

US 97 Parkway Plan Phase 2

Draft Technical Memorandum – Right-In/Right-Out Closure and
Modification Alternatives Analysis

April 22, 2019

Prepared for:



Prepared by:





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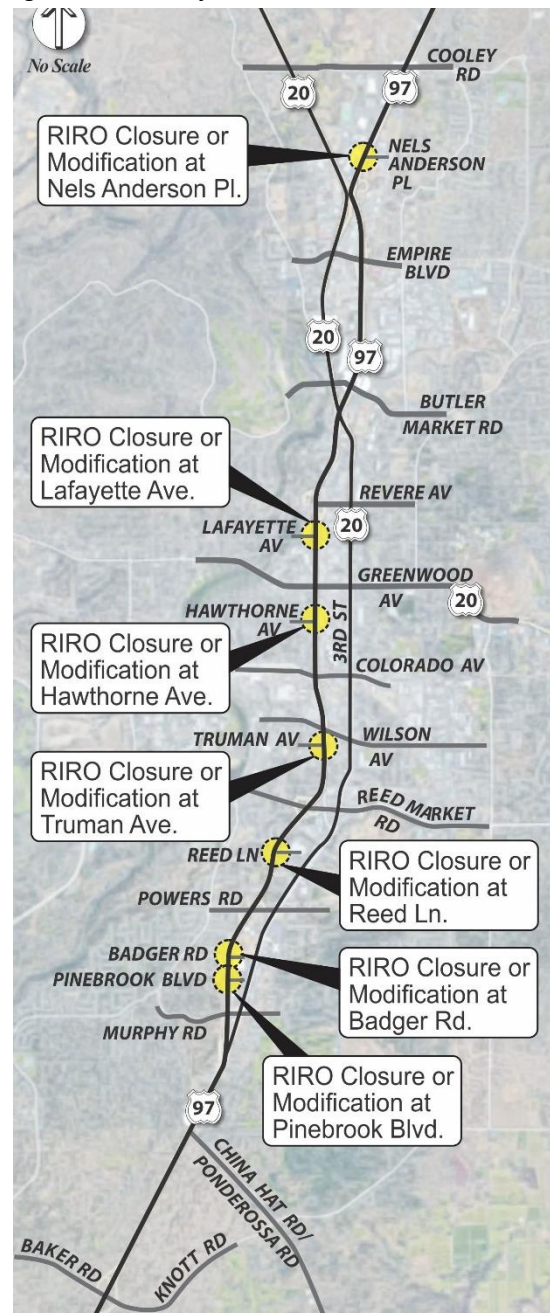
INTRODUCTION

In the Preliminary Alternatives memorandum¹, potential projects were identified to address the deficiencies in operations and safety flagged in the Existing Conditions² and Future Conditions³ Memoranda. These projects were initially screened and qualitatively evaluated in the First Level Alternatives Evaluation memorandum⁴ (Level 1 Evaluation). The outcome of the Level 1 Evaluation consisted of two bundles of projects (Bundle A and Bundle B) advanced for further analysis in the Level 2 Evaluation.

One of the projects recommended for inclusion in both project bundles in the Level 2 Evaluation consisted of either closing or modifying right-in/right-outs (RIROs) intersections along US 97. A right-in/right-out (RIRO) refers to a type of intersection where the turning movements are restricted to right turns only. On US 97, this refers to minor street stop-controlled intersections of a local road with US 97, where only right turns to and from the local road are allowed. The locations where either partial or full closure was recommended for further analysis in the Level 2 Evaluation (see Figure 1) were based on deficiencies in operations and safety identified by Existing and Future Conditions analysis.

The Level 1 Evaluation did not provide the detailed analysis to determine the impacts of each individual RIRO closure or modification. Ramp metering was identified both by the Level 1 Evaluation and by the ongoing Bend TSP/MTP Update as a corridor improvement solution with likely benefits to travel time reliability and system management on US97. Unsignalized right turns onto the Parkway would provide alternate access to metered ramps, potentially decreasing the effectiveness of ramp meters as a traffic management tool. In addition, RIRO closures or modifications have significant impacts to traffic routing throughout the project study area, particularly at interchanges. To analyze the two bundles of projects identified by the Level 1 Evaluation, a reasonable RIRO closure scenario must be identified as a baseline

Figure 1: RIRO Projects



¹ US 97 Parkway Plan Phase 2: Technical Memorandum #5 Preliminary Alternatives, Draft, 2019

² US 97 Parkway Plan Phase 2: Revised Technical Memorandum #2 Existing Conditions, August 14, 2018

³ US 97 Parkway Plan Phase 2: Technical Memorandum #4 Future Conditions, November 9, 2018

⁴ US 97 Parkway Plan Phase 2: Technical Memorandum #6 First Level Alternatives Evaluation, Draft, 2019 April 22, 2019



assumption across both project bundles to ensure an even comparison between other projects throughout the study area. In addition, other projects identified in the ongoing Bend TSP/MTP Update may also conflict with keeping open certain RIRO access locations on US 97.

The purpose of this analysis was to learn and understand the traffic diversion impacts of RIRO closures to the local street system. To do so, six RIRO closure scenarios were selected (described in the methodology below) to help form an understanding of the impacts through a variety of RIRO closure combinations. The RIRO access points likely have significant influence on each other, where closing one might significantly increase traffic either at an adjacent RIRO, interchange, or on the local system. Based on this analysis and discussion of the results with project stakeholders, a reasonable RIRO scenario will be advanced within both project bundles. This scenario may be further refined based on the findings of the Level 2 Evaluation, but for analysis purposes should capture the maximum traffic impacts of likely RIRO closures or modifications.

METHODOLOGY

The following methodology was used to help identify impacts of RIRO closures/modifications along the Parkway.

SCENARIO DESCRIPTIONS

While closing the RIROs will likely improve the operations and safety on US 97, the access provided by each intersection must also be addressed. Closing all RIRO intersections without mitigation could be detrimental to local business and downtown access. Therefore, several modifications and configurations were explored, and particular attention was given to access to key destinations, such as the downtown Central Business District (CBD). Based on this assessment and consultation with study advisory committees, the following RIRO closure and modification scenarios were tested to capture the range of impacts and to identify the appropriate mitigations and/or phasing strategies to manage these access points:

- Scenario 1: Closure of Lafayette Avenue
- Scenario 2: Closure of Hawthorne Avenue
- Scenario 3: Conversion of Lafayette Avenue to right-in only
- Scenario 4: Conversion of Hawthorne Avenue to right-in only
- Scenario 5: Closure of Nels Anderson Place, Truman Avenue and Reed Lane
- Scenario 6: Closure of all intersections listed above

Note that the closure of the Pinebrook Boulevard and Badger Road RIRO access to US 97 was assumed as part of the No-Build analysis due to assumed improvements to the Murphy Road interchange area, including a northbound on-ramp and southbound off-ramp at Murphy Road and north-south frontage road between Powers Road and Murphy Road.

Findings and results from each of the six scenarios, are presented in the following sections for each RIRO to explain the impact that different RIRO modifications would have on intersection operations both on the state and local system, along with the daily volume diversions caused by changes in network routing options.



Results from the following scenarios are included under each RIRO to guide the discussion of the impacts of RIRO modifications at that location to the surrounding transportation network:

- RIRO Modifications at Lafayette Avenue:
 - Scenario 1: Closure of Lafayette Avenue
 - Scenario 3: Conversion of Lafayette Avenue to right-in only
 - Scenario 6: Closure of all analyzed RIRO intersections
- RIRO Modifications at Hawthorne Avenue:
 - Scenario 2: Closure of Hawthorne Avenue
 - Scenario 4: Conversion of Hawthorne Avenue to right-in only
 - Scenario 6: Closure of all analyzed RIRO intersections
- RIRO Modifications at Truman Avenue:
 - Scenario 5: Closure of Nels Anderson Place, Truman Avenue and Reed Lane
 - Scenario 6: Closure of all analyzed RIRO intersections
- RIRO Modifications at Reed Lane:
 - Scenario 5: Closure of Nels Anderson Place, Truman Avenue and Reed Lane
 - Scenario 6: Closure of all analyzed RIRO intersections
- RIRO Modifications at Nels Anderson Place:
 - Scenario 5: Closure of Nels Anderson Place, Truman Avenue and Reed Lane
 - Scenario 6: Closure of all analyzed RIRO intersections

ANALYSIS TOOLS

The future “No-Build” (ongoing Bend TSP/MTP “Baseline” scenario) network was modified to test each RIRO scenario using the Bend-Redmond Travel Demand Model. The year 2040 daily traffic volumes were then reassigned to the network and used to determine the changes in traffic patterns. The pm peak hour volumes were also re-assigned and forecasted for the year 2040 to determine changes in traffic operations. The future forecasting methodology can be found in the Future Traffic Forecast Technical Memorandum.⁵ In the Existing Conditions Memorandum⁶, the peak hour of traffic was identified to occur from about 4:30 PM to 5:30 PM.

Intersection traffic operations were analyzed using the same tools and methodology applied for existing and future conditions. Intersection traffic operations were analyzed at any study intersection that received an additional 50 PM peak hour trips or more. The analysis was conducted at all the impacted study intersections⁷ using the forecasted seasonally factored 30 HV traffic volumes for the year 2040.

PERFORMANCE MEASURES

Two main measures of impacts are reported for each RIRO closure: changes in average daily traffic and intersection operations.

The change in average daily traffic is a measure of the scale of diversion expected from the RIRO closure. These measures indicate where daily traffic is likely to re-route after RIRO closures or modifications and

⁵ US 97 Parkway Plan Phase 2 Technical Memorandum #3 – Future Traffic Forecast, September 2018.

⁶ US 97 Parkway Plan Phase 2: Revised Technical Memorandum #2 Existing Conditions, August 14, 2018

⁷ Additional intersections beyond the US 97 Parkway Study area were included in the analysis to capture the extent of changes to traffic operations on the local system caused by the RIRO closures or modifications.



indicate the level of magnitude of access change between US 97 and key destinations, such as the downtown CBD.

