Self-Enforcing Roadways

Visual Guide

COLORADO
Department of Transportation

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ACKNOWLEDGMENTS

Colorado Department of Transportation

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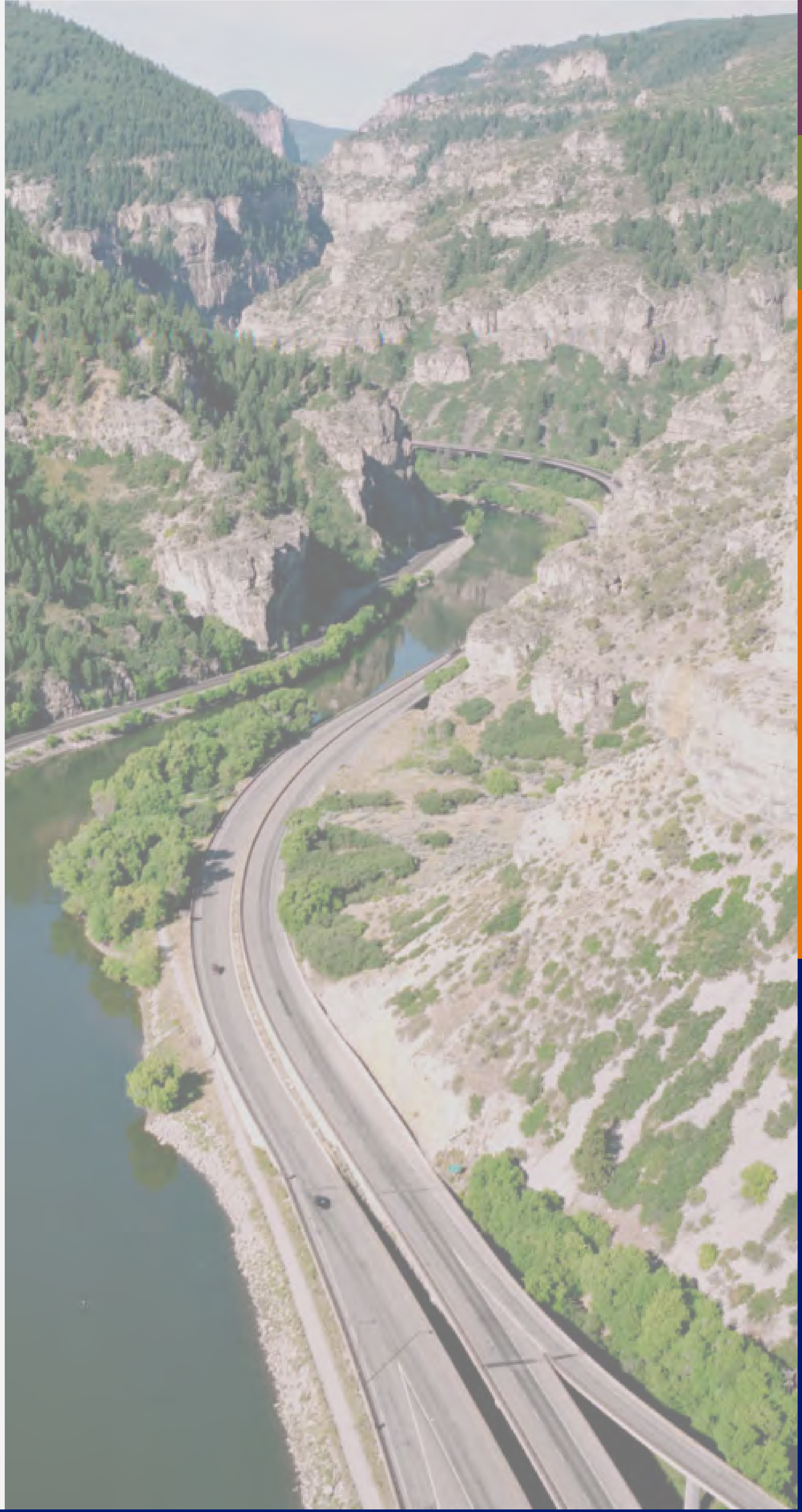


Table of Contents

Purpose of This Guide

This guide is designed to **inform and empower agencies, planners, engineers, community partners, and community members** by explaining how roadway design influences speed and safety. **Understanding what a street designed for a specific speed looks like is essential for shaping conversations and advocating for change.**

How to Use This Guide

This guide is structured to help practitioners quickly find the information most relevant to their goals. Here's how to use it effectively:

1. Start with Chapter 1 to Build Knowledge

- Learn why speed affects safety and comfort for all users.
- Learn what factors play a role in speed setting—why signs alone don't slow traffic.
- Use this section to build a foundation for conversations about speed changes.

2. Move to Chapter 2 to Visualize Target Speed

- Find the target speed (e.g., 30 MPH) and see what that type of environment looks like.
- Review diagrams, roadway elements, and Colorado examples to understand the design cues that make that speed feel natural.
- Use case studies to see real-world before/after transformations.

3. Use Chapter 3 to Explore Design Solutions

- See which countermeasures may help achieve the target speed for a specific roadway type (Road, Street, Interstate).
- Check the tables for context-sensitive solutions and element effectiveness.

4. Refer to Chapter 4 for Special Use Cases

- If the situation does not align with the standard examples, this section provides guidance for unique conditions and troubleshooting.
- Use it as a resource for creative solutions when typical approaches aren't enough.

From Concept to Project

1. Identify Roadway
2. Review Context and Geometric Conditions
3. Pick Roadway Elements
4. Develop Preliminary Design and Cost Estimates
5. Analyze Design
6. Finalize Design and Construct
7. Evaluate Effectiveness

CHAPTER 1
WHY SPEEDS MATTER

Historical Speed Limit Setting: Why the 85th Percentile was Adopted

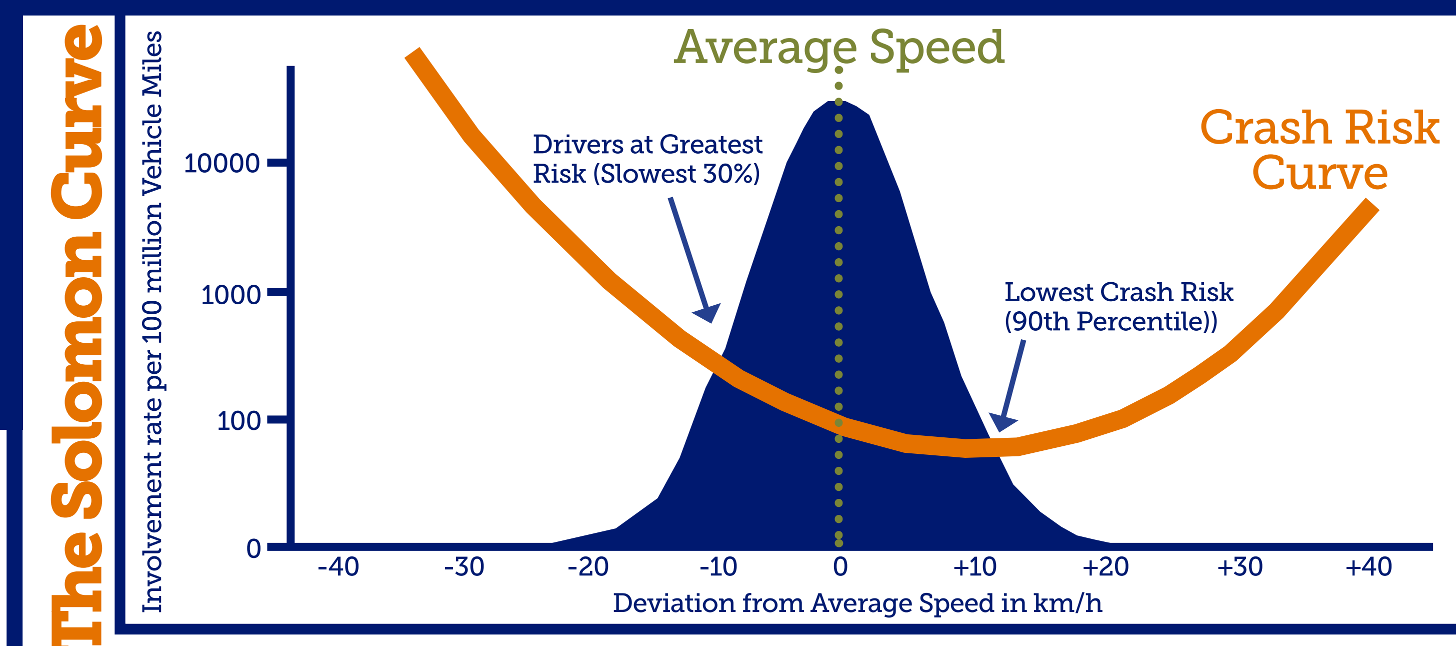
The first "speed limit" was set in the colony of New Amsterdam (now New York) in 1652, restricting horse-drawn carriages to a walking pace. Connecticut was the first state to pass a speed limit law back in 1901. This law limited the legal speed of motor vehicles to 12 MPH in cities and 15 MPH on country roads (History.com Editors, 2009).

In the United States, speed limits have historically been established at the state level. A national maximum speed limit was first implemented during the 1973 oil embargo as a fuel conservation measure. In 1984, Transportation Research Board Special Report 204 estimated that the reduced speed limit contributed to saving approximately 3,000 to 5,000 lives in 1974 and between 2,000 and 4,000 lives annually thereafter, largely due to lower and more uniform highway travel speeds (National Research Council, 1984).

Early Traffic Engineering

With the proliferation of automobiles in the 20th century, traffic engineers started to evaluate data-driven approaches to setting speed limits. Several studies by state highway departments in the 1930s - 1960s found that:

- Even in the absence of posted speed limits, most drivers tend to travel within a narrow range of speeds. This behavior reflects perceived roadway comfort and establishes an operating speed based on the roadway's geometric design and surrounding conditions.
- The 85th percentile concept originated in 1930s-1940s engineering practice as a traffic management rule. Solomon's 1964 study, while measuring speed deviation rather than absolute speed thresholds, was subsequently cited to reinforce this pre-existing approach despite the methodological differences between his findings and the 85th percentile framework.



The Solomon Curve, based on data collected in the late 1950s on rural two-lane highways and published in 1964, found that crash involvement rates were lowest near the mean traffic speed and increased as vehicle speed deviated from that mean in either direction - producing the characteristic U-shaped curve. This study was based on rural two-lane roadways, included turning vehicles, and has significant methodological limitations. Even for rural contexts, its findings can be misleading, as higher prevailing speeds may mask underlying crash risk and severity. As a historical study, it should not be used to justify higher operating speeds and does not reflect current safety research (Federal Highway Administration, 1998).

Speed is a critical factor in roadway safety, influencing both crash risk and crash severity. Crash risk reflects the likelihood that a crash will occur, while crash severity describes the degree of injury or damage when a crash happens- both of which increase as speeds rise. Self-enforcing roadway design is essential because roadway geometry and environmental cues exert a stronger influence on driver behavior than regulatory signage alone, encouraging safe operating speeds through design rather than compliance.

Context for a Change in Setting Speed Limits

In 2015, CDOT entered a new era for transportation safety in Colorado, launching 'Moving Towards Zero Deaths', which sets a visionary goal of zero deaths for every family and community using Colorado's transportation network.

MOVING TOWARDS ZERO DEATHS

The table below compares the 85th Percentile and Context Sensitive approaches to speed limit setting. The first relies on typical driver speeds, the second prioritizes safety using crash data and street design. Per the 2023 MUTCD, the 85th percentile is no longer the sole factor in setting speed limits. Agencies must also consider context-based engineering studies.

85th Percentile vs Context Sensitive

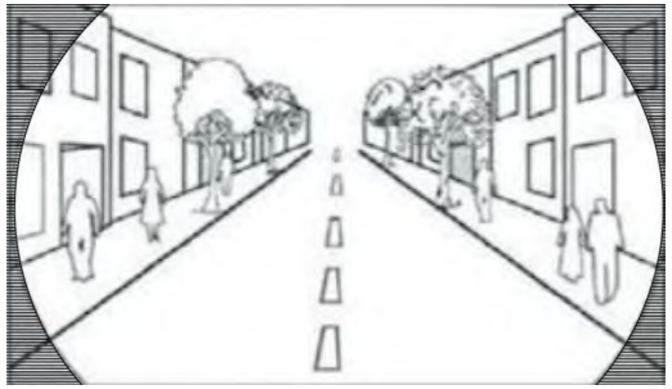
Aspect	85th Percentile Approach to Speed Limit Setting	Context Sensitive Approach to Speed Limit Setting
Core Principle	Speed limits reflect the speed that 85% of drivers naturally choose	Speed limits reflect roadway context, user safety needs, land use, and crash data - with the goal of minimizing crash frequency and severity for all users.
Primary Focus	Driver behavior and vehicle mobility	Safety of all users (pedestrians, cyclists, drivers, transit riders).
Safety Assumptions	Most drivers choose safe speeds	People make mistakes. Road context and speed limits should minimize severity of crashes.
Basis for Setting Speeds	Measured spot speed analysis	Street design, bicycle and pedestrian presence, crash data, adjacent land use, daily traffic volumes, etc.
Treatment of Vulnerable Road Users (VRUs)	Vulnerable road users are not explicitly covered	Vulnerable road users are a central factor in determining appropriate speed limits.
Crash Considerations	Emphasis is on minimizing crash frequency	Emphasis is on minimizing both crash frequency and severity.
Risk of Escalation	Increasing speeds can lead to rising posted speed limits	Speeds are tied to human survival thresholds.
Where it Works Best	Freeways and rural highways with limited access *	Urban/suburban streets, rural roads, multimodal corridors, and school zones.

**Even in these contexts, the 2023 MUTCD requires consideration of additional factors beyond the 85th percentile.*

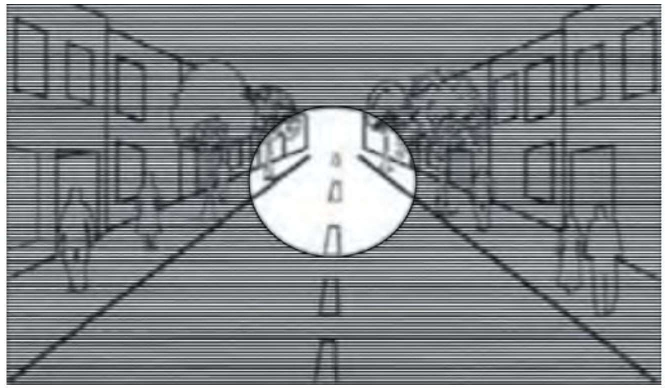
The Impact of Speed on Safety

Speed is a critical factor in the frequency and severity of crashes. A few miles per hour difference can make a big impact on a person's chance of survival. Useful field of view, reaction distance, and stopping distance are all negatively affected as speed increases.

Useful Field of View at 20 MPH



Useful Field of View at 40 MPH

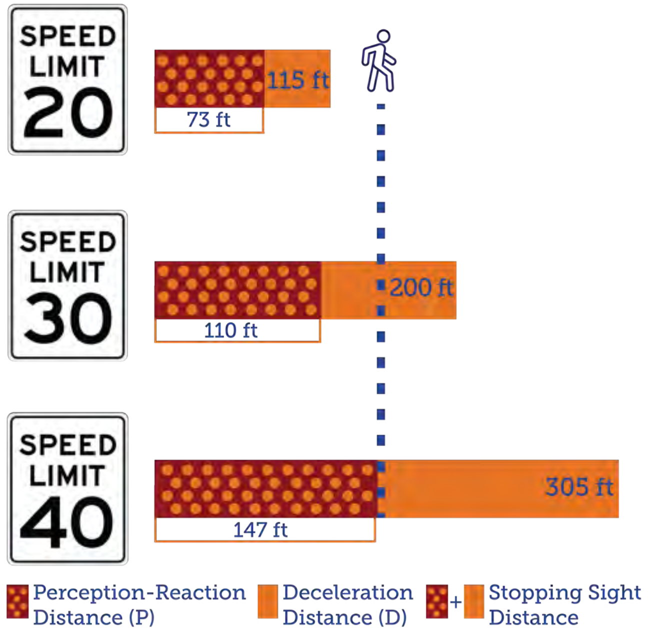


A driver's useful field of view increases as speed decreases. At lower speeds, drivers can see more of their surroundings and have more time to react to potential hazards (Federal Highway Administration, 2009).

Reaction and Braking Distance by Speed

(Federal Highway Administration, 2009)

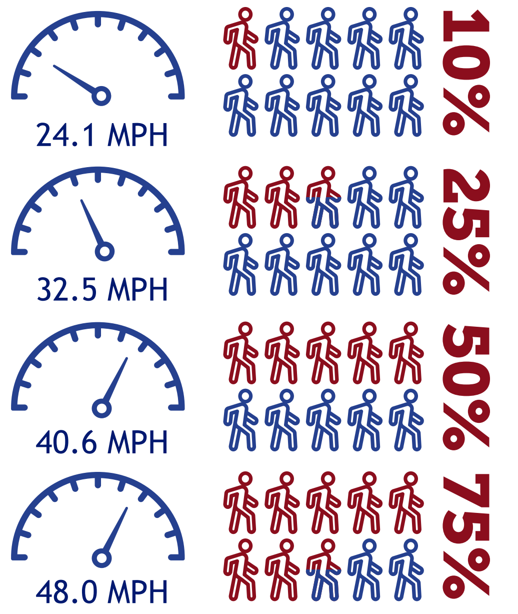
Driver identifies a pedestrian 150 ft away. Reaction time, braking ability, and roadway conditions are assumed constant.



Impact Speed and Pedestrian Fatalities

(Tefft, 2013)

As speed increases, both reaction and braking distances grow, making it much more likely that a driver cannot stop in time, and if a pedestrian is struck, the likelihood of a fatal outcome rises sharply with increased impact speed.



Road Design Shapes Speed and Behavior

Speed choice is not random - it is shaped by what drivers see and feel.

- **Design Speed - The speed a road is designed for.**
- **Posted Speed - The speed posted on the side of the road.**
- **Operating Speed - The actual speed drivers travel.**
- **Target Speed - The speed practitioners want drivers to travel.**

Historically, design speeds were higher than posted speeds. Safety best practices indicate design speed should be equal to posted speed to reinforce appropriate driver behavior. Roadway design sends powerful signals about safety and appropriate speed. These perceptions drive behavior. Drivers often go faster when a road feels forgiving, even if conditions don't support higher speeds. Understanding this chain: **design influences perception, perception shapes speed, and speed determines crash severity**, is essential for creating roads that manage speed safely.

Road Design and Perceived Safety

Drivers rarely rely on posted speed limits alone- they interpret the road's physical design and surrounding context to decide what feels safe. This perception is shaped by visual and physical cues that signal the complexity of the roadway environment.

Key Design Cues

Design Consideration	Why it Matters
Lane Width	Wider lanes suggest comfort and forgiveness, encouraging higher speeds. Narrow lanes signal caution and lower speeds.
Shoulder Width and Clear Zones	Large shoulders and open space create a sense of forgiveness, reducing perceived risk.
Horizontal and Vertical Alignment	Flat, straight roads allow drivers to feel safe traveling at higher speeds. Winding and curvy roads naturally slow drivers.
Sight Distance	Extended visibility makes drivers feel safe at higher speeds.
Roadside Environment	Trees, parked cars, driveways, and pedestrian activity add friction, prompting slower speeds.

Additional roadway elements that influence speed are provided in Chapter 2.

Perceived Safety and Speed Choice

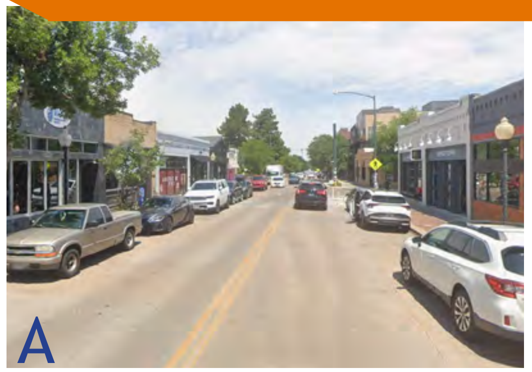
A roadway design with low complexity creates a sense of security, which often leads to higher speeds. This is called risk compensation: when perceived safety increases, drivers use less caution.

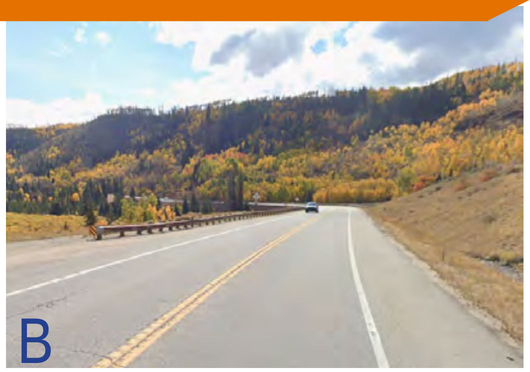
Why Perception Matters

Perceived safety can work against actual safety outcomes. When roads are designed for comfort, they may unintentionally encourage drivers to travel at speeds that exceed what the environment can safely support, especially near intersections, driveways, or pedestrian areas. Drivers base their speed choices on how safe a road feels. Design must align that perception with reality.

Guess the speed for each example below.

Answers provided at the bottom of the page.


A


B

Design Response

The physical design, not just speed limit signs, must adjust to align with the target speed. The design should consider both the roadway context and the complexity of the environment when identifying which elements would be most effective at obtaining speed compliance.

Design dictates behavior. Signs merely suggest it.

- Reinforce target speed with speed limit signage and context-sensitive design.
- Use traffic calming roadway elements to reduce speed.
- Apply safety-focused roadway elements to align with the Safe System Approach, especially where higher speeds are necessary.

Answers: A = 20 MPH, B = 45 MPH

CHAPTER 2
DESIGNING SELF-ENFORCING ROADWAYS

Design speed is one of the most powerful parameters for shaping safe, predictable travel behavior. Whether the goal is a calm 20 MPH neighborhood street or an interstate at 75 MPH, roadway design should make the intended speed feel natural and provide a level of forgiveness appropriate to that speed. This chapter provides guidance for roadways across a range of speed environments, with strategies tailored to each speed increment.

Speed Management Vs Forgiving Design

Speed management seeks to align vehicle speeds with surrounding context, while forgiving roadway design reduces crash severity when errors occur. Higher speeds demand more forgiving roadway design, as crashes at greater speeds result in more severe outcomes even when speeds are managed.

Speed Table of Contents

Click the speed limit signs below to view detailed guidance and best practices for that speed category. If viewing a printed version of this document, use the table of contents to find the Speed Chapters for guidance by speed category.

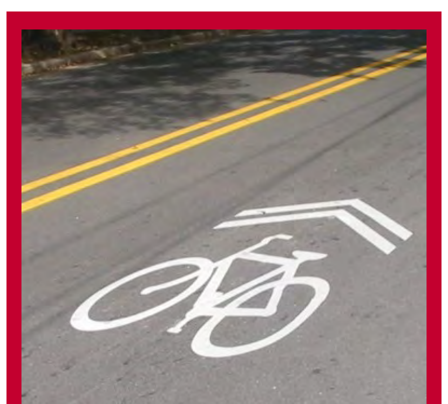
SPEED LIMIT 20

Designing for Twenty Mile-Per-Hour Travel

Roadway Elements for Consideration on 20 MPH Roadways

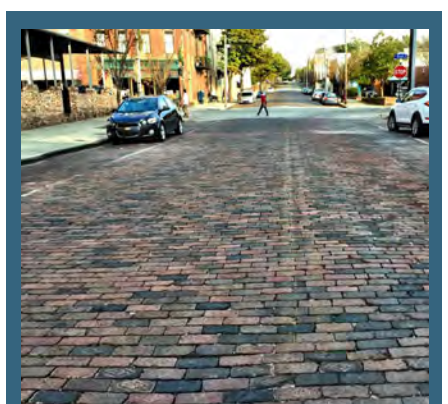
To encourage drivers to naturally adhere to a 20 MPH speed limit, roadway design should signal a lower-speed environment through physical and visual cues. Not all elements described in this chapter will be appropriate for every 20 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



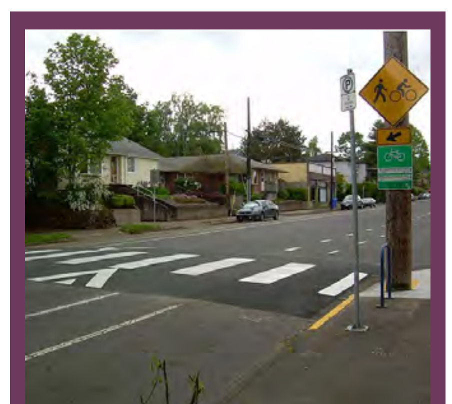
Bicycle Lane or Sharrow

Designates space for cyclists within the roadway, either through striping or shared lane markings.



Textured Surface

Cues drivers to slow down by creating discomfort through vibration and noise at higher speeds. Signals a need for caution.



Raised Crosswalk or Intersection

Features with a vertical aspect slow vehicles, improve pedestrian visibility, and signal a pedestrian zone.

Enhanced Pedestrian Crossings

Frequent, regularly spaced crossings enhanced with signage, striping, and lighting require drivers to stay attentive.

Street Trees and Landscaping

Plantings along the roadway make roads feel narrower and more community-oriented, encouraging speed reduction.

Reduce Vehicle Lane Width

Makes streets feel less like highways, encouraging drivers to slow down and pay attention. Lane widths of 10.5 feet or less are a good target.

Speed Feedback Signage

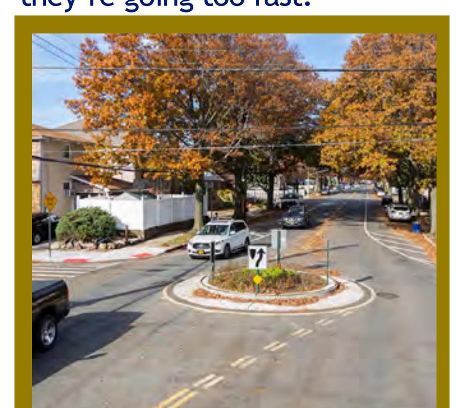
Displays driver speed next to posted limit, encouraging immediate self-correction when they're going too fast.

Shared Street Design

Streets designed for pedestrians, cyclists, and vehicles to share the same space. Drivers must proceed slowly and cautiously.

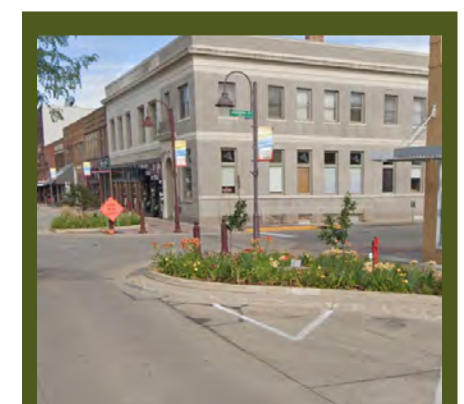
Single Lane Roundabout

Manages speed through a combination of geometric design and limited sight distance, forcing low speeds.



Mini-Roundabout

Retrofits existing intersections to reduce vehicle speeds. Tight curb geometry and a small center island encourage yielding behavior in constrained spaces.



Curb Extension or Pinchpoint

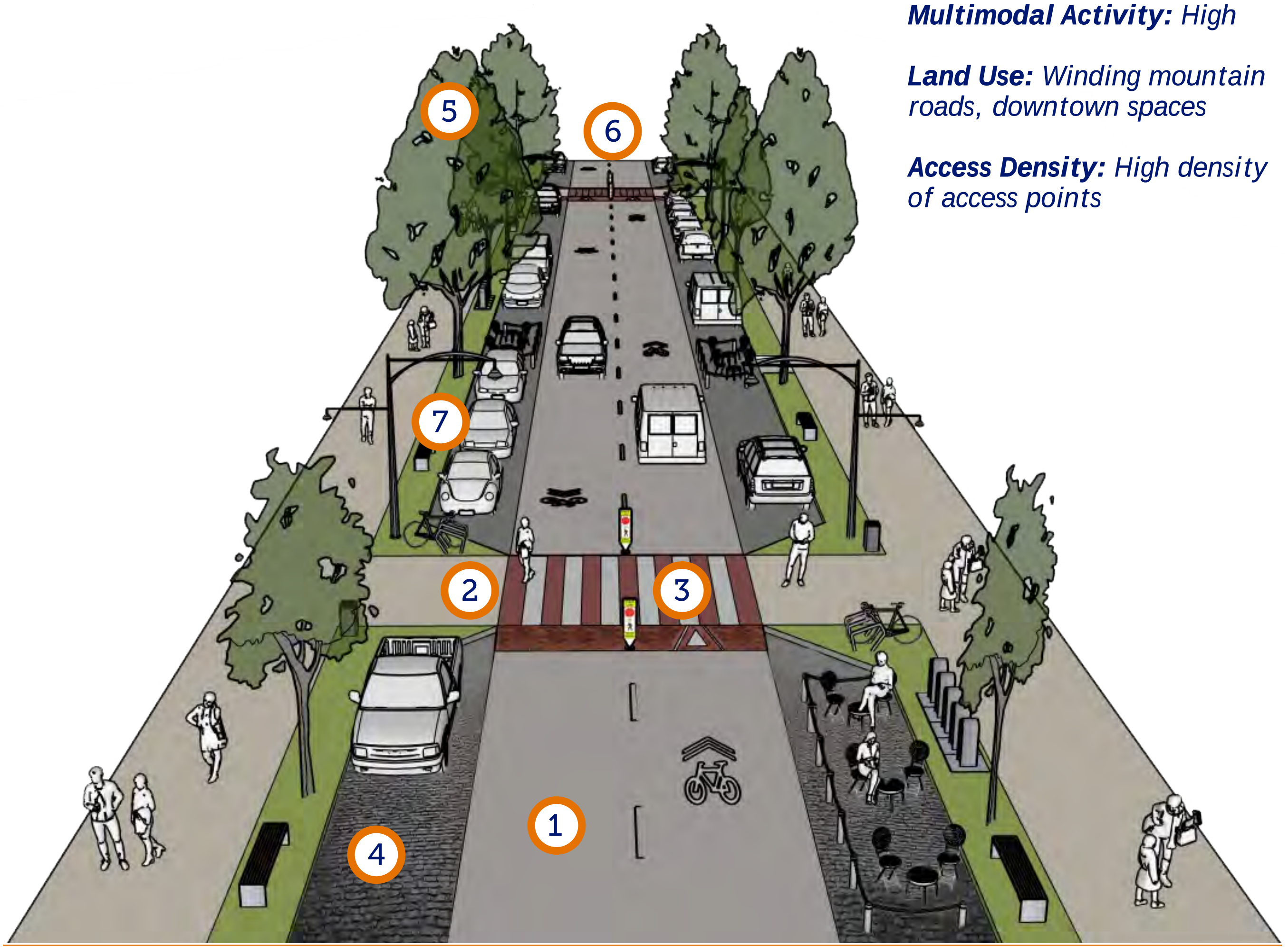
Narrows the roadway and encourages reduced speeds and turns. Naturally increases driver attentiveness.

On-Street Parking

Visually narrows the driving space and adds friction to the edge of the road. Reduces traffic speed and makes streets feel more active.

Twenty Mile-Per-Hour Roadway

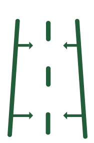
This diagram illustrates the application of 20 MPH treatments discussed previously.

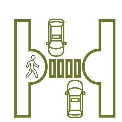


Multimodal Activity: *High*

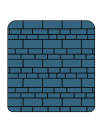
Land Use: *Winding mountain roads, downtown spaces*

Access Density: *High density of access points*

1 Travel lanes are 10 feet. 

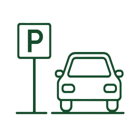
2 The crossings are shortened by curb extensions. 

3 Pedestrian crossings are highly visible. 

4 Crosswalks and parking spaces are textured. 

5 Both sides of the street have street trees. 

6 Two raised crossings prioritize pedestrians. 

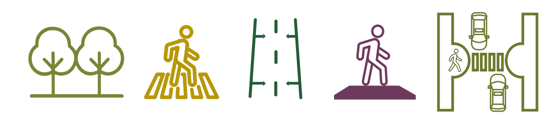
7 On-street parking is provided. 

Twenty Mile-Per-Hour Road Types in Colorado

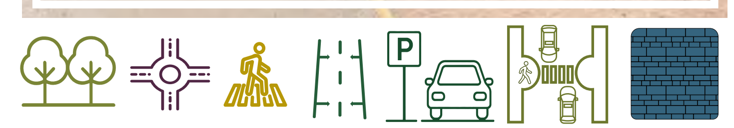
Below are examples of different types of roads throughout Colorado that can be set to 20 MPH based on the characteristics of the roadway.

Rural Mountain
Idaho Springs, CO
Guanella Pass Rd

Traditional Neighborhood
Golden, CO
Ford St



Downtown Places
Manitou Springs, CO
US-24 Business



Rural Mountain
Golden, CO
Lariat Loop Rd

Case Study: Marion Street in Denver, CO

Marion Street near Washington Park in Denver was reconfigured to better align with its residential setting and high levels of bicycle and pedestrian activity. The addition of protected bicycle lanes and defined parking lanes visually narrows the roadway, encouraging lower speeds and improving comfort and safety for all users.

Before:

Despite serving a residential neighborhood adjacent to Washington Park, Marion St functioned more like a through street, with a wide, undefined roadway and open sight lines. The lack of lane definition and dedicated space for other users encouraged higher speeds and felt misaligned with the surrounding neighborhood context and activity.

After:

With the addition of painted parking lanes and a protected bicycle lane, Marion St now feels more structured and constrained. These changes narrow the perceived travelway, reinforcing lower speeds and better aligning the street with its residential, park-adjacent context.

What Changed:

Case Study: US-24 Business in Manitou Springs, CO

This intersection evolved from a wide, vehicle-focused design to one that prioritizes safety and multimodal access. Previously the road's design encouraged higher speeds. The redesign introduced clear cues that calm traffic and create a more pedestrian-friendly environment.

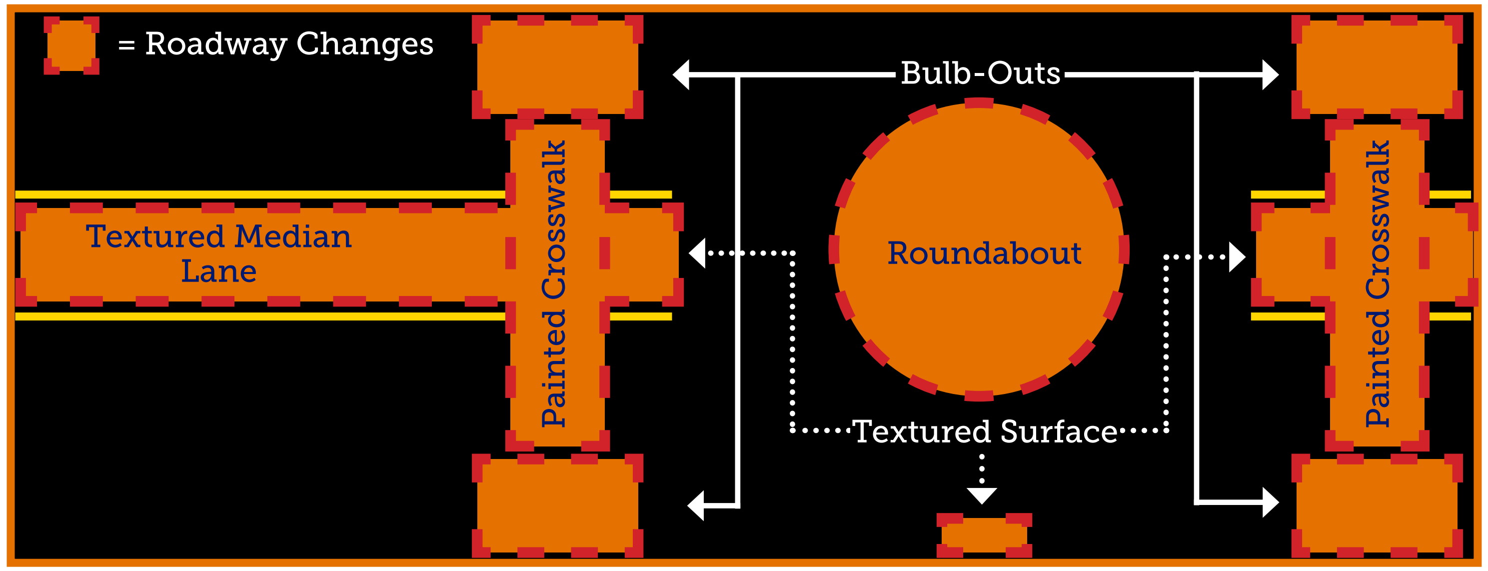
Before:

Before improvements, the corridor had wide lanes, a two-way left-turn lane, minimal pedestrian infrastructure, street parking, and a large three-pronged intersection—conditions that encouraged higher speeds and prioritized vehicles over people.

After:

After improvements, the intersection now features textured surfaces, defined crosswalks on all legs, and a roundabout. These elements introduce visual and physical cues that organize movement and slow vehicles.

What Changed:



Designing for Twenty-Five Mile-Per-Hour Travel

Roadway Elements for Consideration on 25 MPH Roadways

To encourage drivers to naturally adhere to a 25 MPH speed limit, roadway design should signal a lower-speed environment through physical and visual cues. Not all elements described in this chapter will be appropriate for every 25 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.

Enhanced Pedestrian Crossings

Frequent, regularly spaced crossings enhanced with signage, striping, and lighting require drivers to stay attentive.

Street Trees and Landscaping

Plantings along the roadway make roads feel narrower and more community-oriented, encouraging speed reduction.

Reduce Vehicle Lane Width

Makes streets feel less like highways, encouraging drivers to slow down and pay attention. Lane widths of 10.5 feet or less are a good target.

Speed Feedback Signage

Displays driver speed next to posted limit, encouraging immediate self-correction when they're going too fast.

Gateway Treatment

Visual cues signal a change in environment. Drivers reduce speed in response.

Single Lane Roundabout

Manages speed through a combination of geometric design and limited sight distance, forcing low speeds.

Bicycle Lane or Sharrow

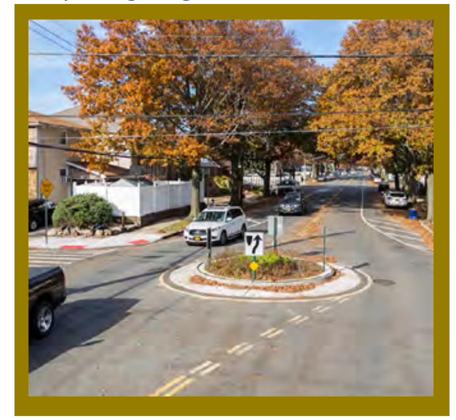
Designates space for cyclists within the roadway, either through striping or shared lane markings.

Textured Surface

Cues drivers to slow down by creating discomfort through vibration and noise at higher speeds. Signals a need for caution.

Raised Crosswalk or Intersection

Features with a vertical aspect slow vehicles, improve pedestrian visibility, and signal a pedestrian zone.



Mini-Roundabout

Retrofits existing intersections to reduce vehicle speeds. Tight curb geometry and a small center island encourage yielding behavior in constrained spaces.

Curb Extension or Pinchpoint

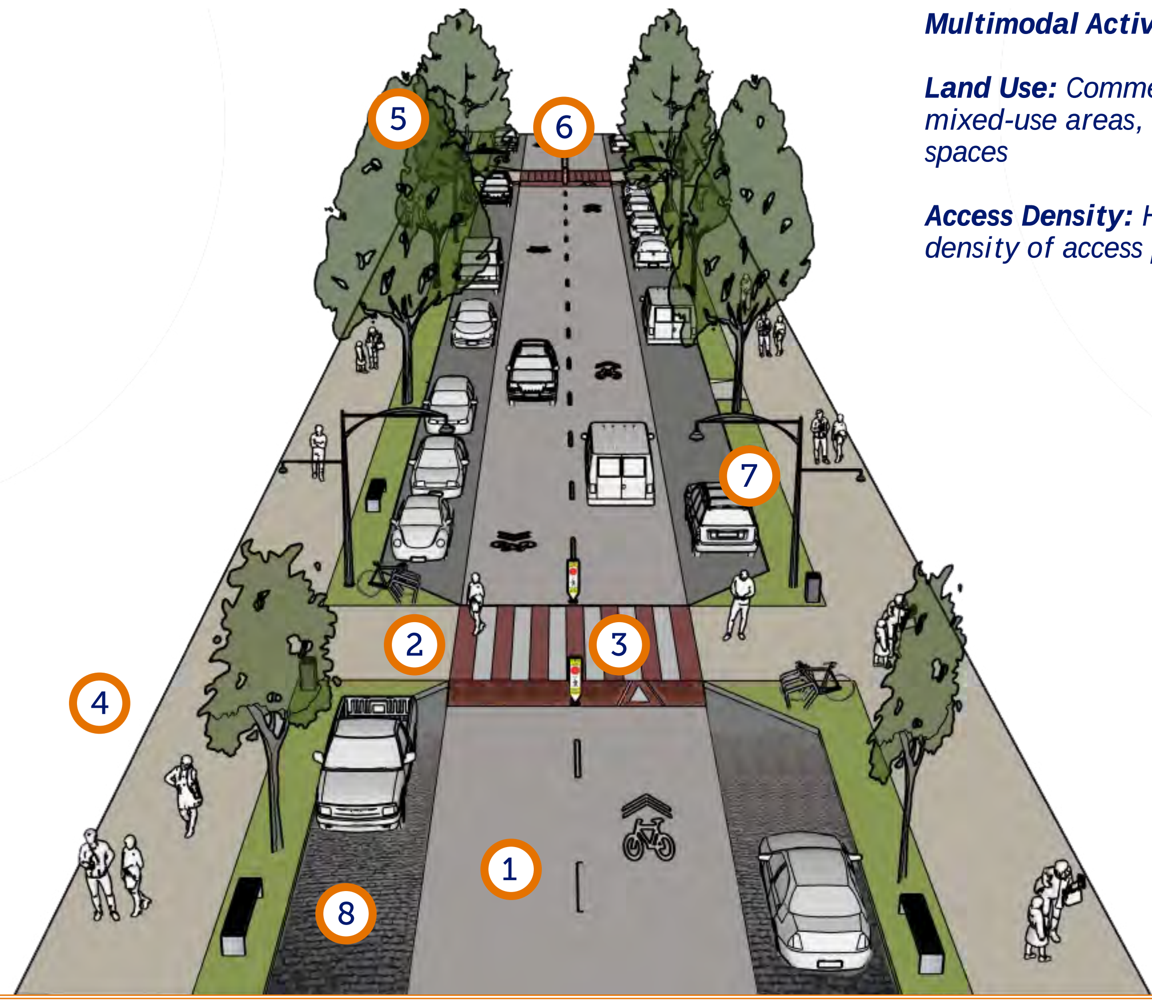
Narrows the roadway and encourages reduced speeds and turns. Naturally increases driver attentiveness.

On-Street Parking

Visually narrows the driving space and adds friction to the edge of the road. Reduces traffic speed and makes streets feel more active.

Twenty-Five Mile-Per-Hour Roadway

This diagram illustrates the application of 25 MPH treatments discussed previously.



Multimodal Activity: *High*

Land Use: *Commercial and mixed-use areas, downtown spaces*

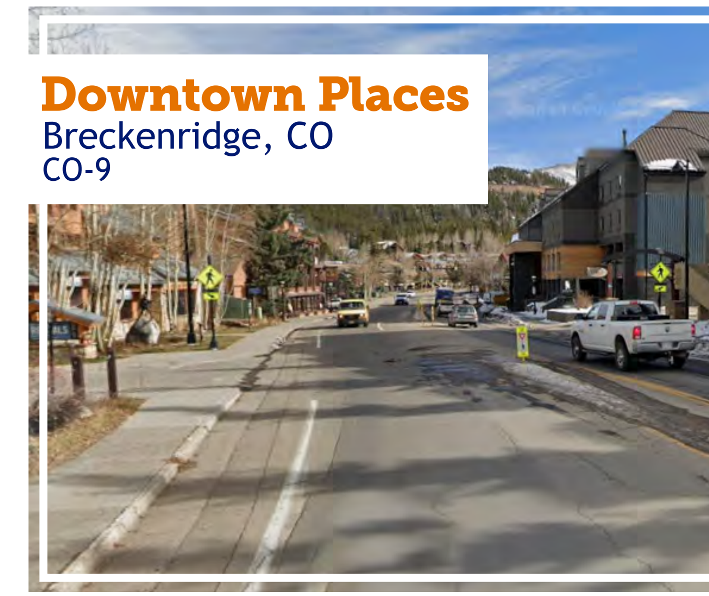
Access Density: *High density of access points*

1. Both travel lanes are 10 feet.
2. The crossings are shortened by curb extensions.
3. Pedestrian crossings are highly visible.
4. A sharrow indicates a shared space for vehicles and bicyclists.
5. Both sides of the street have street trees.
6. Two raised crossings prioritize pedestrians.
7. On-street parking is provided.
8. Crosswalks and parking spaces are textured.

Twenty-Five Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 25 MPH based on the characteristics of the roadway.

Urban Core
Loveland, CO
US-287



Downtown Places
Breckenridge, CO
CO-9

Rural Town Center
Leadville, CO
Harrison Ave

Traditional Neighborhood
Aspen, CO
Cooper Ave

Case Study: US-160 in Alamosa, CO

Despite a 25 MPH speed limit, drivers sped through downtown Alamosa due to US-160's highway-like design. To slow traffic and enhance safety, the city implemented a road diet—narrowing lanes and expanding pedestrian areas—to foster a more community-friendly environment with calming visual cues.

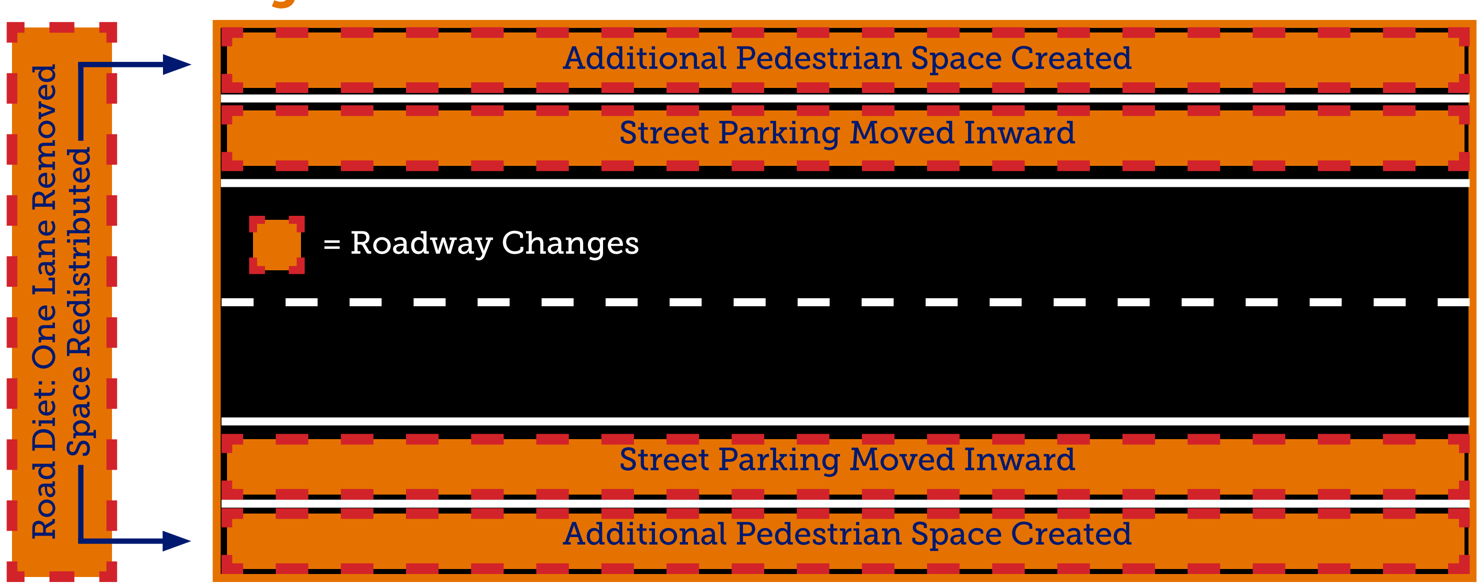
Before:

As US-160 runs through downtown, its wide lanes and open sight lines create a thoroughfare-like experience for drivers. Even with a posted speed limit of 25 MPH, the lack of visual constraints and the separation between vehicles and pedestrians encourage faster driving.

