



SNOQUALMIE WINTER OPERATIONS STUDY

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
Cause and Cost of Closures	1
Tire and Chain Compliance Closures	1
Avalanche Closures	1
Frequency and Length of Closures	1
Cost of Closures	1
Options Investigated	2
Recommendations	2
BACKGROUND	3
Chain and Tire Compliance	3
Avalanche Control Events	4
Frequency and Length of Delays and Closures	4
Cost of Closures	6
Adverse Effects on Communities	6
Emergency Services and Critical Care Facilities	6
Effects on Freight and Nearby Communities	6
OPTIONS AND RECOMMENDATIONS	7
Options Investigated	7
Social Media Campaign	8
Informational Billboards	8
Large Regulatory Signs	9
Snow Preparation Meetings	9
Increased Fines for Violators	10
Statewide Requirement to Carry Chains	10
Allow On-Site Chain Sales	11
Implementing Drivewyze Technology	11
Chain Detection Utilizing Existing Transponders	12
Automated Chain Detection System	12
Require Permits for Out-of-State Carriers	13
WSP Overtime Enforcement	13
On-Call Class C Tow Contract	14
Remote Avalanche Control System	14
Recommendations	15
Higher Priority Options - Recommended for Implementation	15
Lower Priority Options - Not Preferred for Implementation	16

EXECUTIVE SUMMARY

In compliance with Engrossed Substitute House Bill 2134, Section 217 (8), this report lists prioritized recommendations for improving safety and mobility on Interstate 90 (I-90) between North Bend and Cle Elum during winter weather events, including estimated costs. The recommendations include options to improve compliance with traction tire and chain requirements and reduce snow-related closures.

On I-90 from North Bend through Cle Elum, two major causes of closures over Snoqualmie Pass were identified as non-compliance with traction and tire requirements and closures because of avalanche control activities. A committee, with representation from the Washington State Patrol (WSP) and the Washington State Department of Transportation (WSDOT), was formed to investigate the causes and develop recommended options working in conjunction with WSDOT South Central Region.

Cause and Cost of Closures

Tire and Chain Compliance Closures

Non-compliance with chain and tire requirements on the pass is the leading cause of closures in the winter months. Closures resulting from non-compliant trucks accounted for 63% of the closures since 2017, or a combined closure time of 299 hours and 41 minutes for Eastbound and Westbound closures. Because of that, efforts to improve compliance, particularly among truck traffic, are likely to have the greatest impact on the state's ability to keep the road open.

Avalanche Closures

Snoqualmie Pass has experienced increased traffic volumes, including truck traffic volume, and backcountry and ski area use has also grown substantially. Along with increased population growth of full-time residents along I-90 from Cle Elum to North Bend, closing both sides of I-90 on Snoqualmie Pass because of avalanche control measures has become a more onerous and difficult task affecting a greater population than

ever before. Long-term reliance on 80+ year-old surplus military artillery equipment for avalanche control is unsustainable because the US Army plans to end the program.

Frequency and Length of Closures

WSDOT has been tracking incident data linked to unchained vehicles for this stretch of I-90 since 2017. This data tracks dates, general locations, timing, and the type of closure (for example, traction collisions, avalanche control, maintenance, and non-traction-related collisions). The data is summarized on **Figure 4**, including the project area that has been tracked.

Figures 2 and 3 summarize the number of closures occurring and the hours of closure within the I-90 corridor between the winters of 2017 and 2024. The data summarized shows that closures linked to traction or unchained infractions amounted to 114 incidents amounting to 458 hours and 7 minutes of closures. This equates with an average delay time of 4 hours and 1 minute per incident and does not include compounding effects of traffic queues caused by longer delays.

Cost of Closures

WSDOT completed an analysis and documented in a report, *Estimated Road User Cost of Snoqualmie Pass Closure (WSDOT 2024)*, using the volumes of traffic in the winter months to determine an average total hourly cost of delays based on weekday/weekend calculations. For weekdays, the average hourly cost of a delay is \$52,743, while for a weekend, the average hourly cost of a delay is \$67,576.

The cumulative delay cost because of traction-related incidents and avalanche control for the 2017 to 2024 winters is \$13.6 million, and that does not include compounding effects of longer delays. In addition to the road user costs, there are additional costs to WSDOT for maintenance crews to clean up after an incident which could equate to \$1,900 to \$2,500 an hour.

