WHITE PAPER
FOR
NORTH I-25 (US 36 TO 104TH AVENUE)
SUPPLEMENTAL OPTIONS ANALYSIS

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North I-25 (US 36 to 104th Avenue) Supplemental Options Analysis

1. Executive Summary

This white paper summarizes the supplemental operational analyses conducted for potential interim options for improvements to Interstate 25 (I-25) between US Highway 36 (US 36) and 104th Avenue in Adams County, Colorado, as well as validation of the Proposed Action identified in the draft *I-25 (US 36 to 104th Avenue Project Environmental Assessment (EA)* (CDOT, 2020).

This segment of I-25 between US 36 and 104th Avenue is one of the most congested corridors in the Denver metropolitan area with over 250,000 vehicles per day and has been identified as a bottleneck in the regional transportation network for over the last 15 years. This segment of the I-25 corridor crosses multiple jurisdictional boundaries, including Adams County and the Cities of Thornton and Northglenn, and provides major access between Downtown Denver and the communities of the northern Denver metropolitan area.

The Proposed Action included several improvements to address the congestion and safety-related needs of this segment of corridor. This analysis has been designed to confirm the methodologies of the EA and the Proposed Action and to use the EA assumptions to evaluate additional options for improvements to northbound I-25 between US 36 and 104th Avenue.

What causes bottleneck delays?

Bottleneck delays occur on freeways because of many reasons, such as:

- Short or noncontiguous auxiliary lanes or acceleration lanes from on-ramps;
- Sections with high vehicle weaving movements between closely spaced on-ramps and off-ramps;
- Freeway sections and interchanges built many years ago to less efficient design standards and geometrics;
- Locations where the freeway loses a lane, also known as a lane drop;
- Steep upgrades/downgrades along the freeway;
- Tight curves that cause vehicles to slow down;
- Narrow lanes, or the perception of narrow lanes, that cause drivers to slow down as they approach the area (i.e. at tunnels, underpasses, or areas without shoulders);
- Joining of major roadways (i.e. traffic from one freeway merging with the traffic of another freeway); and
- Any combination of the above characteristics may contribute to a higher incidence of traffic crashes, which leads to more congestion (DRCOG, 2009).

What are the transportation needs of this segment of I-25 between US 36 and 104th Avenue?

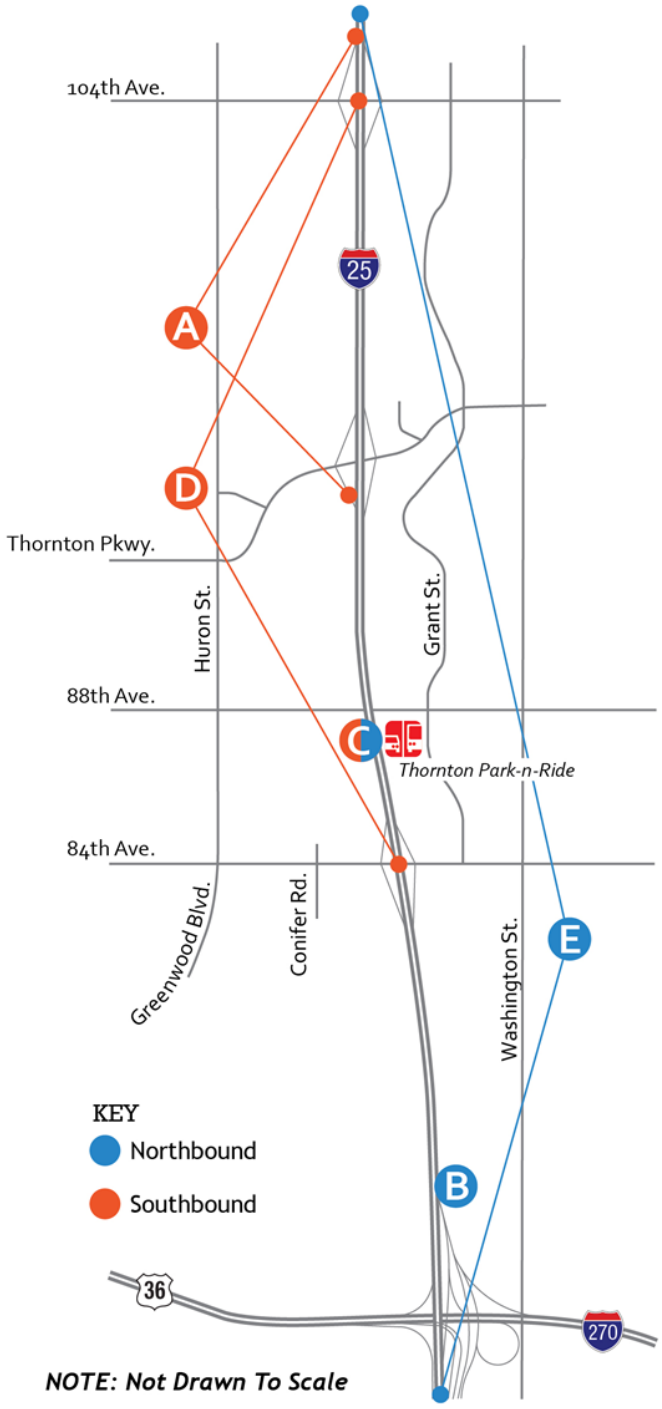
Northbound I-25 experiences significant evening (PM) peak hour delays and congestion that result in:

- The formation of bottlenecks at the on-ramps from Interstate 76 (I-76), US 36 and Interstate 270 (I-270) and through the 84th Avenue and Thornton Parkway interchanges
- Weaving turbulence from vehicles merging onto northbound I-25 and mainline I-25 vehicles exiting at 84th Avenue at the on- and off-ramps from I-76, US 36 and I-270 due to high merging volumes

- High concentrations of rear-end and sideswipe same-direction crashes
- Higher than average greenhouse gas (GHG) emissions associated with congested speeds and turbulent traffic flow

These needs are depicted further on **Figure ES-1**.

Figure ES-1 Existing and Projected 2040 Operational Deficiencies



A The southbound on-ramp vehicles at Thornton Parkway merging onto southbound I-25 create queues on I-25 that currently extend north of Thornton Parkway. By 2040 this southbound morning (AM) peak hour queue is projected to extend north of the 104th Avenue.

B The northbound evening (PM) peak hour merge and weaving interactions from the US 36 and I-270 ramps onto I-25 currently operate at LOS D. By 2040 increased travel demand is expected to reduce operation to LOS F.

C Buses exiting the Thornton Park-n-Ride at 88th Avenue create queues, slow traffic, and reduce vehicle through-put along I-25 when merging and weaving across northbound and southbound traffic into the Express Lanes from the bus-only on-ramps.

D The existing average AM peak hour southbound speeds range from 30 to 50 miles per hour (MPH) (on an incident-free day). By 2040 these speeds are projected to decrease to between 20 and 45 MPH. Morning AM peak hour southbound travel times between the 104th Avenue and 84th Avenue interchanges are projected to nearly double from 2 to 4 minutes in 2017 to 4 to 6 minutes in 2040.

E The existing average PM peak hour northbound speeds range from 25 to 45 MPH (on an incident-free day). By 2040, these speeds are projected to decrease to between 10 and 40 MPH. Evening PM peak hour northbound travel times from US 36/I-270 to 104th Avenue, are projected to nearly double from 6 to 8 minutes in 2017 to 10 to 12 minutes in 2040.

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What is the purpose of the planned I-25 (US 36 to 104th Avenue) project?

The purpose of the planned I-25 (US 36 to 104th Avenue) project is to relieve congestion and improve safety on I-25 between US 36 and 104th Avenue. In addition to the 2020 draft I-25 (US 36 to 104th Avenue) Environmental Assessment (EA) Proposed Action, this effort identified and evaluated six phased and/or interim options (Options A, B, C, D, E, and F) to address the operations and safety needs of the corridor.

What are the results of these analyses?

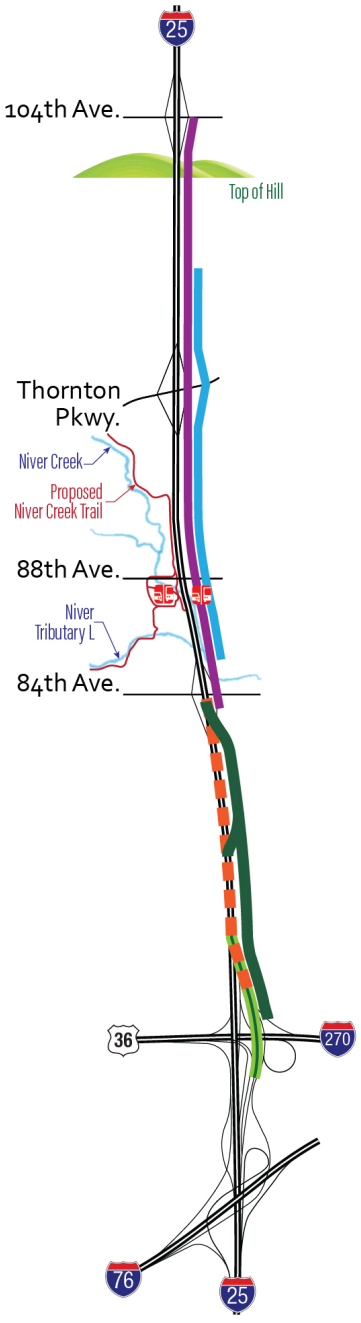
The analyses found that:

- Reconstructing the segment to include standard 10-foot inside and 12-foot outside shoulders provides space for:
  - Drivers to maneuver to avoid crashes and increases the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover
  - Law enforcement and emergency vehicles to operate on the shoulders
- Providing a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers entering and exiting the Express Lanes unexpectedly.
- Providing a CD road system between I-270 and 84th Avenue with a climbing lane that extends past Thornton Parkway is projected to:
  - Alleviate the bottlenecks at the on-ramps from Interstate 76 (I-76), US 36 and Interstate 270 (I-270) and through the 84th Avenue and Thornton Parkway interchanges.
  - Reduce the frequency of rear end crashes associated with high speed variability
  - Decrease the number of vehicle conflict points and increases separation of entering/exiting vehicle movements reducing the frequency of sideswipe same-direction crashes
  - Increase average speeds by 20+ MPH and decrease PM peak hour GHG emissions – speed improvements 10 mph can provide GHG emission reductions of up 70 percent.

Improvements are needed to address both bottlenecks and the safety and operational needs of the corridor and there is limited ability to address the bottleneck from vehicles merging onto northbound I-25 from I-76, US 36 and I-270 (south of the 84th Avenue interchange) without addressing the bottleneck to the north at Thornton Parkway.

Constructing a continuous auxiliary lane between I-270 and 84th Avenue in isolation (Option B) is projected to demonstrate negligible benefit to vehicular flow, LOS or traveled speed.

Auxiliary lane improvements to this segment should be paired with a climbing lane that extends, at a minimum, to the Thornton Parkway Interchange (Options C, D and F).



OPTION F

LEGEND

- Bring Corridor to Standard
- Add Climbing Lane
- Add Accel/Decel Lane
- Ramp Spacing Modification
- Add C-D Roads

Extending the climbing lane through the congestion at the Thornton Parkway interchange (to the 104th Avenue interchange) provides the greatest benefit to resolving the congestion-related bottlenecks along the corridor (EA Proposed Action).

Accommodating the I-270 northbound merge and the exit to 84th Avenue in a barrier separated CD road demonstrates the greatest potential to improve corridor travel speeds without providing the climbing lane to Thornton Parkway. The CD road system alone is projected to increase average network speed by 3 percent and decrease network delay by 7 percent.

However, combining the CD road with the climbing lane to 104th Avenue (Option F) is projected to provide the greatest benefit to the corridor and increase average network speeds by over 22 percent and decrease average network delay by 25 percent.

2. Introduction

This white paper summarizes the supplemental operational analyses conducted for supplemental options for improvements to Interstate 25 (I-25) between US Highway 36 (US 36) and 104th Avenue in Adams County, Colorado. It also validates the Proposed Action identified in the *I-25 (US 36 to 104th Avenue Project Environmental Assessment (EA)* (CDOT and FHWA, 2020).

In cooperation with the Regional Transportation District (RTD) and in coordination with Adams County and the City of Thornton, the Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) began the EA in 2017. The I-25 (US 36 to 104th Avenue) EA included a Proposed Action with several improvements designed to address the congestion and safety-related needs of the corridor (CDOT and FHWA, 2020). This analysis has been designed to confirm the methodologies of the EA and the Proposed Action and to use the EA assumptions to evaluate additional options for improvements to northbound I-25 between US 36 and 104th Avenue.

Where is this segment of I-25 located?

This segment of I-25 is located in southern Adams County, Colorado, and crosses the boundaries of the cities of Northglenn and Thornton. This approximately 4-mile segment of I-25 is bounded by US 36 and Interstate 270 (I-270) to the south and 104th Avenue on the north. I-25 provides major access between Downtown Denver and the communities of the northern Denver metropolitan area (**Figure 2.1**).

Figure 2.1. I-25 North (US 36 to 104th Avenue) Segment Location and Vicinity

Why is this segment of I-25 being evaluated?