After:

With the removal of a lane of traffic and addition of outdoor seating spaces, this section of US-160 now signals a shift into a more pedestrian-oriented environment. Increased street activity and narrower lanes serve as visual cues that reinforce the 25 MPH speed limit and encourage slow speeds through downtown Alamosa.

What Changed:



Case Study: Powers Ave in Littleton, CO

This neighborhood street transitioned from a wide, fast-moving design to one with intentional traffic calming. Mini roundabouts and plantings introduced pinchpoints, creating a more structured, residential feel that slows vehicles and enhances safety.

Before:

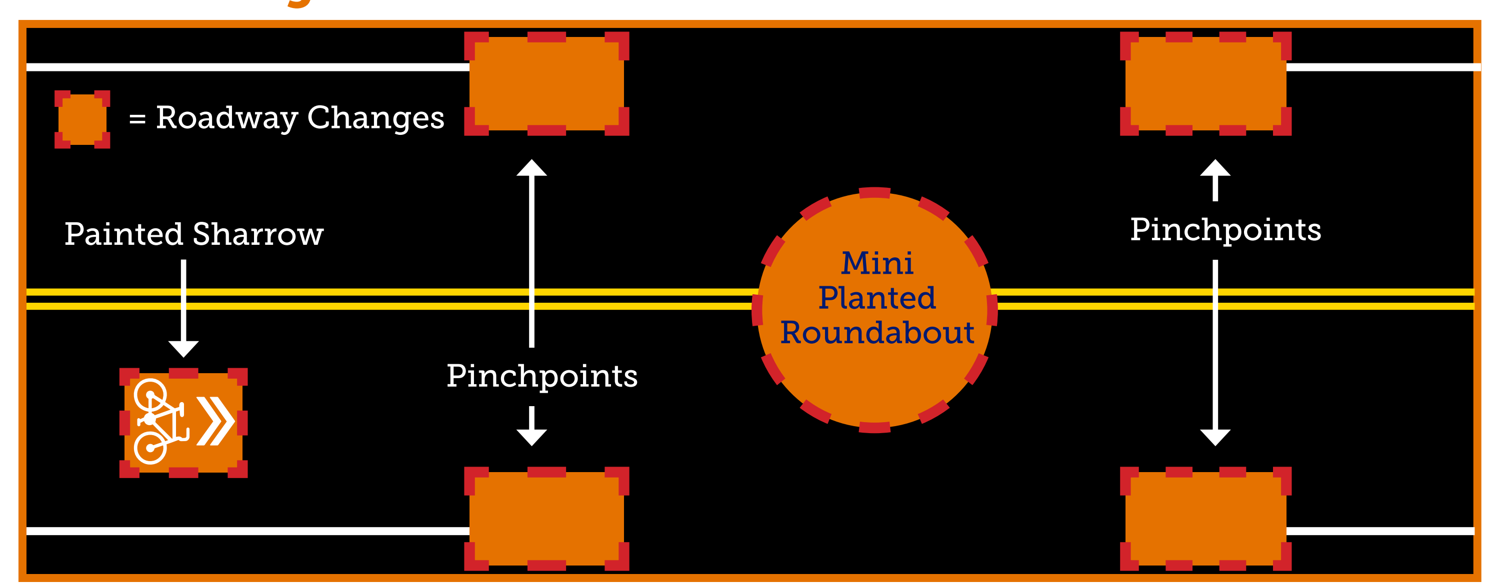
Before improvements, Powers Ave was wide and open with little physical or visual constriction. The lack of space defining elements created a broad travel-way that encouraged higher speeds and offered few cues for drivers to slow down.

After:

Photo Provided by City of Littleton

After improvements, Powers Ave now features mini roundabouts at key intersections and pinchpoints. These elements introduce physical and visual constriction, breaking up the previously wide, straight alignment. The added curvature and landscaped islands create a calmer, more organized environment that naturally slows vehicle speeds.

What Changed:



Designing for 30 MPH Travel

Roadway Elements for Consideration on 30 MPH Roadways

To encourage drivers to naturally adhere to a 30 MPH speed limit, roadway design should signal a lower-speed environment through physical and visual cues. Not all elements described in this chapter will be appropriate for every 30 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.

Enhanced Pedestrian Crossings

Frequent, regularly spaced crossings enhanced with signage, striping, and lighting require drivers to stay attentive.

Street Trees and Landscaping

Plantings along the roadway make roads feel narrower and more community-oriented, encouraging speed reduction.

Reduce Vehicle Lane Width

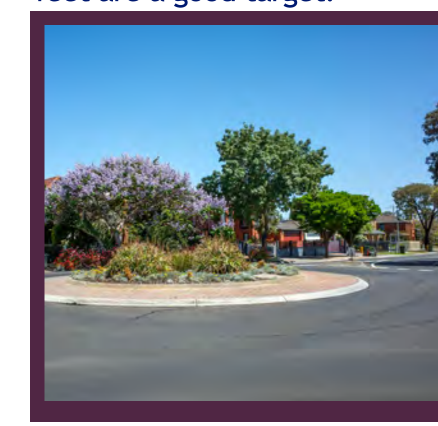
Makes streets feel less like highways, encouraging drivers to slow down and pay attention. Lane widths of 10-11 feet are a good target.

Speed Feedback Signage

Displays driver speed next to posted limit, encouraging immediate self-correction when they're going too fast.

Gateway Treatment

Visual cues signal a change in environment. Drivers reduce speed in response.

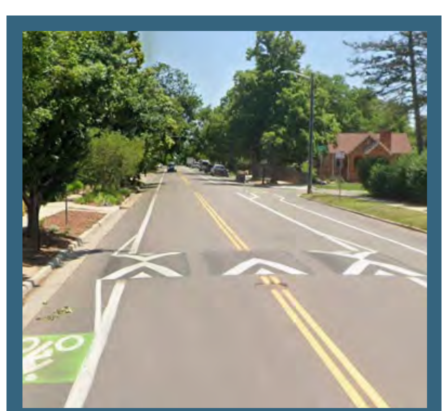


Single Lane Roundabout

Manages speed through a combination of geometric design and limited sight distance, forcing low speeds.

Painted/Protected Bicycle Lane

Physically separates cyclists from traffic and visually signals drivers to slow down. Protected is preferred.

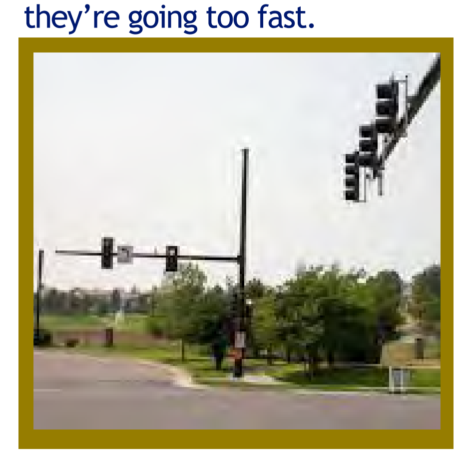


Speed Cushion

Creates raised sections with gaps designed to slow most vehicles while allowing emergency vehicles to pass through the gaps without delay.

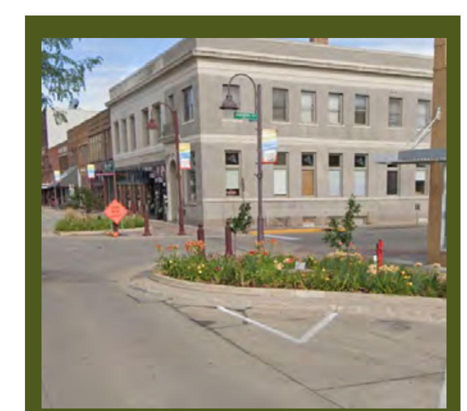
Raised Crosswalk or Intersection

Features with a vertical aspect slow vehicles, improve pedestrian visibility, and signal a pedestrian zone.



Signal Timing Adjustment

Promotes reduced speeds by coordinating signals to reward steady, safe driving and discourage racing between intersections.



Curb Extension or Pinchpoint

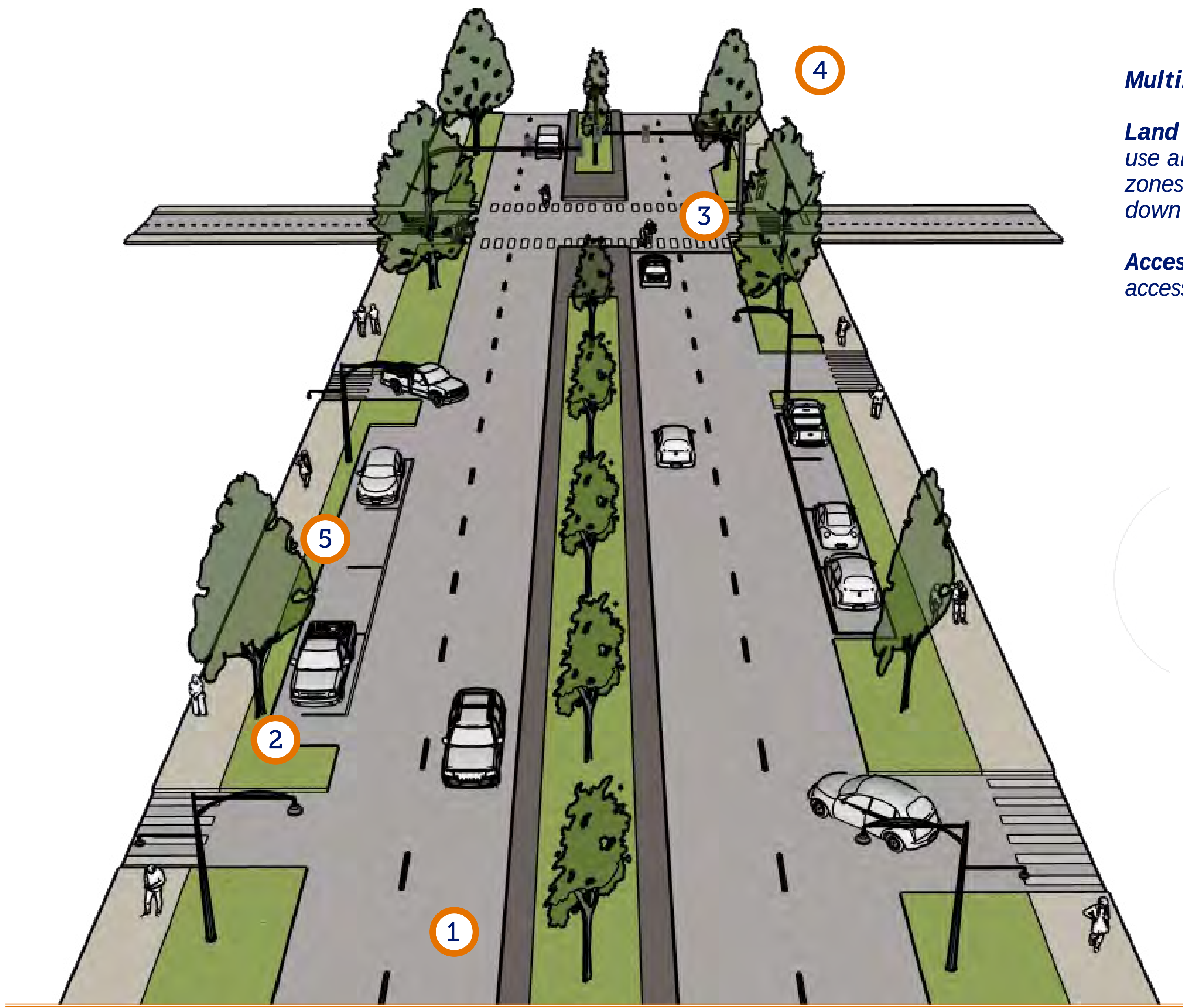
Narrows the roadway and encourages reduced speeds and turns. Naturally increases driver attentiveness.

On-Street Parking

Visually narrows the driving space and adds friction to the edge of the road. Reduces traffic speed and makes streets feel more active.

Thirty Mile-Per-Hour Roadway

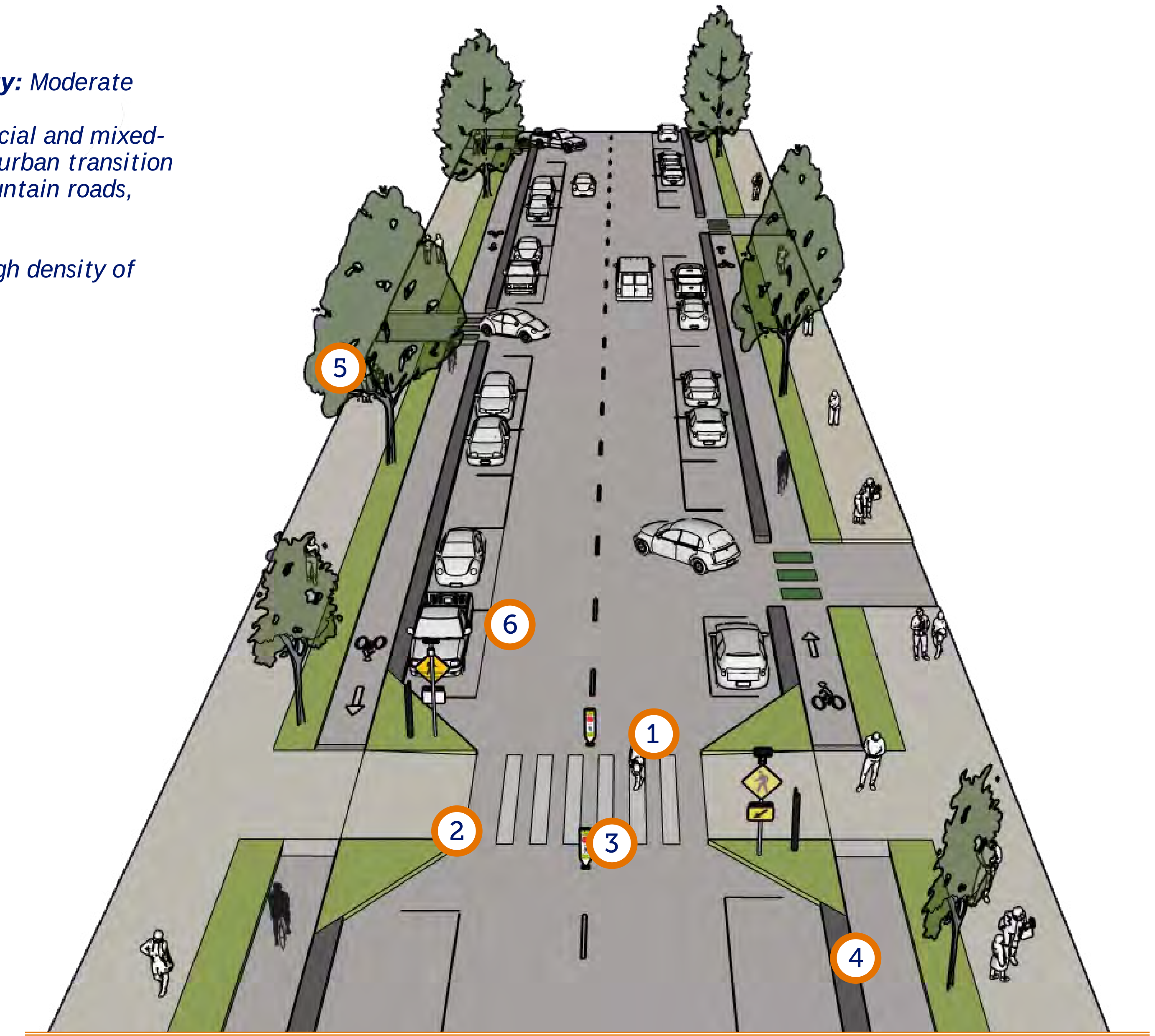
These diagrams illustrate the application of 30 MPH treatments discussed previously.



Multimodal Activity: *Moderate*

Land Use: *Commercial and mixed-use areas, rural to urban transition zones, winding mountain roads, downtown spaces*

Access Density: *High density of access points*



1. Travel lanes are 10 feet.
2. Blub-outs exsit along the roadway.
3. Pedestrian crossings are highly visible.
4. Both sides of the street and the median have street trees.
5. On-street parking is provided.

1. Travel lanes are 11 feet.
2. The crossing is shortened by a curb extension.
3. Pedestrian crossings are highly visible.
4. Protected bicycle lanes exist on both sides of the street.
5. Both sides of the street have street trees.
6. On-street parking is provided.

Thirty Mile-Per-Hour Road Types in Colorado

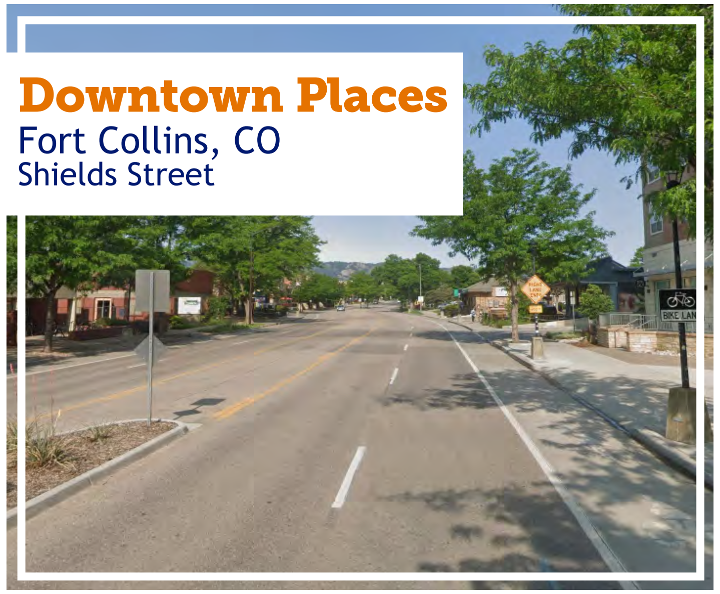
Below are examples of different types of roads throughout Colorado that can be set to 30 MPH based on the characteristics of the roadway.

Urban Core
Denver, CO
E Colfax Ave

Traditional Neighborhood
Dillon, CO
Cove Blvd

Rural Town Center
Delta, CO
US-50

Downtown Places
Fort Collins, CO
Shields Street



Case Study: Cove Blvd in Dillon, CO

Cove Blvd was once wide and undefined, encouraging high speeds. Recent upgrades added facilities for walking and biking, creating structure and visual cues that signal drivers to slow down—making the corridor safer for everyone.

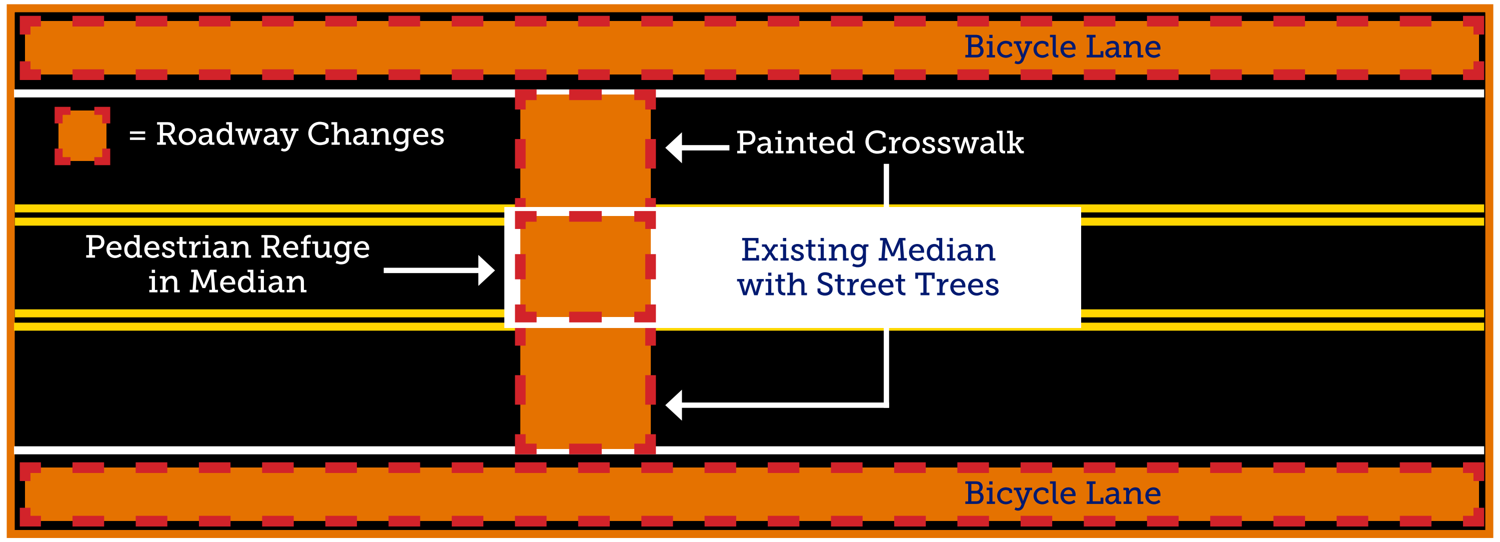
Before:

Cove Blvd presented a wide, open roadway with few visual cues to slow drivers. Undefined edge space created the perception of extra width with little enclosure or sense of scale. These conditions reduced visual friction and encouraged drivers to travel faster than intended.

After:

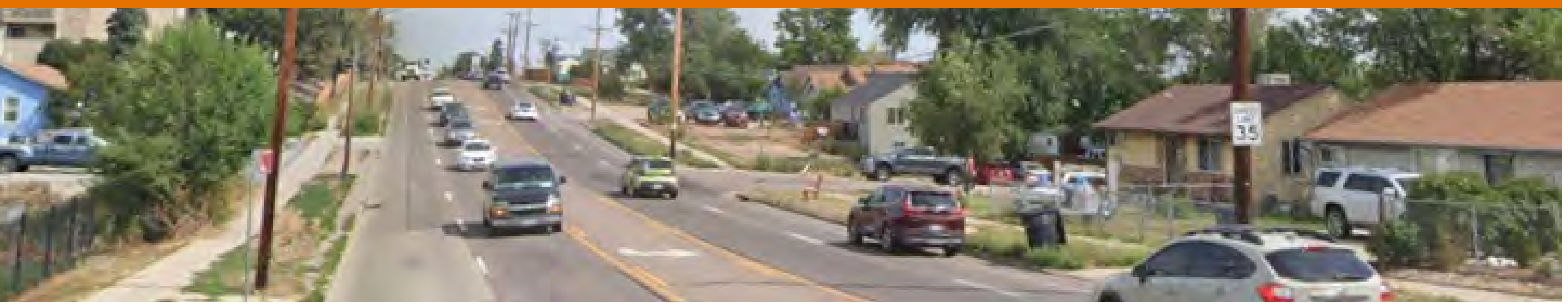
After improvements, Cove Blvd includes a bicycle lane and a pedestrian space, crosswalks, and pedestrian refuges in the median, creating safer space for non-motorized users. Clear edge lines provide visual narrowing. These changes introduce activity and structure, reducing the sense of openness that previously encouraged speeding.

What Changed:



Back to Speed TOC

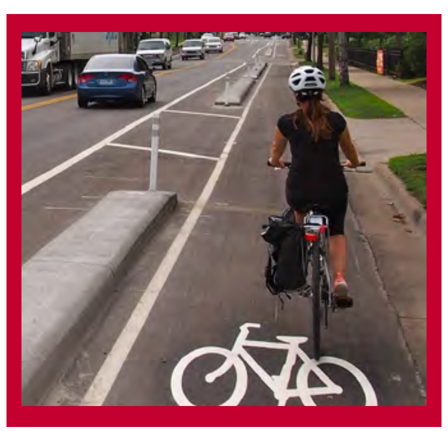
Designing for 35 MPH Travel



Roadway Elements for Consideration on 35 MPH Roadways

To encourage drivers to naturally adhere to a 35 MPH speed limit, roadway design should signal a lower-speed environment through physical and visual cues. Not all elements described in this chapter will be appropriate for every 35 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



Protected Bicycle Lane

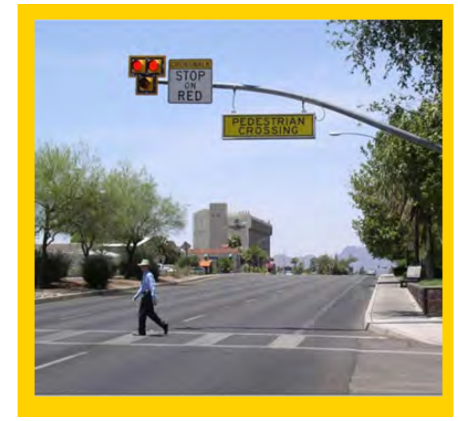
Physically separates cyclists from traffic and creates friction that results in lower speeds.

Multi-Lane Roundabout

Manages speed at high volume intersections through a combination of geometric design and limited sight distance, forcing low speeds.

Raised/Landscaped Median

Slows traffic by narrowing lanes and separating opposing flows, and at this speed, adding pedestrian refuge islands can further enhance safety.

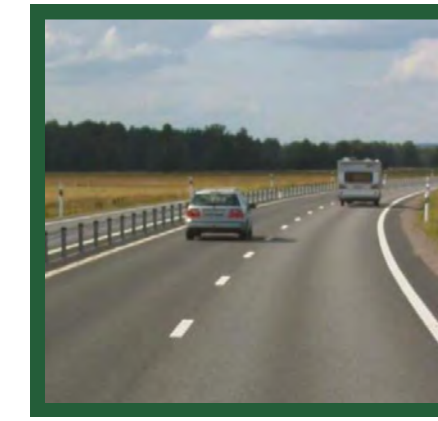


Controlled Mid-Block Pedestrian Crossings

Mid-block crossings that use a signalized feature to safely cross pedestrians. Lighting is critical for visibility.

Street Trees and Landscaping

Plantings along the roadway make roads feel narrower and more community-oriented, encouraging speed reduction.



Reduce Vehicle Lane Width

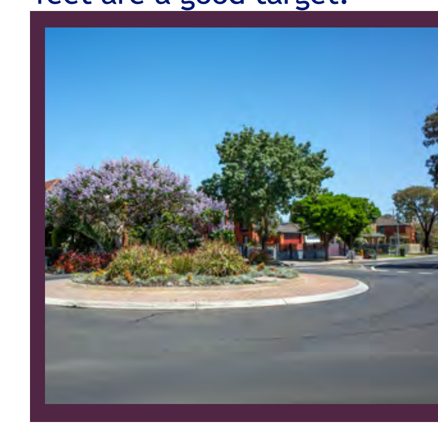
Makes streets feel less like highways, encouraging drivers to slow down and pay attention. Lane widths of 11 feet are a good target.

Speed Feedback Signage

Displays driver speed next to posted limit, encouraging immediate self-correction when they're going too fast.

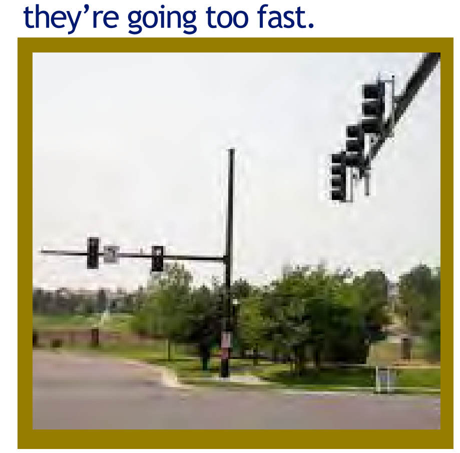
Gateway Treatment

Visual cues signal a change in environment. Drivers reduce speed in response.



Single Lane Roundabout

Manages speed through a combination of geometric design and limited sight distance, forcing low speeds.



Signal Timing Adjustment

Promotes reduced speeds by coordinating signals to reward steady, safe driving and discourage racing between intersections.

Curb Extension

Narrows the roadway at corners, which encourages lower speeds and turns. Improves the visibility of people crossing.

Maintain/Enhance Clear Zone

Improves reaction time to oncoming hazards, traffic signs, people or animals entering the roadway.

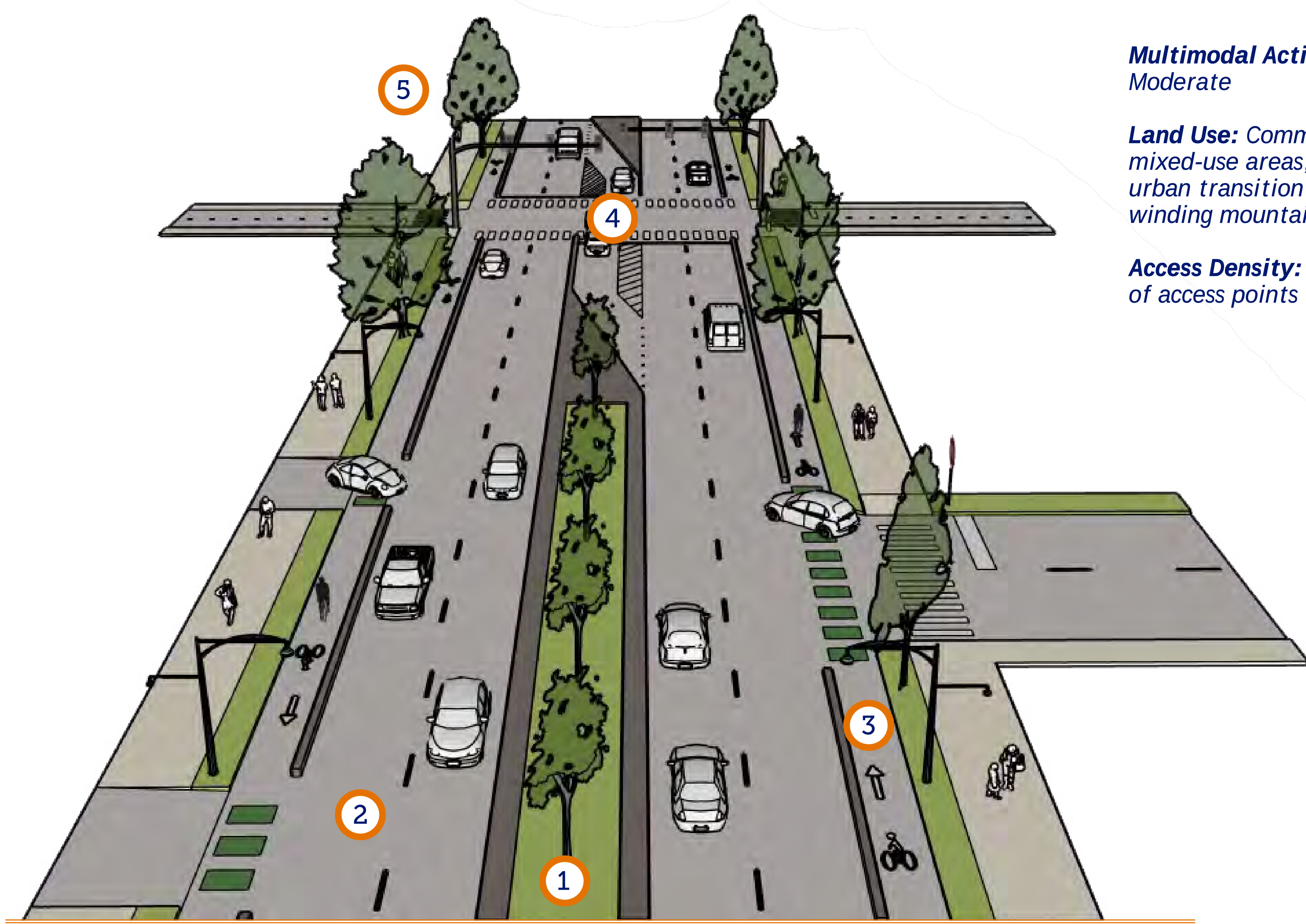
Thirty-Five Mile-Per-Hour Roadway

This diagram illustrates the application of 35 MPH treatments discussed previously.

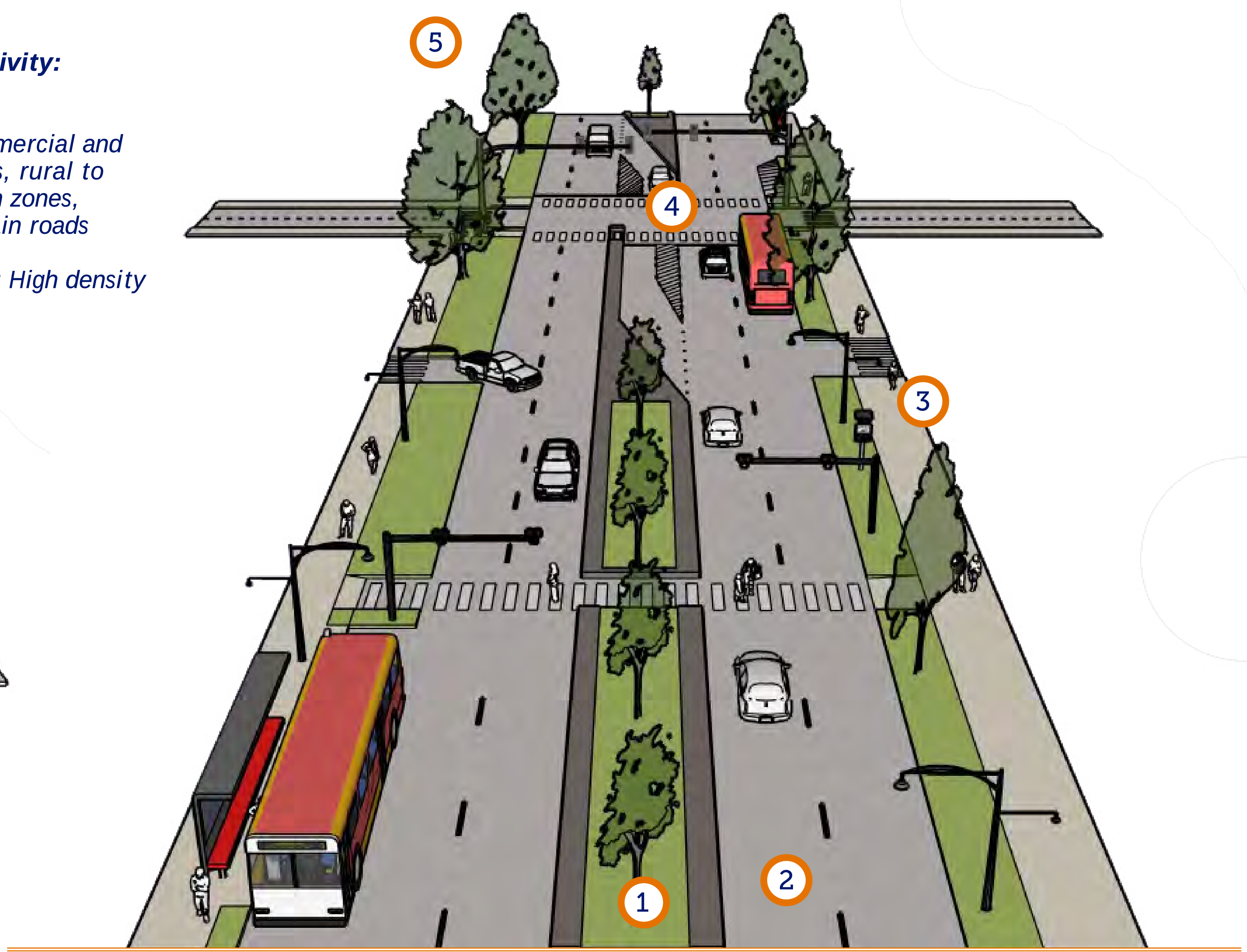
Multimodal Activity: *Moderate*

Land Use: *Commercial and mixed-use areas, rural to urban transition zones, winding mountain roads*

Access Density: *High density of access points*



1. A raised median exists.
2. Travel lanes are 11 feet.
3. Protected bike lanes exist on both sides of the street.
4. Traffic signals located every ¼ to ½ mile and are coordinated to keep traffic at 35 MPH.
5. Both sides of the street and the median have street trees.



1. A raised median exists.
2. Travel lanes are 11 feet.
3. Speed feedback signs reinforce posted speed.
4. Traffic signals located every ¼ to ½ mile and are coordinated to keep traffic at 35 MPH.
5. Both sides of the street have street trees.

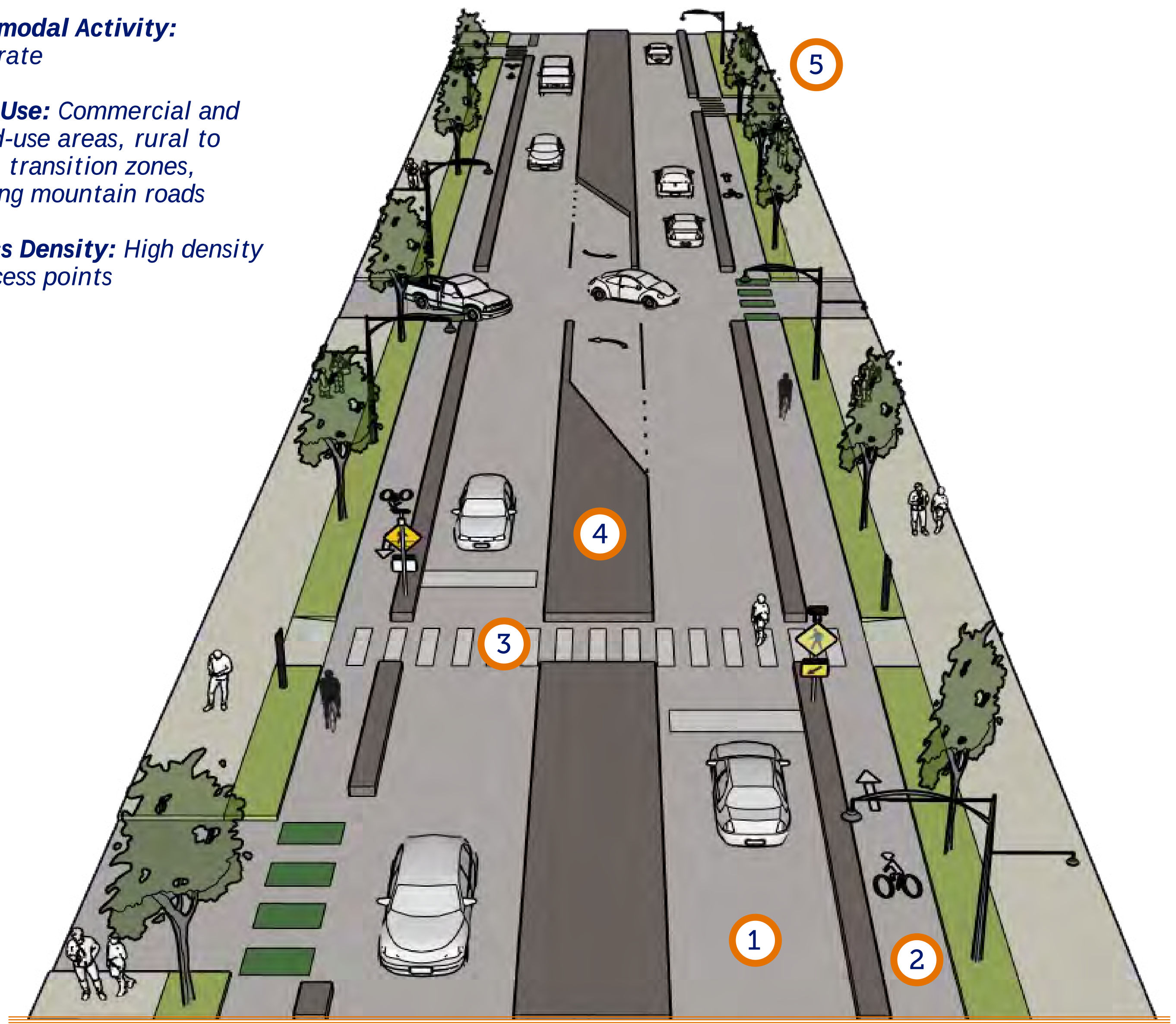
Thirty-Five Mile-Per-Hour Roadway Cont.

This diagram illustrates the application of 35 MPH treatments discussed previously.

Multimodal Activity: *Moderate*

Land Use: *Commercial and mixed-use areas, rural to urban transition zones, winding mountain roads*

Access Density: *High density of access points*

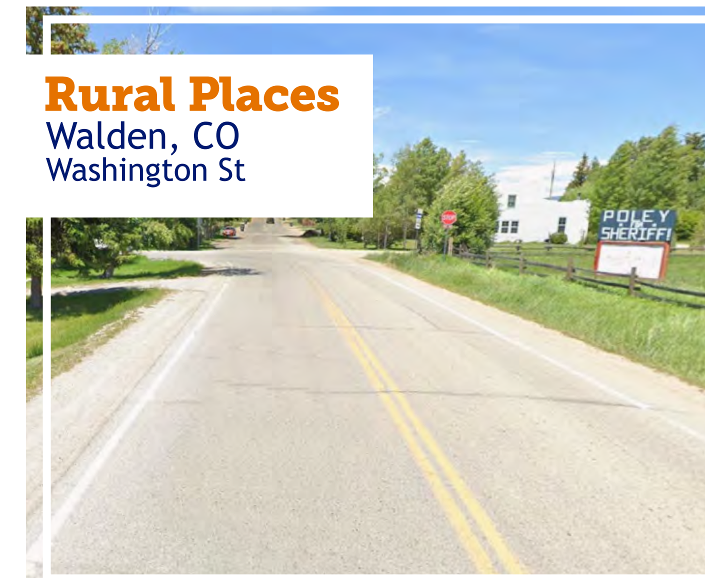


1. A raised median with a pedestrian refuge island exists.
2. Travel lanes are 11 feet.
3. Pedestrian crossings are controlled and highly visible.
4. Protected bicycle lanes exist on both sides of the street.
5. Both sides of the street have street trees.

Thirty-Five Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 35 MPH based on the characteristics of the roadway.

Rural Mountain
Golden, CO
CO-70



Rural Places
Walden, CO
Washington St

Rural Town Center
Durango, CO
US-550

Suburban Places
Fruita, CO
US-50

Case Study: US-550 in Durango, CO

US-550 through Durango once had a continuous two-way, left-turn lane, prioritizing vehicle flow but offering little separation. The redesign added a raised, landscaped median and bicycle lanes, improving safety for pedestrians and cyclists while calming traffic.

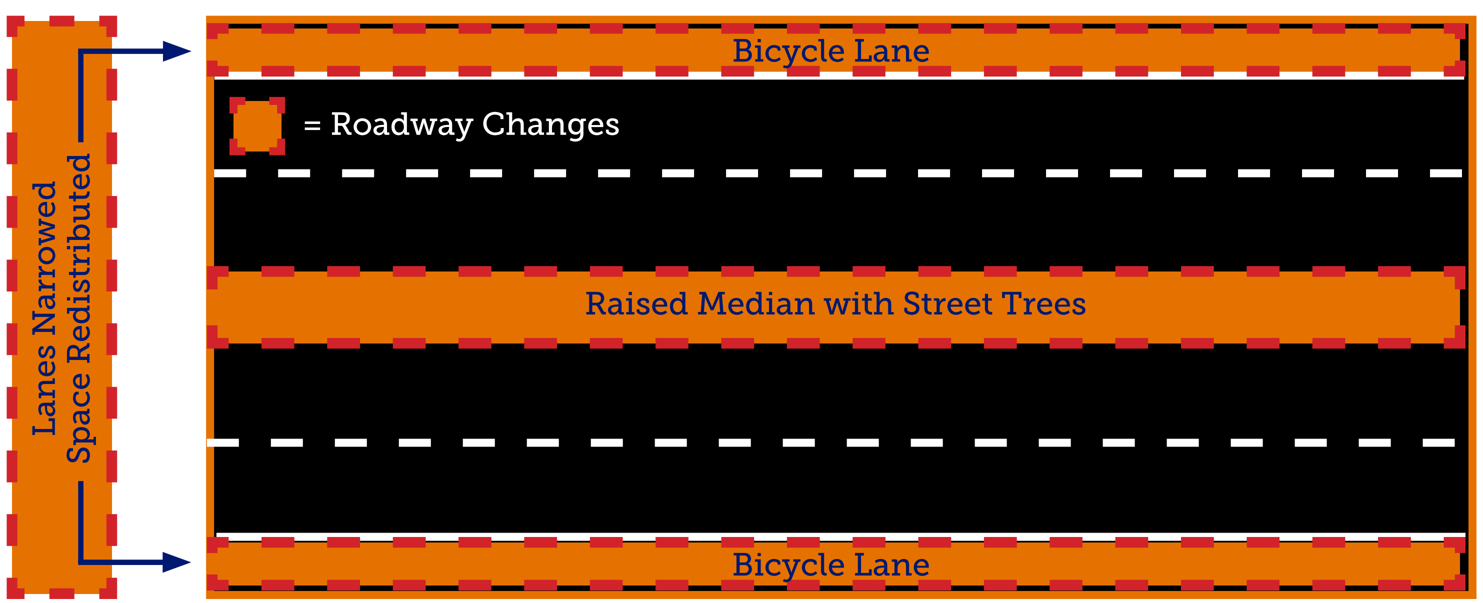
Before:

Before its redesign, US-550 through Durango functioned as a vehicle-oriented thoroughfare. The wide roadway, continuous two-way, left-turn lane, and lack of dedicated space for other modes contributed to higher vehicle speeds and reduced comfort for pedestrians and cyclists.

After:

With the addition of a raised landscaped median and dedicated bicycle lanes, this section of US-550 creates a more welcoming environment for all travelers. These design changes serve as visual cues that help organize traffic and encourage drivers to slow down as they enter the community.

What Changed:



Case Study: US-40 in Empire, CO

As US-40 enters Empire, the speed limit drops—but drivers kept speeding because the road still felt like a highway. To signal a transition, the town added a raised median with landscaping, creating a clear gateway. This simple change helped drivers slow down and made the road safer for everyone.

