APPENDIX C

Draft Evaluation of Managed-lane Concepts

Little Cottonwood Canyon ENVIRONMENTAL IMPACT STATEMENT
S.R. 210 | Wasatch Blvd. to Alta

Draft Evaluation of Managed-lane Concepts

Little Cottonwood Canyon Environmental Impact Statement S.R. 210 - Wasatch Boulevard to Alta

Lead agency:
Utah Department of Transportation

April 3, 2020

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Acronyms and Abbreviations

EIS	Environmental Impact Statement
LED	light-emitting diode
MP	milepost
mph	miles per hour
PPSL	peak-period shoulder lane
S.R.	state route
UDOT	Utah Department of Transportation

1.0 Introduction

The purpose of this report is to summarize the Utah Department of Transportation's (UDOT) evaluation of managed lane concepts for State Route (S.R.) 210 in Little Cottonwood Canyon as part of the Little Cottonwood Canyon Project. This report provides information that UDOT will use during the alternatives development and screening process, which will evaluate how well managed-lane concepts would satisfy the purpose of the Little Cottonwood Canyon Environmental Impact Statement (EIS). The EIS identifies five primary objectives, one of which is to improve overall mobility on S.R. 210 from Wasatch Boulevard through the town of Alta. Managed lanes are being considered for a portion of the EIS study area to add roadway capacity and improve mobility.

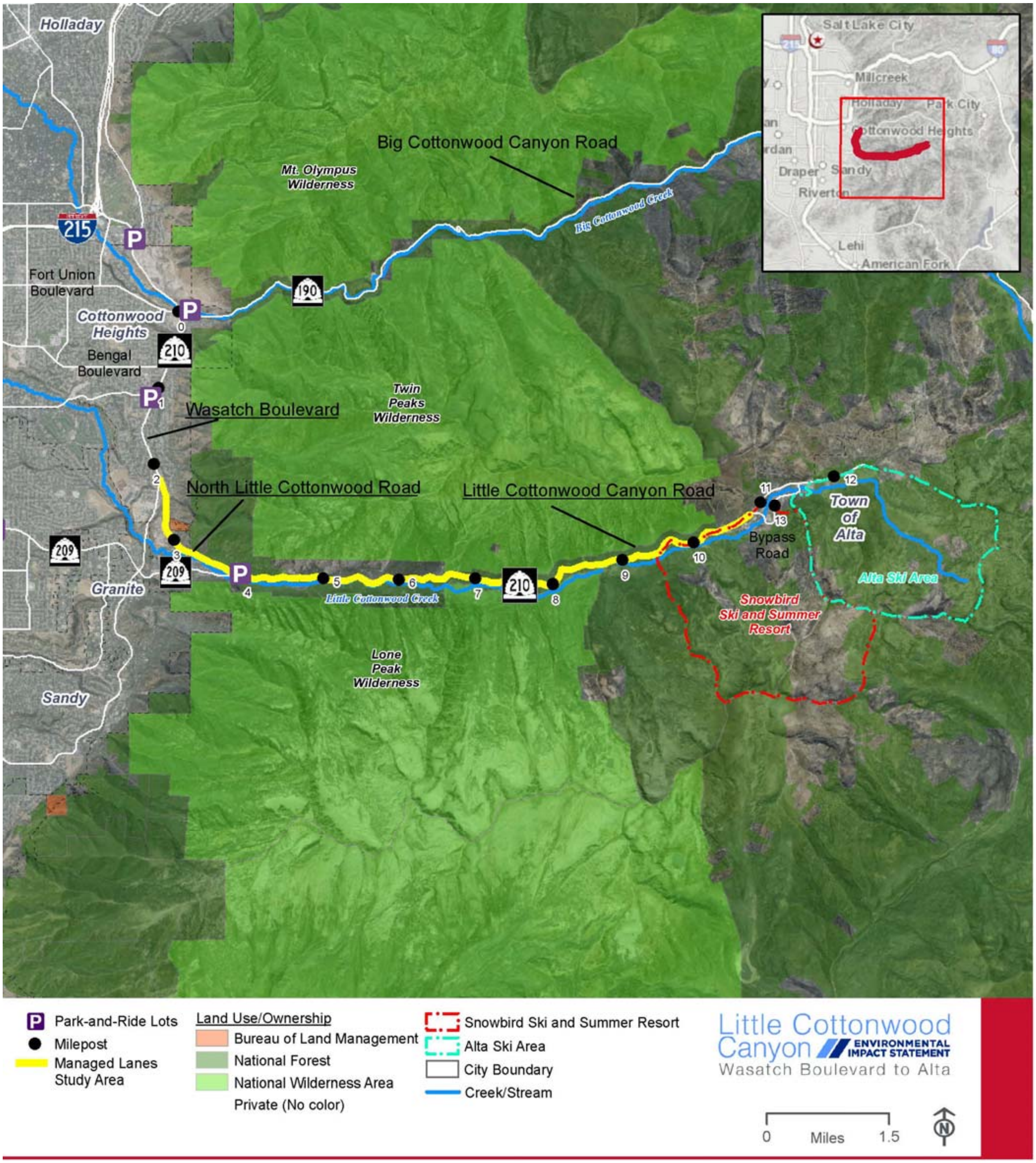
1.1 Study Area for Managed Lanes

The study area for the EIS extends along S.R. 210 from its intersection with Fort Union Boulevard (S.R. 190, at milepost [MP] 0.0) to the town of Alta (MP 12.5). Through the EIS study area, S.R. 210 is designated with different street names.

- **Wasatch Boulevard** – S.R. 210 from Fort Union Boulevard (S.R. 190; MP 0.0) to North Little Cottonwood Road (MP 2.2)
- **North Little Cottonwood Road** – S.R. 210 from Wasatch Boulevard (MP 2.2) to the intersection with S.R. 209 (MP 3.8)
- **Little Cottonwood Canyon Road** – S.R. 210 from the intersection of North Little Cottonwood Road and S.R. 209 (MP 3.8) to the town of Alta (MP 12.5)

The study area for managed lanes does not include Wasatch Boulevard but does include North Little Cottonwood Road and a portion of Little Cottonwood Canyon Road. The study area for managed lanes extends about 8.6 miles on S.R. 210 from the intersection with Wasatch Boulevard (MP 2.2) to the Bypass Road (MP 10.8). UDOT selected the intersection with Wasatch Boulevard as the starting point because S.R. 210 transitions from urban to rural at this location. The lower end of the Bypass Road (Snowbird Entry 4) was selected as the ending point because the need for additional traffic capacity decreases after vehicles headed for Snowbird resort exit S.R. 210. Figure 1-1 shows the study area for managed lanes.

Figure 1-1. Study Area for Managed Lanes



1.2 Traffic Operations

Traffic operations on S.R. 210 in Little Cottonwood Canyon are characterized by traffic congestion and decreased mobility in the winter. These issues are related primarily to avalanche control and visits to ski areas, with the greatest traffic volumes occurring on weekends and holidays and during and after snowstorms. Peak traffic is directional, with heavy traffic going up canyon (eastbound) in the morning and down canyon (westbound) in the evening.