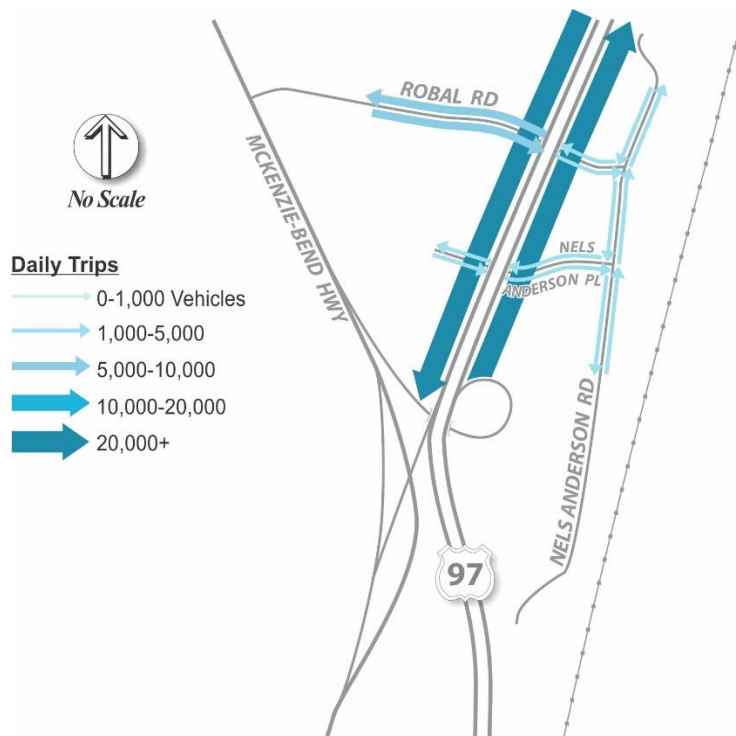
Intersection operation results are reported for each RIRO, under each tested modification. Intersection operations are reported as volume-to-capacity (V/C) ratios or seconds of control delay (for City two-way stop-controlled intersections), based on existing adopted mobility targets.⁸ These measures are intended to capture the peak hour operations impacts to the local system caused by limiting access to US 97 through RIRO closures or modifications. Intersection operations reports are included in Appendix A.

RESULTS

NO-BUILD DAILY TRAFFIC

To provide context to the magnitude of daily traffic re-routing for each RIRO closure or modification, 2040 No-Build daily traffic volumes are shown in Figures 2a-2c.

Figure 2a: No-Build 2040 Daily Volumes (near Nels Anderson Place)



⁸ Mobility targets for ODOT facilities obtained from the 1999 Oregon Highway Plan. Mobility targets for City of Bend facilities obtained from the 2016 City of Bend Development Code.



Figure 2b: No-Build 2040 Daily Volumes (near downtown)

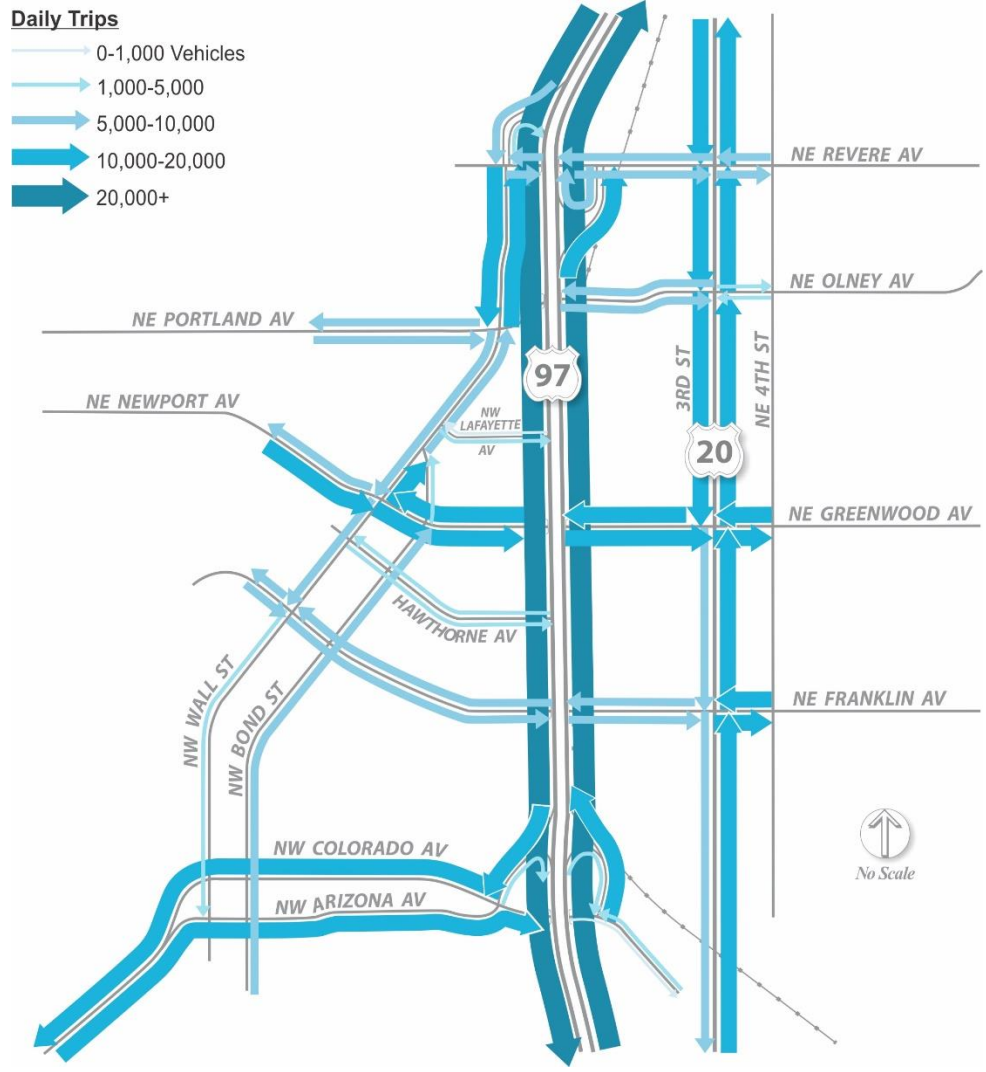
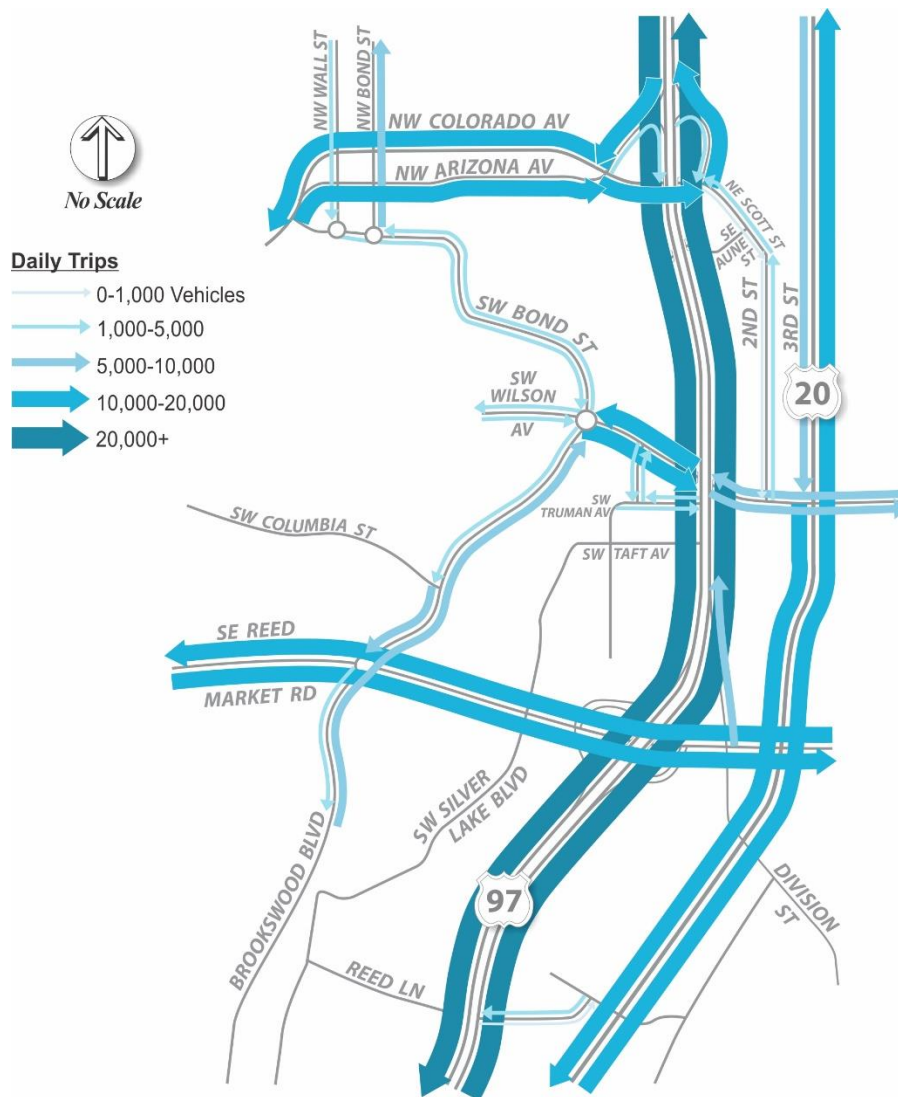




Figure 2c: No-Build 2040 Daily Volumes (near Reed Market Road)



RIRO MODIFICATIONS AT LAFAYETTE AVENUE

Under existing conditions, the Lafayette Avenue RIRO access was flagged as a safety focus due to a high proportion of rear-end crashes. As noted during field observations, drivers also demonstrate aggressive gap selection behavior at this location, which is also a sign of accepting a greater crash risk. As traffic volumes increase in the future, the crash frequency at US 97 and Lafayette is expected to be higher than comparable sites, as described in the Future Conditions Memorandum.

Both the Existing Conditions and Future No-Build analysis indicated over-capacity conditions and extensive eastbound queuing on Lafayette Avenue. By 2040, eastbound pm peak hour queues were expected to extend at least to Wall Street. In addition, Lafayette Avenue was flagged as a location with both deficient acceleration and deceleration lanes. While the deceleration lane at this location could be extended without incurring large ROW costs, building a new acceleration lane would impact the US 97 overcrossing at Greenwood Avenue, leading to structural impacts and high costs.



