COLORADO
Department of Transportation
Division of Maintenance & Operations

Colorado Traction Law (House Bill 19-1207)

Initial Research and Evaluation of Enforcement Options

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1. Introduction

1.1. Purpose

Governor Polis signed House Bill (HB) 19-1207 into law on May 17, 2019. The law requires the Colorado Department of Transportation (CDOT) and the Colorado State Patrol (CSP) to meet with stakeholders to discuss options and methods of traction control enforcement.

The purpose of this report is to determine how best to enforce the requirements of HB 19-1207, particularly for non-commercial passenger vehicles traveling along the I-70 Mountain Corridor. For purposes of this report, the I-70 Mountain Corridor is defined, in accordance with the language in HB 19-1207, as the segment of I-70 between milepost (MP) 133 (Dotsero) and MP 259 (Morrison).

This report provides a high-level overview and evaluation of the following:

1. History and passage of HB 19-1207 within the First Regular Session of the Colorado General Assembly; summary of key changes resulting from the new law.
2. Data related to traction and chain law implementation along the I-70 Mountain Corridor for the 2018-2019 winter season, with respect to traffic volumes, traction law citations, spin outs, crashes, and roadway closures (full and safety-related).
3. Technical feasibility assessment of various enforcement options.
4. Recommendations and timeframes for implementation for CDOT and CSP to consider.

1.2. Background

Under current law (2 CCR 601-14), CDOT has the authority to close any portion of a state highway to public travel or to prohibit travel by vehicles that are not equipped with tire chains, four-wheel or all-wheel drive with adequate tires for existing conditions, or snow tires with a "mud and snow" or all-weather rating from the manufacturer. CDOT can do this whenever it considers such a closure or restriction of use necessary for the protection and safety of the public. Highway closures and restrictions are achieved with cooperation from CSP.

The Transportation Commission has statutory authority to promulgate rules to implement Colorado's traction/chain laws, which apply to all state, federal, and interstate highways. For non-commercial vehicles, the Commission has determined two levels of traction/chain law: Code 15 and Code 16. For commercial motor vehicles (CMVs), there are also two levels of chain law, referred to as Code 17 and Code 18.

- **Code 15** requires the use of snow tires or traction devices such as cable chains; however, four-wheel drive vehicles are permitted to operate without a traction device.
- During a **Code 16**, use of conventional, steel-link chains or an approved traction control device is required for all vehicles, including four-wheel drive and all-wheel drive vehicles. Code 16 is very rarely implemented and is the final safety measure before a highway is closed.

- **Code 17** requires straight trucks, single drive axle combinations, buses, and auto transporters to use tire chains, AutoSocks, tire cables, auto chains, or sanders.
- **Code 18** requires the aforementioned CMV types along with tandem drive axle combinations to use tire chains, AutoSocks, tire cables, auto chains, or sanders.

1.3. Summary of Legislation

HB 19-1207 was first introduced in the House on February 21, 2019. Governor Polis signed HB 19-1207 on May 17, 2019. The bill requires all motor vehicles (non-commercial passenger and CMVs) driving on I-70 between MP 133 (Dotsero) and MP 259 (Morrison), from September 1 to May 31 of each year, to be equipped with:

- Tire chains or an alternative traction control device (i.e. cable chains);
- Four-wheel drive or all-wheel drive with tires that have a tread depth of 3/16" and that are adequate for the conditions; or
- Tires with any form of the mountain-snowflake symbol or mud/snow rating (i.e. M&S, M+S, or M/S) imprinted by the manufacturer or that are all-weather rated by the manufacturer and a tread depth of at least 3/16".

Under the bill, "equipped" means that a motor vehicle uses or carries the appropriate traction equipment for icy or snow-packed conditions.

A non-commercial violator of these requirements commits an existing Class B traffic infraction and is subject to a $100 fine and a $32 surcharge. If a violation results in the closure of at least one lane of traffic, the violator is subject to a penalty of $500 and a $156 surcharge.

1.4. Overview of Key Changes

The law reaffirms CDOT's ability to close state highways during, "dangerous driving conditions, during construction or maintenance operations, or when necessary for the protection and safety of the traveling public."

The law formalizes traction/chain law requirements for non-commercial passenger vehicles. When icy or snow-packed conditions exist on a highway, CDOT may restrict travel to any motor vehicle not properly equipped for the conditions, as defined in the above section with respect to chains, four-wheel drive or all-wheel drive, and tire tread depth and all-weather, M&S, or mountain-snowflake ratings.

In addition, the law changes the required minimum tire tread depth for vehicles on snowy/icy roads from 2/16" to 3/16".

While the bill specifies the I-70 Mountain Corridor, this does not limit the applicability of the law to this corridor. CDOT traction and chain laws apply to all state highways. The legislation speaks to the I-70 corridor because it is a critical highway to keep open, and because the high number of spinouts and crashes that occur along this road from September through May.

1.5. Quick Primer on Traction & Tire Tread Depth

Traction can be defined as the friction between a drive wheel and the surface it moves upon. It is the amount of force a wheel can apply to a surface before it slips. Tire tread depth is important because a tire's grooves work to squeeze out water, snow and debris. This allows tires to maintain traction with the road surface and keep the vehicle running safely.

A tire's tread depth impacts a vehicle's ability to stop, referred to as stopping distance. This is particularly true in wet, snowy, or icy road conditions. **Table 1** summarizes the stopping distance from 60 mph for a typical passenger vehicle equipped with tires of tread depths varying from 10/32" to 2/32". As can be seen, tires with tread depth not compliant with the new traction law (anything less than 6/32") take anywhere from 50' to 126' farther to stop in wet conditions.

Table 1. Relationship Between Tread Depth and Stopping Distance

Tire Tread Depth	Wet Weather Stopping Distance from 60 mph
10/32"	230'
6/32"	253'
4/32"	280'
2/32"	356'

Furthermore, **Table 2** describes how tires with varying tread depths perform in wet weather when at rest, at 45 mph, and at 60 mph. Tires with worn tread do not displace water as efficiently. The result is that the tire's center loses contact with the road, thereby reducing a vehicle's traction.

Table 2. Tire Performance at Varying Speeds and Tread Depths

Speed	Tire Tread Depth		
	10/32"	**4/32"**	**2/32"**
At Rest	New tires show clearly defined tread ensuring efficient water displacement	When comparing stationary tires, little difference in tread definition new tire tread and a tire worn to 4/32"	At minimal tread depth, tread definition is barely visible.
45 MPH	Tires with well-defined tread will maintain better contact.	Unable to displace water efficiently, water begins to pool at the front of the tire with worn tread.	Tires with severely worn tread have far less contact with the road and allow a dangerous amount of water to pool at the front of the tire.
60 MPH	At high speeds, even tires with well-defined tread cannot sufficiently displace water. Eventually, only the sides and back of the tire will make contact with the road.	Tire's center has no contact with the road. With only the sides of the tire somewhat in control, high-speed road travel is hazardous on slightly worn tread.	At high speeds with minimal tread depth, water can no longer be displaced properly, lifting the tire off the road surface – hydroplaning out of control.
Source: Hunter Engineering Company: https://www.hunter.com/inspection/quick-tread			

2. Past Winter Season Research

2.1. Purpose and Overview

This section displays key metrics about the current operating strategies and environmental conditions on the I-70 Mountain Corridor from MM 133 to 259 performed the past winter season (September 1, 2018 to May 31, 2019). The purpose is to establish a baseline understanding of environmental conditions and operating strategies. The following metrics are used:

1. **Traction Law:** The number of times traction law was implemented, and the average duration.
2. **Traffic Volumes:** The total volume during the winter period, and Average Daily Traffic (ADT) for all vehicles and CMVs.
3. **Safety Patrol - Passenger Vehicles:** The count and type of dispatches all winter to passenger vehicles by CDOT Safety Patrol operators.
4. **Safety Patrol/Heavy Tow – CMVs:** The count and type of dispatches all winter to CMVs by CDOT Safety Patrol and Heavy Tow operators.
5. **Full Closures:** The number of full roadway closures in each direction at five locations.
6. **Safety Closures:** The number of safety closures this past winter season.

