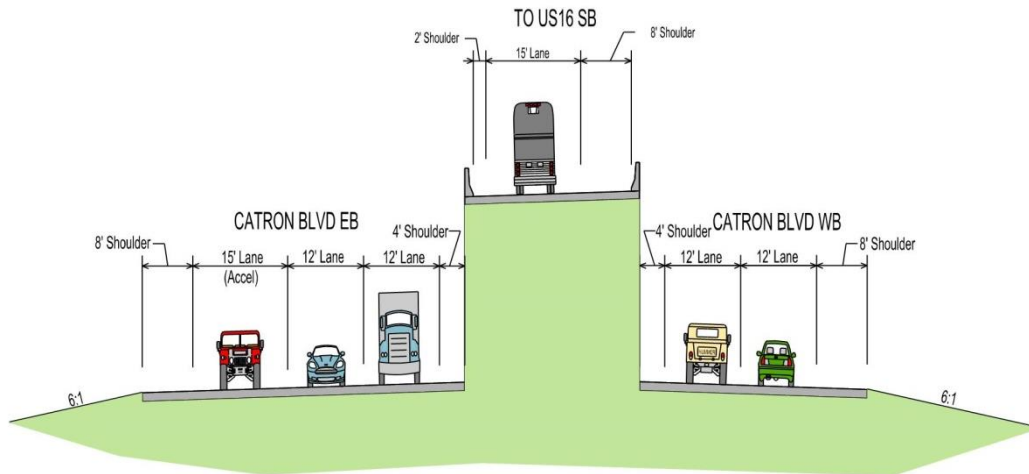
Figure  
**18**

### 4.3.6 Alternative 6: SPUI with Flyover

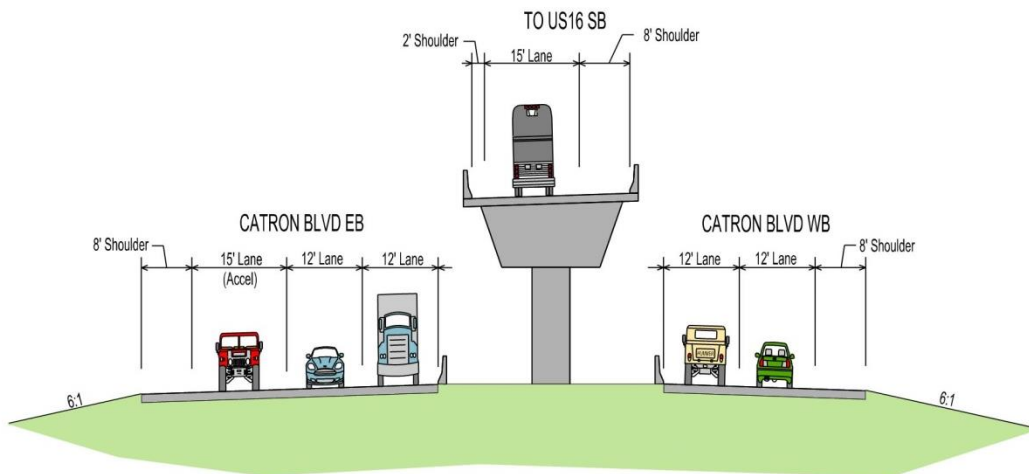
The plan layout for Alternative 6 is shown in Figure 19. This is the same configuration as Alternative 2 with one major modification; it includes a westbound to southbound flyover ramp. A single lane flyover takes the place of the two westbound left turn lanes, allowing continuous flow for westbound to southbound traffic. This configuration works very efficiently for traffic, but may not be worth the additional cost. The SPUI traffic signal will still operate with three phases. Alternative 6 will provide a future LOS B.

The flyover would be constructed with retaining walls and embankment until it crosses over traffic. Then it would become a bridge structure. The structures for the US16 overpass are identical to Alternative 2. The flyover structure is anticipated to have a roadway width of 25 feet and a length of 810 feet. The structure would be a girder bridge with either a 4 or 5 span configuration. The long, curved structure combined with lengthy retaining walls will be a significant expense. The elevated section would also have potential maintenance issues due to icing and snow drifting in adjacent lanes.

The flyover ramp would require an additional lane and gore area on US16B / Catron Boulevard east of Healing Way for positioning eastbound to southbound left turning traffic prior to the elevated section. Careful attention to signage and pavement markings would also be critical to traffic operations and safety.