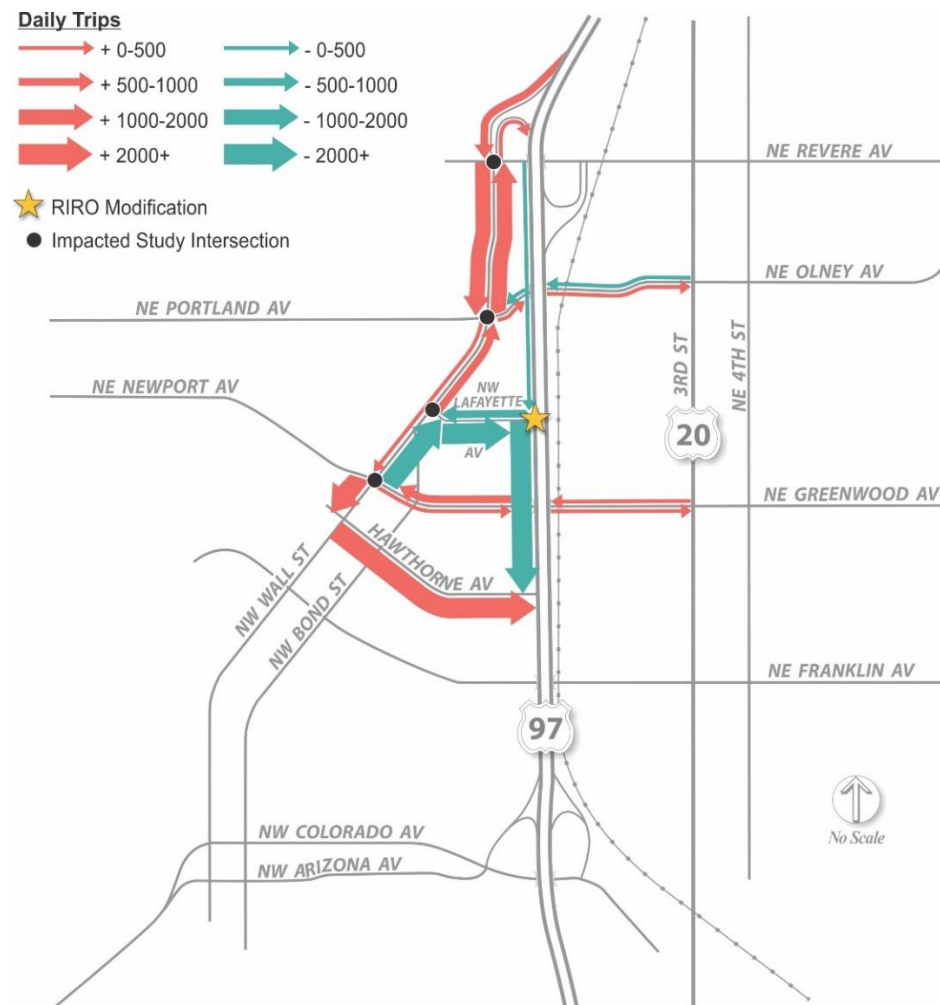
Lafayette Avenue provides direct access to businesses including social and governmental services in downtown Bend for southbound drivers on US 97. This location also provides a southbound US 97 alternative to the Revere Avenue interchange.

An alternative to closing the RIRO at Lafayette Avenue would be to convert the intersection to right-in only. This means that drivers would be able to make a right-turn from US 97 onto Lafayette Avenue, but the right-turn onto US 97 would be prohibited. As part of this conversion, the southbound deceleration lane on US 97 could be reconstructed to meet ODOT standards to help decrease the risk of rear-end collisions. Restricting only the right-turn onto US 97 would eliminate the eastbound queueing issues projected at Lafayette Avenue and US 97 in the future.

Traffic Volume Impacts

With a full closure of the Lafayette Avenue RIRO (Scenario 1), most former Lafayette Avenue trips exiting downtown use Hawthorne Avenue instead, with some trips shifting to the Revere Avenue interchange, as shown in Figure 5. Daily trips traveling to the downtown area are not significantly impacted, as the overall daily demand forecasted to use the Lafayette Avenue right-off movement is less than 1,000 vehicles per day, and this volume mainly shifts to a combination of Hawthorne Avenue (if open) and the Revere Avenue interchange. The pm peak hour impacts are relatively localized, with only a handful of study intersections impacted.

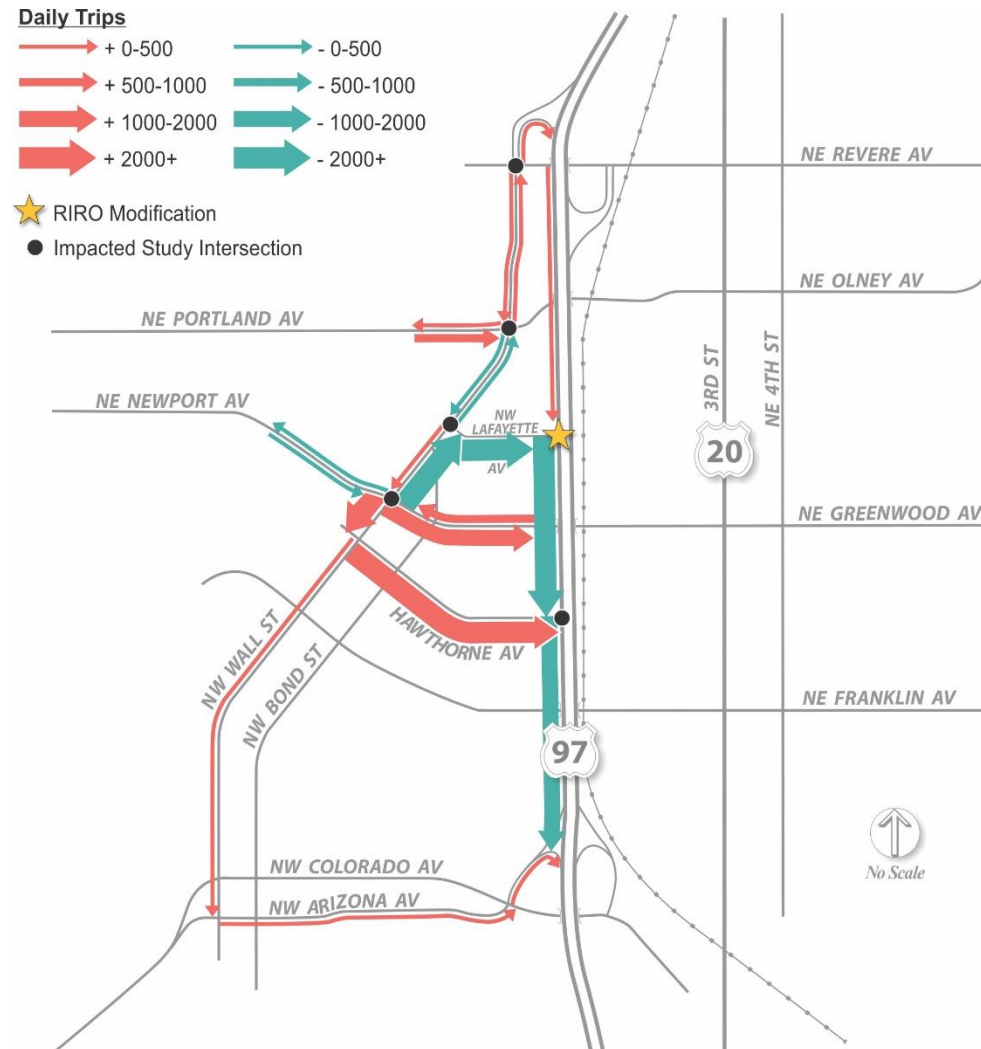
Figure 3: Lafayette Avenue RIRO Full Closure Daily Volume Shifts





With a partial closure of Lafayette Avenue to right-in only (Scenario 3), southbound US 97 trips traveling to downtown still use the US 97 right-in access at Lafayette Avenue. However, trips accessing southbound US 97 again shift to Hawthorne Avenue, as shown in Figure 6. Some southbound trips also shift north to the Revere Avenue interchange to access US 97.

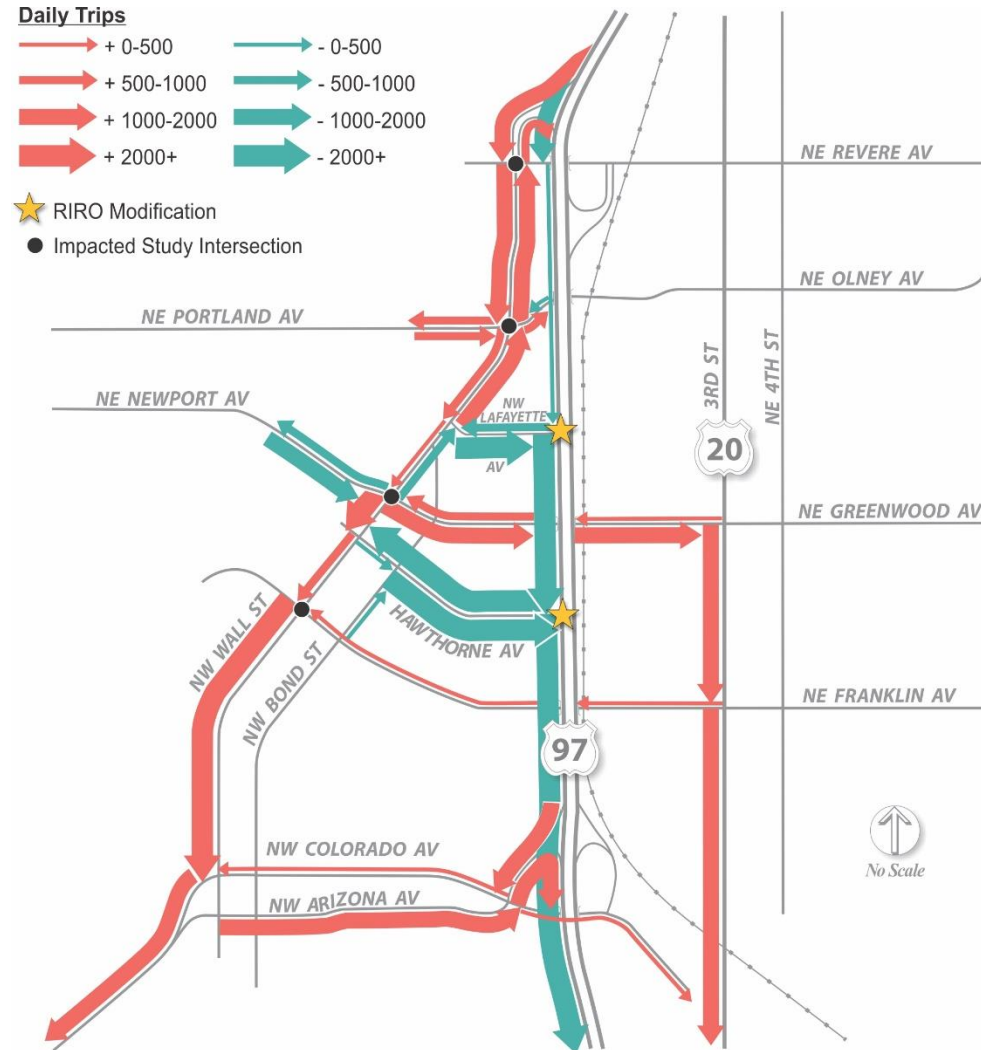
Figure 4: Lafayette Right-In Only Daily Volume Shifts



With all RIRO access closed along the Parkway (Scenario 6), more trips exit and access US 97 at the Revere Avenue interchange due to the combined diversion impacts from closing the Lafayette and Hawthorne RIROs, increasing the daily volumes by nearly 15 percent over 2040 No Build conditions. These combined impacts increase traffic in both directions of travel on Wall Street, as shown in Figure 7. Additional traffic shifts south to the Colorado Avenue interchange, although this traffic likely originated from the Hawthorne access. Some trips remain on the local system, traveling along 3rd Street instead of accessing US 97.