> **What is travel demand?**
>
> Travel demand is the expected number of transportation trips in an area. Travel demand can be met by various modes of travel, such as automobile, bus, aerial transit, carpooling, and bicycling.

The population in Salt Lake County is projected to increase by 36% by 2050 (Kem C. Gardner Policy Institute 2017). UDOT expects this increase in population to cause increased travel demand in Little Cottonwood Canyon through 2050.

1.3 Roadway Context

S.R. 210 is generally a two-lane road (one travel lane in each direction), but there are passing lanes in three locations:

- Westbound from about MP 7.7 to MP 8.1 (near Tanner's Flat Campground)
- Eastbound from about MP 8.6 to MP 9.4 (near White Pine trailhead)
- Westbound from about MP 9.6 to MP 9.9 (near Snowbird Entry 1)

The path of S.R. 210 in the canyon is steep and windy due to the canyon terrain. The roadway grade exceeds 8% for 40% to 50% of S.R. 210's length in the canyon, and the maximum grade is 11%. The sight distance for drivers is limited because trees and steep embankments block visibility around curves.

Little Cottonwood Canyon receives heavy snow in the winter; the average snowfall at the Alta Guard Station is about 500 inches (more than 41 feet) per year (Utah Avalanche Center 2019). S.R. 210 in the canyon is threatened by 35 major avalanche paths, and an average of 33 avalanche flows hit the road annually (UDOT 2006). UDOT is responsible for t operating and maintaining S.R. 210 in the canyon, including removing snow and controlling avalanches.

S.R. 210 in Little Cottonwood Canyon is a designated scenic byway. The *Cottonwood Canyons Scenic Byways Corridor Management Plan* (UDOT 2008) describes strategies for protecting scenic vistas along this byway. It recommends a scenery management plan and a signage plan to manage detracting uses, minimize clutter, and establish a protocol for approving new signs along the byway.

2.0 Reversible-lane Concepts

Reversible lanes can move traffic in either direction. They can be used when there is a heavy directional split in traffic (that is, heavy traffic in one direction in the morning and in the opposite direction in the evening) to minimize the overall number of lanes needed, thereby minimizing impacts to the surrounding environment.

What are reversible lanes?

Reversible lanes move traffic in alternating directions during different periods of the day. They can be used where there is heavy traffic in one direction in the morning and in the opposite direction in the evening.

To implement a reversible lane on S.R. 210, UDOT would need to widen S.R. 210 to add a third lane. The reversible lane would be open to eastbound traffic during the morning peak period and westbound traffic during the evening peak period on peak traffic days (weekends during the ski season, holidays, and special events). Traffic traveling in different directions can be physically separated by a moveable barrier or directed to the appropriate lane by overhead lane-control signals or signs.

2.1.1 Moveable Barrier

Reversible lanes can be implemented using a moveable barrier, in which a median barrier is moved from one side of the reversible lane to the other to change the direction of traffic. The moveable barrier is made of short segments of concrete connected by heavy-duty steel hinges to form a continuous wall. To move the barrier, a transfer machine lifts up each segment of barrier, moves it sideways, and sets it back down on the other side of the reversible lane (Figure 2-1).

Figure 2-1. Moveable Barrier and Transfer Machine

A moveable barrier system is used for reversible lanes in several locations in the United States including high-occupancy vehicle lanes on Interstate 93 in Boston, Interstate 30 in Dallas, and Interstate 15 in San Diego.

Considerations for S.R. 210

The intersection where S.R. 209 merges into S.R. 210 (at MP 3.8, where North Little Cottonwood Road becomes Little Cottonwood Canyon Road) is a key intersection with respect to travel demand. S.R. 210 is the main route to Little Cottonwood Canyon from the north, and S.R. 209 is the main route to the canyon from the south. About 40% of the canyon traffic enters or exits the canyon on S.R. 209.

When inbound traffic backs up during the morning peak, the main bottleneck is on North Little Cottonwood Road entering the canyon. During the evening peak, the bottleneck is at the ski resorts at the top of Little Cottonwood Canyon Road heading outbound. The outbound PM travel demand on North Little Cottonwood Road is less where S.R. 209 splits off at MP 3.8. As a result, there is a greater need for additional southbound/eastbound lanes than for additional westbound/northbound lanes on North Little Cottonwood Road.

The reversible-lane concepts discussed in this report assume three travel lanes on S.R. 210 all the way from the intersection with Wasatch Boulevard (MP 2.2) to the Bypass Road (MP 10.8). However, on North Little Cottonwood Road (MP 2.2 to MP 3.8), the lanes would not be reversible. In this segment, there would be two southbound/eastbound lanes and one westbound/northbound lane at all times. On Little Cottonwood Canyon Road from the intersection with S.R. 209 (MP 3.8) to the Bypass Road (MP 10.8), the center lane would be reversible for 7.0 miles.

Figure 2-2 shows the typical section for reversible lanes with a moveable barrier on Little Cottonwood Canyon Road. UDOT would widen the road to include three travel lanes and two 8-foot-wide shoulders. The two outer travel lanes would be 12 feet wide, and the center reversible lane would be 17.5 feet wide. The moveable barrier would be 1.5 feet wide and would require a 2-foot-wide shy distance from the travel lane on each side, resulting in an additional 5.5 feet of pavement needed for the moveable barrier. The total pavement width would be 57.5 feet. The clear zone would be measured from the edge of the lane for a total roadway width of 73.5 feet.

What is a shy distance?