For the last 15 years, the Denver Regional Council of Governments (DRCOG) has identified this segment of I-25 north of the I-25/I-270/US 36 Interchange as a bottleneck in the regional transportation system because of the:

- Northbound I-25 lane drop from five to three lanes,
- Increase in grade as I-25 climbs north from the Niver Creek drainage,
- High southbound on-ramp volumes at the I-25/84th Avenue, I-25/Thornton Parkway, and I-25/104th Avenue interchanges, and
- Higher percentage of overall truck traffic (DRCOG, 2009).

In addition to the bottleneck issues identified by DRCOG, CDOT identified the lack of continuous acceleration/deceleration lanes as contributing to the bottleneck. Continuous acceleration/deceleration lanes are additional travel lanes located between the on-ramp and off-ramp of two adjacent freeway interchanges. A continuous acceleration/deceleration lane eliminates the termination of the previous freeway on-ramp providing more merge and diverge distance for vehicles entering and leaving the roadway and lessens the effect of bottlenecks experienced when forced merge sections occur. Acceleration/deceleration lanes between interchanges on I-25 are currently not present—notably between the I-25/I-270/US 36, I-25/84th Avenue, I-25/Thornton Parkway, and I-25/104th Avenue interchanges (CDOT, 2014).

This segment of I-25 is one of the most congested corridors in the Denver metropolitan area and carries 258,000 vehicles per day (vpd) near US 36, 168,500 near the I-25/84th Avenue Interchange, approximately 167,900 vpd at the I-25/Thornton Parkway Interchange and dropping to 142,500 vpd at the I-25/104th Avenue Interchange. Operations along this segment of I-25 are primarily impacted by heavy peak hour demands causing congestion.

The PM peak hour currently experiences significant demand and congestion in the northbound direction, the primary peak hour direction of travel. Bottlenecks form at two segments: (1) on-ramps from I-76, US 36 and I-270, and (2) through the 84th Avenue and Thornton Parkway interchanges.

- Drivers merging onto northbound I-25 from I-76, US 36 and I-270 cause turbulent flow. Existing PM peak hour vehicles flow through the area at a rate of 1,300 to 1,500 vehicles per hour per lane limiting the functional capacity of the facility during this period.
- The existing demand for northbound travel is approximately 1,900 vehicles per hour per lane along northbound I-25 through the Thornton Interchange and 1,650 vehicles per hour per lane through the 84th Avenue Interchange.

As one of the most congested and heavily traveled corridors, the US 36 to 104th Avenue segment of I-25 experiences a high number of congestion-related crash types:

- Rear-end crashes, typically associated with congestion, account for 71 percent of total crashes. The highest concentrations of rear-end crashes occur near the 84th Avenue and 104th Avenue interchanges.
- Sideswipe same direction crashes are the second most frequent crash type at 18 percent, with the highest concentration of crashes occurring near the 88th Avenue bridge and at the tolled express lane sign bridges, just south of the 84th Avenue Interchange.
- Lack of shoulders, combined with high volumes and speeds, increases the risk of secondary crashes and makes enforcement dangerous:

- 26 percent of sideswipe same direction crashes involved one or more lane changes
- 30 percent of crashes involved a speed differential of 30 mph+ between vehicles

3. What previous studies have occurred along this segment of I-25?

This segment of I-25 between US 36 and 104th Avenue has been evaluated over the past 10 to 15 years as part of the following efforts.

Freeway Bottleneck Locations in the Denver Region (DRCOG, 2009)

In 2009, DRCOG evaluated 18 previously identified bottleneck locations on the freeway within the Denver metropolitan area and identified possible actions to improve conditions at those locations. DRCOG first identified these bottleneck locations in the *2006 Annual Report on Traffic Congestion in the Denver Region* (DRCOG, 2006). A major source of travel delays, freeway bottlenecks can increase the prices of goods that must be transported in congested conditions and increase air pollution due to stop-and-go traffic with vehicles idling in-place. As previously discussed, the segment of I-25 north of the I-25/I-270/US 36 Interchange was identified as a bottleneck location.

North I-25 Final Environmental Impact Statement (FHWA and CDOT, 2011a) and Record of Decision 1 (FHWA and CDOT, 2011b)

In 2011, CDOT and FHWA completed the North I-25 Final Environmental Impact Statement, Final Section 4(f) Evaluation (FEIS) (FHWA and CDOT, 2011a) and North I-25 Record of Decision 1 (ROD1) (FHWA and CDOT, 2011b). The FEIS identified and evaluated multimodal transportation improvements along the 61-mile I-25 transportation corridor extending from the Fort Collins/Wellington area to Denver.

Between US 36 and 104th Avenue, the following elements of the FEIS Preferred Alternative have been constructed:

- Six 12-foot general-purpose lanes (three in each direction),
- Two 12-foot Express Lanes (one in each direction),
- A concrete barrier between the northbound and southbound directions of the roadway,
- Tolling and intelligent transportation system infrastructure, and
- Four new noise walls and the rehabilitation of existing noise walls.

The following elements of the FEIS Preferred Alternative have not been constructed:

- A 4-foot buffer along the inside travel lane between the Express Lane and general-purpose lane (one in each direction),
- 12-foot inside and outside shoulders in each direction, and
- Replacement of the 88th Avenue bridge over I-25.

North I-25, US 36 to SH 7 Planning and Environmental Linkages Study (CDOT, 2014)

CDOT completed the North I-25, US 36 to SH 7 Planning and Environmental Linkages (PEL) study in 2014 (CDOT, 2014). This PEL study evaluated improvements to reduce congestion and improve safety on I-25 between US 36 and State Highway 7 (SH 7) by implementing near-term, multimodal, and cost-effective transportation improvements that were compatible with long-term options and the recently constructed interchange structures along the corridor, including the I-25/84th Avenue Interchange.

Within the project area, the PEL Recommended Alternative included:

- Adding a fourth 12-foot general-purpose lane in each direction from 84th Avenue to Thornton Parkway;
- Constructing 12-foot continuous acceleration and deceleration auxiliary lanes between the I-25/104th Avenue Interchange and the I-25/Thornton Parkway Interchange; and
- Reconstructing the Thornton Park-n-Ride to include an I-25 median transit station accessed by an above-ground pedestrian bridge.

I-25 (US 36 to 104th Avenue) Environmental Assessment (CDOT and FHWA, 2020)

In 2017, CDOT initiated the I-25 (US 36 to 104th Avenue) EA. The improvements identified as the Proposed Action resulted from an alternatives analysis that began with the *North I-25, US 36 to SH 7 PEL Study* and incorporated the previously not constructed elements of the North I-25 ROD1 Preferred Alternative. A four-step evaluation process was used as part of the PEL study to develop and evaluate alternatives resulting in the Recommended Alternative. In addition to the planned and recommended transportation improvements from the ROD1 Preferred Alternative and PEL Recommended Alternative, the EA Proposed Action includes the extension of the additional (fourth) northbound general-purpose lane to 104th Avenue to meet the existing and projected operational deficiencies. The EA Purpose and Need and Proposed Action are further discussed in the following sections.

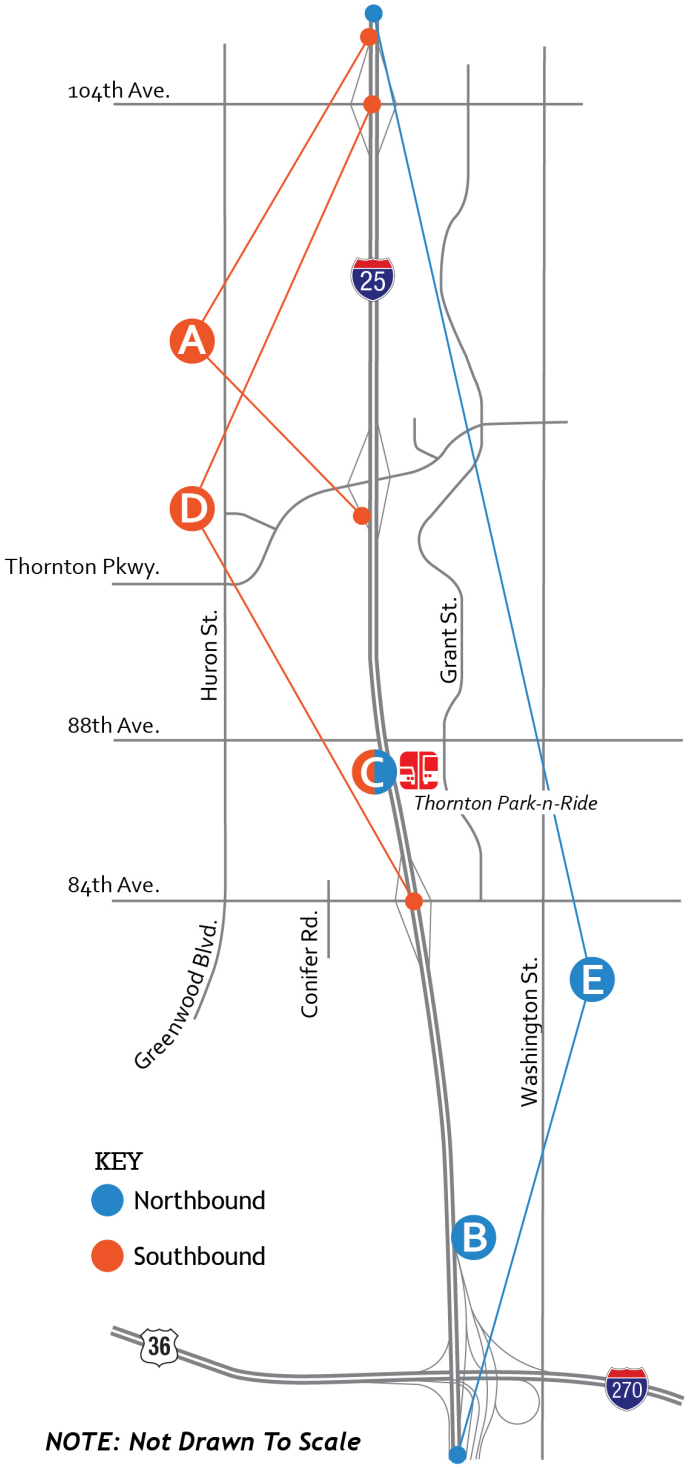
4. What was the Purpose and Need of the I-25 (US 36 to 104th Avenue) EA?

The purpose of this project is to relieve congestion and improve safety on I-25 between US 36 and 104th Avenue in Adams County, Colorado. Transportation improvements are needed to address:

- **Traffic Operations** - Existing traffic volumes along I-25 between the US 36/I-270 Interchange complex and 104th Avenue are nearing or exceeding capacity. Population and employment growth is projected to increase travel demand, further reducing travel speeds and increasing congestion along I-25.
- **Safety** - The total annual crash rate for I-25 between the US 36/I-270 Interchange complex and 112th Avenue has been increasing since 2012. Rear-end crashes, typically associated with congestion, are the predominant crash type.

Figure 4.1 illustrates the existing and projected operational deficiencies identified as part of the EA.

Figure 4.1. Existing and Projected 2040 Operational Deficiencies



A The southbound on-ramp vehicles at Thornton Parkway merging onto southbound I-25 create queues on I-25 that currently extend north of Thornton Parkway. By 2040 this southbound morning (AM) peak hour queue is projected to extend north of the 104th Avenue.

B The northbound evening (PM) peak hour merge and weaving interactions from the US 36 and I-270 ramps onto I-25 currently operate at LOS D. By 2040 increased travel demand is expected to reduce operation to LOS F.

C Buses exiting the Thornton Park-n-Ride at 88th Avenue create queues, slow traffic, and reduce vehicle through-put along I-25 when merging and weaving across northbound and southbound traffic into the Express Lanes from the bus-only on-ramps.

D The existing average AM peak hour southbound speeds range from 30 to 50 miles per hour (MPH) (on an incident-free day). By 2040 these speeds are projected to decrease to between 20 and 45 MPH. Morning AM peak hour southbound travel times between the 104th Avenue and 84th Avenue interchanges are projected to nearly double from 2 to 4 minutes in 2017 to 4 to 6 minutes in 2040.

E The existing average PM peak hour northbound speeds range from 25 to 45 MPH (on an incident-free day). By 2040, these speeds are projected to decrease to between 10 and 40 MPH. Evening PM peak hour northbound travel times from US 36/I-270 to 104th Avenue, are projected to nearly double from 6 to 8 minutes in 2017 to 10 to 12 minutes in 2040.

NORTH

The safety analyses for this evaluation have been conducted based on the safety analyses completed for the North I-25 EA which used the findings from the CDOT/FHWA 2017 Road Safety Audit (RSA). Several of the recommendations from the RSA have been implemented along the corridor. An updated safety evaluation is recommended for the option or options from this analysis that may move on for further evaluation.

What is the EA Proposed Action?

The EA Proposed Action would provide improvements to an approximately 4-mile segment of I-25 between US 36 and 104th Avenue.