Figure 5: Lafayette Avenue - All RIRO Closures Daily Volume Shifts



Intersection Operations

Table 1 lists the operations at intersections impacted by RIRO modifications at Lafayette Avenue.

Table 1: 2040 PM Peak Hour Intersection Operations - Lafayette Avenue RIRO Modifications Impacts

Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance			
				2040 No-Build	Lafayette Ave RIRO Full Closure	Lafayette Ave Right-In Only	All RIRO Closures
US 97/Bend Parkway Study Intersections							
12	Bend Pkwy SB Ramps & Revere Ave	Signalized	< 0.85	0.99	1.01	1.02	1.04
14	Bend Pkwy & Lafayette Ave	TWSC ^D	< 0.85 (major) < 0.95 (minor)	NA/> 2.00	NA ^C	NA ^C	NA ^C
15	Bend Pkwy & Hawthorne Ave	TWSC	< 0.85 (major) < 0.95 (minor)	NA/> 2.00	NA/> 2.00	NA/> 2.00	NA ^C
Study Intersections Paralleling US 97							



Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance			
				2040 No-Build	Lafayette Ave RIRO Full Closure	Lafayette Ave Right-In Only	All RIRO Closures
-	US 20 (NE 3rd St) & Olney Ave	Signalized	< 0.85	0.82	-	-	0.85
-	Wall St & NW Lafayette Ave	TWSC	≤ 50 s (Delay) ^B	9.8/48.4	9.4/29.3	9.4/28.7	9.8/37.6
-	Wall St & Portland Ave	Signalized	< 1.00	1.09	1.09	1.10	1.18
-	Wall St & Greenwood Ave	Signalized	< 1.00	0.90	0.89	0.90	0.91
-	US 20 (NE 3 rd St) & Greenwood Ave	Signalized	< 0.85	1.29	1.37	-	1.37

A Overall intersection V/C ratio at signalized intersections, worst case approach V/C at roundabouts and all-way stop-controlled intersections, and V/C ratio for Major Street/Minor Street at two-way stop-controlled.

B The delay mobility target for the City of Bend only applies to critical lane groups with 100+ vehicles per hour.

C Intersection performance is not applicable when the RIRO access is closed or modified to right-in only.

D Two-way stop-controlled (TWSC).

Bold values indicate performance measures failing to meet adopted mobility targets.

The operational impacts to each intersection impacted by 50 additional peak hour vehicles or more are summarized below:

- Bend Pkwy SB Ramps & Revere Ave: Closing both Lafayette Avenue and Hawthorne Avenue access to US 97 southbound has the largest combined impacts at the Revere Avenue interchange and the intersection of Wall Street/Portland Avenue. Any modification of Lafayette Avenue access would cause the Revere Avenue southbound ramp to US 97 to exceed capacity and would likely trigger some long term (possibly by year 2035) mitigation at this location.
- Bend Pkwy & Lafayette Ave: Any access modification at Lafayette Avenue would improve operations at the intersection, where the demand is more than twice the capacity under 2040 No-Build conditions.
- Bend Pkwy & Hawthorne Ave: Closing or modifying access at Lafayette Avenue would send more traffic to the Hawthorne Avenue access. Without closing or modifying access at Hawthorne Avenue, significant mitigation would be required to limit queue spillback on the local system and allow for safe operation of the intersection.
- US 20 (NE 3rd St) & Olney Ave: Although peak hour volumes are forecasted to increase, no significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.
- Wall St & NW Lafayette Ave: Although peak hour volumes are forecasted to increase on Wall Street, the overall operations at this intersection improve under all closure scenarios as the minor street (Lafayette Avenue) volumes decrease significantly with any modifications of the RIRO access to the Parkway.
- Wall St & Portland Ave: This intersection is expected to operate over capacity in 2040 No Build conditions. More traffic will travel through this intersection with a closure of all RIRO access on the Parkway, increasing the v/c from 1.09 to 1.18, and could potentially trigger mitigation at this location earlier (possibly by year 2030) than under No Build conditions.
- Wall St & Greenwood Ave: Although peak hour volumes are forecasted to increase, no significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.



- US 20 (NE 3rd St) & Greenwood Ave: This intersection is over capacity under 2040 No Build conditions. However, with a full closure of Lafayette Avenue, the intersection v/c will increase to 1.37 from 1.29. Any mitigation identified at this location through the ongoing Bend TSP/MTP Update process would likely be triggered earlier, possibly as soon as the year 2025.

Overall, intersections that fail to meet mobility standards under the 2040 No-Build conditions continue to fail with any RIRO modification at Lafayette Avenue. One location (Bend Pkwy SB Ramps & Revere Ave) that was under capacity in the 2040 No-Build is expected to exceed capacity with any RIRO modifications at Lafayette Avenue. The volume shifts caused by a modification of the RIRO access at Lafayette Avenue are not expected to cause any intersections beyond those already failing under Future No-Build conditions to exceed adopted mobility targets.

Findings

Any RIRO modification at Lafayette Avenue is expected to shift 5-15 percent more daily traffic volume to the Revere Avenue interchange. This impact may conflict with the lane reallocation project on Revere Avenue (to be analyzed as part of Project Bundle A), which is expected to support low-stress pedestrian and bicycle crossings of US 97 and simplify traffic operations on Revere between the northbound and southbound ramp terminals. Ramp meters at the Revere Avenue and Colorado Avenue interchanges could increase the popularity of the Lafayette Avenue right-on movement to US 97 (if left open) due to increased delay at the interchanges. The ongoing Bend TSP/MTP Update does not as yet include any capacity enhancements to the Wall Street/Portland Avenue intersection, which is expected to already operate over capacity under No-Build conditions. Any improvements identified for this location through the TSP process will likely be triggered sooner under a full closure condition at the Lafayette Avenue RIRO Access. Closing RIRO access at Lafayette Avenue would improve safety at a location that was flagged as a safety focus area, particularly for rear-end collisions as the main conflict (southbound right turns) leading to these collisions would be removed. Given the low ADT for the right-off movement and potential benefits to US 97 both for safety and operations (travel time reliability and throughput) a full closure of the Lafayette Avenue RIRO is recommended for inclusion in the Level 2 Evaluation.

RIRO MODIFICATIONS AT HAWTHORNE AVENUE

Similar to Lafayette Avenue at US 97, the Hawthorne Avenue RIRO access was flagged as a safety focus due to a high proportion of rear-end crashes. As noted during field observations, drivers also demonstrate aggressive gap selection behavior at this location, which is also a sign of accepting a greater crash risk. As traffic volumes increase in the future, the crash frequency at US 97 and Hawthorne is expected to be higher than comparable sites, as described in the Future Conditions Memorandum. In addition, Hawthorne Avenue was flagged as a location with both deficient acceleration and deceleration lanes. While the deceleration lane at this location could be extended without incurring large ROW costs, building an acceleration lane would impact the US 97 overcrossing at Franklin Avenue. Both the Existing Conditions and Future No-Build analysis indicated over-capacity conditions and extensive eastbound queuing. By 2040, eastbound queues were expected to extend back up Hawthorn Avenue and Oregon Avenue to at least to Bond Street.

Similar to Lafayette Avenue, Hawthorne Avenue provides direct access to businesses including social and governmental services in downtown Bend for southbound drivers on US 97, especially businesses located along Oregon Avenue and Minnesota Avenue. This location also provides a southbound US 97 alternative to both the Revere Avenue and Colorado Avenue interchanges.

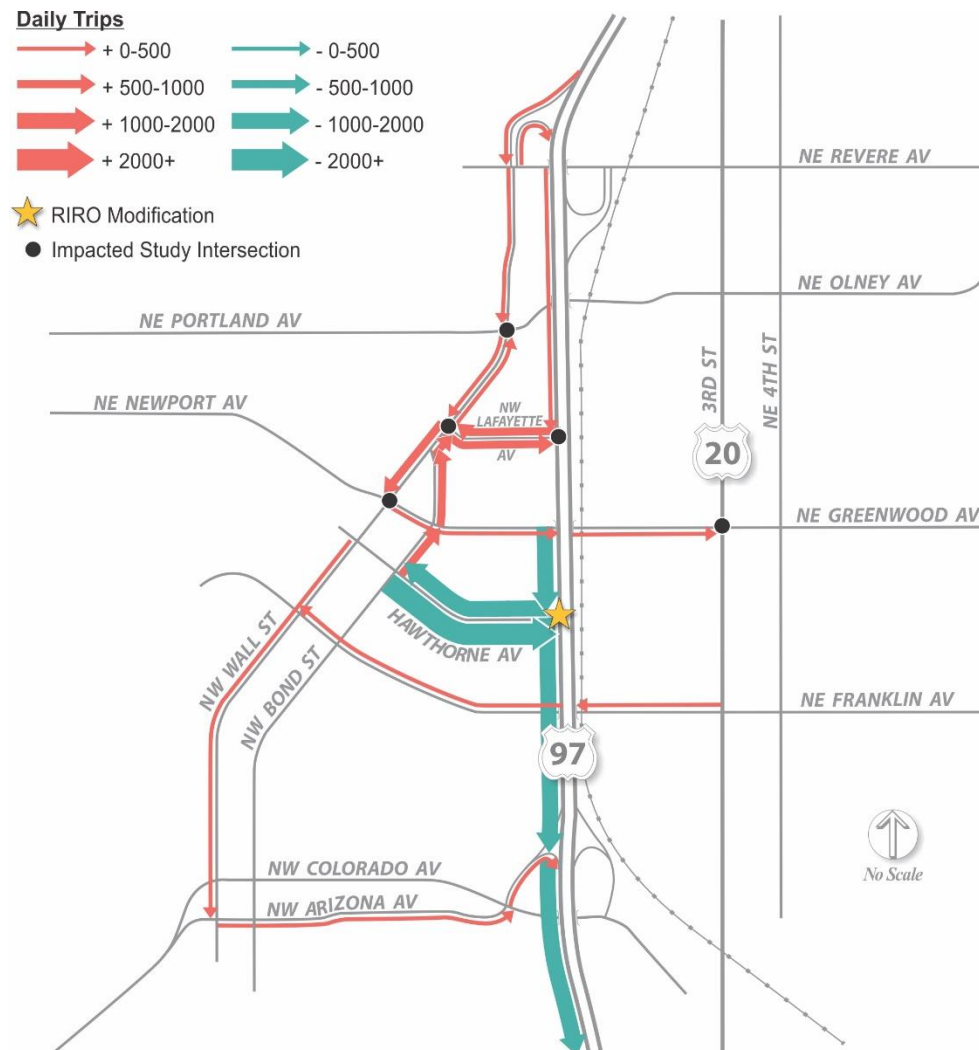


An alternative to closing the RIRO at Hawthorne Avenue would be to convert the intersection to right-in only. This means that drivers would be able to make a right-turn from US 97 onto Hawthorne Avenue but the right-turn onto US 97 would be prohibited. As part of this conversion, the southbound deceleration lane on US 97 could be reconstructed to meet ODOT standards to help decrease the risk of rear-end collisions. Restricting only the right-turn onto US 97 would eliminate the queueing issues projected at Hawthorne Avenue and US 97 in the future but would still allow drivers to exit US 97.

