City and County of Denver

Vision Zero
Road Safety Audit

Federal Boulevard: 46th Avenue to 52nd Avenue

DECEMBER 2021 – DRAFT
MARCH 2022 – FINAL

Felsburg Holt and Ullevig
Fehr & Peers
NOT FOR CONSTRUCTION – Recommendations contained in this document are intended ONLY for use by
the local agency in determining possible future changes at the RSA location.

Information provided in this report does not reflect the opinion of any one team member. The
recommendations reflect the collective suggestions of all team members based on their individual education,
training, and experience.

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Table of Contents

City and County of Denver RSA Process .................................................................................................................. 1
RSA Team ........................................................................................................................................................................ 2
Background Information, Observations, and Recommendations ............................................................................ 2
  Pre-Audit Meeting .................................................................................................................................................. 2
  Observation Process ............................................................................................................................................... 3
  Recommendation Process ..................................................................................................................................... 3
Federal Boulevard Corridor .......................................................................................................................................... 4
  Background Information ........................................................................................................................................ 4
  Crash Review ....................................................................................................................................................... 5
  Crash Data Summary ............................................................................................................................................ 6
  Pre-Audit Comments ........................................................................................................................................... 6
  Corridor-Wide Observations ................................................................................................................................. 8
  Corridor-Wide Recommendations ........................................................................................................................ 11
I. Federal Boulevard & 46th Avenue ......................................................................................................................... 14
  Background Information ...................................................................................................................................... 14
  Crash Review ....................................................................................................................................................... 14
  Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting ...................................... 15
  Observations ....................................................................................................................................................... 15
  Recommendations ............................................................................................................................................... 17
II. Federal Boulevard & 47th Avenue ......................................................................................................................... 18
  Background Information ...................................................................................................................................... 18
  Crash Review ....................................................................................................................................................... 18
  Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting ...................................... 19
  Observations ....................................................................................................................................................... 19
  Recommendations ............................................................................................................................................... 20
III. Federal Boulevard & I-70 Eastbound Ramps .................................................................................................... 22
  Background Information ...................................................................................................................................... 22
  Crash Review ....................................................................................................................................................... 22
  Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting ...................................... 23
  Observations ....................................................................................................................................................... 23
  Recommendations ............................................................................................................................................... 25
IV. Federal Boulevard & I-70 Westbound Ramps ..................................................................................................... 27
  Background Information ...................................................................................................................................... 27
  Crash Review ....................................................................................................................................................... 27
  Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting ...................................... 28
  Observations ....................................................................................................................................................... 28
  Recommendations ............................................................................................................................................... 30
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>V.</td>
<td>Federal Boulevard &amp; 49th Avenue</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Background Information</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Crash Review</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Recommendations</td>
<td>34</td>
</tr>
<tr>
<td>VI.</td>
<td>Federal Boulevard &amp; 50th Avenue</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Background Information</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Crash Review</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Recommendations</td>
<td>38</td>
</tr>
<tr>
<td>VII.</td>
<td>Federal Boulevard &amp; 51st Avenue</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Background Information</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Crash Review</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Recommendations</td>
<td>43</td>
</tr>
<tr>
<td>VIII.</td>
<td>5100 Block of Federal Boulevard</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Background Information</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Crash Review</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Recommendations</td>
<td>47</td>
</tr>
<tr>
<td>IX.</td>
<td>Federal Boulevard &amp; 52nd Avenue</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Background Information</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Crash Review</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Recommendations</td>
<td>51</td>
</tr>
</tbody>
</table>

### Appendices
- Appendix A: RSA Recommendations Table
- Appendix B: RSA Pre-Audit Meeting Presentation
- Appendix C: RSA Intent Memorandum
- Appendix D: Preliminary Findings Presentation

### List of Figures
- Figure 1. Project Location Map .................................................. 1
- Figure 2. RSA Team Members ...................................................... 2
Figure 3. Project Area Speed Limits and Average Annual Daily Traffic................................................................................. 4
Figure 4. Corridor Crash Map..................................................................................................................................................... 5
Figure 5. Crashes by Location .................................................................................................................................................. 6
Figure 6. Examples of Roadway Users................................................................................................................................... 8
Figure 7. LPI at 52nd Avenue .................................................................................................................................................... 8
Figure 8. Pedestrian near Bus Stop.......................................................................................................................................... 8
Figure 9. Sidewalk Obstruction north of 47th Avenue.............................................................................................................. 9
Figure 10. Substantial Southbound Queue North of I-70.......................................................................................................... 9
Figure 11. Median Landscaping South of I-70 .......................................................................................................................... 10
Figure 12. Edge Line Striping Concept near 51st Avenue......................................................................................................... 11
Figure 13. Federal Boulevard & 46th Avenue........................................................................................................................... 14
Figure 14. Misaligned 46th Avenue Eastbound-Westbound Lanes............................................................................................ 16
Figure 15. Narrow Eastbound 46th Avenue Bike Lane............................................................................................................... 16
Figure 16. Federal Boulevard & 46th Avenue Recommendation Map.................................................................................... 17
Figure 17. Federal Boulevard & 47th Avenue ........................................................................................................................... 18
Figure 18. Limited Visibility from 47th Avenue Median Refuge .............................................................................................. 19
Figure 19. Federal Boulevard & 47th Avenue Recommendation Map.................................................................................... 20
Figure 20. Federal Boulevard & 47th Avenue Curb Extension Concepts ................................................................................ 21
Figure 21. Federal Boulevard & I-70 EB Ramps ........................................................................................................................ 22
Figure 22. Insufficient Refuge Area in I-70 EB Channelizing Island ....................................................................................... 24
Figure 23. Wide Outside Lane on I-70 Bridge .......................................................................................................................... 24
Figure 24. Federal Boulevard & I-70 EB Ramps Recommendation Map................................................................................ 25
Figure 25. Federal Boulevard & I-70 EB Ramps Concept ......................................................................................................... 26
Figure 26. Federal Boulevard & I-70 WB Ramps ....................................................................................................................... 27
Figure 27. Southbound Vehicle Queue Beyond I-70 Bridge ...................................................................................................... 29
Figure 28. Southbound Right Turn Yield Sign at I-70 WB Ramps .......................................................................................... 29
Figure 29. Federal Boulevard & I-70 WB Ramps Recommendation Map ................................................................................ 30
Figure 30. Federal Boulevard & I-70 WB Ramps Concept ....................................................................................................... 31
Figure 31. Federal Boulevard & 49th Avenue............................................................................................................................. 32
Figure 32. Diagonal Pedestrian Curb Ramp & SB Queue at 49th Avenue ................................................................................ 33
Figure 33. Federal Boulevard & 49th Avenue Recommendation Map ....................................................................................... 34
Figure 34. Federal Boulevard & 50th Avenue ............................................................................................................................ 35
Figure 35. Skewed West Crosswalk at 50th Avenue ................................................................................................................ 37
Figure 36. 50th Avenue Buffered Bike Lane Missing Crosshatch Striping ............................................................................. 37
Figure 37. Federal Boulevard & 50th Avenue Recommendation Map ....................................................................................... 39
Figure 38. Federal Boulevard & 50th Avenue Concepts ........................................................................................................ 40
Figure 39. Federal Boulevard & 51st Avenue .......................................................................................................................... 41
Figure 40. Southbound Queue at 51st Avenue ........................................................................................................................... 42
Figure 41. Federal Boulevard & 51st Avenue Recommendation Map ........................................................................................ 43
Figure 42. 5100 Block of Federal Boulevard ......................................................................................................................... 44
Figure 43. Southbound Speed Limit Transition within 5100 Block .............................................................................................. 46
Figure 44. 5100 Block Federal Boulevard Recommendation Map .............................................................................................. 47
Figure 45. Federal Boulevard & 52nd Avenue ........................................................................................................................ 48
Figure 46. Missing Pedestrian Signals at 52nd Avenue West Crosswalk .................................................................................. 50
Figure 47. Wide Westbound 52nd Avenue Approach ............................................................................................................ 50
Figure 48. Federal Boulevard & 52nd Avenue Recommendation Map .................................................................................. 51

List of Tables
Table 1. Recommended Left Turn Operations .................................................................................................................... 13
Table 2. Federal Boulevard & 46th Avenue Crash Summary .............................................................................................. 15
Table 3. Federal Boulevard & 47th Avenue Crash Summary .............................................................................................. 19
Table 4. Federal Boulevard & I-70 EB Ramps Crash Summary .......................................................................................... 23
Table 5. Federal Boulevard & I-70 WB Ramps Crash Summary ........................................................................................ 28
Table 6. Federal Boulevard & 49th Avenue Crash Summary .................................................................................................. 33
Table 7. Federal Boulevard & 50th Avenue Crash Summary .............................................................................................. 36
Table 8. Federal Boulevard & 51st Avenue Crash Summary .............................................................................................. 42
Table 9. 5100 Block of Federal Boulevard Crash Summary ............................................................................................... 45
Table 10. Federal Boulevard & 52nd Avenue Crash Summary ........................................................................................... 49
City and County of Denver RSA Process

The Denver Vision Zero Action Plan is a five-year plan to achieve zero traffic deaths and serious injuries by 2030. The Denver Vision Zero program provides traffic safety professionals a unique opportunity to work as part of a dedicated traffic safety improvement program by collaborating with law enforcement, first-responders, government officials, and other stakeholders.

