

A graphic for the US Highway 16 Corridor Study. It features a light green background with a dark green mountain range silhouette at the bottom. An orange horizontal bar at the top contains the text "US Highway 16" in white. Below the bar, the words "CORRIDOR STUDY" are written in dark green.

US Highway 16

CORRIDOR STUDY

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# US16/US16B/Catron Boulevard Intersection Build Option Evaluation

Pennington County, South Dakota

July 14, 2021



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## 1.0 Introduction

The South Dakota Department of Transportation (SDDOT) has initiated a study of the US16 corridor between the Keystone Wye (US16A) and Cathedral Drive/Fairmont Boulevard. Within the overarching corridor study, the SDDOT has identified a future project, currently planned for fiscal year 2026, at the US16/US16B/Catron Boulevard intersection.

The purpose of this report is to present and evaluate Build Options developed to address transportation issues and needs at the US16/US16B/Catron Boulevard intersection and other area access points. This report supports the US16/US16B/Catron Boulevard Intersection Build Options Report, which is the full technical analysis of proposed Build Options, and serves as a transition document between the technical study and environmental process.

In this report, benefits, drawbacks, and recommendations are listed for each Build Option. Based on this evaluation, a Build Option is recommended to be carried forward into the NEPA review. The main criteria used to evaluate the Build Options includes (not necessarily in order of importance):

- Whether a Build Option meets project purpose and need
- Traffic operations
- Traffic safety
- Right of way needs
- Construction costs
- Benefit-cost analysis
- Constructability, Maintenance, and Operations
- Public input
- Bicycle and pedestrian accommodations
- Potential environmental impacts

The following Build Options were developed for evaluation:

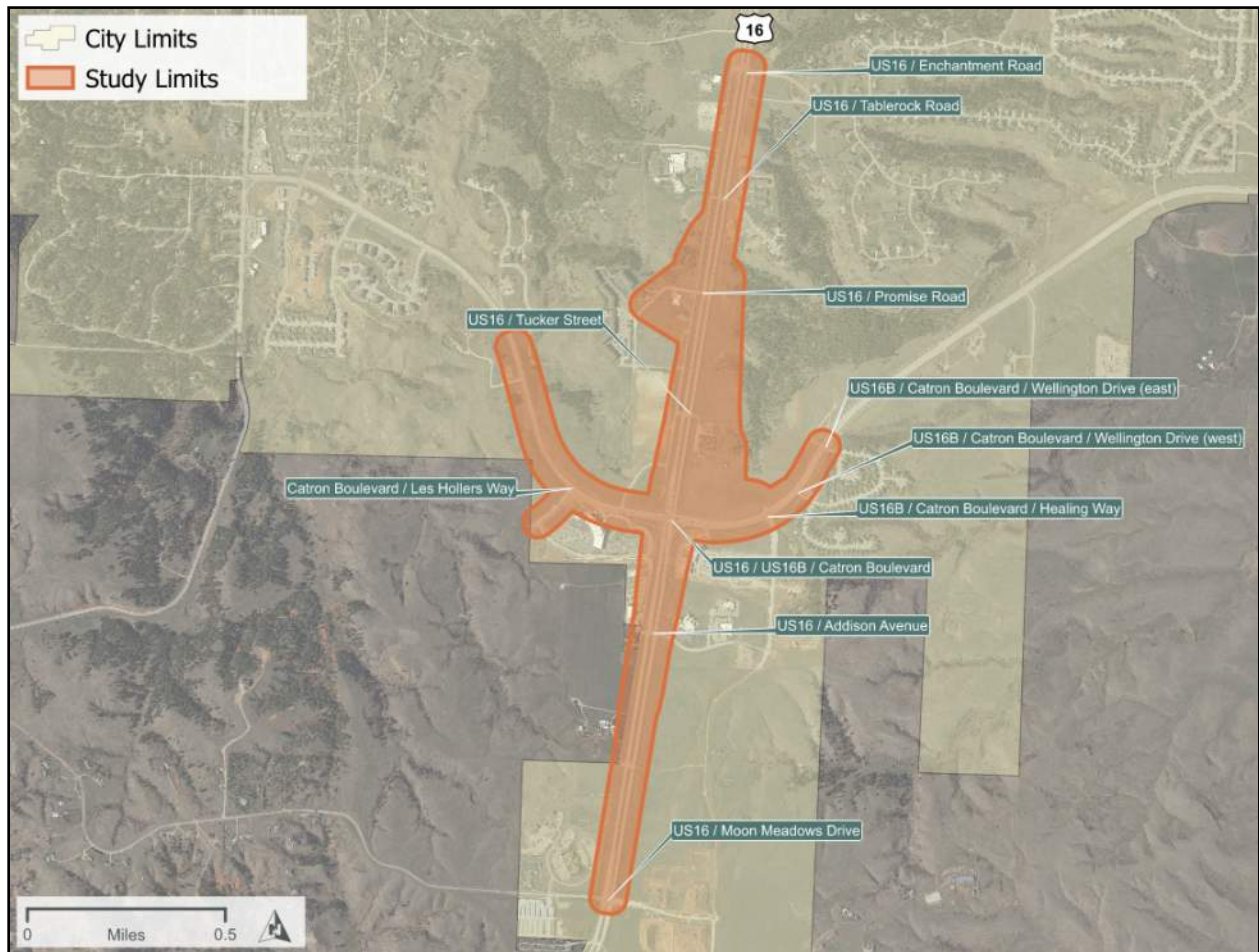
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## 2.0 Study Area

The study area for the US16/US16B/Catron Boulevard intersection project is as follows (and shown in **Figure 1**):

- US16: Moon Meadows Drive to Enchantment Road.
- US16B/Catron Boulevard: Les Hollers Way to Wellington Drive (east).
- US16 service roads along west side of US16 between Moon Meadows Drive and Enchantment Road.

This intersection is part of the overall US16 Corridor Study, which extends approximately 20 miles along US16 between the Keystone Wye and Cathedral Drive/Fairmont Boulevard in Rapid City.



**Figure 1: US16/US16B/Catron Boulevard Intersection Study Area**

### 3.0 Background

The US16/US16B/Catron Boulevard intersection was previously studied in 2016 where several concepts were developed and analyzed. Those concepts included:

- Alternative 1: Tight Diamond Urban Interchange (TDUI)
- Alternative 2: Single Point Urban Interchange (SPUI) (also known as a Single Point Interchange, or SPI)
- Alternative 3: Diverging Diamond Interchange (DDI)
- Alternative 4: At-Grade Intersection
- Alternative 5: Continuous Flow Intersection (CFI) (also known as a DLT intersection)
- Alternative 6: SPUI with Flyover
- Alternative 7: Echelon Interchange
- Alternative 8: At-Grade Intersection with Flyover

The US16/US16B/Catron Boulevard Intersection Alternatives Report<sup>1</sup> recommended that the SPI and CFI (or DLT intersection) be carried forward for further refinement and analysis.

The SDDOT currently has a project planned at this intersection for fiscal year 2026.

### 4.0 Purpose and Need Summary

The draft purpose and need statement for a project at the US16/US16B/Catron Boulevard intersection is as follows (as of April; 2020):

The purpose of the Project is to improve traffic operations and safety at the US16/US16B/Catron Boulevard intersection, and with the goal of supporting the planned mix use urban development that is occurring in the area.

This purpose is to address the following needs:

- Poor traffic operations
- High crash rates
- Rapidly urbanizing land use

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<sup>1</sup> SDDOT website: [https://dot.sd.gov/media/documents/US16\\_16B\\_Intersection\\_Study\\_Final\\_Report\\_12232016.pdf](https://dot.sd.gov/media/documents/US16_16B_Intersection_Study_Final_Report_12232016.pdf)

## 5.0 Evaluation Methodology

The following methodology was used to compare Build Options and determine the feasibility, benefits, and drawbacks of each.

### 5.1 Evaluation Categories

#### *Meets Purpose and Need*

Each Build Option was evaluated on whether it meets the US16/US16B/Catron Boulevard project purpose and need.

#### *2050 Planning Horizon Traffic Operations*

Comparative intersection and interchange traffic operational measures are based on the Highway Capacity Manual, 6<sup>th</sup> Edition (HCM6) methodology measures of average intersection delay (seconds per vehicle) and associated level of service (LOS). The 2050 Planning Horizon US16/US16B/Catron Boulevard intersection LOS goal for this study is LOS C with no individual movements worse than LOS D.

Travel time was the second comparative measure used. Each scenario incorporated similar start/end points within the model and measured the average travel time (seconds per vehicle) to travel between the two points.

Two analysis tools were used for this study:

- Highway Capacity Software (HCS)
- Vissim microsimulation

HCS traffic operations analysis categories include:

- Experienced Travel Time (ETT) - measured delay or out of direction travel at the intersection or series of intersections associated with US16/US16B/Catron Boulevard. This measure accounts for northbound/southbound free movements in the SPI and delay at crossover intersections in the DLT.
  - ETT is the basis for HCS-derived LOS.
- US16 corridor travel time - measured travel time between Moon Meadows Drive and Promise Road.

Vissim traffic operations analysis categories include:

- Intersection delay - measured delay of all vehicles entering the US16/US16B/Catron Boulevard intersection or interchange.
  - Intersection delay is the basis for Vissim-derived LOS
- US16 corridor travel time - measured travel time from approximately 0.5 miles south of Moon Meadows to approximately one mile north of Promise Road.
- US16B/Catron Boulevard corridor travel time - measured travel time from approximately 0.3 miles west of Les Hollers Way to approximately 0.3 miles east of Healing Way.

## *Traffic Safety*

This measure demonstrates a Build Options' predicted improvement over the No Build condition as well as establishes a comparative framework for gauging predicted safety improvements between each Build Option. The Federal Highway Administration's Interactive Highway Safety Design Model (IHSDM) was used to evaluate the expected decrease or increase in crashes between years 2026 and 2050 for each Build Option, summarized in terms of:

- 'Total Crashes' consists of all crash types (property damage only, injury, and fatal).
- 'Fatal and Injury Crashes' reflects the higher severity type crashes.

## *Traffic*

The traffic category presents two measures based on engineering interpretation of study traffic and safety models and human factors that play a notable role in developing design standards.

Closely spaced intersection considerations:

- US16 northbound/southbound right turn to downstream (Healing Way or Les Hollers Way) left turn weave movement.
  - Account for right turn movement delay, total stops, weave movement simulation review, and effect on overall intersection operations.
- Spacing between US16 and US16 service road intersection.
- US16B/Catron Boulevard corridor operations, weave movements, and intersection functional area.

Driver expectancy and ability to sign considerations:

- Expected performance during inclement weather conditions common to the intersection (fog, snow, etc.).
- Ability to sign local access and differentiate between local access and regional routes.
- Tourist traffic, unfamiliar drivers, and importance of the intersection to regional travel.

A rating of 5 to 1 was applied to each Build Option that summarizes answers to these questions, with 5 being the most favorable and 1 being the least favorable.

## *Right of Way Needs and Total Costs*

Build Option right of way and total cost components include:

- Right of way and easement acquisition (total acres)
- Total cost (construction cost + ROW cost + contingency)

## *Benefit-Cost Ratio*

Reflects findings from a Benefit-Cost Analysis (BCA) that accounts for the following:

- Travel Time Savings
- Emissions Cost Savings



- Accident Cost Savings
- Operations and Maintenance (O&M) Cost Savings
- Infrastructure Residual Value
- Capital Costs

A BCA greater than 1.0 represents a feasible project as the benefits are expected to exceed the costs within the analysis period. The BCA ratio presented in the matrix includes an estimation of daily traffic operations.

### *Construction, Maintenance, and Operations*

This category measures the constructability, maintenance, and operations to assess the build, own, and operate aspects of each Build Option.

Constructability is measured by considerations such as:

- Overall timeline for construction and construction limits.
- Maintenance of traffic along US16.
- Exposure of workers to traffic.
- Traffic signal infrastructure and timing plan development.

Maintenance and Operations considerations include:

- Winter weather maintenance.
- Signal phasing and timing plans.
- Roadway maintenance and SDDOT/City/contractor familiarity.
- Roadway maintenance costs (primarily accounted for in BCA).
- Traffic signal equipment maintenance costs.

A rating of 5 to 1 was applied to each Build Option that summarizes answers to these questions, with 5 being the most favorable and 1 being the least favorable.

### *Public Input*

This measure accounts for input provided by the public and project stakeholders during the December 10, 2019, stakeholder and public meetings. Much of the feedback the study team received focused on the following:

- Commuter traffic.
- Tourist traffic.
- Bicycle/pedestrian connectivity.
- Local network access.
- Planning effort to date.
- Local agency support.
- Does US16 through traffic need to stop?

The measure is based on support provided by the public and stakeholders in the form of written verbal comments at or following the meetings. A rating of 5 to 1 was applied to each Build Option that summarizes the overall support for each Build Option based on the considerations noted above. A 5 is the most favorable and 1 is the least favorable.