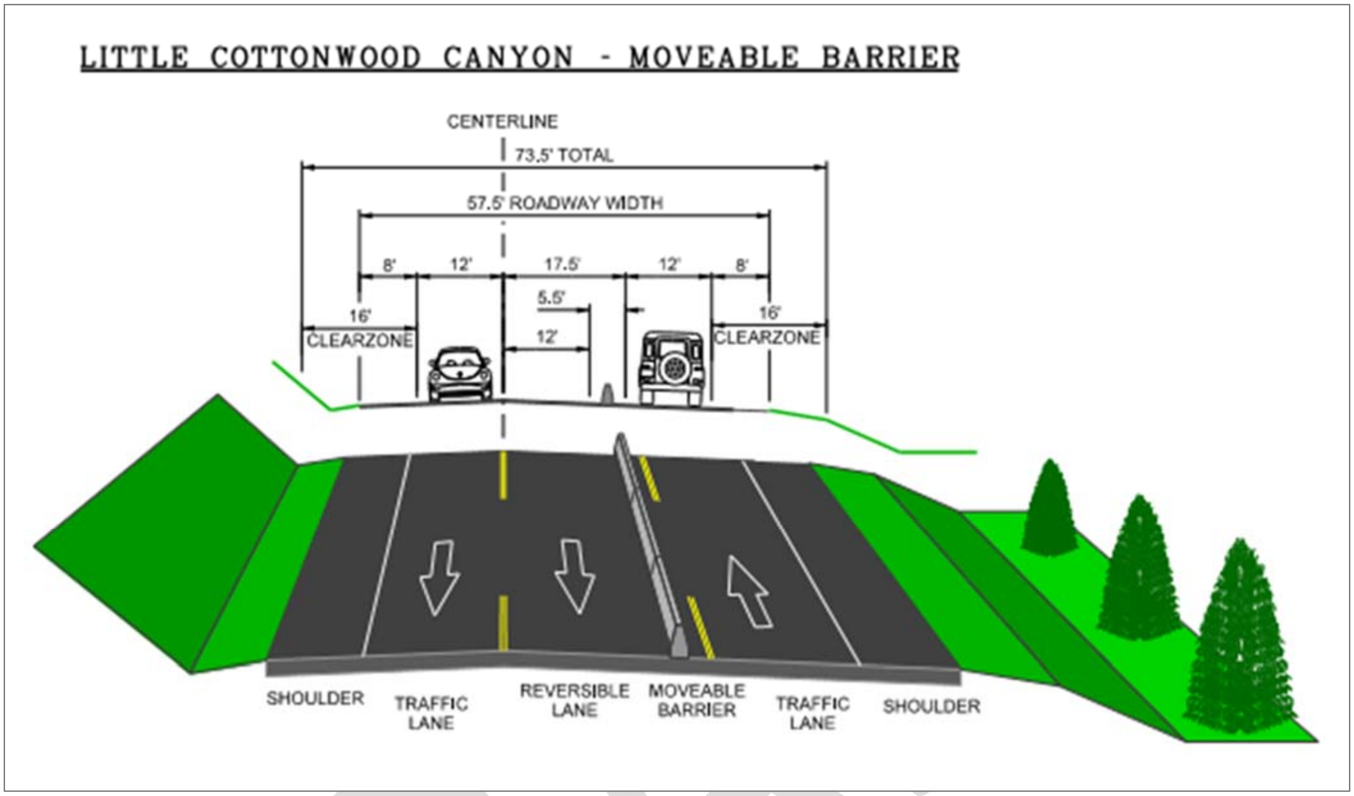
Shy distance is the space needed between a travel lane and a barrier so that a typical driver will not shift out of the center of the lane or reduce speed.

The barrier would be moved on peak traffic days only (weekends during the ski season, holidays, and special events). UDOT would place the barrier to provide two eastbound lanes and one westbound lane in the morning. After the peak morning traffic passed, the barrier would be moved to provide two westbound lanes and one eastbound lane for the evening peak traffic. After the evening peak traffic passed, the barrier would be moved back to the morning position to be ready for the next day.

On off-peak days, the barrier could be left in place with two eastbound lanes and one westbound lane. During the summer, the barrier could be placed to provide one eastbound lane, one westbound lane, and a protected bicycle lane on the south side of the road.

A heated storage facility for the transfer machine would be needed near the west end of the barrier at the mouth of the canyon, and a second facility might be needed near the east end of the barrier at the Bypass Road.

Figure 2-2. Typical Section with Moveable Barrier



The windy curves and steep grades on Little Cottonwood Canyon Road do not prevent using moveable barriers, but they would influence the transfer speed and cost of a barrier. On grades up to 8%, the maximum speed at which a barrier can be transferred from one side of the reversible lane to the other is 8 miles per hour (mph), but this speed decreases with steeper grades. Transferring a barrier from the inside of a curve to the outside changes the radius and length of the barrier. For larger-radius curves, the hinges can compensate for the change in length. For tighter curves, this option would require variable-length barriers with special operating restrictions and hardware.

The minimum radius to transfer a barrier across a 12-foot-wide lane without special operating restrictions and hardware is 1,000 feet. As the number of tight curves increases, transfer speeds drop and costs increase. Considering the steep grades and tight curves in Little Cottonwood Canyon, the transfer speed could drop to 5 mph or slower. At 5 mph, it would take about 1.4 hours (1 hour 25 minutes) to transfer 7.0 miles of barrier from the intersection with S.R. 109 to the Bypass Road once the transfer machine was in place.

There are 10 connecting roads or driveways and an additional eight informal parking areas on Little Cottonwood Canyon Road between the intersection with S.R. 209 and the Bypass Road. Gaps or breaks in the barrier would be necessary to allow vehicles to access these areas from either direction. In order to meet safety standards, crash cushions would be required at each end of the barrier. Anchorless liquid-filled crash cushions could be transferred with the barrier.

According to representatives for moveable barrier systems, the technology can be used even with 24 inches of snowfall in one day or 500 inches of snowfall over a season (Ferguson 2019a). A snow-removal plan would be required for implementation. During snow events, it would be necessary to remove snow before moving the barrier. Given that an average of 33 avalanche flows hit Little Cottonwood Canyon Road each year, moveable barriers could be hit. There is no information available regarding avalanche flows hitting moveable barriers, but semitrucks have hit them and pushed them out of place. If the barriers and hinges are not damaged, the transfer machine can pull the barriers back into place. If the barriers are damaged, the road needs to be closed while the barriers are replaced (Ferguson 2019a).

Clear signing would be critical where the road transitions to reversible lanes. Overhead reversible-lane control signs or signals would be needed in the transition areas. West of the S.R. 209 intersection, there would be two eastbound lanes and one westbound lane on S.R. 210 at all times. The transition would be straightforward during the morning peak, since there would also be two eastbound lanes and one westbound lane on S.R. 210 east of the intersection (Figure 2-3). However, during the evening peak, the center lane would reverse direction. The eastbound center lane (west of the intersection) could either merge right to continue traveling through the intersection or turn left into the adjacent park-and-ride lot. The westbound center lane (east of the intersection) could either merge right to continue traveling through the intersection or turn left onto S.R. 209. Figure 2-4 shows the transition to reversible lanes at S.R. 209 during the evening peak.