The Federal Boulevard corridor is part of Denver’s High Injury Network (HIN). The HIN has been identified in City and County of Denver (CCD) as part of the Vision Zero initiative as the network of corridors with the highest number of fatal and injury crashes for all travel modes. The choice of Road Safety Audit (RSA) corridors is driven by their proximity to the Equity Index Areas, i.e., areas of Denver where more vulnerable populations live. As stated in Denver’s Vision Zero statement, these areas are places with higher speeds, in closer proximity to schools and high school density, elderly populations, people with disabilities, and those without vehicles. Figure 1 shows the project location. The study area includes both directions of Federal Boulevard between 46th Avenue and 52nd Avenue in northeast Denver.

Figure 1. Project Location Map

RSAs are formal examinations of selected roadway entities from a safety performance viewpoint. All RSAs are performed by an independent multidisciplinary team and are highly benefited by including one or more professionals trained in performing RSAs. An RSA qualitatively estimates and reports on potential road safety issues and identifies opportunities for safety improvements for all road users. RSAs can be used in any phase of project development from planning to preliminary engineering to design to construction. RSAs can also be used on any sized project from a minor intersection and roadway retrofits to long corridors. The RSA team considers the safety of all road users, qualitatively estimates and reports on potential road safety issues, and identifies opportunities for safety improvements. The RSA team reviews police crash reports, reviews local agency crash data, and conducts field observations during different times of the day such as day/night and peak/non-peak hours.
RSA Team

Gaurav Vasisht of Felsburg Holt and Ullevig (FHU) led the independent multidisciplinary RSA team, which included:

- Gaurav Vasisht, PE, PTOE, RSP21, FHU
- Charles Alexander, PE, AICP, RSP1, Fehr & Peers
- Ryan Saline, PE, FHU
- Patrick Picard, AICP, RSP1, Fehr & Peers
- Faith Kelley, EIT, FHU
- Hilda Ofori-Addo, Fehr & Peers

Figure 2. RSA Team Members

The RSA team conducted this audit to the best of its ability within the time allotted. The initial recommendations are based on background information provided during the Kickoff and Preliminary Findings Meeting, an evaluation of historic crash data, and both day and night field reviews, as discussed previously. This information assisted the RSA team in identifying potential opportunities to improve the safety performance of Federal Boulevard from 46th Avenue to 52nd Avenue. This information was initially presented to stakeholders at the Preliminary Findings Meeting. While every attempt has been made to identify potential safety issues, the safety performance of the roadway remains the responsibility of the roadway owner and roadway users.

Background Information, Observations, and Recommendations

The following sections provide background information, crash review, comments from the RSA Pre-Audit Meeting, observations from the field review, and recommendations for the Federal Boulevard corridor and for each study intersection. Appendix A includes a comprehensive list of all recommendations, including location, countermeasures, crash modification factors (i.e., factors used to compute the expected number of crashes after implementing a countermeasure), return on investment (a subjective low, medium and high rating), and planning-level cost estimate.

Pre-Audit Meeting

The RSA team met virtually on Monday, November 8, 2021, via Microsoft Teams with CCD staff Mike King (CCD Project Manager), David DiGiacomo, and Karen Good to discuss background information and the RSA schedule. Tony Brindisi from Colorado Department of Transportation (CDOT) was also present as the study corridor is owned by CDOT (US Highway 287). Finally, District 1 Council Member Amanda Sandoval and Council Aide Gina Volpe-Beasley were also present. The RSA Pre-Audit Meeting presentations can be found in Appendix B. Information presented and discussed at the Pre-Audit/Kickoff Meeting is included under background information, crash review, and comments provided by City staff and RSA stakeholders.
Observation Process

The RSA team began the observation period by driving the Federal Boulevard corridor in both directions in its entirety, followed by driving every approach to each intersection. The corridor-wide observations are based on the general observations made by the RSA team during the windshield review and while conducting the walking field reviews. Observations included road user behavior, traffic signal operations, Americans with Disabilities Act (ADA) facility conditions including ramps and sidewalks, sign visibility, design deficiencies, bicycle infrastructure, spot speed measurements, and windshield review.

Field reviews were conducted on:

- Monday, November 8 (RSA Day 1) – 4:00 PM to 6:00 PM
- Monday, November 8 (RSA Day 1) – 7:00 PM to 9:00 PM
- Tuesday, November 9 (RSA Day 2) – 7:00 AM to 9:00 AM
- Tuesday, November 9 (RSA Day 2) – 10:00 AM to 12:00 PM

Further information regarding presentations and site visits can be found in the RSA Intent Memorandum included in Appendix C. The weather was clear with a high temperature of 61 degrees Fahrenheit on the Tuesday of observations. The observation periods consisted of driving and walking the road and observing road users. Information provided in this report does not reflect the opinion of any one team member.

Recommendation Process

The recommendations reflect the collective suggestions of all team members based on their individual education, training, and experience. The safety and mobility of all road users are considered. The recommendations listed below have been grouped into:

i. Short-term: (Less than 1 year) Denoted by a green circle

ii. Medium-term: (1 to 3 years) Denoted by a blue square

iii. Long-term: (More than 3 years) Denoted by a black diamond

Appendix A summarizes the recommendations and includes a planning level cost estimate. This estimate is based on the following assumptions:

i. Low: Operational Improvements

ii. Medium: Up to $100,000

iii. High: Greater than $100,000

The RSA team met virtually on Monday, November 15, 2021, via Microsoft Teams, to present preliminary findings during the Post-Audit presentation to CCD staff Mike King (CCD Project Manager), David DiGiaco, Karen Good, Abi Subramanian, and Rolf Eisinger. Tony Brindisi from CDOT was also present. Observations and potential opportunities for improvements were discussed during this meeting. Presentation slides from this meeting are provided in Appendix D.
Federal Boulevard Corridor

The following section provides background information, observations, and recommendations for the Federal Boulevard corridor, including intersection geometry, user behavior, signal control, and multimodal infrastructure.

Background Information

Between 46th Avenue and 52nd Avenue, Federal Boulevard is a four-lane, north-south arterial. Through most of the project limits, the posted speed limit is 35 miles per hour (MPH). On southbound Federal Boulevard, the posted speed limit is 45 MPH until approximately 250 feet south of 52nd Avenue, where it transitions to 40 MPH. The southbound speed limit then transitions to 35 MPH approximately 400 feet south of 52nd Avenue. Federal Boulevard varies in width throughout the study area. From 46th Avenue to 50th Avenue, the curb-to-curb distance is approximately 60 feet. From 50th Avenue to 51st Avenue, the curb-to-curb distance is approximately 70 feet. Finally, from 51st Avenue to 52nd Avenue, the curb-to-curb distance is approximately 80 feet.

Sidewalks are provided throughout the entire project area. There are no bike lanes on Federal Boulevard, but on-street bike infrastructure is provided on 50th Avenue and 46th Avenue. Annual Average Daily Traffic (AADT) varies within the project limits from 39,500 vehicles per day (vpd) north of Interstate 70 (I-70) to 35,100 vpd south of I-70. RTD bus route 31 serves Federal Boulevard within the project limits. Route 52 serves 50th Avenue across the study area. Figure 3 shows the corridor roadway characteristics.
Crash Review
Between March 2017 and March 2020, there were a total of 300 crashes along Federal Boulevard within the RSA project limits. Figure 4 illustrates the corridor crash map, and Figure 5 shows crashes by location.