Options Investigated

Three primary criteria were developed for assessing options and they are Anticipated Effectiveness and Benefit, Level of Safety Risks to State Employees, and Cost. Also, three additional criteria were also given secondary consideration and they are Benefit to the Transportation System, Time to Implement/Develop, and the Level of Effort required to implement and maintain. Fourteen options were developed for evaluation, and they are:

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|--|--|--|
| 1. Social Media Campaign | 7. Allow On-Site Chain Sales | 11. Require Permits for Out-of-State Carriers |
| 2. Informational Billboards | 8. Implementing Drivewyze Technology | 12. WSP Overtime Enforcement |
| 3. Large Regulatory Signs | 9. Chain Detection Utilizing Existing Transponders | 13. On-Call Class C Towing Contract |
| 4. Snow Preparation Meetings | 10. Automated Chain Detection System | 14. Installing a Remote Avalanche Control System |
| 5. Increased Fines for Violators | | |
| 6. Statewide Requirement to Carry Chains | | |

Recommendations

After review of all options, six options were selected as recommended options for implementation. They are listed in **Table 1** with a brief description and the cost to implement and maintain.

Table 1. Recommended Options

Option	Cost to Implement and Maintain	Description
Large Regulatory Signs	Initial Cost: \$45,000	Install large regulatory signs at each chain up area to improve education and ability to enforce chain laws.
Increased Fines for Violators	Annual Cost: \$20,000	Improve the effectiveness of the existing statute, by pursuing financial recovery for the labor and equipment required to reopen after a ticketed incident through the 3rd Party Damages recovery process.
Statewide Requirement to Carry Chains	Initial Cost: \$310,000	Change state regulations to require chain carrying statewide and allow enforcement on weigh scales throughout the state to improve compliance.
WSP Overtime Enforcement	Annual Cost: \$400,000	Earmark funds to add 1-2 full time troopers to the WSP North Bend detachment to provide additional patrols and timely enforcement when chains are required to improve chain compliance and prevent incidents.
On-Call Class C Towing Contract	Annual Cost: \$100,000	Secure a towing company with Class C towing capabilities to be on-call for quick deployment during storm events to reduce closure times after an incident.
Remote Avalanche Control System	Initial Cost: \$3,000,000 Annual Cost: \$40,000	Install a remote avalanche control system (RACS) to replace the current, antiquated artillery-based system. The US Army does not offer a replacement artillery system, and the RACS will improve avalanche control response, shorten closure times, and increase highway safety.

BACKGROUND

Each winter, Interstate 90 (I-90) faces closures and delays because of factors like severe weather, avalanche control, maintenance, collisions, and vehicles without the required chains or traction tires attempting to traverse Snoqualmie Pass from North Bend through Cle Elum. The two major causes of closures on I-90 are non-compliance with traction and tire requirements and closures because of avalanche control activities. These closures hinder mobility and connectivity between the east and west sides of the state, costing taxpayers and the state millions of dollars annually and disrupting access for emergency services. While some closures are necessary for safety and maintenance reasons, any reduction and/or efficiency gained in reducing or minimizing closure events and length would result in a net positive for the state. **Figure 1** showcases the closure causes from the 2023 to 2024 winter season, noting that both Traction Collisions and Avalanche Control makes up for 85 percent of all closures of I-90 from October 2023 through April 2024.



Picture 1: A semi-truck accident and traffic backup.

Chain and Tire Compliance

Non-compliance with chain and tire requirements on the pass is the leading cause of closures in the winter months. Additionally, 23 percent of I-90's annual average daily traffic (AADT) is freight traffic (7,800 trucks per day). Closures because of these non-compliant trucks accounted for 63 percent of the closures since 2017, or 299 hours and 41 minutes. Because of that, efforts to improve compliance, particularly among truck traffic, are likely to have the greatest impact on the state's ability to keep the road open.

Efforts to discourage this behavior have already started, as encouraged by WSDOT. In the winter of 2023 to 2024, the Washington State Patrol (WSP) increased enforcement for infractions related to chain compliance. This past winter season, WSP issued a total of 624 chain infraction tickets from December 2023 through February of 2024, reducing closure length because of chain and traction tire compliance by 45 percent from the previous winter of 2022 to 2023.

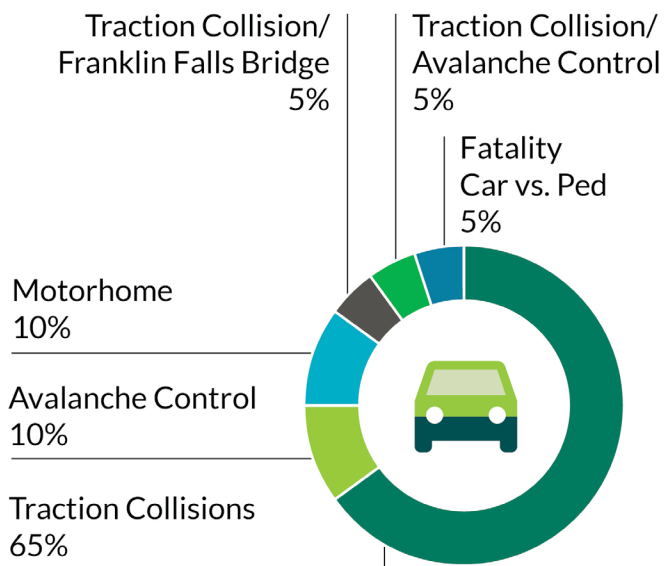


Figure 1: Closure Reasons for the 2023 to 2024 Winter



Picture 2: Image of an accident involving an unchained semi-truck blocking lanes.

