

SR 161/RIVERSIDE DRIVE ROUNDABOUT OPERATIONS REVIEW APPENDIX

Introduction

A comprehensive review and study has been completed of the SR 161/Riverside Drive roundabout. The work included a thorough review of the following items:

- Crash data
- Design studies and analysis
- Performance design checks
- Morning and afternoon peak hour traffic operations
- Traffic Count video (January 2017 and March 2017)
- Existing signing and pavement markings

In addition to the review of the items above, speed data for entering vehicles was collected at key points and a detailed roundabout operational analysis was conducted. All of this information was reviewed and analyzed to develop the recommendations contained in this report.

Functional Design

The safety and operational performance of roundabouts is strongly anchored in human factors, i.e. how drivers receive the visual information of the geometrics, signs and pavement markings, and how they react to them. For optimal safety and operations, the visual information must be designed to both simplify decision-making and provide clear, concise information on the correct way to drive the roundabout. Therefore, the safety performance of a roundabout emerges from the whole system interaction of design elements rather than to individual design components.

High traffic flow multi-lane roundabouts can introduce complexity for a driver navigating the roundabout. More traffic means more lanes which means more complexity for drivers. Certainly, the same is true for all intersection types, but roundabouts rely more heavily on visual cues than other intersection types.

The traffic and transportation engineering practice is becoming increasingly aware of how seemingly unrelated design specifications affect how drivers receive, process and react to visual information at roundabouts.

As previously documented, the northbound approach into the roundabout is experiencing the highest frequency of crashes, with 58% of the total number of crashes occurring on this approach from August 13, 2016 through July 9, 2017. The eastbound approach has the next highest number of crashes, with 11% of the total crashes occurring here. The improvements are focused on reducing these frequently occurring crashes and improving overall operations at the roundabout.

To improve driver comprehension and provide better overall safety performance, the improvements are focused on simplifying driver's decision making by:

- 1) Modifying the northbound approach entry lane assignment
- 2) Revising the pavement markings
- 3) Revising several signs



Lane Assignments

Comparison of the January 2017 video traffic counts versus those of March 2017 indicate that due to the North High Street detour currently in place, the March 2017 northbound and eastbound traffic volumes are approximately 30-35% higher than the January 2017 counts. The video comparison from January to March visually shows much longer queues for northbound and also for westbound traffic for the PM peak, caused by both the higher northbound flow but also by the greater eastbound flow passing in front of the northbound entry.

Sensitivity testing and analysis was performed for various lane assignments on both the 2017 video counts, with and without the 30-35% increase due to detoured traffic, and projected 2030 traffic volumes. This analysis, conducted using RODEL, the roundabout analysis software, identified an important lane assignment change to the northbound entry that will assist with improving both the safety and capacity of this approach. All other entries will remain as they are in terms of the number of lanes and their lane assignments.

Figure 1 depicts the existing lane assignments for the northbound approach, and the lane numbering nomenclature used. As Figure 1 shows, Lane #1 is a Left Only lane, Lane #2 is a shared Through/Left lane, and Lane #3 is a shared Through/Right lane. Based on field observations, the current lane assignments do not distribute traffic flow evenly across all approach lanes. Lane #1, or the Left Only lane, is underused, which is pushing the movements with the highest volume into Lanes #2 and #3.