### *Bicycle and Pedestrian*

Considerations for bicycle and pedestrian travel through the US16/US16B/Catron Boulevard intersection area include:

- Route connectivity (along and across US16 corridor)
- Crossing delay.
- Route travel time.
- Signalized crossings.
- Crossing impacts to vehicular traffic and traffic signal timings.

A rating of 5 to 1 was applied to each Build Option that summarizes answers to these questions, with 5 being the most favorable and 1 being the least favorable.

### *Potential Environmental Impacts*

Two resource categories were used to qualitatively evaluate potential Build Option impacts:

- Socioeconomics and land use.

## 5.2 Evaluation Measure

Each Build Option was evaluated on how they compare with other Build Options in a given category and/or whether they meet study goals. This evaluation is summarized through the following color coding in the evaluation matrix.

- **Bold Green** text indicates a Build Option measure was favorable compared to the other Build Options in a category
- Black text indicates a Build Option measure was in the middle compared to other Build Options in a category
- **Bold Red** text indicates a Build Option measure was unfavorable compared to the other Build Options in a category or the measure does not meet study goals.

## 6.0 Evaluation

The following presents US16/US16B/Catron Boulevard intersection Build Options, evaluation findings, and recommendations. A graphical layout (see **Appendix A** for a full-size pdf), description, summary of benefits and drawbacks, and recommendation is provided for each Build Option. The US16/US16B/Catron Boulevard intersection Build Option evaluation matrix is provided in **Table 1**. **Appendix B** provides a summary of considerations for each measure incorporated into the matrix from the technical report. Tables in this appendix are color-coded to align with what is presented in the evaluation matrix.

### 6.1 No Build Condition

The No Build option is carried throughout the technical and environmental analysis for consideration as an option and as a baseline comparison for the Build Options. However, as noted in the evaluation matrix, the No Build option does not:

- Meet project purpose and need.
- Achieve LOS goals at the US16/US16B/Catron Boulevard intersection in the 2050 Planning Horizon.
- Improve intersection safety.
- Address growing traffic volumes from rapidly urbanizing land use.

## 6.2 Build Option Overview

Build Options developed for the US16/US16B/Catron Boulevard intersection are as follows:

- SPI 1.1a: SPI with Separated, Free NB and SB Right Turn Lanes
- SPI 1.1b: SPI with Separated, Free NB and SB Right Turn lanes and EB Right Turn lane at Healing Way
- SPI 1.2: SPI with Signalized NB and SB Dual Right Turn Lanes and EB Right Turn Lane at Healing Way
- DLT 2.1a: DLT with Separated, Free NB and SB Right Turn Lanes
- DLT 2.1b: DLT with Separated, Free Right Turn Lanes at Main Intersection (all Quadrants)
- DLT 2.2a: DLT with Signalized Right Turn Lanes at Main Intersection (all Quadrants)
- DLT 2.2b: DLT with NB and SB Signalized Right Turn Lanes, Free EB and WB Right Turn Lanes
- DLT 2.3: DLT with Unseparated, Signalized Right Turn Lanes at Main Intersection

The SPI Build Options require the Addison Avenue and Tucker Street access points to be closed due to the extension of interchange ramps through the access points. The opportunity to consider maintaining some level of access at Addison Avenue and Tucker Street was a primary reason for carrying forward DLT Build Options from the previous 2016 intersection study. Analyzed access treatments are noted in each respective DLT Build Option description.

Design-related considerations incorporated into the Build Options include:

Design-related considerations incorporated into the Build Options include:

- Due to the required closure of US16/Tucker Street access in the SPI Build Options, an extension of Promise Road is required to either:
  - US16/Promise Road intersection and/or
  - US16B/Catron Boulevard/Healing Way intersection.
- All Build Options include reconstruction of US16 between Catron Boulevard and Addison Avenue to flatten a vertical curve that does not meet current design speed.
- US16 intersections with Moon Meadows Drive and Promise Road were assumed signalized in the Build Condition analysis.

Several corridor elements were being developed and analyzed concurrently as part of the overarching US16 Corridor Study. As many of these involved an iterative process throughout the corridor study and this sub-study, the following elements are reflected in the recommended Build Option layout at the end of the report.

- US16 corridor design speed.
- US16 corridor typical section.
- Promise Road/Tablerock Road intersection location/access type.
- Promise Road intersection signalization needs and planning-level anticipated timeframe for meeting traffic signal warrants.
- Minor road access and local network connectivity.
- Bicycle and pedestrian accommodations.

Additional information regarding the concept development, refinement, and analysis for these recommendations incorporated into the Build Options is documented in the overarching *US16 Corridor Study* report.



## 6.3 Single Point Interchange Build Options

### 6.3.1 SPI 1.1a: SPI with Separated, Free NB and SB Right Turn Lanes

SPI 1.1a includes an SPI at the US16/US16B/Catron Boulevard intersection. US16 northbound and southbound mainline through lanes go over the single point intersection, which is located below the US16 structures on US16/B/Catron Boulevard. Both US16 mainline and the US16B/Catron Boulevard corridor consists of two through lanes in each direction through the signalized single point intersection.

The interchange includes free (unsignalized) right turn movements on the northbound and southbound US16 off-ramps. To accommodate a free right turn movement, an additional lane is extended to east (northbound to eastbound right turn) or west (southbound to westbound right turn) through the downstream intersection and merged back into US16B or Catron Boulevard through lanes.

Based on the 2050 traffic operations analysis findings, the northbound and southbound off-ramp right turn lanes are designed to accommodate dual right turn lanes in the future. If and/or when traffic volumes grow to a point where the downstream weave movement becomes prohibitive without providing signalized gaps in traffic, the pavement infrastructure will be in place to make a smooth transition.

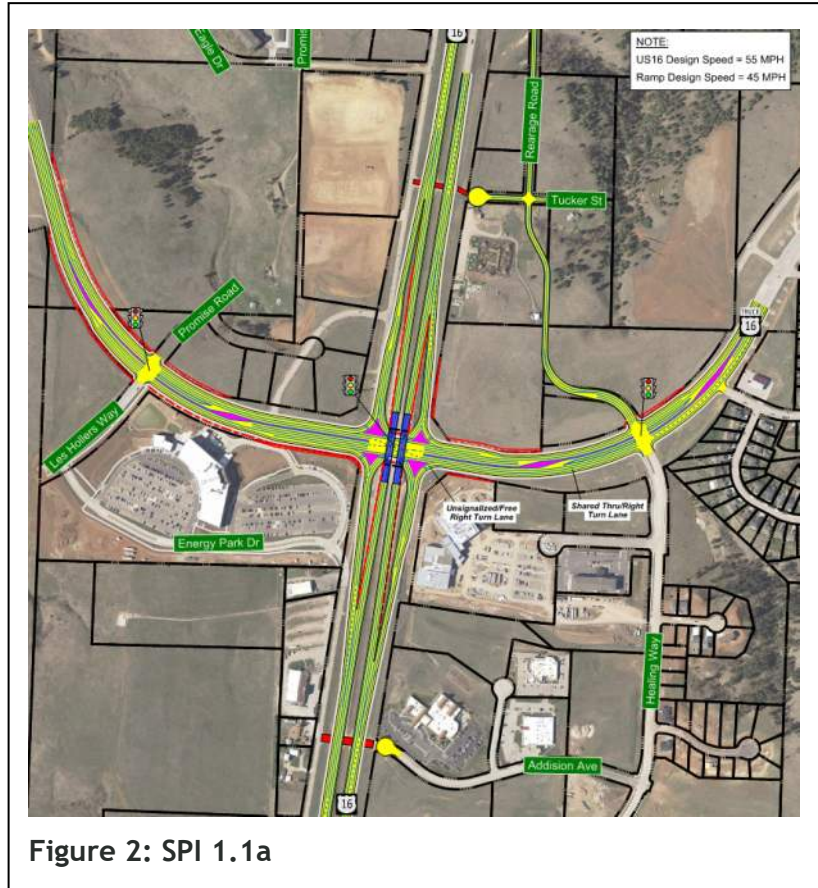


Figure 2: SPI 1.1a

The US16B/Catron Boulevard intersections with Les Hollers Way, US16 single point intersection, and Healing Way are all signalized. US16 access to Tucker Street and Addison Avenue, north and south of the single point intersection respectively, is closed due to the SPI ramps extending through the existing access points.

## Benefits

- Lowest overall interchange/intersection delay.
  - LOS B in 2050 Planning Horizon AM and PM peak hours.
  - Greatest available capacity to accommodate traffic growth and fluctuations within interchange/intersection.
- Shortest travel time along US16 corridor.
- Shortest travel time along US16B/Catron Boulevard corridor.
- Greatest expected reduction in crashes.
  - Fatal and injury crashes: 33% reduction.
  - Total crashes: 27% reduction.
- Largest separation between US16 and Les Hollers Way and Healing Way.
- Free northbound/southbound US16 traffic movements expected to best manage traffic operations for much of the Planning Horizon.
  - Free movements particularly advantageous during off-peak and non-tourist season timeframes.
- Greater ability to sign due to separation of intersections, familiar interchange type, northbound/southbound US16 does not need to stop.
- Addresses weather-related US16 corridor safety concerns related to fog and ice on the downgrades to the signalized intersection.
  - Eliminates downgrade into an existing signalized intersection by taking US16 over US16B/Catron Boulevard.
- BCA greater than 1.0.
- SPI construction, maintenance, and operation are familiar to SDDOT, City of Rapid City, and contractors in the area.
- Public and stakeholder support for improved and long-term traffic operations and safety benefits.
- Consistent with local jurisdiction planning documents.

## Drawbacks

- Higher construction costs compared to DLT Build Options.
- Utility impacts associated with SPI footprint.
- Closure of US16 access with Addison Avenue and Tucker Street and potential impact to impulse tourism.

## Recommendation

*It is recommended that SPI 1.1a be selected as the recommended Build Option for this future intersection project for the following reasons:*

1. Traffic and safety benefits:

- a. Lowest overall interchange/intersection delay.
  - b. Shortest travel time along US16 corridor.
  - c. Shortest travel time along US16B/Catron Boulevard corridor.
  - d. Greatest expected reduction in crashes.
2. Closely spaced intersection benefits:
    - a. SPI Build Options provide the greatest separation between US16 and next adjacent US16B/Catron Boulevard signalized intersections.
      - i. Best addresses weave concerns without degrading overall intersection/interchange operations.
  3. Public and stakeholder support for long-term traffic operations and safety benefits.
  4. Familiarity: driver expectancy, construction, maintenance, and operation.
  5. Areas affected by access closures to be accommodated through frontage and rearage roads, consistent with local network planning completed to date.
  6. BCA ratio greater than 1.0 showing that benefits are expected to exceed costs, even with the higher costs of an interchange.

*Due to the maximum queues and number of stops measured in the high volume 2050 PM peak hour, it is recommended that the grading for dual right turn lanes be incorporated into SPI 1.1a for an easy transition to signalized, dual right turn lanes when needed to meet operational goals for the intersection (see SPI 1.2 for more discussion).*

*It is also recommended that an eastbound US16B/Catron Boulevard right turn lane be incorporated at Healing Way (see SPI 1.1b for more discussion) due to the following benefits:*

- *Separates accelerating traffic from traffic slowing to turn right,*
- *Allows right turn overlap phasing within traffic signal, and*
- *Driver expectancy of right turn lanes at major intersections and a right turn lane at the existing intersection.*





### 6.3.3 SPI 1.2: SPI with Signalized NB and SB Dual Right Turn Lanes and EB Right Turn Lane at Healing Way

SPI 1.2 incorporates much of the same layout as 1.1a. US16 northbound and southbound mainline through traffic goes over the single point intersection, which is located below the US16 structures on US16/B/Catron Boulevard. Both US16 mainline and US16B/Catron Boulevard carries two through lanes in each direction through the SPI.

The primary difference between SPI 1.1a and 1.2 is the treatment of northbound and southbound US16 off-ramp right turns. Unlike 1.1a where the right turns are free movements into an additional lane, these right turns in 1.2 are signalized to create signal-controlled gaps in traffic to turn directly into the eastbound and westbound US16B/Catron Boulevard through lanes. Due to signalizing these high-volume movements, dual right turn lanes are required. The Build Option does not include acceleration lanes for the right turning traffic.