Before:

As US-40 curves into Empire, the posted speed limit drops from 55 MPH, but the road design remains unchanged with wide lanes and open sight-lines. Drivers aren't discouraged from maintaining highway speeds because nothing else changes.

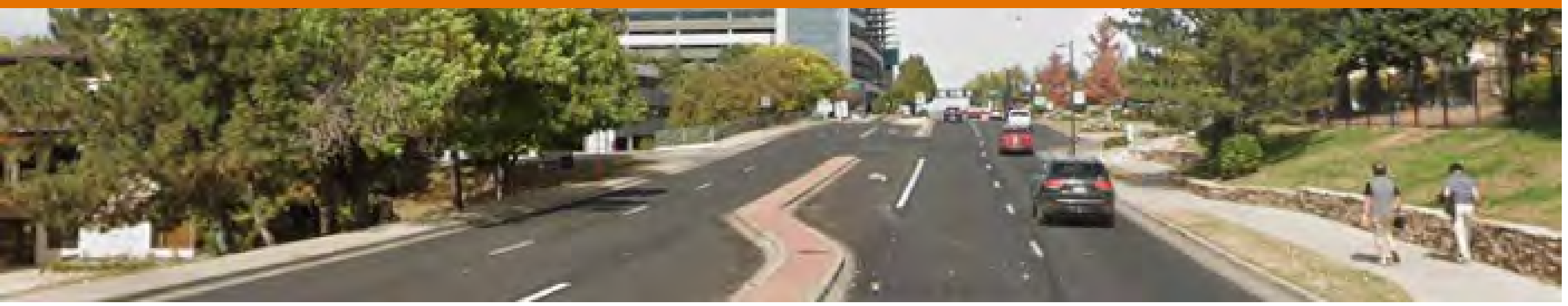
After:

With the addition of a gateway feature, this section of US-40 now signals a transition into town. These visual cues help reinforce the lower speed limit and encourage drivers to slow down as they enter town.

What Changed:

Back to Speed TOC

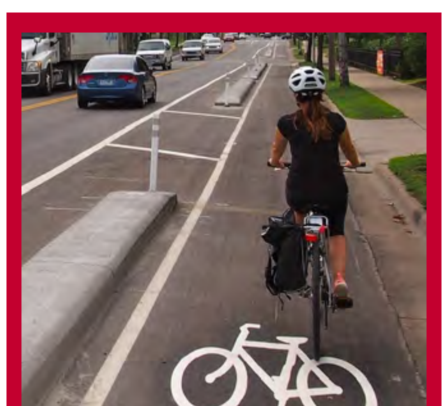
Designing for 40 MPH Travel



Roadway Elements for Consideration on 40 MPH Roadways

To balance speed management with safety at a 40 MPH speed limit, roadway design should integrate features that encourage appropriate speeds while providing elements that enhance safety for all users. Not all elements described in this chapter will be appropriate for every 40 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements discussed in further detail in Appendix A.



Protected Bicycle Lane

Physically separates cyclists from traffic and creates friction that results in lower speeds.

Multi-Lane Roundabout

Manages speed at high volume intersections through a combination of geometric design and limited sight distance, forcing low speeds.

Raised/Landscaped Median

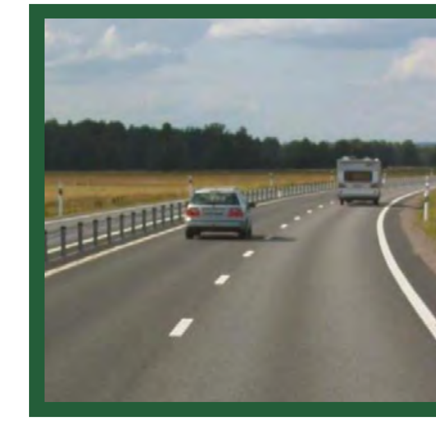
Slows traffic by narrowing lanes and separating opposing flows, and at this speed, adding pedestrian refuge islands can further enhance safety.

Controlled Mid-Block Pedestrian Crossings

Mid-block crossings that use a signalized feature to safely cross pedestrians. Lighting is critical for visibility.

Street Trees and Landscaping

Plantings along the roadway make roads feel narrower and more community-oriented, encouraging speed reduction.



Reduce Vehicle Lane Width

Makes streets feel less like highways, encouraging drivers to slow down and pay attention. Lane widths of 11 feet are a good target.

Speed Feedback Signage

Displays driver speed next to posted limit, encouraging immediate self-correction when they're going too fast.

Consolidate Access Points

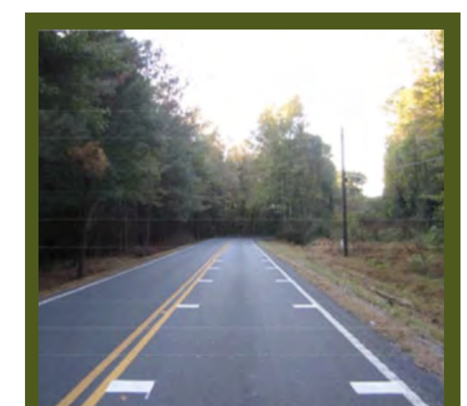
Reduces conflict areas, simplifies decision-making, and encourages smoother traffic flow.

Protected Left Turn Movements

As speeds increase, dedicated signal phases for left turns reduce conflicts and improve flow.

Signal Timing Adjustment

Promotes reduced speeds by coordinating signals to reward steady, safe driving and discourage racing between intersections.



Optical Speed Bars

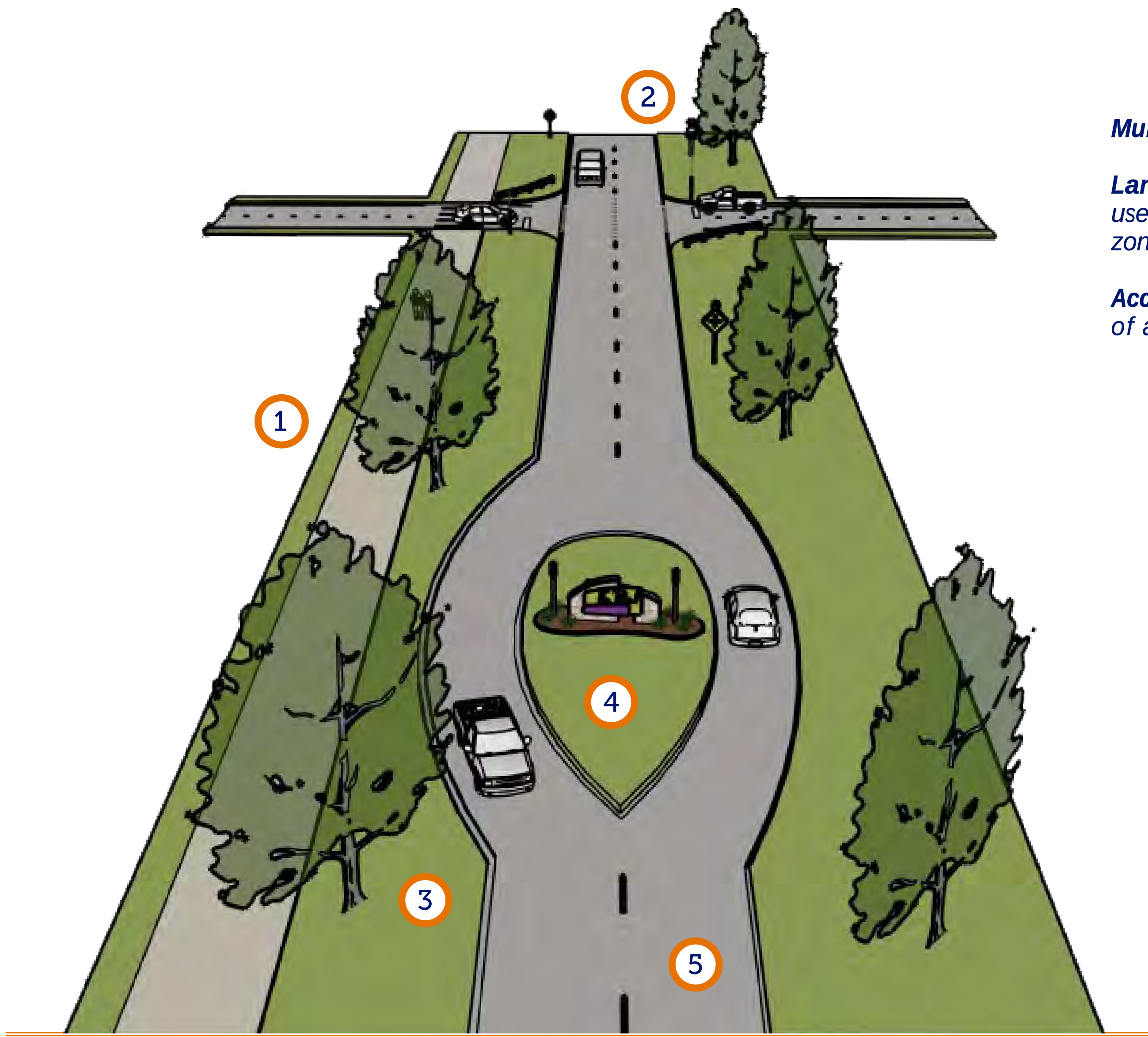
Repeated pavement markings that create a sense of speeding up, encouraging drivers to slow down. Most effective at specific hazard locations rather than corridor-wide.

Maintain/Enhance Clear Zone

Improves reaction time to oncoming hazards, traffic signs, people or animals entering the roadway.

Forty Mile-Per-Hour Roadway

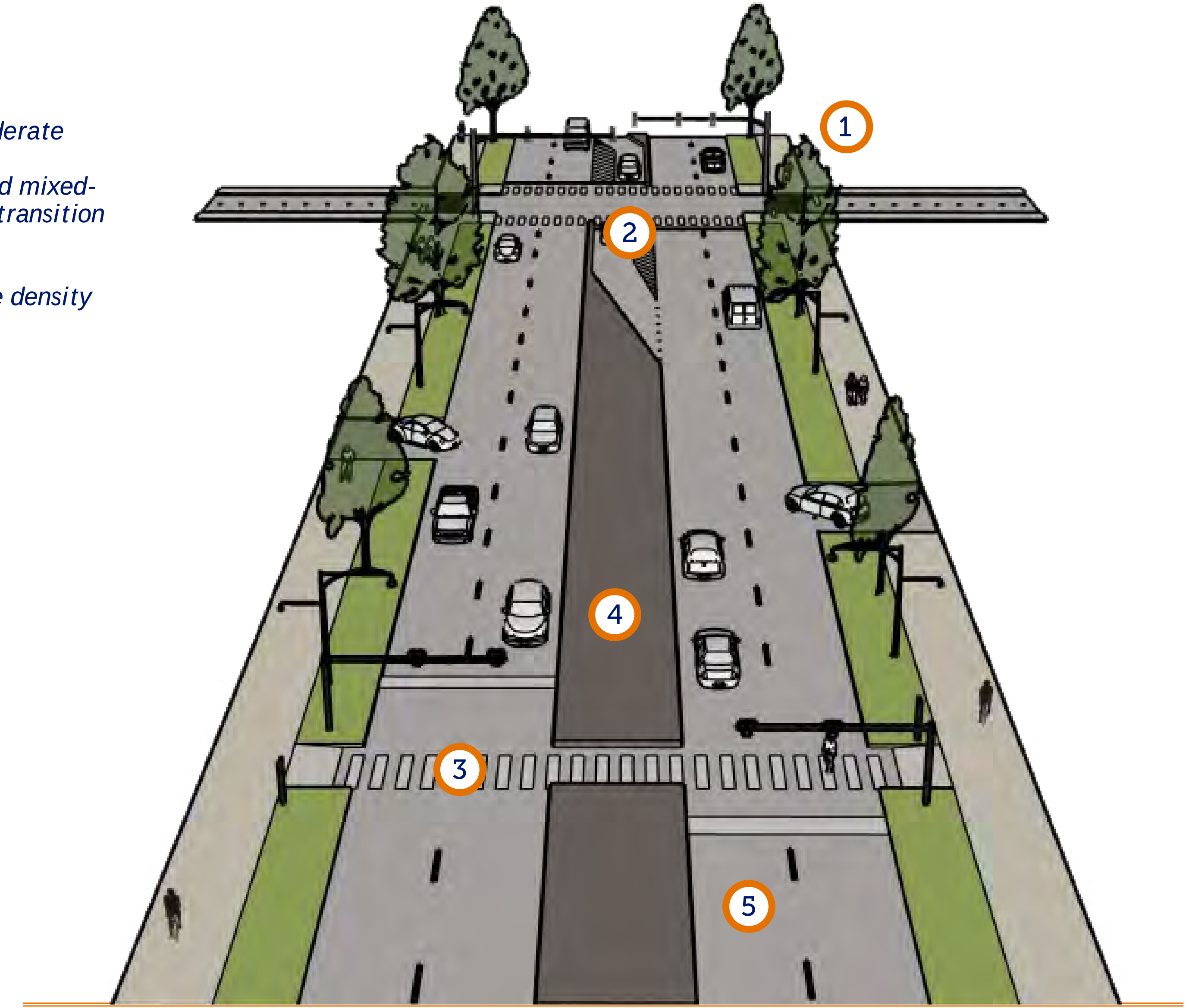
This diagram illustrates the application of 40 MPH treatments discussed previously.



Multimodal Activity: *Moderate*

Land Use: *Commercial and mixed-use areas, rural to urban transition zones*

Access Density: *Moderate density of access points*



1. Both sides of the street have street trees.
2. Speed feedback signs reinforce posted speed.
3. Clear zones have been maintained.
4. Gateway signage encourages transitional speeds.
5. Travel lanes are 11 feet.

1. Both sides of the street have street trees.
2. Protected left turning movements are provided at each signal.
3. Pedestrian crossings are controlled and highly visible.
4. A raised median with a pedestrian refuge island exists.
5. Travel lanes are 11 feet.

Forty Mile-Per-Hour Road Types in Colorado

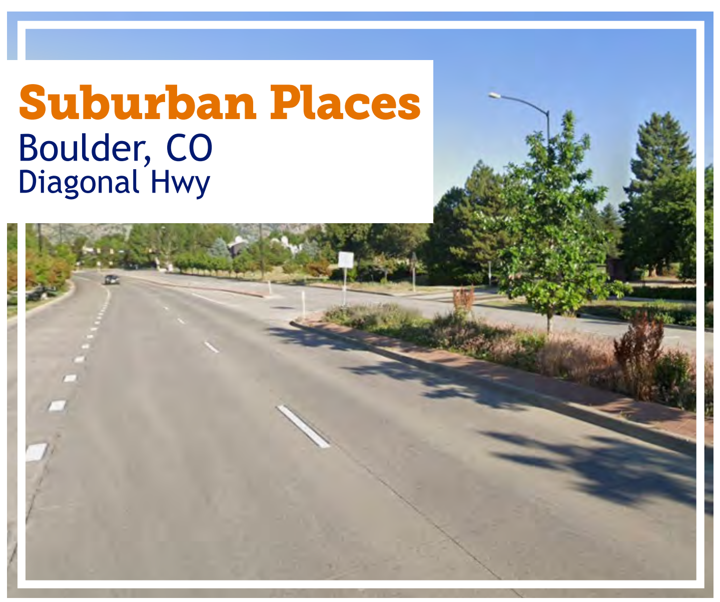
Below are examples of different types of roads throughout Colorado that can be set to 40 MPH based on the characteristics of the roadway.

Suburban Places
Greenwood Village, CO
S Quebec St

Rural Places
Olathe, CO
CO-348

Rural Places
Palmer Lake, CO
CO-105

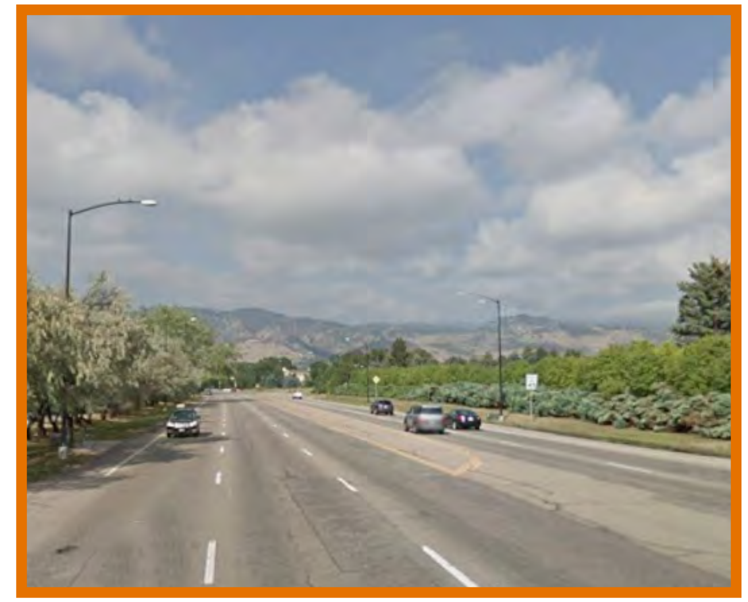
Suburban Places
Boulder, CO
Diagonal Hwy



Case Study: CO-119 in Boulder, CO

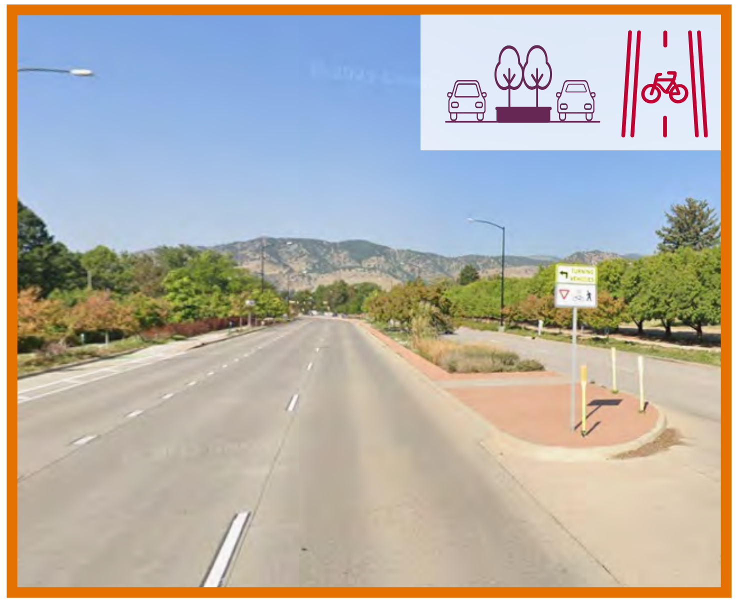
CO-119 in Boulder once prioritized vehicle flow with a continuous turn lane and little multimodal access. The redesign added a raised landscaped median, a separated bicycle lane, and a shared-use path, improving safety and traffic calming for all users.

Before:



CO-119 previously featured a continuous two-way, left-turn lane, with no dedicated space for cyclists or pedestrians. The wide, vehicle-focused layout encouraged higher speeds and offered limited support for multimodal travel through the corridor.

After:



With the addition of a raised, landscaped median, separated bicycle lane, and shared use path, this section of CO-119 now supports safer and more balanced travel. These improvements provide clear visual cues that calm traffic and enhance safety for all users.

What Changed:

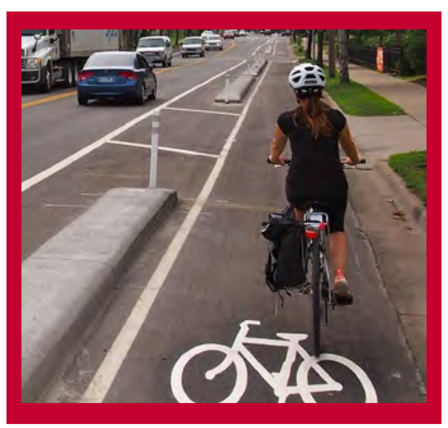
Back to Speed TOC

Designing for 45 MPH Travel

Roadway Elements for Consideration on 45 MPH Roadways

To balance speed management with safety at a 45 MPH speed limit, roadway design should integrate features that encourage appropriate speeds while providing elements that enhance safety for all users. Not all elements described in this chapter will be appropriate for every 45 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



Protected Bicycle Lane

Physically separates cyclists from traffic and creates friction that results in lower speeds.

Multi-Lane Roundabout

Manages speed at high volume intersections through a combination of geometric design and limited sight distance, forcing low speeds.

Raised/Landscaped Median

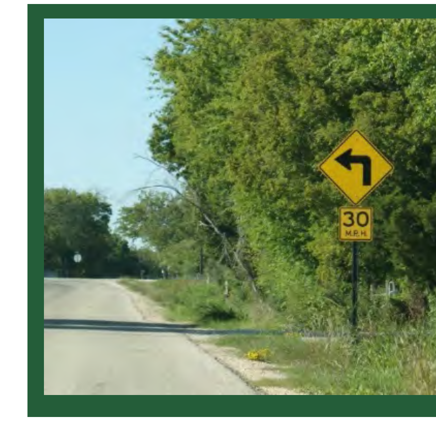
Medians help slow traffic by narrowing lanes and separating opposing flows, and at this speed, adding pedestrian refuge islands can further enhance safety.

Controlled Mid-Block Pedestrian Crossings

Mid-block crossings that use a signalized feature to safely cross pedestrians. Lighting is critical for visibility.

Street Trees and Landscaping

Plantings along the roadway make roads feel narrower and more community-oriented, encouraging speed reduction.

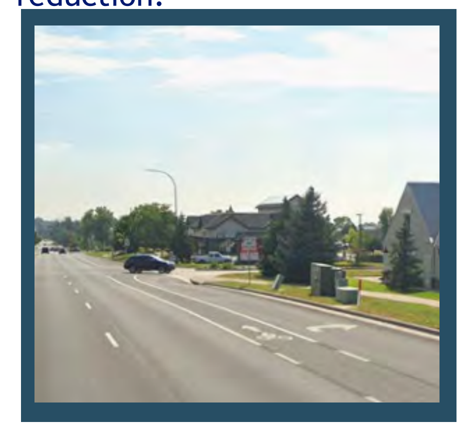


Advanced Warning Signage

Slows drivers by signaling upcoming changes, prompting earlier attention and braking.

Speed Feedback Signage

Displays driver speed next to posted limit, encouraging immediate self-correction when they're going too fast.

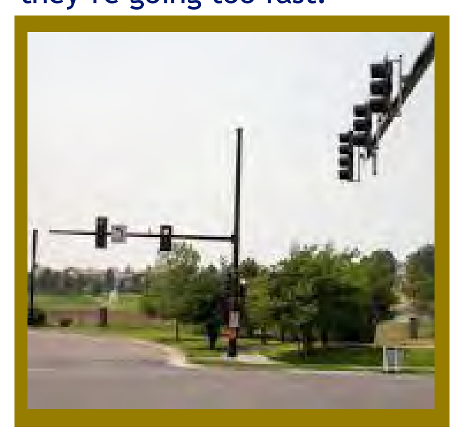


Consolidate Access Points

Reduces conflict areas, simplifies decision-making, and encourages smoother traffic flow.

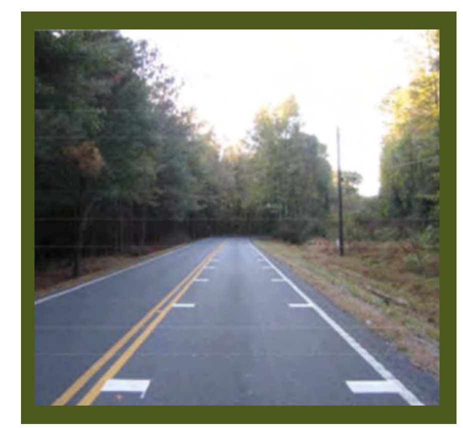
Protected Left Turn Movements

As speeds increase, dedicated signal phases for left turns reduce conflicts and improve flow.



Signal Timing Adjustment

Promotes reduced speeds by coordinating signals to reward steady, safe driving and discourage racing between intersections.



Optical Speed Bars

Repeated pavement markings that create a sense of speeding up, encouraging drivers to slow down. Most effective at specific hazard locations rather than corridor-wide.

Maintain/Enhance Clear Zone

Improves reaction time to oncoming hazards, traffic signs, people or animals entering the roadway.

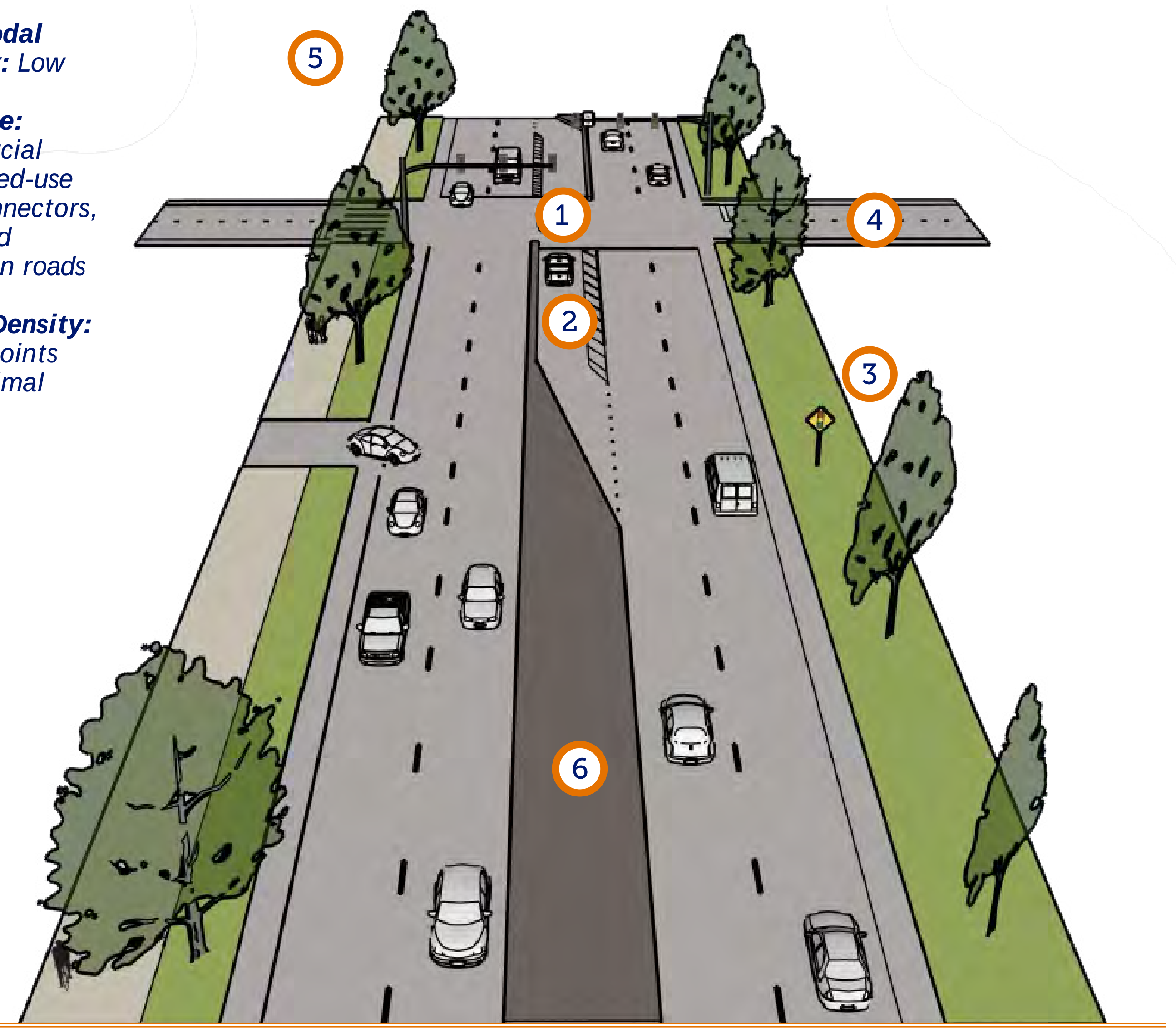
Forty-Five Mile-Per-Hour Roadway

This diagram illustrates the application of 45 MPH treatments discussed previously.

Multimodal Activity: *Low*

Land Use: *Commercial and mixed-use area connectors, rural and mountain roads*

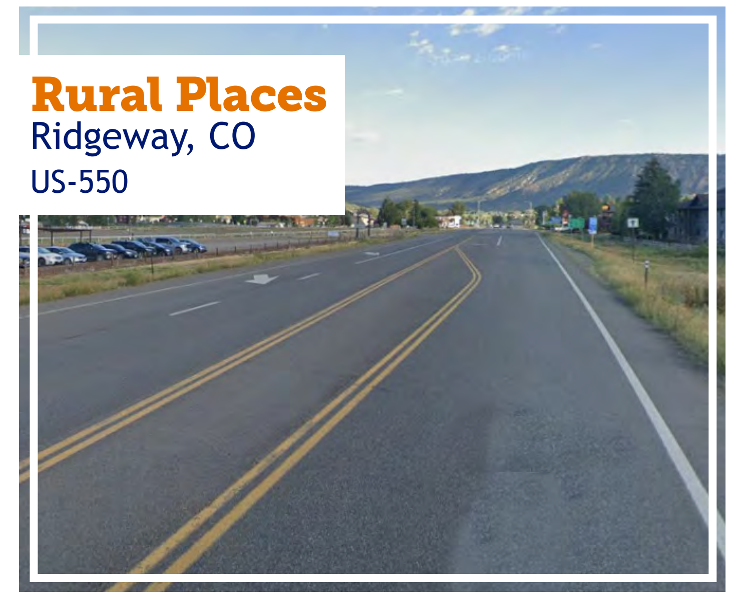
Access Density: *Access points are minimal*



1. Traffic signals along the corridor are coordinated to keep traffic at 45 MPH.
2. Protected left turning movements are provided at each signal.
3. Advanced warning signage alerts drivers of an upcoming intersection.
4. Access is generally consolidated or provided on the sidestreets.
5. Both sides of the street have street trees.
6. A raised median exists.

Forty-Five Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 45 MPH based on the characteristics of the roadway.



Rural Places
Ridgeway, CO
US-550

Suburban Places
Aurora, CO
S Parker Rd

Rural Places
Naturita, CO
CO-141

Rural Mountain
Nederland, CO
CO-119

Case Study: CO-9 in Silverthorne, CO

CO-9 is a winding mountain corridor where speed feedback signage was added to complement existing static speed limit signs, improving driver speed awareness and encouraging compliance for safer, more consistent travel speeds along the corridor.

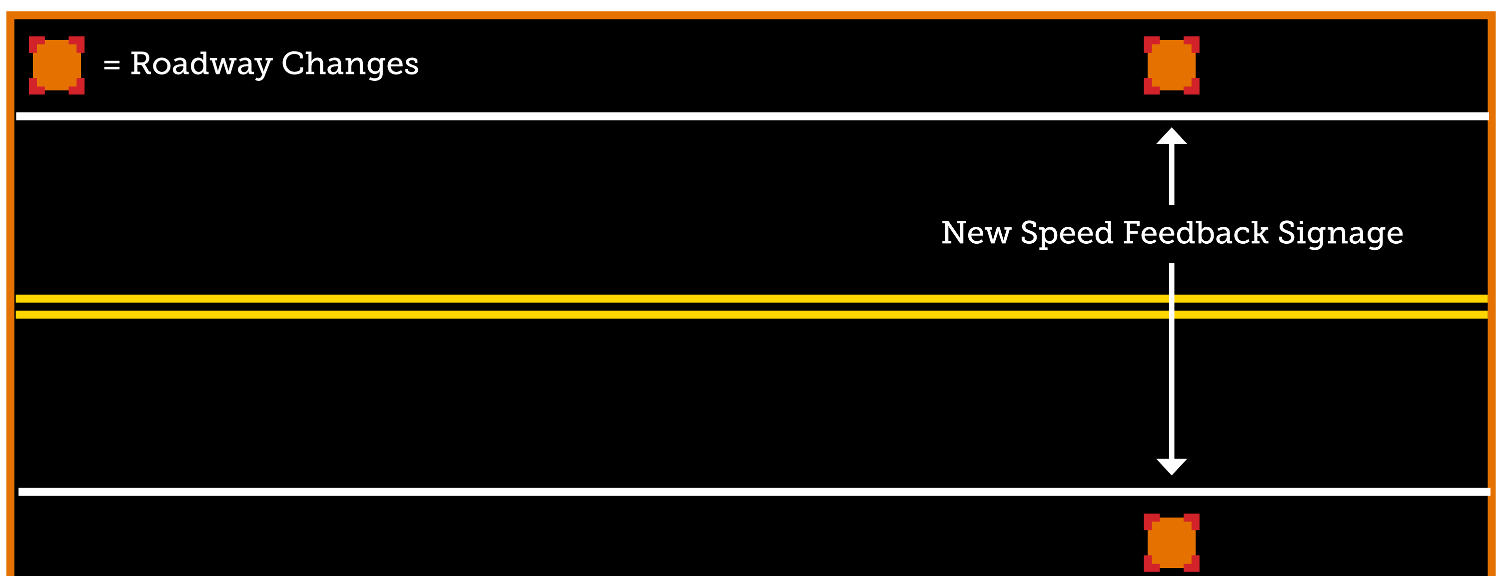
Before:

CO-9 relied solely on static speed limit signs, providing no real-time feedback to drivers. Without dynamic reminders, drivers were less aware of their actual speeds, which could lead to higher operating speeds and inconsistent compliance with posted speed limits.

After:

Speed feedback signs were installed along the corridor, displaying drivers' current speeds and encouraging compliance with the posted speed limit. This low-cost measure improves speed awareness, reduces speeding behavior, and supports safer conditions without altering the roadway geometry.

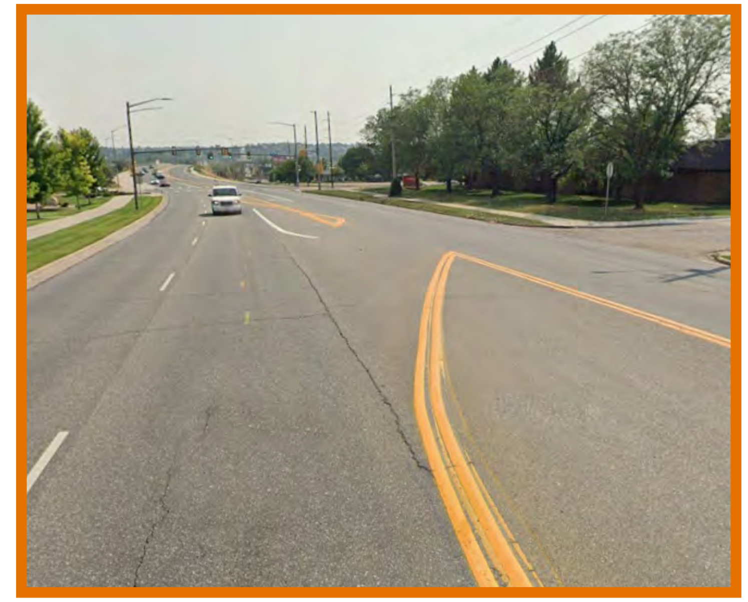
What Changed:



Case Study: CO-95 in Arvada, CO

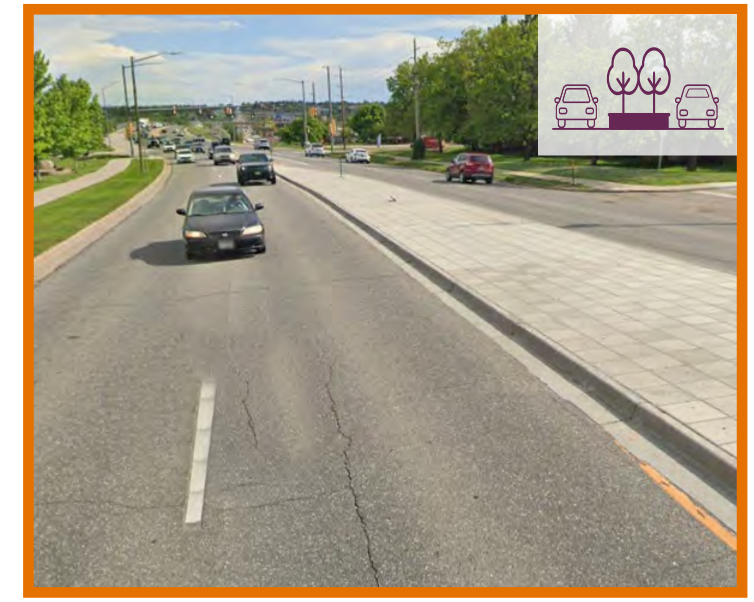
CO-95 shifted from a wide, open roadway with little visual friction to a more structured suburban design. The painted median was replaced with a raised median, improving traffic separation, reducing conflict points, and calming speeds for a safer, more controlled corridor.

Before:



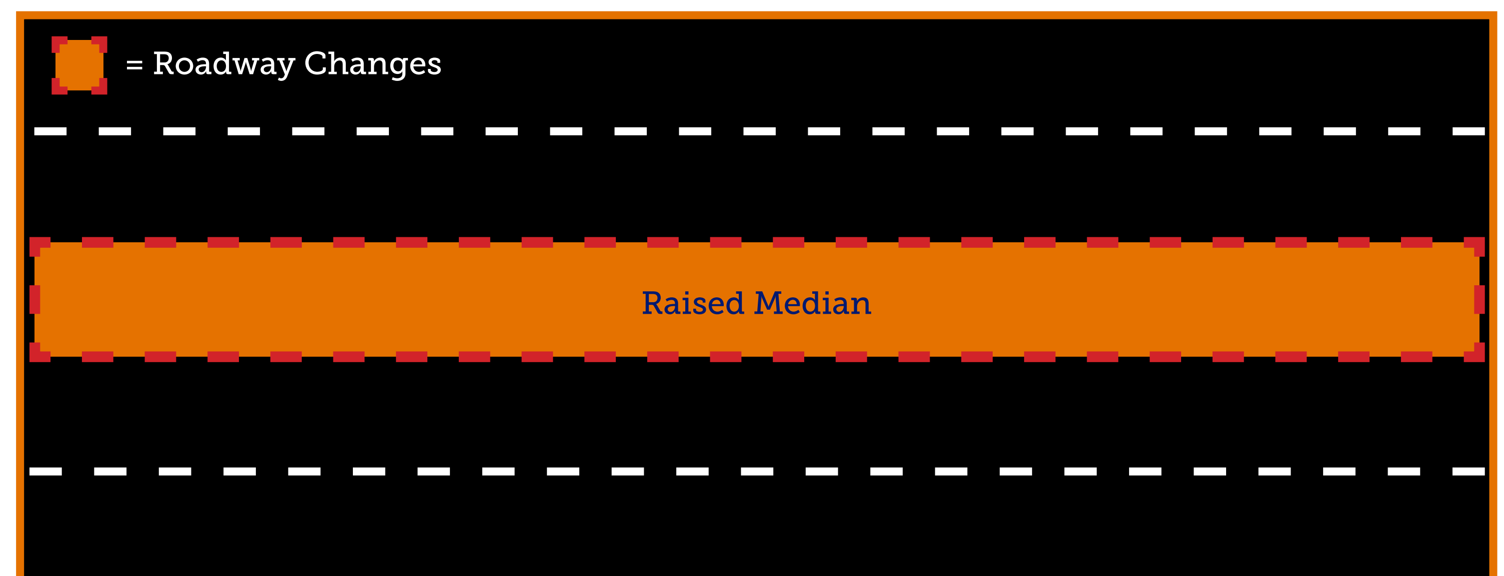
CO-95 previously featured a painted median, providing minimal separation between opposing traffic and allowing unrestricted turning movements. This design offered little physical guidance or protection, contributing to higher operating speeds and multiple conflict points.

After:



The redesign introduced a raised median, created a physical barrier between directions of travel, and restricted left turns to locations with adequate sight distance. This improvement enhances safety by reducing head-on and angle crash risks, provides better access control, and visually narrows the roadway- helping calm traffic and influencing speed limit considerations.

What Changed:

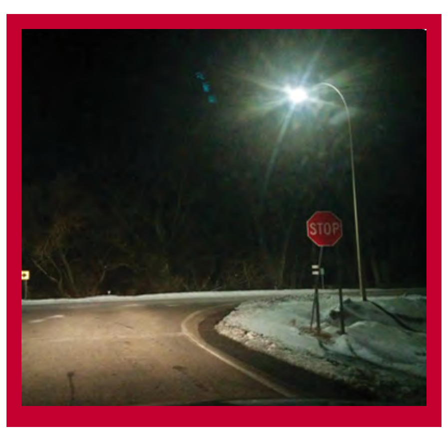


Designing for 50 MPH Travel

Roadway Elements for Consideration on 50 MPH Roadways

To ensure drivers can safely travel at a 50 MPH speed limit, roadway design should create a forgiving, predictable environment through physical and visual features. Not all elements described in this chapter will be appropriate for every 50 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



Lighting

Improves visibility and reaction time, helping drivers detect vehicles, pedestrians, and potential hazards earlier.

Guardrails or Barriers at Fixed Objects

Prevents vehicles from leaving the roadway or striking objects, helping to reduce crash severity.

Median Barriers

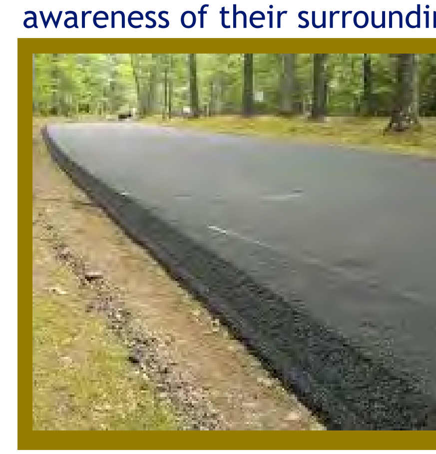
Prevents dangerous head-on collisions between vehicles traveling in opposite directions.

Pedestrian Upgrades at Signalized Intersections

Pedestrian crossings occur at predictable points where drivers already expect to stop, with lighting enhancing visibility.

Intersection Conflict Warning System (ICWS) or Transverse Rumble Strips

Alerts drivers to upcoming intersections and creates awareness of their surroundings.

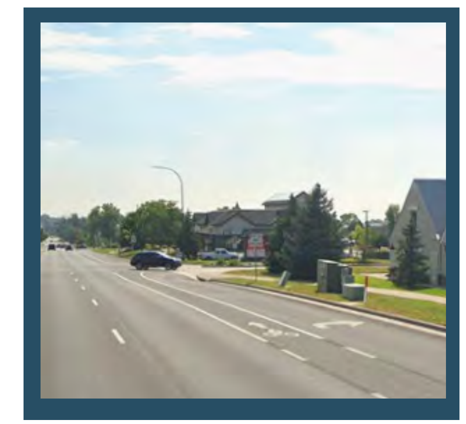


SafetyEdge

Angled pavement edges replace steep drop-offs, making it easier for run off the road vehicles to safely re-enter the roadway.

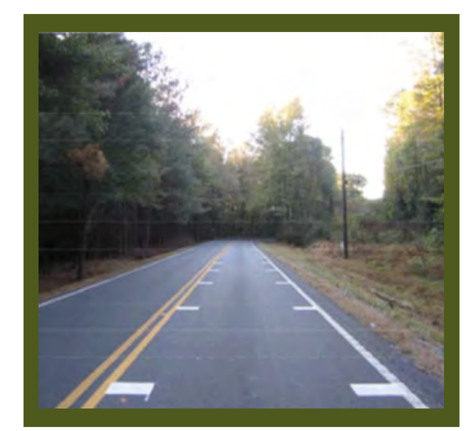
Shoulders

Additional pavement provides recovery space for vehicles, but shoulders wider than 2' can lead to higher operating speeds.



Consolidate Access Points

Reduces conflict areas, simplifies decision-making, and encourages smoother traffic flow.

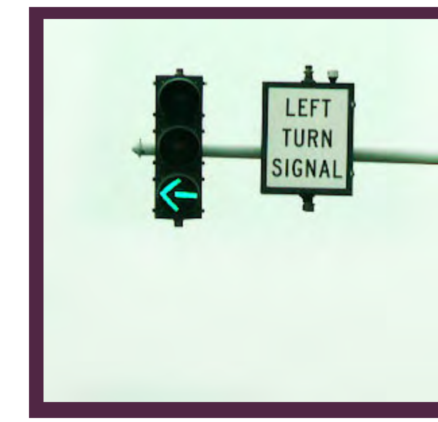


Optical Speed Bars

Repeated pavement markings that create a sense of speeding up, encouraging drivers to slow down. Most effective at specific hazard locations rather than corridor-wide.

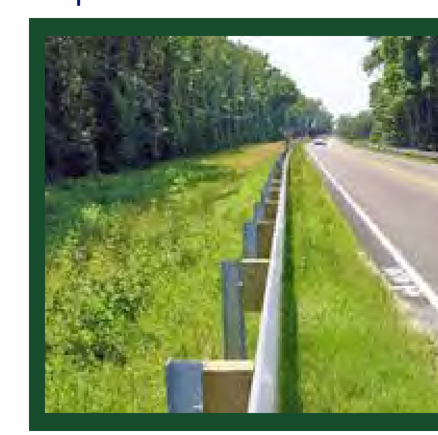
Advanced Warning Signage

Slows drivers by signaling upcoming changes, prompting earlier attention and braking.



Protected Left Turn Movements

As speeds increase, dedicated signal phases for left turns reduce conflicts and improve flow.



Maintain/Enhance Clear Zone

Improves reaction time to oncoming hazards, traffic signs, people or animals entering the roadway.

