The Colorado Department of Transportation (CDOT **Region 4**

BICYCLE & PEDESTRIAN SAFETY STUDY

Final Report

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The goal of this study is to improve the safety of the bicycle and pedestrian network on CDOT roads within Region 4 (Boulder, Broomfield, Cheyenne, Elbert, Kit Carson, Larimer, Lincoln, Logan, Morgan, Phillips, Sedgewick, Washington, Weld and Yuma Counties). A Project Management Team (PMT) consisting of up to two staff from each of the Cities and Counties within Region 4, plus Colorado Department of Transportation (CDOT), Federal Highway Administration (FHWA) and Denver Regional Council of Governments (DRCOG) staff guided the inputs and assumptions during the study, while local agencies and the public provided feedback on areas of concern and ideas for improvement through a robust online survey called MetroQuest.

HOW TO USE THIS DOCUMENT

This document is intended to serve as a tool to help municipal staff, elected officials, and community stakeholders improve bicycle and pedestrian safety on CDOT roads throughout Region 4. This study evaluated all CDOT roads within Region 4 and identified a set of 10 priority locations for which safety countermeasures and conceptual designs were developed. While many locations within the region were identified as having an elevated level of risk or high demand for bicycle and pedestrian improvements, the scope of this project was limited to 10 top locations. Despite the limited number of top locations selected, there are several elements of this study that cities, counties, and stakeholders can use in pursuing transportation safety grants and prioritizing and budgeting for safety improvements on state and local roadways within the region.

Corridor Risk

The process for identifying top locations included two steps: 1) crash identification, and 2) systemic evaluation. Figure 5 within this report shows the crash scores for every ½ mile segment of state roads within the region. The segments with the highest scores are those with the largest number and/or severity of crashes, representing an elevated level of risk and likely a greater need for the introduction of safety countermeasures.

The second piece of the study included a systemic evaluation which looked at the roadways where crashes occurred and identified specific features (i.e. speed, volume, number of lanes, shoulder width, etc.) that correlated to an increased level of risk. These risk factors were scored and the combined score by ½ mile segment of road is shown in Figure 38 of this report. The roads with the highest scores are associated with the highest level of systemic risk. When preparing safety grant applications, this report can be referenced to show the level of risk (crash and/or systemic) a specific corridor was shown to exhibit.

Bicycle/Pedestrian Demand & Areas of Concern

During this study, an online survey tool was used to gather feedback from local agency staff, advocacy groups, and the general public. Over 1,000 people responded to the survey, providing over 2,400 data points on the mapping portion of the survey. The full dataset of responses was provided to the PMT members during this project and can be used to identify areas of concern, interest, or demand for bicycle and pedestrian improvements. Once this project is complete, CDOT can be contacted directly for the dataset, which includes a map showing where comments were located and the comments themselves.

Safety Countermeasures

Reviewers can consider and apply the countermeasures identified in this report to improve bicycle and pedestrian safety at intersections or along roadway segments. While CDOT roadways were the focus of this project, countermeasures may be considered for both state and local facilities.

As previously indicated, the project team identified 10 specific locations throughout the region. For each location, a set of countermeasures was identified to address specific crash patterns, risk factors, or field observations. Users of this report should review the 10 locations and their identified crash patterns and field observations to determine if they are dealing with comparable facilities or intersections. Figures 43 through 53 provide detail on the crash data, field observations and potential countermeasures for each of the top locations. As users of this report identify comparable facilities, the countermeasures, concept designs and cost estimates on Figures 54 through 66 may prove valuable for future planning / design work and budgeting purposes.

As requested by the PMT, the final section of the report "Additional Countermeasures" provides a sample of acceptable countermeasures, resources where additional measures can be found, and links to sites containing design guidance, cost estimates, research, and case studies

NETWORK SCREENING

The primary analysis for this study was a network screening comprised of two components, 1) bicycle and pedestrian crash analysis and 2) systemic safety analysis was conducted to identify roadways with a history of severe bicycle and pedestrian crashes, high crash density, or potential for a higher risk of crashes.

The crash analysis included the latest five (5) years of available bicycle and pedestrian crash data (January 2015 to December 2019). Only bicycle and pedestrian crashes on CDOT roads within Region 4 were evaluated due to the size of the region and CDOT's ability to program state funds and maintenance. A total of 836 bicycle and pedestrian crashes were identified.

As shown on Figures ES1 and ES2, pedestrian crashes accounted for approximately 40 percent of the 836 crashes, but 74 percent of the fatalities, indicating that pedestrians are at higher risk for fatalities. Figures ES3 and ES4 show the regional distribution of bicycle and pedestrian crashes. Pedestrian crashes were more distributed across the region than bicycle crashes. No bicycle crashes occurred south of the eastern portions of US 36 and the majority occurred west of US 85.

Figure ES 1: Bicycle & Pedestrian Crashes

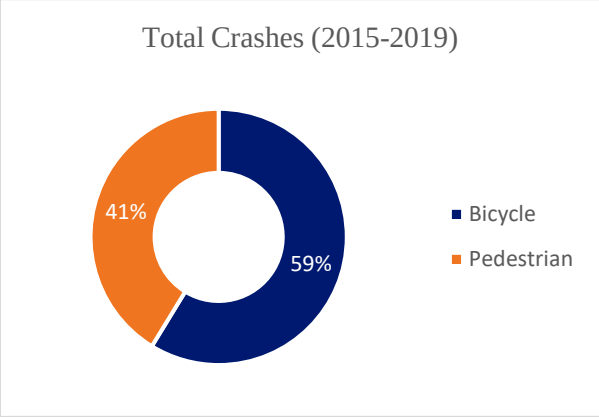


Figure ES 2: Bicycle & Pedestrian Fatalities

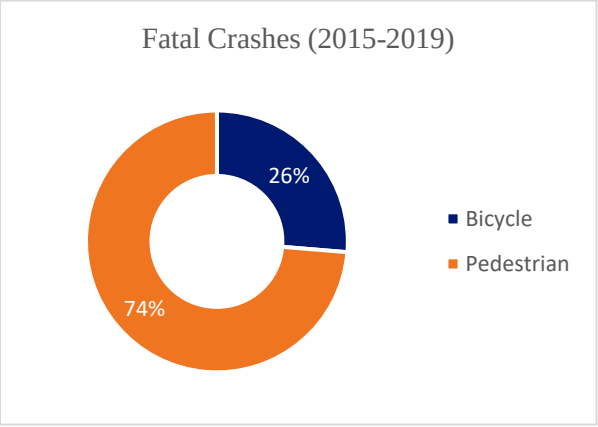


Figure ES 3: Bicycle Crash Locations (2015-2019)

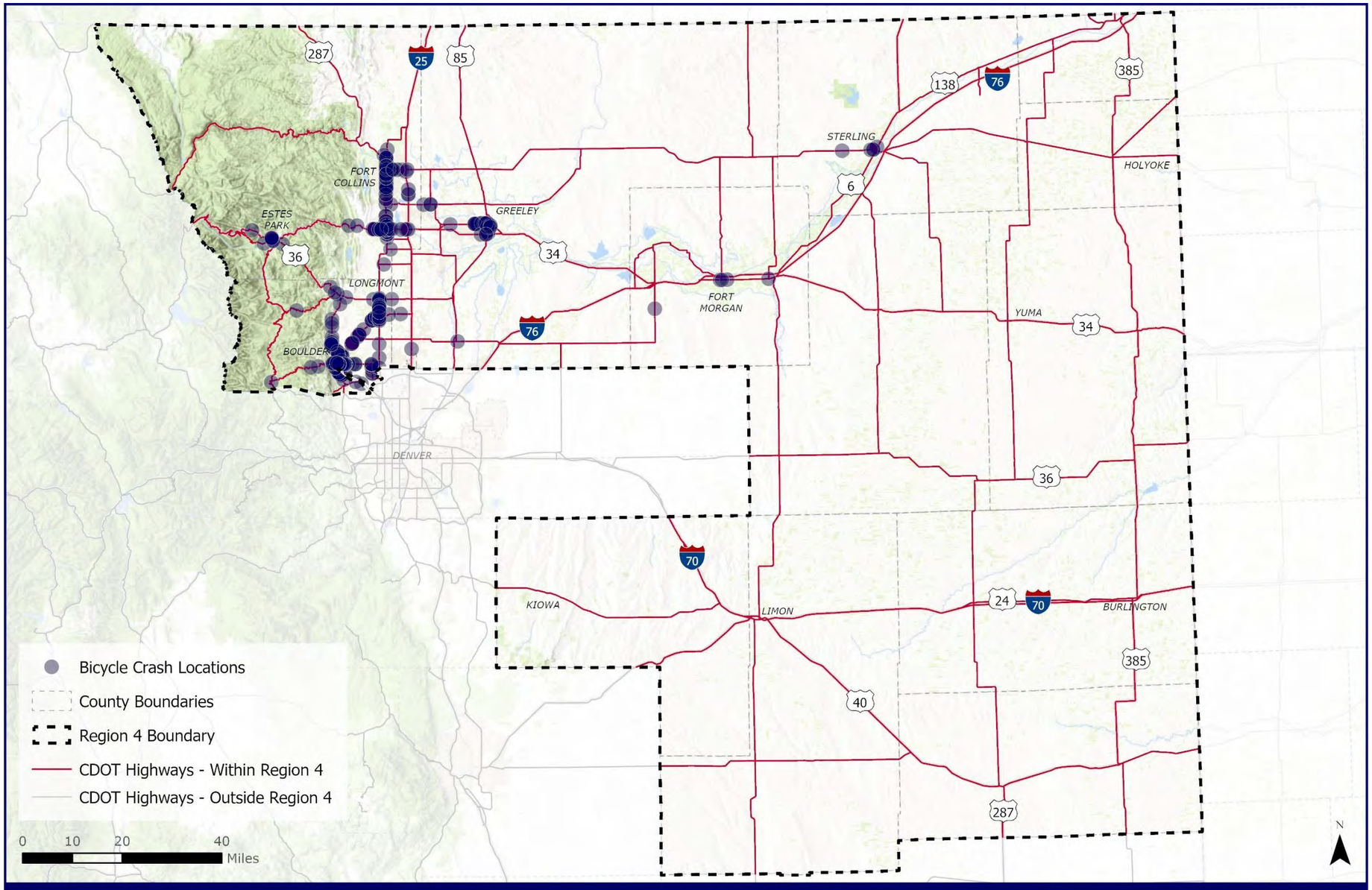
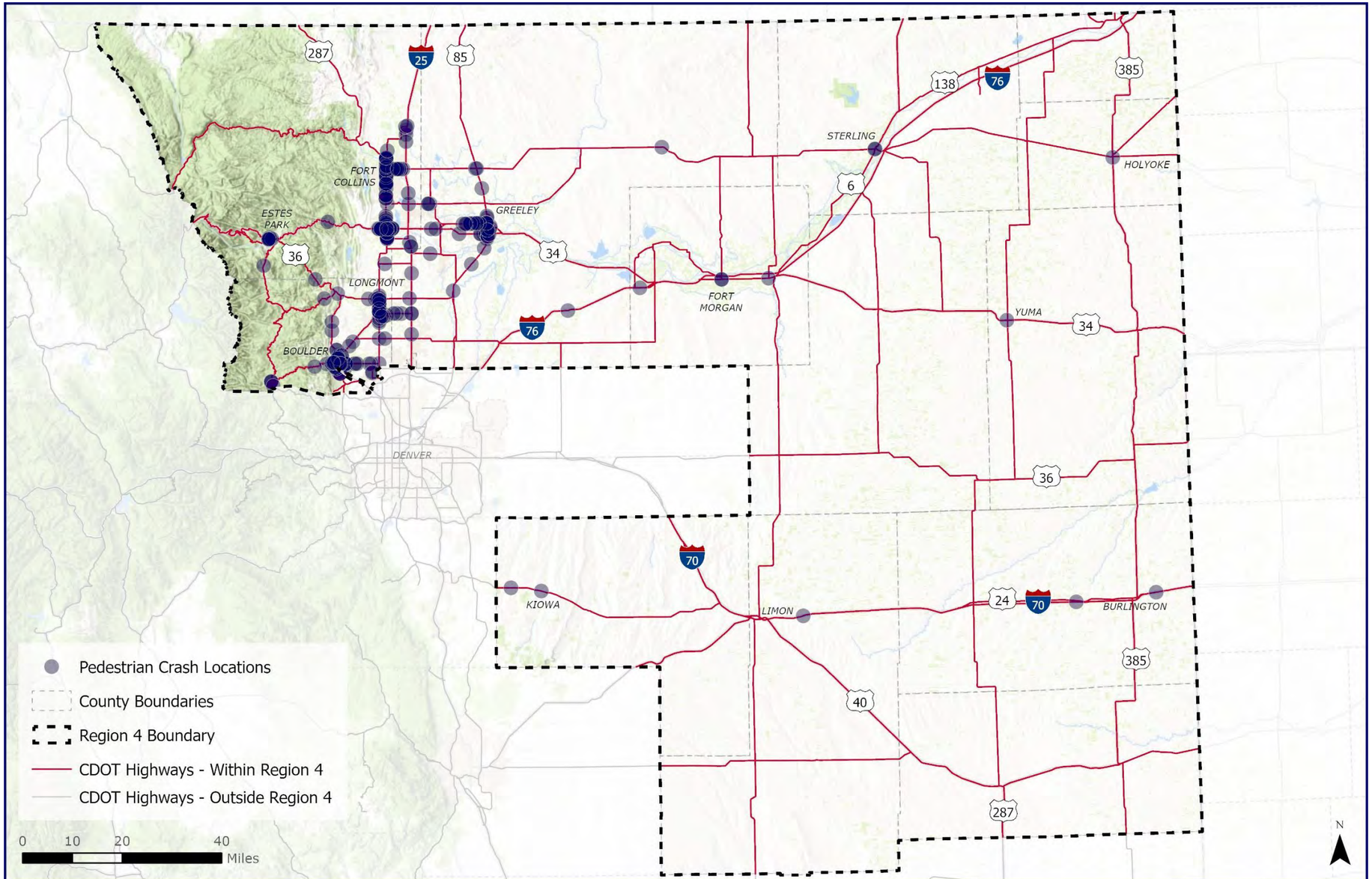


Figure ES 4: Pedestrian Crash Locations (2015-2019)



For the network screening, the roadway network was divided into ½ mile segments. Each segment was assigned a crash score based on the presence and severity of bicycle and pedestrian crashes. Segments and intersections with high crash scores were evaluated and a list of top crash locations identified. Systemic risk features were developed based on the roadway characteristics of the high scoring crash segments and each ½ mile segment of the network was scored for risk. Figure ES 5 illustrates the resulting systemic risk score per segment for the region.

Concurrent with the network screening and risk analysis, a MetroQuest interactive online survey was conducted. The survey resulted in over 1,000 people identifying over 2,400 points of concern associated with pedestrian and bicycle travel in Region 4. Concentrations of comments within MetroQuest were evaluated and added to a list of MetroQuest hot spot locations that were cross referenced with the systemic risk scores and placed in order of highest to lowest systemic risk score.

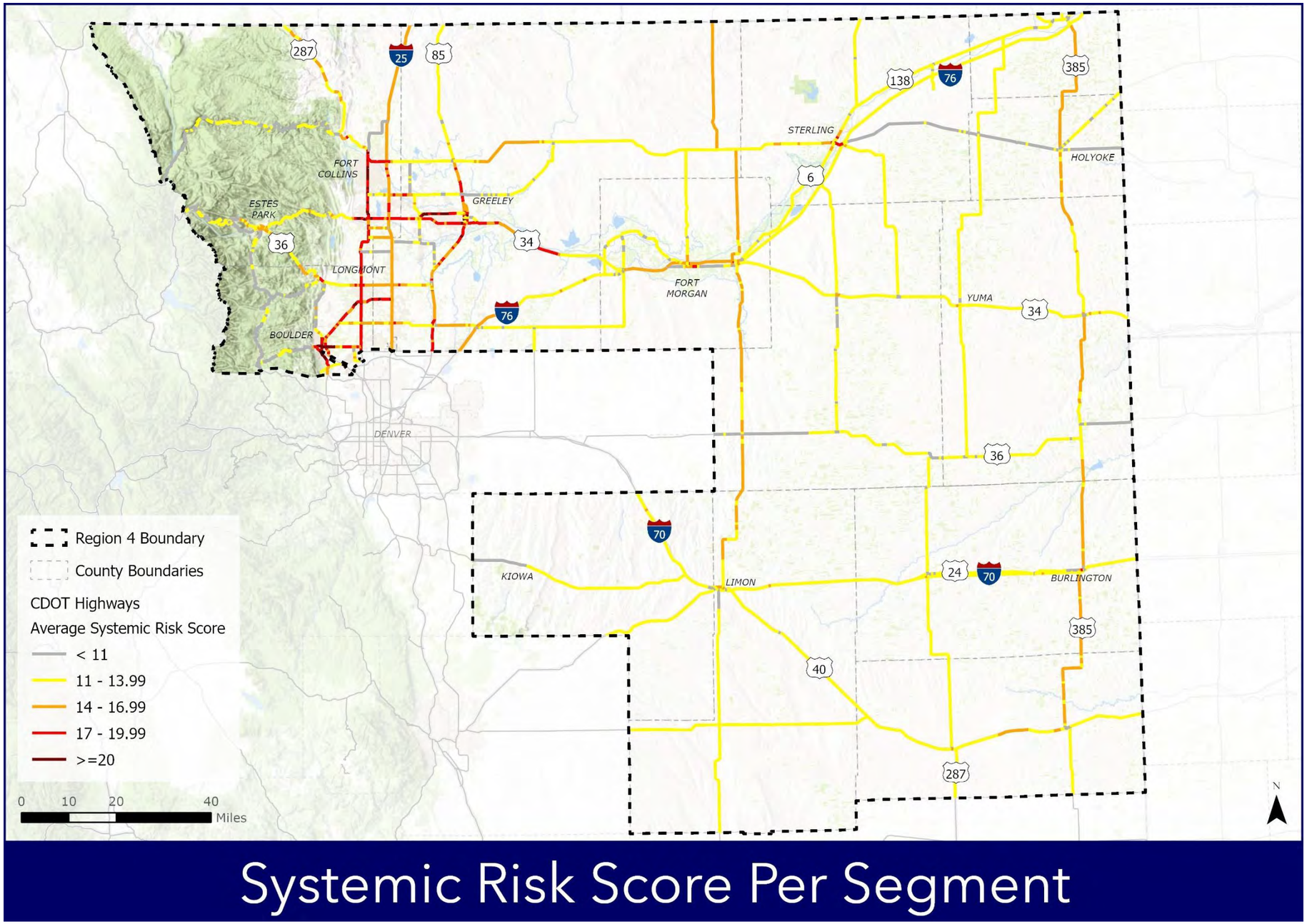
TOP LOCATIONS

CDOT's goal for this study was to identify top locations both from the crash analysis, and the more proactive approach to safety, the systemic analysis. Seven of the top locations came from the list of bicycle and pedestrian crash hot spots, and the remaining three locations were selected from the list of MetroQuest hot spots. The list of top locations is shown in Table ES1, below.

Table ES 1: Top Locations

Local Agency	***Top Locations***	***Type***
Longmont	Intersection of US 287/23rd Ave Top Countermeasure	Crash
Longmont	Intersection of US 287/17th Ave	Crash
Longmont	Intersection of US 287/Mountain View Ave	Crash
Longmont	Intersection of US 287/9th Ave	Crash
Longmont	Segment of US 287 from Mountain View Ave to 9th Ave	Crash
Fort Collins	Segment of US 287 from Laurel Street to Laporte Ave	Crash
Greeley	Intersection of US 34/11th Ave	Crash
Estes Park	US 34 from Riverside Dr to St Vrain Ave	Systemic
Estes Park	CO 7 from US 36 to Peak View Drive	Systemic
Estes Park	US 36 from Crags Drive to Rocky Mountain National Park (RMNP) Entrance	Systemic

Figure ES 5: Systemic Risk Score Per Segment



Systemic Risk Score Per Segment

SAFETY COUNTERMEASURES

An evaluation of the top locations was completed. Available bicycle and pedestrian crash data were reviewed to identify any patterns in the data or unique characteristics related to each location, and MetroQuest comments were reviewed to better understand existing concerns. Traffic counts were collected and reviewed, and field evaluations were conducted to gather a better understanding of the specific conditions of each site. Traffic patterns were observed, site specific challenges noted, and various safety countermeasures were considered. For each of the top locations, a detailed summary of the bicycle and pedestrian crash results, field observations, and safety countermeasures are provided in Figures 43 thru 53 of the final report. Concept designs, crash modification factors, cost estimates, and benefit to cost ratios for each of the top locations are included in Figures 54 through 66 of the report. A summary of the top countermeasures for each location is included in Table ES2 below.

Table ES 2: Top Countermeasures by Location

Local Agency	***Top Locations***	***Top Countermeasure***
Longmont	Intersection of US 287/23rd Ave	• Protected or Protective-permissive left turn signal when warranted • On street bicycle lane improvements at the intersection (systemic improvement)
Longmont	Intersection of US 287/17th Ave	• Leading Pedestrian Interval and No Right Turn on Red • On street bicycle lane improvements at the intersection (systemic Improvement)
Longmont	Intersection of US 287/Mountain View Ave	• LED illuminated border bicycle/pedestrian warning signage (W11-15) with passive pedestrian detection
Longmont	Intersection of US 287/9th Ave	• Reduce turning radii (northeast corner) and narrow northbound outside through lane • Bulb-outs (southwest and southeast corners)
Longmont	Segment of US 287 from Mountain View Ave to 9th Ave	• Access control on the east side of US 287 between Mountain View Avenue and 11th Avenue
Fort Collins	Segment of US 287 from Laurel Street to Laporte Ave	• Reconfigure parking along the corridor o Provide back in angle parking with instructional signage o Stripe buffers between the median parking and through lanes and add a treatment to create separation between moving motor vehicles and the buffer zone (Specific treatment has not been identified yet) o Add mid-block crossings with raised bulb-out medians and Rectangular Rapid Flashing Beacon warning system o Add parking blocks in all parking spaces to prevent motor vehicles from encroaching on the sidewalks and buffer zone, and prevent pulling through the space
Greeley	Intersection of US 34/11th Ave	• LED illuminated border bicycle/pedestrian warning signage (W11-15) with passive pedestrian detection

		• Increased intersection illuminance (all corners) • Raised crosswalk (northeast corner)
Estes Park	US 34 from Riverside Dr to St Vrain Ave	• Raised median from Riverside Drive to St Vrain Avenue, or • Median refuge at the pedestrian signal, and • Pedestrian Access Route (PAR) functional space improvements
Estes Park	CO 7 from US 36 to Peak View Drive	• Continuous Pedestrian Access Route (PAR) and marked crosswalk review • Road diet from US 36 to Graves Avenue
Estes Park	US 36 from Crags Drive to RMNP Entrance	• Continuous pedestrian / bicycle pathway (variations on / off street) • All alternatives anticipate a connection to the proposed loop road sidewalk on the north side of US 36

ACCEPTABLE COUNTERMEASURES

PMT members indicated that identification of acceptable countermeasures was something they hoped would come out of this study. As a result, Tables 20 and 21, within this report provide a list of resources for identifying acceptable countermeasures, design guidance, best practices, research, and case studies. Many of the countermeasures provided are also great candidates for safety grant funding.

IMPROVING THE PLAN

The final section of the report outlines ways that this plan could be improved in the future. Suggestions include enhancing the crash data set by following the Model Minimum Uniform Crash Criteria Guideline (MMUCC)[1]. MMUCC identifies a minimum set of motor vehicle crash data elements and their attributes that States should consider collecting and including in their state crash data system. Additionally, it is suggested that for future studies, datasets such as intersection locations, intersection control (signal versus stop control or roundabout), intersection geometry, on-street parking, access spacing, location of sidewalks to the vehicle travel lane (separated versus adjacent) would be helpful in identifying additional risk factors.

[1] MMUCC | NHTSA

FINAL REPORT

INTRODUCTION

CDOT has historically focused on safety and mobility of motor vehicles on CDOT roadways. More recently CDOT has shifted to a policy of improved safety and mobility for all users. Policy Directive 1602.0 and Procedural Directive 1602.1 state that CDOT will promote transportation mode choice by enhancing safety and mobility for bicyclists on or along the state highway system. Additionally, in 2015, CDOT launched Moving Colorado Towards Zero Deaths, which sets a goal of zero deaths for every individual, family or community using Colorado's transportation network.

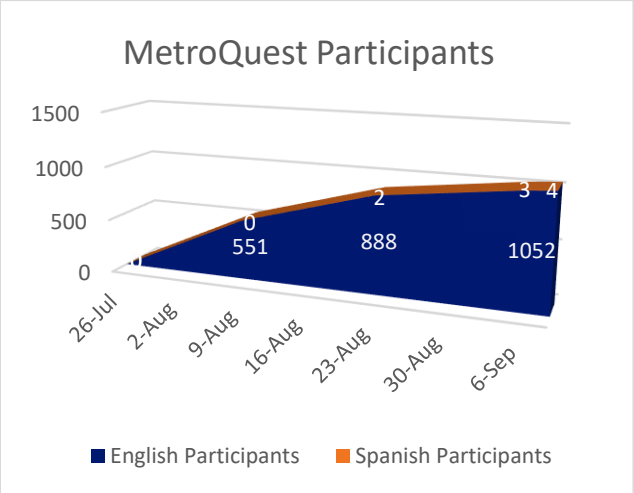
The goal of this study is to improve the safety of the bicycle and pedestrian networks on all CDOT roads within Region 4 through the identification of a program of projects and working collaboratively with local agencies on funding opportunities. This study started with a network screening which is an evaluation of crash history and available roadway data to identify roadways with the potential for higher risk. From the network screening and public engagement results, ten initial locations were identified for development of safety countermeasures. The top countermeasures were advanced into conceptual designs with estimates of cost.

ENGAGEMENT

Overview

Engagement for this project included a robust online MetroQuest survey and regular meetings with the Project Management Team (PMT). The MetroQuest survey was made available to the public, in both English and Spanish, from July 26, 2021, through September 9, 2021, and received over 1,000 responses across the region (Figure 1). A summary of the MetroQuest results and discussion of how the results were incorporated into this study are discussed later in this report.

Figure 1: MetroQuest Participants Over Time



The purpose of the PMT was to discuss progress and assumptions, and garner support on various elements of the project. The PMT consisted of up to two staff from each of the Cities and Counties within Region 4, plus multiple staff from Colorado Department of Transportation (CDOT), Federal Highway Administration (FHWA) and Denver Regional Council of Governments (DRCOG). A summary of the first PMT meeting is provided below. Summaries of the remaining PMT meetings are provided in the relevant sections of the report.

PMT #1 – Project Overview

The first PMT meeting was held on May 20th, 2021 and included a discussion of PMT roles & responsibilities and the project study area, goals, overview, and schedule. During this meeting participants were polled

on their thoughts regarding what they hoped the project would achieve, their top two project selection priorities and how the project could benefit their municipality in the long term. The PMT's top two priorities for selecting projects were safety and network connectivity. Common responses for the goals of this project and how it could support the local agencies included:

- Develop strategies for project prioritization beyond crash history
- Reduce the "barrier" effect of CDOT highways
- Changing CDOT culture to focus more on bicycles and pedestrians
- To have friendlier Main Streets on CDOT roads
- To identify acceptable countermeasures
- To identify countermeasures that could apply on local roads
- Implementation of Vision Zero and safer designs
- To have the flexibility to implement new treatments

NETWORK SCREENING

Overview

A network screening is the process by which high-risk roadways or intersections are identified. The network screening was completed in two steps: 1) an analysis of bicycle and pedestrian crashes was completed to identify locations with a history of severe crashes, and/or high crash density (hot spots), and 2) a systemic safety analysis was conducted to identify roadways with higher risk for bicycle and pedestrian crashes based on the general roadway characteristics.

The goal for the network screening was to identify locations on the CDOT Region 4 roadway network where the implementation of safety countermeasures would result in a significant increase in safety for bicyclists and pedestrians. The results from the network screening were used to prioritize locations for further study.

Data Collection

Table 1: Datasets Used in the Analysis

Datasets Used in the Analysis
Bicycle and Pedestrian Crash Data (Jan 2015 – Dec 2019)
Jurisdictional Classification
Functional Classification
Lighting
Speed Limit
Number of Thru Lanes
AADT (2019)
Shoulder Width
Sidewalks
Bike Lanes
Medians

Before crash analysis or systemic safety analysis could be completed, available data was gathered and reviewed. Available data from the Colorado Department of Transportation's Online Transportation Information System (CDOT OTIS), the Denver Regional Council of Governments (DRCOG) and the North Front Range Metropolitan Planning Organization (NFRMPO) was reviewed to determine applicability and usability for this study. Applicable data was not available from the Upper Front Range or Eastern Transportation Planning Regions. Data sources that were associated with a CDOT route and milepost were generally applicable to this study. Route and milepost fields connected the data back to the CDOT highway network in a cohesive manner that enabled route event overlays (dynamic segmentation) to analyze multiple sets of attributes together. While there was sufficient data with a route and milepost for this study, some data sources did lack these fields and could not be incorporated into the study (i.e. bicycle facility inventory and transit stops).

Additionally, it should be noted that location (intersection versus non-intersection) and light condition (daylight versus dark) information reported in this study comes directly from the crash database. Location information is not associated with or derived from a CDOT intersection dataset, as CDOT does not currently have a comprehensive intersection dataset available. Many of the linear attributes (AADT, speed, thru lanes, etc.) were sourced directly from the CDOT Highway dataset. In addition, CDOT provided data from their Bicycle Level of Stress analysis, conducted in 2018, which allowed for the incorporation of bike lane and sidewalk data.

Crash Analysis

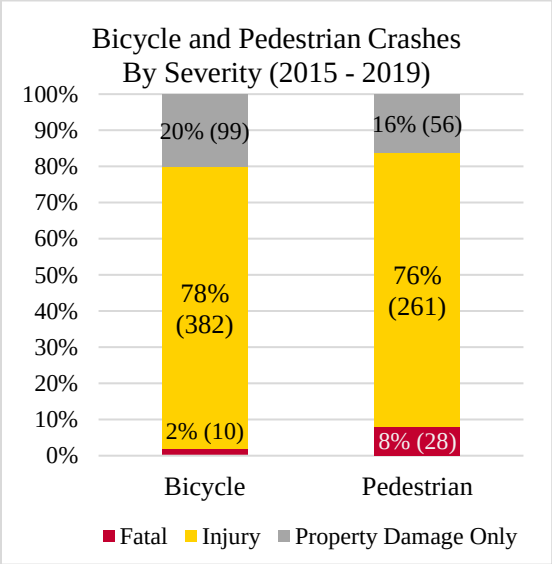
Overview

The bicycle and pedestrian crash data were evaluated to identify locations with a history of severe crashes and/or high crash density (hot spots). The crash analysis included the latest five (5) years of available bicycle and pedestrian crash data (January 2015 to December 2019). Only crashes on CDOT roads within Region 4 were evaluated due to the size of the region and the availability of crash data on local roads. It is important to note that the crash analysis only includes reported bicycle and pedestrian crashes. Some cities across the U.S. have compared crash reports with hospital discharge, noting that a large percentage (45%) of bicycle/pedestrian injuries resulting from a traffic crash had not been reported.

Crash Severity and Distribution

A total of 836 crashes (345 involving pedestrians and 491 involving bicycles) were identified. Crash severity was evaluated to identify the proportion of severe crashes (defined as fatal and injury) to property damage only crashes on the network. As shown in Figure 2, of the 836 bicycle and pedestrian crashes recorded along CDOT Region 4 highways, 38 were fatal, 643 resulted in injury, and 155 resulted in property damage only (PDO). The percent of crashes resulting in an injury were similar between bicycle and pedestrian crashes; however, the percent of crashes resulting in a fatality were higher for pedestrian crashes. There were 28 pedestrian crashes and 10 bicycle crashes resulting in fatalities, despite there being fewer pedestrian crashes overall.

Figure 2: Bicycle & Pedestrian Crashes by Severity



After summarizing the bicycle and pedestrian crash data for the region, bicycle and pedestrian crashes were mapped based on level of severity (fatal, injury and PDO). Although national safety approaches typically focus on severe crashes, CDOT has determined that bicyclists and pedestrians are vulnerable users and that there is a fine line between fatal, injury or property damage crashes for these types of users. As such, the presence of any bicycle or pedestrian crash indicates some level of risk and all levels of crash severity were included in the crash analysis.

Figures 3 and 4 below show the distribution of bicycle and pedestrian crashes across the region (darker dots represent a higher density of crashes). No bicycle crashes were identified south of the eastern portions of US 36 and the majority occurred west of US 85. Most pedestrian crashes also occurred west of US 85, but a portion of the crashes were distributed evenly across the eastern part of the region, primarily on rural roadways.

Figure 3: Bicycle Crash Locations (2015-2019)

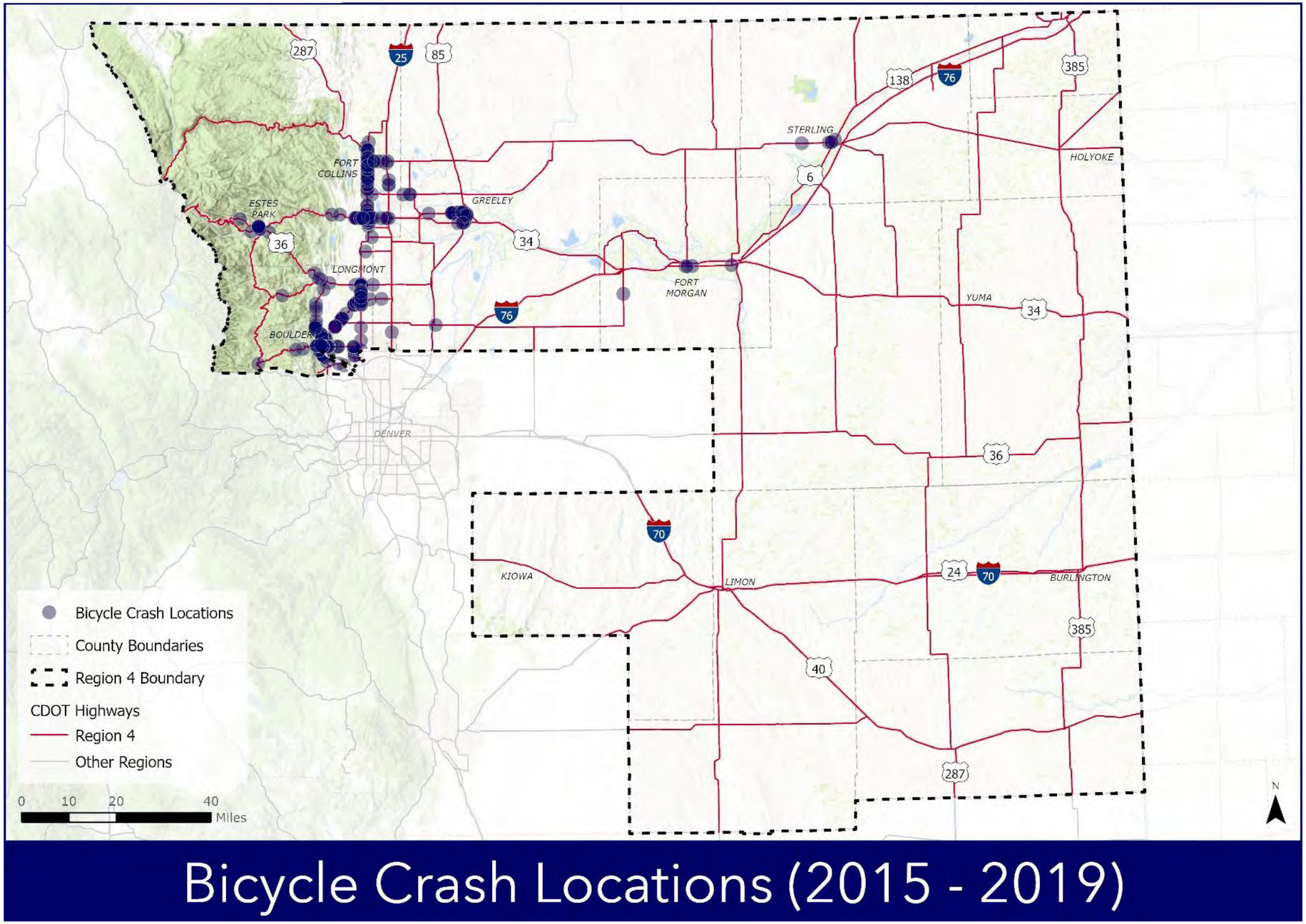
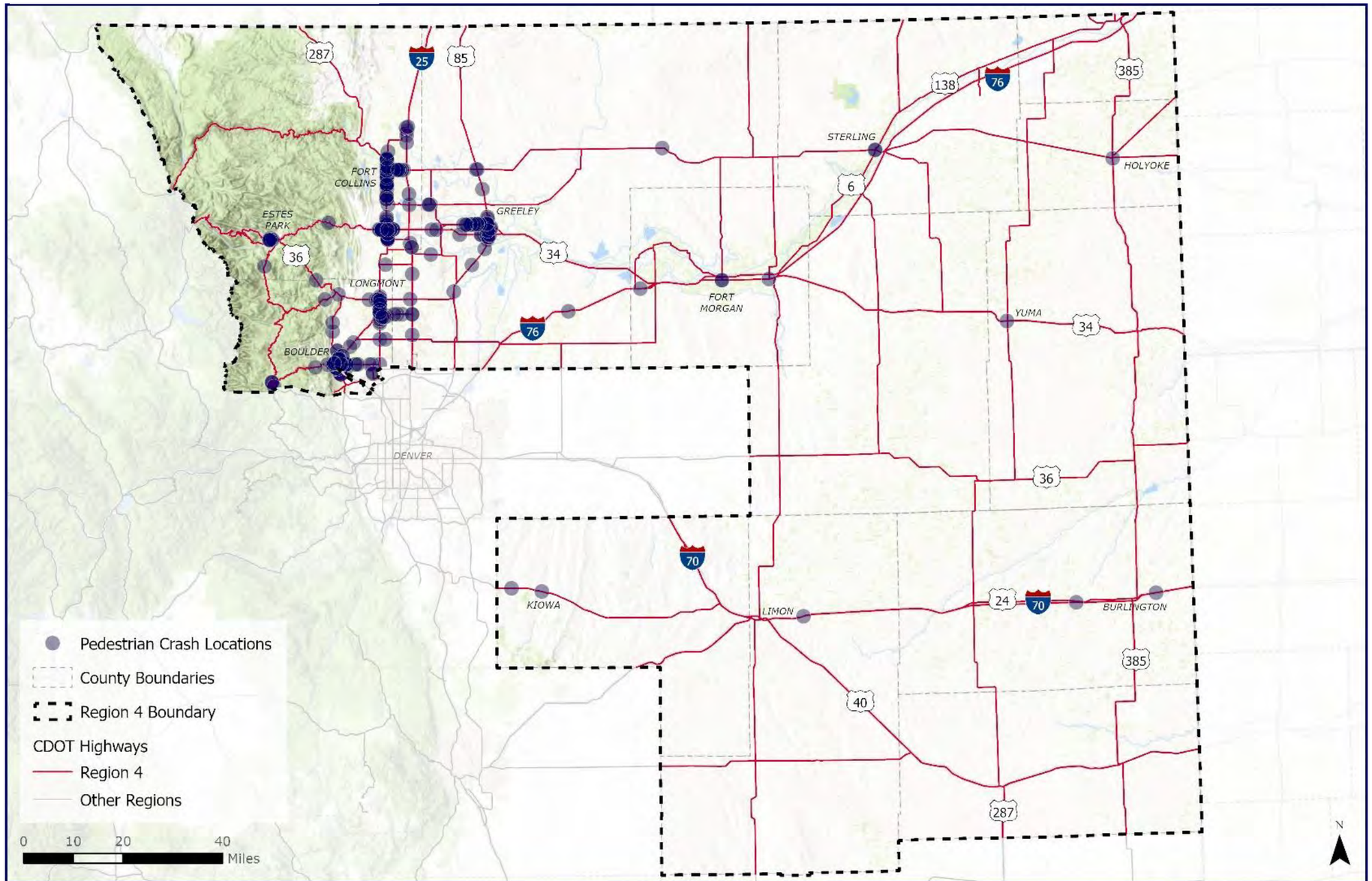


Figure 4: Pedestrian Crash Locations (2015-2019)



Crash Score

Identifying the location of crashes is helpful to understand geographically where crashes occur, but further evaluation was needed to identify the areas with the highest number of severe bicycle and pedestrian crashes and/or the highest density of bicycle and pedestrian crashes (hot spots). In order to identify these locations, crash scores were applied to the entire network through the following process.

The roadway network was broken into ½ mile segments based on milepost. Segmentation of the roadway allowed for consistency between segments to simplify scoring of the roadway network. On each ½ mile segment, the total number of fatal, injury and PDO bicycle and pedestrian crashes was identified. A score was assigned to each crash type. Fatal crash received 100 points, injury crashes received 50 points and PDO crashes received 25 points. The points for each segment were added and the segments with the highest scores were identified as the locations with inherently higher risk.

Figure 5 shows that the segments in Region 4 with the highest crash scores occurred in Boulder, Longmont, and Fort Collins. Loveland and Greeley show a concentration of crashes, but they are fewer or less severe, so the scores are not as high as Boulder, Longmont, or Fort Collins. Based on discussions with the City and County of Boulder, at the time of this study, they were working on a Vision Zero plan that addresses the high scoring locations. As a result, the crashes at the high crash locations within the City and County of Boulder were not evaluated further, and none of the roads within the City and County of Boulder were included in the top locations for identification of safety countermeasures, designs and cost estimates.

Crash Hot Spots

The next step in narrowing down bicycle and pedestrian hot spot locations within the region was to identify whether the segments identified in Figure 5 were risky because of the geometry of the segment, or because of an intersection along the segment. Since a comprehensive intersection dataset was not available, a detailed review of crash reports in the highest scoring crash segments within Longmont, Fort Collins, Loveland, and Greeley was conducted. Figures 6 through 9 provide more detail about the specific location and severity of crashes within the segments scoring over 400 points. Using the same scoring of 100 points for a fatal crash, 50 points for an injury, and 25 points for a PDO crash, intersections received a crash score based on the crashes that were reported as intersection related. The remaining crashes were reported as either non-intersection or driveway related. These crashes made up the new segment scores. Table 2 provides the final crash hot spots and their associated scores. It should be noted that although US 34/11th Avenue in Greeley did not fall within a segment scoring over 400 points, as shown on Figure 10, the total crashes identified at that intersection, including one fatal crash, resulted in a score that was consistent with other high scoring locations listed on Table 2, and therefore was added to the list of crash hot spots. As discussed later in this report, one of the higher scoring crash locations was already included in planned or existing projects that will address bicycle and pedestrian safety, so that location was also not evaluated further.

Figure 5: Crash Scores Per Segment

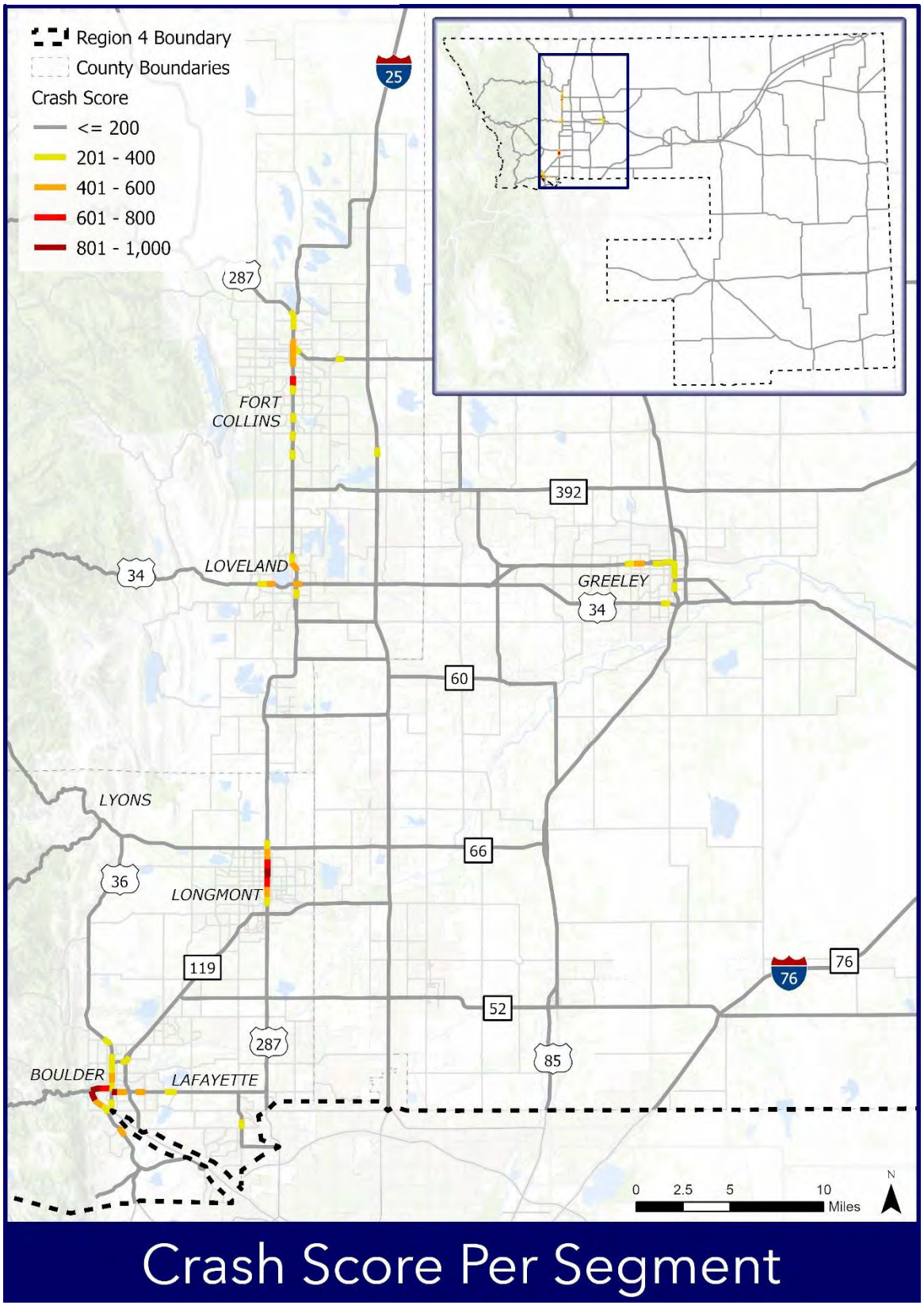


Figure 6: Longmont Crash Hot Spots

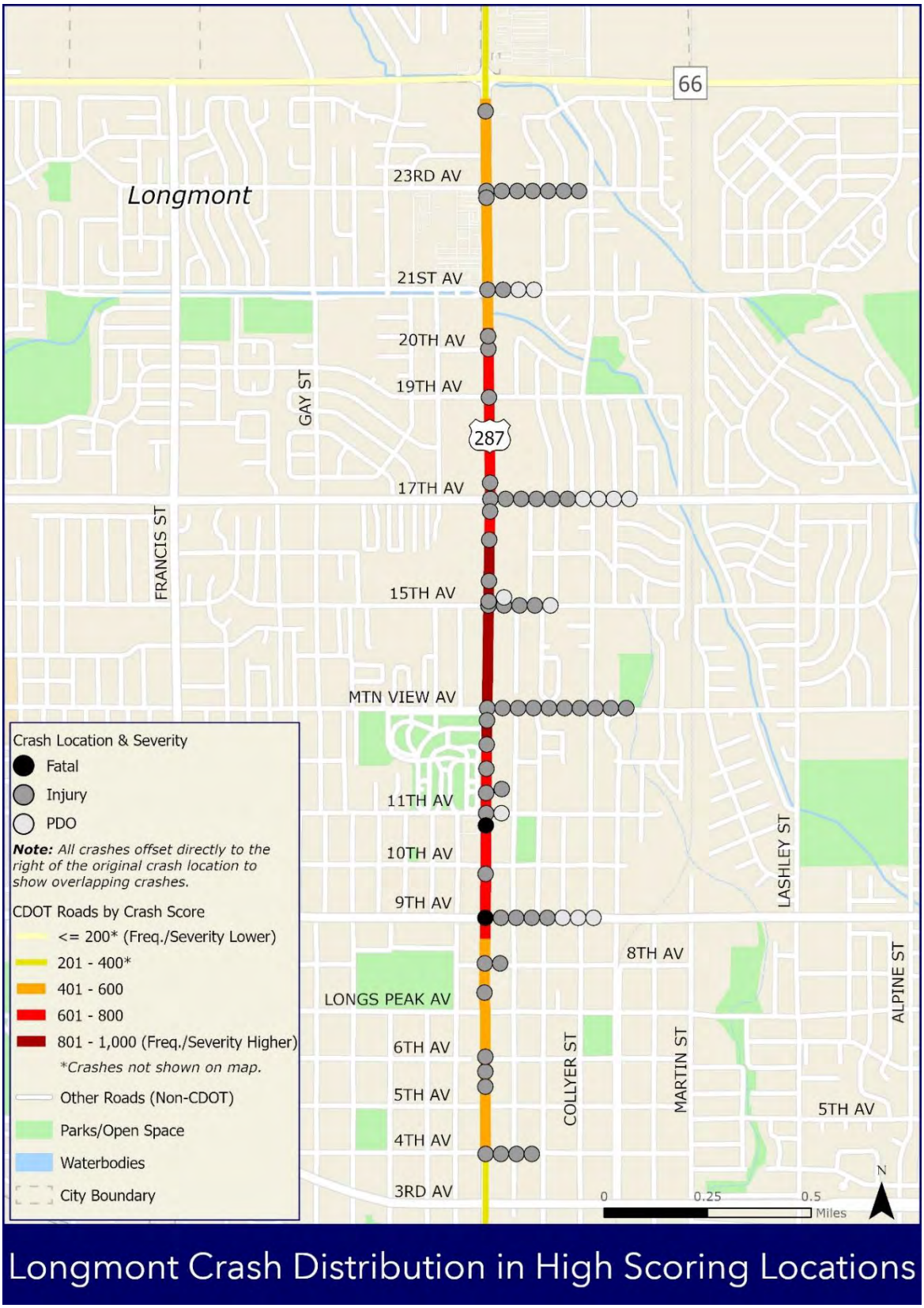
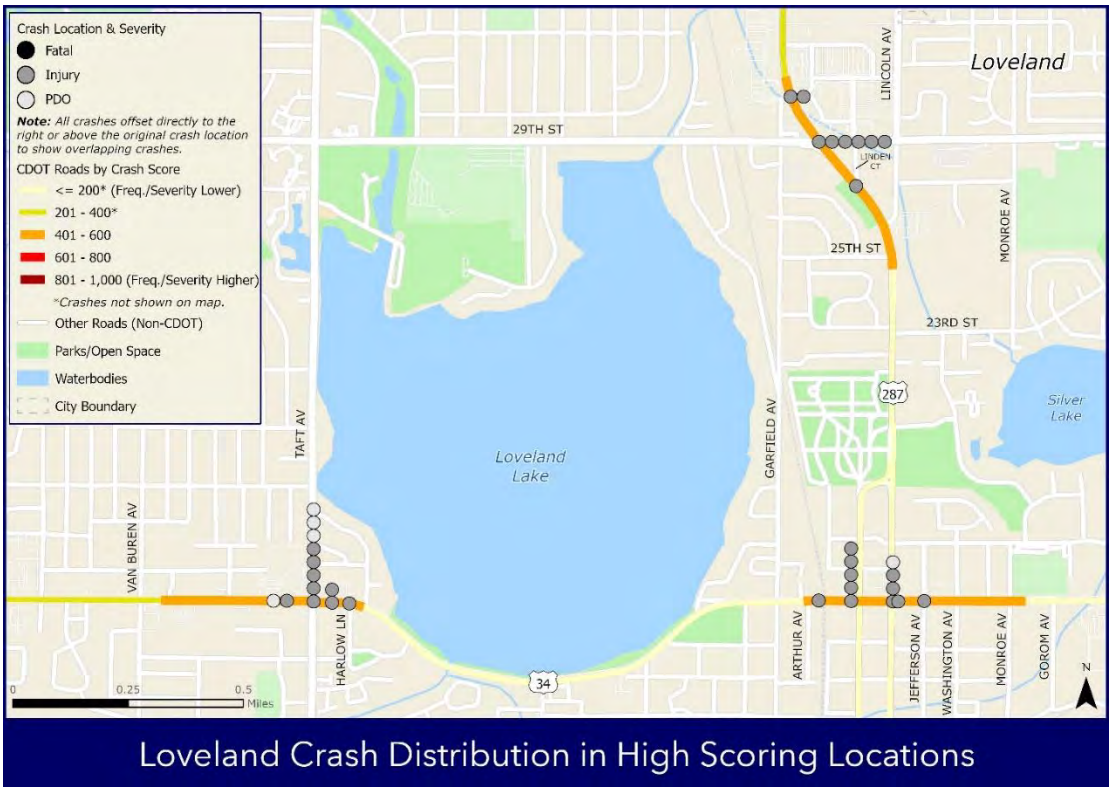