The Proposed Action includes the following elements:

- **Element 1** – Reconstruct I-25 from 84th Avenue to Thornton Parkway to a typical cross-section of four 12-foot general-purpose lanes, a 12-foot Express Lane along the inside travel way, a 4-foot buffer between the Express Lane and nearest general-purpose lane, a 12-foot outside auxiliary lane between each interchange, and 12-foot inside and outside shoulders in the northbound and southbound directions (**Figure 4.2**). The four northbound general-purpose lanes will extend to 104th Avenue, with the fourth northbound general-purpose lane exiting at the 104th Avenue off-ramp;
- **Element 2** - Construct a median transit station and transit-user pedestrian bridge for the Thornton Park-n-Ride just south of 88th Avenue; and
- **Element 3** - Separate the northbound and southbound lanes of I-25 with a concrete barrier and separate the Express Lanes from the median bus station and bus lanes with a concrete barrier.

Figure 4.3 illustrates the cross section at the Thornton Park-n-Ride Station at 88th Avenue and the impacts of Elements 2 and 3 on the I-25 cross section.

Figure 4.4 provides an overview of the EA Proposed Action.

Figure 4.2. Proposed Action Cross-Section Between the US 36/I-270 Merge and the Thornton Park-n-Ride Station and Between the Thornton Park-n-Ride Station and 104th Avenue

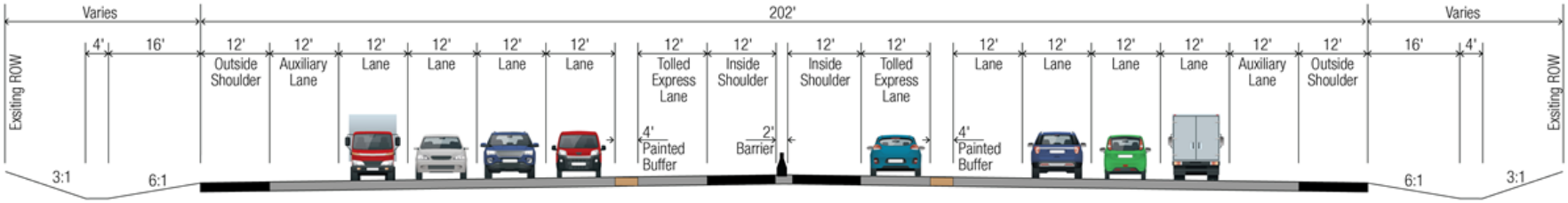


Figure 4.3 Proposed Action Cross-Section at the Thornton Park-n-Ride Station at 88th Avenue

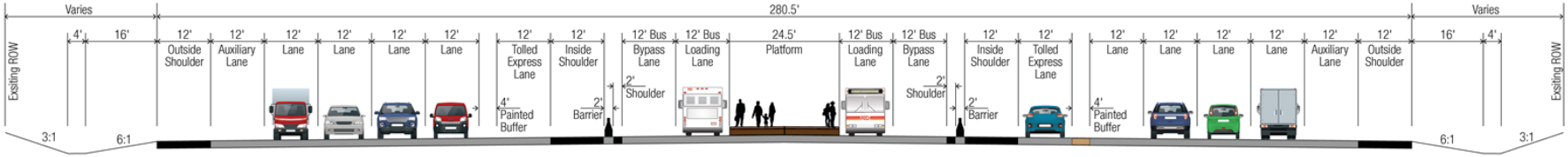


Figure 4.4 EA Proposed Action – Transportation Improvements Previously Evaluated and Recommended

How well does the EA Proposed Action meet the EA Purpose and Need?

Traffic Operations.

- The Proposed Action would provide added capacity to accommodate peak travel demand by adding a fourth general-purpose lane in both the northbound and southbound directions. An auxiliary lane would also be added between each interchange, thereby reducing the number of vehicles in the general-purpose lanes and lengthening the merging area for incoming traffic.
- Under the 2040 Proposed Action, northbound travel times are projected to improve travel times from 10 to 12 minutes (No Action) to 7 to 9 minutes.
- Under the Proposed Action, the northbound PM peak hour is projected to improve to Level of Service (LOS) D/E between the 84th Avenue and 104th Avenue interchanges compared to the No Action Alternative.
- The Proposed Action would address the northbound PM peak hour bottleneck at Thornton Parkway and improve operations from LOS E/F to LOS D/E compared to the No Action Alternative.

Safety.

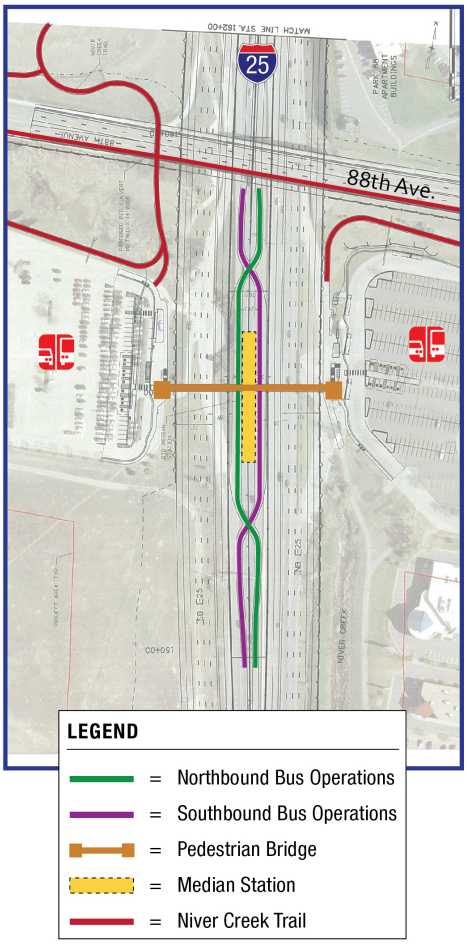
- The EA Proposed Action would include a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers unexpectedly entering and exiting the Express Lanes.
- The EA Proposed Action would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- The EA Proposed Action would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

RTD Median Station

The existing RTD Thornton Park-n-Ride, located between 84th Avenue and 88th Avenue, is accessed from northbound and southbound I-25 by bus-only slip ramps that exit via outside lanes on the right.

The EA reviewed several station concepts, evaluating impacts to vehicular and transit operations. The EA Proposed Action includes a proposed median station at the Thornton Park-n-Ride. **Figure 4.5** illustrates the EA Proposed Action median station concept.

Figure 4.5. Thornton Park-n-Ride Proposed Median Station



What is the cost of the EA Proposed Action?

The EA Proposed Action requires a substantial financial investment. Cost estimates assembled in September 2019 for the 30 percent design of the Proposed Action came in at $183.4 million. RTD provided cost estimates of $28 million for the Thornton Park-n-Ride and median station improvements, representing approximately 15 percent of the total project costs.

Accommodating the Thornton Park-n-Ride and median station requires significant widening and investment along I-25, as shown on **Figure 4.3**, beyond the footprint of the station. Cost estimates compiled in 2017 to evaluate configurations for the Thornton Station Park-n-Ride compared a No Action scenario in which the Thornton Station is closed to the median station option. The median station option is projected to cost nearly 20 percent more to construct than the No Action Alternative. The inclusion of the Thornton Park-n-Ride and median in the Proposed Action reflects a $59.0 million investment (32 percent of the total project costs).

CDOT and RTD have been exploring options to accommodate more cost-effective, safe and efficient I-25 bus operations. As a result, there is a desire to identify phased improvements that can lower overall project costs and/or can be completed while CDOT and RTD continue to evaluate options for the Thornton Park-n-Ride and station. The options evaluated as part of this effort did not explicitly contemplate the configuration of the Thornton Park-n-Ride and station.

5. How were the operations methodology and assumptions conducted for the EA validated?

CDOT and the project team revisited the travel demand and microsimulation model inputs and assumptions:

- The *I-25 North, US 36 to SH 7 - Methods and Assumptions* (June 2017) memorandum documented the process for the technical analysis of improvements to I-25 between US 36 and SH 7. The memorandum addressed two segments along I-25; the EA focused on Segment 1 – US 36 to 104th Avenue.
- The *Data Collection Technical Memo* (June 2017) summarized the collection efforts to support development and calibration of the TransModeler model for the evaluation of proposed improvements on I-25 between US 36 and 104th Avenue.
- The *TransModeler Calibration Memo* (September 2017) documents the TransModeler microsimulation model development and calibration process to evaluate proposed improvements on I-25 between US 36 and 104th Avenue (Segment 1).
- The *I-25 North, US 36 to SH 7 - Microsimulation Traffic Operations Evaluation* (July 2018) technical memorandum documents the TransModeler microsimulation model evaluation of the proposed improvements and included documentation of the traffic growth and travel demand modeling assumptions used to develop the 2040 traffic forecasts.

The CDOT project team reviewed the methodology and assumptions for the microsimulation model and operational analyses. The review team included CDOT staff (HQ Traffic and the Statewide Model Team from the Information Management Branch) who were not on the EA project team.

The project team for this modeling effort confirmed that the assumptions, inputs and results of the EA operational analyses were acceptable and did not recommend model input or design changes for this effort. The calibrated EA 2040 No Action and Build microsimulation models have been used as the basis of the operational analyses included in this evaluation.

6. What additional supplemental options were evaluated?

Options include a range of improvements that have been packaged together to evaluate the potential for smaller packages to address the operational and safety needs of the corridor.

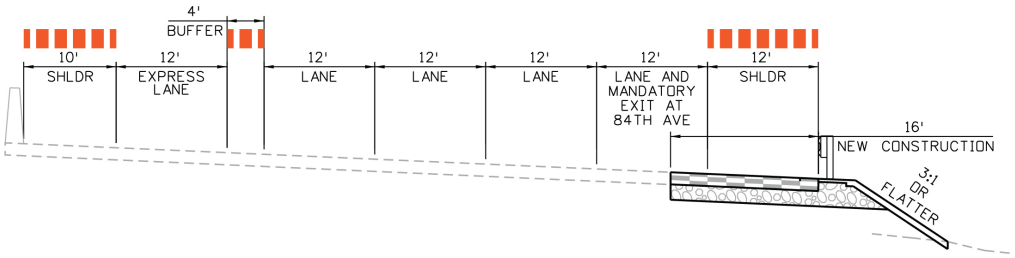
CDOT originally supplied four supplemental options for northbound I-25 roadway improvements. The options were developed using the following list of alternative elements:

- Bringing the corridor to standard – including 12-foot general-purpose lanes, 12-foot outside shoulder, 10-foot inside shoulder and a 4-foot buffer between the Express Lanes and the general-purpose lanes
- Extending the I-76 northbound on-ramp auxiliary lane past the 84th Avenue off-ramp
- Extending the I-270 northbound on-ramp auxiliary lane to form a continuous acceleration/deceleration lane with the 84th Avenue off-ramp
- Restriping or reconstructing the northbound 84th Avenue off-ramp as a two-lane taper type exit
- Adding an auxiliary deceleration lane for the 84th Avenue off-ramp
- Adding a barrier to separate the I-76/US 36 and I-270 auxiliary lanes

Several iterations of operational analyses and project team collaboration resulted in the development and evaluation of six option packages. The subsequent sections describe each option package. Conceptual designs of each option are included in **Appendix A**.

Option A – Bring Corridor to Standard

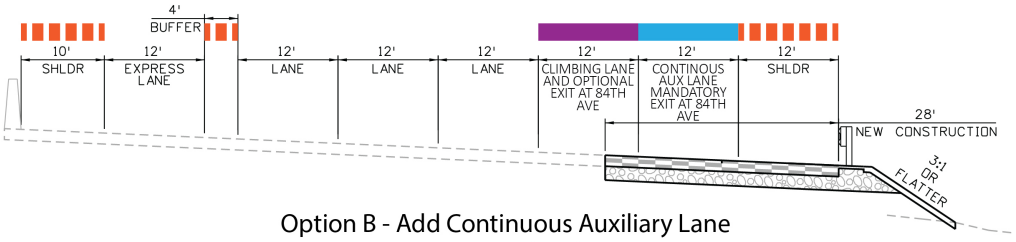
- **Element 1** – Reconstruct I-25 from US 36 to 84th Avenue to bring the corridor up to standard: 12-foot general-purpose lanes, 12-foot outside shoulder, 10-foot inside shoulder, and a 4-foot buffer between the Express Lanes and the general-purpose lanes.



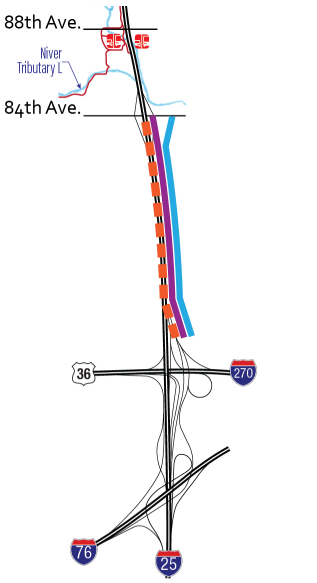
Option A - Bring Corridor to Standard
(NB I-25 Looking North)

Option B – Add Continuous Auxiliary Lane between I-270 and 84th Avenue

- **Element 1** – Reconstruct I-25 from US 36 to 84th Avenue to bring the corridor up to standard: 12-foot general-purpose lanes, 12-foot outside shoulder, 10-foot inside shoulder, and a 4-foot buffer between the Express Lanes and the general-purpose lanes.
- **Element 2** – Extend the I-270 on-ramp to a 12-foot continuous auxiliary lane between I-270 and 84th Avenue. The auxiliary lane drops at 84th Avenue as a mandatory exit.
- **Element 3** – Retain the existing I-76/US 36 on-ramp auxiliary lane as a climbing lane. The existing auxiliary lane serves as an optional exit lane to 84th Avenue and merges back into mainline I-25 north of the 84th Avenue exit.