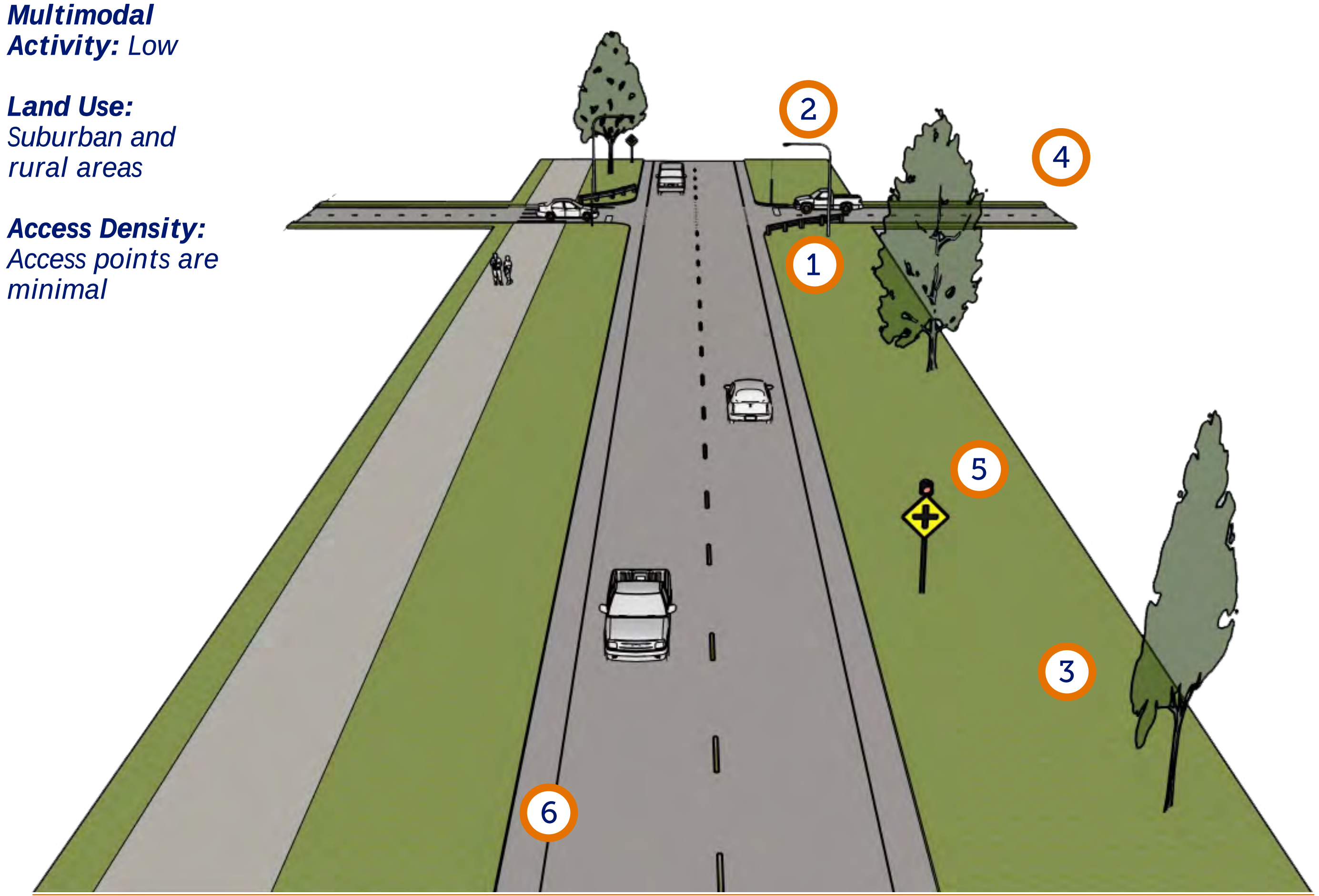
Fifty Mile-Per-Hour Roadway

This diagram illustrates the application of 50 MPH treatments discussed previously.

Multimodal Activity: *Low*

Land Use: *Suburban and rural areas*

Access Density: *Access points are minimal*



1. Guardrails are located to protect fixed objects.
2. Lighting is present near intersections.
3. The clear zone is wide with limited hazards.
4. Access is generally consolidated or provided on the sidestreets.
5. Advanced warning signage informs drivers of an upcoming intersection.
6. 4-foot shoulders line the highway.

Fifty Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 50 MPH based on the characteristics of the roadway.

Case Study: CO-9 in Breckenridge, CO

CO-9 was once a two-lane road plagued with congestion. Recent upgrades added two lanes in each direction and a landscaped median, creating structure and separation that improve traffic flow and make drivers feel more comfortable at the higher 50 MPH speed limit.

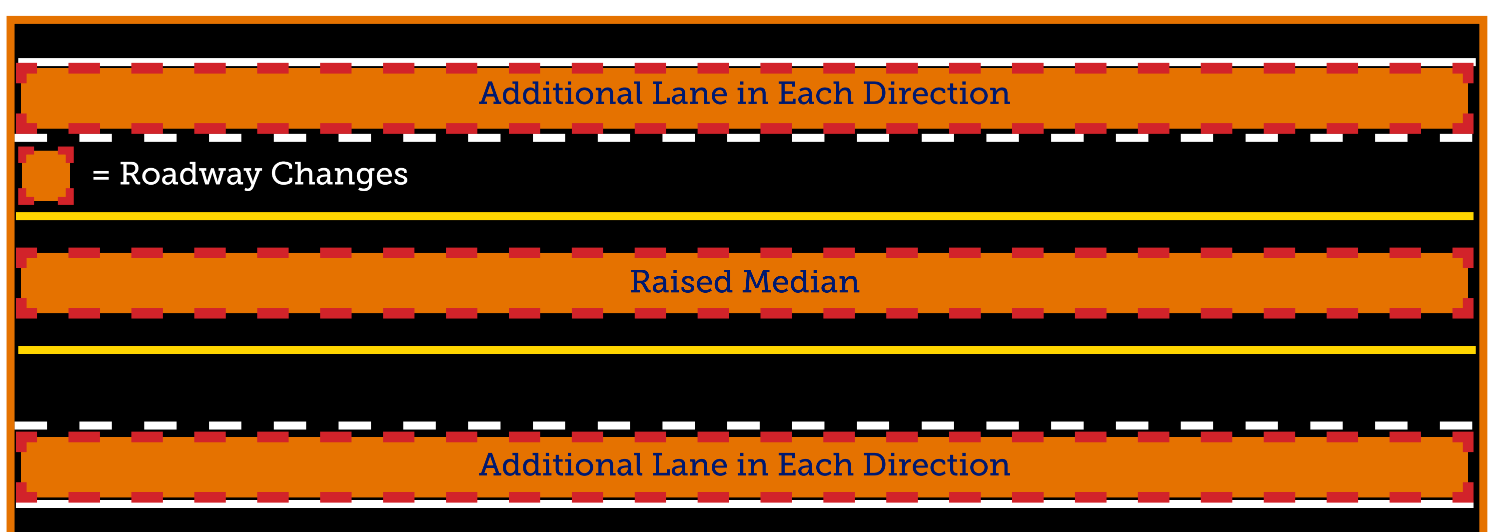
Before:

CO-9 was originally a two-lane rural highway. The roadway had limited capacity and minimal separation between opposing traffic, which could lead to congestion during peak travel times and slowed traffic below the 50 MPH speed limit.

After:

The corridor has been reconstructed into a four-lane divided highway separated by a raised median. This improvement significantly enhances traffic flow and reduces conflict points between opposing directions of travel. The added lanes provide greater capacity for vehicles and allow traffic to travel at 50 MPH. On multi-lane corridors like this one, a median primarily manages access, separates opposing traffic, and improves operational efficiency without narrowing travel lanes.

What Changed:



Case Study: US-285 in Bailey, CO

US-285 shifted from raised medians to concrete median barriers, adding lane guidance, guardrails at fixed objects, and consolidated access. Acceleration and deceleration lanes were introduced at intersections, creating smoother transitions and a safer, more controlled roadway.

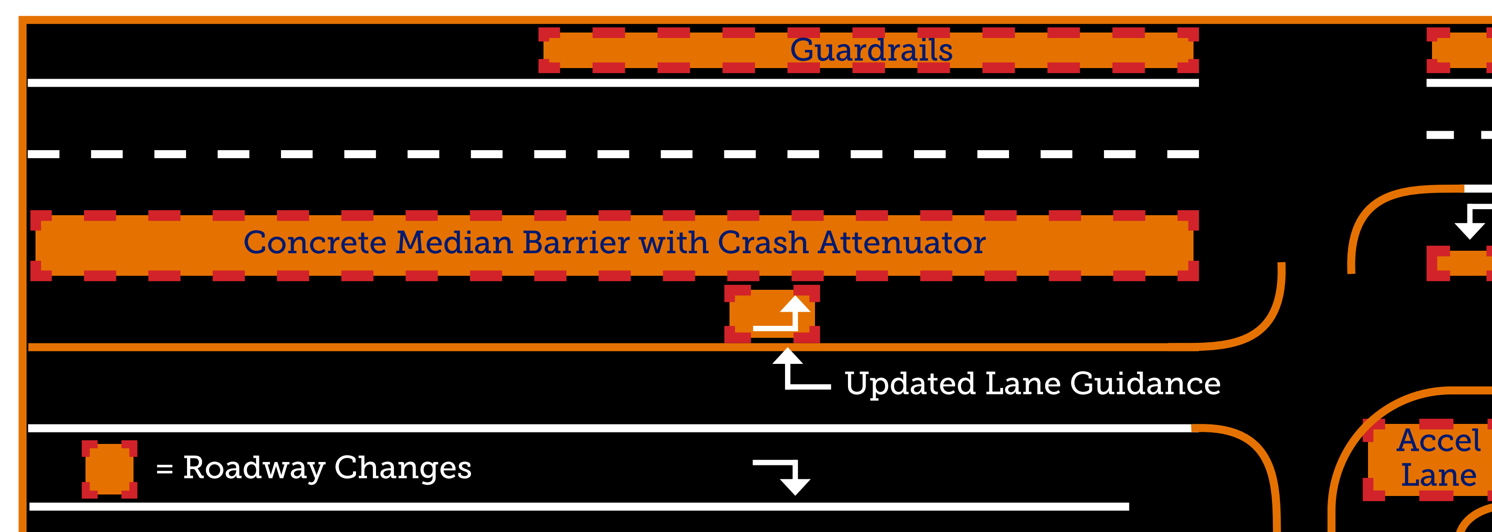
Before:

The US-285 corridor featured raised medians with limited physical protection and less constrained access points. Fixed objects lacked guardrail protection, and intersections did not include acceleration or deceleration lanes, resulting in abrupt merging and turning movements.

After:

The redesign installed a concrete median barrier for stronger lane separation. Lane guidance was enhanced, guardrails were added at fixed objects, and access points were consolidated to reduce conflict areas. Intersections now include acceleration and deceleration lanes, providing smoother transitions for entering and exiting traffic.

What Changed:

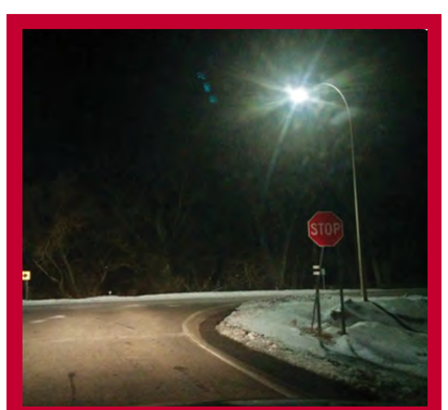


Designing for 55 MPH Travel

Roadway Elements for Consideration on 55 MPH Roadways

To ensure drivers can safely travel at a 55 MPH speed limit, roadway design should create a forgiving, predictable environment through physical and visual features. Not all elements described in this chapter will be appropriate for every 55 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



Lighting
Improves visibility and reaction time, helping drivers detect vehicles, pedestrians, and potential hazards earlier.

Guardrails or Barriers at Fixed Objects
Prevents vehicles from leaving the roadway or striking objects, helping to reduce crash severity.

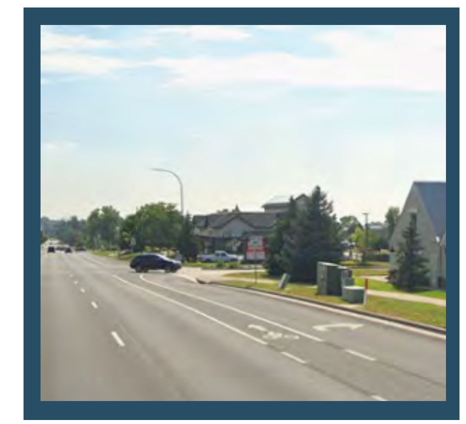
Median Barriers
Prevents dangerous head-on collisions between vehicles traveling in opposite directions.

Pedestrian Upgrades at Signalized Intersections
Pedestrian crossings occur at predictable points where drivers already expect to stop, with lighting enhancing visibility.

Shoulders with Rumble Strips
Alerts drivers as they drift out of their lane and gives them more time to recover before encountering hazards.

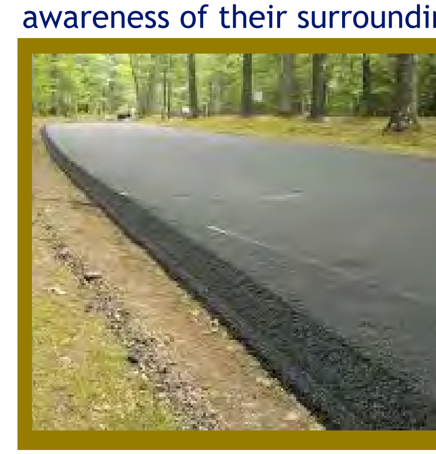
Advanced Warning Signage
Slows drivers by signaling upcoming changes, prompting earlier attention and braking.

Intersection Conflict Warning System (ICWS) or Transverse Rumble Strips
Alerts drivers to upcoming intersections and creates awareness of their surroundings.

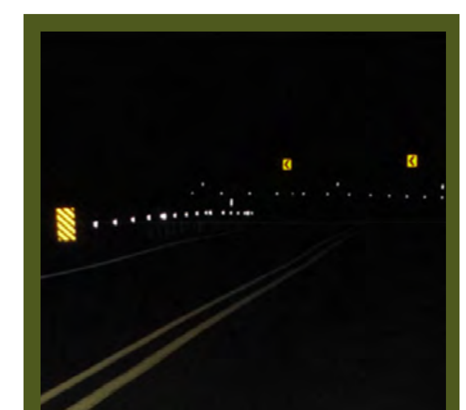


Consolidate Access Points
Reduces conflict areas, simplifies decision-making, and encourages smoother traffic flow.

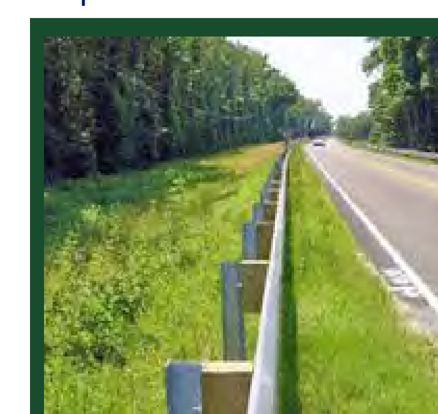
Protected Left Turn Movements
As speeds increase, dedicated signal phases for left turns reduce conflicts and improve flow.



SafetyEdge
Angled pavement edges replace steep drop-offs, making it easier for run off the road vehicles to safely re-enter the roadway.



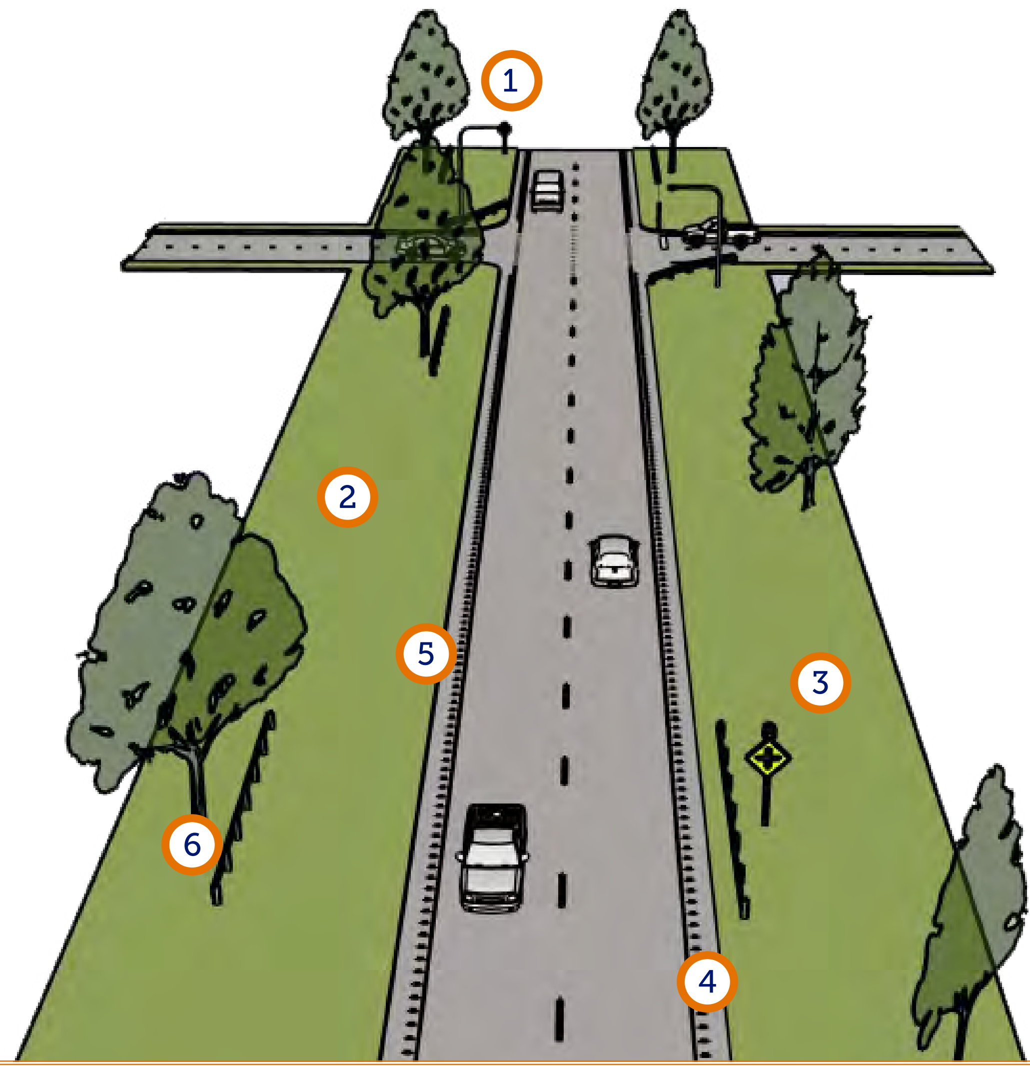
Roadside Delineation
Improves safety by outlining the roadway path and guiding drivers, especially at night or in poor weather.



Maintain/Enhance Clear Zone
Improves reaction time to oncoming hazards, traffic signs, people or animals entering the roadway.

Fifty-Five Mile-Per-Hour Roadway

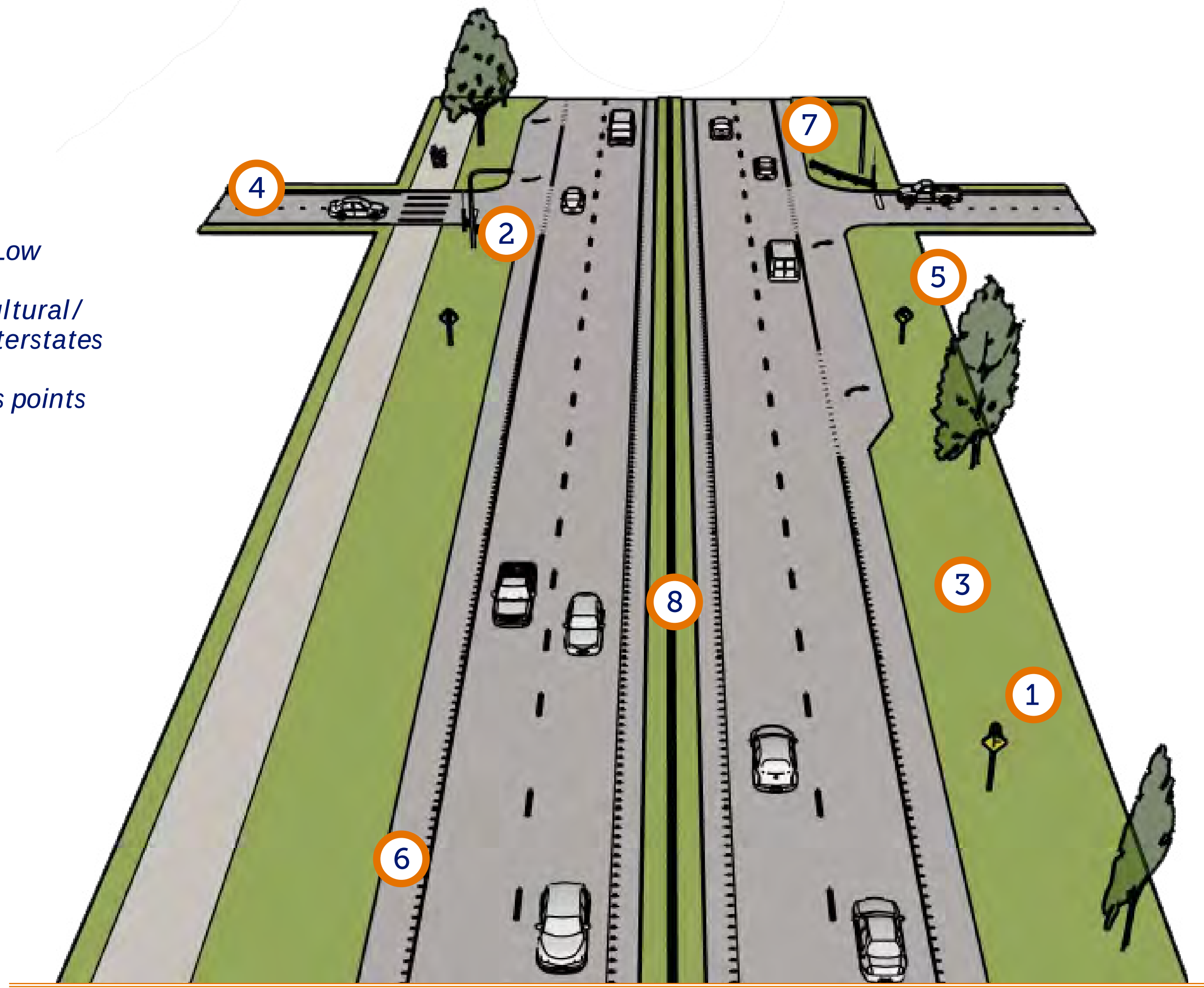
These diagrams illustrate the application of 55 MPH treatments discussed previously.



Multimodal Activity: *Low*

Land Use: *Rural agricultural/ open space areas or interstates*

Access Density: *Access points are minimal*



1. Lighting is present near intersections.
2. Clear zones have been maintained.
3. Advanced warning signage informs drivers of an upcoming intersection.
4. Narrow shoulders are lined with rumble strips.
5. SafetyEdge uses a sloped pavement edge to help drivers safely recover after leaving the travel lane.
6. Guardrails are placed at fixed objects.

1. Intersection conflict warning systems exist to help drivers anticipate turning movements.
2. Lighting is present near intersections.
3. The clear zone is maintained with limited hazards.
4. Access is provided on sidestreets where possible.
5. Advanced warning signage informs drivers of possible animal crossings.
6. 6-foot shoulders with rumble strips line the highway.
7. Guardrails are located to protect fixed objects.
8. An 8-foot median with a barrier exists.

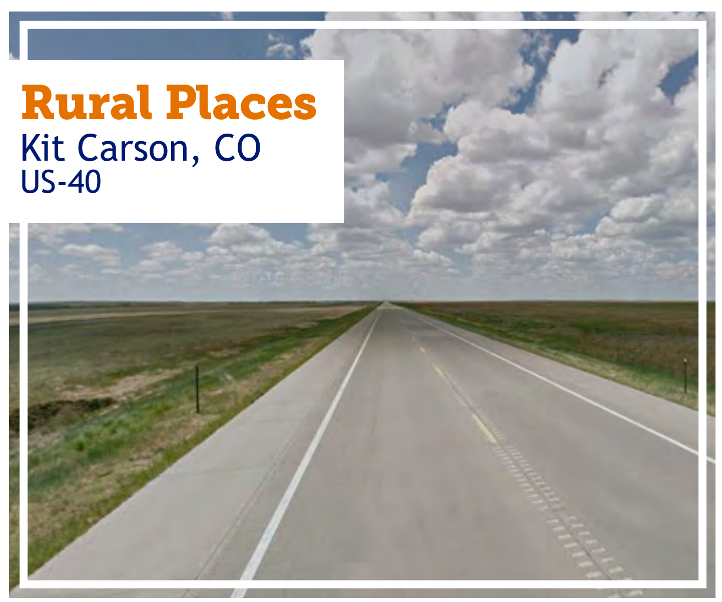
Fifty-Five Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 55 MPH based on the characteristics of the roadway.

Rural Mountain
Lyons, CO
CO-7

Suburban Places
Denver, CO
US-87

Rural Places
Pueblo, CO
CO-45



Rural Places
Kit Carson, CO
US-40

Case Study: CO-9 in Heeney, CO

CO-9 was widened to include extended shoulders with rumble strips and guardrails at fixed objects, creating a safer, more forgiving roadway for higher speed travel. These improvements reduce run-off-road crash risk, enhance driver awareness, and provide better protection from roadside hazards.

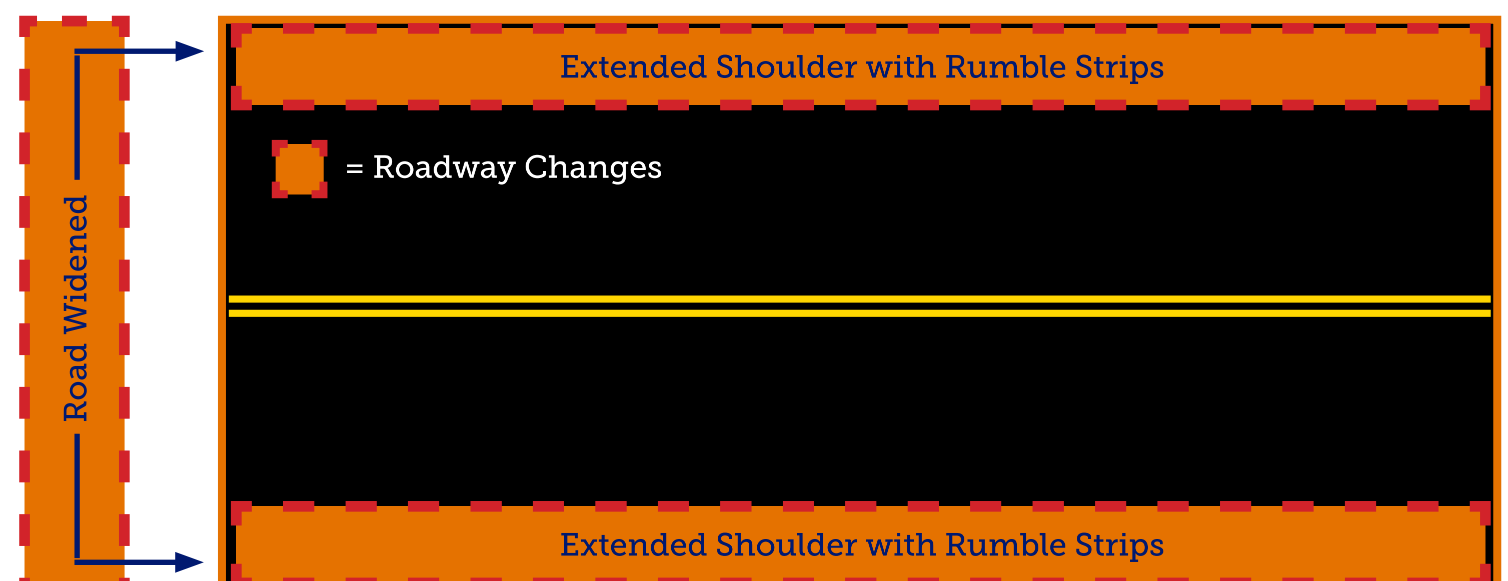
Before:

The corridor had narrow shoulders with no rumble strips and limited recovery space for drivers. Guardrails were absent at fixed objects, leaving roadside hazards exposed. These conditions increased the risk of run-off-road crashes and provided little margin for error.

After:

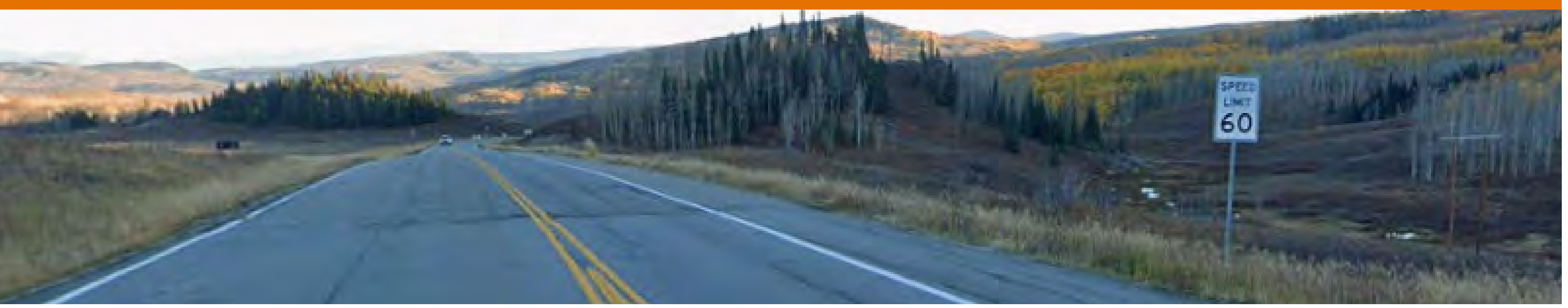
The roadway was widened to include extended shoulders with rumble strips, improving driver awareness and reducing lane departure crashes. Guardrails were installed at fixed objects to protect against severe collisions, creating a safer and more forgiving roadside environment that supports higher speeds.

What Changed:



Back to Speed TOC

Designing for 60 MPH Travel



Roadway Elements for Consideration on 60 MPH Roadways

To ensure drivers can safely travel at a 60 MPH speed limit, roadway design should create a forgiving, predictable environment through physical and visual features. Not all elements described in this chapter will be appropriate for every 60 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

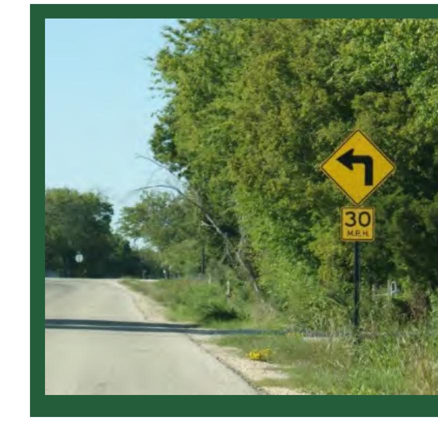
All elements are discussed in further detail in Appendix A.

Grade-Separated Crossings for Bicycles/Peds

Bridges or tunnels at key locations that allow pedestrians and cyclists to cross roads without interacting with vehicle traffic.

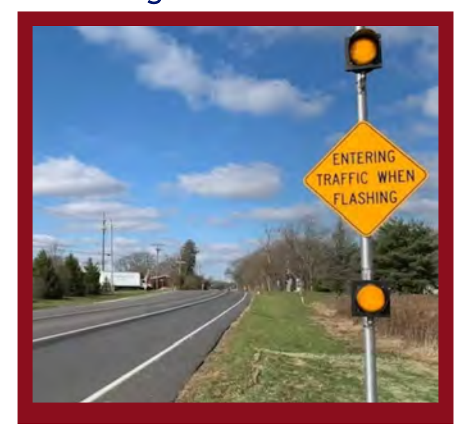
Shoulders with Rumble Strips

Alerts drivers as they drift out of their lane and gives them more time to recover before encountering hazards.



Advanced Warning Signage

Slows drivers by signaling upcoming changes, prompting earlier attention and braking.

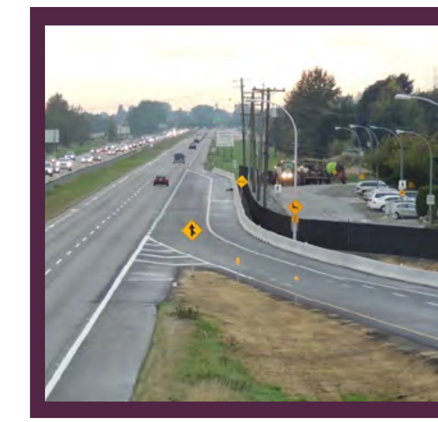


Intersection Conflict Warning System (ICWS) or Transverse Rumble Strips

Alerts drivers to upcoming intersections and creates awareness of their surroundings.

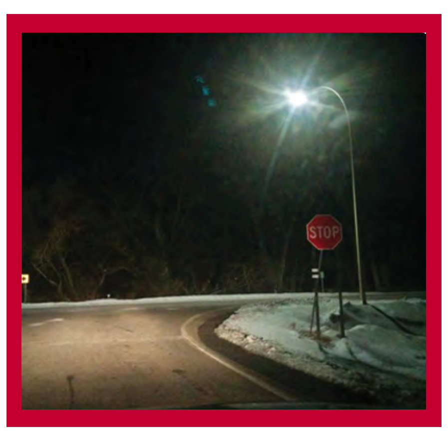
Variable Speed Limit Signs

Smooths traffic flow by adjusting posted speeds to match real-time traffic, weather, and road conditions.



Ramp Accel or Decel Lanes

Improves safety by giving drivers extra space to adjust speed when entering or exiting the roadway.

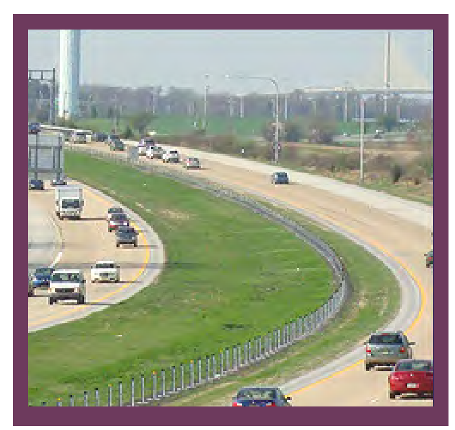


Lighting

Improves visibility and reaction time, helping drivers detect vehicles and potential hazards earlier.

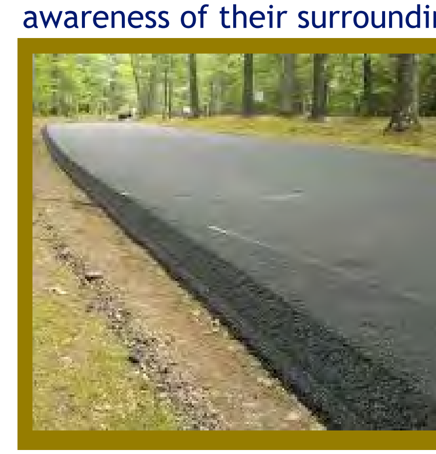
Guardrails or Barriers at Fixed Objects

Prevents vehicles from leaving the roadway or striking objects, helping to reduce crash severity.



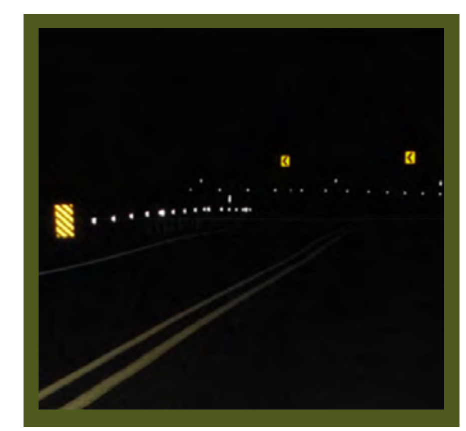
Wide Medians with Barriers

Prevents dangerous head-on collisions between opposing traffic lanes. Provides extra space to recover or stop.



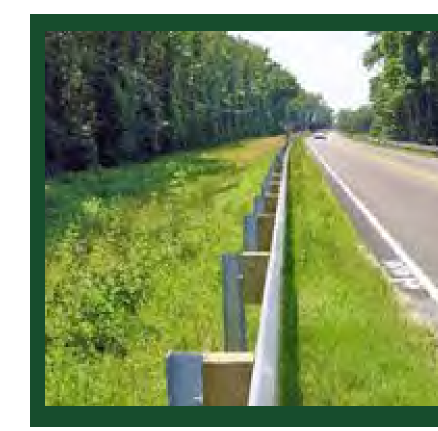
SafetyEdge

Angled pavement edges replace steep drop-offs, making it easier for run off the road vehicles to safely re-enter the roadway.



Roadside Delineation

Improves safety by outlining the roadway path and guiding drivers, especially at night or in poor weather.



Maintain/Enhance Clear Zone

Improves reaction time to oncoming hazards, traffic signs, and animals entering the roadway.

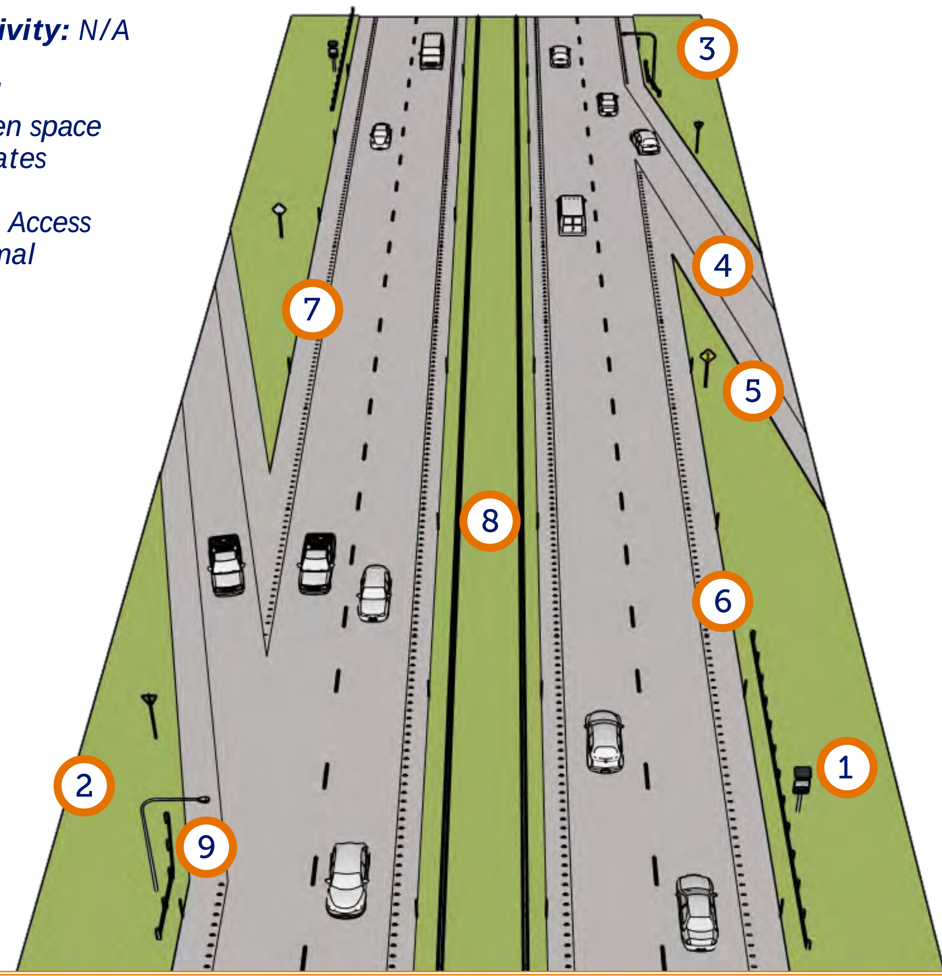
Sixty Mile-Per-Hour Roadway

This diagram illustrates the application of 60 MPH treatments discussed previously.

Multimodal Activity: *N/A*

Land Use: *Rural agricultural/open space areas or interstates*

Access Density: *Access points are minimal*



1. Variable speed limits allow this highway to respond to traffic conditions.
2. Lighting is present near intersections or interchanges.
3. The clear zone is wide with limited hazards.
4. Acceleration and deceleration lanes provide safe ways for slow traffic to enter the roadway.
5. Advanced warning signage informs drivers of upcoming merging traffic.
6. 6-foot shoulders with rumble strips line the highway.
7. Reflective roadside delineators line the pavement.
8. A 20-foot median with barriers exists.
9. Guardrails are located to protect fixed objects.

Sixty Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 60 MPH based on the characteristics of the roadway.

Rural Places
Kremmling, CO
US-40

Rural Places
Granby, CO
US-34

Rural Places
Penrose, CO
CO-115

Rural Mountain
Vail, CO
Interstate 70

Case Study: I-70 in Vail, CO

I-70 near Vail faces rapidly changing weather and traffic conditions. Fixed speed limits often created unsafe situations, so variable speed limit signs were installed to adjust speeds in real time - improving safety and traffic flow along this busy mountain corridor.

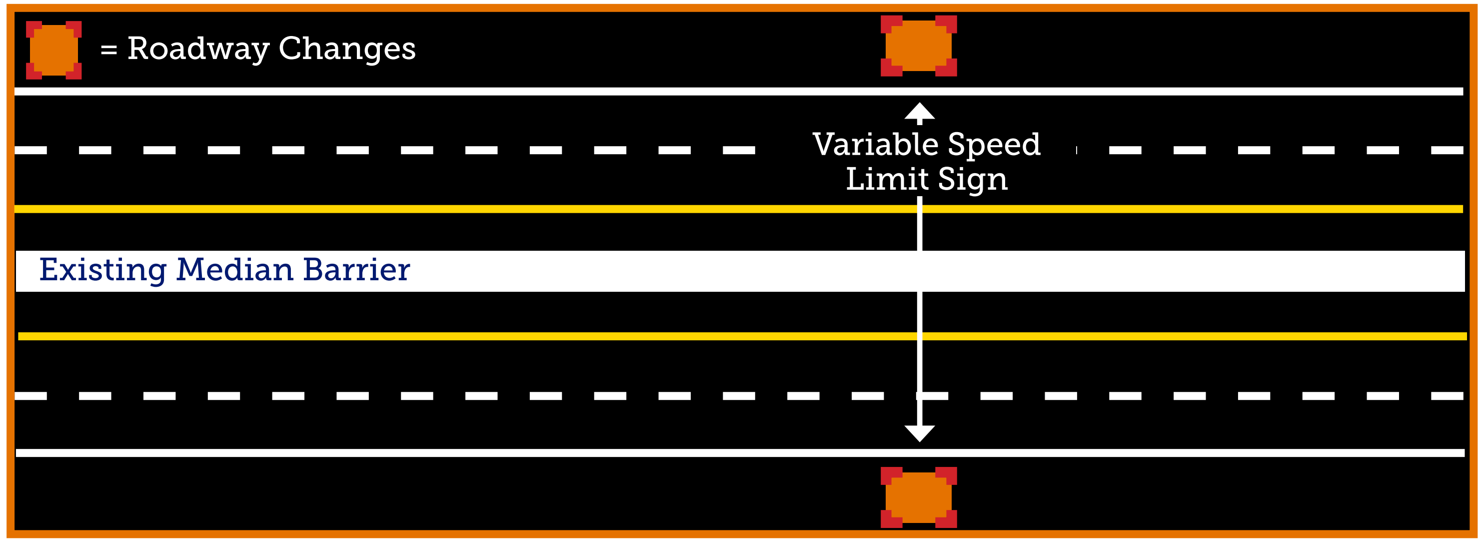
Before:

I-70 through Vail operated with a fixed speed limit, even during heavy snow, congestion, or crashes. This lack of flexibility often led to unsafe conditions, as drivers encountered sudden changes in traffic flow without advance warning.

After:

Variable speed limit signs now adjust speeds in real time based on weather, traffic, and incidents. These dynamic limits help smooth traffic flow, reduce crash risk, and improve safety for all users along this high-altitude corridor.

What Changed:



Case Study: US-34 in Granby, CO

US-34 is a long, uninterrupted, rural corridor with wide open sight-lines. As a simple, cost-effective safety enhancement, rumble strips were added to the shoulders to reduce roadway departure crashes and encourage operating speeds to align more closely with the posted speed limit.

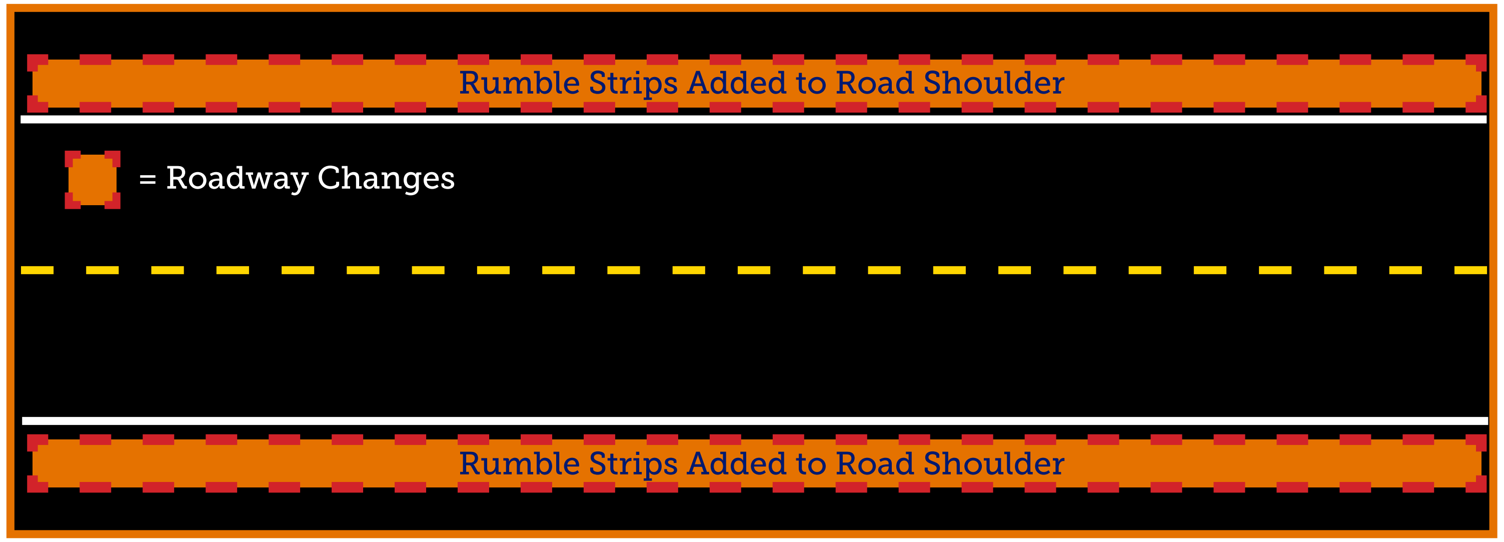
Before:

The roadway had paved shoulders but lacked rumble strips, offering no tactile or audible warning for drivers drifting out of their lane. This increased the risk of run-off-road crashes, especially in rural areas with long, uninterrupted segments.

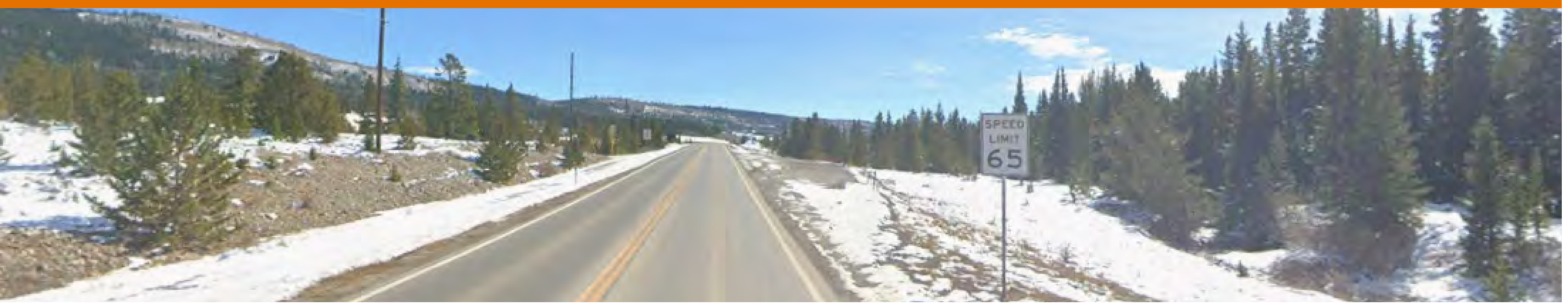
After:

Rumble strips were added to the existing shoulders, providing an effective alert system for lane departures and improving safety without changing the width of the road.