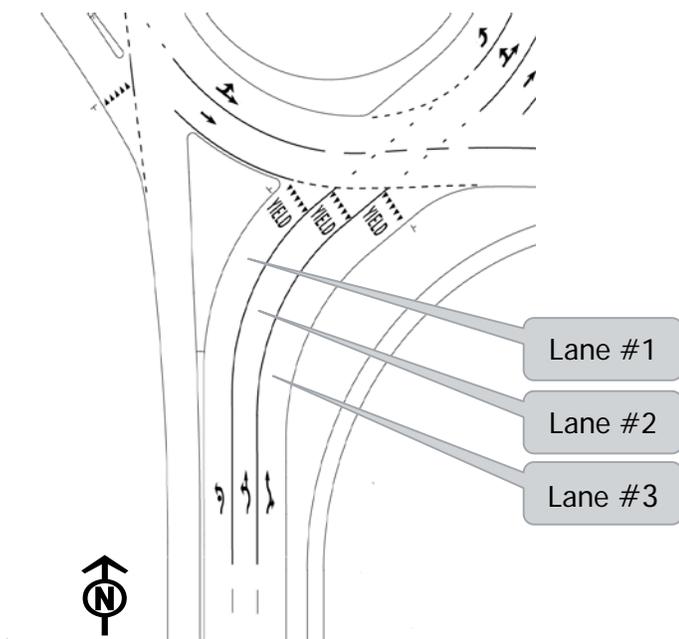


Figure 1: Existing NB Lane Assignments

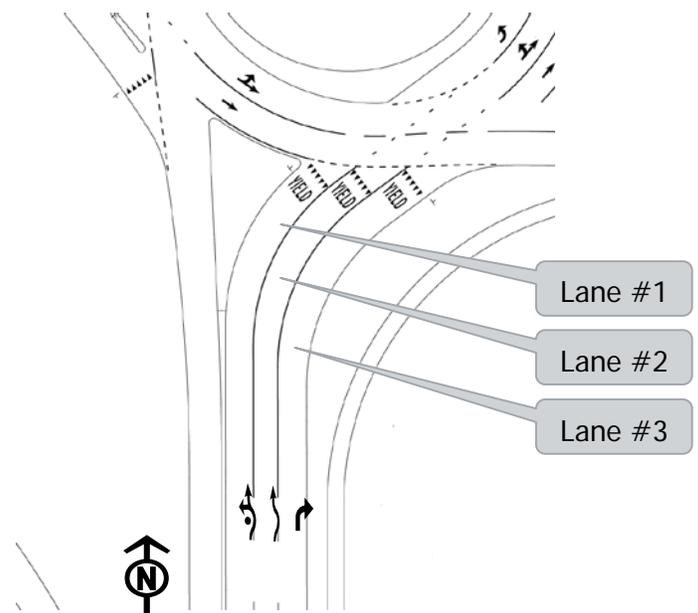


Figure 2: Revised Northbound Lane Assignments

Based on the sensitivity testing and analysis, the recommended lane assignments are shown in Figure 2 above for the northbound approach.

As Figure 2 shows, Lane #1 becomes a shared Through/Left lane, Lane #2 is a Through lane, and Lane #3 is a Right Only lane. The RODEL analysis with this lane configuration still shows the northbound approach operating very well through the long range (2030) traffic projections.

Changing the northbound entry lane assignments to the arrangement shown in Figure 2 will have several positive effects on safety performance while still meeting the long range operational requirements. The revised northbound lane assignments are expected to improve these identified issues:

- Simplifies driver decision making on the northbound approach by making lane assignments more intuitive.
- Distributes traffic volumes more evenly over all three entry lanes, improving lane use/balance
- Removes the conflict point (Lane #3 with inside circulating lane) with the highest number of crashes.
- Places the major traffic flow in Lane #1 and Lane #2, where with striping changes, the entry geometry is substantially improved compared to Lane #3.
- Places the right turn volume, which has the lowest volume on the northbound approach, in Lane #3, or the curb lane, which does not circulate in the roundabout.
- Provides a shorter crossing distance into the roundabout for the major traffic flow reducing the necessary decision making time to enter.
- Reduces the number of northbound approach lanes that will potentially conflict with the circulating lanes from three to two.

Pavement Markings

In addition to revising the lane assignments on the northbound approach, several revisions to the pavement markings at the roundabout are necessary. Figure 3 below depicts the existing pavement markings in place for the roundabout northbound approach.