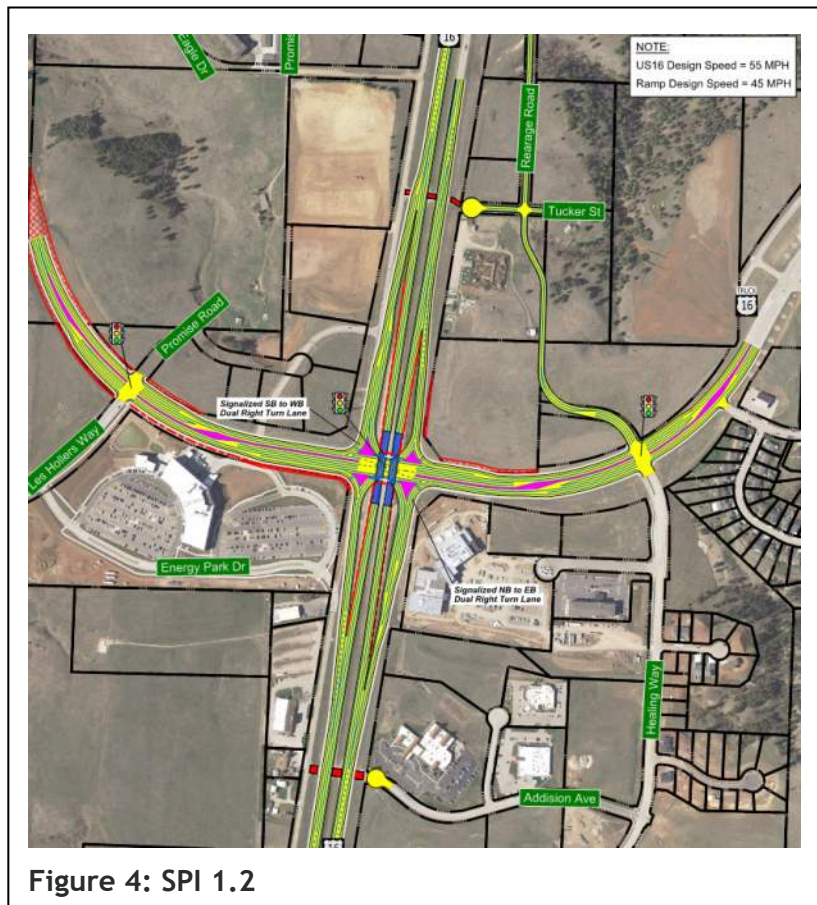


Figure 4: SPI 1.2

#### Benefits

Similar benefits to SPI 1.1a, with the following differences:

- Signalized, dual northbound/southbound US16 traffic lanes expected to best manage traffic operations towards the end of the Planning Horizon.
  - Provides signal-controlled gaps in traffic for right turning vehicles to weave across lanes to downstream left turn lanes.

#### Drawbacks

Similar drawbacks to SPI 1.1a, with the following differences:

- Signalized, dual northbound/southbound right turn lanes not needed to manage peak hour traffic operations through most of the Planning Horizon and during off-peak hours. Creates a stop condition that otherwise would be a free movement in SPI1.1a.

## Recommendation

*It is recommended that SPI 1.2 be eliminated from further consideration as a stand-alone Build Option for the following reasons:*

1. Traffic and safety benefits were slightly less than SPI 1.1a through most of the Planning Horizon.
2. While the signalized, dual US16 northbound/southbound right turn lanes provide signal-controlled gaps in traffic during high volume conditions, they create unnecessary stops and delay during peak hours through most of the Planning Horizon and during off-peak hours.

*Due to the operational benefits afforded to US16 northbound/southbound right turning traffic towards the end of the Planning Horizon (reflecting notable traffic growth), it is recommended that the grading for dual right turn lanes be incorporated into SPI 1.1a for an easy transition to signalized, dual right turn lanes when needed to meet operational goals for the intersection.*

## 6.4 Displaced Left Turn Intersection Build Options

### 6.4.1 DLT 2.1a: DLT with Separated, Free NB and SB Right Turn Lanes

DLT 2.1a includes a DLT intersection at US16/US16B/Catron Boulevard. The intersection reflects a traditional at-grade intersection except that the eastbound and westbound US16B/Catron Boulevard left turn lanes are crossed over opposing through traffic upstream of the main intersection. This crossover intersection is signalized for the cross-over left turn traffic and opposing through traffic.

Similar to SPI 1.1a, the northbound and southbound US16 right turns are free (unsignalized) movements. This right turn traffic enters the US16B/Catron Boulevard mainline via an additional lane outside of the east or west crossover intersection. The additional lane is extended through the downstream intersection, Los Hollers Way or Healing Way, and merged back into US16B or Catron Boulevard through lanes. Spacing between the add-lane point and the downstream signalized intersection is much shorter than what is provided with an SPI.

The overall pavement reconstruction footprint is notably smaller for the DLT intersection Build Options compared to the SPI Build Options since the interchange is reconstructed on existing grade and there are no structures.

The DLT intersection Build Options necessitates five traffic signals along US16B/Catron Boulevard, located at Les Hollers Way, west DLT crossover, US16 main intersection, east DLT crossover, and Healing Way. Maintaining US16 access to/from Addison Avenue and Tucker Street access points is a possibility with this Build Option.

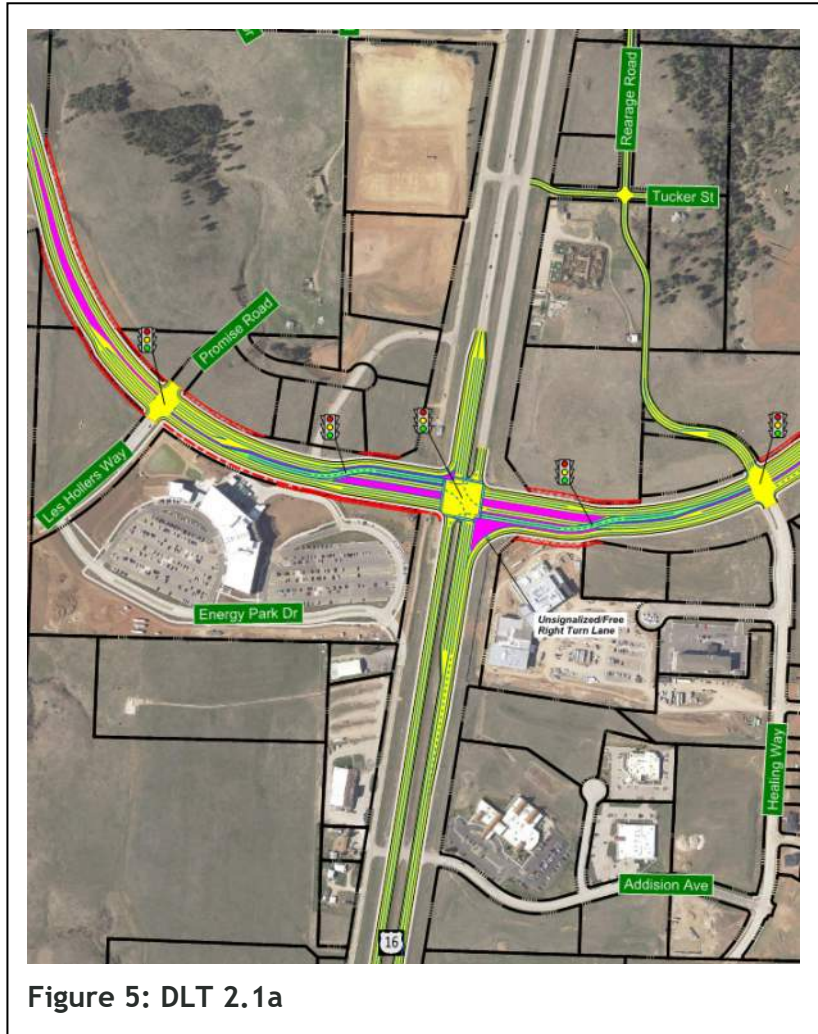


Figure 5: DLT 2.1a

## Benefits

- Meets LOS C goal for overall interchange/intersection delay.
  - LOS C in 2050 Planning Horizon AM and PM peak hours.
- Free northbound/southbound US16 traffic movements expected to best manage traffic operations for much of the Planning Horizon.
  - Free movements particularly advantageous during off-peak and non-tourist season timeframes.
- BCA greater than 1.0 and greatest of DLT Build Options.
- Lower cost than SPI Build Options.
- Public and stakeholder support for maintaining access at Addison Avenue and Tucker Street and creating more of an urban corridor.
- Consistent with recent local jurisdiction planning documents.

## Drawbacks

- Less available capacity in main intersection than SPI to accommodate additional future traffic growth and volume fluctuations.
- Longest travel time along US16 corridor of all Build Options.
- Longest travel time along US16B/Catron Boulevard corridor of all Build Options.
- Least expected reduction in crashes of all Build Options.
  - Fatal and injury crashes: 18% reduction (33% for SPI Build Options).
  - Total crashes: 11% reduction (27% for SPI Build Options).
- Least separation between US16 and Les Hollers Way and Healing Way of all Build Options.
- US16B/Catron Boulevard guide signs need to be placed within the maneuver location for a downstream turn movement or in advance of a major intersection due to tight intersection spacing between Healing Way (or Les Hollers Way), the adjacent crossover signalized intersection, and US16 main intersection.
- Unfamiliar intersection type for SDDOT, City of Rapid City, and contractors in the area.
  - Signal timing, maintenance, and operations is notably more complex than what is needed for the SPI Build Options.
- Does not address weather-related safety concerns related to fog and ice on the downgrades to the signalized intersection.
- While the intersection permits pedestrian crossings of all four legs, pedestrian phases are anticipated to significantly impact traffic signal coordination along US16 and US16B/Catron Boulevard corridors. Pedestrian-actuation of a pedestrian phase will push the main DLT intersection out of coordination with adjacent traffic signals for multiple cycles. This will be particularly problematic for the closely spaced US16B/Catron Boulevard signalized intersections that depend on tight coordination for efficient operations.

- Utility impacts associated with DLT footprint.
- Does not address public and stakeholder desires for the best long-term traffic operations and safety benefits

### **Recommendation**

*It is recommended that DLT 2.1a be eliminated from further consideration for the following reasons:*

1. Least expected reduction in crashes of all Build Options; notably less than the SPI Build Options.
  - a. Fatal and injury crashes: 18% reduction (33% for SPI Build Options).
  - b. Total crashes: 11% reduction (27% for SPI Build Options).
2. Traffic operations:
  - a. Higher interchange/intersection delay in terms of one full LOS grade (DLT LOS C vs SPI LOS B).
  - b. US16 corridor travel times nearly 20 percent greater than SPI Build Options.
  - c. Similar to longer US16B/Catron Boulevard corridor travel times.
  - d. Pedestrian phase impacts on intersection coordination.
3. Closely spaced intersections:
  - a. DLT Build Options provide the least separation between US16 and next adjacent US16B/Catron Boulevard signalized intersections (shortest available distance for weave movement to downstream turn lanes).
4. Public and stakeholder support was mixed. While this Build Option provides access desired by some, the additional access has a notable impact on safety and operations.
5. Unfamiliar intersection type: driver expectancy, construction, maintenance, and operation.
6. Complex traffic signal timing development, maintenance, and operation.

### 6.4.2 DLT 2.1b: DLT with Separated, Free Right Turn Lanes at Main Intersection (all quadrants)

DLT 2.1b reflects a similar footprint as 2.1a, with the primary difference being that the eastbound and westbound right turn lanes are accommodated via free right turns instead of signalized movements in the main intersection.

An acceleration lane is provided in the northbound and southbound directions and merged near Tucker Street or Addison Avenue. Because of the merge locations, Addison Avenue and Tucker Street access will need to be modified. For this analysis, both access points are analyzed as closed.

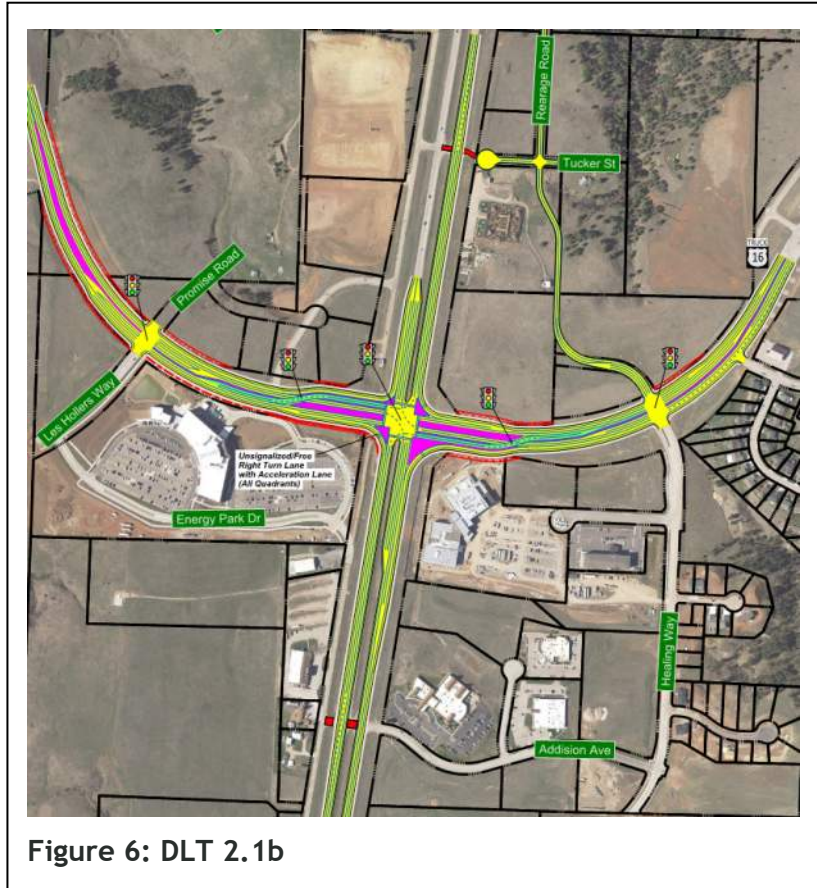


Figure 6: DLT 2.1b

#### Benefits

*Similar benefits to DLT 2.1a, with the following differences:*

- Provides the best US16 corridor travel time of all DLT Build Options due to signal timing improvements with US16B/Catron Boulevard eastbound/westbound free right turn movements.
  - Provides additional green time for US16 through traffic.
- Expected reduction in crashes is better than DLT 2.1a due to the closure of Addison Avenue and Tucker Street access points.
  - However, if a modified access is provided at Addison Avenue and Tucker Street, the expected reduction in crashes would be reduced.
- Low cost compared to SPI Build Options, but approximately 10 percent higher than DLT 2.1a.

