# CITY SAFETY PLAN

FEBRUARY 2022

PREPARED FOR THE CITY OF RICHLAND

PREPARED BY DKS ASSOCIATES

# Acknowledgements

**RICHLAND**

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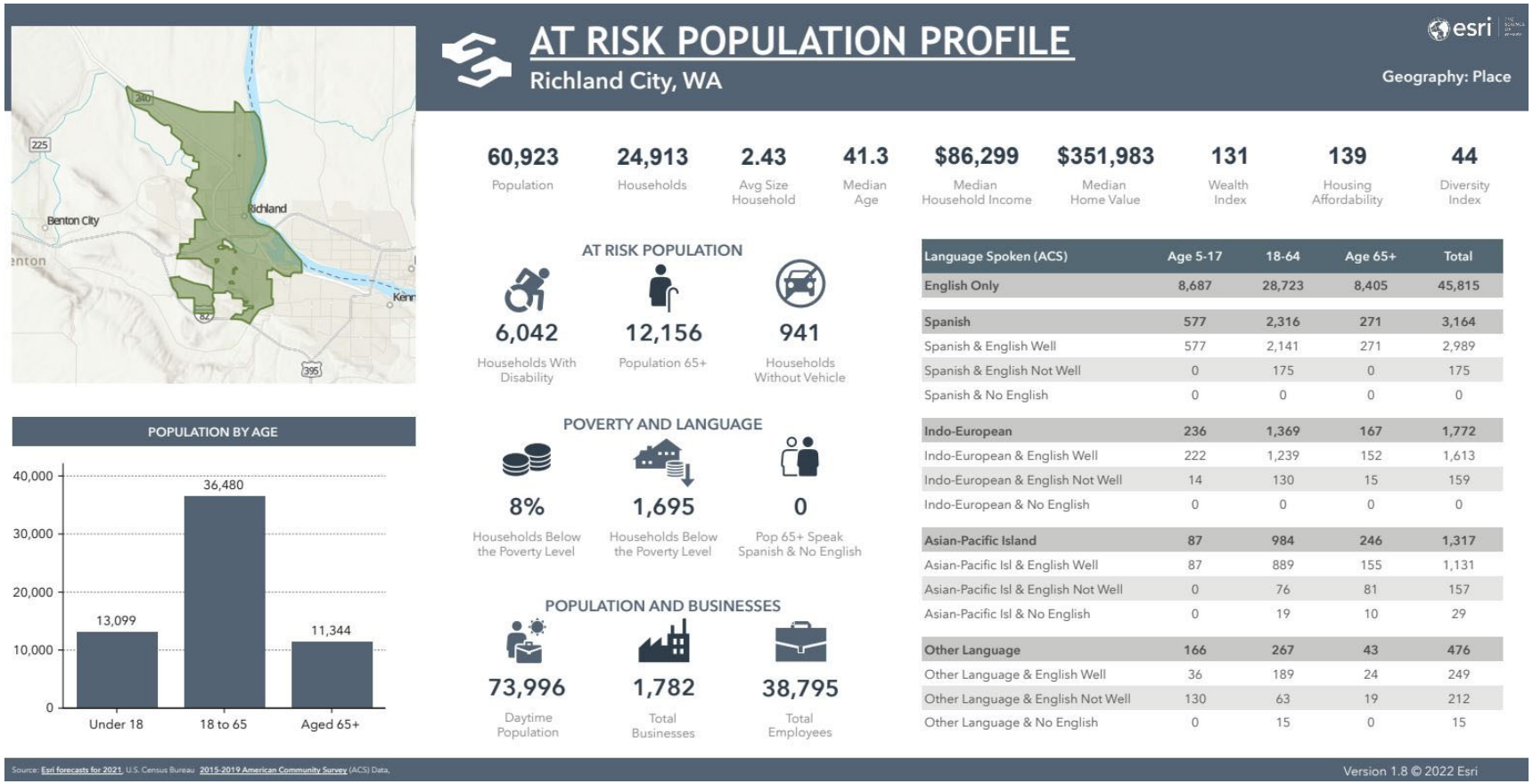
# INTRODUCTION

The City of Richland is located on the east side of Benton County, Washington, located at the confluence of the Yakima River and Columbia River. It is home to 60,000 residents and noted for excellence in technology, medicine, education, recreation, tourism, and citizen participation. The following 'At Risk Population Profile' provides key population and equity statistics based on 2021 data.




Source: ESRI Business Analysis Tool. https://storymaps.arcgis.com/stories/52764a9948074c4b9d527a390aefdc67

## LOCAL ROAD SAFETY PLAN: PURPOSE AND NEED

This Local Road Safety Plan (LRSP) has been developed in response to the WSDOT 2022 City Safety Program, which distributes federal Highway Safety Improvement Program (HSIP) funding to local agencies. The goal of this program is to reduce fatal and serious injury crashes on city streets using engineering improvements and countermeasures. Since fatality and serious injury crashes are rare and dispersed around the city, addressing them requires in-depth analysis and study of various crash trends.

The WSDOT 2022 City Safety Program is a grant program which seeks to target fatal and serious collisions by determining the typical crash types and conditions specific to a jurisdiction, evaluating the causative factors in those crash types, identifying the best locations and risk factors to address, and then selecting a prioritized list of mitigation strategies to address these collisions. The program includes two subprograms, defined by WSDOT as follows:[1]

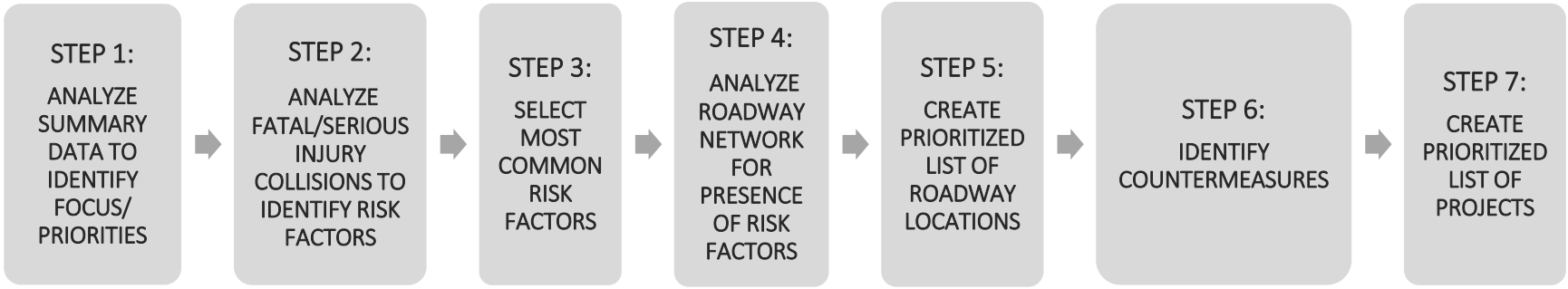
- **Spot Location:** Projects must be at a specific intersection(s), spot or mid-block location(s), or corridor(s) and must address at least one fatal or serious injury crash in the most recent five year period.
- **Systemic:** Projects are identified through a city/town's local road safety plan that identifies and prioritizes projects based on the top crash type(s) in the city/town. Projects can be at intersection(s), spot or mid-block location(s), and/or on corridor(s) throughout a city/town or over wide areas within a city/town.

This plan has been developed using a risk-based analysis of the crashes within the City of Richland that occurred from 2016 through 2020. Though its primary purpose is to help develop a prioritized project list for the WSDOT 2022 City Safety grant program, a secondary purpose is to provide a guiding document to staff in the design and development of future projects and programs. Every year, City public works staff develop a variety of transportation related projects, many of which are capital improvements or maintenance to existing facilities where there are opportunities for both operational and safety enhancements. This plan, by outlining a set of key mitigation strategies and programs, will help City staff to develop safety projects that take advantage of appropriate City and grant funded transportation improvements to improve the overall safety of Richland's transportation network. By doing so, we are making a concerted effort to help meet Washington State's Target Zero program goals of reducing traffic fatalities and serious injuries on Washington's roadways to zero by the year 2030.

[1] WSDOT Support for Local Programs: Highway Safety Improvement Program. https://wsdot.wa.gov/business-wsdot/support-local-programs/funding-programs/highway-safety-improvement-program

## LOCAL ROAD SAFETY PLAN PROCESS

The development of a Local Road Safety Plan is centered on the analysis of citywide crash data in order to effectively identify safety trends, contributing factors, associated risk factors and deficiencies present in the City's road network. Following this approach allows for the effective identification of appropriate safety countermeasures to be implemented for the purpose of crash reduction. The following plan includes a summary of existing safety conditions in Richland, identification of safety needs, and recommended treatments to address high-priority collision types and locations.




Appendix E, Safety Countermeasures Toolbox, includes a description of each treatment, when it should be used, estimated costs, and crash modification factor.

The data used and the process followed are consistent with WSDOT's guidelines from the 2022 City Safety Program. The recommended safety countermeasures are limited to infrastructure-based treatments eligible for one or more of the following grant programs, which are further described in Appendix A:

- WSDOT grant programs: City Safety, Safe Routes to School, Bicycle-Pedestrian, and Railway-Highway Grade Crossings
- Transportation Improvement Board (TIB) grants, including Complete Streets
- Programs specific to the Benton-Franklin Council of Governments.

The sections below describe the process of collecting and analyzing available data and identifying safety needs from that analysis.

## STEP 1: ANALYZE SUMMARY DATA TO IDENTIFY FOCUS/PRIORITIES

The City of Richland and its consultant support staff worked with WSDOT Transportation Data, WSDOT Local Programs, other City staff, and a third-party provider to acquire and analyze the following data sets.

- WSDOT database of all collisions on City of Richland streets, Jan 2016 - Dec 2020 (provided by WSDOT Transportation Data)
- Summary crash data from WSDOT Local Programs with comparisons to Statewide Average, City Average, and Eastside City Average proportions of several collision types and other contributors.
- Third-party database provided (MS2) for data aggregation.

**Stop-controlled Intersection Prioritization.** In order to further refine rankings within categories, like stop-controlled intersections, City staff worked with a third party database provider, MS2, to aggregate crash information from the overall state crash database. This data was scrubbed, filtered, and sorted to populate a custom spreadsheet with details about the crash severity and entering traffic volumes. This resulted in a list of stop-controlled intersections ranked by the combination of crash rate (normalized by intersection Average Daily Traffic (ADT) and Equivalent Property Damage Only (EPDO). The City used this to determine sites for systemic intersection treatments.

**Pedestrian Crossing Prioritization.** The City of Richland maintains on ongoing list of desirable locations for pedestrian crossing treatments, including Rectangular Rapid Flashing Beacons (RRFBs). The ranking matrix includes the following data elements for scoring:

- Average Daily Traffic
- Posted Speed Limit
- Number of Travel Lanes
- History of Pedestrian-involved and Bicyclist-involved Collisions
- Proximity to Transit Stops, Public Facilities, Paths, or Schools
- Nearby Curve or other Sight Distance Restriction

The City used a scoring system that combines these elements to determine sites for systemic pedestrian crossing treatments.

## DATA ANALYSIS OVERVIEW

As illustrated in Figure 1, over the past five years there were a total of nine fatal collisions and 28 serious injury collisions in the City of Richland.[2]

The number of all reported collisions (regardless of severity) has ranged between 484 and 777, as shown in Figure 2. In the most recent year of data available, 2020, the city experienced 484 reported collisions (a 29% decline from 2016). However, the frequency of combined fatal and serious injury collisions in 2020 was 12, more than double the five that occurred in 2016. The impacts of the COVID-19 pandemic response and associated travel patterns likely influenced collision frequency and severity in 2020.

Figure 3 shows the heat map of fatal and serious injury collisions over the five-year study period. Figure 4 provides a heat map of all reported collisions that occurred on City-owned streets in Richland during the study period.

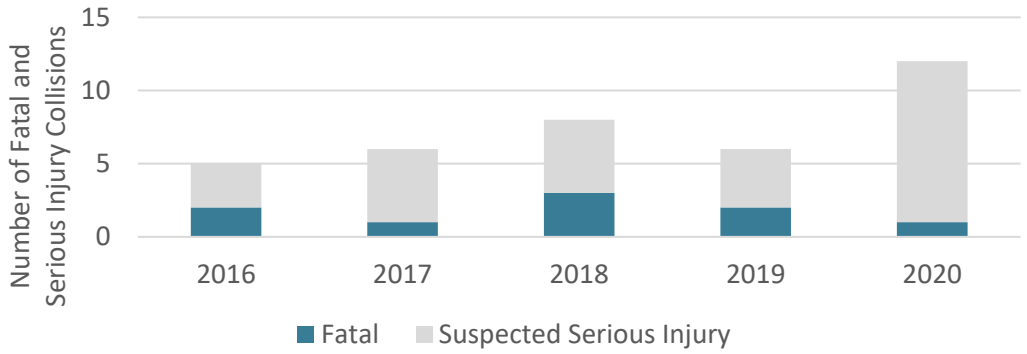



**Figure 1. Fatal and Serious Injury Collisions in Richland, 2016-2020.**

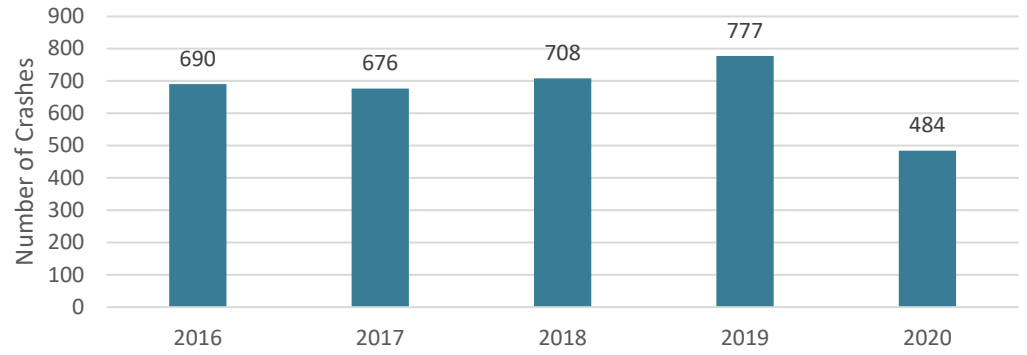



**Figure 2. All Reported Collisions in Richland, 2016-2020**

[2] Database note: The WSDOT raw crash data identified 9 fatal crashes in the study period. The City's own data review showed 8 fatal crashes. WSDOT's Data Summary Excel workbook from November 2021 shows 10 fatal crashes. The reason for the discrepancy is that WSDOT includes some State Routes that are maintained by the City, and this subset is a "grey area" that is not easily defined.