What Changed:



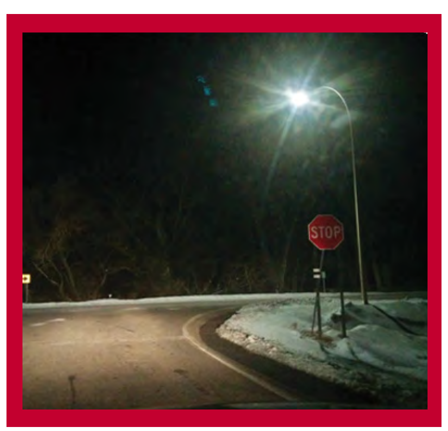
Designing for 65 MPH Travel



Roadway Elements for Consideration on 65 MPH Roadways

To ensure drivers can safely travel at a 65 MPH speed limit, roadway design should create a forgiving, predictable environment through physical and visual features. Not all elements described in this chapter will be appropriate for every 65 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



Lighting
Improves visibility and reaction time, helping drivers detect vehicles and potential hazards earlier.

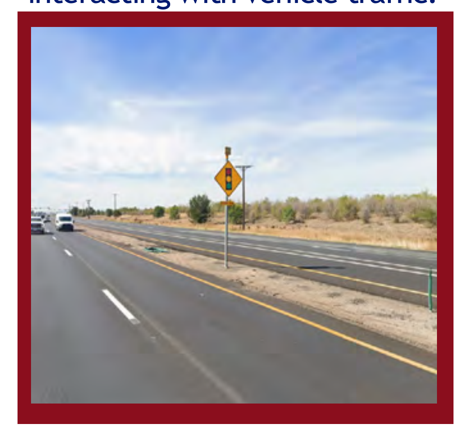
Guardrails or Barriers at Fixed Objects
Prevents vehicles from leaving the roadway or striking objects, helping to reduce crash severity.

Wide Medians with Barriers
Prevents dangerous head-on collisions between opposing traffic lanes. Provides extra space to recover or stop.

Grade-Separated Crossings for Bicycles/Peds
Bridges or tunnels at key locations that allow pedestrians and cyclists to cross roads without interacting with vehicle traffic.

Wide Shoulders with Rumble Strips
Alerts drivers as they drift out of their lane and gives them more space to recover before encountering hazards.

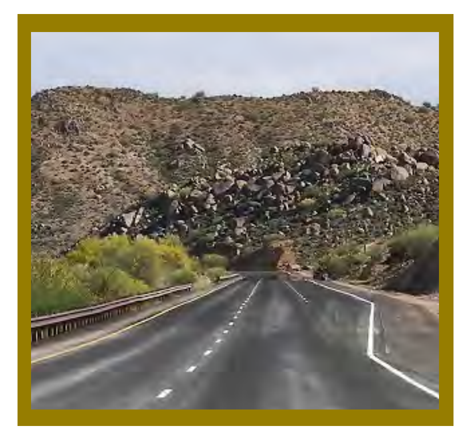
Advanced Warning Signage
Slows drivers by signaling upcoming changes, prompting earlier attention and braking.



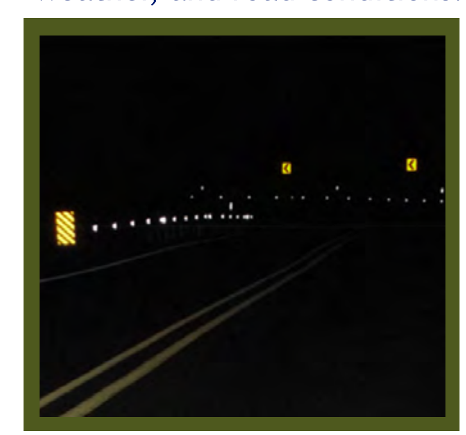
Limited Access
Manages conflict points with controlled ramps and signal-controlled intersections to reduce crash risks from turning and cross traffic.

Variable Speed Limit Signs
Smooths traffic flow by adjusting posted speeds to match real-time traffic, weather, and road conditions.

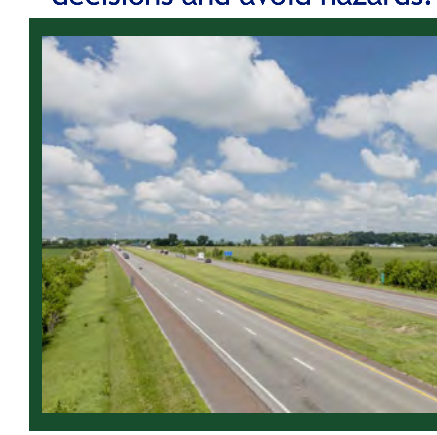
Dynamic Message Signs
Provides drivers with real-time alerts and guidance, helping them make informed decisions and avoid hazards.



Heavy Vehicle Climbing Lane
Added uphill lanes give slower, heavy vehicles space to climb without impeding traffic. This reduces abrupt speed changes.



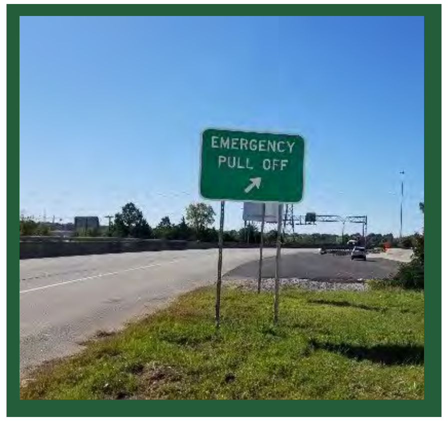
Roadside Delineation
Improves safety by outlining the roadway path and guiding drivers, especially at night or in poor weather.



Maintain/Enhance Clear Zone
Improves reaction time to oncoming hazards, traffic signs, and animals entering the roadway.

Continued Roadway Elements

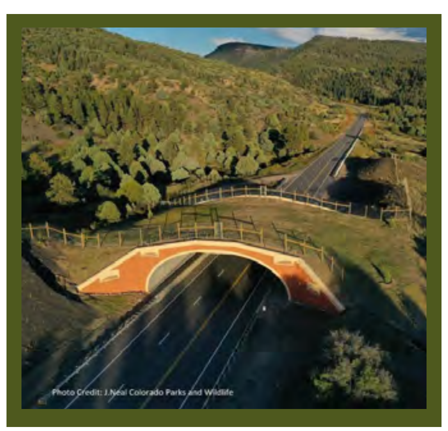
Lane Guidance Signage
Clearly directs drivers into the correct lanes for exits, turns or destinations, helping drivers choose the correct lane early and reducing sudden lane changes.



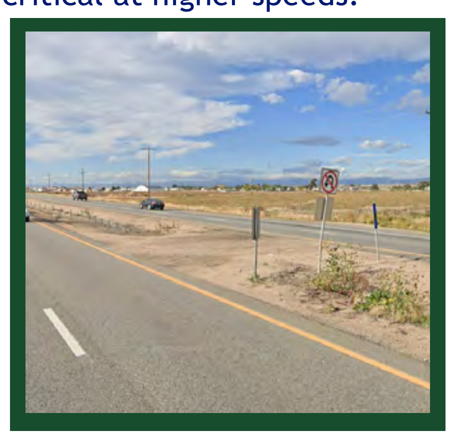
Emergency Pull-Off Areas
Gives drivers a designated space to stop during breakdowns or emergencies, reducing risk of collisions.

Crash Attenuators at Gore Points
Absorbs impact and reduces the severity of crashes when vehicles stray from travel lanes into hazardous areas.

Increased Stopping Sight Distance
Gives drivers more time to detect hazards and make decisions, which is especially critical at higher speeds.



Wildlife Crossing Infrastructure
Reduces animal-vehicle collisions through designated over or under passes and fencing that guide wildlife away from traffic.



Emergency Vehicle Turnaround
Provides designated openings on divided highways for quick response, reducing delays during incidents and minimizing secondary crash risks.

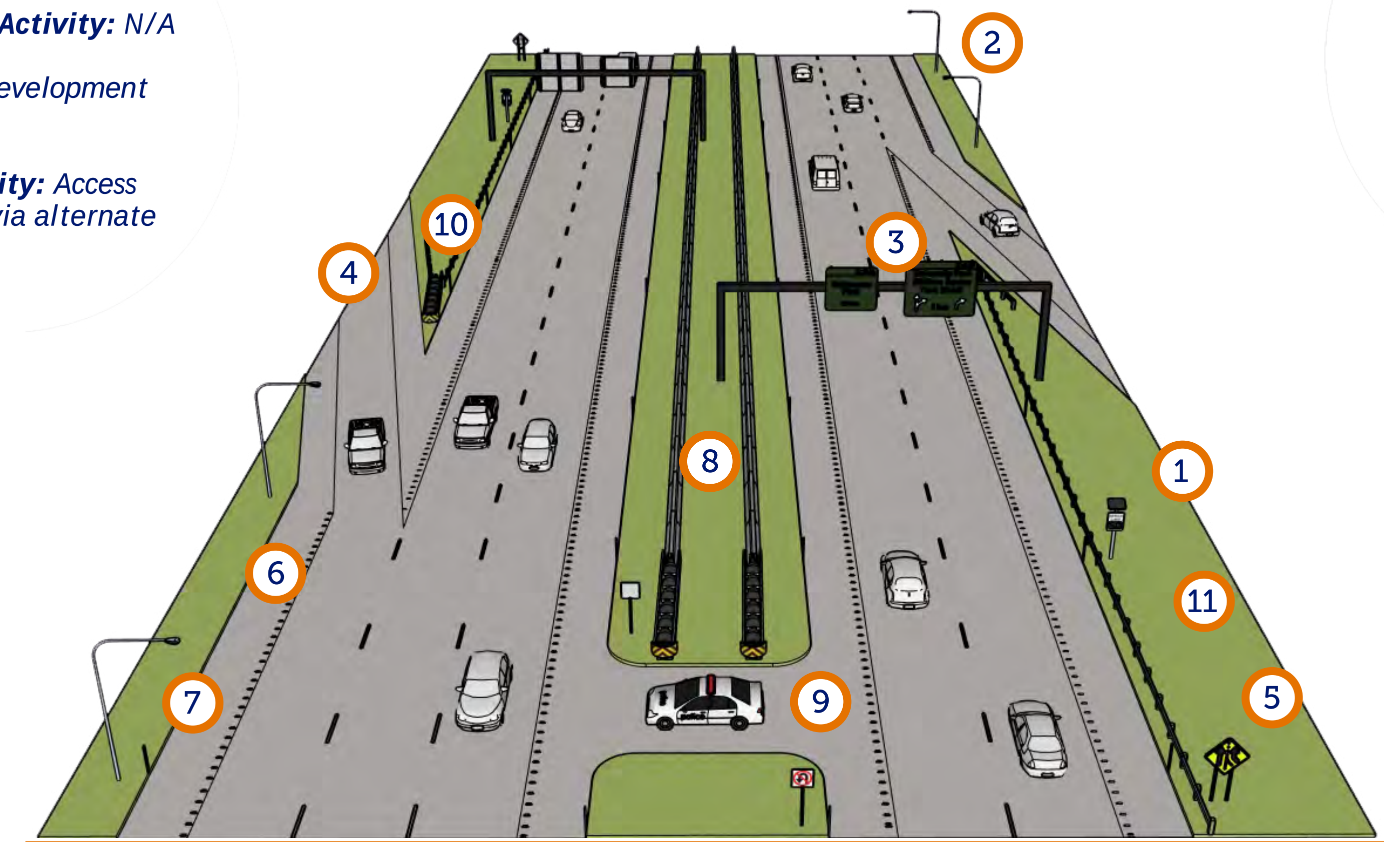
Sixty-Five Mile-Per-Hour Roadway

This diagram illustrates the application of 65 MPH treatments discussed previously.

Multimodal Activity: *N/A*

Land Use: *Development type varies*

Access Density: *Access is provided via alternate roadways*

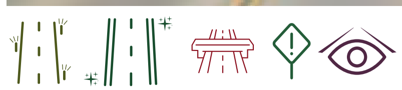


1. Variable speed limits allow this highway to respond to traffic conditions.
2. Lighting is present near interchanges.
3. Lane guidance hangs above the lanes.
4. There are no at-grade intersections.
5. Advanced warning signage informs drivers of upcoming merging.
6. 8-foot shoulders with rumble strips line the highway.
7. Reflective roadside delineators line the pavement.
8. A 28-foot median with concrete barriers exists.
9. An emergency vehicle access point provides access along this divided highway.
10. Crash attenuators are present at gore points.
11. Clear zones are enhanced for safety.

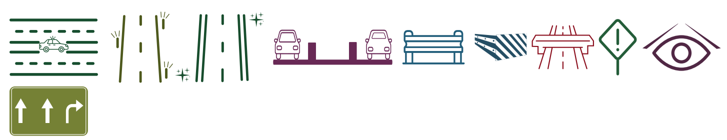
Sixty-Five Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 65 MPH based on the characteristics of the roadway.

Rural Mountain
Fairplay, CO
CO-9



Suburban Places
Denver, CO
Interstate 76



Rural Places
Walden, CO
CO-14

Rural Places
Morrison, CO
CO-470

Case Study: I-70 in Golden, CO

The high-speed corridor of I-70 through Golden had wide, open medians with no physical separation. Median barriers and advanced warning signs were installed to create a safer, more controlled environment for high-speed travel and improve compliance with posted speed limits.

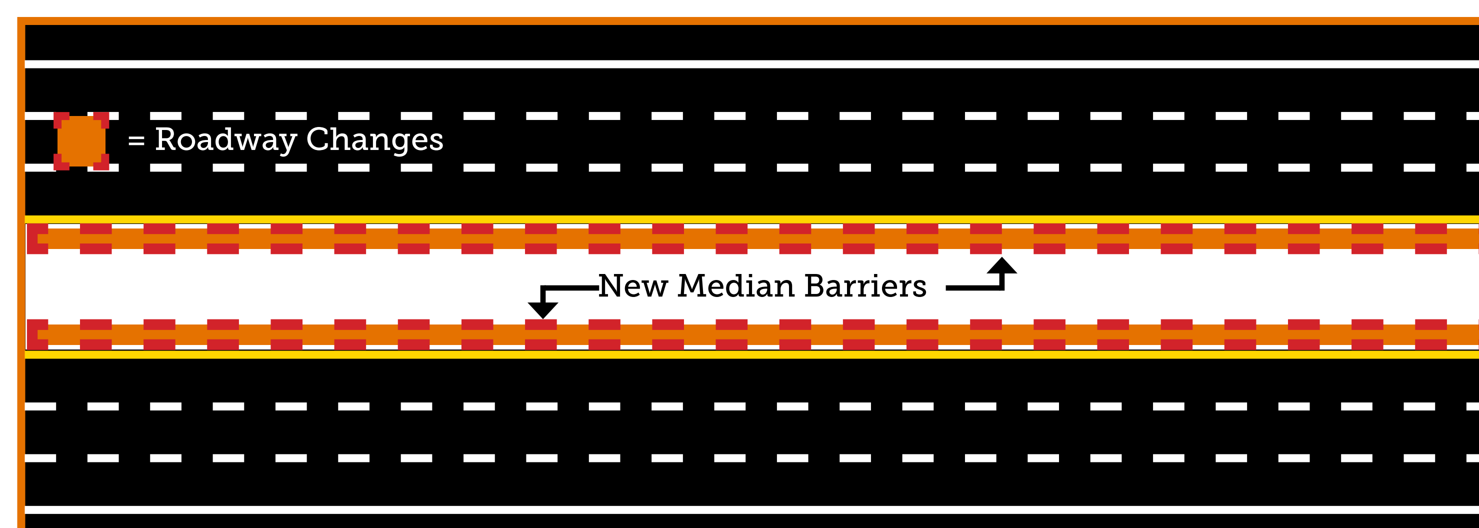
Before:

I-70 had a wide, open median with no physical barrier, increasing the risk of high-speed cross-median crashes. Several key advanced warning signs were also missing, reducing driver awareness of upcoming changes in the roadway.

After:

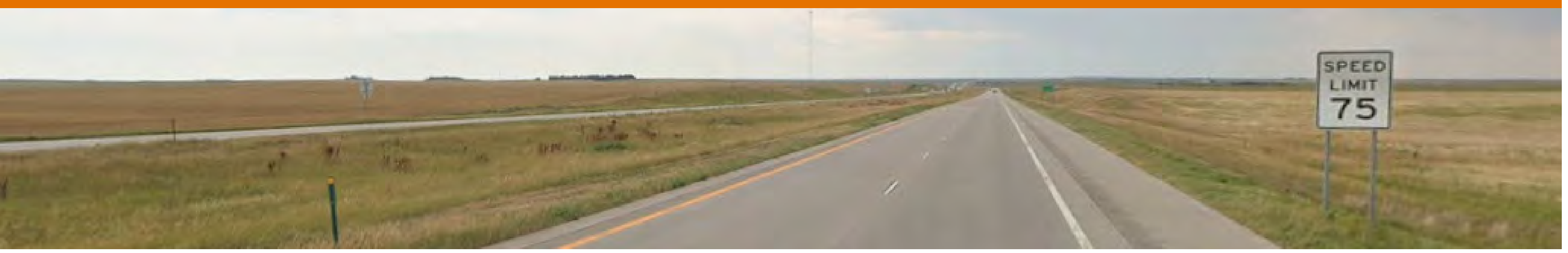
Median barriers and advanced warning signs were installed to better align the posted speed limit with the roadway's design. These improvements create a more controlled environment and reduce the likelihood of severe crashes by preventing cross-over incidents and improving driver awareness.

What Changed:



Back to Speed TOC

Designing for 70/75 MPH Travel

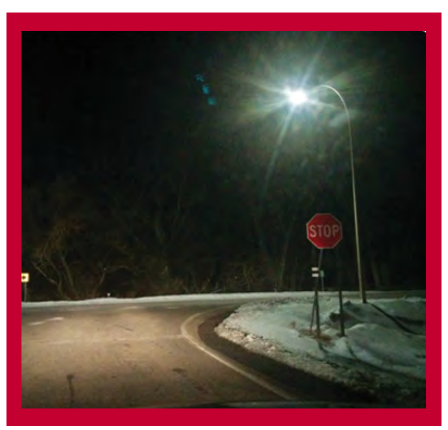


Roadway Elements for Consideration on 70/75 MPH Roadways

A 70 MPH road and a 75 MPH road look almost identical, but small design changes make the higher speed safe and comfortable. At 75 MPH, shoulders are slightly wider, curves are longer and gentler, and sight distances are extended for better reaction time.

To ensure drivers can safely travel at a 70/75 MPH speed limit, roadway design should create a forgiving, predictable environment through physical and visual features. Not all elements described in this chapter will be appropriate for every 70/75 MPH roadway. The following pages outline common approaches that can be applied selectively based on local conditions.

All elements are discussed in further detail in Appendix A.



Lighting
Improves visibility and reaction time, helping drivers detect vehicles and potential hazards earlier.

Guardrails or Barriers at Fixed Objects
Prevents vehicles from leaving the roadway or striking objects, helping to reduce crash severity.

Wide Medians with Barriers
Prevents dangerous head-on collisions between opposing traffic lanes. Provides extra space to recover or stop.

Grade-Separated Crossings for Bicycles/Peds
Bridges or tunnels at key locations that allow pedestrians and cyclists to cross roads without interacting with vehicle traffic.

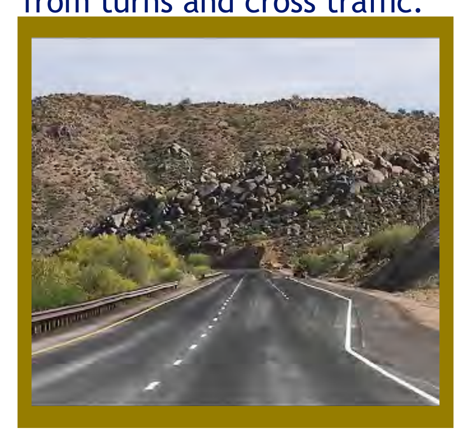
Wide Shoulders with Rumble Strips
Alerts drivers as they drift out of their lane and gives them more space to recover before encountering hazards.

Advanced Warning Signage
Slows drivers by signaling upcoming changes, prompting earlier attention and braking.

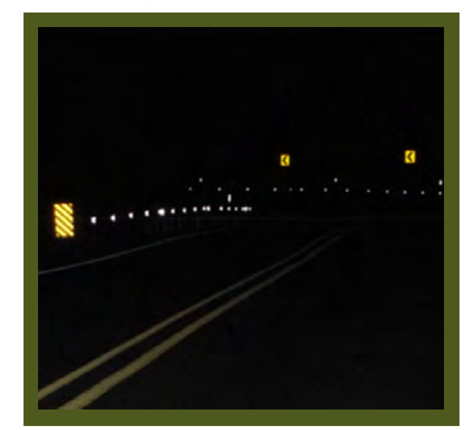
Controlled Access
Reduces conflict points with controlled ramps and consistent, higher travel speeds, lowering crash risks from turns and cross traffic.

Variable Speed Limit Signs
Smooths traffic flow by adjusting posted speeds to match real-time traffic, weather, and road conditions.

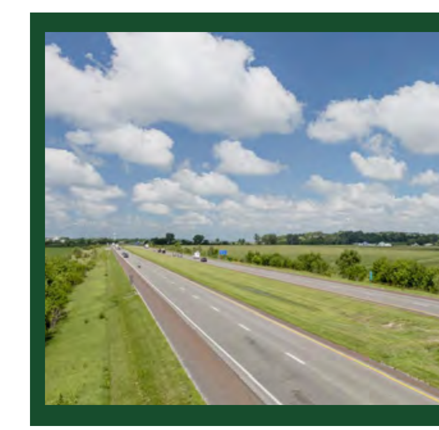
Dynamic Message Signs
Provides drivers with real-time alerts and guidance, helping them make informed decisions and avoid hazards.



Heavy Vehicle Climbing Lane
Added uphill lanes give slower, heavy vehicles space to climb without impeding traffic. This reduces abrupt speed changes.



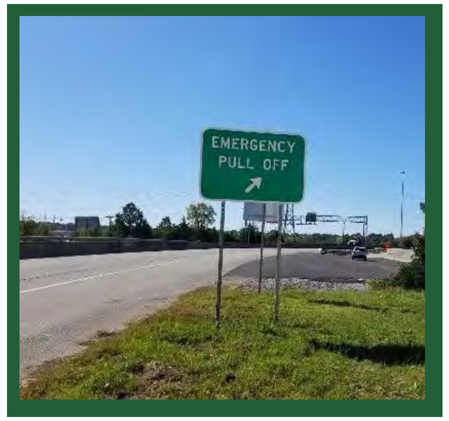
Roadside Delineation
Improves safety by outlining the roadway path and guiding drivers, especially at night or in poor weather.



Maintain/Enhance Clear Zone
Improves reaction time to oncoming hazards, traffic signs, and animals entering the roadway.

Continued Roadway Elements

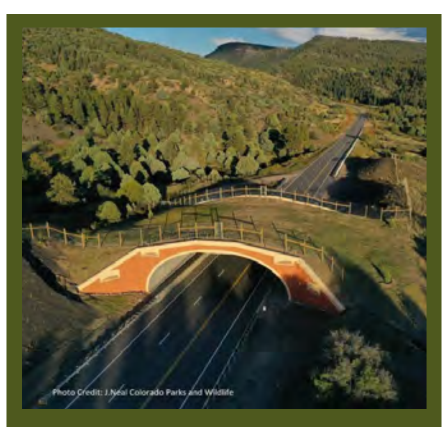
Lane Guidance Signage
Clearly directs drivers into the correct lanes for exits, turns or destinations, helping drivers choose the correct lane early and reducing sudden lane changes.



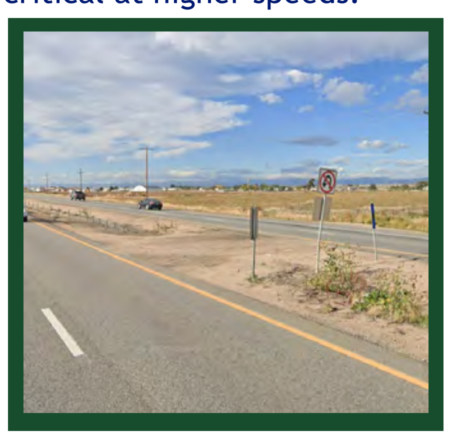
Emergency Pull-Off Areas
Gives drivers a designated space to stop during breakdowns or emergencies, reducing risk of collisions.

Crash Attenuators at Gore Points
Absorbs impact and reduces the severity of crashes when vehicles stray from travel lanes into hazardous areas.

Increased Stopping Sight Distance
Gives drivers more time to detect hazards and make decisions, which is especially critical at higher speeds.



Wildlife Crossing Infrastructure
Reduces animal-vehicle collisions through designated over or under passes and fencing that guide wildlife away from traffic.



Emergency Vehicle Turnaround
Provides designated openings on divided highways for quick response, reducing delays during incidents and minimizing secondary crash risks.

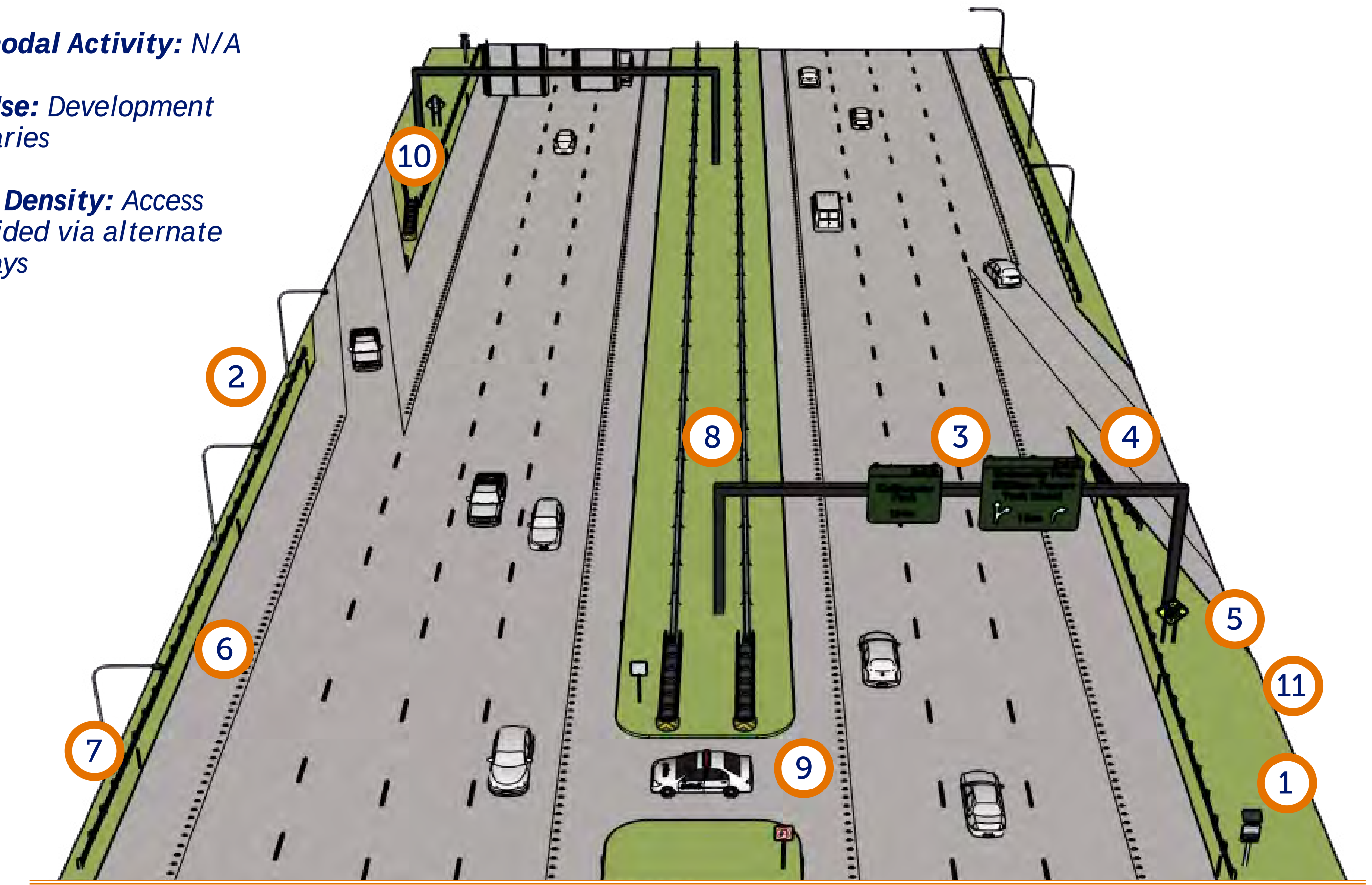
Seventy/Seventy-Five Mile-Per-Hour Roadway

This diagram illustrates the application of 70/75 MPH treatments discussed previously.

Multimodal Activity: *N/A*

Land Use: *Development type varies*

Access Density: *Access is provided via alternate roadways*

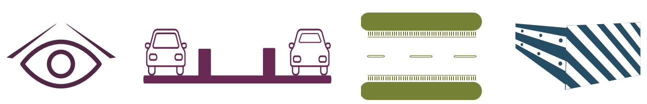


1. Variable speed limits allow this highway to respond to traffic conditions.
2. Lighting is present near interchanges.
3. Lane guidance hangs above the lanes.
4. There are no at-grade intersections.
5. Advanced warning signage informs drivers of upcoming merging.
6. 11-foot shoulders with rumble strips line the highway.
7. Reflective roadside delineators line the pavement.
8. A 28-foot median with concrete barriers exists.
9. An emergency vehicle access point provides access along this divided highway.
10. Crash attenuators are present at gore points.
11. Clear zones are enhanced for safety.

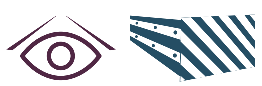
Seventy/Seventy-Five Mile-Per-Hour Road Types in Colorado

Below are examples of different types of roads throughout Colorado that can be set to 70/75 MPH based on the characteristics of the roadway.

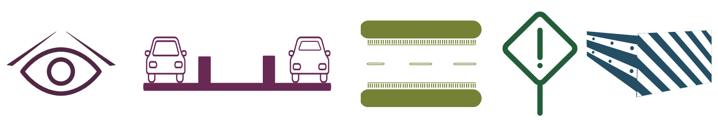
Rural Places
Stratton, CO
Interstate 70



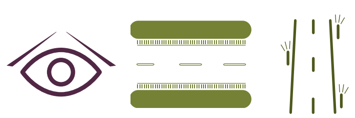
Rural Mountain
Mack, CO
Interstate 70



Rural Places
Larkspur, CO
Interstate 25



Rural Places
Sedgwick, CO
Interstate 76



Case Study: I-25 in Larkspur, CO

I-25 near Larkspur, CO is a 75 MPH highway that was expanded from four lanes to six, adding an express lane in each direction, wider shoulders, and a concrete median barrier. These improvements boost capacity, provide safer separation, and create a more reliable, high-speed corridor for drivers.

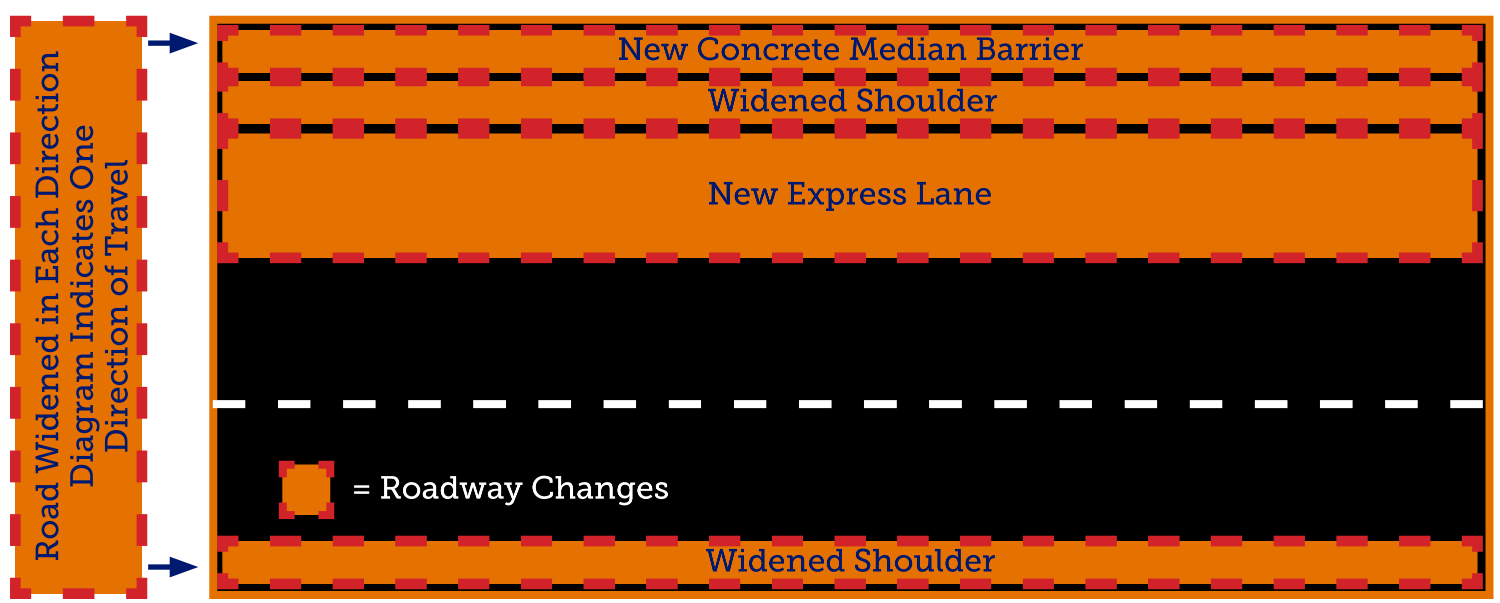
Before:

I-25 operated as a four-lane road with two lanes in each direction and guardrails as a physical barrier between opposing traffic. Limited shoulders and high speeds increased crash severity and left little room for recovery.

After:

The corridor now features six lanes, including an express lane in each direction, large shoulders, and a concrete median barrier. These improvements increase capacity, provide safer separation, and create a more forgiving environment for drivers at high speeds.

What Changed:



From lane narrowing and curb extensions to roadside delineators and advanced warning signs, each roadway element has an ideal application based on roadway classification and context. This chapter illustrates which roadway elements are applicable in each of the roadway contexts shown to the right. By matching roadway elements to speed goals and context, agencies can create safer, more predictable environments without relying solely on enforcement.

Context Classifications for State of Colorado Roadways

Roadway context classifications help agencies match design elements and target speeds to the surrounding environment. Each classification reflects land use, development patterns, and transportation needs, ensuring that speed management strategies align with safety, mobility, and community character. These context classifications come from the 2023 CDOT Roadway Design Guide.

C1 - Rural Mountainous Environment

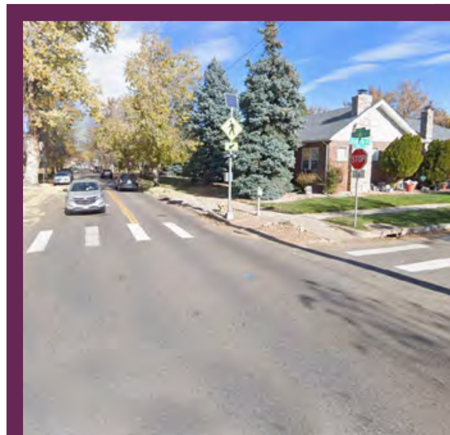
C1 is characterized by wilderness or forested areas that may include mountains, canyons, and rivers. The challenging geographic and environmental conditions in these areas have a strong influence on the alignment, design, and performance of a highway. The roadways may have right of way and environmental constraints. They may be in more remote areas with access to outdoor recreation, such as bicycling, mountain biking, skiing, hiking, river activities, and camping. There may also be interregional transit in areas where towns and business centers tend to be interspersed across rural geographic areas. Roadways may have passenger vehicles, buses, freight transport, recreational vehicles, and the occasional bicyclist. Examples of roadways in a C1 context classification include I-70 through Glenwood Canyon and US 550 between Durango and Ouray.

C2 - Rural Places

C2 is characterized by agricultural lands, ranches, rural towns, or farming areas. Roadways may have passenger vehicles, freight vehicles, interregional transit, and occasional bicycle and pedestrian activity. Oversized agricultural equipment may regularly use the roadway to travel to fields. Examples of roadways in a C2 context classification include US 285 in the San Luis Valley and CO 71 north and south of Brush, Colorado.

C3 - Suburban Places

C3 is characterized by housing areas and strip commercial development just outside of larger urban cores or small pockets of housing outside of rural town cores. In the Denver area, Highlands Ranch is considered suburban - in Grand Junction, the Redlands is considered suburban. Roadway uses in this context classification can vary depending upon the density of development the roadway supports, and the uses may evolve as the area grows and becomes more populated. Roadways may have passenger vehicles, buses, freight transport, trains, pedestrians, and bicyclists.



C4 - Traditional Neighborhoods

C4 is characterized by well-connected or established streets and blocks with a range of housing types, amenities, schools, and businesses. It is often located in or adjacent to an urban area and is closer to the downtown core than a suburb. Traditional neighborhoods are found in large urban areas and rural towns. Travel between the Traditional Neighborhood and an Urban Core may occur by foot, bicycle, or transit, in addition to vehicular travel. In Denver, the Washington Park neighborhood would be considered a Traditional Neighborhood. In Greeley, the Glenmere/Cranford neighborhood would be an example.

C5 - Downtown Places/ Rural Town Center

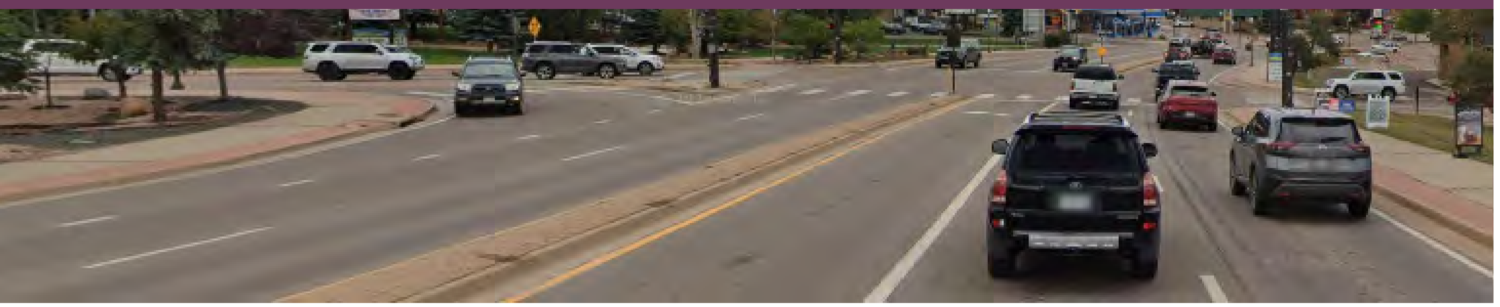
C5 is characterized by retail, office, and other business activity in both large and small towns, with main streets or civic spaces like town squares. Its roadways support a greater percentage of bus transit, pedestrian, bicycle, and passenger vehicle activity, as well as some freight and delivery traffic. The variability of this context classification is demonstrated by downtown Lamar or Alamosa, larger city centers in Grand Junction or Fort Collins, or town squares in the mountain communities of Aspen or Steamboat Springs.

C6 - Urban Core

C6 is characterized by a primarily built environment with a mix of multi-use buildings (office, residential, retail), civic spaces, and cultural or entertainment districts in large, densely populated cities. Numerous amenities are available within walking distance to those who live or work in the Urban Core. Downtown Denver and downtown Colorado Springs are examples of this context classification. Roadways accommodate multiple uses with complex interrelationships. This context classification has the highest level of pedestrian, bicycle, bus and light rail transit, and freight and delivery activity.

Street

C3 Suburban Places
C4 Traditional Neighborhoods
C5 Downtown Places
C6 Urban Core / Rural Town Center



Streets are facilities generally designed with curb and gutter, sidewalks, and storm sewers. Streets are generally located in more urban contexts with speeds between 20 and 45 MPH and may include on-street parking, bicycle lanes, and transit stops.

The table below identifies where elements are most appropriate for a specific street, based on speed and context. There are many unique cases but these indicate the most common cases for these treatments. See Appendix A for additional information on these roadway elements, how they work, and where they are typically found. See Appendix B for planning level cost estimates for each roadway element.

The symbols indicate the relative level of implementation complexity (or barrier to installation) for each countermeasure. Implementation complexity may vary based on site conditions, jurisdictional requirements, and project scope.

Low: Generally involves signage, striping or temporary treatments within the existing right-of-way with limited traffic impacts.

Mid: Requires moderate design efforts, stakeholder coordination, and approvals. Typically located within the existing right-of-way, with some utility and/or traffic conflicts.

High: Difficult to implement, often involving multi-discipline design, major utility relocations, right-of-way acquisition, stakeholder coordination, and significant traffic impacts.

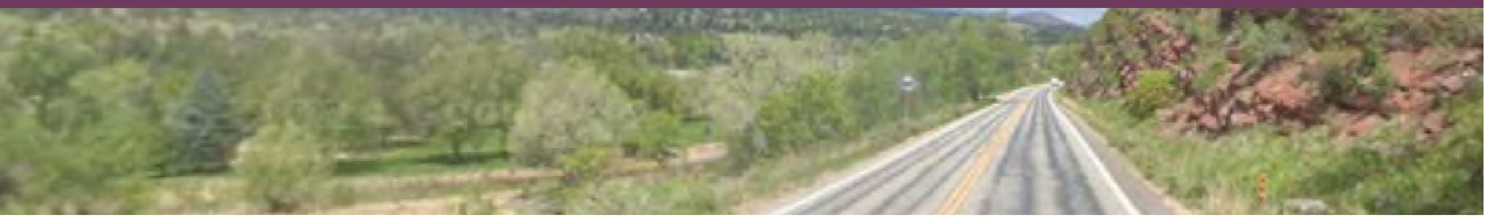
Roadway Elements by Target Speed

Street

Speed	Context	Shared Street Design	Sharrow	Painted Bicycle Lane	Reduce Vehicle Lane Width	On-Street Parking	Pedestrian Upgrades at Signalized Intersections	Lighting	Signal Timing Adjustment	Speed Feedback Signs	Speed Cushion	Enhanced Pedestrian Crossing	Protected Bicycle Lanes	Raised Crosswalk or Raised Intersection	Mini-Roundabout	Single Lane Roundabout	Curb Extension or Pinchpoint	Textured Surfaces	Street Trees and Landscaping	Multi-Lane Roundabout	Gateway Treatment	Raised/ Landscaped Median	Controlled Pedestrian Crossing	Consolidate Access Points	Protected Left Turn Movements
20 MPH	C3 Suburban Places	High	Low	Low	Low		Mid	Mid	Low	Low	Low	Low	Low	Mid	Low	Mid	Mid	Mid	Mid		Mid	Mid	Mid		
	C4 Traditional Neighborhoods	High	Low	Low	Low	Low	Mid	Mid	Low	Low	Low	Low	Low	Mid	Low	Mid	High	Mid	Mid		Mid	Mid	Mid		
	C5 Downtown Places / Rural Town Center	High	Low	Low	Low	Low	Mid	Mid	Low	Low	Mid	Low	Mid	High		Mid	High	Mid	Mid		Mid	Mid	Mid		
	C6 Urban Core	High	Low	Low	Low	Low	Mid	Mid	Low	Low	Mid	Low	Mid	High		Mid	High	Mid	Mid		Mid	Mid	Mid		
25 MPH	C3 Suburban Places	High	Low	Low	Low		Mid	Mid	Low	Low	Low	Low	Low	Mid	Low	Mid	Mid	Mid	Mid	High	Mid	Mid	Mid		
	C4 Traditional Neighborhoods	High	Low	Low	Low	Low	Mid	Mid	Low	Low	Low	Low	Low	Mid	Low	Mid	High	Mid	Mid		Mid	Mid	Mid		
	C5 Downtown Places / Rural Town Center	High	Low	Low	Low	Low	Mid	Mid	Low	Low	Mid	Low	Mid	High		Mid	High	Mid	Mid	High	Mid	Mid	Mid		
	C6 Urban Core	High	Low	Low	Low	Low	Mid	Mid	Low	Low	Mid	Low	Mid	High		Mid	High	Mid	Mid	High	Mid	Mid	Mid		
30 MPH	C3 Suburban Places			Low	Low		Mid	Mid	Low	Low	Low	Low	Low	Mid		Mid	Mid	Mid	Mid	High	Mid	Mid	Mid		
	C4 Traditional Neighborhoods			Low	Low	Low	Mid	Mid	Low	Low	Low	Low	Low	Mid		Mid	High	Mid	Mid		Mid	Mid	Mid		
	C5 Downtown Places / Rural Town Center			Low	Low	Low	Mid	Mid	Low	Low	Mid	Low	Mid	High		Mid	High	Mid	Mid	High	Mid	Mid	Mid		
	C6 Urban Core			Low	Low	Low	Mid	Mid	Low	Low	Mid	Low	Mid	High		Mid	High	Mid	Mid	High	Mid	Mid	Mid		
35 MPH	C3 Suburban Places				Low		Mid	Mid	Low	Low			Mid			Mid	Mid		Mid	High	Mid	Mid	Mid	High	
	C4 Traditional Neighborhoods				Low		Mid	Mid	Low	Low			Mid			Mid	High		Mid		Mid	Mid	Mid	High	
	C5 Downtown Places / Rural Town Center				Low		Mid	Mid	Low	Low			Mid			Mid	High		Mid	High	Mid	Mid	Mid	High	
	C6 Urban Core				Low		Mid	Mid	Low	Low			Mid			Mid	High		Mid	High	Mid	Mid	Mid	High	
40 MPH	C3 Suburban Places				Low		Mid	Mid	Low	Low			Mid						Mid	High	Mid	Mid	Mid	High	High
	C4 Traditional Neighborhoods				Low		Mid	Mid	Low	Low			Mid						Mid		Mid	Mid	Mid	High	High
	C5 Downtown Places / Rural Town Center				Low		Mid	Mid	Low	Low			Mid						Mid	High	Mid	Mid	Mid	High	High
	C6 Urban Core				Low		Mid	Mid	Low	Low			Mid						Mid	High	Mid	Mid	Mid	High	High
45 MPH	C3 Suburban Places						Mid	Mid	Low	Low			Mid						Mid	High	Mid	Mid	Mid	High	High
	C4 Traditional Neighborhoods						Mid	Mid	Low	Low			Mid						Mid		Mid	Mid	Mid	High	High
	C5 Downtown Places / Rural Town Center						Mid	Mid	Low	Low			Mid						Mid	High	Mid	Mid	Mid	High	High

Road

C1 Rural Mountainous Environment
C2 Rural Places
C3 Suburban Places



Roads are facilities generally designed with shoulders and roadside ditches. Roads are primarily found in rural, low-density settings with speeds between 35 MPH and 65 MPH.