#### Drawbacks

*Similar drawbacks to DLT 2.1a, with the following differences:*

- Travel times are shorter than DLT 2.1a, but longer than SPI Build Options.

- Pedestrian crossing impacts on traffic signal timing coordination with other corridor intersections would likely be less pronounced than DLT 2.1a due to the free US16B/Catron Boulevard right turn movements. This offers greater flexibility to apply longer green times to other phases.
- With the closure of Addison Avenue and Tucker Street access points due to acceleration lanes, this Build Option would not meet stakeholder and public desires for maintaining access at this intersection or providing high levels of traffic operations and safety.

### **Recommendation**

*It is recommended that DLT 2.1b be eliminated from further consideration for the following reasons:*

1. While traffic operations and safety are improved over DLT 2.1a, the Build Option:
  - a. Requires closure of Addison Avenue and Tucker Street to achieve safety benefits.
  - b. Does not meet public and stakeholder desires of either access at Addison Avenue and Tucker Street or high levels of traffic operations and safety.
  - c. Exhibits many similar drawbacks as DLT 2.1a.



### 6.4.3 DLT 2.2a: DLT with Signalized Right Turn Lanes at Main Intersection (all quadrants)

DLT 2.2a incorporates much of the same DLT intersection layout as 2.1a. The intersection reflects a traditional at-grade intersection except that the eastbound and westbound US16B/Catron Boulevard left turn lanes are crossed over opposing through traffic upstream of the main intersection. This crossover intersection is signalized for the crossing left turn traffic and opposing through traffic.

The primary difference between DLT 2.1a and 2.2a is treatment of the northbound and southbound US16 right turn lanes. Unlike 2.1a where the right turns are free movements into an additional lane around the respective crossover intersection, 2.2a signalizes right turns at the crossover intersection to provide signal-controlled gaps in traffic. This is particularly beneficial for right turning traffic wishing to turn left at the downstream signalized intersection due to the shortened spacing between the crossover intersections and Les Hollers Way or Healing Way. Due to signaling these high-volume movements, dual right turn lanes are required. The Build Option does not include acceleration lanes for the right turning traffic.

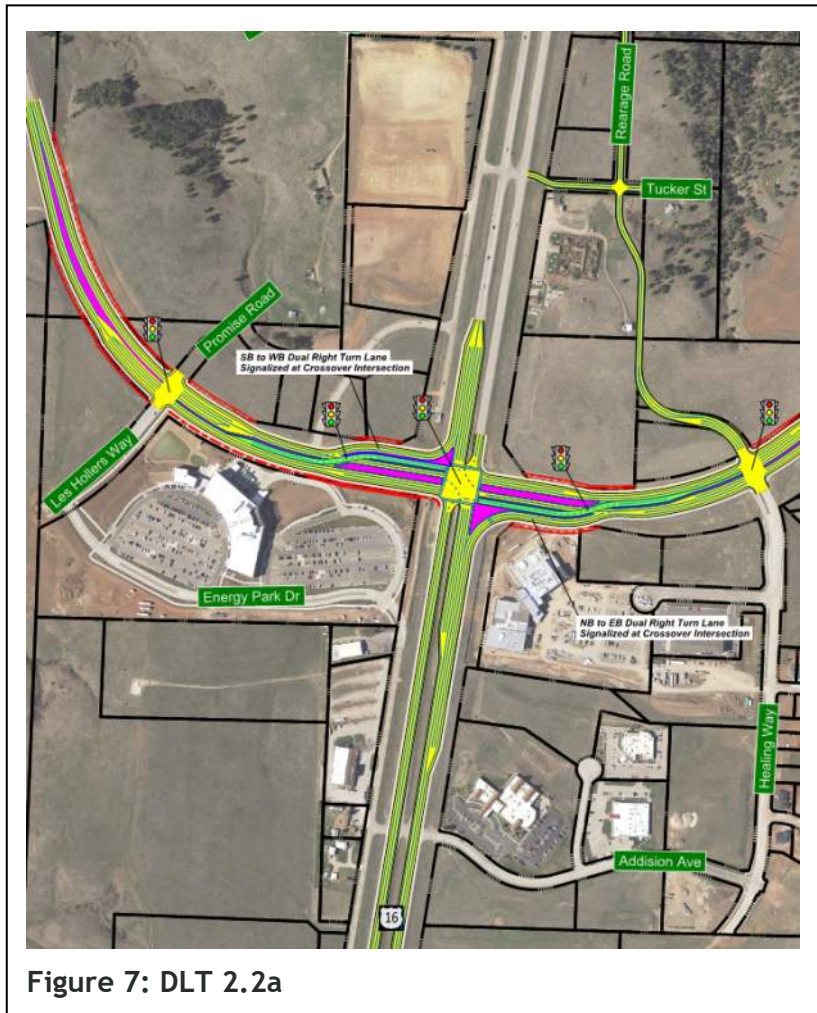


Figure 7: DLT 2.2a

#### Benefits

- Signalized, dual US16 northbound/southbound traffic movements expected to best manage turn movements by providing a signal-controlled gap in traffic for downstream weave movements towards the end of the 2050 Planning Horizon.
  - However, this also adds delay to the intersection and results in 2050 PM peak hour LOS D.
- BCA greater than 1.0.
- Lower cost than SPI Build Options, but highest of all DLT Build Options.

- Public and stakeholder support for maintaining access at Addison Avenue and Tucker Street and creating more of an urban corridor.
- Consistent with recent local jurisdiction planning documents.

### **Drawbacks**

*Similar drawbacks to DLT 2.1a, with the following differences:*

- LOS D in 2050 Planning Horizon PM Peak hour does not meet LOS C goal.

### **Recommendation**

*It is recommended that DLT 2.2a be eliminated from further consideration for the following reasons:*

1. Does not meet LOS C goal for intersection in 2050 Planning Horizon (LOS D measured).
2. DLT 2.2a provides the least expected reduction in crashes of all Build Options; notably less than the SPI Build Options.
  - i. Approximately 2.5 times less expected reduction in crashes compared to the SPI Build Option (1.75 times less reduction in fatal and injury crashes).
3. Traffic operations:
  - a. US16 corridor travel times nearly 20 percent greater than SPI Build Options.
  - b. Similar to longer US16B/Catron Boulevard corridor travel times.
  - c. Pedestrian phase impacts on intersection coordination.
4. Closely spaced intersections:
  - a. DLT Build Options provide the least separation between US16 and next adjacent US16B/Catron Boulevard signalized intersections (shortest available distance for weave movement to downstream turn lanes).
5. Public and stakeholder support was mixed. While this Build Option provides access desired by some, the additional access has a notable impact on safety and operations.
6. Unfamiliar intersection type: driver expectancy, construction, maintenance, and operation.
7. Complex traffic signal timing development, maintenance, and operation.

### 6.4.4 DLT 2.2b: DLT with NB and SB Signalized Right Turn Lanes, Free EB and WB Right Turn Lanes

DLT 2.2B combines the overall footprint and signaling dual right turn lanes for northbound and southbound US16 of 2.2a with the eastbound and southbound free right turn movements provided in 2.1b. Similar to 2.1b, access would need to be modified at Addison Avenue and Tucker Street. For this analysis, both access points are analyzed as closed.

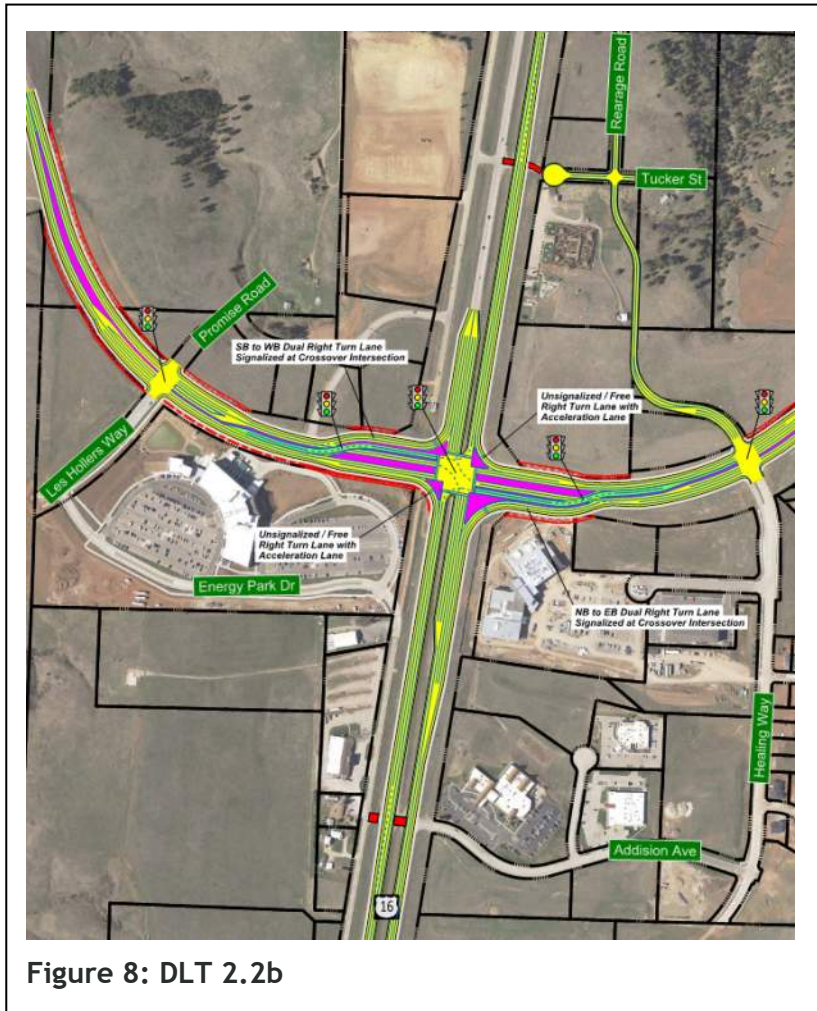


Figure 8: DLT 2.2b

#### Benefits

Similar benefits to DLT 2.2a, with the following differences:

- Provides the best US16 corridor travel time of all DLT Build Options due to signal timing improvements with US16B/Catron Boulevard eastbound/westbound free right turn movements.
  - Provides additional green time for US16 through traffic.
- Expected reduction in crashes approximately 50 percent greater than DLT 2.2a due to the closure of Addison Avenue and Tucker Street access points.
  - If a modified access is provided at Addison Avenue and Tucker Street, the expected reduction in crashes would be reduced.
- Low cost compared to SPI Build Options, but approximately 10 percent higher than DLT 2.2a.

## Drawbacks

*Similar drawbacks to DLT 2.2a, with the following differences:*

- Travel times are shorter than DLT 2.2a, but longer than SPI Build Options.
- Pedestrian crossing impacts on traffic signal timing coordination with other corridor intersections would likely be less pronounced than DLT 2.1a due to the free US16B/Catron Boulevard right turn movements. This offers greater flexibility to apply longer green times to other phases.
- With the closure of Addison Avenue and Tucker Street access points due to acceleration lanes, this Build Option would not meet stakeholder and public desires for maintaining access at this intersection or providing high levels of traffic operations and safety.

## Recommendation

*It is recommended that DLT 2.2b be eliminated from further consideration for the following reasons:*

2. While traffic operations and safety are improved over DLT 2.1a, the Build Option:
  - a. Does not meet LOS C goal for intersection in 2050 Planning Horizon (LOS D measured).
  - b. Requires closure of Addison Avenue and Tucker Street to achieve safety benefits.
  - c. Does not meet public and stakeholder desires of either access at Addison Avenue and Tucker Street or high levels of traffic operations and safety.
  - d. Exhibits many similar drawbacks as DLT 2.2a.