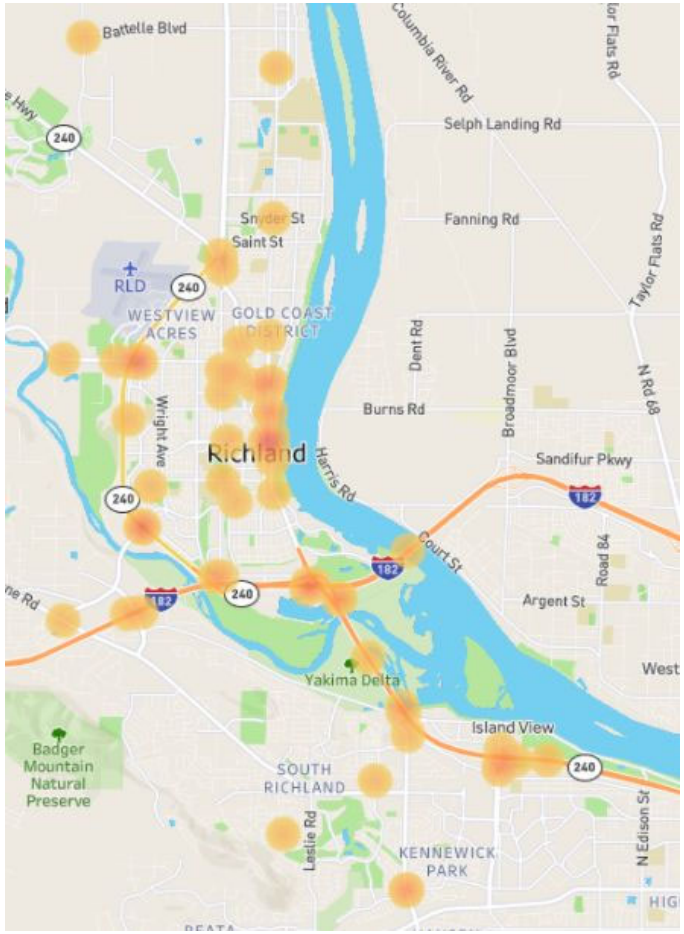



**Figure 3. Heat Map of Fatal and Serious Injury Collisions in Richland, 2016-2020.**

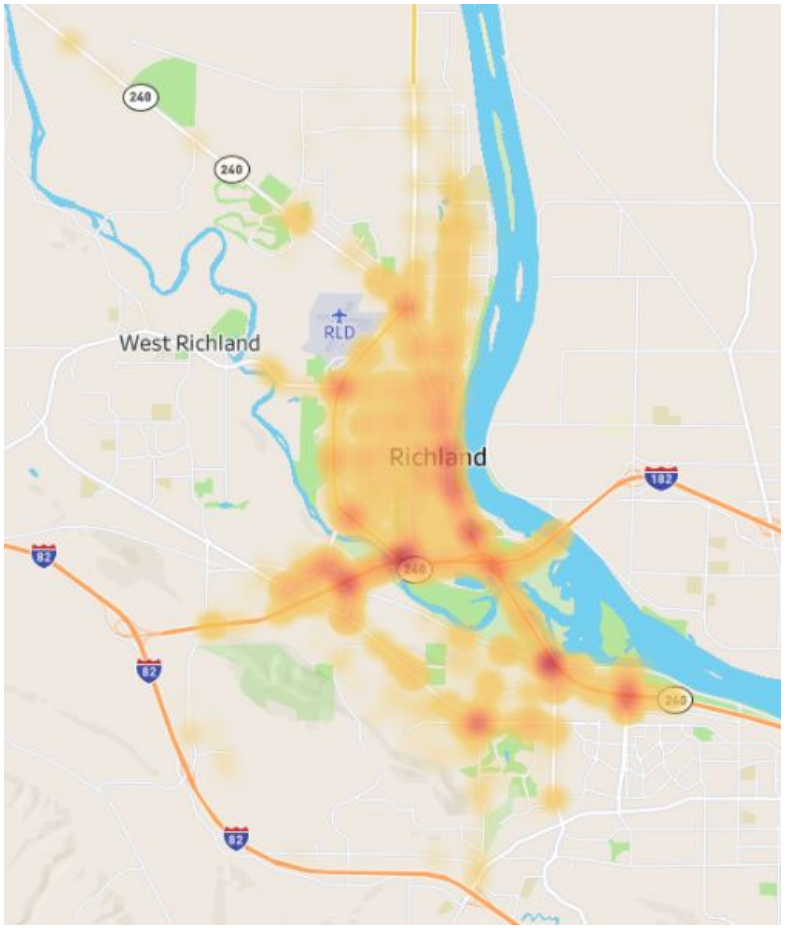



**Figure 4. Heat Map of All Reported Collisions in Richland, 2016-2020**

## STEP 2: ANALYZE FATAL/SERIOUS INJURY COLLISIONS TO IDENTIFY RISK FACTORS

The City studied each risk factor (collision attribute) to determine those most likely to contribute to future fatal and serious collisions in Richland. Table 1 shows some of the most common attributes present in collisions that occur on City-owned streets in Richland. Collision attributes with a notably higher percentage of fatal and serious injury collisions versus all-severity collisions have an increased likelihood of contributing to fatal and serious injury crashes.

**Table 1. Most Common Collision Attributes, Richland, 2016-2020**

| Data Element | Collision Attribute | Total Collisions | Fatal Collisions (F) | Serious Injury Collisions (SI) | Percent of all Richland Collisions with this Attribute (1) | Percent of F&SI Richland Collisions with this Attribute (2) |
|---|---|---|---|---|---|---|
| *Citywide* | *Any* | 3,335 | 9 | 28 | | |
| Collision Type | Roadway Departure | 298 | 2 | 3 | 9% | 14% |
| | Head-On | 16 | 0 | 1 | <1% | 3% |
| | Entering at Angle | 1,069 | 1 | 6 | 32% | 19% |
| Contributing Circumstance (For at least one vehicle) | Exceeding Reasonable Safe Speed or Exceeding Stated Speed Limit | 153 | 1 | 1 | 5% | 5% |
| | Alcohol-Impaired (3) | 128 | 1 | 5 | 4% | 16% |
| | Drug-Impaired (3) | 30 | 0 | 2 | 1% | 5% |
| | Inattention / Distraction | 570 | 2 | 2 | 17% | 16% |
| Motor Type Involved | Motorcycle | 47 | 4 | 5 | 1% | 24% |
| | Heavy Vehicle | 80 | 1 | 0 | 2% | 3% |

| Data Element | Collision Attribute | Total Collisions | Fatal Collisions (F) | Serious Injury Collisions (SI) | Percent of all Richland Collisions with this Attribute (1) | Percent of F&SI Richland Collisions with this Attribute (2) |
|---|---|---|---|---|---|---|
| Lighting Condition | Dark/Dusk/Dawn | 901 | 5 | 12 | 27% | 46% |
| Intersection | At Intersection or Intersection Related | 1,791 | 6 | 15 | 54% | 57% |
| | Signalized Intersection | 976 | 3 | 8 | 29% | 30% |
| Road User | Pedestrian Involved | 67 | 3 | 5 | 2% | 22% |
| | Cyclist Involved | 52 | 0 | 4 | 2% | 11% |
| Roadway Surface | Wet | 315 | 3 | 0 | 9% | 8% |
| | Ice | 106 | 0 | 0 | 3% | 0% |
| Age | Driver Age 16 to 25 Involved | 1,469 | 2 | 11 | 44% | 35% |
| | Driver Over Age 65 Involved | 687 | 1 | 5 | 21% | 16% |
| Restraint (Seat Belt) Usage | No Restraints Used | 44 | 2 | 4 | 1% | 16% |

*(1) For example, in Richland 32% of all collisions involved a vehicle entering at an angle.*

*(2) For example, in Richland 14% of all fatal and serious injury collisions involved roadway departure.*

*(3) As of this writing, WSDOT has identified an issue with 2020 impaired driving data and is looking into the details.*

The City identified the following notable trends from this analysis:

- Intersections are the most common type of location for collisions to occur (54% of all collisions and 57% of fatal and serious injury collisions occurred at intersections). They were generally split equally between signalized and unsignalized intersections.
    - 30% of fatal and serious injury collisions occurred at **signalized** intersections.
    - 27% of fatal and serious injury collisions occurred at **unsignalized** intersections.
- Entering at Angle is the most common collision type (32% of all collisions, and 19% of fatal and serious injury collisions).
- Nearly half (46%) of fatal or serious injury collisions occurred in dark conditions (including dusk and dawn).
- Young drivers (age 16 to 25) were involved in 44% of all collisions and 35% of fatal or serious injury collisions.
- While pedestrians and bicyclists were involved in only 4% of all collisions, pedestrians or bicyclists were involved in 33% of fatal or serious injury collisions.
    - Similarly, motorcyclists were involved in only 1% of all reported collisions, but 24% of fatal or serious injury collisions.
- Roadway departure crashes made up 9% of all collisions and 14% of fatal or serious injury collisions.

## STEP 3: SELECT MOST COMMON RISK FACTORS (COLLISION ATTRIBUTES)

Based on the findings of Step 1 and Step 2, the City identified the following collision attributes correlated with the highest frequency or severity of collisions. These collision attributes are the focus of the network analysis in Step 4:

- Vulnerable Users Involved [Pedestrians or Bicyclists]
- Entering at Angle
- Occurred at Signalized Intersection [3]
- Occurred at Unsignalized Intersections
- Roadway Departure
- Dusk/Dark/Dawn Lighting Conditions
- Motorcyclist Involved

[3] The City previously received funding for systemic signal project starting in March 2022. The project includes reflectorized backplates, Flashing Yellow Arrow conversions, completion of our Audible Pedestrian Systems (APS), new calculated clearance times and addition of Leading Pedestrian Intervals.

## STEP 4: ANALYZE ROADWAY NETWORK FOR PRESENCE OF RISK FACTORS

Following WSDOT's recommended procedure,[4] the City applied the most common risk factors in fatal/serious injury crashes to the entire network using frequency of collisions based on the most common risk factors / collision attributes.

The City mapped crash frequency based on the seven most common risk factors in fatal and serious injury crashes. The heat maps in Appendix B illustrate the locations of crashes with these attributes.

## STEP 5: CREATE PRIORITIZED LIST OF ROADWAY LOCATIONS

### 5.1 INTERSECTION AND SEGMENT PRIORITIZATION

Table 2 and Table 3 list the intersections and segments, respectively, ranked by the number of risk factors / collision attributes that the City identified. A location received 1, 2, or 3 "points" (shown in the first column, "Weighting Factors")[5] for a risk factor if it experienced a relatively high frequency of crashes with that attribute compared to the rest of the City of Richland's roadway network.

An additional 2 points were added at locations that experienced at least one fatal or serious injury crash during the study period. This is required for the location to be eligible for a spot location treatment under the WSDOT 2022 City Safety Program.

[4] WSDOT Local Road Safety Plans Guidance, https://wsdot.wa.gov/sites/default/files/2021-10/LP-Local-Road-Safety-Plan.pdf

[5] Weighting Factors were developed by the City to further prioritize certain items: roadway departure crashes, pedestrian- and bicyclist-involved crashes, locations with a history of fatal and serious injury crashes, and the supplemental EDPO and Crash Rate calculations.

**Table 2. Prioritized Intersection Safety Needs by Number of Risk Factors**

| Weighting Factor | 1 | 1 | 3 | 1 | 2 | |
|---|---|---|---|---|---|---|
| **Intersection** | **Entering at Angle** | **Dark Conditions** | **Ped/Bike** | **Motorcycle** | **At Least 1 Fatal or Serious Injury Crash** | **Weighted Total** |
| Symons Street and George Washington Way | ✓ | - | ✓ | - | ✓ | **6** |
| Symons Street and Jadwin Avenue | ✓ | | ✓ | | ✓ | **6** |
| Gage Boulevard and Leslie Road | ✓ | ✓ | ✓ | - | - | **5** |
| Jadwin Avenue and McMurray Street | ✓ | ✓ | ✓ | - | - | **5** |
| Keene Road and Queensgate Drive | ✓ | ✓ | ✓ | - | - | **5** |
| Swift Boulevard and Jadwin Avenue | ✓ | ✓ | - | - | ✓ | **4** |
| Keene Road and Duportail Street | ✓ | ✓ | - | - | ✓ | **4** |
| Aaron Drive and Wellsian Way | ✓ | ✓ | - | - | ✓ | **4** |
| Jadwin Avenue and George Washington Way | - | ✓ | - | ✓ | ✓ | **4** |

**Table 3. Prioritized Segment Safety Needs by Number of Risk Factors**

| Weighting Factor | 1 | 2 | 1 | 3 | 1 | 2 | |
|---|---|---|---|---|---|---|---|
| Segment | Entering at Angle | Roadway Departure | Dark Conditions | Ped/Bike | Motorcycle | At Least 1 Fatal or Serious Injury Crash | Weighted Total |
| George Washington Way: Jadwin Avenue to McMurray Street | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | **10** |
| Aaron Drive: Bypass Highway to Goethals Drive | - | - | ✓ | ✓ | ✓ | ✓ | **7** |
| Bellerive Drive: Gage Boulevard to Canyon Street | - | ✓ | - | ✓ | - | ✓ | **7** |
| Jadwin Avenue: Lee Boulevard to McMurray Street | ✓ | - | - | ✓ | - | ✓ | **6** |
| Van Giesen Street: Bypass Highway to Thayer Drive | - | - | - | ✓ | ✓ | ✓ | **6** |
| Duportail Street: Keene Road to Bypass Highway | ✓ | ✓ | ✓ | - | - | - | **4** |
| W Gage Blvd: Penney Royal Ave to N Steptoe Street | ✓ | ✓ | ✓ | - | - | - | **4** |
| Keene Road: Kennedy Road to Gage Blvd | - | ✓ | ✓ | - | ✓ | - | **4** |

## SYSTEMIC SAFETY NEEDS

The City identified the following safety needs for potential systemic safety improvements.

1. **Unsignalized Intersections.** In Richland, intersection collisions (signalized and unsignalized) are the most common types to occur. Unsignalized intersections (typically stop-controlled, but also including roundabouts and intersections with no traffic control devices) have experienced the following proportions: 25% of all collisions and 27% of fatal and serious injury collisions. The City has an active project to address systemic needs at signalized intersections, so this plan will focus on unsignalized intersection needs.
2. **Pedestrian Crossings.** Pedestrians were involved in only 2% of all collisions in the city, but 22% of fatal and serious injury collisions. This project would also help address bicycle collisions as well which share a high rate of fatal and serious injury collisions relative to overall collisions.
3. **Roadway Departure.** Collisions involving a vehicle that left their lane or the roadway were the next most common general collision type behind intersection crashes. The City has experienced roadway departure in the following proportions: 9% of all collisions and 14% of fatal and serious injury collisions. Systemic treatments addressing roadway departure also help reduce the potential for future head-on collisions.

# STEP 6: IDENTIFY COUNTERMEASURES TO ADDRESS PRIORITZED LOCATIONS

## 6.1 LOCATIONS FOR FURTHER ANALYSIS

The City compared the list of prioritized intersections and corridors identified in Step 5 to recent and already-funded projects to identify the most pressing safety needs, and then further analyzed collision data and existing conditions at the following locations shown in Table 4.

