

I-70 Reversible Lane Georgetown to Floyd Hill

Phase II Feasibility Study



December 2010



I-70 Reversible Lane Georgetown to Floyd Hill

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INTRODUCTION

This *Phase II I-70 Reversible Lane Feasibility Study* report provides information on the benefits and risks associated with Reversible Lane implementation along the I-70 Mountain Corridor. This document builds on the information provided in the Phase I analysis and discusses the trade-offs that must be considered prior to implementation.

PROBLEM STATEMENT

What is the problem facing I-70?

The segment of Interstate 70 (I-70) between the Eisenhower Johnson Memorial Tunnel (EJMT) and Denver typically experiences recurring peak period congestion (westbound in the mornings and eastbound in the evenings) during summer and winter weekends. The majority of the congestion occurs in a segment between Georgetown and the Floyd Hill area for the following reasons:

- Heavy traffic volumes enter and exit I-70 at Empire Junction (U.S. 40 interchange) just east of Georgetown.
- The roadway geometry through Idaho Springs is constrained, with narrow shoulders and tight curves.
- The Twin Tunnels (between Idaho Springs and Floyd Hill) are operationally constrained because of the narrow width of shoulders.
- Roadway users have to contend with 3 to 4% grades.
- Slow-moving vehicles contribute to congestion.
- Significant amount of recreation and tourist-related travel to ski resorts, National Forests and other locations of interest.



I-70 congestion typically occurs on summer and winter weekends between Georgetown and Floyd Hill for a variety of reasons.

These operational and geometric issues lead to several consequences:

- The traveling public experiences substantial delays – typical winter Sunday travel times up to 79 minutes – during congested periods from Georgetown to Evergreen. This represents double the travel time during uncongested weekend period conditions.
- Motorists divert to alternate routes, such as the limited frontage road system, causing congestion and affecting areas beyond the Interstate itself.
- Additional accidents occur in the traffic backups, further delaying motorists.
- Congested travel conditions results in traffic metering at the EJMT, a process of holding and releasing traffic to prevent backups within the tunnel. Metering results in additional backups, further exacerbating the wait.
- Emergency services and transportation-dependent commerce are delayed.

While the Colorado Department of Transportation (CDOT) worked collaboratively with stakeholders to identify a long-term, multimodal transportation solution to address congestion and mobility issues facing I-70, funding for these improvements remains a challenge. Solutions that reduce congestion and benefit I-70 motorists in the short-term should also be investigated while agreed upon, long-term transportation projects are pursued.



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Why look at a Reversible Lane?

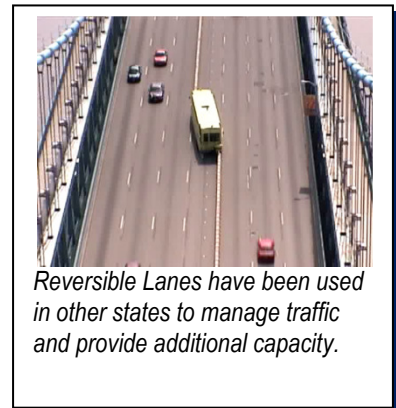
The desire for immediate congestion relief led to the passage of Senate Bill 10-184 by the Colorado General Assembly. While CDOT had already begun looking into the possibility of a Reversible Lane, the legislation directed the Department to study and implement (if appropriate) a Reversible Lane along I-70 from the EJMT to Floyd Hill, consistent with the federally-mandated planning and environmental processes. The legislation identified a goal of reporting findings to the General Assembly by Jan. 1, 2011. The legislation also authorized the Colorado High Performance Transportation Enterprise, a division within CDOT, to enter into a single or multiple lease or lease-purchase agreement to operate.

REVERSIBLE LANE FACTS & ASSUMPTIONS

What is a Reversible Lane?

Reversible Lanes successfully manage traffic flows in several other states where there is heavy traffic in one direction and light traffic in the other. If a clear directional traffic volume split is determined, one or more of the lanes in the lighter direction are reversed to accommodate the heavier direction traffic. Reversible Lanes have not been used on an Interstate resulting in only one lane in a given direction or in a unique mountain environment such as I-70.

A Reversible Lane is composed of a moveable barrier made of short concrete and metal segments that are hinged together to form a continuous wall. A special piece of equipment, called a transfer machine, moves the barrier to and from the shoulder and into place for a specified time period.



Reversible Lanes have been used in other states to manage traffic and provide additional capacity.

Where could a Reversible Lane be implemented?

CDOT analyzed the feasibility of implementing a Reversible Lane given the traffic patterns in the study area proposed by the legislation. The *Phase I Reversible Lane Feasibility Study*¹ completed in August 2010 found implementation of a Reversible Lane has the potential for greatest benefit during winter Sunday afternoons when westbound traffic volumes were low enough to accommodate a third eastbound lane.