Option B - Add Continuous Auxiliary Lane Between I-270 and 84th Avenue
(NB I-25 Looking North)

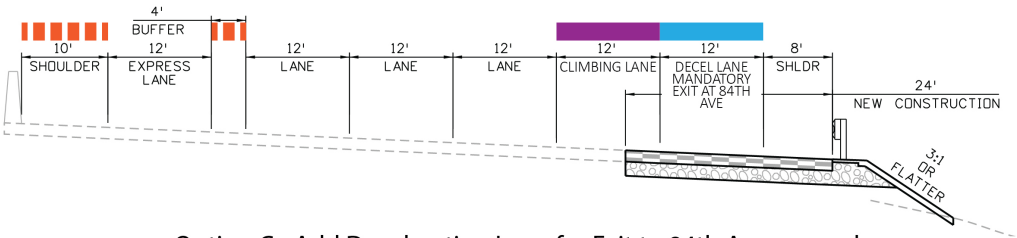


OPTION B

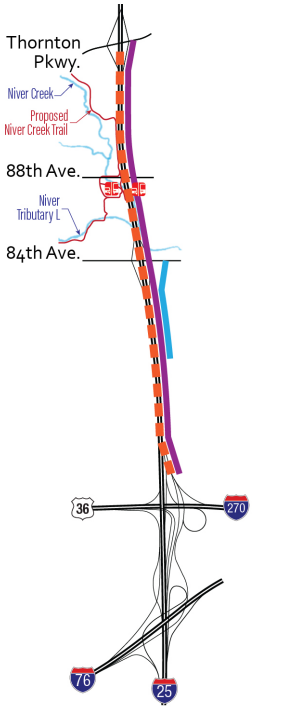
LEGEND
- Bring Corridor to Standard
- Add Climbing Lane
- Add Accel/Decel Lane

Option C – Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

- **Element 1** – Reconstruct I-25 from US 36 to Thornton Parkway to bring the corridor up to standard: 12-foot general-purpose lanes, 12-foot outside shoulder, 10-foot inside shoulder, and a 4-foot buffer between the Express Lanes and the general-purpose lanes.
- **Element 2** – Add a 12-foot deceleration auxiliary lane to serve as the mandatory exit to 84th Avenue.
- **Element 3** – Retain the existing I-76/US 36 on-ramp auxiliary lane as a climbing lane. The existing auxiliary lane would extend north as a climbing lane to Thornton Parkway and serve as the mandatory exit lane to Thornton Parkway.



Option C - Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway
(NB I-25 Looking North)

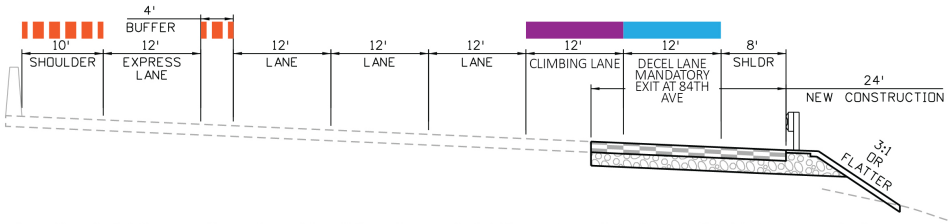


OPTION C

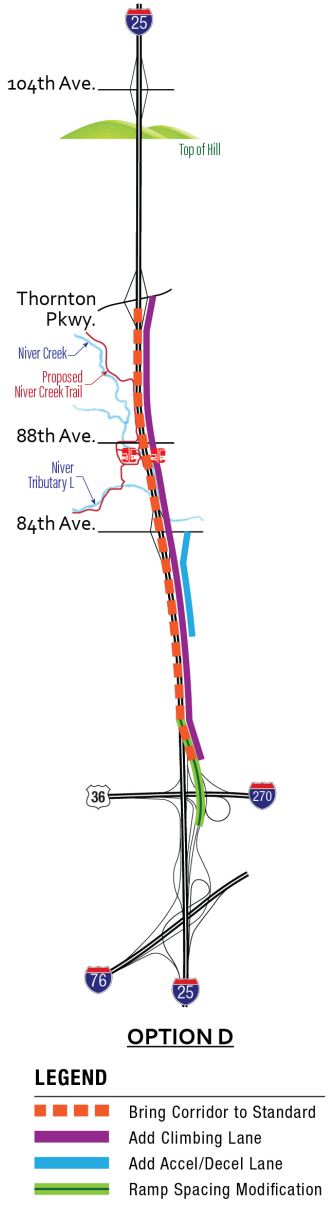
LEGEND
- Bring Corridor to Standard
- Add Climbing Lane
- Add Accel/Decel Lane

Option D – Ramp Spacing Modifications, Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

- **Element 1** – Reconstruct I-25 from US 36 to Thornton Parkway to bring the corridor up to standard: 12-foot general-purpose lanes, 12-foot outside shoulder, 10-foot inside shoulder, and a 4-foot buffer between the Express Lanes and the general-purpose lanes
- **Element 2** – Add a 12-foot deceleration auxiliary lane to serve as the mandatory exit to 84th Avenue.
- **Element 3 -** Realign the I-76 and US 36 on-ramps to northbound I-25 to increase ramp spacing and reduce lane crowding and operational turbulence.
- **Element 4** – Retain the existing I-76 on-ramp auxiliary lane as a climbing lane. The existing auxiliary lane extends north as a climbing lane to Thornton Parkway and serves as the mandatory exit to Thornton Parkway.

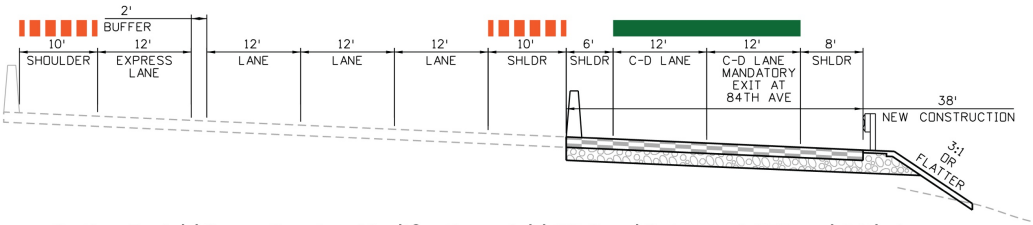


Option D - Add Ramp Spacing Modifications, Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway
(NB I-25 Looking North)

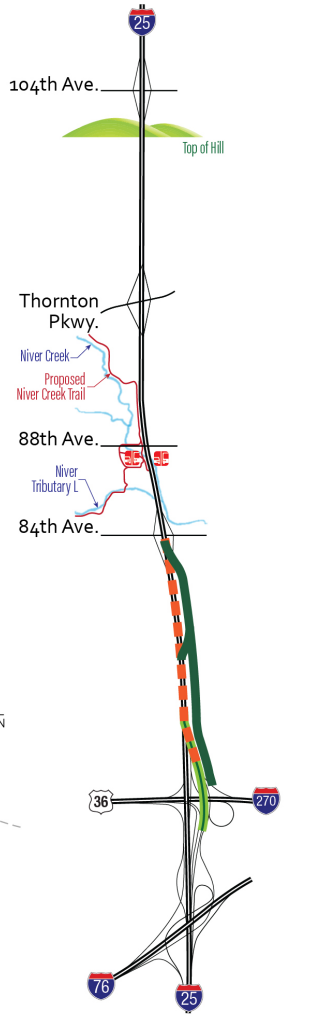


Option E – Ramp Spacing Modifications, Add CD Road between I-270 and 84th Avenue

- **Element 1** – Reconstruct I-25 from US 36 to 84th Avenue to a typical cross-section of three 12-foot general-purpose lanes and a 12-foot Express Lane along the inside travel way.
- **Element 2** - Construct a 2-lane CD Road from westbound I-270 with a typical cross-section of 12-foot lanes, a 6-foot barrier separated inside shoulder between mainline I-25 and the CD Road, and an 8-foot outside shoulder. The CD Road on-ramp to I-25 would merge onto mainline I-25 just south of the 84th Avenue bridge and the exit to 84th Avenue would shift to the south. This option would preclude the ability of vehicles traveling northbound in the Express Lanes to exit at 84th Avenue in the absence of modifications to the Express Lane ingress/egress locations south of the study area.
- **Element 3** - Realign and reconstruct the I-76 and US 36 on-ramps to northbound I-25 to increase ramp spacing and reduce lane crowding and operational turbulence.



Option E - Add Ramp Spacing Modifications, Add CD Road Between I-270 and 84th Avenue
(NB I-25 Looking North)



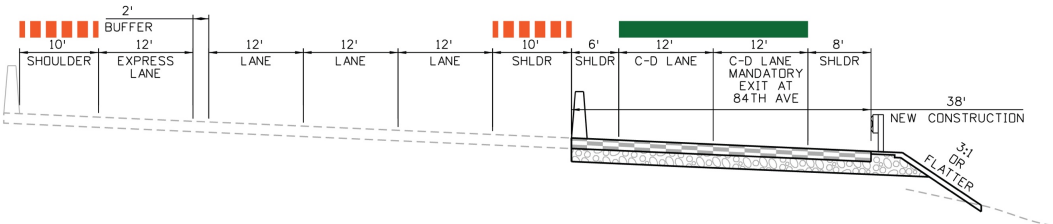
OPTION E

LEGEND

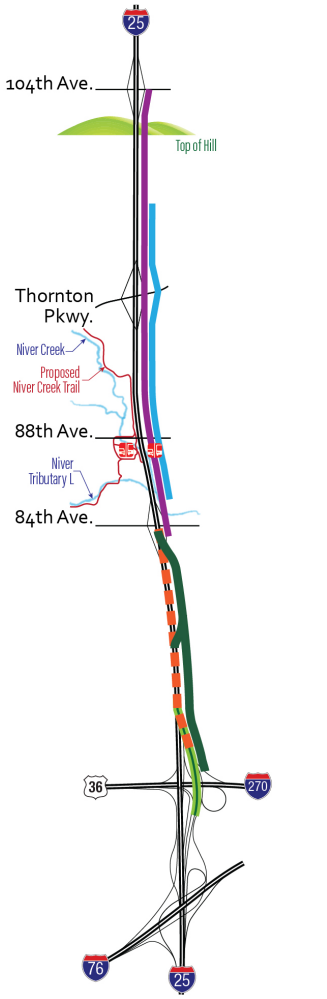
- Bring Corridor to Standard
- Ramp Spacing Modification
- Add C-D Roads

Option F – EA Proposed Action & Option E Hybrid

- **Element 1** – Reconstruct I-25 from 84th Avenue to Thornton Parkway to a typical cross-section of three 12-foot general-purpose lanes, a 12-foot climbing lane (see Element 3), a 12-foot Express Lane along the inside travel way, 12-foot outside auxiliary lane between each interchange, a 2- to 4-foot buffer between the Express Lane and nearest general-purpose lane, and 10-12-foot inside shoulders and 12-foot outside shoulders.
- **Element 2** - Construct a 2-lane CD Road from westbound I-270 with a typical cross-section of 12-foot lanes, a 6-foot buffered inside shoulder between mainline I-25 and the CD Road, and an 8-foot outside shoulder. The CD Road on-ramp to I-25 would merge onto mainline I-25, which becomes the climbing lane just south of the 84th Avenue bridge. The exit to 84th Avenue would shift to the south. This option would preclude the ability of vehicles traveling northbound in the Express Lanes to exit at 84th Avenue in the absence of modifications to the Express Lane ingress/egress locations south of the study area.
- **Element 3**- Realign and reconstruct the I-76 and US 36 on-ramps to northbound I-25 to increase ramp spacing and reduce lane crowding and operational turbulence.



Option F - Add Ramp Spacing Modifications, Add CD Road Between I-270 and 84th Avenue and Extend Climbing Lane to Thornton Parkway
(NB I-25 Looking North)



OPTION F

LEGEND

- Bring Corridor to Standard
- Add Climbing Lane
- Add Accel/Decel Lane
- Ramp Spacing Modification
- Add C-D Roads

7. How were the operations of the supplemental options analyzed?

TransModeler microsimulation modeling and validated 2040 microsimulation model inputs have been used to evaluate and refine the options under the 2040 planning horizon. The EA 2040 No Action volumes were used to evaluate options with improvements restricted to the segment between US 36/I-270 and 84th Avenue (Options A and B). The EA 2040 Build volumes were used to evaluate options for improvements extending to Thornton Parkway and beyond (Options C through F).

The operational analyses included network-wide performance metrics to understand the impacts of the improvements to the large EA study area network. The analyses also included segment-based performance metrics to provide a more granular understanding of the location-specific impacts of improvements.