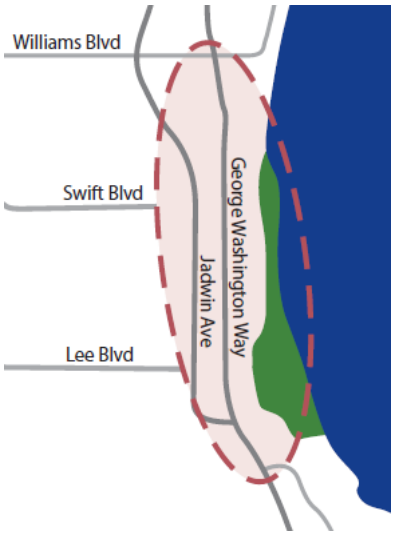
**Table 4. Prioritized Safety Study Locations for Further Analysis**

| Location | Primary Crash Patterns | Fatal or Serious Injury Collision History | Potential Countermeasures |
|---|---|---|---|
| **Stop-controlled Intersection:** Symons Street and Stevens Drive | 100% Angle collisions | 1 Serious Injury in daylight/dry conditions (alcohol involved) | Mini-roundabout, signing and marking improvements |
| **Signalized Intersection:** Symons Street and George Washington Way \| Symons Street and Jadwin Avenue (Signalized Intersection) | Rear-end, pedestrian-related, left-turns | GW: 2 SI, including 1 pedestrian-related<br>Jadwin: 1 Fatal, pedestrian-related | One-way couplet planned, Intersection Lighting, Signal Visibility Upgrades, Left-turn Signal Upgrades, Pedestrian Signal Upgrades |
| **Signalized Intersection:** Swift Boulevard and Jadwin Avenue | Angle, red-light running | 1 Serious Injury angle crash | One-way couplet planned, Clearance interval review, Automated red light enforcement, Lead Pedestrian Interval |

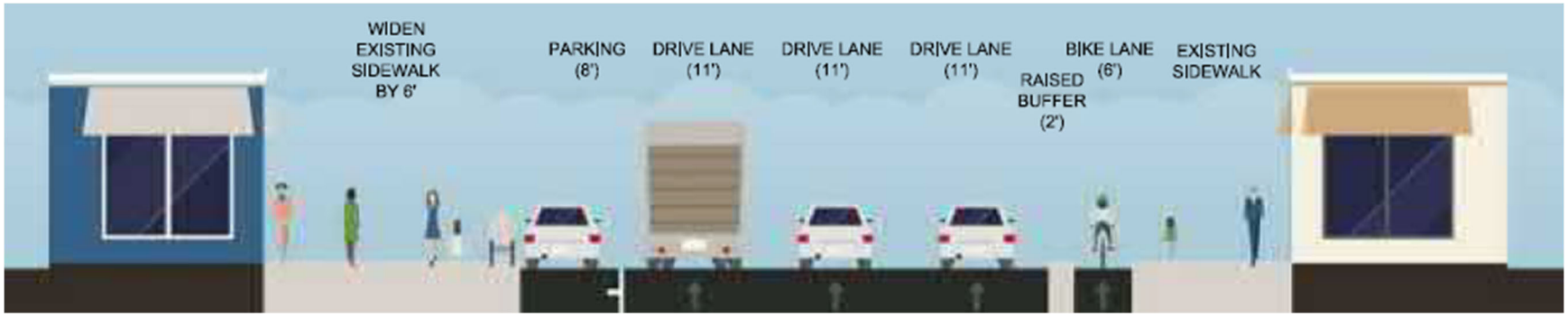
| | | | |
|---|---|---|---|
| **Signalized Intersection:** Aaron Drive and Wellsian Way | Dual right turn sideswipe, left-turns, pedestrian- and bicycle-related | 1 Serious Injury left-turning crash | Signal visibility upgrades. Advanced signal warning, Protected-only left turn phasing, Signal timing changes, Lead Pedestrian Interval |
| **Signalized Intersection:** Jadwin Avenue / George Washington Way | Congestion-related rear-ends, lane-changing sideswipes | 1 Fatal overturning crash involving speeding | Signal Coordination, Lane Use Control Upgrades, Protected-only left turn phasing |
| **Segment:** Aaron Drive: Bypass Highway to Goethals Drive | Rear-end, angle, sight distance limitations | 1 Serious Injury overturning crash | Curve warning signs, sight distance improvements |
| **Pedestrian Crossing:** Bellerive Drive: Gage Boulevard to Canyon Street | Vehicle-Pedestrian conflicts near trail crossing in a residential area | 1 Fatal pedestrian-involved crash | Enhanced warning signs, RRFB, Raised crosswalk |

## 6.2 UPCOMING ONE-WAY COUPLET: JADWIN AVE AND GEORGE WASHINGTON WAY

The City of Richland has been working since the early 2000s to improve the Central Business District, and several planning studies had been completed to develop and advance this priority. In 2018, the City Council adopted an update to its Strategic Leadership Plan with six focus areas. One of the focus areas, Increase Economic Vitality, includes an objective to improve streets to enhance walkability in the core downtown area.




The 2019 City budget included funds to advance this walkability objective with a Downtown Connectivity Study. [6] Its purpose was to advance the City Council's vision for a pedestrian-friendly waterfront and downtown, while maintaining or enhancing the vehicular travel flow through the area. The project team developed, evaluated, and prioritized street improvements downtown. The findings and recommendation formed the basis of a City Council decision to convert George Washington Way and Jadwin Avenue to one-way streets between Symons Street on the north and the George Washington Way / Jadwin Avenue intersection on the south. This conversion will enable enhancements for pedestrians, bicyclists, and on-street parking features downtown. The figure below illustrates a typical cross-section for the two corridors (cross-sections vary by street and location).




[6] https://cleargov.com/washington/benton/city/richland/projects/785/downtown-connectivity-study

Several of the high-priority intersections and segments identified during the 2022 Local Road Safety Plan development process will be significantly affected by this upcoming project. Therefore, instead of identifying additional projects along those corridors, the Local Road Safety Plan will list specific safety-related items the City and its transportation stakeholders should consider during alternatives analysis and design of the one-way couplet.

**Intersection: Symons Street and George Washington Way.** More than 30% of collisions at or near the intersection were rear-end crashes on George Washington Way, likely related to congestion at the signal. Current operation includes permissive left turn phasing in all directions. Considerations should include:

- ***Upgraded intersection lighting*** to increase visibility of vehicles, bicycles, and pedestrians at night.
- ***Signal visibility upgrades*** including signal heads (larger lenses, reflectorized back plates, supplemental signal heads) to improve driver compliance with signal indications.
- ***Left-turn signal phasing*** modifications include conversion to flashing yellow arrow (FYA) for permissive left-turns and providing permissive-protected left-turn phasing where practical.
- ***Pedestrian signal upgrades*** could include pedestrian countdown timers, disallowing permissive left-turns with a conflicting pedestrian call, and providing leading pedestrian interval (LPI) to reduce vehicle-pedestrian conflicts.

**Intersection: Symons Street and Jadwin Avenue.** Approximately 40% of collisions involved at least one vehicle entering at an angle, and five others involved a left-turning motorist. Considerations should include:

- ***Upgraded intersection lighting*** to increase visibility of all road users at night.
- ***Left-turn signal phasing*** modifications include conversion to flashing yellow arrow (FYA) for permissive left-turns and providing permissive-protected left-turn phasing where practical.

**Intersection: Swift Boulevard and Jadwin Avenue.** Of the 57 collisions, 40 were angle crashes and 20 included a vehicle disregarding the red light indication. Considerations should include:

- ***Signal Coordination.*** Improved coordination with adjacent signals could reduce system delay, which can reduce the frequency of rear-end collisions on the mainline. It can also reduce arrivals on red, which has an effect on reducing red-light running.
- ***Review of Signal Change Intervals.*** The high frequency of red-light running in crash reports could be related to signal timing. The City developed and implemented new yellow change and all-red clearance intervals citywide in late 2018 and 2019 based upon industry practices and City policy.

- ***Automated Red Light Enforcement.*** The high frequency of red-light running in crash reports could be indicative of aggressive driver behavior at this location. Automated enforcement of the red light indications could be appropriate to reduce the frequency of violations.

**Intersection: Jadwin Avenue and George Washington Way.** Of the 37 collisions 94% occurred on George Washington Way. One-third were rear-end collisions, and 10 involved same-direction sideswipes. Considerations should include:

- ***Signal Coordination.*** Improved coordination with adjacent signals along the George Washington Way corridor could reduce system delay, which can reduce the frequency of rear-end collisions on the mainline. These efforts should be balanced with impacts to pedestrian delay as it is related to cycle lengths as well since this intersection sits on the border between a 7 lane 35 mph arterial and a downtown where a shorter cycle length is necessarily employed.
- ***Lane Use Control.*** Consider additional overhead or post-mounted lane assignment signing and pavement marking to clearly indicate lane use for northbound and southbound George Washington Way motorists. Left Turn Only signs may also be placed on the back of the opposite mast arm to better align with left-turn lanes.

**Pedestrian Crossings.** The one-way couplet area is intended to have a robust set of pedestrian crossings. Locations will be determined during analysis and conceptual design.

## 6.3 LOCATION ASSESSMENT

The City reviewed each study location to identify potential treatments. Following is an assessment of those locations not along George Washington Way or Jadwin Avenue to determine appropriate considerations and next steps.

**Signalized Intersection: Aaron Drive and Wellsian Way.** This signalized T-intersection includes protected-permissive left-turn phasing (via a doghouse style signal head) for eastbound left-turning motorists. Of the 41 collisions that occurred during the study period, at least 12 involved an eastbound left-turning vehicle, including one serious injury collision. Advanced visibility of the intersection and signal indications is limited by the horizontal curve on the eastbound approach. Eight crashes occurred in the southbound dual-right-turn lane. Three reported crashes involved pedestrians or bicyclists, all resulting in possible or minor injuries.

- **Considerations and Next Steps.** When the adjacent intersection at SR 240 and Aaron Drive is reconstructed as a roundabout, southbound dual-right turns may not be necessary, and other operations and safety issues could change that should be observed before making changes. The City will consider low-cost maintenance treatments including protected-only left-turn phasing and a left-mounted supplemental signal head to address horizontal curve-related sight distance limitations.

**Segment: Aaron Drive: Bypass Highway to Goethals Drive.** This 1/3-mile segment experienced 19 non-intersection collisions during the study period, including one serious injury crash that involved an overturned vehicle. The most common collisions were rear-end and angle crashes associated with turning movements at the commercial driveways along the segment. The horizontal curve east of Bypass Highway experienced five crashes, including the overturning crash that resulted in a serious injury. Further east, Aaron Drive has a typical 5-lane urban section. The primary commercial driveway has potential sight distance limitations caused by vegetation, electrical boxes, and large decorative stones on both sides of the driveway - one of which may impact line of sight. Five collisions have occurred at this driveway during the study period.

- **Considerations and Next Steps:** The City will further study the details of collisions between Wellsian Way and SR 240 to determine in collisions in the curve were directly related to the horizontal curvature; if yes, the City will consider horizontal curve signing in that subsegment. In the east subsegment, the City will continue to monitor potential sight distance obstructions for motorists as they leave the commercial property. Future improvements planned for SR 240 and Aaron Drive may allow for changes at Wellsian Way and Aaron that would also reduce crashes.

**Pedestrian Crossing: Bellerive Drive: Gage Boulevard to Canyon Street.** This trail crossing has experienced three reported crashes during the study period. In two situations a pedestrian was struck, and one of those pedestrians was killed in the collision. The third involved a vehicle stopped at the crossing (waiting for a pedestrian) that was rear-ended by another vehicle.

The northbound approach to the crossing is a 700-foot downhill vertical curve from Gage Boulevard. Southbound vehicles approach from a residential neighborhood; there is some horizontal curvature, but the roadway is tangent for 350 feet in advance of the curve. Current pavement markings and signs include an advanced Pedestrian Crossing Warning sign in each direction, a standard Pedestrian Crossing sign and diagonal down arrow at the crossing, and a ladder-style crosswalk. There is no lighting at the crosswalk, but there are overhead street lights approximately 120 feet north and 170 feet south of the crossing. For bicyclists and pedestrians on the trail, a pedestrian-style STOP sign is present on both sides.

- **Considerations and Next Steps:** Treatments may include enhanced warning signs, RRFBs, and a raised crosswalk. The City added this location to the systemic pedestrian crossing application for 2022 City Safety Program funding.

## STEP 7: DEVELOP A PRIORITIZED LIST OF PROJECTS

Upon completion of the crash data analysis, identification of potential countermeasures, and comparison with recently-completed and planned project locations, the City selected the priority safety projects shown in Table 5.

**Table 5. Richland Safety Projects to Pursue**

| Prioritized Location or Systemic Collision Type | Safety Project | Next Step |
|---|---|---|
| 1. Systemic Stop-controlled Intersections | Low-cost Signing and pavement marking improvements; Advanced Intersection Warning System; low-cost curb extensions; mini roundabouts. | Apply for 2022 WSDOT City Safety Program grant funding |
| 2. Systemic Pedestrian Crossings | Marked crosswalks, advanced warning signs, Rectangular Rapid Flashing Beacons (RRFBs) | Apply for 2022 WSDOT City Safety Program grant funding |
| 3. Systemic Roadway Departure: Citywide Horizontal Curves | Horizontal Curve Signing | Apply for 2022 WSDOT City Safety Program grant funding |

The following sections detail existing conditions, countermeasures, estimated project costs, monetary value of estimated safety benefits, and the estimated benefit/cost ratio of each recommended safety project. The projects are organized by City priority, with the highest-priority project first.

## PRIORITY 1: SYSTEMIC STOP-CONTROLLED INTERSECTIONS

**Identified Safety Needs.** In Richland, intersection collisions (at or related to signalized and unsignalized intersections) are the most common types to occur for all crash severities. Approximately 27% of fatal and serious injury collisions occurred at unsignalized intersections or were intersection-related, and 25% of all collisions occurred at intersections or were intersection-related. In particular, a considerable number of two-way stop-controlled (TWSC) intersections experience a reasonably high collision frequency and rate in the City of Richland.

**Potential Safety Treatments.** Some of the low-cost systemic treatments that may mitigate these issues include:

- Doubled-up stop signs
- Retroreflective post sleeves
- "Cross Traffic Does Not Stop" plaques under the stop signs
- Additional pavement marking
- Double-wide stop bars
- Fluorescent yellow sign sheeting
- Advance intersection warning signs with street name plaques
- Oversize warning and regulatory signs
- Raised median on the side street

At particular locations, more advanced safety needs may necessitate one or more of the following enhanced treatments:

- Advance Intersection Warning System
- Low-cost Mini-roundabouts
- Low-cost Curb extensions (signs, delineators, "tough curb")

Figure 5 illustrates low-cost curb extension that provides space for moving Stop signs closer to the road and reduces crossing distances for pedestrians.