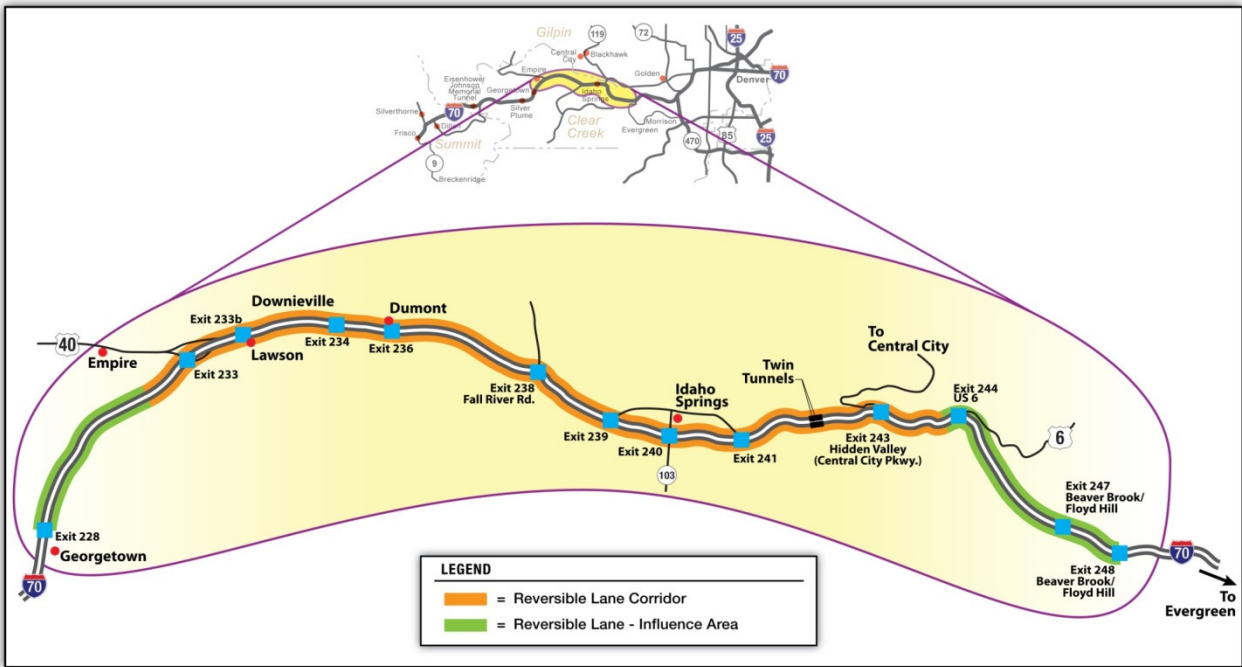
The approximately 13-mile eastbound Reversible Lane would begin west of Empire Junction and end east of the Hidden Valley interchange, with no midway points for entry or exit of the lane. The limits of the Reversible Lane were determined in the Phase I Report mainly due to geography and engineering requirements for the most beneficial and operationally sound configuration. This Phase II Report further refined the project limits.

¹ The complete report can be found at <http://www.coloradodot.info/projects/i70reversiblelane>



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Figure 1. Reversible Lane Study Area



Drivers will access the Reversible Lane west of Empire, which will maximize travel time benefits for U.S. 40 and I-70 travelers. Extending the current exit lane to U.S. 6 from eastbound I-70 for more than a half-mile eases the transition for drivers exiting the Reversible Lane east of Hidden Valley. Westbound I-70 drivers will merge to one lane at the bottom of Floyd Hill to accommodate the Reversible Lane operation.

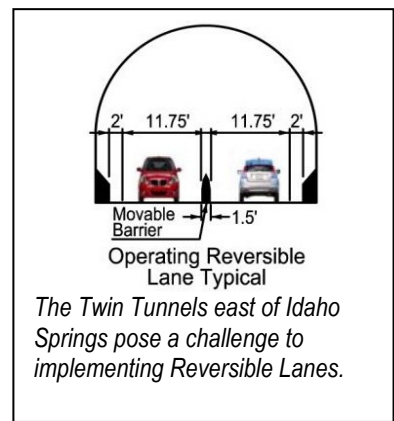
Roadway geometry and topography do not pose any constraints that would prohibit the use and operational safety of the moveable barrier technology along this section. While there is limited pavement along I-70, standard width (12-ft.) lanes could be provided with the exception of the Twin Tunnels. In that location, lane width would be reduced to 11.75-ft., with 2-ft. shoulders, but still within acceptable engineering standards.

Who could use the Reversible Lane?

The Reversible Lane would be open to passenger vehicles. Heavy vehicles (26,000 pounds Gross Vehicle Weight Rating) would be prohibited from using the eastbound Reversible Lane due to:

- Lack of access to the Port-of-Entry.
- Lack of access to chain stations when chain law is in effect.
- Increased complexities in responding to and relieving heavy vehicle incidents (such as a jackknifed semi) in the Reversible Lane.

Heavy vehicles would be allowed in the eastbound general purpose lanes and in the westbound lane on I-70 during Reversible Lane operations.





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What is the expected growth of traffic volumes in the corridor?

Historically, I-70 corridor traffic has increased at a rate of 1.5 to 1.8% annually. If a Reversible Lane is not implemented, eastbound and westbound traffic is expected to continue to grow at this historic rate, reaching 10% growth in approximately 5 years. If a Reversible Lane is implemented, it is anticipated westbound traffic volumes will reach the 10% threshold in 5 to 10 years, recognizing the historical growth rate may be less due to westbound traffic backups that occur with the Reversible Lane. The opposite occurs in the eastbound direction, where the Reversible Lane adds additional roadway capacity and creates a higher growth rate of 15% in 5 to 10 years than historically would occur otherwise. Given the uniqueness of the corridor, traffic models are unable to predict with certainty the increased amount of traffic that would use (or not use) I-70 if a Reversible Lane was implemented.

If implemented, what travel time savings could be realized?

For 2010 conditions during the Reversible Lane operation, it is estimated eastbound travel time would decrease by 38 minutes while the westbound travel time would increase by 35 minutes. Due to the heavier volume of traffic in the eastbound direction, it is projected that 11,866 person-hours of travel would be saved, which represents about a 13% improvement in total person-hours of travel.

Table 1. Travel Times

Scenario		Eastbound Travel Time (min)	Westbound Travel Time (min)	Person Hours of Travel Saved ^{1,2}
<i>2010 Traffic Volumes</i>				
	Without Reversible Lane ¹	79	34	—
	With Reversible Lane ¹	41	69	11,866
<i>Future Traffic Volumes</i>				
(Baseline ³)	Without Reversible Lane	111	34	—
(With induced eastbound travel)	With Reversible Lane	68	97	2,626
¹ Reported person hours of travel savings does not account for delays to eastbound and westbound travelers due to accidents.				
² Based on Average Vehicle Occupancy of 2.6.				
³ From Phase I Feasibility Study.				

With anticipated 10 to 15% growth, eastbound travel time would decrease by 43 minutes (when comparing future volumes with and without the Reversible Lane); however, westbound travel time would increase by 63 minutes. The large increase in westbound travel time would reduce the amount of person-hours of travel saved to 2,626. While this is still a positive saving time, it represents only a 3% total improvement over maintaining the current condition of I-70.