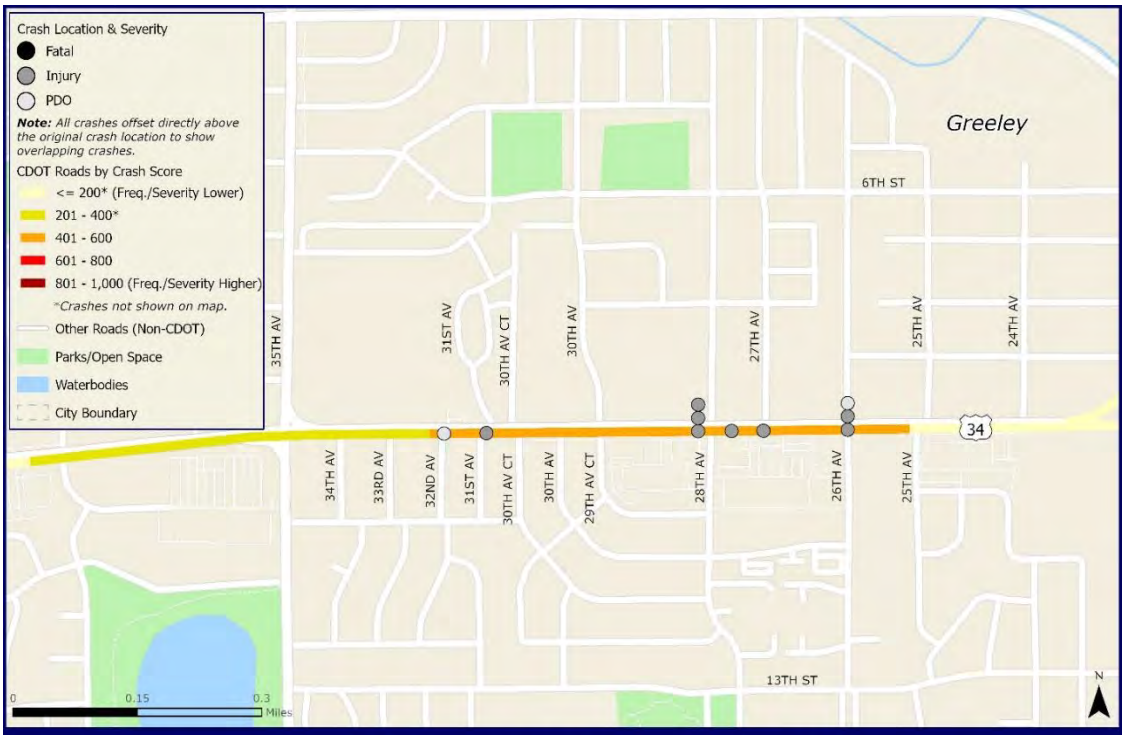
Figure 7: Fort Collins Crash Hot Spots

Figure 8: Loveland Crash Hot Spots



Loveland Crash Distribution in High Scoring Locations

Figure 9: Greeley Crash Hot Spots



Greeley Crash Distribution in High Scoring Locations

Figure 10: Greeley US 34/11th Avenue

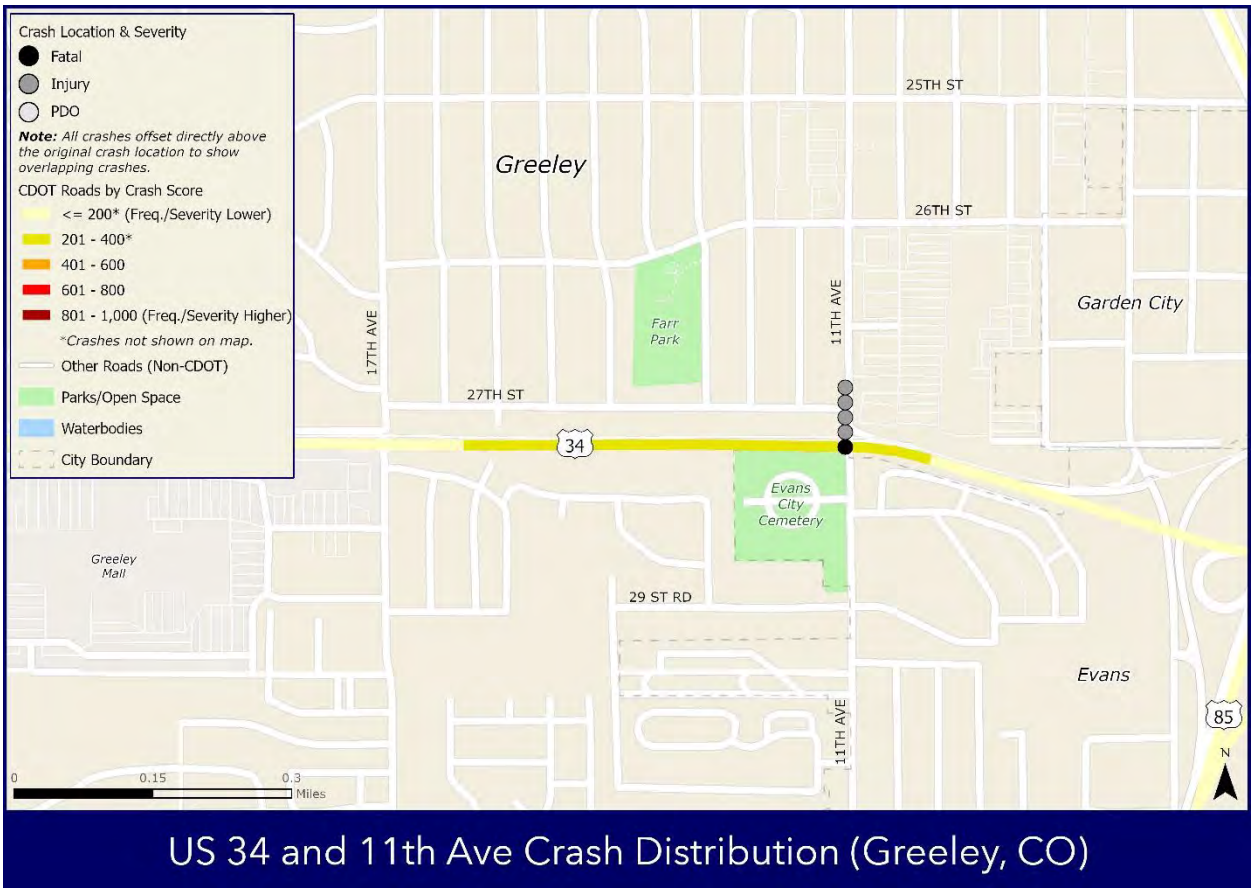


Table 2: Crash Hot Spots

City	Segment/Intersection	Crash Score
Longmont	Intersection of US 287/Mountain View Ave	500
Longmont	Segment of US 287 from Mountain View Ave to 9th Ave	500
Longmont	Intersection of US 287/23rd Ave	400
Longmont	Intersection of US 287/17th St	375
Fort Collins	Segment of Laporte Ave to Laurel Street	325
Longmont	Intersection of US 287/9th Ave	325
Loveland	Intersection of US 34 (Eisenhower Blvd)/Taft Ave	325
Greeley	Intersection of US 34/11th Ave	300
Fort Collins	Intersection of US 287/Mountain Ave	300

Loveland	Intersection of US 287/29th Street	300
Fort Collins	Segment of US 287 from Stuart Street to the River	275
Longmont	Segment of US 287 North of 17th Ave to 15th Ave	250
Fort Collins	Intersection of US 287/Vine Drive	250
Loveland	Intersection of US 34 (Eisenhower Blvd)/Cleveland Street	250

Crash Summary

Bicycle and pedestrian crash data from 2015 to 2019 was evaluated to identify severity of crashes and their locations across the region. Pedestrian crashes accounted for approximately 40 percent of the crashes and 74 percent of the fatalities indicating that pedestrians are at higher risk for fatalities. Additionally, pedestrian crashes were more distributed across the region than bicycle crashes. No bicycle crashes occurred south of the eastern portion of US 36 and the majority occurred west of US 85.

Dividing the roads in the region into ½ mile segments and applying scores for each crash based on severity, the crash analysis identified the segments with the highest crash scores as shown in Figure 5. To further narrow down intersection versus segment hot spots, crash reports associated with these high scoring segments were evaluated, revealing specific segments or intersections with a high number or severity of bicycle and pedestrian crashes. The final bicycle and pedestrian crash hot spots are listed in Table 2, above.

Systemic Safety Analysis

Overview

The second step in the network screening was to perform a systemic safety analysis. Systemic analysis looks at the characteristics of the roadways (i.e., speed limit, AADT, shoulder width, number of lanes, presence of bike lanes and sidewalk) associated with hot spot crash locations, then uses those roadway characteristics to identify roads with similar roadway characteristics that may or may not have a crash history. The resulting roadways are identified as posing inherently more risk to bicyclists and pedestrians than other roads in the region. This approach is a more proactive approach to safety than the historically reactive approach which requires a crash history to implement safety improvements. Additionally, systemic analysis is becoming an acceptable approach to securing safety grant funding such as Highway Safety Improvement Program (HSIP) and Funding Advancements for Surface Transportation and Economic Recovery Act of 2009 (FASTER) funds.

FHWA's Systemic Safety Project Selection Tool[2] was used as a guide to complete this systemic safety analysis and presents a process for incorporating systemic safety planning into traditional safety management processes. Per FHWA's tool, the first steps in identifying systemic improvements are to identify crash types that represent potential for crash reduction on the roadway network and then identify where (under what conditions) they typically occur. For purposes of this study, the crash types that are being evaluated are bicycle and pedestrian crashes. The conditions, or risk factors, under which those crashes occur are discussed in more detail below.

[2] *Systemic Safety Project Selection Tool, FHWA, SA-13-019*

Identification of Risk Factors

The 836 bicycle and pedestrian crashes identified within Region 4 were broken down based on a list of potential risk factors. Risk factors are defined as variables that either on their own, or in combination with each other, can be associated with either an increased or decreased risk of crashes occurring. Table 3 shows the percent of the 836 bicycle and pedestrian crashes associated with each of the potential risk factors. Highlights from this analysis include outcomes such as:

- 92% occurred in urban areas
- 80% occurred at driveways or intersections
- 78% occurred on a roadway functionally classified as a "Principal Arterial – Other"
- 67% occurred during daylight and 9% occurred in dark-unlit conditions
- 82% occurred on roadways with greater than or equal to 4 vehicle travel lanes
- 81% occurred on roadways with an AADT greater than 15,000
- 74% occurred on roadways with a shoulder of < 4 feet in width
- 89% occurred on roadways without bike lanes

Table 3: Summary of Crash Types

		All Bicycle and Pedestrian Crashes					
		Bicycle		Pedestrian			
2015 2019 Crash History		# Crashes	% by Type	# Crashes	% by Type	**Total # of Crashes**	**Total % by Type**
Overall Numbers	Total # of Crashes	491	100%	345	100%	836	100%
By Jurisdictional Classification	Urban	463	94%	310	90%	773	92%
	Rural	28	6%	35	10%	63	8%
By Location	Intersection	369	75%	217	63%	586	70%
	Driveway	66	13%	14	4%	80	10%
	Non-Intersection	56	11%	114	33%	170	20%
By Functional Classification	Interstate	5	1%	15	4%	20	2%
	Freeway & Expressway	45	9%	35	10%	80	10%
	Principal Arterial - Other	390	79%	259	75%	649	78%
	Minor Arterial	47	10%	33	10%	80	10%
	Major Collector	4	1%	3	1%	7	1%
	Minor Collector	0	0%	0	0%	0	0%
	Local	0	0%	0	0%	0	0%
By Light Condition	Daylight	388	79%	176	51%	564	67%
	Dark - Lit	62	13%	90	26%	152	18%
	Dark - Unlit	15	3%	58	17%	73	9%
	Dawn or Dusk	26	5%	21	6%	47	6%
By Speed Limit	<=30 mph	82	17%	89	26%	171	20%
	35 mph	162	33%	80	23%	242	29%
	40 mph	98	20%	57	17%	155	19%
	>=45 mph	149	30%	119	34%	268	32%
By AADT	<= 9,000	28	6%	35	10%	63	8%

	9,001-12,000	24	5%	24	7%	48	6%
	12,001-15,000	30	6%	17	5%	47	6%
	>15,000	409	83%	269	78%	678	81%
By Number of Lanes	2	58	12%	44	13%	102	12%
	3	30	6%	17	5%	47	6%
	4+	403	82%	284	82%	687	82%
By Shoulder Width	< 4 feet	379	77%	241	70%	620	74%
	4 - 6 feet	29	6%	21	6%	50	6%
	> 6 feet	83	17%	83	24%	166	20%
By Presence of Sidewalk	Yes	400	81.5%	259	75.1%	659	79%
	No	91	23.5%	86	24.9%	177	21%
Presence of Bike Lanes	Yes	64	13%	30	9%	94	11%
	No	427	87%	315	91%	742	89%
By Median Type	Depressed	29	6%	38	11%	67	8%
	Raised	72	15%	53	15%	125	15%
	Channelized - Raised Curb	175	36%	87	25%	262	31%
	Painted	85	17%	61	18%	146	17%
	Parking	5	1%	9	3%	14	2%
	None	125	25%	97	28%	222	27%

Another way to evaluate the data is to look at the density of crashes associated with each of the risk factors. Table 4 takes the total number of crashes for each of the risk factors and divides that into total lane miles associated with the same risk factor to come up with a number of crashes per lane mile.

Across the Region 4 roadway network, there were a total of 836 bicycle and pedestrian crashes on 2,544 miles, resulting in an average of 1 crash every 3 miles, or 0.33 crashes/mile. For comparison purposes, factors that resulted in a number greater than 0.33 crashes/mile experienced a higher density of crashes than the roadway network as a whole. The crash density for each of the factors ranged from 0.02 to 25.41 crashes per mile.

In theory, the higher the resulting number, the riskier that factor is to the network. However, much research has been done into many of the potential risk factors identified and that data/research must also be considered to determine whether each of these factors actually represent a risk on the roadway network. This concept is referred to as the dilemma of correlation versus causation which speaks to two things happening at the same time and mistakenly concluding that one causes the other. The evaluation of each of the potential risk factors is discussed below, in the order in which they are presented in Tables 2 and 3, above. The location and light condition risk factors were not included in the crash/mile evaluation as the data came from the crash reports.

Table 4: Crashes per Lane Mile

2015 2019 Crash History		All Bicycle and Pedestrian Crashes		
		Total # Crashes	Total # Lane Miles	Crashes / Lane Mile
Overall Numbers	Total # of Crashes	836	2544.3	0.33
By Jurisdictional Classification	Urban	773	336.4	2.3
	Rural	63	2207.8	0.03
By Functional Classification	Interstate	20	346.3	0.06
	Freeway & Expressway	80	87.5	0.91
	Principal Arterial - Other	649	894.6	0.73
	Minor Arterial	80	839.1	0.1
	Major Collector	7	327.3	0.02
	Minor Collector	0	46.7	0
	Local	0	2.8	0
By Speed Limit	<=30 mph	171	44.1	3.88
	35 mph	242	91.6	2.64
	40 mph	155	102.4	1.51
	>=45 mph	268	2306.3	0.12
By AADT	<= 9,000	63	1940.3	0.03
	9,001-12,000	48	218.2	0.22
	12,001-15,000	47	79.2	0.59
	>15,000	678	306.6	2.21
By Number of Lanes	2	102	1932.5	0.05
	3	47	39.3	1.2
	4+	687	572.5	1.2
By Shoulder Width	< 4 feet	620	934.314	0.66
	4-6 feet	50	533.964	0.09
	> 6 feet	166	1076.013	0.15
By Presence of Sidewalk	Yes	659	119.0	5.54
	No	177	2425.3	0.07
By Presence of Bike Lanes	Yes	94	15.2	6.18
	No	742	2529.1	0.29
By Median Type	Depressed	67	434.0	0.15
	Raised	125	19.7	6.35
	Channelized - Raised	262	28.5	9.18
	Painted	146	43.4	3.37
	Parking	14	0.6	25.41
	None	222	2018.1	0.11

Evaluation of Risk Factors

Jurisdictional Classification

Table 5: Jurisdictional Classification Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
Jurisdictional Classification	Urban	773	92%	773	336.4	2.3
	Rural	63	8%	63	2207.8	0.03

***Defined**: Jurisdictional classification refers to CDOT's classification of urban versus rural roadways, which is based on the US Census Bureau's categorization of a geographic area by the population count.*

Of the 836 bicycle and pedestrian crashes that occurred on CDOT Region 4 roadways between 2015 and 2019, 92% occurred on urban classified roadways despite only 13% of the roadways being classified as urban. As a result, the crashes per lane mile for urban roads is much higher than it is for rural roads. This is likely a result of larger populations in urban areas and more conflicts between bicyclists/pedestrians and motor vehicles. Figures 11 and 12, show the breakdown of bicycle and pedestrian crashes on urban and rural roads.

Figure 11: Summary of Bicycle Crashes by Jurisdictional Classification

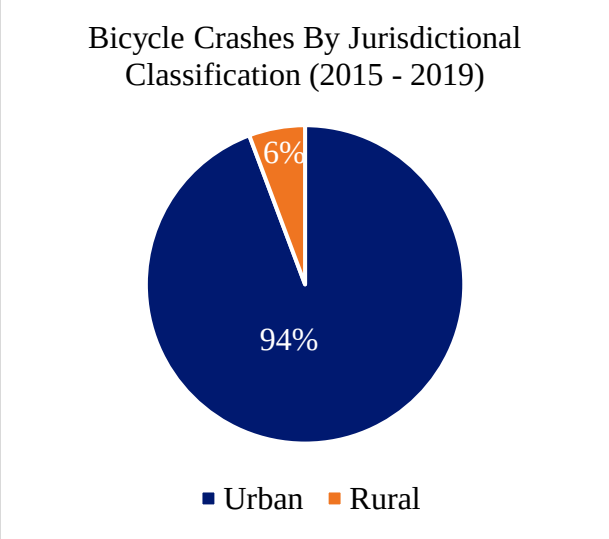
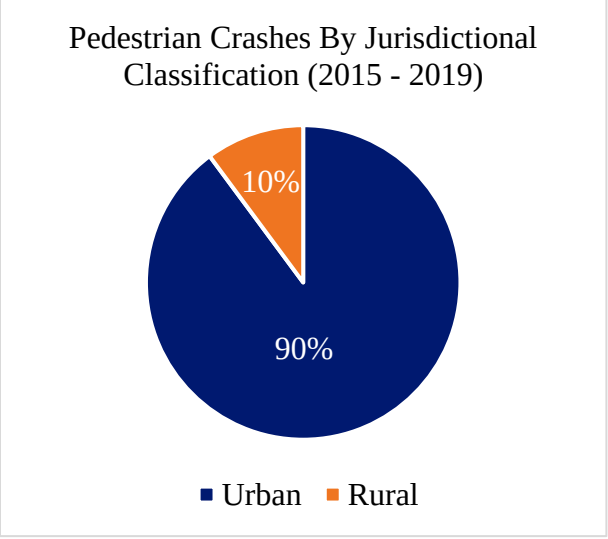


Figure 12: Summary of Pedestrian Crashes by Jurisdictional Classification



Despite the smaller proportion of total bicycle and pedestrian crashes on rural roads, these rural crashes have a higher probability of resulting in injury or fatality (97%), as compared to urban areas (80%), as shown in Figure 13. Even though rural crashes only make up 8% of the total crashes, they accounted for 24% of the total fatalities. This is slightly higher than national statistics of pedestrian fatalities in urban and rural areas. According to a May 2021 report[3], the National Highway Traffic Safety Administration (NHTSA) stated that in 2019, more pedestrian fatalities occurred in urban areas (82%) than rural areas (18%). This indicates that rural roads in Region 4 represent a higher risk for fatalities than rural roads nationally. One observation that could explain the higher risk for fatalities in rural areas is shown in Figure 14. Figure 14 shows the correlation between fatal crashes, speed limits and urban versus rural classified roadways. All of the fatalities on rural roads, and 30 of the 38 total fatalities occurred on roadways where posted speed limits were greater than or equal to 45MPH.

Figure 13: Urban and Rural Crashes by Severity

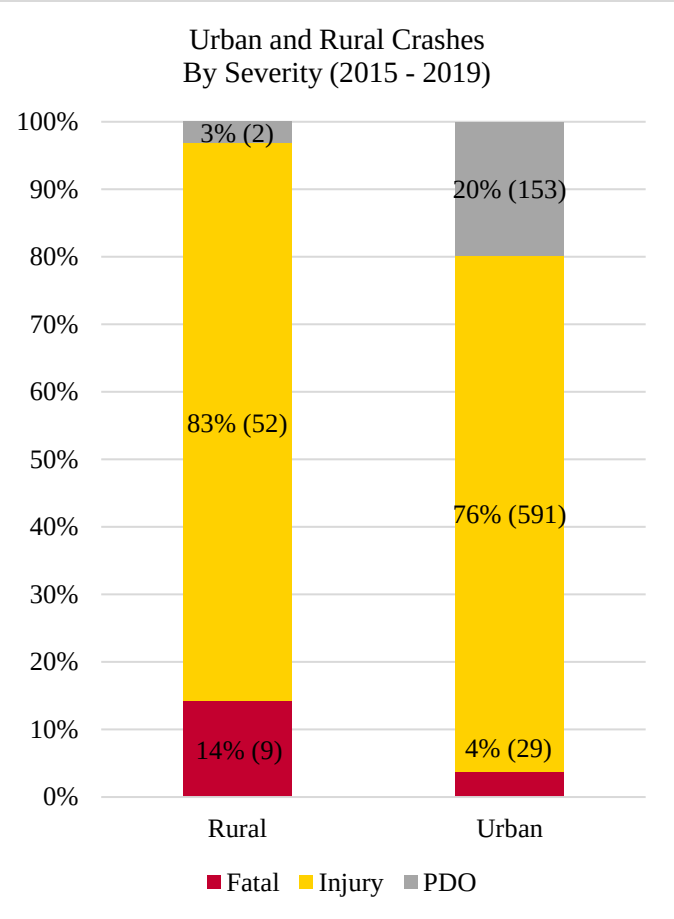
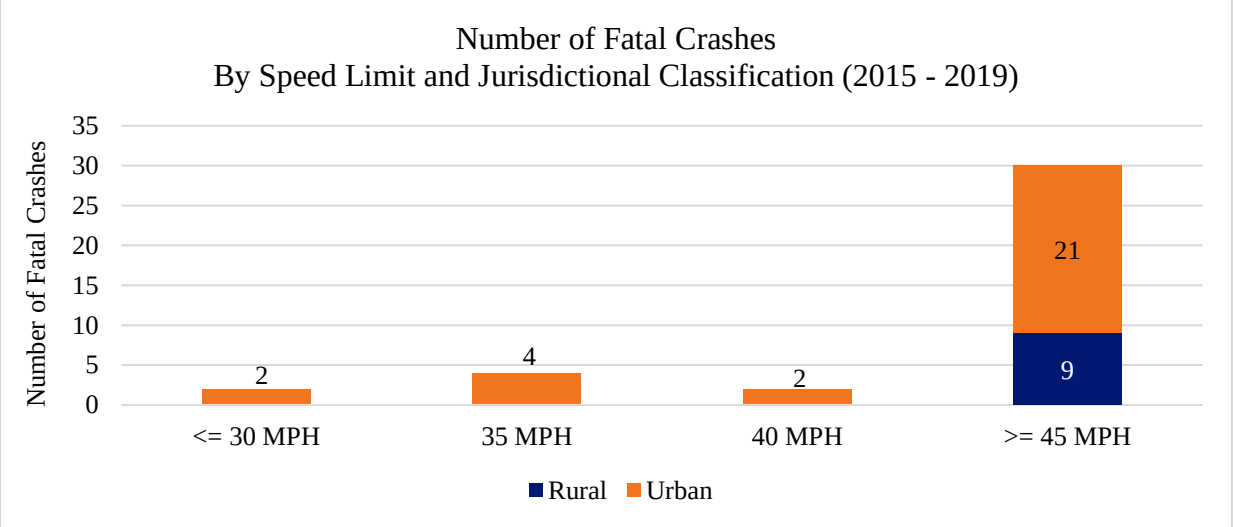


Figure 14: Number of Fatal Crashes by Speed Limit and Jurisdictional Classification



[3] 2019 Data: Pedestrians (dot.gov)

Location

Table 6: Location Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type
Location	Intersection	586	70%
	Driveway	80	10%
	Non Intersection	170	20%

***Defined**: Location refers to where the crash happened along the road as defined in the crash reports. Intersection crashes include those identified on the crash reports as "intersection" or "intersection related", driveway crashes include all crashes that occurred near a curb cut serving residential or commercial businesses/complexes, and non-intersection crashes represent all other crashes in the crash reports. The location of crashes was not included in the crash/mile evaluation as they are data points, not data segments.*

In the crash database provided by CDOT, the majority (70%) of bicycle and pedestrian crashes occurred at (or related to) intersections. As shown on Figures 15 and 16, this number is slightly higher for bicycle crashes. Since intersections represent a juncture of two roadways where different modes of travel (motor vehicles, bicycles, pedestrians) intersect and experience increased conflict points, it is logical that the majority of crashes occurred at these locations.

Figure 15: Summary of Bicycle Crashes by Location

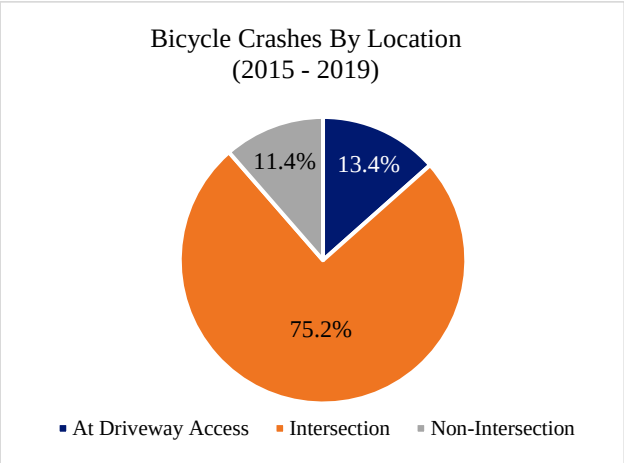
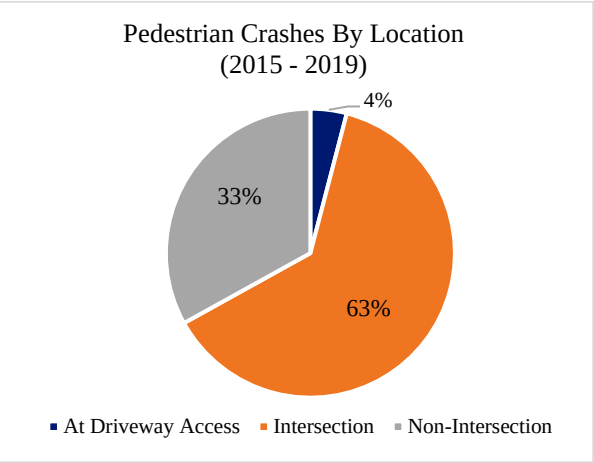


Figure 16: Summary of Pedestrian Crashes by Location



While bicycle and pedestrian crashes both occurred predominantly at intersection locations, 33% of pedestrian crashes occurred at non-intersection locations whereas only 11% of bicycle crashes occurred at non-intersection locations (Figures 15 and 16 above). This indicates that proximity to an intersection of two roadways is a more significant risk factor for bicycle crashes than for pedestrian crashes. Additionally, Figures 15 and 16 above show that driveways are a higher risk factor for bicycles than pedestrians; this is likely due to the speed at which bicycles approach and the habit for drivers to focus their attention on approaching motor vehicles as they enter or exit driveways.

The crash tree in Figure 17 below compares crash severity by location and shows that intersection crashes tend to result in more injuries for bicyclists and pedestrians (74% and 65%, respectively), than crashes at driveways or non-intersections. Fatalities for bicyclists are split evenly between intersection and non-intersection locations, but pedestrian fatalities are highest (61%) at non-intersection locations.

Figure 17: Bicycle and Pedestrian Crash Severity by Location

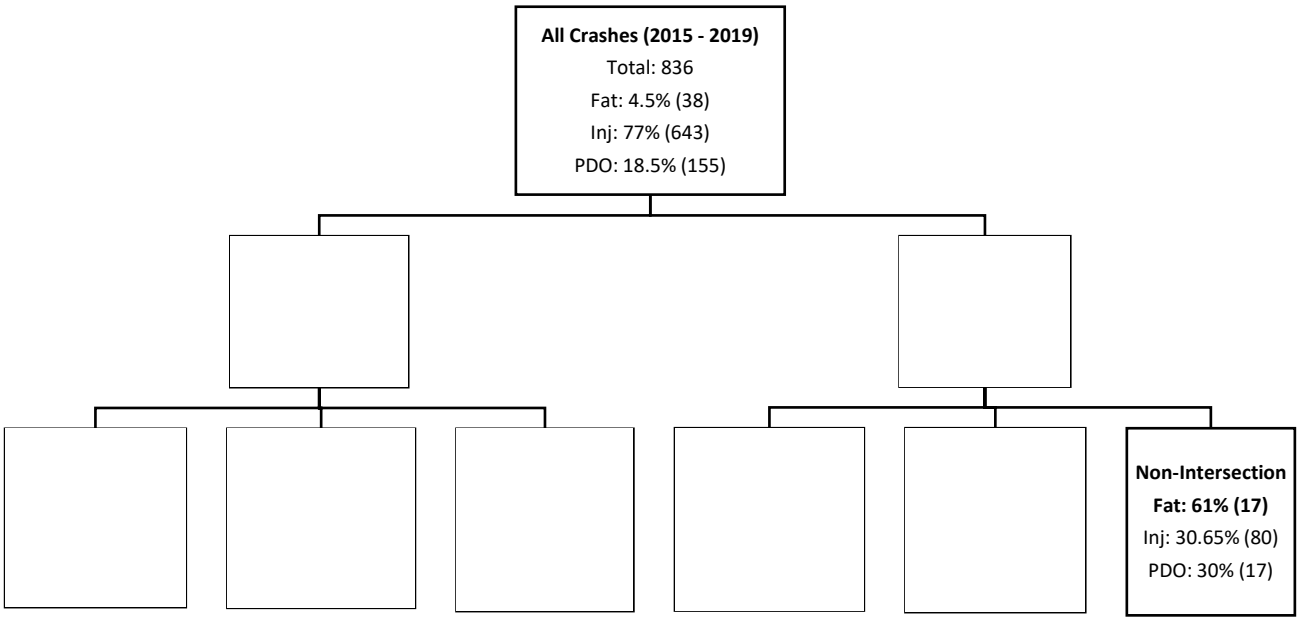
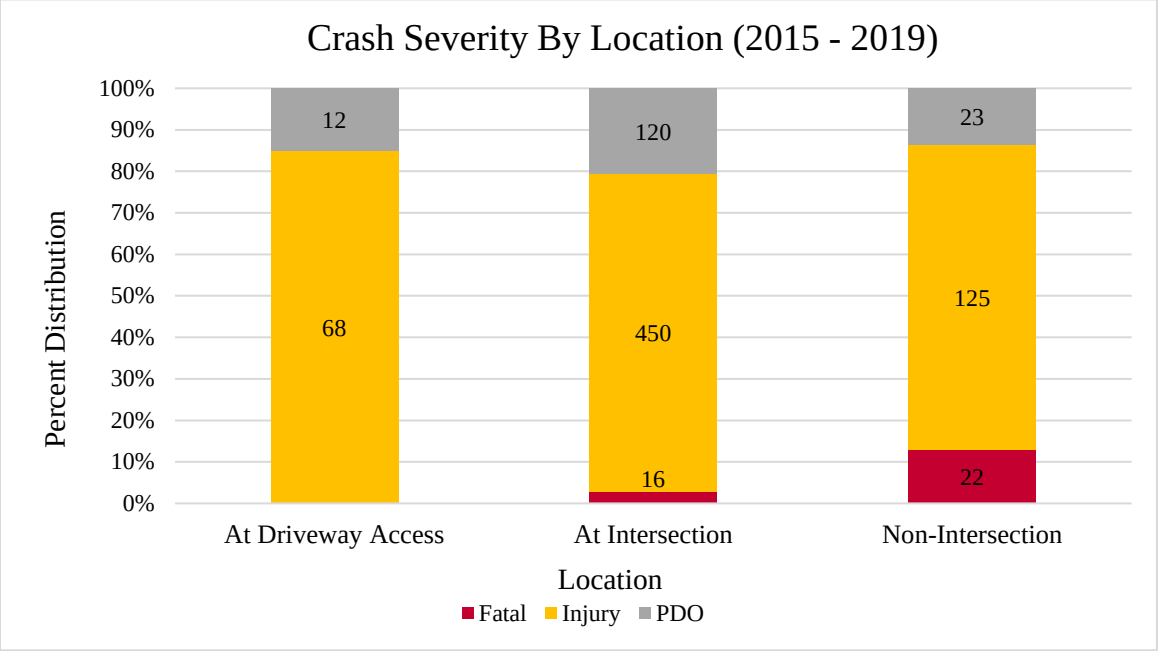


Figure 18 shows the percent distribution of crashes by severity and location. Non-intersection crashes experience the highest risk for fatalities (13%), compared to intersection crashes (3%) and driveways (0%). According to a May 2021 report by the US Department of Transportation[4] non-intersection crashes also experience the highest percentage of pedestrian fatalities in the US (73%), compared to intersection crashes (18%) and other crash types (9%). Looking at severe crashes, Figure 18 shows that driveways and non-intersections have the same risk of severe crashes (85%) and intersection crashes experience slightly less risk for severe crashes (80%).

[4] 2019 Data: Pedestrians (dot.gov)

Figure 18: Crash Severity by Location



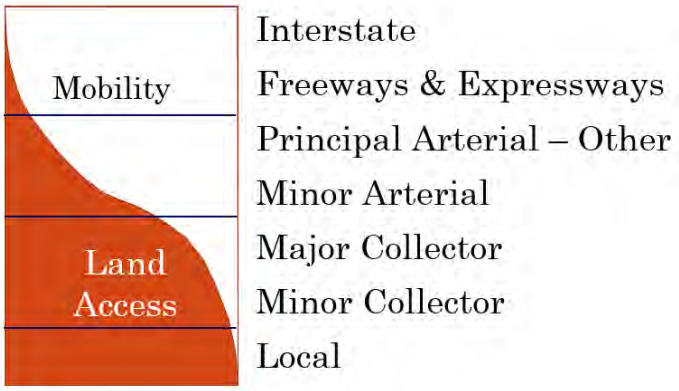
Functional Classification

Table 7: Functional Classification Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
Functional Classification	Interstate	20	2%	20	346.3	0.06
	Freeway & Expressway	80	10%	80	87.5	0.91
	Principal Arterial - Other	649	78%	649	894.6	0.73
	Minor Arterial	80	10%	80	839.1	0.1
	Major Collector	7	1%	7	327.3	0.02
	Minor Collector	0	0%	0	46.7	0
	Local	0	0%	0	2.8	0

***Defined**: F*unctional classification is an ordering system for roadways that defines how a road should function within the network. The classifications listed have varying relationships between traffic mobility and access to adjacent properties, where mobility of traffic decreases in priority from top to bottom and access to properties increases in priority from top to bottom.

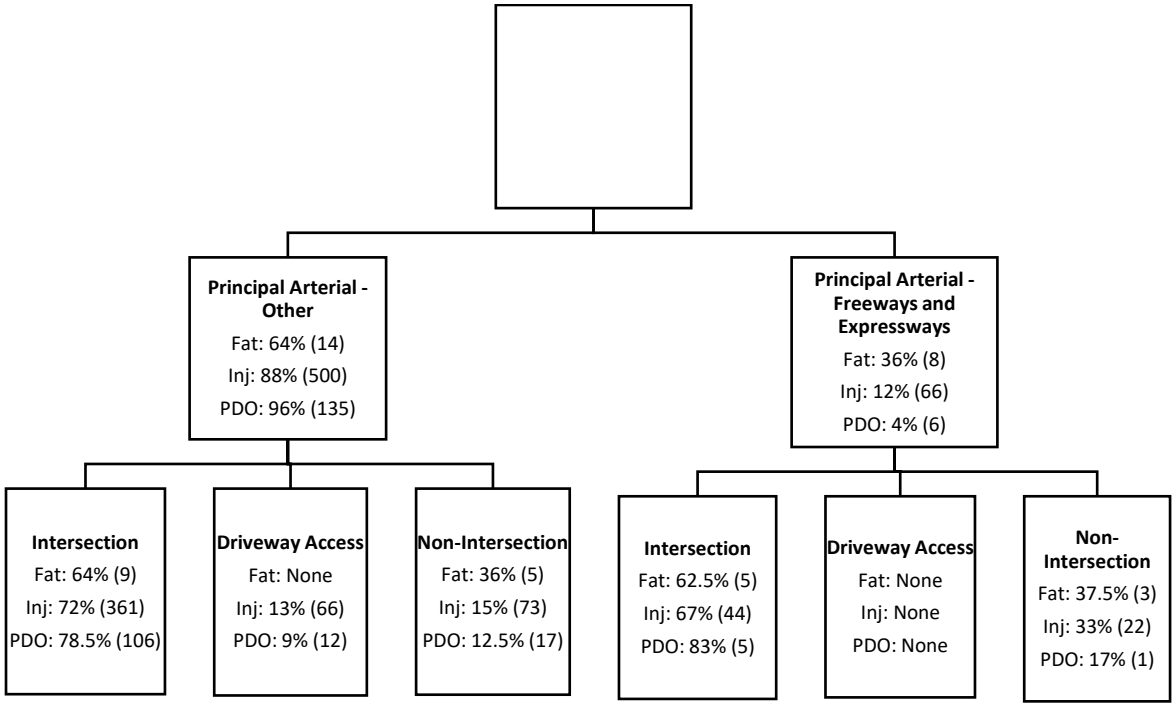
Figure 19: Mobility & Access by Functional Classification



As shown on Figure 19, interstates prioritize mobility of traffic thru the corridor over access, thereby resulting in fewer driveway cuts and higher speed traffic. On the other hand, local roads prioritize land access over mobility and provide many curb cuts resulting in slower moving traffic. The majority of crashes occurred on roadways classified by CDOT as *Principal Arterial – Other*. When comparing total crashes for each classification to the respective number of miles, *Freeways & Expressways* generated the most crashes per mile (0.91) followed by *Principal Arterial – Other* (0.73). The remaining roadway classifications experienced significantly fewer crashes per mile (0-0.1). This implies that the introduction of access on higher speed roads such as Freeways, Expressways and Principal Arterials results in significantly higher risk for crashes. Looking at the location where crashes occurred on *Principal Arterial – Other* roadways, as shown on Figure 20, indicates that the access and intersection density is likely playing a role in the risk for crashes on these types of roadways. Figure 20 shows that 87% of crashes on *Principal Arterial – Other* roadways occurred at driveways or intersections.

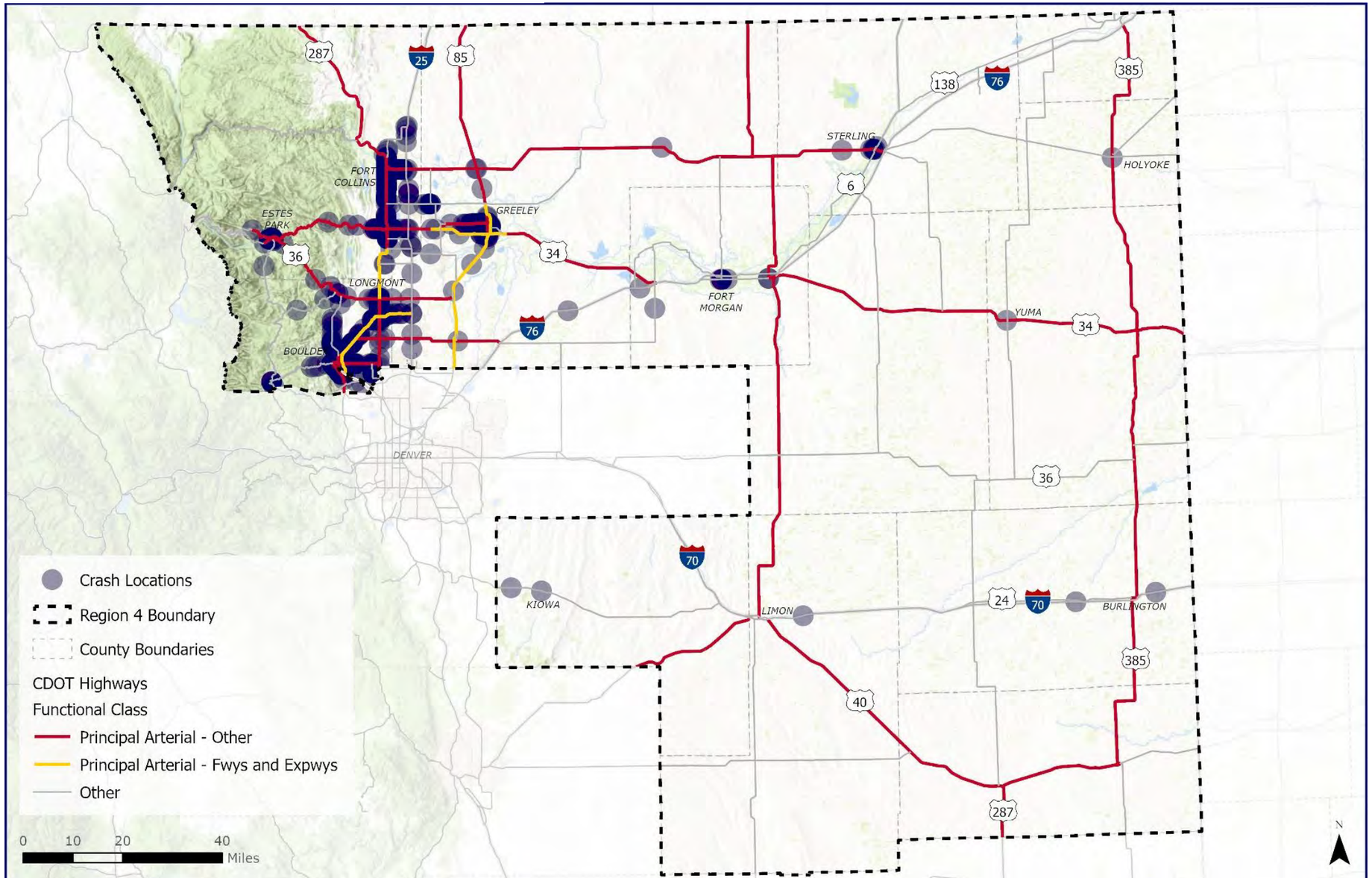
Understanding CDOT's intended function of these high crash roadways helps to provide insight into what may be the cause of these crashes. *Principal Arterial – Other* is defined by CDOT as a roadway that serves activity centers and provides a high degree of mobility. It also provides additional access to parcels and has at-grade intersections. *Freeways & Expressways* are defined by CDOT as looking similar to Interstates in that they have full access control (i.e. no direct access to adjacent properties). Freeways provide access via on/off ramps and no at grade intersections while Expressways are more common in rural settings and at grade intersections are permitted to varying degrees depending on context. Despite the limitations to direct access and at grade intersections, 68% of crashes (Figure 20) on *Freeways & Expressways* occurred at intersections indicating that the presence of intersections is likely a riskier factor than speed on these types of roads.

Figure 20: Breakdown of Crash Severity by Functional Classification



While freeways are designed to provide limited access and minor arterials are designed to provide connectivity between communities (indicating they provide a higher degree of access), speed and intersection density likely play a role in the number and severity of bicycle and pedestrian crashes on these types of roads. According to CDOT, roadways classified as *Principal Arterial – Other* provide a similar service in both urban and rural areas. The primary difference between urban and rural areas is that urban areas have a higher quantity of arterials serving a particular area (higher intersection density), whereas rural areas are typically served by one arterial. However, as the *Principal Arterial – Other* roadways travel through rural towns, increases in access on these high-risk arterial roadways likely increased risk for all users on the roadway. FHWA's Safe System Approach notes that redundancy is crucial to reducing risks, which requires that all parts of the transportation system are strengthened so that if one part fails, the other parts still protect people. A couple of ways to achieve redundancy are to reduce the number of access points on higher speed roads, and/or reduce speed in areas of higher access density. Figure 21 shows the relationship between crashes and roadways functionally classified as *Principal Arterial – Other* or *Principal Arterial – Freeways and Expressways*. These *Principal Arterial* roadways experience significantly more bicycle and pedestrian crashes than other classified roadways.

Figure 21: Functional Classification & Crash Locations



Lighting Conditions

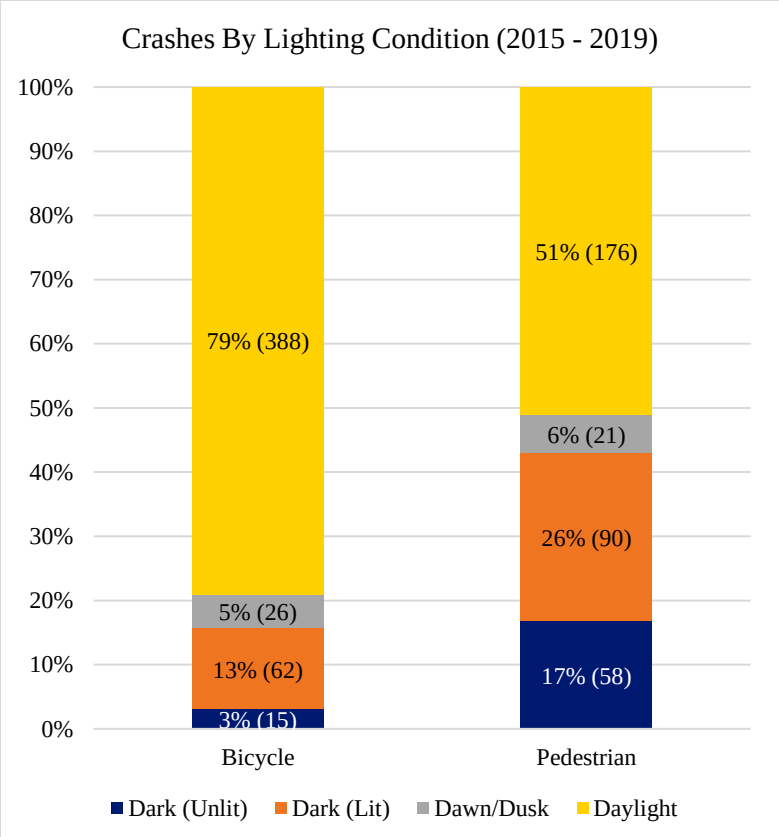
Table 8: Light Condition Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type
Light Condition	Daylight	564	67%
	Dark - Lit	152	18%
	Dark - Unlit	73	9%
	Dawn or Dusk	47	6%

***Defined**: The categories of light condition were defined in the crash reports based on the presence of light from the sun or other sources. Lighting was not included in the crash/mile evaluation as lighting shows up in the data as points, not segments.*

Lighting condition data for each bicycle and pedestrian crash was recorded in the crash database provided by CDOT. Dark conditions can be either unlit or lit with streetlights. Other lighting conditions include dawn/dusk or daylight. Figure 22 shows that the majority of crashes for both bicyclists and pedestrians occur in daylight, 79% and 51% respectively. However, pedestrians experience more crashes during dark (lit and unlit) conditions than bicyclists. A total of 17% of pedestrian crashes occurred in dark, unlit conditions whereas only 3% of bicycle crashes occurred in dark, unlit conditions. The requirement for bicycles to have lights and reflectors may explain why they experience fewer crashes in dark (unlit) conditions.

Figure 22: Bicycle & Pedestrian Crashes by Lighting Condition



It is also plausible that more bicyclists are outside during the daylight hours which could correlate with the higher volume of bicycle crashes during daylight hours. As for pedestrians, it is plausible that there are more pedestrians than bicyclists outside during the nighttime hours and that dark conditions present an additional risk factor to pedestrians. Of the 58 pedestrian crashes that occurred during dark (unlit) conditions, 84%, or 49 occurred at non-intersection locations and 69%, or 40 occurred in the urban areas.

It was previously noted that pedestrian crashes have a higher fatality rate than bicycle crashes. To further explore a possible correlation between fatal accidents and lighting conditions, Figures 23 and 24 summarize the lighting conditions for fatal accidents.

Sixty percent of fatal bicycle crashes occurred in daylight conditions with only 20% occurring in dark, unlit conditions. Contrary to this, pedestrian crashes show a correlation between fatal crashes and dark, unlit conditions, where 64% of fatal crashes occurred in dark, unlit conditions and 14% occurred in the daylight. According to a May 2021 report[5], the National Highway Traffic Safety Administration (NHTSA) stated that in 2019, 76% of pedestrian fatalities occurred in the dark, 21% in the daylight, and 4% in the dawn or dusk. Based on this data, it can be concluded that in Region 4, dark conditions correlate more strongly with pedestrian fatalities than bicycle fatalities, but lighting conditions are less of a risk factor in Region 4 than nationally.