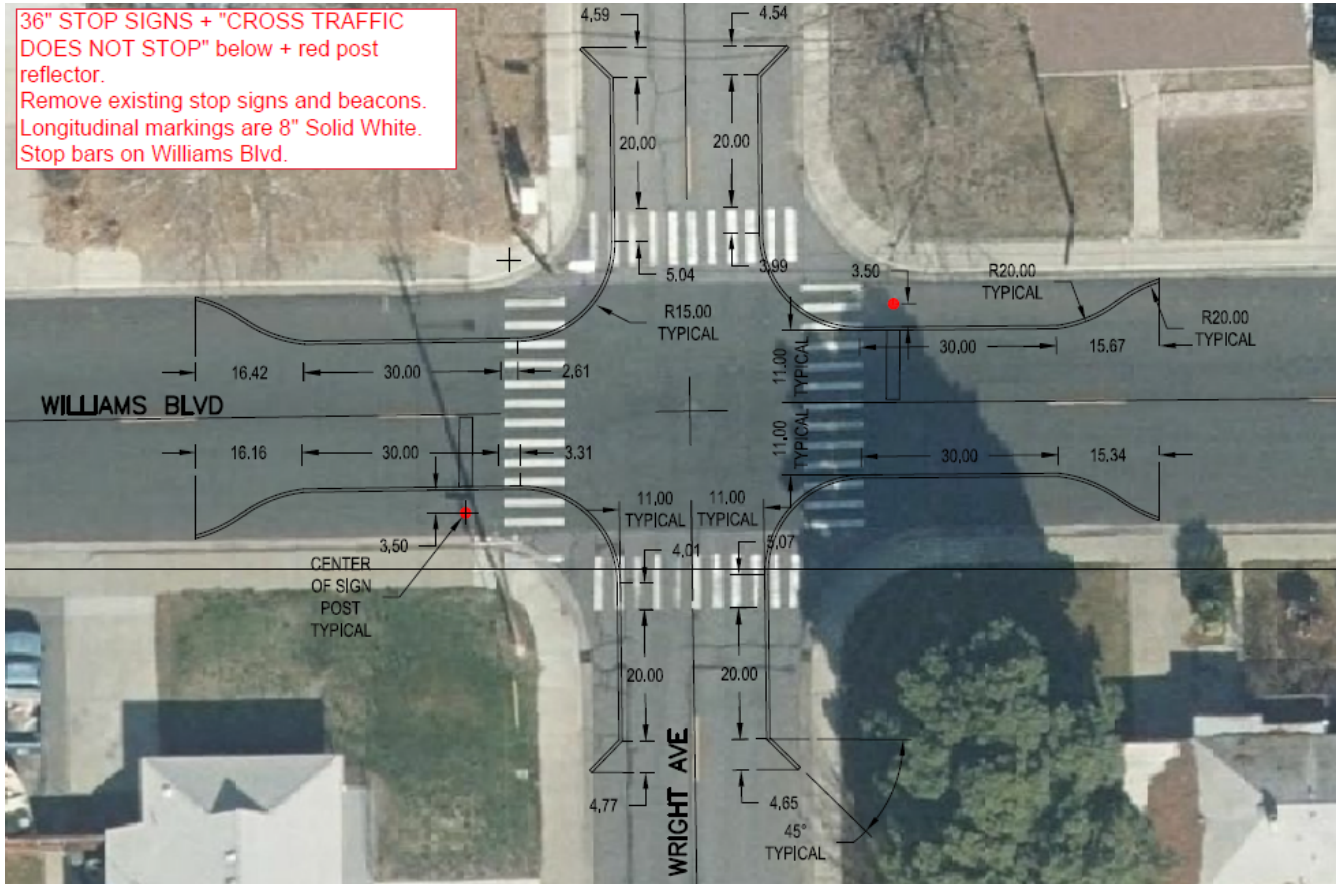



**Figure 5. Low-cost Signing and Marking Treatments with Low-cost Curb Extensions**

Another critical component for stop controlled intersections is to make sure that the necessary sight distance triangles are maintained, and that vegetation does not obstruct the necessary sight lines or the signage. The City of Richland has recently updated the intersection Sight Distance Code (RMC Chapter 12.11) and has included a new section to cover the obstruction of traffic control devices.

**Mini Roundabouts.** Available pavement at select location make it feasible for a mini roundabout installation. Roundabouts are a proven countermeasure to reduce the frequency and severity of intersection crashes by reducing operating speeds and flattening the angle of conflict. It will be important for this design to accommodate truck and transit vehicle movements.

The City proposes installation of mini roundabouts at the following locations:

- Thayer Drive and Williams Boulevard
- Stevens Drive and Symons Street
- Swift Boulevard and Wright Street
- Thayer Drive and Symons Street
- Canyon Street and Bellerive Drive/Status Street

To address the safety risks at intersections and the low cost of the recommended treatments, the City proposes a combination of these treatments at the stop-controlled intersections listed below. The locations are prioritized by calculating crash rates per total entering volume and Equivalent Property Damage Only (EPDO) weighted crash frequency (see details in Appendix C

**Table 6. Systemic Stop-controlled Treatment Locations**

| Location | | Treatments | | | |
|---|---|---|---|---|---|
| | | Low-cost Signing and Pavement Marking | Actuated Advanced Intersection Warning | Mini Roundabout | Low-cost Curb Extensions |
| 1 | Thayer Drive and Williams Boulevard | ✓ | | ✓ | |
| 2 | Stevens Drive and Symons Street | ✓ | | ✓ | |
| 3 | Wright Street and Williams Boulevard | ✓ | | | ✓ |
| 4 | Goethals Drive and Torbett Street | ✓ | | | ✓ |
| 5 | Wright Street and Lee Boulevard | ✓ | | | ✓ |
| 6 | Duportail Street and Kennedy Road | ✓ | ✓ | | |
| 7 | Swift Boulevard and Wright Street | ✓ | | ✓ | |
| 8 | Columbia Park Trail and Leslie Road | ✓ | ✓ | | |
| 9 | Thayer Drive and Symons Street | ✓ | | ✓ | |
| 10 | Goethals Drive and Symons Street | ✓ | | | |
| 11 | Canyon Street and Bellerive Drive/Satus Street | ✓ | | ✓ | |
| 12 | Steptoe Street and Canyon Street | ✓ | ✓ | | |

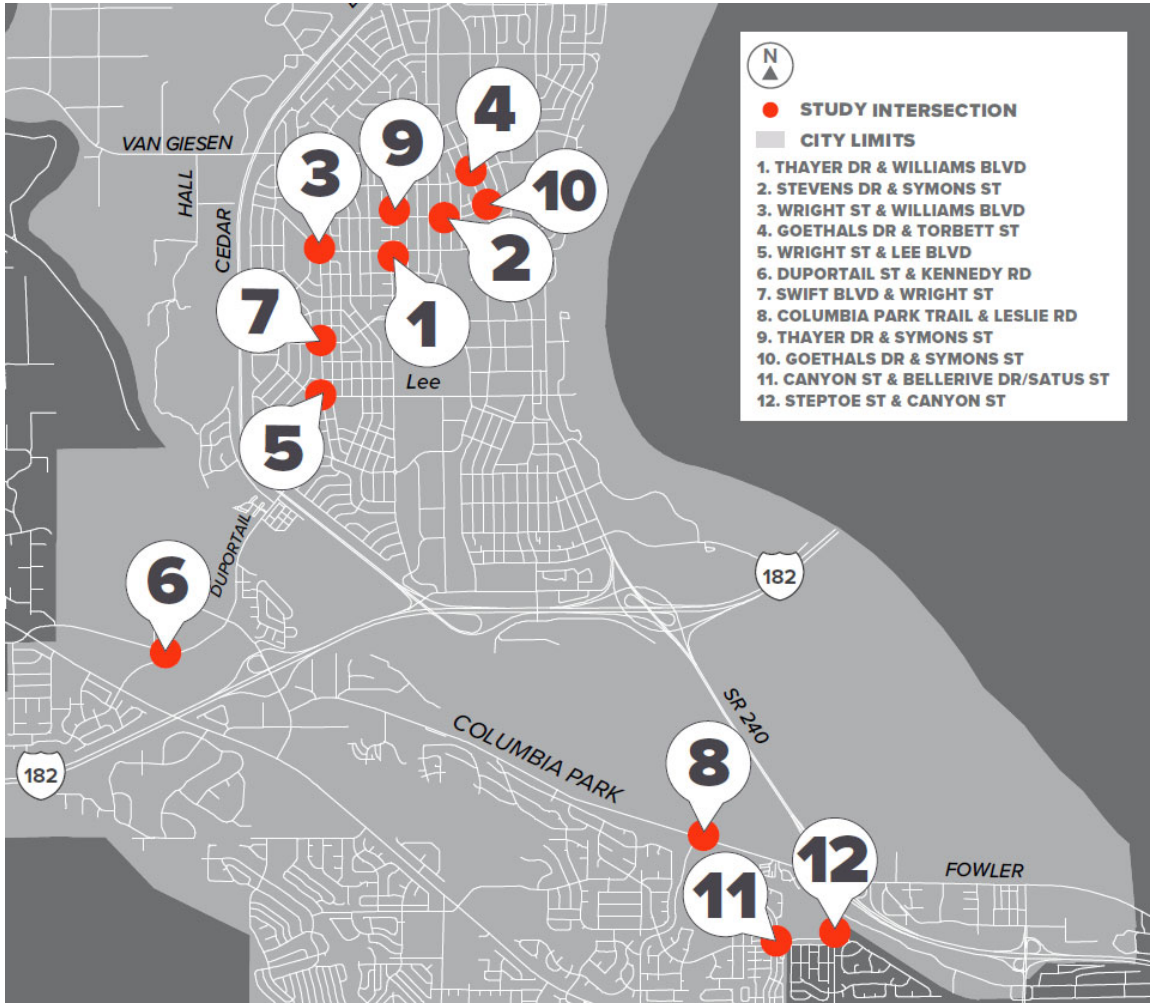



**Figure 6. Systemic Stop-Controlled Intersection Locations**

**Richland Systemic Stop-Controlled Intersection Safety Countermeasures and Five Mini Roundabouts**

**Project Description**

Install upgraded signing and pavement marking. At select locations add Actuated Advance Warning Beacons or Low-Cost Curb Extensions.

At five locations add mini roundabout.

**Cost Estimate**

$2,178,000

Benefit / Cost Ratio

16.35

Time Frame

Short-term

Medium-term

Crash Reduction

~70%

**Combined reduction for the treatments described.**

**History:** 164 intersection collisions at the selected intersections from 2016-2020, including 2 suspected serious injury.

**Expected Benefit:** 23 fewer crashes per year

## PRIORITY 2: SYSTEMIC PEDESTRIAN CROSSINGS

Pedestrians are the most vulnerable users of the transportation system, especially when crossing the street. While pedestrian-involved collisions in Richland comprised only 2% of all crashes, 22% of fatal and serious injury collisions during the study period involved a pedestrian.

**Potential Safety Treatments.** All intersections have legal crosswalks, marked or not (unless posted otherwise), and the treatments selected for these crosswalks vary. Several enhanced treatments (e.g., signing, striping, flags, medians) are used in Richland. The City uses guidance from FHWA on selection of treatments as well as crosswalk warrant information developed by Boulder, Colorado and implemented by many other agencies to make decisions about crosswalks and crosswalk treatments.

Typical treatments are striping, signing, protective medians, or Rectangular Rapid Flashing Beacons (RRFB). Pedestrian Hybrid Beacons (PHBs) are an even higher level pedestrian crossing that provides more positive pedestrian control at higher volume locations while also being capable of integrating into a coordinated traffic signal system. The City considers a variety of treatments and when those treatments may be most appropriate based on pedestrian volumes, vehicle volumes, transit volumes, number of lanes crossed, travel speed, and roadway functional classification. It should also ensure that proper lighting is considered for

crosswalks. At this time, the City is reviewing crosswalk locations on surfacing projects to decide if all crosswalks will be replaced or if some will be consolidated. The city is also aggressively pursuing crosswalk upgrades, typically RRFB installation via grant projects and capital projects.

**Figure 7. Example Pedestrian Crossing Treatments**

For the 2022 City Safety Program, Richland proposes pedestrian crossing treatments at the following locations. See Appendix D for the full pedestrian crossing ranking matrix and individual site details, and Figure 8 below for a vicinity map of these crossings.

1. Jadwin Avenue at Catskill Street
2. Aaron Drive and Jadwin Avenue
3. Stevens Drive at Mansfield Street
4. Van Giesen Street and Birch Avenue
5. Leslie Road just south of Mattis Drive
6. Gage Boulevard west of Venus Circle
7. George Washington Way at Torbett Street
8. Columbia Center Boulevard and Fowler Street
9. Leslie Road and Center Parkway / Lorayne J Boulevard
10. Stevens Drive at Knight Street
11. Lee Boulevard at Goethals Drive
12. Columbia Point east of WinCo Primary Driveway
13. Thayer Drive and Long Avenue
14. McMurray Street & Pike Avenue
15. Bellerive Drive at path crossing north of Gage Boulevard
16. Knight Street at The Parkway

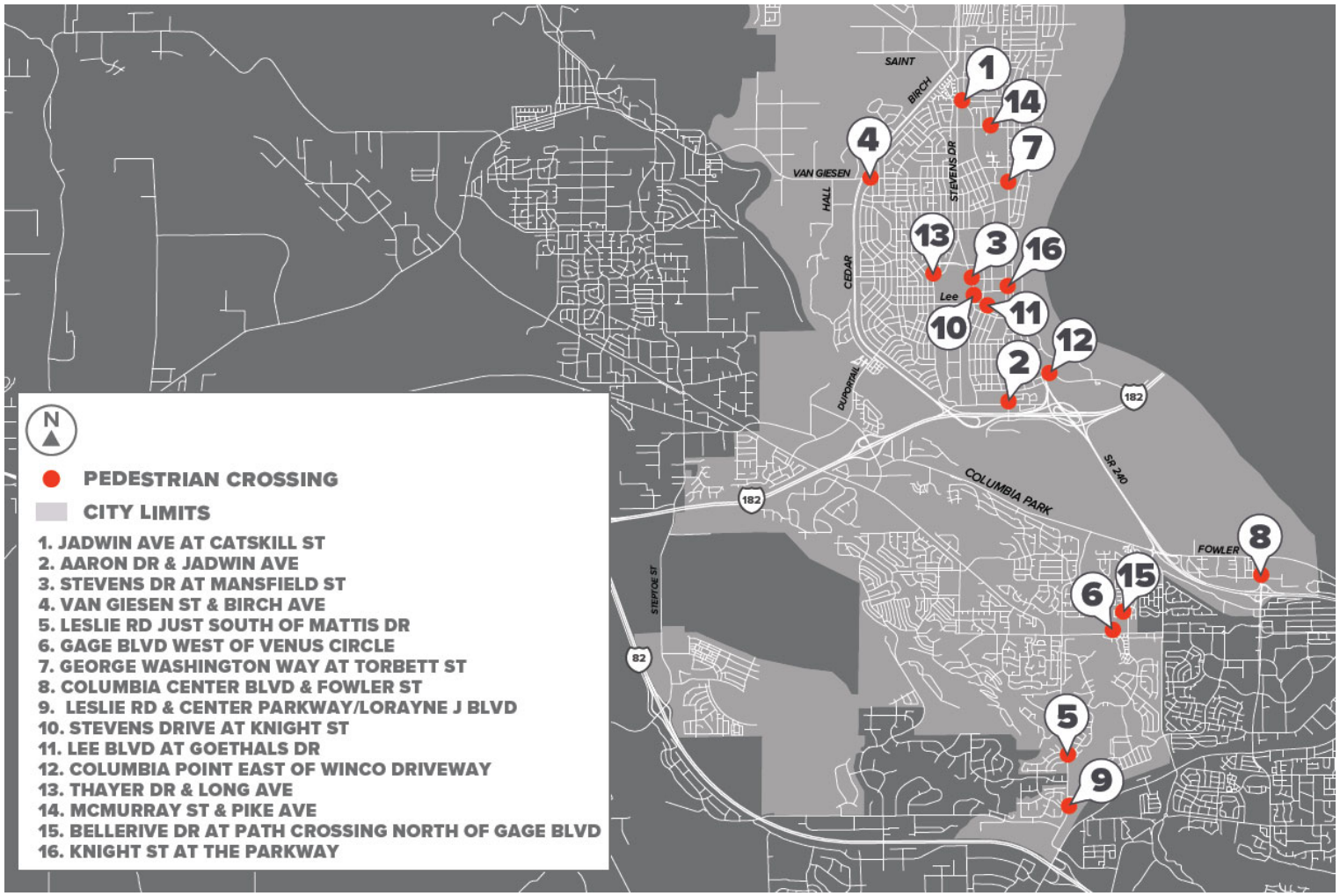



**Figure 8. Systemic Pedestrian Crossing Locations**

**Richland: Systemic Pedestrian Crossing Countermeasures**

**Project Description**

Install upgraded signing and pavement marking and Rectangular Rapid Flashing Beacons (RRFBs).