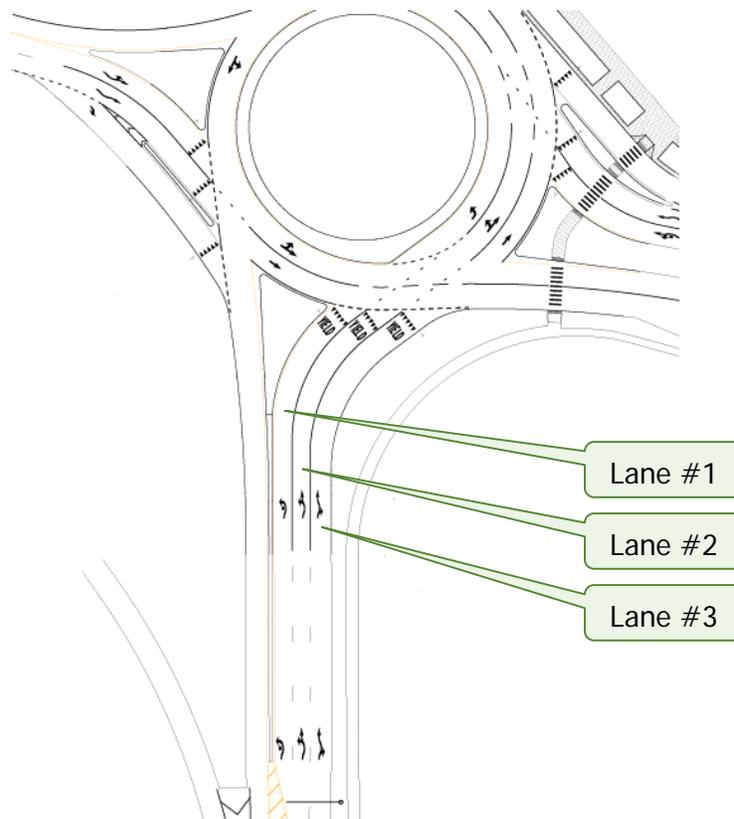


Figure 3: Existing Northbound Pavement Markings

Several pavement marking elements will be modified with the intent to improve driver comprehension relative to the crashes that are occurring. The existing pavement markings that will be improved are listed below and shown on Figure 4:

1. Dotted edge line extended tangent to downstream exit leg contributes to a poor left view angle for Lanes #2 and #3 for the northbound, westbound and eastbound approaches, confusing the priority message of who yields to whom
2. Multiple line types at entry creates information overload and reduces comprehension
3. Varying lane marking types in the circulatory roadway reduces driver recognition of correct lane assignment

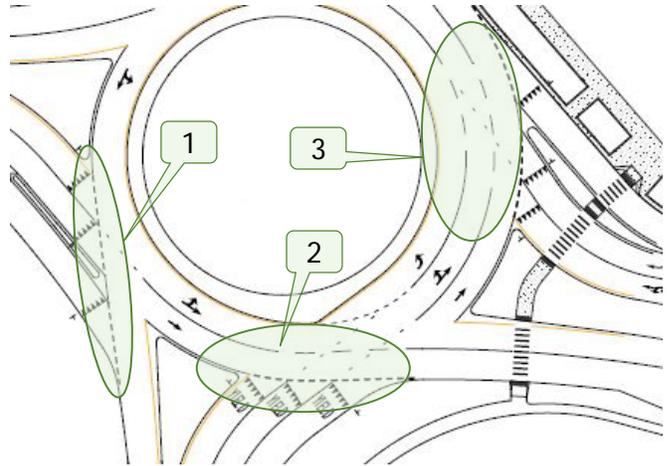


Figure 4: Existing Pavement Markings

In order to improve driver comprehension, lane discipline, and priority messaging, the following changes will be made to the pavement markings, which are shown in Figure 5 to the right, Figure 6 on page 5, and Figure 7 on page 6:

1. Place an additional set of directional arrows on the pavement for the westbound approach
2. Provide consistent lane assignment markings in the circulatory roadway
3. Provide a 13-foot lane for the inside circulatory lane which will result in a wider outside circulatory lane
4. Modify entry markings on the northbound, westbound, and eastbound approaches to reduce lane widths to 12 feet and align with revised circulatory roadway pavement marking location
5. Remove the shark's teeth and dotted edge line pavement markings at all entries and replace with new bolder yield line placed to clearly delineate yield condition to entry drivers

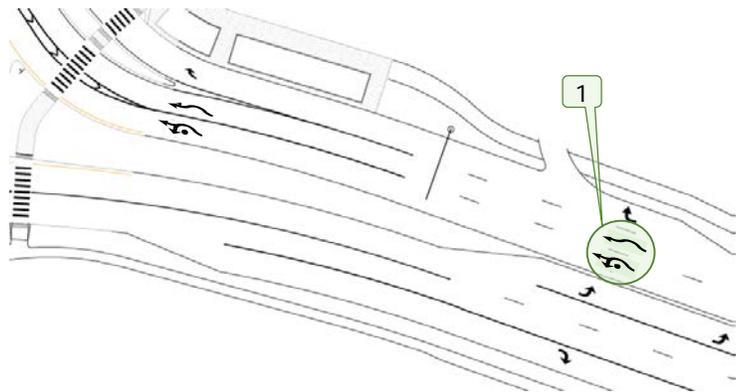


Figure 5: Additional set of Pavement Directional Arrows for Westbound Approach

6. Add pavement markings to extend the splitter island on the east side of the roundabout to reflect the proposed northbound Right Only lane. Additionally, reflective raised pavement markers will be installed to define this gore area and reinforce to drivers that this is not an area to be driven on. In the future, granite curb could be added to extend the splitter island to replace the pavement markings. Staff will evaluate if this should be a future upgrade to ensure the roundabout performance and operations have improved.