What impact would a Reversible Lane have on westbound I-70?

In addition to longer travel times when the Reversible Lane is implemented, a 2.5-mile traffic back-up on westbound I-70 (top of Floyd Hill) is predicted during the heaviest travel time. It is anticipated incident response when the Reversible Lane is implemented also will increase backups on westbound I-70, which is discussed in more detail under SAFETY.

The following table summarizes the anticipated westbound I-70 backups (or queue lengths) when the Reversible Lane is implemented and with anticipated traffic growth. Over time, 6.1-mile back-ups (reaching west of I-70/El Rancho Exit) would occur when 10% westbound growth



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is reached. Historically, a 6-mile back-up becomes unmanageable both from an operational and public tolerance perspective.

Table 2. Westbound I-70 Traffic Queues

Time (P.M.)	2010 Queue Length (miles) ^{1,2}	10% Growth Queue Length (miles) ²
1:00	0.8	3.1
2:00	1.6	4.4
3:00	2.5	5.9
4:00	1.8	6.1
5:00	0.9	5.2
6:00	No queue	2.2
7:00	No queue	No queue
8:00	No queue	No queue
9:00	No queue	No queue

¹From Phase I Feasibility Study.
²This queues are not reflective of backups that could occur while setting up the Reversible Lane.

How long would the Reversible Lane project be useful?

It is expected that the Reversible Lane would reduce overall congestion in the corridor for the next 5 to 10 years, after which point traffic volumes and congestion in the westbound direction may exceed acceptable levels.

IMPLEMENTATION

Is a Reversible Lane technically feasible?

Consistent with the legislation, a *Phase I Reversible Lane Feasibility Study* focused on geometry, topography and traffic volumes. The study found there were no fatal flaws that prevented technical implementation of a Reversible Lane in the I-70 Mountain Corridor and that the most feasible location is from west of Empire Junction to east of the Hidden Valley interchange. Traffic modeling results indicated that a Reversible Lane, when implemented, would:

- Decrease eastbound I-70 travel time by half
- Double westbound I-70 travel time, and
- Given the amount of traffic, yield a net positive travel benefit for the corridor.

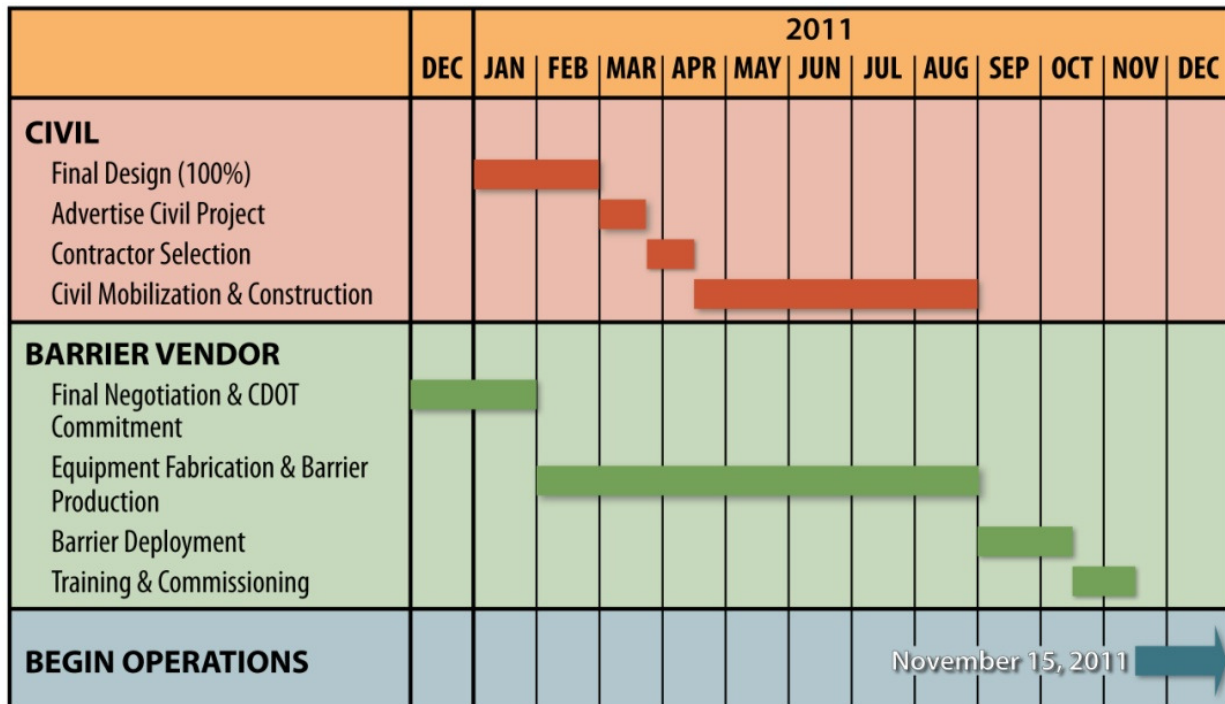
While demonstrating travel time savings, the Phase I study raised questions about the operations, safety, and social/natural impacts of implementing a Reversible Lane. These questions led to this Phase II study, which completed a risk assessment of the 3 considerations above in conjunction with extensive stakeholder outreach. This *Phase II Reversible Lane Feasibility Study* affirmed there are no fatal flaws with proposed implementation; however, serious concerns associated with operations, safety, socio-natural impacts and cost remain. These are discussed in more detail below.

If implemented, a 2-year Reversible Lane Pilot Program could be operational in 2011. The following schedule shows how this could be achieved, absent FHWA approvals. Fabrication of the barrier system is on the critical path, as it requires 9 months to complete.



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Figure 2. Proposed Pilot Program Implementation



Should the Pilot Program be extended, additional features may be needed to enhance the program (referred to as the Enhanced Program). Decision-makers will need to balance the trade-offs and associated risks prior to a decision on implementation.