**Cost Estimate**

$1,124,000

Benefit / Cost Ratio

9.81

Time Frame

Medium-term

Crash Reduction

~54%

**Reduction in pedestrian collisions.**

**History:** 3 pedestrian collisions at the selected crossings from 2016-2020.

**Expected Benefit:** 0.32 fewer pedestrian crashes per year

## PRIORITY 3: CITYWIDE HORIZONTAL CURVE SIGNING

While roadway departure collisions were a less-common collision type than some other cities, 14% of fatal and serious injury collisions involved a vehicle departing its lane. Additionally, Richland experienced a higher proportion of crashes occurring on horizontal curves than other Eastside Cities, as follows:

**Table 7. Horizontal Curve Proportion Comparison: Richland to Eastside Cities**

| | Fatal/Serious Injury Crash Proportion | | Total Crash Proportion | |
|---|---|---|---|---|
| | Eastside Cities | Richland | Eastside Cities | Richland |
| **Horizontal Curve or Horizontal Curve & Grade** | 10.7% | 14.3% | 5.9% | 8.9% |

The City proposes horizontal curve safety improvements for two important reasons. First, motorists are more than three times as likely to be involved in a collision on a curve than a tangent section. Second, the most recent MUTCD (2009) included a legal requirement for every publicly-owned road with 1,000+ vehicles per day to meet horizontal curve requirements by December 31, 2019.

The City of Richland has captured advisory speeds (e.g., "ball bank speeds") for all city streets, so this safety project will provide current MUTCD standard curve warning signs at all horizontal curves on arterials and major collectors in the city limits (approximately 70 curves).

- Assess Existing Conditions
  - Calculate the difference between previously-collected advisory speed and the posted speed limit (per MUTCD)
- Design signing treatments
  - Determine the required (shall) and recommended (should) sign package for each curve per MUTCD Table 2C-5 (e.g., advanced warning sign, advisory speed plaque, chevrons, and/or one direction large arrow).
  - Confirm sign placement feasibility via field review
  - Produce plans, specifications, and estimates (PS&E) for curve signing
- Install horizontal curve warning signs

**Richland: Citywide Horizontal Curve Safety Improvements**

Project Description

Provide current MUTCD standard curve warning signs or enhanced warning treatments at all horizontal curves and turns on arterials and major collectors

Cost Estimate

$589,000

Benefit / Cost Ratio

23.06

Time Frame

Short-term

Crash Reduction

15% Injury

7% Property Damage Only

**History:** 336 curve crashes observed from 2016-2020.

**Expected Benefit:** 5.76 fewer crashes per year

# APPENDICES

**Appendix A: Grant Programs**

**Appendix B: Collision Heat Maps**

**Appendix C: Stop-controlled Intersections Prioritization Table**

**Appendix D: Pedestrian Crossing Prioritization Table**

**Appendix E: Safety Countermeasures Toolbox**

## APPENDIX A: GRANT PROGRAMS

Cities may be eligible to submit projects based on this safety analysis to the following grant programs.

**WSDOT City Safety Program.** WSDOT Local Programs sends out a call for projects each even-numbered year. This program's funding is for projects enhancing safety on city streets by reducing the severity of crashes and utilizing transportation engineering improvements and countermeasures. https://wsdot.wa.gov/LocalPrograms/Traffic/CitySafetyProgram

**WSDOT Pedestrian and Bicycle Program.** WSDOT Active Transportation Program sends out a call for projects each even-numbered year. The Pedestrian and Bicycle Program objective is to improve the transportation system to enhance safety and mobility for people who choose to walk or bike. https://wsdot.wa.gov/LocalPrograms/ATP/funding.htm

**WSDOT Safe Routes to School Program.** WSDOT sends out calls early in even numbered years for project awards in the following biennium. The purpose of the Safe Routes to Schools program is to improve safety and mobility for children by enabling and encouraging them to walk and bicycle to school. Funding from this program is for projects within two-miles of primary, middle, and high schools (K-12). https://wsdot.wa.gov/LocalPrograms/SafeRoutes/funding.htm

**WSDOT Railway-Highway Crossings Program.** Open call for projects depends on future federal funding and Washington State priorities. This program's funding is for projects enhancing safety at public grade crossings by reducing the severity of crashes and installing or upgrading protective mechanisms at railroad crossings. https://wsdot.wa.gov/localprograms/traffic/railway-crossings-program

**Transportation Improvement Board (TIB) Complete Streets.** The Complete Streets Award is a funding opportunity for local governments that have an adopted complete streets ordinance. Board-approved nominators may nominate an agency for planning and building streets to accommodate all users, including pedestrians, access to transit, cyclists, and motorists of all ages and abilities. http://www.tib.wa.gov/grants/grants.cfm?inav=3#other2

**Surface Transportation Block Grant (STBG).** Benton-Franklin Council of Governments (BFCG) funds a variety of projects in both urban and rural areas of Benton and Franklin Counties. The flexibility inherent in STBG means that most types of transportation projects. Project sponsors eligible to receive STBG funds include cities, counties, and Ben Franklin Transit. Roadway projects must be located on federal-aid routes. Projects located on rural minor collectors and local roads are ineligible. Eligible safety-related projects include bicycle and pedestrian facilities (including trails), modification of sidewalks to comply with the Americans with Disabilities Act, highway and transit safety projects, hazard eliminations, and railway/highway grade crossings. https://bfcog.us/wp-content/uploads/2020/01/2020-Call-for-Projects-Guidebook.pdf

**STBG Set-Aside / Transportation Alternatives Program (TAP).** BFCG will consider all eligible project types equally in this TAP grant process. However, BFCG typically has invested TAP funds in bicycle and pedestrian projects and programs. Eligible projects and activities include:

- Planning, design, and construction of on-road and off-road trail facilities for pedestrians, bicyclists, and other non-motorized forms of transportation, including sidewalks, bike infrastructure, pedestrian and bicycle signals, traffic calming techniques, lighting, and other safety-related infrastructure, and transportation projects to achieve compliance with the Americans with Disabilities Act of 1990.
- Planning, design, and construction of infrastructure-related projects and systems that will provide safe routes for non-drivers, including children, older adults, and individuals with disabilities to access daily needs.

https://bfcog.us/wp-content/uploads/2020/01/2020-Call-for-Projects-Guidebook.pdf

## APPENDIX B: COLLISION HEAT MAPS

Figure B1 illustrates that **Entering at Angle Collisions** occur at most intersections in the city. There are several clusters of collisions of locations where this collision type occurred the most often. Examples include:

- Swift Boulevard and Jadwin Avenue intersection
- Williams Boulevard and Wright Avenue intersection
- N Steptoe Street and Canyon Street intersection
- Duportail Street: Keene Road to Queensgate Drive
- George Washington Way: Falley St to University Drive

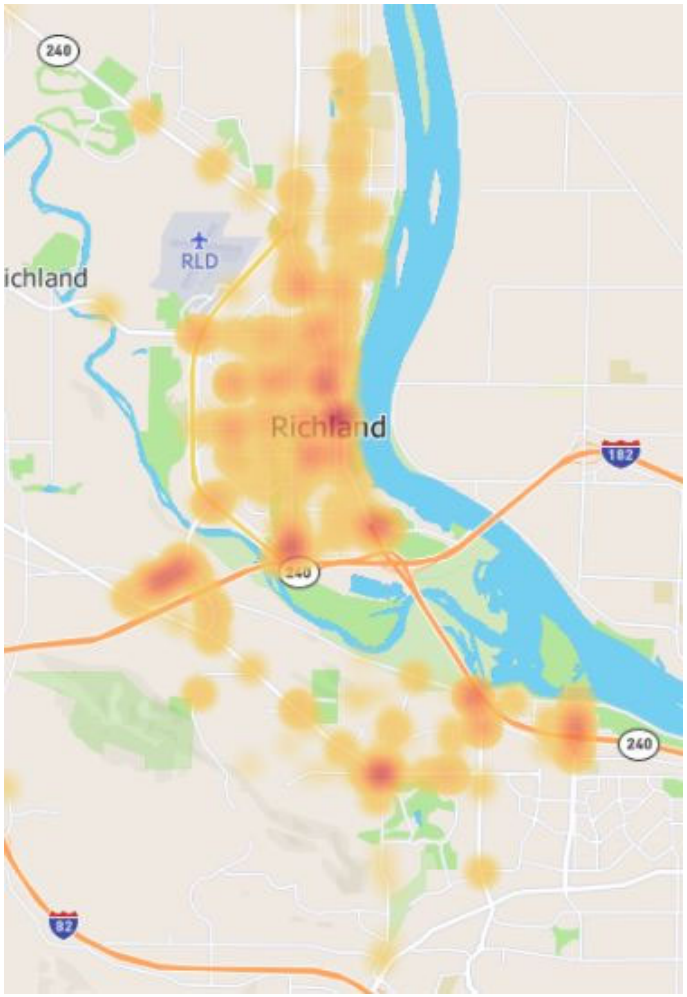



**Figure B1. Heat Map of Entering at Angle Collisions, Richland, 2016-2020.**

The City of Richland maintains and operates 54 signalized intersections within the city limits.

Figure B2 shows the priority locations with the highest frequency of collisions at signalized intersections in the city.

- Swift Boulevard and Jadwin Avenue
- Williams Boulevard and Jadwin Avenue
- Gage Boulevard and Leslie Road
- Keene Road and Duportail Street
- Duportail Street and Queensgate Drive
- Aaron Drive and Wellsian Way
- Jadwin Avenue and Van Giesen Street
- Jadwin Avenue and McMurray Street
- Keene Road and Queensgate Drive

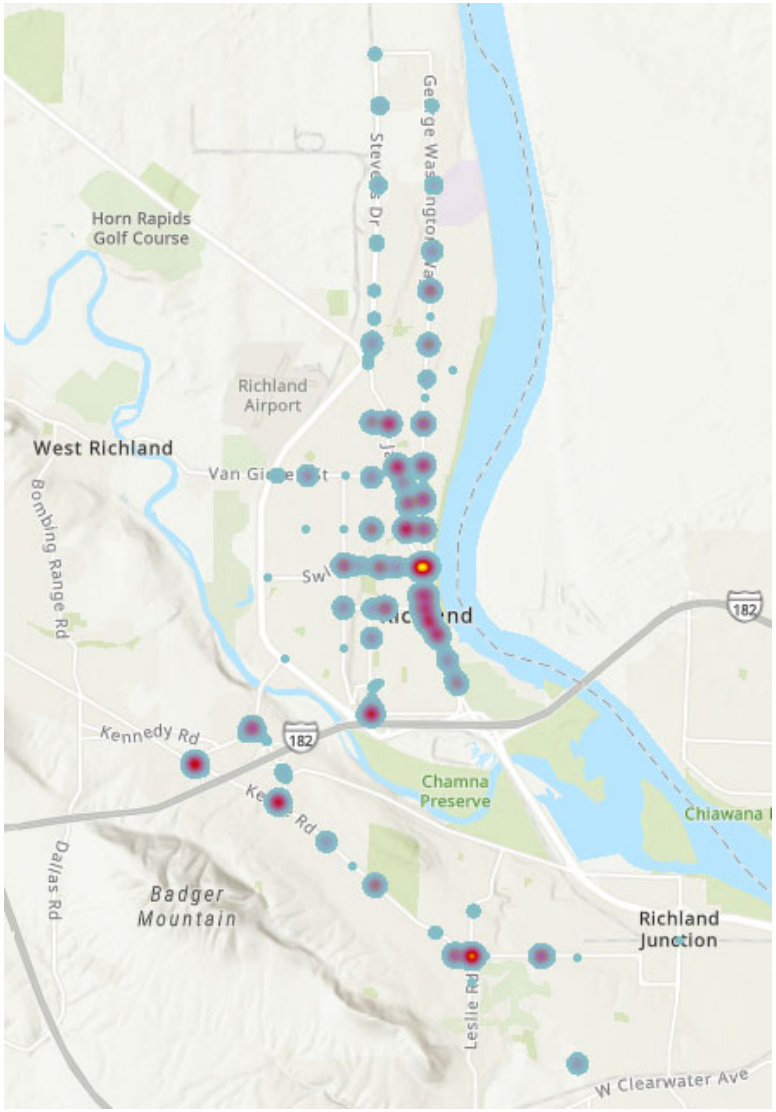



**Figure B2. Heat Map of Collisions at Signalized Intersections, Richland, 2016-2020.**

Figure B3 shows the areas in Richland where roadway departure collisions occurred at the greatest frequency. Several locations show clusters of roadway departure collisions, including these intersections and segments.

- Columbia Park Trail and Leslie Road intersection
- N Steptoe Street and Tapteal Drive intersection
- George Washington Way: Jadwin Avenue to Williams Boulevard
- Keene Road: Kennedy Road to Gage Blvd
- Bellerive Drive: Gage Boulevard to Canyon Street
- Thayer Drive: Lee Boulevard to Swift Boulevard

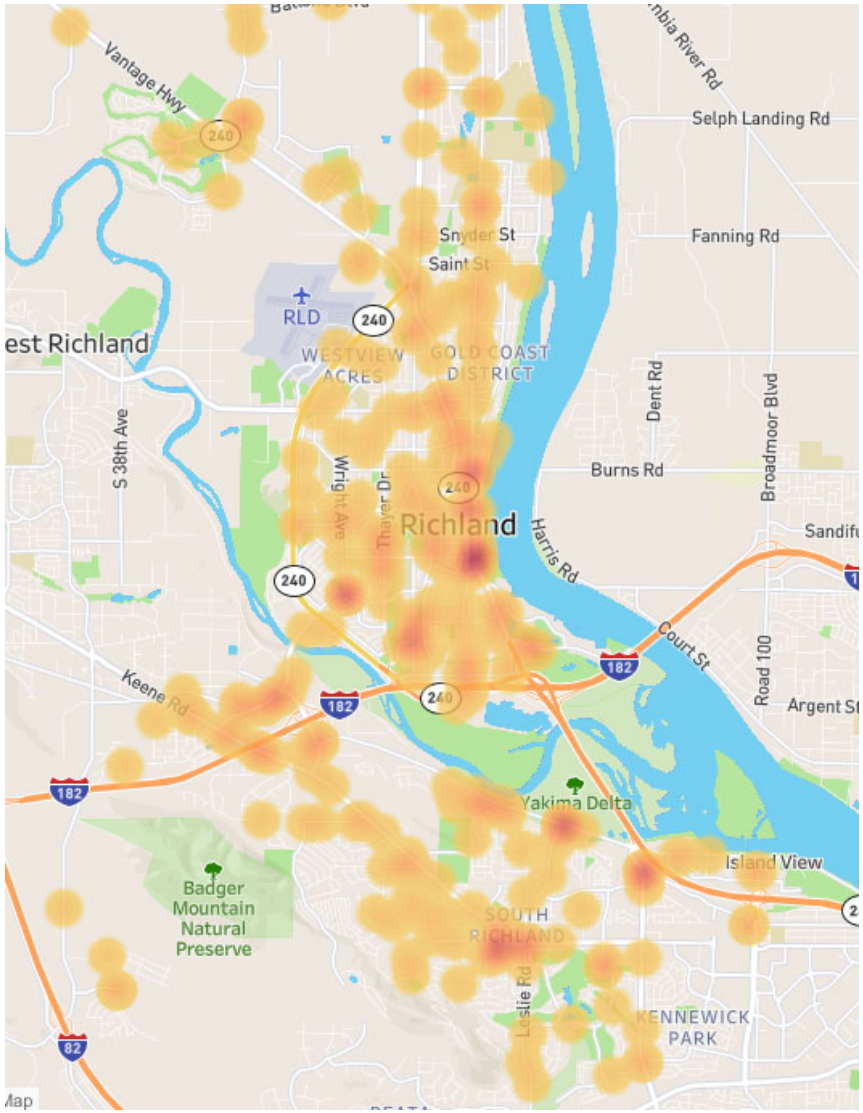



**Figure B3. Heat Map of Roadway Departure Collisions, Richland, 2016-2020.**

Figure B4 presents the heat map of all the collisions occurring in dark, dusk, or dawn conditions. There was a high concentration of dark crashes at the following intersections and along these corridors, among others.