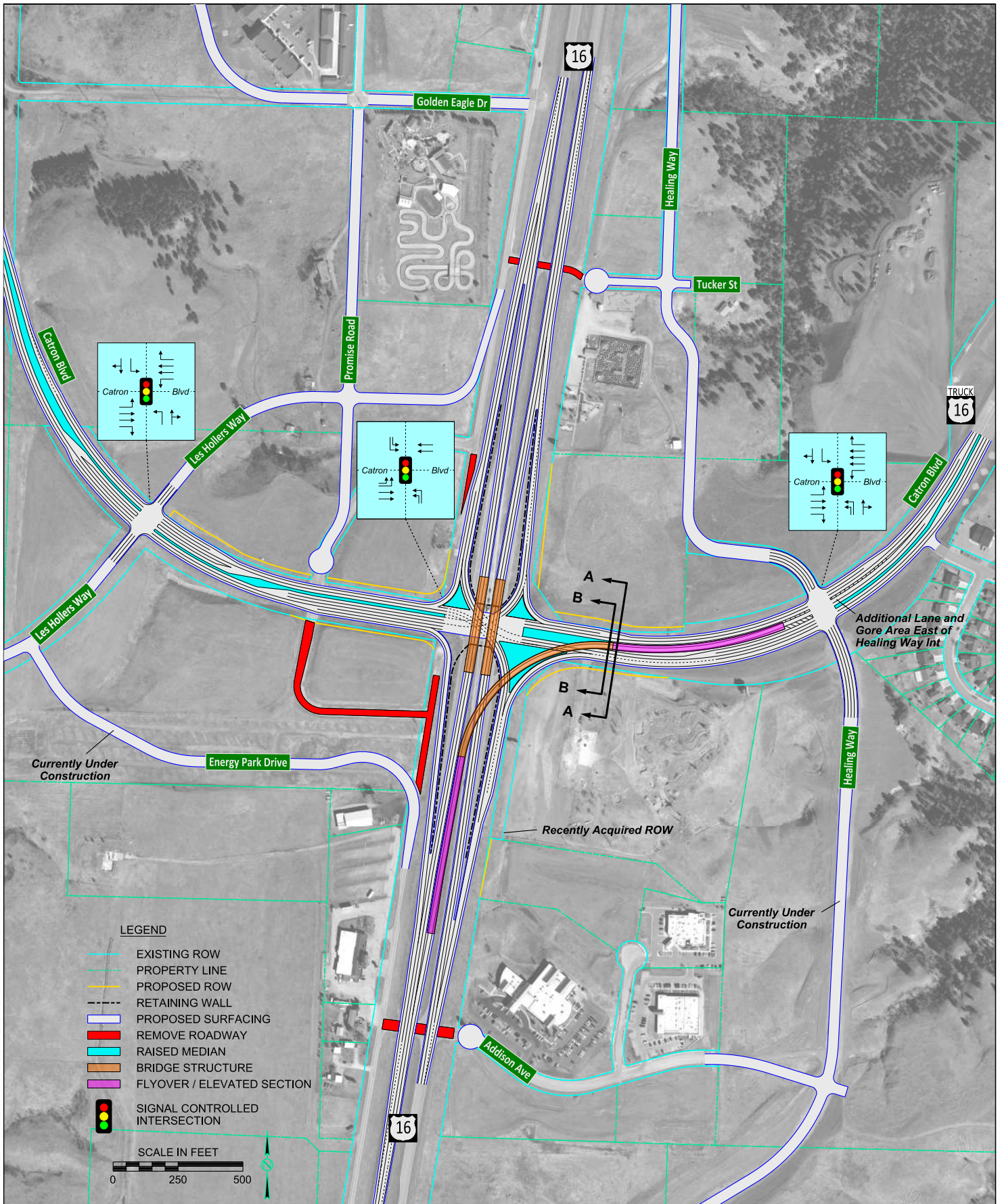


**Typical Section – US16B / Catron Boulevard Flyover with Retaining Wall (Figure 19, Section A-A)**



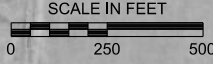
**Typical Section – US16B / Catron Boulevard Flyover with Bridge (Figure 19, Section B-B)**