Data on these metrics are described in sub-sections 2.2.1 – 2.2.6. Each section is accompanied by a description of the metrics and key findings. Section 2.3 identifies the key takeaways.

2.2. Past Winter Season Data

2.2.1. Traction Laws

Figure 1: Average duration of traction laws.

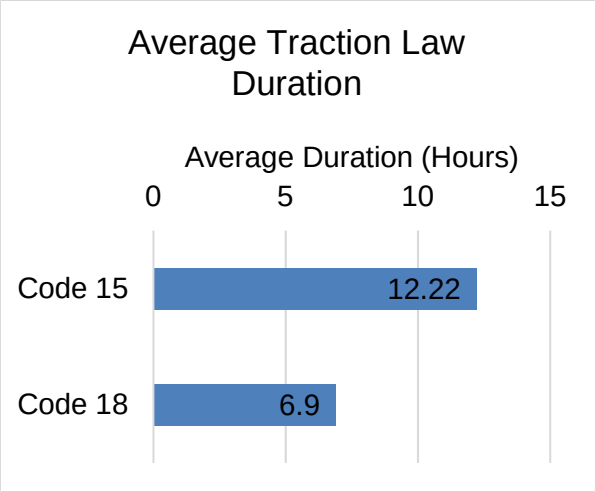
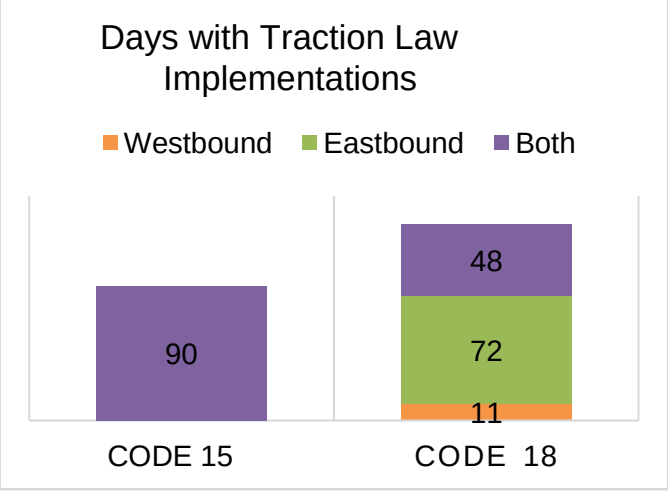


Figure 2: Number of days (i.e., storm events) where traction law was implemented.

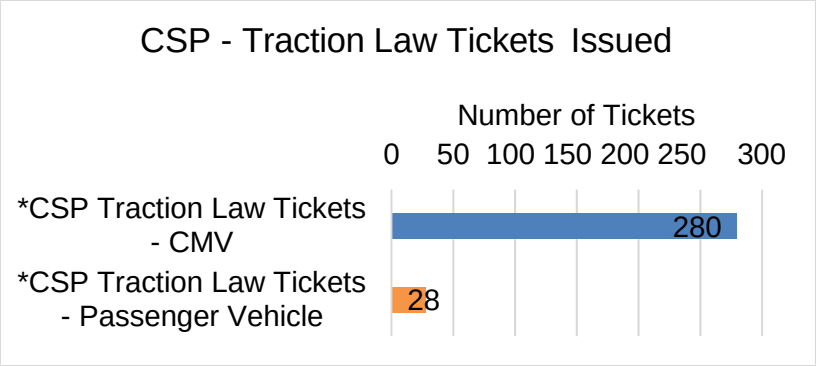


Key Findings:

- Code 18 was implemented 131 days, 41 more days than Code 15.
- However, Code 15 has an average duration of ~12 hours, whereas Code 18 has an average duration of ~7 hours.
- Code 16 was not implemented.

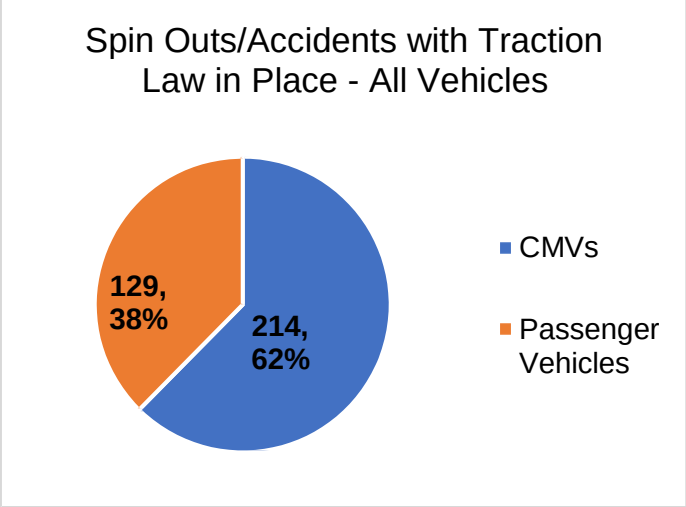
2.2.2. Traction Law Tickets and Spin Outs / Accidents during Traction Law

Figure 3: Number of Traction Law Tickets written.*



***** Data only October 2018-March 2019

Figure 4: Spin outs[1] / accidents with traction law in place.



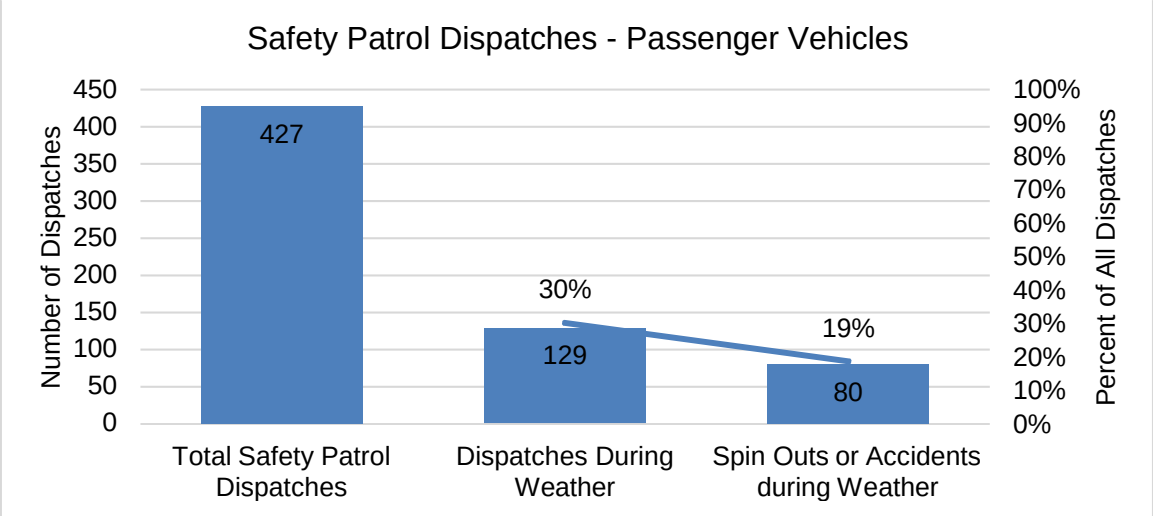
Key Findings:

- Only 28 traction law violations to passenger vehicles were written this past winter.
  - Increased enforcement would be a major change from the status quo, though responses by motorists to ticketing as a secondary offense would likely remain isolated.
  - This is significantly lower than the total recorded number of passenger vehicle spin outs / accidents with traction law in place (214).
- The 280 Traction Law tickets written exceeds the number of spin outs / accidents by CMVs with traction law in place (214).
- Existing enforcement appears to target CMVs more effectively than passenger vehicles
- It is important to note that the data on number of tickets are limited in detail, and no higher resolution data regarding the types of tickets issued were available

[1] Spin outs classified by the TMC Operators in charge of Courtesy Patrol dispatch.