What are the differences between the Pilot and Enhanced Programs?

Both Phase I and Phase II studies indicate while concerns have been identified, there are no fatal flaws for implementation. CDOT then asked the following questions:

- When could a program be implemented?
- Can the risks be mitigated?
- How much would it cost?

A Pilot Program with associated risks and reduced cost would allow this innovative idea to be tested. After 2 years, the Pilot Program would be evaluated to determine if it should be continued. An Enhanced Program could be implemented with appropriate additional features that would improve its performance and facilitate longer-term operations.

The following table summarizes the different features of the Pilot and Enhanced Programs. Program differences and potential benefits or consequences are further discussed within the report.



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Table 3. Pilot vs. Enhanced Program Features

Element	Pilot Program	Enhancement Program
Twin Tunnels (Westbound direction)	<ul style="list-style-type: none"> Add supplemental lighting at west entrance only, standard (non-LED) lighting 	<ul style="list-style-type: none"> Add directional, LED tunnel lighting
Staged assets for emergency response	<ul style="list-style-type: none"> Local agencies responsible for ambulance and fire response 	<ul style="list-style-type: none"> Stage additional emergency response vehicles along the Reversible Lane corridor
Intelligent Transportation System (ITS) components	<ul style="list-style-type: none"> Portable variable message signs Lighting and gates at the east and west transitions 	<ul style="list-style-type: none"> Implement traffic monitoring equipment and additional ramp metering provided for westbound traffic Replace portable variable message signs (VMS) with overhead VMS signs Complete Closed Circuit Television (CCTV) coverage
Incident Response services	<ul style="list-style-type: none"> CDOT only contracts for courtesy patrol and heavy tow services 	<ul style="list-style-type: none"> Provide incident command, dedicated operator/dispatcher, and specialized response services

What Federal approvals are necessary to implement?

Restricting I-70 to one westbound lane constitutes a Federal action, consistent with 23 CFR 658.11. Reducing the Interstate to one lane outside of a construction project with a reversible lane system has not been done anywhere in the nation with positive results. As such, the Federal Highway Administration (FHWA) has a rigorous, 45-day approval process, which is further described in APPROVALS. The FHWA Colorado Division Office has indicated their concerns with the Reversible Lane proposal as currently defined.

What planning approvals are necessary to implement?

Senate Bill 10-184 stated if a feasibility study demonstrates that such a system is viable, a transportation demand management contract may be established consistent with planning provisions in Section 43-1-1103, C.R.S. While there has been stakeholder engagement, there has not been a formal request for the Reversible Lane project to be added to the statewide or regional long-range plan. This step would need to happen through the Denver Regional Council of Governments (DRCOG) prior to implementation.

What was the outcome of stakeholder engagement?

CDOT created a Project Leadership Team consistent with the *I-70 Mountain Corridor Context Sensitive Solutions* guidance. This 12-member group represented local governments, corridor users, emergency responders, and federal and state agencies. The purpose of this group was to identify questions that needed to be answered before the decision to implement a Reversible Lane was made, as well as review the risks associated with the project. A 40-person technical team supported the study to provide input. Both groups met at least 6 times over the course of six months to review information.

The Project Leadership Team (PLT) remains concerned with the associated risks and trade-offs identified by the feasibility studies. Many stakeholders felt it was not appropriate to move



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forward with a Reversible Lane. The PLT acknowledges that short-term solutions are needed and are willing to discuss other strategies that could address congestion (see NEXT STEPS). For the most part, stakeholders are uncomfortable with Reversible Lanes as currently defined.

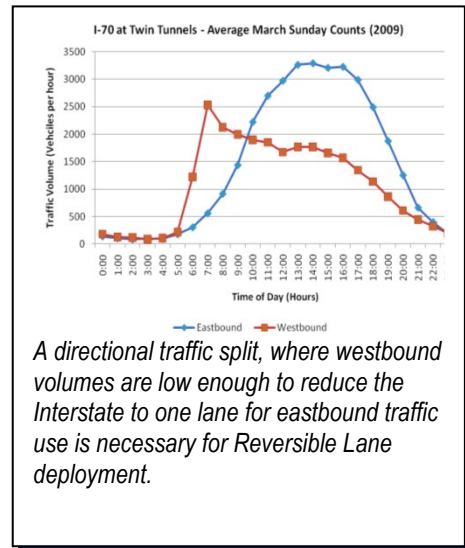
OPERATIONS

How often would the Reversible Lane be deployed?

Traffic volumes were analyzed for the weekday and weekend period when congestion typically occurs on the I-70 corridor. The purpose was to identify times when, and in which direction, the implementation of a reversible lane would be feasible and would have the potential of yielding the highest benefit. Roadway capacity helps determine when reversible lanes may be beneficial and assesses their impact on the opposite direction travel. A roadway's capacity is often determined by the most constrained section, which in this case is the Twin Tunnels.

Based on historic counts, it is anticipated that traffic conditions are suitable for the Reversible Lane to be deployed on approximately 17 winter Sundays (November through March) during the winter ski season assuming weather conditions allow. The *Phase I Feasibility Study* demonstrated there would be little benefit to deploying a Reversible Lane on an average weekday due to traffic flows. Further, the directional split in traffic volumes needed to operate a Reversible Lane does not occur in the summer timeframe. The Phase I study also showed winter Saturdays did not produce conditions that favored Reversible Lane deployment.

During this timeframe, 2 Monday holidays (Martin Luther King, Jr. Day and Presidents' Day) may also be candidates for deployment due to lower traffic volumes in the westbound direction. Traffic conditions during spring, summer, fall, and winter's from the Christmas through New Year's holiday period may not meet the threshold for activating the system.



How would you make the decision to deploy?

The decision to deploy the Reversible Lane will be made each time based on several factors. A deployment decision plan would need to be developed but some initial deployment considerations are summarized below.