### 6.4.5 DLT 2.3: DLT with Unseparated, Signalized Right Turn Lanes at Main Intersection

DLT 2.3 focuses on signaling all right turn movements at the main intersection. Instead of routing the northbound and southbound US16 right turn movements around the main intersection, this Build Option brings the right turn lanes into the main intersection. This creates a situation where these right turn movements must travel past the eastbound or westbound crossed-over left turn lanes before turning right.

This DLT configuration is generally more applicable in tight urban conditions where ROW is limited as bringing all right turns into the main intersection degrades traffic operations.

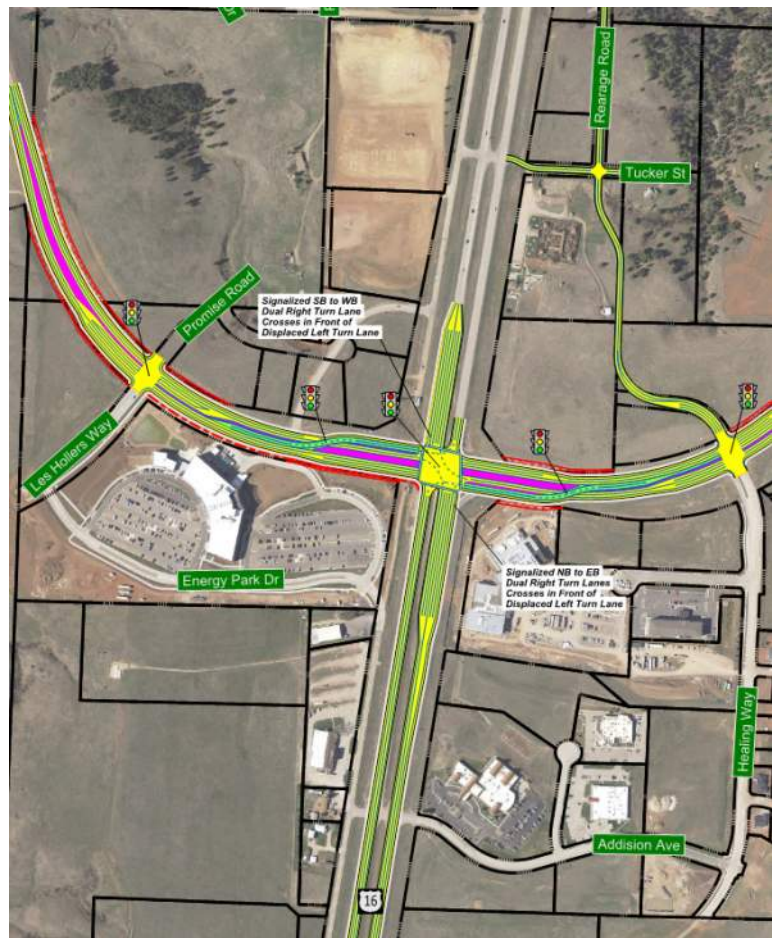


Figure 9: DLT 2.3

#### Benefits

- Overall, benefits are limited when compared to all other Build Options.
- Lowest cost of all Build Options.
- Greatest separation between US16 northbound/southbound right turn lane and downstream Les Hollers Way or Healing Way intersections of all Build Options.
- Public and stakeholder support for maintaining access at Addison Avenue and Tucker Street and creating more of an urban corridor.

#### Drawbacks

- Does not meet LOS C goal for overall interchange/intersection delay in 2050 AM and PM peak periods.
- Driver expectancy is a notable drawback. In addition to signing constraints and an unfamiliar intersection type, DLT 2.3 requires US16 northbound/southbound right

turning traffic to turn within the main intersection. The receiving lanes for these turns are beyond the US16B/Catron Boulevard eastbound/westbound crossed-over left turn lanes. This can lead to potential confusion for unfamiliar drivers, particularly during snow conditions.

- Similar drawbacks to the other DLT Build Options in terms of traffic operations, safety, constructability, maintenance, and operations.

### **Recommendation**

*It is recommended that DLT 2.3 be eliminated from further consideration for the following reasons:*

1. Does not meet overall intersection LOS C goal for both AM and PM peak hour traffic operations in 2050 Planning Horizon (LOS D measured).
2. Significant drawbacks to this Build Option compared to others developed for the intersection.

## **7.0 Recommendations**

The following tables summarize recommendations from this report regarding Build Options to carry forward or eliminate from further consideration. These recommendations are based on a comparison and analysis of key geometric features, such as intersection type, access, and treatment, as well as several other quantitative and qualitative measures supporting the project purpose and need.

The recommended Build Option, SPI 1.1a, is shown in **Figure 10**. It incorporates recommended modifications from SPI 1.1b and 1.2 and design elements from the overall US16 Corridor Study.

**Table 2: Build Option to be Carried Forward**

Build Option	Description	Main Reason(s) for Carrying Forward
1.1a	SPI with Separated, Free NB and SB Right Turn Lanes	<ul style="list-style-type: none"> <li>• Greatest expected reduction in crashes (33% fatal and injury; 26% total).</li> <li>• Lowest overall interchange/intersection delay (LOS B).</li> <li>• Shortest travel time along US16 and US16B/Catron Blvd corridors.</li> <li>• Greatest separation between US16 and next adjacent US16B/Catron Blvd signalized intersections.</li> <li>• Best addresses US16B/Catron Blvd weave concerns without degrading overall intersection/interchange operations.</li> <li>• Public and stakeholder support for long-term traffic operations and safety benefits.</li> <li>• Familiarity: driver expectancy, construction, maintenance, and operation.</li> <li>• BCA ratio greater than 1.0 showing that benefits are expected to exceed costs, even with the higher costs of an interchange.</li> </ul>
	<b>Proposed modification:</b> Include off-ramp grading for dual, signalized US16 northbound/southbound right turn lanes	<p><i>Due to the maximum queues and number of stops measured in the high volume 2050 PM peak hour, it is recommended that the grading for dual right turn lanes be incorporated for a future transition to signalized, dual right turn lanes when needed to meet operational goals for the intersection (see SPI 1.2 for more discussion).</i></p> <p><i>It is also recommended that an eastbound US16B/Catron Boulevard right turn lane be incorporated at Healing Way (see SPI 1.1b for more discussion).</i></p>

**Table 3: SPI Build Options Not Carried Forward**

Build Option	Description	Main Reason(s) for Not Carrying Forward
1.1b	SPI with Separated, Free NB and SB Right Turn lanes and EB Right Turn lane at Healing Way	<p>SPI 1.1b reflects the same footprint as SPI 1.1a with the addition of an eastbound US16B/Catron Boulevard right turn lane at Healing Way.</p> <p><i>While SPI 1.1b was eliminated as a stand-alone Build Option, it is recommended that the eastbound US16B/Catron Boulevard right turn lane at Healing Way be incorporated into SPI 1.1a.</i></p>
1.2	SPI with Signalized NB and SB Dual Right Turn Lanes and EB Right Turn Lane at Healing Way	<p>SPI 1.2 was eliminated as a stand-alone Build Option in favor of 1.1a for the following reasons:</p> <ul style="list-style-type: none"> <li>• Traffic and safety benefits were slightly less than 1.1a through most of the Planning Horizon.</li> <li>• While the signalized, dual US16 northbound/southbound right turn lanes provide signal-controlled gaps in traffic during high volume conditions, they create unnecessary stops and delay during peak hours through most of the Planning Horizon and during off-peak hours.</li> </ul> <p><i>Due to the operational benefits afforded to US16 northbound/southbound right turning traffic towards the end of the Planning Horizon (reflecting notable traffic growth), it is recommended that the grading for dual right turn lanes be incorporated into SPI 1.1a for a future transition to signalized, dual right turn lanes when needed to meet operational goals for the intersection.</i></p>

**Table 4: DLT Build Options Not Carried Forward**

Build Option	Description	Main Reason(s) for Not Carrying Forward
2.1a	2.1a: DLT with Separated, Free NB and SB Right Turn Lanes	<ul style="list-style-type: none"> <li>• Least expected reduction in crashes (18% fatal and injury; 11% total).</li> <li>• Interchange/intersection delay LOS C (SPI LOS B).</li> <li>• US16 corridor travel times 20% longer than SPI Build Options.</li> <li>• Pedestrian phase impacts on intersection traffic signal coordination.</li> <li>• Closely spaced intersections on US16B/Catron Boulevard.</li> <li>• Public and stakeholder support was mixed. Maintains access but impacts safety and operations.</li> <li>• Unfamiliar intersection type: driver expectancy, construction, maintenance, and operation.</li> <li>• Complex traffic signal timing development, maintenance, and operation.</li> </ul>
2.1b	2.1b: DLT with Separated, Free Right Turn Lanes at Main Intersection (all Quadrants)	<ul style="list-style-type: none"> <li>• Less expected reduction in crashes compared to SPI (23% fatal and injury; 16% total). Maintaining Addison Ave and Tucker St access would decrease this reduction.</li> <li>• Interchange/intersection delay LOS C (SPI LOS B).</li> <li>• US16 corridor travel times 10-15% longer than SPI Build Options.</li> <li>• Pedestrian phase impacts on intersection traffic signal coordination.</li> <li>• Closely spaced intersections on US16B/Catron Boulevard.</li> <li>• Public and stakeholder support: neither maintains Addison Ave and Tucker St access nor provides operational and safety benefits comparable to SPI.</li> <li>• Unfamiliar intersection type: driver expectancy, construction, maintenance, and operation.</li> <li>• Complex traffic signal timing development, maintenance, and operation.</li> </ul>
2.2a	2.2a: DLT with Signalized Right Turn Lanes at Main Intersection (all Quadrants)	<ul style="list-style-type: none"> <li>• Interchange/intersection delay LOS D in 2050 PM peak hour (does not meet LOS C goal).</li> <li>• Similar reasons to 2.1a, with the exception that the US16 NB/SB right turns are signalized to provide gaps in traffic for weave movements. However, this benefit is directly attributable to the LOS D measure.</li> </ul>
2.2b	2.2b: DLT with NB and SB Signalized Right Turn Lanes, Free EB and WB Right Turn Lanes	<ul style="list-style-type: none"> <li>• Interchange/intersection delay LOS D in 2050 PM peak hour (does not meet LOS C goal).</li> <li>• Similar reasons to 2.1b, with the exception that the US16 NB/SB right turns are signalized to provide gaps in traffic for weave movements. However, this benefit is directly attributable to the LOS D measure.</li> </ul>
2.3	2.3: DLT with Unseparated, Signalized Right Turn Lanes at Main Intersection	<ul style="list-style-type: none"> <li>• Build Option provides minimal benefit across nearly all categories compared to other Build Options.</li> <li>• Interchange/intersection delay LOS D in 2050 AM and PM peak hours (does not meet LOS C goal).</li> <li>• Least expected reduction in crashes (18% fatal and injury; 11% total).</li> <li>• Intersection configuration typically applied to urban areas with limited ROW.</li> </ul>





Scale in Feet  
0 250 500

**US16/US16B/Catron Boulevard Intersection Recommendation**  
Intersection Project: Single Point Interchange (SPI)  
Corridor: 4-Lane Divided with 40-foot Raised Median (Suburban) - Shifted East

- Legend**
- Proposed Roadway
  - Depressed Median
  - Raised Median
  - Sidewalk
  - Bridge Construction
  - Remove Roadway
  - Existing ROW / Property Line
  - Retaining Wall
  - ROW Acquisition
  - Existing Signalized Intersection
  - STOP Stop Condition Intersection

**US16/Addison Avenue Intersection**

- Close due to conflict with SPI ramps
- Maintain existing US16 service road connections to:
  - Les Hollers Way (via Energy Park Drive) and
  - Section Line Road
- Maintain existing east connection to Healing Way

**US16/Tucker Street Intersection**

- Close due to conflict with SPI ramps
- Construct rearage road to Promise Road intersection

**US16/Promise Road Intersection**

- Shift intersection north
- Prepare for signalization (need anticipated around opening year)
- Reconstruct US16 service road to provide 250-foot intersection spacing from US16 mainline