Avalanche Control Events

Avalanche control events and the closures surrounding them are necessary to ensure the safety and mobility of the I-90 corridor throughout the winter. The reliance on surplus military artillery for avalanche control poses two significant impacts on highway operations: the practice is very time-consuming compared to modern methods, and the US Army intends to end the aging artillery program soon with no replacement available.

Artillery-based avalanche control involved closing the eastbound and westbound lanes for up to 6 hours before the event to evacuate traffic and recreational users and secure access to the road. The specific areas of concern are the Denny Mountain and Granite Mountain locations, both located above the westbound lanes of I-90.

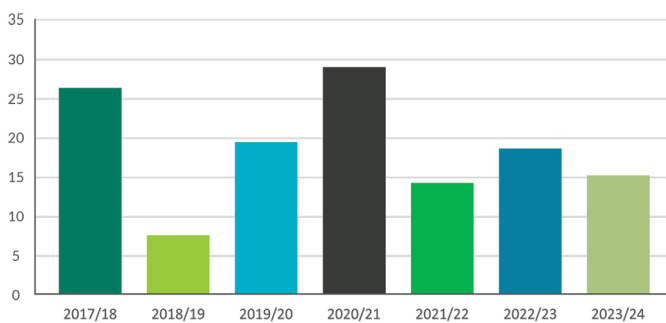
Artillery shells used for avalanche control are less effective than modern systems, such as Remote Avalanche Control Systems (RACS). Artillery use requires firing more shells onto the avalanche slopes, increasing closure times while offering little increase in overall effectiveness.

Implementing RACS ensures better timing for avalanche risk reduction, a safer work environment, and shorter traffic delays while ensuring long-term viability when the US Army shuts down the existing program.

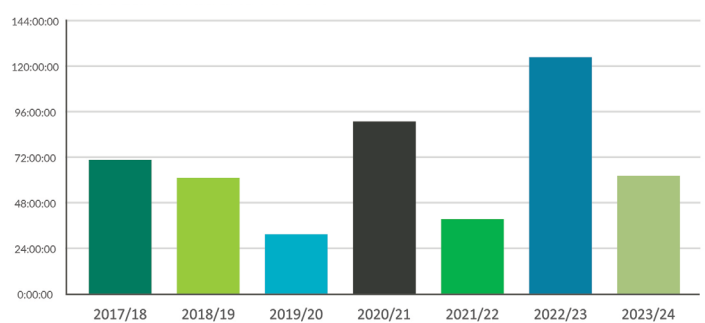
Frequency and Length of Delays and Closures

The Washington Department of Transportation (WSDOT) has been collecting incident data for this stretch of I-90 since 1992. However, it has only been since 2017 that WSDOT has been tracking incident data that is linked to unchained vehicles on I-90. This data tracks dates, general locations, timing, and the type of closure (for example, traction collisions, avalanche control, maintenance, and non-traction-related collisions). An overall view of the data is summarized on **Figure 4** on the following page, including the project area that has been tracked.

Figures 2 and 3 summarize the number of closures occurring and the hours of closure within the I-90 corridor between the winters of 2017 and 2024. The data summarized shows that since tracked in