Figure 23: Percent of Bicycle Crashes by Lighting Condition

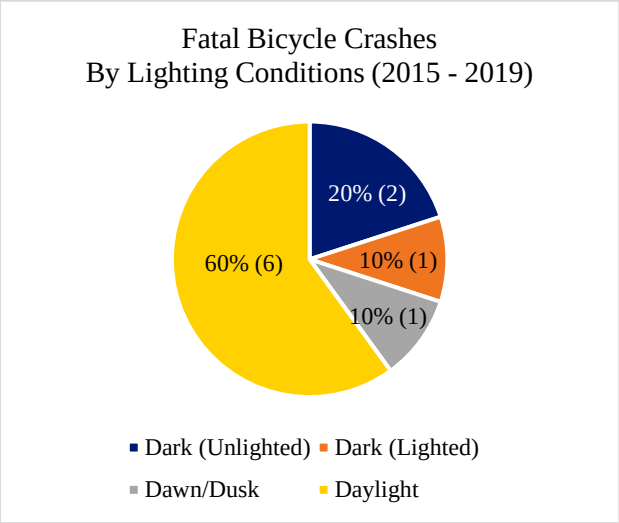
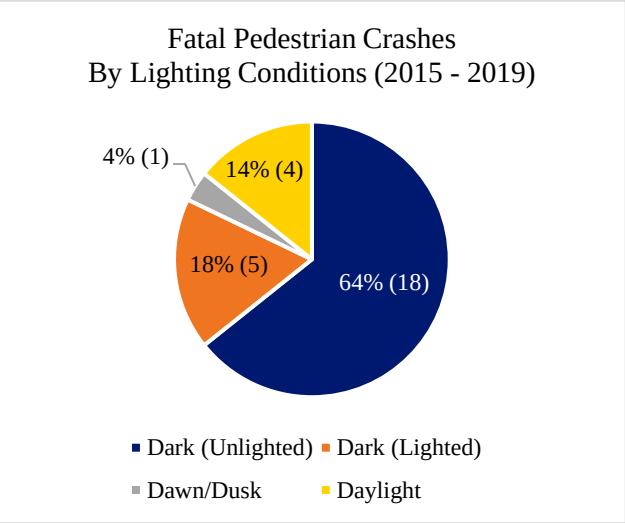


Figure 24: Percent of Pedestrian Crashes by Lighting Condition



Speed Limit

Table 9: Speed Limit Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
Speed Limit	<=30 mph	171	20%	171	44.1	3.88
	35 mph	242	29%	242	91.6	2.64
	40 mph	155	19%	155	102.4	1.51
	>=45 mph	268	32%	268	2306.3	0.12

***Defined**: Speed limit is the posted speed limit as seen when driving on the road.*

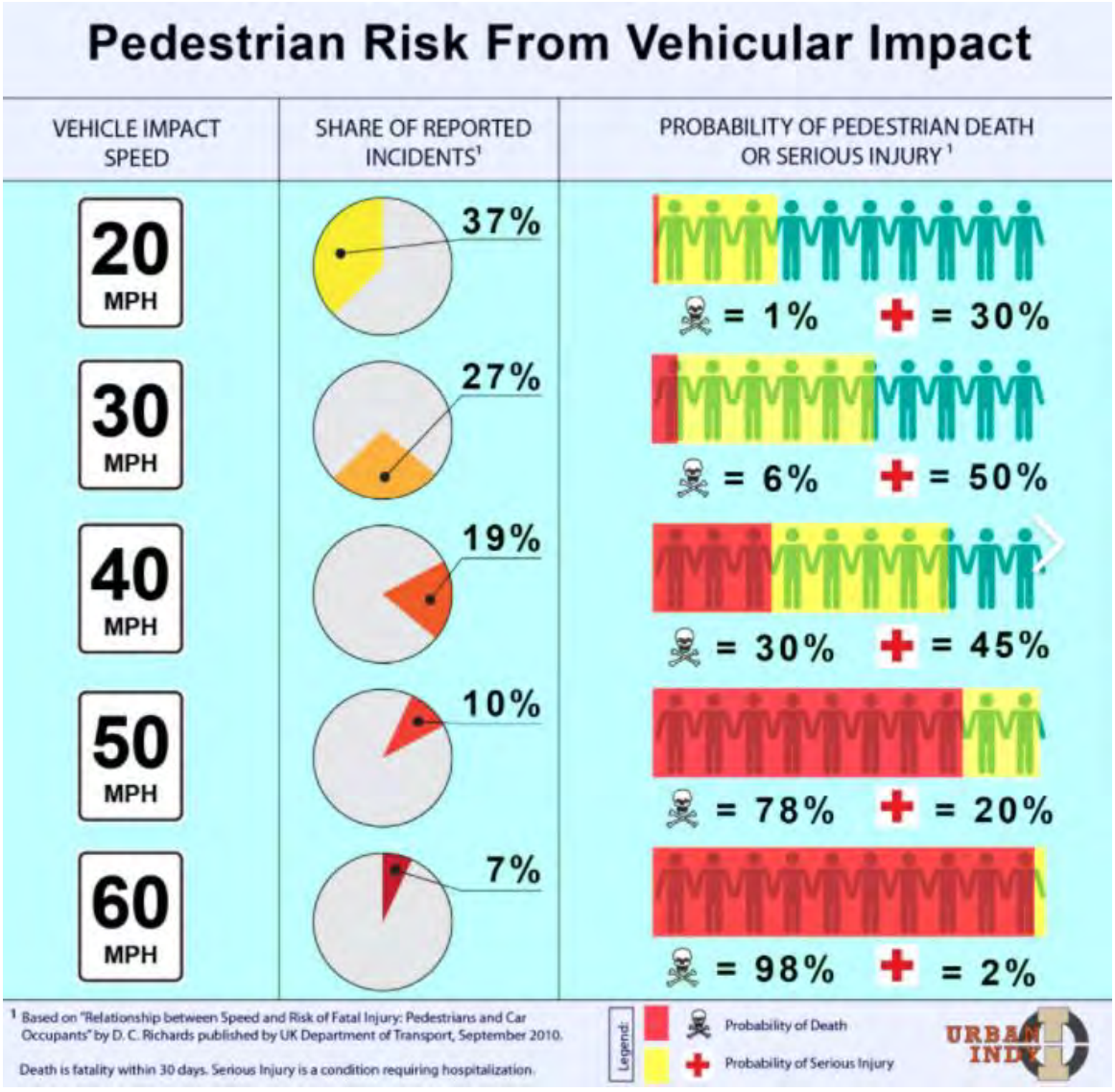
Of the 836 bicycle and pedestrian crashes that occurred on CDOT Region 4 roadways, nearly 1/3 of them occurred on roadways with posted speeds greater than or equal to 45mph and just over half (51%) occurred on roads with posted speeds of 40mph or higher. When considering the total number of lane miles, significantly more bicycle and pedestrian crashes occur per mile on lower speed roads (35mph or

[5] 2019 Data: Pedestrians (dot.gov)

less). It is possible that this is a result of higher volumes of bicycles and pedestrians traveling on lower speed roadways.

A study provided by NACTO (National Association of City Transportation Officials) that evaluates the relationship between speed and risk of fatal injury[6], concluded that the risk of fatality for a pedestrian who has been injured, "increases slowly until impact speeds of around 30mph. Above this speed, risk increases rapidly – the increase is between 3.5 and 5.5 times from 30mph to 40mph." Additionally, this report states that "even though the risk of pedestrians being killed at 30mph is relatively low, approximately half of pedestrian fatalities (and injuries) occur at this impact speed or below." Figure 25 provides a visual representation of these statistics from the report.

Figure 25: Pedestrian Risk from Vehicular Impact



[6] Relationship between Speed and Risk of Fatal Injury: Pedestrians and Car Occupants (nacto.org)

With half of Region 4 bicycle and pedestrian crashes occurring on roads with a posted speed of 40mph or higher, and data showing that at these speeds, 75% of crashes are expected to result in fatality or injury, assessing and possibly reducing posted speed limits seems critical to the goals of FHWA's Safe System Approach to eliminate fatal & serious injury crashes. CDOT is currently updating their process for setting speed limits. The new procedure is expected to be less focused on the 85th percentile speed and more in line with the upcoming MUTCD standards that look at historical data and roadway specifics.

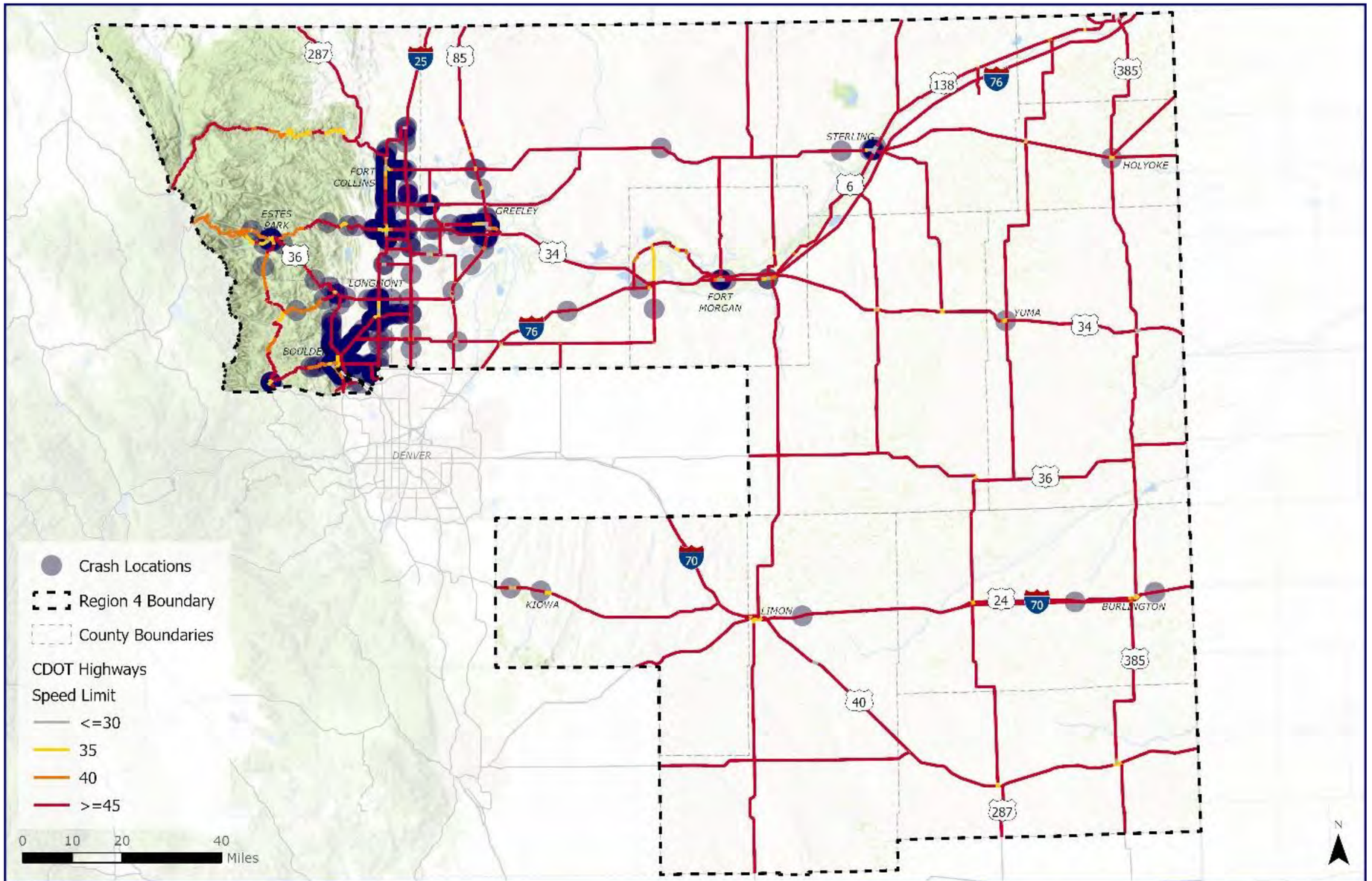
While reducing the posted speed limit may be desired on some roads, the design speed of the road and the drivers' level of comfort typically dictate the speed in which motor vehicles travel, requiring additional modifications to the geometry or police enforcement to physically slow motor vehicles. Some resources identify reduced vehicle lane width as a way to reduce motor vehicle speeds and improve safety. For example, FHWA's PEDSAFE (Pedestrian Safety Guide and Countermeasure Selection System) program identifies "lane narrowing"[7] as a countermeasure that is tied to reduced speeds on roadways where there are safety and speeding problems, and motor vehicle lane widths are greater than recommended minimums. They also note that reducing lane widths can help improve the safety and comfort for pedestrians, bicyclists, transit riders and motor vehicles. The following outlines PEDSAFE's recommended minimum lane widths:

- 9 feet lanes on rural roadways
- 10 feet for most vehicular travel lanes
- 10 feet for turn lanes
- 11 feet for lanes that accommodate a large volume of trucks, buses, or large motor vehicles (greater than 8%)

However, in some cases reduced lane widths can increase crashes. Data from the CMF (Crash Modification Factor) Clearinghouse indicates that reducing lane width from 12-feet to 10-feet on 4-lane median divided rural roads can reduce crashes (CMF ID 7827)[8] by 42 percent, but on urban roads with speeds between 20 and 55mph, CMF 8157[9] indicates that a reduction in lane width from 12-feet to 10-feet would result in a 28 percent increase in crashes. Lane reductions should be assessed on a case-by-case basis and additional treatments considered to slow motor vehicles when reduced speed is desired. Other treatments that may be appropriate to reduce speeds include roundabouts, speed humps, bulb outs / curb extensions, and on-street parking. Figure 26 shows the relationship between posted speed limits and reported crashes. As discussed above, nearly half of bicycle and pedestrian crashes occurred on roads that are 35mph or less (grey or yellow in color) despite only 5 percent of the roads having these speeds.

[7] Pedestrian Safety Guide and Countermeasure Selection System (pedbikesafe.org)
[8] CMF Clearinghouse >> CMF / CRF Details
[9] CMF Clearinghouse >> CMF / CRF Details

Figure 26: Speed Limit & Crash Locations



AADT (Average Annual Daily Traffic)

Table 10: AADT Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
AADT	<= 9,000	63	8%	63	1940.3	0.03
	9,001-12,000	48	6%	48	218.2	0.22
	12,001-15,000	47	6%	47	79.2	0.59
	>15,000	678	81%	678	306.6	2.21

***Defined**: AADT is the Average Annual Daily Traffic, or an annual average of the total demand on a road in both directions within a 24-hour period.*

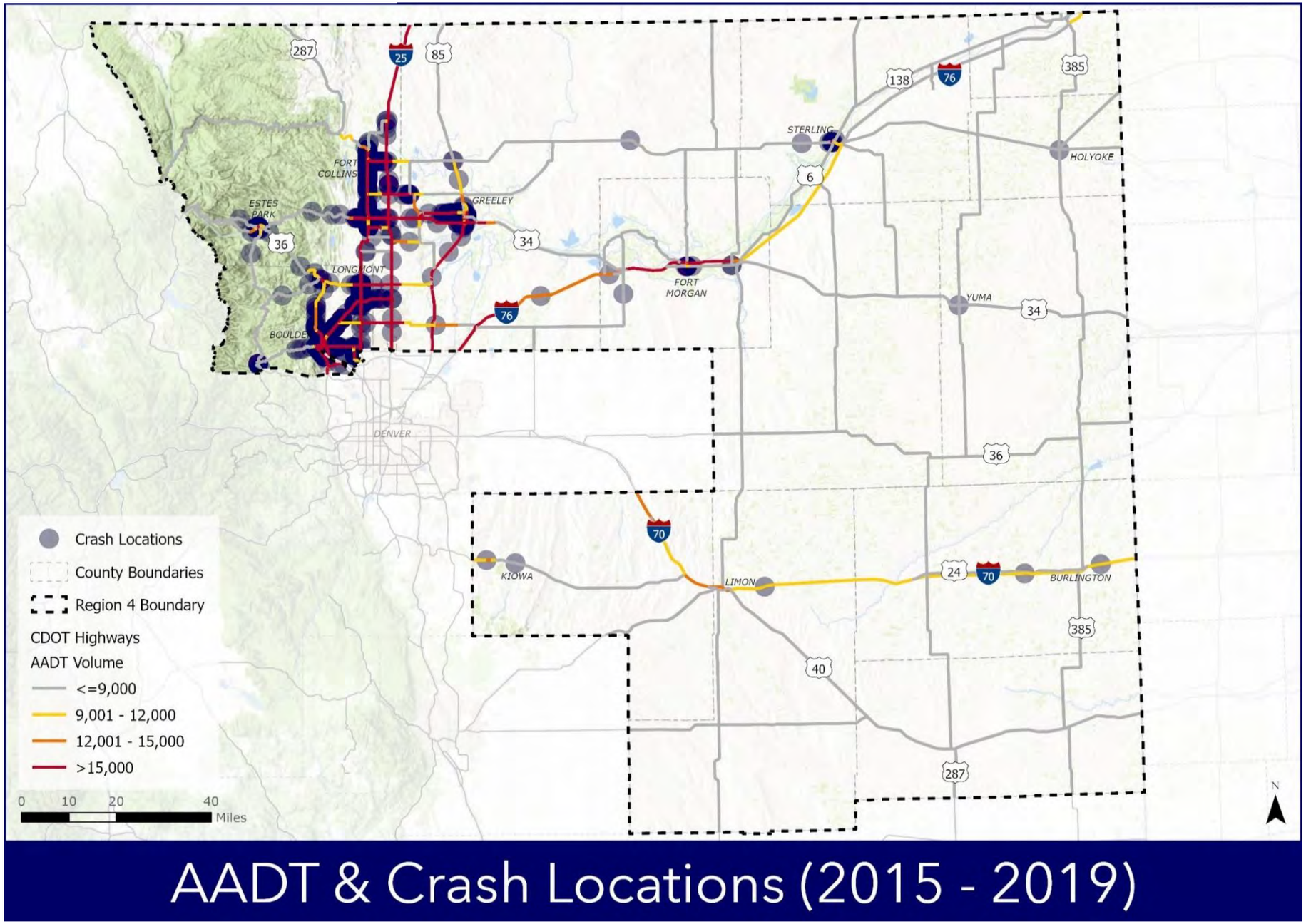
Over 80% of bicycle and pedestrian crashes occurred on roadways with an Average Annual Daily Traffic (AADT) of greater than 15,000 motor vehicles per day (vpd) even though only 12% of roads in the region have an AADT of greater than 15,000 vpd. The AADT is an average of daily traffic for an entire year, whereas ADT (Average Daily Traffic) is a measure of any 24 (or more) hour period where traffic volumes are measured. The former is data that was available thru CDOT's database. The latter is typically used to measure peaks in travel, such as when school is in session or when counts for an entire year are not feasible to obtain. Typically, case studies are based on ADT's because it is not feasible to have traffic counters across an entire road network.

The Highway Safety Manual (HSM)[10] has historically been the approach used to justify where safety funds should be applied. The HSM uses a method of predicting average crash frequency for a segment or intersection through safety performance functions (SPF's). SPFs are equations that estimate expected crash frequency as a function of traffic volume and roadway characteristics such as number of lanes, median type, intersection control (i.e. stop, signal or roundabout), or number of approach legs. This analysis is used to identify sites with the most potential for crash frequency or severity reduction. The focus on traffic volume in the HSM points to the level of risk associated with higher volume roads.

In Figure 27, AADT is displayed against severe bicycle and pedestrian crash locations to show the relationship between AADT and crash occurrence. The map illustrates that a high density of crashes occurred on highways with a higher relative AADT. Increased AADT exposes bicyclists and pedestrians to a higher number of motor vehicles which may increase the likelihood of a crash occurring. Wider roads are almost always associated with higher traffic volumes and bring the added challenge of reduced sight distance to and from pedestrians and traveling motor vehicles along with longer distances for pedestrians to cross the street.

[10] An Introduction to the Highway Safety Manual

Figure 27: AADT & Crash Locations



Number of Lanes

Table 11: Number of Lanes Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
Number of Lanes	2	102	12%	102	1932.5	0.05
	3	47	6%	47	39.3	1.2
	4+	687	82%	687	572.5	1.2

***Defined**: Number of lanes describes the combined quantity of vehicle travel lanes in both directions.*

Over 80% of bicycle and pedestrian crashes resulting in fatality or injury occurred on roadways with 4+ vehicle thru lanes even though only 25% of roads in the region have more than 2 lanes. Figure 28 shows the relationship between number of vehicle travel lanes and reported bicycle and pedestrian crashes. More travel lanes result in wider roads for pedestrians and bicycles to cross as well as reduced visibility between motor vehicles and bicycles/pedestrians. In FHWA's *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*[11] report (2005) data was collected at 2,000 sites. 1,622 sites were at uncontrolled intersections, and 278 sites were at midblock crossings. Conclusions from that report indicate:

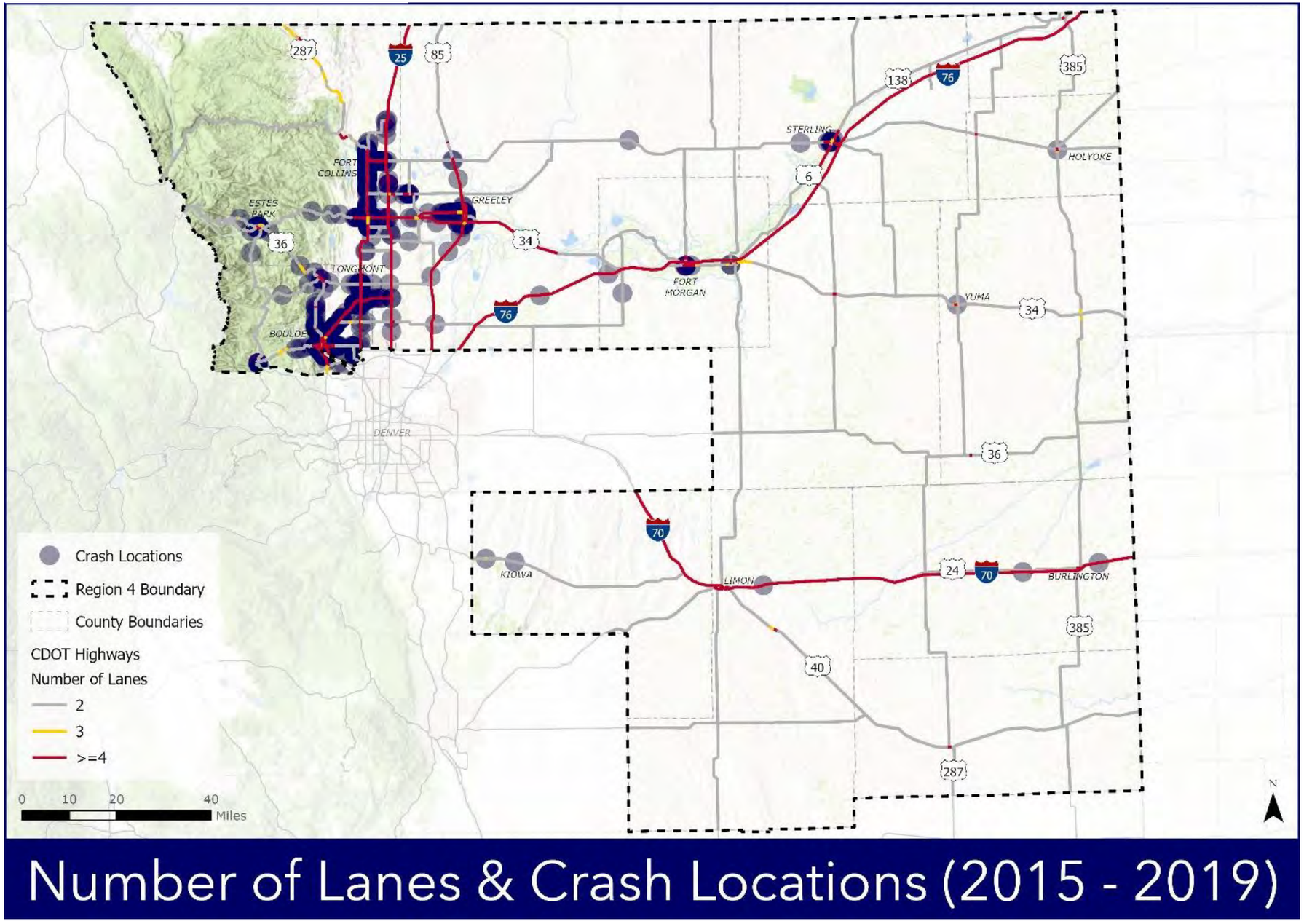
- On 2-lane roads, there was no significant difference in pedestrian crash rates between marked and unmarked sites;
- On multilane roads with an Average Daily Traffic (ADT) of 12,000 motor vehicles per day (vpd) or less, there was no difference in pedestrian crash rates between marked and unmarked sites;
- On multilane roads with no raised median and an ADT greater than 12,000 vpd, marked crosswalks had a higher crash rate than unmarked crossings; and
- On multilane roads with an ADT greater than 15,000 vpd and raised medians, a significantly higher crash rate was associated with marked crosswalks as compared to unmarked.

The results of this study appear counterintuitive as they indicate that marked crosswalks result in higher crash rates than unmarked crosswalks. However, the simple act of marking a crosswalk may result in pedestrians and bicyclists feeling more confident about stepping into traffic and it is possible that bicyclists and pedestrians may incorrectly think it is only legal to use marked crosswalks. The reality is that motor vehicles do not always stop for pedestrians and proper signage and roadway markings are necessary to provide safe crossings at these locations. Multilane highways have the added effect of creating blind spots from the pedestrian crosswalk to the motor vehicle on the inside lane of travel when multiple motor vehicles are present. In these cases, additional treatments such as Pedestrian Hybrid Beacons (PHB) are recommended to stop traffic so that the pedestrian can safely cross the road.

FHWA identifies PHB's as a proven safety countermeasure[12] that provides a 55% reduction in pedestrian crashes, 29% reduction in total crashes, and 15% reduction in serious injury and fatal crashes. They further state that PHB's are very effective at locations where three or more lanes will be crossed, or traffic volumes exceed 9,000 AADT. In addition to the installation of a PHB, marked crosswalks and pedestrian countdown signals are recommended. FHWA's Safe Transportation For Every Pedestrian Program[13] also notes that PHB's address safety concerns regarding conflicts at crossing locations, excessive motor vehicle speed, inadequate visibility, drivers not yielding and insufficient separation from traffic. Additional guidance is available via CDOT's Pedestrian Crossing Installation Guide (2021).

[11] Safety Effects of Marked versus (dot.gov)
[12] Pedestrian Hybrid Beacons - Safety | Federal Highway Administration (dot.gov)
[13] EDC-5: Safe Transportation for Every Pedestrian (STEP) 2.0 | Federal Highway Administration (dot.gov)

Figure 28: Number of Lanes & Crash Locations



Shoulder Width/Sidewalks/Bike Lanes

Table 12: Shoulder Width/Sidewalk/Bike Lane Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
Shoulder Width	< 4 feet	620	74%	620	934.3	0.66
	4-6 feet	50	6%	50	534.0	0.09
	> 6 feet	166	20%	166	1076.0	0.15
Presence of Sidewalk	Yes	659	79%	659	119.0	5.54
	No	177	21%	177	2425.3	0.07
Presence of Bike Lanes	Yes	94	11%	94	15.2	6.18
	No	742	89%	742	2529.1	0.29

***Defined**: Shoulders are the additional pavement found adjacent to the outside of motor vehicle travel lanes. Sidewalks are paved paths for pedestrians adjacent to a roadway. Sidewalks can either be directly adjacent to the motor vehicle travel lane or can be separated, usually by grass, providing additional space between pedestrians and motor vehicles. Bike lanes are typically found adjacent to the motor vehicle travel lane and are typically marked with painted lines, for use by cyclists.*

The presence of a "walkway" is shown to improve safety for bicyclists and pedestrians. Walkways are one of FHWA's Proven Safety Countermeasures and are defined as "any type of defined space or pathway for use by a person traveling by foot or wheelchair. These may be pedestrian walkways, shared use paths, sidewalks, or roadway shoulders"[14]. In addition, FHWA states that in areas where sidewalks are not feasible, roadway shoulders provide an area for pedestrians to walk next to the roadway. Adding sidewalks, where none currently exist, is shown to reduce crashes involving pedestrians walking along roadways (without sidewalks) by 65-89%. The addition of paved shoulders, to a minimum of 4 feet in width[15], has been found to reduce the same crashes by 71%. According to CDOT's 2018 Roadway Design Guide, the minimum recommended shoulder width on CDOT roadways is 4 feet.

It should be noted that only 0.005%, or 15.2 miles, of CDOT roads within Region 4 provide dedicated bike lanes, which are generally located at intersections where a local road crosses a CDOT road. Additionally, less than 5%, or 119 miles, of CDOT roads within Region 4 provide sidewalks, which are predominantly located in the urban areas. Figures 29 and 30 show the location of sidewalks and bike lanes respectively, as compared to crashes across the region. On the remainder of the roadway network, where no sidewalks or bike lanes exist, it is assumed that many pedestrians and bicyclists will use the shoulders to travel.

The crash analysis indicated that 77% of bicycle-involved crashes and 71% of pedestrian-involved crashes occurred on roadways with shoulders that are less than 4 feet in width. As would be expected with the small quantity of bike lanes present on the roadway network, a high percentage (87%) of bicycle crashes occurred at locations without bike lanes present. Conversely, 81.5% of bicycle crashes and 75% of pedestrian crashes occurred at locations where sidewalks ***are*** present. While sidewalks are important for reducing bicycle and pedestrian crashes, this data indicates that the majority of crashes that have occurred on CDOT Region 4 roadways were not the result of a lack of sidewalks. It should be noted that in some cases, bicyclists are prohibited from riding on sidewalks.

[14] Proven Safety Countermeasures - Walkways - Safety | Federal Highway Administration (dot.gov)

[15] *Desktop Reference for Crash Reduction Factors*, FHWA-SA-08-011, Table 11

Figure 29: Sidewalk & Crash Locations

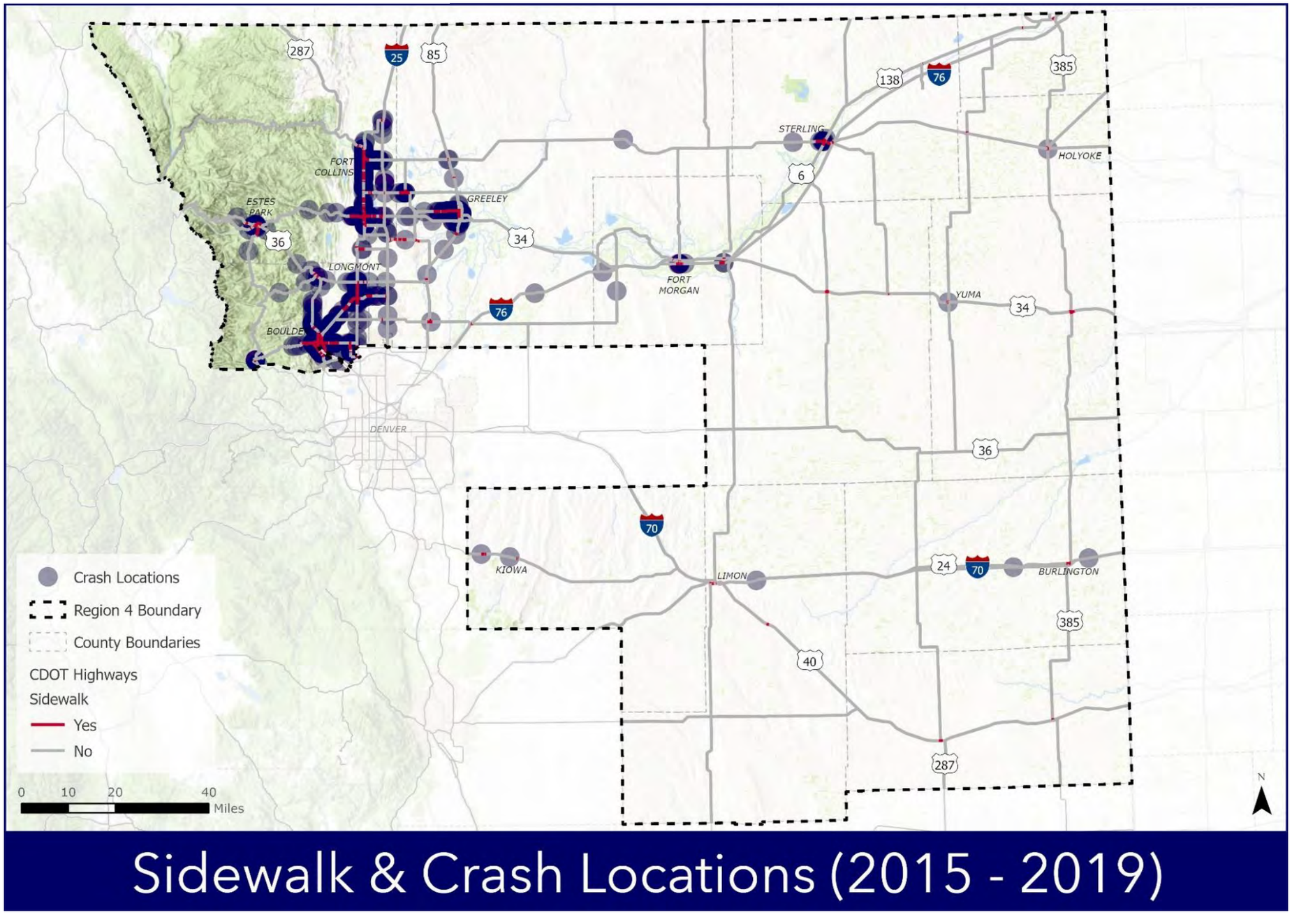
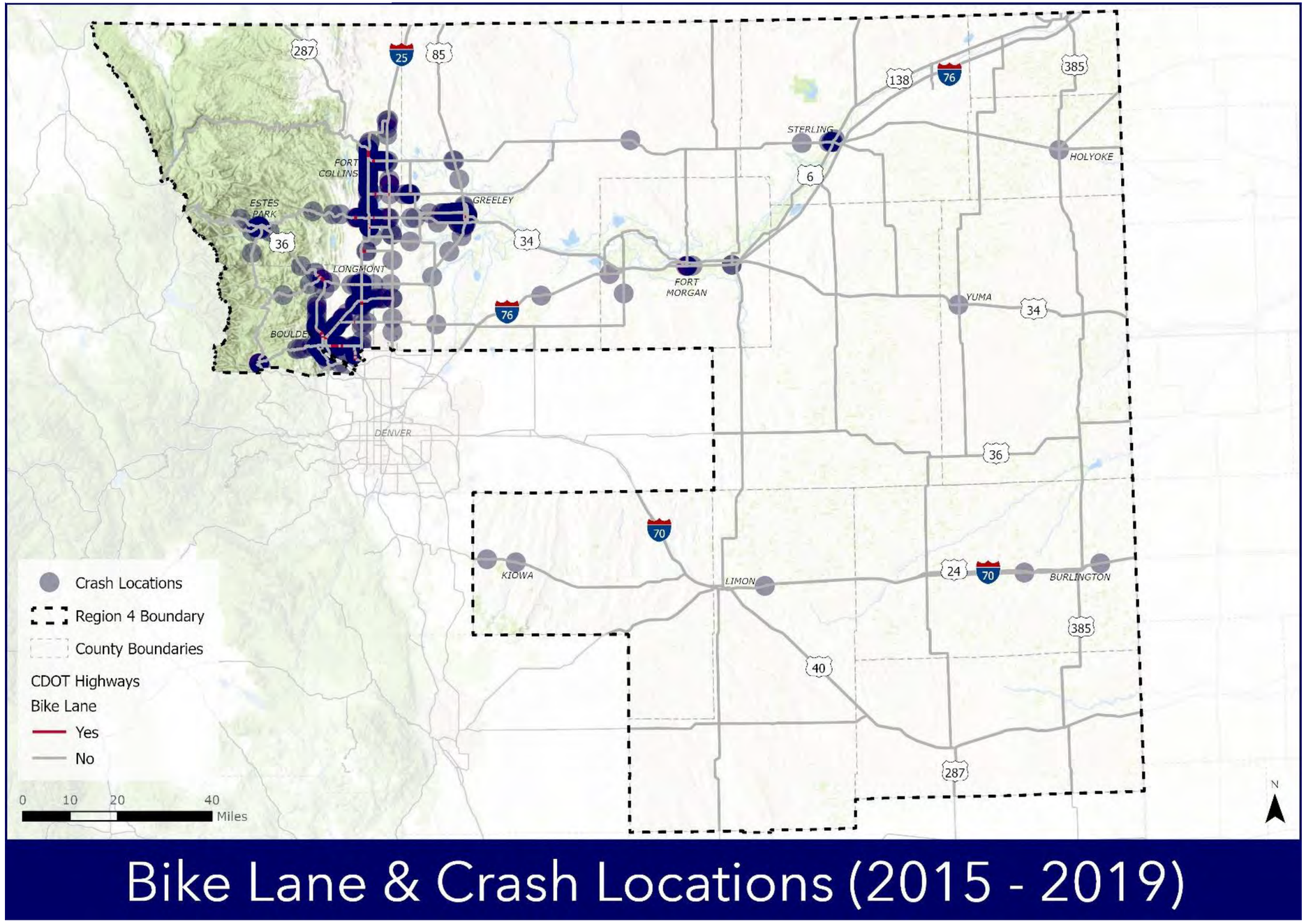


Figure 30: Bike Lane & Crash Locations



Bike Lane & Crash Locations (2015 - 2019)

Looking at the data another way, Table 13 shows the relationship between shoulder width/type and the presence of sidewalks. The purpose of analyzing this data is to identify whether sidewalks are present at crash locations where shoulders are narrow or lacking. The data indicates that nearly 100% of crashes occurring on urban roads with a curb or without a shoulder, do have a sidewalk present. On rural roads, over half of crashes occur on roads with a curb or without a shoulder, but with a sidewalk. The results are quite the opposite on roads with a narrow to average (6 ft or less) shoulder. On roads with narrow to average shoulder widths, no sidewalks are present at 100% of the crash locations with gravel shoulders and on average, 75% of crash locations with paved shoulders. Notably, approximately half of crashes occurring on urban roadways with wide shoulders, also have sidewalks present.

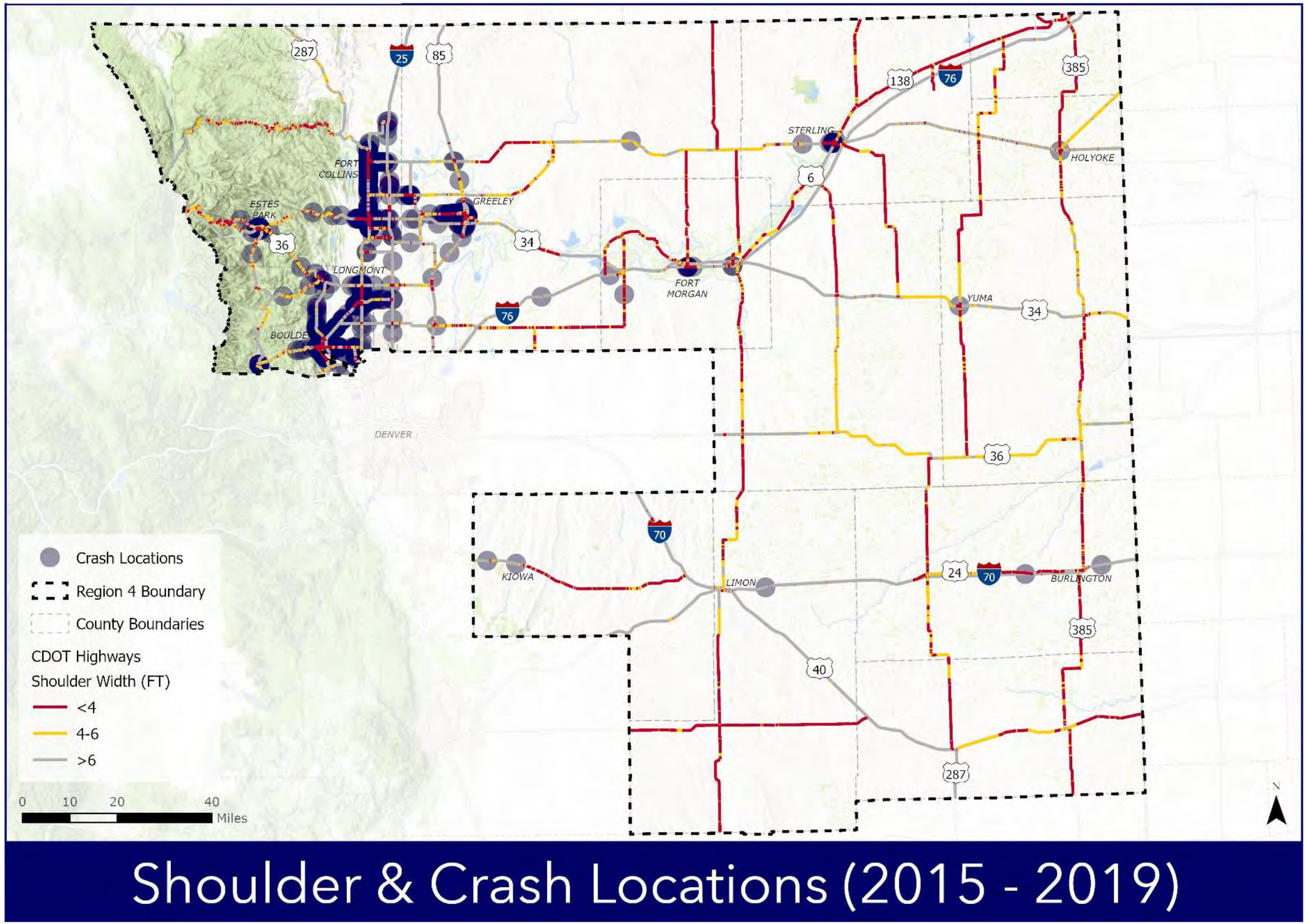
Table 13: Relationship between shoulder width/type and presence of sidewalks

	Number of Crashes							
	Urban				Rural			
Shoulder Type	Sidewalk	%	No Sidewalk	%	Sidewalk	%	No Sidewalk	%
No Shoulder	51	96%	2	4%	2	67%	1	33%
Curbed	1006	97%	32	3%	6	55%	5	45%
Narrow to Avg Width (6 ft or less) and Gravel	0	0%	6	100%	0	0%	4	100%
Narrow to Avg Width (6 ft or less) and Paved	11	38%	18	62%	1	13%	7	88%
Wide (>6 ft) and Gravel	7	54%	6	46%	2	22%	7	78%
Wide (>6 ft) and Paved	50	45%	61	55%	1	3%	28	97%

Figure 29, above, shows the location of sidewalks within the region. While the majority of roadways do not have sidewalks, crashes generally occurred in the urban areas where sidewalks are present. When comparing the total number of crashes with miles of road that have sidewalks and bike lanes, the number of crashes per mile is significantly higher in areas where sidewalks and bike lanes are present. This could be explained by the fact that 92% of crashes occurred in urban areas, where sidewalks are primarily located, and 70% of crashes occurred at or near intersections, which is where bike lanes are generally located. Further, the high crash per mile results associated with the presence of sidewalks and bike lane indicates that presence of bicycles and pedestrians may be higher at signalized intersections in the urban areas and additional treatments are needed to allow them to safely cross major roads or intersections.

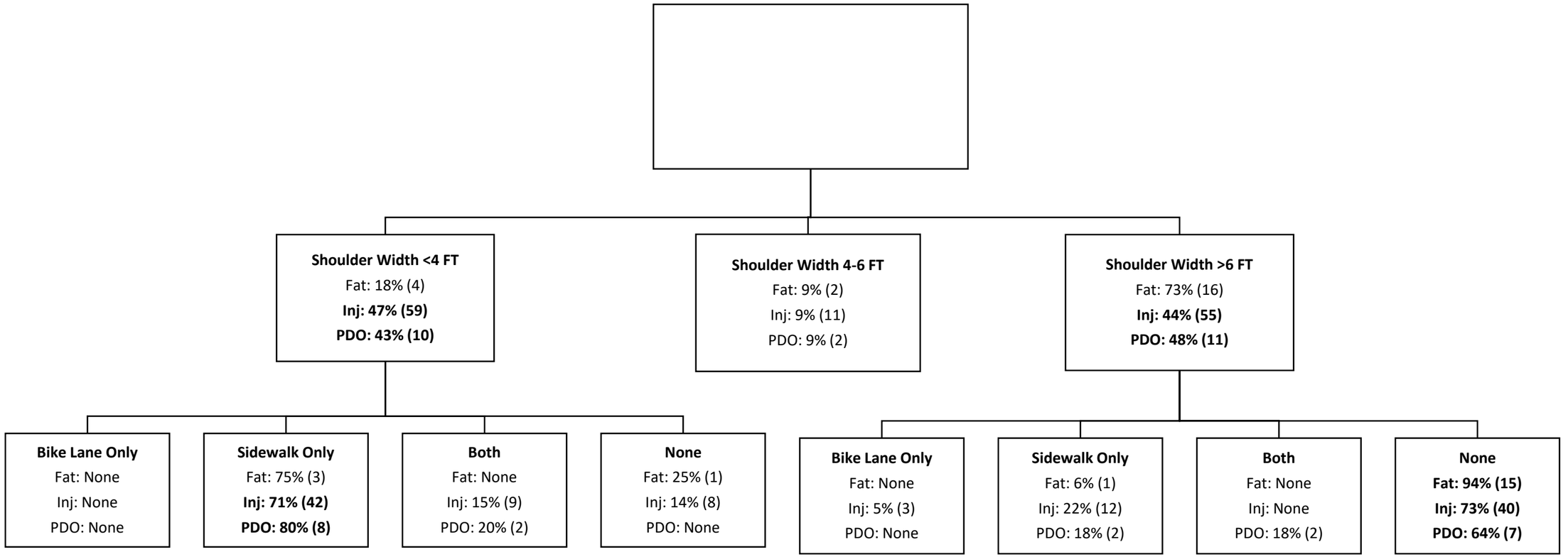
Figure 31 shows the relationship between shoulder width and crash locations. To better understand whether adequate “walkways” were present at non-intersection related crashes, Figure 32 shows the relationship between non-intersection crashes, shoulder width, and the presence of sidewalk or bike lanes. Based on this information, in most of the non-intersection crashes that occurred on roadways with narrow shoulders (<4 feet), sidewalks or a combination of sidewalks and bike lanes were present. Additionally, most non-intersection crashes that occurred on roadways with a wide (>6 foot wide) shoulder did not have sidewalks or bike lanes. This indicates that either sidewalks or wide shoulders are generally present at non-intersection crash locations, though this could also indicate that bicyclists and pedestrians use roads with shoulders and sidewalks at a much higher rate than roads without them.

Figure 31: Shoulder Width & Crash Locations



Shoulder & Crash Locations (2015 - 2019)

Figure 32: Relationship Between Non-Intersection Crashes, Shoulder Width, Sidewalks and Bike Lanes



Median Type

Table 14: Median Type Crash Summary

Potential Risk Factor	Categories	Total # of Crashes	Total % by Type	Total # of Crashes	Total # Lane Miles	Crashes / Lane Mile
Median Type	Depressed	67	8%	67	434.0	0.15
	Raised	125	15%	125	19.7	6.35
	Channelized - Raised	262	31%	262	28.5	9.18
	Painted	146	17%	146	43.4	3.37
	Parking	14	2%	14	0.6	25.41
	None	222	27%	222	2018.1	0.11

***Defined**: Medians provide separation between motorists driving in opposing directions. Interstates and freeways generally have depressed medians and two-lane roads typically have none. Two unique median types included in CDOT's data are "channelized-raised curb" which is generally a 4-foot-wide median that provides channelization between opposing left turn lanes, and "parking" which is parking within the right-of-way that is separating opposing directions of vehicular travel.*

As shown on Figure 33, the crash analysis shows that the majority of bicycle and pedestrian crashes occurred on either roads with a Channelized - Raised Curb (31%), or no median (27%). Channelized – Raised Curbs (Figure 34) are typically found in areas where high concentrations of access to adjacent properties are provided. They designate where left turn access can be provided or where access will be restricted to only right-in and right-out movements. While these types of medians are helpful for restricting some conflicting turning movements, the left turn restrictions typically result in additional U-turn movements and weaving maneuvers as motorists cut across traffic to get into the turn lane so they can make a U-turn and head in the opposite direction. The shorter the distance between allowable left turn movements, the less time a motor vehicle has to get across the road, but the more distributed the U-turn movements. Roadways with Channelized – Raised Curbs should be evaluated to identify whether providing additional distance between median openings and allowable left turn movements would improve safety. Some considerations that should be evaluated include, proximity of access points to the median opening (this will influence the danger of weaving movements), volume of traffic at the intersection (U-turn maneuvers take longer to make than left turn movements), and space to comfortably make a U-turn maneuver.

Since *Channelized - Raised Medians* typically occur in areas with a high density of driveways and intersections, this indicates that driveway density could be a high, risk factor. During the functional classification discussion, it was also noted that the introduction of access points on higher speed roads results in more bicycle and pedestrian crashes, so managing access may be a solution to improve safety on these types of roads. One of FHWA's proven safety countermeasures is "Corridor Access Management"[16], which is proven to reduce fatal and injury crashes on urban/suburban arterials by 25-31%. FHWA states that every intersection, from a signalized intersection to an unpaved driveway, has the potential for conflicts between motor vehicles, pedestrians, and bicycles. Additionally, they state that the

[16] Proven Safety Countermeasures - Corridor Access Management - Safety | Federal Highway Administration (dot.gov)

number and types of conflict points, and locations where the travel paths of two users intersect, influence the safety performance of the intersection or driveway.

Figure 33: Number of Crashes by Median Type

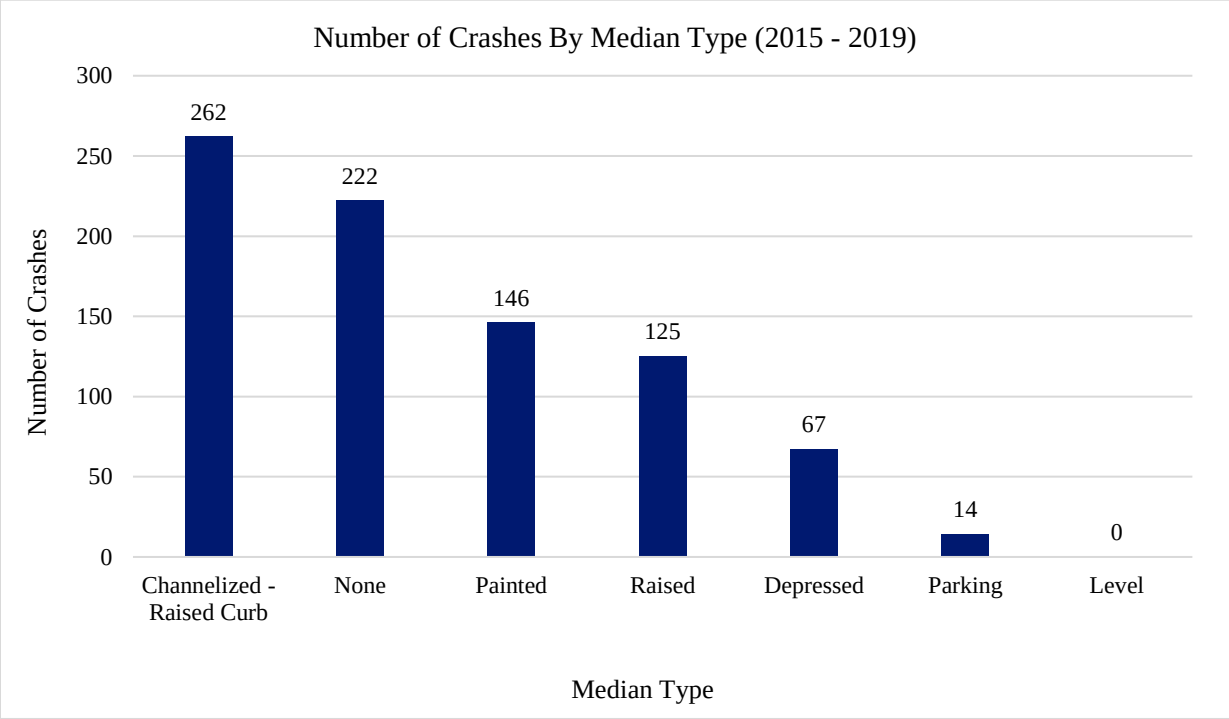


Figure 34: Example of Channelized – Raised Curb

Roadways with no median experienced 27% of crashes, but 80% of roads do not have a median, so the ratio of bicycle and pedestrian crashes per lane mile is much smaller for this type of road (0.11). Figure 35 shows the location of each of the median types in relation to the reported bicycle and pedestrian crashes. When compared with the number of lanes map, it appears that the majority of roadways with no median are 2-lane roadways.

In addition to roadways with *Channelized – Raised Curbs*, the evaluation of crashes per lane mile also brings to attention those roadways with parking in the median (Figure 36). This unique characteristic occurs only on 6/10^{ths} of a mile on US 287 in Fort Collins. An example of this condition is shown in Figure 37. When considering the short segment of road where this occurs, it is surprising that 14 crashes occurred here, resulting in 25.41 crashes per lane mile.

The high ratio of bicycle and pedestrian crashes per lane mile on this section of US 287 likely stem from the following factors.

- Motorists are pulling into and out of parking spaces on both sides of the road, plus in the median,
- Pedestrians are crossing the road at all points along this segment, traveling to and from their parked motor vehicles, and
- Bikes are prohibited from riding on the sidewalks.

All of these factors create a significant number of conflict points for roadway users. It has been noted that Fort Collins constructed a parking garage within a short distance of this location, which may provide adequate parking if the median parking were removed, but the removal of parking spaces typically comes with significant push back from businesses and property owners. Any changes to this situation would likely require additional analysis and justification to support removal of these spaces.