Traffic Volume Impacts

With a full closure of Hawthorne Avenue RIRO, most trips accessing downtown use Lafayette Avenue instead, with some trips shifting to the Colorado Avenue interchange, as shown in Figure 8. Daily trips traveling to the downtown area do shift significantly away from the Hawthorn Avenue/Oregon Avenue corridor, as the overall daily demand forecasted to use the Hawthorne Avenue right-off movement is less than 2,000 vehicles per day, and this volume mainly shifts to a combination of Lafayette Avenue (if open), the Revere Avenue interchange, and other local routes. The traffic impacts are relatively localized, but one more study intersection is impacted than by the Lafayette Avenue RIRO full closure due to approximately five percent more traffic volume shifting to the Greenwood Avenue corridor.

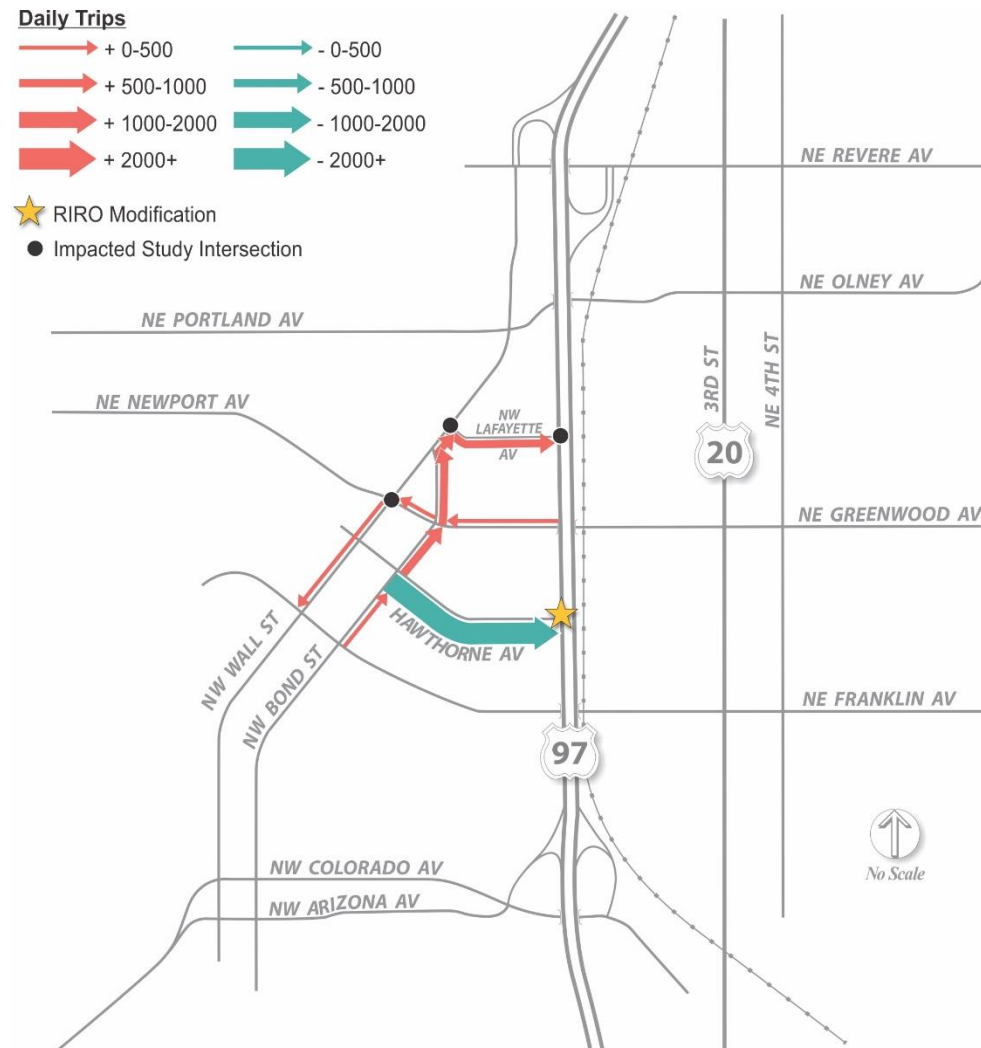
Figure 6: Hawthorne Avenue RIRO Full Closure Daily Volume Shifts





With a partial closure of Hawthorne Avenue (right-in only), trips traveling to downtown still use the US 97 right-in access at Hawthorne Avenue. However, trips entering US 97 instead shift to Lafayette Avenue, as shown in Figure 9. This nearly 15 percent increase in daily volume would exacerbate existing safety concerns at Lafayette Avenue if access was not modified at Lafayette Avenue. Hawthorne Avenue/Oregon Avenue east of Bond Street would experience significant daily traffic decreases, but the remainder of the downtown area would either experience minimal change or slight increases.

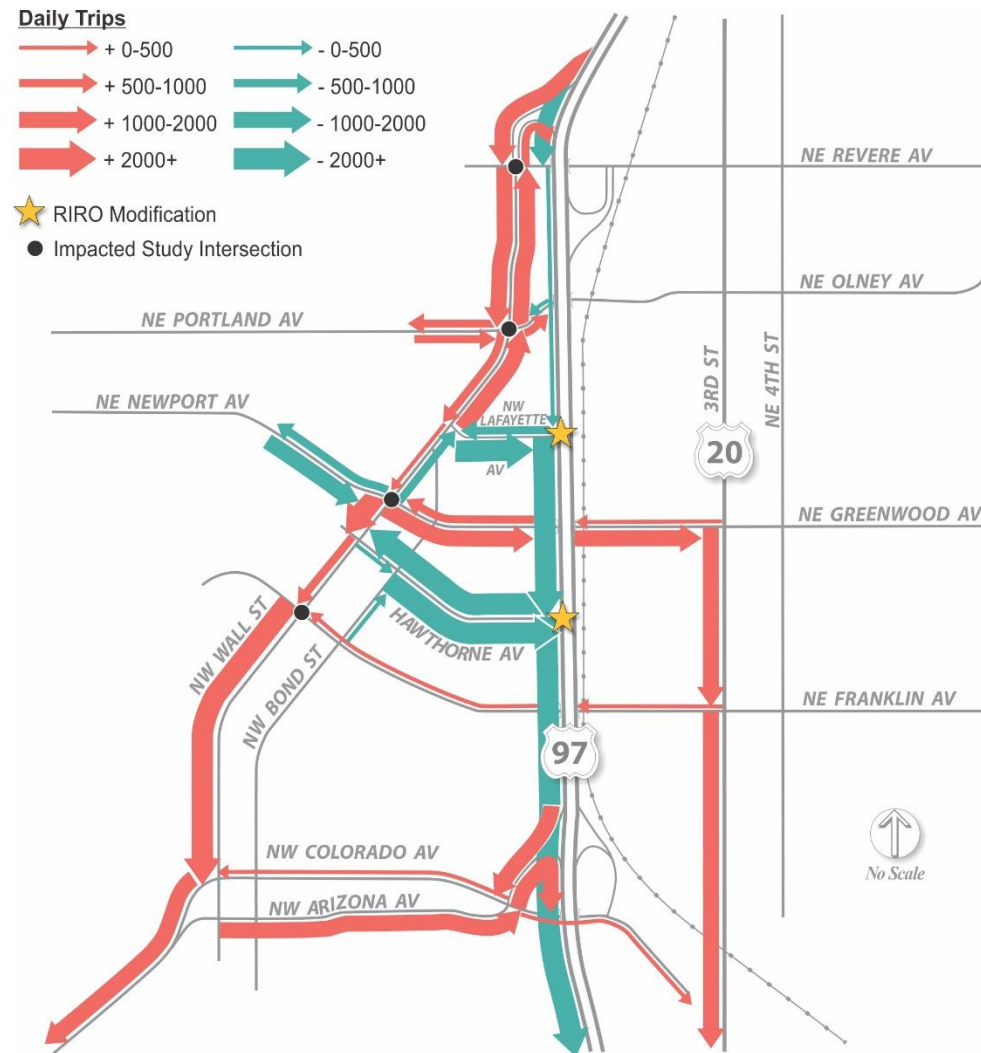
Figure 7: Hawthorne Avenue Right-In Only Daily Volume Shifts



With all RIRO access closed, 10-15 percent more daily trips access US 97 via the Colorado Avenue and Revere Avenue interchanges, as shown in Figure 10. Ten percent more daily traffic volume travels down Wall Street and an additional five percent uses Franklin Avenue to access 3rd street, instead of traveling along US 97. Note that Franklin Avenue is part of the City of Bend Low Stress Network (LSN) for bicycles and pedestrians. The daily volume on Greenwood Avenue also increases by nearly 10 percent.



Figure 8: Hawthorn Avenue - All RIRO Closures Daily Volume Shifts



Intersection Operations

Table 2 lists the operations at intersections impacted by RIRO modifications at Hawthorne Avenue.

Table 2: 2040 PM Peak Hour Intersection Operations - Hawthorne Avenue RIRO Modifications

Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance			
				2040 No-Build	Hawthorne Ave RIRO Full Closure	Hawthorne Ave Right-In Only	All RIRO Full Closures
US 97/Bend Parkway Study Intersections							
14	Bend Pkwy & Lafayette Ave	TWSC ^D	< 0.85 (major) < 0.95 (minor)	NA/>2.00	NA/>2.00	NA/>2.00	NA ^C
15	Bend Pkwy & Hawthorne Ave	TWSC	< 0.85 (major) < 0.95 (minor)	NA/>2.00	NA ^C	NA ^C	NA ^C
Study Intersections Paralleling US 97							
-	Wall St & NW Lafayette Ave	TWSC	≤ 50 s (Delay) ^B	9.8/48.4	10.2/>100	10.2/>100	9.8/37.6



Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance			
				2040 No-Build	Hawthorne Ave RIRO Full Closure	Hawthorne Ave Right-In Only	All RIRO Full Closures
-	Wall St & Portland Ave	Signalized	< 1.00	1.09	1.08	-	1.18
-	Wall St & Greenwood Ave	Signalized	< 1.00	0.90	0.91	0.91	0.91
-	Wall St & Franklin Ave	Signalized	< 1.00	0.98	-	-	1.04
-	Bond St & Franklin Ave	Signalized	< 1.00	1.03	-	-	1.10
-	NE 3rd St & Franklin Ave	Signalized	< 1.00	1.21	-	-	1.32
-	US 20 (NE 3 rd St) & Greenwood Ave	Signalized	< 0.85	1.29	1.36	-	1.37

A Overall intersection V/C ratio at signalized intersections, worst case approach V/C at roundabouts and all-way stop-controlled intersections, and V/C ratio (or delay at City intersections) for Major Street/Minor Street at two-way stop-controlled.