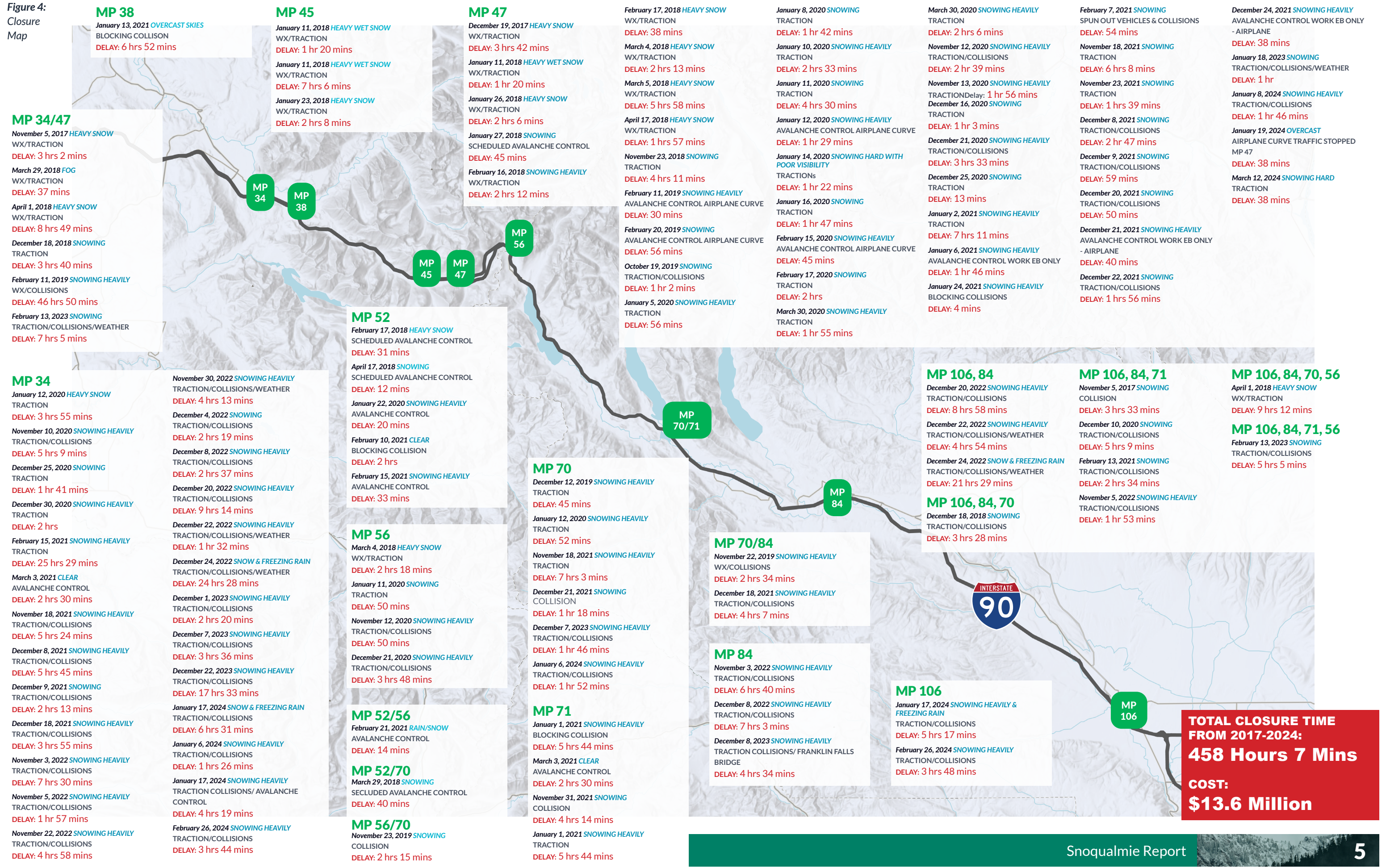


Figures 2: Number of Closures of I-90 (Winters of 2017-2024)



Figures 3: Closure Hours (Winters of 2017-2024)

Figure 4:
Closure
Map



2017, closures linked to traction and unchained infractions amounted to 114 incidents amounting to 458 hours and 7 minutes of combined closure time for the eastbound and westbound directions. This equates with an average delay time of 4 hours and 1 minute per incident. Beyond the delay or closure time noted by WSDOT, there is a compound effect for longer delays, as traffic queues begin to grow and those that are further back will experience not only the closure timing, but additional delay until traffic begins flowing normally again. However, these additional delays were not calculated because of the variability of the data.

Cost of Closures

Classified as a T-1 freight corridor (more than 10 million tons of annual freight tonnage moved), I-90 is one of the most important and heavily used freight routes in the state. With 23 percent of AADT being freight traffic (7,800 trucks per day), any closure has an enormous fiscal impact in terms of time lost because of closures and delay. WSDOT completed an analysis and documented in a report, *Estimated Road User Cost of Snoqualmie Pass Closure* (WSDOT 2024), using the volumes of traffic in the winter months to determine an average total hourly cost of delays based on weekday and weekend calculations. For weekdays, the average hourly cost of a delay is \$52,743, while for a weekend, the average hourly cost of a delay is \$67,576.

Of the 114 incidents, 15 incidents occurred on weekends and 99 occurred on weekdays. Using these values and the closure data, the delay cost of the 2017 to 2024 winters is estimated to be \$13.6 million. However, this is a conservative estimate because the compounding effects of longer delays are not included in this calculation, nor the financial burden to the state and/or public and businesses (personal/commercial insurance, truck operators, injuries, etc.), and the cost does not include societal cost related to secondary collisions. In addition to road user costs, there

are additional costs to WSDOT for maintenance crews to clean up after incidents, which are estimated to be between \$1,900 and \$2,500 per hour.

Adverse Effects on Communities

In addition to the monetary costs related to the closure of I-90, there are also adverse effects to the nearby communities and other indirect costs associated with closing I-90. These include disrupting access to emergency services, critical care facilities, and the issues of where freight traffic goes when I-90 is closed.