2.2.3. Safety Patrol – Passenger Vehicles and CMVs

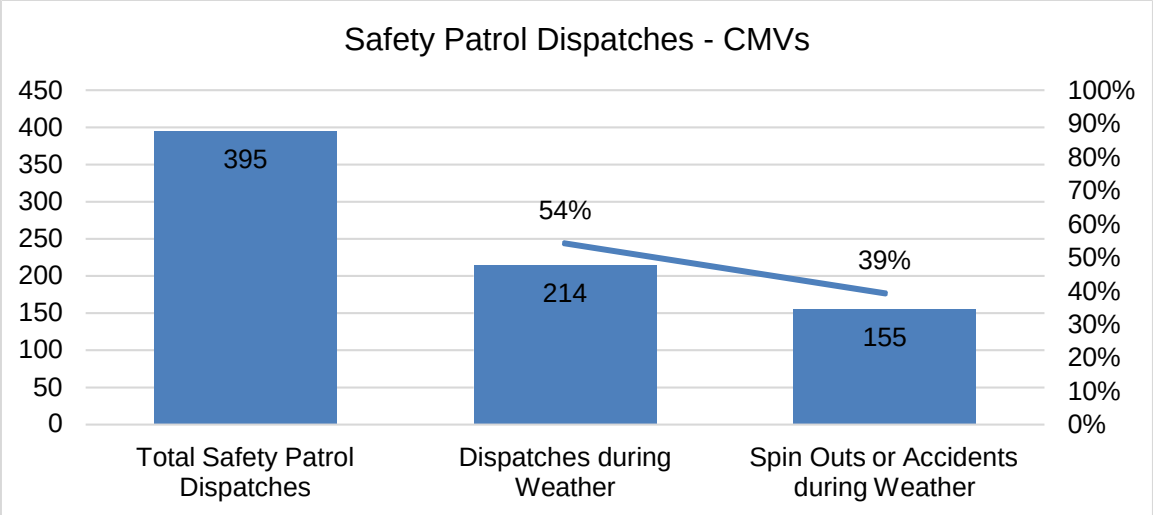
Figure 5: Breakdown of all Safety Patrol dispatches to passenger vehicles.



Key Findings:

- Last winter, there were 427 safety patrol dispatches to passenger vehicles.
  - 30% of all dispatches were during weather.
  - 19% of ***all*** dispatches were to spin outs / accidents during weather.
  - Note that 62% of ***weather dispatches*** were to spin outs or accidents (not shown).

Figure 6: Breakdown of all Safety Patrol dispatches to CMVs.



Key Findings:

- About twice as many dispatches to spin outs / accidents during weather were to CMVs as opposed to passenger vehicles
- Last winter, there were 395 safety patrol dispatches to CMVs.
  - 54% of all dispatches were during weather.
  - 39% of **all** CMV dispatches were to spin outs / accidents during weather.
  - Note that 72% of ***weather dispatches*** were to spin outs or accidents (not shown).

2.2.4. Traffic Volumes

Figure 8: Average daily traffic volumes this past winter.

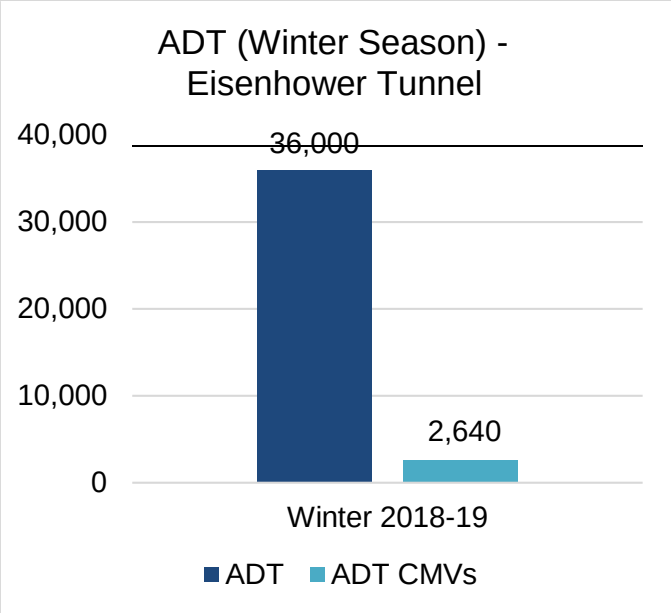
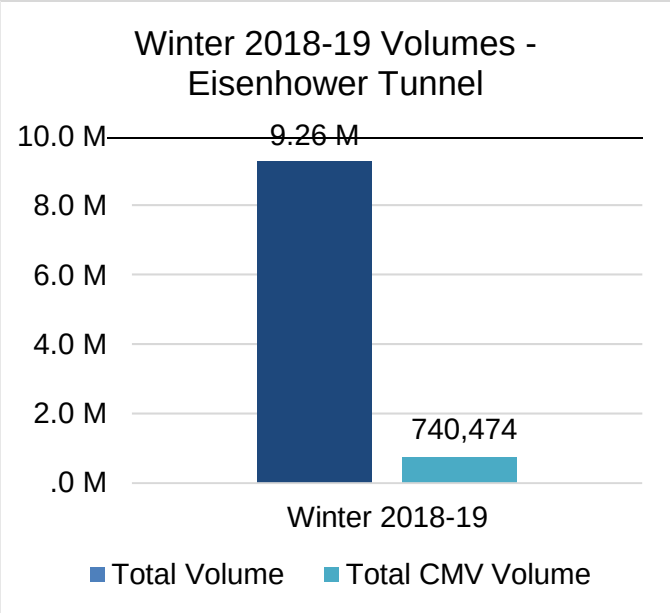


Figure 7: EJMT Cumulative Traffic Volumes (Winter '18-2019).



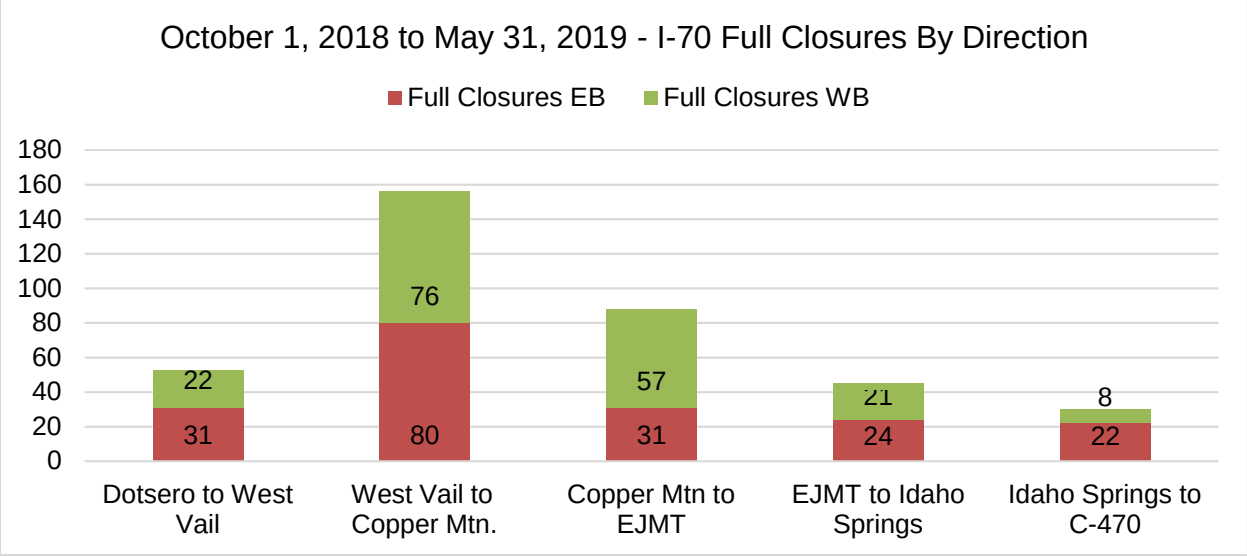
Key Findings:

- The cumulative number of vehicles passing through the tunnel the past winter season was over 9 Million; ~750k of those vehicles were CMVs, and 8.5 million of these vehicles are passenger vehicles.
- Each day, 36,000 vehicles pass through the tunnel; over 2,500 of these are CMVs, and 33,360 of these vehicles are passenger vehicles.