Figure 2-3. Transition to Reversible Lane at S.R. 209 – Morning Peak

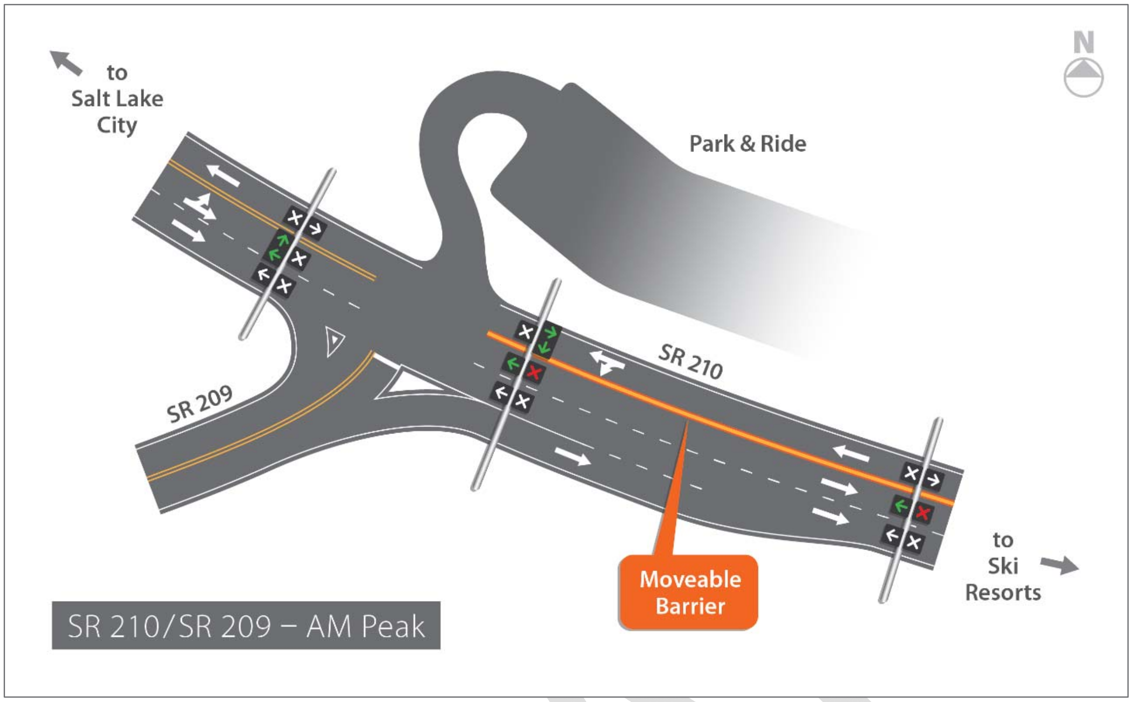
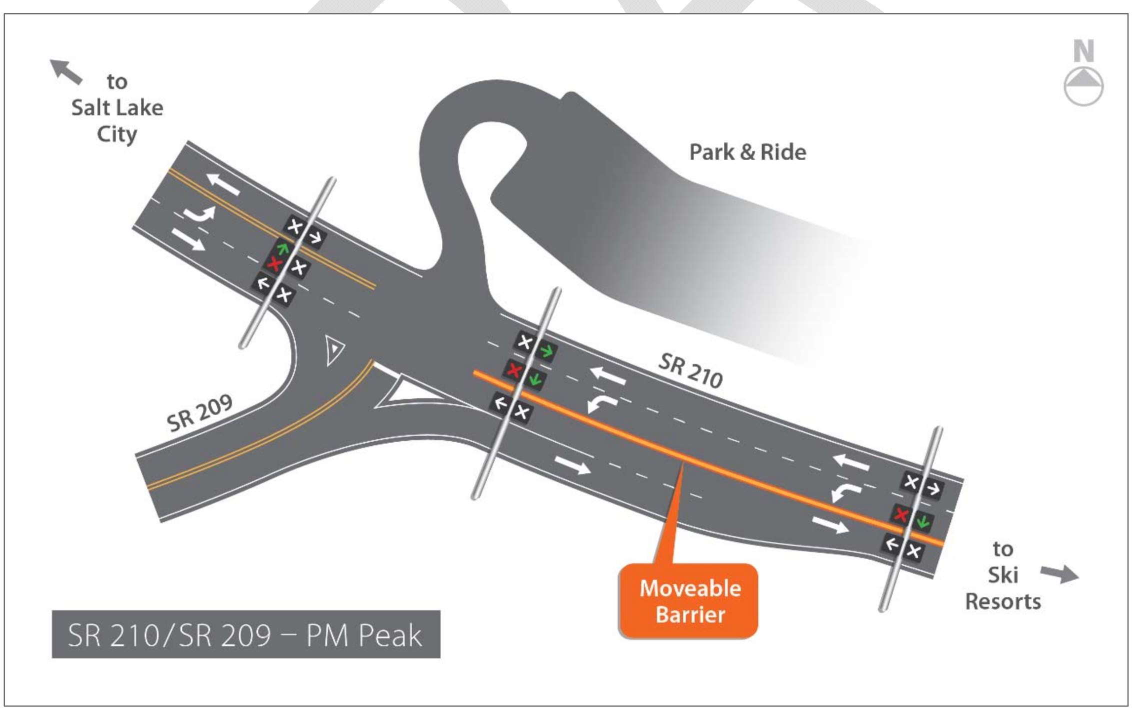


Figure 2-4. Transition to Reversible Lane at S.R. 209 – Evening Peak



East of the Bypass Road, there would be one travel lane in each direction at all times. At the Bypass Road intersection, there would be four lanes total (one lane in each direction, one dedicated right-turn lane onto the Bypass Road, and one receiving lane for left turns onto Little Cottonwood Canyon Road). West of the Bypass Road, there would be one eastbound lane and one westbound lane at all times, plus the center lane that would transition between eastbound and westbound travel.

During the morning peak, the center lane would be open to eastbound traffic. Figure 2-5 shows the transition at the Bypass Road during the morning peak. During the evening peak, the center lane would be open to westbound traffic. Vehicles turning left from the Bypass Road could continue down the canyon in the center lane. Figure 2-6 shows the transition to reversible lanes at the Bypass Road during the evening peak. It would be necessary to have a transition similar to what is shown in Figure 2-5 and Figure 2-6 at each location where there is a high-T intersection with reversible lanes. However, reversible-lane control signs or signals would be needed on both sides of the intersection.

What is a high-T intersection?

A high-T intersection is a three-way intersection with a barrier or curb that separates traffic moving straight through the intersection from the traffic turning left onto the main road.

A median barrier would reduce the risk of crossover accidents and vehicles sliding into oncoming traffic when the roads are icy. However, if a vehicle breaks down or crashes in the single lane, the median barrier could make it more difficult for an emergency response vehicle to assist. Also, it would be more difficult for traffic to detour around accidents or disabled vehicles.

Median barriers affect the movements and mortality of a wide range of wildlife, from large to small animals. Barriers can increase the number of wildlife deaths and decrease wildlife movements across the road (Caltrans 2006).