**LEGEND**

- EXISTING ROW
- PROPERTY LINE
- PROPOSED ROW
- RETAINING WALL
- PROPOSED SURFACING
- REMOVE ROADWAY
- RAISED MEDIAN
- BRIDGE STRUCTURE
- FLYOVER / ELEVATED SECTION
- SIGNAL CONTROLLED INTERSECTION



**Alternative 6 - SPUI with Flyover**

US16 / US16B / Catron Blvd Study Rapid City, SD

Figure

**19**

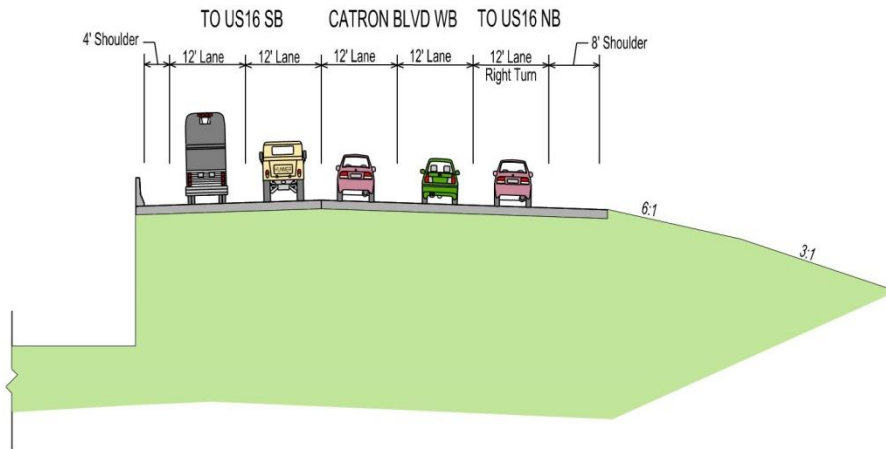
### 4.3.7 Alternative 7: Echelon Interchange

The Echelon Interchange would split the existing single intersection into two intersections that would function with two phase traffic control. One intersection would be elevated above the other, allowing movements to cross over conflicting lanes of traffic from the at-grade intersection. The Echelon Interchange is shown in Figure 20.

The proposed layout requires two separate structures, one oriented primarily for northbound traffic and the other for westbound traffic. The bridge for northbound traffic is anticipated to have a roadway width of 96 feet and an overall out-out length of 100 feet. The bridge for the westbound traffic is anticipated to have a roadway width of 36 feet and an overall out-out length of 165 feet. It is anticipated that both structures will be single span girder bridges with concrete decks.