B The delay mobility target for the City of Bend only applies to critical lane groups with 100+ vehicles per hour.

C Intersection performance is not applicable when the RIRO access is closed or modified to right-in only.

D Two-way stop-controlled (TWSC).

Bold values indicate performance measures failing to meet adopted mobility targets.

The operational impacts to each intersection are summarized below:

- Bend Pkwy & Lafayette Ave: Closing or modifying access at Hawthorne Avenue would send more traffic to the Lafayette Avenue access. Without closing or modifying access at Hawthorne Avenue, significant mitigation would be required to limit queue spillback on the local system and allow for safe operation of the intersection.
- Bend Pkwy & Hawthorne Ave: Any access modification at Hawthorne Avenue would improve operations at the intersection, where the demand is more than twice the capacity under 2040 No-Build conditions.
- Wall St & NW Lafayette Ave: Modifying or removing RIRO access at Hawthorne Avenue without modifying or removing RIRO access at Lafayette Avenue would cause this intersection to exceed mobility standards as a two-way stop-controlled intersection due to pm peak hour traffic diversion, triggering a need for short term mitigation at this location. Again, note that this mitigation would only be triggered by a closure or modification to the Hawthorne Avenue RIRO access coupled with no changes to the Lafayette Avenue RIRO access.
- Wall St & Portland Ave: No significant impacts to intersection operations are expected at this intersection with a closure or modification of just the Hawthorne Avenue RIRO. Closing all RIRO access along the Parkway would increase the v/c ratio from 1.09 under 2040 No Build conditions to 1.18, and could potentially trigger mitigation at this location earlier (possibly by year 2030) than under No Build conditions.
- Wall St & Greenwood Ave: Although peak hour volumes are forecasted to increase, no significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.
- Wall St & Franklin Ave: With the combined effects of a closure at Hawthorne Avenue and Lafayette Avenue (under the all RIRO closure scenario), more trips travel through the intersection of Wall Street/Franklin Avenue, causing the intersection to slightly exceed mobility standards, possibly triggering some mitigation by the year 2040.



- Bond St & Franklin Ave: This intersection exceeds mobility standards under 2040 No Build conditions. Impacts to intersection operations at this location with a closure of all RIRO access to the Parkway are expected to increase the intersection v/c from 1.03 to 1.10, triggering mitigation at this location possibly by the year 2030.
- NE 3rd St & Franklin Ave: This intersection exceeds mobility standards under 2040 No Build conditions. With additional volume from all RIRO closures along the Parkway, the v/c at this location is expected to increase to 1.32 from 1.21, triggering mitigation on a shorter timeframe, possibly as early as the year 2025.
- US 20 (NE 3rd St) & Greenwood Ave: This intersection is over capacity under 2040 No Build conditions. However, with a full closure of Hawthorne Avenue, the intersection v/c will increase to 1.36 from 1.29. Any mitigation identified at this location through the ongoing Bend TSP/MTP Update process would likely be triggered earlier, possibly as soon as the year 2025.

Overall, intersections that fail to meet mobility standards under the 2040 No-Build continue to fail with any RIRO modification at Hawthorne Avenue. One intersection (Wall St & Franklin Ave) which meets mobility standards under 2040 No-Build conditions would exceed mobility standards with a closure of all RIRO access along the Parkway due to traffic re-routing impacts from the Hawthorne Avenue RIRO closure.

Findings

A bicyclist and pedestrian overcrossing of US 97 at Hawthorne Avenue is proposed as part of the City of Bend's Low Stress Bicycle Network (LSN). The overcrossing would likely require at a minimum a partial closure of access at US 97 and Hawthorne Avenue, to support low-stress pedestrian and bicyclist crossings of US 97. As with the Lafayette Avenue RIRO access, ramp meters at the Revere Avenue and Colorado Avenue interchanges could increase the popularity of the Hawthorne Avenue right-on movement to US 97 (if left open) due to increased delay at the interchanges. Closing Right-On access at Hawthorne Avenue would improve safety at a location that was flagged as a safety focus area. Given the higher ADT (compared to Lafayette Avenue) and more direct access provided to downtown businesses, a partial closure (conversions to right-off only) of the Hawthorne Avenue RIRO is recommended for inclusion in the Level 2 Evaluation.

RIRO MODIFICATIONS AT TRUMAN AVENUE

Under existing conditions, drivers demonstrate behavior of aggressive gap selection at US 97/Truman Avenue. By 2040, queues on Truman Avenue are expected to spill back to Wilson Avenue as conflicting volumes increase on US 97, decreasing right turn capacity onto the Parkway. In addition, there are no deceleration or acceleration lanes at Truman Avenue, leading to a higher crash risks at this location. Building a deceleration lane to current standards is infeasible without significant capital cost, as widening the Wilson Avenue bridge and/or constructing a pedestrian/bicyclist tunnel under the existing overcrossing would be required. Building an acceleration lane to current standards is also costly with significant capital ROW cost and likely impacts to adjacent homes.

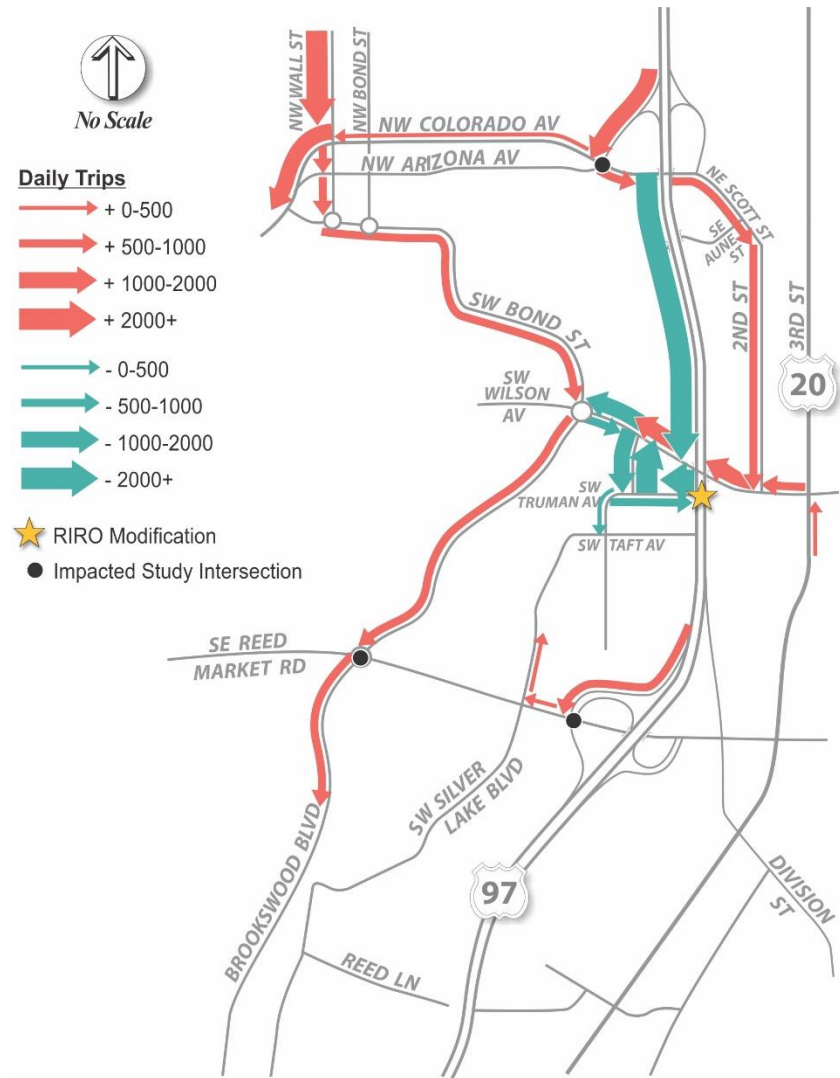
The Truman Avenue RIRO access combined with the Wilson Avenue overcrossing acts as a de-facto half interchange, serving southbound US 97 traffic both east and west of the Parkway. This de-facto interchange provides some southbound traffic relief to both the Colorado Avenue and Reed Market Road interchanges under Future No-Build Conditions.



Traffic Volume Impacts

With a full closure of the Truman Avenue RIRO, most trips shift to the Colorado Avenue or the Reed Market Road interchanges, as shown in Figure 11. Nearly twice the daily trips would travel through Aune Road/NE Scott Street intersections to exit the Colorado Avenue interchange.

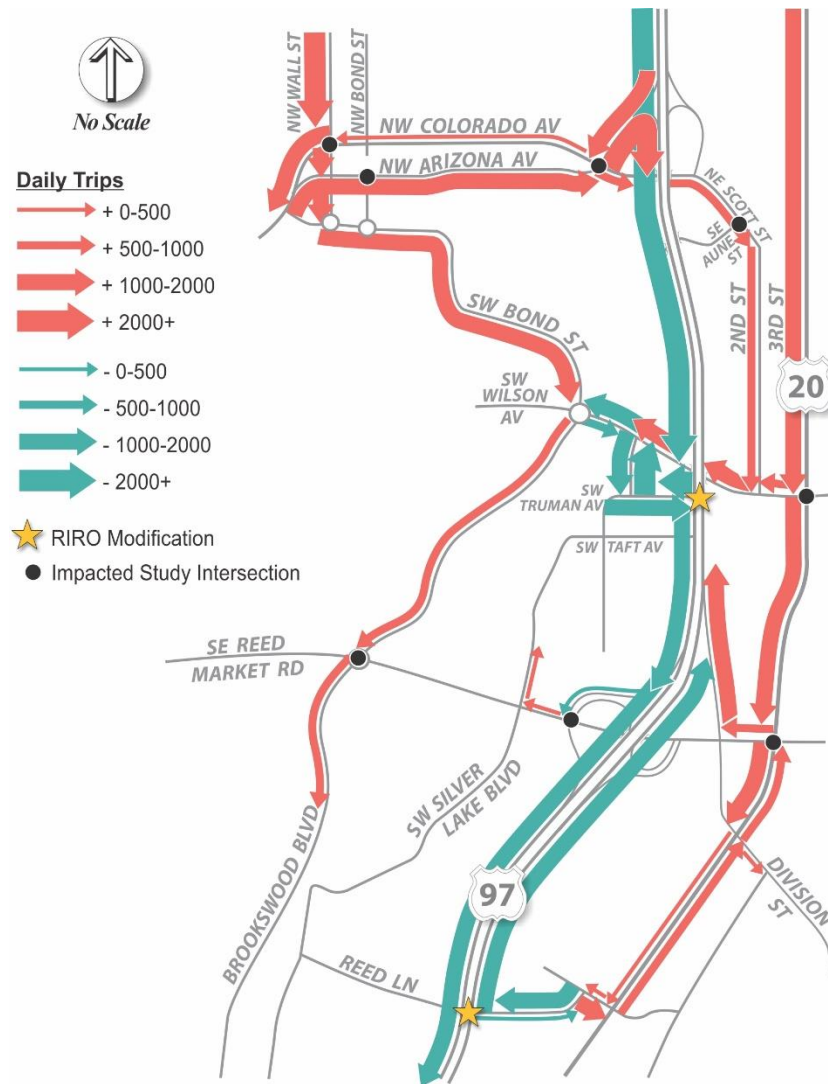
Figure 9: Truman Avenue RIRO Full Closure Daily Volume Shifts



With all RIRO access closed, including Lafayette Avenue, Hawthorne Avenue and Truman Avenue, nearly 15 percent more daily trips access US 97 at the Colorado Avenue interchange, as shown in Figure 12. The closure of all the RIROs, including Truman Avenue and Reed Lane, cause nearly 15-20 percent more daily trips to remain on the local system, traveling along 3rd Street instead of accessing US 97. This impacts more non-US 97 study intersections.