- 7 killed/serious injury (KSI) crashes were recorded during the study period.
  - 2 fatal crashes were reported.
- 5 crashes involved pedestrians/cyclists.
- 28 percent of total crashes were between 3:00 PM and 6:00 PM; KSI crashes were distributed fairly evenly between 6:00 AM and 9:00 PM.
- Total crashes: 35 percent Broadside, 35 percent Rear End, and 11 percent Sideswipe.
- KSI crashes: 38 percent Pedestrian, 25 percent Head On, and 25 percent Broadside.
- 4 additional KSI crashes have been recorded since March 2020.
  - 3 crashes involved pedestrians (1 was killed).
  - 1 crash was a Broadside.
Crash Data Summary

The following summarize the corridor-wide crash data and present common trends at intersections and along midblock segments:

- Broadside/Head On and Rear End crashes were the most common types observed at intersections within the study area. This may be influenced by the frequency of unprotected left turn movements and congestion along the corridor.
- Pedestrian crashes observed on the corridor occurred close to RTD bus stops. Three fatal crashes (including one that occurred after the study period) involved pedestrians crossing at midblock locations.
- Total crash frequency along the study corridor was substantially elevated from 12:00 PM to 6:00 PM. This is likely associated with generally higher traffic volumes.
- KSI crash frequency was generally even between 6:00 AM and 9:00 PM, which was influenced by elevated vehicle and pedestrian activity along the corridor.
- The highest crash frequencies were observed at the I-70 Interchange intersections.

Pre-Audit Comments

City staff and RSA stakeholders provided several comments during the Pre-Audit Meeting, including:

- Crash data were selected between March 2017 and March 2020 to evaluate pre-pandemic conditions before radical alterations to traffic volume and travel patterns. This is consistent with CDOT’s procedures over the last 1.5 years. KSI crash history was evaluated between 2020 and 2021 to understand impacts of more recent travel patterns.
- Several planned projects along the study area corridor are expected to substantially alter the roadway and provide safety benefits.
- Due to frequent driveway spacing with limited movements along the corridor, U-turns are commonly observed, especially at 49th Avenue. Ideas for simplified access should be considered during the RSA.
- Some bus stop locations are far away from signalized intersections, which may contribute to the high frequency of midblock pedestrian crossings that are observed. A previous Federal Boulevard transit study identified recommended bus stop locations along the corridor, but these changes have not yet been implemented.
I-70 Interchange intersections were observed to have the most crashes during the study period. This interchange presents several problems:

- Congestion causes northbound and southbound left turn lanes to queue beyond the bridge, blocking visibility of opposing left turn movements and creating multiple threat situations.
- Northbound and southbound left turns are currently protected-only during peak hours. Off-peak operations use permissive phasing.
- Westbound left turns off I-70 during peak hours cannot always be completed due to congestion along Federal Boulevard. Drivers will sometimes block the intersection.
- The tight-diamond configuration of the interchange does not provide a substantial amount of space between intersections, contributing to the congestion observed during peak hours.
- Pedestrian crossings are inconvenient and uncomfortable with many instances of conflict with vehicles observed.
- Panhandling activity blocks pedestrian access due to the current configuration of medians and channelized islands.

Council Member Sandoval provided several comments, including:

- Midblock crossings are common between 50th Avenue and 52nd Avenue due to proximity to the Regis University campus. Redevelopment plans from the campus will change the nature of activity on the west side of Federal. The University plans to have less impactful development in terms of vehicular activity/access.
- Fatal pedestrian crashes have occurred after raised medians were constructed along Federal Boulevard. The new medians do not provide ADA-compliant pedestrian refuges like some medians on the south end of the corridor.
- Pedestrian crossings of I-70 are uncomfortable and have a high potential for conflict. The Lowell Boulevard underpass is a more comfortable (out of direction) crossing location; however, pedestrians still see this crossing as uncomfortable, and Department of Transportation & Infrastructure (DOTI) has some possible improvements envisioned for the area that may be integrated into bike facility work along Lowell Boulevard.
- Left turn phasing should be evaluated throughout the corridor. Lack of left turn arrows (protected phasing) leads to congestion and poor gap judgment, especially during peak hours.
- The 46th Avenue intersection has several unique characteristics that make it challenging for users:
  - Southbound left turns must pull out a substantial distance into the intersection to complete movements due to the offset nature of 46th Avenue approaches. Doing so creates visibility issues for finding gaps in northbound traffic.
  - Denver Fire frequently uses 46th Avenue.
  - Peak hour congestion creates conflict between movements, including red light running and permitted left turns attempting to find gaps in opposing through traffic.
  - 46th Avenue bike lanes provide convenient and comfortable infrastructure for cyclists; however, at the intersection of 46th Avenue with Federal Boulevard, the bike facility is dropped on the east side due to the narrow cross-section.
Corridor-wide Observations

The following section summarizes general observations that apply to the project corridor.

Road Users

The following road users were observed along the corridor (Figure 6):
- Vehicles
- Tractor trailers
- Motorcycles
- Bicyclists/shared scooters
- Pedestrians
- RTD buses

Observations & Issues

Pedestrian Crossings

- Most pedestrian activity along the study corridor was observed north of I-70.
- Several pedestrians crossed at unsignalized/unmarked locations north of I-70.
- Leading pedestrian intervals (LPIs) are provided to cross Federal Boulevard only at 52nd Avenue.
- High levels of activity related to transit were observed at 50th Avenue and 52nd Avenue.
  - 50th Avenue is a transfer point between RTD Route 31 (Federal Boulevard) and Route 52 (50th Avenue).
  - Some bus stops are far from marked crossing locations, making midblock pedestrian crossings more common.
Sidewalk Conditions

- Sidewalks are present on both sides of Federal Boulevard throughout the study area. A mix of attached and detached sidewalks is provided.
- Sidewalks on the south side of I-70 are narrow and less comfortable than ideal.
- Sidewalks on the north side of I-70 are frequently interrupted by curb cuts for driveway access to adjacent businesses.
- Several curb ramps within the study area are poorly aligned with receiving ramps.
- Vegetation, channelizing islands, and light poles occasionally impede sidewalks throughout the study area.

![Figure 9. Sidewalk Obstruction north of 47th Avenue](image)

Traffic Operations

- Substantial southbound vehicle queues were observed during AM and PM peak hours that extended from the I-70 Interchange area and blocked multiple intersections and driveways.
- Numerous turning movements were observed at intersections and driveways north of I-70.
- Several motorists were observed staging in and turning across painted medians (where left turn movements are prohibited).

![Figure 10. Substantial Southbound Queue North of I-70](image)
Roadway

- Curb-to-curb distance is noticeably wider in the north end of the corridor than in the south end:
  - 52\textsuperscript{nd} Avenue to 51\textsuperscript{st} Avenue: \textapprox 80 feet
  - 51\textsuperscript{st} Avenue to 50\textsuperscript{th} Avenue: \textapprox 70 feet
  - 50\textsuperscript{th} Avenue to 46\textsuperscript{th} Avenue: \textapprox 60 feet

- Vegetation and landscaping on Federal Boulevard south of I-70 create a sense of a narrower corridor but sometimes interfere with line-of-sight.

- Street lighting provided throughout the corridor was consistent and seems adequate for vehicular traffic.

- Most drivers obeyed the posted speed limit, possibly due to the narrow cross-section, frequency of driveways, and friction from traffic.

- Some pedestrian signal heads do not provide countdown timers.

- Retroreflective backplate tape is not provided for any traffic signal heads.
Corridor-wide Recommendations

The following recommendations are based on the collaborative effort of the RSA multidisciplinary team and stakeholder interviews. Corridor-wide recommendations are based on the team’s experience driving and walking the corridor. As a reminder, the recommendations listed below have been grouped into three categories based on expected implementation timeline:

i. **Short-term:** (Less than 1 year)  Denoted by a green circle
ii. **Medium-term:** (1 to 3 years)  Denoted by a blue square
iii. **Long-term:** (More than 3 years)  Denoted by a black diamond

Corridor-wide recommendations were categorized based on three safety objectives: reduce midblock pedestrian crashes through reduced exposure and increased visibility, reduce Broadside crashes at uncontrolled locations, and reduce Broadside crashes at signalized intersections.

Reduce Exposure / Increase Visibility of Pedestrians Crossing at Midblock Locations

1. Reduce roadway width through striping.

Existing striping, especially in the north end of the corridor, provides wide outside lanes and creates uncertainty of vehicle movements. Reducing the width of outside lanes would reduce pedestrians’ exposure during midblock crossings.