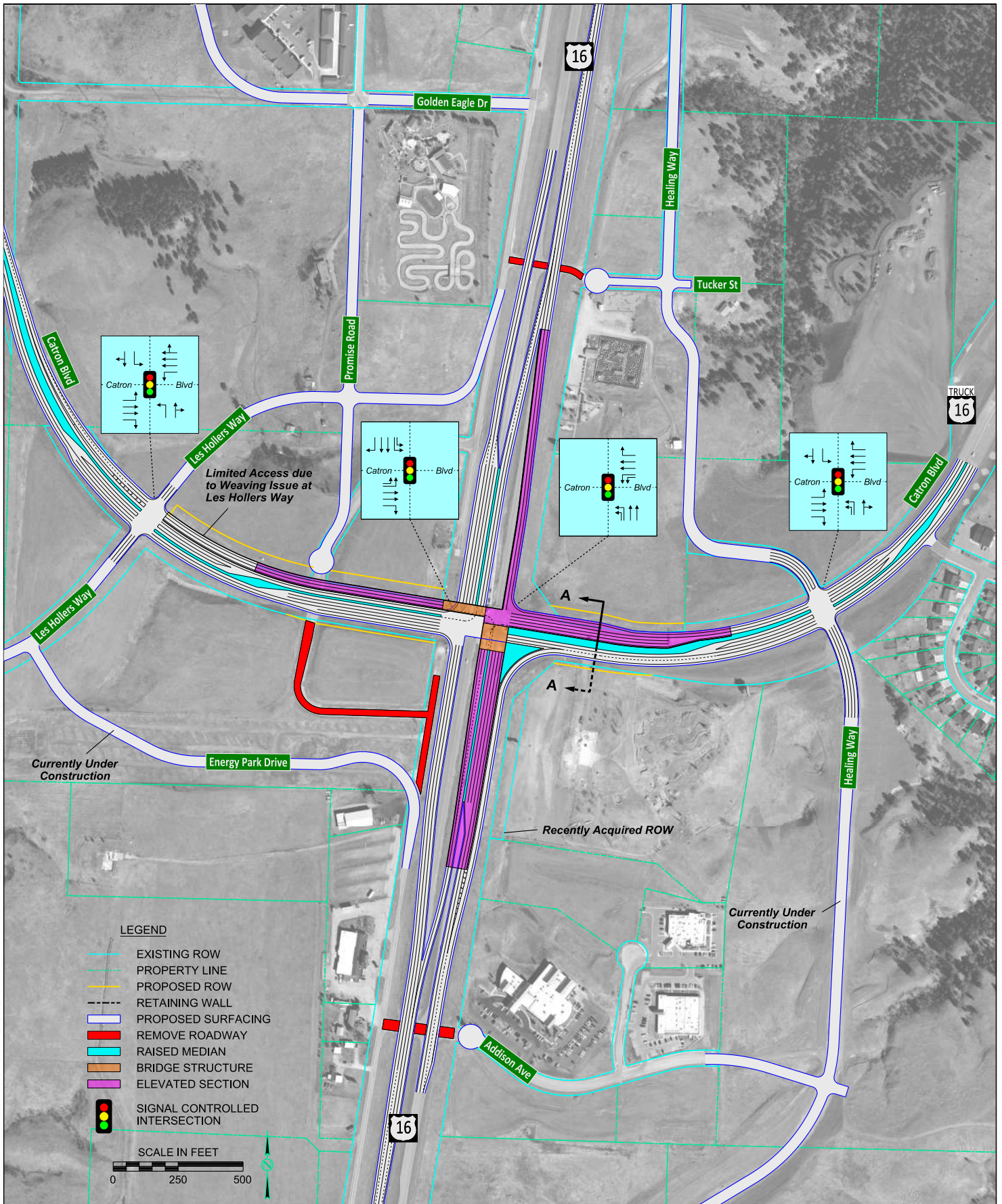
The Echelon Interchange provides efficient traffic operations under future conditions with LOS B. However, there are significant challenges with the elevated section along US16B / Catron Boulevard. The proposed layout elevates westbound Catron Boulevard, which creates weaving conflicts as it approaches the Les Hollers Way intersection. Access at Les Hollers Way would be limited with the Echelon Interchange. Traffic heading westbound on the elevated section would not be permitted to turn left at Les Hollers Way due to the adjacent at-grade westbound through lane and the proximity of the left turn lanes. Similarly, westbound traffic in the at-grade through lane would not be permitted to turn right at Les Hollers Way, since they would have to cross the two westbound lanes from the elevated section over a very short distance to make the right turn.

The weaving issue would be compounded if the eastbound lanes were elevated instead of the westbound lanes. There would be two lanes of westbound traffic on both the at-grade and elevated sections, along with a greater eastbound to southbound right turn demand at Healing Way. Elevation of the eastbound lanes would be preferable for winter maintenance, but it is not recommended due to the operational challenges.



Typical Section – US16B / Catron Boulevard Westbound Elevated Section (Figure 20, Section A-A)