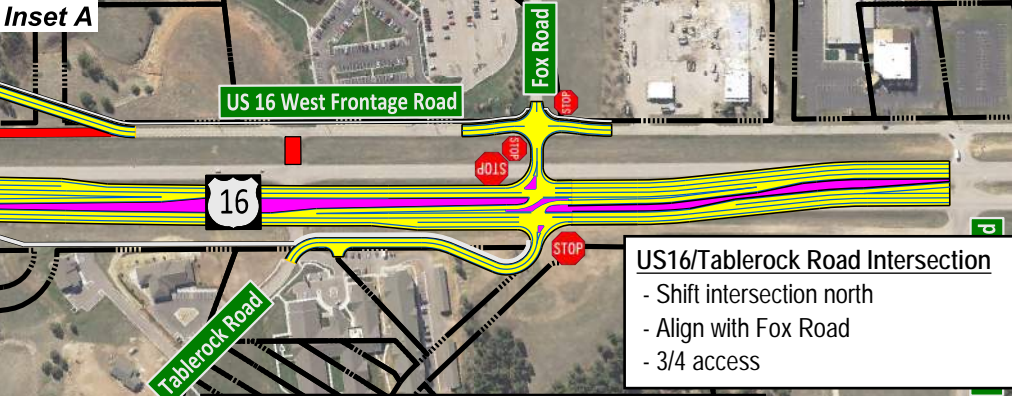
Prepare for signalization at opening

See Inset A

**US16/Section Line Road**

- Shift intersection south
- RIRO access
- Construct Section Line Road/US16 service road intersection
- Maintain existing US16 mainline pavement through intersection

**NOTE:**  
 US16 Design Speed (North of US-16B) = 60 MPH  
 US16 Design Speed (South of US-16B) = 65 MPH  
 NB Entrance Ramp Design Speed = 45 MPH  
 SB Ramps and NB Exit Ramp Design Speed = 50 MPH



**US16/Tablerock Road Intersection**

- Shift intersection north
- Align with Fox Road
- 3/4 access

**US16/Wellington Drive Intersections**

- West: maintain RIRO access
- East: 3/4 access
- Extend EB LT lane back to RIRO access to provide direct movement into LT lane for downstream U-turn

Build Option:  
**SPI 1.1a**



US16/US16B/Catron Boulevard Intersection Recommendation  
Single Point Interchange (SPI) Build Option 1.1a  
US16 Corridor Study

Figure  
**10**  
Rapid City, SD

## Appendix A. US16/US16B/Catron Boulevard Intersection Build Options.



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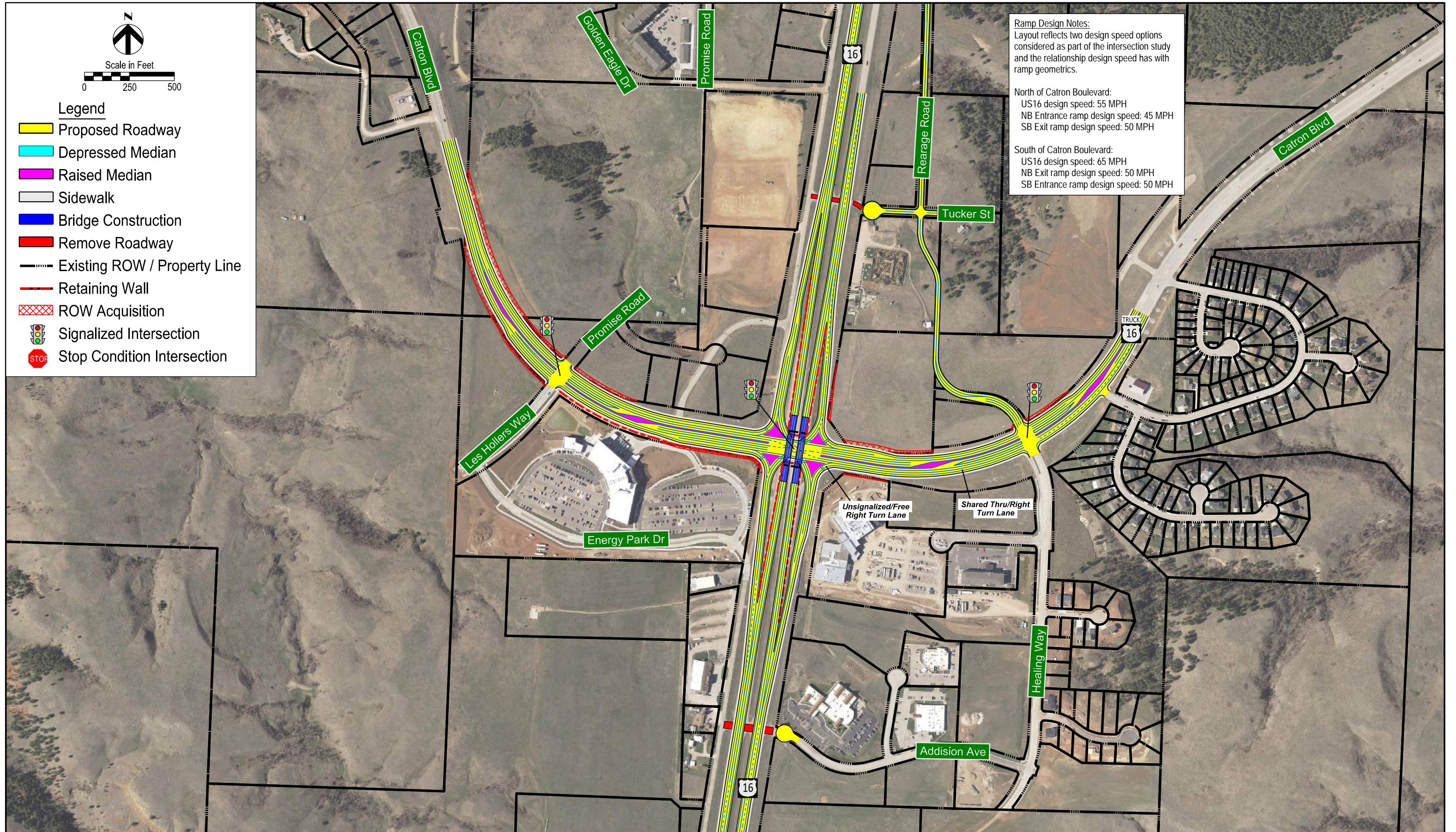
Legend

- Proposed Roadway
- Depressed Median
- Raised Median
- Sidewalk
- Bridge Construction
- Remove Roadway
- Existing ROW / Property Line
- Retaining Wall
- ROW Acquisition
- Signalized Intersection
- Stop Condition Intersection

**Ramp Design Notes:**  
Layout reflects two design speed options considered as part of the intersection study and the relationship design speed has with ramp geometrics.

North of Catron Boulevard:  
US16 design speed: 55 MPH  
NB Entrance ramp design speed: 45 MPH  
SB Exit ramp design speed: 50 MPH

South of Catron Boulevard:  
US16 design speed: 65 MPH  
NB Exit ramp design speed: 50 MPH  
SB Entrance ramp design speed: 50 MPH



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Date:  
Chkd By:  
Date:  
Revision:



Alternative 1.1a  
SPI with Separated, Free NB and SB Right Turn Lanes  
US16 Corridor Study

Rapid City, SD

Figure  
1.1a



Scale in Feet  
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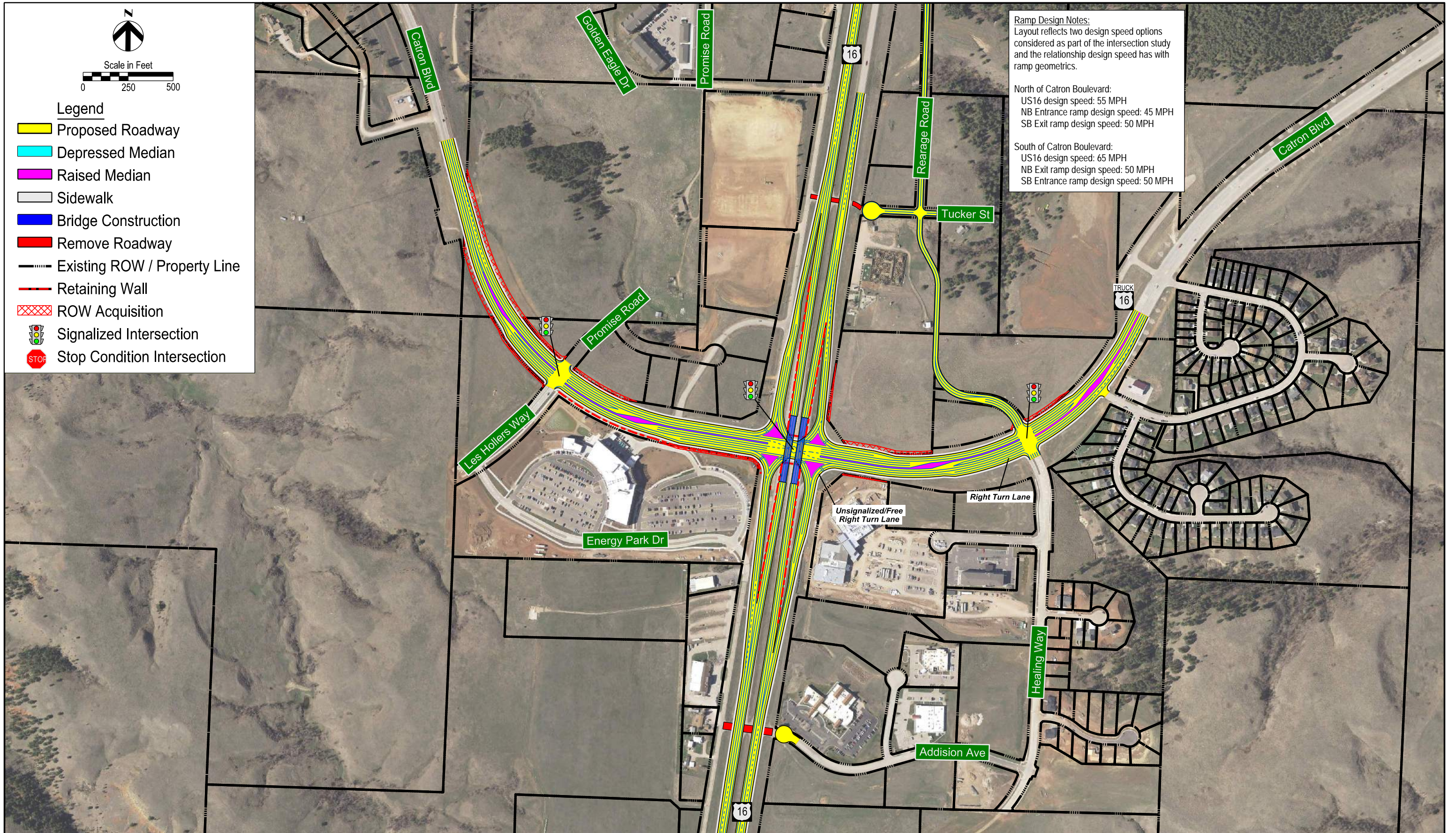
Legend

- Proposed Roadway
- Depressed Median
- Raised Median
- Sidewalk
- Bridge Construction
- Remove Roadway
- Existing ROW / Property Line
- Retaining Wall
- ROW Acquisition
- Signalized Intersection
- Stop Condition Intersection

**Ramp Design Notes:**  
Layout reflects two design speed options considered as part of the intersection study and the relationship design speed has with ramp geometrics.