- Swift Boulevard and Jadwin Avenue intersection
- Gage Boulevard and Leslie Road intersection
- N Steptoe Street and Canyon Street intersection
- Keene Road and Duportail Street intersection
- Jadwin Avenue and McMurray Street intersection
- N Steptoe Street: Canyon Street to Columbia Park Trail
- W Gage Blvd: Penney Royal Ave to N Steptoe St
- George Washington Way: Falley Street to University Drive

The City also analyzed a spatial distribution (heat map) of the 17 fatal or serious injury collisions occurring in dark conditions, and did not identify any specific hot spots or patterns.

The City is completing a street lighting retrofit in 2022 that includes a consistent lighting standard.

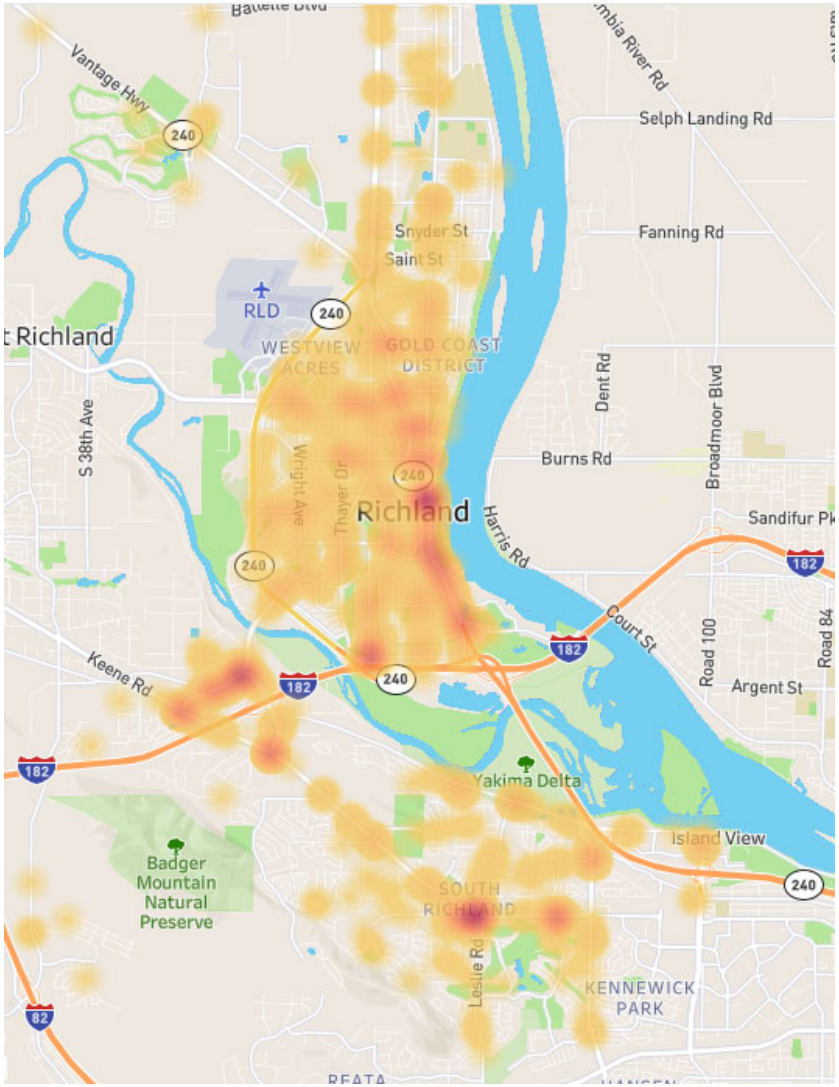



**Figure B4. Heat Map of Collisions in Dark, Dusk, or Dawn Conditions, Richland, 2016-2020**

There were 67 pedestrian-involved collisions and 52 bicyclist-involved collisions during the study period. Figure B5 displays a heat map of all the pedestrian-involved collisions to help identify areas where they occur most often. Figure B6 displays a heat map of bicyclist-involved collisions for the same purpose. The following locations are a sample of those that experienced the most pedestrian or bicyclist collisions in Richland.

- Gage Boulevard and Leslie Road intersection
- Jadwin Avenue and McMurray Street intersection
- Van Giesen Street and Birch Avenue intersection
- George Washington Way: Falley Street to University Drive
- N Steptoe Street: Canyon Street to Columbia Park Trail

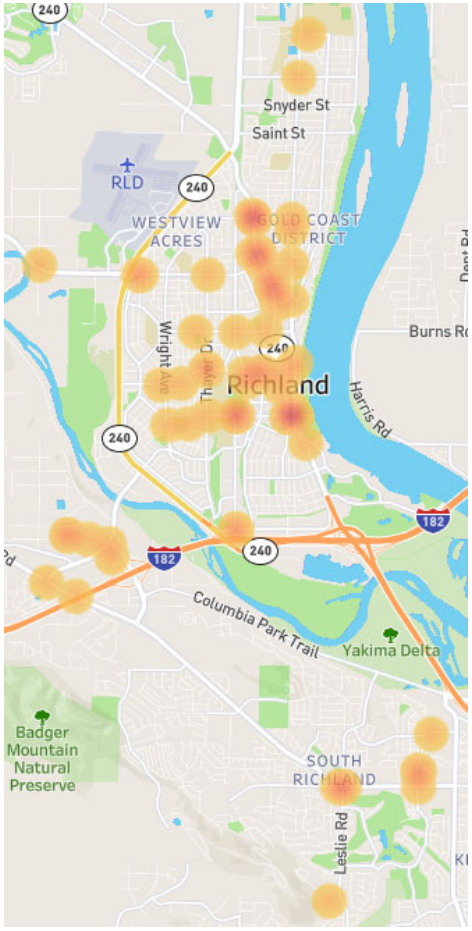



**Figure B5. Heat Map of Collisions Involving Pedestrians, Richland, 2016-2020.**

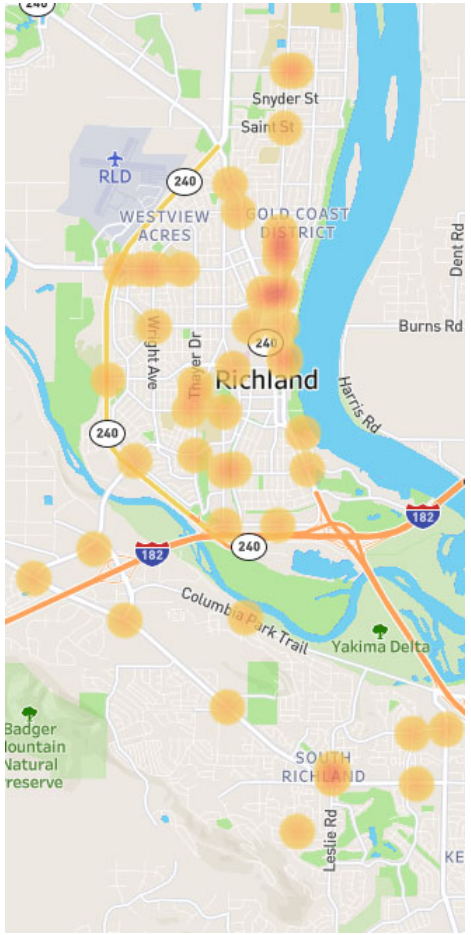



**Figure B6. Heat Map of Collisions Involving Bicyclists, Richland, 2016-2020.**

There were 47 motorcyclist-involved collisions during the study period. Figure B7 displays a heat map of all motorcyclist-involved collisions to identify intersections and segments with a high frequency of this attribute. The most common locations for motorcycle-involved crash events were the following:

- Jadwin Avenue / Harding Street and George Washington Way intersection
- George Washington Way: Falley Street to University Drive
- Keene Road: Kennedy Road to Gage Blvd
- N Steptoe Street: Canyon Street to Columbia Park Trail
- Van Giesen St: Bypass Highway to Thayer Drive
- Aaron Drive: Bypass Highway to Goethals Drive

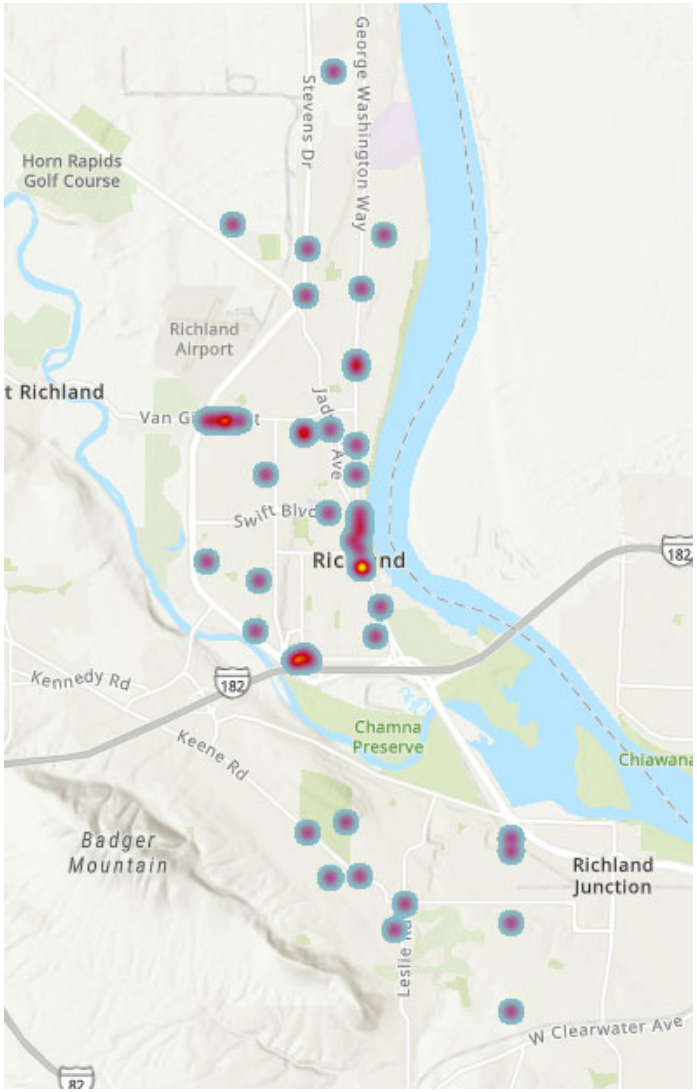



**Figure B7. Heat Map of Collisions Involving Motorcyclists, Richland, 2016-2020.**

## APPENDIX C: STOP-CONTROLLED INTERSECTION PRIORITIZATION METHOD

The information in this the table below is generated using the City's third party crash management system provider MS2. Average Daily Traffic (ADT) data from the biennial traffic count contract (provided by the Benton-Franklin Council of Governments) is used to develop rates normalized based upon traffic volumes, and an Equivalent Property Damage Only (EPDO) score is added to weight collision severity. The City has found a fair balance for rankings assessments to be a combination of the standard Crash Rate Ranking added to the EPDO ranking and then sorting based upon the sum. A combined ranking is shown based on the sum of these two ranks and is in the yellow highlighted column.