**Alternative 7 - Echelon Interchange**

US16 / US16B / Catron Blvd Study Rapid City, SD

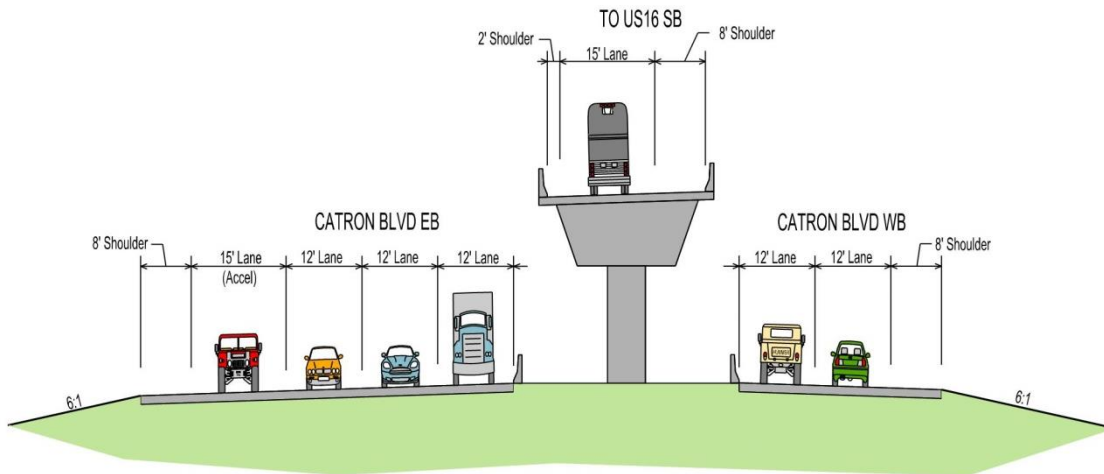


#### 4.3.8 Alternative 8: At-Grade Intersection with Flyover

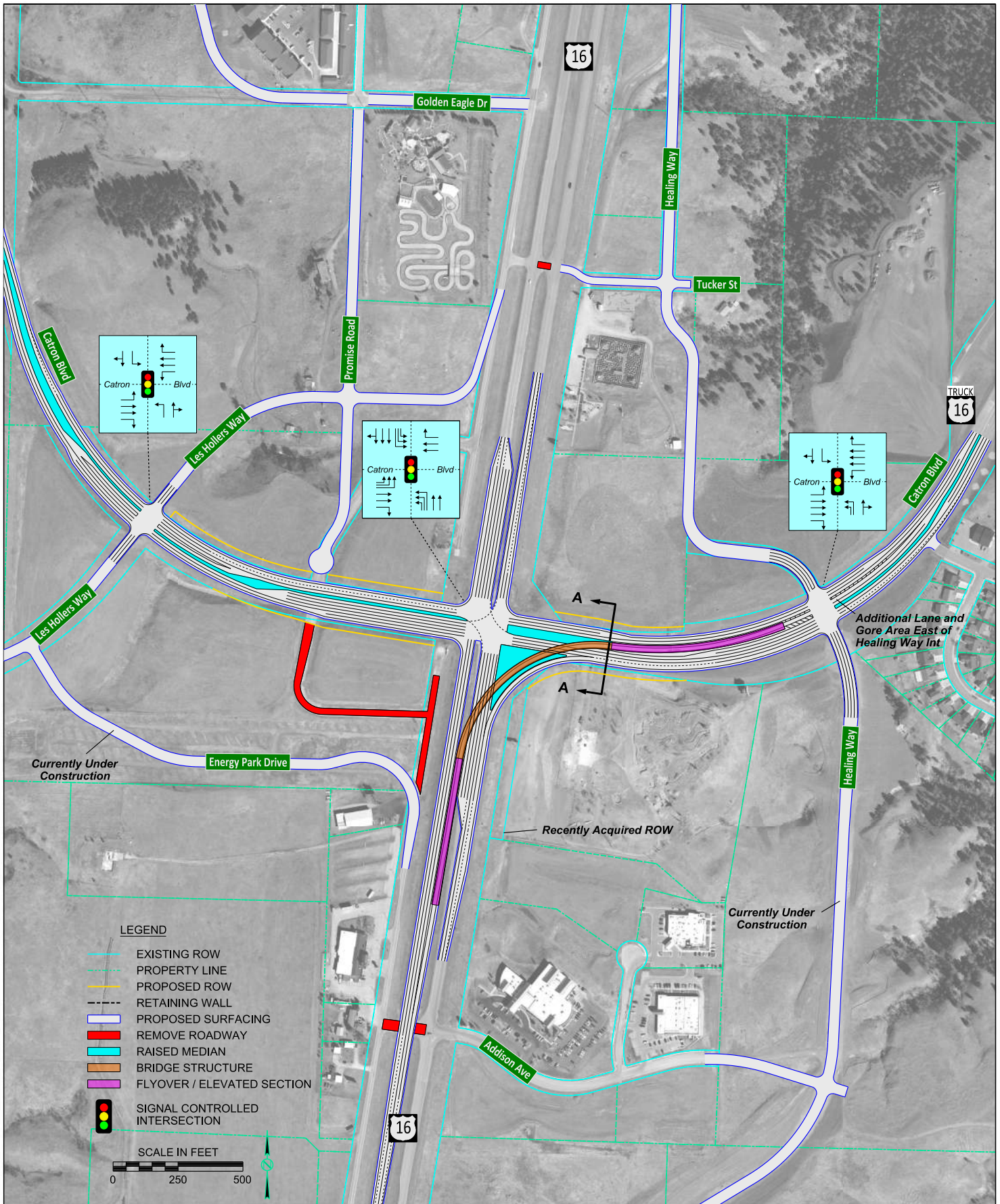
Alternative 8 consists of an at-grade intersection with an eastbound to southbound flyover ramp (See Figure 21). The flyover improves traffic operations, allowing for a smaller signalized intersection than what is shown in Alternative 4. The at-grade intersection for Alternative 8 would have two through lanes in all directions with a shared through / right lane on the north approach. Three of the approaches would have triple left turn lanes, and the east approach would have a single lane flyover to accommodate left turning vehicles. Alternative 8 will provide a future LOS C.