2.2.5. Full Closures

Frequency of full closures are investigated in this and the next section. Note that safety closures represent a subset of full closures and are only implemented reactively in response to an incident. Implementation of full closures of any kind are restricted to locations with no grade, allowing vehicles to regain traction after stopping. There must also be access to services and the ability to make a U-turn.

Figure 9: I-70 Full Closures by Direction and Location (Winter 2018-2019).

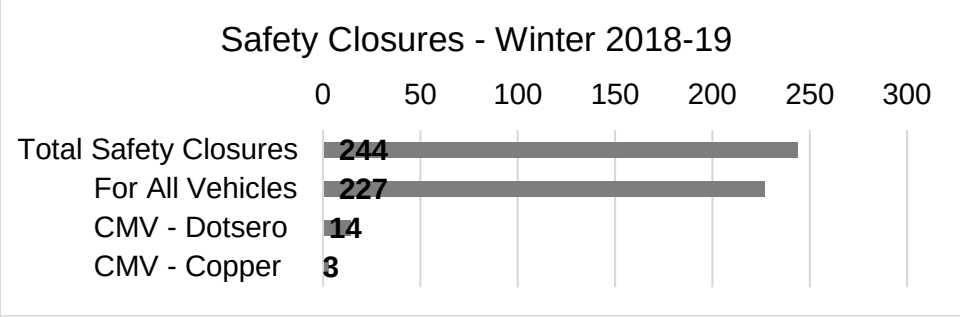


Key Findings:

- The majority of full roadway closures, in both directions, are between Vail and EJMT.
  - 156 total from West Vail to Copper and 88 from Copper to EJMT.
- The fewest closures, 30 total, were closest to Denver between Idaho-Springs and C-470 (Golden).

2.2.6. Safety Closures

Figure 10: I-70 Safety Closure Summary (Winter 2018-2019)



Key Findings:

- There were 244 safety closures all winter.
- The majority, 227, were for all vehicles.
- Only 17 instances were for CMVs only.

2.2.7. Impacts and Costs of Full Closures

For this section, three representative full closure events were examined to determine the maximum and average queue length, average hourly cost of congestion, and total cost of the closure event. These are meant to provide an indication of the costs associated with full closures.

Figure 11: Queue lengths from full closures.

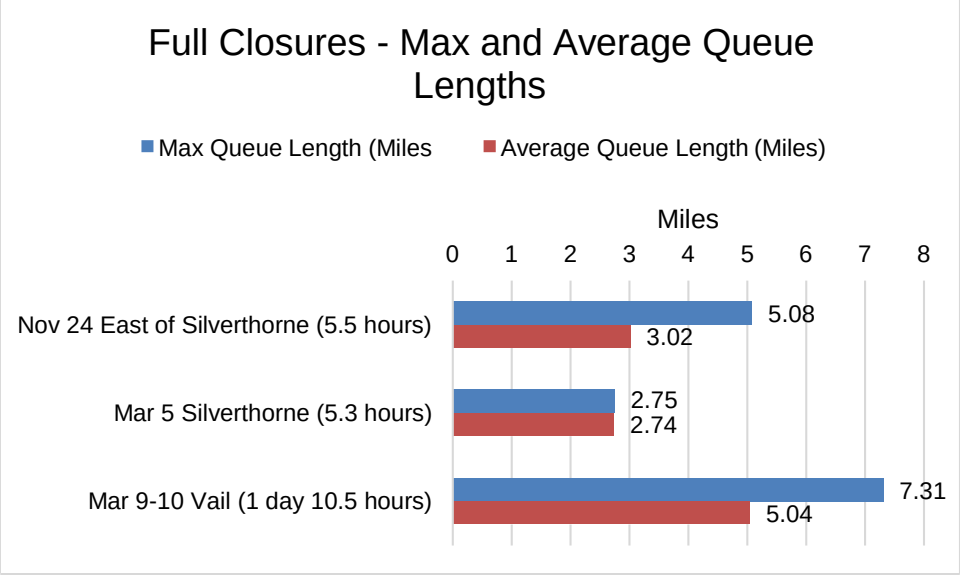
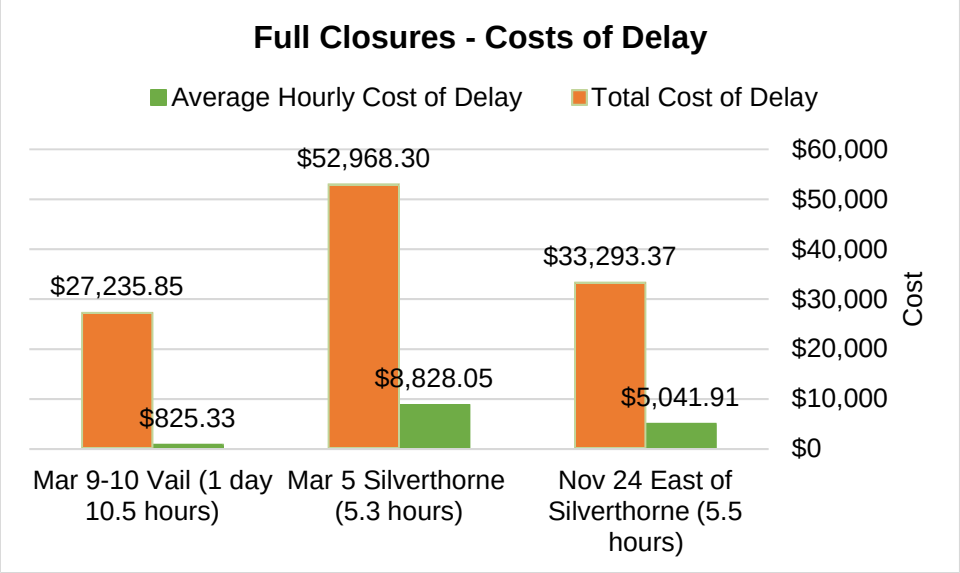


Figure 12: Average and total cost of delay caused by full closures.



Key Findings:

- Queue lengths, on average, range from ~2.5-5 miles and can reach over 7 miles
- The average hourly costs range from $825 to nearly $9,000
- The total costs of a full closure, which depends on the total duration and the severity, ranged from over $27,000 to ~$53,000.

- The three incidents sampled represent less than 1% of all full closures implemented during the winter season
- The closures sampled represent highly variable costs and cue lengths, limiting the ability to predict overall impact
- Traction law checkpoints are expected to generate more severe queues and costs, as the diversion of traffic for closures likely removes vehicles at a faster rate than can be processed by a checkpoint

2.3. Takeaways

- Only 28 traction law violation tickets have been written to passenger vehicles, so enhanced enforcement will be a major change to the status quo.

- Based on volumes collected at the Eisenhower Tunnel (EJMT) this past winter, a high number of passenger vehicles would be impacted by traction law changes: 33,360 passenger vehicles pass through the tunnel on an average winter day.

- 38% of all spin outs / accidents with traction law in place were for passenger vehicles; the remaining 62% were CMVs

- 19% of safety patrol dispatches to passenger vehicles are for spin outs or accidents during weather

- There is no data available regarding what percentage of the traveling public would comply with new (or existing) traction laws. Data on tread depth is not collected by CSP or Safety Patrol.

- Full closures have significant costs to the traveling public associated with them due to the delay caused.
    - Queues can range from 2 to 7 miles
    - On average, each hour of delay costs travelers $5,000
    - The total costs can be over $50,000 for one full closure event

3. Evaluation of Enforcement Options

3.1. Description of Enforcement Options

This section briefly describes the seven enforcement options being evaluated in this report. The options were identified working with CDOT and CSP staff.

Options 1 through 3 are primarily education and engineering focused efforts that can be implemented with minimal disruption to existing resources. The options exist to provide additional data and information to stakeholders with respect to the feasibility and viability of more extensive enforcement focused efforts, which Options 4 through 7 encompass.