Network Performance

The following network-wide performance metrics were used to evaluate each TransModeler model:

- **Total Network Trips** - Vehicle throughput as an indicator of the productivity of a facility or a network by reflecting the number of vehicles processed by the system for the analysis period (PM peak hour).
- **VHT** - Vehicle hours traveled; the sum total travel time experienced by all vehicles that completed their trips in the analysis period for the total model network.
- **VMT** - Vehicle miles traveled; the sum total distance traveled by all vehicles that completed their trips in the analysis period for the total model network.
- **Average Network Speed** - Travel speed (in miles per hour) averaged over all vehicles that completed their trips in the analysis period for the total model network.
- **Average Network Delay** - Total difference between experienced travel time and free-flow travel time, averaged over all vehicles that completed their trips in the analysis period for the total model network and reported as seconds per vehicle.

Table 7-1 compares the network performance of the EA Proposed Action and options against Option A. Options have been compared to Option A because Option A functions like the No Action Alternative from a purely operational perspective.

Table 7-1. PM Peak Hour Model Network Performance Metrics

Scenario	Total Network Trips		VMT		VHT		Avg. Network Speed (mph)		Avg. Network Delay (s/veh)	
Option A	39,852		98,377		3,888		25.3		127.9	
Option B	39,638	↓0.5%	97,635	↓0.8%	3,842	↓1.2%	25.4	↑0.4%	124.7	↓2.5%
Option C	40,141	↑0.7%	102,844	↑4.5%	3,988	↑2.6%	25.8	↑2.0%	126.5	↓1.1%
Option D	40,271	↑1.1%	103,209	↑4.9%	3,939	↑1.3%	26.2	↑3.6%	121.2	↓5.2%
Option E	40,241	↑1.0%	102,777	↑4.5%	3,942	↑1.4%	26.1	↑3.2%	119.0	↓7.0%
Option F	41,072	↑3.1%	113,670	↑15.5%	3,664	↓5.8%	31.0	↑22.5%	97.0	↓24.2%
EA Proposed Action	40,660	↑2.0%	108,470	↑10.3%	3,805	↓2.1%	28.5	↑12.6%	103.7	↓18.9%

Segment Performance

Freeway Operational Analysis – Level of Service & Bottleneck Evaluation

Density-based LOS was calculated for all freeway segments of northbound I-25 for each alternative (basic freeway segments, merge segments, weaving segments, and diverge segments). Freeway LOS results are shown on **Figure 7.1**.

Freeway capacity is typically reported as a maximum flow rate associated with a breakdown resulting in reduced flow rates, slower speeds, and higher densities. Once the oversaturation point is reached, queues form, and vehicles discharge from the bottleneck at a reduced flow rate. The Highway Capacity Manual indicates that, under base conditions, a facility like I-25 would be expected to have a capacity of 2,000 to 2,200 vehicles per hour per lane.

As noted, the PM peak hour bottlenecks form at two segments: (1) on-ramps from I-76, US 36 and I-270, and (2) through the 84th Avenue and Thornton Parkway interchanges. The following summarizes the peak hour flow rate in vehicles per hour (veh/hr) at the two bottleneck locations. Vehicle per hour per lane (veh/hr/ln) capacities that are accompanied by reduced speeds and high densities reflecting an operational breakdown are indicated in red text.

- Drivers merging onto northbound I-25 from I-76, US 36 and I-270 make lane changes that create turbulence in the traffic flow. This limits the existing PM peak hour vehicles flow rate to 1,300 to 1,500 vehicles per hour per lane, which is significantly lower than the expected per lane free-flow capacity. **Table 7-2** summarizes the projected 2040 flow and per-lane flow for each option at the 84th Avenue Interchange.
- The existing demand for traveling north is approximately 1,900 vehicles per hour per lane through the Thornton Interchange and 1,650 vehicles per hour per lane through the 84th Avenue Interchange. **Table 7-3** summarizes the projected 2040 flow and per-lane flow at the Thornton Parkway Interchange bottleneck for each option.

Table 7-2. 84th Avenue Bottleneck 2040 –Total Northbound Evening Peak Hour Flow on Mainline I-25

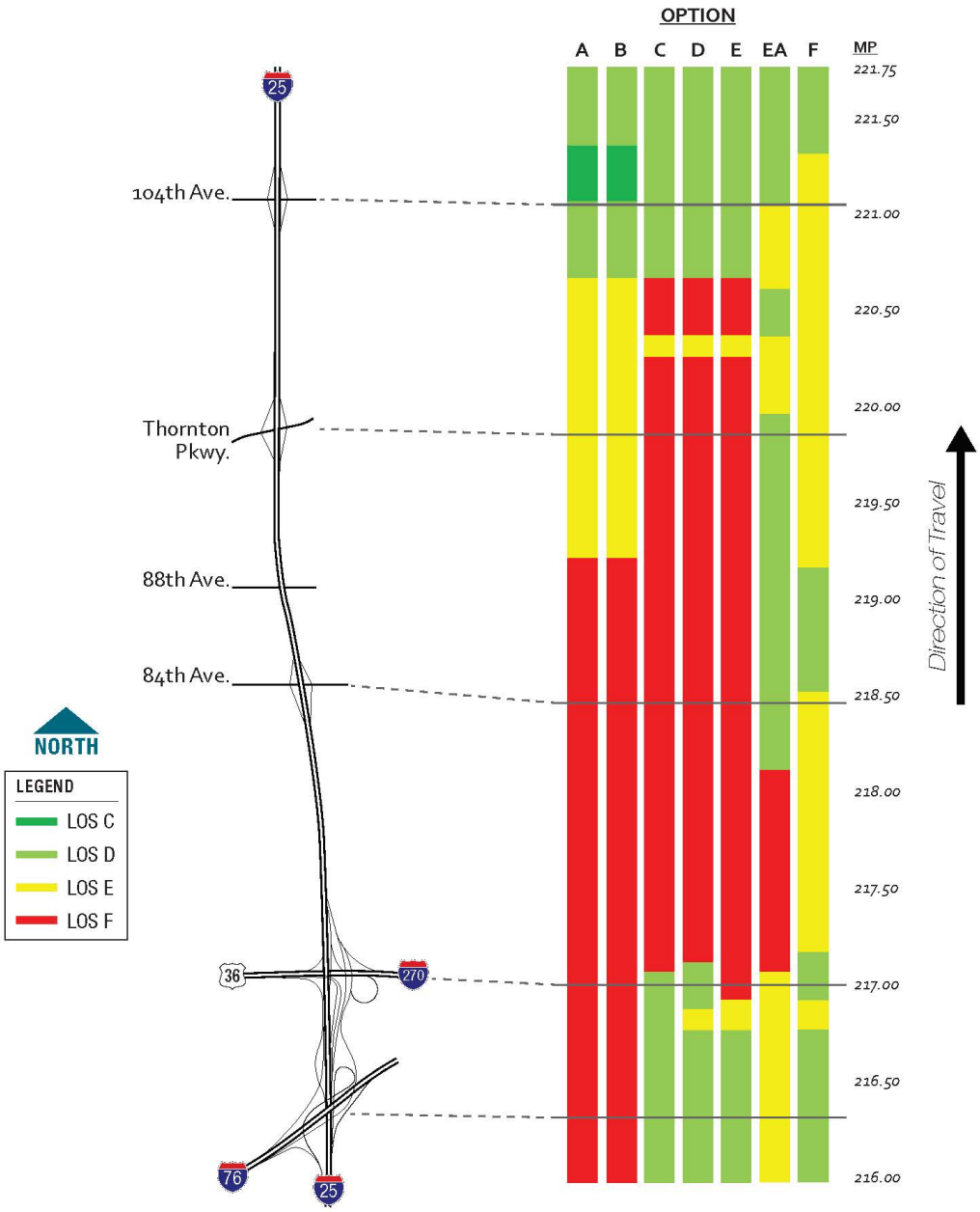
	Option A	Option B	Option C	Option D	Option E	Option F	EA Proposed
Flow (veh/hr)	7,750	7,800	9,050	9,100	6,450	6,750	8,750
# of Lanes	5	6	5	5	4	4	5
veh/hr/ln	1,550	1,300	1,800	1,800	1,600	1,700	1,750

Table 7-3. Thornton Parkway Bottleneck 2040 – Total Northbound Evening Peak Hour Flow on Mainline I-25

	Option A	Option B	Option C	Option D	Option E	Option F	EA Proposed
Flow (veh/hr)	6,400	6,350	7,100	7,150	7,100	7,750	7,200
# of Lanes	4	4	4	4	4	5	5
veh/hr/ln	1,600	1,600	1,800	1,800	1,800	1,550	1,450

The ability of each option to meet the operational needs of the corridor is summarized in the following section - **How well do the options meet the EA Purpose and Need?**

Figure 7.1. Evening Peak Hour Freeway LOS Comparison

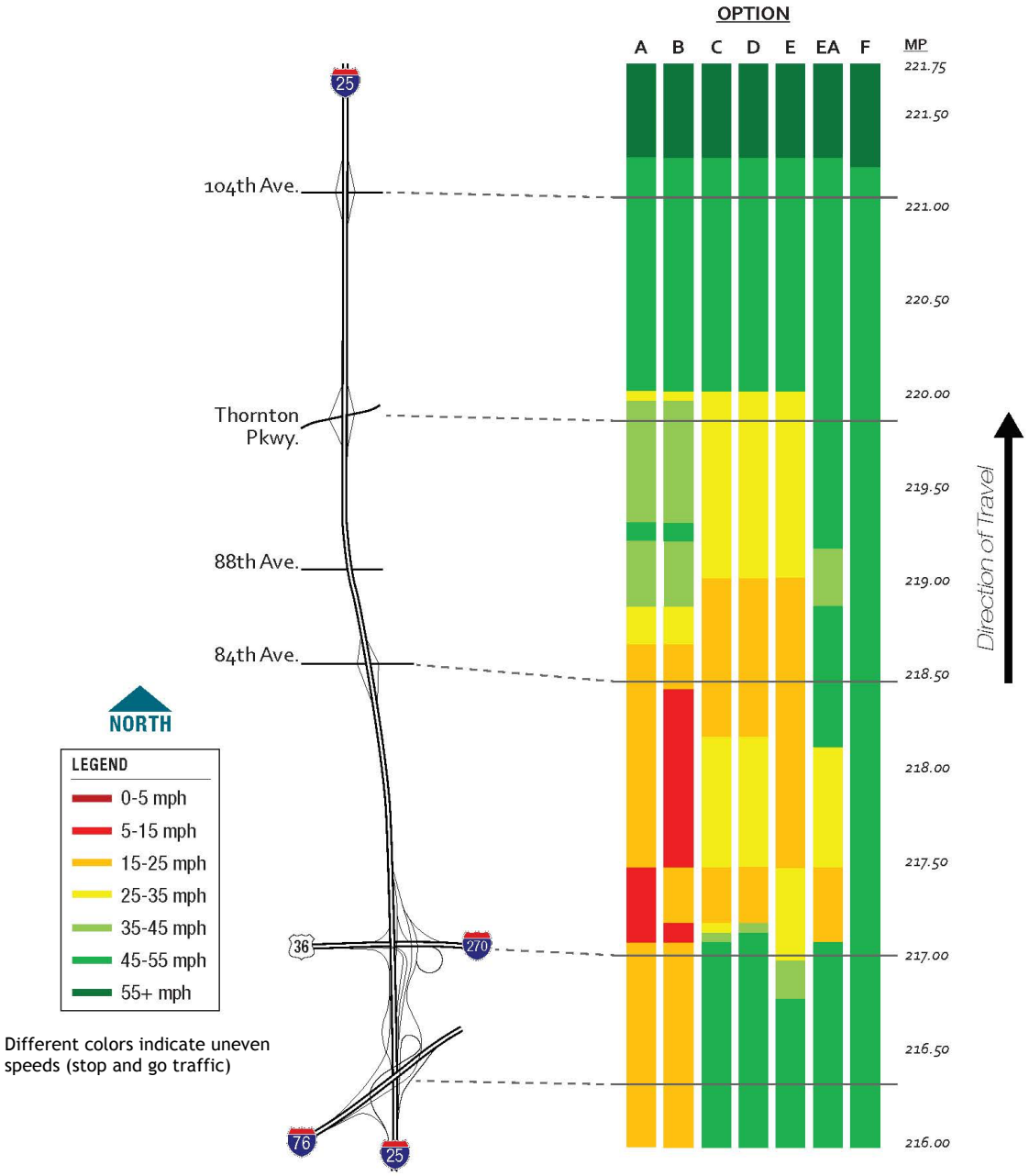


Traveled Speeds

The EA identified inconsistent travel speeds on I-25 as a significant contributing factor to the two predominant corridor crash types: rear end crashes and sideswipe same direction crashes.

Figure 7.2 illustrates the projected PM peak hour travel segment travel speeds for all options. The anticipated impacts of traveled speed on safety are also discussed in the following section - **How well do the options meet the EA Purpose and Need?** The EA Purpose and Need is presented in **Section 4**.

Figure 7.2 PM Peak Hour Speed Comparison



How well do the options meet the EA Purpose and Need?

The EA Purpose and Need is presented in **Section 4**.

Option A – Bring Corridor to Standard

Traffic Operations.