Table 4. Deployment Criteria Factors

Criteria	Threshold	Resources
Traffic volumes	<ul style="list-style-type: none"> Westbound volume below 2000 vehicles per hour 	<ul style="list-style-type: none"> Historic traffic count data Automatic traffic counters
Weather	<ul style="list-style-type: none"> Maximum 1 inch snowfall per hour Maximum 6 inches of snow accumulation over deployment period 	<ul style="list-style-type: none"> Forecast weather conditions Current weather conditions



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Criteria	Threshold	Resources
Snow accumulation since last deployment	<ul style="list-style-type: none"> Ability to remove snow during low volume periods pre-deployment 	<ul style="list-style-type: none"> Historic traffic count data Forecast weather conditions for pre-deployment period Current weather conditions
Existing traffic conditions	<ul style="list-style-type: none"> Incident free Reversible Lane corridor Chain law not in effect 	<ul style="list-style-type: none"> CDOT Traffic Operations and Maintenance Colorado State Patrol CCTV
Reversible Lane equipment condition	<ul style="list-style-type: none"> Transfer machine free of mechanical problems Movable barrier segments free of damage that would disable transfer machine 	<ul style="list-style-type: none"> Pre-deployment inspection of transfer machine and movable barrier segments

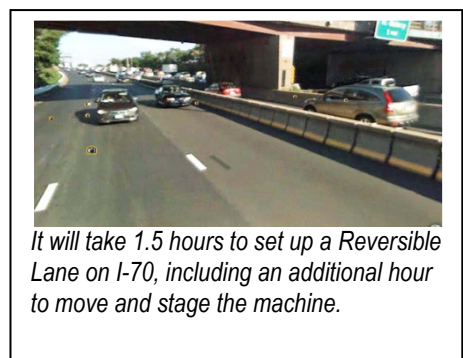
What would be the process for deploying the Reversible Lane?

In the case of I-70, the transfer machine would relocate moveable concrete barrier to the center of the 2 westbound lanes, converting 1 westbound lane to an eastbound lane. When implemented, there would be 3 eastbound lanes and 1 westbound lane on I-70 for approximately 13 miles from west of Empire Junction to east of the Hidden Valley interchange.

The transfer machine would be stored at CDOT's Hidden Valley maintenance facility. On days of deployment, the machine would be moved to the eastern staging area of I-70, escorted by a pilot car due to travel speeds ranging from 10-20 miles per hour (mph).

The barrier transfer process would begin at 11:30 a.m. Automatic gates would close the left lane of westbound I-70 at the eastern terminus near the Hidden Valley Interchange. The transfer machine would then move the barrier into place and proceed to the western terminus, where it would pull beyond the Reversible Lane and remain parked behind barriers. Transfer machine drivers would need to visually confirm if the barrier was properly deployed and ensure the lane is clear in the Pilot Program. Transfer machine drivers and the addition of surveillance cameras and operators would confirm this in the Enhanced Program. Automatic gates at the eastbound entrance would then open to traffic at 1 p.m.

The Reversible Lane would close at 8 p.m., with automatic gates closing the eastbound entrance. The barrier transfer machine would then move the barrier back to the stored position in the north shoulder of the westbound lanes. The transfer machine would complete the transfer and reopen all westbound lanes by approximately 9:30 p.m., driving back to the storage facility with a pilot escort on westbound I-70.



How long would it take to deploy the Reversible Lane?

It will take 3 hours to set up and remove the Reversible Lane. Moving at 10 mph, the transfer machine needs 1.5 hours, travel the 13-mile Reversible Lane corridor. Permanently positioned automated gates in each direction would control traffic at each end of the facility, thus no additional time would be required to open the lane or set traffic control.



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It will take an additional hour to move the machine from its storage location to the Reversible Lane. Another hour is needed to move the machine back to CDOT's maintenance facility. These operations would be done during non-peak hours and would have a minimum impact to the traveling public.

If snow accumulated along the moveable barrier during the week, it is estimated an additional 20 minutes would be required to clear the corridor prior to opening the lane. In this case, deployment would begin 20 minutes earlier. After deployment is complete, additional snow removal may be required during off-peak hours.

Is measurable snow likely during the Reversible Lane deployment period?

Annual snowfall in the Denver metropolitan area averages approximately 60 inches, whereas many higher elevations along the I-70 Mountain Corridor average more than 160 inches. Based on historic snowfall data reported for Georgetown and Evergreen, an average snowfall of 75.5 inches per winter season is calculated for the Reversible Lane corridor.

The I-70 Mountain Corridor typically experiences 60 days of measurable snowfall per winter season. Seasonally, measurable snowfall occurs on approximately 30 percent of days. Therefore, measurable snowfall could be expected on approximately 5 of the 17 Sundays that the Reversible Lane would be deployed. The amount of snow could impact the ability to deploy the Reversible Lane.

How would CDOT remove snow?

CDOT would use existing personnel and equipment to remove snow for both the Pilot and Enhanced Programs. Since local CDOT forces do not have excess personnel, crews from other locations within the state would be assigned to the Reversible Lane corridor during the deployment period. Existing equipment would not fit through the westbound Twin Tunnel portal due to reduced lane width resulting from the added barrier. As such, retrofitting and/or purchasing new equipment for the I-70 corridor would be necessary to accommodate snow removal operations for the Reversible Lane for both the Pilot and Enhanced Programs. The shorter plow length will decrease the efficiency of snow removal along other sections of I-70 and U.S. 6.

Prior to deploying the Reversible Lane, snow that accumulated since the last deployment would be removed, giving special attention to areas where shading from removable barrier causes icing on the roadway. For operating conditions with a maximum of 1 inch per hour of snowfall or less than 6 inches of accumulation, standard de-icing materials and plowing operations would be sufficient. However, the Reversible Lane may need to be closed during the snow removal process if accumulations exceed this amount and cause excessive narrowing in the lane. While manageable, the snow removal operation would cause minor delays for westbound traffic. When Reversible Lane operations end, snow and ice that has accumulated adjacent to the moveable barrier may need to be removed.