The table below identifies where elements are most appropriate for a specific road, based on speed and context. There are many unique cases but these indicate the most common cases for these treatments. See Appendix A for additional information on these roadway elements, how they work, and where they are typically found. See Appendix B for planning level cost estimates for each roadway element.

The symbols indicate the relative level of implementation complexity (or barrier to installation) for each countermeasure. Implementation complexity may vary based on site conditions, jurisdictional requirements, and project scope.

Low: Generally involves signage, striping or temporary treatments within the existing right-of-way with limited traffic impacts.

Mid: Requires moderate design efforts, stakeholder coordination, and approvals. Typically located within the existing right-of-way, with some utility and/or traffic conflicts.

High: Difficult to implement, often involving multi-discipline design, major utility relocations, right-of-way acquisition, stakeholder coordination, and significant traffic impacts.

Roadway Elements by Target Speed

Road

Target Speed	Context	Transverse Rumble Strips	Optical Speed Bars	Roadside Delineation	Advanced Warning Signage	Speed Feedback Signage	Signal Timing Adjustment	Variable Speed Limit Sign	Lighting	Intersection Conflict Warning System	SafetyEdge	Increased Stopping Sight Distance	Protected Left Turn Movements	Guardrails or Barriers at Fixed Objects	Pedestrian Upgrades at Signalized Intersections	Shoulder Widening	Maintain/ Enhance Clear Zone	Consolidated Access Points	Grade Separated Bicycle/ Pedestrian Crossing	Median with Barrier
35 MPH	C1 Rural Mountainous	Low		Low	Low	Low						Mid		Mid	Mid		Mid		High	
	C2 Rural Places			Low	Low	Low			Mid			Mid		Mid	Mid		Mid		High	
	C3 Suburban Places				Low	Low	Mid		Mid			Mid		Mid	Mid		Mid	High	High	
40 MPH	C1 Rural Mountainous	Low		Low	Low	Low				Mid		Mid		Mid	Mid		Mid		High	
	C2 Rural Places			Low	Low	Low			Mid	Mid		Mid		Mid	Mid		Mid		High	
	C3 Suburban Places				Low	Low	Mid		Mid			Mid	High	Mid	Mid		Mid	High	High	
45 MPH	C1 Rural Mountainous	Low	Low	Low	Low	Low				Mid	High	Mid	High	Mid	Mid	High	Mid		High	
	C2 Rural Places		Low	Low	Low	Low	Mid		Mid	Mid	High	Mid	High	Mid	Mid	High	Mid	High	High	
	C3 Suburban Places				Low	Low	Mid		Mid		High	Mid	High	Mid	Mid	High	Mid	High	High	
50 MPH	C1 Rural Mountainous	Low	Low	Low	Low	Low				Mid	High	High	High	Mid	Mid	High	High		High	
	C2 Rural Places	Low	Low	Low	Low	Low	Mid		Mid	Mid	High	High	High	Mid	Mid	High	Mid	High	High	
	C3 Suburban Places	Low		Low	Low	Low	Mid		Mid		High	High	High	Mid	Mid	High	High	High	High	
55 MPH	C1 Rural Mountainous	Low	Low	Low	Low	Low		Mid		Mid	High	High	High	Mid	Mid	High	High	High	High	High
	C2 Rural Places	Low	Low	Low	Low	Low	Mid	Mid	Mid	Mid	High	High	High	Mid	Mid	High	Mid	High	High	High
	C3 Suburban Places	Low		Low	Low	Low	Mid	Mid	Mid		High	High	High	Mid	Mid	High	High	High	High	High
60 MPH	C1 Rural Mountainous	Low	Low	Low	Low	Low		Mid		Mid	High	High	High	Mid	Mid	High	High	High	High	High
	C2 Rural Places	Low	Low	Low	Low	Low		Mid	Mid	Mid	High	High	High	Mid	Mid	High	Mid	High	High	High
	C3 Suburban Places	Low		Low	Low	Low		Mid	Mid		High	High	High	Mid	Mid	High	High	High	High	High
65 MPH	C1 Rural Mountainous	Low	Low	Low	Low	Low		Mid		Mid	High	High	High	Mid	Mid	High	High	High	High	High
	C2 Rural Places	Low	Low	Low	Low	Low		Mid	Mid	Mid	High	High	High	Mid	Mid	High	Mid	High	High	High
	C3 Suburban Places	Low		Low	Low	Low		Mid	Mid		High	High	High	Mid	Mid	High	High	High	High	High

Freeway, Expressway, Interstate

C1 Rural Mountainous Environment
C2 Rural Places
C3 Suburban Places
C4 Traditional Neighborhoods
C5 Downtown Places
C6 Urban Core / Rural Town Center

Freeways, expressways, and interstates generally have speeds posted between 55 and 75 MPH and are designed with varying levels of access control. On rural freeways or expressways, lower traffic volumes make at-grade intersections acceptable, whereas urban and suburban freeways and expressways have much higher traffic volumes and are typically accessed via interchanges.

The table below identifies where elements are most appropriate for a specific roadway, based on speed and context. There are many unique cases but these indicate the most common cases for these treatments. See Appendix A for additional information on these roadway elements, how they work, and where they are typically found. See Appendix B for planning level cost estimates for each roadway element.

The symbols indicate the relative level of implementation complexity (or barrier to installation) for each countermeasure. Implementation complexity may vary based on site conditions, jurisdictional requirements, and project scope.

Low: Generally involves signage, striping or temporary treatments within the existing right-of-way with limited traffic impacts.

Mid: Requires moderate design efforts, stakeholder coordination, and approvals. Typically located within the existing right-of-way, with some utility and/or traffic conflicts.

High: Difficult to implement, often involving multi-discipline design, major utility relocations, right-of-way acquisition, stakeholder coordination, and significant traffic impacts.

Roadway Elements by Target Speed

Freeway, Expressway, Interstate

Speed	Context	Roadside Delineation	Lane Guidance Signage	Variable Speed Limit Sign	Intersection Conflict Warning System	Advance Warning Signage	Wildlife Crossing Infrastructure	Emergency Vehicle Turnaround	Guardrails and Gore Attenuators	Shoulders with Rumble Strips	Maintain/ Enhance Clear Zone	Dynamic Message Sign	Lighting	Emergency Pull-off Area	Increased Stopping Sight Distance	Ramp Accel/ Decel Lanes	Wide Median with Barrier	Grade Separated Bicycle/ Pedestrian Crossing
55 MPH	C1 Rural Mountainous	Low	Low	Mid		Low	Low		Mid	High	Mid	Mid	Mid	High	High			High
	C2 Rural Places	Low	Low	Mid		Low	Low	Mid	Mid	Mid	Mid		Mid	Mid	High		High	
	C3 Suburban Places		Low	Mid	Mid	Low		Mid	Mid			Mid	Mid	Mid	High	High	High	High
	C4 Traditional Neighborhood		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
	C5 Downtown Places / Rural Town Center		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
	C6 Urban Core		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
60 MPH	C1 Rural Mountainous	Low	Low	Mid		Low	Low		Mid	High	Mid	Mid	Mid	High	High			High
	C2 Rural Places	Low	Low	Mid		Low	Low	Mid	Mid	Mid	Mid		Mid	Mid	High		High	
	C3 Suburban Places		Low	Mid	Mid	Low		Mid	Mid			Mid	Mid	Mid	High	High	High	High
	C4 Traditional Neighborhood		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
	C5 Downtown Places / Rural Town Center		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
	C6 Urban Core		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
65 MPH	C1 Rural Mountainous	Low	Low	Mid		Low	Low		Mid	High	Mid	Mid	Mid	High	High	High		High
	C2 Rural Places	Low	Low	Mid		Low	Low	Mid	Mid	Mid	Mid		Mid	Mid	High	High	High	
	C3 Suburban Places		Low	Mid	Mid	Low		Mid	Mid				Mid	Mid	High	High	High	High
	C4 Traditional Neighborhood		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
	C5 Downtown Places / Rural Town Center		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
	C6 Urban Core		Low	Mid	Mid	Low			Mid			Mid	Mid		High	High		High
70 / 75 MPH	C1 Rural Mountainous	Low	Low	Mid		Low	Low		Mid	High	Mid	Mid	Mid	High	High	High		High
	C2 Rural Places	Low	Low	Mid		Low	Low	Mid	Mid	Mid	Mid		Mid	Mid	High	High	High	
	C3 Suburban Places		Low	Mid	Mid	Low		Mid	Mid			Mid	Mid	Mid	High	High	High	High

CHAPTER 4
OTHER SPEED SETTING CONSIDERATIONS

Beyond design speed and roadway context, a range of supporting factors influence how drivers perceive and maintain speed. This chapter addresses design scenarios and operational strategies that require additional guidance beyond the standard speed-environment applications in Chapter 2.

Setting Speeds Between Roundabouts

Closely Spaced Roundabouts

Roundabouts are considered closely spaced if they are less than or equal to 1,000 feet from each other, center to center (Wisconsin Department of Transportation, 2025). Queue lengths should be considered when designing closely spaced roundabouts to prevent an overflow of vehicles from one roundabout into the next. When closely spaced, drivers cannot meaningfully accelerate between roundabouts.

Speeds Between Roundabouts

Within 100 feet of exiting a roundabout, drivers reach the speed that they were driving prior to approaching the roundabout (Saldivar-Carranza et al., 2024). This suggests that drivers would likely accelerate to their original speed or higher between roundabouts that are spaced far apart. Spacing of ½ mile to one mile is long enough to allow speed recovery between roundabouts. The roadway begins to function less like a continuous traffic calming corridor and more like a series of linked intersections. Apply the elements within this guide to maintain lower target speeds or practice gradual speed transitions between widely spaced roundabouts.

Speeds Entering Roundabouts

Roundabout entry speeds are usually 20-25 MPH with circulating speeds typically less than 20 MPH. Large speed changes between roundabouts can increase crash risk, therefore, posted speeds prior to a roundabout should not require aggressive braking. On higher speed approaches of 45 MPH or more or rural locations, long splitter islands of 150 feet or more should be considered to provide additional speed control through a visual "tunneling" effect (Tennessee Department of Transportation, n.d.).

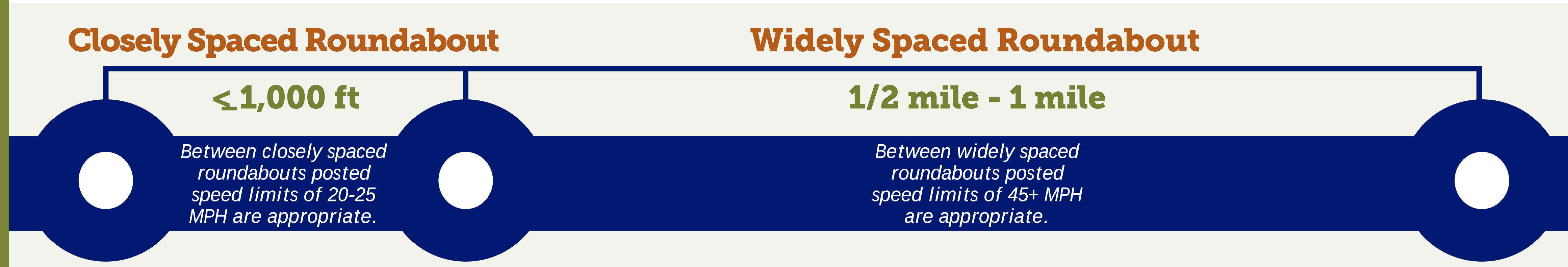
Key Design Considerations

Urban Context = Lower Speeds (20-30 MPH)

Suburban context= moderate speeds (30-40 MPH)

Rural context = higher speed between roundabouts, but strong transitions

Roundabouts and signalized intersections are generally not recommended in close proximity. Signals create tight vehicle platoons that can struggle to enter a roundabout when circulating traffic is present (Wisconsin Department of Transportation, 2025).



The Effect of Roadway Element Density on Speed

Overview

Traffic calming effectiveness is strongly influenced by device spacing. Closely spaced elements create smaller gaps between influence zones, allowing a greater portion of the roadway to operate under reduced speeds and promoting more consistent driver behavior.

In contrast, **wider spacing gives drivers more distance to accelerate between devices**, leading to higher peak speeds and greater speed variability, conditions that can raise safety concerns. This dynamic is especially relevant for widely spaced roundabouts (previously discussed), where drivers may treat the segment between intersections as a higher-speed roadway rather than part of a continuous speed-managed corridor.

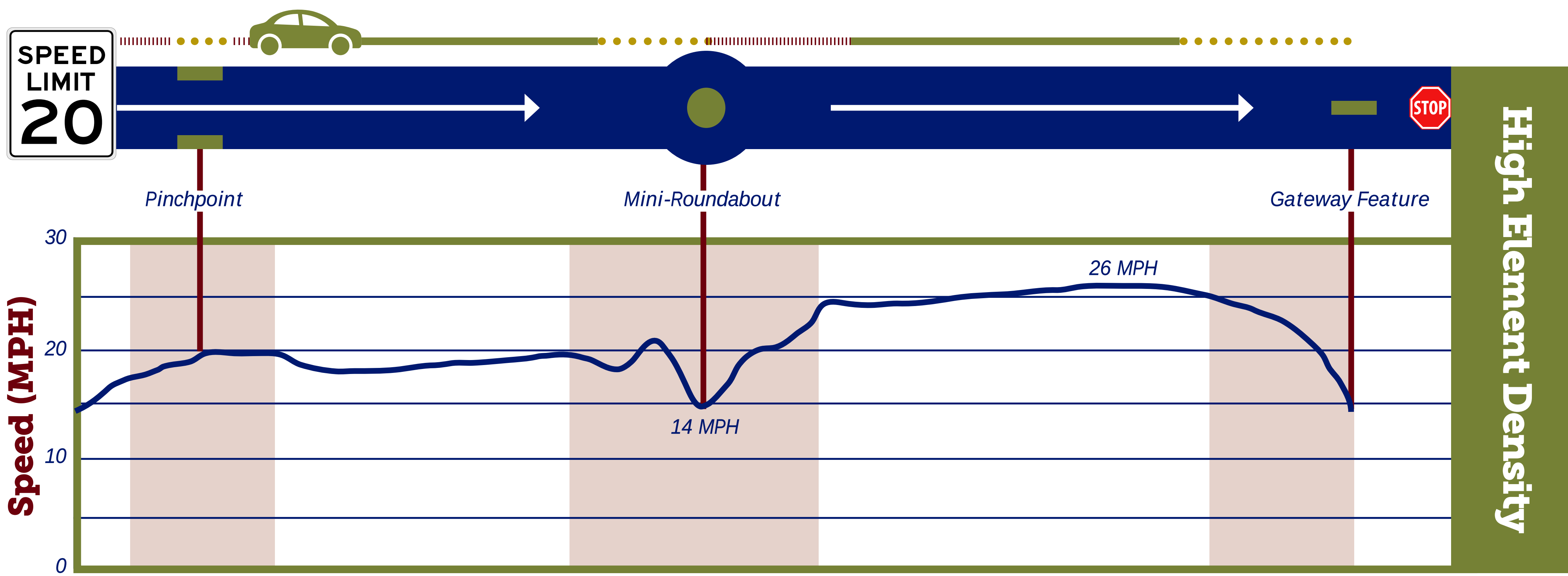
While some speed fluctuation occurs in all cases, closely spaced devices produce smaller, more controlled changes in speed. As a result, **a coordinated system of closely spaced traffic calming measures is more effective than isolated devices**, supporting lower, steadier operating speeds along the corridor.

Speed Profiles

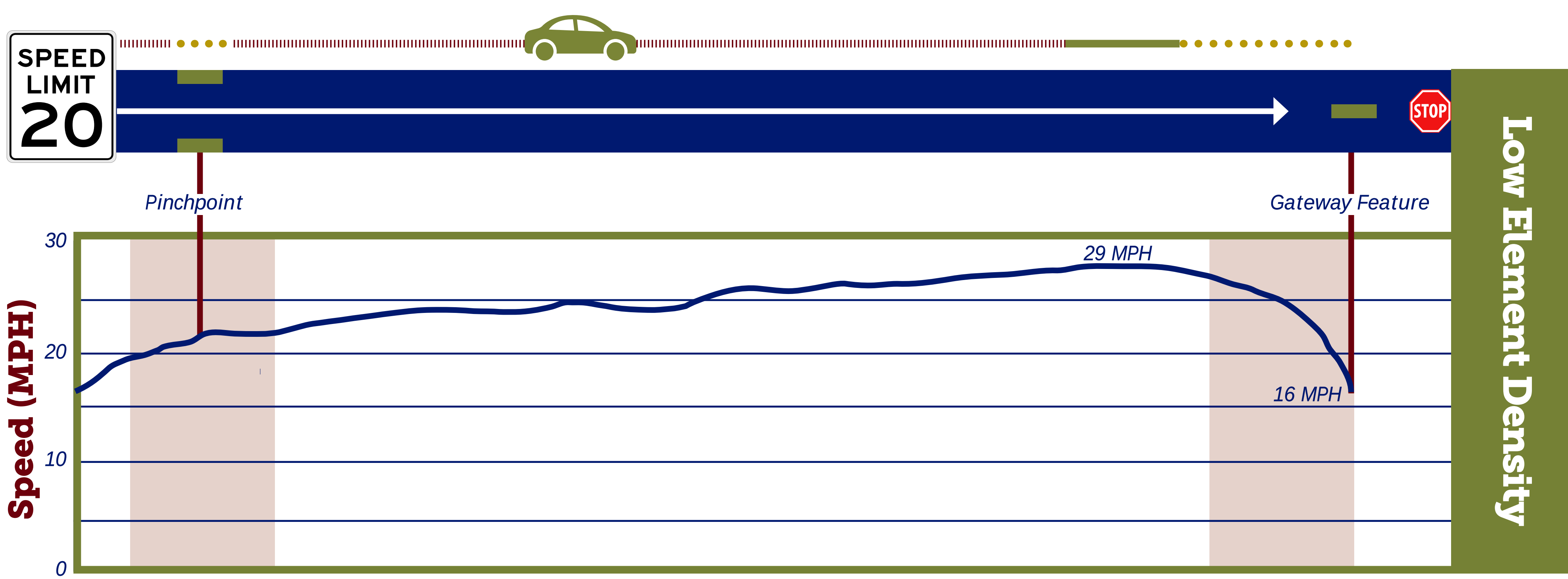
Speed profiles provide a graphical representation of this behavior. Seen on the graphs to the right, **vehicle speeds increase, reach a peak, and decrease between traffic calming devices**. The peak speeds are higher when the distance between devices is larger. The top graph illustrates high element density while the bottom illustrates low element density.

Legend

Gradual Slowdown
Speed Increase
Steady Speed
Actual Speed
Influence Zone



Peak speed hits 26 MPH with a low speed of 14 MPH. Speeds vary by six MPH from the posted speed limit. A smaller gap exists between the pinchpoint and mini-roundabout influence zones than between the mini-roundabout and gateway feature influence zones, causing slightly elevated speeds between the latter two elements (Ewing et al., 2019).



Peak speed hits 29 MPH with a low speed of 16 MPH. Removing the mini-roundabout allows for higher rates of acceleration and higher peak speeds. Speeds vary by up to nine MPH from the posted speed limit due to a large gap between the pinchpoint and gateway feature influence zones, which allows drivers to accelerate between treatments.

Managing Transitions from High-Speed Rural Roads to Community Streets

Speed Zones: Rural, Transition, and Community

- **Rural zones**: characterized by higher speeds, limited access points, and longer travel distances.
- **Community zones**: defined by lower speeds, increased pedestrian and bicycle activity, more intensive land use, and more complex roadway features such as turn lanes and on-street parking.
- **Transition zones**: represent the segment between these two contexts, serving as a critical buffer where drivers are prompted to adjust their speed and heighten their awareness before entering a more active and complex community environment.

Transition Zone Features

The transition zone is divided into two areas to support a gradual reduction in speed. The first, the perception-reaction area, uses warnings and perceptual treatments, signage and enhanced roadside elements like landscaping, to signal a change in context to drivers. The second, the deceleration area, introduces more pronounced physical changes that have a stronger influence on speed, including vertical and horizontal geometric shifts, surface treatments, and gateway features. These physical treatments should extend into the community zone to help maintain consistently low speeds throughout the town.

Transition Zone Length

Factors such as existing speed zone boundaries and observed driver behavior should guide the length of a transition zone. Where rural and community zones are clearly defined, the area between them may function as the transition zone, but this alone should not determine its length. A transition zone that begins too far from town and extends too long may reduce drivers' willingness to comply with lower speeds, while one that starts too close to town may not provide sufficient distance for safe deceleration. An effective transition zone strikes a balance between these extremes, allowing drivers to gradually and safely reduce speed before entering the community environment.

Recommended Minimum Lengths of Transition Zones
(National Research Council, 2012)

Community Zone Target Speed (MPH)

Rural Zone Speed (MPH)	20		25		30		35		40		45	
45	170	385	170	345	170	305	170	255	-	-	-	-
	555		**515**		**475**		**425**		**-**		**-**	
50	190	450	190	415	190	380	190	330	190	270	-	-
	640		**605**		**570**		**520**		**460**		**-**	
55	210	510	210	480	210	440	210	400	210	340	210	265
	720		**690**		**650**		**610**		**550**		**475**	
60	230	595	230	565	230	520	230	485	230	425	230	365
	825		**795**		**750**		**715**		**655**		**595**	
65	240	680	240	655	240	600	240	570	240	510	240	465
	920		**895**		**840**		**810**		**750**		**705**	

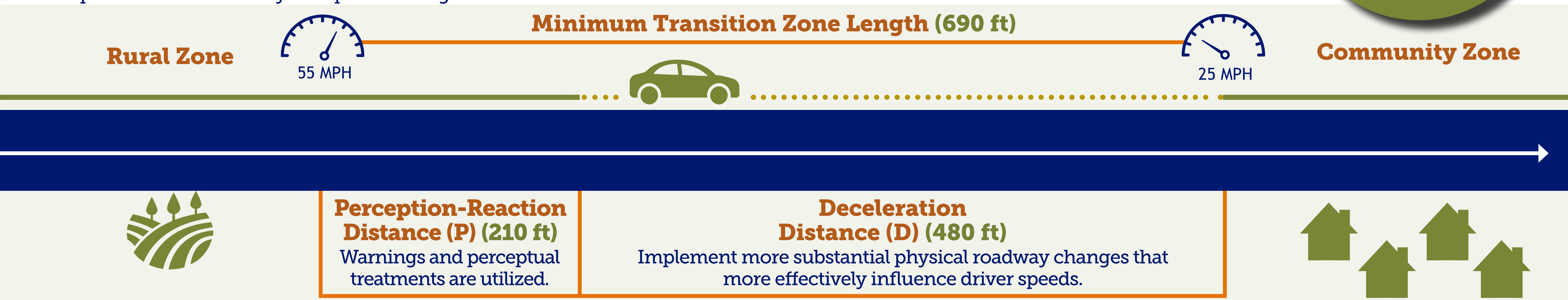
P	D
Total	

P = Perception-reaction distance (ft)
D = Deceleration distance (ft)
Total is the transition zone length (ft)

Transition Zone Speed Limit

The transition zone speed limit should function as a bridge between higher-speed rural areas and lower-speed community streets. A common approach is to set the posted speed at approximately the midpoint between the two zones to support a gradual and intuitive reduction in speed. For example, when transitioning from a 55 MPH rural zone to a 25 MPH community zone, a transition speed of 40 MPH helps ease drivers into slower conditions and reinforces the need to decelerate before entering the community environment.

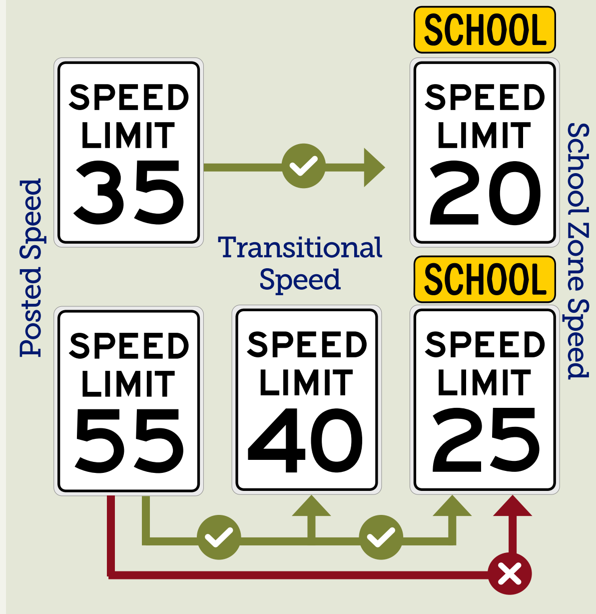
Since each community zone has unique attributes, transition zones should be designed on a case-by-case basis rather than following a single standard.



Establishing Reduced Speed Zones at Schools

Setting the Speed Limit

When traveling at 20 MPH, drivers yield to pedestrians 75% of the time, but when traveling at 37 MPH, drivers only yield 17% of the time (Bertulis & Dulaski, 2014). Lower speeds create a **significantly higher likelihood of yielding to pedestrians;** therefore, reduced speed limits within school zones are preferred to enhance student safety. School zone speed limits should not exceed 35 MPH and, for corridors with posted speeds of 50 MPH or less, the school zone speed limit should be established based on observed operating speeds, pedestrian volumes, available crossing treatments, stopping sight distance, etc.



The transition into a school zone is also critical. When the difference between the posted speed and the school zone speed limit exceeds 20 MPH, a buffer zone, typically 500 feet in length, should be used to support a more gradual transition. Without this transition, drivers may not reduce speed quickly enough upon entering the school zone, increasing the risk of conflicts with students and other pedestrians.

Stopping Sight Distance

Stopping sight distance reflects the distance a vehicle travels during the time it takes a driver to perceive, react to, and fully stop for an obstacle. It increases as vehicle speeds rise. In school zones, this has direct safety implications: drivers must have sufficient distance to recognize students crossing and reduce speed in time. One key strategy to support adequate stopping sight distance is **restricting on-street parking 20–30 feet in advance of crosswalks**. This improves visibility of crossing pedestrians and therefore, stopping sight distance. The table on the right provides guidance on the recommended distance needed for a vehicle to stop based on the posted speed limit and the school zone speed limit.

Speed Zone Length

School speed zones must be authorized through CDOT headquarters before being installed.

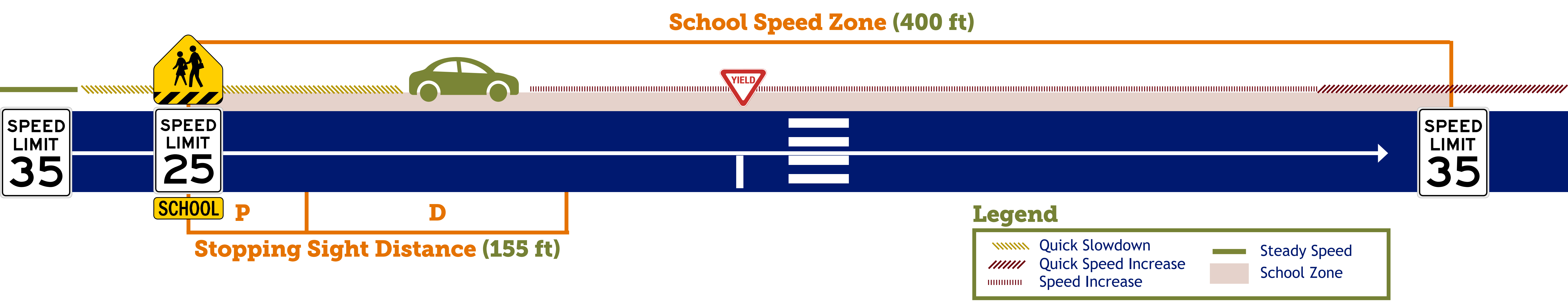
School speed zones should be kept short to enhance driver compliance. One report indicates that minimum speeds in school zones typically occur at the beginning of the school zone and that speeds increase approximately one MPH for every 500 feet in a school zone. **The longer the speed zone, the lower driver compliance** as drivers may begin to perceive the restriction as unnecessary.

Speed zones should begin 100 to 200 feet from the school property line or school crosswalk, whichever is determined to be the most appropriate. Additionally, crossing locations in close proximity to one another should be consolidated. If there is one crossing location, the school zone should typically begin/end approximately 200-300 feet from the crossing, for a total length of 400-600 feet.

Recommended Distance from Start of School Zone to Crosswalk

Posted Speed Limit (MPH)	School Speed Limit (MPH)	Stopping Sight Distance (ft)	Recommended Min Distance (ft)
25-35	20	115	150
35-40	25	155	200
40-45	30	200	300

Recommended minimum distance (ft) based on speed and stopping sight distance.



Corridor Signal Timing

Overview

Traffic signal timing, using the "alternate system", helps manage vehicle speeds and improve safety for all users. This approach uses fixed, predictable timing that keeps groups of cars, called platoons, moving together at steady speeds. When done correctly, this reduces speeding, cuts down on sudden stops, and creates larger gaps between groups of vehicles. These gaps make it safer for people walking, biking, or turning from side streets or driveways.

The main idea is simple: If drivers travel at a reasonable, consistent speed, they will hit a series of green lights. If they speed, they arrive too early and hit a red light—removing the "reward" for driving fast. Over time, drivers naturally slow to the intended pace, which makes the road safer and more predictable.

This method is not a one-size-fits-all solution, but when applied to the right corridors with thoughtful engineering judgment, it can improve traffic flow, reduce speeding, and make streets safer for everyone.

Colorado Applications

This method works best on corridors where intersections are evenly spaced and traffic volumes aren't constantly overwhelming. It has been successfully used on two major streets in the Denver metro area:

Colfax Avenue, where a "single alternate" pattern (red/green/red/green) is used overnight and during busy daytime periods. This has dramatically reduced serious pedestrian crashes and nighttime speeding.

Wadsworth Boulevard, where a "triple alternate" pattern (red, red, red/green, green, green/red...) is used during the evening rush hour to control heavy congestion. Grouping signals this way helps meter traffic, reduce long backups, and create safer gaps for turning vehicles and people crossing.

Key lessons:

Predictability helps both drivers and pedestrians make safer decisions.

Short, consistent signal cycles reduce frustration and discourage risky behavior like red-light running.

Managing speeds through signal timing can significantly reduce crashes.

More information on how and when to apply this approach, and details regarding the implementation in Colorado can be found in Appendix C.

Additional Resources

Federal Highway Administration (FHWA) Safety Programs

FHWA Traffic Calming ePrimer

FHWA Proven Safety Countermeasures

Institute of Transportation Engineers - Guide to Vertical Deflection Speed Reduction Techniques

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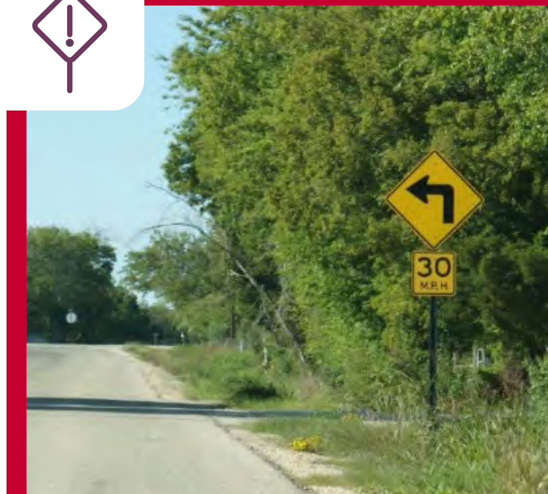


Advanced Warning Signage

What It Is: Signs placed ahead of curves, intersections, or hazards to alert drivers early, giving them time to adjust speed and prepare for changing conditions.

How It Works: Placed at calculated distances before the hazard based on speed and stopping sight distance, these signs, often paired with flashing beacons, give drivers advance warning, prompting earlier and more consistent slowing.

Typical Locations: Approaches to sharp curves, intersections, work zones, school zones.

Crash Attenuators at Gore Points

What It Is: Energy-absorbing devices placed at the triangular area (gore point) where ramps split from main lanes.

How It Works: Designed to collapse or absorb impact energy, reducing crash severity. They reduce injury severity while helping drivers feel safer and maintain appropriate speeds without over-braking.

Typical Locations: Freeway exit and entrance ramp gores, high-speed interchanges.

Consolidated Access Points

What It Is: Combining multiple driveways or access points into fewer, shared locations to reduce conflict points.

How It Works: Limits turning movements and organizes entry/exit points, reducing sudden braking and weaving.

Typical Locations: Commercial and suburban corridors.

Crash Reduction: CMF ID 178; 31% reduction of all injury crashes when reducing driveways from 26-48 to 10-24 per mile. FHWA Proven Safety Countermeasure.

Curb Extension or Pinchpoint

What It Is: Bulb-outs that extend the curb into the parking lane to narrow the roadway and reduce crossing distance.

How It Works: Narrows the travel way at targeted points, improves sight lines to crossings. Drivers slow due to the constricted travel lane.

Typical Locations: Main streets, near schools, bus stops, at crosswalks, on wide roads to improve pedestrian visibility.

Other Considerations: Curb extensions also increase visibility to pedestrians by daylighting the crossing location.

Crash Reduction: 13% reduction of all intersection-related crashes (Guerra et al., 2026).

Controlled Mid-Block Pedestrian Crossing

What It Is: Pedestrian-activated signals (e.g., Pedestrian hybrid Beacons or pedestrian signals) to provide controlled crossings and increase driver yielding.

How It Works: Pedestrian activation brings a stop or yield indication, drivers slow and stop during the crossing phase.

Typical Locations: Multilane arterials, trail and transit crossings, near schools.

Other Considerations: Controlled pedestrian crossings must comply with MUTCD warrants. Lighting at these locations is critical for visibility.

Crash Reduction: CMF ID 11752; 34% reduction of all fatal and injury crashes.

Dynamic Message Sign

What It Is: Large electronic boards that display real-time messages helping drivers make informed decisions.

How It Works: Controlled by traffic management centers, these signs display real-time messages on traffic conditions, incidents, safety alerts, or speed advisories—prompting drivers to slow down or pay attention in response.

Typical Locations: Freeways, near work zones.

Emergency Pull-Off Area

What It Is: Designated paved areas along highways for vehicles to stop safely during emergencies or breakdowns.

How It Works: Located at intervals, marked for visibility, often include signage and sometimes lighting. Reduces sudden stops in travel lanes, and helps maintain steady traffic flow.

Typical Locations: Freeways, mountain corridors, long rural stretches.

Emergency Vehicle Turnaround

What It Is: Designated paved areas on divided highways that allow emergency vehicles to reverse direction quickly during incidents.

How It Works: Located at intervals along highways and restricted for authorized use, these areas enable quicker crash clearance, restoring normal speeds sooner.

Typical Locations: Freeways, expressways, long rural divided highways.

Enhanced Pedestrian Crossing

What It Is: Signage and striping treatments installed to increase driver yielding.

How It Works: Adds visibility and cues drivers where to stop when a pedestrian is present. Can also increase yielding behavior and result in lower approach speeds.

Typical Locations: Multilane arterials, near schools, transit stops, trail crossings, main streets.

Crash Reduction: CMF ID 9017; 25% reduction of all pedestrian-vehicle crashes on minor arterial roadways. FHWA Proven Safety Countermeasure.

Gateway Treatment

What It Is: Distinct design elements at town or district entries (signage, texture, monuments, narrowing) to signal a lower-speed environment.

How It Works: Visual transition and cues prompt speed adjustments upon approach with lower speeds carrying inward as well.

Typical Locations: Town limits, campus entries, neighborhood or retail districts.

Grade-Separated Bicycle/Pedestrian Crossing

What It Is: Bridges or tunnels that allow pedestrians and bicylists to cross roads without interacting with vehicle traffic.

How It Works: Provides a fully separate path, eliminating crossing conflicts and allowing vehicles to maintain speed without stopping.

Typical Locations: High speed arterials or freeways near pedestrian destinations or trail crossings.

Other Considerations: Grade separated crossings are very costly improvements that require ADA ramps or elevators. The cost and space needed for ADA components can make an overpass infeasible.

Guardrails or Barriers at Fixed Objects

What It Is: Protective barriers installed near rigid hazards (like bridge piers, poles, or steep drop-offs) to prevent severe crashes.

How It Works: Redirects vehicles away from hazards or absorbs impact energy. They reduce injury severity while helping drivers feel safer and maintain appropriate speeds without over-braking.

Typical Locations: Bridge approaches, curves, roadside hazards, steep embankments.

Heavy Vehicle Climbing Lane

What It Is: An added uphill lane provided on steep grades to allow slower-moving heavy vehicles to travel separately from general traffic.

How It Works: By removing slow-moving trucks from the main travel lane, climbing lanes reduce speed differentials and platooning. This separation improves overall traffic flow, minimizes risky passing maneuvers, and creates a more consistent operating speed for all users.

Typical Locations: Rural highways, mountainous or rolling terrain, and corridors with significant truck volumes and sustained grades where heavy vehicles experience substantial speed loss.

Crash Reduction: CMF ID 10074; 43% reduction of all crashes on principal arterial interstates.

Increased Stopping Sight Distance

What It Is: Improve a driver's ability to see far enough ahead to stop safely at posted speeds.

How It Works: Adjusting roadway alignment, removing visual obstructions (vegetation, barriers), or regrading curves and hills allow drivers to maintain smoother, more consistent speeds.

Typical Locations: Curves, rural highways, areas with limited visibility, intersection approaches.

Other Considerations: Adequate stopping sight distance is critical at intersections and driveways where limited visibility contributes to angle and left-turn crashes. Practitioners should maintain clear sight triangles by addressing obstructions such as on-street parking, trees and landscaping, utility and signal cabinets, and signs. In constrained settings, this may require parking restrictions, relocation of elements, or vegetation management to preserve visibility.

Intersection Conflict Warning System (ICWS)

What It Is: Electronic warning system that alerts drivers on major or minor approaches when cross traffic is present, reducing surprise conflicts at intersections.

How It Works: Sensors detect approaching vehicles and activate flashing signs or beacons to warn of potential conflicts, helping drivers slow earlier and reduce abrupt braking.

Typical Locations: Rural two-way stop-controlled intersections, high-speed approaches, areas with limited sight distance.

Crash Reduction: CMF ID 8439; 31% reduction of all injury crashes at rural intersections.

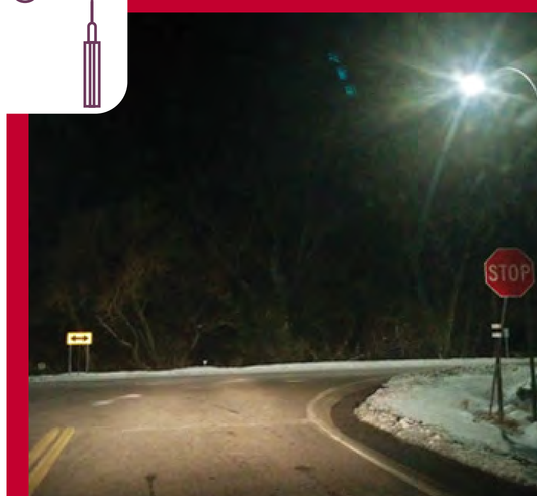
Lane Guidance Signage

What It Is: Overhead or roadside signs that clearly indicate lane assignments for destinations or exits, helping drivers choose the correct lane early and reducing sudden lane changes.

How It Works: Placed well before interchanges or complex intersections to give drivers time to adjust speed and position.

Typical Locations: Freeway interchanges, urban expressways, complex intersections.

Lighting



What It Is: Roadway lighting at intersections, interchanges, and pedestrian crossings to improve visibility and reduce nighttime crashes.

How It Works: Lights illuminate key conflict and decision points, making pedestrians, signs, lane markings, and vehicles easier to see and improving visibility so drivers can maintain appropriate speeds.

Typical Locations: Pedestrian crossings, Urban intersections, rural crossroads, freeway interchanges, major junctions, high-volume ramps.

Reference Material: CDOT Lighting Design Guidelines

Other Considerations: Lighting is important on all roadways, but becomes more critical at higher speeds due to longer reaction and stopping distances. Consistent lighting along corridors helps avoid abrupt visibility changes that can affect driver perception.

Crash Reduction: CMF ID 433; 38% reduction of nighttime injury crashes when lighting is installed at intersections. FHWA Proven Safety Countermeasure.

Maintain/Enhance Clear Zone

What It Is: Removing or relocating obstacles (trees, poles, steep slopes) from the roadside to create a recovery area.

How It Works: Provides an unobstructed area beyond the travel lane so vehicles can safely stop or regain control. Drivers feel safer and maintain consistent speeds without over-braking near hazards.

Typical Locations: Rural highways, curves, high-speed corridors, intersections and trail crossings.

Crash Reduction: CMF ID 1024; 38% reduction of all crashes. Moving obstacles just 3 feet farther from the roadway is associated with a 22% reduction in crashes. Greater offsets provide larger safety benefits, with crash reductions of 34%, 49%, 57%, and 66% associated with tree setbacks of 5, 8, 10, and 13 feet, respectively (Fitzpatrick et al., 2000).

Median Barriers

What It Is: A physical barrier installed between opposing directions of traffic to prevent cross-median crashes.

How It Works: Barriers separate opposing traffic streams and prevent vehicles from crossing into oncoming lanes. Drivers maintain steady speeds due to reduced conflict risk.

Typical Locations: Freeways, urban, suburban, and mountainous divided highways.

Crash Reduction: CMF ID 7040; 97% reduction in cross-median crashes on four-lane freeways. FHWA Proven Safety Countermeasure.

Mini-Roundabout

What It Is: A compact, low-speed roundabout, designed to fit within a conventional intersection footprint. Mini-roundabouts are only appropriate at speeds of 20-25 MPH.

How It Works: Deflection at the entry introduces slight curvature, requiring drivers to slow and yield. The central island and tighter turning geometry reduce speeds and organize movements.

Typical Locations: Residential streets, low-volume local streets.

Crash Reduction: CMF ID 11522; 37% reduction in crashes at intersections converted from stop-controlled to mini-roundabout. FHWA Proven Safety Countermeasure.

Multi-Lane Roundabout

What It Is: Multi-lane or higher-capacity roundabouts for major intersections.

How It Works: Entry curvature, splitter islands, and lane assignments control approach and circulating speeds and conflicts.

Typical Locations: Regional arterials, state highways, higher-volume crossroads.

Reference Material: FHWA Roundabouts: An Informational Guide

Crash Reduction: CMF ID 226; 78% reduction in injury crashes at intersections converted from a signalized intersection to a roundabout. FHWA Proven Safety Countermeasure.

On-Street Parking

What It Is: Curbside parking that visually narrows the roadway and adds friction to the side of the road.

How It Works: Parked cars create edge friction and perceived narrowing, drivers slow due to potential dooring and crossing movements.

Typical Locations: Main streets, mixed-use corridors, neighborhoods, commercial districts.

Other Considerations: It is important to restrict parking at intersections, crosswalks and driveways, in accordance with Colo. Rev. Stat. § 42-4-1204 (2024) to improve stopping sight distance.

Reference Material: Colorado Revised Statutes Title 42

Optical Speed Bars

What It Is: Repeated pavement markings (transverse bars) that create a visual “tunnel” effect to cue drivers to slow down.

How It Works: Bars are spaced progressively closer together, giving the impression of increased speed and prompting measurable deceleration on approach segments.

Typical Locations: Unexpected curves, exit ramps, and approaches to small towns.

Painted Bicycle Lane

What It Is: Designated on-street lanes for bicyclists, marked by pavement striping and symbols but without physical separation from motor vehicle traffic.

How It Works: Striping reallocates roadway space and visually narrows travel lanes, which can reduce vehicle speeds. The presence of bicyclists and lane delineation adds side friction, encouraging more cautious driving behavior.

Typical Locations: Urban and suburban arterials, collector streets, downtown grids, and corridors with moderate bicycle demand where full separation is not feasible.

Other Considerations: With higher speeds and/or higher percentages of heavy vehicles, greater separation and/or protection from traffic is necessary. In these cases, protected bike lanes are more appropriate.

Crash Reduction: CMF ID 10738; 49% reduction in all crashes on urban undivided roads. FHWA Proven Safety Countermeasure.

Pedestrian Upgrades at Signalized Intersections

What It Is: Enhancements to pedestrian elements at signalized intersections, such as high-visibility crosswalks, countdown signals, accessible curb ramps, pedestrian refuges, enhanced lighting, adequate pedestrian crossing times, dedicated pedestrian phases, and restriction of conflicting permissive left turn phases when a pedestrian call is placed.

How It Works: Improved visibility, dedicated crossing time, and accessible design elements clarify right-of-way and reduce conflicts between pedestrians and vehicles. These upgrades increase driver awareness, encourage yielding behavior, and provide safer, more predictable crossing conditions.

Typical Locations: Urban and suburban intersections with a focus near schools, transit stops, and downtown areas. Intersections with high pedestrian activity or documented safety concerns.

Protected Bicycle Lane

What It Is: Bicycleways separated from motor vehicle traffic by vertical posts, curbs, or medians, creating separation and calming traffic.

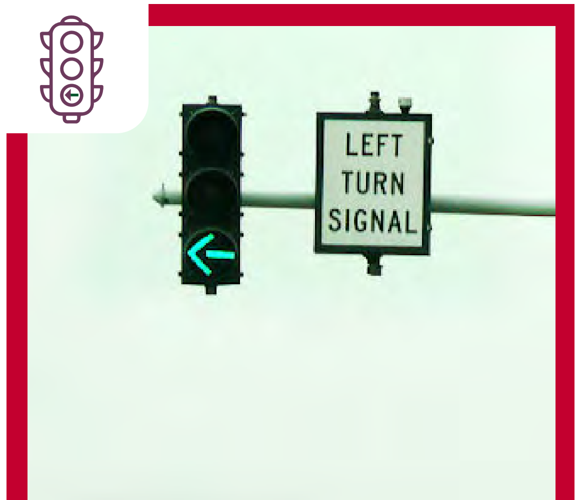
How It Works: Physical separation narrows the perceived roadway for drivers and introduces side friction. Vehicles slow due to added complexity and lane narrowness.

Typical Locations: Urban arterials, downtown grids, campus areas, corridors with high bicycle demand.

Other Considerations: Protected bicycle lanes are preferred to other bicycle facility types when a high percentage of heavy vehicles is present. Snow plows may be unable to clear protected bicycle lanes depending on the width. Where less confident riders are present, another option is to shift the curb inward and install protected bicycle lanes adjacent to and at the same level as the sidewalk rather than on the street to provide additional protection for the cyclist.

Crash Reduction: CMF ID 11553; 54% reduction in all non-weather-related crashes. FHWA Proven Safety Countermeasure.

Protected Left-Turn Movements



What It Is: Dedicated signal phases for left turns to reduce conflicts and improve flow.

How It Works: Provides exclusive green arrow for left turns, separating movements and reducing sudden stops and erratic maneuvers.