**Recommendation:**

- Install consistent edge lines and right turn lane lines throughout the corridor. **Figure 12** displays an example of edge line striping that could be implemented near 51st Avenue.

![Figure 12. Edge Line Striping Concept near 51st Avenue](image-url)
2. Evaluate bus stop locations.
Some bus stop locations are located midblock, far away from marked pedestrian crossings. Pedestrians may choose to cross midblock to reduce their travel time but often increase their exposure by doing so.

Recommendation:
- Consolidate/relocate bus stops closer to signalized intersections, including far-side locations where possible.

3. Evaluate uncontrolled vehicular movements at intersections.
Uncontrolled intersections and driveways present opportunities for desired pedestrian crossings but are not always safe due to increased exposure. As anticipated redevelopment occurs along the corridor, the attractiveness of these crossing locations will increase.

Recommendation:
- Evaluate uncontrolled intersections (51st Avenue, 49th Avenue, 47th Avenue) for the potential for signalization, turning movement restrictions, and provision of pedestrian refuges at unmarked/uncontrolled locations.

4. Reconstruct the Federal Boulevard cross-section.
During redevelopment, more permanent measures should be considered to reduce crossing distance by narrowing the cross-section of Federal Boulevard where possible. Reducing the width of outside lanes would reduce pedestrians’ exposure during midblock crossings.

Recommendation:
- Narrow Federal Boulevard as redevelopment occurs.

5. Improve pedestrian visibility at signalized intersections.
At signalized intersections, increasing the visibility of pedestrians is a proven strategy to reduce conflict with vehicles by emphasizing right-of-way. Several improvements should be considered to increase pedestrian visibility.

Recommendations:
- Add LPIs to locations listed in later sections (46th Avenue, 50th Avenue).
- Evaluate pedestrian walk and clearance intervals at signalized intersections.
- Provide pedestrian countdown timers at all intersections.
- Implement protected left turns to isolate conflicting pedestrian and vehicle movements.
- Install curb extensions (bulb-outs) to narrow crossing distances.

Reduce Broadside Crashes at Uncontrolled Locations

6. Reduce congestion and opportunities for multiple-threat crashes.
Multiple-threat crashes are often caused by blocked line of sight due congestion at crossing locations. Improving the flow of through traffic to provide efficient platoons and sufficient gaps reduces conflict and the potential for such crashes.

Recommendation:
- Evaluate signal timing and progression to reduce congestion.

7. Conduct access management evaluations.
Broadside crashes at uncontrolled locations are often caused by failure to yield right-of-way or the inability to correctly judge gaps to through traffic. Improving the flow of through traffic to provide efficient platoons and sufficient gaps reduces conflict and the potential for Broadside crashes.

Recommendation:
- Conduct corridor-wide access management evaluations and consider consolidation of uncontrolled driveway locations onto Federal Boulevard.
Reduce Broadside Crashes at Signalized Intersections

8. Improve signal head visibility.

Nighttime visibility of traffic signal heads is imperative for drivers to make correct judgments of gaps in traffic and clearance intervals. None of the signals observed on the corridor had retroreflective backplate tape to improve visibility. Federal Highway Administration includes backplates with retroreflective borders on their list of proven safety countermeasures.

Recommendation:
- Provide retroreflective borders to all signal heads along the corridor.

9. Review left-turn operations.

A mixture of permitted (perm), protected/permissive (prot/perm), and protected-only (prot) left turn operations exists on the corridor. Failure to yield right-of-way crashes resulting from left turns are common at some locations on the corridor. Adjustments to these operations should be considered to reduce conflict between left turning vehicles, opposing through vehicles, and pedestrians.

Recommendation:
- Review and adjust left turn operations throughout the corridor.

Table 1 summarizes the RSA team’s proposals for left turn operation at traffic signals along the corridor.

Table 1. Recommended Left Turn Operations

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Movement</th>
<th>Existing Operation</th>
<th>Recommended Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>52nd Avenue</td>
<td>Northbound Left</td>
<td>Perm</td>
<td>Prot/Perm</td>
</tr>
<tr>
<td>50th Avenue</td>
<td>Northbound Left</td>
<td>Prot/Perm</td>
<td>Prot</td>
</tr>
<tr>
<td></td>
<td>Southbound Left</td>
<td>Perm</td>
<td>Prot/Perm</td>
</tr>
<tr>
<td>I-70 Westbound</td>
<td>Northbound Left</td>
<td>Prot/Perm</td>
<td>Prot</td>
</tr>
<tr>
<td>I-70 Eastbound</td>
<td>Southbound Left</td>
<td>Prot/Perm</td>
<td>Prot</td>
</tr>
<tr>
<td>46th Avenue</td>
<td>Northbound Left</td>
<td>Perm</td>
<td>Prot/Perm</td>
</tr>
<tr>
<td></td>
<td>Eastbound Left</td>
<td>Perm</td>
<td>Prot/Perm</td>
</tr>
<tr>
<td></td>
<td>Westbound Left</td>
<td>Perm</td>
<td>Prot/Perm</td>
</tr>
</tbody>
</table>

Notes: Proposed operations may be different during late-night and overnight hours.
Recommendations are based on traffic volume estimates; traffic counts are recommended to verify that these changes are warranted.
Eastbound and westbound changes at 46th Avenue would be recommended only when a pedestrian call is made.
I. Federal Boulevard & 46th Avenue

Background Information

The Federal Boulevard & 46th Avenue intersection is signalized and represents the southern boundary of the project study area (Figure 13). Federal Boulevard consists of two through lanes in each direction, plus dedicated left turn lanes. Northbound and southbound right turns must be made from the shared through lane. The west leg of 46th Avenue does not align directly with the east leg and includes dedicated eastbound left turn, through, and right turn lanes, and one westbound receiving lane. On-street parking is permitted on the north side of 46th Avenue (weekdays only). The east leg of 46th Avenue includes a dedicated westbound left turn lane and a shared through/right turn lane, as well as one eastbound receiving lane.

Painted sharrows are provided in both directions of 46th Avenue west of Federal Boulevard. On-street bike lanes are provided in both directions of 46th Avenue east of Federal Boulevard; however, the bike lanes are dropped at the intersection of 46th Avenue with Federal Boulevard on the east side due to the narrowed cross-section. Southbound left turns from Federal Boulevard operate with protected/permitted phasing. All other left turns operate with permitted-only phasing. Federal Boulevard has a posted speed limit of 35 MPH, and 46th Avenue has a posted speed limit of 30 MPH.

Crash Review

Between March 2017 and March 2020, there were a total of 13 crashes at the Federal Boulevard & 46th Avenue intersection. Table 2 displays a summary of crash history for the intersection:

- 7 Rear End crashes constitute 54 percent of crashes.
- 5 Broadside crashes constitute 38 percent of crashes.
- 1 KSI Broadside crash occurred involving a southbound left turning motorist and a northbound motorcyclist.
An additional KSI crash occurred in 2021 involving an eastbound left turning motorist failing to yield right-of-way to a pedestrian in the crosswalk.

Crashes were most common in the northbound (31 percent) and southbound (38 percent) directions.

**Table 2. Federal Boulevard & 46th Avenue Crash Summary**

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Crashes</strong></td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>15%</td>
<td>15%</td>
<td>31%</td>
<td>38%</td>
</tr>
<tr>
<td><strong>Most Harmful Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td>54%</td>
<td></td>
<td></td>
<td>29%</td>
<td>29%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Broadside/head on</td>
<td>38%</td>
<td>100%</td>
<td></td>
<td>20%</td>
<td>40%</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>Bicycle with other vehicle</td>
<td>8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Driver Action</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Followed too closely</td>
<td>38%</td>
<td></td>
<td></td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>15%</td>
<td>100%</td>
<td></td>
<td>50%</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Movement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making left turn</td>
<td>38%</td>
<td>100%</td>
<td></td>
<td>20%</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting**

The following comments were received from Council Member Sandoval:

- Southbound left turns must pull out a substantial distance into the intersection to complete movements due to the offset nature of 46th Avenue approaches. Doing so creates visibility issues for finding gaps in northbound traffic.
- Denver Fire frequently uses 46th Avenue.
- Peak hour congestion creates conflict between movements, including red light running and permitted left turns attempting to find gaps in opposing through traffic.
- 46th Avenue bike lanes provide convenient and comfortable infrastructure for cyclists.