Option 1: Parking Facilities Surveys

Conduct tire tread depth measurement surveys on vehicles parked in lots at the ski resorts along or accessed primarily from the I-70 Mountain Corridor. These ski resorts include Loveland, Copper Mountain, Vail, Arapahoe Basin, Keystone, and Breckenridge. Leave informational notes/brochures on windshields educating motorists about the new traction law and its requirements. Through recorded data, gain a general understanding of what percentage of the non-commercial vehicle fleet is or is not in compliance with the new traction law. Also, through separate tracking, gain an understanding of what percentage of rental cars are or are not in compliance with the new traction law. Use data to guide and inform implementation of potential future enforcement options.

There is digital tire scanner technology on the market that could potentially be used to assist with gathering a more robust sample of data related to the tire tread depth of the current non-commercial vehicle fleet. Digital tire scanner technology can measure tire tread depth of each tire in seconds and instantly display the results. The technology cannot on its own, however, distinguish between privately owned and rental vehicles. There are unknowns about the cost of this technology and its ability to perform in the field under adverse weather conditions. The technology also requires very strict speed control, as measurements can only be taken within a very limited, low speed range of between 2 and 8 mph.

Option 2: Tire Tread Pre-Check Inspections

Establish partnerships with local tire shops and/or local law enforcement agencies to conduct tire tread depth inspections. Tire shops are the most logical and motivated partner to offer inspections at no cost to motorists with the aim of increasing tire sales. Vehicles that pass inspection would receive a sticker indicating their tires are compliant with the new traction law. Inspections would be valid for one winter season based on certain conditions and standards that are yet to be determined. Pre-checked vehicles may have the ability to bypass or receive expedited service at compliance checks, if implemented.

There are potential liability and bureaucratic drawbacks to vehicles with measured tire tread near the required minimum of 3/16” receiving a compliant sticker. Tire tread depth wears somewhat proportionally to the number of miles driven. It is hard to know whether a tire near the limit would remain above it through the duration of the 9-month winter season.

Option 3: Enhanced Corridor Management & Secondary Offense Enforcement

Enhance and expand the continued use of various management techniques and technologies along the I-70 Mountain Corridor, such as speed harmonization, variable speed limits, and CMV lane use restrictions. Emphasize enforcement of the traction law as a secondary offense. Based on feedback from CSP, it is easy to add enforcement of the new traction law as a secondary offense using current CSP resources.

Options 4 through 7 are enforcement focused efforts that involve physically inspecting the tire tread depth of non-commercial motor vehicles. The options entail conducting compliance checks to varying degrees (full compliance versus spot checks) under varying weather conditions (fair/dry to big winter storms) at both mainline and interchange ramp/chain-up area locations. With these four options, there are political, economic, legal and engineering impacts that must be fully understood and evaluated prior to implementation. These four options are also anticipated to require the reallocation or reassignment of law enforcement resources, potentially during adverse weather conditions, which will impact emergency response and life-safety. Finally, a full-fledged public relations campaign involving CDOT, CSP, local law enforcement agencies, ski resorts, etc. is required prior to implementation of any one of these compliance check options.

Option 4: Mainline Compliance Checks in Fair/Dry Weather Conditions

CDOT/CSP set up and conduct compliance checks at specific agreed upon locations along mainline I-70. Under this option, compliance checks would be conducted in fair/dry weather conditions.

Option 5: Mainline Compliance Checks for Big Winter Storms

CDOT/CSP set up and conduct compliance checks at specific agreed upon locations along mainline I-70. Under this option, compliance checks would be conducted only during winter storms meeting certain criteria. A typical winter season might experience approximately five storms meeting the criteria required to implement compliance checks.

Option 6: Mainline Compliance Checks for All Winter Storms

CDOT/CSP set up and conduct compliance checks at specific agreed upon locations along mainline I-70. Under this option, compliance checks would be conducted during all winter storms resulting in icy/snow-packed conditions at key locations along the corridor, such as Vail Pass or the Eisenhower-Johnson Memorial Tunnels (EJMT).

Option 7: Spot Compliance Checks at Interchange Ramps or Chain Stations

CDOT/CSP and/or local law enforcement set up and conduct compliance checks at specific agreed upon interchange ramp or chain station locations along the I-70 Mountain Corridor. Under this option, periodic spot compliance checks would be conducted on non-commercial motor vehicles under a variety of conditions and at a varying number of interchange ramp locations, dependent upon available CSP and local law enforcement resources. The legality of this option with respect to the 4th Amendment needs to be researched more comprehensively to understand if it is feasible or not. The complexities of redirecting only certain vehicles into spot check areas also needs to be considered.

3.2. Technical Feasibility Assessment Criteria

This section describes the criteria used to assess and evaluate each of the considered enforcement options from a technical feasibility standpoint. Pros and cons for each option were developed based on the following five criteria:

- **Complexity** – Overall complexity of the enforcement idea based on several factors such as perceived legal/liability concerns; formation of new agencies or processes; allocation of resources; estimated time to mobilize and implement; and anticipated costs, risks, challenges, and benefits.
- **Public Relations Campaign** – Extent to which public information officers and public relations office resources would be needed to educate, inform, and update motorists before, during, and after execution of an enforcement idea.
- **Resources Required** – High-level estimate of CDOT, CSP, local law enforcement, and/or other agency/consultant resources required, as well as a list of any specialized equipment, infrastructure upgrades, or training needed.
- **Potential Costs** – High-level estimate of annualized or individualized labor and/or material costs associated with each enforcement idea.
- **Potential Implications** – High-level assessment of anticipated challenges, risks, and outcomes associated with each enforcement idea.

3.3. Subjective Scoring Methodology

In addition to the above described technical assessment criteria, each enforcement idea was also subjectively rated using a one to five scale assigned to each of the five technical assessment criteria to assess, at a very broad level, the relative ease or difficulty with which the option could be implemented. The subjective rating scale applied to each of the five technical feasibility assessment criteria is described as follows:

- **1 = Easy** – Requires minimal new resources or processes to be established. Simple in form and execution. Low-cost with either very little risk and/or few anticipated challenges.
- **2 = Somewhat Easy** – Requires some additional resources or diversion from existing resources to complete. Fairly simple in form and execution. Relatively low-cost with low risk and/or few anticipated challenges.
- **3 = Neutral (not particularly easy or difficult)** – Balance of perceived or anticipated resource allocation, complexity/time to implement, and estimated costs, risks, and challenges.
- **4 = Somewhat Difficult** – Requires new resources in the form of additional staff, equipment, or infrastructure. Complex or lengthy implementation process due to anticipated legal/liability issues, estimated delay/queue length, costs, etc.
- **5 = Difficult** – Requires significant new resources in the form of additional staff, equipment, or infrastructure. Very complex or very lengthy implementation process due to anticipated legal/liability issues, estimated delay/queue length, costs, etc.

3.4. Technical Feasibility Assessment of Enforcement Options

For each of the seven enforcement options, points related to the advantages and disadvantages of each were developed with respect to the five technical feasibility assessment criteria. In addition, a general conclusion was developed for each enforcement option based on a compilation of the assessment criteria. The high-level conclusions pertaining to each option are stated below:

Option 1: Parking Facilities Surveys

- Easy to implement.
- Data from surveys will educate stakeholders of relative level of compliance within current non-commercial and rental car vehicle fleets.
- Uncertainty regarding costs of digital tire scanner technology and ability to assist with surveys at parking lots; requires strict control of motor vehicle speed before driving over device.
- Educational option. Good first step toward collecting data to inform stakeholders and to educate traveling public.
- Not an enforcement option.

Option 2: Tire Tread Pre-Check Inspections

- Complexities regarding requirements and standards for inspections, who performs them, how they are funded, and how records are documented/stored. Uncertainty regarding interest from tire shops.
- Potential bureaucratic and liability issues related to continued tire tread wear during period when inspection sticker is valid. Need to determine threshold for approving tires with respect to anticipated future tread wear compared to the traction law minimum.
- Hard to gauge public response to program.
- Not a standalone enforcement option; benefits are tied to ability to bypass compliance checks or reduced likelihood of secondary offense.