Typical Locations: Signalized intersections with significant pedestrian presence or high volume of turning crashes.

Other Considerations: Left-turn movements can be restricted by time of day, and newer equipment will allow permissive left-turn movements to be restricted when a pedestrian places a call to cross.

Crash Reduction: CMF ID 333; 99% reduction in angle crashes.

Raised Crosswalk or Intersection

What It Is: Intersection area or crosswalk elevated to sidewalk level to slow turning and through movements and improve visibility of crossing pedestrians.

How It Works: Vertical plane change forces slower entry speeds and heightens driver attention.

Typical Locations: Main streets, Neighborhood centers, pedestrian-oriented districts, near schools.

Other Considerations: Raised elements may present challenges for emergency vehicles, buses, snowplows, and nearby drainage features. Their placement and design should follow applicable MUTCD guidance and other relevant standards to avoid impacts on visibility, maneuverability, or overall roadway function. Raised crosswalks are typically used on 2- or 3-lane roads with speed limits of 30 mph or less, while raised intersections are generally limited to roads with speed limits of 35 mph or less. These treatments should generally be avoided on truck routes, primary emergency routes, and arterial streets.

Reference Material: CTDOT Technical Brief: Raised Crosswalks/Intersections

Crash Reduction: CMF ID 135; 36% reduction in injury crashes on urban and suburban local roadways.

Raised/Landscaped Median

What It Is: Elevated center medians with planting that separate directions of traffic and visually narrow the roadway.

How It Works: Physical separation reduces cross-traffic conflicts, while landscaping creates a sense of enclosure and narrows perceived width. These visual cues help lower operating speeds.

Typical Locations: Arterials, boulevards, multi-lane corridors.

Other Considerations: The impact of a raised median depends on the roadway context. On multi-lane corridors like the one pictured, a median primarily manages access, separates opposing traffic, and improves operational efficiency without narrowing travel lanes. In contrast, on lower-speed, two-lane roadways, vertical elements and roadway narrowing can create a stronger sense of enclosure that encourages slower speeds. Careful consideration is needed in the placement of vertical elements such as trees within the median to avoid creating sight distance obstructions for turning vehicles on any approach.

Crash Reduction: CM ID 2219; 71% reduction in all crashes on principal arterial roadways.

Ramp Acceleration or Deceleration Lanes

What It Is: Extra lanes that allow vehicles to speed up before merging or slow down before exiting, reducing conflicts with through traffic.

How It Works: Provides space for vehicles to adjust speed outside the main travel lanes, facilitating smoother speed transitions.

Typical Locations: Freeway on-ramps and off-ramps, high-speed interchanges.

Crash Reduction: CMF ID 474; 11% reduction in all crashes with the extension of an acceleration lane by 98 ft. CMF ID 475; 7% reduction in all crashes with the extension of a deceleration lane by 100 ft.

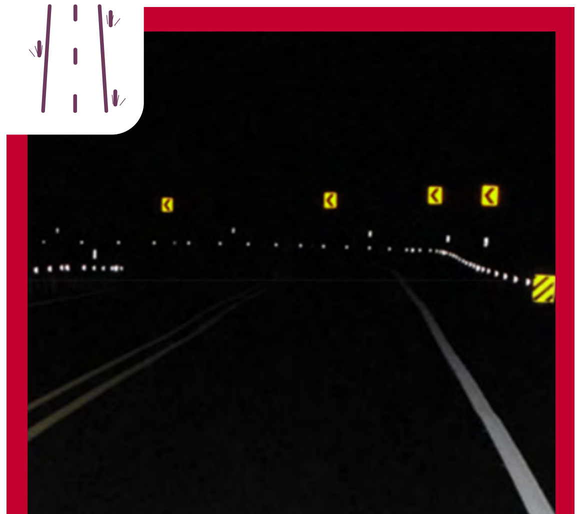
Reduce Vehicle Lane Width

What It Is: Narrower travel lanes (e.g., from 12’ to 10-11’) encourage lower driving speeds.

How It Works: Reduces visual and physical space for vehicles, prompting drivers to slow and maneuver more carefully.

Typical Locations: Urban arterials, main streets, neighborhood collectors, downtown grids.

Other Considerations: Lane widths should reflect roadway speed and vehicle mix; narrower lanes (e.g., 10 feet) may support lower-speed contexts but are generally not appropriate for higher-speed roadways or corridors with a high percentage of heavy vehicles.

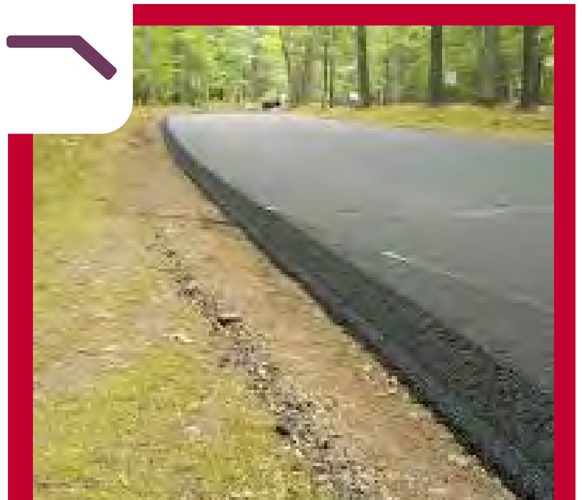


Roadside Delineation

What It Is: Reflective posts or markers along the road edge that outline the roadway path, improving visibility and guiding drivers through curves, especially at night or in poor weather.

How It Works: Reflective surfaces catch headlights to create a continuous visual cue for road alignment, improving visibility and encouraging appropriate speeds.

Typical Locations: Rural highways, curves, mountain roads, areas with limited lighting.



SafetyEdge

What It Is: A pavement edge treatment that creates a 30-35 degree tapered edge between the roadway and shoulder during paving.

How It Works: The sloped edge allows drivers who drift off the roadway to safely re-enter without overcorrecting, reducing the risk of loss-of-control crashes. It also improves edge durability and reduces pavement edge drop-off over time.

Typical Locations: Rural highways, two-lane roads, and corridors without curbs where unpaved or lower-quality shoulders are present and run-off-road crashes are a concern.

Crash Reduction: CMF ID 9205; 11% reduction all fatal and injury crashes. CMF ID 9211; 21% reduction in run-off road crashes on principal arterial roads. FHWA Proven Safety Countermeasure.

Shared Street Design

What It Is: Streets designed for slow speeds where pedestrians, cyclists, and vehicles share the same space, often without traditional curbs or lane markings.

How It Works: Creates an environment of uncertainty that encourages drivers to proceed cautiously, reducing speeds and prioritizing pedestrian movement.

Typical Locations: Downtown districts, mixed-use areas, plazas, and neighborhood commercial streets.

Other Considerations: Shared streets can be plowed but can pose special challenges. Smaller or specialized plows are recommended for snow removal instead of standard large trucks due to possible obstacles and roadway edges. Some cities choose to close the street to vehicles during large snow events.

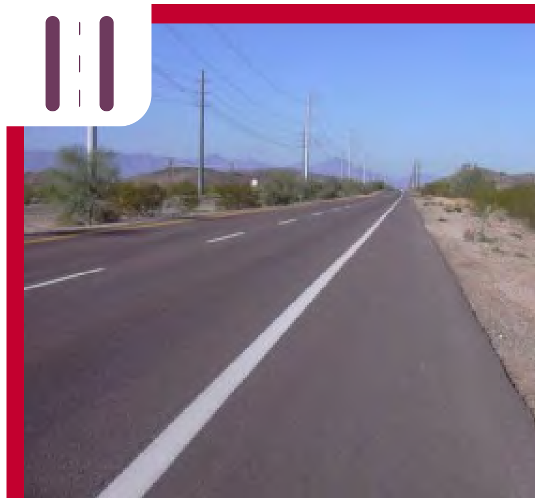
Sharrow

What It Is: Pavement markings placed within a travel lane to indicate that bicycles and motor vehicles share the same space.

How It Works: Sharrows reinforce proper bicyclist positioning within the lane and alert drivers to expect and accommodate bicycle traffic. This shared presence introduces side friction and can encourage lower speeds and more cautious driving behavior.

Typical Locations: Low-speed streets, constrained corridors where bike lanes are not feasible, neighborhood routes.

Other Considerations: Sharrows are not meant for roads with a high percentage of heavy vehicle traffic. This element is only appropriate for roadways with a posted speed limit of 25 MPH or less.



Shoulders

What It Is: Increasing shoulder width to provide recovery space and improve safety for stopped vehicles.

How It Works: Adds paved area beyond the travel lane for emergencies and maneuvering. Drivers feel safer and maintain steady speeds.

Typical Locations: High speed rural roads or winding mountain roads.

Other Considerations: The added recovery space influences driver comfort and perceived safety, which can lead to higher operating speeds if shoulders are wider than two feet. In certain circumstances shoulders can serve as a bicycle facility. However, wider shoulders can encourage higher vehicle speeds on high-speed facilities, while narrower widths may reduce comfort for bicyclists. As a result, shoulder width should be carefully balanced based on roadway speed, traffic volumes, and the intended role of the facility, with consideration of whether a dedicated bicycle facility may be more appropriate.

Crash Reduction: CMF ID 5279; 13% reduction in all crashes with the increase of shoulder width from three to five feet.

Shoulders with Rumble Strips

What It Is: Increased shoulder width paired with rumble strips provide tactile and audible alerts when drivers drift from their lane, while also offering recovery space and improving safety for stopped vehicles.

How It Works: Rumble strips generate vibration and noise when crossed, providing immediate driver feedback and helping reduce run-off-road crashes. The adjacent shoulder provides space for recovery and correction; however, wider shoulders can increase driver comfort, which may lead to higher operating speeds if not carefully considered.

Typical Locations: Rural highways, high-speed roadways, and corridors with a history of run-off-road or lane departure crashes.

Other Considerations: Rumble strips can create noise impacts and are generally not recommended adjacent to developed areas where noise would be disruptive. In these contexts, low-noise designs (e.g., "mumble strips") may be appropriate. Where shoulders are expected to serve bicyclists, rumble strip placement and offset should be carefully designed to maintain usable riding space. Please see Shoulders for additional information about shoulders serving as a facility for bicyclists.

Crash Reduction: CMF ID 2423; 23% reduction in run-off road crashes.

Signal Timing Adjustment

What It Is: Traffic signal coordination that rewards compliance with target speeds.

How It Works: Signals are timed to promote a target speed. Vehicles exceeding the speed are presented with red lights, while those traveling the speed get a wave of green lights.

Typical Locations: Urban and suburban corridors with multiple signals.

Other Considerations: Signal timing adjustments are recommended for mid-range speed environments in this visual guide. These strategies may also be applicable on lower-speed roadways depending on context. In addition, signal timing can be used to support bicycle routes by improving travel continuity and reducing conflicts at intersections.

**Learn more about signal timing adjustments in Chapter 4 and Appendix C*

Single-Lane Roundabout

What It Is: A single-lane roundabout designed to manage traffic at moderate-volume intersections.

How It Works: Entry curvature and splitter islands slow approaching vehicles, while a single circulating lane simplifies movements and reduces conflict points. Yield control at entries keeps traffic moving efficiently without the need for signalization.

Typical Locations: Intersections with steady traffic volumes, areas experiencing crash patterns related to turning movements, or locations where improving safety and maintaining continuous traffic flow are priorities.

Reference Material: FHWA Roundabouts: An Informational Guide

Crash Reduction: CMF ID 211; 82% reduction in injury crashes when converting from a two-way stop-controlled intersection to a roundabout. CMF ID 226; 78% reduction in injury crashes when converting from a signalized intersection to a roundabout. FHWA Proven Safety Countermeasure.

Speed Cushion

What It Is: A raised pavement section (similar to speed humps but with gaps) designed to slow cars while allowing larger emergency vehicles to pass without delay.

How It Works: Cars must slow to 15-25 MPH to cross the cushions, but emergency vehicles with wider wheelbases can pass without impact by straddling the gaps.

Typical Locations: Residential streets, school zones, areas needing emergency access.

Other Considerations: Speed cushions may be applied on roadways with operating speeds under 30 MPH where textured surface treatments are not present. Speed cushions could cause challenges or concerns for snow plows. Speed cushions are not advised for transit corridors.

Crash Reduction: CMF ID 134; 50% reduction in all injury crashes.

Speed Feedback Signage

What It Is: Radar-based signs displaying driver speed next to posted limit to prompt compliance.

How It Works: A radar unit detects speed and updates a conspicuous digital display, can include "Slow Down" messaging. This delivers immediate, short-term reductions in driver speed.

Typical Locations: School zones, neighborhood collectors, transition areas entering towns.

Crash Reduction: 31% reduction in casualty crashes (Winnett and Wheeler, 2002).

Street Trees and Landscaping

What It Is: Planting along the roadway frames the street and introduces vertical elements that encourage calmer driving.

How It Works: Visual enclosure narrows perceived width, rhythm and verticality cue drivers to moderate speed.

Typical Locations: Boulevards, main streets, residential corridors.

Other Considerations: Trees should not be placed in the clear zone at intersections where unprotected movements are being made. Spacing and location of trees should be coordinated with local agencies and/or CDOT engineers/ Landscape Architects. In locations where existing trees create sight distance concerns, curb extensions can provide visibility to crossing vehicles and pedestrians.

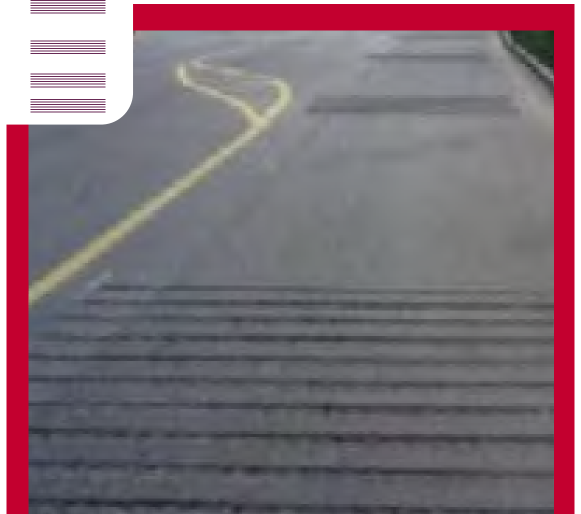
Textured Surface

What It Is: Pavement textures (stamped asphalt, pavers) that signal gateway or slow-zone areas and prompt speed reduction.

How It Works: Audible/tactile feedback and visual cues indicate a change in context (e.g., entering a town center) and encourage slower speeds.

Typical Locations: Gateways, shared streets, city/town centers.

Other Considerations: Textured surfaces are only appropriate for roadways with a posted speed limit of 25 MPH or less. Textured surfaces can be plowed but often require smaller or specialized plows equipped with rubber blades or rotary brushes to protect special pavers. Some cities choose to close streets with textured surfaces to vehicles during large snow events.



Transverse Rumble Strips

What It Is: Raised or grooved strips placed across the lane to warn drivers of upcoming hazards or intersections.

How It Works: When tires pass over the strips, they create a strong vibration and noise that encourages speed reduction. Strips are often spaced in a series, with intervals decreasing as the hazard approaches.

Typical Locations: Approaches to rural stop and signal-controlled intersections, work zones, sharp curves.

Other Considerations: If motorcycles have a heavy presence, consider implementing optical speed bars or an intersection conflict warning system instead. Rumble strips are not recommended adjacent to development where the resulting noise would be problematic. Consider low noise rumble strips (i.e., mumble strips) instead.

Crash Reduction: 28-35% reduction in all crashes (Federal Highway Administration, 2011).

Variable Speed Limit Sign

What It Is: Electronic signs that display speed limits which can change based on real-time conditions, adjusting speeds to match traffic, weather, or incidents for safer travel.

How It Works: Sensors monitor conditions and update the displayed speed limit automatically with the goal of maintaining a safe traffic flow.

Typical Locations: Freeways, high-volume corridors, areas prone to congestion or severe weather.

Crash Reduction: CMF ID 11002; 34% reduction in all crashes on principal arterial interstates. FHWA Proven Safety Countermeasure.

Wide Median with Barrier

What It Is: A wide separation between opposing traffic flows, often with a barrier to prevent cross-median crashes.

How It Works: Physical space and barriers reduce head-on collision risk and provide recovery room. Drivers maintain steady speeds due to reduced conflict risk.

Typical Locations: Freeways, rural divided highways.

Crash Reduction: CMF ID 7040; 97% reduction in cross-median crashes on four-lane freeways and expressways. FHWA Proven Safety Countermeasure.

Wide Shoulders with Rumble Strips

What It Is: Extra pavement width along the roadway edge combined with rumble strips to alert drivers who drift out of their lane and provide recovery space.

How It Works: Rumble strips create vibration and noise when tires cross them, while wide shoulders provide space for correction, helping drivers maintain safer lane discipline and reducing erratic speed changes.

Typical Locations: Rural highways, high-speed roads, areas with frequent run-off-road crashes.

Other Considerations: Rumble strips are not recommended adjacent to development where the resulting noise would be problematic. Consider low noise rumble strips (i.e., mumble strips) instead.

Crash Reduction: CMF ID 5279; 13% reduction in all crashes with the increase of shoulder width from three to five feet. CMF ID 2423; 23% reduction in run-off road crashes with the installation of edgeline rumble strips.

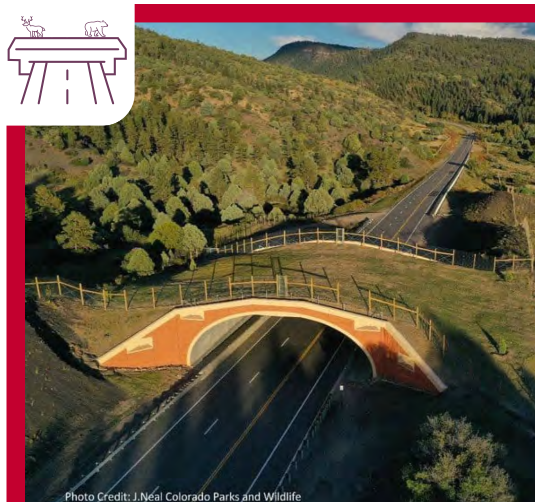


Photo Credit: J.Neal Colorado Parks and Wildlife

Wildlife Crossing Infrastructure

What It Is: Overpasses, underpasses, fencing, and StriderLite™ wildlife reflectors are used to guide animals safely across roadways and reduce wildlife-vehicle collisions. StriderLite™ reflectors create the visual appearance of a fence when illuminated by vehicle headlights.

How It Works: Fencing guides animals toward designated crossings designed to mimic natural paths, helping drivers maintain speed with fewer sudden stops or swerves.

Typical Locations: Rural highways, areas with high wildlife activity, near parks or migration routes.

Crash Reduction: CMF ID 11310; 45% reduction in wildlife-vehicle crashes with the addition of a wildlife crossing structure with fencing.

Appendix B
Roadway Element Cost Estimates

Cost estimates provided in this appendix are based on 2026 cost data and are intended for planning-level purposes only. Actual project costs should be developed during project design and refined based on site-specific conditions, project scope, and implementation requirements.

Roadway Element	Complexity	Cost Range	Details
Advanced Warning Signage Per sign	Low	\$2,000 - \$3,000	Small standard sign
	High	\$5,000 - \$7,000	Large flashing sign
Consolidated Access Points	Low	\$5,000 - \$7,000	Closing one existing access point with barrier
	High	\$27,000 - \$33,000	Closing one existing access point on main road with curb and gutter, installing an alternate access on a side road
Controlled Access Highway/ Freeway	Low	\$11,000 - \$35,000	Closing access with barrier, fence, or gate
	High	\$1,000,000 - \$2,000,000	Closing access and providing alternate access plan to other interchanges
Controlled Mid-Block Pedestrian Crossing	Low	\$55,000 - \$60,000	RRFB, curb ramps, signing and striping
	High	\$250,000 - \$300,000	Full HAWK signal + everything involved
Crash Attenuators at Gore Points Per attenuator Assumes guardrail is existing	Typical	\$50,000	Crash attenuator
Curb Extension or Pinchpoint	Low	\$1000	Paint post scenario: pavement striping, post installation, no hardscape changes, existing pavement in good condition
	Medium	\$9,000 - \$13,000	Small bulb-out, minor sidewalk work, minimal demolition, existing drainage is okay
	High	\$25,000 - \$35,000	Large curb extension, full curb and gutter/sidewalk work, heavy demolition, utilities relocation, ADA curb ramps, new drainage infrastructure, pavement patching, possibly aesthetic or landscaping work
Dynamic Message Sign Per sign	Typical	\$155,000	Includes one message sign and necessary electronic elements
Emergency Pull-Off Area	Low	\$100,000 - \$130,000	Minimal widening of the shoulder (0-4 feet), signage, lighting
	High	\$500,000 - \$550,000	Significant pavement area (full area) and grading, signage, lighting
Emergency Vehicle Turnaround	Low	\$5,000 - \$6,000	Gravel in existing median, signage
	High	\$30,000 - \$40,000	Pavement in median, grading, signage, possible barrier removal (cost varies based on size)
Enhanced Pedestrian Crossing	Low	\$4,000 - \$8,000	Basic high-visibility crosswalk: Ladder or continental pattern, durable paint or thermoplastic, decent existing pavement, basic signage, minimal traffic control, one crossing (one street width)
	Medium	\$20,000 - \$25,000	Larger crossing (wider road, multiple lanes), more durable material, basic signage, potential ramp work, moderate traffic control, may include lighting/reflections etc.
	High	\$45,000 - \$55,000	Very wide crossing, elaborate materials (inlaid, preformed, maybe decorative), full compliance/ramp work, complex signage, multiple enhancements, possibly new power for lighting, concrete or pavement work
Gateway Treatment	Low	\$3,000 - \$5,000	Striping and signage
	Medium	\$120,000 - \$150,000	Landscaped median, curb extensions, striping and signage
	High	\$150,000 - \$200,000	Additional large overhead sign, w/ lighting

Roadway Element	Complexity	Cost Range	Details
Grade-Separated Bicycle/ Pedestrian Crossing Assumes the crossing spans a roadway with two travel lanes in each direction	Low	$50,000 - 75,000	Utilize existing bridge or tunnel infrastructure for crossing, may include pavement, signage
	High	$12,000,000	Complete construction of a new, grade-separated crossing involving structures, grading, and signing. Includes design phase
Guardrails or Barriers at Fixed Objects Per linear foot	Low	$50	Standard metal guardrail
	High	$200	Concrete barrier
Heavy Vehicle Climbing Lane	Low	$1,500 - $2,500	Signage, assumes lane exists
	Medium	$16,000 - $20,000	Signage, striping (per mile), assumes pavement width for new lane exists
	High	$650,000 - $700,000	Widening the road to accommodate a new lane, grading, signage, striping
Increased Stopping Sight Distance Highly context dependent	Low	$25,000 - $30,000	Clearing existing vegetation and trees (per acre)
	High	$500,000-$750,000	Realigning roadway to create better sightlines, assumes 1000 linear feet
Intersection Conflict Warning System (ICWS)	Low	$55,000 - $60,000	Intersection conflict warning system at an intersection of roads with two lanes each
	High	$145,000 - $155,000	Intersection conflict warning system at an intersection of roads, one with two lanes and one with four
Lane Guidance Signage	Low	$1,000 - $2,000	Small sign, assumes it will be added to an existing structure
	Medium	$75,000 - $170,000	Large sign, support post, spans 2-4 lanes
	High	$260,000 - $300,000	Large signs, large support structure, spans 4-6 lanes
Lighting Per intersection	Typical	$175,000	Assumes installation of lighting on two corners of the intersection, wiring, and power supply/meter
Limited Access Highly context dependent	Low	$8,000 - $10,000	Closing one access point, may involve use of bollards or barrier
	High	$1,000,000 - $2,000,000	Closing one access point and providing alternate access plan to other signals
Maintain/Enhance Clear Zone Per acre	Low	$5,000 - $7,000	Mowing existing grass or low maintenance landscaping, trimming back existing vegetation
	Medium	$25,000 - $30,000	Tree removal, ground cover removal
	High	$40,000 - $45,000	Grading and earthwork
Median Barriers Per linear foot	Low	$40	Cable scenario: Cable median barrier (three-cable, high tension, posts installed in median, moderate terrain, median slope manageable, sites not too constrained).
	Low-Medium	$50	Metal scenario: Metal beam guardrail (W-beam or similar).
	Medium	$200	Concrete scenario: Precast concrete barrier/rigid concrete median barrier.
	High	$250 - $350	Constrained site scenario: High-end/difficult terrain/constrained site (steep slopes, constrained median width, major foundation work, drainage/utility conflicts, high traffic control cost).
Mini-Roundabout Assumes no right-of-way acquisition	Typical	$18,000 - $23,000	Raised island, signage, striping, potential bollards along curb returns, traffic control

Roadway Element	Complexity	Cost Range	Details
Multi-Lane Roundabout Assumes no right-of-way acquisition	Low	\$590,000 - \$620,000	Hardscape elements (pavement, curb and gutter, medians), striping, signage (and advanced warning signage), traffic control
	High	\$700,000 - \$730,000	Hardscape elements (pavement, curb and gutter, medians), sidewalks, pedestrian crossing and ADA ramps, reconfiguring lanes for the approaches, landscaping within islands, traffic control
On-Street Parking Per ¼ mile	Low	\$3,000 - \$6,000	Painted parking spots, existing lanes are wide enough to divide into vehicle and parking lane, signage
	High	\$140,000 - \$150,000	Reconfiguring roadway geometry with striping, permeable pavers, signage
Optical Speed Bars Per curve	Typical	\$1,000	Pavement markings, existing pavement is in good condition
Painted Bicycle Lane Per mile	Typical	\$55,000 - \$65,000	Striping on existing pavement (no widening), no buffer, green paint and pavement markings
Pedestrian Upgrades at Signalized Intersections	Low	\$6,000 - \$8,000	Intersection with existing posts, new ped heads, minimal new wiring/power work, simple push-button, no sidewalk/ADA ramp upgrades
	Medium	\$23,000 - \$27,000	New posts, new ped heads, crosswalk upgrades, better visibility features, moderate traffic control, some utility or electrical work
	High	\$65,000 - \$75,000	Challenging site (many lanes to cross, long crosswalks), overhead or mast arm beacons, significant foundation work, major sidewalk/ADA ramp upgrades, possibly new power service, complex traffic control, possible landscaping
Protected Bicycle Lane Per mile	Low	\$70,000 - \$110,000	Buffered bike lane scenario: painted buffer, planter boxes, or flexible posts to separate bikes from vehicular traffic (does not include cement or protected bike lane features), possible roadway configuration changes or traffic control, striping
	High	\$330,000 - \$360,000	Continuous concrete separation (curb), some roadway reconfiguration: C&G and sidewalk work, lighting, signage and striping
Protected Left-Turn Movements Per approach	Low	\$4,000 - \$7,000	Intersection signal timing
	Medium	\$8,000 - \$10,000	Restriping roadway to include left turn lane (no hardscape improvements), new signal head and signage, signal timing
	High	\$40,000 - \$50,000	Adding a lane (widening road or removing median island), new signal head and signage, signal timing, traffic control
Raised Crosswalk or Intersection Assumes no drainage work	Low	\$45,000 - \$55,000	Simple raised crosswalk scenario: Narrow existing road, good existing pavement, minimal grading/drainage work, basic materials, simple crosswalk size (10-15 ft width), ramps and ADA features included
	Medium	\$55,000 - \$65,000	Moderate raised crosswalk scenario: Wider existing road, more lanes, more elevation change, new drainage infrastructure, possibly better lighting/signage, more traffic control needed
	High	\$120,000 - \$180,000	Full raised intersection or large scale crossing scenario: Includes all approaches, more lanes, substantial site prep, new drainage infrastructure, decorative or high visibility materials, possibly aesthetic/streetscape enhancements, significant traffic control
Raised/Landscaped Median Per mile	Low	\$820,000 - \$840,000	Narrow raised median (2-4 ft), simple curb, minimal landscaping, good existing pavement, few utility/ drainage conflicts, minimal traffic control
	Medium	\$1,200,000	Wider median (5-10 ft), curb and gutter, pavement patching, modest landscaping (grass, shrubs), drainage adjustment (inlets, etc.), possible utility or sign relocation, moderate traffic control
	High	\$1,400,000	Wide median (10+) with full planting, irrigation, possibly decorative surfacing, major drainage/utility relocation, possibly lighting, special finishes, significant traffic control

Roadway Element	Complexity	Cost Range	Details
Ramp Acceleration or Deceleration Lanes Per 250 feet Assumes exit and on ramps are existing	Low	$10,000 - $15,000	Existing pavement in good condition and space allows for lanes (no widening required), striping, signage, minimal traffic control
	High	$80,000 - $120,000	Widening roadway, striping, signage
Reduce Vehicle Lane Width Per mile Assumes no drainage work	Low	$15,000 - $18,000	Narrow lanes to nominal width by restriping, repainting lines, removing old extra lane lines, no major curb work, minimal traffic control
	Medium	$25,000 - $35,000	Restriping and adding bike lane or shoulder, some signs changed, maybe minor curb or gutter adjustments
	High	$190,000 – $220,000	More comprehensive reconfiguration of roadway: adjusting curbs, sidewalks, significant traffic control
Roadside Delineation Per ¼ mile	Low	$3,000 - $6,000	Basic enhancements scenario: Add/re-install chevrons, upgrade sign sheeting, add post-mounted delineators, upgrade pavement striping in the curve, maybe some reflective markers.
	Medium	$6,000 - $12,000	Moderate treatment scenario: Similar enhancements along the segment, possibly in-lane pavement warning markings, maybe dynamic or enhanced signs, more delineators, full reflective materials.
	High	$12,000 - $20,000	High treatment/premium delineation scenario: More robust equipment (LED or dynamic chevron or warning signs, speed feedback, large or custom signs), intensive pavement markings, many delineators, possibly raised markers, all reflective materials, enhanced.
SafetyEdge Per mile	Medium	$13,000 – $15,000	Asphalt safety edge
	High	$53,000 - $55,000	Concrete safety edge
Shared Street Design Per ¼ Mile	Low	$50,000	Add streetscape furniture to existing pedestrian areas
	Medium	$$65,000-$75,000	Repurposing parking lanes for pedestrian use, narrowing lanes with striping
	High	$800,000 - $1,200,000	Narrowing the traveled way with hardscape features, raising the street so it's the same level as the sidewalk, textured pavement
Sharrow Per Sharrow	Typical	$1,000	Painted sharrow marking on existing roadway pavement
Shoulders Per mile, one side of the roadway	Low	$6,000 - $8,000	Striping, existing pavement is in good condition
	High	$240,000 – $670,000	Widening the road 4-12 feet (pavement and grading), striping, traffic control
Shoulders Rumble Strips Per mile Assumes continuous rumble strips	Low	$3,000 - $5,000	Asphalt pavement in good condition, shoulder rumble strips, minimal traffic control, accessible location
	Medium	$9,000 - $11,000	Shoulder rumble strips, some traffic control, pavement prep required, two directions.
	High	$17,000 - $19,000	Concrete or rough pavement needing prep/repair, substantial traffic control or lane closures, mobilization into remote area.
Signal Timing Adjustment Assumes signal infrastructure exists and no additional equipment is required	Low	$4,000	Very simple intersection scenario: Few approaches, existing detector data, minimal modeling.
	Medium	$5,000	Typical intersection scenario: 4 approaches, turning movements, pedestrian phases, field data collection, consultant/agency work.
	High	$7,000	High complexity scenario: Complex intersection with corridor coordination and heavy data collection/or adaptive signal control refinement

Roadway Element	Complexity	Cost Range	Details
Single-Lane Roundabout Assumes no right-of-way acquisition	Low	$435,000 - $445,000	Hardscape elements (pavement, curb and gutter, medians), striping, signage (and advanced warning signage), traffic control
	High	$560,000 - $570,000	Hardscape elements (pavement, curb and gutter, medians), sidewalks, pedestrian crossing and ADA ramps, reconfiguring lanes for the approaches, landscaping within islands, traffic control
Speed Cushion	Low	$3,000	Simple asphalt cushion, standard size, minimal site prep, existing pavement in good shape, minimal signage/markings
	High	$5,000 - $6,000	More complex design, pavement repair, new warning signs, paint or reflective markings, moderate traffic control
Speed Feedback Signage	Typical	$2,500 - $7,500	Includes message sign and necessary electronic elements
Street Trees and Landscaping Per ¼ mile Dependent on number of trees	Low	$15,00 - $20,000	Some small trees and basic landscaping, existing irrigation system, no grading required
	High	$35,000 - $50,000	Many larger trees and complex landscaping, installing new irrigation system, potential grading in steeper areas
Textured Surface Per ¼ mile Cost is highly dependent on roadway width	Low	$390,000 - $400,000	Installed at crosswalks and parking spaces
	High	$900,000 - $1,400,000	Installed for full streetscape width (24-38 ft)
Transverse Rumble Strips	Low	$24	Lane reduction transition: three sets of rumble strips
	Medium	$32	Stop sign approach: four sets of rumble strips
	High	$48	Curve approach: three sets of rumble strips in each direction (six sets of strips total)
Variable Speed Limit Sign	Typical	$25,000	Includes variable speed limit sign and necessary electronic elements
Wide Median with Barrier Per linear foot Assumes median exists and is clear of obstacles. If not, see number 20 for clearing costs	Low	$40	Cable scenario: Cable median barrier (three-cable, high tension, posts installed in median, moderate terrain, median slope manageable, sites not too constrained).
	Low-Medium	$50	Metal scenario: Metal beam guardrail (W-beam or similar).
	Medium	$200	Concrete scenario: Precast concrete barrier/rigid concrete median barrier.
	High	$250 - $350	Constrained site scenario: High-end/difficult terrain/constrained site (steep slopes, constrained median width, major foundation work, drainage/utility conflicts, high traffic control cost).
Wildlife Crossing Infrastructure	Low	$55,000 - $66,000	Installing fencing (per mile for both sides of roadway), signage
	Medium	$6,000,000	Repurposing an existing bridge or tunnel, signage
	High	$15,000,000	Constructing a new bridge or tunnel, grading, signage (cost will vary based on roadway width)

Introduction

This technical memorandum provides guidance in using traditional fixed-time coordination signal timing techniques as a tool to platoon and manage motor vehicle speeds. Applied correctly, this methodology results in improved safety and fewer crashes for all roadway users.

As discussed in more detail later in this memorandum, this methodology, if implemented correctly and on the appropriate corridor, can have the following benefits:

- Maintain reasonable speeds and reduce speed differential that can contribute to severe crashes.
- Platoon vehicles in a defined headway with larger gaps which improves safety for:
  - Pedestrians crossing lawfully at unsignalized intersections.
  - Motorists crossing or turning lawfully into or from a driveway or unsignalized intersection.
- Reduce red-light running and associated broadside/approach turn crashes.
- Manage congestion during peak periods to prevent traffic from diverting to lower classification roadways.
- Improve efficiency of traffic flow, helping reduce aggressive driving, leading to less risky behavior and crashes.
- Increase predictability and reduce surprises for drivers and pedestrians, which improves safety.
  - Drivers quickly learn the ideal speed to drive to reduce stops and delay, resulting in platooning and a reduction in unpredictable "stray" high-speed vehicles.
  - Pedestrians learn that the walk phase is recalled every signal cycle at each intersection.
  - Pedestrians learn there are longer gaps in traffic making it safer to cross the street.
- Reduce driver frustration by rewarding drivers with a green light if they follow the corridor speed, which reduces the volume and severity of crashes.
- Reduce motor vehicle emissions.

This signal-timing technique is not a one size fits all application. The following should be considered to determine if this methodology is appropriate for a specific corridor.

- While generally used for fixed-time coordination, semi-actuated/coordinated corridors can work if the permissive green windows with side streets and left turns are well managed to reduce variability in early return to greens and late starts on the mainline.
- The whole corridor should not be oversaturated, but oversaturation of a few intersections can work when the intersections are used to meter downstream traffic.
- This methodology is typically applied on lower-speed corridors (≤ 45 mph).

Urban arterial corridors.

Downtown grid networks.

Cross coordinated corridors.

One-way streets.

Corridors with equidistant signals/street spacing.

- This methodology can also be applied on higher-speed corridors (>45 mph), such as suburban arterials and limited-access expressways with regularly spaced signals. Although higher speeds and longer distances between intersections tend to create more dispersed platoons, consistent intersection spacing still allows the formula to establish predictable progression relationships between signals. As a result, the methodology can provide reasonable bi-directional progression even on higher-speed corridors where individual intersections may be spaced one-half mile to one mile apart.
- Most of the corridor should have consistent intersection spacing or multiples of the minimum spacing – (1x, 2x, 3x, 4x, etc.).
- Corridors with smaller curb-to-curb widths and shorter side street pedestrian clearance intervals perform best with this methodology since it allows for shorter and snappier cycle lengths.

- Use of Leading Pedestrian Intervals (LPIs) with max recall at every intersection is not advised with this methodology, for both the primary street and side streets at night. Based on observations along the two corridors analyzed, drivers can get used to them, see the glow of the cross-street signal indication and run the red light when the cross street is red, putting pedestrians in the crosswalk at risk.
- Vehicle detection is not required due to the fixed-time operations.
- Roadways with multiple intersections spaced 1 mile apart with low side-street friction generally create a higher differential in speed and more dispersed platoons, which means this approach wouldn't be as effective as on a roadway with more closely spaced intersections. Regardless, if signals are consistently spaced, the formula would still provide a reasonable means for progression, bi-directionally, between signals.
- This methodology can limit the ability to minimize delay at intersections because of its fixed-time nature, prioritization of corridor progression, and reduction of early returns to green and late starts to green on the main street.

Methodology

The signal timing methodology referenced in this document follows the fundamentals of coordinating adjacent fixed-timed signals, which is defined as alternate mode operation as described in the Federal Highway Administration's (FHWA's) Signal Timing on a Shoestring and Introduction to Transportation, 2nd Edition by James Banks. This method generally benefits bi-directional progression of traffic regardless of whether there is an imbalance in volume on the opposing direction or not. Both directional platoons (whether high or low volume) should arrive near the beginning of the green since this methodology is based on speed and distance. This method can also be applied to downtown grid networks and one-way pair corridors. Cycle lengths are determined by the block spacing and the desired progression speed of traffic. To have equal progression in both directions, the intersection offsets must be integral multiples of one-half the cycle length. The best-case scenario is to have all cycle lengths the same within the corridor.

Depending on the adjacent block lengths of the corridor and the desired speed progression of traffic, several different alternate mode systems can be used:

Single Alternate System

- The signal display of two consecutive signals is opposite.
- Pattern: (Red / Green / Red / Green)

Double Alternate System

- The signal display of two consecutive signals is grouped together.
- Pattern: (Red, Red / Green, Green / Red, Red / Green, Green)

Triple Alternate System

- The signal display of three consecutive signals is grouped together.
- Pattern: (Red, Red, Red / Green, Green, Green / Red, Red, Red / Green, Green, Green)

The single, double and triple alternate systems are represented in a time-space diagram below in **Figure 1**. Each intersection in the corridor is drawn to scale along the horizontal axis while the vertical axis represents time. The repeating signal cycle (Green/Red) is then graphed for each intersection, and trajectory lines can be drawn continuously through the green phases of each signal on the graph to create a "Green Band" representing the progression of traffic through the coordinated corridor. For the single alternate, the green band is maximized and uses the whole green phase, whereas the double alternate's green band is reduced by one half, and the triple alternate's green band is reduced by one third.

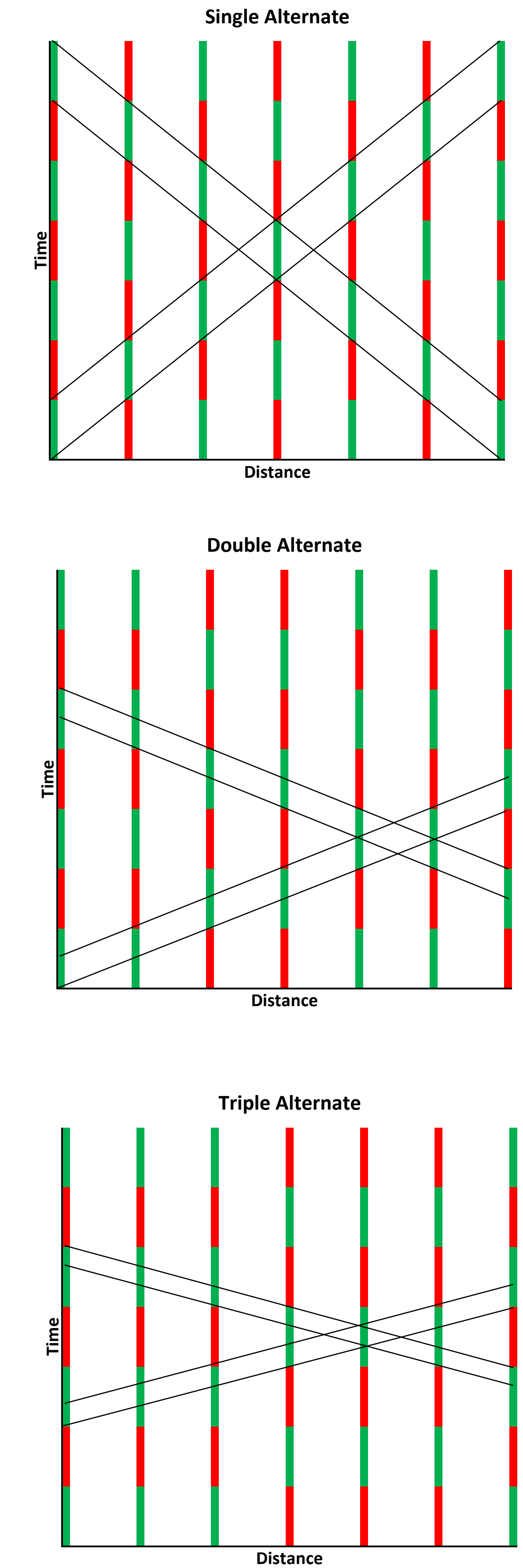


Figure 1: Alternate Systems

The relationship between speed progression, block length and signal cycle length can be represented as follows:

Formula 1: $$S = \frac{2NL}{C}$$

Where S = speed of progression (feet/second)

N = alternate number (1, 2, 3)

L = block length (feet)

C = cycle length (seconds)

Start by calculating the cycle length C by rearranging Formula 1 and inputting a desired speed progression for the corridor along with the block length L and the alternate number N as shown below:

Formula 2: $$C = \frac{2NL}{S}$$

Where C = cycle length (seconds)

N = alternate number (1, 2, 3)

L = block length (feet)

S = speed of progression (feet/second)

It is recommended to solve for (C) using all three alternates to determine what cycle length options are available. Round the result of each calculated cycle length to the nearest five seconds. Multiples of the calculated cycle length also work for the single, double and triple alternates. For example, if the formula results in a cycle length of 30 seconds, then a cycle length of 60, 90, 120, etc. will also work. Only realistic cycle lengths need to be carried forward. Calculate the revised speed of progression (S) for each alternate. It should be close to the original target speed of progression. If the calculated speed of progression (S) varies too much from the target speed of progression, recalculate using a 5 second variation of the desired cycle length until the desired speed of progression is reached.

When determining cycle lengths using this methodology, consider that the target speed of progression should be set based on what the average driver considers reasonable, not an arbitrary speed that provides the maximum bandwidth. A good starting point is using the 85th percentile speed if it is known and within 5 mph of the posted speed. In all cases, the characteristics of the corridor should also be considered when determining which speed to start with. Reasonable speeds will vary by time of day and cycle lengths should be selected for the time of day being evaluated. For example, the peak hours may have more friction due to congestion, reducing the average speed of traffic. If this is neglected, a timing plan that looks good initially on paper may not work in the field because vehicles are traveling either faster or slower than originally assumed.

Downtown Grid

For a downtown grid network where signals are coordinated in both the north-south and east-west directions, the objective is to identify a common cycle length that allows progression on both street systems. When all blocks within the grid are uniformly spaced, determining the cycle length is straightforward. The travel time between adjacent intersections is first calculated using the desired progression speed. The cycle length is then selected so that the travel time between intersections is equal to an integral multiple of one-half cycle length for a single alternate system, one-quarter cycle length for a double alternate system, or one-sixth cycle length for a triple alternate system.

For example, consider a grid where all east-west and north-south blocks are 300 feet and the desired progression speed is 20 mph (29.3 ft/sec). The travel time between adjacent intersections is approximately 10 seconds. A single alternate system would therefore require a 20-second cycle length, a double alternate system a 40-second cycle length, and a triple alternate system a 60-second cycle length.

These values represent the minimum cycle lengths required to maintain the progression relationship between adjacent signals. In practice, longer cycle lengths are often selected to accommodate vehicular capacity, pedestrian clearance requirements, and other operational considerations. Provided the alternate progression relationship is preserved, progression can still be maintained using longer cycle lengths that are integral multiples of the minimum cycle length or otherwise maintain the same phase relationship between intersections.

When block spacing differs between the north-south and east-west directions, separate candidate cycle lengths should first be calculated for each street system. The engineer should then identify a common cycle length that reasonably satisfies both progression patterns. This is often accomplished by identifying overlapping candidate cycle lengths, or by slightly adjusting the desired progression speed on one street system so that both directions converge on a common cycle length.

For example, one direction of the grid may support candidate cycle lengths of 40, 60, 80, 100, and 120 seconds based on its block spacing and desired progression speed, while the perpendicular direction may support candidate cycle lengths of 30, 60, 90, and 120 seconds. In this case, both 60 seconds and 120 seconds are common candidate cycle lengths. A 60-second cycle may provide shorter delays and a more responsive operation where pedestrian clearance and capacity needs can be accommodated, while a 120-second cycle may provide additional green time and capacity at critical intersections but at the cost of longer delays and potentially slower pedestrian service. The selected cycle length should balance progression quality, intersection capacity, pedestrian requirements, and overall network performance.

In most grid systems, perfect progression in every direction is rarely achievable. The objective is to identify a common cycle length that provides acceptable progression in both directions while maintaining the progression relationships established by the alternate mode system and balancing the operational needs of the overall network. In practice, many successful downtown grid systems prioritize achieving predictable progression and minimizing stops over maximizing bandwidth in any single direction.

Alternate Use Cases

The alternate signal timing system methodology has been successfully implemented and tested on two corridors in the City of Lakewood - Colfax Avenue (US 40) and Wadsworth Boulevard (CO 121). Each of these corridors have unique characteristics and challenges that require variations to the alternate timing system. These are detailed below.

Colfax Ave (US 40) – From Kipling St to Harlan St

- Roadway Functional Classification – Principal Arterial.
- Access Control – Non-Rural B Arterial (High density of accesses, raised medians).
- Posted Speed Limit – 35 mph.
- Number of Lanes – Six total.
- Corridor Length – 2.5 miles.
- Number of Signals – Eight.
- Signalized Intersection Spacing –one-quarter mile and one-half mile.
- Annual Average Daily Traffic (AADT) – 20,000 to 25,000 Vehicles Per Day (VPD) in 2023.