The flyover structure is anticipated to have a roadway width of 25 feet and a length of 810 feet. The structure would be a girder bridge with either a 4 or 5 span configuration. The long, curved structure combined with lengthy retaining walls will be a significant expense. The elevated section would also have potential maintenance issues due to icing and snow drifting in adjacent lanes.

Similar to Alternative 6, the flyover ramp would require an additional lane and gore area on US16B / Catron Boulevard east of Healing Way for positioning eastbound to southbound left turning traffic prior to the elevated section. Careful attention to signage and pavement markings would also be critical to traffic operations and safety. Another drawback to this option is the need for triple left turn lanes (and receiving lanes) at the intersection. This increases the overall footprint of the project, both at the primary intersection and adjacent intersections as the lanes are added and dropped to meet the turning demands.



**Typical Section – US16B / Catron Boulevard Flyover with Bridge (Figure 21, Section A-A)**



**Alternative 8 - At-Grade Intersection with Flyover**

US16 / US16B / Catron Blvd Study Rapid City, SD

## 5. Road Safety Audit

A Road Safety Audit (RSA) was conducted on May 25, 2016. As the alternatives were refined and evaluated, Alternative 2 (Single Point Urban Interchange) and Alternative 5 (Continuous Flow Intersection) emerged as the highest ranked options. Both of these alternatives were discussed and evaluated at the RSA.

### 5.1 Alternative 2: Single Point Urban Interchange

Some of the highlights of the discussion related to Alternative 2 are as follows:

- The potential for weaving conflicts on US16B / Catron Boulevard between US16 and Healing Way was discussed. The best approach for meeting the competing demands of safety, operations, and access in relation to the weaving area is by inclusion of an eastbound auxiliary lane as discussed in Section 4.
- Use of a three-span structure in the urban interchange alternative would give drivers a perception of better “comfort” sight distance.
- Ramp layouts should be similar to successful single point applications in South Dakota in relation to handling of the right turning traffic; either having a merging lane after their turn or having an adequate approach angle and sufficient sight distance to judge gaps in traffic.

### 5.2 Alternative 5: Continuous Flow Intersection

Some of the highlights of the discussion related to Alternative 5 are as follows:

- Offsetting opposing left turn lanes is recommended at some intersections to provide better sight distance for turning vehicles. The ultimate intersection configuration does not require offsetting the left turns on US16 since dual left turn lanes would be operated in protected-only phasing. There may be additional factors and the need for offsetting the left turn lanes on US16 should be considered during design.
- Pedestrian crossings in the CFI concept would have to be multi-stage with pedestrian refuge areas.
- Positive guidance should be provided for the diverted left turn traffic to make sure they proceed in the right direction and don't end up head-to-head with opposite direction traffic.
- There is frequent fog at this location which can make operations more difficult. The design should carefully provide visible/understandable signing, marking and positive guidance. A grade-separated interchange may be better suited to address fog/visibility problems at this location.





### 5.3 General Comments

- Speed limit reduction on US 16 may be needed in the future as development occurs, particularly with intersection alternatives. The interchange concepts with free-flow US 16 traffic may mitigate the need for speed limit changes.
  - Safety analysis indicated that speed may have been a factor in the current crash history.
  - Some of the interchange alternatives that include a US16 overpass would eliminate conflicts from higher speed traffic on US 16, mitigating the need for speed limit changes.
  - The intersection alternatives would reduce conflicts for traffic on US 16, but would require slower operation and more stops.
  - Relative Operating Speed for US 16 (estimated 85<sup>th</sup> percentile):

	<b>SPUI (US16 overpass)</b>	<b>CFI (US16 signalized intersection)</b>
<b>Posted Speed Limit (mph)</b>	60	45
<b>Operating Speed (mph)</b>	66	52

- Team members expressed no objections to the concepts presented for the project that could not be addressed during design. The comments presented during the Road Safety Audit should be carried forward to the design phase of the projects.
- A full summary of the RSA meeting minutes can be found in Appendix G.