Option 3: Enhanced Corridor Management & Secondary Offense Enforcement

- Corridor management strategies do not focus on direct enforcement of traction law.
- Potential challenges related to funding additional corridor management resources, both in terms of law enforcement and infrastructure/technology upgrades.
- Blends engineering with enforcement.
- Relatively easy to implement this coming winter season with current CDOT and CSP resources, particularly with respect to enforcement of traction law as secondary offense.

Option 4: Mainline Compliance Checks in Fair/Dry Weather Conditions

- Provides flexibility in terms of resource allocation and availability; minimizes disruption to emergency response and life-safety issues during winter storms.
- Reduces exposure/risk to law enforcement officers performing compliance checks and need to tow or re-route non-compliant vehicles.
- Allows delays/queues to be managed through selection of days/time periods with lower traffic volumes.

- Risk that vehicles that have cleared compliance check speed to make up lost time.
- Purely an enforcement option; full compliance does not appear feasible during peak daytime travel periods.

Option 5: Mainline Compliance Checks for Big Winter Storms

- Shifts focus of limited law enforcement resources during inclement weather, resulting in degradation of emergency response.
- Exposes law enforcement officers to risk of injury due to slippery conditions and/or limited visibility near compliance check areas.
- Potential for long delays to motorists and increased potential for back of queue crashes. Potential risk for motor vehicles to get stuck in queue due to loss of momentum if not able to start up again after stopping.
- Risk that vehicles that have cleared compliance check speed to make up lost time.
- An enforcement option that draws resources away from emergency response and creates a potentially hazardous working environment for law enforcement officers.
- Full compliance does not appear feasible during peak daytime travel periods. Screening during the majority of the day would need to be limited to roughly every fifth to tenth vehicle to minimize and manage delays/queues.

Option 6: Mainline Compliance Checks for All Winter Storms

- Requires extensive and ongoing public relations campaign throughout winter season.
- Requires extensive law enforcement officer resources to be added or diverted to compliance check areas, resulting in degradation of emergency response.
- Significantly hinders mobility within mountain corridor for non-commercial vehicles during winter season.
- Risk that vehicles that have cleared compliance check speed to make up lost time.
- An enforcement option that significantly diverts resources away from emergency response and creates a potentially hazardous working environment for law enforcement officers.
- Full compliance does not appear feasible during peak daytime travel periods. Screening during these periods would have to be limited to roughly every fifth to tenth vehicle to minimize and manage delays/queues.

Option 7: Spot Compliance Checks at Interchange Ramps or Chain Stations

- Provides flexibility for law enforcement officers to select any combination of interchanges/ramps or chain stations at which to conduct spot compliance checks, depending on available resources.
- Potential for motorists to divert around known compliance check areas.
- Potential legal issues related to 4th Amendment.
- Purely an enforcement option. Potential challenges with diverting select number of motor vehicles into check areas.

Table 3 summarizes the complete technical feasibility assessment of enforcement options and the area each option emphasizes with respect to the four E's of traffic safety – education, engineering, enforcement, and emergency response.

Table 3. Technical Feasibility Assessment of Enforcement Options

Option Number/Description/ (Emphasis Area)	Complexity	Public Relations Campaign	Resources	Anticipated Costs	Potential Implications
1 Parking Facilities Surveys (Education)	- Easy to conduct. - Minimal legal concern.	- Publicize on CDOT website, social media, etc. - Post notice at lot entrance. - Create courtesy notices & educational materials.	- Team of 2-3 people for 2-4 hours for each survey. - Tire tread depth gauges, vests, data sheets. - Courtesy notices & educational materials.	- Dependent upon number/location of surveys conducted. - Estimate $1,000/survey/site/day.	- Wariness from public regarding survey process. - Data storage and usage concerns. - Only an educational tool. - Time consuming to gather robust & statistically significant sample size.
2 Tire Tread Pre-Check Inspections (Education)	- Establish partnerships to perform inspections. - Explore potential liability issues related to tread wear over time. - Identify funding & tracking mechanisms. - Determine data storage policies.	- Emphasize value of pre-check to motorists. -Publicize list of authorized inspection locations.	- Requires partnerships with tire shops. - Inspection stickers.	- Minimal costs to motorists. - Agreements with tire shops assume the shops take on cost of inspections with aim of increasing tire sales.	- Popularity of program will be tied to perceived benefits or convenience. - Consider buffer for minimum tread depth (tires may wear 1/16" or more during nine-month winter season). - Bureaucratic and liability concerns.
3 Enhanced Corridor Management & Secondary Offense Enforcement (Engineering & Enforcement)	- Enhance existing strategies, such as speed harmonization, reduced speed limits, and CMV lane restrictions, to proactively manage the I-70 Mountain Corridor. - Review prior efforts and results to prioritize what strategies to implement along corridor.	- Minimal public relations needed; emphasis on informing motorists what they can expect in terms of expanded secondary offense enforcement campaign.	- Requires significant investment into additional CSP and Safety Patrol resources, depending on areas of emphasis and level of implementation. - Structure of enhanced enforcement needs to be vetted (overtime pay versus additional FTEs).	- Expect this to be in the low to mid millions of dollars annually, dependent upon trooper resource costs and infrastructure investment costs (additional VSLs, etc.).	- Argument of how strategies relate directly to enforcement versus corridor management. - Evaluate effectiveness and prioritization of strategies. - Potential for reduction in crashes, but not necessarily tied to traction law enforcement. - Solid engineering option, paired with an enforcement component.
4 Mainline Compliance Checks in Fair/Dry Weather Conditions (Enforcement & Emergency Response)	- Complex legal requirements for checkpoints tied to 4th Amendment. - Reduced liability issues during fair/dry weather. - Easier/safer to conduct checks in fair/dry weather. - Difficult to predict delays/queues resulting from checkpoints.	- Full-fledged, professional and coordinated public relations campaign required. - Fair/dry weather checks give public relations campaign more flexibility and advanced notice capability. - Weather remains unpredictable and a publicized time may not necessarily have ideal conditions.	- 12 troopers minimum per mainline check area. - Need a minimum of two check areas – one for each direction of travel – between Vail and Georgetown. - Full compliance not as critical during fair/dry weather. - Reduced need for additional tow resources for non-compliant vehicles.	- Estimate low hundreds of thousands of dollars for trooper pay alone (approx. $20,000 minimum per check area per day).	- Danger of "Big Brother" public perception since checks performed during good weather. - Reduces need to tow non-compliant vehicles. - Does not divert law enforcement resources during storms. - Motorists may be compelled to be properly equipped during winter storms. - Manual tire tread depth checks are time consuming and subject to operator error.