## Table C1. High Crash Two-Way Stop-Controlled Intersections, City of Richland, 2016-2020

| Primary | Secondary | Control | Fatal or Serious | 2016-2020 Total Crashes | 2016-2020 Crash Rank | Annual Average Crashes | Crash Rate | Crash Rate Ranking | Annual Average EPDO | EPDO Rank | Sum of Crash Rate + EPDO Rank | Rank by Sum of Crash Rate + EPDO | Average Annual Societal Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Columbia Center Blvd | Fowler St | TWSC | | 29 | 1 | 5.8 | 1.26 | 6 | 26.9 | 10 | 16 | 1 | $ 397,900 |
| Thayer Dr | Williams Blvd | TWSC | | 20 | 8 | 4.0 | 1.72 | 3 | 18.6 | 13 | 16 | 1 | $ 275,740 |
| Stevens Dr | Symons St | TWSC | Yes | 9 | 25 | 1.8 | 0.73 | 13 | 50.9 | 4 | 17 | 3 | $ 752,880 |
| Wright St | Williams Blvd | TWSC | | 21 | 6 | 4.2 | 2.10 | 1 | 15.4 | 16 | 17 | 3 | $ 227,700 |
| Goethals Dr | Torbett St | TWSC | Yes | 2 | 56 | 0.4 | 0.88 | 12 | 46.5 | 7 | 19 | 5 | $ 687,640 |
| Wright St | Lee Blvd | TWSC | | 11 | 20 | 2.2 | 1.09 | 8 | 16.4 | 15 | 23 | 6 | $ 242,620 |
| Columbia Park Trl | Columbia Center Blvd | TWSC | | 12 | 17 | 2.4 | 0.94 | 10 | 15.3 | 17 | 27 | 7 | $ 226,560 |
| Duportail St | Kennedy Rd | TWSC | | 22 | 5 | 4.4 | 0.66 | 15 | 20.3 | 12 | 27 | 7 | $ 300,680 |
| Goethals Dr | Fitch St | TWSC | Yes | 4 | 44 | 0.8 | 0.51 | 21 | 48.6 | 6 | 27 | 7 | $ 719,060 |
| George Washington Way | Snyder St | TWSC | Yes | 12 | 17 | 2.4 | 0.43 | 27 | 59.6 | 1 | 28 | 10 | $ 882,780 |
| Swift Blvd | Wright St | TWSC | | 24 | 3 | 4.8 | 1.18 | 7 | 10.0 | 27 | 34 | 11 | $ 147,540 |
| Steptoe St | Canyon St | TWSC | | 23 | 4 | 4.6 | 0.45 | 26 | 27.4 | 9 | 35 | 12 | $ 405,640 |
| Duportail St | Cottonwood Dr | TWSC | | 11 | 20 | 2.2 | 0.66 | 17 | 11.2 | 21 | 38 | 13 | $ 166,120 |
| Steptoe St | Tapteal Dr | TWSC | Yes | 16 | 12 | 3.2 | 0.34 | 36 | 54.0 | 2 | 38 | 13 | $ 799,100 |
| Jadwin Ave | Catskill St | TWSC | | 13 | 15 | 2.6 | 0.53 | 20 | 11.6 | 19 | 39 | 15 | $ 172,040 |
| Duportail St | Vintner's Square | TWSC | | 18 | 10 | 3.6 | 0.47 | 24 | 14.3 | 18 | 42 | 16 | $ 212,340 |
| Columbia Park Trl | Leslie Rd | TWSC | | 19 | 9 | 3.8 | 0.72 | 14 | 9.0 | 31 | 45 | 17 | $ 132,740 |
| Saint St | Davison Ave | TWSC | | 5 | 36 | 1.0 | 1.37 | 4 | 5.7 | 41 | 45 | 17 | $ 84,820 |
| Columbia Center Blvd | Tapteal Dr/Arrowhead Ave | TWSC | Yes | 27 | 2 | 5.4 | 0.35 | 35 | 21.8 | 11 | 46 | 20 | $ 321,960 |
| Thayer Dr | Symons St | TWSC | | 6 | 31 | 1.2 | 0.98 | 9 | 5.9 | 40 | 49 | 21 | $ 87,780 |
| George Washington Way | Benham St | TWSC | | 21 | 6 | 4.2 | 0.28 | 41 | 27.4 | 8 | 49 | 21 | $ 406,200 |
| Goethals Dr | Symons St | TWSC | | 6 | 31 | 1.2 | 1.93 | 2 | 4.2 | 47 | 49 | 21 | $ 62,280 |
| George Washington Way | Newton St | TWSC | | 18 | 10 | 3.6 | 0.30 | 38 | 18.2 | 14 | 52 | 24 | $ 269,820 |
| Wellsian Way | Lawless Dr | TWSC | | 13 | 15 | 2.6 | 0.48 | 23 | 9.1 | 30 | 53 | 25 | $ 134,000 |
| Canyon St | Bellerive Dr/Satus St | TWSC | | 5 | 36 | 1.0 | 0.55 | 19 | 7.5 | 34 | 53 | 25 | $ 110,320 |
| Keene Rd | Lambert St | TWSC | | 14 | 13 | 2.8 | 0.37 | 34 | 11.4 | 20 | 54 | 27 | $ 168,940 |
| George Washington Way | Newcomer St | TWSC | | 11 | 20 | 2.2 | 0.37 | 32 | 10.4 | 22 | 54 | 27 | $ 153,580 |
| Jadwin Ave | Wilson St | TWSC | Yes | 4 | 44 | 0.8 | 0.21 | 51 | 52.9 | 3 | 54 | 27 | $ 782,600 |
| Van Giesen St | Birch Ave | TWSC | Yes | 5 | 36 | 1.0 | 0.21 | 50 | 50.5 | 5 | 55 | 30 | $ 747,520 |
| Goethals Dr | Lee Blvd | TWSC | | 9 | 25 | 1.8 | 0.46 | 25 | 8.3 | 32 | 57 | 31 | $ 122,160 |
| Van Giesen St | Alder Ave | TWSC | | 9 | 25 | 1.8 | 0.39 | 29 | 9.5 | 28 | 57 | 31 | $ 141,180 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| George Washington Way | Sprout Rd | TWSC | | 9 | 25 | 1.8 | 0.49 | 22 | 7.0 | 37 | 59 | 33 | $ 103,140 |
| Gage Blvd | Peach Tree Ln | TWSC | | 12 | 17 | 2.4 | 0.29 | 39 | 10.1 | 25 | 64 | 34 | $ 150,060 |
| Gage Blvd | Penny Royal Ave | TWSC | | 5 | 36 | 1.0 | 0.40 | 28 | 7.0 | 36 | 64 | 34 | $ 103,840 |
| Van Giesen St | Terminal Dr | TWSC | | 14 | 13 | 2.8 | 0.38 | 31 | 8.0 | 33 | 64 | 34 | $ 117,940 |
| Fowler St | Georgia Ave | TWSC | | 5 | 36 | 1.0 | 1.37 | 4 | 1.0 | 62 | 66 | 37 | $ 14,800 |
| Queensgate Dr | Skyline Dr | TWSC | | 11 | 20 | 2.2 | 0.26 | 44 | 10.4 | 22 | 66 | 37 | $ 153,580 |
| Dallas Rd | Ava Way | TWSC | | 5 | 36 | 1.0 | 0.39 | 30 | 5.7 | 41 | 71 | 39 | $ 84,820 |
| Jadwin Ave | Comstock St | TWSC | | 5 | 36 | 1.0 | 0.91 | 11 | 1.0 | 62 | 73 | 40 | $ 14,800 |
| Swift Blvd | Cottonwood Dr | TWSC | | 4 | 44 | 0.8 | 0.23 | 49 | 10.3 | 24 | 73 | 40 | $ 151,880 |
| Keene Rd | Kapalua Ave | TWSC | | 9 | 25 | 1.8 | 0.24 | 48 | 10.0 | 26 | 74 | 42 | $ 147,660 |
| Goethals Dr | Gillespie St | TWSC | | 5 | 36 | 1.0 | 0.61 | 18 | 2.7 | 57 | 75 | 43 | $ 40,300 |
| Stevens Dr | Snyder St | TWSC | | 10 | 24 | 2.0 | 0.24 | 46 | 7.2 | 35 | 81 | 44 | $ 106,100 |
| Columbia Park Trl | Fowler St | TWSC | | 3 | 53 | 0.6 | 0.24 | 47 | 6.6 | 38 | 85 | 45 | $ 97,920 |
| Stevens Dr | Mansfield St | TWSC | | 6 | 31 | 1.2 | 0.27 | 43 | 4.6 | 45 | 88 | 46 | $ 68,760 |
| Swift Blvd | Birch Ave | TWSC | | 4 | 44 | 0.8 | 0.25 | 45 | 5.5 | 43 | 88 | 46 | $ 81,860 |
| Goethals Dr | Aaron Dr | TWSC | | 6 | 31 | 1.2 | 0.37 | 33 | 2.9 | 56 | 89 | 48 | $ 43,260 |
| Leslie Rd | Canyon St | TWSC | | 7 | 30 | 1.4 | 0.28 | 42 | 3.1 | 55 | 97 | 49 | $ 46,220 |
| Leslie Rd | Reata Rd | TWSC | | 4 | 44 | 0.8 | 0.17 | 54 | 4.2 | 46 | 100 | 50 | $ 62,840 |
| Goethals Dr | Williams Blvd | TWSC | | 2 | 56 | 0.4 | 0.13 | 59 | 5.1 | 44 | 103 | 51 | $ 75,940 |
| Swift Blvd | Sanford Ave | TWSC | | 4 | 44 | 0.8 | 0.29 | 40 | 0.8 | 64 | 104 | 52 | $ 11,840 |
| George Washington Way | Horn Rapids Rd | TWSC | | 1 | 65 | 0.2 | 0.31 | 37 | 0.2 | 68 | 105 | 53 | $ 2,960 |
| George Washington Way | Davenport St | TWSC | | 4 | 44 | 0.8 | 0.06 | 67 | 6.0 | 39 | 106 | 54 | $ 88,340 |
| Tapteal Dr | Center Pkwy | TWSC | | 1 | 65 | 0.2 | 0.18 | 53 | 3.2 | 53 | 106 | 54 | $ 47,480 |
| Duportail St | City View Dr | TWSC | | 2 | 56 | 0.4 | 0.16 | 55 | 3.4 | 51 | 106 | 54 | $ 50,440 |
| Aaron Dr | Jadwin Ave | TWSC | | 2 | 56 | 0.4 | 0.15 | 57 | 3.4 | 51 | 108 | 57 | $ 50,440 |
| Keene Rd | Country Ridge Dr | TWSC | | 3 | 53 | 0.6 | 0.09 | 61 | 3.6 | 49 | 110 | 58 | $ 53,400 |
| Keene Rd | Keene Ct | TWSC | | 3 | 53 | 0.6 | 0.08 | 65 | 3.6 | 49 | 114 | 59 | $ 53,400 |
| Gage Blvd | Kapalua Ave | TWSC | | 1 | 65 | 0.2 | 0.09 | 62 | 3.2 | 53 | 115 | 60 | $ 47,480 |
| Van Giesen St | Gomer Rd | TWSC | | 4 | 44 | 0.8 | 0.14 | 58 | 2.5 | 58 | 116 | 61 | $ 37,340 |
| Gage Blvd | Venus Cir | TWSC | | 2 | 56 | 0.4 | 0.05 | 69 | 3.8 | 48 | 117 | 62 | $ 56,920 |
| George Washington Way | Battelle Blvd | TWSC | | 2 | 56 | 0.4 | 0.20 | 52 | 0.4 | 65 | 117 | 62 | $ 5,920 |
| Van Giesen St | Goethals Dr | TWSC | | 2 | 56 | 0.4 | 0.15 | 56 | 0.4 | 65 | 121 | 64 | $ 5,920 |
| George Washington Way | Torbett St | TWSC | | 4 | 44 | 0.8 | 0.09 | 63 | 2.5 | 58 | 121 | 64 | $ 37,340 |
| Stevens Dr | Knight St | TWSC | | 2 | 56 | 0.4 | 0.08 | 64 | 2.1 | 60 | 124 | 66 | $ 31,420 |
| Swift Blvd | Northgate Dr | TWSC | | 2 | 56 | 0.4 | 0.11 | 60 | 0.4 | 65 | 125 | 67 | $ 5,920 |
| Swift Blvd | Elm Ave | TWSC | | 1 | 65 | 0.2 | 0.06 | 66 | 1.9 | 61 | 127 | 68 | $ 28,460 |
| Leslie Rd | Center Pkwy/Lorayne J Blvd | TWSC | | 1 | 65 | 0.2 | 0.05 | 68 | 0.2 | 68 | 136 | 69 | $ 2,960 |
| Leslie Rd | Rachel Rd | TWSC | | 1 | 65 | 0.2 | 0.05 | 70 | 0.2 | 68 | 138 | 70 | $ 2,960 |
| Leslie Rd | Broadmoor St | TWSC | | 0 | 71 | 0.0 | 0.00 | 71 | 0.0 | 71 | 142 | 71 | $ - |
| Dallas Rd | Trowbridge Blvd | TWSC | | 0 | 71 | 0.0 | 0.00 | 71 | 0.0 | 71 | 142 | 71 | $ - |

## APPENDIX D: PEDESTRIAN CROSSING RANKING MATRIX

The City has developed a ranking system for pedestrian crossing the incorporates Average Daily Traffic (ADT), posted speed limit, number of lanes, collision history, potential curves or other distractions, and the proximity to destinations: transit stops, paths, schools, or other public facilities. The list below is the current ranking (February 2022).

| RRFB Ranking Matrix | | ADT | | | Speed | | | Lanes | | | Ped/Bike Related Crashes | Transit Stops | Public Facility, Path or School | Curve or Other Distraction | Point Total | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <9,000 | 9,000-15,000 | >15,000 | ≤30 | 35 | ≥40 | 2 | 3 | 4+ | | | | | | |
| **Location/Weighted Points Scale** | **Treatment Details** | **0** | **1** | **2** | **0** | **1** | **2** | **0** | **1** | **2** | **3** | **2** | **2** | **1** | | |
| Jadwin Avenue at Catskill | 2 med mast arm poles. 2 Type 1 posts. 4 push buttons. 6 signs + RRFB | | X | | | X | | | | X | X | X | X | X | 12 | 1 |
| Aaron & Jadwin | 4 Type 1 ground-mount posts. 4 push buttons. 4 RRFBs | X | | | | | X | | | X | X | | X | | 9 | 2 |
| Stevens at Mansfield | 4 Type 1 ground-mount posts. 4 push buttons. 4 RRFBs. 4 ramps | | X | | X | | | | X | | X | X | X | | 9 | 2 |
| Van Giesen & Birch | 4 Type 1 ground-mount posts. 2 ramps. 4 push buttons. 4 RRFBs | | X | | X | | | X | | | X | X | X | | 8 | 4 |
| Leslie just south of Mattis | 3 ground-mount posts. 2 push buttons. 3 signs + RRFBs. Ped refuge island | | X | | | | X | | X | | | X | X | | 8 | 4 |
| Gage west of Venus | 1 Type 2 pole and long mast arm. 1 ground-mount Type 1 pole. 2 push buttons. 6 signs + RRFBs | | | X | | | X | | | X | | X | | | 8 | 4 |
| George Washington at Torbett | 3 ground-mount posts. 3 push buttons 3 signs + RRFBs. Ped refuge island | | | X | | X | | | | X | | | X | | 7 | 7 |
| Columbia Center Blvd & Fowler (north side) | 2 ground-mount posts. 2 push buttons 2 signs + RRFBs. 2+ ADA ramps (extra cost - complicated corner) | X | | | | X | | | X | | | X | X | X | 7 | 7 |
| Leslie & Center Parkway / Lorayne J Blvd. | 2 ground-mount posts. 2 push buttons. 2 signs + RRFBs | | X | | | | X | | X | | | | X | X | 7 | 7 |
| Stevens at Knight | 2 ground-mount posts. 2 ramps. 2 push buttons. 2 RRFBs | | X | | X | | | | X | | X | | X | | 7 | 7 |
| Lee Blvd at Goethals | 4 ground-mount posts. 4 push buttons. 4 signs + RRFBs | X | | | X | | | | X | | X | X | | | 6 | 11 |
| Columbia Point east of WinCo Primary Driveway | 3 ground-mount posts. 2 push buttons. 3 signs + RRFBs. Ped refuge island. 2 ADA ramps | X | | | | X | | | | X | | X | | X | 6 | 11 |
| Thayer Drive & Long Avenue | 4 ground-mount posts. 4 push buttons. 8 signs + RRFBs | X | | | X | | | | X | | | X | X | X | 6 | 11 |
| McMurray & Pike | 2 ground-mount posts. 2 push buttons. 4 RRFBs | X | | | X | | | X | | | X | | X | | 5 | 14 |
| Bellerive at Path Crossing (north of Gage Blvd) | New Crosswalk w Signs. 2 ground-mount posts. 2 push buttons. 4 RRFBs. 2 ADA ramps | X | | | X | | | X | | | X | | X | | 5 | 14 |
| Knight at The Parkway | New Crosswalk w Signs. 2 ground-mount posts. 2 push buttons. 4 RRFBs. 2+ ADA ramps (extra cost - complicated corner) | X | | | X | | | | X | | | | X | X | 4 | 16 |

# APPENDIX E: SAFETY COUNTERMEASURES TOOLBOX

# Countermeasures Toolbox

## Signalized Intersections

### S1. Improve Intersection Lighting

A permanent source of artificial light applied to signalized intersections that have a disproportionate number of night-time crashes and do not currently provide sufficient lighting at the intersection or at its approaches.

#### Benefit-Cost

» Implementation of this treatment reduces nighttime injury crashes by 38% and nighttime pedestrian crashes by 42%. (WSDOT)

» 20 years of expected life

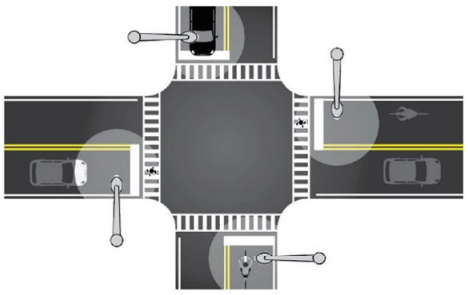
» Estimated $75,000

» The provision of lighting involves both a fixed cost for lighting installation and an ongoingmaintenance and power cost which results in a moderate to high cost.

Sources: CA-Local Roadway Safety Manual, FHWA, WSDOT

EXISTING CONDITION

IMPLEMENTATION



### S2. Improve Signal Hardware (lenses, back-plates, mounting, size, number of heads)

Applicable at signalized intersections with a high frequency of right-angle and rear-end crashes because drivers are unable to see traffic signals sufficiently in advance to safely negotiate the intersection being approached. Examples include increasing the size of indications from 8 in. to 12 in. and adding supplemental heads (e.g., side-mount, near-side mount).

#### Benefit-Cost

» Implementation of this treatment can reduce crashes by 3-7% (WSDOT).