Figure 35: Median Type & Crash Locations

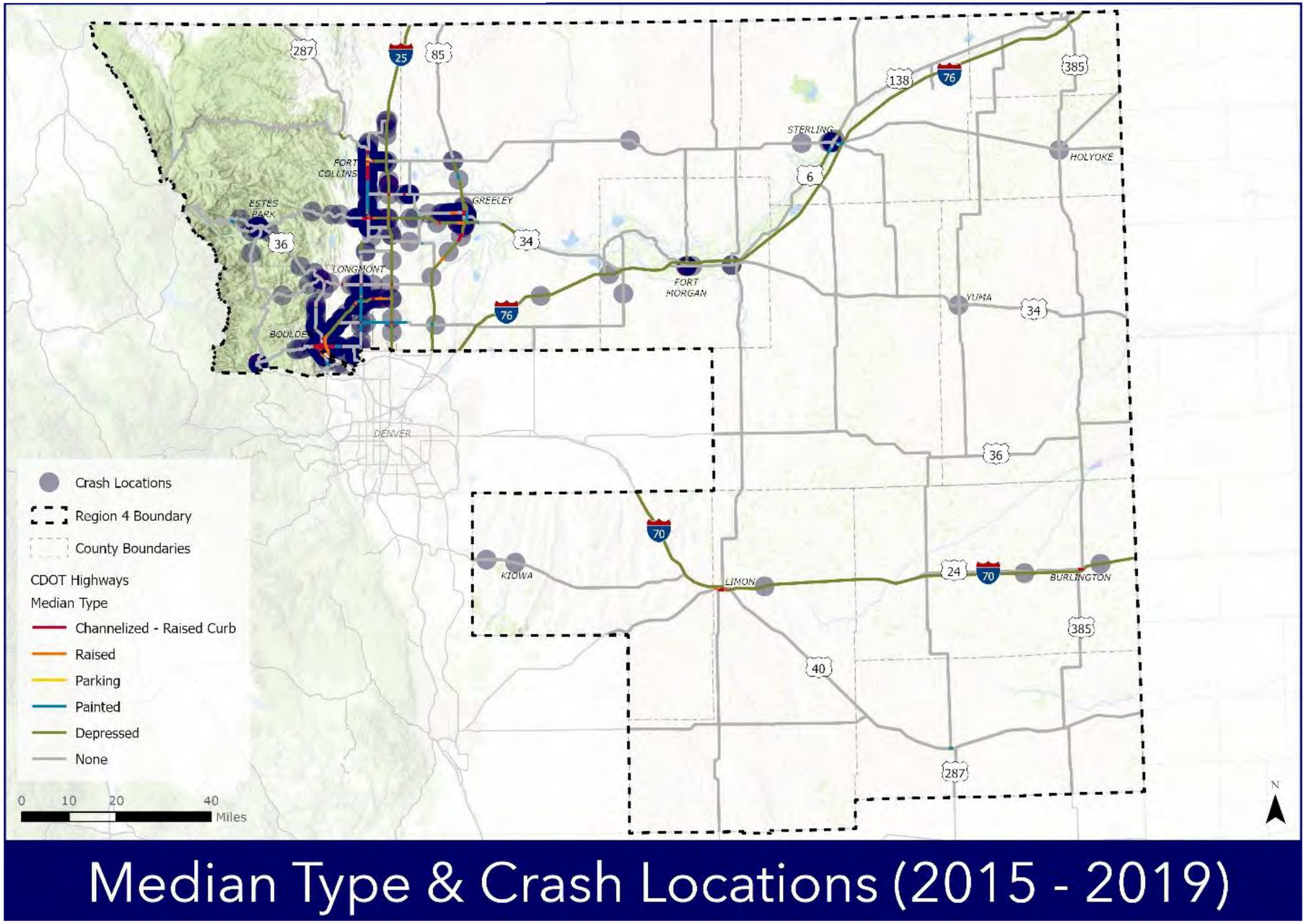


Figure 36: Number of Crashes Per Lane Mile

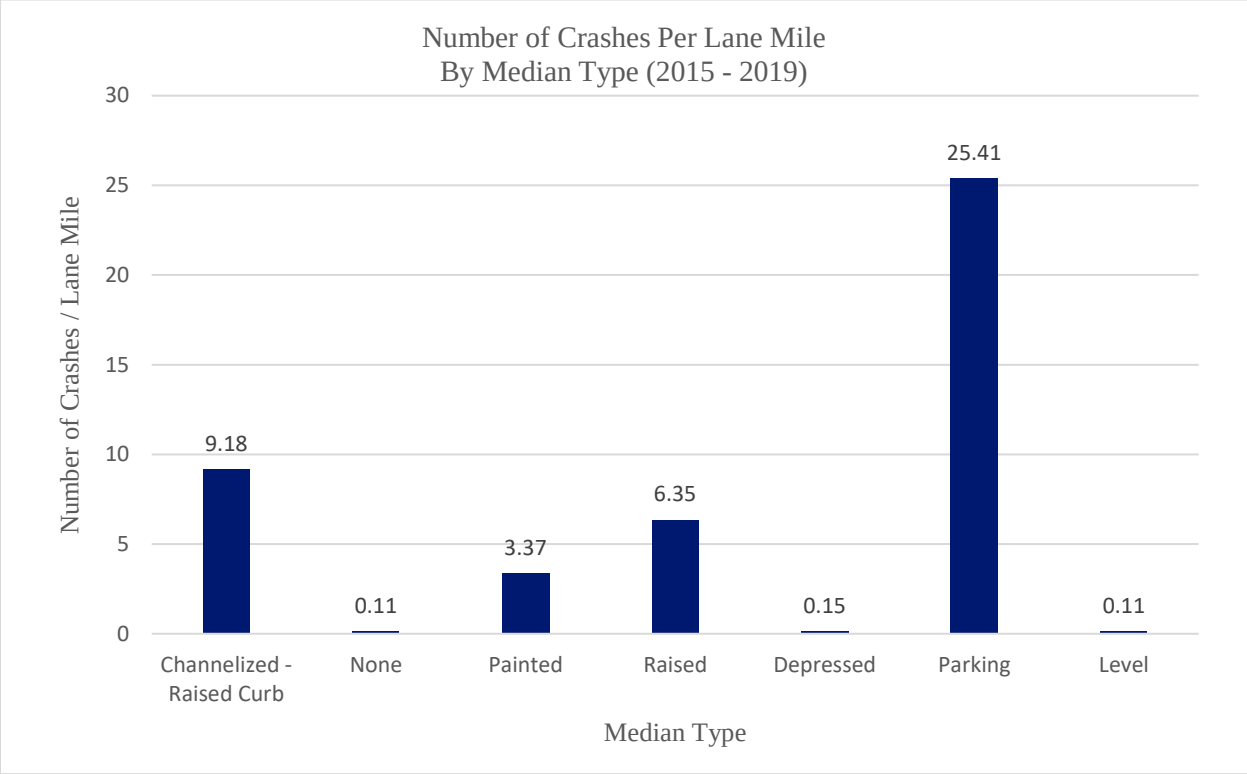


Figure 37: Example of Parking in the Median

PMT #2 – Discuss Crash Analysis and Network Screening

The second PMT meeting was held on August 12, 2021, and included an overview of the results of the crash analysis and network screening elements. The PMT was polled after showing the crash results and crash scoring. When asked whether the results made sense, 83 percent responded affirmatively. After providing an overview of all risk factors studied, the PMT was asked what three elements they believed were the highest risk factors. The results showed speed limit as the highest perceived risk factor (29%) followed by number of lanes (18%), shoulder width (16%), and Average Annual Daily Traffic (AADT) (15%).

Systemic Risk Scores

To better understand which roads on the CDOT roadway network have greater potential risk to bicyclists and pedestrians, risk scores were applied to each of the risk factors outlined in the sections above. The scores were developed based on the relative level of risk (as described below) that each risk factor adds to the roadway network and approved by the Project Management Team (PMT) during the third PMT meeting before proceeding forward. The applied risk scores are shown in Table 15 below.

Systemic Analysis Summary

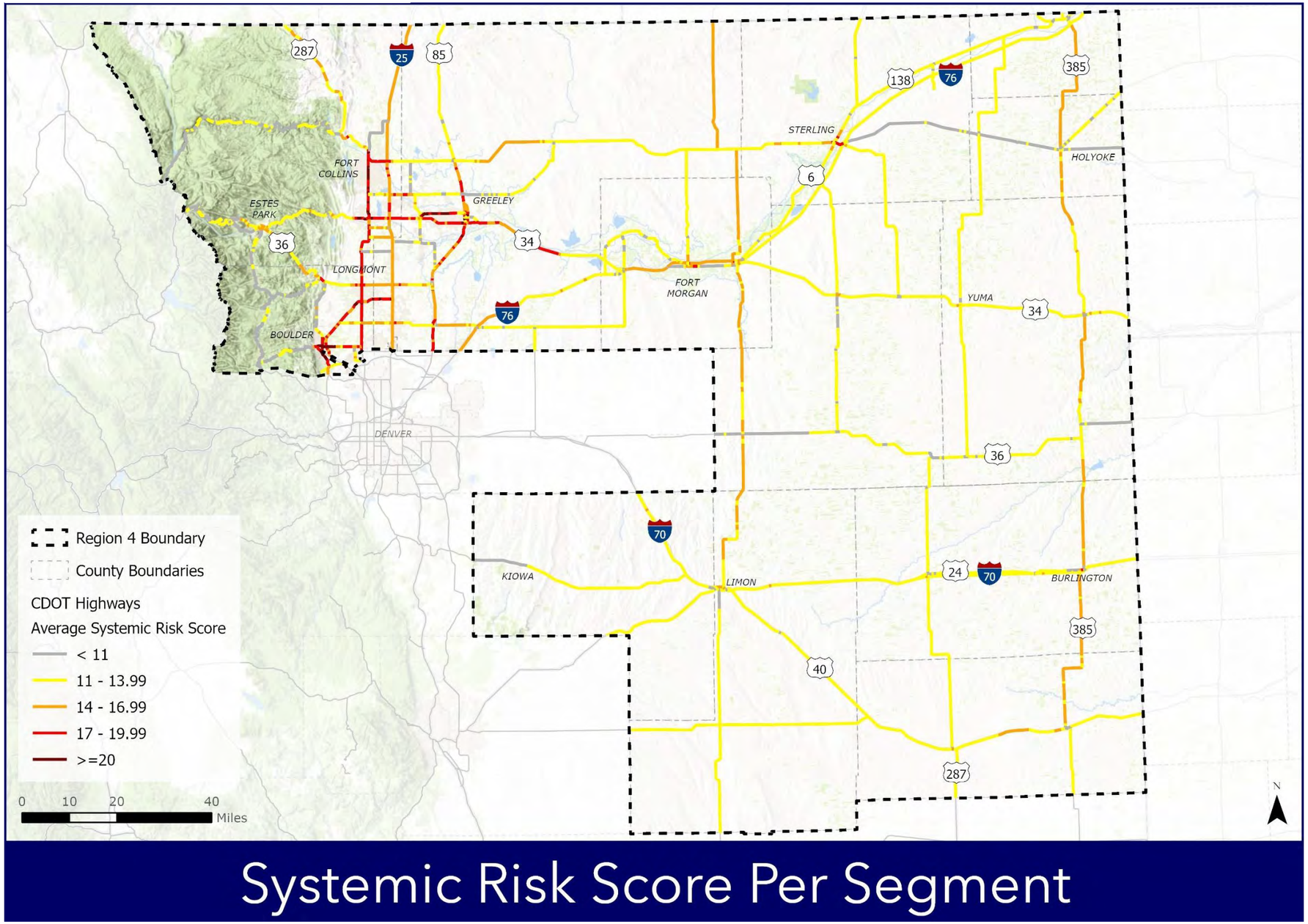
A total of eleven potential risk factors were evaluated to identify the level of risk they pose to bicyclists and pedestrians on the Region 4 roadway network. The evaluation included research on proven safety countermeasures, national statistics, existing reports and studies, and crash reduction factors to determine the true correlation between the analysis results and the level of risk for bicyclists and pedestrians. Considering all the relevant information, scores were applied to each of the risk factors indicating a relative level of risk. The scores were then applied to each of the ½ mile roadway segments created during the crash analysis to show those roads with an increase in level of risk.

Table 15: Systemic Risk Scoring

		All Bicycle and Pedestrian Crashes		
2015 2019 Crash History		**Total # of Crashes**	**Total % by Type**	**Risk Score**
Overall Numbers	Total # of Crashes	836	100%	N/A
By Jurisdictional Classification	Urban	773	92%	1
	Rural	63	8%	0
By Location	Intersection	586	70%	N/A
	Driveway	80	10%	N/A
	Non-Intersection	170	20%	N/A
By Functional Classification	Interstate	20	2%	0
	Freeway & Expressway	80	10%	1
	Principal Arterial - Other	649	78%	2
	Minor Arterial	80	10%	0
	Major Collector	7	1%	0
	Minor Collector	0	0%	0
	Local	0	0%	0

By Light Condition	Daylight	564	67%	-
	Dark - Lighted	152	18%	-
	Dark - Unlighted	73	9%	-
	Dawn or Dusk	47	6%	-
	No Street Lights	-	-	1
	<=26 Street Lights	-	-	0.5
	>26 Street Lights	-	-	0
By Speed Limit	<=30 mph	171	20%	2
	35 mph	242	29%	3
	40 mph	155	19%	4
	>=45 mph	268	32%	5
By AADT	<= 9,000	63	8%	0.5
	9,001-12,000	48	6%	1
	12,001-15,000	47	6%	1.5
	>15,000	678	81%	3
By Number of Lanes	2	102	12%	0
	3	47	6%	2
	4+	687	82%	4
By Shoulder Width	< 4 feet	620	74%	4
	4 - 6 feet	50	6%	2
	> 6 feet	166	20%	0
By Presence of Sidewalk	Yes	659	79%	0
	No	177	21%	1
Presence of Bike Lanes	Yes	94	11%	0
	No	742	89%	1
By Median Type	Depressed	67	8%	0
	Raised	125	15%	1
	Channelized - Raised	262	31%	2
	Painted	146	17%	1
	Parking	14	2%	5
	None	222	27%	1

Figure 38: Systemic Risk Score Per Segment



MetroQuest Online Survey

Overview

The MetroQuest survey was open for 9 weeks, between July 12, 2021, and September 6, 2021. Over 1,000 people participated in the online survey. Survey participants were asked to provide general input and ideas, thoughts on obstacles they face walking and biking within the region, and general input and ideas on a map of the region. Participants provided over 2,400 data points on the mapping portion of the survey. The feedback indicated preferences for types and locations of safety improvements, areas where safety was of concern, and locations where bicycle and pedestrian demand exists. A summary of the survey results is provided below. A comprehensive overview of the survey and the respective results are provided in Attachment 1.

Survey Summary

What Obstacles Do You Face?

Participants were asked to rank the obstacles they faced regarding bicycle and pedestrian movement and safety. The highest survey responses were 'Unsafe Traffic Conditions' (844 responses), 'Lack of Sidewalks/Paths (842 responses), and 'Unsafe Crossings' (813 responses). 'Unsafe Traffic Conditions' was defined as motor vehicle speeds being too high or motor vehicles not yielding to bicycles or pedestrians. Many participants pointed to the need for distinct spaces for bicycles, pedestrians, and motor vehicles and general education about how various modes should interact when encountering one another. The next tier of responses included 'Distance to Destination', 'Poor Lighting', and 'Safe Routes to School', and received approximately 500 responses. At the bottom of the ranking was 'Physical Health' with 158 responses.

Tell Us What You Think

The survey collected demographic data about each participant and asked them questions about how they traveled, if they currently bike and walk in Region 4, and how easy they find biking and walking. The majority of survey participants were white, between the ages of 55 and 74, and their primary language spoken was English. Most survey respondents own both a bike and a car, and walk or bike for exercise, leisure, or as a means of transportation. Slightly more survey respondents found it "Very Easy" or "Somewhat Easy" (474 participants) to bike and walk in Region 4, compared to the survey respondents who found it "Somewhat Difficult" or "Very Difficult" (300 respondents). Given that the majority of respondents bike for exercise or leisure (over 1400 respondents), it makes sense that biking and walking facility barriers are not preventing people from using the CDOT Region 4 roadways to walk and bike.

Table 16 shows participants responses when asked where they would like to see improvements in Region 4 for biking and walking.

Table 16: MetroQuest Requested Locations for Improvements

	I would like to see improved conditions for bikes and pedestrians (select top 2):	Responses
1	Across high-speed/volume roads	486
2	On main streets	335
3	At intersections	237
4	Within my immediate community	125
5	Between my community and adjacent communities	278
6	On rural roads	150
7	Other (write details below)	51

The survey also provided open ended questions allowing participants to provide ideas for improvement. There were over 2000 additional ideas for how to improve connections for bikes and pedestrians. These ranged from physical improvements like detached bike lanes, wider shoulders, signage to inform and educate drivers and multi-modal trail users about walking and biking, underpasses at high-traffic crossings, and flashing crossing signals to ideas about connections and complete biking and walking networks that link neighborhoods and nodes through a robust system for walking and biking that parallels the current vehicular connection network.

Participants were asked "What can CDOT do?". The replies to this question mirrored the answers to the question about how to improve conditions for bikes and pedestrians. The top responses (by category) were:

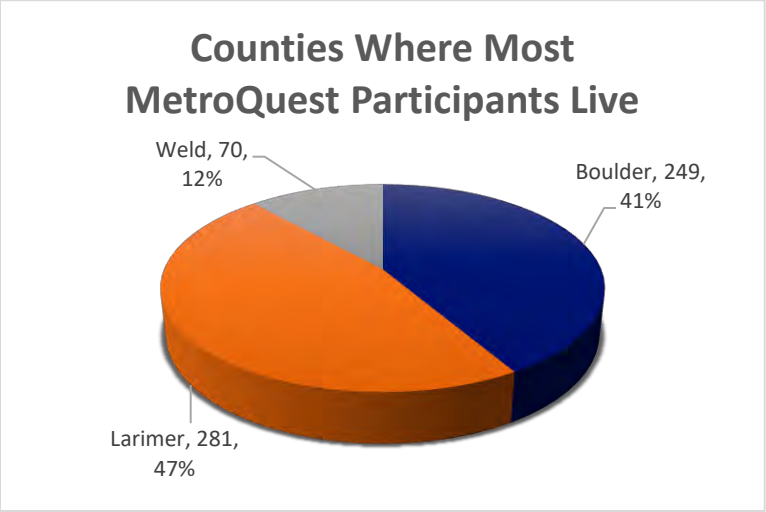
- Complete the network
- Separate bicycle and pedestrian facilities
- Make biking and walking a systemwide priority
- Ensure adequate maintenance
- Improve the user experience, and
- Encourage driver etiquette, awareness, and education

Participants were also asked where they would like to see bicycle or pedestrian connections on or across CDOT roads. There were many specific examples of locations where survey respondents would most like to see bicycle or pedestrian improvements along CDOT Region 4 roads, but the common thread among survey respondents was the desire to prioritize these improvements where crash data indicates a need.

Tell Us About You

The final questions on the survey were intended to better understand where participants were from and whether they were associated with or representing a bicycle or pedestrian advocacy group. As shown on Figure 39, the majority of participants were from Larimer County (281 participants), followed by Boulder County (249 participants) and Weld County (70 participants). The remaining counties had less than 15 participants each. This distribution is representative of the heavy population centers within the region.

Figure 39: Counties Where Most MetroQuest Participants Live



Of the participants that responded to the question about whether they were associated with an advocacy group, just over 100 participants answered 'yes', and approximately 550 participants answered 'no'. The two most common advocacy groups mentioned were Boulder Mountainbike Alliance (BMA) and Estes Park Cycling Coalition.

Interactive Map

Participants were directed to drag and drop at least three map markers on the interactive map. A total of 2,433 markers were placed. As shown on Figure 40, the top marker placed was 'poor biking condition'. Figure 41 shows the reasons stated for 'What makes it hard to bike here?', which included the lack of bike lanes or bike pavement markings, followed by narrow roadway shoulders.

Figure 40: MetroQuest Map Marker Summary

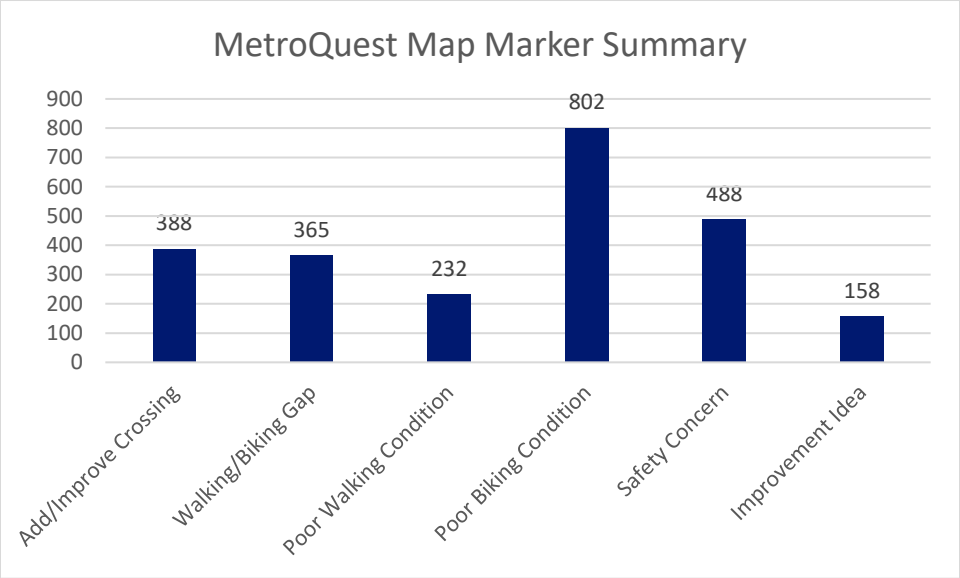
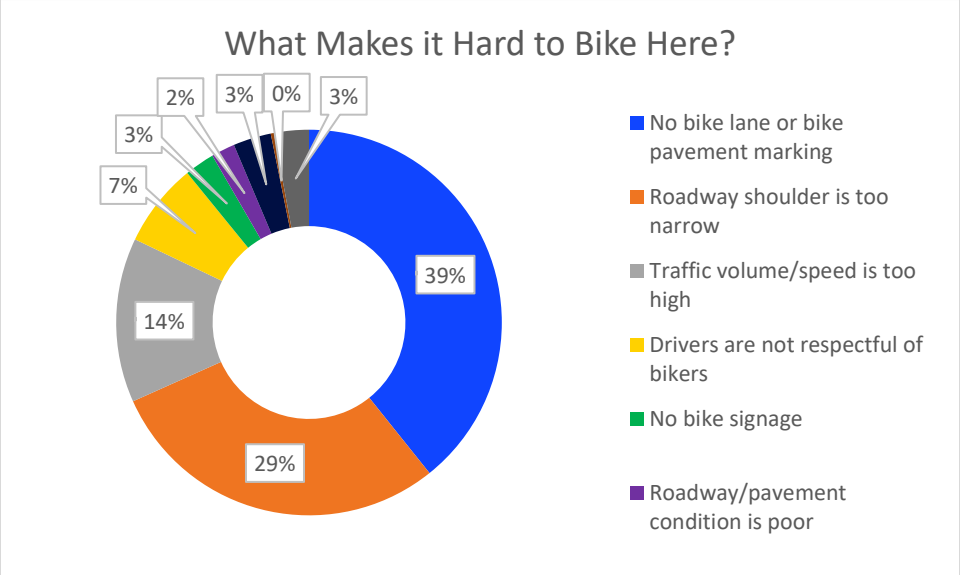
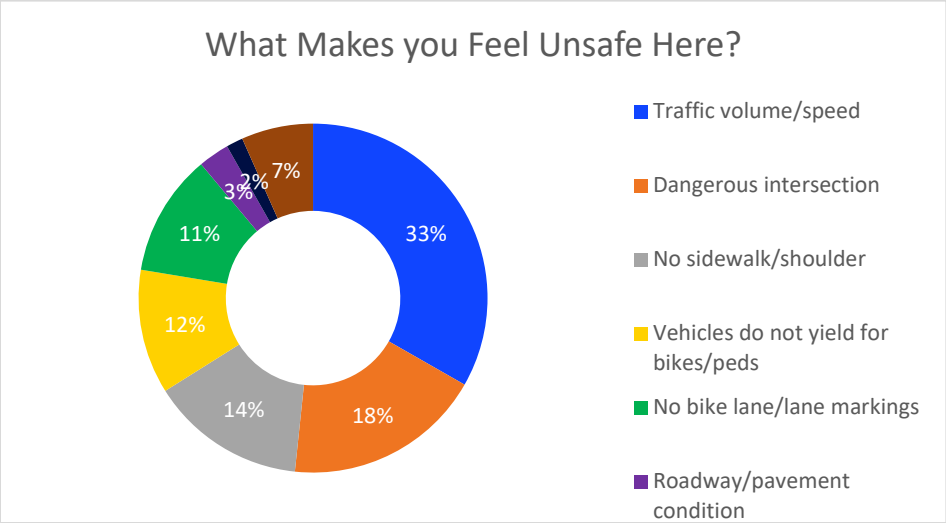


Figure 41: MetroQuest Response to 'What Makes it Hard to Bike Here?'



The second highest number of map markers were placed for 'safety concern'. As shown on Figure 42, below, when asked 'what makes you feal unsafe here?' participants top three responses were 'traffic volume/speed', 'dangerous intersection', and no sidewalk/shoulder.

Figure 42: MetroQuest Response to 'What Makes you Feel Unsafe Here?'



MetroQuest Heat Mapping

The 2,400 map markers placed on the interactive map and the open-ended responses provided on some of the map markers prompted a focus on factors that could not be measured with available data. Concentrations of map markers point to areas of demand for biking and walking within the region, while some of the open-ended responses point to other risk factors such as roadway curvature causing poor sight distance between motor vehicles and bicycles / pedestrians that were not measured during the systemic safety analysis.

Absent bicycle and pedestrian counts across the region, the MetroQuest data demonstrated where demand existed for bicycle and pedestrian infrastructure and where support for improvements was likely high due to the volume of comments received. Concentrations of participant comments were identified and are listed as MetroQuest hot spots in Table 17 below. A total of 14 hot spot locations were identified across the region. With awareness of data required to provide a successful safety grant application, the MetroQuest hot spot locations were cross referenced with the systemic risk scores. A higher risk score combined with data indicating demand and support for improvements is expected to produce a successful outcome when safety grant funding is sought. The resulting hot spot locations and respective systemic risk scores are outlined in Table 17 below.

Table 17: MetroQuest Hot Spot Locations

City	Location	Systemic Risk Score
Longmont	US 287 (Main St) from 3rd Ave to 6th Ave	18
Boulder County Unincorporated / Lafayette	CO 7 (Arapahoe Rd) from 75th Street to US 287**	15.5-18

Lyons / Unincorporated	US 36 (Ute Highway) from US 36 (N Foothills Hwy) to Lyons*	14.6-18.7
Estes Park	US 34 (E Elkhorn Ave) between US 36 (Moraine Ave) and US 36 (N St Vrain Ave)	15.2
Estes Park	US 34 (Big Thompson Ave) between Estes Park Visitor Center and the Stanley Village shopping center	14.8
Lyons	US 36 (W Main St) at Intersection with Apple Valley Rd*	14.1
Estes Park	US 34 between Sleepy Hollow Ct and Fish Hatchery Rd*	11.1 - 14.2
Estes Park	CO 7 (S St Vrain Ave) between US 36 and Peak View Dr	9.1 - 14.6
Boulder County Unincorporated	US 36 (N Foothills Hwy) from St Vrain Road to Boulder*	10.5-11.6
Estes Park	US 36 (Moraine Ave) between US 34 (Elkhorn Ave) and Rocky Mountain National Park Entrance Road	9.0 - 13.7
Lyons / Unincorporated	CO 7 (S St Vrain Dr) from Lyons to the Hall Ranch Trailhead (Bitterbrush Bike Path)	8.4-11.5
Wellington	CO 1 (Cleveland Ave) From N 1st St to Overpass	10.5-10.9
Boulder County Unincorporated	CO 119 (Boulder Canyon Dr) From Chapman Dr to Betasso Link Trail	8.8-10.1
Boulder County Unincorporated	CO 119 (Boulder Canyon Dr) at Intersection w/ Fourmile Canyon Dr	8.8

The projects noted above with a * or ** were not advanced to the top ten prioritization list for reasons explained below:
* Improvements currently in progress/funded that will address bicycle and pedestrian needs
** Several studies and projects have been identified and are currently in progress along this corridor that will address bicycle, pedestrian, and transit needs.

PMT #3 – Discuss Priority Crash Locations, Risk Scores, and MetroQuest

The third PMT meeting was held on September 30, 2021, and included an overview of bicycle and pedestrian crash hot spots, the MetroQuest results, and MetroQuest hot spots. PMT members were presented with graphics showing the distribution of crashes on the high scoring crash locations and a list of crash hot spots that resulted from this evaluation. When asked about the level of support members had for the process by which bicycle and pedestrian crash hot spot locations were selected, members either agreed, strongly agreed, or were neutral. Members were then presented with the proposed scoring for the risk factors discussed in the prior PMT meeting, an overview of the MetroQuest results, and a list of top systemic locations based on a combination of hot spots in the MetroQuest data and risk scores. Again, PMT members supported the process for selecting top systemic locations, as well as the top locations.

TOP LOCATIONS

Overview

CDOT's goal for this study was to identify top locations based on typical crash analysis, but also to include systemic improvement locations based on the evaluation of roadway characteristics that indicate a higher level of risk for bicycles and pedestrians.

Top Crash Locations

Starting with the list of the bicycle and pedestrian crash hot spot locations provided in Table 2, seven top locations were identified. The top crash locations were selected based on the locations with the highest score. The intersection of US 34 and Taft Avenue in Loveland was among the hot spots with the highest scores, however, Loveland staff indicated that they were moving forward with a project at that location which would reconstruct the intersection and included bicycle and pedestrian improvements, as such that location was not included in the selection of top projects. The top seven bicycle and pedestrian crash locations are shown in Table 18, above.

Table 18: Top Crash Locations

Local Agency	*Top Crash Locations*
Longmont	**Intersection of US 287/23rd Ave**
Longmont	**Intersection of US 287/17th Ave**
Longmont	**Intersection of US 287/Mountain View Ave**
Longmont	**Intersection of US 287/9th Ave**
Longmont	**Segment of US 287 from Mountain View Ave to 9th Ave**
Fort Collins	**Segment of US 287 from Laurel Street to Laporte Ave**
Greeley	**Intersection of US 34/11th Ave**

Top Systemic Locations

Committed to identifying proactive safety improvements, CDOT selected the remaining three locations from the MetroQuest hot spot locations identified in Table 17, above. Starting at the top of the list, with the MetroQuest hot spot locations that had the highest systemic risk score, each location was evaluated, and a determination made as to whether that location should be included in the top 10. The location in Longmont was eliminated because five other Longmont locations had been selected through the crash analysis and CDOT wanted to provide an opportunity for other projects to come to the top. Other locations were eliminated because of current projects, studies or grant funding that would result in the evaluation of bicycle and pedestrian improvements, and additional locations were eliminated due to the lack of feasible bicycle or pedestrian improvements identified during prior evaluations. The top systemic locations are shown in Table 19.

Table 19: Top Systemic Locations

Local Agency	Top Systemic Locations	Notes
Estes Park	**US 34 from Moraine Ave to N St Vrain Ave**	Excluded portion that was part of the Downtown Loop project. Final segment is from Riverside Drive to St Vrain Ave
Estes Park	**CO 7 from US 36 to Peak View Dr**	
Estes Park	**US 36 from US 34 to the Rocky Mountain National Park (RMNP) Entrance Road**	Excluded portion that was part of the Downtown Loop project. Final segment is from Crags Dr to RMNP Entrance Road.

SAFETY COUNTERMEASURES

Overview

After selecting the top ten locations, an evaluation of each location was completed. Available bicycle and pedestrian crash data were reviewed to identify any patterns in the data or unique characteristics related to each location, and MetroQuest comments were reviewed to better understand existing concerns. Traffic counts were collected and reviewed, and field evaluations were conducted to gather a better understanding of the specific conditions of each site. Traffic patterns were observed, site specific challenges noted, and various safety countermeasures were considered. A high-level discussion of the evaluation is included below.

Crash Patterns, Field Observations, Countermeasures

During the evaluation of bicycle and pedestrian crash data one pattern occurred over and over. Bicycles, and sometimes pedestrians, traveling in the opposite direction to the traffic next to them, were many times overlooked. Motorists at the intersection or driveway would be stopped and looking left for a gap in traffic. Upon receiving the gap, drivers would proceed forward and hit a bicycle or pedestrian that had entered the crosswalk. In some of these cases, poor sight distance resulting from trees or buildings in close proximity to the intersection, or traffic signal cabinets and signs contributed to the occurrence of these crashes.

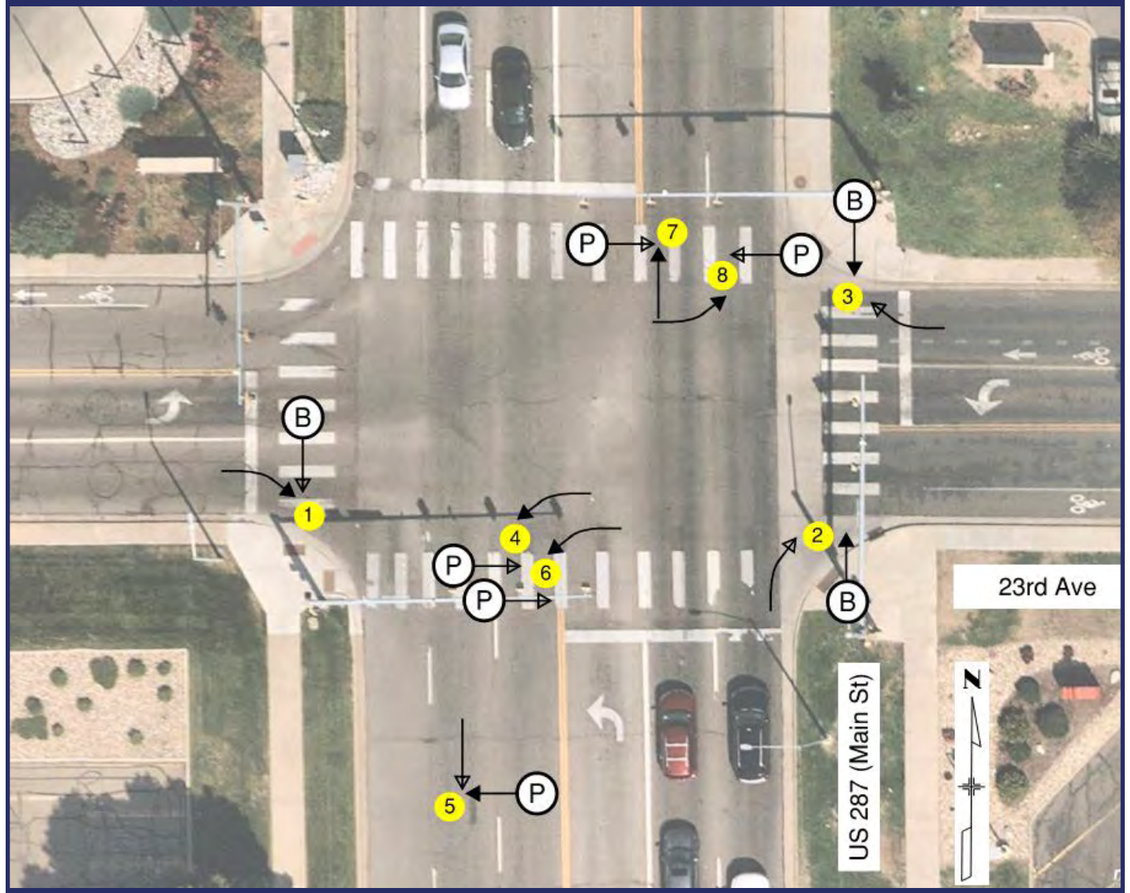
While observing the top locations in the field, there were a few common themes:

- As a result of high speeds and high volumes on CDOT roadways, motorists entering mainline traffic focus more on approaching motor vehicles than approaching bicycles or pedestrians
- Trees in the intersections typically result in poor sight distance to bicycles and pedestrians, or a lack of focus on bicycles and pedestrians,
- Traffic controller boxes are frequently placed in such a way that they cause sight distance issues between turning motorists and approaching bicycles or pedestrians,
- Intersection illuminance appeared lacking or poor in many cases,
- General maintenance was needed at many of these locations to bring existing conditions up to current standards.

A list of potential countermeasures for each site was identified based on an understanding of the crash patterns and field observations. For each of the top locations, a detailed summary of the crash results, field observations, and safety countermeasures are provided in Figures 43 thru 53, below

Figure 43: US 287 & 23rd Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram



P Pedestrian
B Bicycle
X PDO
X Injury
X Fatality
Vehicle 1
Vehicle 2
Turning
Angle

Crash Summary

- This intersection shows a pattern of bicycle crashes that occur when bicycles are traveling in the opposite direction of the vehicle traffic adjacent to them. As they approach the intersection during the pedestrian phase, right turning motorists stopped at the traffic light are looking left for a gap in traffic. Bicycles approach and enter the crosswalk as vehicles move forward and hit them.
- Pattern of left and right turning vehicles hitting bicycles and pedestrians in the crosswalk
- 50% of crashes occurred in dawn, dusk or dark but lit conditions.
- All but one of the at-fault persons whose ages were provided, fell between the age of 9 and 21.

Field Observations

- Diagonal curb ramps are not ideal as they don't align with crosswalks.
- Push buttons may not meet PROWAG or ADA requirements for accessibility.
- Right turning motorists looking for a gap to turn while not looking for conflicting pedestrians.
- Bicycle sharrow pavement markings on east leg are confusing as the sharrow is offset from the bicycle and arrow ahead symbols and old dashed pavement markings clutter the area.
- The northeast corner is not well lit at night.
- Bollard on northwest corner appears to have been previously struck by a vehicle.
- Vertical grade and sight obstructions on west side of intersection may create visibility conflicts with pedestrians/bikes traveling north/south with vehicles traveling east.

TOP Countermeasures

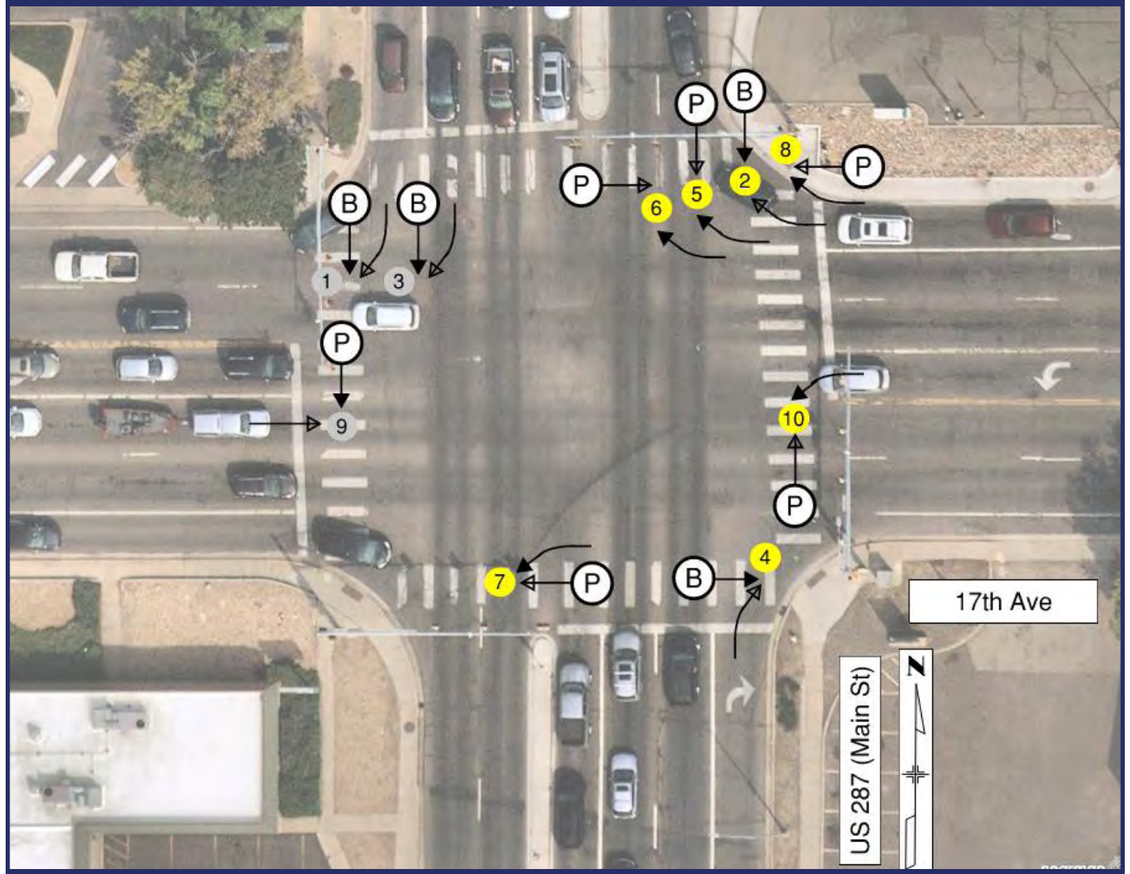
- On street bicycle lane improvements at the intersection
- Protective-permissive left turn signal when warranted (northbound and southbound)

Additional Countermeasures

- Improve intersection illumination
- Reflective backplates for signal heads
- "Turning traffic yield to ped/bike" signage
- General Maintenance (ADA, pavement surface, signal timings)

Figure 44: US 287 & 17th Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- (P) Pedestrian
- (B) Bicycle
- (X) PDO
- (X) Injury
- (X) Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- This intersection shows a pattern of bicycle crashes that occur when bicycles are traveling in the opposite direction of the vehicle traffic adjacent to them. As they approach the intersection during the pedestrian phase, right turning motorists stopped at the traffic light are looking left for a gap in traffic. Bicycles approach and enter the crosswalk as vehicles move forward and hit them.
- Pattern of left and right turning vehicles hitting bicycles and pedestrians in the crosswalk.
- 70% of crashes occurred between noon and 10:00pm
- 40% of at-fault persons are between the age of 54 and 75, another 40% were not reported
- 50% of crashes occurred between the hours of 11:00am and 1:00pm

Field Observations

- Right turning motorists looking for gap to turn while not looking for conflicting pedestrians.
- Northeast corner east/west sidewalk is 4.6 feet and backed by a retaining wall. The narrow sidewalk against back of curb puts pedestrians very close to moving vehicles.
- Nighttime lighting seems adequate.
- Bicycles primarily use the sidewalk to cross and travel.
- Curb ramps are less than ideal as they are not directional.
- Push buttons may not meet PROWAG or ADA requirements for accessibility.
- Ped "Walk" timing feels short.
- On street bike lane striping is not readily apparent at the intersection.
- Intersection pavement is showing signs of alligator cracking.
- Some crosswalk markings are faded.

TOP Countermeasures

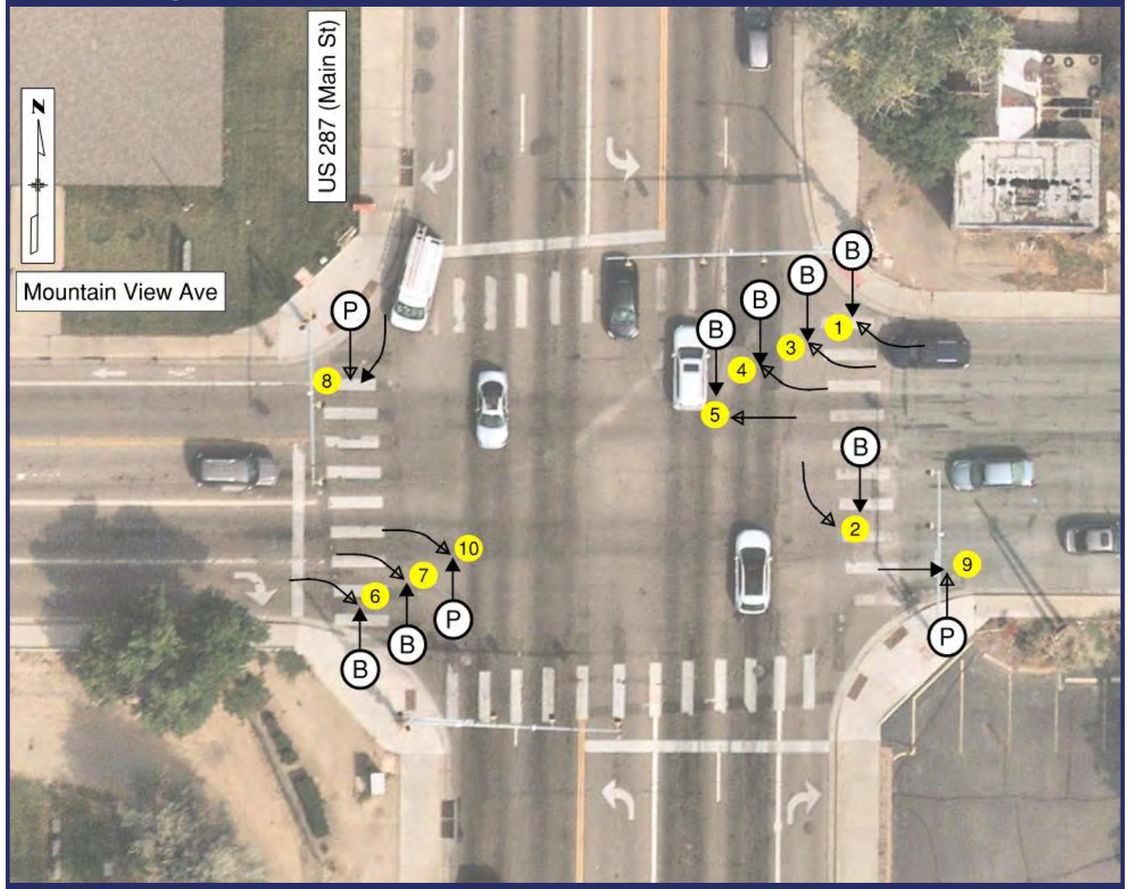
- On street bicycle lane improvements at the intersection
- Leading Pedestrian Interval and No Right Turn on Red

Additional Countermeasures

- "Turning traffic yield to ped/bike" signage
- General Maintenance (ADA, pavement surface, signal timings)

Figure 45: US 287 & Mountain View Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- (P) Pedestrian
- (B) Bicycle
- (X) PDO
- (X) Injury
- (X) Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- This intersection shows a pattern of bicycle crashes that occur when bicycles are traveling in the opposite direction of adjacent vehicle traffic. As they approach the intersection during the pedestrian phase, right turning motorists stopped at the traffic light are looking left for a gap in traffic. Bicycles approach and enter the crosswalk as vehicles move forward and hit them.
- All the bicycles are listed as at-fault (i.e. Vehicle 1). The crash reports noted a few are due to bicycles not dismounting before entering the crosswalk. This law has since been removed as it was not effective, and the definition of "dismount" was unclear.
- 60% of crashes occurred between noon and 6:00pm

Field Observations

- The building in the northeast corner of the intersection creates poor sight distance between westbound right turning vehicles and southbound traveling bicycles and pedestrians, approaching the intersection.
- Trees hanging over the sidewalk in the northeast corner of the intersection create shadows over the sidewalk making it more difficult to see approaching bicycles and pedestrians.
- The geometry of the pedestrian ramp and location of the signal controller cabinet and signal pole in the southwest corner of the intersection may encourage northbound bicycles and pedestrians into the road via the east/west ramp, which does not meet driver expectations for eastbound moving vehicles.
- Intersection illuminance could be improved.

TOP Countermeasure

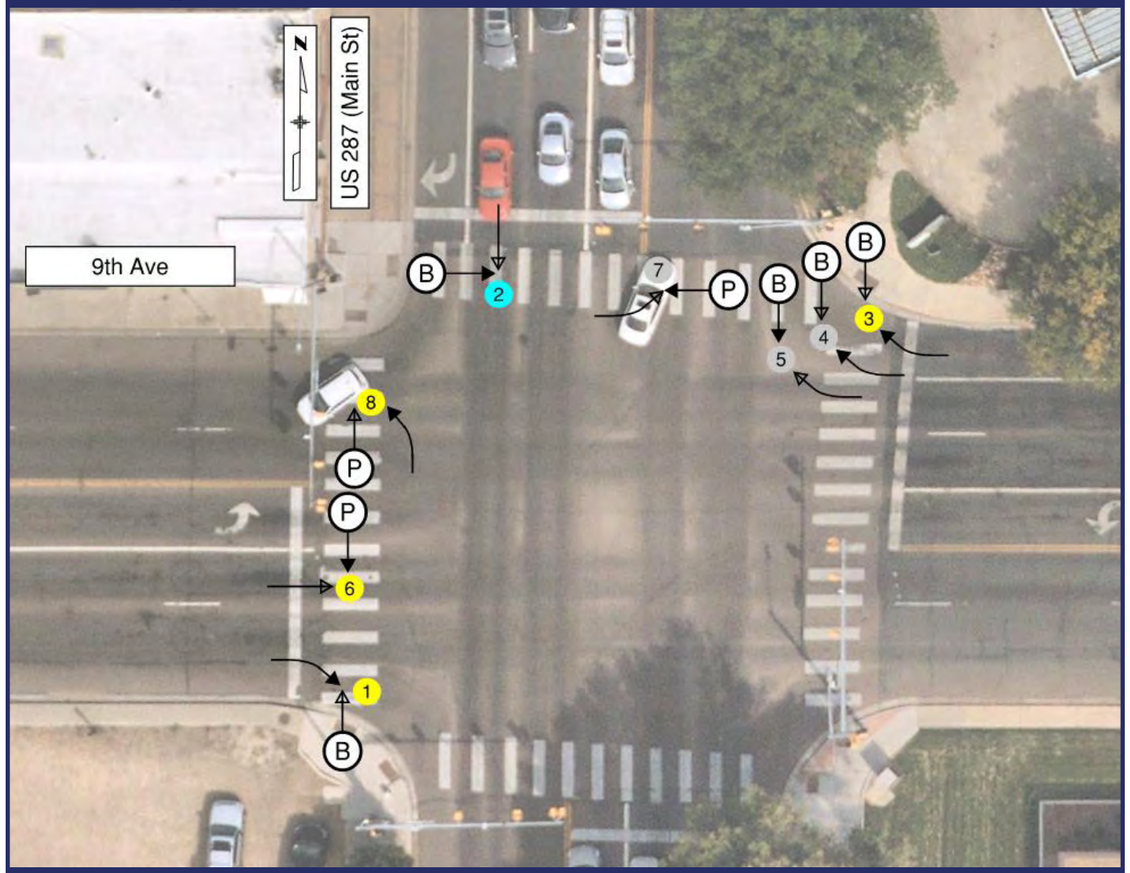
- LED illuminated border bicycle/pedestrian warning signage (W11-15) with passive pedestrian detection

Additional Countermeasures

- Increase intersection illuminance
- Relocate traffic signal cabinet and redesign curb ramp
- Restrict right-turn-on-red (RTOR)
- Signage
  - "No Turn on Red" (R10-11)
  - "Turning Vehicles Yield to Ped/Bike" (R10-15)
  - "Wrong Way" (R5-1b)/"Ride With Traffic" (R9-3cP)

Figure 46: US 287 & 9th Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- (P) Pedestrian
- (B) Bicycle
- (X) PDO
- (X) Injury
- (X) Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- This intersection shows a pattern of bicycle crashes that occur when bicycles are traveling in the opposite direction of adjacent vehicle traffic. As they approach the intersection during the pedestrian phase, right turning motorists stopped at the traffic light are looking left for a gap in traffic. Bicycles approach and enter the crosswalk as vehicles move forward and hit them.
- Two of the crashes, one of which was a fatality, involved a bicycle or pedestrian that walked in front of thru moving traffic.
- 75% of at-fault persons were between the age of 18 and 31
- 50% of crashes occurred in June or July

Field Observations

- The gas station sign in the northeast corner obstructs the view of bicycles and pedestrians traveling southbound toward the intersection. The location of the southbound sidewalk between the grass strip and the gas station parking lot also puts pedestrians at a place where drivers do not expect them.
- Westbound right turning motorists have poor visibility looking south at northbound through traffic due to the large trees in the southeast corner of the intersection. As a result, when making a right turn on red, vehicles primary focus is on finding an acceptable gap in northbound approaching traffic.
- The building in the northwest corner creates poor sight distance between southbound right turning vehicles and eastbound bicycles/pedestrians.
- Parking for northbound and southbound traffic is permitted within the influence of the intersection, resulting in poor intersection sight distance.