Option Number/Description/ (Emphasis Area)	Complexity	Public Relations Campaign	Resources	Anticipated Costs	Potential Implications
5 Mainline Compliance Checks for Big Winter Storms (Enforcement & Emergency Response)	- Complex legal requirements for checkpoints; potential liability issues. - Checks in inclement weather (snow, cold, low visibility) expose troopers to risk of injury. - Mainline checkpoints alone do not provide full compliance; need to also check vehicles at interchange ramps.	- Full-fledged, professional and coordinated public relations campaign required. - Each compliance check requires advanced notice to public, both in terms of signs along road and other media.	- 12 troopers minimum per mainline check area. - Need two check areas – one for each direction of travel – between Vail and Georgetown. - Additional law enforcement resources needed for full compliance. - Additional tow resources for non-compliant vehicles.	- Estimate low hundreds of thousands of dollars for trooper pay alone (approx. $20,000 per check area per day).	- Must adhere to legal requirements/procedures. - Hard to estimate queues/congestion due to uncertainty of driver reactions. - Potential liability issues. - Difficult to take non-compliant vehicles out of service without additional tow resources. - Manual tire tread depth checks are time consuming and subject to operator error. -Diverts law enforcement resources from emergency response and requires work in challenging environment.
6 Mainline Compliance Checks for All Winter Storms (Enforcement & Emergency Response)	- Complex legal requirements for checkpoints; potential liability issues. - Mainline checkpoints alone do not provide full compliance. - Extensive resource coordination & mobilization to cover all winter storms.	- Full-fledged, professional and coordinated public relations campaign required. - Covering all winter storms adds complexity to public relations campaign since some storms may intensify on short notice.	- 12 troopers minimum per mainline check area. - Need two check areas – one for each direction of travel – between Vail and Georgetown. - Additional law enforcement resources needed for full compliance. - Additional tow resources for non-compliant vehicles.	- Estimate mid to high hundreds of thousands of dollars for trooper pay alone (approx. $20,000 per check area per day).	- Impedes mobility during all storms. - Requires diversion of resources to checkpoints during all winter storms. - Manual tire tread depth checks are time consuming and subject to operator error.
7 Spot Compliance Checks at Interchange Ramps or Chain Stations (Enforcement & Emergency Response)	- Legal issues related to spot checks; full investigation into legality required before implementation. - Difficult to selectively divert mainline traffic into check areas.	- Full-fledged, professional and coordinated public relations campaign required.	- 3 troopers minimum per spot check area. - Coordination with and use of CDOT and local law enforcement resources.	- Estimate high tens to low hundreds of thousands of dollars for trooper pay alone.	- Potential for queue spillback onto mainline if queues not properly managed or processing of vehicles is delayed. - Likely requires far more than minimum number of personnel to minimize delays. - May result in diversion around checkpoints. - Manual tire tread depth checks are time consuming and subject to operator error.

3.5. Analysis of Anticipated Delays/Queues at Checkpoints

The purpose of this subsection is to calculate the anticipated delays and queues that would result on mainline I-70 due to the implementation of full Compliance Checks (Options 4-6). For purposes of this report, eastbound and westbound mainline I-70 traffic volumes at the EJMT were reviewed and used for illustrative purposes. There is undoubtedly some variation in traffic volumes along the I-70 Mountain Corridor, but the EJMT was selected as a representative location of typical traffic volumes. As specific checkpoint locations are more thoroughly evaluated, similar calculations can be completed to estimate the anticipated delay and queue length.

The calculations in **Table 4** on the following page are based on the assumptions noted below:

- **Traffic Volumes:** Traffic volumes are based on September 2018 through May 2019 data from an automated traffic recorder located to the east of Silverthorne.
- **Compliance Check Capacity:** Compliance check capacity is estimated on the presupposition that all vehicles take the same time to process; in reality, some vehicles may take much longer to process, particularly if troopers suspect any other offenses, such as driving under the influence, or if motorists ask questions or are uncooperative.
- **Processing Time:** The average time to process vehicles was assumed to be 2 min/vehicle. This is a highly uncertain and potentially overly optimistic estimate of the processing time. CSP protocols require that the tire tread depth on all four tires be checked. Measurements must be taken in all the grooves of every tire. Additional time per vehicle is required for the vehicle to pull up to and stop at the check area and for the trooper to contact the motorist and inform them of the purpose of the check.
- **Number of Check Areas/Troopers:** Furthermore, compliance check capacity is dependent upon the number of troopers and number of vehicle check areas. For this exercise, it was assumed that a full compliance check would be configured with as many as 10 vehicle check areas and at least 10 troopers. This would require significantly more trooper resources than what are currently available. The CSP troops/posts along the I-70 Mountain Corridor currently have about 6 or 7 troopers working during each shift.
- **Queue Length Assumptions:** Queue length estimates are based on a 25 foot/vehicle assumption. During winter conditions, motorists may naturally leave more space between vehicles and the length between vehicles may vary as the speed within the queue varies. The queue length estimates likely underestimate what might potentially occur upstream of a check area. Queue length estimates are reported in a half mile long range to account for variability in the vehicle length and following distance.

Table 4 steps through the calculations used to estimate the anticipated delay and queue length due to a full mainline compliance check. For the analyzed weekday time period, the eastbound and westbound hourly volumes are, on average, the same for both directions of travel.

Table 4. Analysis of Anticipated Delays/Queues at Checkpoints

Metric	EB at EJMT	WB at EJMT
Average Hourly Weekday Volume from 9 a.m. to 6 p.m. (Sept. through May)	1,100 vehicles-per-hour (vph)	1,100 vph
Compliance Check Capacity[2]	300 vph	300 vph
Unserved Demand after First Hour of Full Compliance Check	800 vph	800 vph
Unserved Demand after Second Hour of Full Compliance Check	1,600 vph	1,600 vph
Delay after First Hour of Full Compliance Check	2.5 to 3.0 hrs	2.5 to 3.0 hrs
Delay after Second Hour of Full Compliance Check	5.0 to 5.5 hrs	5.0 to 5.5 hrs
Queue Length after First Hour of Full Compliance Check	1.5 to 2.0 mi.	1.5 to 2.0 mi.
Queue Length after Second Hour of Full Compliance Check	3.5 to 4.0 mi.	3.5 to 4.0 mi.
Estimated Cost of Delay after First Hour of Full Compliance Check	$78,000	$78,000

Key Points

- Even based on the potentially overly optimistic assumptions used for trooper resources and vehicle processing time, full compliance checks performed on mainline I-70 are not feasible during the weekday daytime travel hours.
- Delays even after the first hour of a full compliance check are excessively long and may threaten life-safety. The long delays will contribute to driver fatigue, distraction, and boredom, as well as potentially hazardous conditions inside vehicles due to low temperatures, excessive condensation, potential carbon monoxide build-up, and potential for vehicles idling in queue to run out of fuel.
- The estimated queue length after the second hour of a full compliance check would potentially begin to extend beyond and block access to the next adjacent interchange

[2] Assumes 10 check areas and 2 min./vehicle to complete inspection.

upstream of the check area. This potentially could result in more widespread loss of mobility.

Table 5 illustrates potential delays/queues as a result of full mainline compliance checks during the weekend peak periods, which were assumed to be westbound on Saturdays from 6 a.m. to noon and eastbound on Sundays between 10 a.m. and 7 p.m.

Table 5. Analysis of Anticipated Delay/Queue of Weekend Peak Period Checkpoints

Metric	EB at EJMT	WB at EJMT
Average Hourly Weekend Peak Period Volume (Sept. through May)	1,900 vph	1,400 vph
Compliance Check Capacity[3]	300 vph	300 vph
Unserved Demand after First Hour of Full Compliance Check	1,600 vph	1,100 vph
Unserved Demand after Second Hour of Full Compliance Check	3,200 vph	2,200 vph
Delay after First Hour of Full Compliance Check	5.0 to 5.5 hrs	3.5 to 4.0 hrs
Delay after Second Hour of Full Compliance Check	10.5 to 11.0 hrs	7.0 to 7.5 hrs
Queue Length after First Hour of Full Compliance Check	3.5 to 4.0 mi.	2.5 to 3.0 mi.
Queue Length after Second Hour of Full Compliance Check	7.5 to 8.0 mi.	5.0 to 5.5 mi.
Estimated Cost of Delay after First Hour of Full Compliance Check	$250,000	$130,000

Key Points

- With the increased volumes during the weekend peak periods, the estimated delay and queue length increase significantly compared to weekday daytime travel periods. Full compliance checks during these times would effectively grind the interstate to a halt, making travel impractical.
- Even after one hour of conducting full compliance checks during the weekend peak periods, there would be a risk of impacting the next adjacent upstream interchange.

[3] Assumes 10 check areas and 2 min./vehicle to complete inspection.

3.6. Subjective Scoring Matrix

The results of the subjective scoring assessment are summarized in **Table 6**. Of the seven evaluated enforcement options, two score as somewhat easy, two score as neither easy or difficult, two score as somewhat difficult, and one scores as difficult to implement. The subjective rating exercise demonstrates that the easiest options to implement are not standalone enforcement options. They are options that could be implemented initially to gain a better understanding of anticipated compliance rates or help the traveling public feel more prepared for enforcement-focused options, such as compliance checks. Enhanced corridor management stands out as a viable option; however, there are questions about how corridor management strategies will be perceived by stakeholders as a pure enforcement option.