Figure 10: Truman Avenue - All RIRO Closures Daily Volume Shifts



Intersection Operations

Table 3 lists the operations at intersections impacted by RIRO modifications at Truman Avenue.

Table 3: 2040 PM Peak Hour Intersection Operations - Truman Avenue RIRO Modifications

Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance		
				2040 No-Build	Truman Ave RIRO Full Closure	All RIRO Closures
US 97/Bend Parkway Study Intersections						
16	Bend Pkwy SB Ramps & Colorado Ave	Signalized	< 0.85	1.17	1.23	1.29
18	Bend Pkwy & Truman Ave	TWSC ^D	< 0.85 (major) < 0.95 (minor)	NA/> 2.00	NA ^C	NA ^C
19	Bend Pkwy SB Ramps & Reed Market Rd	Signalized	< 0.85	1.29	1.32	1.26
Study Intersections Paralleling US 97						



Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance		
				2040 No-Build	Truman Ave RIRO Full Closure	All RIRO Closures
49	Reed Market Rd & Brookswood Blvd	Roundabout	< 1.00	>2.00	>2.00	>2.00
-	Wall St & Colorado Ave	Signalized	< 1.00	0.73	-	0.81
-	Bond St & Arizona Ave	Signalized	< 1.00	1.00	-	1.10
-	NE 3rd St & Wilson Ave	Signalized	< 1.00	1.32	-	1.43
-	Aune St & NE Scott St	TWSC	≤ 50 s (Delay) ^B	7.8/16.3	-	7.8/17.1

A Overall intersection V/C ratio at signalized intersections, worst case approach V/C at roundabouts and all-way stop-controlled intersections, and V/C ratio for Major Street/Minor Street at two-way stop-controlled.

B The delay mobility target for the City of Bend only applies to critical lane groups with 100+ vehicles per hour.

C Intersection performance is not applicable when the RIRO access is closed.

D Two-way stop-controlled (TWSC).

Bold values indicate performance measures failing to meet adopted mobility targets.

The operational impacts to each intersection are summarized below:

- Bend Pkwy SB Ramps & Colorado Ave: This intersection significantly exceeds capacity under 2040 No-Build conditions. The increased pm peak hour traffic volume due to closure of Truman Avenue RIRO access (and other RIRO access such as Hawthorne Avenue and Lafayette Avenue) would slightly worsen intersection operations over No-Build. Note that mitigations at this location will be analyzed as part of the Level 2 evaluation.
- Bend Pkwy & Truman Ave: Any access modification at Truman Avenue would improve operations at the intersection which is more than two times over capacity under 2040 No-Build conditions. Note that while this RIRO access location does not experience the traffic operations issues that exist today at the Hawthorne Avenue and Lafayette Avenue RIROs, under forecasted future conditions this location would see significant increases in demand due to congestions at the Reed Market and Colorado Avenue interchanges, leading to increased eastbound queuing.
- Bend Pkwy SB Ramps & Reed Market Rd: This intersection is significantly over capacity under 2040 No Build conditions. No significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.
- Reed Market Rd & Brookswood Blvd: This roundabout intersection is significantly over capacity under 2040 No Build conditions with a worst case approach v/c over 2.00. No significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway. The ongoing Bend TSP/MTP Update process is investigating a capacity improvement to this roundabout.
- Wall St & Colorado Ave: Although peak hour volumes are forecasted to increase, no significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.
- Bond St & Arizona Ave: This intersection is just at capacity under 2040 No-Build conditions. Closing all RIRO access to the Parkway would increase the v/c at this location to 1.10. The ongoing Bend TSP/MTP Update has identified the Colorado/Arizona Avenue couplet as part of a key east-west corridor likely to need capacity enhancements, allowing traffic capacity mitigations at this location to match with TSP goals.



- NE 3rd St & Wilson Ave: While this location would see an increase in v/c with all RIRO access to the Parkway closed, it is near capacity today, and significantly over capacity under 2040 No Build conditions and would likely need short-term (prior to 2025) intersection capacity improvements prior to RIRO access closures on the Parkway.
- Aune St & NE Scott St: Although peak hour volumes are forecasted to increase, no significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.

Overall, intersections that fail to meet mobility standards under 2040 No-Build conditions continue to fail with any RIRO modification at Truman Avenue. The Colorado Avenue interchange is significantly impacted by a closure at Truman, particularly if the US 97/Lafayette Avenue and the US 97/Hawthorne Avenue accesses are also closed, diverting more traffic to the Colorado Avenue interchange via Scott Street/Colorado Avenue/Arizona Avenue. In addition, when all RIRO access along US 97 is closed, 10 to 15 percent more daily traffic diverts to 3rd Street instead of using US 97. This accounts for the degraded intersection performance at 3rd Street and Wilson Avenue (1.32 v/c to 1.43 v/c), as well as slightly improved intersection performance at the US 97 SB ramps at Reed Market Road (1.29 v/c to 1.26 v/c).

Findings

The ongoing Bend TSP/MTP Update is studying the potential benefits of a Wilson Avenue extension (to either Pettigrew Road or 27th Street) to the Reed Market corridor. The potential traffic diversion benefits to the Reed Market Road corridor of this roadway extension would likely be reduced by closure of the RIRO access at Truman Avenue since vehicles would not be able to exit the Parkway at Truman Avenue to access the Wilson Avenue extension.

One of the project bundles advancing to the Level 2 Evaluation includes major capacity enhancements to the Colorado Avenue and Reed Market Road interchanges. The interchange improvements being evaluated would have the flexibility to serve multiple future demand scenarios, including increased demand due to the Truman Avenue RIRO access closure. With the forecasted increased demand combined with the lack of (and feasibility to construct) a southbound deceleration lane at this location, the risk of crashes at this location increases in the future. Given the potential benefits to US 97 both for safety and operations (travel time reliability and throughput), the lack of feasibility to modify this RIRO with standard deceleration and acceleration lanes, and need for full demand sensitivity testing at the Colorado Avenue and Reed Market Road interchanges, a full closure of the Truman Avenue RIRO is recommended for inclusion in the Level 2 Evaluation.

RIRO MODIFICATIONS AT REED LANE

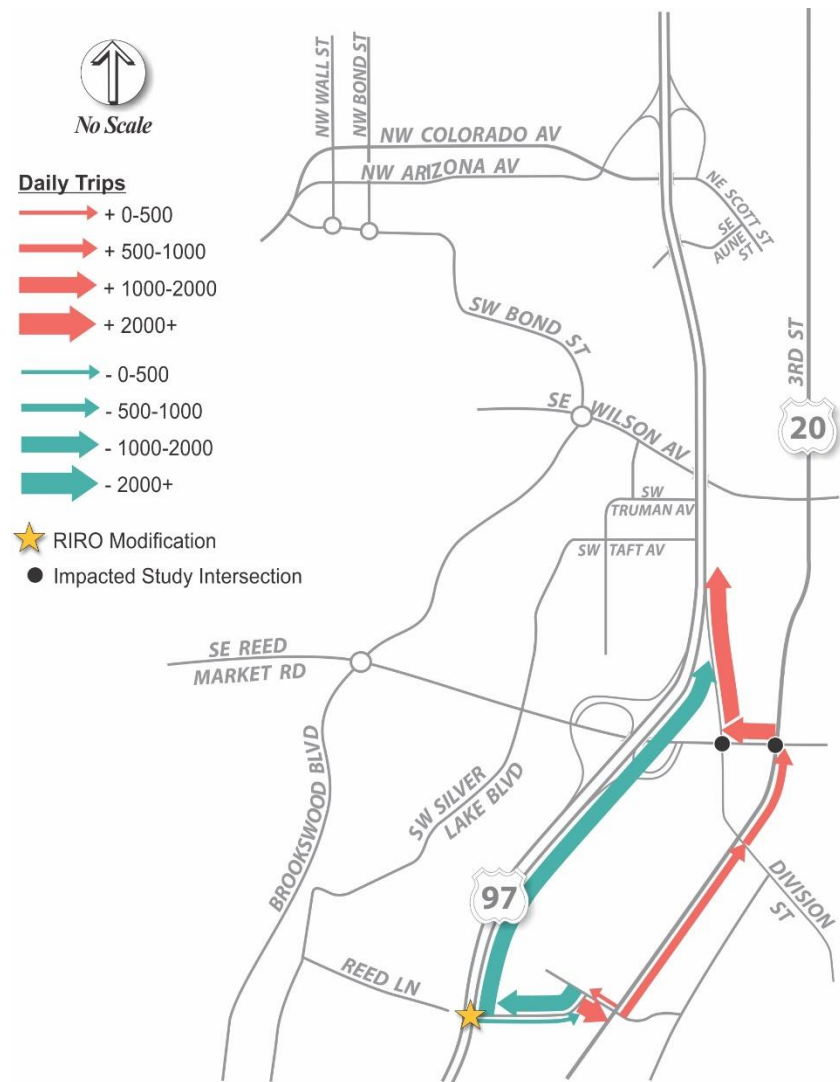
By 2040, the intersection of US 97/Reed Lane is expected to exceed mobility standards, with queues spilling back along Reed Lane to the Fred Meyer store and 3rd Street as volumes increase on US 97. There are no deceleration or acceleration lanes at Reed Lane, leading to a higher risk of crashes at this location.

Traffic Volume Impacts

The impact of traffic volumes shifts is relatively localized with a full closure of Reed Lane, as shown in Figure 13. Instead of using the Reed Lane RIRO, drivers continue to the Reed Market interchange via 3rd Street. This adds trips to the intersection of Reed Market Road/SE 3rd Street and Reed Market Road/Division Street. This trend does not significantly change when all the RIRO accesses are closed, as shown in Figure 12 (above in the Truman Avenue discussion).



Figure 11: Reed Lane RIRO Full Closure Daily Volume Shifts



Intersection Operations

Table 4 lists the operations at intersections impacted by RIRO modifications at Reed Lane.