TOP Countermeasure

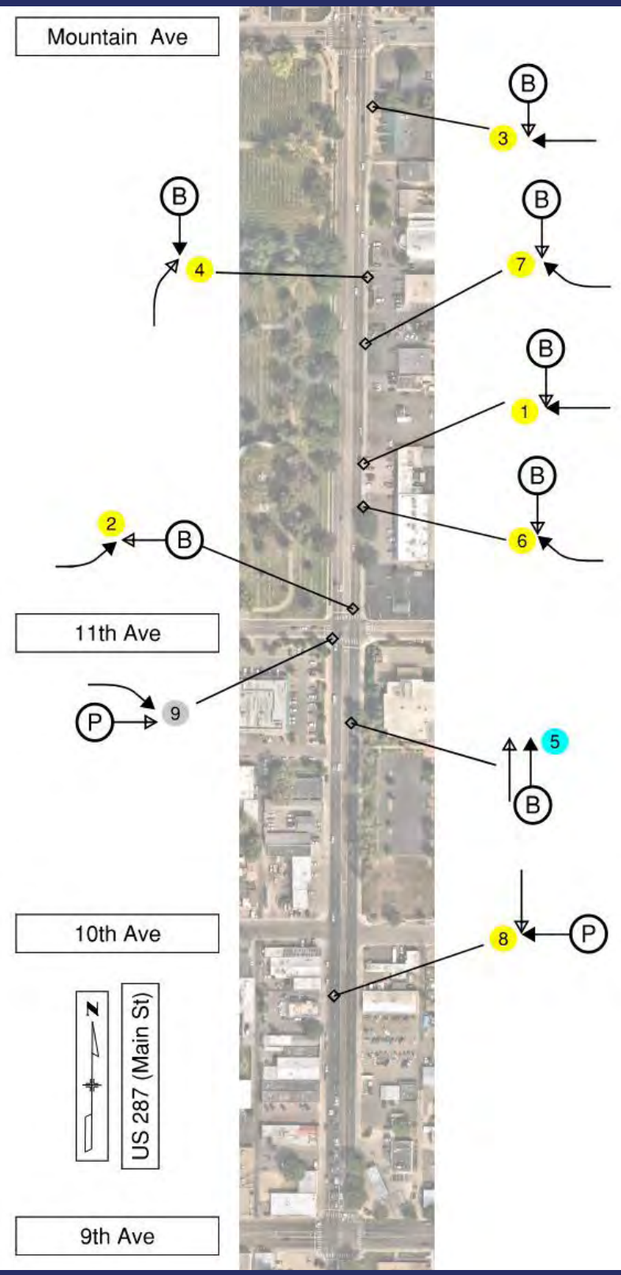
- Bulb-outs (southwest and southeast corners)
- Reduce turning radii (northeast corner) and narrow northbound outside through lane.

Additional Countermeasures

- Restrict parking on northbound and southbound approaches to the intersection
- Modify location of the gas station sign in the northeast corner to improve sight distance
- Signage
  - "Turning Vehicles Yield to Ped/Bike" (R10-15)
  - "Wrong Way" (R5-1b)/"Ride With Traffic" (R9-3cP)
- Signal Timing (if additional measures are needed beyond the top countermeasure)
  - Protected left turns on mainline
  - Restrict RTOR on side street and add overlap phase
  - Install Flashing Yellow Arrow (FYA) and utilize Leading Pedestrian Interval

Figure 47: US 287 from Mountain View Ave to 9th Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- (P) Pedestrian
- (B) Bicycle
- (X) PDO
- (X) Injury
- (X) Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- This segment shows a pattern of bicycle crashes that occur when bicycles are traveling in the opposite direction of the adjacent vehicle traffic. As bicycles approach driveways between Mountain View Avenue and 11th Avenue, motorists are looking left for a gap in traffic, bicycles approach as vehicles move forward into traffic, resulting in a crash.
- Nearly all crashes occurred between the hours of 11:00am and 6:00pm.

Field Observations

- High speeds on US 287 and a lack of right turn lanes into businesses on the east side between Mountain View Avenue and 11th Avenue result in northbound right turning vehicles traveling at high speeds into businesses in order to avoid being rear-ended.
- Observed vehicles exiting the businesses that were more focused on the approaching traffic than the bicycles or pedestrians on the sidewalk.
- Trees along the east sidewalk, between 11th Avenue and Mountain Avenue, create poor sight distance for vehicles exiting businesses.
- The sidewalk adjacent to the cemetery on the west side of US 287 is narrow with poor lighting but was much more comfortable than walking on the sidewalk on the east side of US 287.
- Sidewalks on the west side of US 287 widen as you go north or south of the cemetery segment.
- Lighting along the corridor was poor. In some cases, trees blocked streetlights, contributing to poor visibility of bicycles and pedestrians.
- The leading pedestrian interval at 11th Avenue across US 287 was short and did not appear to provide adequate time for pedestrians to get into the intersection.

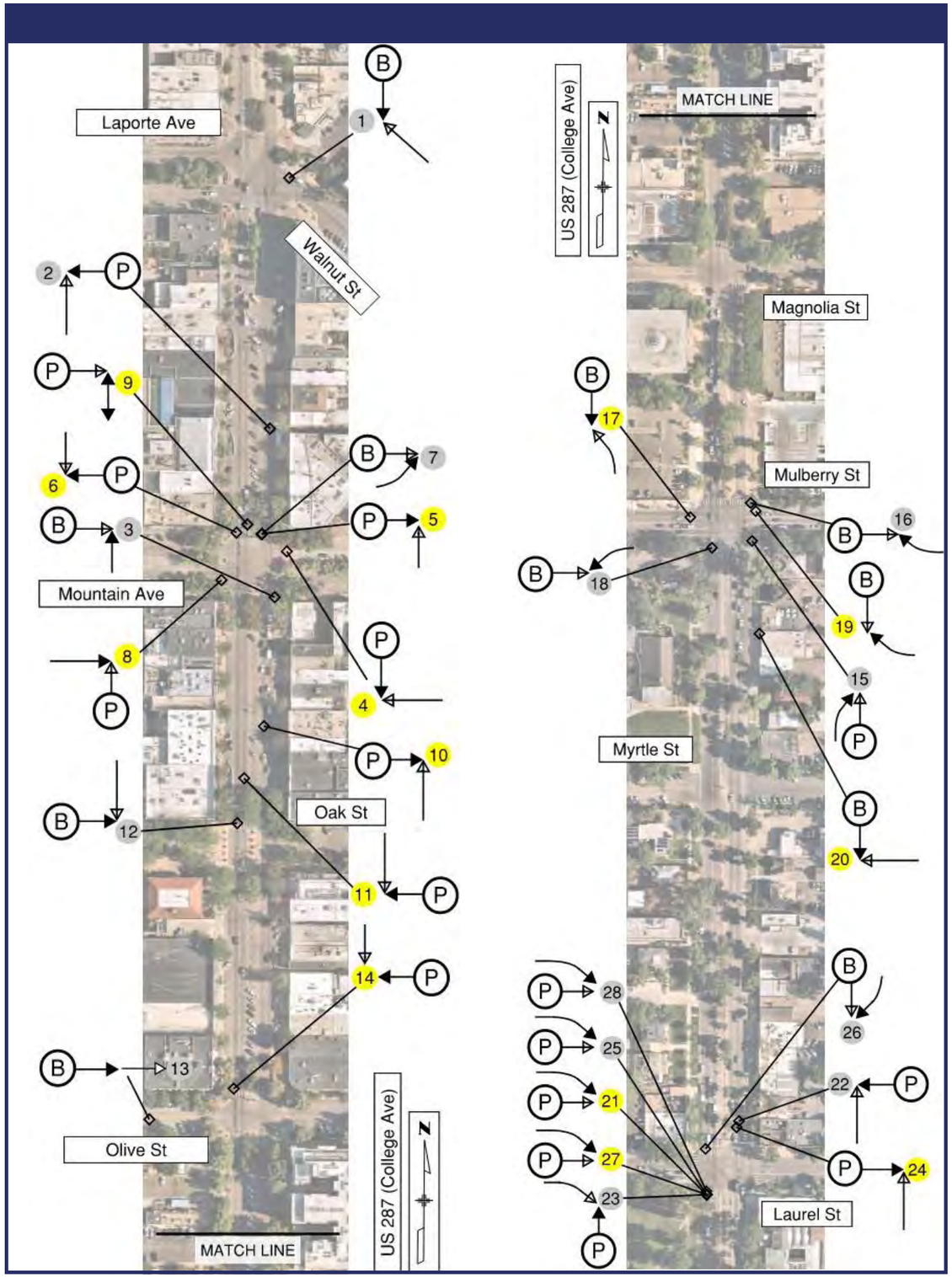
TOP Countermeasure

- Access control on the east side of US 287 between Mountain View Avenue and 11th Avenue

Additional Countermeasures

- Widen the sidewalk adjacent to the cemetery, on the west side of US 287 to encourage its use
- Increase the Leading Pedestrian Interval at the intersection with 11th Avenue from three seconds to five seconds
- Improve corridor illumination

Figure 48: US 287 from Laporte Ave to Laurel St Crash Summary, Field Observations & Countermeasures



Crash Summary

- When selecting top locations, this segment scored high enough to be included in the top 10 locations based only on non-intersection related crashes. However, when considering both the intersection and non-intersection related crashes, a total of 28 crashes were noted and are shown here.
- Most crashes involve pedestrians or bicycles trying to cross US 287.
- There is a pattern of crashes at Laurel Street where eastbound right turning vehicles are hitting pedestrians as they attempt to cross US 287 on the south side of the intersection.
- No fatalities were identified.
- 75% of the persons at-fault were between the age of 14 and 37
- Nearly 70% of crashes occurred between September and April, and approximately 40% occurred during the winter months of November to February.
- Nearly 40% of crashes occurred between the hours of 2:00pm and 6:00pm, and another 50% of crashes occurred between 6:00pm and 2:00am.
- 50% of crashes occurred where the median is defined by parking, and over 25% of crashes occurred where the median is a channelized – raised curb

Field Observations

- Observed a lot of bicycle, pedestrian and vehicular activity. The section from Laporte Avenue on the north, to Magnolia Street on the south consists of 45-degree parking adjacent to the sidewalk plus parking in the median. Bicycles are not permitted on sidewalks and pedestrians were observed crossing mid-block to access cars parked in median.
- Trees and landscaping at intersections create a nice atmosphere for pedestrians but create poor vehicular sight distance to crossing bicycles and pedestrians.
- Observed cars encroaching on the crosswalk when stopping at intersections, rather than in advance of the crosswalk.
- Some sections of the corridor appeared adequately lit while others appeared lacking. When walking on the sidewalk, lighting in the median seemed adequate, but as a driver, the medians appeared dark and difficult to see pedestrians between vehicles.
- Observed small vehicles backing blindly into moving traffic, sometimes due to large vehicles next to them.
- Noted that vehicles could access all median parking while traveling in either direction.

Legend

(P) Pedestrian
(B) Bicycle
(X) PDO
(X) Injury
(X) Fatality
Vehicle 1
Vehicle 2
Turning
Angle

US 287 from Laporte Avenue to Laurel Street

Figure 49: US 287 from Laporte Ave to Laurel St Crash Summary, Field Observations & Countermeasures (Cont.)

TOP Countermeasure

- Reconfigure parking along the corridor
  - Provide back in angle parking with instructional signage

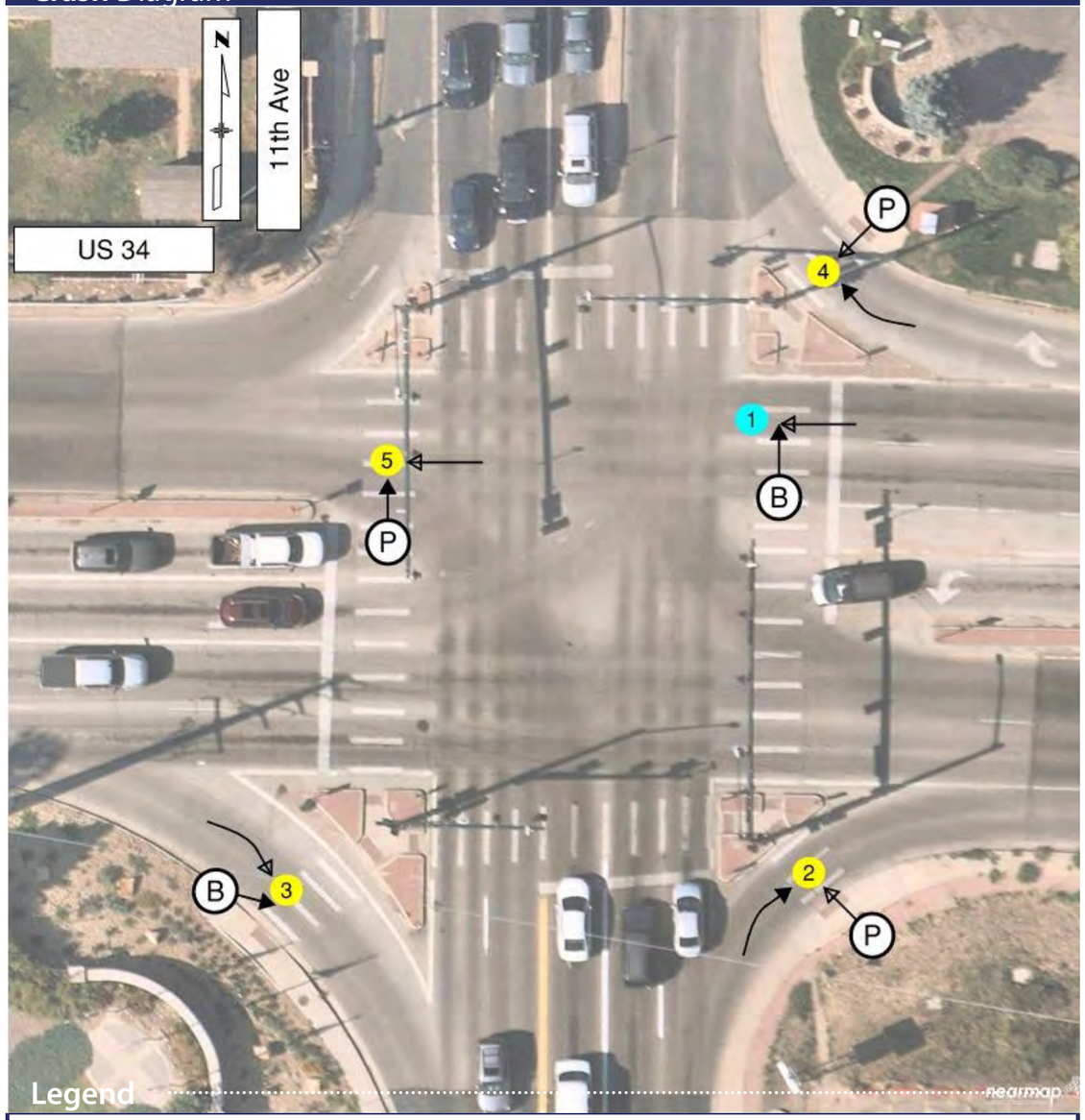
    Benefits include: better visibility from driver to approaching bikes and pedestrians, directs passengers to the sidewalk, drivers don't have to back into oncoming traffic, and the trunk can be loaded via the sidewalk
  - Stripe buffers between the median parking and through lanes and add a treatment to create separation between moving vehicles and the buffer zone (Specific treatment has not been identified yet)
  - Add mid-block crossings with raised bulb-out medians and Rectangular Rapid Flashing Beacon warning system
  - Add parking blocks in all parking spaces to prevent vehicles from encroaching on the sidewalks and buffer zone, and prevent pulling through the space

Additional Countermeasures

- Increase intersection, corridor and median illuminance, as appropriate
- Laurel Street – Increase illuminance, convert outside southbound through lane to a right turn only and add a bulb out in southwest corner to make bicycles and pedestrians more visible to eastbound right turning vehicles
- Signage and Striping Improvements to improve visibility of pedestrians
  - Replace brick paver crosswalks with high visibility crosswalk markings
  - Add stop bars prior to all striped crosswalks
  - Add bike sharrow markings
  - Add more obvious "No Turn on Red" (R10-11) signage (side of pole) at intersections
  - Add "Stop Here on Red" (R10-6) signage, as appropriate
  - Upgrade signal heads at the Oak St pedestrian crossing to have three, 12-inch indications with reflective border back plates
  - Add pedestrian crossing warning signage at the Oak St pedestrian crossing

Figure 50: US 34 & 11th Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- (P) Pedestrian
- (B) Bicycle
- (X) PDO
- (X) Injury
- (X) Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- The crash pattern at this intersection involved pedestrians and bicyclists getting hit in the channelized right turn lanes.
- The one fatality involved a bicycle crossing in front of a through moving vehicle who had a green light.
- All of the at-fault persons whose ages were provided, fell between the age of 12 and 31.
- Nearly all crashes occurred between the months of October and March.

Field Observations

- Sight distance to/from eastbound right turning vehicles and pedestrians crossing the channelized right turn in the southwest corner is severely limited due to grade changes, the cemetery wall and existing utilities.
- Lighting in the corners of the intersection are dark at night.
- Sight distance from westbound right turning vehicles to pedestrians in the northeast corner is poor due to the traffic signal cabinet and low hanging trees.
- The pedestrian "walk" time seemed short.
- The channelized right turn lanes appeared to be very wide but tracking from tractor trailers onto the sidewalk was observed in all corners except the southwest corner.
- The crosswalk striping appeared narrow.
- Eastbound left turning vehicles were observed overtracking into the southbound left turn lane.
- The curb ramp in the northwest corner does not appear to meet ADA requirements.
- Bicycles and pedestrians primarily cross US 34 on the east side of the intersection.

TOP Countermeasures

- LED illuminated border bicycle/pedestrian warning signage (W11-15) with passive pedestrian detection
- Increased intersection illuminance (all corners)
- Raised crosswalk (northeast corner)

Additional Countermeasures

- Enhanced 2'x10' crosswalk striping
- Shift traffic controller box and trim trees to improve sight distance in the northeast corner
- Truck aprons in the channelized right turn lanes
- General Maintenance (ADA, MUTCD sign compliance)

Figure 51: US 34 from Riverside Drive to St Vrain Ave Crash Summary, Field Observations & Countermeasures

Crash Diagram

Legend

- (P) Pedestrian
- (B) Bicycle
- (X) PDO
- (X) Injury
- (X) Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- There were a total of four crashes on this segment.
- All crashes involved pedestrians.
- Half of the crashes involved pedestrians crossing US 34.

MetroQuest Summary

- There were 38 comments on this segment of road.
- The corridor is congested.
- There is no room for bicycles on street and there are no bike lanes.
- There is too much pedestrian traffic on sidewalks to ride a bike on the sidewalk, even if it were allowed.
- Would like a separated bike trail and/or dedicated bike lanes.
- Take advantage of the Estes Park Look construction and consider multimodal improvements.

Field Observations

- Observed pedestrians pushing pedestrian signal button, but did not always wait for active pedestrian signal to cross US 34.
- The sidewalk felt tight for a group of three to walk side by side.
- Observed confusion with the all-pedestrian phase at the Riverside Drive intersection.

TOP Countermeasures

- Raised median from Riverside Drive to St Vrain Avenue, or
- Median refuge at the pedestrian signal, and
- Pedestrian Access Route (PAR) functional space improvements

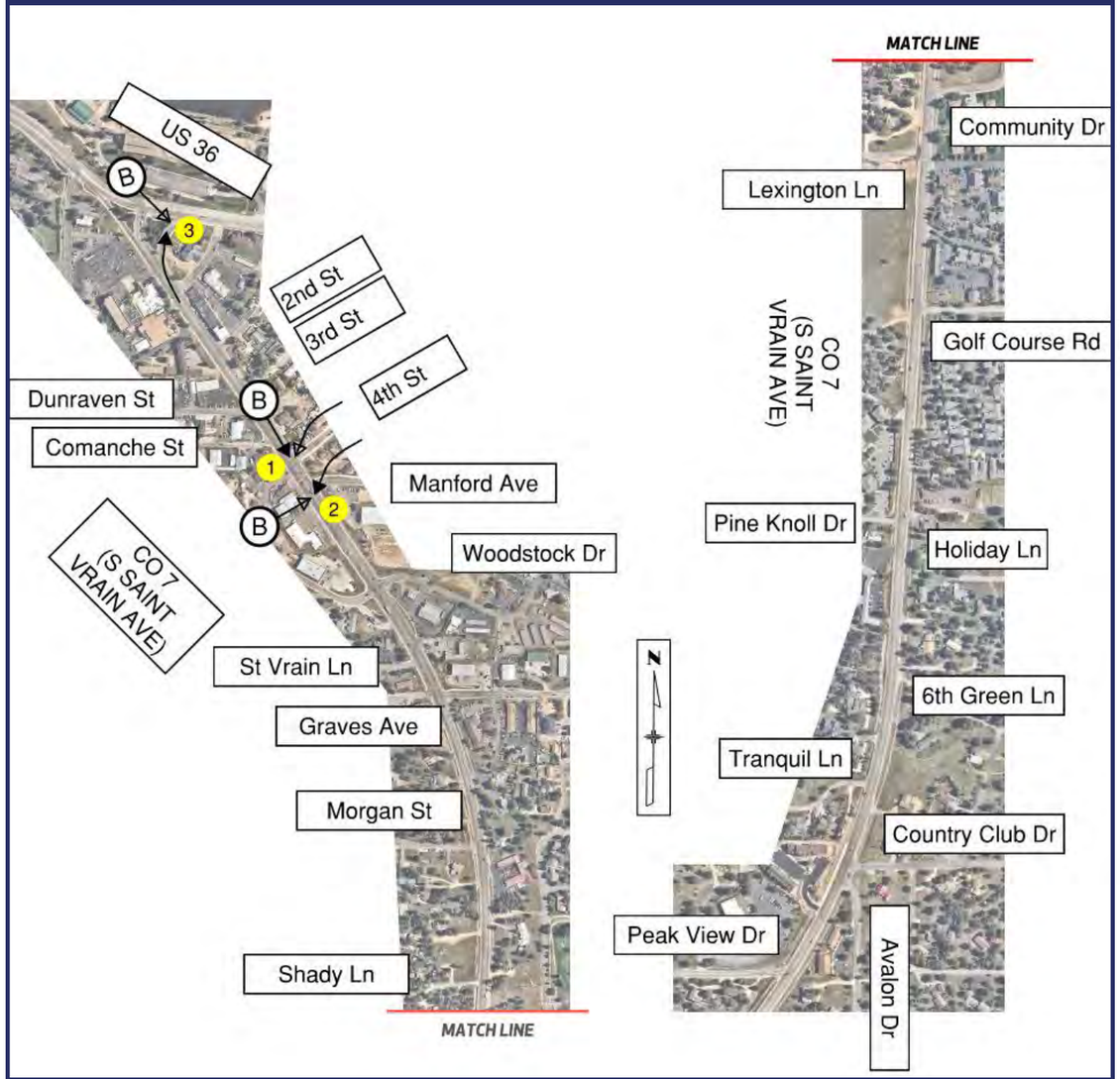
Additional Countermeasures

- Additional advanced pedestrian and bicycle warning signs
- Safety review of planned improvements

US 34 from Riverside Drive to St Vrain Avenue

Figure 52: CO 7 from US 36 to Peak View Dr Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- Pedestrian
- Bicycle
- PDO
- Injury
- Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- There were a total of three crashes on this segment of road.
- All crashes involved bicycles.
- Two of the crashes were located around 4th Street.

MetroQuest Summary

- There were 102 comments on this segment of road.
- Traffic speeds and wide roads make it hard for pedestrians to cross CO 7.
- Children can not safely cross CO 7 to access schools on east side.
- The west side of CO 7 lacks a multiuse path to access crossings of CO 7.
- Cars do not stop when the RRFB at Graves Avenue is flashing. Recommend a median refuge.
- Requesting crosswalks across CO 7 at Stanley Avenue and Woodstock Drive where there are existing curb ramps.

Field Observations

- Two lanes in each direction felt wider than necessary.
- Crosswalk signing and striping appeared to be highly visible.
- Observed higher speeds towards the southern end of the segment.
- Observed a potential embankment and/or drainage concerns with installing a new multiuse path on the west side of CO 7.

TOP Countermeasures

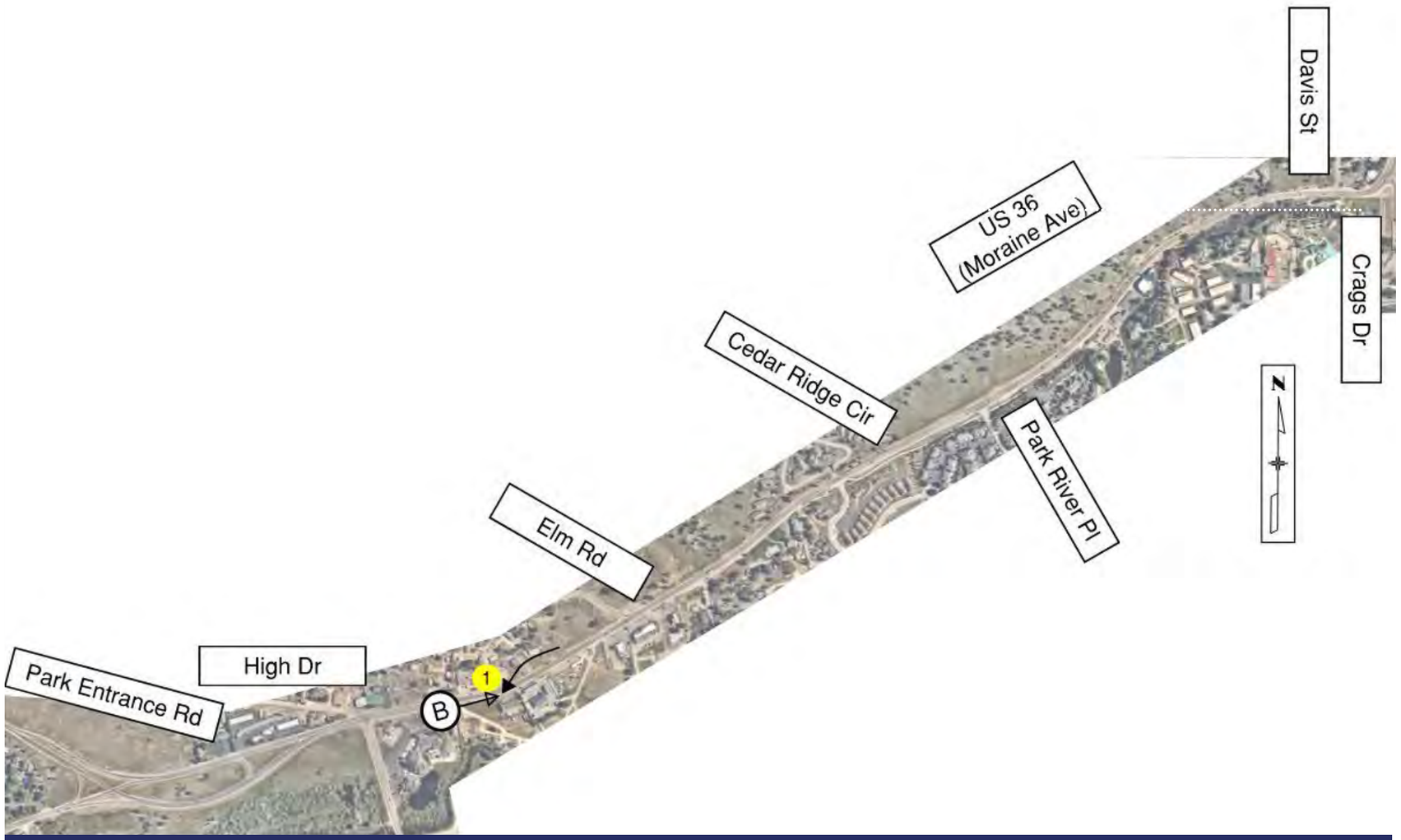
- Continuous Pedestrian Access Route (PAR) and marked crosswalk review

Additional Countermeasures

- Road diet from US 36 to Graves Avenue
- Median refuge at east/west crosswalks

Figure 53: US 36 from Crags Dr to RMNP Entrance Crash Summary, Field Observations & Countermeasures

Crash Diagram



Legend

- Pedestrian
- Bicycle
- PDO
- Injury
- Fatality
- Vehicle 1
- Vehicle 2
- Turning
- Angle

Crash Summary

- No patterns were observed in the crash data since only one crash was identified.

MetroQuest Summary

- There were 115 comments on this section of road.
- There are no sidewalk or bike lanes on this section of the road.
- It is dangerous to walk or ride with the amount of traffic, but people do it anyway.
- Traffic is heavy.
- Shoulders are narrow.

Field Observations

- Did not observe any pedestrians or bicycles on the path or roadway.
- Observed a narrow shoulder close to the parallel creek.
- There are several driveways along this stretch. A multiuse path which crosses these driveways may create conflict.
- Consider the safety of bicycles and pedestrians with potential elk crossing.

Review of Existing Loop Road Improvement Plans

- The sidewalk/multiuse path terminates west of Crags Drive on the north side of the road.

TOP Countermeasure

- Continuous pedestrian / bicycle pathway (variations on / off street)
  - All alternatives anticipate a connection to the proposed loop road sidewalk on the north side of US 36.

Top Countermeasures, Concept Designs, Cost Estimates, & Crash Modification Factors

The list of countermeasures for each location were evaluated and, in some cases, eliminated due to maintenance concerns or concerns regarding compliance with current standards (i.e. ADA or MUTCD). One of the countermeasures that was recommended but ultimately eliminated from consideration was in road lighting along the length of crosswalks. Upon further correspondence with the manufacturers and CDOT maintenance crews, it was determined that the lifespan of this product (typically around 3-5 years) along with the inability to easily replace the batteries when they failed, would lead to significant maintenance issues and concerns. Another recommendation that was eliminated due to concerns regarding compliance with ADA was raised crosswalks in the channelized right turn lanes at US 34/11th Avenue, with the exception of the northeast corner. Due to the small size of the triangle median islands, there was not enough space to provide adequate transition from the raised crosswalk to grade for bicycles and pedestrians to cross.

Top countermeasures were identified based on how well the specific countermeasure could address an existing bicycle and/or pedestrian crash pattern. In some cases systemic improvements were included in the top countermeasures when obvious bicycle or pedestrian amenities were lacking. Where crash data was limited, a summary of MetroQuest comments related to the top locations was reviewed and improvements considered. Designs and cost estimates for the top countermeasures were prepared and Crash Modification Factors (CMF's) identified. When considering Crash Modification Factors (CMF's), some countermeasures did not have an established CMF, so the most applicable CMF was selected.

Benefit to Cost Ratios

It should be noted that the list of countermeasures associated with each of the top locations were intended to limit right-of-way impacts while still improving bicycle and pedestrian safety. The reason for this is that right-of-way impacts and high-cost improvements can result in a benefit to cost ratio that is not competitive for typical safety grant funding.

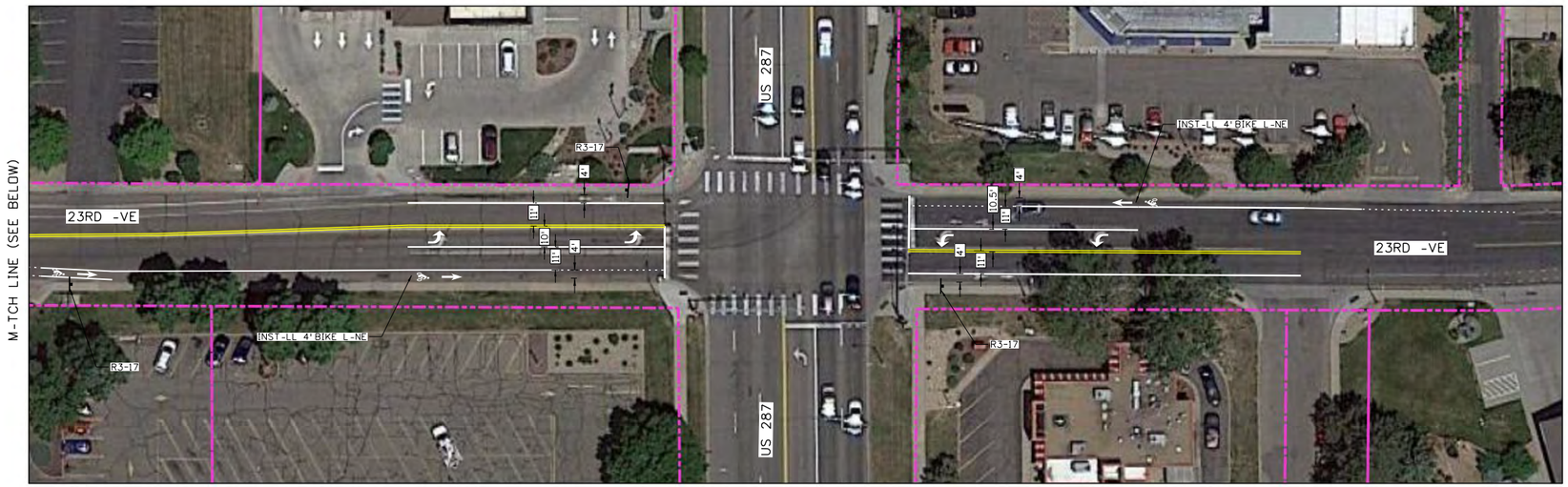
Benefit to cost ratios for the top countermeasures were calculated using the Colorado Highway Safety Improvement Program (HSIP) methodology. This methodology was used as it is consistent with the type of grant funding that is likely applicable to many of the proposed countermeasures. An annual interest rate of four percent and an applicable service life of 5, 10 or 20 years was applied to the cost of each of the top countermeasures and an Estimated Uniform Annual Cost (EUAC) was calculated. CMFs were applied to the PDO, Injury and Fatal crashes for each of the top locations and an Estimated Uniform Annual Benefit (EUAB) was calculated. The EUAB was divided by the EUAC to determine a benefit to cost ratio for each project. It should also be noted that some studies from the CMF Clearinghouse indicate that it would be appropriate to include motor vehicle to motor vehicle crashes when calculating the anticipated crash reduction of a proposed improvement. Motor vehicle to motor vehicle crashes were not evaluated during this study, but in the cases where it is appropriate to include vehicle to vehicle crashes, it has been noted in the detailed benefit to cost calculations (Attachment 2). If the data is available, it is recommended to include motor vehicle to motor vehicle crashes as it would show an improved benefit to cost ratio and a better benefit to cost ratio when applying for safety grant funding. Concept designs, crash modification factors, cost estimates, and benefit to cost ratios for each of the top locations are included in Figures 54 through 66.

PMT #4 – Discuss Countermeasures, Concept Designs and Cost Estimates

The fourth PMT meeting was held on February 10, 2022 and started with a review of the lists of bicycle and pedestrian crash hot spots and MetroQuest hot spots, including a discussion of how the top 10 locations were selected. For each of the top 10 locations, crash history, field observations, lists of countermeasures, concept designs for the top countermeasure, and cost estimates were provided. PMT members provided a couple recommendations for countermeasures that were included in the recommendations within this report.

Figure 54: US 287 & 23rd Ave Concept Design & Cost Estimate

Concept Design



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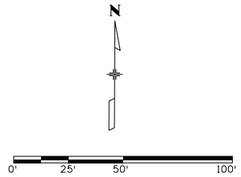
PROPOSED ALTERNATIVES

US 287AND 23RD AVENUE
BICYCLE LANE IMPROVEMENTS

LEGEND

P-RCELS

NOT FOR CONSTRUCTION



Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.944 (Bike Improvements), 0.69 (Signal Improvements)
Cost Estimate:	$30,000 (Bike Improvements) + $40,000 (Signal Improvements)
B/C Ratio:	0 (Bike Improvements), 5.82 (Signal Improvements)

TOP Countermeasures

- On Street Bicycle Lane Improvements

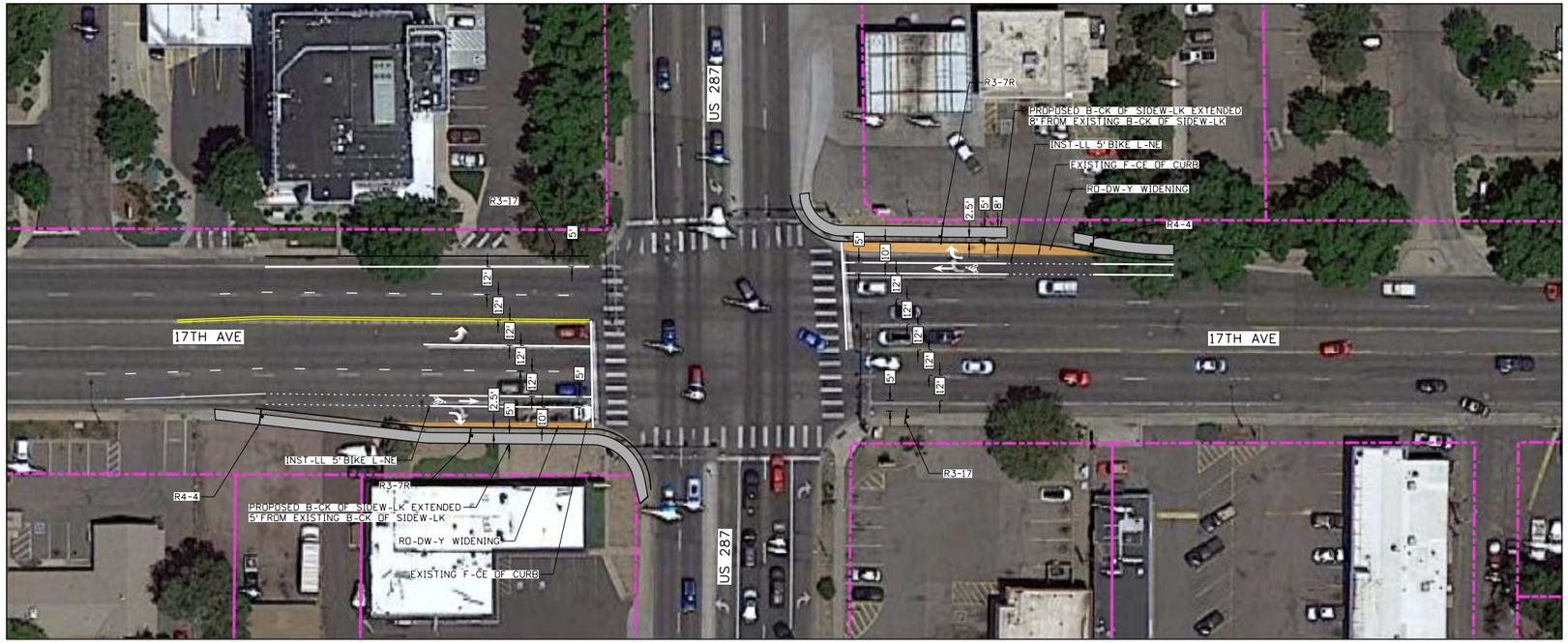
  CMF Reference: https://www.mautc.psu.edu/docs/PSU-2014-01.pdf#page=93
  Explanation: This improvement will modify intersection pavement markings to include dedicated bicycle lane markings through the intersection.

- Protective-Permissive Left Turn Phasing (when warranted)

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: While current traffic and safety data indicate that north and southbound protected-permissive traffic signal phases may not yet be warranted, a slight increase in traffic volumes on US 287 may change this determination. Therefore, it is recommended that traffic volumes are collected annually at this intersection to continue to evaluate the need for protected-permissive left turn signal phases.

Figure 55: US 287 & 17th Ave Concept Design & Cost Estimate

Concept Design



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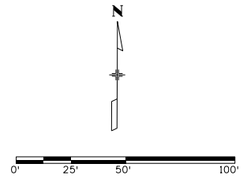
PROPOSED ALTERNATIVES

US 287 AND 17TH AVENUE
BICYCLE LANE IMPROVEMENTS

LEGEND
- RO-DW-Y WIDENING
- PROPOSED SIDEW-LK
- P-RCELS

NOT FOR CONSTRUCTION



Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.944 (Bike Improvements), 087 (Signal Improvements)
Cost Estimate:	$190,000 (Bike Improvements) + $90,000 (Signal Improvements)
B/C Ratio:	0.04 (Bike Improvements), 2.66 (Signal Improvements)

TOP Countermeasures

- On Street Bicycle Lane Improvements

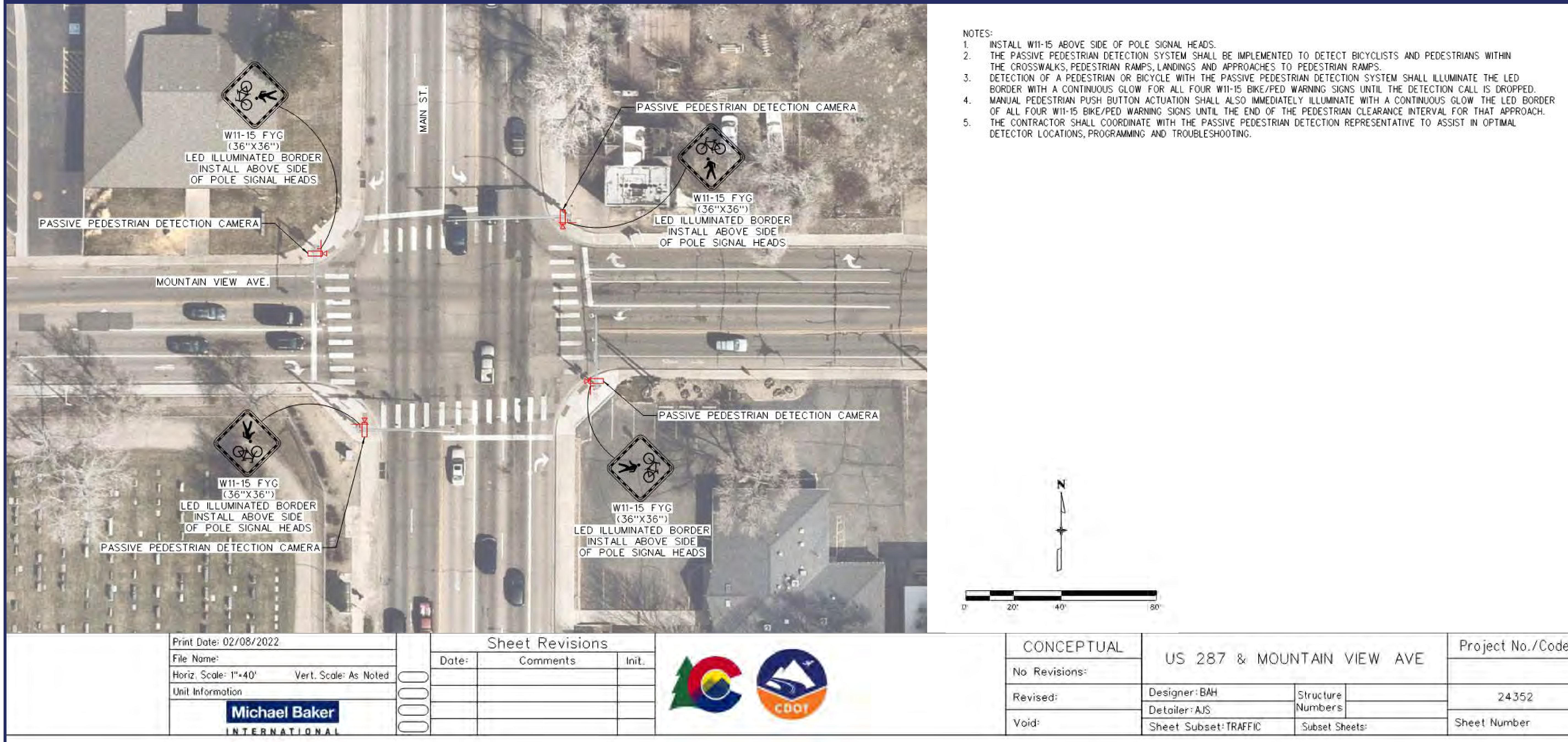
  CMF Reference: https://www.mautc.psu.edu/docs/PSU-2014-01.pdf#page=93
  Explanation: This improvement will modify intersection pavement markings to include dedicated bicycle lane markings through the intersection.

- Leading Pedestrian Interval and No Right Turn on Red

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: Traffic analysis shows that implementing the combined countermeasure will only slightly increase overall delay at this intersection. The "No Right Turn On Red" restriction should only accompany an actuated pedestrian phase. Additionally, no right turn on red blank out signs should be installed in conjunction with this countermeasure.

Figure 56: US 287 & Mountain View Ave Concept Design & Cost Estimate

Concept Design



TOP Countermeasure

- LED illuminated border bicycle/pedestrian warning signage with passive pedestrian detection

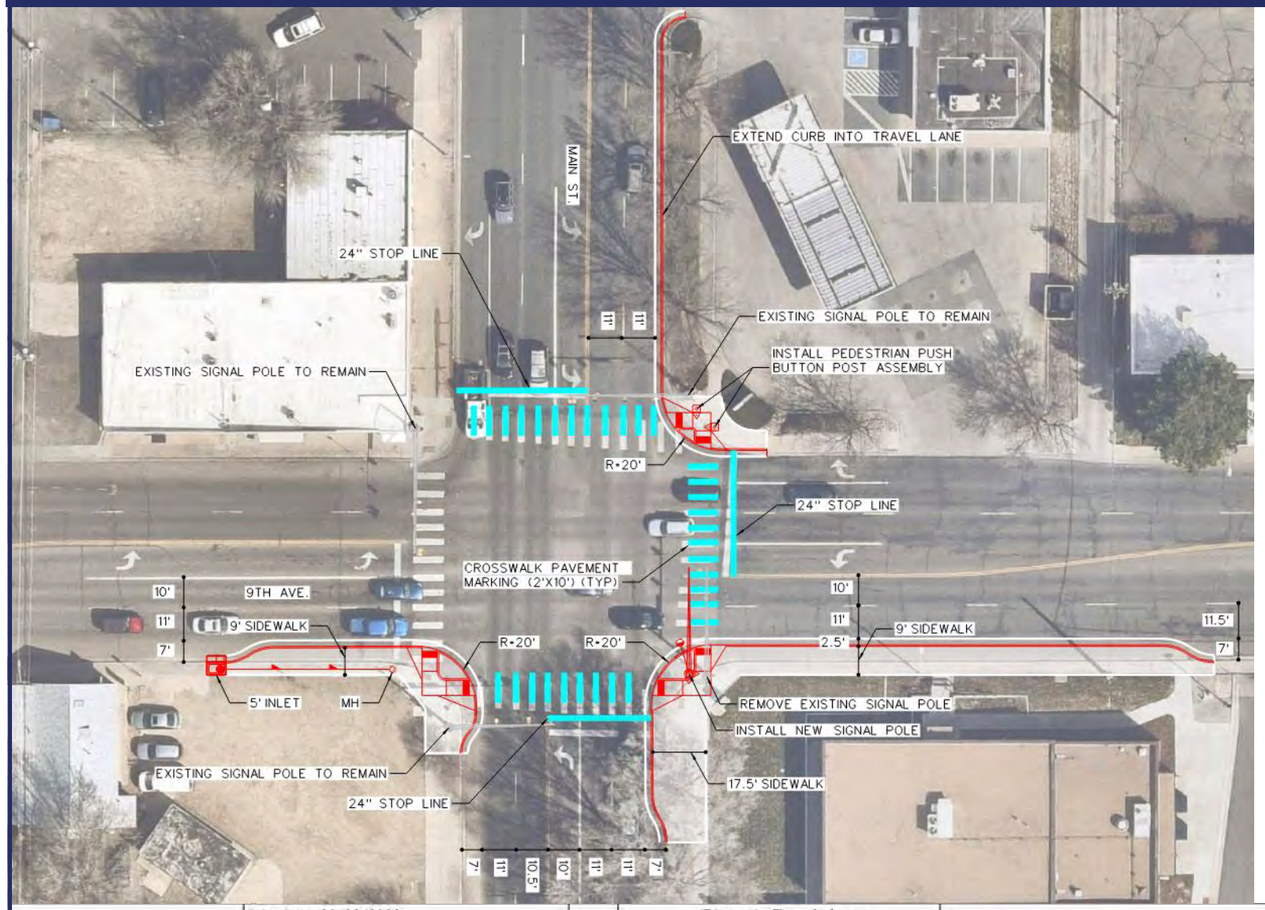
CMF Reference: CMF Clearinghouse >> CMF / CRF Details
Explanation: This improvement will notify vehicles either stopped at or approaching the intersection of the presence of bicycles and pedestrians at the intersection.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.75
Cost Estimate:	$63,000
B/C Ratio:	5.55

Figure 57: US 287 & 9th Ave Concept Design & Cost Estimate

Concept Design



Print Date: 02/08/2022	Sheet Revisions			CONCEPTUAL	US 287 & 9TH AVE
File Name:	Date:	Comments	Init.	No. Revisions:	
Horiz. Scale: 1"=40' Vert. Scale: As Noted				Revised:	Designer: BAH / Detailer: AJS / Sheet Subset: TRAFFIC
Unit Information				Void:	Structure Numbers / Subset Sheets:
Michael Baker INTERNATIONAL					Project No./Code: 24352 / Sheet Number

TOP Countermeasure

- Bulb outs and reduced turning radii

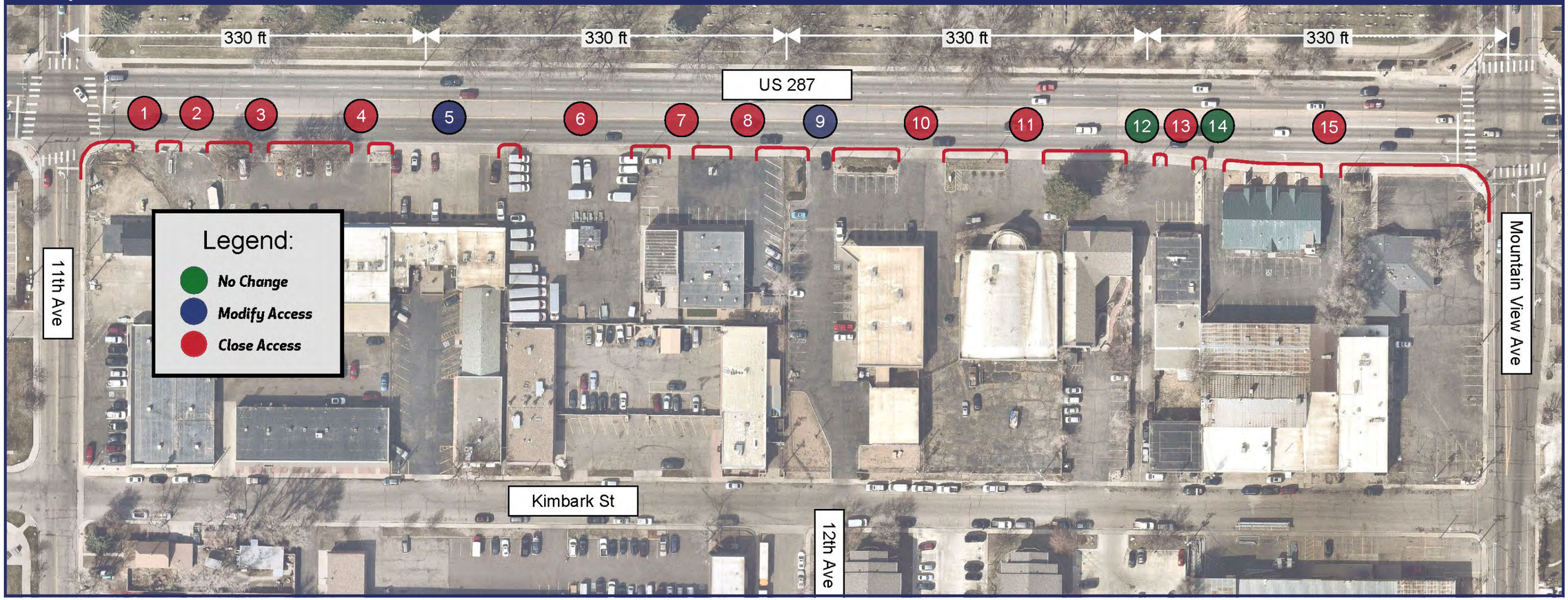
CMF Reference: CMF Clearinghouse >> CMF / CRF Details
Explanation: Bulbouts in the southwest and south east corners of the intersection and the reduced turning radii in the northeast corner of the intersection will slow vehicles through the intersection and make pedestrians more visible to drivers. A bulbout on the northwest corner was not feasible as it would push southbound right turning RTD buses into oncoming traffic.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.685
Cost Estimate:	$398,000
B/C Ratio:	4.52

Figure 58: US 287 from Mountain View Ave to 9th Ave Concept Design & Cost Estimate

Proposed Access Control



TOP Countermeasure

- Access Control (East side of US 287 between Mountain View Avenue and 11th Avenue)

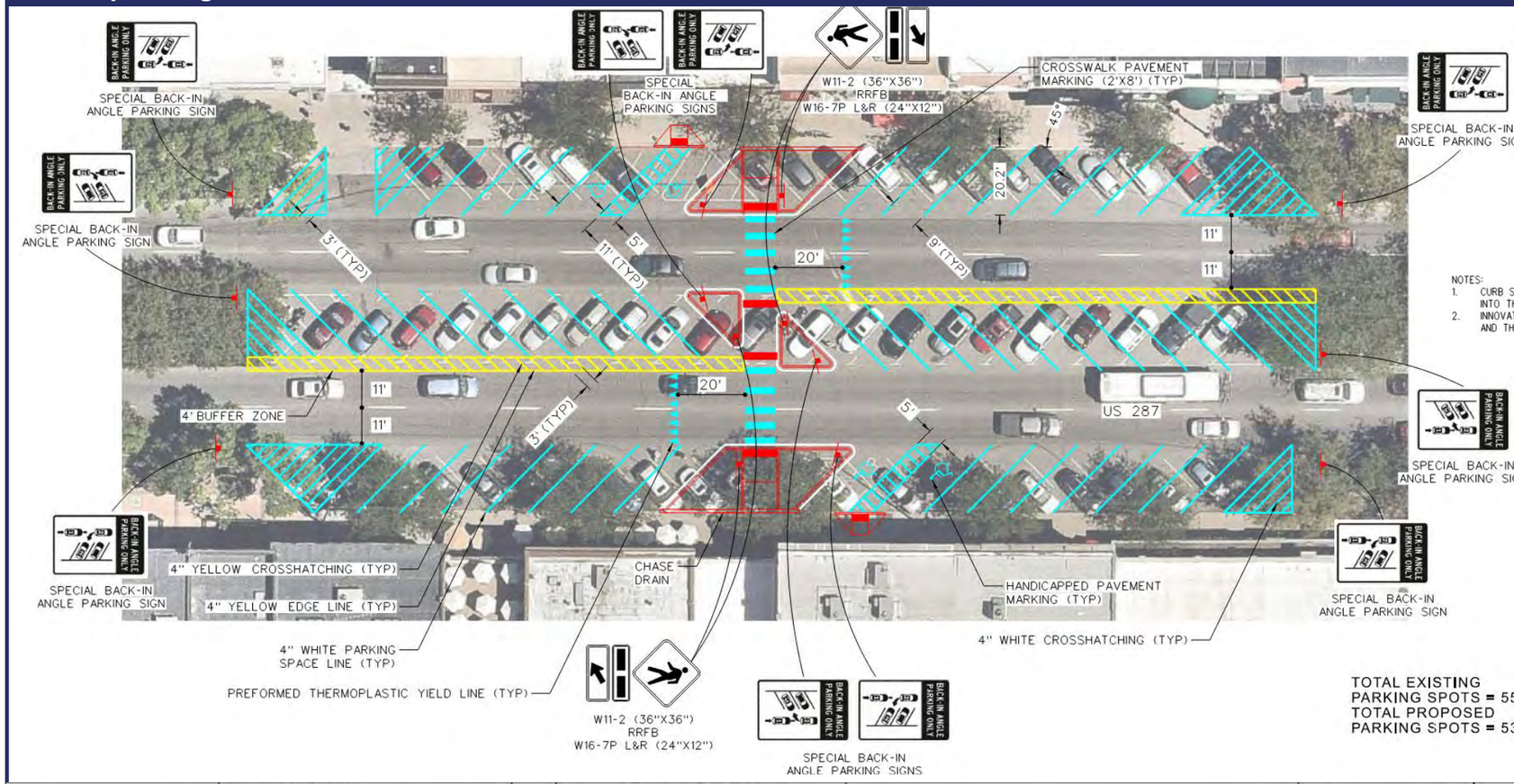
  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: This segment of US 287 is only ¼ mile in length but currently has 15 curb cuts, some of which are very wide. CDOT standards indicate that no direct access should be provided to US 287 in this location. However, many of these properties were developed decades ago and have no other form of access. Some communities use a standard of 330 feet to provide safe access between properties. While this is typically a standard for a local road, it would allow for some compromise until this area redevelops. Some businesses have direct access to Kimbark Street (a parallel road east of US 287) and the businesses served by accesses one through 11 are generally level and only obstructed by curbs, bollards and in some cases parking. If a drive aisle were provided between these properties, the number of access points could reasonably be reduced. North of access 11, grade changes separate properties and limit the ability to consolidate access.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.69 (injury crashes only)
Cost Estimate:	$249,000
B/C Ratio:	1.56

Figure 59: US 287 from Laporte Ave to Laurel St Concept Design & Cost Estimate

Concept Design



NOTES:
1. CURB STOPS SHOULD BE PROVIDED FOR ALL PARKING SPACES TO PREVENT VEHICLES FROM BACKING TOO FAR INTO THE SIDEWALK AND BUFFER ZONES.
2. INNOVATIVE TREATMENTS SHOULD BE CONSIDERED TO PROVIDE SEPARATION BETWEEN THE VEHICLE TRAVEL LANE AND THE 4' BUFFER ZONE WHILE ALSO CHANNELIZING PEDESTRIANS TO THE MID-BLOCK CROSSING LOCATION.