Figure 2-5. Transition to Reversible Lane at Bypass Road – Morning Peak

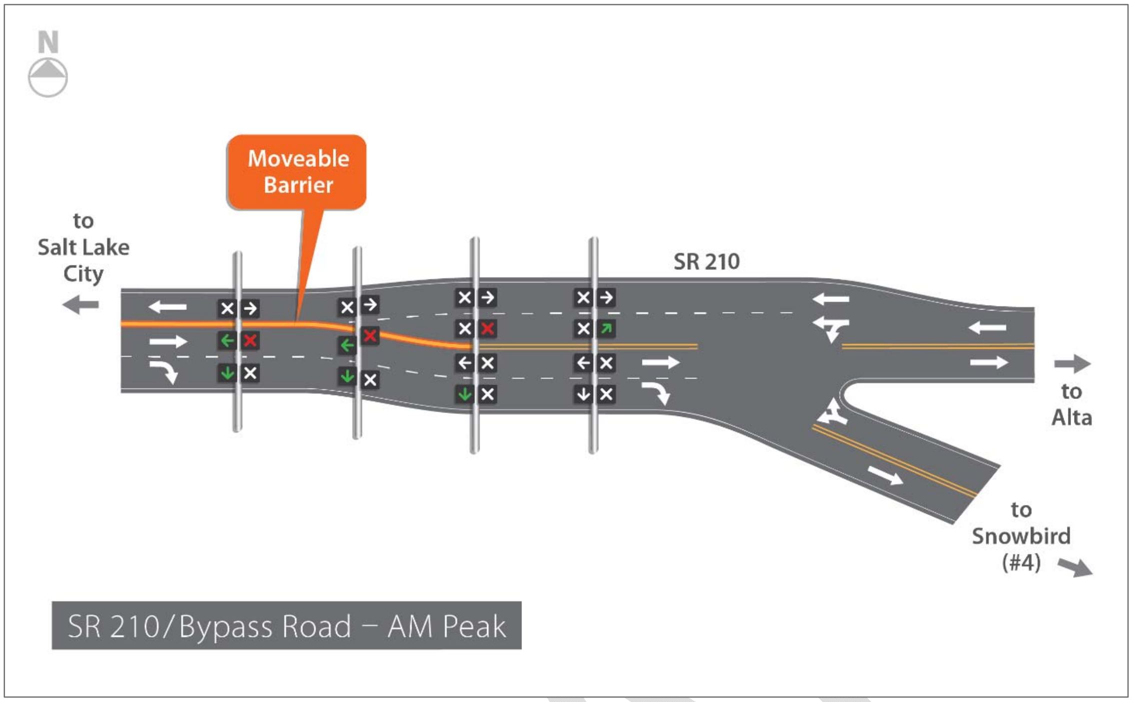
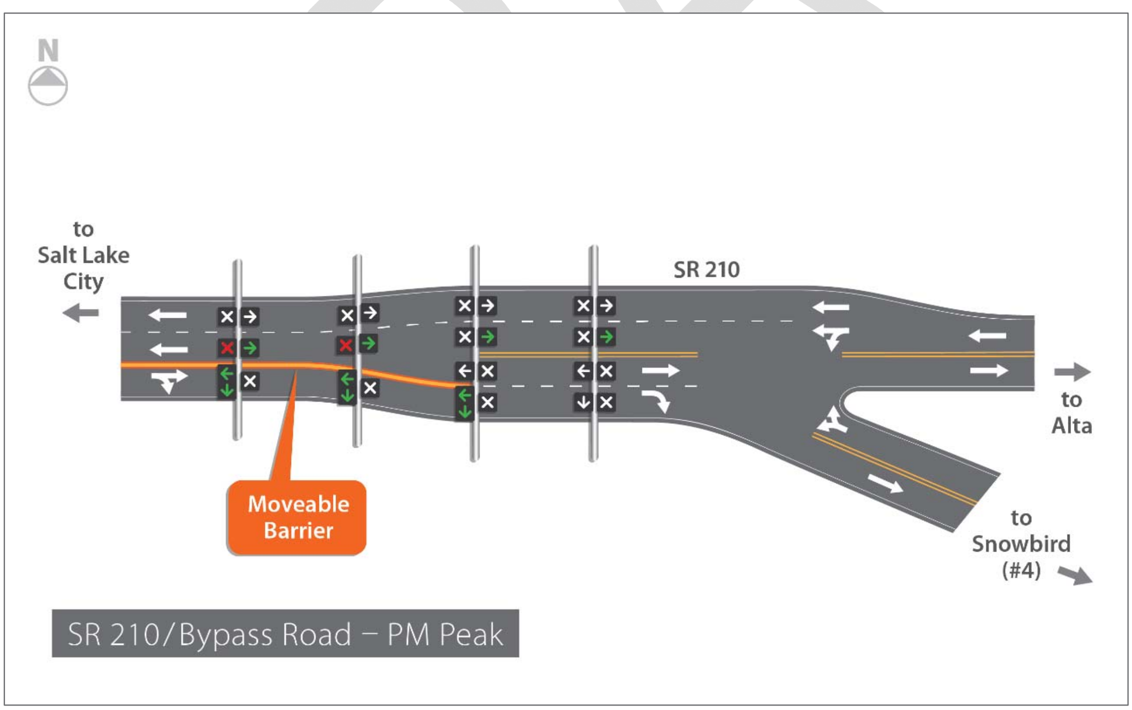


Figure 2-6. Transition to Reversible Lane at Bypass Road – Evening Peak



2.1.2 Reversible-lane Control Signals and Signs

Reversible lanes can be implemented without a barrier using lane-control signs to change the direction of traffic. The lane-control signs are placed over each lane on an overhead horizontal pole (gantry) and can be changeable (Figure 2-7) or static (Figure 2-8).

UDOT constructed reversible lanes with changeable lane-control signals on 5400 South in Salt Lake County in 2013. The road has seven lanes, three of which are reversible. Gantry spacing was typically based on the drivers' line of sight and a requirement that drivers should be able to see at least two gantries at any time. Typically, this resulted in a spacing of 500 to 700 feet (Guebert and others 2010). Figure 2-7 shows changeable lane-control signals on 5400 South.

Figure 2-7. Changeable Lane-control Signals

Photo credit: Hartmann 2012

UDOT might determine through an engineering study that physical barriers or changeable lane-control signals are not necessary and that the reversible lane can be controlled by static overhead lane-control signs. Figure 2-8 shows an example of a static lane-control sign (UDOT 2011).

Figure 2-8. Static Lane-control Sign

Reversing the flow of traffic can be controlled with pavement markings and static lane-control signs when the following conditions are met:

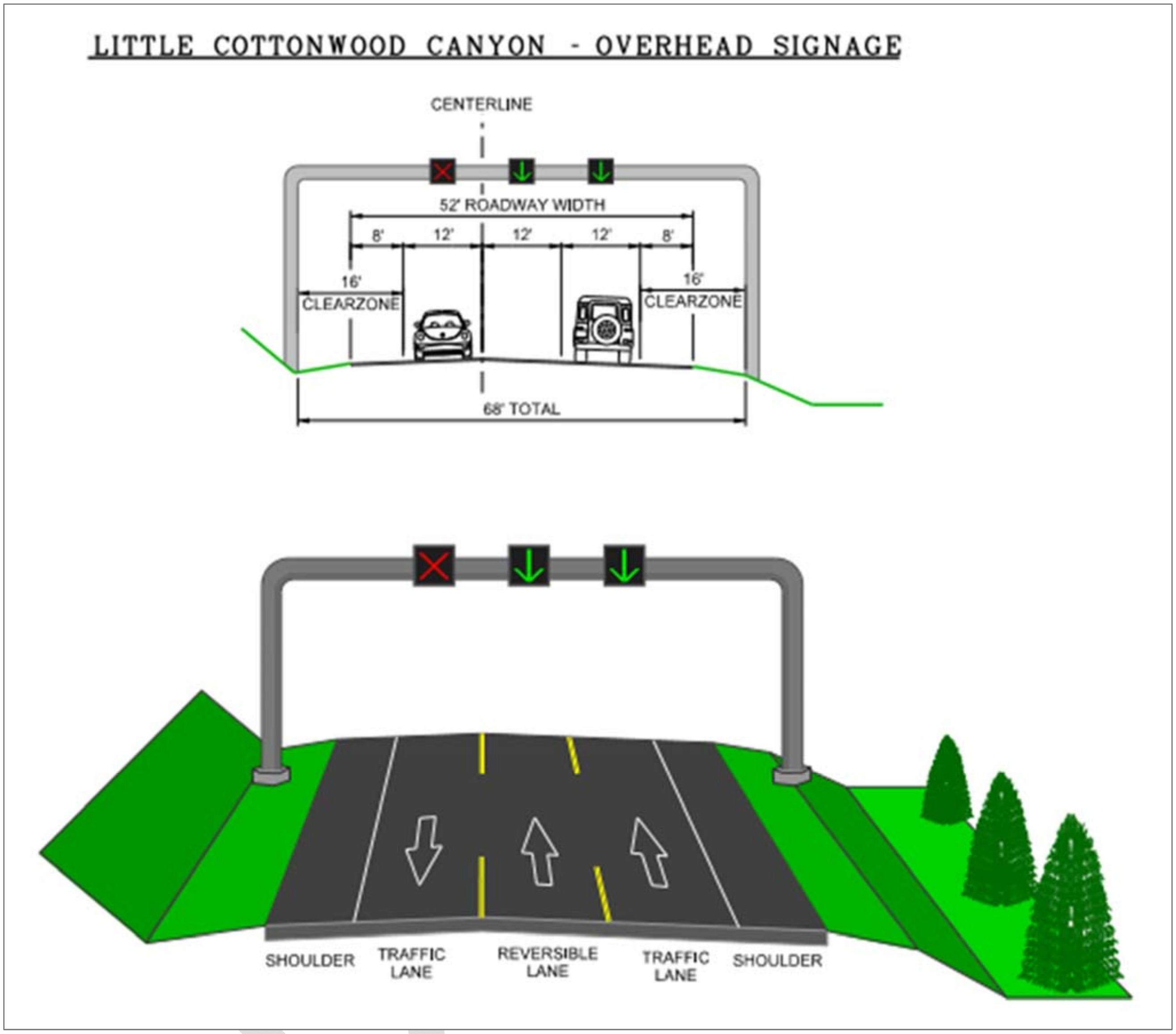
- Only one lane is being reversed,
- An engineering study indicates that the use of reversible lane-control signs alone would result in an acceptable level of safety and efficiency, and
- There are no unusual or complex operations in the reversible-lane pattern (UDOT 2011).

Static lane-control signs would not give UDOT flexibility in implementing reversible lanes based on weather, holidays, and special events.

Considerations for S.R. 210

Figure 2-9 shows the typical section for reversible lanes with a changeable lane-control signal on Little Cottonwood Canyon Road. The road would be widened to include three 12-foot-wide travel lanes and two 8-foot-wide shoulders. The total pavement width would be 52 feet. The overhead gantry would span the clear zone for a total roadway width of 68 feet.

Figure 2-9. Typical Section with Lane-control Signal



For S.R. 210, lane-control signals would indicate that two lanes are open to eastbound traffic and one lane is open to westbound traffic during the morning peak on peak traffic days. After the peak morning traffic passed, the signal for the center lane would shift to indicate that two lanes are open to westbound traffic and one lane is open to eastbound traffic.

The overhead gantries should be placed such that the driver has a definite indication of the lanes specifically reserved for use at any given time. The maximum allowable spacing is 1/3 mile (UDOT 2011), with additional gantries recommended where sight distance is limited by sharp horizontal curves. About 41 overhead gantries spaced at 1/3 mile would be needed on S.R. 210 between the intersection with S.R. 209 and the Bypass Road. This number would increase to 62 if UDOT wanted drivers to see two gantries at a time.

The visual impacts of overhead gantries would need to be evaluated considering the strategies for protecting scenic vistas in the *Cottonwood Canyons Scenic Byways Corridor Management Plan*. Figure 2-10 shows an example of what an overhead gantry might look like in Little Cottonwood Canyon. Given the scenic nature of Little Cottonwood Canyon, gantries would detract from the scenic canyon.

Figure 2-10. Simulation of Overhead Gantry in Little Cottonwood Canyon

The transition to reversible lanes with lane-control signals would be similar to what was discussed for the moveable barrier in Section 2.1.1. Because drivers might be confused by reversible lanes that are controlled by overhead signals, drivers would need to be educated. During periods of peak traffic, drivers would likely be a combination of locals and out-of-state tourists.

Reversible lanes would not impede wildlife movement or increase the number of wildlife deaths. However, the overhead lights could attract or confuse birds.

2.1.3 Other Reversible-lane Technologies

UDOT also considered other reversible-lane technologies: electroluminescent paint, in-pavement light-emitting diode (LED) markers, retractable bollards, and barriers on each side of the reversible lane. However, UDOT does not consider these technologies feasible for Little Cottonwood Canyon, as described below.

Considerations for S.R. 210

Electroluminescent Paint. Electroluminescent paint lights up when an electric current passes through it. By using this paint, it might be possible to change the pavement markings (roadway striping) from a dashed white line to a solid yellow line to indicate the allowed lane use. However, this technology is still in the early stages of development (Arvind 2015). UDOT does not consider this technology feasible for Little Cottonwood Canyon because the technology is not yet available and the paint would not be visible when covered by snow.

In-pavement LED Markers. In-pavement LED markers are currently used to illuminate crosswalks and delineate ramps and curves. With the addition of intelligent features, they could be used to indicate directional traffic flow by turning the lights on or off. Implementing LED markers would require them to be controlled remotely, reliably, and dynamically. The LED markers would need to be closely spaced so that they would collectively emit enough light to be seen during the daytime. This close spacing could produce an uncomfortable ride for drivers and passengers because vehicles might pass over multiple markers while changing lanes (Arvind 2015). UDOT does not consider this technology feasible in Little Cottonwood Canyon because the markings would not be visible when covered by snow.

Retractable Bollards. Retractable bollards are vertical posts that can be extended above the pavement to act as a barrier or retracted below the pavement to remove the barrier. They are commonly used in parking and pedestrian areas. Implementing retractable bollards for reversible lanes would require UDOT to modify the bollard design to withstand impacts from vehicles traveling at high speeds. UDOT would also need to easily extend and retract multiple bollards and control the bollard operations remotely (Arvind 2015). UDOT does not consider this technology feasible in Little Cottonwood Canyon because the technology is not currently available and because snow and ice could interfere with retracting the bollards.