Emergency Services and Critical Care Facilities

I-90 serves as a connection nexus for remote communities, and often serves as one of the few ways emergency services are able to reach towns such as Easton and Hyak. When I-90 is closed, the residents in those areas cannot access hospital facilities without helicopter transport. Additionally, closures on the pass cut off access for patients on the east side of the pass to the critical care facilities in the Puget Sound Area, such as Harborview Medical Center and Seattle Children's Hospital.

Effects on Freight and Nearby Communities

As I-90 closes, there are adverse impacts not only on the stuck truck drivers but the nearby communities of Cle Elum and North Bend. There are over 1,000 trucks that use Exit 34 in North Bend on a daily basis, but when the pass closes it is estimated that there are an additional 300 to 400 stranded trucks that park along the freeway. In addition to parking along the freeway, trucks will park along city streets in North Bend, Ellensburg, and Cle Elum, causing concerns from the communities about noise, exhaust, traffic, and congestion on the city streets.

OPTIONS AND RECOMMENDATIONS

Options Investigated

Engrossed Substitute House Bill 2134, Section 217 (8) contained a requirement for WSDOT to prepare and submit a report to the transportation committees of the legislature by December 1, 2024, with recommended options for improving safety and mobility on I-90 during winter weather events. These options are meant to address the leading cause of winter safety and mobility issues on I-90, which includes non-compliance on chain and traction requirements and improved response and mitigation for closures because of avalanche events.

As part of this effort, WSDOT assembled a committee which included representatives from the Traffic Management Center, Maintenance, Communications, Commercial Vehicle Services, and Traffic Operations along with representation from WSP Motor Carrier Division. The committee was tasked with reviewing traffic data, closure reports and incidents, investigating improvement options used by other agencies across the country, and developing criteria used to evaluate options for evaluation and recommendation. The committee then selected and developed 13 separate options which would meet the intended effects of reducing the non-compliant vehicles traveling during winter events.

Once the 13 options were selected, the committee developed considerations for evaluating options that would improve compliance with traction tire and chain requirements, reducing snow-related closures.

In addition, region staff and leadership developed an option to address the eventual phase-out of the current practice of US Army supplied artillery and munitions for avalanche control. The considerations for evaluation the committee developed for traction tires and chain requirements also apply to closures because of avalanche events and are listed below:

- **Anticipated Effectiveness** – How well will the option evaluated address the overall issue of non-compliant vehicles.
- **Level of Safety Risks to State Employees** – The effect on safety for state employees in implementing and maintaining the option.
- **Cost** – The cost to develop, implement, and maintain the option.
- **Benefit to the Transportation System** – The overall net benefit to I-90 corridor in terms of improving mobility.
- **Time to Implement/Develop** – How soon the option can be deployed after funding is procured.
- **Level of Effort** – Time, resources, and staff required to develop and maintain the option.

The primary criteria that were considered most important for determining the best options were anticipated effectiveness and benefit, level of safety risks to state employees, and cost. Additional criteria that were considered were benefit to the transportation system, time to implement/develop, and the level of effort. Given the criteria listed above and using all available information and data, the committee and regional staff then evaluated the following 14 options for consideration.

SOCIAL MEDIA CAMPAIGN



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The first option considered was implementing a social media campaign about driving safely in snow conditions on Snoqualmie Pass and using chains when required. This option would provide continuous messaging with weather and road condition alerts on social media networks with the intent to capture driver's attention prior to entering Snoqualmie Pass in either direction. The communication would include notification when chains are required and road closure information.

The strengths for this option are the low level of safety risks to state employees and the low cost to implement and maintain. The concern is its overall effectiveness to address the situation. Additional benefits include immediate implementation and the minimal level of effort to implement and maintain, while the low expected benefit to the transportation system was noted as an additional concern.

INFORMATIONAL BILLBOARDS



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The second option considered was the placement of billboards informing drivers of the penalties and fines for violating chaining requirements with the goal of reducing commercial vehicle violators. At a minimum, the billboards would be placed at the base on each side of Snoqualmie Pass with the option of locating them at other strategic locations that would be easy to see with appropriate spacing along I-90.

After review of this option, the strengths are its low level of safety risks to state employees and the low cost to implement and maintain. The primary concern is its low anticipated effectiveness to address the situation. Additional benefits include immediate implementation and the minimal level of effort to implement and maintain while the low expected benefit to the transportation system was noted as an additional concern.

LARGE REGULATORY SIGNS



Ratings



Discussion

The third option reviewed and evaluated was the placement of regulatory signs at both the eastbound and westbound chain-up areas. Signs would be large enough to attract drivers' attention. They could be up to 12 feet in width, depending on the configuration.