Print Date: 02/08/2022	Sheet Revisions			CONCEPTUAL	US 287 BETWEEN MOUNTAIN AVE & OAK ST	Project No./Code
File Name:	Date:	Comments	Init.	No Revisions:		
Horiz. Scale: 1"=30' Vert. Scale: As Noted				Revised:	Designer: BAH / Structure Numbers	24352
Unit Information				Void:	Detailer: AJS	
Michael Baker INTERNATIONAL					Sheet Subset: TRAFFIC / Subset Sheets:	Sheet Number

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.68 (average of 3 CMF's)
Cost Estimate:	$337,000
B/C Ratio:	4.05 (average of 3 CMF's)

TOP Countermeasures

- Reconfigure Parking: back in angle parking, striped buffers between parking and travel lanes, parking blocks for all spaces,and narrow travel lanes

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: The benefits of back in angle parking are discussed on the prior page. Buffer zones provide space for pedestrians to access the mid-block crossing, parking blocks limit where vehicles can enter a parking space, and narrow travel lanes are expected to slow vehicle speeds.

- Bulbouts at Mid-Block Crossing Location

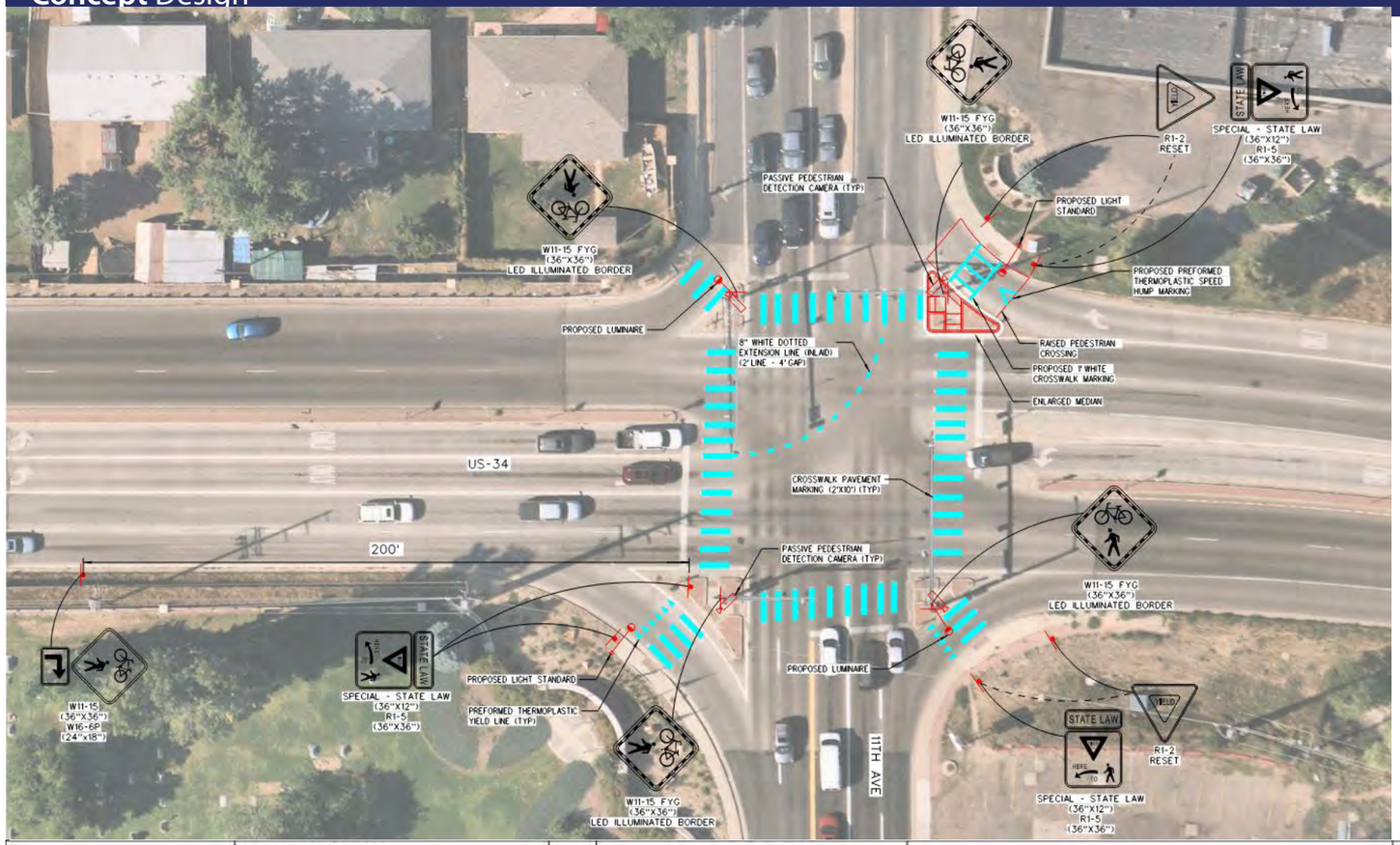
  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: Pulling the sidewalk into the street narrows the crossing distance, improves visibility of crossing pedestrians, and provides more clarity for visually impaired pedestrians.

- New Mid-Block Crossing with RRFB

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: This treatment would provide a safe pedestrian crossing where one currently does not exist.

Figure 60: US 34 & 11th Ave to Laurel St Concept Design & Cost Estimate

Concept Design



NOTES:
1. INSTALL W11-15 ABOVE SIDE OF POLE SIGNAL HEADS.
2. THE PASSIVE PEDESTRIAN DETECTION SYSTEM SHALL BE IMPLEMENTED TO DETECT BICYCLISTS AND PEDESTRIANS WITHIN THE UNCONTROLLED CHANNELIZED RIGHT TURN CROSSWALKS, PEDESTRIAN RAMPS, LANDINGS AND APPROACHES TO PEDESTRIAN RAMPS.
3. DETECTION OF A PEDESTRIAN OR BICYCLE WITH THE PASSIVE PEDESTRIAN DETECTION SYSTEM SHALL ILLUMINATE THE LED BORDER WITH A CONTINUOUS GLOW FOR ALL FOUR W11-15 BIKE/PED WARNING SIGNS UNTIL THE DETECTION CALL IS DROPPED.
4. MANUAL PEDESTRIAN PUSH BUTTON ACTUATION SHALL ALSO IMMEDIATELY ILLUMINATE WITH A CONTINUOUS GLOW THE LED BORDER OF ALL FOUR W11-15 BIKE/PED WARNING SIGNS UNTIL THE END OF THE PEDESTRIAN CLEARANCE INTERVAL FOR THAT APPROACH.
5. THE CONTRACTOR SHALL COORDINATE WITH THE PASSIVE PEDESTRIAN DETECTION REPRESENTATIVE TO ASSIST IN OPTIMAL DETECTOR LOCATIONS, PROGRAMMING AND TROUBLESHOOTING.

N

0' 20' 40' 80'

Print Date: 02/08/2022	Sheet Revisions			CONCEPTUAL	US 34 & 11TH AVE	Project No./Code
File Name:	Date:	Comments	Init.	No Revisions:		
Horiz. Scale: 1"=40' Vert. Scale: As Noted				Revised:	Designer: BAH	Structure Numbers	24352
Unit Information					Detailer: AJS		
Michael Baker INTERNATIONAL				Void:	Sheet Subset: TRAFFIC	Subset Sheets:	Sheet Number

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.48 (Illuminance), 0.75 (RRFB), 0.55 (injury only – Raised Crosswalk)
Cost Estimate:	$314,000
B/C Ratio:	2.60 (Illuminance), 12.54 (RRFB), 1.17 (Raised Crosswalk)

TOP Countermeasures

- LED illuminated border bicycle/pedestrian warning signage with passive pedestrian detection

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: This improvement will notify vehicles either stopped at or approaching the intersection of the presence of bicycles and pedestrians at the intersection.

- Increased Intersection Illumination

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: Increased illuminance in the far corners of this intersection will make pedestrians more visible to oncoming vehicles.

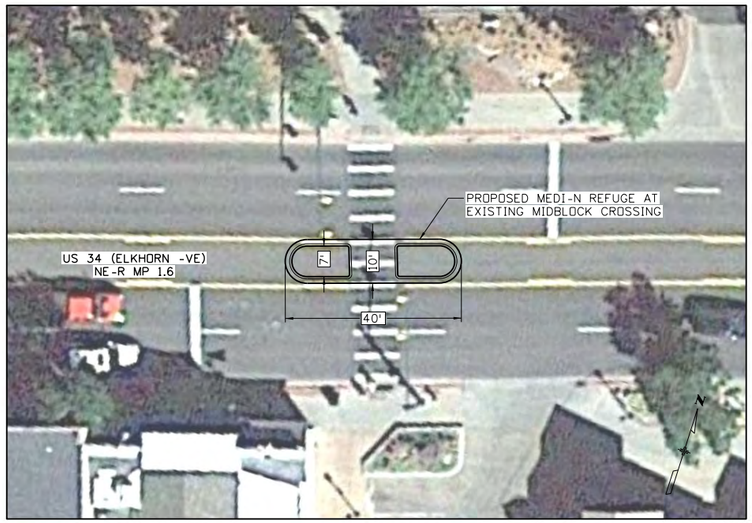
- Raised Crosswalk (northeast corner)

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: This treatment is intended to provide a clearly defined crossing point where pedestrians should be expected.

Figure 61: US 34 from Riverside Dr to St Vrain Ave Concept Design & Cost Estimate

Concept Design

NOT FOR CONSTRUCTION



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PROPOSED ALTERNATIVES

US 34 (ELKHORN AVE)
FROM RIVERSIDE DR TO ST VRAIN AVE
MEDIAN REFUGE

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.697 (Continuous Raised Median), 0.685 (Pedestrian Refuge)
Cost Estimate:	$50,000 (Pedestrian Refuge)
B/C Ratio:	2.63 (Pedestrian Refuge)

TOP Countermeasures

- Raised Median From Riverside Drive to St Vrain Avenue

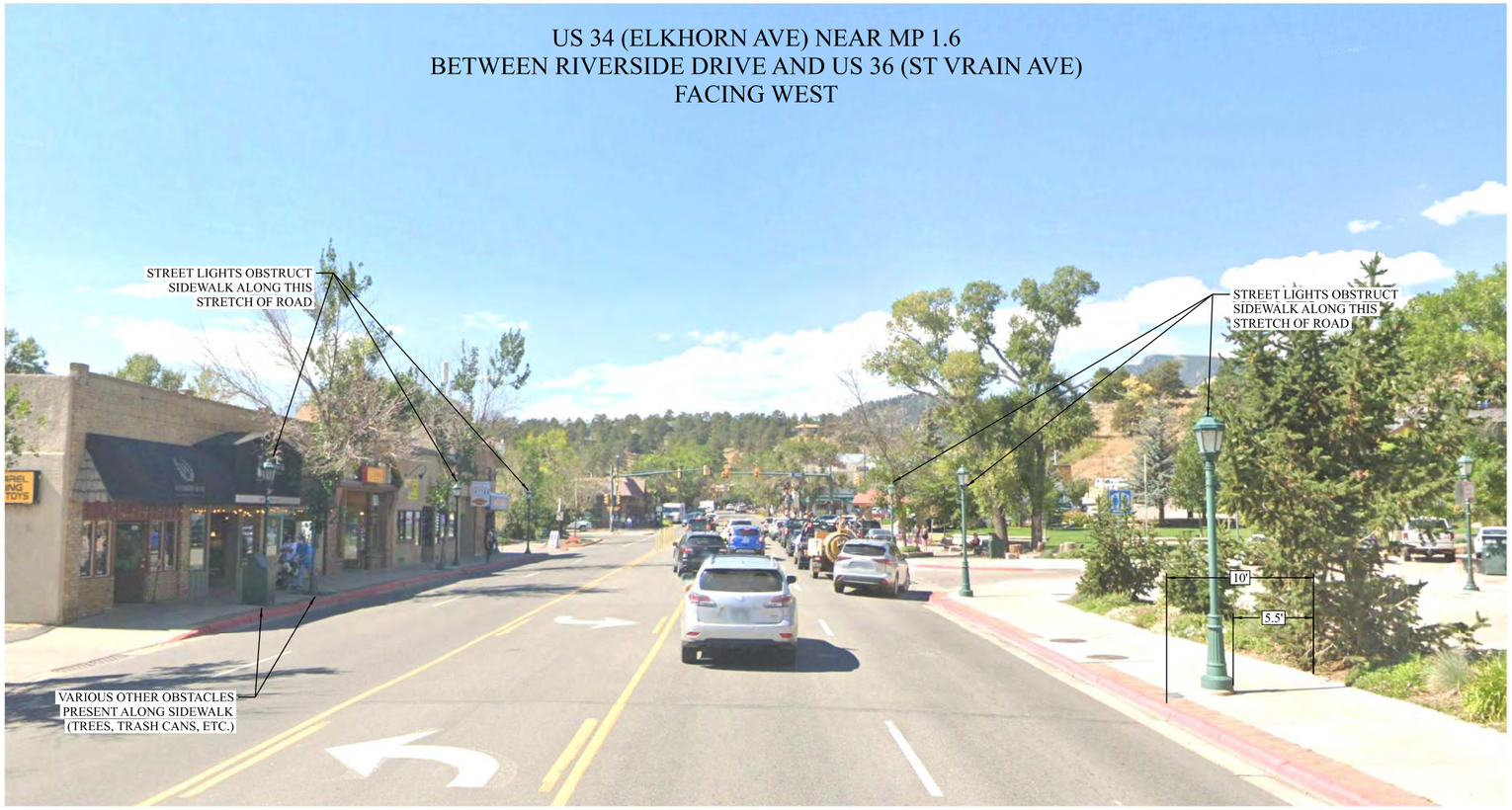
  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: Continuous raised medians can simplify and improve safety for pedestrians and bicyclists by eliminating motorist turning conflicts as well as acting as a visual speed deterrent for vehicles.

- Install Pedestrian Refuge at Pedestrian Signal

  CMF Reference: CMF Clearinghouse >> CMF / CRF Details
  Explanation: This can serve as both a visual speed deterrent for vehicles as well as an additional visual queue for pedestrians crossing US 34.

Figure 62: US 34 from Riverside Dr to St Vrain Ave Concept Design & Cost Estimate (Cont.)

Concept Design



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PROPOSED ALTERNATIVES

US 34 (ELKHORN AVE)
FROM RIVERSIDE DR TO ST VRAIN AVE
PAR FUNCTIONAL SPACE IMPROVEMENTS

NOT FOR CONSTRUCTION

TOP Countermeasure

- Improve Pedestrian Access Route Functional Width

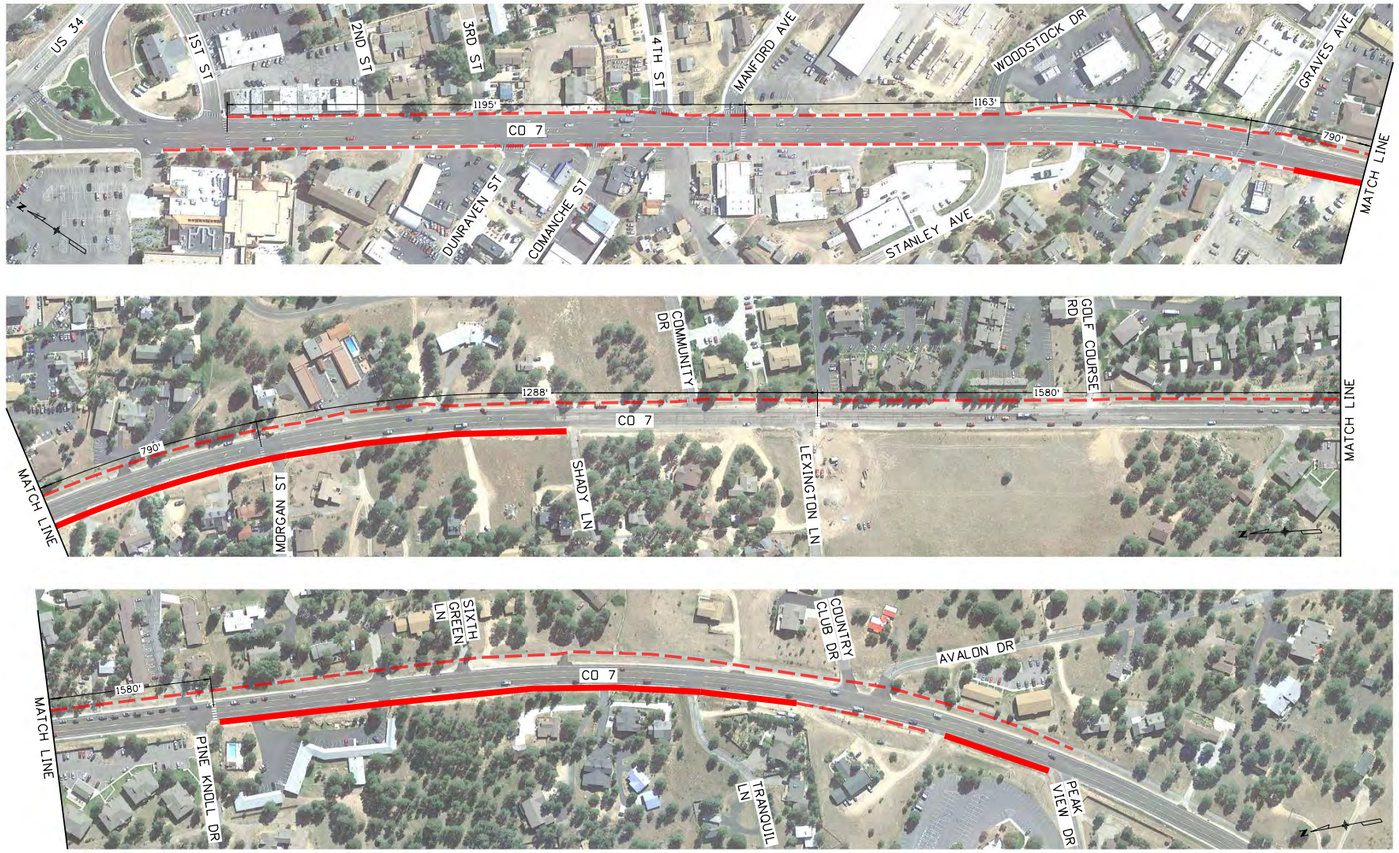
CMF Reference: Unknown
Explanation: The functional width of the sidewalk is impeded by several fixed objects such as streetlights, furniture, and trash receptacles. By relocating some or all of these objects outside of the sidewalk, the functional width of the PAR will be improved. In practice, this could mean fewer pedestrian or bicycles get "bumped off" the sidewalk into the street.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	Unknown (Pedestrian Access Route Improvements)
Cost Estimate:	Unknown
B/C Ratio:	Unknown

Figure 63: CO 7 from US 36 to Peak View Dr Concept Design & Cost Estimate

Concept Design



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PROPOSED ALTERNATIVES

CO 7 FROM US 36 TO PEAK VIEW DR
CONTINUOUS PAR AND
MARKED CROSSWALK REVIEW

LEGEND

- EXISTING SIDEW-LK/MULTIMOD-L P-TH
- PROPOSED SIDEW-LK/MULTIMOD-L P-TH

NOT FOR CONSTRUCTION

TOP Countermeasure

- Continuous Pedestrian Access Route

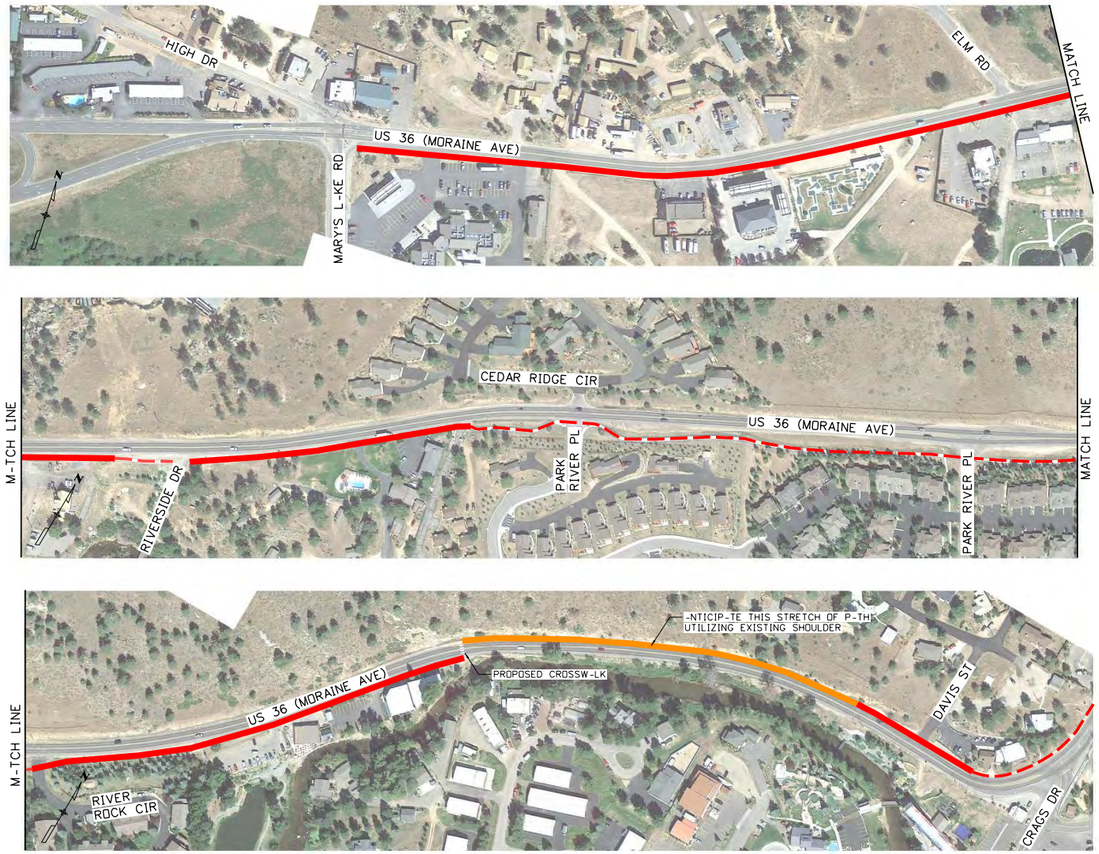
CMF Reference: OregonCMF.pdf (cmfclearinghouse.org)
Explanation: No additional crossings are recommended. This analysis also included a path connectivity and gap analysis. The Purpose of this analysis was to minimize inequities for path access for residents on both the east and west side of CO 7. With the addition of the proposed path, equitable and nearby (less than approximately 1,000 feet when possible) access is achievable.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.8
Cost Estimate:	$590,000
B/C Ratio:	0.17

Figure 64: US 36 from Crags Dr to RMNP Entrance Alternative #1 Concept Design & Cost Estimate

Concept Design - **Alternative #1**



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PROPOSED ALTERNATIVES

US 36 (MORAINE AVE)
FROM RMNP ENTRANCE TO CRAGS DR
US 36 CONTINUOUS MULTIMODEL PATH
OPTION #1

LEGEND

- EXISTING SIDEW-LK/MULTIMOD-L P-TH
- PROPOSED MULTIMOD-L P-TH
- PROPOSED MULTIMOD-L P-TH (GR-DING CONSTR-INTS)

NOT FOR CONSTRUCTION

CONCEPTUAL DRAWING
EXACT LOCATIONS AND DIMENSIONS OF PATHS AND CROSSINGS TO BE DETERMINED WITH FURTHER ANALYSIS.

TOP Countermeasure

- Continuous Pedestrian/Bicycle Pathway

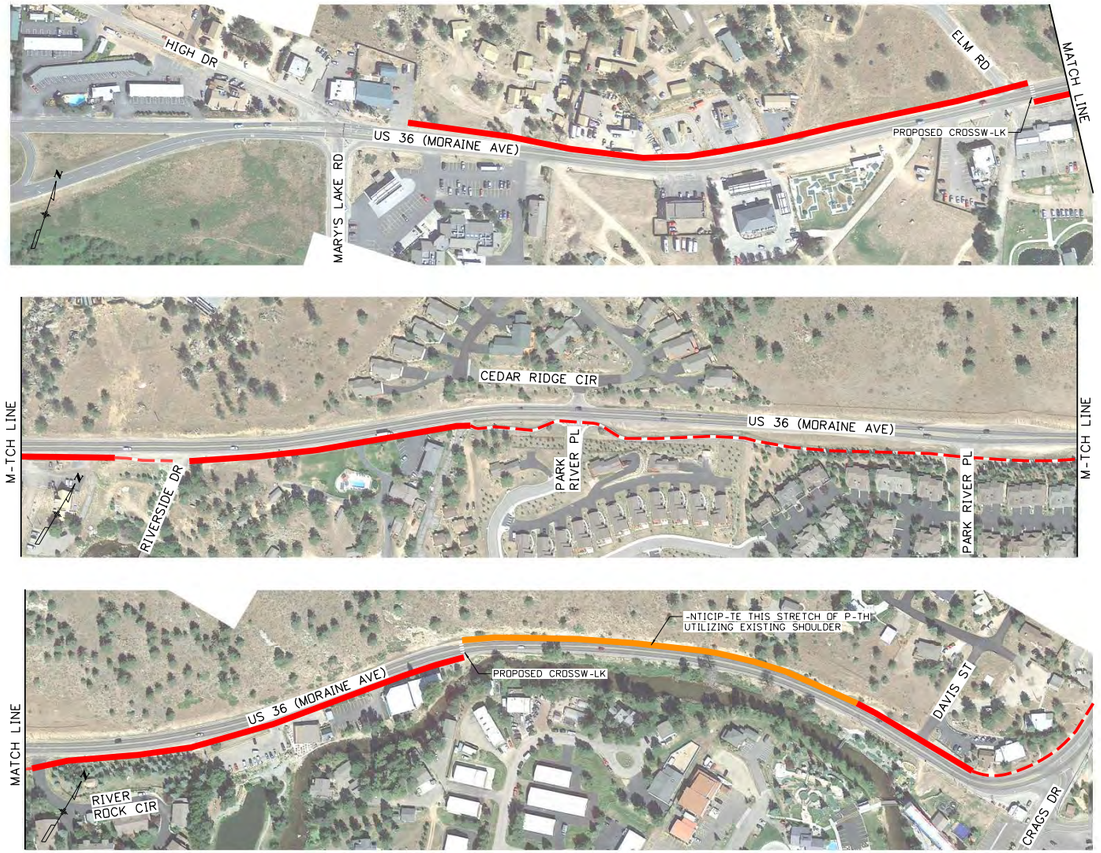
CMF Reference: OregonCMF.pdf (cmfclearinghouse.org)
Explanation: The proposed plan is intended to be completed within existing ROW while connecting the proposed path from the loop road project to the south and west. The Town of Estes Park has design concepts for a trail on US 36 west of Crags Drive that would include ROW acquisition and road widening. As that project is not currently funded, one of these proposed alternatives could serve as an interim solution.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.8
Cost Estimate:	$910,000
B/C Ratio:	0.05

Figure 65: US 36 from Crags Dr to RMNP Entrance Alternative #2 Concept Design & Cost Estimate

Concept Design - **Alternative #2**



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PROPOSED ALTERNATIVES

US 36 (MORAINE AVE)
FROM RMNP ENTRANCE TO CRAGS DR
US 36 CONTINUOUS MULTIMODEL PATH
OPTION #2

LEGEND

- EXISTING SIDEW-LK/MULTIMOD-L P-TH
- PROPOSED MULTIMOD-L P-TH
- PROPOSED MULTIMOD-L P-TH (GR-DING CONSTR-INTS)

NOT FOR CONSTRUCTION

CONCEPTUAL DRAWING
EXACT LOCATIONS AND DIMENSIONS OF PATHS AND CROSSINGS TO BE DETERMINED WITH FURTHER AN-LYSIS.

TOP Countermeasure

- Continuous Pedestrian/Bicycle Pathway

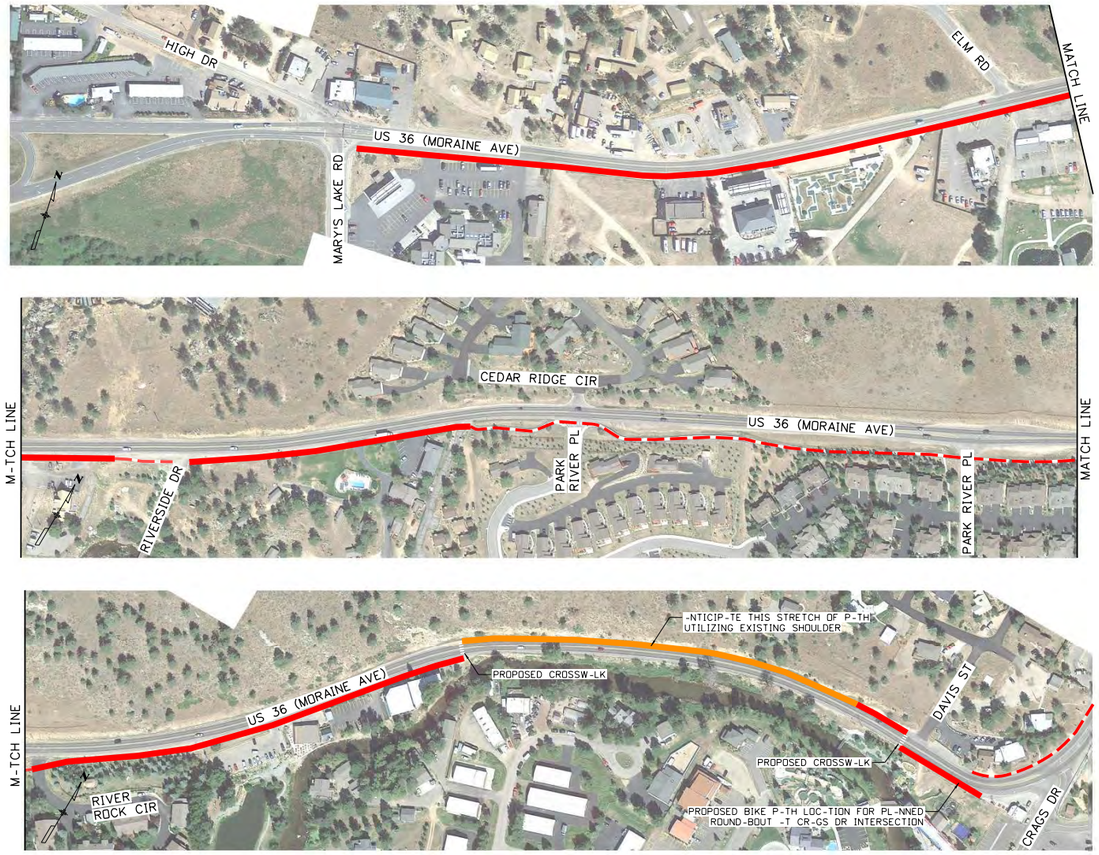
CMF Reference: OregonCMF.pdf (cmfclearinghouse.org)
Explanation: The proposed plan is intended to be completed within existing ROW while connecting the proposed path from the loop road project to the south and west. The Town of Estes Park has design concepts for a trail on US 36 west of Crags Drive that would include ROW acquisition and road widening. As that project is not currently funded, one of these proposed alternatives could serve as an interim solution.

Summary Data

Draft Report:	April 2022
Crash Data:	1/2015 - 12/2019
CMF:	0.8
Cost Estimate:	$910,000
B/C Ratio:	0.05

Figure 66: US 36 from Crags Dr to RMNP Entrance Alternative #3 Concept Design & Cost Estimate

Concept Design - **Alternative #3**



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PROPOSED ALTERNATIVES

US 36 (MORAINE AVE)
FROM RMNP ENTRANCE TO CRAGS DR
US 36 CONTINUOUS MULTIMODEL PATH
OPTION #3

LEGEND

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ACCEPTABLE COUNTERMEASURES

At the first PMT meeting for this project, members were asked how this project could benefit them if none of the top locations selected were located within their City, Town, or County. The responses included identifying acceptable countermeasures for CDOT roads, Main Streets, and local roads, and a desire to implement new treatments. During this project many acceptable countermeasures and some innovative solutions were identified for the top locations. Additionally, CDOT has indicated an openness in discussing proposed improvements on CDOT roads and has shown a willingness during this process to consider some innovative solutions to challenging conditions. Table 20 summarizes resources that provide guidance, research, best practices, and safety countermeasures to improve the roadway network. The first three resources listed in Table 20 come from FHWA and include generally acceptable countermeasures that could apply to a variety of CDOT and local roads. Many of the countermeasures listed on these sites are also great candidates for safety grant funding.

Table 20: Safety Countermeasure Resources

Resource	Description	Link
Safe Transportation for Every Pedestrian (STEP) Studio	Comprehensive compilation of resources, design guidance, research, and best practices for practitioners to identify appropriate countermeasures for improved pedestrian safety.	STEP STUDIO - Tools for Selecting and Implementing Countermeasures for Improving Pedestrian Crossing Safety (dot.gov)
FHWA Proven Safety Countermeasures	Provides a collection of countermeasures and strategies for reducing fatalities and serious injuries. Includes guidance for placement of countermeasures and expected percentage reduction in crashes.	Proven Safety Countermeasures | Federal Highway Administration - Safety | Federal Highway Administration (dot.gov)
PEDSAFE	Identifies 67 countermeasures for engineering, education, and enforcement. Includes preliminary cost estimates.	Pedestrian Safety Guide and Countermeasure Selection System (pedbikesafe.org)
pedbikeinfo	Provides facts, resources, and webinars around bicycle and pedestrian health, safety, environment, economics, and equity.	Pedestrian & Bicycle Information Center (pedbikeinfo.org)
walkinginfo.org	Provides facts, statistics, guidance for implementing solutions, case studies and training opportunities.	walkinginfo.org: School Zone Improvements
bicyclinginfo.org	Provides facts, statistics, guidance for implementing solutions, case studies and training opportunities.	bicyclinginfo.org
Crash Modification Factors (CMF) Clearinghouse	Provides a searchable database of CMF's along with guidance and resources on using CMFs.	Crash Modification Factors Clearinghouse (cmfclearinghouse.org)
National Association of City Transportation Officials (NACTO)	Provides design guides for Urban Streets, Urban Bikeways and Transit Streets that include guidance on these types of facilities and all relevant elements such as intersection signal timing details.	National Association of City Transportation Officials | National Association of City Transportation Officials (nacto.org)

The challenge in applying safety countermeasures is that while many countermeasures are considered acceptable by CDOT, they are not necessarily acceptable on every road or intersection. For example, while a Rectangular Rapid Flashing Beacon (RRFB) is considered an acceptable countermeasure by CDOT, available guidance states that it is not an acceptable countermeasure on roads with 4 or more lanes, or high volume 2-lane roads that don't provide gaps in traffic. On wider roads or those with high volumes, other countermeasures would likely be more appropriate. When applying safety countermeasures it is critical to ensure that the countermeasure is appropriate for the proposed location and will not cause unforeseen safety concerns. Table 21 provides a list of acceptable countermeasures that could apply to state and local roads within the region and guidance on where they would apply, although it is not inclusive and other countermeasures could be considered. Cities, Counties and Towns that are interested in discussing these countermeasures on their state highways should reach out to CDOT to discuss the appropriateness and level of support for specific locations.

Table 21: Acceptable Countermeasures

Safety Countermeasure	When to Apply	Pros	Cons
Access Control *(Consolidating or reducing the number of access points)*	On arterial and collector roads, high speed roads, adjacent to major intersections, where access does not meet current spacing standards, and/or where a high volume of bicycles and/or pedestrians are present. At locations where motorists are known to make higher speed turns into or out of driveways.	• Reduced conflict points between vehicles and bicycles/pedestrians. • Can help with continuity of sidewalk or multiuse path. • Can reduce the speed of turning vehicles into and out of driveways.	• Potential opposition from property owners. • Could increase vehicle speeds on the mainline when there is less friction caused by vehicles entering and exiting the roadway.
Improve Lighting *(horizontal and vertical illuminance, luminance, and uniformity)*	Where lighting is lacking, the quality of the lighting is poor, lighting is not uniform, or where there is a history of nighttime crashes.	• Increased visibility of key roadway features such as lane markings, crosswalk markings, curbs, and vulnerable users. • Increased perception of safety.	• The installation and maintenance of lighting in rural areas provides a lower return on investment. • May require a system of installation to ensure consistent illuminance.

	When to Apply	Pros	Cons
Protected Mid-Block Crossing *(i.e. High-Intensity Activated CrosswalK beacon [HAWK], Rectangular Rapid Flashing Beacon [RRFB], Raised median for refuge plus signage and striping)*	Mid-block crossings are generally recommended where long distances exist between stop or signal controlled intersections, or in locations where vulnerable users are known to cross. Adequate sight distance to a mid-block crossing is necessary for safe crossing. On roads with more than 2 lanes of travel, high speeds or high volume, HAWK signals are recommended. RRFB's or raised medians with a pedestrian refuge and adequate signage and striping are more appropriate on lower speed, lower volume, 2-lane roads. It is generally recommended that protected mid-block crossings are not installed until pedestrian volumes reach 20 pedestrians per hour for two hours of the day. Additional guidance is provided in *CDOT's Pedestrian Crossing Installation Guide (2021)*.	• Reduce instances of users crossing roads in unprotected, potentially dangerous locations. • Increases motorist awareness of where vulnerable users will be crossing the road. • Reduces distances between bicycle/pedestrian destinations.	• Consideration of existing access could limit feasibility of mid-block crossing locations. • Using the wrong type of mid-block crossing can result in poor motorist compliance.

	When to Apply	Pros	Cons
Widen Shoulders	When shoulder widths are less than 4 feet in width. On higher speed and/or volume roadways, or those with a high percentage of heavy vehicles, wider shoulders are recommended.	• Increase distance between motorists and vulnerable users on shoulder, particularly when going around curves.	• Regular maintenance required to address collection of debris, snow, and water on shoulders. • In rural areas, requires a process to determine adequate locations.

Safety Countermeasure	When to Apply		Cons
Add Sidewalks and Fill Gaps	Where sidewalks would connect pedestrian destinations such as bus stops and retail centers, and in areas where demand for walking is likely higher due to factors such as lack of access to a vehicle, disability, age, etc.	• Provides greatest number of potential users with enhanced mobility options. • Provides connections to pedestrian destinations. • Provides a predictable facility on which motorists expect pedestrians to be. • Reduces potential for conflict that is higher when separation does not exist.	• Comparatively expensive to construct and maintain, in relation to other countermeasures. • Installation in physically constrained areas can be challenging.
Reduce Sight Line Obstructions *(i.e. traffic signal cabinets, bushes, trees, etc.)*	In locations where fixed objects or vegetation obstruct the ability of motorists, bicyclists, or pedestrians to effectively see and make decisions (i.e. turn movements, reduction in speed, yielding) based on the location and distance from other vehicles, bikes, or people walking.	• Increased visibility across thru lanes and at turn points (including driveways) reduces the potential for conflict between roadway users.	• Relocation of utilities can be an expensive undertaking and coordination with utility providers can be time-consuming. • Stakeholders may be opposed to the removal of vegetation (i.e. mature trees) even if within the public right-of-way and required to address a safety hazard.
Add Protected Bike Lanes *(on segments and at intersections)*	Where vehicle speeds or volumes are high, or where demand exists to connect to destinations. Bike lanes can be substituted for wider shoulders on rural roadways. Protected bike lanes should be provided at intersections where shoulders are limited.	• Provides separation from adjacent travel lanes and motorists increasing real and perceived safety for a wider range of bicyclists. • Provides predictability for motorists about bicyclist's location. • Reduces potential for conflict that is higher when separation does not exist.	• Some installations require frequent maintenance costs (i.e. plastic flex bollards). • May be confusing to some motorists. • Are not typically plowed/shoveled in the winter. • When placed adjacent to on-street parking, conflicts due to car door openings may present a hazard.

IMPROVING THE PLAN

The plan described in this report identifies a method of selecting bicycle and pedestrian safety projects within CDOT Region 4. With new bicycle and pedestrian safety funding opportunities becoming available through new transportation funding bills, CDOT may consider updating the plan every 2-3 years to account for updated crash history and new data that may be available for use in systemic safety analysis. There are additional opportunities to improve the results of this plan in the future through improved crash data collection and the addition of new datasets.

Crash Data Collection

Crash pattern analysis and network screening were both limited by data availability and format. One resource for improving crash data is the Model Minimum Uniform Crash Criteria Guideline (MMUCC)[17]. MMUCC identifies a minimum set of motor vehicle crash data elements and their attributes that States should consider collecting and including in their state crash data system. The 5th Edition was made available in 2017 and increased the number of data elements to 115. On the National Highway Traffic Safety Administration (NHTSA) website, they state that the 5th Edition was "the result of an 18-month collaboration between NHTSA, the Federal Highway Administration (FHWA), the Federal Motor Carrier Safety Administration (FMCSA), the National Transportation Safety Board (NTSB), the Governors Highway Safety Association (GHSA), and subject matter experts from State DOT's, local law enforcement, emergency medical services, safety organizations, industry partners, and academia." A crash report form showing all 115 elements is also available on the NHTSA website[18]. Specific elements from this report that would have been beneficial to understanding the nature of crashes in Region 4 include:

- Contributing circumstances in the roadway environment (i.e. obstructed crosswalks, related to a bus stop, shoulders, visual obstructions, etc.)
- Specific location of a crash (i.e. acceleration/deceleration lane, shared use path or trail, etc.)
- Overall intersection geometry (i.e. angled/skewed, roundabout, or perpendicular)
- Overall traffic control device (i.e. signalized, stop-all way, stop-partial, yield)
- Trafficway description (i.e. travel directions, divided, barrier type, etc.)
- Roadway alignment and grade
- Traffic control device data (i.e. signs, signals, pavement markings, any inoperative or missing)
- Motor vehicle maneuver/action (i.e. backing, negotiating a curve, stopped in traffic, etc.)
- Person type (i.e. motorist, non-motorist, incident responder)
- Driver actions at time of crash
- Access control (i.e. no access control, partial access control, full access control)
- Non-motorist action/circumstance prior to crash
- Non-motorist location at time of crash

Specific to this study, the following could also help improve future bicycle and pedestrian analyses.

- Indicating the location of the pedestrian when struck (i.e., on sidewalk, in road, etc.), the direction of pedestrian travel, and the type of collision that occurred (i.e., motor vehicle struck pedestrian from behind, from front, from side, etc.)

[17] MMUCC | NHTSA

[18] mmucc5_crashreportform2017.pdf (nhtsa.gov)

- Improving the completeness of reports that are submitted. Narratives are very helpful for understanding exactly what happened during a crash, but many crash reports do not include the narrative.

Limitations of the Data

The data available for this study did not include certain roadway characteristics that would be helpful in identifying high risk locations. As noted earlier in this study, data sources that were associated with a CDOT route and milepost were generally applicable to this study. Route and milepost fields connected the data back to the CDOT highways network in a cohesive manner that enabled route event overlays (dynamic segmentation) to analyze multiple sets of attributes together. For future studies, datasets such as intersection locations, intersection control (signal versus stop control or roundabout), intersection geometry, on-street parking, access spacing, location of sidewalks to the motor vehicle travel lane (separated versus adjacent) would be helpful in identifying additional risk factors.

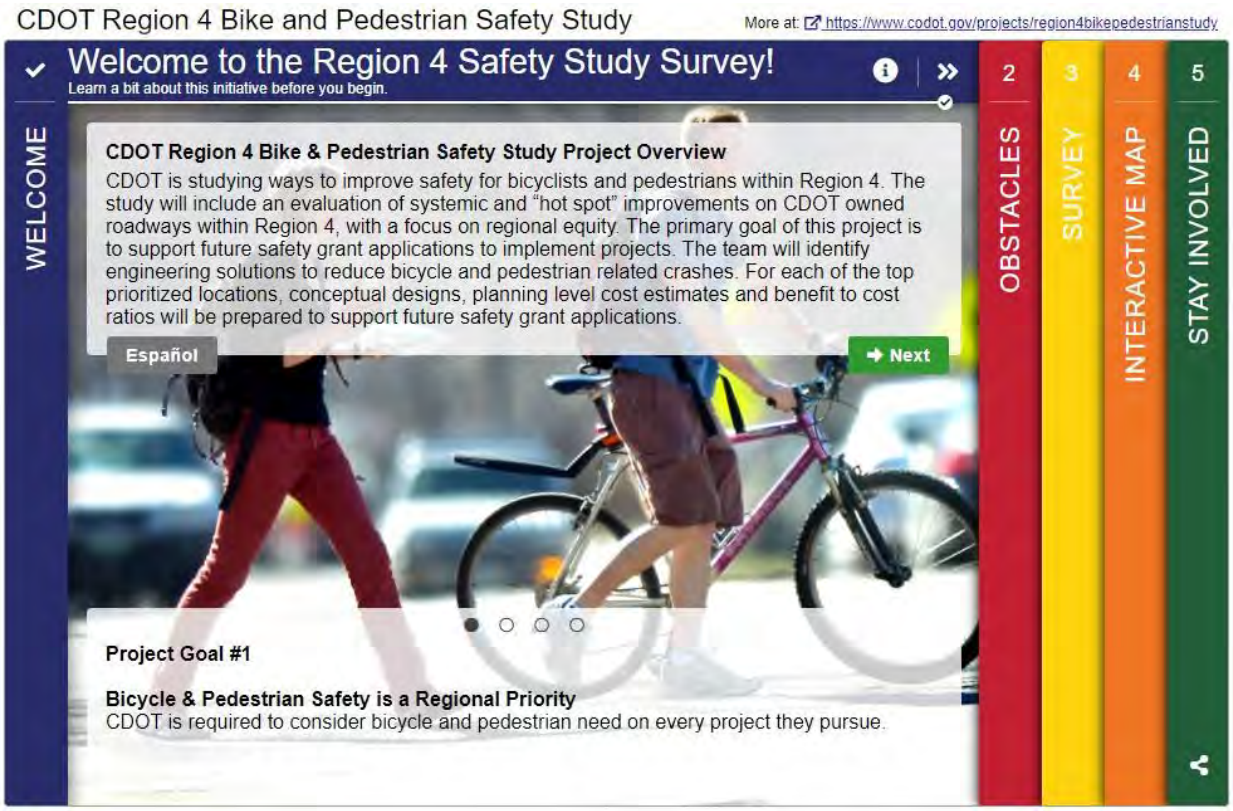
Attachment 1 – MetroQuest Survey Results Summary

Survey Open Timeframe

The online survey was open for 9 weeks, between July 12, 2021 and September 6, 2021.