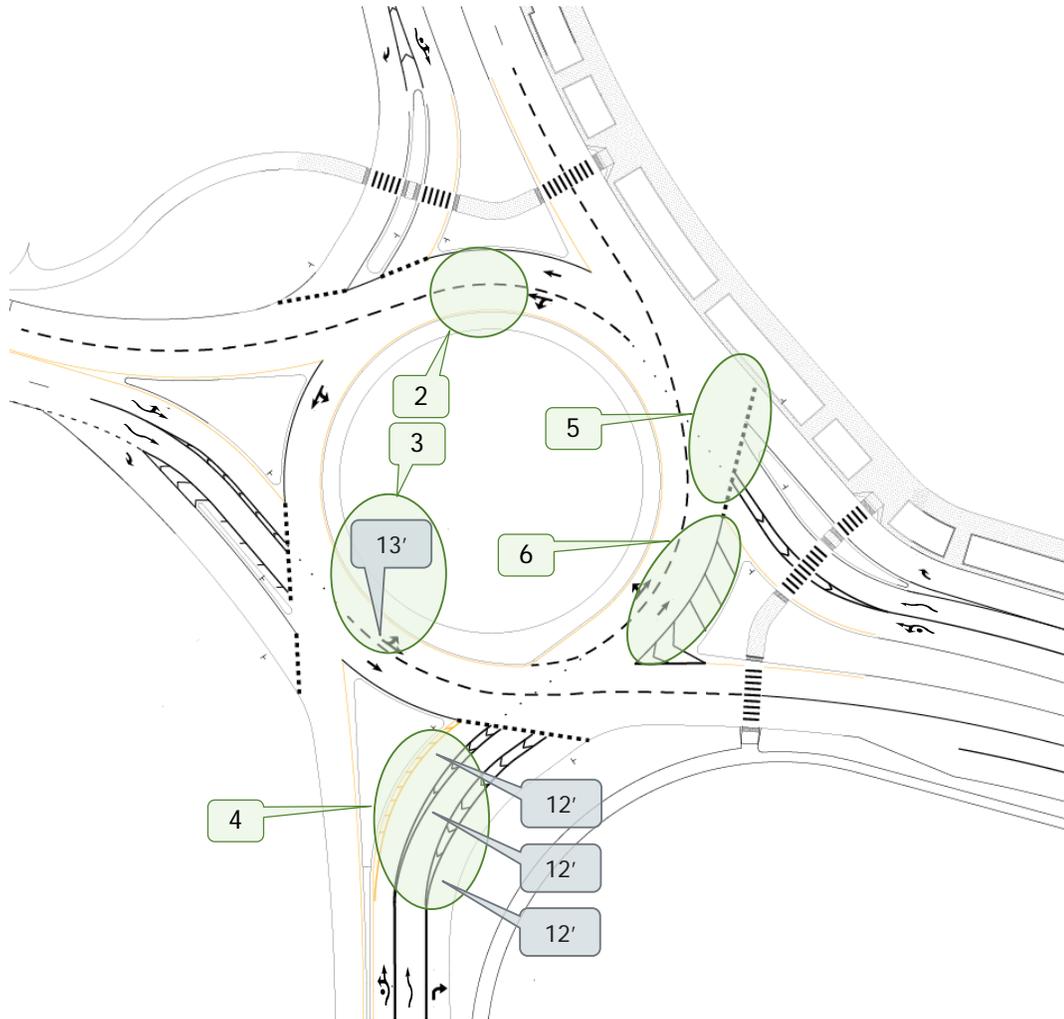


Figure 6: Proposed Pavement Markings

7. Remove the turn lane taper markings for the Left Only lane on the northbound approach and add turn lane taper markings for the Right Only lane and add an additional set of pavement arrows

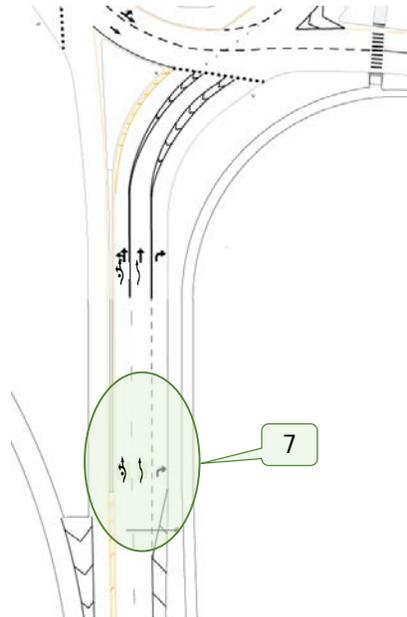


Figure 7: Northbound Right Turn Only Development/Added Set of Arrows

Due to the amount of pavement marking removal to be done, a 1.25-inch mill and pavement overlay will also be completed to provide the best and cleanest final surface course possible, that will be free of pavement scarring.

As part of the original design, as shown in Figure 1 on page 2, Lane #1 was a Left Turn Only, and so vehicles making an eastbound left turn were directed to the outside lane on the east side of the roundabout. Now that Lane #1 will become a Shared Left/Through, as shown in Figure 2 on page 2, the curb on the southern side of the central island will be modified in order to simplify the eastbound left turn movement, as shown in Figure 8 below.