The strengths of this option are its low level of safety risks to state employees and the low cost to implement and maintain. The anticipated effectiveness is expected to provide improvement over existing conditions. Additional benefits include immediate implementation, minimal level of effort to implement and maintain, and overall expected benefit to the transportation system. During evaluation of this option, the committee found no concerns with the implementation of this option.

SNOW PREPARATION MEETINGS



Ratings



Discussion

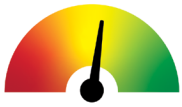
The fourth option is conducting snow preparation meetings between affected agencies including WSDOT, WSP, and the cities and counties located within and around the I-90 corridor from Cle Elum to North Bend. These meetings would occur when snow is predicted and allow affected agencies to coordinate snow removal equipment and operations, detour routes, and law enforcement engagement.

This option's strengths are its low level of safety risks to state employees and its low cost to implement and maintain. The primary concern is its low anticipated effectiveness to address the situation. Additional benefits include immediate implementation and minimal level of effort to implement and maintain. A moderate overall expected benefit to the transportation system is anticipated. This option was discussed and not furthered for action because it has already been implemented.

INCREASED FINES FOR VIOLATORS



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The fifth option reviewed and evaluated requires the unchained commercial carrier responsible for a crash and closure to pay a closure cost or an established maximum fine. This statute exists and has recently been implemented, which means data will be generated in the next several years to determine its effectiveness.

To further improve the effectiveness of the existing statute, the option for Increased Fines for Violators could further benefit the state by providing a means for financial recovery related to mountain pass closures resulting from a third party. In the event a pass closure is required because of an accident or blocking incident where WSP cites a driver, WSDOT has the ability to pursue financial recovery for the labor and equipment required to reopen after the incident through the 3rd Party Damages recovery process.

Upon evaluation of this option, it was determined that the strengths of this option are its low level of safety risks to state employees and the low cost to implement and maintain. The anticipated effectiveness is expected to provide improvement over existing conditions. Additional benefits include immediate implementation, minimal level of effort to implement and maintain, and overall expected benefit to the transportation system.

STATEWIDE REQUIREMENT TO CARRY CHAINS



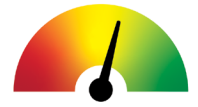
Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The sixth option is to require chain carrying statewide and allow enforcement on weigh scales throughout the state. This option was suggested by WSP to reduce commercial vehicles without chains available and it would allow more WSP officers to provide better coverage regarding chained vehicle enforcement.

The strengths are its low level of safety risks to state employees and its moderate cost to implement and maintain. The anticipated effectiveness is expected to provide improvement over existing conditions. Additional benefits include overall expected benefit to the transportation system and minimal level of effort to implement and maintain. An additional concern with this option is the anticipation that it will require several years to implement.

ALLOW ON-SITE CHAIN SALES



Ratings



Discussion

The seventh option reviewed is to allow paid installers to sell market value chains or provide other on-site incentives to improve compliance through the convenience of on-site availability of chain products. On-site means located on state property at locations like turnouts, chain-up areas, and weigh stations. By providing chain products at these locations, vehicles not equipped with chains would have the opportunity to purchase chains rather than rely on traditional vendor locations which are not as convenient, especially just prior and during a winter storm event.

The strengths of this option are its low level of safety risks to state employees and its low cost to implement and maintain. The anticipated effectiveness is expected to provide improvement over existing conditions. The primary concern is its low anticipated effectiveness to address the situation. An additional benefit is the minimal level of effort required to implement and maintain this option. The overall benefit to the transportation system is expected to improve existing conditions. An additional secondary concern is the time to implement this option given legislative approval is required to allow transactions from private entities on state property.

IMPLEMENTING DRIVEWYZE TECHNOLOGY



Ratings



Discussion

The eighth option reviewed and evaluated was implementing Drivewyze technology. Drivewyze is a system that provides information to commercial vehicles on real time conditions and events. This includes winter snowstorm information, current road conditions and closures, and if chains are required. The system is currently deployed in Oregon and Drivewyze would provide a pilot project at no cost. An initial assessment provided by Drivewyze to WSDOT staff is the annual cost would be \$70,000 for 200 locations statewide.

The strengths of this option are its low level of safety risks to state employees. The primary concerns are the cost of this option and the anticipated effectiveness to address unchained commercial drivers during winter storm events. Additional benefits are the minimal level of effort required to implement and maintain this option and the time required to implement. The overall benefit to the transportation system is expected to improve existing conditions.

CHAIN DETECTION UTILIZING EXISTING TRANSPONDERS



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The ninth option evaluated by the committee was using existing transponders in pre- and post-chain-up areas to detect violators during mandatory chain-up events by detecting vehicles that do not install chains during winter storm events.