- Option A is projected to yield the same operational conditions as the EA No Action Alternative.

Safety.

- Option A would include a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers unexpectedly entering and exiting the Express Lanes.
- Option A would include standard shoulders that would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- Option A would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

Option A has the potential to reduce secondary crashes on northbound I-25.

Option B – Add Continuous Auxiliary Lane between I-270 and 84th Avenue

Traffic Operations.

- Under Option B, 2040 northbound PM peak hour average speeds are projected to increase by 0.4 percent to 25.4 mph compared to those of the No Action Alternative, and average network delay (s/veh) would decrease by 2.5 percent.

Safety.

- Option B would include a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers unexpectedly entering and exiting the Express Lanes.
- Option B would include standard shoulders that would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- Option B would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

Option B has the potential to reduce secondary and merge-related crashes on northbound I-25.

Option C – Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

Traffic Operations.

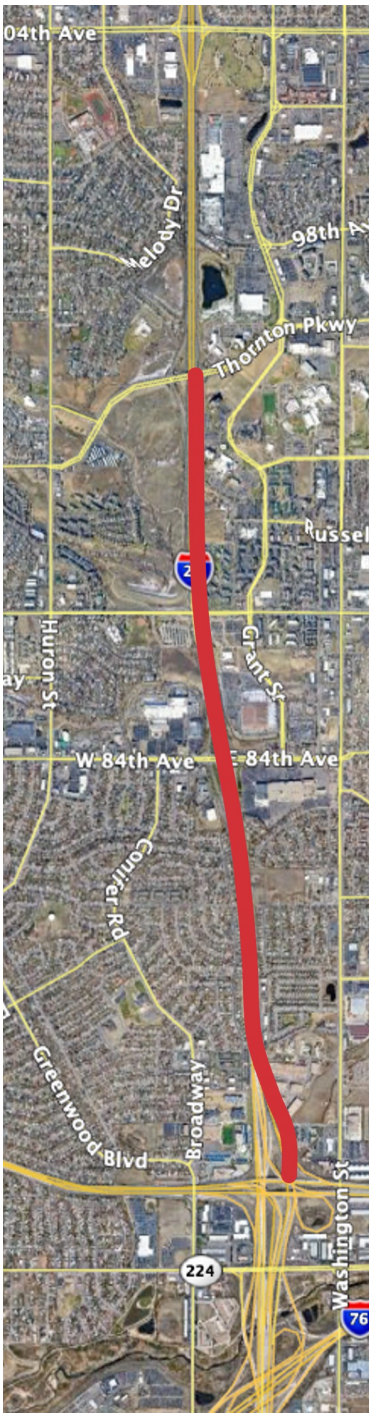
- Option C would improve existing and projected congestion between US 36 and the Thornton Parkway Interchange by providing a deceleration lane for vehicles exiting I-25 to 84th Avenue and providing an auxiliary climbing lane to Thornton Parkway.
  - The deceleration lane is projected to reduce turbulence at the exit to 84th Avenue and increase the vehicle throughput to 9,050 vehicles per hour and the per lane vehicle throughput to 1,800 vehicles per hour per lane.
- Under Option C, 2040 northbound PM peak hour average speeds are projected to increase compared to those of the No Action Alternative by 2 percent to 25.8 mph and average network delay (s/veh) would decrease by 1.1 percent.
- Under Option C, the 2040 northbound PM peak hour is projected to improve to LOS D/E between the I-76 merge and the US 36 merge compared to that of the No Action Alternative.

Safety.

- Option C would include a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers entering and exiting the Express Lanes unexpectedly.
- Option C would include standard shoulders that would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- Option C would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

Option C has the potential to reduce secondary and congestion-related crashes on northbound I-25.

Option D – Ramp Spacing Modifications, Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway



Traffic Operations.

- Option D would improve existing and projected congestion between US 36 and the Thornton Parkway Interchange by providing a deceleration lane for vehicles exiting I-25 to 84th Avenue, improving vehicle flow at the US 36, I-76 and I-270 on-ramps by improving ramp spacing, and providing an auxiliary climbing lane to Thornton Parkway.
  - The deceleration lane and improved ramp spacing are projected to reduce turbulence and increase the vehicle throughput to 9,100 vehicles per hour and the per lane vehicle throughput to 1,800 vehicles per hour per lane.
- Under Option D, 2040 northbound PM peak hour average speeds are projected to increase by 3.6 percent to 26.2 mph compared to those of the No Action Alternative, and average network delay (s/veh) would decrease by 5.2 percent.
- Under Option D, the 2040 northbound PM peak hour is projected to improve to LOS D between the I-76 merge and the I-270 merge compared to that of the No Action Alternative.

Safety.

- Option D would include a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers unexpectedly entering and exiting the Express Lanes.
- Option D would include standard shoulders that would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- Option D would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

Option D has the potential to reduce secondary, merge- and congestion-related crashes on northbound I-25.

Option E – Ramp Spacing Modifications, Add CD Road between I-270 and 84th Avenue

Traffic Operations.

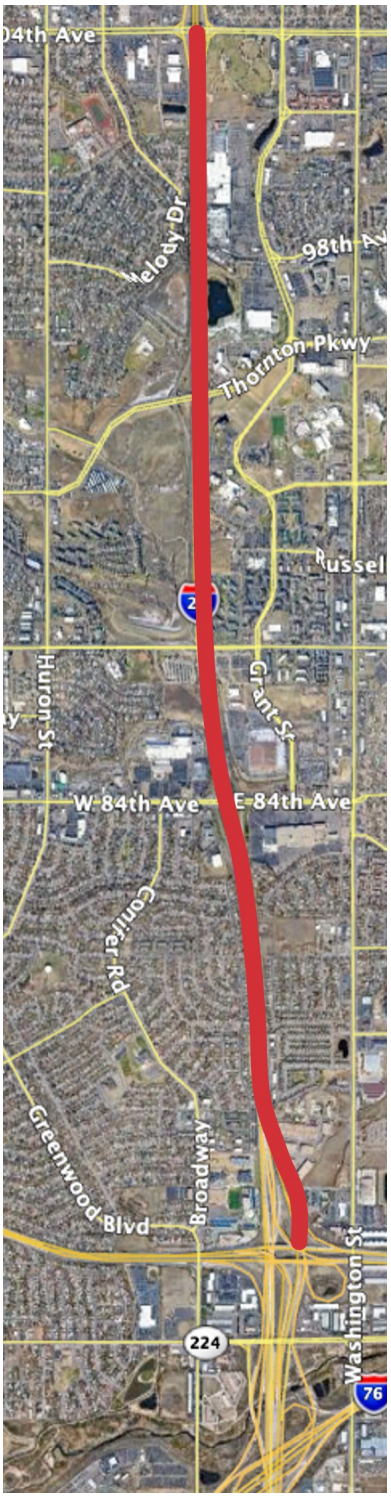
- Option E would improve existing and projected congestion between US 36 and the Thornton Parkway Interchange by providing a CD Road for vehicles exiting I-25 to 84th Avenue and merging onto northbound I-25 from I-270, improving spacing between the I-76 and US 36 northbound on-ramp, and providing an auxiliary climbing lane to Thornton Parkway.
  - The ramp spacing modifications and addition of the CD Road would reduce turbulence at the merge locations and increase the per lane vehicle throughput to 1,600 vehicles per hour per lane.
- Under Option E, 2040 northbound PM peak hour average speeds are projected to increase by 3.2 percent to 26.1 mph compared to those of the No Action Alternative, and average network delay (s/veh) would decrease by 7.0 percent.
- Under Option E, the 2040 northbound PM peak hour is projected to improve to LOS D/E between the I-76 merge and the I-270 merge compared to that of the No Action Alternative.

Safety.

- Option E would include a 4-foot buffer between the Express Lane and general-purpose lanes allowing more time for drivers to react to other drivers unexpectedly entering and exiting the Express Lanes.
- Option E would be expected to reduce sideswipe crashes due to the addition of barrier separation of the northbound I-25 traffic from vehicles exiting I-25 to 84th Avenue and merging onto northbound I-25 from I-270.
- Option E includes standard shoulders that would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- Option E would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

Option E has the potential to reduce secondary crashes and significantly reduce merge- and congestion-related crashes on northbound I-25. Reducing speed differential is expected to significantly reduce rear-end crashes.

Option F – EA Preferred & Option E Hybrid



Traffic Operations.

- Option F would improve existing and projected congestion between US 36 and the Thornton Parkway Interchange by providing a CD Road for vehicles exiting I-25 to 84th Avenue and merging onto northbound I-25 from I-270, improving spacing between the I-76 and US 36 northbound on-ramp, and providing an auxiliary climbing lane past the existing bottleneck at Thornton Parkway to 104th Avenue.
  - The ramp spacing modifications and the addition of the CD Road would reduce turbulence at the merge locations and increase the per lane vehicle throughput to 1,700 vehicles per hour per lane.
  - Extending the auxiliary climbing lane past the existing bottleneck at Thornton Parkway to 104th Avenue would increase the per lane vehicle throughput to 7,750 vehicles per hour and improve to LOS E.
- Under Option F, 2040 northbound PM peak hour average speeds are projected to increase by 22.5 percent to 31.0 mph compared to those of the No Action Alternative, and average network delay (s/veh) would decrease by 24.2 percent.
- Under Option F, the 2040 northbound PM peak hour is projected to improve to LOS D/E for the entire length of the corridor (from the I-76 merge to the 104th Avenue Interchange) compared to that of the No Action Alternative.

Safety.

- Option F would include a 4-foot buffer between the Express Lanes and general-purpose lanes allowing more time for drivers to react to other drivers unexpectedly entering and exiting the Express Lanes.
- Option F would be expected to reduce sideswipe crashes due to the addition of barrier separation of the northbound I-25 traffic from vehicles exiting I-25 to 84th Avenue and merging onto northbound I-25 from I-270.
- Option F would include standard shoulders that would provide safe space for law enforcement and emergency vehicles to operate on the shoulders.
- Option F would also provide space for drivers to maneuver to avoid crashes; having a 12-foot shoulder would increase the likelihood that a driver who has entered the shoulder to avoid a crash can safely recover.

Option F has the greatest potential to significantly reduce secondary, congestion- and merge-related crashes on northbound I-25.

8. What are the implications to Greenhouse Gas Emissions?

The Colorado Greenhouse Gas Pollution Reduction Roadmap found transportation as one of the largest sources of GHG emissions in Colorado, with passenger vehicles serving as the largest contributor to GHG emissions. Transportation is not only the leading source of GHG pollution in Colorado but also a leading source of nitrogen oxides, a precursor to ground level ozone, and particulate matter, a damaging pollutant and contributor to ozone. These pollutants are concentrated in North Denver and Commerce City; the North I-25 project is in an area of high emissions.

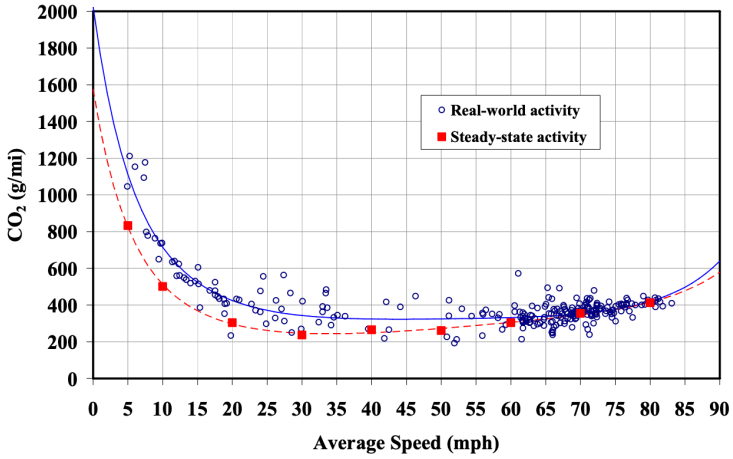
Population and employment growth are projected to increase travel demand, further reducing travel speeds and increasing congestion. Without improvement, congestion on I-25 will continue to increase resulting in increased traffic accidents, decreased safety performance, and increased GHG emissions. In addition to improving vehicle efficiency and promoting the widespread adoption of zero-emission vehicles, GHG emissions can be significantly lowered by improving traffic operations and reducing congestion.

A study conducted by the University of California – Riverside found that GHG emissions can be reduced by nearly 20 percent via three operational strategies:

- Congestion mitigation to reduce severe congestion and increase traffic speeds;
- Speed management techniques to reduce high free-flow speeds; and
- Shock wave suppression techniques to eliminate acceleration/deceleration events associated with stop-and-go traffic that exists during congested conditions.

The study evaluated modeled and real-world carbon dioxide (CO_2) emissions as a function of average running speed, as shown on **Figure 8.1**. Small changes in average traffic speeds (e.g., 2.5 mph) can result in significant emission reductions. Speed improvements of 2.5 mph, 5 mph, and 10 mph can provide reductions of up to 25 percent, 45 percent, and 70 percent, respectively.

Figure 8.1. CO_2 Emissions (grams/mile) as a Function of Average Trip Speed (mph)[1]



[1] Barth, Matthew, and Kanok Boriboonsomsin. "Real-World Carbon Dioxide Impacts of Traffic Congestion." *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2058, no. 1, 2008, pp. 163-171., DOI: 10.3141/2058-20.