Snow removal equipment would need to either be retrofitted or new equipment purchased to accommodate snow removal for both the Reversible Lane and I-70 operations due to narrow lane width.



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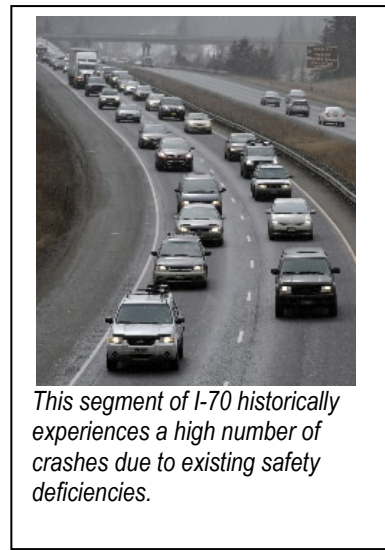
SAFETY

What is the historic crash data in this area of I-70?

When compared to similar Colorado Interstate highways, this segment of I-70 historically experiences a high number of crashes. The *I-70 Mountain Corridor PEIS* identified several existing safety deficiencies in the corridor, including:

- Heavy congestion attributed to frequent rear-end crashes along the corridor
- Moderate grades, ramp merging and weaving movements contribute to rear end and sideswipe crashes
- Sharp curves between the Twin Tunnels and Floyd Hill are a contributing factor to crashes within this segment of the corridor

Historic crash data on I-70 during heavy periods of winter congestion from 2001 through 2006 were analyzed, specifically looking for crashes on winter Sundays within the Reversible Lane corridor during the hours of 1 p.m. – 8 p.m. During this period, both the eastbound and westbound directions of I-70 each experience approximately 5.1 accidents per year for the same timeframe a Reversible Lane would be deployed, between west of Empire and east of the Hidden Valley interchange, for a total of 10.2 accidents annually. This does not include Floyd Hill discussed below.



This segment of I-70 historically experiences a high number of crashes due to existing safety deficiencies.

What is the severity of these crashes?

From the perspective of crash severity (injury and fatal crashes), the corridor's safety performance is on par with other similar highways. Approximately 20% of crashes result in an injury while the remaining 80% result in property damage only (PDO). Fatal accidents occur very infrequently.

How often could crashes happen within the Reversible Lane corridor?

The Reversible Lane is expected to reduce congestion in the eastbound general purpose lanes, thereby reducing the number of crashes in these lanes (winter Sundays) from 5.1 to 3.5 per year.

Table 5. Historic and Predicted Crash Data

	2 Eastbound General Purpose Lanes	2 Westbound General Purpose Lanes	1 Westbound General Purpose Lane With Reversible Lane	Estimated Total Number of Crashes
Historic average number of crashes ¹	5.1	5.1	-----	10.2
Expected number of crashes during Reversible Lane operation	3.5	-----	9.3	12.8
Net change	-1.6		+4.2	+2.6

¹Total crashes annually during 17 winter Sundays.



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Safety in the westbound facility would decline as a result of the placement of the moveable barrier, which reduces lane and shoulder widths. Analysis predicts there would be 9.3 crashes per year on the 17 Sundays during the ski season in the single westbound lane and the single eastbound Reversible Lane. These results indicate that one crash, on average, would occur for every 2 days in which the Reversible Lane is in operation. Of these crashes, approximately 20% could involve an injury. It's important to note while these are the predicted crash results, the data is not absolute; crashes could increase or decrease, as could their severity.

The design characteristics of the moveable barrier show it would prevent head-on type crashes. The confined space of the Reversible Lane means the primary hazard for eastbound vehicles in the lane would be rear-end crashes and fixed-object crashes where a vehicle hits the barrier on either side at a low angle. Although fatal crashes cannot be ruled out as a hazard for the Reversible Lane, it is anticipated they would occur infrequently.

How often would crashes occur on Floyd Hill?

Floyd Hill, just east of the Reversible Lane corridor, includes a steep 2-mile long, 6% westbound downgrade. By its nature, Floyd Hill has been the site of serious traffic crashes in the past. As noted in OPERATIONS, westbound traffic back-ups would occur past the top of Floyd Hill when the Reversible Lane is operational. Winter driving conditions could also potentially exacerbate this condition, leading to an increase in rear-end crashes or even more serious incidents.

To assess this safety concern, historic crash data from 2001 to 2006 was analyzed for the Floyd Hill segment of I-70. It was determined that heavy congestion and subsequent traffic backups occur most Saturday mornings during ski season on Floyd Hill. This condition is analogous to what could be expected to occur on Sunday afternoons when the Reversible Lane is in operation.

Crash data from this condition was used to provide an estimate of potential crashes that could occur with a Reversible Lane. Analysis indicates westbound traffic along Floyd Hill could expect an additional 3 rear-end crashes when the Reversible Lane is in operation; however, it's difficult to determine the severity.

With the installation of crash mitigation measures such as active queue detection and VMS (included in the Enhanced Program), it is estimated that westbound rear-end crashes along Floyd Hill could be reduced by 25%.

Would crashes increase or decrease with a Reversible Lane?

Analysis predicts a 49% increase in crashes is likely within the 13-mile corridor and Floyd Hill area when the Reversible Lane is operating during winter Sundays. This would represent a 2% annual increase for crashes within the Reversible Lane corridor.



The nature of Floyd Hill's steep, two-mile long, 6% westbound downgrade has resulted in serious traffic crashes in the past. A Reversible Lane could result in a 2.5-mile westbound backup, or to the top of Floyd Hill, if implemented.



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How would emergency responders react to incidents?

Emergency responders and CDOT respond to incidents along the Reversible Lane corridor by following the *I-70 Mountain Corridor Traffic Incident Management Plan for Clear Creek County*. Implementing the Reversible Lane would necessitate an update to this plan.

To respond to any incident in the Reversible Lane, a closure of the I-70 westbound lane and I-70 eastbound Reversible Lane would be required. Currently, an average incident on the I-70 Mountain Corridor can be cleared from traffic within approximately 30 minutes. It is expected that closures of I-70 to clear incidents will increase queues, clearing rates and travel time.