When reviewing this option, the noted strength is a high level of anticipated effectiveness that the option will produce. The concerns are the option's high level of safety risks to state employees and the cost to implement. Because the transponders would only notify WSP of a potential violation, troopers would still be required to pull over and cite violators. The overall benefit to the transportation system is considered an additional benefit. The time to implement and the required level of effort to implement and maintain this option are considered significant concerns for this option.

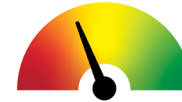
AUTOMATED CHAIN DETECTION SYSTEM



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The tenth option was the creation of an automated video or audio system for chain detection that would message law enforcement or the Traffic Management Center (TMC) about the detection of unchained vehicles. The University of Washington has conducted some research using AIWaysion and the initial indication is there is confidence that this technology can be developed to detect chains. The initial cost assessment is \$50,000 for a research student to conduct the work and \$20,000 for processing.

The strengths noted are a high level of effectiveness that this option will produce. The concerns are the option's high level of safety risks to state employees and the cost to implement. Because the automated system would only notify WSP of a potential violation, troopers would still be required to pull over and cite violators. Additionally, the overall benefit to the transportation system was determined to be a benefit upon implementation. Additional concerns are the length of time required to develop and implement and the level of effort required for this option.

REQUIRE PERMITS FOR OUT-OF-STATE CARRIERS



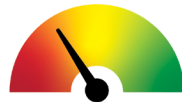
Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The eleventh option was implementing an out-of-state permit requirement for those carriers. After review of the data and on-site observations, many violators including repeat offenders are not local. After repeat violations for unchained commercial vehicles by the same carrier, the carrier would be subject to a time suspension for its hauling units. This action is similar to the [Oregon Chain Law | TripCheck - Oregon Traveler Information](#). Currently, there is a statute in place for oversized vehicles only.

The committee noted the strengths of this option are a high anticipated level of effectiveness and its low level of safety risks to state employees. The cost to implement and maintain this option was deemed as reasonable. Additionally, the overall benefit to the transportation system was considered a positive attribute. Additional concerns are the time required to implement this option over several years and the level of effort required for its implementation.

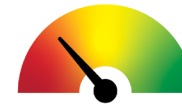
WSP OVERTIME ENFORCEMENT



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The twelfth option is providing an earmark in the amount of \$400,000 per year for WSP officer overtime which provides additional and timely enforcement over current levels. WSP currently has a North Bend detachment, which is only partially staffed. Increased enforcement in conjunction with coordinating between WSP and WSDOT is a proven method of detecting, citing, and improving the situation of unchained commercial vehicles. Adding one or two full-time troopers, with the earmarked funds, to participate in chain enforcement would guarantee coverage by WSP during winter storm events. Providing chain enforcement is a core responsibility of this detachment, but additional troopers could also provide additional WSP duties throughout the year.

The strengths of this option are the anticipated level of effectiveness of its implementation. The cost to implement and maintain was deemed an acceptable cost. The concern of implementing this options is the high level of safety risks to state employees. Additional benefits include the implementation would be immediate upon funding approval, and its overall benefit to the transportation system. Additional concerns noted are the level of effort required to implement and maintain this option.

ON-CALL CLASS C TOW CONTRACT



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The thirteenth option is securing a towing company with Class C towing capabilities on-site in a timely manner. Currently, there is a company in Easton, one in North Bend, and one in Cle Elum that clears most of the commercial vehicle crashes in the Snoqualmie Pass I-90 corridor. Developing an agreement with these towing companies for standby services during storm events would provide improved response time and reduce overall times for closure events.

The strengths of this option are the anticipated level of effectiveness of its implementation and the low level of safety risks to state employees. The cost to implement and maintain was deemed an acceptable cost. Additional benefits include the implementation would be immediate upon funding approval, and its overall benefit to the transportation system. Additional concerns noted are the level of effort required to implement and maintain this option.

REMOTE AVALANCHE CONTROL SYSTEM



Ratings



Anticipated Effectiveness



Level of Safety Risks to State Employees



Cost

Discussion

The final option is implementing RACS. This system replaces the current artillery-based program, which WSDOT coordinates with the US Army to implement and execute during avalanche events. The RACS delivers an explosive charge that affects an area four times in size compared to the current artillery shells. A RACS-based closure takes 30 minutes to implement, not including cleanup time, while artillery closures take hours to initiate and at least 2 hours to fire the weapon.

The primary strength of this option is the anticipated level of effectiveness, which results in significant improvements in closure time to mitigate avalanche risks. Despite a \$3 million dollar replacement cost, implementing and maintaining RACS was deemed acceptable, because **the current US Army artillery practice will become obsolete, requiring WSDOT to replace the practice.** A second strength is the reduced level of safety risks to state employees. Using a more precise system, risk during events is dramatically reduced compared to the current practice.