Barrier on Each Side. UDOT considered using a reversible lane in the center of S.R. 210 with a permanent barrier on each side of the lane. This reversible lane would be open to eastbound traffic during the morning peak and westbound traffic during the evening peak. UDOT does not consider this option feasible in Little Cottonwood Canyon because the reversible lane could not be plowed. UDOT's maintenance crews need 10 to 15 feet of clear space on the right side of the roadway for storing snow.

3.0 Peak-period Shoulder Lane Concept

A peak-period shoulder lane (PPSL) is an upgraded shoulder that functions as a travel lane during periods of peak congestion. During non-peak times, it functions as a shoulder.

> **What is a peak period shoulder lane?**
>
> A peak period shoulder lane (PPSL) is an upgraded shoulder that functions as a travel lane during periods of peak congestion. During non-peak times, it functions as a shoulder.

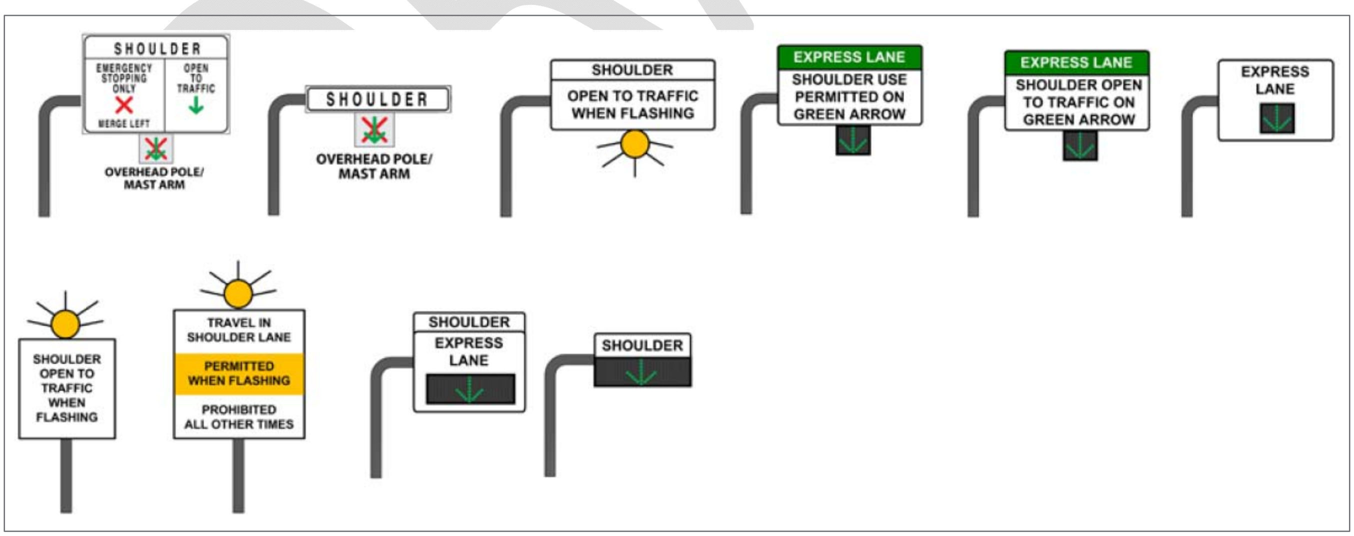
PPSLs are a way to provide additional traffic capacity within a constrained right-of-way and improve mobility during periods of peak congestion without adding another lane. The shoulders must be wide enough and have an appropriate pavement section to handle traffic. In the event of an emergency or blocking vehicle, the PPSL is closed until the lane is cleared.

PPSLs are used in several locations in Europe and the United States including on Interstate 35 West in Minnesota, Interstate 405 and U.S. Highway 2 in Washington State, and Interstate 70 in Colorado. European agencies have realized safety and mobility benefits as a result of PPSL projects (CDOT 2014).

PPSLs rely on various technology. Dynamic message signs inform motorists whether the PPSL is open to traffic. Closed-circuit television (CCTV) cameras ensure that the lane is clear of vehicles, snow, and debris and monitors the flow of traffic when the lane is operational. If an incident occurs while the PPSL is open, UDOT’s Traffic Operations Center would communicate with emergency responders to assist with crashes or disabled vehicles and use variable message signs to notify the travelling public that the PPSL is closed.

A clear signing plan is needed to let drivers know when the PPSL is open and, if access to the lane is controlled, where they can enter and exit the lane. Lane-use signals are located next to the PPSL to indicate whether it is open or closed (Figure 3-1).

Figure 3-1. Examples of Lane-use Signals for PPSLs



Considerations for S.R. 210

The PPSL concepts in this report would be implemented on S.R. 210 for 8.6 miles from the intersection with Wasatch Boulevard (MP 2.2) to the Bypass Road (MP 10.8). Figure 3-2 shows the typical section for PPSLs in Little Cottonwood Canyon. S.R. 210 would be widened to include two 12-foot-wide travel lanes and two 11-foot-wide shoulders with 2 feet of pavement beyond the shoulder stripe. The total pavement width would be 50 feet. The clear zone would be measured from the edge of the PPSL for a total roadway width of 78 feet.

The PPSLs would be open to eastbound traffic during the morning peak and open to westbound traffic during the evening peak on peak traffic days (weekends during the ski season, holidays, and special events). The PPSLs could be open to general-purpose traffic without restrictions, or they could be limited to buses only. The transition areas at the beginning and end of each PPSL would be fairly straightforward. Lane-use signals would alert drivers as to whether the PPSL is open or closed. When the lane is closed, drivers would merge back into the general-purpose lane.