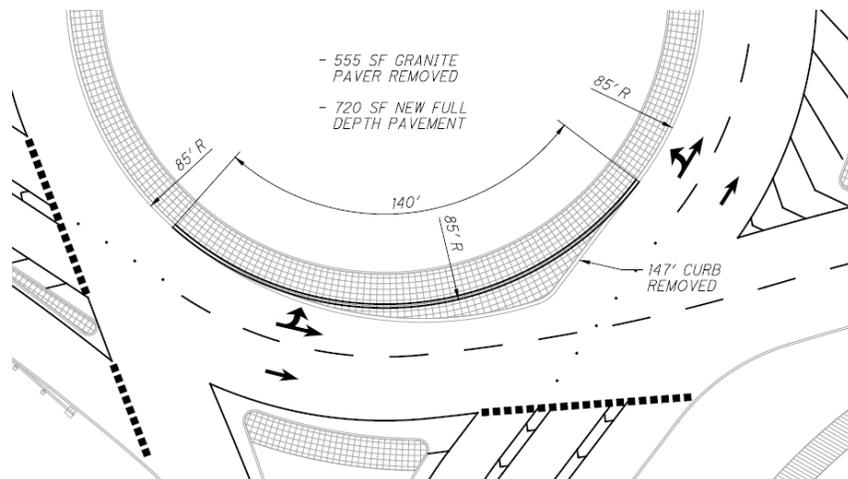


Figure 8: Full Spiral Removal along Southern Edge of Central Island

Signs

The existing signing plan has several items identified that will be modified to improve driver comprehension and minimize confusion. In order to be effective, a traffic sign must fulfill a need, command attention, command respect, convey a clear and simple meaning, and provide adequate time for a proper response by the road user. The sign changes are as follows:

The overhead directional signs in all directions will be modified as follows:

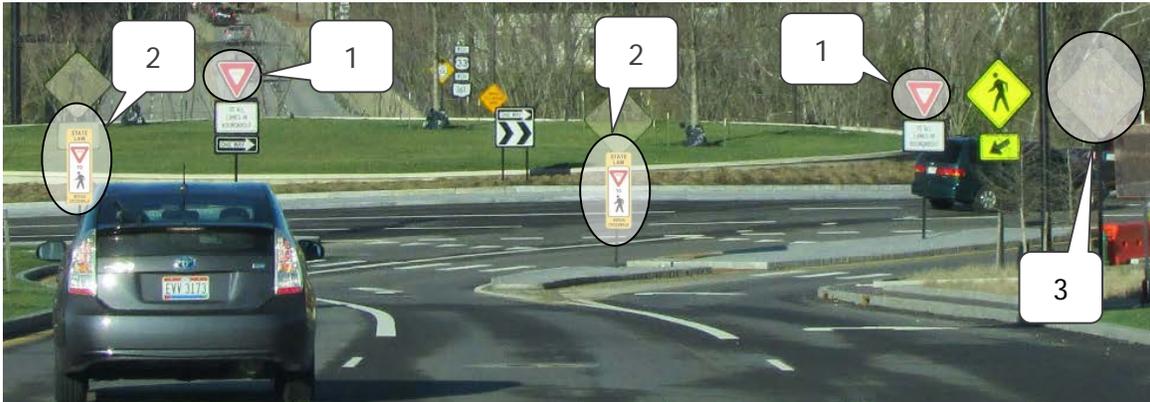
- Install black fishhook arrows on a white background for maximum contrast over the white fishhook arrows and lane indication on the grey background.
- Install an advance lane assignment side-mounted sign to improve driver awareness and to supplement overhead lane use messaging as needed.



The modification provides a simple, clear sign message for better driver comprehension and decision making and will be installed based on feedback received, field observations, and its simple, clear sign message. Staff will continue to monitor the operations and performance of the intersection to determine if the overhead signs should be modified any further to better clarify and simplify sign messaging.

Other Sign Modifications:

1. Replace the existing 36-inch Yield signs with 42-inch Yield signs on all approaches to increase sign visibility
2. Replace the standard diamond shape Pedestrian Crosswalk signs with the Yield to Pedestrians in Crosswalk sign on auxiliary splitter islands and inside island
3. Remove Yield Ahead signs



Costs

The total cost to implement the proposed pavement marking and sign revisions is expected to cost approximately \$260,000, as listed below:

Total cost for pavement markings and signs:

Pavement Subtotal	=	\$254,000
<u>Signs Subtotal</u>	=	<u>\$6,000</u>
Total Estimated Costs	=	\$260,000