## 6. Public Outreach Summary

### 6.1 Public Meeting #1

An Open House Public Meeting was held November 12, 2015 for the purpose of announcing the intersection study and obtaining input from the public. Approximately 52 people attended the Open House and provided a variety of comments. No clear themes emerged at the first Open House and a summary of comments is included in the Appendix F.

### 6.2 Neighborhood Landowner Meetings and Public Meeting #2

Neighborhood Landowner Meetings and a second Open House Public Meeting were held on October 12, 2016, for the purpose of presenting the two leading alternatives for the US16/US16B/Catron Boulevard intersection. The alternatives under consideration were Alternative 2 (Single Point Urban Interchange) and Alternative 5 (Continuous Flow Intersection).

Public support for one alternative over the other was somewhat divided. However, the majority of comments that expressed a preference favored Alternative 2 (SPUI). Support for Alternative 5 (CFI) was primarily due to the alternative having lesser impacts to local access. Implementing the SPUI would require elimination of existing access to US16 at Addison Avenue and Tucker Street. This access could be maintained with the CFI, although it would be limited to right-in-right-out. Alternative 5 (CFI) also generated numerous concerns because of the unfamiliar configuration. There were concerns related to out-of-town / recreational traffic being able to navigate the crossovers, confusion during adverse weather conditions, and difficulty with snow maintenance. A summary of the meetings and comments received can be found in Appendix F.

## 7. Summary and Recommendations

A number of parameters were used to analyze and develop rankings for the build alternatives. Some of the parameters such as Construction Cost and ROW Impact are easily quantified, while others are more relative in nature. Each alternative is scored on a five point scale for each parameter, which is then multiplied by the weight to develop the overall ranking. The highest score of 5 is given to best alternatives when considering a particular parameter, while 1 would be the lowest score.

The first parameter considered is Construction Cost. The Total Construction Cost ranged from approximately \$12 million to \$35 million. As expected, the Alternatives that include bridge structures and ramps were significantly more expensive than those that can be constructed at natural grade. Construction Costs were scored as follows:

- 5 = <\$10M
- 4 = \$10.0M to \$14.9M
- 3 = \$15.0M to \$19.9M
- 2 = \$20.0M to \$24.9M
- 1 = >\$25.0M

Alternative Cost Estimates are included in Appendix H.

ROW acquisition was estimated for each Alternative based on the approach described in Section 4. The cost of ROW was assumed to be \$3.50 per square foot. The projected ROW costs ranged from \$0.2 million to \$1.2 million. The SPUI and At-Grade Intersection with Flyover ranked highest in regard to ROW impacts. The ROW Impacts were scored as follows:

- 5 = <\$0.4M
- 4 = between \$0.4M and \$0.6M
- 3 = between \$0.6M and \$0.8M
- 2 = between \$0.8M and \$1.0M
- 1 = >\$1.0M

The estimated ROW needs (area and estimated cost) are included in the Alternative Cost Estimates in Appendix H.

The Traffic Operations parameter was an assessment of projected future intersection delay. Alternatives were also penalized for interference with adjacent intersections. This would include Alternatives 4 through 8 as they all required additional lanes on Catron Boulevard extending through the Healing Way and / or Les Hollers Way intersections. The SPUI and DDI ranked highest in this category.

Driver Familiarity tries to anticipate the driver's level of comfort with the surrounding environment while progressing through the intersection. Intersections that are common to Rapid City include At-Grade intersections and SPUI's. These would receive higher rankings if the intersections have typical lane configurations and geometry. Intersections / interchanges that are not common to the City or region receive lower rankings. Intersections with more than 2 left turn lanes were also considered less familiar. Although there are currently no DDIs in South Dakota, the DDI received a score of 3 since there is one currently planned for construction in Rapid City.