The Enhanced Program would allow CDOT to maintain current incident clearance times by contracting with private companies to provide additional pre-positioned resources in the corridor. Incident response teams composed of fire, ambulance, law enforcement, towing, courtesy patrol and maintenance personnel and equipment, would be staged at interchanges located throughout the Reversible Lane corridor to allow immediate response to corridor incidents. The incident response teams would be dedicated to the Reversible Lane corridor and would not conduct concurrent, off-highway assignments or respond to on-highway incidents outside of the corridor. The incident response teams also would be specifically trained and specially equipped to respond to incidents requiring opening the barrier, holding traffic to facilitate incident access to minimize traffic flow disruption.



If an incident occurs when traffic volumes are at their peak, it is estimated westbound I-70 traffic may take 3-4 hours to recover, while eastbound I-70 may take 1-2 hours.

The Pilot Program only assumes pre-positioned towing assistance and courtesy patrol, not emergency response (ambulance, fire, and law enforcement). The Pilot Program calls for emergency services to continue to be provided by local resources, which would not be staged. These emergency service providers may experience delays in arrival at incident sites if incidents need to be approached from the east, which could result in delayed service to injured parties, as well as extended lane clearance time.

In order to mitigate these issues, the westbound shoulder will have a minimum of 7.5 feet in width to allow for emergency vehicles to pass stopped or slow moving traffic.

How will incidents affect traffic operations?

Traffic incidents in the eastbound Reversible Lane and westbound general purpose lanes were modeled. If an incident were to occur in the Reversible Lane at 3 p.m. when traffic volumes are at their peak, it's most likely that it would fully block both directions of travel (eastbound Reversible Lane and westbound general purpose lane) for 30 minutes due to clearance requirements. The average duration of an I-70 incident, based on past incident management experience in the corridor, was determined to be 30 minutes. For the purposes of modeling this condition, the incident was assumed to be located 0.5 miles west of the Twin Tunnels.

The results of the incident analysis show westbound traffic would be more negatively impacted, and might take 3 to 4 hours to fully recover from a 30 minute incident. Eastbound travel would only take 1 to 2 hours to fully recover. Westbound traffic backups would be approximately 6.5



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miles in length from the point of the accident while eastbound Reversible Lane traffic would experience a 2.3-mile backup.

SOCIAL/NATURAL RESOURCES

What is the current business and economic conditions within the corridor?

Clear Creek County experiences two seasonal business peaks in summer and winter. The summer season is slightly busier than the winter, with 35 to 40 percent of annual retail, eating and drinking sales occurring in the June to September time period. Winter retail, eating and drinking sales account for 30 to 35 percent of annual sales. Over the past 10 to 15 years, annual sales have been increasing and the seasonal swings in sales have lessened. While traffic volumes on I-70 are actually higher during the summer months, the peak traffic impacts are distributed over more hours and there are fewer weather-related delays that cause congestion.

How would a Reversible Lane affect business and economic conditions along the corridor?

It is estimated that winter Sunday retail, eating and drinking sales account for no more than 10 percent of annual sales in Clear Creek County. If travel times are shorter and people do not wish to stop in Clear Creek County, there could be a negative impact on sales. Also, there is no access from the Reversible Lane to highway exits leading to local businesses. Conversely, increased traffic volume could result in increased business, potentially cancelling out negative impacts from drivers not exiting the Reversible Lane.

Beyond Clear Creek County, other business and economic impacts include:

- **Skier Visits.** Many Denver Metro Area day skiers are frustrated with the level of I-70 congestion to the point they voluntarily reduce their ski visits. Any improvements to I-70 that increase capacity are likely to induce additional travel, with an expected modest increase in skier visits to Grand, Summit, and Eagle County ski resorts.
- **Mountain Resident Travel and Shopping Patterns.** The Reversible Lane will increase westbound travel time on Sunday afternoons. Many westbound travelers are mountain community residents returning from a Denver Metro Area shopping or entertainment trip. Mountain residents may adjust the timing of their trip to avoid the single lane westbound configuration or might forego Denver Metro Area trips altogether, shopping locally and increasing local retail sales.
- **Deliveries.** Travel time for westbound trucks would be slower on winter Sundays when the Reversible Lane is deployed. Trucks are less than 10 percent of the total traffic volume on I-70. Trucks are even a smaller percentage of traffic volumes on weekends. This suggests there could be a small overall impact on deliveries and supplies to businesses, given the limited days the Reversible Lane is in operation. However, businesses might be able to adjust their planning to account for the Sunday westbound congestion.

What are the environmental and social impacts of implementing a Reversible Lane?

Addressing transportation needs in the I-70 Mountain Corridor requires careful consideration of the physical, environmental and community resources created by the mountain terrain. The protection of these resources is critical to the State and corridor communities. Solutions must be developed with consideration for preserving these resources. Fourteen environmental and



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social resources were evaluated to determine the impacts of implementing a Reversible Lane and suggested mitigation strategies for consideration. Using the *I-70 Mountain Corridor PEIS* as the information source, the following eight resources were found to have impacts and would require some mitigation strategies:

- Visual and aesthetic resources
- Traffic noise
- Biological resources
- Wetlands
- Water resources
- Hazardous materials and historic mining
- Geologic hazards
- Historic properties

The following six resources are not anticipated to be impacted and as such do not require mitigation.

- Air Quality
- Land Use
- Low-income and/or minority communities
- Energy
- Recreation
- Paleontology

FUNDING

What would the Reversible Lane program cost?

The Pilot and Enhanced Program costs are as follows. These represent the total cost for each program and are not additive.