**Observations**

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- Eastbound and westbound lanes are not aligned across Federal Boulevard due to the difference in width of the cross-sections on each side of the intersection.
- The protected phase for southbound left turns is short and does not provide sufficient time for queues to dissipate. Frustrated drivers sometimes run the red light at the end of the permitted phase.
- The westbound on-street bike lane (east of Federal Boulevard) is only 4 feet wide, including the gutter. This is less than the AASHTO design guidelines for bicycle lanes.
- The westbound receiving lane is very wide (approximately 22 feet).
- Eastbound and westbound left turning vehicles failed to yield to pedestrians in the crosswalk on multiple occasions.
Figure 14. Misaligned 46th Avenue Eastbound-Westbound Lanes

Figure 15. Narrow Eastbound 46th Avenue Bike Lane
Recommendations

The following improvements are recommended for the intersection. See Figure 16 for a map of general improvements.

10. Implement LPIs for eastbound and westbound crossings.

11. Evaluate signal timing parameters, especially the minimum green time for southbound left turn movements.

12. Evaluate on-street bike lane designs.
   - Widen the westbound approach bike lane.
   - Create a westbound receiving bike lane (currently a sharrow).

13. Provide positive guidance skip-striping for eastbound and westbound movements.

14. Construct curb extensions with paint and delineators on the northwest corner of the intersection.

15. Adjust left-turn operations.
   - **Northbound:** Convert from permitted-only to protected/permitted.
   - **Southbound:** Retain existing protected/permitted operation.
   - **Eastbound:** Consider protected/permitted phasing when a pedestrian call is made.
   - **Westbound:** Consider protected/permitted phasing when a pedestrian call is made.

---

**Figure 16. Federal Boulevard & 46th Avenue Recommendation Map**
II. Federal Boulevard & 47th Avenue

Background Information

The Federal Boulevard & 47th Avenue intersection is a limited-movement intersection; no left turns or east-west crossing movements are permitted (Figure 17). Federal Boulevard consists of two through lanes in each direction. Pedestrian refuge areas are provided within the raised median of Federal Boulevard for east-west crossings. Federal Boulevard has a posted speed limit of 35 MPH.

Crash Review

Between March 2017 and March 2020, there were a total of 5 crashes at the Federal Boulevard & 47th Avenue intersection. Table 3 displays a summary of crash history for the intersection.

- 4 Rear End crashes constitute 80 percent of crashes.
- 1 Broadside crash constitutes 20 percent of crashes.
- No KSI crashes occurred during the study period.
- Most crashes occurred in the northbound direction (60 percent).
### Table 3. Federal Boulevard & 47th Avenue Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Crashes</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>20%</td>
<td>0%</td>
<td>60%</td>
<td>20%</td>
</tr>
<tr>
<td>Most Harmful Event</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td>80%</td>
<td></td>
<td></td>
<td>75%</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside</td>
<td>20%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Followed too closely</td>
<td>80%</td>
<td></td>
<td></td>
<td>75%</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>20%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making right turn</td>
<td>20%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- CDOT recently installed a solar-powered luminaire in the median pedestrian refuge area and requested that the RSA team review its efficacy.

### Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- 47th Avenue is very wide (approximately 45 feet) on the west leg of the intersection.
- RTD bus stops are located midblock north of 47th Avenue.
- Overgrown landscaping in the southwest corner of the intersection obstructs the sidewalk.
- Though pedestrian refuges are provided in the median, visibility is difficult due to trees.
- The solar luminaire was not observed to be working in the early night period but was later observed to be functioning properly during dashcam review.

![Limited Visibility from 47th Avenue Median Refuge](image)
Recommendations

The following improvements are recommended for the intersection. See Figure 19 and Figure 20 for a map of general improvements and a concept sketch.

16. Narrow the cross-section of 47th Avenue (especially the west leg) by constructing curb extensions with paint and delineators.

17. Trim landscaping infringing on the sidewalk in the southwest corner of the intersection.

18. Remove trees/trim landscaping within the median to improve visibility for pedestrians using the refuge area to cross Federal Boulevard.

19. Evaluate bus stop relocation closer to a signalized intersection or consolidation.

20. Upgrade quick-build curb extensions to permanent construction.

Figure 19. Federal Boulevard & 47th Avenue Recommendation Map
Figure 20. Federal Boulevard & 47th Avenue Curb Extension Concepts
III. Federal Boulevard & I-70 Eastbound Ramps

Background Information

The Federal Boulevard & I-70 Eastbound Ramps intersection is signalized (Figure 21). Northbound Federal Boulevard consists of three through lanes, one of which is designated for northbound left turns at the westbound interchange intersection, and a dedicated channelized right turn lane. Southbound Federal Boulevard consists of two through lanes and one left turn lane. The I-70 Eastbound Off-Ramp consists of one dedicated left turn lane and a shared through/right turn lane. The I-70 Eastbound On-Ramp consists of a single lane. Northbound right turn movements are yield-controlled.

Federal Boulevard has a posted speed limit of 35 MPH through the intersection. The I-70 Eastbound Off-Ramp has an advisory speed of 35 MPH.

Crash Review

Between March 2017 and March 2020, there were a total of 55 crashes at the Federal Boulevard & I-70 Eastbound Ramps intersection. Table 4 displays a summary of crash history for the intersection.

- 29 Broadside crashes constitute 53 percent of crashes.
- 10 Rear End crashes constitute 18 percent of crashes.
- 10 Head On crashes constitute 18 percent of crashes.
- No KSI crashes occurred during the study period.
- One KSI crash occurred in 2021 involving a northbound motorist who ran the red light and struck a southbound left turning motorist.
- 64 percent of crashes involved southbound left turning motorists.
- Failure to yield right-of-way was cited in 47 percent of all crashes, all of which involved southbound motorists.
Table 4. Federal Boulevard & I-70 EB Ramps Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Crashes</strong></td>
<td>55</td>
<td>0</td>
<td>0</td>
<td>24%</td>
<td>0%</td>
<td>13%</td>
<td>64%</td>
</tr>
<tr>
<td><strong>Most Harmful Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside</td>
<td>53%</td>
<td>10%</td>
<td>14%</td>
<td>76%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td>18%</td>
<td>60%</td>
<td>20%</td>
<td>20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head on</td>
<td>18%</td>
<td>10%</td>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Driver Action</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Failed to stop at signal</td>
<td>18%</td>
<td>22%</td>
<td>44%</td>
<td>33%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Movement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making left turn</td>
<td>58%</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>90%</td>
</tr>
</tbody>
</table>

Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- CDOT intends to provide improvements to pedestrian curb ramps and channelizing islands at this intersection as part of an upcoming overlay project along Federal Boulevard.
- Southbound left turns are currently protected-only during peak hours. Off-peak operations use permissive-only phasing, but there are plans to extend this phasing to longer hours due to congestion, limited visibility, and conflict potential with opposing through movements.
- Congestion causes northbound and southbound left turn lanes to queue beyond the bridge, blocking the visibility of opposing left turn movements and creating multiple threat situations.
- Panhandling activity blocks pedestrian access due to the current configuration of medians and channelized islands.
- Pedestrian crossings of I-70 are uncomfortable and have a high potential for conflicts with vehicles. The Lowell Boulevard underpass is a more comfortable crossing location despite being out of direction.

Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- Pedestrian curb ramps do not meet ADA standards. The channelizing island for northbound right turns does not provide a sufficient refuge area and does not have any pedestrian curb ramps.
- Federal Boulevard is very wide across the I-70 bridge. Outside lanes are approximately 16 feet wide, and no edge lines are provided.
- The northbound right turn lane striping is missing/faded.
- Southbound left turns were confirmed to operate with protected-only phasing during peak periods. During this time, left turn movements were double served at the beginning and end of the northbound/southbound phase.
- Poor progression between the I-70 Eastbound and Westbound intersections resulted in many vehicles making multiple stops and in queues extending beyond upstream intersections.
- Multiple motorists exiting Conoco (southwest corner) made illegal left turns to go northbound on Federal Boulevard. This maneuver was more common during off-peak periods.
- Significant guardrail damage was observed in the northeast corner of the intersection.
- The southeast pedestrian pushbutton was not functioning properly.
Figure 22. Insufficient Refuge Area in I-70 EB Channelizing Island

Figure 23. Wide Outside Lane on I-70 Bridge
Recommendations

The following improvements are recommended for the intersection. See Figure 24 and Figure 25 for a map of general improvements and a concept sketch.

21. Convert southbound left turn operations to protected-only beyond peak periods. Further evaluation is needed to determine operations needs during late-night and overnight hours.