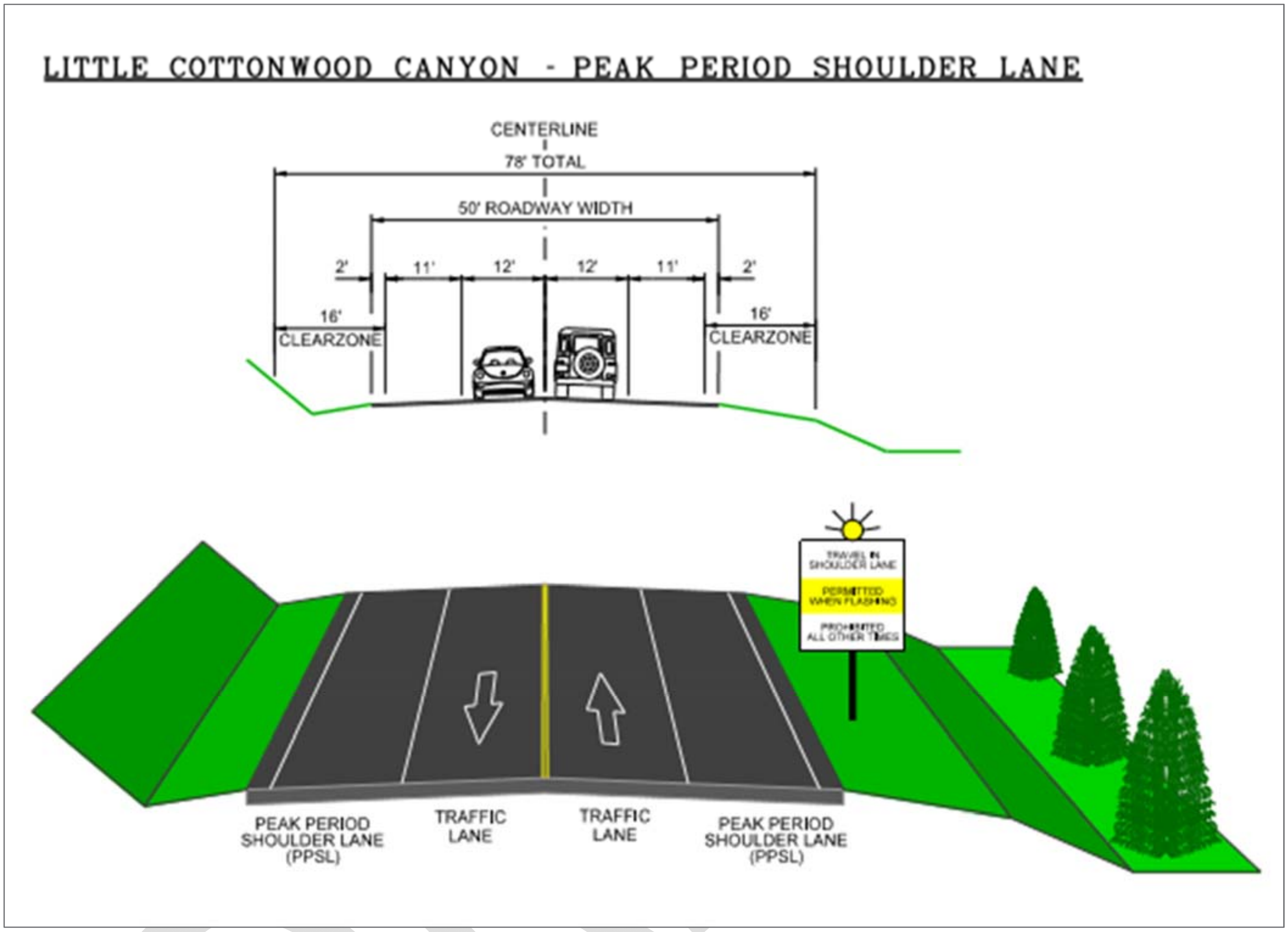
North Little Cottonwood Road currently has signed and striped bicycle lanes. These bicycle lanes would cause conflicts between cyclists and vehicles when the PPSL is open, and these conflicts would need to be resolved. However, the PPSL would generally be open when bicycle use is low (that is, during the winter).

Lane-use signals would be placed so that drivers have a clear indication whether the PPSL is open. The recommended spacing ranges from 1/3 to 2/3 mile (CDOT 2014). About 27 signs spaced at 1/3 mile (about 54 signs total) would be required on S.R. 210 in each direction between the intersection with Wasatch Boulevard and the Bypass Road. The signs would be evaluated considering the strategies in the *Cottonwood Canyons Scenic Byways Corridor Management Plan* for protecting scenic vistas. Compared to lane-control signs and signals for reversible lanes, the lane-use signals for PPSLs would be less intrusive because they would be placed adjacent to the shoulders, not over every lane.

Vehicles using the open PPSL would have only a 2-foot-wide outside shoulder; however, the clear zone (recovery area for errant vehicles) would be 16 feet wide. The existing shoulder on S.R. 210 is 2 feet wide in some locations. The closed PPSL could provide enough space to keep bicycles out of the travel lanes, especially on tight curves with poor sight distance.

There is a risk that drivers would use the PPSL when the lane is closed to pass slow-moving vehicles. This could cause problems, especially in the summer when there could be heavy bicycle traffic in the PPSL. Enforcement would be necessary to keep drivers from using the PPSLs when the lanes are not open. The presence of the PPSL would not allow roadside parking on S.R. 210 at any time of year. The PPSL concept would not impede wildlife movement or increase the number of wildlife deaths.

Figure 3-2. Typical Section with Peak-period Shoulder Lane



4.0 Comparison of Concepts

Table 4-1 provides a high-level comparison of the reversible-lane and PPSL concepts. A reversible lane with a moveable barrier would cost more and would require a greater level of effort for ongoing operation and maintenance than the other concepts; however, it would have lower visual impacts because fewer signs and signals would be required. A reversible lane with lane-control signs (or signals) and PPSLs would each cost less than a reversible lane with a moveable barrier and would require a lower level of effort for ongoing operation and maintenance. However, these concepts would have larger visual impacts. A reversible lane with lane-control signs (or signals) would have larger visual impacts than PPSLs.

Table 4-1. Comparison of Managed-lane Concepts

Managed-lane Concept	Cost	Level of Effort Required for Operation and Maintenance	Visual Impacts	Wildlife Impacts	Safety Considerations
Reversible Lane with Moveable Barrier	**$15 million** for 7.0 miles of barrier, transfer machine, crash cushions, and training for UDOT personnel (Ferguson 2019b, 2019c)	**High** • Mobilization and operation of transfer machine • Snow plowing considerations • Repair of avalanche-damaged barriers • Monitoring by UDOT Traffic Operations Center	**Moderate** • Crash cushions at each end of the barrier	**Moderate** • Barrier would impede wildlife movement and increase the number of wildlife deaths	• Reduces potential for crossover accidents. • Limits ability for vehicles to go around vehicle accidents or breakdowns. • Limits ability of emergency responders to access an accident location with the barrier in place. • Could accommodate roadside parking. • 8-foot-wide shoulder for summer use by cyclists.
Reversible Lane with Lane-control Signs or Signals	**$14 million** for 62 signs or signals (overhead signs or signals across all lanes)	**Low** • Monitoring by UDOT Traffic Operations Center	**High** • About 62 lane-control signs or signals across all lanes	**Low** • Overhead signals could attract or confuse birds	• Risk of driver confusion. Many drivers would be from out of state and not familiar with the roadway. • Could accommodate roadside parking. • 8-foot-wide shoulder for summer use by cyclists.
Peak-period Shoulder Lanes (PPSL)	**$6.5 million** for 54 signals on shoulder or **$14 million** for overhead signals	**Low** • Monitoring by UDOT Traffic Operations Center	**Moderate** • About 54 lane-use signals adjacent to shoulders	**Low**	• Provides wide, 11-foot uphill and downhill bicycle lane for summer use. • Possible enforcement issues with drivers using the wide shoulder lanes when they are not open. • No roadside parking allowed.

5.0 References

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2019a Email messages from Steve Ferguson, Lindsay Corporation, to Andrea Clayton, HDR, regarding use of moveable barriers in snowy environments. June 13 and June 16.

2019b Telephone conversation between Steve Ferguson, Lindsay Corporation, and Andrea Clayton, HDR, regarding cost of moveable barriers. June 27.

2019c Email message from Steve Ferguson, Lindsay Corporation, to Andrea Clayton, HDR, regarding cost of moveable barriers. July 9.

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