North of Catron Boulevard:  
US16 design speed: 55 MPH  
NB Entrance ramp design speed: 45 MPH  
SB Exit ramp design speed: 50 MPH

South of Catron Boulevard:  
US16 design speed: 65 MPH  
NB Exit ramp design speed: 50 MPH  
SB Entrance ramp design speed: 50 MPH



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Date:  
Revision:



Alternative 1.1b  
SPI with Separated, Free NB and SB Right Turn Lanes with EB Right Turn Lane at Healing Way  
US16 Corridor Study

Figure  
**1.1b**

Rapid City, SD



Scale in Feet  
0 250 500

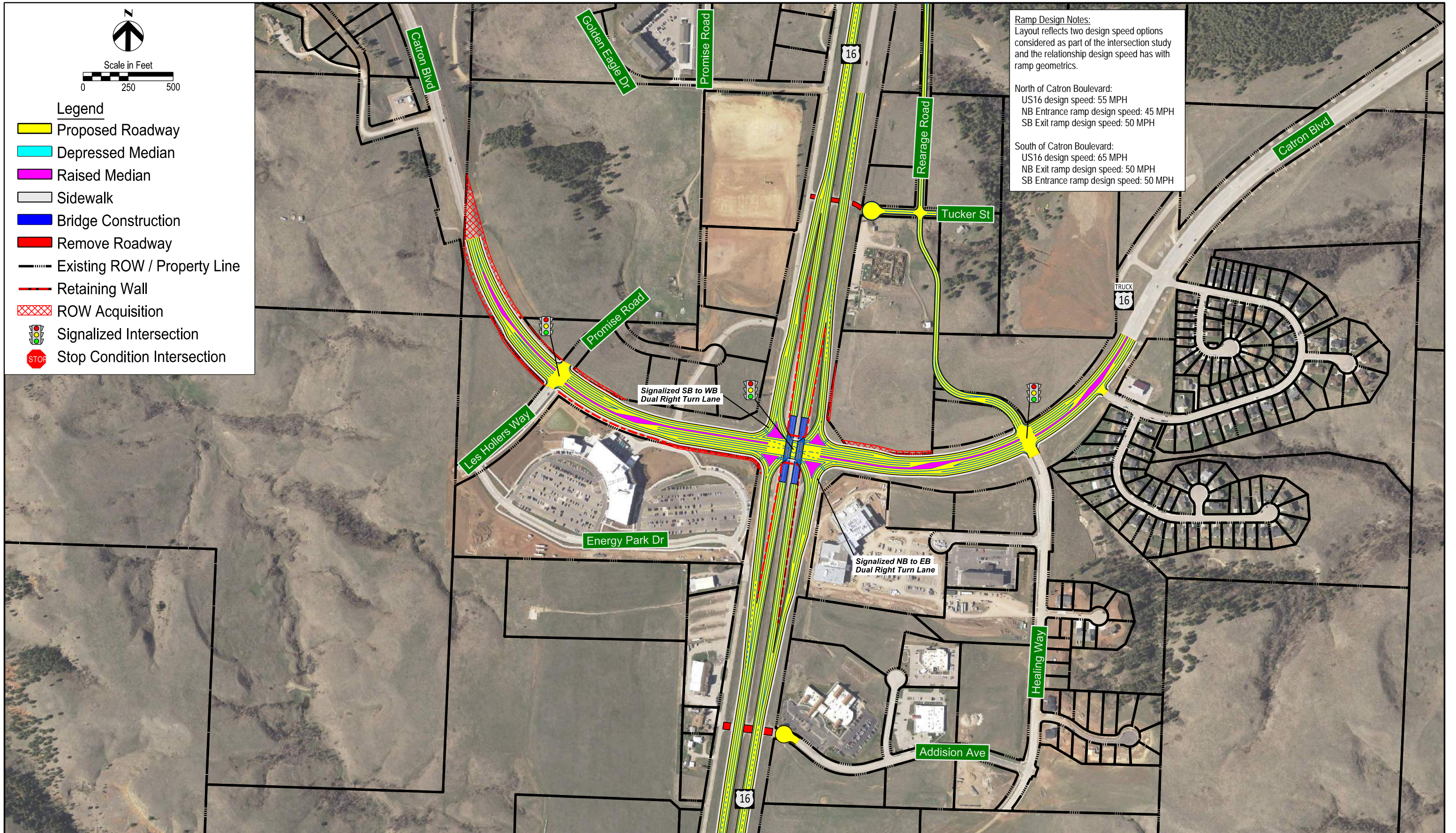
Legend

- Proposed Roadway
- Depressed Median
- Raised Median
- Sidewalk
- Bridge Construction
- Remove Roadway
- Existing ROW / Property Line
- Retaining Wall
- ROW Acquisition
- Signalized Intersection
- Stop Condition Intersection

Ramp Design Notes:  
Layout reflects two design speed options considered as part of the intersection study and the relationship design speed has with ramp geometrics.

North of Catron Boulevard:  
US16 design speed: 55 MPH  
NB Entrance ramp design speed: 45 MPH  
SB Exit ramp design speed: 50 MPH

South of Catron Boulevard:  
US16 design speed: 65 MPH  
NB Exit ramp design speed: 50 MPH  
SB Entrance ramp design speed: 50 MPH



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Alternative Scenario 1.2  
SPI with Signalized NB and SB Dual Right Turn Lanes and EB Right Turn Lane at Healing Way  
US16 Corridor Study





Figure  
1.2

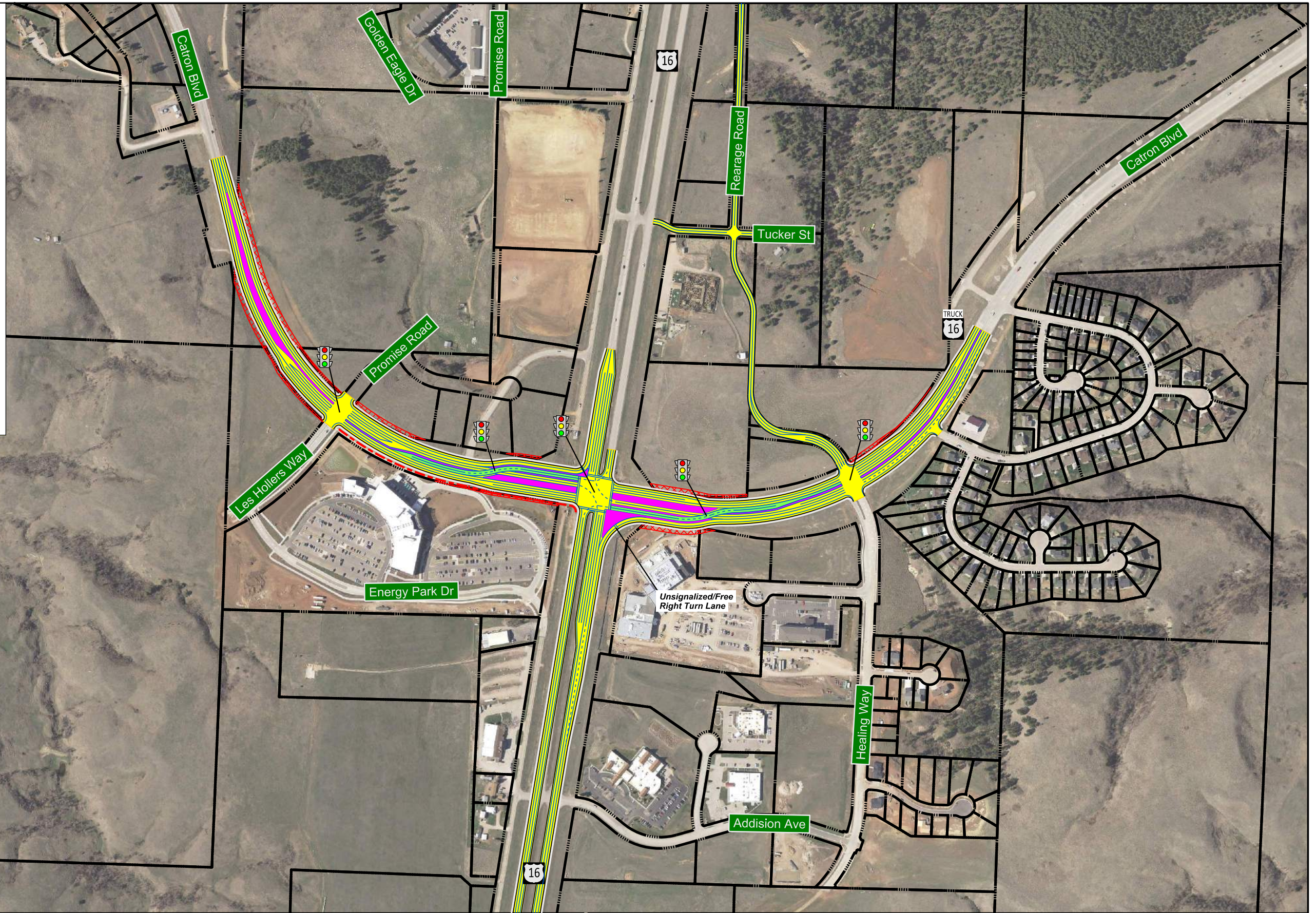
Rapid City, SD



Scale in Feet  
0 250 500

Legend

-  Proposed Roadway
-  Displaced Left
-  Depressed Median
-  Raised Median
-  Sidewalk
-  Bridge Construction
-  Remove Roadway
-  Existing ROW / Property Line
-  Retaining Wall
-  ROW Acquisition
-  Signalized Intersection
-  Stop Condition Intersection



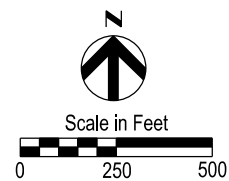
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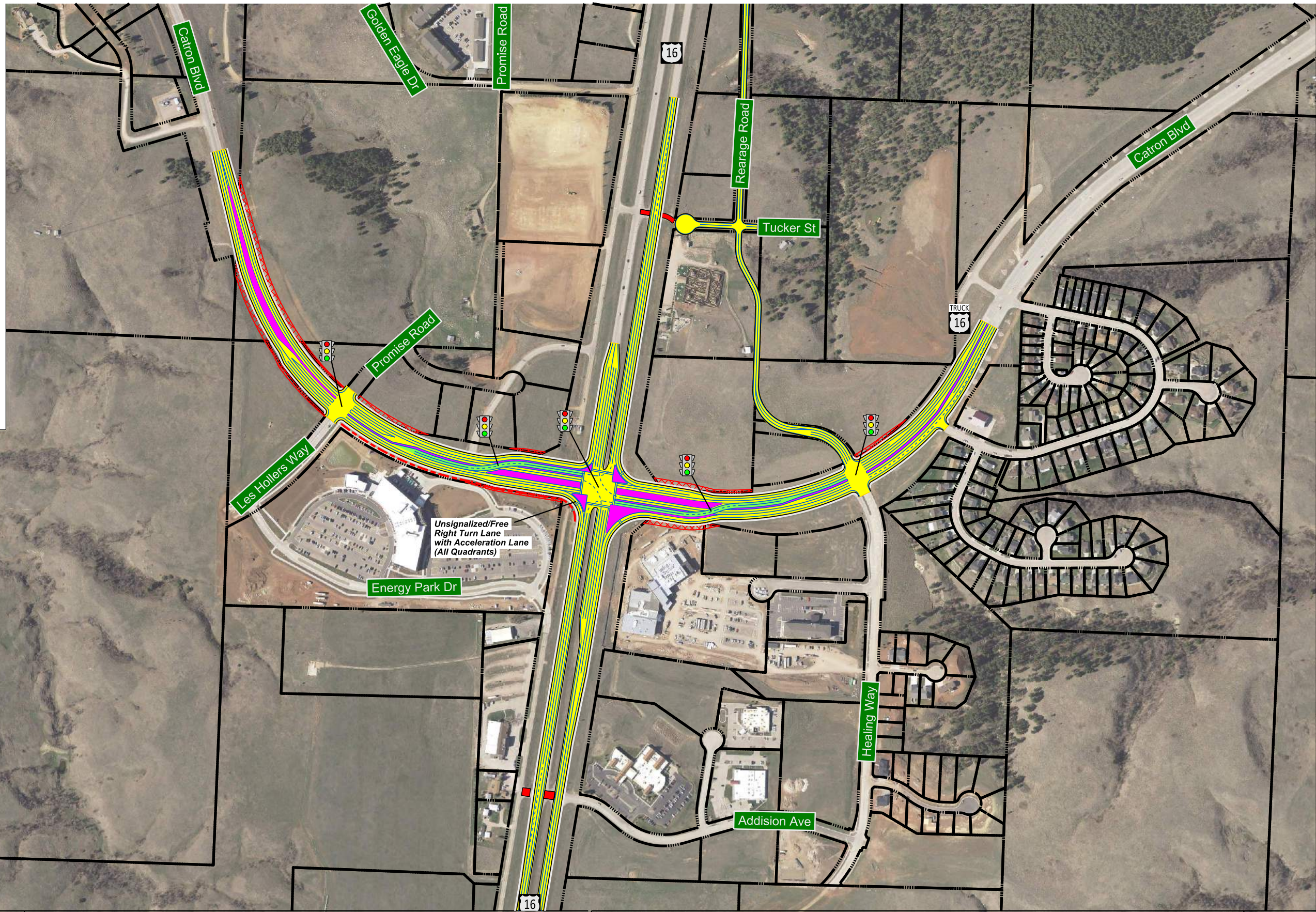
Alternative 2.1a  
DLT with Separated, Free NB and SB Right Turn Lanes  
US16 Corridor Study

Rapid City, SD

Figure  
**2.1a**



- Legend**
- Proposed Roadway
  - Displaced Left
  - Depressed Median
  - Raised Median
  - Sidewalk
  - Bridge Construction
  - Remove Roadway
  - Existing ROW / Property Line
  - Retaining Wall
  - ROW Acquisition
  - margin-right: 5px;"> Signalized Intersection
  - margin-right: 5px;"> Stop Condition Intersection