Problem

The Colfax Avenue corridor is a famous high-profile corridor with a lot of history. The corridor is a US Highway and is lined with a variety of businesses including restaurants, department stores, grocery stores, auto shops, automotive dealerships, gas stations, motels, liquor stores and more. Colfax Ave sees a lot of pedestrian traffic. Within the past several years, the city of Lakewood has seen a significant increase (one to two per year) in fatal motor vehicle versus pedestrian crashes at night. Upon further investigation, it became apparent that all the pedestrians involved in these crashes were vulnerable users dealing with substance abuse, which leads to unpredictable behavior and poor judgement when it comes to crossing Colfax Avenue mid-block in front of approaching vehicles.

To provide some context, **Figure 2** shows a heatmap of pedestrian crossings in a 24-hour period in and around the intersection of Colfax Avenue and Harlan Street. There are several motels located in the vicinity of this intersection and pedestrians are observed both crossing in the crosswalk and jaywalking, especially west of Harlan St. **Figure 3** shows a heatmap of pedestrians crossing mid-block in a 24-hour period back and forth between motels and the liquor store on the northwest corner of Ingalls Street and Colfax Avenue.

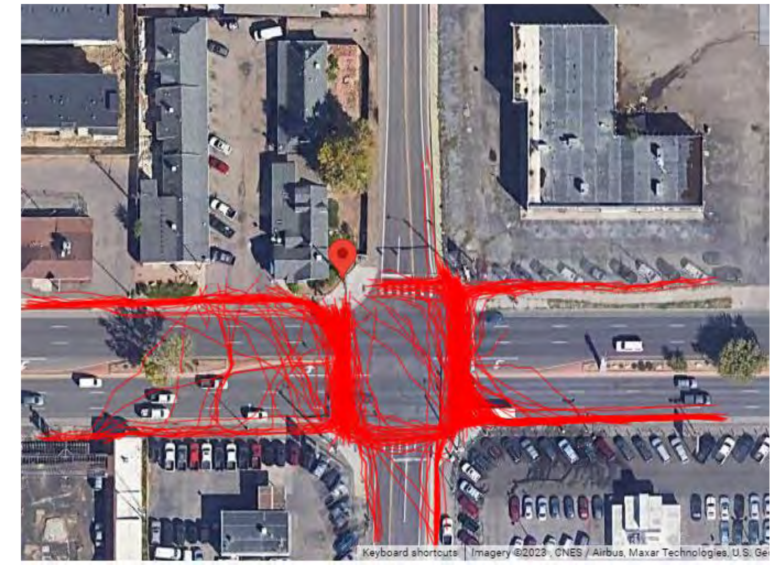


Figure 2: 24-hour Pedestrian Crossing Heatmap (Colfax Avenue and Harlan Street)

Another factor for consideration is the overnight signal timing plan for Colfax Avenue, which historically consisted of resting Colfax in green and serving side street pedestrians and motor vehicles upon actuation, which is common practice. With lighter traffic volume overnight, drivers on Colfax see a long stretch of green lights creating the appearance of a "raceway." This can encourage drivers to speed, creating speed differential and unpredictability for pedestrians judging approaching traffic.

Figure 3: 24-hour Pedestrian Crossing Heatmap (Colfax Avenue and Ingalls Street)

Solution

With this information, a fixed-time overnight signal timing plan was developed using the single alternate system with the intent of reducing the number of fatal motor vehicle versus pedestrian crashes and improving overall safety of the Colfax Avenue corridor.

Below are critical elements specific to the Colfax overnight signal timing plan used to successfully make the single alternate system work:

- Overnight Colfax Avenue Cycle Length Calculations:
  - Goal - manage platoons that result in reasonable operating speeds and defined headways. Reward the drivers who follow the appropriate speeds with a green light. Strive to never stop the driver as long as they follow the progression speed of the signal.
  - Identified a "snappy" short cycle length to create a tight platoon. At night, the traffic volume is light, drivers are generally familiar with the area, and the tolerance for stopping at a bunch of red lights is low, so it is important to balance giving green time with clearing platoons, while limiting excess green time.
  - Identified a narrower green window to discourage speeding through several consecutive intersections.
  - Shortest signalized block spacing: L = one-quarter mile or 1,320 ft.
  - Posted speed: S = 51.33 ft/sec or 35 mph.
  - Calculated cycle length: C = 51.4 seconds.
    - Wadsworth at Colfax Avenue was running a 110-second cycle for the Wadsworth corridor overnight.
    - Rounded up to 55 seconds to get a half cycle and have cross coordination.
  - Solved backwards for speed with revised cycle length S = 48 ft/sec = 32.7 mph
    - 32.7 mph is a reasonable speed for Colfax in a posted 35 mph zone and when traffic volumes are low.
- Pedestrian Phasing:
  - Recalled Colfax Avenue and side street pedestrian phases.
    - Ensured walk and pedestrian clearance times fit within cycle length.
    - Reduced walk times from 7 seconds to minimum allowable of 4 seconds to fit within the 55 second cycle. The 4-second walk is run by time of day so daytime plans can still run a 7-second walk. The ability to create gaps in traffic by creating vehicle platoons was a priority over a longer cycle length, especially since the pedestrians in this case were crossing mid-block rather than in the crosswalk.
    - Some older controllers on the Colfax corridor do not allow changing the walk times by time of day. As a result, some walk times are set at 4 seconds for all time-of-day plans. Longer cycle lengths during the day provide a longer walk display on the coordinated movement because they are set to rest in walk.
    - Eliminated variability with early return to green or late starts on Colfax Avenue.
    - Placed calls for pedestrians who may not push the pedestrian button or in some cases, assisted pedestrians who may be crossing lawfully at unsignalized intersections between signals.
- Left Turn Phasing:
  - Protected/Permissive left turns – programmed to run in permissive mode during the overnight plan to prevent variability with early return to green or late starts. The protected phase is typically not needed due to low volumes during the overnight timing plan.
    - Considerations for running in permissive mode overnight (reference Colorado Department of Transportation's Left-Turn Treatment Guidelines for Signalized Intersections – July 2023)
      - Left turn volume less than or equal to 2 vehicles/cycle/hour.
      - Low left turn volumes plus low opposing through volumes.
      - The cross-product rule: cross product = (left turn volume x opposing through volume).
        - If the cross product ≤ 50,000 for instances with a single opposing through lane – consider use of permissive lefts.
        - If the cross product ≤ 100,000 for instances with two opposing through lanes – consider use of permissive lefts.
      - Locations with negative offsets – ensure adequate sight distance with reduced opposing volume.
  - Protected-only left turns – programmed to run a short max recall to prevent variability with early return to green or late starts.

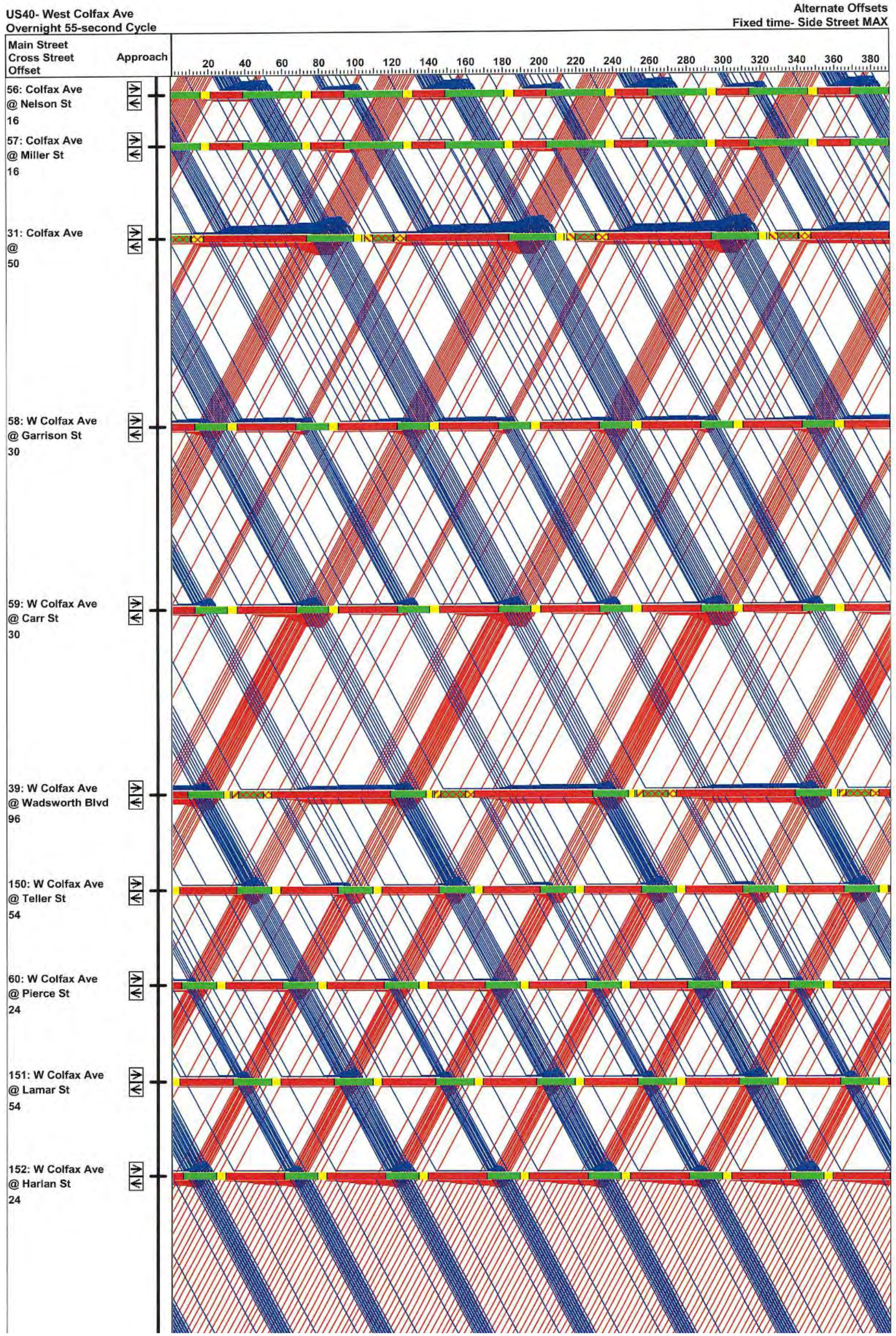


Figure 4 - Colfax Avenue Overnight Timing Plan - Synchro Time/Space Diagram

Figure 4 shows the Colfax Avenue overnight time/space diagram from Synchro, which is very similar to the single alternate system shown previously in **Figure 1**.

The single alternate system eliminates the stretch of successive green signals that creates a "raceway" along Colfax Avenue overnight by providing an alternate signal display pattern at each consecutive signal (Red / Green / Red / Green). As the platoon approaches the first intersection in the system, they receive a green. As they pass through the green approaching the next signal in the system they will be faced with a red until about the time they arrive, when they are rewarded with a green if they are traveling at or slightly below the desired speed of 32.7 mph. With the overnight plan, there are less distractions and drivers are more focused on the next signal ahead. Displaying red on the downstream signal and changing it to green just ahead of the approaching platoon discourages excessive speeding and encourages consistent speeds so that braking is rarely required when the progression speed is followed. This also helps keep the platoon of vehicles together, which results in larger gaps for pedestrians who decide to cross illegally mid-block.

Overnight Results

Prior to implementation, every 5 minutes, 20 people were traveling at least 1 mph over the posted speed limit. After implementation, drivers adjusted quickly and that number dropped to four people every 5 minutes. Drivers familiar with the area only took a few nights to show compliance. Many drivers adapted and adjusted their speed when they were within the coordinated signal system because of consistency and repetition of the operations from intersection to intersection and the consistent reward of receiving a green as they approached at the programmed speed. This was evident from observing recorded footage as vehicles encountering the first several signals in the corridor stopped more frequently compared to signals towards the middle or end of the system where fewer stops were observed. There were instances where motor vehicles slowed down as they approached the red light at an intersection, but they were quickly rewarded with a green to continue moving unless their speed was significantly high. After the overnight timing plan was in place for some time to give corridor users a chance to get used to it, speed data was pulled to see how the timing plan was performing. **Figure 5** shows a 5-day average number of overspeeding vehicles for the eastbound approach of Colfax Avenue at Harlan Street. The vertical axis shows the "Average Number of Overspeeding Vehicles," and the horizontal axis shows time of day in a 24-hour period. The overspeeding vehicles are shown in 5-minute intervals. The figure shows a sharp drop in overspeeding vehicles around 9 p.m. when the overnight timing plan is implemented. This trend continues through the night until about 5 a.m. when the AM-Peak plan is implemented.

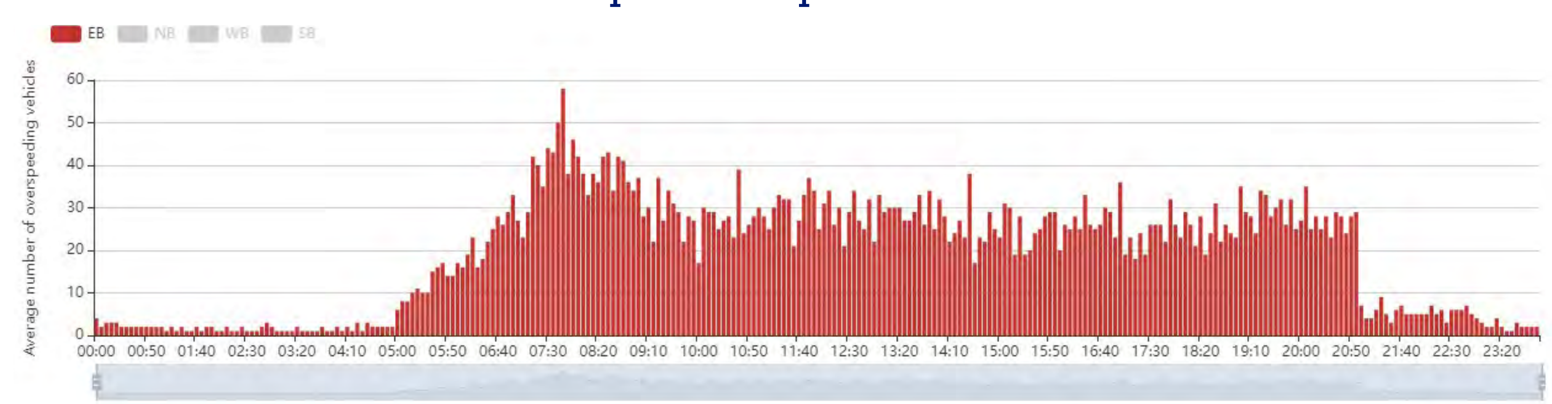


Figure 5 – Reduction in Average Overspeeding Vehicles (Overnight)

Midday and PM Peak Single Alternate Implementation

After successful implementation of the overnight timing plan, development and implementation of midday and PM peak timing plans using the single alternate system were evaluated. Daytime operations require a longer signal-cycle length of 75 seconds as it allows for half cycle cross coordination with Kipling Street and Wadsworth Boulevard which are running a 150-second cycle for the midday and PM peak. Using the single alternate system, the 75-second cycle length results in a progression speed equal to S = 35.2 ft/sec = 24 mph, which would typically be considered too low for a posted 35 mph road. However, Colfax Avenue, during the midday and PM peak experiences a lot of friction from bus stops, driveways, unsignalized intersections and six lanes of traffic, causing traffic to travel at slower speeds than the 35 mph posted speed. The protected/permissive left turns were set to max recall to accommodate the left turn volume and prevent variability with early return to green or late starts for traffic progression on Colfax Avenue. Data was pulled after both the overnight and midday plans were in place for a while. As shown in **Figure 6**, the results during the midday are similar to the overnight plan. The PM peak timing plan was implemented soon after the midday plan with similar results. Unfortunately, the same graphical representation of the after condition for the PM peak was not available at the time this was written.

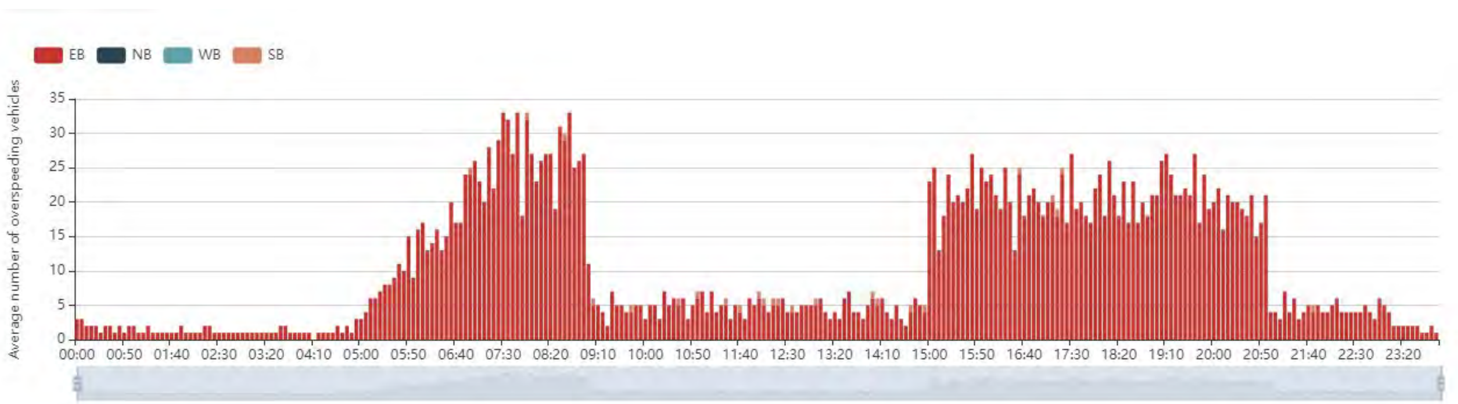


Figure 6 – Reduction in Average Overspeeding Vehicles (Overnight & Midday)

AM Peak Colfax Avenue

The single alternate system timing plan has not been implemented for Colfax Avenue for the AM peak at this time. Colfax Avenue would have to run a 75-second cycle length to cross coordinate two major arterials (Kipling Street and Wadsworth Boulevard) as they run 150-second cycle lengths during the AM peak. The resultant speed for a single alternate system with a 75-second cycle length is 24 mph. This is too slow of progression on Colfax Avenue during the AM peak because there is less friction on the corridor at this time of day. During the AM peak many of the businesses are not open and traffic volumes are generally lower, allowing vehicles to travel at higher speeds than during the midday and PM peaks.

Colfax (US 40) Summary

Overall, the strategic implementation of the single alternate system on the Colfax Ave corridor has proven to work well for the midday, PM peak and overnight timing plans. These timing plans create and manage the speed of tight platooned vehicles through snappy and consistent signal timing that is quickly learned, predictable and creates respect and compliance. Overall, a drastic reduction in the severity and number of motor vehicle versus pedestrian crashes has been observed. The overnight plan was implemented in January 2020 and the midday and PM peak plans in July 2024. At the time this document was written (June 2026), no additional fatal pedestrian collisions had occurred during the time of day the alternate signal timing approach was in place. Prior to implementation, this segment of roadway typically experienced one or two pedestrian deaths each year, all occurring in the twilight or overnight hours.

Wadsworth (CO 121) – From Mansfield Avenue to 26th Avenue

- Roadway Functional Classification – Principal Arterial.
- Access Control – Non-Rural A Principal Highway.
- Posted Speed Limit – 40 mph (Jewell Avenue to 26th Avenue) 45 mph (Mansfield Avenue to Jewell Avenue).
- Number of Lanes – four to six total.
- Corridor Length – 7.5 miles.
- Number of Signals – 24.
- Signalized Intersection Spacing – one-quarter mile and one-half mile.
- AADT – 36,000 to 64,000 VPD in 2023.

Problem

The Wadsworth Boulevard corridor is a major north/south urban principal arterial that carries a lot of local and regional traffic. The corridor is a state highway and provides access to commercial districts, transit corridors, several East/West US Highways, and residential neighborhoods. Especially during the PM peak, Wadsworth Boulevard sees significant congestion at a few bottleneck locations.

Signal timing strategies

Several attempts had been made to address queuing, delays, and crashes through signal timing, with limited success. Traditional coordination strategies often prioritize the dominant direction of travel (e.g., outbound in the AM peak and inbound in the PM peak). However, Wadsworth Boulevard carries approximately 60,000 VPD with substantial demand in both directions. Under conventional timing approaches, prioritizing one direction often resulted in excessive delay and additional stops for the opposing direction.

Also, the longer progression patterns associated with traditional coordination resulted in platoons becoming increasingly dispersed as they traveled through the corridor. Differences in driver speed and vehicle spacing created larger headways between vehicles, reducing the efficiency of the available green time. With few options to improve corridor operations, a variation of the alternate signal timing system was evaluated.

Below are elements specific to the Wadsworth Boulevard PM peak timing plan. They are critical to successfully making the alternate system work:

- PM Peak Cycle Length Calculations
  - Corridor includes 24 signalized intersections with varying spacing.
  - Shortest signalized block spacing: L = one-quarter mile or 1,320 ft.
  - Shopping center signals (typically 600-800 ft spacing) can generally be accommodated depending on the left-turn phasing at neighboring intersections.
  - Calculations were made for single, double and triple alternates to see what cycle length and travel speed combinations could work.
  - Ultimately ended up using quarter mile spacing with a triple alternate system.
  - Posted speed: S = 58.67 ft/sec or 40 mph.
  - Calculated cycle length: C = 135 seconds.
    - Cycle length is too short and incompatible for cross coordination.
    - Decided to use 150-second cycle length.
  - Solve backwards for speed with chosen cycle length S = 52.8 ft/sec = 36 mph.
    - 36 mph is a reasonable speed for Wadsworth in a posted 40 mph zone during congestion.

The signals on the Wadsworth Boulevard corridor were then grouped into three-quarter mile alternate blocks (clusters) on a map to identify which group of signals would be green at the same time and which ones would be red at the same time. The intersections with the most congestion or those that determine the cycle length are good starting points for clustering intersections. The three-quarter mile clusters were a result of the minimum spacing of intersections being one-quarter mile within a triple alternate. This creates a maximum block distance of three-quarters of a mile. **Figure 7** shows the three-quarter mile cluster spacing on a generic time/space diagram and **Figure 8** shows the cluster spacing drawn on a map for the Wadsworth Boulevard corridor.

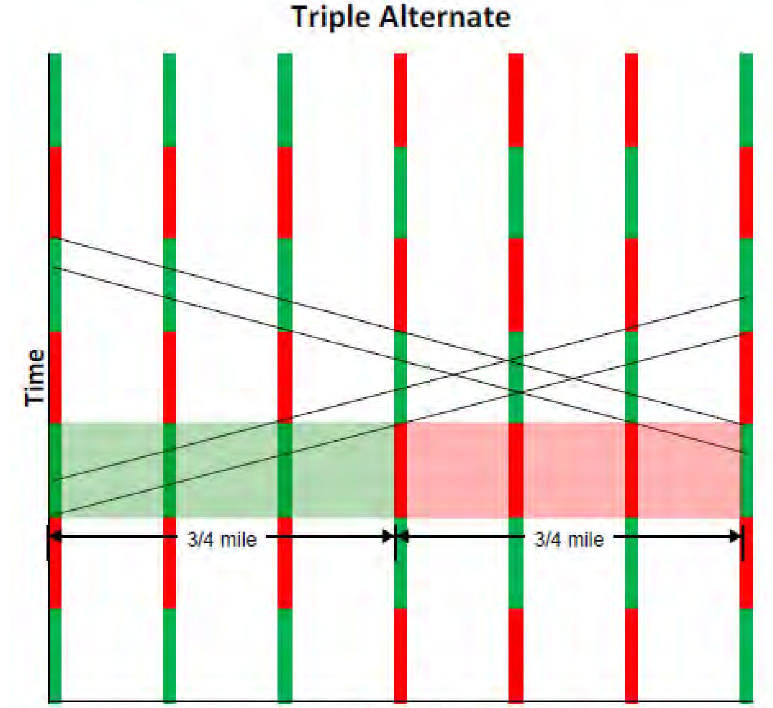


Figure 7 – Wadsworth Boulevard (CO 121) Block Spacing

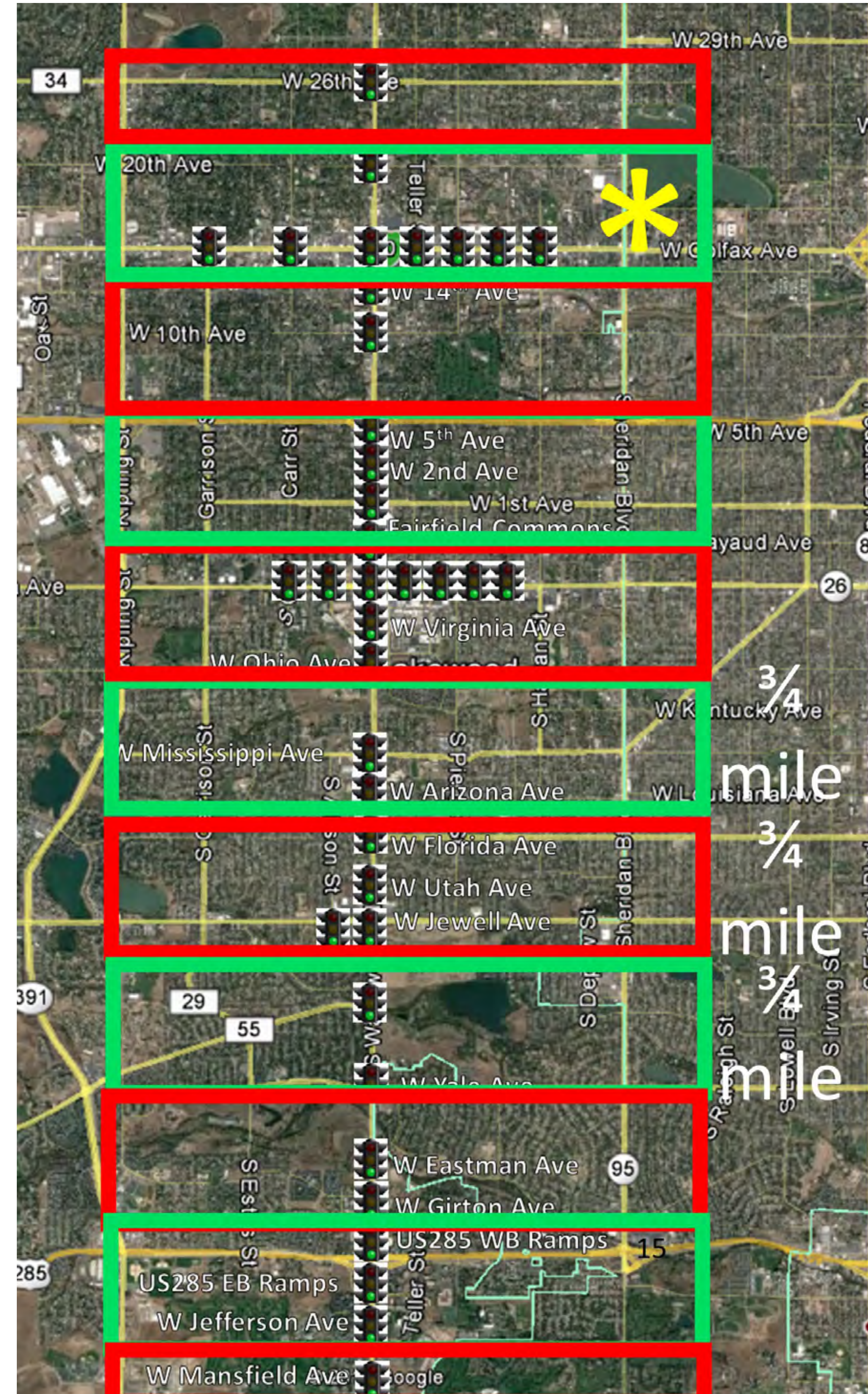


Figure 8 – Wadsworth Boulevard (CO 121) Three-Quarter Mile Block Spacing

- Pedestrian Phasing:
  - During the PM peak there are a lot of vehicle calls on the side streets so pedestrian recalls are not necessary.
  - It is important to keep the side street splits and mainline left turn phases consistent to the point where they are close to using their maximum allotted green time. This will reduce the opportunity for the side street to gap out or terminate the side street green early, creating an early return to green on Wadsworth. An early return to green will release platooned vehicles earlier than desired, which can affect coordination. This strategy mimics pedestrian recall or side street max recall.
  - The larger intersections (Arterial/Arterial) on the Wadsworth corridor can cover the pedestrian signal phase within the adjacent vehicle split and retain coordination.
  - Several intersections on Wadsworth have crosswalk phases that do not fit within the side street vehicle split which will cause the signal to go out of coordination if not mitigated. In these instances, a side street pedestrian call would cause the traffic signal controller to go into transition (out of coordination) requiring several signal cycles to get back into coordination and creating a late release to green on Wadsworth. To mitigate this potential concern, at most locations on Wadsworth the pedestrian phase on the side street is covered with the coordinated split to prevent major transitions or losing the offset with neighboring intersections. The traffic signal controller timing parameters are set to ensure the coordinated vehicle split covers the pedestrian phase. A short max green time is used, the "max inhibit" setting is removed, and the max green is set to "MAX1," which truncates the side street vehicle split except for when a pedestrian call is placed.
  - Locations where the pedestrian phase does not fit within the vehicle phase typically have infrequent pedestrian calls, so the impact to coordination is relatively low. Care should be taken to reduce the number of intersections where coordination is affected due to side street pedestrian calls. If this cannot be mitigated or managed effectively, the alternate timing methodology may not operate as intended.
  - The Wadsworth/Colfax Avenue and Wadsworth/Alameda Avenue intersections run pedestrian recalls on all four approaches to accommodate the high pedestrian activity at these locations. This ensures pedestrians have a safe opportunity to cross without relying on pushing the pedestrian signal push button. This also increases safety for vulnerable users who may not care to push the pedestrian push button. Using pedestrian recalls also meters the release of traffic upstream and downstream, managing congestion and platoon progression throughout the corridor.
- Main Street Left-Turn Phasing:
  - Wadsworth has a mix of protected-only left-turn signal heads and protected/permissive flashing yellow arrow (FYA) left-turn signal heads. During the PM peak, a variety of left-turn phasing combinations are used to enhance block transitions within the triple alternate system. These result in improved safety and progression:
  - Protected Only:
    - Most left-turn movements on Wadsworth are programmed to operate protected only.
    - Addresses safety issues such as negative offsets and/or poor sight distance.
    - Eliminates the yellow trap. A yellow trap can occur for the "permissive only" left turn when the opposite direction has a lagging protected left-turn movement. The permissive left-turning vehicle sees the onset of yellow thinking the opposing through movement also has a yellow and they decide to clear the intersection, when in fact the opposing through movement still has a green.
    - Can be used as lead/lead, lag/lag and lead/lag configurations.
  - Protected/Permissive (FYA):
    - Protected/permissive operation is evaluated on a case-by-case basis with considerations for available sight distance, left turn volume and sufficient storage, available gaps in opposing traffic, and adequate traffic operations.
    - Can be used as lead/lead, lag/lag configurations.
    - To avoid a perceived yellow trap conflict, opposing lead/lag protected/permissive left-turn phasing is avoided in place of protected-only phasing on the lead approach.
      - This prevents the lead approach motorist from seeing consecutive through signal heads go from solid green to solid yellow, and assuming they need to clear the intersection (in front of an approaching vehicle facing an extended green).

- Lead/Lag
    - Optimizes signal progression by maximizing the green band width.
    - Allows the onset of yellow from one signal to the next to be set at the end of the green band, reducing arrivals on red and red light running.
    - Lead the left turn at the first signal entering the block.
    - Lag the left turn at the last signal exiting the block.
    - Left turn phasing at signals in the middle of the block should be evaluated on a case-by-case basis and can run lead/lead, lead/lag or lag/lag.
    - Allows the turn lane to fill up as the main platoon passes the intersection during the green, then flush.
    - Reduces chances of the left turn lane being "starved" or blocked by the queue of the adjacent through-lane queue resulting in inefficient use time.
    - It is preferred to lag the approach that has the most through traffic, so that the opposing lead approach can gap out.
- Lead/Lead
    - Lead/lead signal phasing is utilized on the Wadsworth corridor during the PM peak on a case-by-case basis.
    - Typically lead/lead left-turn phasing occurs at signals that are located within the middle of a defined three-quarter mile alternate block to accommodate the green progression or locations where a significant mismatch in opposing left turn volumes exists, especially if the low volume approach would have been a lag left. This is not ideal because a low volume approach with a lag will always max out even if one vehicle is present, but when no vehicles are present, results in an inconsistent onset of yellow.
- Lag/Lag
    - Lag/lag signal phasing is used on the Wadsworth corridor during the PM peak on a case-by-case basis.
    - Typically lag/lag left turn phasing occurs at signals that are located within the middle of a defined three-quarter mile alternate block to accommodate the green progression.
    - When both approaches are lagged, they can gap out, which may be beneficial over lead/lag in some scenarios. Occasionally, and only when running protected-only, mismatched opposing lag left-turn splits are used.
    - Permissive-protected lag/lag left-turn phasing is always run with equal split time and forced to terminate together to avoid the virtual yellow trap. This is done by programming equal left-turn splits and copying detector calls from one left turn to the other and vice versa.

- Minor Side Street Left-Turn Phasing
    - Typically, lag/lag permissive/protected FYA left-turn phasing is run on the minor side streets. This:
        - Reduces time needed for the side street by allowing left turns to permissively make turns first if there are gaps. The protected green arrow may not be needed but is there in case.
        - Reduces pressure for drivers making a permissive left. If a driver is unable to find a gap to turn, they learn over time they will eventually get a protected green arrow to clear safely. Leading protected/permissive left turns can make a driver feel more pressure to turn, especially during the yellow clearance phase. This puts them in a potentially dangerous situation with opposing red-light runners.
        - Mitigates situations where left-turning vehicles are queued behind through vehicles and can't access the left turn lane.
        - Allows pedestrians to go first, generally when there is adjacent through traffic. The through traffic reduces gaps for permissive opposing left turning vehicles until after the through traffic has cleared the intersection. This can reduce permissive left turn/pedestrian conflicts.
            - Observations are that drivers who miss the protection of a leading left-turn phase are more focused on seeking a gap to make a permissive left turn movement than observing a pedestrian crossing in an adjacent crosswalk. With the onset of yellow, the turning drivers are still typically focused ahead on the opposing vehicle(s) clearing, and less focused to the left where the adjacent pedestrian is clearing, creating the potential for a motor vehicle and pedestrian crash.

- Prior to the implementation of lagging left turns on the side streets, many pedestrians would start walking on DON'T WALK during the conflicting protected lefts, which was not desirable. Lagging the left turns and allowing pedestrians to cross first also helps with coordination/congestion on mainline. Motorists can turn left when the pedestrians cross the non-conflicting half of the roadway during the FYA and by the end of pedestrian clearance interval, usually most left-turning vehicles have made their turn, so there is less wasted time due to a side street protected left turn phase and more time given back to the mainline. Again, this helps minimize late releases on mainline as well as controller transitions.

Figure 9 shows the Colfax Avenue overnight time/space diagram from Synchro, which is very similar to the Triple Alternate System shown previously in **Figure 1**.

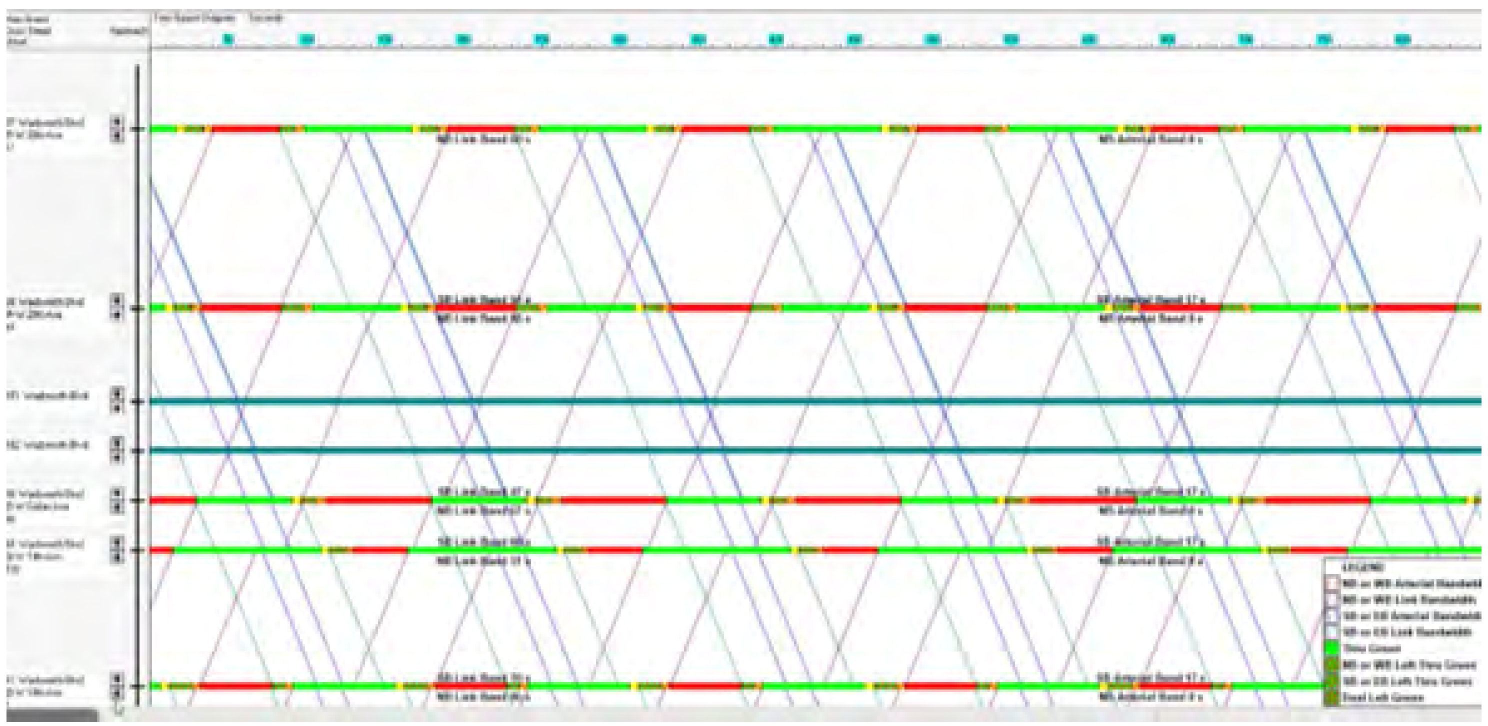


Figure 9 – Wadsworth Boulevard PM Peak Timing Plan – Synchro Time/Space Diagram

PM Peak Results

After implementation of the PM peak timing plan, it was evident reevaluation of some of the alternate blocks would be required even though the initial signal timings and time/space diagrams looked good on paper. Field observations noted problematic congestion and queuing at a couple major intersections, which led to experimenting with and adjusting the boundary limits of the three-quarter mile alternate blocks to either move a signal into the block or take it out. The results improved after making some of these changes and field optimizing the timings.

Wadsworth (CO 121) Summary

Overall, the triple alternate system for the PM peak of the Wadsworth corridor helped address congestion on the corridor by managing platoons of cars and metering traffic at strategic locations. The platooning of vehicles and creation of gaps allow for the safer crossing of Wadsworth at unsignalized side streets, accesses, and permissive left turns. Additionally, a significant reduction in crashes has been observed both on Wadsworth and on the side streets and adjacent roadways that were affected by cut-through traffic. Improved operational performance of the Wadsworth corridor was observed through recorded traffic footage. This improved performance reduced driver frustration, risky driver and pedestrian behavior, and cut-through traffic on adjacent parallel streets. Unfortunately, a before and after study was not performed, but crashes on both Wadsworth and neighboring collector and local streets have declined since the implementation of this timing. This hints at reduced frustration and cut-through traffic as an outcome. Standing queues were also observed to be significantly reduced in the PM peak.

The primary reason for implementing the triple alternate system to the PM peak plan was that the traditional approach to signal timing was no longer working due to over-capacity intersections and the alternate system functioned as a metered approach. The triple alternate system could be implemented for the AM peak and midday timing plans, however, the current timing plans are adequate, so revised timing plans are not needed at this time. Implementation of the triple alternate system overnight would not work well on the Wadsworth corridor because it would require too long of a cycle length to accommodate long recalled side street pedestrian phases and all the protected-only, left-turn phases would have to be recalled. This would create unnecessary delay in the middle of the night and make it difficult to have snappy signal phasing to manage small platoons of vehicles. It is believed this would encourage red light running out of frustration, and the unpredictability of pedestrian actuations would not have resulted in the green reward and consistent platoon speeds that were realized on Colfax overnight.

Additional Signal Timing Considerations for Managing Speeds and Improving Safety

- General:
  - Evaluate the existing environment—are people familiar with the area? Two roads could have the same geometry but different users, so the issues and time of day could be very different.
  - It is critical to use sound engineering judgement and closely monitor a retimed corridor after implementation to ensure the signal timings do not create unintended consequences.
  - Older signal equipment may have limitations. For example, older controllers may not allow flexibility in modifying base timing parameters by time of day. As mentioned previously for Colfax Ave, the walk time for the overnight plan was reduced from a standard of 7 seconds to the minimum Manual on Uniform Traffic Control Devices (MUTCD) allowable 4 seconds to be able to make the 55-second cycle length work.
  - Maximum recall for vehicle phases is better than minimum recall in the alternate timing system. Minimum recall is typically too variable for the alternate timing system. A short minimum recall can encourage speeding to catch or extend the green light.
- Signal Coordination:
  - It is suggested to avoid progressing traffic from a stop condition into yellow at the next signal as this creates frustration for drivers and can lead to risky behavior or red-light running. This includes traffic entering the system from a side street left turn movement into a mainline downstream yellow.
  - Avoid back-to-back stops on a coordinated corridor.
- Adjacent Signals:
  - New signals being constructed, changes to signal timings, and additional phases to existing signals (e.g. left turn or bike/transit/pedestrian phases) along a corridor, or within the center of a city grid will require adjustments to signal timing on cross-coordinated corridors, as well as coordination with neighboring jurisdictions.
  - It is suggested to avoid progressing traffic into a yellow or a signal that just turned red. Adjust timings so the signal is red early enough to discourage drivers from speeding to beat the signal or risk running a red light.
- Leading Pedestrian Interval:
  - It is suggested to avoid using an LPI at night. Staff observed that drivers who could see the side-street signal heads may recognize that the side street was displaying red and incorrectly conclude that there are no conflicting users in the intersection. During the LPI, the delay between the mainline yellow change interval and the appearance of a conflicting vehicle movement can feel unusually long, creating a potential expectancy violation. Some drivers may perceive this period as excessive lost time and choose to proceed through the red signal, believing the intersection is clear. In reality, pedestrians may be entering the crosswalk under the LPI and could be difficult for drivers to detect, particularly at night when pedestrian conspicuity is reduced.
  - It is suggested to avoid using an LPI on recall. If recall must be used for an LPI, it is advised not to apply it systemwide so drivers don't catch on and start running the red during the LPI.
  - It is suggested to avoid using an LPI on recall, especially for the mainline. Impatient drivers may use the LPI and violate their red signal to get a head start and clear the intersection. This can also happen with a permissive left turn opposing a long-standing queue that may delay the turning driver until an acceptable gap in traffic occurs.
- Pedestrian Timings:
  - It is suggested to use side street pedestrian recall whenever possible for overnight side streets when using the alternate system. Consistency and uniformity are very important within the system for predictability.
  - For main street pedestrian phasing, it is suggested to recall the pedestrian phases and "rest in walk." This provides pedestrians with the largest available window to cross the street and provides a countdown clearance interval with the remaining time left to cross which coincides with the end of the adjacent non-conflicting green phase for motor vehicles.

- Recalling the main street pedestrian phases and resting in "Don't Walk" can create an unsafe condition for pedestrians who arrive at the intersection at the end of the pedestrian clearance and are faced with a solid "Don't Walk". Oftentimes there is enough time remaining with the adjacent non-conflicting green phase for a pedestrian to still clear the intersection. However, should a pedestrian choose to cross during the green and a solid "Don't Walk", they will be unaware of the remaining clearance time before the signal turns red and can get stranded in the street or median.
- Resting in a solid "Don't Walk" with an opposing lagging left-turn signal phase can result in a vehicle/pedestrian conflict. The pedestrian, seeing adjacent through red signals, fails to realize the opposing left turn signal is green. The same can occur on the side street when the pedestrian only has a view of the lead signals being red, but not the lag approach signals being green. This is an issue for a pedestrian who unlawfully crosses against a red and "Don't Walk" signal. This sometimes occurs due to a perceived, unnecessary delay by the pedestrian. A pedestrian that is otherwise accustomed to seeing the walk or "Flash Don't Walk" when it is safe to cross, may not make this same mistake.

- Queue Jumps:
  - Incorporation of queue jump signals would require further evaluation to ensure it wouldn't cause more issues with the overall operation. Consideration should be made for the bus frequency, cycle length, driver expectancy, geometry (dedicated bus lanes, dedicated turn lanes/queue-jump lanes, bus pullouts, etc).
  - Generally, removing time from the front of the green for queue jumps in this type of system will cause significant queuing, especially because vehicle delay is minimized by ensuring traffic passes through the signal at-speed. In these cases, a queue-jump signal may create backups that result in standing queues that otherwise would not have existed, delaying subsequent motorists and transit operators alike. Increasing the cycle length to accommodate the queue jump may result in less dense platoons, which also would increase side street delays of pedestrians and bicyclists and may also result in them having less respect for the red or "Don't Walk" indications if they perceive wasted green or adequate gaps not being used by platoons. In this system it is very important that signal operations remain snappy, with little wasted green time. When timed correctly, transit users, vehicles, pedestrians and bicyclists all experience less delay and well-defined headways that improve safety systemwide.

Conclusion

This technical memorandum provides guidance in using traditional fixed-time coordination signal timing techniques, known as the alternate system, as a tool to platoon and manage motor vehicle speeds. This can improve safety and reduce crashes for all roadway users. This signal timing technique is not a one size fits all application. The following should be considered to determine if this methodology is appropriate to use:

- While generally used for fixed-time coordination, semi-actuated/coordinated corridors can work if the permissive green windows with side streets and left turns are well managed to reduce variability in early return to greens and late starts on the mainline.
- The whole corridor should not be oversaturated, but oversaturation of a few intersections can work.
- This methodology is typically applied on lower-speed corridors (≤ 45 mph).
- This methodology can also be applied on higher-speed corridors with limited access (> 45 mph).
- Most of the corridor should have consistent intersection spacing or multiples of the minimum spacing – (1x, 2x, 3x, 4x, etc.).
- Corridors with smaller curb-to-curb widths and shorter side-street pedestrian clearance intervals perform best with this methodology, which supports shorter and snappier cycle lengths.
- Roadways with larger than one-half mile signal spacing may not benefit from this methodology as the platoons can disperse between intersections if there are a lot of busy accesses that create friction.

Two corridors using the alternate signal timing system methodology were successfully tested and implemented in the City of Lakewood, Colorado - Colfax Avenue (US 40) and Wadsworth Boulevard (CO 121). Each corridor has unique characteristics, considerations and challenges which were addressed using variations of the alternate timing system. This technical memorandum documents how the alternate method was applied, considerations for detailed signal timings, and the results from implementation.