The study also found that smoother traffic flow can result in up to 45 percent reductions if steady flow can be achieved, including for low-speed conditions (see **Figure 8.2**). Smoothing flow at congested speeds can result in emission reductions of up to 12 percent as compared to typical stop-and-go driving in congestion.

Figure 8.2. Potential CO_2 Reduction as a Result of Smoother Traffic Flow[1]

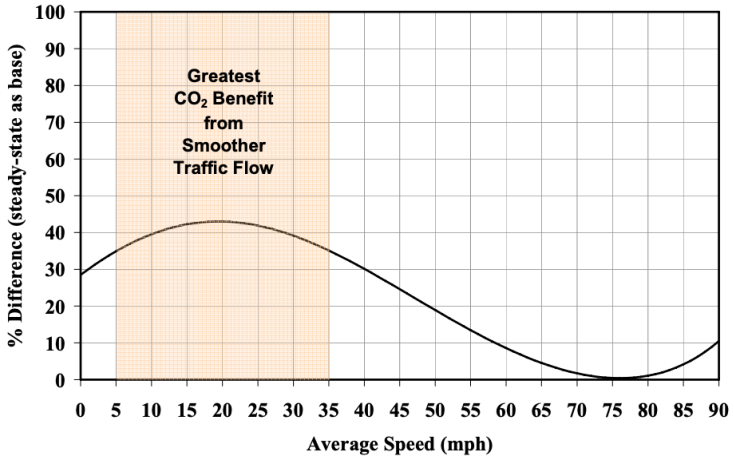


Figure 8.3 illustrates the modeled speed variability on I-25 of the options evaluated as part of this effort.

- Option A (No Action) and Option B are projected to experience significant speed reductions along the segments where the I-76, US 36 and I-270 on-ramps merge onto northbound I-25.

  Option B has the potential to increase congestion-related GHG emissions.

- Option C and Option D experience reduced variability in speed along I-25. However, both options are projected to experience a speed reduction after the I-76, US 36 and I-270 on-ramps and at the 84th Avenue Interchange.

  Options C and D have the minimal potential to significantly reduce congestion-related GHG emissions associated with low average speed.

- Option E is projected to experience a less abrupt drop in speed after the I-76, US 36 and I-270 on-ramps. Speeds would remain in the 15 to 25 mph range past the 84th Avenue Interchange, and speeds would return to 45 to 55 mph north of the Thornton Parkway Interchange.

  Option E has moderate potential to reduce congestion-related GHG emissions associated with increased travel speeds and reductions in speed variability.

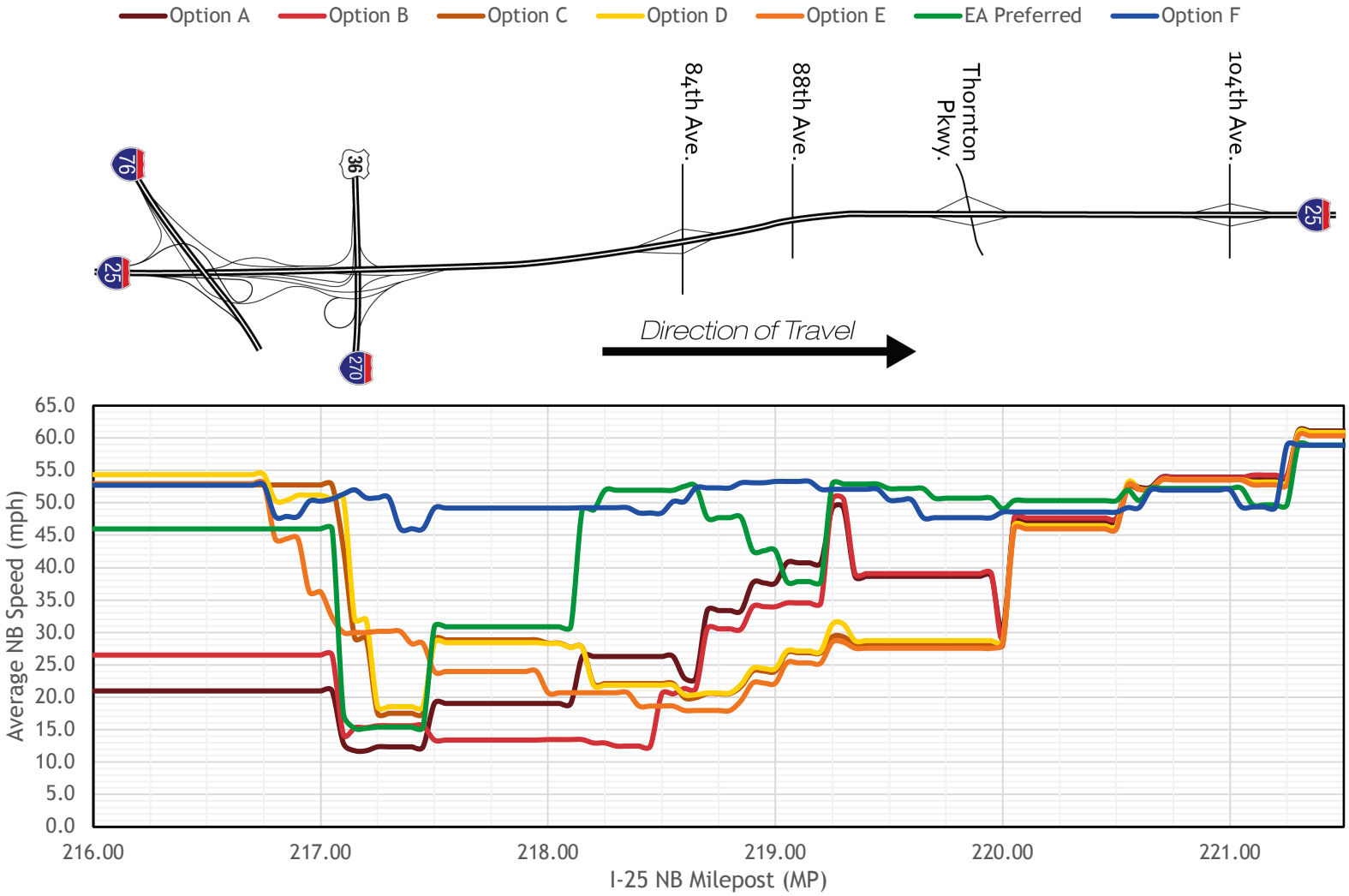
- The EA Proposed Action experiences a speed reduction after the I-76, US 36 and I-270 on-ramps with speed returning to 45 to 55 mph approaching the 84th Avenue Interchange.

  The EA Proposed Action has high potential to significantly reduce congestion related GHG emissions.

- Option F is projected to eliminate congestion-related low speeds and related speed variability along the I-25 North corridor.

  Option F has the greatest potential to significantly reduce congestion-related GHG emissions.

Figure 8.3. Comparison of I-25 Northbound Speed



9. What are the design & right-of-way (ROW) considerations of the evaluated options?

Option A – Bring Corridor to Standard

- Option A is not projected to require significant design and/or ROW considerations.

Option B – Add Continuous Auxiliary Lane between I-270 and 84th Avenue

- Option B is not projected to require significant design and/or ROW considerations.

Option C – Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

- Improvements would require a decision on how to accommodate the RTD Thornton Park-n-Ride/Station because the climbing lane would impact existing station slip ramps.

Option D – Ramp Spacing Modifications, Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

- Improvements would require a decision on how to accommodate the RTD Thornton Park-n-Ride/Station because the climbing lane would impact existing station slip ramps.

Option E – Ramp Spacing Modifications, Add CD Road between I-270 and 84th Avenue

- Improvements would require a decision on how to accommodate the RTD Thornton Park-n-Ride/Station because the climbing lane would impact existing station slip ramps.
- CD Road has the potential to impact the existing noise wall and at least one property near the existing exit ramp to 84th Avenue.

Option F – EA Preferred & Option E Hybrid

- Improvements would require a decision on how to accommodate the RTD Thornton Park-n-Ride/Station because the climbing lane would impact existing station slip ramps.
- CD Road has the potential to impact the existing noise wall and at least one property near the existing exit ramp to 84th Avenue.

10. What are the environmental clearance considerations for the evaluated options?

Which potential supplemental options move first into the National Environmental Policy Act (NEPA) process is currently undetermined. This will depend on future funding. However, it is anticipated that the majority of the supplemental options would qualify for a Categorical Exclusion (CatEx) NEPA Class of Action under the category:

- C26. Modernization of a highway by resurfacing, restoration, rehabilitation, reconstruction, adding shoulders, or adding auxiliary lanes (including parking, weaving, turning, and climbing lanes), if the action meets the constraints in 23 CFR 771.117(e).

Depending on the specific project, additional categories may apply. If an action does not qualify under one of the CatEx categories or would be considered regionally significant, a Documented CatEx may be applicable. CDOT and FHWA will make the final determination of the NEPA Class of Action, as appropriate.

If the option is combined with the EA Proposed Action, the draft EA should be updated with 2050 traffic volumes, current safety conditions, and completed.

11. What are the key findings?

The operational analyses provide better understanding of the impacts of each improvement included in the packaged options. The following sections summarize how well each improvement addresses the existing operational and safety challenges of the corridor.

Addressing the bottleneck from vehicles merging onto northbound I-25 from I-76, US 36 and I-270 and at Thornton Parkway

Constructing a continuous auxiliary lane between I-270 and 84th Avenue in isolation (Option B) is projected to demonstrate negligible benefit to vehicular flow, LOS, or traveled speed. Releasing the bottleneck south of the 84th Avenue Interchange without addressing the bottleneck at Thornton Parkway allows vehicles to reach the Thornton Parkway bottleneck sooner and creates a higher speed differential as vehicles travel through the corridor.

Auxiliary lane improvements to this segment should be paired with a climbing lane that extends at least as far as the Thornton Parkway Interchange to help vehicles accelerate up the hill (Options C, D and E).

Extending the climbing lane increases the functional capacity, flow, and average traveled speeds at the bottleneck from vehicles merging onto northbound I-25 from I-76, US 36 and I-270. The combination of the auxiliary lane (continuous or a deceleration lane) and the climbing lane shifts the bottleneck south of 84th Avenue to the north and distributes the congestion over more lanes. In doing so, it reduces speed variations and distributes lane changing activity over a longer area further reducing congestion associated with turbulent vehicular flow.

Extending the climbing lane through the congestion at the Thornton Parkway Interchange (to the 104th Avenue Interchange) provides the greatest benefit to resolving the congestion-related bottlenecks along the corridor (EA Proposed Action).

As shown on **Figure 7.1**, for the EA Proposed Action, PM peak hour LOS is projected to improve to LOS D/E north of the 84th Avenue Interchange. Additionally, operational analyses of the EA Proposed Action demonstrate a 12 percent increase in average network speed, an 18 percent decrease in

average network delay and a 10 percent increase in peak hour VMT. Because the operational analyses focus on the peak hour, increased VMT does not necessarily reflect induced demand associated with the Proposed Action but demonstrates a reduction in the duration of peak period congestion associated with increasing the number of vehicles that can travel through the corridor during the peak hour.

There is limited ability to address the bottleneck from vehicles merging onto northbound I-25 from I-76, US 36 and I-270 (south of the 84th Avenue Interchange) without addressing the bottleneck to the north at Thornton Parkway. Improvements are needed to address both bottlenecks and the safety and operational needs of the corridor.

Existing on- and off-ramp spacing creates turbulence resulting in operational and safety challenges

The closely spaced existing on-ramps from I-76, US 36 and I-270 and the high merging volumes create weaving turbulence from vehicles merging onto northbound I-25 and mainline I-25 vehicles exiting at 84th Avenue.

Adding auxiliary lanes (Options B and C) show minor operational improvements at the bottleneck south of 84th Avenue and provides additional space for non-weaving traffic and to accommodate lane changes, increasing the vehicle throughput for the segment. However, these improvements do not completely address the lane crowding and turbulence in the auxiliary lanes and the operational and safety impacts to the adjacent general-purpose lanes.

Accommodating the I-270 northbound merge and the exit to 84th Avenue in a barrier separated CD Road (Option E) demonstrates the greatest potential to improve corridor travel speeds without providing the climbing lane to Thornton Parkway. Option E limits improvements to the area between US 36 and the Thornton Parkway Interchange. The Option E CD Road concept is projected to increase average network speed by over 3 percent, while decreasing average network delay by 7 percent and increasing VMT by 4.5 percent.

Option F combines the CD Road concept from Option E with the EA Proposed Action improvements. Option F is projected to increase average network speeds by over 22 percent, decrease average network delay by nearly 25 percent, and increase PM peak hour VMT by over 15 percent. As shown on **Figure 7.1**, Option F improves corridor area LOS to LOS D/E for all segments, eliminates traveled speed variability (**Figure 7.2**) and improves PM peak hour average mainline speeds to 45 to 55 mph.