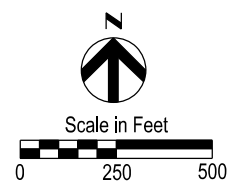


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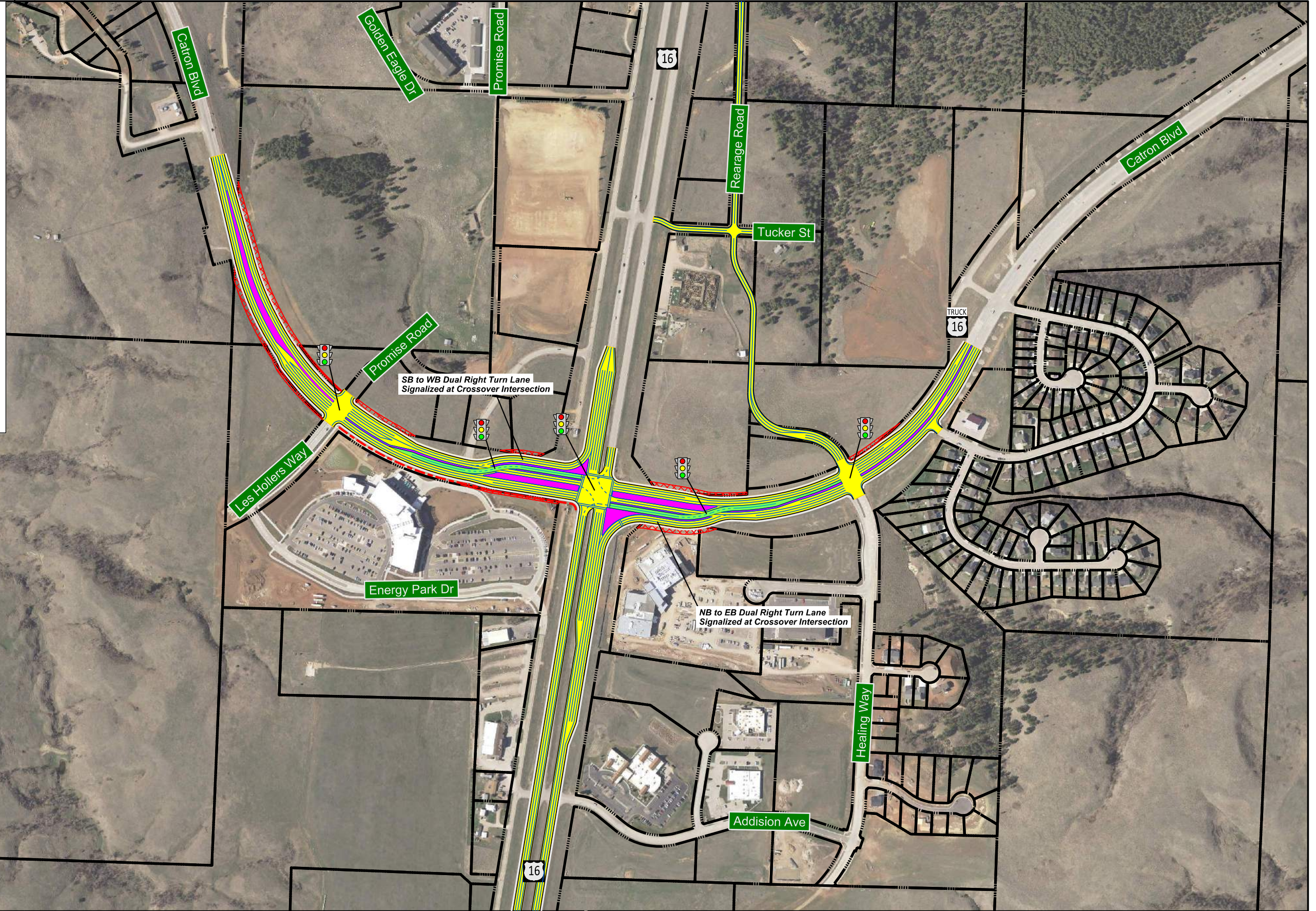


Alternative 2.1b  
DLT with Separated, Free Right Turn Lanes at Main Intersection (all Quadrants)  
US16 Corridor Study

Figure  
**2.1b**  
Rapid City, SD



- Legend**
- Proposed Roadway
  - Displaced Left
  - Depressed Median
  - Raised Median
  - Sidewalk
  - Bridge Construction
  - Remove Roadway
  - Existing ROW / Property Line
  - Retaining Wall
  - ROW Acquisition
  - Signalized Intersection
  - Stop Condition Intersection



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Date:  
Revision:



Alternative 2.2a  
DLT with Signalized Right Turn Lanes at Main Intersection (all Quadrants)  
US16 Corridor Study

Figure  
**2.2a**  
Rapid City, SD

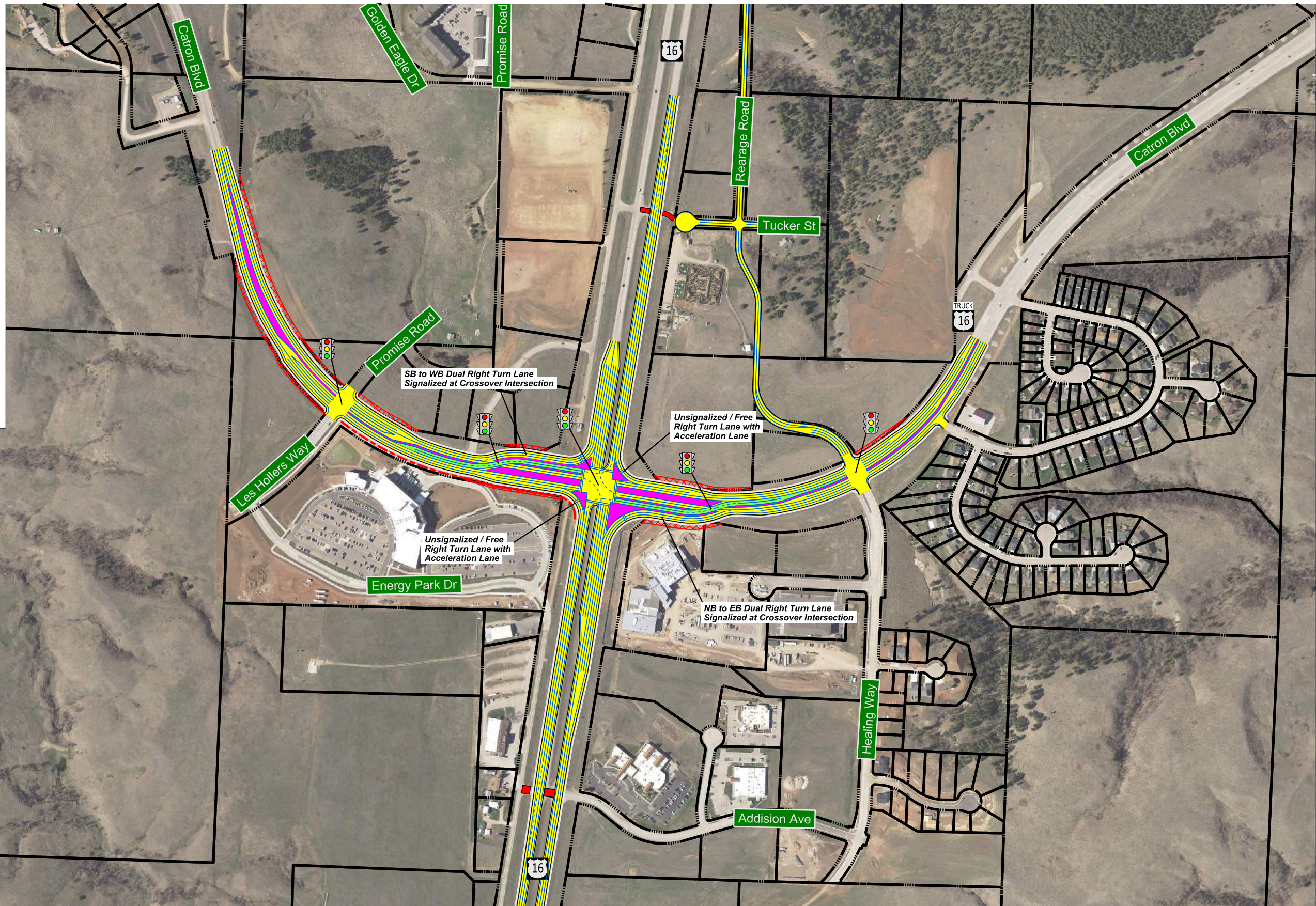




Scale in Feet  
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Legend

- Proposed Roadway
- Displaced Left
- Depressed Median
- Raised Median
- Sidewalk
- Bridge Construction
- Remove Roadway
- Existing ROW / Property Line
- Retaining Wall
- ROW Acquisition
- Signalized Intersection
- Stop Condition Intersection



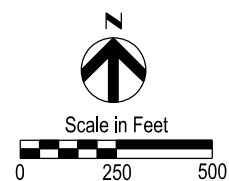
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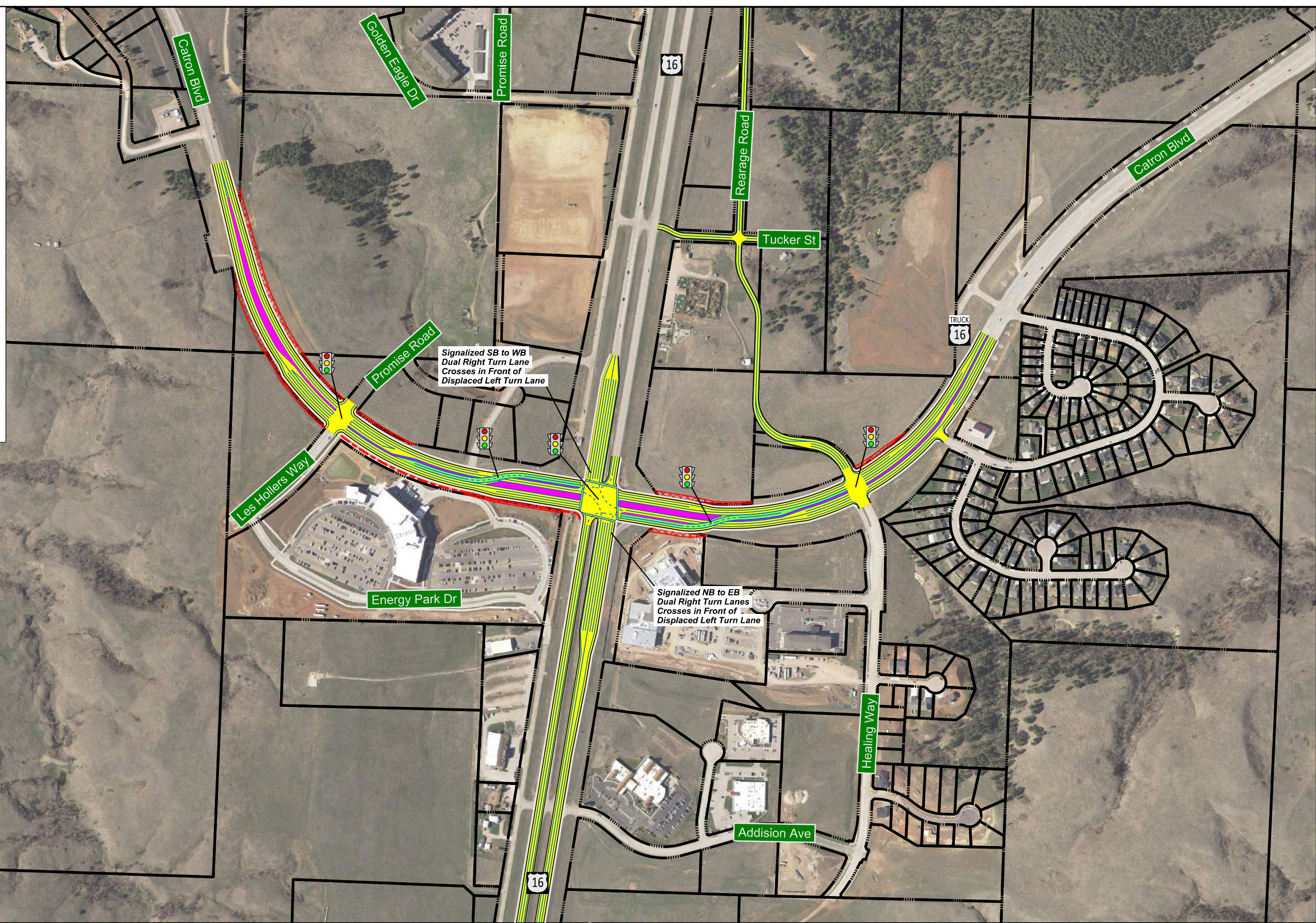
Alternative 2.2b  
DLT with NB and SB Signalized Right Turn Lanes, Free EB and WB Right Turn Lanes  
US16 Corridor Study

Rapid City, SD

Figure  
**2.2b**



- Legend**
- Proposed Roadway
  - Displaced Left
  - Depressed Median
  - Raised Median
  - Sidewalk
  - Bridge Construction
  - Remove Roadway
  - Existing ROW / Property Line
  - Retaining Wall
  - ROW Acquisition
  - Signalized Intersection
  - STOP Stop Condition Intersection



Alternative 2.3a  
 DLT with Unseparated, Signalized Right Turn Lanes at Main Intersection  
 US16 Corridor Study

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 Date:  
 Revision:

Figure  
**2.3a**  
 Rapid City, SD