22. Add retroreflective backplate tape to all signal heads.

23. Install edge line on the I-70 bridge to increase the buffer between vehicles and the sidewalk.


25. Improve pedestrian curb ramps and channelized island refuge areas to meet ADA standards.

26. Consider providing additional signing/pavement markings to improve route guidance to I-70.

27. Bring the southbound stop bar closer to the intersection to increase the storage area on the I-70 bridge.

28. Construct a raised median south of the intersection.

Figure 24. Federal Boulevard & I-70 EB Ramps Recommendation Map
Figure 25. Federal Boulevard & I-70 EB Ramps Concept
IV. Federal Boulevard & I-70 Westbound Ramps

Background Information

The Federal Boulevard & I-70 Westbound Ramps intersection is signalized (Figure 26). Northbound Federal Boulevard consists of two through lanes and one left turn lane. Southbound Federal Boulevard consists of three through lanes, one of which is designated for southbound left turns at the eastbound interchange intersection, and a dedicated right turn slip lane. The I-70 Westbound Off-Ramp consists of one dedicated left turn lane and a shared left turn/through/right turn lane with a channelizing island. The I-70 Westbound On-Ramp consists of a single lane. Southbound right turn movements are signed for yield-control.

Federal Boulevard has a posted speed limit of 35 MPH through the intersection. The I-70 Westbound Off-Ramp has an advisory speed of 35 MPH.

Figure 26. Federal Boulevard & I-70 WB Ramps

Crash Review

Between March 2017 and March 2020, there were a total of 31 crashes at the Federal Boulevard & I-70 Westbound Ramps intersection. Table 5 displays a summary of crash history for the intersection.

- 22 Broadside/Head On crashes constitute 71 percent of crashes.
- 1 KSI crash occurred during the study period involving a northbound left turning motorist.
- 82 percent of Broadside/Head On crashes involved northbound left turning motorists.
- Failure to yield right-of-way was cited as a causal factor in 42 percent of all crashes.
### Table 5. Federal Boulevard & I-70 WB Ramps Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Crashes</strong></td>
<td>31</td>
<td>1</td>
<td>0</td>
<td>0%</td>
<td>14%</td>
<td>66%</td>
<td>21%</td>
</tr>
<tr>
<td><strong>Most Harmful Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside/head on</td>
<td>71%</td>
<td>100%</td>
<td>5%</td>
<td>82%</td>
<td>14%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td>16%</td>
<td></td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Driver Action</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>42%</td>
<td>100%</td>
<td>50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to stop at signal</td>
<td>19%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Movement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making left turn</td>
<td>52%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- CDOT intends to provide improvements to pedestrian curb ramps and channelizing islands at this intersection as part of an upcoming overlay project along Federal Boulevard.
- Northbound left turns are currently protected-only during peak hours. Off-peak operations use permissive-only phasing, but there are plans to extend this phasing to longer hours due to congestion, limited visibility, and conflict potential with opposing through movements.
- Planned redevelopment in the northeast corner of the intersection will result in increased demand at the intersection and increased activity along Federal Boulevard.
- Congestion causes northbound and southbound left turn lanes to queue beyond the bridge, blocking the visibility of opposing left turn movements and creating multiple threat situations.
- Panhandling activity blocks pedestrian access due to the current configuration of medians and channelized islands.
- Pedestrian crossings of I-70 are uncomfortable and have a high potential for conflicts. The Lowell Boulevard underpass is a more comfortable crossing location; however, it is out of direction and pedestrians still see this crossing as uncomfortable. DOTI has some possible improvements envisioned for the area that may be integrated into bike facility work along Lowell Boulevard.

### Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- Pedestrian curb ramps do not meet ADA standards. The channelizing island for the northbound right turn does not provide a sufficient refuge area and does not have any pedestrian curb ramps.
- Federal Boulevard is very wide across the I-70 bridge. Outside lanes are approximately 16 feet wide, and no edge lines are provided.
- The southbound right turn slip lane is narrow/short and was improperly used by multiple motorists. Additionally, southbound right turns appear to be controlled by a yield sign, which is confusing given the current configuration of the intersection and the placement of the sign (hidden behind a traffic signal pole).
- Northbound left turns were confirmed to operate with protected-only phasing during peak periods. During this time, left turn movements were double served at the beginning and end of the northbound/southbound phase.
- Poor progression between the I-70 Eastbound and Westbound intersections resulted in many southbound vehicles making multiple stops and in queues extending beyond upstream intersections.
- A painted median exists on Federal Boulevard north of the intersection, but adjacent business accesses do not display signs prohibiting left turn movements.
- Some westbound right turn motorists get stuck behind left turn queues due to the shared lane configuration.
Figure 27. Southbound Vehicle Queue Beyond I-70 Bridge

Figure 28. Southbound Right Turn Yield Sign at I-70 WB Ramps
Recommendations

The following improvements are recommended for the intersection. See Figure 29 and Figure 30 for a map of general improvements and a concepts sketch.

29. Convert northbound left turn operations to protected-only beyond peak periods. Further evaluation is needed to determine operations needs during late-night and overnight hours.

30. Add retroreflective backplate tape to all signal heads.

31. Install edge line on the I-70 bridge to increase the buffer between vehicles and the sidewalk.

32. Evaluate the removal of the southbound right turn yield sign.

33. Improve pedestrian curb ramps and channelized island refuge areas to meet ADA standards.

34. Explore the creation of a dedicated westbound right turn lane and improvements to the channelizing island to accompany redevelopment of the northeast corner.

35. Consider providing additional signing/pavement markings to improve route guidance to I-70.

36. Construct a raised median north of the intersection.
Figure 30. Federal Boulevard & I-70 WB Ramps Concept
V. Federal Boulevard & 49th Avenue

Background Information

The Federal Boulevard & 49th Avenue intersection is unsignalized, and stop signs control eastbound and westbound movements from 49th Avenue (Figure 31). Federal Boulevard consists of two through lanes in each direction, plus dedicated left turn lanes. Northbound and southbound right turns must be made from the shared through lane. Eastbound and westbound approaches of 49th Avenue are not striped. The west leg of 49th Avenue is wide enough to serve right turn movements separately.

Federal Boulevard has a posted speed limit of 35 MPH, and 49th Avenue has a posted speed limit of 25 MPH.

Crash Review

Between March 2017 and March 2020, there were a total of 23 crashes at the Federal Boulevard & 49th Avenue intersection. Table 6 displays a summary of crash history for the intersection.

- 12 Broadside crashes constitute 52 percent of crashes.
- 8 Rear End crashes constitute 35 percent of crashes.
- No KSI crashes occurred during the study period.
- 43 percent of crashes involved left turning motorists.
- Most Broadside crashes resulted from westbound motorists failing to yield right-of-way.
Table 6. Federal Boulevard & 49th Avenue Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
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<tr>
<td><strong>Total Crashes</strong></td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>9%</td>
<td>35%</td>
<td>17%</td>
<td>39%</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside</td>
<td>52%</td>
<td></td>
<td></td>
<td>8%</td>
<td>50%</td>
<td>25%</td>
<td>17%</td>
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<tr>
<td>Rear end</td>
<td>35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13%</td>
<td>88%</td>
</tr>
<tr>
<td><strong>Driver Action</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>39%</td>
<td></td>
<td>11%</td>
<td>44%</td>
<td>22%</td>
<td>22%</td>
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<tr>
<td><strong>Movement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Making left turn</td>
<td>43%</td>
<td></td>
<td>20%</td>
<td>30%</td>
<td>30%</td>
<td>20%</td>
<td></td>
</tr>
</tbody>
</table>

Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- U-turn frequency at 49th Avenue is very high due to proximity to I-70 and adjacent land use types.
- A quick-build project is currently planned to convert the 49th Avenue to a 3/4-movement intersection.

Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- Heavy peak hour volumes make left turns and through movements from the minor street difficult. Southbound queues limit visibility for motorists on 49th Avenue.
- Several motorists from eastbound 49th Avenue turned around to find a signalized intersection to make their movements.
- The west leg of 49th Avenue is very wide (approximately 42 feet).
- Pedestrian curb ramps are currently diagonal and point toward the middle of the intersection. Crossings of Federal Boulevard were not frequently observed at this location, likely due to the high rate of delay/conflict.

Figure 32. Diagonal Pedestrian Curb Ramp & SB Queue at 49th Avenue
**Recommendations**

The following improvements are recommended for the intersection. See Figure 33 for a map of general improvements.