Table 6. Subjective Scoring Matrix of Enforcement Options

Option Number/Description	Complexity	Public Relations Campaign	Resources	Anticipated Costs	Potential Implications	Total Score
1 Parking Facilities Surveys	1	1	2	2	2	8
2 Tire Tread Pre-Check Inspections	2	2	3	2	2	11
3 Enhanced Corridor Management & Secondary Offense Enforcement	3	1	4	4	2	14
4 Mainline Compliance Checks in Fair/Dry Weather Conditions	4	3	4	4	3	18
5 Mainline Compliance Checks for Big Winter Storms	4	3	4	4	4	19
6 Mainline Compliance Checks for All Winter Storms	5	4	5	5	5	24
7 Spot Compliance Checks at Interchange Ramps or Chain Stations	3	3	4	4	3	17

1 = easy; 2 = somewhat easy; 3 = medium; 4 = somewhat difficult; 5 = difficult

3.7. Review of Other Mountain/Western States' Traction/Chain Laws

As a point of comparison to Colorado's HB 19-1207, the traction and chain laws of other mountain/western states were researched. The laws of various states appear to be fairly similarly structured. What is not clear from a cursory literature review is how other states enforce the traction/chain laws. Note that the research was limited in its extent and is not comprehensive with respect to review of impacts to motorists (delays/queues) or specific details related to states' enforcement strategies (costs, resources, additional legislation, etc.)

Like Colorado, the California Department of Transportation (Caltrans) has four levels of chain requirements, referred to as R-0 to R-3, as briefly described below:

- R-0: No chains required.
- R-1: Chains required, unless the vehicle is equipped with snow tires.
- R-2: Chains required, except on 4-wheel drive vehicles with snow tires.
- R-3: Chains required, no exceptions.

Caltrans performs "chain control" checks approaching Donner Pass along I-80, which has an AADT of approximately 30,000 vpd (slightly lower than AADT of 36,000 vpd at the EJMT). When chains are required on all vehicles (R-3), Caltrans conducts checks to ensure all vehicles are properly chained up or equipped with alternative traffic control devices. Vehicles that are not properly equipped are not allowed to proceed and are re-routed to a lower elevation. The Nevada Department of Transportation (NDOT) only enforces chain law violations as a secondary offense in the event of a crash or other traffic infraction. NDOT cites lack of personnel and cost as a reason for not setting up checkpoints. The chain control along I-80 over Donner Pass is possible due to the presence of logistics areas and resources available to assist motorists with putting on chains; similar logistics areas and chain up assistance is not available for passenger cars along the I-70 Mountain Corridor.

The Washington State Department of Transportation (WSDOT) also has four levels of traction and chain laws, as described below:

- Traction Tires Advised: Oversize loads are prohibited during severe weather conditions.
- Traction Tires Required: Passenger vehicles must use approved traction tires. Chains required on all vehicles over 10,000 gross vehicle weight rating (GVWR), including non-commercial vehicles over 10,000 GVWR.
- Tire Chains Required: Chains required on all vehicles except 4-wheel/all-wheel drive.
- Chains Required on All Vehicles: Chains required on all vehicles, even 4-wheel/all-wheel drive.

In addition, WSDOT has special seasonal requirements for the time of year when vehicles over 10,000 GVWR must carry chains on certain mountainous segments of state routes.

The Wyoming Department of Transportation (WYDOT) has a two-tiered chain law. "Level 1" is declared when conditions are "hazardous." Travel is restricted to vehicles equipped with tire chains, or to vehicles with adequate snow tires, or to all-wheel drive vehicles. When conditions deteriorate to an "extremely hazardous" rating, "Level 2" of the chain law is declared. Travel is then restricted to vehicles equipped with tire chains or all-wheel drive vehicles equipped with adequate mud and snow or all-weather tires.

4. Conclusions

4.1. Timelines for Implementation

HB 19-1207 takes effect on August 2, 2019. By September 1, 2019 CDOT and CSP are to report their recommendations for enforcement to stakeholders. Given this tight timeline, a phased approach is recommended to implement various enforcement options.

Conducting parking facilities surveys would be a good first step to implement this coming winter season. The relative compliance level of the current non-commercial vehicle fleet is not known. The data from surveys will inform stakeholders about the magnitude of the issue and guide decisions related to the implementation of enforcement options.

Research into tire tread pre-check inspections can be postponed until the research required into the legality and feasibility of physical inspection checkpoints is completed. The basis for the pre-check inspections is to facilitate faster movement through checkpoints. There is much more work that needs to be done to fully vet and more comprehensively understand the potential implications, both in terms of the political and economic impacts, of physical inspection checkpoints.

With respect to enhanced corridor management, CSP and CDOT can continue to maintain the status quo on those strategies next winter season, while at the same time evaluating areas for expansion and the resources required, both in terms of law enforcement officers, Safety Patrol/Heavy Tow, and infrastructure. Additionally, CSP can emphasize traction law enforcement a secondary offense.

The timelines for implementation can be summarized as follows:

Phase 1: Before September 1, 2019

- CDOT and CSP present preliminary assessment and evaluation of enforcement options to stakeholders.
- Based on received feedback and direction, revise enforcement options.

Phase 2: Winter 2019-2020

- Conduct parking facilities surveys and analyze data to guide and inform future enforcement plans.
- Launch a formal, full-fledged public relations campaign, using resources and input from CDOT, CSP, local law enforcement, ski resorts, rental car companies, etc. Conduct general educational campaign aimed at making the traveling public aware of the new traction law and its requirements and what it means for motorists.
- Continue to work with CDOT legal staff to understand the legality of physical inspection checkpoints, particularly with respect to spot checks and compliance with 4th Amendment protocols.
- Explore stakeholder receptiveness to expanding corridor management strategies to reduce spinouts and crashes.
- Begin to ticket traction law violations as secondary offenses to speeding and other citations.
- Pending legality, begin to conduct spot checks of passenger vehicles following major snow storms.

Phase 3: Winter 2020-2021

- Potentially expand and implement additional corridor management strategies, such as speed harmonization, variable speed limits, and CMV lane restrictions.
- Potentially begin implementing compliance checks on a limited basis, assuming guidelines, processes, and procedures for conducting physical inspections have been developed.

4.2. Conclusions

Through this collaborative effort, CDOT and CSP have developed and evaluated several potential options for enforcement of HB 19-1207. This report focuses primarily on the technical feasibility of implementing options. A similar report that focuses on the political, economic, financial and legal aspects of potential enforcement options must also be completed.

Full compliance checks will assuredly have wide-ranging impacts to mobility and economy along the I-70 Mountain Corridor. Full compliance checks appear infeasible from a technical perspective due to the incredibly extensive amount of CDOT, CSP and other resources that will be required for check areas to be adequately sized and appropriately staffed to keep pace with the traffic volumes along mainline I-70. If checkpoints result in excessive delays, life-safety issues for motorists waiting in the queue to be checked can arise. Other technical complications include limited areas where checkpoints are feasible. There are few locations along the I-70 Mountain Corridor that are suitable to conduct full compliance checks. Locations must meet criteria, such as ability to provide proper advanced notification and opt-out option, a flat/downgrade in the highway profile, access to services, and ability for non-compliant vehicles to turnaround.

Spot checks remain a viable option; however, there are serious legal implications related to the 4th Amendment that must be completely understood before these can be implemented. Furthermore, there are other logistical challenges associated with managing spot checks, such as traffic control and inspection selection methods.

For these reasons, the enhancement of traction law enforcement is expected to be phased in over time. The initial options that are most feasible focus on gathering data to identify the magnitude of the issue, as well as educating and encouraging the traveling public to take steps to comply with the new traction law through a coordinated, formal public relations campaign. These options, when paired with continued corridor management strategies, such as speed harmonization and CMV lane restrictions, and increased emphasis on enforcing traction law violations as a secondary offense provide a manageable approach that will not significantly disrupt mobility and freight movement along the I-70 Mountain Corridor.