Safety Impacts scores were taken directly from the Safety Assessment which is included as Appendix E. Interchanges generally provide improved safety conditions when compared to At-Grade intersections. The SPUI and DDI were the highest ranked options when considering safety.





Bicycle and Pedestrian Use scores are based on research of intersection / interchange literature, length of travel when crossing traffic, and whether the crossing is signal protected. Based on the scoring approach, traditional intersections would generally be favored for accommodating bicycle and pedestrian activity since the crossings can be protected with signalized movements. However, the At-Grade intersection Alternatives in this study scored low primarily due to the length of the pedestrian crossings and the unprotected right turn crossing movements.

Environmental impacts were deliberately omitted from the alternative comparison matrix. The anticipated environmental impacts were very similar for all the alternatives that were considered with the exception of ROW impacts (from an environmental perspective). Since ROW is addressed as its own category, an additional category for environmental impacts would have been redundant.

The relative weighting places the highest emphasis on Construction Cost, ROW Impact, Traffic Operations, and Safety Impacts. Driver Familiarity and Bicycle and Pedestrian Use were apportioned lower weights in the matrix.

**Table 1. Alternative Comparison Matrix**

	<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 12.5%;"><i>Tight Diamond Urban Interchange</i></td> <td style="width: 12.5%;"><i>Single Point Urban Interchange</i></td> <td style="width: 12.5%;"><i>Diverging Diamond Interchange</i></td> <td style="width: 12.5%;"><i>At-Grade Intersection</i></td> <td style="width: 12.5%;"><i>Continuous Flow Intersection</i></td> <td style="width: 12.5%;"><i>SPUI with Flyover</i></td> <td style="width: 12.5%;"><i>Echelon Interchange</i></td> <td style="width: 12.5%;"><i>At-Grade Int. with Flyover</i></td> </tr> </table>								<i>Tight Diamond Urban Interchange</i>	<i>Single Point Urban Interchange</i>	<i>Diverging Diamond Interchange</i>	<i>At-Grade Intersection</i>	<i>Continuous Flow Intersection</i>	<i>SPUI with Flyover</i>	<i>Echelon Interchange</i>	<i>At-Grade Int. with Flyover</i>
<i>Tight Diamond Urban Interchange</i>	<i>Single Point Urban Interchange</i>	<i>Diverging Diamond Interchange</i>	<i>At-Grade Intersection</i>	<i>Continuous Flow Intersection</i>	<i>SPUI with Flyover</i>	<i>Echelon Interchange</i>	<i>At-Grade Int. with Flyover</i>									
<b>Alternative</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>								
Roadway Cost (\$ Millions)	16.8	19.2	16.5	17.4	11.6	16.8	14.9	11.2								
Structure Cost (\$ Millions)	4.0	9.2	3.9	0.0	0.0	18.5	11.3	9.3								
Total Construction Cost (\$ Millions)	20.8	28.4	20.4	17.4	11.6	35.3	26.2	20.5								
ROW Cost (\$ Millions)	0.8	0.3	1.2	0.7	0.4	0.3	0.4	0.2								
Total Cost (\$ Millions)	21.6	28.7	21.6	18.1	12.0	35.6	26.6	20.7								
Construction Cost	2	1	2	3	4	1	1	2								
ROW Impact	2	5	1	3	4	5	4	5								
Traffic Operations	2	4	4	3	4	5	4	3								
Driver Familiarity	3	5	3	3	2	3	2	3								
Safety Impacts	4	5	5	2	4	4	3	2								
Bicycle and Pedestrian Use	3	2	3	1	3	1	4	1								
Score	260	370	300	260	370	340	300	280								
<b>Rank</b>	<b>7</b>	<b>1</b>	<b>4</b>	<b>7</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>6</b>								

Weight
20
20
20
10
20
10
100

As the alternatives were refined, evaluated and scored, the Single Point Urban Interchange (Alternative 2) and Continuous Flow Intersection (Alternative 5) emerged as the highest ranked options. The Continuous Flow Intersection is a newer concept than the Single Point Urban Interchange and therefore may be perceived as a less comfortable solution. However, the Continuous Flow Intersection has already been implemented by numerous agencies and is likely to gain additional traction with the passing of time. It is recommended that Alternative 2 and Alternative 5 be carried forward and further evaluated during an environmental study to be conducted after a project for the intersection has been added to the SDDOT's developmental program.