37. Construct a 3/4-movement quick-build project consistent with current designs.

38. Narrow the cross-section of 49th Avenue (especially the west leg) by constructing curb extensions with paint and delineators.

39. Reconfigure curb ramps from diagonal orientation to directional ramps.

40. Upgrade quick-build curb extensions and 3/4-movement islands to permanent construction.

---

**Figure 33. Federal Boulevard & 49th Avenue Recommendation Map**
VI. Federal Boulevard & 50th Avenue

Background Information

The Federal Boulevard & 50th Avenue intersection is signalized (Figure 34). Federal Boulevard consists of two through lanes in each direction, as well as left turn lanes and a northbound right turn lane. Northbound left turns operate with protected/permitted phasing while southbound left turns operate with permitted-only phasing. 50th Avenue is a two-lane facility on both sides of Federal Boulevard. Westbound 50th Avenue includes a dedicated left turn lane and shared through/right turn lane. Eastbound 50th Avenue (Regis Boulevard) includes dedicated lanes for left turn, through, and right turn movements. Eastbound and westbound left turns operate with permitted-only phasing.

Buffered bicycle lanes are provided west of Federal Boulevard. Bike lanes are provided east of Federal Boulevard, though the westbound bike lane combines with vehicular traffic just before the intersection due to geometry constraints.

Federal Boulevard has a posted speed limit of 35 MPH. 50th Avenue has a posted speed limit of 30 MPH.

Crash Review

Between March 2017 and March 2020, there were a total of 24 crashes at the Federal Boulevard & 50th Avenue intersection. Table 7 displays a summary of crash history for the intersection.

- 10 Rear End crashes constitute 42 percent of crashes.
- 9 Broadside/Head On crashes constitute 38 percent of crashes.
2 pedestrian crashes occurred at this intersection:
- 1 KSI crash involved a pedestrian crossing Federal Boulevard against the signal who was struck by a northbound motorist.
- A motorist making a westbound left turn struck a pedestrian in the crosswalk.
- An additional KSI Broadside crash occurred involving an eastbound left turning vehicle and a westbound motorcycle.
- Most Rear End crashes involved southbound motorists, but most Broadside/Head On crashes involved northbound motorists.

Table 7. Federal Boulevard & 50th Avenue Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
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<td>Total Crashes</td>
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<td>42%</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td></td>
<td></td>
<td></td>
<td>42%</td>
<td>10%</td>
<td>30%</td>
<td>60%</td>
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<tr>
<td>Broadside/head on</td>
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<td></td>
<td>38%</td>
<td>11%</td>
<td>56%</td>
<td>33%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td></td>
<td></td>
<td></td>
<td>8%</td>
<td>50%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Driver Action</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>29%</td>
<td>100%</td>
<td>14%</td>
<td>14%</td>
<td>57%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>Failed to stop at signal</td>
<td>17%</td>
<td></td>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Movement</td>
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<td></td>
<td></td>
<td>25%</td>
<td>100%</td>
<td>17%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- Pedestrian crossings of Federal Boulevard are very common at 50th Avenue due to the proximity to Regis University.
- Redevelopment plans from the campus will change the nature of activity on the west side of Federal Boulevard. The University plans to have less impactful development in terms of vehicular activity/access.

Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- Tree branches are overgrowing and obscuring signal heads and signs in the southwest corner of the intersection.
- The eastbound-southbound acceleration lane is very short, and its purpose is not clearly marked.
- Differences in cross-sections on each of the four intersection legs create skewed crosswalks, resulting in a longer crossing distance and more exposure for pedestrians.
- The west leg of 50th Avenue (Regis Boulevard) was recently restriped, but crosshatch striping was not reinstalled for the buffered bike lane.
- An access driveway for the gas station in the northeast corner of the intersection is pointed toward the westbound receiving lanes of 50th Avenue (Regis Boulevard).
- The eastbound buffered bicycle lane terminates within the right turn lane rather than combining with through traffic.
- The southbound RTD bus stop is located approximately 200 feet south of the intersection. Multiple pedestrians were observed crossing Federal Boulevard midblock to reach this bus stop.
Figure 35. Skewed West Crosswalk at 50th Avenue

Figure 36. 50th Avenue Buffered Bike Lane Missing Crosshatch Striping
Recommendations

The following improvements are recommended for the intersection. See Figure 37 and Figure 38 for a map of general improvements and a concepts sketch.

41. Implement LPIs for eastbound and westbound crossings.
42. Trim landscaping to improve the visibility of traffic signal heads and signs.
43. Install consistent edge lines and right turn lane lines.
44. Provide positive guidance skip-striping, especially for westbound movements.
45. Reinstall crosshatch striping in the buffered bike lane.
46. Evaluate bus stop relocation closer to the signalized intersection.
47. Remove the eastbound-southbound acceleration lane using paint and delineator curb extensions.
48. Adjust left turn operations.
   - **Northbound:** Convert from protected/permited to protected-only.
   - **Southbound:** Convert from permitted-only to protected/permited.
   - **Eastbound:** Retain existing permitted-only operation.
   - **Westbound:** Retain existing permitted-only operation.
49. Eliminate access to the gas station in the northeast corner, which is pointed toward the westbound receiving lanes of 50th Avenue (Regis Boulevard).
50. Upgrade quick-build curb extensions to permanent construction. Improve intersection geometry to reduce unused space and realign skewed crosswalks.
51. Consider bicycle infrastructure improvements to provide additional connectivity across Federal Boulevard at this intersection.
Figure 37. Federal Boulevard & 50th Avenue Recommendation Map
Figure 38. Federal Boulevard & 50th Avenue Concepts
VII. Federal Boulevard & 51st Avenue

Background Information

The Federal Boulevard & 51st Avenue intersection is unsignalized. Stop signs control eastbound and westbound movements from 51st Avenue (Figure 39). Federal Boulevard consists of two through lanes in each direction, plus dedicated left turn lanes. Northbound and southbound right turns must be made from the shared through lane. Eastbound and westbound approaches of 51st Avenue are not striped. The west leg of 51st Avenue serves as a full-movement access to a shopping center and Regis University.

Federal Boulevard has a posted speed limit of 35 MPH. 51st Avenue west of the intersection is a residential street with a speed limit of 25 MPH.

Figure 39. Federal Boulevard & 51st Avenue

Crash Review

Between March 2017 and March 2020, there were a total of 9 crashes at the Federal Boulevard & 51st Avenue intersection. Table 8 displays a summary of crash history for the intersection.

- 8 Broadside crashes constitute 89 percent of crashes.
- No KSI crashes occurred during the study period.
- 56 percent of crashes involved left turning motorists.
- Most Broadside crashes resulted from motorists failing to yield right-of-way.
Table 8. Federal Boulevard & 51st Avenue Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
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<th>NB</th>
<th>SB</th>
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<tr>
<td>Total Crashes</td>
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<td>0</td>
<td>0%</td>
<td>44%</td>
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<td>Most Harmful Event</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside</td>
<td>89%</td>
<td>50%</td>
<td>13%</td>
<td>38%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>67%</td>
<td>67%</td>
<td>17%</td>
<td>17%</td>
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<td></td>
<td></td>
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<tr>
<td>Movement</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Making left-turn</td>
<td>56%</td>
<td></td>
<td></td>
<td>40%</td>
<td>20%</td>
<td>40%</td>
<td></td>
</tr>
</tbody>
</table>

Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- Redevelopment is planned for several commercial parcels by Regis University on the west side of Federal Boulevard approximately between 50th Avenue and 52nd Avenue. The master plan process was completed several years ago, but development review is ongoing.
- Planned redevelopment would formalize the west leg of the 51st Avenue intersection as a public street with direct access into the Regis University campus.

Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- Southbound queues from 50th Avenue backed up beyond 51st Avenue during the AM peak period.

Figure 40. Southbound Queue at 51st Avenue
Recommendations

The following improvements are recommended for the intersection. See Figure 41 for a map of general improvements.

52. Restripe northbound/southbound left turns to achieve positive offset.

53. Consider access restriction and/or signalization in conjunction with Regis University and 51st Avenue redevelopment.

Figure 41. Federal Boulevard & 51st Avenue Recommendation Map
VIII. 5100 Block of Federal Boulevard

Background Information

The 5100 Block of Federal Boulevard is a four-lane arterial (Figure 42). The southern portion of Federal Boulevard closer to 51st Avenue includes a painted median, whereas a raised median is provided in the northern portion closer to 52nd Avenue. Several driveway accesses are present on both sides of Federal Boulevard in this segment. Northbound Federal Boulevard has a posted speed limit of 35 MPH. Southbound Federal Boulevard has a posted speed limit of 45 MPH near 52nd Avenue, which quickly transitions to 35 MPH.
Crash Review

Between March 2017 and March 2020, there were a total of 8 crashes along the 5100 Block of Federal Boulevard. Table 9 displays a summary of crash history for this block of Federal Boulevard.