Additional benefits include the immediate implementation timeframe contingent upon funding approval and its overall benefit to the transportation system on Snoqualmie Pass. The level of effort required to implement this option is considered reasonable and necessary, given that the current practice will soon become obsolete. **The need to replace artillery is urgent;** if the artillery program ends soon, the WSDOT has few options to mitigate the avalanche risk under Denny and Granite Mountains. The loss of an active avalanche control system is likely to result in more closures, including multi-day closures.

Recommendations

All 14 options were evaluated based on the three primary criteria along with consideration given to the three additional or secondary criteria. The primary criteria are the anticipated effectiveness of each option, level of safety risks to state employees, and the cost to implement and maintain the option. The additional or secondary criteria are overall benefit to the transportation system, time to implement/develop the option, and the level of effort required to execute and maintain the option. This approach prioritized solutions that were deemed to provide the greatest benefit to the traveling public.

The recommendations include options that can be implemented very quickly to start addressing the issue immediately, and some options that will take several years to implement but are expected to have greater effectiveness. Some of the recommended options are expected to reduce the number of incidents by increasing compliance and enforcement of chain laws, while others will reduce the delay time when there is an incident or closure.

Higher Priority Options - Recommended for Implementation

Large Regulatory Signs. Installing large regulatory signs at each chain up area reinforces the requirements set forth in state statute and provides clear communication to drivers, which improves enforceability.

- The cost to implement this option is approximately \$45,000, as a one-time installation cost. Signs could be installed within one month if weather allows.

Increased Fines for Violators. Increasing fines for violators motivates drivers to adhere to chain-up requirements so they avoid high fines; thereby increasing compliance. Additionally, seeking reimbursement for 3rd Party Damages provides a means for the state to recover costs related to closures and damage caused by third parties.

- The cost to implement reimbursement of 3rd Party Damages is estimated to be \$20,000 per year, and systems to track and apply 3rd Party Damages could be set up within a couple months. The regulation is already in place, and WSP started issuing tickets this past winter, so cost and timeline to implement this option only represents the additional cost to implement reimbursement of 3rd Party Damages.

Statewide Requirement to Carry Chains. Expanding the requirement to carry chains throughout the state allows better enforcement because it increases the number of contact points where WSP can cover the topic; thereby increasing compliance.

- The cost to implement this option is approximately \$310,000, and it is estimated to take three to four years before new requirements take effect.

WSP Overtime Enforcement. Providing WSP patrols on-site at the chain-up areas has proven to be an effective measure for reducing collisions and was highly recommended by the committee. However, the committee recommends providing a separate line item for funding of this option, because it currently puts a strain on the existing maintenance budgets.

- The cost to implement this option is \$400,000 per year. An agreement with WSP can be set up within a couple of weeks.

On-Call Class C Tow Contract. When there is an incident, closure times are highly dependent on the response time and availability of Class C Tow vehicles. Securing an on-call contract with the companies that provide this service could greatly reduce the time it takes to clear an incident and reopen the roadway.

- The cost to implement this option is estimated to be \$100,000 per year, and agreements could likely be set up within the next year.

Remote Avalanche Control System. Upgrading to the RACS system moves WSDOT away from the legacy artillery program and into a more effective and efficient solution that can reduce avalanche closures and improve worker and highway user safety. This system would allow WSDOT to use shorter closure times when avalanche control is necessary, thereby improving mobility for roadway users.

- The cost to implement this option is estimated to be \$3,000,000, and the installation could be completed within a couple of months. In addition to the up-front cost to implement the RACS system, the estimated cost to operate, administer, and maintain the system is \$40,000 per year, which is comparable to the cost to operate the current artillery program.

Lower Priority Options - Not Preferred for Implementation

- Social Media Campaign and Informational Billboards are lower priority options for implementation at this time because of low anticipated effectiveness.
- Allowing On-Site Chain Sales is a lower priority solution because of the time and challenge to implement. Also, this option is anticipated to be only moderately effective.
- Drivewyze technology is not recommended for implementation at this time because of the low anticipated effectiveness.

- Options for implementing Chain Detection Utilizing Existing Transponders and Automated Chain Detection System are lower priority solutions at this time. The cost to implement these options is expected to be higher than WSP Overtime Enforcement, but they do not significantly lessen the risk to state employees. Because the targeted WSP Enforcement is still anticipated to be more effective than either of these options, that option is given a higher priority for implementation.
- The Snow Preparation Meetings option was discussed and is not being put forth as a recommendation because this option has already been implemented. WSDOT will continue to track effectiveness of this solution and evaluate whether there are ways to further improve effectiveness.
- Requiring Permits for Out-of-State Carriers is a lower priority because of the time required to implement the option, but this option may be considered in the future if additional measures are deemed necessary.

For questions regarding this report, please contact James Todd Daley, South Central Region Traffic Engineer, at 509-577-1992 or todd.daley@wsdot.wa.gov.