Table 6. Program Costs

	Pilot Program	Enhanced Program
Roadway	\$6,170,000	\$15,330,000
Barrier Systems	\$16,000,000 ¹	\$ 24,600,000
<i>One-Time Capital Costs</i>	<i>\$22,170,034</i>	<i>\$39,930,000</i>
Operations	\$130,000	\$540,000
Emergency Response	\$580,000	\$1,220,000
<i>Annual Costs</i>	<i>\$710,000</i>	<i>\$1,760,000</i>
<i>¹Two-year equipment lease</i>		

There is a rental option for the Barrier Systems equipment, which would equate to a \$9 million one-time cost. This option relies on existing and used equipment, including a barrier that would be a larger width and would further reduce the travel lane width along I-70.



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Could user fees defray the costs?

Implementing user fees for just the Reversible Lane isn't practical, as traffic volumes in the eastbound reversible lane would need to provide a significantly better travel time savings than the time it takes to travel in the eastbound general purpose lanes. If travel times for both the Reversible Lane and General Purpose lanes were roughly equal, it would reduce the attractiveness for those willing to pay user fees. Providing fee-paying drivers a better travel time at the expense of the general purpose lanes reduces the ability of a Reversible Lane to provide a corridor-wide benefit for the maximum number of people.

While it would be difficult to implement user fees on the Pilot Program, charging user fees for all 3 eastbound lanes during Reversible Lane operations could help offset the costs of implementing an Enhanced Program. A per-trip charge ranging from \$0.65 to \$2.50 could result in annual revenues ranging from \$200,000 to \$750,000.

User fees would require a variety of approvals, including the FHWA and local communities in accordance with Senate Bill 09-108. It is anticipated these approvals would take a significant amount of time to obtain and may be difficult to secure.

How could this program be funded?

There are several federal and state funding sources that could provide funding for a Reversible Lane. Given the limited dollars available and the challenges in just maintaining the quality of the existing system, priorities would need to be reallocated to fund either program. CDOT and the Colorado Transportation Commission would need to shoulder Pilot Program costs if no user fees are charged. The Colorado High Performance Transportation Enterprise could manage the Reversible Lane program if user fees were implemented.

APPROVALS

What is the anticipated environmental clearance needed for this program?

Based on the environmental analysis, all expected impacts could likely be mitigated. It is anticipated that the Reversible Lane could be cleared by a documented Categorical Exclusion, consistent with the National Environmental Policy Act (NEPA) of 1969. If a different level of NEPA documentation is needed after consultation with FHWA, the implementation time period would be extended.

What is FHWA's approval process for the program?

As noted in IMPLEMENTATION, reducing westbound I-70 to 1 lane constitutes a Federal action and results in a rigorous approval process. The FHWA identified a 45-day approval process that CDOT would need to follow if implementation is desired. These steps include:

- CDOT submits a proposal to the FHWA Colorado Division Office.
- The Division needs to be able to support the proposal prior to forwarding onto FHWA Headquarters.
- Five FHWA Offices review the proposal (Office of Operations, Office of Safety, Office of Infrastructure, Office of Environment, and Chief Counsel) concurrently with the Division, responding to questions concurrently.
- Decision on proposal is received within 45-days pending accurate and complete information.



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What information would CDOT need to provide to the FHWA?

FHWA Colorado Division Office requires the following information prior to submitting the proposal for official FHWA Headquarters review:

- Compare alternatives to analyze other solutions to congestion.
- Review safety, benefits, roadway geometry, lane and shoulder width, etc. associated with the proposed alternatives.
- Perform a traffic analysis on current proposed Reversible Lane and other alternatives.
- Completed required NEPA clearance.
- Stakeholder involvement.
- Develop operational and incident management plans.
- Evaluate impacts on:
 - Access and Interchanges.
 - Travelers, especially in the westbound direction.
 - Interstate commerce.
 - Emergency response.
 - Public transportation.

While much of this work has been completed to finalize the *Phase II Feasibility Study*, additional detail may be required to satisfy the FHWA information needs.

What is FHWA's current position on the Reversible Lane project?

The FHWA has been partner with CDOT's Project Leadership Team and has seen much of the information provided to date. While a formal proposal has not been received by the Colorado Division Office, officials indicated they are not convinced spending approximately \$25 million on a Reversible Lane Pilot Program is the best use of public monies. Federal officials note that as part of any formal proposal, CDOT will need to demonstrate to FHWA that other alternatives have been explored and there isn't a better short-term solution to address congestion.²

NEXT STEPS

Have other ideas been considered?

The use of hard shoulders is an emerging idea raised during stakeholder discussions and alternative analysis required by the FHWA.

The hard shoulder concept allows vehicles on existing or expanded shoulders during limited time periods, resulting in three eastbound lanes and at least two westbound lanes on I-70. Given constraints at the Twin Tunnels, a Reversible Lane would still be needed from west of Idaho Springs to east of the Hidden Valley interchange – a distance of approximately 5 miles.



The hard shoulder concept allows vehicles to travel on existing shoulders during limited time periods, resulting in additional roadway capacity to manage congestion.

² "Price of I-70 ski fix a hitch", Denver Post, December 16, 2010, pg. 1.



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While this solution could provide congestion benefits, CDOT needs to look at this in more detail, working with stakeholders to answer the same questions raised by the Reversible Lane.

Given the costs of the Pilot and Enhanced Programs, another idea raised by FHWA and stakeholders is considering longer-term solutions sooner that could provide short-term congestion relief. The limited shoulder and lane widths created by the Twin Tunnels east of Idaho Springs, for example, could be addressed by advancing elements of the long-term transportation solution identified in the *I-70 Mountain Corridor PEIS*.



Advancing long-term solutions identified in the PEIS, such as fixing the Twin Tunnels east of Idaho Springs, could address congestion problems in the short-term.

The Colorado Transportation Commission directed CDOT staff to further investigate these concepts, reporting their findings as soon as possible.

What is the timeline for considering these ideas and advancing a short-term solution?

Technical analysis of these other ideas is currently underway. The Department also is actively engaging stakeholders consistent with the *I-70 Mountain Corridor Context Sensitive Solutions* guidance to better understand the opportunities and challenges associated with these concepts.

CDOT anticipates reporting findings to the Transportation Commission in March 2011 for their consideration.