- 3 Broadside/Head On crashes constitute 38 percent of crashes.
- 2 fatal crashes in this segment involved pedestrians crossing midblock who were struck by southbound motorists.
- 1 other KSI crash involved a northbound motorist asleep at the wheel who drifted into the southbound travel lanes, causing a Head On crash.

Table 9. 5100 Block of Federal Boulevard Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
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<th>WB</th>
<th>NB</th>
<th>SB</th>
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</thead>
<tbody>
<tr>
<td><strong>Total Crashes</strong></td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>0%</td>
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<td>63%</td>
<td>13%</td>
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<td><strong>Most Harmful Event</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside/head on</td>
<td>38%</td>
<td>33%</td>
<td></td>
<td>0%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td>25%</td>
<td>67%</td>
<td>100%</td>
<td>0</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Driver Action</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lane violation</td>
<td>13%</td>
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<td>100%</td>
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<td></td>
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<tr>
<td>Failed to yield right-of-way</td>
<td>13%</td>
<td>100%</td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Movement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>13%</td>
<td>100%</td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting

- Redevelopment is planned for several commercial parcels by Regis University on the west side of Federal Boulevard approximately between 50th Avenue and 52nd Avenue. The master plan process was completed several years ago, but development review is ongoing.
- Midblock crossings are very common between 50th Avenue and 52nd Avenue due to proximity to the Regis University campus. Redevelopment plans from the campus will change the nature of activity on the west side of Federal. The University plans to have less impactful development in terms of vehicular activity/access.
- Fatal pedestrian crashes have occurred after raised medians were constructed along Federal Boulevard. The new medians do not provide ADA-compliant pedestrian refuges like some medians on the south end of the corridor.

Observations

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- The southbound speed limit transitions from 45 MPH to 40 MPH to 35 MPH in a short span (approximately 150 feet).
- Federal Boulevard is much wider in this segment compared to other portions of the study corridor. This increases exposure for pedestrians crossing at midblock locations.
- RTD bus stops are located midblock within this segment.
Figure 43. Southbound Speed Limit Transition within 5100 Block
Recommendations

The following improvements are recommended for this area. See Figure 44 for a map of general improvements.

54. Remove/consolidate 45-40-35 MPH speed limit signs on southbound Federal Boulevard.
55. Install consistent edge lines and right turn lane lines.
56. Relocate RTD bus stops closer to crosswalks.
57. Consider driveway access consolidation in conjunction with Regis University redevelopment.

Figure 44. 5100 Block Federal Boulevard Recommendation Map
IX. Federal Boulevard & 52nd Avenue

Background Information

The Federal Boulevard & 52nd Avenue intersection is signalized and represents the northern boundary of the project study area (Figure 45). Federal Boulevard consists of two through lanes in each direction, plus dedicated left turn lanes. Northbound and southbound right turns must be made from the shared through lane. The west leg of 52nd Avenue serves as a driveway access for local businesses. The east leg of 52nd Avenue is striped for only one approach lane and one receiving lane, but sufficient space exists for a second westbound approach lane. Southbound left turns operate with protected/permitted phasing; all other left turn movements operate with permitted-only phasing.

Northbound Federal Boulevard has a posted speed limit of 35 MPH approaching the intersection, whereas southbound Federal Boulevard has a posted speed limit of 45 MPH. 52nd Avenue has a posted speed limit of 30 MPH.

Crash Review

Between March 2017 and March 2020, there were a total of 11 crashes at the Federal Boulevard & 52nd Avenue intersection. Table 10 displays a summary of crash history for the intersection.

- 5 Broadside/Head On crashes constitute 45 percent of crashes.
- 5 Rear End crashes constitute 45 percent of crashes.
- No KSI crashes occurred during the study period.
- 45 percent of crashes involved left turning motorists.
- Crashes were most common in the northbound (45 percent) and southbound (36 percent) directions.
### Table 10. Federal Boulevard & 52nd Avenue Crash Summary

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>KSI</th>
<th>Fatal</th>
<th>EB</th>
<th>WB</th>
<th>NB</th>
<th>SB</th>
</tr>
</thead>
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<td>0%</td>
<td>18%</td>
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<td>36%</td>
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<td><strong>Most Harmful Event</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadside/head on</td>
<td>45%</td>
<td></td>
<td></td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td>45%</td>
<td></td>
<td></td>
<td>60%</td>
<td>40%</td>
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<td></td>
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<tr>
<td><strong>Driver Action</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failed to yield right-of-way</td>
<td>36%</td>
<td></td>
<td></td>
<td>50%</td>
<td>25%</td>
<td>25%</td>
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<td></td>
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<tr>
<td>Making left turn</td>
<td>45%</td>
<td></td>
<td></td>
<td>40%</td>
<td>20%</td>
<td>40%</td>
<td></td>
</tr>
</tbody>
</table>

**Comments Provided by City Staff and RSA Stakeholders during Pre-Audit Meeting**

The following comments were received from Council Member Sandoval:

- The Council office has received fewer calls/comments since sidewalk improvements were installed as part of the recent Starbucks construction (northeast corner of intersection). Current comments often relate to signal timing parameters for pedestrian crossings being too short.

**Observations**

The RSA team made the following observations during the morning, afternoon, and evening field reviews:

- LPIs are provided for east-west crossings of the north leg of the intersection.
- The northeast pedestrian pushbutton to Federal Boulevard faces the wrong direction.
- The driveway on the west leg of the intersection is offset.
- Boulders and curbs opposite of westbound movements are difficult to see at night.
- Crosswalk markings on the southern leg of the intersection are missing/faded. No pedestrian signal heads or curb ramps are provided.
- Pedestrian signal heads were missing from the west intersection leg (driveway). Conflicts between pedestrians and eastbound motorists were observed.
- Despite lack of striping, motorists use the wide westbound approach to form two queues of traffic (dedicated left turns and right turns).
- RTD bus stops are located far away from the intersection. Midblock crossings south of 52nd Avenue were observed.
Figure 46. Missing Pedestrian Signals at 52nd Avenue West Crosswalk

Figure 47. Wide Westbound 52nd Avenue Approach
Recommendations

The following improvements are recommended for the intersection. See Figure 48 for a map of general improvements.

58. Fix northeast pedestrian pushbutton to face correct direction.
59. Install object markers on the west side of the intersection to clarify offset.
60. Install striping, lane assignment signs for two lanes on westbound 52nd Avenue.
61. Relocate RTD bus stops closer to crosswalks.
62. Install pedestrian signals and crosswalk on west leg (May be dependent on redevelopment characteristics of Regis University).

63. Adjust left turn operations.
   - **Northbound:** Convert from permitted-only to protected/permitted.
   - **Southbound:** Retain existing protected/permitted operation.
   - **Eastbound:** Retain existing permitted-only operation.
   - **Westbound:** Retain existing permitted-only operation.

64. Further evaluate possible changes to east-west operations.
   - Add missing crosswalk on south leg.
   - Operate using split phases.
   - Provide additional lane control signs and pavement legends.
   - Consider alignment of west leg during redevelopment.

Figure 48. Federal Boulevard & 52nd Avenue Recommendation Map
### Appendix A. RSA Recommendations Table

<table>
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<tr>
<th>Recommendation</th>
<th>Description</th>
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<td>Improve lighting</td>
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<tr>
<td>2</td>
<td>Install speed humps</td>
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<td>3</td>
<td>Increase pedestrian crossing visibility</td>
</tr>
<tr>
<td>4</td>
<td>Implement traffic calming measures</td>
</tr>
<tr>
<td>5</td>
<td>Enhance signage</td>
</tr>
<tr>
<td>6</td>
<td>Increase pedestrian safety island placement</td>
</tr>
<tr>
<td>7</td>
<td>Improve traffic signal timing</td>
</tr>
</tbody>
</table>

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The above table outlines several recommendations for improving road safety along Federal Boulevard from 46th Avenue to 52nd Avenue.
Appendix B. RSA Pre-Audit Meeting Presentation
Appendix C. RSA Intent Memorandum
Appendix D. Preliminary Findings Presentation