The addition of CD Roads is expected to reduce sideswipe and rear end crashes due to the addition of barrier separation of the northbound I-25 traffic from vehicles exiting I-25 to 84th Avenue and merging onto northbound I-25 from I-270. The CD Roads (included in Options E and F) are the best improvement to address the operational and safety challenges associated with the vehicular turbulence of the closely spaced existing on-ramps from I-76, US-36 and I-270.

The CD Roads are projected to provide corridor operational and safety benefits even in the absence of other improvements (Option E). Combining Option E with the improvements included in the EA Proposed Action (Option F) has the potential to provide additional benefits to operations and safety.

12. What are the Next Steps for advancing improvements along North I-25?

The information presented in this white paper has been assembled to aid in the selection of an option that can address the operational and safety needs of the North I-25 corridor. This supplemental options analysis validated and used assumptions from the draft North I-25 EA to complete an alternatives evaluation. Following the selection of an option, the following steps are recommended:

- Recommend an Option to carry forward into NEPA and engineering design;
- Incorporate the Option into the alternative development and evaluation process and Proposed Action for the I-25 (US 36 to 104th Avenue) Environmental Assessment;
- Update the operations analysis with 2050 travel demand volumes for the existing conditions, No-Action Alternative, and Proposed Action for the I-25 (US 36 to 104th Avenue) Environmental Assessment;
- Update the safety assessment for existing conditions;
- Complete the I-25 (US 36 to 104th Avenue) Environmental Assessment and Decision Document; and
- Evaluate and coordinate the impact of the proposed alternatives on Express Lane operations and design (e.g., ingress/egress locations) with HPTE.

13. References

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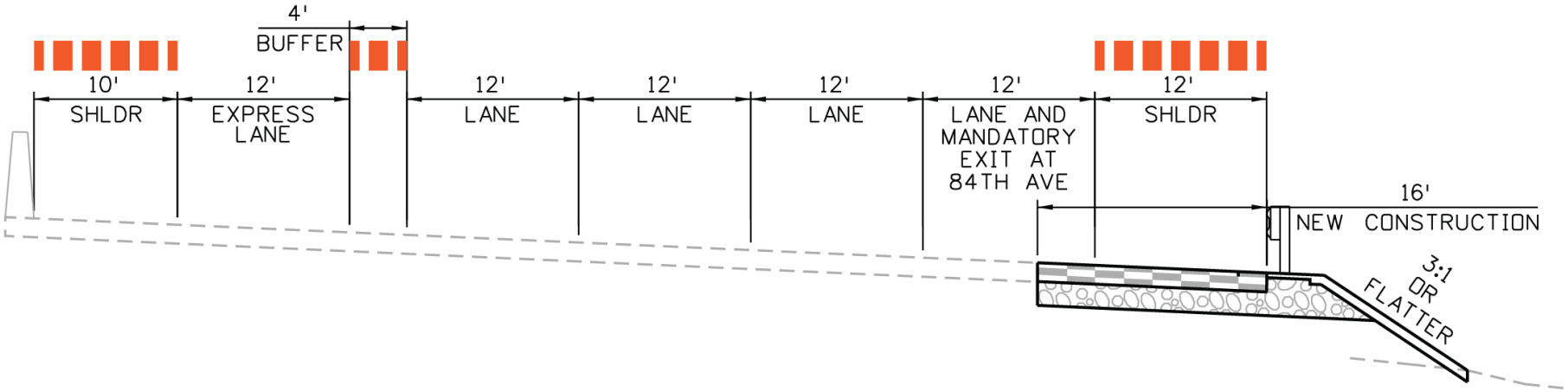
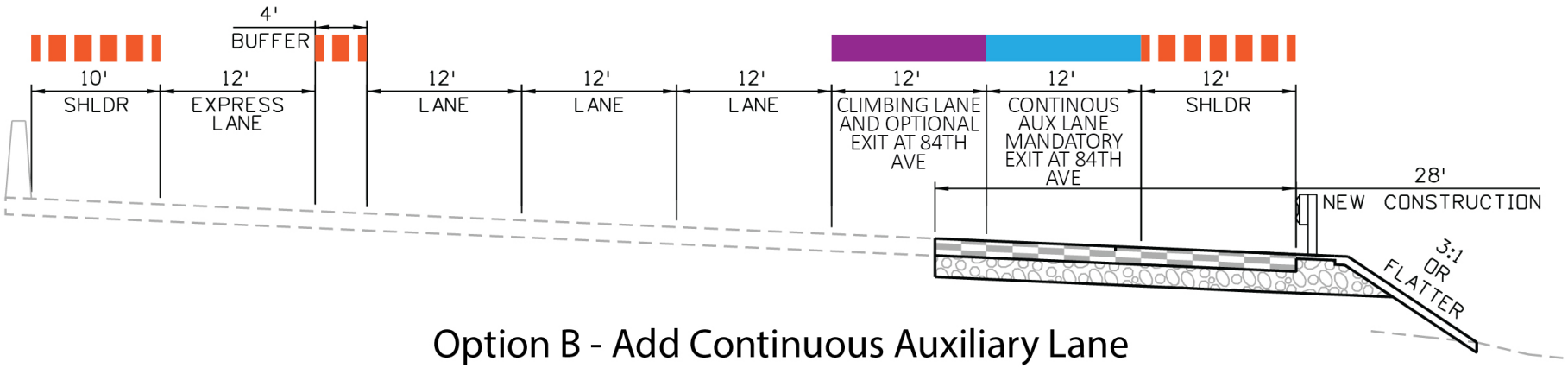
APPENDIX A. CONCEPTUAL DESIGNS AND TYPICAL CROSS-SECTIONS



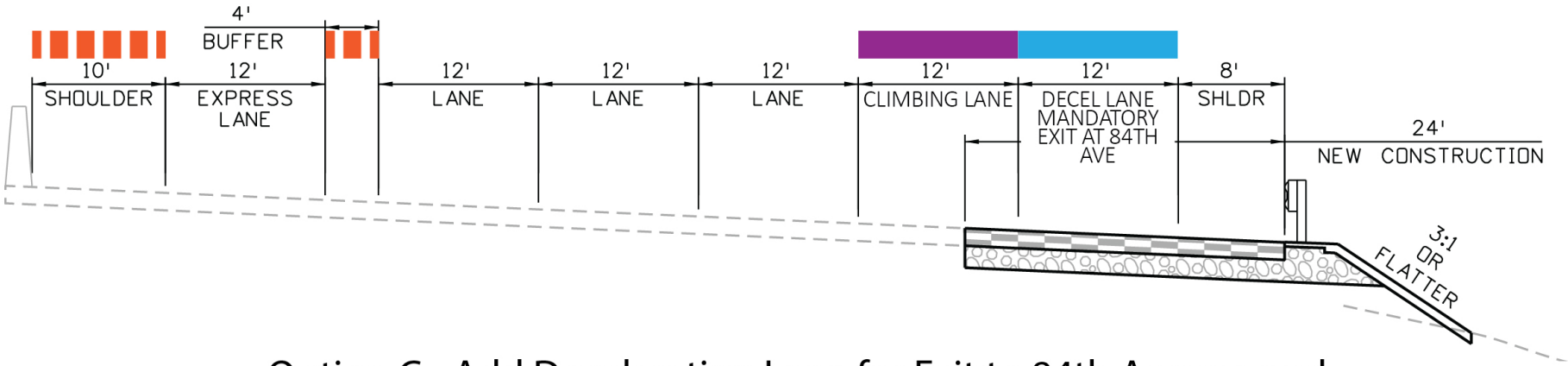
Option A - Bring Corridor to Standard

(NB I-25 Looking North)



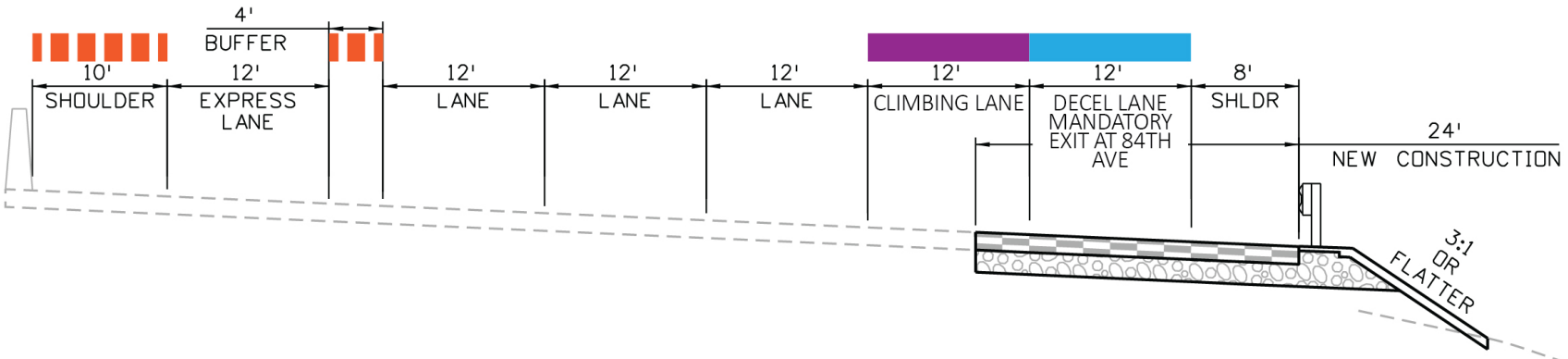
Option B - Add Continuous Auxiliary Lane Between I-270 and 84th Avenue

(NB I-25 Looking North)



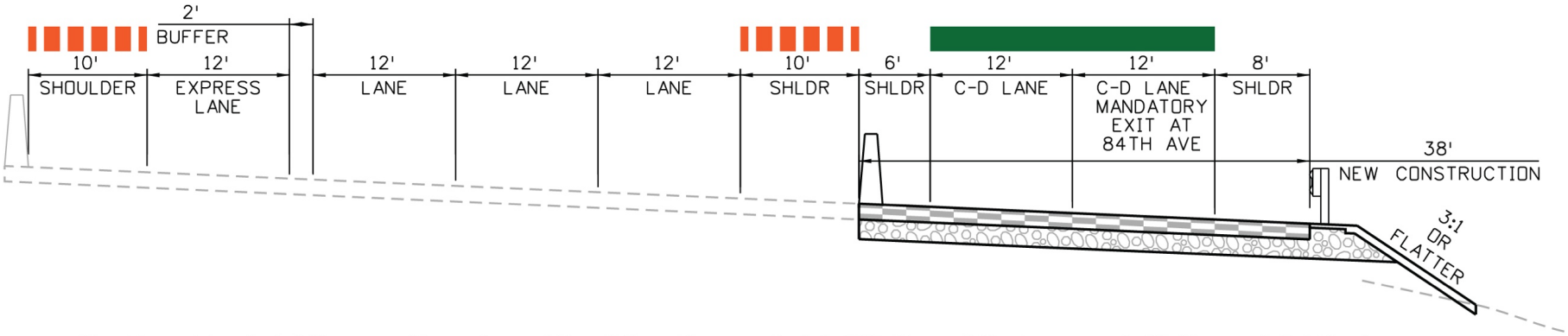
Option C - Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

(NB I-25 Looking North)

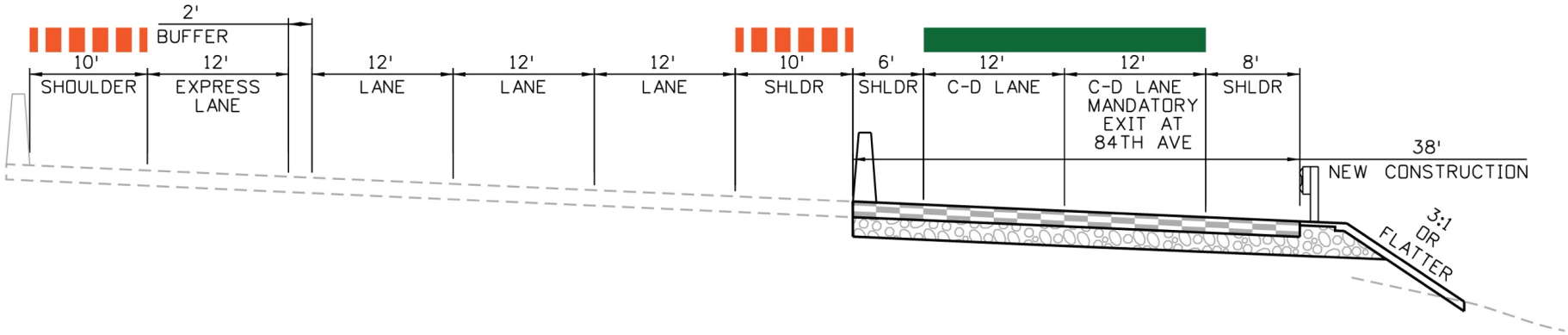


Option D - Add Ramp Spacing Modifications, Add Deceleration Lane for Exit to 84th Avenue and Extend Climbing Lane to Thornton Parkway

(NB I-25 Looking North)



Option E - Add Ramp Spacing Modifications, Add CD Road Between I-270 and 84th Avenue
(NB I-25 Looking North)



Option F - Add Ramp Spacing Modifications, Add CD Road Between I-270 and 84th Avenue and Extend Climbing Lane to Thornton Parkway
(NB I-25 Looking North)