Survey Organization

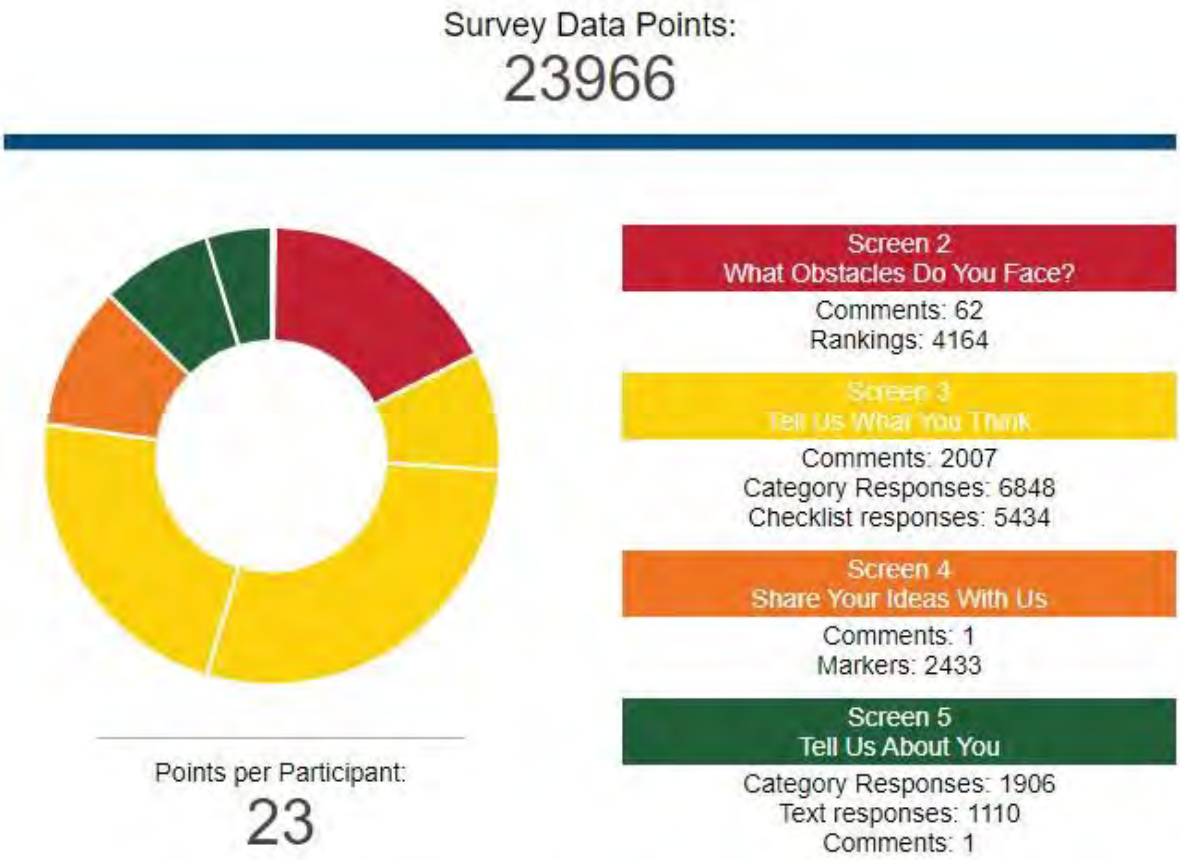
The survey used a 5-tab organizational system to gather data, with each tab asking a different set of themed questions. Survey participants were able to move back-and-forth between the tabs as needed, and their data could be changed and updated until they clicked the 'finish' button on the last survey page. On each tab, the title and information about each survey section was found at the top of the page, and a white circle information button could be used to help answer questions about how to interact with the survey.



SURVEY PARTICIPANTS WERE GREETED WITH A 'WELCOME TO THE REGION 4 SAFETY STUDY SURVEY' INTRO TAB, WHICH PROVIDED AN OVERVIEW OF THE PROJECT AND SUMMARIZED THE PROJECT GOALS. THE GREEN "NEXT" BUTTON ALLOWED PARTICIPANTS TO ADVANCE THROUGH THE TABS, OR PARTICIPANTS COULD ALSO CLICK ON EACH COLORED TAB (1-5) TO BE TAKEN TO THE QUESTIONS FOR THAT PAGE.

Overall Survey Data Points

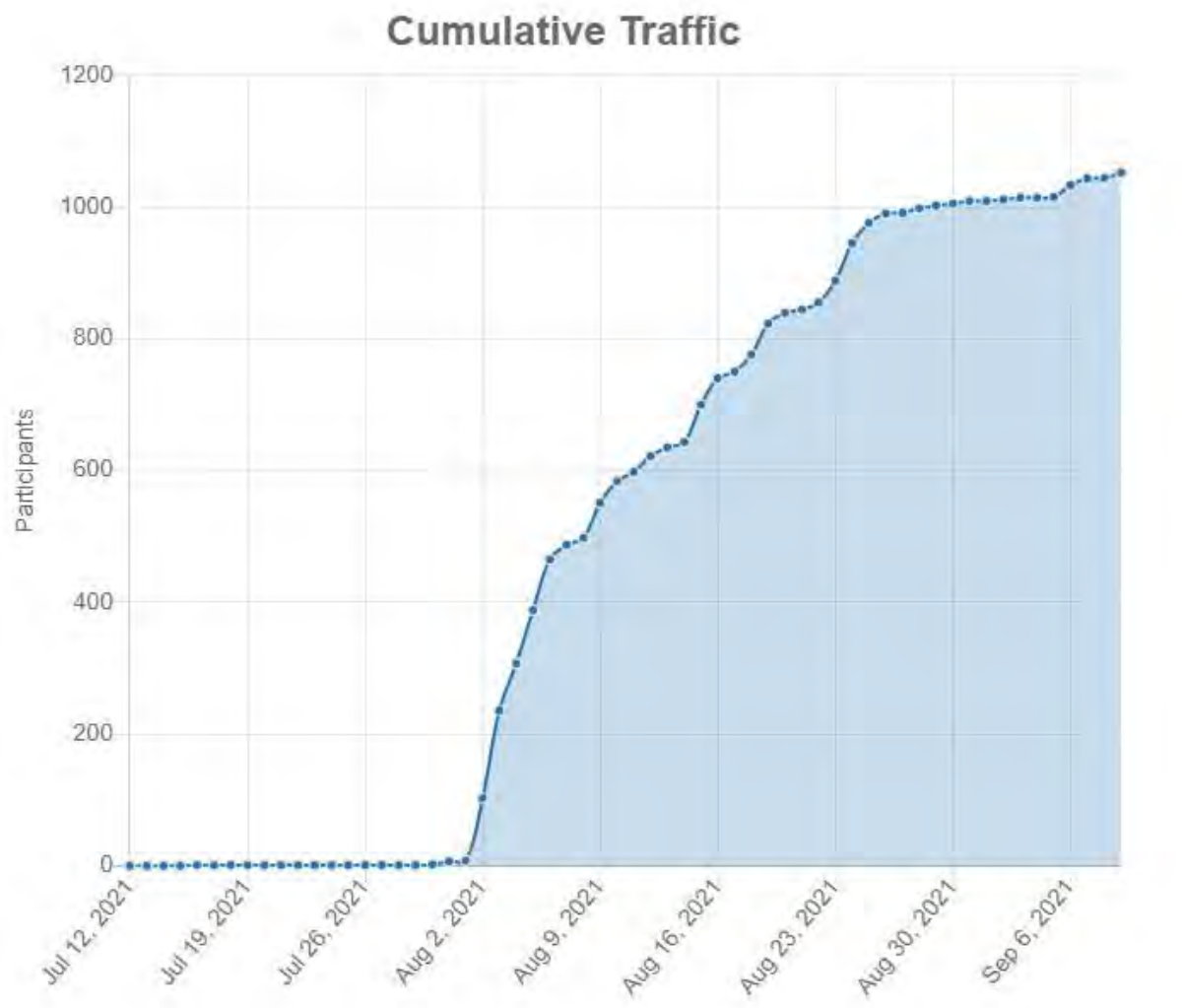
The survey participants provided the largest number of comments and responses in the middle three sections of the survey, where they were asked to provide general input and ideas, and share the obstacles they face, walking, biking, and rolling in CDOT Region 4.



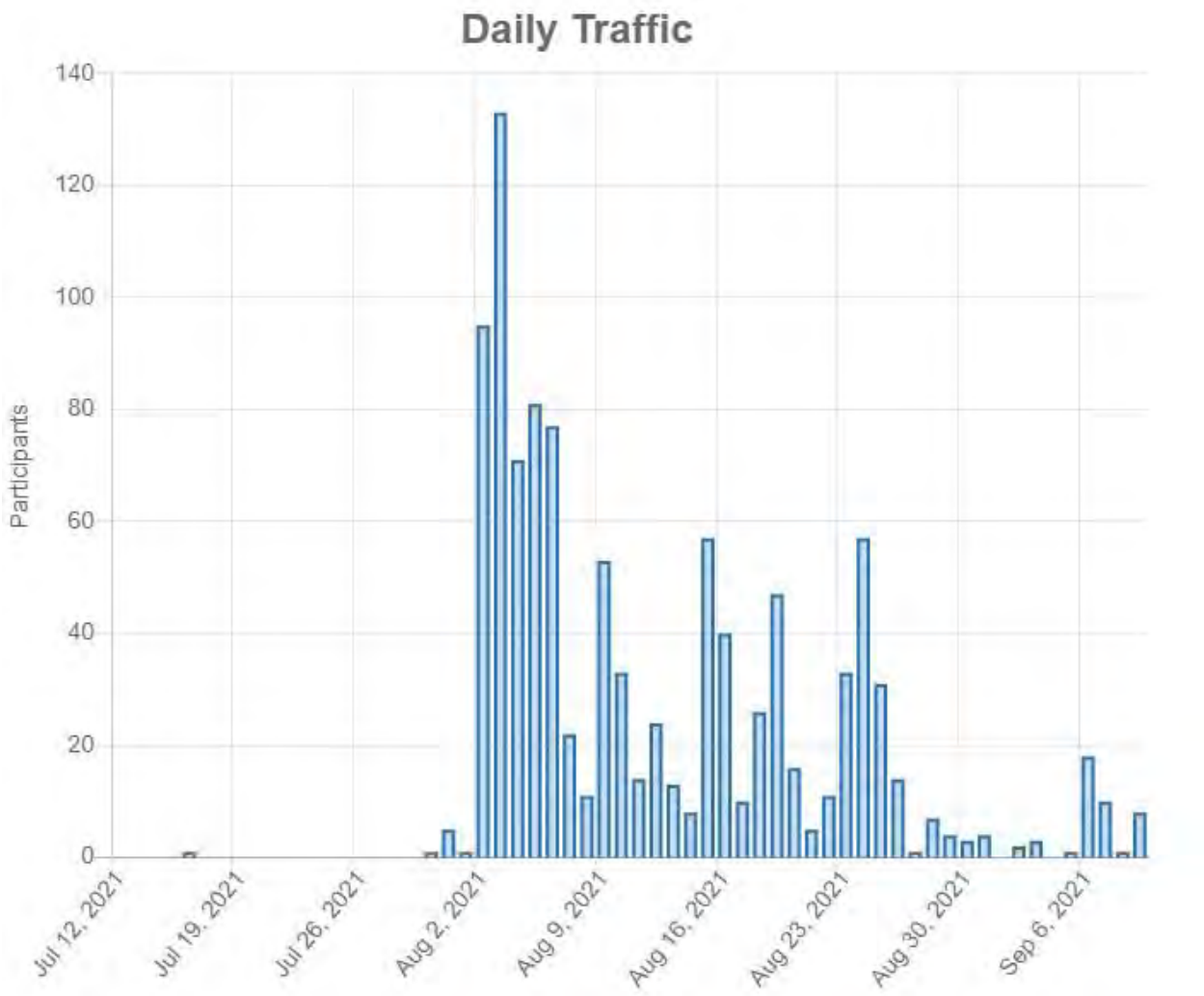
Welcome Page Summary – Tab 1

Number of Survey Visitors: 2007 (47.63%)
Number of Survey Participants: 1052 (53.37%)

Three-fourths (75.2%) of the survey participants completed the survey through a web interface, like their laptop or desktop computer. The other quarter of the survey participants (24.8%) completed the survey on their mobile devices.



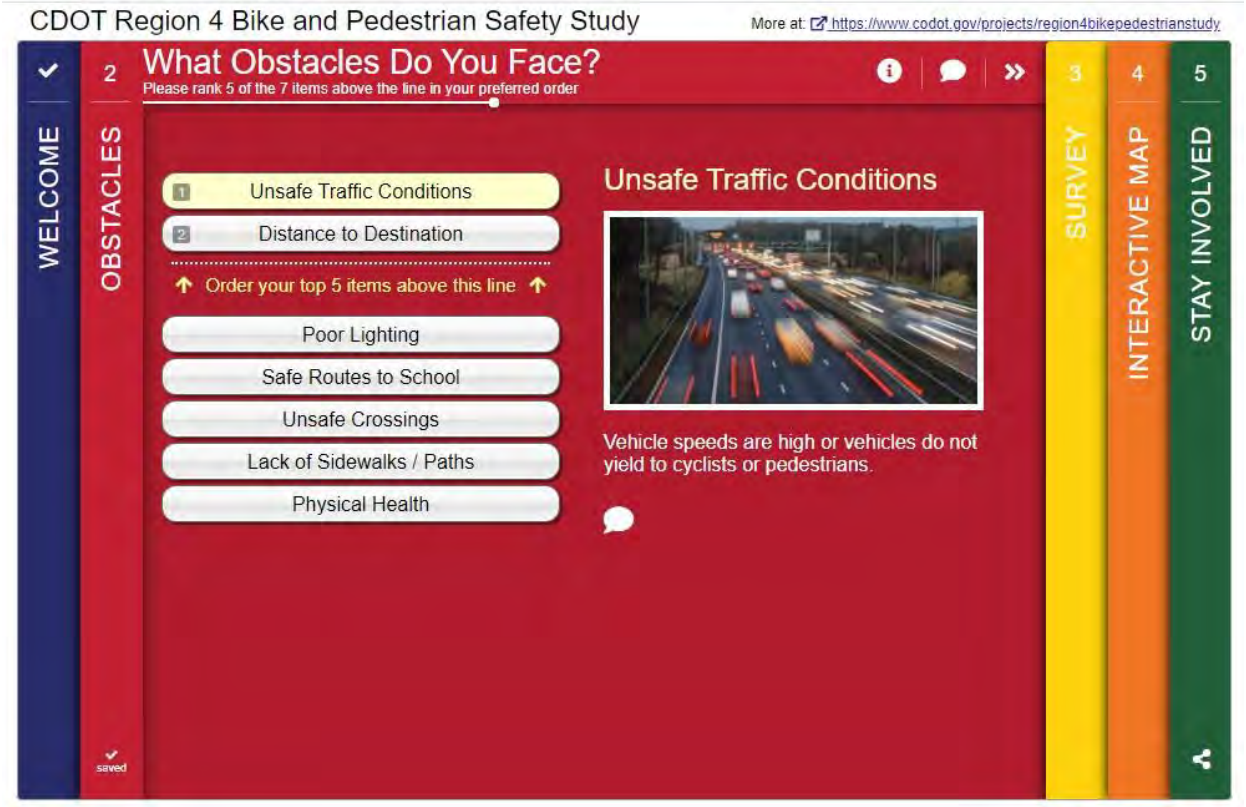
THE CUMULATIVE TRAFFIC SUMMARY ILLUSTRATES ENGAGEMENT WITH THE SITE GREW STEADILY, PLATEAUED, AND THEN GREW SLIGHTLY TOWARD THE END OF THE 9-WEEK PERIOD IN WHICH THE SURVEY WAS OPEN



DAILY TRAFFIC SPIKES ROUGHLY CORRESPOND TO THE SURVEY LAUNCH AND TO SEVERAL SOCIAL MEDIA ADVERTISEMENTS POSTED THROUGHOUT THE PROJECT:

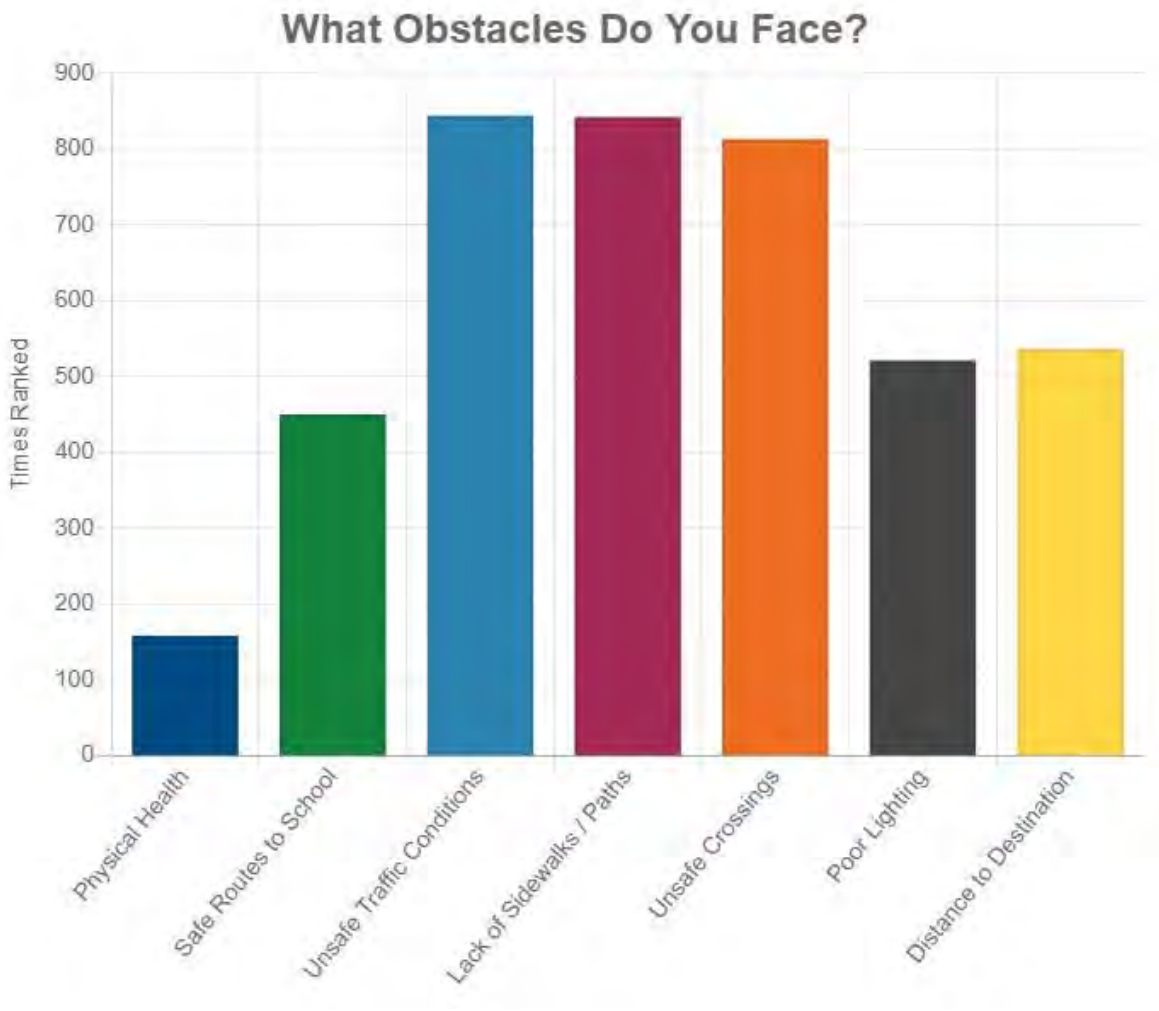
What Obstacles Do You Face? – Tab 2

Tab 2 of the survey asked participants to rank the top 5 obstacles they faced regarding bike and pedestrian movement and safety. For each of the top 5 selections, participants were given the option of adding additional comments about each selection using the white 'text bubble' icon.



Top 5 Survey Responses

The highest survey responses for "what obstacles do you face" within Region 4 were 'Unsafe Traffic Conditions' (844 responses), 'Lack of Sidewalks/Paths' (842 responses), and 'Unsafe Crossings' (813 responses). At the next tier of concerns were 'Distance to Destination' (536 responses), 'Poor Lighting' (521 responses), and 'Safe Routes to School' (450 responses). At the bottom of the ranking was 'Physical Health' (158 responses).



1st Priority Obstacle: 'Unsafe Traffic Conditions'

The above chart illustrates that unsafe traffic was the highest barrier to pedestrian and bike movements and safety within Region 4. Many of the respondents pointed to the need for clarity for how roadways are divided to create distinct spaces for bikes, pedestrians, and motor vehicles. The sentiment that many of the roadways are designed for drivers and there is little signage or information posted to alert drivers to pedestrian and bike facilities was mentioned by several survey participants. In general, the idea that drivers need to be educated about what bike and pedestrian facilities exist, where they could expect to encounter bikers and pedestrians, and how to ensure they are following the safety and etiquette rules for driving in areas with bikes and pedestrians were listed as the improvements that would make the most impact in reducing unsafe traffic conditions.

Unsafe Traffic Conditions Summary of Participant Comments
Too many drivers disobeying laws - speeding, inattentive driving chief among them.
Vehicles have ruled roads for too long and it is hard to change. Roads are too narrow, no bike lanes, trails and sidewalks are not dethatched from the road. Areas are simply not safe for cycling and walking and running.
Bike path does not extend from Estes Park west along HWY 36 to RMNP. Very dangerous to ride west on 36 from Estes Park on the current road.

People are dying on bikes on roads. Please create physical barriers between cars and bikes/peds
Drivers behind the wheels of high-speed cars &trucks are DEADLY
No shoulders. No protected bike lanes. Too much traffic. Impatient drivers. Speeding
Lack of awareness by drivers of the rights of cyclists and the responsibility of the driver to FOCUS ON DRIVING. Every dealership and especially rental shops should be mandated to post visible info on state laws. I can handle every other obstacle on your list.
While we have "sharrows", I find it unsafe to bike around downtown Estes because tourists are not particularly aware.
No shoulders having trucks buzz me
Increased signage indicating bicycles may use right lane and 3' separation when passing are state laws.
In Estes Park, traffic gets very congested and busy in the summer months. Couple this with many easily-distracted out-of-towners who are unfamiliar with the town's road network, and it creates a very difficult and unsafe environment for cyclists. Dedicated bike and pedestrian paths throughout the town would greatly improve this situation. Please consider paths and not simply bike lanes. The roads are too crowded with drivers unfamiliar with the area and do not mix well with cyclists. Thanks! :-)
I only had the top 2 issues, the program just made me choose 5 before i could move on
Unfortunately the app didn't work, and I couldn't rank the "Obstacles" correctly. My main obstacles are "Unsafe Traffic conditions", "Unsafe Crossings", "Safe Routes to School", "Lack of Sidewalks" and "Poor Lighting".
Speeding, texting & driving, no stops, disregard for crosswalks.
I am a cyclist, and the speed limit on roads like County Line is 50 mph without bike lane or shoulder. It's very scary to ride on any of the County roads like CR 3, CR 5, but I'd really like to.
More signage needed to protect bikers and walkers

2nd Priority Obstacles: 'Lack of Sidewalks/Paths' and 'Unsafe Crossings'

At the top of the reported obstacles were missing physical design elements along roadways, like sidewalks, walking paths, and designated pedestrian and bike crossings. Connectivity between nodes like residential areas and employment/retail areas, residential areas and schools, and urban areas and outdoor recreation areas were noted. Participants stated that the lack of physical facilities for bikes and peds not only made traveling by these modes less safe, but also that a lack of contiguous walking and biking networks between destinations made it difficult to access work, schools, and daily retail needs without a car. This was especially true in formerly rural areas with new residential communities that were not connected to existing bike and pedestrian networks.

Participants also stated that the lack of robust biking and walking networks contributed to a lack of driver awareness of how to be respectful and careful around multi-modal roadway users, which made them feel unsafe. It was repeatedly noted that adding dedicated and separated bike and pedestrian facilities was preferred, since these facilities felt safer and more user-friendly. Several notes were also made about the timing of existing crossings, and how extending times for pedestrians and bicyclists to cross the road would make it easier to walk and bike. It was also noted that flashing pedestrian crossings were preferred.

Lack of Sidewalks/Paths and Unsafe Crossings Summary of Participant Comments
too many lighted crosswalks sign take too long to change and people get impatient and cross anyway. people will cross mid-block across multiple lanes with children on a highway - so unsafe. crosswalks are not well marked. need to enforce drivers stop. need to change the culture that ped and bikes have rights.
connectivity is needed especially for commuting.
Moraine Avenue from the Davis Parking lot to Highway 66 is bad both because of unsafe crossing zones and horrible side road and side walk conditions.
The area along Moraine (Hwy 36) in Estes Park is very dangerous for pedestrians and bicyclists. So is Mary's Lake Road, particularly the stretch from Riverside north to Moraine.
Need more *protected* bike lanes
Also street crossings make pedestrians wait and prioritize car traffic. Stop this!
You required 5 - this isn't an issue.
Timnath co needs more accessible bike paths connecting it to Fort Collins. Not having to bike over the harmony/I25 overpass
Particularly around Elementary schools
Connecting the new housing developments and existing housing developments to the bike paths around the Poudre River Trail specially in Timnath
Crosswalks are not always convenient to get across 36 and 34 in Estes Park.
Hwy 36 in Estes Park needs sidewalks into town and a bike path as well!!!
Curbs are also dangerous to bicyclists when attempting to merge from street crossing to a multi-use path
The main north to south route through Lakewood, Garrison Street from Jewell to Colfax has a very limited shoulder, creating a very unsafe situation.
increased use of rapid flashing pedestrian crossings, especially on roads with greater than 25 mph speed limits.
Even a 3'-4' wide bike lane would greatly increase cycling safety along state highways and county roads.
Even in instances where bike lanes exist, they are unprotected and near traffic that is moving at more than 30 miles per hour. This makes me and others feel unsafe still.
I live in Estes Park. My wife and I love the bike trails that do exist here, but unfortunately, there aren't enough dedicated bike paths to make commuting safe within this community. Both US Highways 34 and 36 (within Estes Park) have high traffic volume and often do not have paths nor even sufficient shoulders for biking. For example, it would be dangerous for cyclists to commute to the YMCA or to the Nat Park offices using primary roads. These are two of the biggest employers in town. Thanks!
So many major crossings on busy, high speed roads in Windsor. Drivers constantly ignore them, even when flashing lights are used
Would love to have a crossing at CR 5 & CR 10 to get to soaring heights from the north.
There is no sidewalk on CR 10 or CR 5 to get to Soaring Heights from the north of Colliers Hill.
No contiguous east-west route with safe shoulders/bike lanes from Erie to Boulder
Our neighborhood (Conpass) is an island with no safe connection to any path or sidewalk.
Our town need better bike and walking paths
Lack of crosswalks

Hwy 14 - ault to Fort Collins Hwy 392 - weld county parkway !!!! Hwy 392 - county rd 43!!!! Hwy 392 - county rd 35

3rd Priority Obstacles: 'Distance to Destination' 'Poor Lighting' and 'Safe Routes to School'

Below the top tier of obstacles faced by pedestrians and bicyclists were several physical improvements (Poor Lighting and Safe Routes to School), and concerns that physical distances between nodes in Region 4 make walking and biking more challenging.

Regarding physical improvements, ideas like utilizing regional trails for safe biking and walking between destinations was noted, especially since many roadways do not have biking and walking infrastructure. It was mentioned that trail amenities, like lighting and beautiful vistas, would make the longer distances needed to travel along trails more appealing. However, it was pointed out that participants would prefer to walk and bike along CDOT roadways (rather than use trails), but they currently do not feel safe doing so due to a lack of dedicated walking and biking networks.

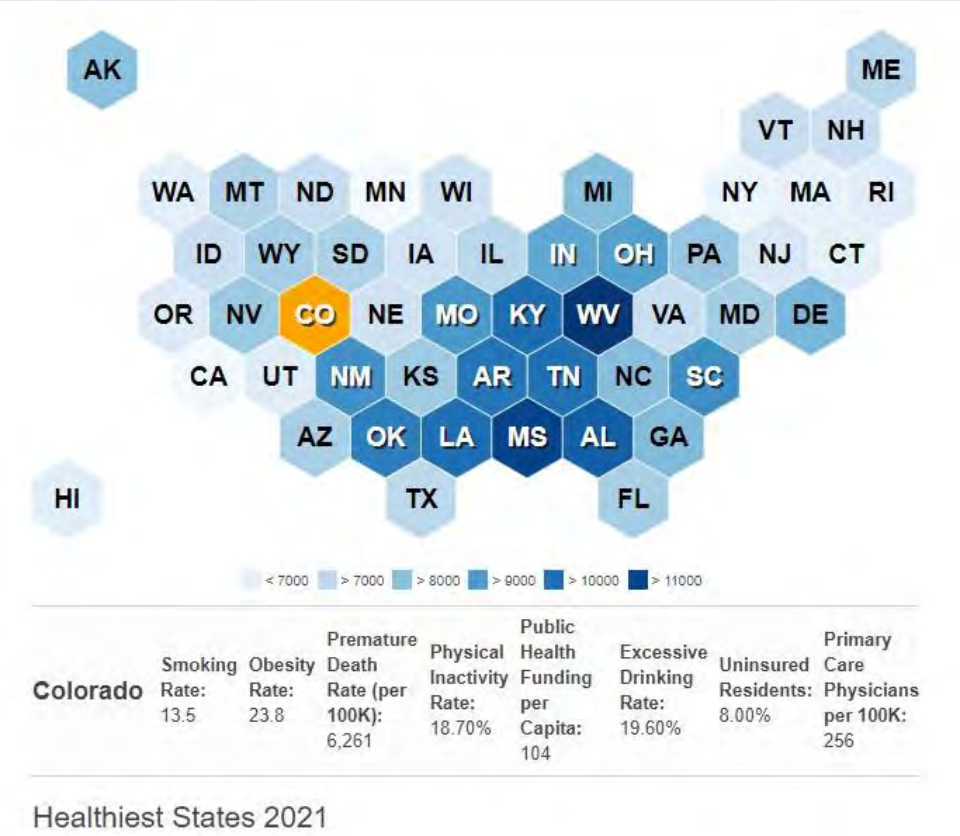
Distances to destinations and safe routes to school were interlinked, with many participants noting that it's often too far for their children (and them) to bike or walk from their homes to schools or other destinations, and that where biking and walking facilities exist, they are directly adjacent to high volume roadways where cars are going very fast compared to the pace of walkers and bikers. Several participants noted that increased land use densities would help reduce the obstacle of distances between destinations being too far and encouraged a more mixed-use approach to planning and zoning that would intermix retail, work, and schools with a variety of residential densities.

Distance to Destination, Poor Lighting, and Safe Routes to School Summary of Participant Comments
If the top 5 obstacles were removed, safer routes to school would follow.
CDOT has a program: Safe Routes to School. How will what you are doing with this project support, be coordinated with SRTS? Please consider this.
We desperately need regional trail connections that are safe and FUN. If you want to get people out of cars, they need to be able to get to the open spaces they love without having to ride on roads. Deaths are mounting in Boulder County roads for cyclists!
It's not distance to a destination per se. It's that the travel to the destination should be fun and a destination on its own. Make trails and paths that are fun and people will use them.
Too many high-speed cars on the way to school
Colorado needs better land-use and higher density, rather than sprawl sprawl sprawl
You required 5 - this isn't an issue.
Too far to bike
This issue is also a land use and zoning issue. Encouraging mixed use development would bring destinations closer to people.
Although I am in very good physical condition and can indeed ride long distances in the mountains, I do not feel safe riding long distances within my hometown of Estes Park because of the lack of dedicated bike paths in the community. In the summer, the roads are frequently very busy/congested and drivers are easily distracted by wildlife and the scenery. Additionally, visitors can

sometimes drive erratically because they are trying to navigate a new place and are confused by the local roads.
School is 1.7 miles away; too far for my 4 & 6year old to scooter or bike both ways in the heat or cold.
Driving or walking, it's not very safe to getto (SIC) Soaring Heights. The backed up traffic on CR 5 is problematic because cars pass at high speeds
More lights needed on the trails at loudy
Far distance to walk or ride to school

4th Priority Obstacle: 'Physical Health'

Nationally, Colorado consistently ranks high in regard to physical health (see chart below, reference: https://worldpopulationreview.com/state-rankings/healthiest-states). Few participants ranked physical health as a barrier to walking and biking, and several participants commented that adding additional biking and walking networks would help encourage physical health and activity in Region 4.



However, although physical health was ranked at the bottom of the list of survey obstacles, it's worth noting that Colorado's population (and that of the entire United States) is rapidly aging, and there is a projected deficit in housing and service facilities for the growing number of older members of our society. One in 7 Coloradans is age 65 or older (in 2019 data), and by 2050, this number will grow to 1 in 5. Of people over 65 who receive Medicare, over 80% have at least one chronic health disease that impacts their physical health (https://www.coloradohealthinstitute.org/blog/aging-communities-colorado). Therefore, although physical health was not listed as a significant concern for survey participants today, the need for facilities that

accommodate people as they age and can no longer drive is important, and directly linked to allowing older adults to be independent, secure, and productive.

It is also worth noting that the demographics of people who are inclined to take a survey about walking and biking are interested in that topic and more likely to be walkers and bikers themselves, which can be correlated with higher levels of health and a lower level of concern about physical health as a barrier to walking and biking.

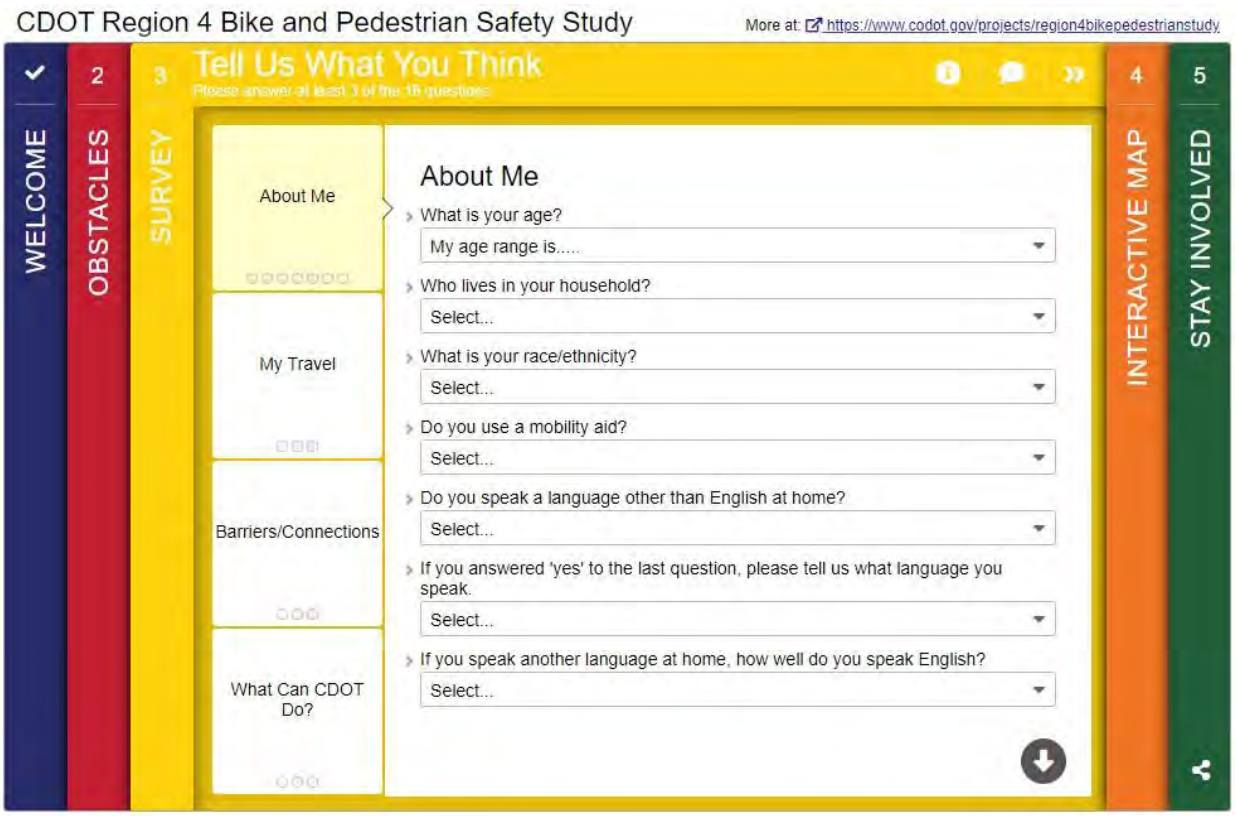
Physical Health	Summary of Comments
If the top 5 were improved, health improvements would follow.	
needs no info. just look around...	
I am blind in my left eye. This makes it difficult to gauge distances to approaching cars from behind coming from my left side. If I have change lanes (e.g. to turn left) to go where I want to go I don't go. Or I will drive.	

What Obstacles Do You Face: General Comments

What Obstacles Do You Face	General Comments
We need an equitable transportation system	
Proximity to loud, deadly cars is the biggest obstacle. Paint on bike lanes is NOT protection from a 2-ton metal mass moving at 50 miles per hour :(	
Weather, load limit, children, time, uneven ground... The obstacles listed do not match my obstacles	

Tell Us What You Think – Tab 3

Tab 3 of the survey collected demographic information about each participant, and asked them questions about how they traveled, if they currently bike and walk in Region 4, and how easy they find walking and biking. Tab 3 also asked participants to share their ideas for the actions and physical improvements/routes that CDOT Region 4 could add or improve that would strengthen walking and biking in the region.

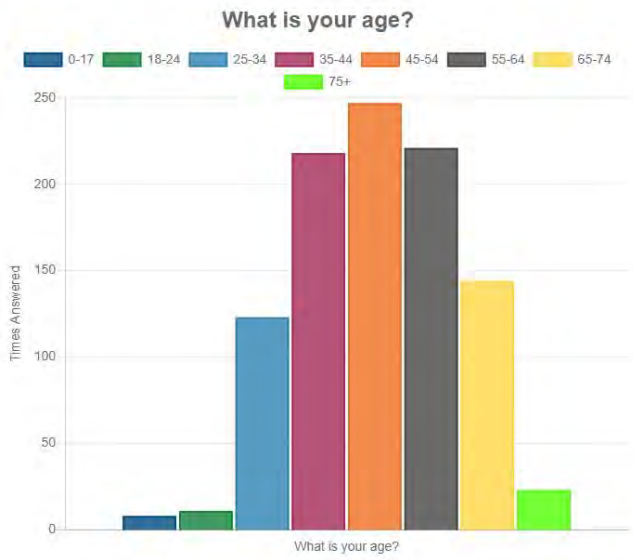


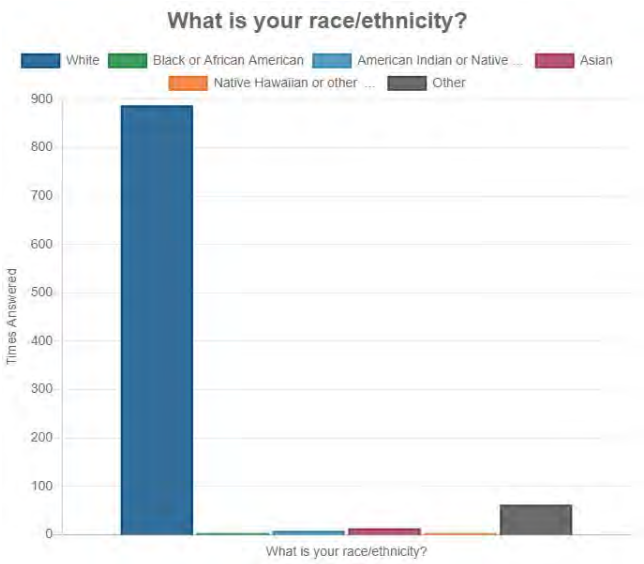
About Me – Age, Race, Household and Mobility Aid Use

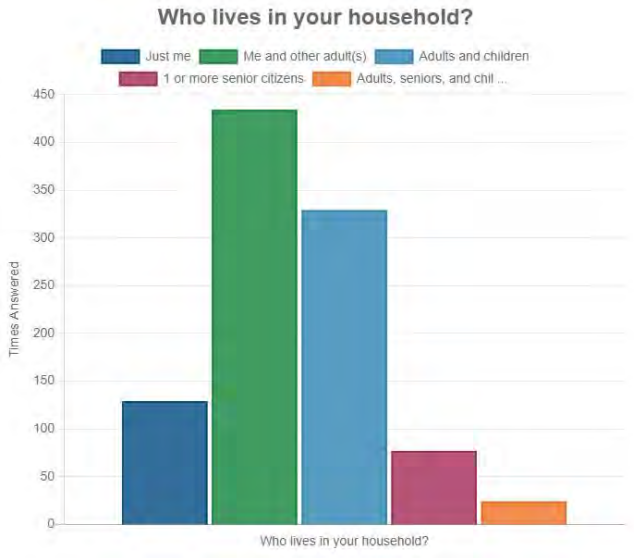
The majority of survey respondents live in households with other adults (434 respondents) or children (329 respondents). 129 respondents live alone, and 77 respondents live with 1 or more senior citizens. The smallest number of respondents (24) live in mixed households of adults, seniors, and children. Demographically, the age of survey respondents reflects some differences from the overall population ages in the United States, which has a higher number of people under the age of 24, 30%, and a lower number of people from age 55-64, over 12% (source: https://www.cia.gov/the-world-factbook/countries/united-states/#people-and-society). In the Region 4 survey, very few youth and children participated in the survey, and many more participants ages 55-64 and 65-74 took the survey than are demographically represented in the US bell curve. It can be surmised that a greater number of older adults in Region 4 are interested in walking and biking than the national average, based on the survey responses.

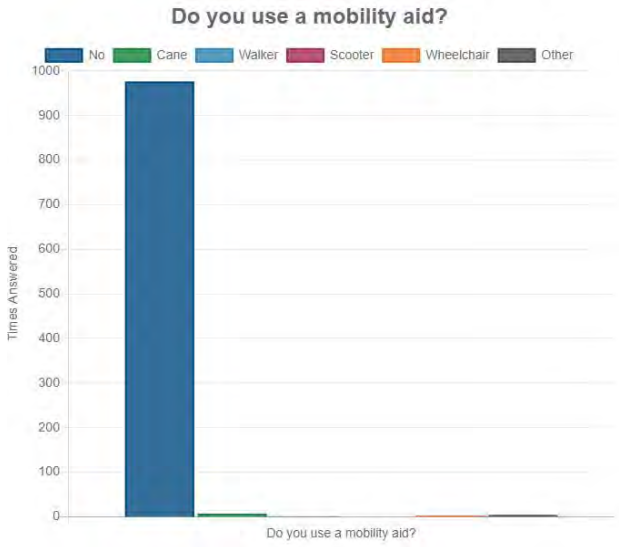
From an ethnic group perspective, the majority of participants (887) identified as White. 'Other' was the second-largest ethnic group (62), followed by Asian (13), American Indian or Native Alaskan (8), and a tie between Black (3) and Native Hawaiian or other Pacific Islander (3). These numbers roughly parallel the US Census data for Colorado (https://www.census.gov/quickfacts/CO) with the exception of the percentages of survey participants who are Black or Asian. There were fewer Black survey respondents than the overall percentage of people in Colorado (4.6% of the Colorado population is Black), and there were more Asian survey respondents than the overall percentage of people in Colorado (3.5%). It's possible that the historic Asian communities that were established in locations within Region 4 contributed to the higher number of Asian survey respondents for this survey.

Of the respondents who said they used a mobility aid (only 15 of the 976 respondents to this question said they used a mobility aid), the majority use a cane or a wheelchair (10). Although the number of people in Colorado under 65 who have a disability is 7.2%, this number is higher than the percentage of survey respondents (less than 2%) who said they required a mobility aid.



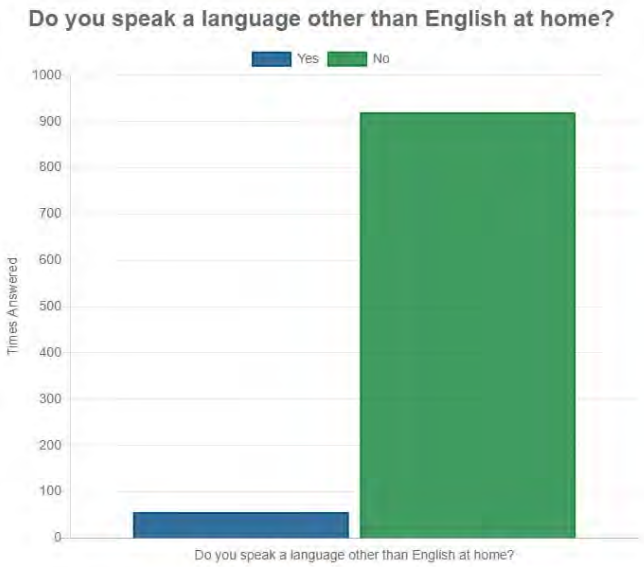


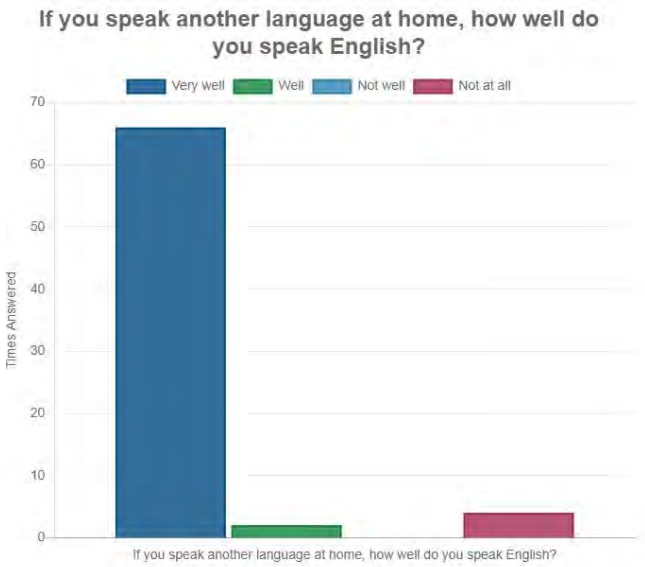




About Me – Languages

The majority of survey respondents to the English-only survey spoke English at home. Of the 56 respondents who said they didn't speak English at home, Spanish was the most common response (21), followed by French (7). There were also 9 people who spoke languages like Russian, Japanese, Italian, Vietnamese and Korean. For those respondents who did not speak English at home, the majority identified as speaking English "Very Well."

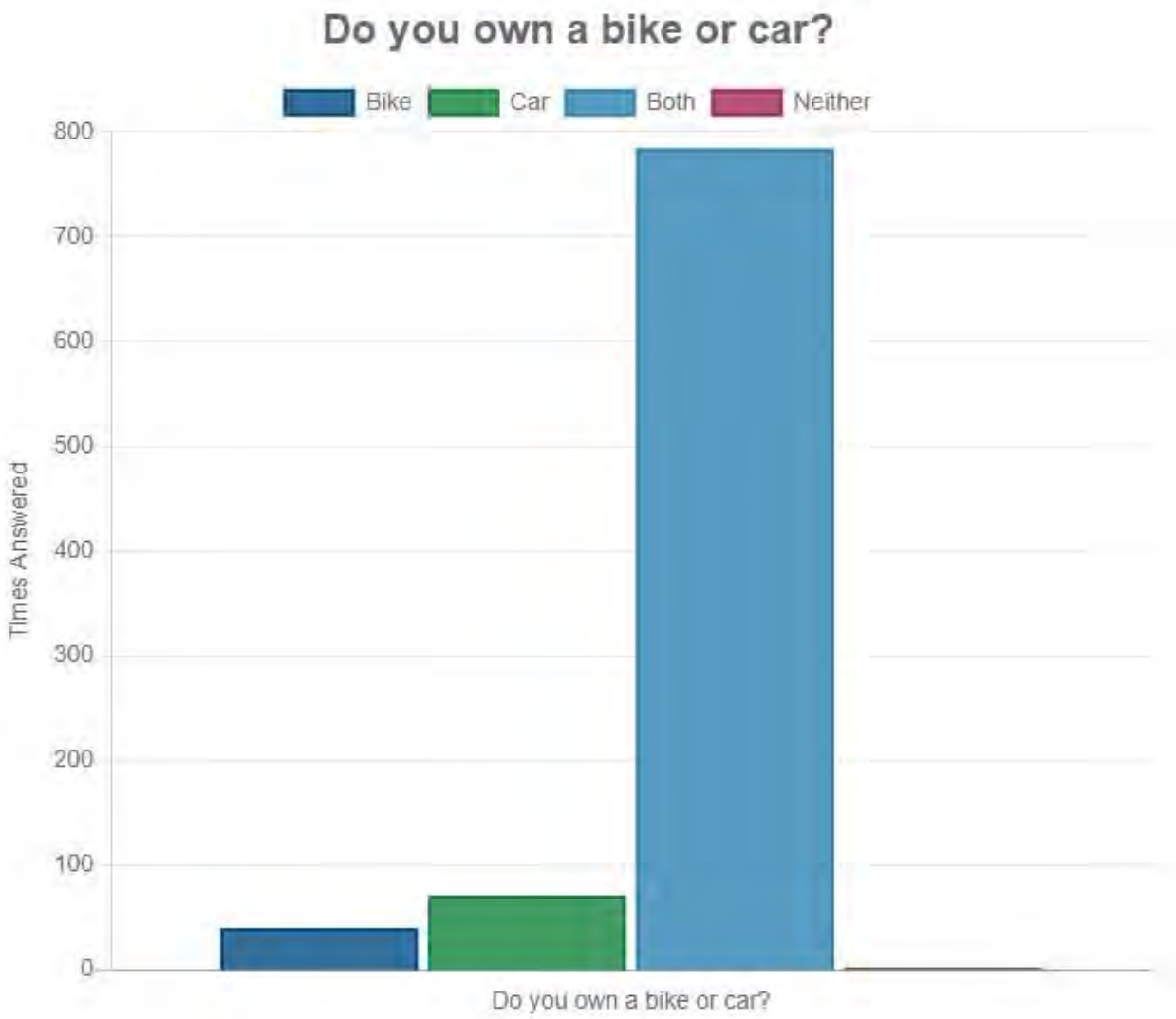




My Travel

Most survey respondents own both a bike and a car, and walk or bike for exercise, leisure, or as a means of transportation. When asked their comfort level with walking and cycling in Region 4, participants stated they are okay with cycling in traffic sometimes, but prefer bike lanes or wide shoulders, and are okay walking near busy streets, but prefer sidewalks with a physical buffer from the street (like on-street parking). Almost 300

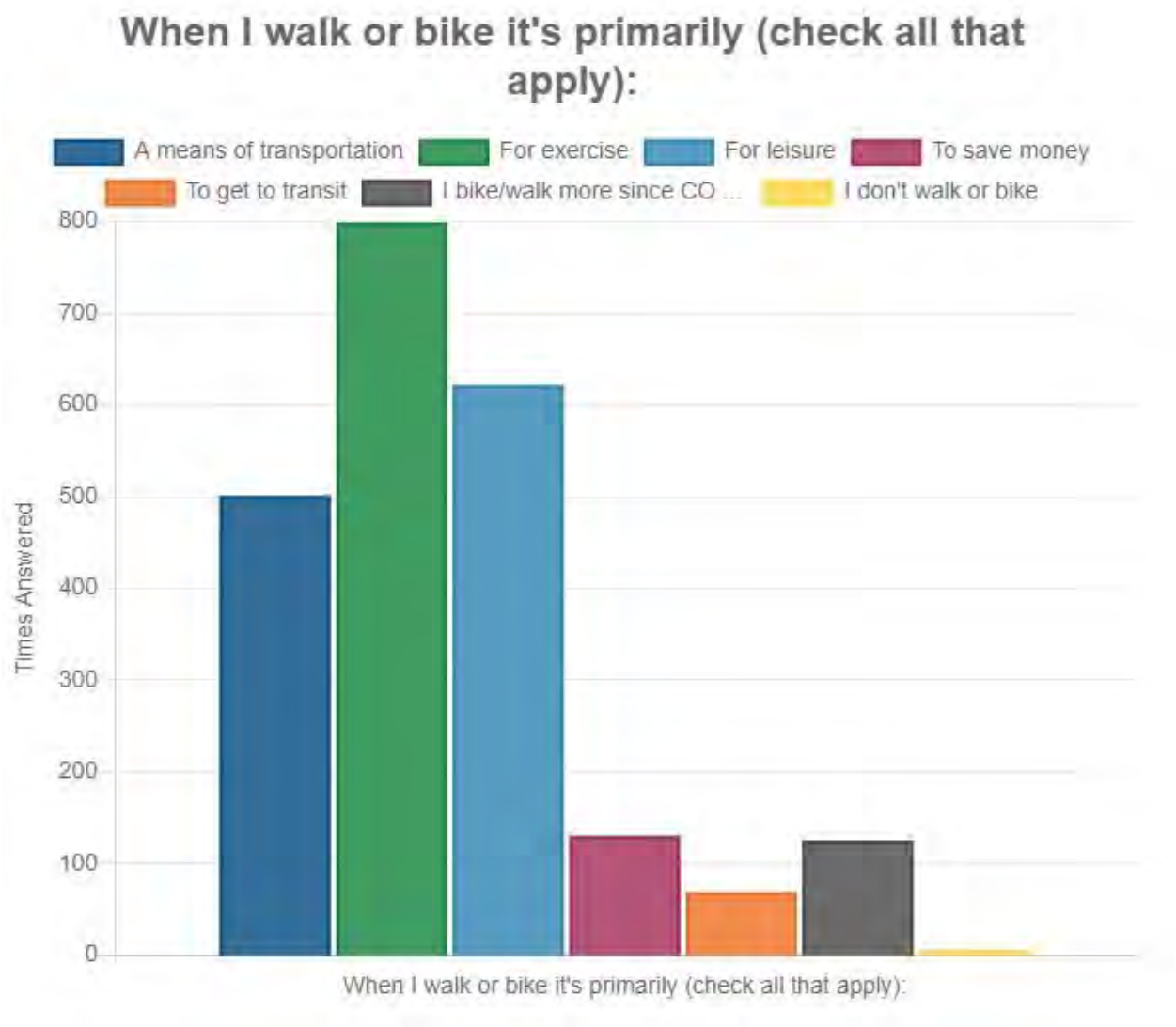
survey participants stated they are only comfortable walking or cycling on quiet streets or on trails away from traffic. Only 20 survey participants said they do not walk or cycle in Region 4.