Table 4: 2040 PM Peak Hour Intersection Operations - Reed Lane RIRO Modifications

Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance		
				2040 No-Build	Reed Lane RIRO Full Closure	All RIRO Closures
US 97/Bend Parkway Study Intersections						
21	Bend Pkwy & Reed Ln	TWSC ^D	< 0.85 (major) < 0.95 (minor)	NA/1.05	NA ^C	NA ^C
Study Intersections Paralleling US 97						
52	Reed Market Rd & SE 3rd St	Signalized	< 1.00	1.53	1.59	1.57
51	Reed Market Rd & Division St	TWSC	< 1.00	0.23/0.31	0.27/0.43	0.27/0.38



- A** Overall intersection V/C ratio at signalized intersections, worst case approach V/C at roundabouts and all-way stop-controlled intersections, and V/C ratio for Major Street/Minor Street at two-way stop-controlled.
- B** The delay mobility target for the City of Bend only applies to critical lane groups with 100+ vehicles per hour.
- C** Intersection performance is not applicable when the RIRO access is closed.
- D** Two-way stop-controlled (TWSC).

Bold values indicate performance measures failing to meet adopted mobility targets.

With a closure at Reed Lane, the intersection operation impacts to the local system are minimal. The operational impacts to each intersection are summarized below:

- Bend Pkwy & Reed Ln: Any access modification at Reed Lane would improve operations at the intersection which is slightly over capacity under 2040 No-Build conditions.
- Reed Market Rd & SE 3rd St: This intersection is significantly over capacity under 2040 No Build conditions with a v/c of 1.53. A capacity improvement to this intersection is already included in the Level 2 Evaluation. No significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.
- Reed Market Rd & Division St: No significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.

Findings

Building deceleration lanes to standard at Reed Lane would likely conflict with any interchange at Powers Road (evaluated in Project Bundle B). Any access modification would also significantly improve the safety at this location by reducing conflicts. Grade separation of pedestrian crossings at Reed Lane was recommended under existing conditions, particularly as at-grade intersections are progressively phased off the Parkway in the future. This is consistent with work to date by the City in the ongoing Bend TSP/MTP update. While closure of Reed Lane would add trips to the intersection of Reed Market Road/SE 3rd Street, both the Level 1 Evaluation and the ongoing Bend TSP/MTP Update process have already identified this location for improvements. Due to the likely safety and traffic operations benefits, a full closure of the Reed Lane RIRO is recommended for inclusion in the Level 2 Evaluation.

RIRO MODIFICATIONS AT NELS ANDERSON PLACE

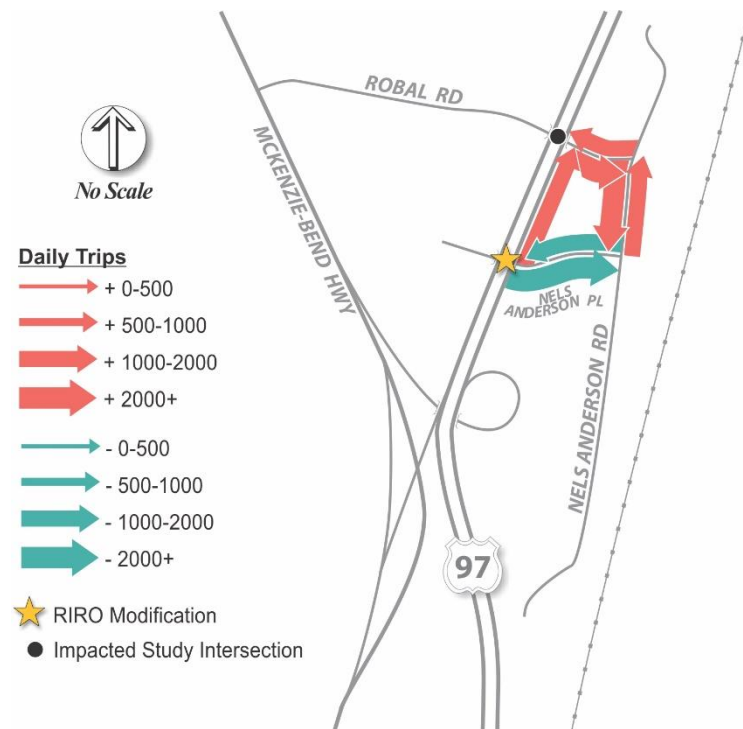
US 97/Nels Anderson Place is over capacity under existing conditions and remains over capacity in the future No-Build conditions.

Traffic Volume Impacts

The impact of traffic volumes shifts is relatively localized with a full closure of Nels Anderson Place, as shown in Figure 14. Instead of using the Nels Anderson Place RIRO, trips shift to US 97/Robal Road.



Figure 12: Nels Anderson Place RIRO Full Closure Daily Volume Shifts



Intersection Operations

Table 5 lists the operations at intersections impacted by RIRO modifications at Nels Anderson Place. The only study intersection impacted by the closure of the Nels Anderson Place RIRO is US 97/Robal Road, which was significantly over capacity under No-Build conditions.

Table 5: 2040 PM Peak Hour Intersection Operations for Intersections Impacted by Reed Lane RIRO Modifications

Int. No.	Intersection	Control	Mobility Target V/C ^A	Intersection Performance	
				2040 No-Build	Nels Anderson PI RIRO Full Closure
US 97/Bend Parkway Study Intersections					
3	US 97 & Robal Rd	Signalized	< 0.85	1.41	1.45
4	US 97 & Nels Anderson Pl/Cascade Village	TWSC ^D	< 0.85 (major) < 0.95 (minor)	>2.00/ >2.00	NA ^C

A Overall intersection V/C ratio at signalized intersections, worst case approach V/C at roundabouts and all-way stop-controlled intersections, and V/C ratio for Major Street/Minor Street at two-way stop-controlled.

B The delay mobility target for the City of Bend only applies to critical lane groups with 100+ vehicles per hour.

C Intersection performance is not applicable when the RIRO access is closed.

D Two-way stop-controlled (TWSC).

Bold values indicate performance measures failing to meet adopted mobility targets.

With a closure at Nels Anderson Place, the intersection operation impacts to the local system are minimal. The operational impacts to each intersection are summarized below:

- US 97 & Robal Rd: This intersection is significantly over capacity under 2040 No Build conditions with a v/c of 1.41. No significant impacts to intersection operations are expected at this intersection with any modifications of RIRO access to the Parkway.



- Any access modification at Nels Anderson would improve operations at the intersection which is more than two times over capacity under 2040 No-Build conditions. Any access modification would also significantly improve safety at this location with reduced conflicts.

Findings

The planned improvements in the US 97 Bend North Corridor Project (FEIS) include a reconfiguration of US 97 to a more local route at Nels Anderson Place/Cascade Village. Under the FEIS, Nels Anderson Place/Cascade Village would not access the new US 97 alignment and would instead access the new local route that is an extension of 3rd Street. Analysis and potential short-term improvements for this intersection will be reviewed in the US 97 North Corridor Study. Due to the likely safety and traffic operations benefits, a full closure of the Nels Anderson Place RIRO is recommended for inclusion in the Level 2 Evaluation.

RECOMMENDATIONS

Based on the results of this analysis, the following combinations of RIRO closures and modifications are recommended as the reasonable scenario for inclusion in both Project Bundle A and Bundle B for Level 2 Evaluation. Note that these recommended RIRO closures and modifications are subject to change based on the findings of the Level 2 Evaluation and could differ from the final preferred solution for the US 97 Parkway Study.

1. Nels Anderson Place – full closure
2. Reed Lane – full closure
3. Truman Road – full closure
4. Hawthorne Avenue – close right-out (onto US 97) only, build deceleration lane to standard
5. Lafayette Avenue – full closure

As stated earlier, allowing stop-controlled right-on movements to US 97 would hinder the effectiveness of ramp metering as a traffic management tool. Therefore, all right-ons at RIRO access locations are recommended for closure on a simultaneous timeline with ramp meter implementation, if ramp meters become part of the final project recommendations. The analysis showed significant impacts to both the Revere Avenue and Colorado Avenue interchanges caused by full closure of both the Lafayette Avenue and Hawthorne Avenue RIRO accesses and especially at Revere Avenue, these impacts may not be easily mitigated. Hawthorne Avenue provides the most direct business access to downtown Bend, serves the highest daily demand, and is therefore recommended to remain open for southbound traffic exiting US 97.

Based on the recommended closures above, Table 6 summarizes the study intersections impacted by each RIRO closure and whether mitigations would likely be triggered at that location. Each “X” indicates where a mitigation would likely be triggered to meet mobility standards due to the impacts of the closures while each “O” indicates an intersection that will be impacted (more than 50 pm peak hour trips) but will likely not trigger any additional mitigation beyond the mitigation needed for 2040 No-Build conditions.



Table 6: Summary of Impacted Study Intersections

Int. No.	Intersection	RIRO Closure/Modification Location				
		Lafayette	Hawthorne	Truman	Reed Lane	Nels Anderson Place
US 97/Bend Parkway Study Intersections						
3	US 97 & Robal Rd	-	-	-	-	O
4	US 97 & Nels Anderson Pl/Cascade Village	-	-	-	-	O
12	Bend Pkwy SB Ramps & Revere Ave	X	-	-	-	-
14	Bend Pkwy & Lafayette Ave	O	O	-	-	-
15	Bend Pkwy & Hawthorne Ave	O	O	-	-	-
16	Bend Pkwy SB Ramps & Colorado Ave	-	-	X	-	-
18	Bend Pkwy & Truman Ave	-	-	O	-	-
19	Bend Pkwy SB Ramps & Reed Market Rd	-	-	O	-	-
21	Bend Pkwy & Reed Ln	-	-	-	O	-
Study Intersections Paralleling US 97						
-	US 20 (NE 3rd St) & Olney Ave	O	-	-	-	-
-	Wall St & NW Lafayette Ave	O	O	-	-	-
-	Wall St & Portland Ave	X	X	-	-	-
-	Wall St & Greenwood Ave	O	O	-	-	-
-	Wall St & Franklin Ave	-	X	-	-	-
-	Bond St & Franklin Ave	-	X	-	-	-
-	NE 3rd St & Franklin Ave	-	X	-	-	-
-	US 20 (NE 3 rd St) & Greenwood Ave	X	X	-	-	-
49	Reed Market Rd & Brookwood Blvd	-	-	O	-	-
-	Wall St & Colorado Ave	-	-	O	-	-
-	Bond St & Arizona Ave	-	-	X	-	-
-	NE 3rd St & Wilson Ave	-	-	O	-	-
-	Aune St & NE Scott St	-	-	O	-	-
52	Reed Market Rd & SE 3rd St	-	-	-	O	-
51	Reed Market Rd & Division St	-	-	-	O	-

X indicates an impacted intersection where a mitigation would likely be triggered earlier than under No-Build conditions.
 O indicates an impacted intersection where no additional mitigations beyond mitigating 2040 No-Build conditions would likely be needed.



Appendix