What is your comfort level with walking/cycling (select up to 2 choices)?

Number of Responses by Selection

	What is your comfort level with walking/cycling (select up to 2 choices)?	Responses
1	I am only comfortable walking/cycling on quiet streets or on trails, away from traffic	294
2	I am OK cycling in traffic sometimes, but prefer bike lanes or wide shoulders	547
3	I am comfortable cycling in traffic on almost any road, without bike lanes or wide shoulders	122
4	I am OK walking near busy streets but prefer sidewalks with a physical buffer from the street (e.g. on-street parking)	416
5	I am comfortable walking in my community, even without sidewalks	121
6	I do not walk or cycle in the area	20



Barriers and Connections

Slightly more survey respondents found it “Very Easy” or “Somewhat Easy” (474 participants) to bike and walk in Region 4, compared to the survey respondents who found it “Somewhat Difficult” or “Very Difficult” (300 respondents). 106 survey respondents said it was neither easy nor difficult to walk and bike in the region. Given that earlier data shows that the majority of respondents bike for exercise or leisure (over 1400 respondents), it makes sense that biking and walking facility barriers are not preventing people from using the CDOT Region 4 roadways to walk and bike.

When asked what improved condition locations for walking and biking they’d like to see in Region 4, survey participants said the following:

I would like to see improved conditions for bikes and pedestrians (select top 2):
Number of Responses by Selection

	I would like to see improved conditions for bikes and pedestrians (select top 2):	Responses
1	Across high-speed/volume roads	486
2	On main streets	335
3	At intersections	237
4	Within my immediate community	125
5	Between my community and adjacent communities	278
6	On rural roads	150
7	Other (write details below)	51

This data tells us that improvements would be most valuable along high-speed and volume roads and main streets, and that areas of connection (like the macro-scale linkages between communities and the micro-scale linkages at intersections) are another high priority for Region 4 improvement locations.

Ideas for Improvements

There were over 2000 additional ideas for how to improve connections for bikes and pedestrians. These ranged from physical improvements like detached bike lanes, wider shoulders, signage to inform and educate drivers and multi-modal trail users about walking and biking, underpasses at high-traffic crossings, and flashing crossing signals, to ideas about connections and complete biking and walking networks that link neighborhoods and nodes through a robust system for walking and biking that parallels the current vehicular connection network.

The noted ideas also included the need for legislation and education about the importance of walking and biking networks, and the ability to build these into new developments and neighborhoods as they are constructed or improved. The educational component of raising awareness for drivers of how to alter their attitudes and behaviors around pedestrian and bicycle courtesy and tolerance was a central theme, with ideas like using signage to post cyclist and vehicular etiquette and expectations, and either lowering of vehicular speeds and/or greater policing of known speed zones. The idea of changing driver's license tests to include questions related to safe driving around bicyclists and pedestrians was also noted as a means to raise awareness of walking/biking for drivers and increasing the fuel tax to provide a funding source for bike and pedestrian improvements was mentioned as a way to install more connected networks.

The desire for regional connector trails being prioritized was echoed by many survey participants, with members of tourism-and-outdoor-recreation-based communities like Estes Park advocating for more equality between vehicular and walking/biking networks. Many tourist locations within Region 4 were noted to have heavy walking and biking traffic that causes conflicts with drivers who feel they have the greater right-of-way. Ideas to solve this issue include a mixture of visible and dedicated biking and walking facilities buffered from vehicular traffic, to adding elements like biking and walking signage for tourists that helps better orient them to multi-modal facilities and their correct use, and illuminated walking and biking networks that feel safer and are more visible.

Anther common theme among survey respondents was the desire to invest in larger bike and pedestrian infrastructure improvements like underpasses and overpasses that help separate travel modes when crossing high-volume roadways, roundabouts to allow for shorter and safer bike and pedestrian crossings at intersections, and a preference for dedicated and separated spaces for people to walk and bike that are wide enough to accommodate multiple bikers and walkers at once. Globally, survey respondents repeated the need for more robust and connected biking and walking facilities, stating specific examples of existing

facilities that are inadequately wide, not separated from motor vehicle traffic, not painted/maintained, or which abruptly end with no warning and no connections between destinations. The desire to "complete the network" was a universal rallying cry among survey respondents who were asked for their improvement ideas. Many survey respondents noted specific gaps in the network, but the universal theme when describing gaps was the isolation felt by neighbors who live in communities that are very walkable and bikeable within their borders, but who do not have walking and biking facilities that connect them to downtowns, schools, and the larger regional network.

When describing the facilities they'd prefer, the survey respondents pointed to elements like flashing lights at roadway crossings and features like bike boxes at intersections to remind drivers that bike lanes are not turn lanes. The most common facility improvement noted by respondents was a desire for separated and/or buffered bike/pedestrian and motor vehicle facilities, and a move away from bikeable shoulders.

Maintenance of bike facilities was also noted by survey participants, with respondents expressing concerns about both existing maintenance practices not keeping current bike and pedestrian facilities clear of debris and regularly painted, and worries that future installed facilities will not have proper maintenance. A need to have a dedicated maintenance budget for current and future biking/walking improvements was noted.

What Can CDOT Do?

The replies to 'What Can CDOT Do?' mirrored the answers to the question of how to improve conditions for bikes and pedestrians. The top responses (by category) to this question were:

Complete the Network – Make dedicated bike lanes and multi-modal paths installed as a complete network within the region. At both a macro and micro scale, connect communities, amenities, destinations, workplaces, and services with walking and biking networks. Ensure bike racks and bike facilities on buses and transit.

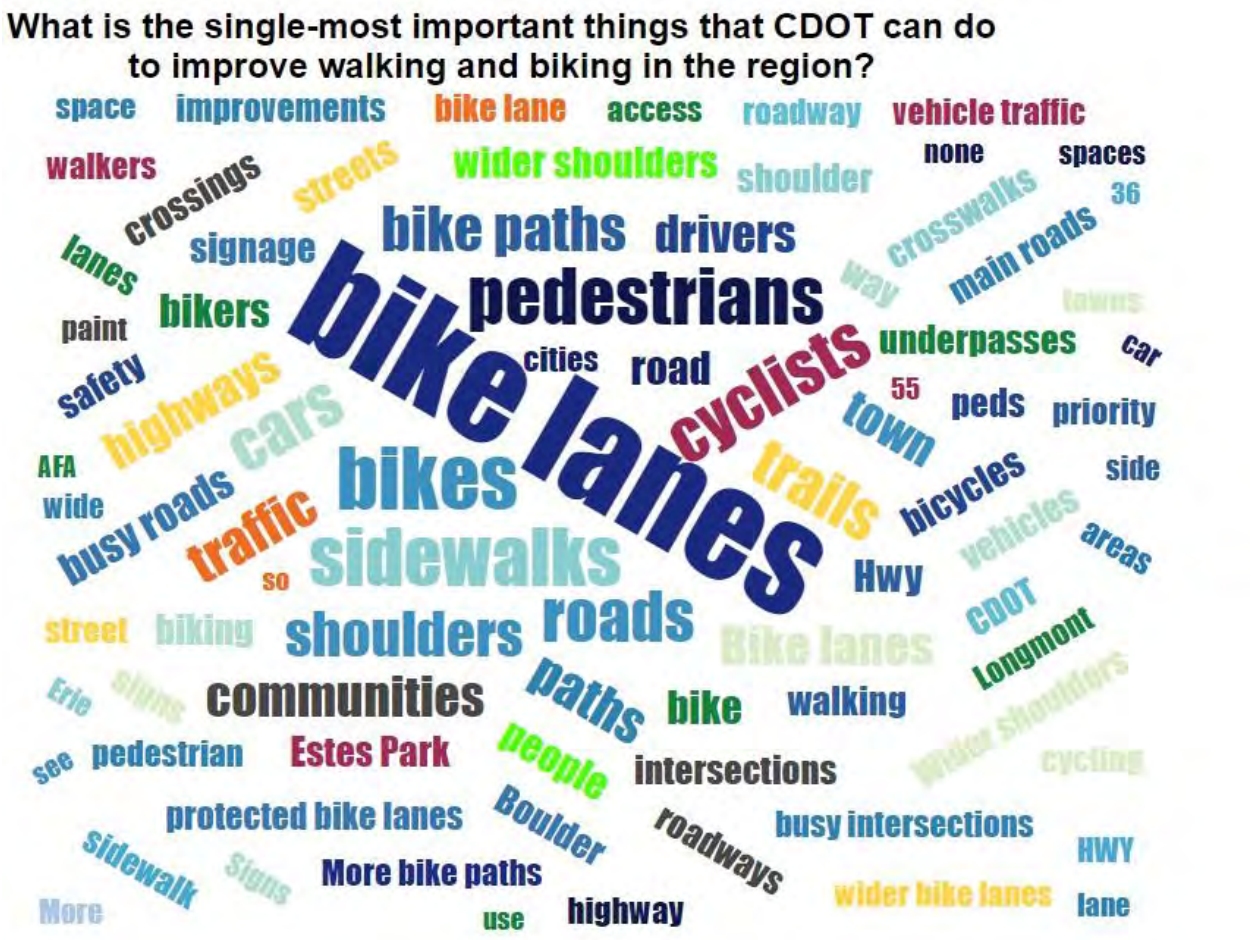
Separate Bike and Ped Facilities - Design and install more barriers and separations between bike/pedestrian facilities and motor vehicle facilities. Ideas for this include separated and buffered bike lanes and sidewalks, pedestrian and bike underpasses/tunnels and overpasses, and enhancement of trail networks so they function as parallel travel facilities for bikes and pedestrians.

Make Biking and Walking a Systemwide Priority - Prioritize walking and biking facilities when planning for new communities or new roadway improvements. Build standards into the planning and regulatory processes that require biking and walking improvements, and partner with municipalities to coordinate the installation and maintenance of biking and walking networks and fund missing gaps in the system (grant program). Adopt complete streets for all future projects, regardless of current roadway demands. Make biking and walking have equal priority to driving and allocate adequate funding for a connected and user-friendly biking and pedestrian network that is equal to that of motor vehicles. Consider a marketing campaign within CDOT that emphasizes "We Value Bikes and Pedestrians!"

Ensure Adequate Maintenance - Dedicate funds, personnel, and equipment to maintaining both existing and planned biking and walking facilities.

Improve the User Experience - Make the biking and walking facilities more user-friendly and high-comfort by installing signage, maps, lighting, and other amenities that make them functional, safe, and appealing. Where bike and pedestrian paths cross intersections or roadways, install flashing lights and painted crosswalks. Have bike boxes at intersections. Provide attractive and easy-to-use signage that directs people from walking and biking facilities to destinations and amenities (including distances and travel times). Design maps that illustrate how the larger and smaller biking and walking trails interconnect and can be accessed.

Encourage Driver Etiquette, Awareness and Education – Take driver speeding along roadways with multi-modal biking and walking facilities seriously, and ticket drivers for speeding and not yielding to walkers and bikers. Post signage alerting drivers to walkers and bikers and include a driver awareness section in the Colorado driver's exam. At intersections, create bike boxes and stripe/raise intersection crossings to make pedestrian and bike movements more visible. Consider legislation and enforcement of distracted driving.



Where Would You Most Like to See Bike or Pedestrian Connections on or Across CDOT Roads?

There were many specific examples of locations where survey respondents would most like to see bike or pedestrian improvements along Region 4 CDOT roads, but the common thread among survey respondents was the desire to prioritize these improvements where crash data indicates a need.

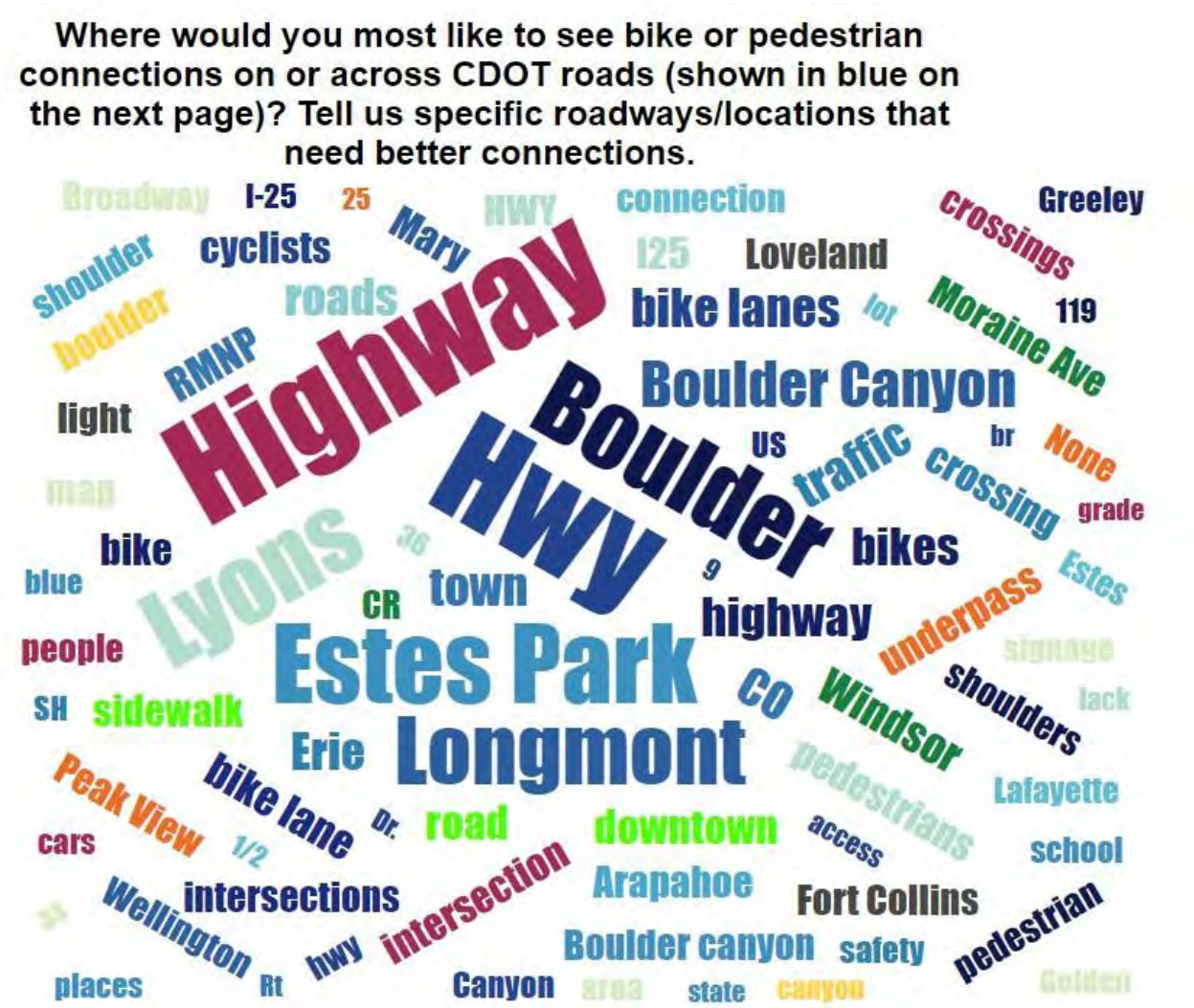
Where locations were noted, the following area themes emerged:

Downtowns and Community Centers – Participants wanted more pedestrian and bicycle connections in the more urban centers of Region 4. Communities like Boulder, Longmont, Estes Park, Lyons, Nederland, Wellington, Fort Collins, Windsor, Greeley, Superior, Broomfield, Erie and Boulder Canyon were mentioned repeatedly.

Intersections of Major Roadways – Participants highlighted the need to create safe crossings at the intersections of major high-volume CDOT roadways, or where CDOT roadways intersected with other significant roadway networks. Traffic speeds were noted as a major barrier to pedestrian and bicycle crossings, and there was a desire to separate pedestrian and bicycle traffic from motor vehicle traffic at major roadway intersections (with raised facilities or underground tunnels/underpasses).

At Entrances to Communities and Large Development Areas – Participants noted that connections across CDOT roadways are needed at the entrances to communities/developments like Centerra. It was noted that many (especially new) residential communities are disconnected from walking and biking networks due to CDOT roadway barriers and unsafe crossings.

At Connections to Trails, Open Spaces and Recreation Areas – Survey participants noted that more pedestrian crossings are needed in locations that provide access to open space and recreational amenities.



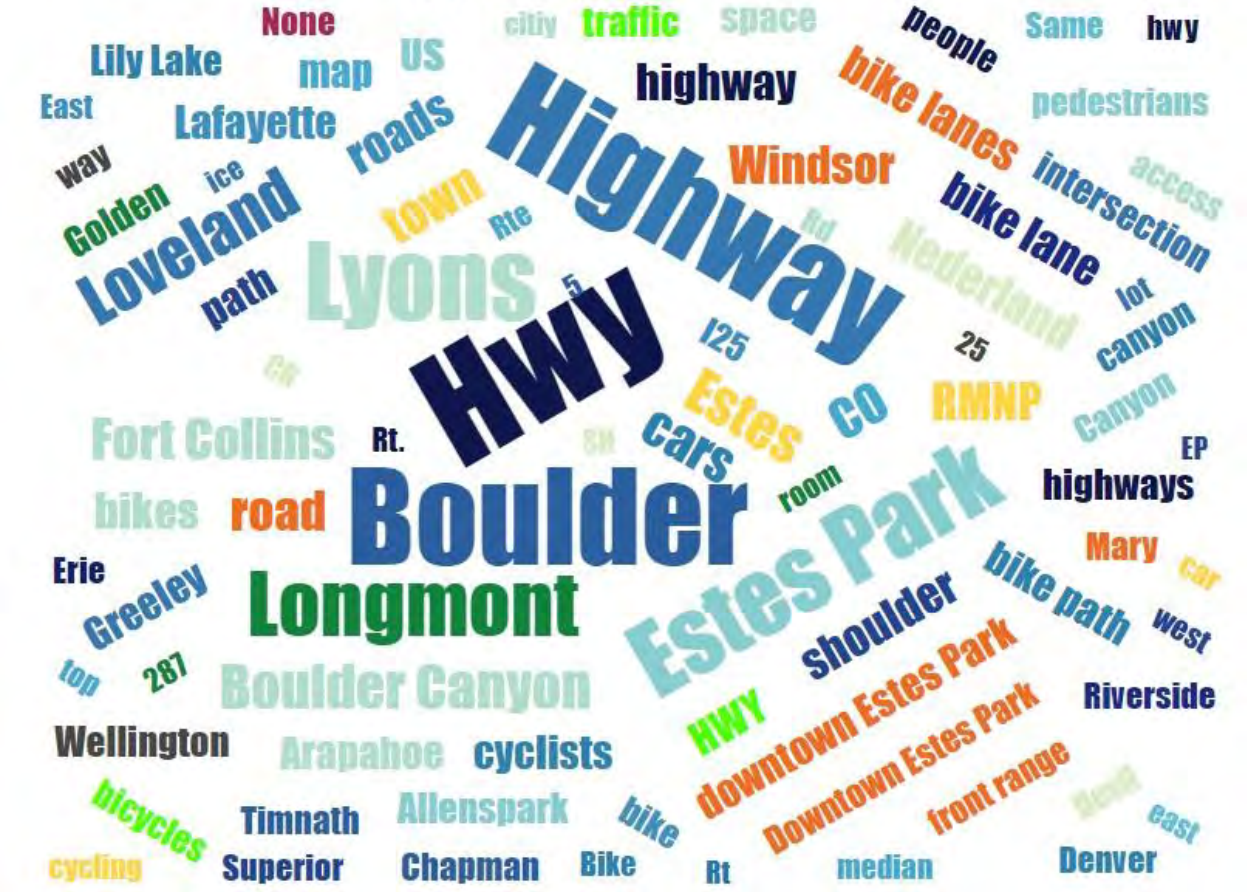
What CDOT Route Would You Most Like to See Space Added for Bikes and Pedestrians?

Most of this data was gathered in the mapping tab (tab 4), but several key routes were mentioned repeatedly by survey participants:

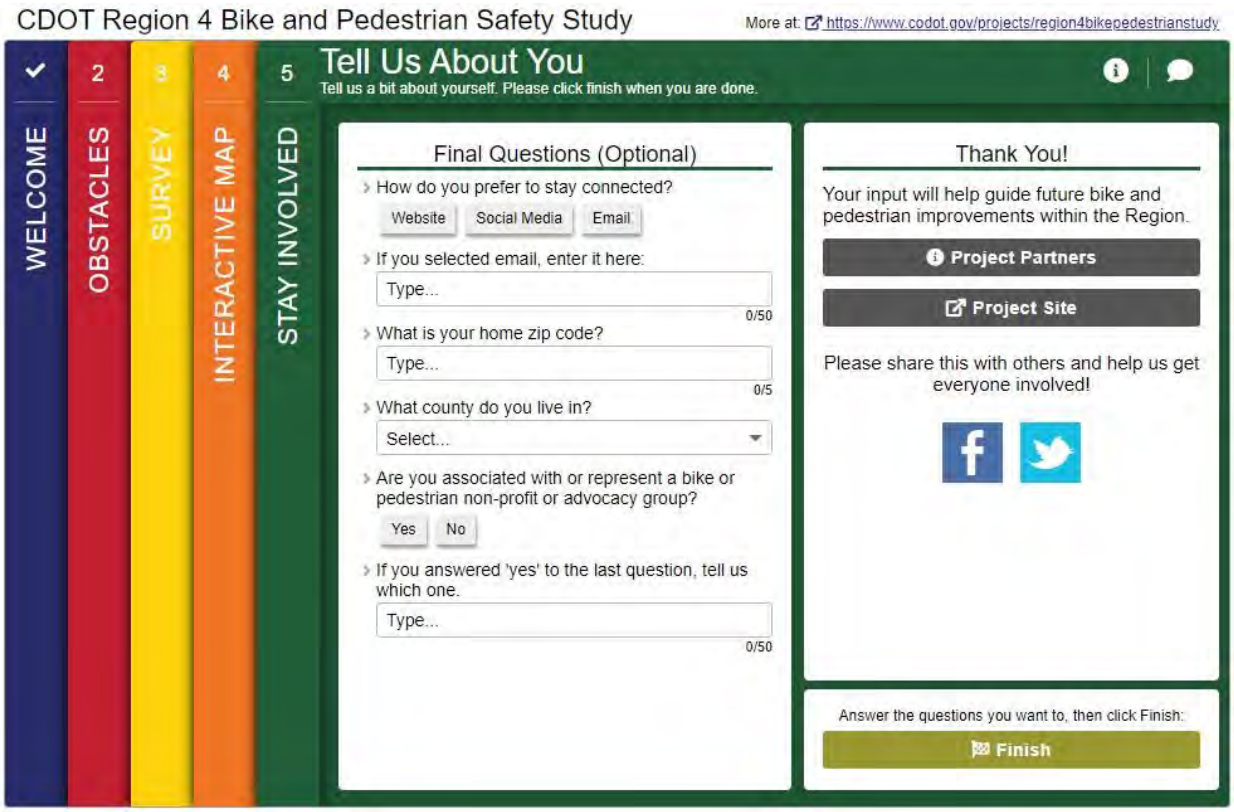
- Peak-to-Peak Highway
- Fall River Road

- Trail Ridge Road
- Stanley Avenue
- Moraine Avenue
- Elkhorn Avenue in Estes Park
- Devils Gulch Road
- Dry Gulch Road
- All Secondary Roads on the Front Range
- Highway 36
- Highway 119
- Highway 170 to Eldorado Springs
- Highway 392
- Highway 287
- Highway 257
- Highway 128
- Highway 157
- Highway 66
- Highway 85
- Highway 52
- Highway 93
- Interstate 25
- Highway 36
- Highway 43
- Highway 50
- Highway 115
- Highway 34
- Highway 14 (Poudre Canyon)
- Highway 7 (specifically from Estes Park to Lyons)
- County Road 13
- 95th Street
- Boulder Canyon (specifically Fourmile Canyon and Boulder Falls)
- All Main Street/Downtown Areas in Region 4

What CDOT route (shown on the next page in blue) would you most like to see space added for bikes or pedestrians? Tell us the specific section of the route you would like to bike or walk on.

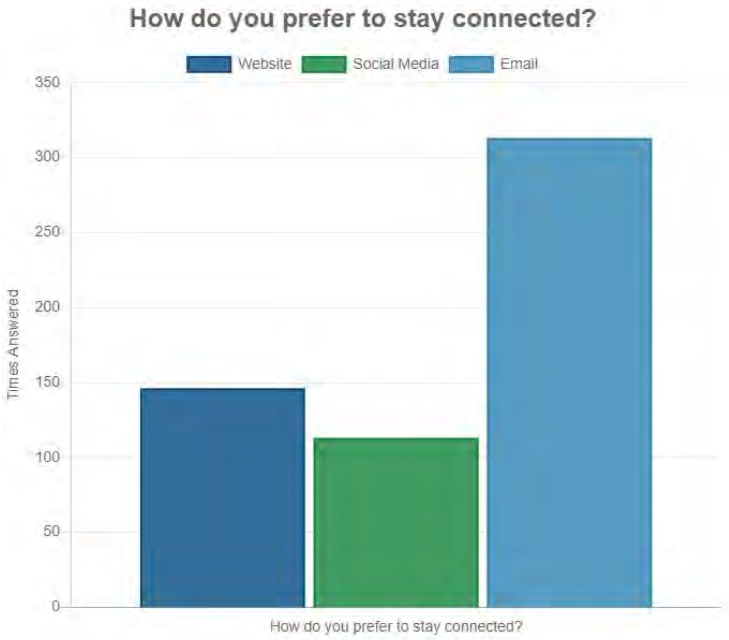


Tell Us About You – Tab 5

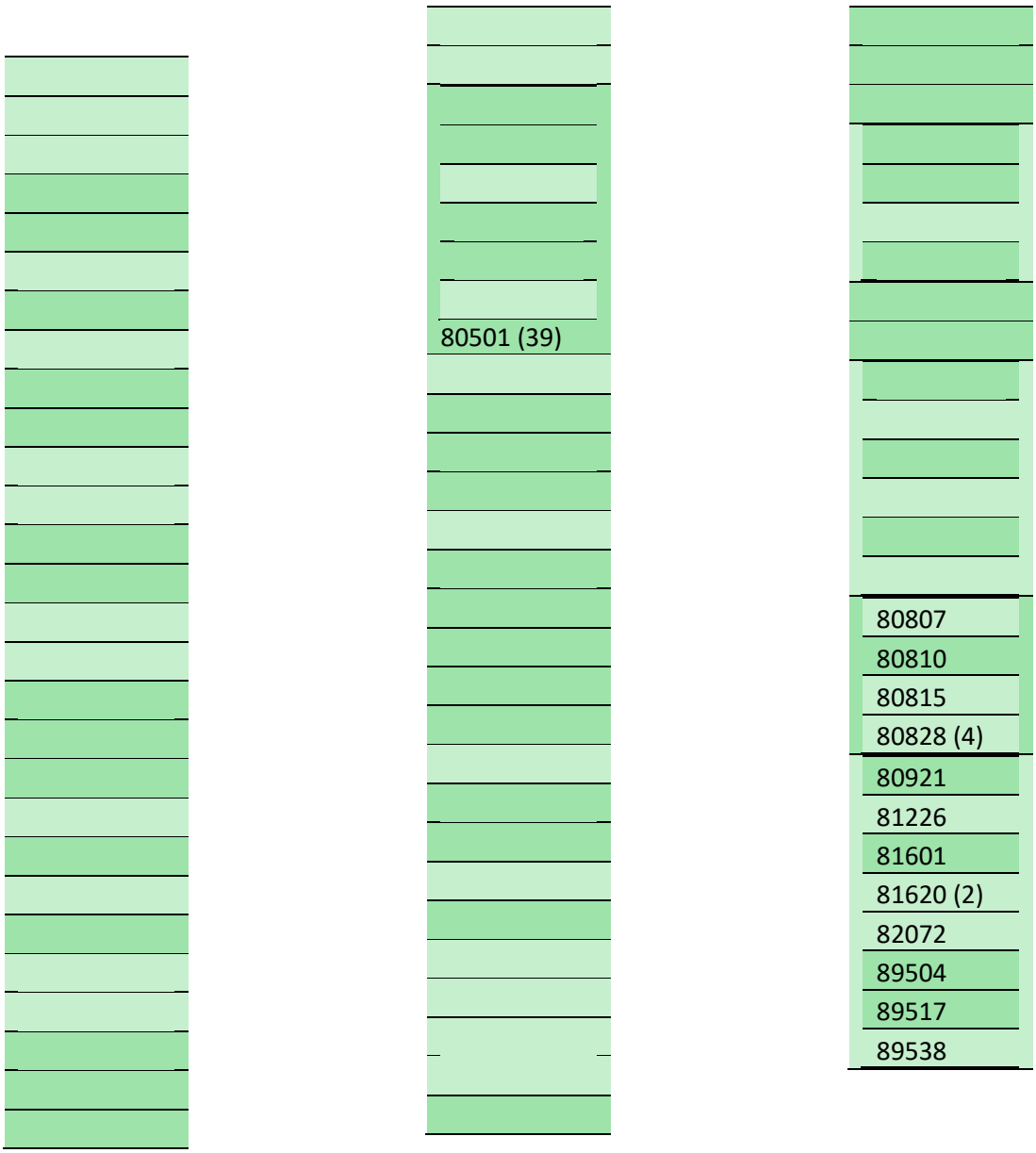


How Do You Prefer to Stay Connected?

Email is the most preferred method for staying connected to survey participants.



What Is Your Home Zip Code?



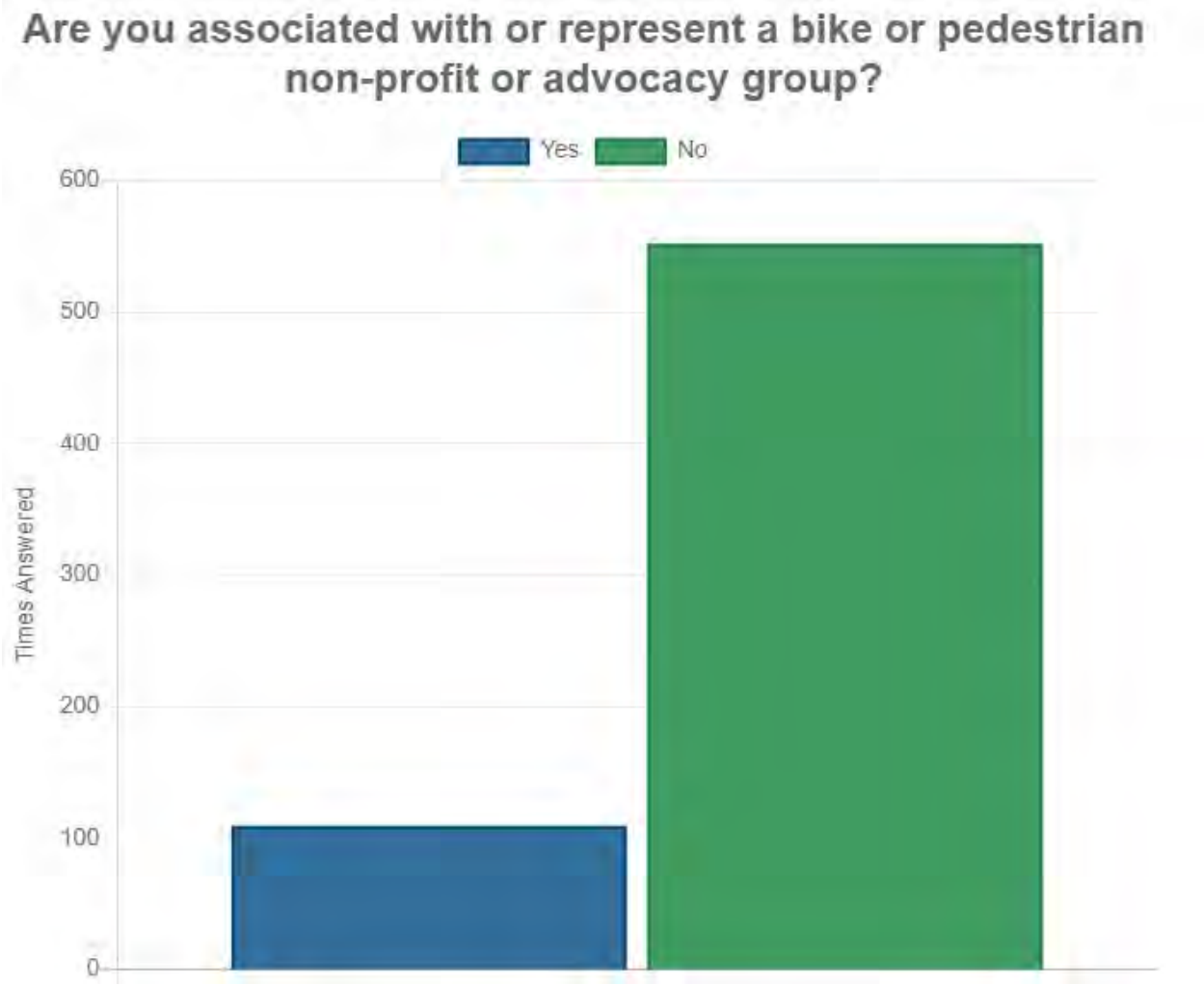
What County Do You Live In?

County	Count
Adams	6
Alamosa	0
Arapahoe	3
Archuleta	0
Baca	0
Bent	0
Boulder	249
Broomfield	4
Chaffee	0
Cheyenne	1
Clear Creek	1
Conejos	0

Costilla	0
Crowley	0
Custer	0
Delta	0
Denver	7
Dolores	0
Douglas	4
Eagle	3
El Paso	0
Elbert	3
Fremont	1
Garfield	1
Gilpin	0
Grand	1
Gunnison	0
Hinsdale	0
Huerfano	0
Jackson	0
Jefferson	6
Kiowa	0
Kit Carson	2
La Plata	0
Lake	0
Larimer	281
Las Animas	0
Lincoln	3
Logan	12

Mesa	0
Mineral	0
Moffat	0
Montezuma	0
Montrose	0
Morgan	1
Otero	0
Ouray	0
Park	0
Phillips	0
Pitkin	0
Prowers	0
Pueblo	0
Rio Blanco	0
Rio Grande	0
Routt	0
Saguache	0
San Juan	0
San Miguel	0
Sedgwick	0
Summit	2
Teller	0
Washington	0
Weld	70
Yuma	0
Other	0

Are You Associated With or Represent a Bike or Pedestrian Non-Profit or Advocacy Group?



If You Answered 'Yes' to the Last Question, Tell Us Which One

Answer
Bike Boulder Bike
Cyclists 4 Community, 501c3
Estes Park Transportation Advisory Board
BMA
member of Community Cycles
Community Cycles
Community Cycles
Bicycle Longmont
Boulder Mountainbike Alliance
Estes Park Cycling Coalition
Boulder mountain bike alliance
Estes Park Cycling Coalition
BMA
Boulder mountain bike alliance
Boulder Mountainbike Alliance, Community Cycles
Boulder Mountain Bike Alliance
www.broomfieldbikes.org
IMBA
Greeley Citizens Transportation Advisory Board
Local Bike Club

Boulder Mountainbike Alliance	Boulder Mtn Bike Alliance and C4C
Boulder Mountain Bike Alliance	Community cycles
BMA	BMA
Estes Park Cycling Coalition	Boulder Mountain Bike Alliance
Estes Park Cycling Coalition	BMA
BMA	Boulder Mountain Bike Alliance
303cycling.com	PeopleForBikes
Bicycle Longmont	Boulder Mountain Bike Patrol
Bicycle Longmont	Adventure cycle, Rails to Trails
Boulder mountain bike alliance	International Mountain Bicycling Association
Fort Collins cycling and fort follies cycle team	Boulder mountain bike alliance
Itcouldbeme	BMA
BIke Ambassador's	Estes Park Running Club
Just Ride Colorado Springs JRCS	Boulder Mountain Bike Alliance
Bicycle Colorado & the Denver Bicycle Touring Club	Boulder Mountain Bike Alliance
Bike Longmont	Cyclists 4 Community
Estes Park Cycling Coalition	Second Wind Cycling Club
Seniors on Bikes; Frasier Bicyclists	Athletes in Tandem
League of Am. Bicyclists.; E. P. Cycling Coalition	Sterling Loop /Tread for Trails
Overland Mountain Bike Bike Ft Collins	Bma
BMA and Cyclists for Community	LoCo Biking
C4C	Bike issues committee with City of Longmont
Bike Estes	BMA
Cyclists 4 Community	Boulder high school mountain biking
Multiple, Overland MTB for one.	Bicycle Longmont
Campus Bike Advisory Commission CSU	Bike Estes (member only)
Poudre River Trail Corridor, Inc.	Estes Park Cycling Coalition
Estes Park Running Club	COMBA
Colorado Mountain Bike Association	City of Fort Collins Safe Routes to School Program
Boulder Mountainbike Alliance	Estes Park Cycling Coalition
BMA	Bicycle Colorado
EP Runners Club, EP Cycling Coalition	City of Fort Collins Bicycle Advisory Committee
Boulder Mountain Bike Alliance	Estes Park Transportation Advisory Board
Estes Park Running Group	Sterling Loop Group
Boulder Mountain Bike Alliance	Community Cycles member,Bicycle Colorado member
Boulder Mountainbike Alliance	Tread for Trails
Boulder mountain bike alliance	Tread for Trails
Boulder MT Bike Alliance, Adventure Cycling	Kiwanis of Glenwood Springs
BMA	Community Cycles
C4C and Bicycle Colorado	Greeley Stampeders Run Club/Greeley Active Social
Boulder Mountainbike Alliance	Estes Park Cycling Coalition

Heartcycle	NFRMPO
Estes Park Cycling Coalition	Bicycle Colorado
BikeEstes/Estes Park Cycling Coalition	

Survey Sharing (if people shared the survey, how did they share it?)

Facebook Share – 11 shares

Twitter Share – 1 share

CDOT R4 Bicycle Pedestrian Safety Study

Attachment 2 - CMF B/C Calculations

Constants	
Interest Rate, i	4%
20 year TF	1.30
ADT Growth Rate, a	1.3%
Begin Date	1/1/2015
End Date	12/31/2019
PDO Cost	$ 9,300
INJ Cost	$ 80,700
FAT Cost	$ 1,500,000

Location	PDO count	INJ count	FAT count	Crash Count Comment	PDO rate before	INJ rate before	FAT rate before	Improvement	Improvement comment	Service Life	Estimated Cost	EUAC	CRF Name	CRF Crash Types	CRF Comment (why this one)	CRF Reference	CRF (PDO)	CRF (INJ)	CRF (FAT)	PDO rate after	INJ rate after	FAT rate after	PDO count reduction	INJ count reduction	FAT count reduction	EUAB (PDO)	EUAB (INJ)	EUAB (FAT)	EUAB Total	Cost Effectiveness ($/crash reduced)	Net Present Value (NPV)	Benefit to Cost Ratio (B/C)
US 287 and 23rd Ave	0	0	0	E/W bike crashes only	0.0	0.0	0.0	On street bicycle lane improvements	design concept	10	$ 30,000	$ 3,699	Install bicycle lanes	All crashes	There are several "add bike lane" CMFs in the clearinghouse. However, this one that PennDOT uses is specific to the US and is also specific to intersections	https://www.mautc.psu.edu/docs/PSU-2014-01.pdf#page=93	6%	6%	6%	0.0	0.0	0.0	0	0	0	$ -	$ -	$ -	$ -	#DIV/0!	$ (30,000)	0.00
US 287 and 23rd Ave	0	3	0	Left turn into crossing ped/bike only	0.0	0.6	0.0	Protective-permissive left turn for all legs	traffic analysis	20	$ 40,000	$ 2,943	Provide protected left-turn phase	Vehicle/bicycle only, see CRF reference comment	3 star CMF in clearinghouse which matched most conditions. Also focused CMF on vehicle/bike crashes as opposed to vehicle/vehicles (tried to use these CMF when available). CRF is stated for vehicle/bicycle, but applied to vehicle/ped as well (judgement call)	https://www.cmfclearinghouse.org/detail.cfm?facid=10233	31%	31%	31%	0.0	0.5	0.0	0	3	0	$ -	$ 17,124	$ -	$ 17,124	$ 15,620	$ 302,473	5.82
US 287 and 17th Ave	3	7	0	Ped/bike only (all directions)	0.6	1.4	0.0	Leading pedestrian interval	traffic analysis	20	$ 90,000	$ 6,622	Modify Signal Phasing (Implement A Leading Pedestrian Interval)	Vehicle/pedestrian only	5 star, relatively up to date study with urban characteristics	http://www.cmfclearinghouse.org/detail.cfm?facid=9918	13%	13%	13%	0.6	1.4	0.0	0	0	0	$ 828	$ 16,755	$ -	$ 17,583	$ 279,441	$ 261,658	2.66
US 287 and 17th Ave	0	1	0	E/W bike crashes only	0.0	0.2	0.0	On street bicycle lane improvements	concept design	10	$ 190,000	$ 23,425	Install bicycle lanes	All crashes	There are several "add bike lane" CMFs in the clearinghouse. However, this one that PennDOT uses is specific to the US and is also specific to intersections	https://www.mautc.psu.edu/docs/PSU-2014-01.pdf#page=93	6%	6%	6%	0.0	0.2	0.0	0	0	0	$ -	$ 966	$ -	$ 966	$ 999,999,999	$ (180,344)	0.04
US 287 & Mountain View	0	10	0	All vehicle / pedestrian crashes and all severities	0.0	2.0	0.0	LED Bike Ped Warning Signage with Passive Pedestrian Detection	concept design	10	$ 63,000	$ 7,767	Install rectangular rapid flashing beacon	Vehicle/pedestrian	CMF specific for vehicle/pedestrian crashes for urban/suburban arterial with 2 to 8 lanes.	http://www.cmfclearinghouse.org/detail.cfm?facid=9024	47%	47%	47%	0.0	1.1	0.0	0	9	0	$ -	$ 81,735	$ -	$ 81,735	$ 7,182	$ 754,345	10.52
US 287 & 9th Avenue	2	4	1	All vehicle / pedestrian crashes and all severities	0.4	0.8	0.2	Bulbouts in the SW and SE corners and tighten radius in NE corner to allow for ADA compliant pedestrian ramp (acts as a bulbout to make pedestrians more visible)	concept design	20	$ 398,000	$ 29,286	Install raised median with or without marked crosswalk (STEP states this is typically used for Bulbouts)	Vehicle/pedestrian	4 star CMF in clearinghouse. Most up to date study addressing vehicle/pedestrian crashes. The pedestrian refuge island is evaluated as one of the pedestrian treatment for intersection and mid-block crossings. Note: the CMFs found in clearinghouse are all for uncontrolled pedestrian crossings and no CMF for bulbouts, this is the closet to most of the conditions.	http://www.cmfclearinghouse.org/detail.cfm?facid=8799	32%	32%	32%	0.3	0.6	0.2	2	4	1	$ 1,337	$ 23,200	$ 107,806	$ 132,342	$ 64,876	$ 2,248,844	4.52
US 287 - Mountain View to 9th Ave	0	5	0	All injury crashes (can include vehicle to vehicle crashes on this segment)	0.0	1.0	0.0	Access control on east side of US 287: including interconnects between properties and reducing turning radii into driveways. Evaluate parking and circulation with interconnections	concept design	20	$ 249,000	$ 18,322	Reduce driveways from 26-48 to 10-24 per mile	All	CMF specific to the driveway density as defined. 2004 study for all crash types. HSM lists this CMF in bold font to indicate that it has the highest reliability since it has an adjusted standard error of 0.1 or less.	http://www.cmfclearinghouse.org/detail.cfm?facid=178	0%	31%	0%	0.0	0.8	0.0	0	4	0	$ -	$ 28,539	$ -	$ 28,539	$ 58,342	$ 321,788	1.56
US 287 - Laporte to Laurel	4	8	0	All crashes and severities (can include vehicle to vehicle crashes on this segment)	0.8	1.6	0.0	Reconfigure parking: back in angle parking, stripe buffer areas on either side of median parked cars, narrow travel lanes	concept design	5	$ 118,000	$ 26,506	Add lane lines on multilane roadway segments	All	Most applicable CMF can found for this countermeasure. There are several CMFs relevant to parking but none of them applicable to the change to back in angle parking.	http://www.cmfclearinghouse.org/detail.cfm?facid=89	18%	18%	18%	0.7	1.4	0.0	1	1	0	$ 1,385	$ 24,030	$ -	$ 25,414	$ 64,377	$ 9,071	0.96
US 287 - Laporte to Laurel	4	8	0	All vehicle / pedestrian crashes and all severities	0.8	1.6	0.0	New mid-block crossing with RRFB's	concept design	10	$ 60,000	$ 7,397	Install RRFB	Vehicle/pedestrian	The CMF for vehicle/pedestrian crashes and treatment of RRFB for unsignalized pedestrian crossings.	http://www.cmfclearinghouse.org/detail.cfm?facid=9024	47%	47%	47%	0.4	0.9	0.0	4	7	0	$ 3,768	$ 65,388	$ -	$ 69,155	$ 5,700	$ 631,553	9.35
US 287 - Laporte to Laurel	4	8	0	All vehicle / pedestrian crashes and all severities	0.8	1.6	0.0	Bulbouts at mid-block crossing location	concept design	20	$ 159,000	$ 11,699	Install raised median with or without marked crosswalk (STEP states this is typically used for Bulbouts)	Vehicle/pedestrian	4 start CMF in clearinghouse. Most up to date study addressing vehicle/pedestrian crashes. The pedestrian refuge island is evaluated as one of the pedestrian treatment for urban multi-lane street without signal controls.	http://www.cmfclearinghouse.org/detail.cfm?facid=8799	32%	32%	32%	0.6	1.3	0.0	4	7	0	$ 2,674	$ 46,400	$ -	$ 49,073	$ 15,119	$ 822,462	4.19
US 34 & 11th Ave	0	3	0	Nighttime crashes of all severity (can include vehicle to vehicle crashes)	0.0	0.6	0.0	Add luminaires back of pole for peds crossing right turn lanes or add lighting in the corners	concept design	20	$ 71,000	$ 5,224	Increase intersection Illuminance from low to medium	Nighttime	CMF for nighttime crash treatment at 4-leg signalized urban intersections.	http://www.cmfclearinghouse.org/detail.cfm?facid=8321	52%	52%	52%	0.0	0.3	0.0	0	5	0	$ -	$ 28,724	$ -	$ 28,724	$ 13,062	$ 503,470	5.50
US 34 & 11th Ave	0	4	1	All vehicle / pedestrian crashes and all severities	0.0	0.8	0.2	Widen crosswalk striping to 2'x10' for enhanced visibility	concept design	5	$ 10,000	$ 2,246	Install high-visibility crosswalk	Vehicle/pedestrian	CMF specific for vehicle/pedestrian crashes at urban 3-leg and 4-leg intersections.	http://www.cmfclearinghouse.org/detail.cfm?facid=4123	40%	40%	40%	0.0	0.5	0.1	0	2	0	$ -	$ 26,700	$ 124,069	$ 150,768	$ 5,260	$ 743,841	67.12
US 34 & 11th Ave	0	4	1	All vehicle / pedestrian crashes and all severities	0.0	0.8	0.2	LED Bike Ped Warning Signage with Passive Pedestrian Detection in Channelized Right Turns	concept design	10	$ 98,000	$ 12,083	Install rectangular rapid flashing beacon	Vehicle/pedestrian	CMF specific for vehicle/pedestrian crashes for urban/suburban arterial with 2 to 8 lanes.	http://www.cmfclearinghouse.org/detail.cfm?facid=9024	47%	47%	47%	0.0	0.4	0.1	0	4	1	$ -	$ 32,694	$ 151,923	$ 184,617	$ 22,345	$ 1,748,167	15.28
US 34 & 11th Ave	0	1	0	Vehicle / pedestrian injury crashes (only included those in NE corner)	0.0	0.2	0.0	Add raised pedestrian crossing in NE corner	concept design	20	$ 135,000	$ 9,934	Install raised pedestrian crosswalks	Vehicle/pedestrian	CMF specific to vehicle/pedestrian CMF for raised pedestrian crosswalks.	http://www.cmfclearinghouse.org/detail.cfm?facid=136	0%	45%	0%	0.0	0.1	0.0	0	1	0	$ -	$ 8,286	$ -	$ 8,286	$ 90,456	$ 30,713	0.83
US 34 from Riverside Drive to St Vrain Ave	0	2	0	All ped/bike crashes near dedicated ped signal	0.0	0.4	0.0	Median refuge at pedestrian signal west of St Vrain Ave	https://www.cityofsacramento.org/-/media/Corporate/Files/Public-Works/Transportation/Active-Transportation/Treatment-Applications-Guide-to-Pedestrian-Crossing-Guidelines-April-2021.pdf?la=en#page=14	20	$ 50,000	$ 3,679	Install raised median with or without marked crosswalk (uncontrolled)	Vehicle/pedestrian only	4 star CMF in clearinghouse. The condition we're applying is atypical (median refuge at a controlled crossing). This was the closest study I could find that matched most of the conditions.	https://www.cmfclearinghouse.org/detail.cfm?facid=8799	32%	32%	32%	0.0	0.3	0.0	0	2	0	$ -	$ 11,600	$ -	$ 11,600	$ 28,526	$ 181,998	3.15
US 36 from Crags Street to RMNP Entrance	0	1	0	All ped/bike on roadway	0.0	0.2	0.0	Continuous pedestrian/bicycle pathway	concept design	20	$ 910,000	$ 66,959	Add sidewalk	Vehicle/pedestrian only	Absent any Colorado specific "add sidewalk" CMF, this was the most reliable CMF I could find. Also stated as a proven FHWA safety countermeasure	https://www.cmfclearinghouse.org/collateral/OregonCMF.pdf#page=152	20%	20%	20%	0.0	0.2	0.0	0	0	0	$ -	$ 3,683	$ -	$ 3,683	$ 2,587,939	$ (836,350)	0.05
CO 7 from US 36 to Peak View Dr	0	2	0	All ped/bike on roadway	0.0	0.4	0.0	Continuous north/south PAR connectivity for both east and west side of roadway	concept design	20	$ 590,000	$ 43,413	Add sidewalk	Vehicle/pedestrian only	Absent any Colorado specific "add sidewalk" CMF, this was the most reliable CMF I could find. Also stated as a proven FHWA safety countermeasure	https://www.cmfclearinghouse.org/collateral/OregonCMF.pdf#page=152	20%	20%	20%	0.0	0.4	0.0	0	1	0	$ -	$ 7,365	$ -	$ 7,365	$ 838,947	$ (442,700)	0.17
CO 7 from US 36 to Peak View Dr	0	2	0	All ped/bike crashes within road diet location	0.0	0.4	0.0	Road diet from US 36 to Graves	concept design	20	$ 140,000	$ 10,301	Converting four-lane roadways to three-lane roadways with center turn lane (road diet)	All crashes	Our condition doesn't match this entirely as we have a divided four lane road, but this is the closest I could find and it has 4 stars in the clearinghouse	https://www.cmfclearinghouse.org/detail.cfm?facid=5554	19%	19%	19%	0.0	0.4	0.0	0	1	0	$ -	$ 6,923	$ -	$ 6,923	$ 235,791	$ (1,538)	0.67

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