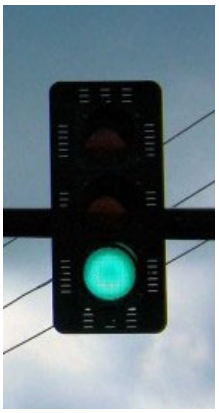
» 10 years of expected life

» Estimated $40,000 per intersection

» Cost varies based on size/number of signal heads.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION



IMPLEMENTATION

## S3. Improve Signal Timing (coordination, phasing, clearance intervals)

Effective at locations that have a crash history at multiple signalized intersections. Signalization improvements may include adding phases, lengthening clearance intervals, eliminating or restricting higher-risk movements, and coordinating signals at multiple locations. This treatment addresses all types of crashes that occur on the approaches / influence area of the new signal timing. For projects coordination signals along a corridor, the crashes related to side-street movements should not be applied.

### Benefit-Cost

» Implementation of this treatment reduces all crashes by 16%, and particularly angle crashes by 32% (WSDOT).

» 10 years of expected life

» Estimated $1,000 per intersection

» Cost variation based on number of signal heads and number of movements.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## S4. Install Left-turn Lane and Add Turn Phase

Installed at signalized intersections that have a significant crash problem and the only alternative is to change the nature of the intersection itself. This treatment addresses all type of crashes and the measure can be very effective at intersection with complex geometry and intersection with frequent left-turn movements. A properly timed protected left-turn phase can also help reduce rear-end, broadside, and sideswipe crashes between left-turning vehicles and the through vehicles as well as vehicles behind them. This countermeasure only applies to crashes occurring on the approaches / influence area of the new left turn phases.

### Benefit-Cost

» Implementation of this treatment reduces all crashes by 35% and head on crashes by 69% (WSDOT).

» 20 years of expected life

» Estimated $12,000 per intersection

» If the existing traffic signal only requires a minor modification to allow for a protected left-turnphase, then the cost would also be low (installation is short because no actual construction). In-house signal maintainers can perform this operation once the proper signal phasing is determined so the cost is low.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## S5. Pavement Marking and RPMs through Intersection

Raised Pavement Markers (RPMs) and pavement marking installed in intersections where the lane designations are not clearly visible to approaching motorists. Can also be applied at intersections noted as being complex and experiencing crashes that could be attributed to a driver's unsuccessful attempt to navigate the intersection.

### Benefit-Cost

» Implementation of this treatment reduces run off road, opposite direction and night crashes by 21% (WSDOT).

» 10 years of expected life

» Estimated $2,000 per installation

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## S6. Improve Pavement Friction (High Friction Surface Treatment

Improvement for signalized Intersections noted as having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than needed for roadway approach speeds. This treatment is intended to target locations where skidding and failure to stop is determined to be a problem in wet or dry conditions and the target vehicle is unable to stop due to insufficient skid resistance. In addition, treatment also addresses night crashes all other crashes. This treatment does not apply to standard chip-seal or open-graded maintenance projects for long segments of corridors or structure repaving projects intended to fix failed pavement.

### Benefit-Cost

» Implementation of this treatment reduces crashes by 40% (WSDOT).

» 10 years of expected life

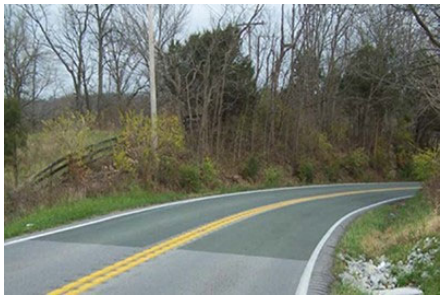
» Estimated $5,000 per intersection for materials and equipment

» Cost variation based on size of intersection and material (Estimated $30/sq.yd.).

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION


IMPLEMENTATION



## S7. Add Median Openings to Allow or Restrict Left-turns and U-turns

Install medians to reduce crashes related to turning maneuvers include angle, rear-end, pedestrian, and sideswipe (involving opposing left turns) type crashes. This treatment only applies to crashes occurring in the intersection/influence area of the new directional openings.

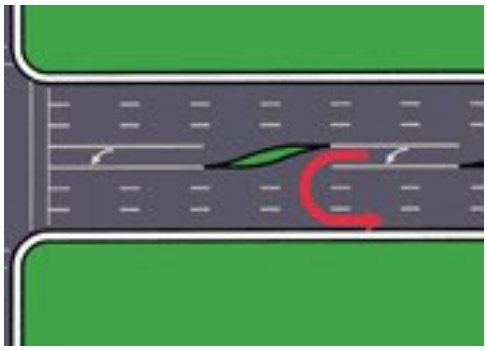
### Benefit-Cost

- Implementation of this treatment reduces crashes by 51% (WSDOT).
- 20 years of expected life
- Estimated $75,000 per installation
- The cost of this strategy will depend on the treatment.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION



## S8. Install Right-turn Lane

Setting up right-turn lane may be appropriate in situations where there are an unusually high number of rear-end collisions on a single major road approach. The need for right turn lanes should be assessed on an individual approach basis. It is also important to ensure that the right-turn lanes are of sufficient length to allow vehicles to decelerate and "queue up" before turning, ideally without affecting the flow of through traffic. This treatment addresses read-end crashes. When considering new right-turn lanes, potential impacts to non-motorized user should be considered and mitigated as appropriate.

### Benefit-Cost

- Implementation of this treatment reduces crashes by up to 8% for all crashes and 17% for fatal/injury crashes (WSDOT).
- 20 years of expected life
- Estimated $300,000 per right turn lane
- Installing right turn lanes require substantial time for development and construction that canvary the cost.

Sources: CA-Local Roadway Safety Manual

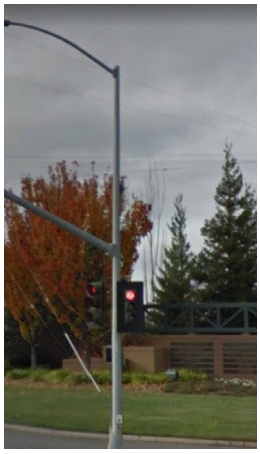
EXISTING CONDITION

IMPLEMENTATION

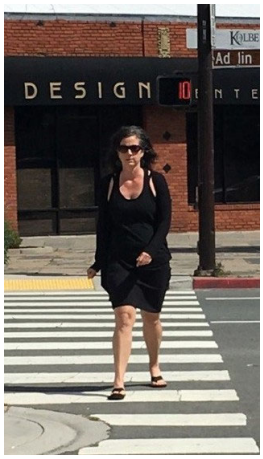
## S9. Install Pedestrian Countdown Signal Heads

Install at signals that have signalized pedestrian crossing with WALK / DON'T WALK indications and where there have been pedestrian-vehicle crashes. The countermeasure addresses both pedestrian and bicycle collisions. This countermeasure only applies to "Ped & Bike" crashes occurring in the intersection/crossing with the newcountdown heads.

EXISTING CONDITION



IMPLEMENTATION




### Benefit-Cost

- Implementation of this treatment reduces pedestrian crashes by 70% (WSDOT).
- 20 years of expected life
- Estimated $1,500 per signal head (does not include push button or pole cost)
- Costs and time of installation will vary based on the number of intersections included in this strategy and if it requires new signal controllers capable of accommodating the enhancement. This countermeasure can be effectively and efficiently implemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek stateor federal funding.

Sources: CA-Local Roadway Safety Manual

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## S10. Flashing Yellow Arrow Left Turn Signal

Flashing yellow arrow (FYA) traffic signals feature a flashing yellow arrow in addition to the standard red, yellow, and green arrows. When illuminated, the flashing yellow arrow allows waiting motorists to make a left-hand turn after yielding to oncoming traffic.

A national study demonstrated that drivers found flashing yellow left-turn arrows more understandable than traditional yield-on-green indications (green ball). Flashing yellow arrow treatment at signalized intersections can reduce the likelihood of left-turn crashes during permissive left-turn phasing. They can be used in either permissive-only or protected-permissive left-turn phasing schemes.

EXISTING CONDITION


### Benefit-Cost

- Implementation of this treatment reduces left turn crashes by 19% (WSDOT).
- 10 years of expected life
- Estimated $200,000 per intersection (assuming 4 new installations)
- Depending on the existing signal heads, signal controller, and signal cabinet, this treatment may require a controller replacement, which would increase the cost of installation.

IMPLEMENTATION


Sources: FHWA, NACTO, Minnesota DOT

# S11. Leading Pedestrian Interval

A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter the crosswalk at an intersection 3-7 seconds before vehicles are given a green indication. Using this "head start," pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn right or left.

LPIs provide increased visibility of crossing pedestrians and increased likelihood of motorists yielding to pedestrians. This results in reduced conflicts between vehicles and pedestrians, improving intersection safety. LPI is particularly useful at signalized intersections with a high volume of turning movements.

## Benefit-Cost

» Implementation of this treatment reduces pedestrian-vehicle crashes by 13-48% (FHWA, WSDOT, City of Seattle).

» 10-20 years of expected life

» Estimated $200-10,000 (based on whether existing controller can accommodate the change)

Sources: FHWA, City of Seattle, WSDOT

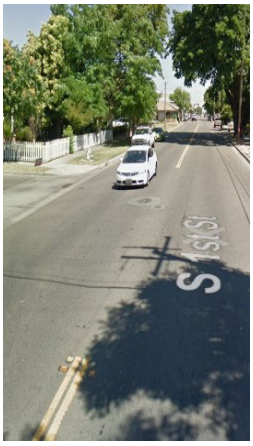
IMPLEMENTATION

# Countermeasures for Non-Signalized Intersections

## NS1. Add Intersection Lighting

Effective at unsignalized intersections that have a disproportionate number of nighttime crashes and do not currently have lighting. This treatment improves the safety of the intersection during nighttime by making drivers more aware of the surroundings at the intersection, enhancing driver'savailable sight distances and improving the visibility of non- motorists. This countermeasure only applies to nightcrashes (all types) occurring within limits of the proposed roadway lighting 'engineered' area.

EXISTING CONDITION



IMPLEMENTATION

### Benefit-Cost

- Implementation of this treatment reduces nighttime injury crashes by 38% and nighttime pedestrian crashes by 42% (WSDOT).
- 20 years of expected life
- Estimated $8,000 per intersection
- Cost variation based on cost for lighting installation and an ongoing maintenance and powercost.

Sources: CA-Local Roadway Safety Manual

## NS2. Convert to All-way Stop Control

Applicable at unsignalized intersection locations (currently with two-way stop control or two-way yield control) with a crash history and have no controls on the major roadway approaches. The all-way stop control is suitable only at intersections with moderate and relatively balanced volume levels on the intersection approaches. This treatment addresses to all type of crashes and only applies to crashes occurring in the intersection and /or influence area ofthe new control. All-way stop warrant should be considered.

EXISTING CONDITION


IMPLEMENTATION


### Benefit-Cost

- Implementation of this treatment reduces crashes by 18-75% (ODOT).
- 10 years of expected life.
- Estimated $5,000 per intersection.
- Cost variation based on numbers of locations.

Sources: CA-Local Roadway Safety Manual

## NS3. Install Roundabout

Effective at intersections that have a high frequency of right-angle and left-turn type crashes, primarily at unsignalized intersections with moderate-volumes. This countermeasure only applies to crashes occurring inthe intersection and/or influence area of the new control and is not eligible for use at existing all-waystop intersections.

### Benefit-Cost

- Implementation of this treatment at 2-way stop controlled intersection reduces crashes by 25% and fatal/injury crashes by 35% (WSDOT).
- 20 years of expected life.
- Estimated $750,000 per intersection.
- Cost variation based on the environmental process, right-of-way acquisition and implementationunder an agency's long-term capital improvement program.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## NS4. Implement Unsignalized Intersection Signing and Marking Improvements

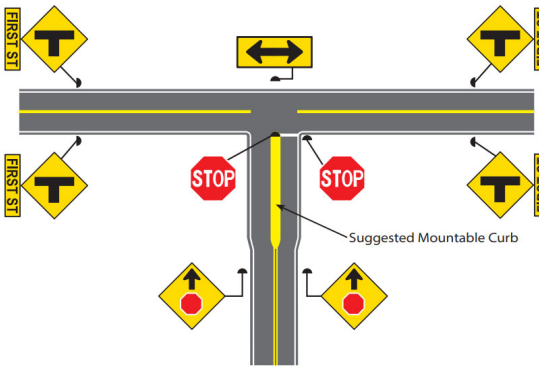
Target unsignalized intersections with patterns of rear-end, right- angle, or turning collisions related to lack of driver awareness of the presence of the intersection. The set of low-cost countermeasures is designed to increase drivers' alertness to the presence of the intersection and reduce potential conflicts with other entering vehicles. These treatments can include advanced intersection warning signs, oversized signs, doubled-up signs, stop ahead signs or painted on side street to supplement STOP sign.

### Benefit-Cost

- Implementation of this treatment reduces crashes by 25% (WSDOT).
- 10 years of expected life.
- Estimated $700 per intersection.
- Cost variation based on the number of signs.

Sources: CA-Local Roadway Safety Manual

IMPLEMENTATION



## NS5. Install Transverse Rumble Strips

Transverse rumble strips are installed in the travel lane for providing an auditory and tactile sensation for each motorist approaching the intersection. They can be used at any stop or yield approachintersection, often in combination with advance signing to warn of the intersection ahead. This countermeasure applies to all crashes occurring on the approach / influence area of the new rumble strips.

### Benefit-Cost

- Implementation of this treatment reduces all crashes by up to 6% and fatal/injury crashes by 7% (WSDOT).
- 10 years of expected life.
- Estimated $5,000 per intersection.
- Cost variation based on the length of the rumble strips.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION


IMPLEMENTATION

## NS6. Install Raised Median

Used at Intersections noted as having turning movement crashes near the intersection as a result of insufficient access control. Application of this countermeasure should be based on current crash data and a clearly defined need to restrict or accommodate the movement. Angle crashes are addressed through this countermeasure. When agencies opt to install landscaping in conjunction with new raised medians, these locations must be excluded from their federally funded HSIP application scope. This countermeasure only applies to crashes occurring on the approaches / influence area of the new raised median.

### Benefit-Cost

- Implementation of this treatment reduces all crashes by up to 39% and fatal/injury crashes by 44% (WSDOT).
- 20 years of expected life.
- Estimated $200,000+ (depends on length, right-of-way, and surface treatment).
- Cost variation based on the size of the new median.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## NS7. Install Right-turn Lane

Applicable when many collisions at unsignalized intersections are related to right-turn maneuvers. This countermeasure provides exclusive right-turn lanes, particularly on high-volume and high-speed major-roadapproaches to minimizing the collisions and applies to crashes occurring on the approaches / influence area of the new right-turn lanes.

### Benefit-Cost

» Implementation of this treatment reduces all crashes by up to 8% and fatal/injury crashes by 17% (WSDOT).

» 20 years of expected life.

» Estimated $200,000 per intersection.

» Cost variation based on how wide the new right lane.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION


IMPLEMENTATION

## NS8. Install Enhanced Pedestrian Crossing wish Advanced Features

Applicable at non-signalized intersections without a marked crossing, where pedestrians are known to cross, that involve significant vehicular traffic. They are important at school crossings and intersections with right and/or left turns pockets. Rectangular rapid flashing beacons (RRFBs), overhead flashing beacons, curb extensions, advanced stop or yield lines and other safety features should be added to complement the standard crossing elements. This countermeasure reduced pedestrian crashes occurring in the crossing (influence area) with the new enhanced safety features.

### Benefit-Cost:

» Implementation of this treatment reduces pedestrian crashes by 40% (WSDOT).

» 20 years of expected life

» Estimated $ 50,000 per intersection

» Cost variation based on the length of the pedestrian crossing and the amount of safety signs.

Sources: CA-Local Roadway Safety Manual

IMPLEMENTATION

## NS9. Install Pedestrian Crossing (signs and markings only)

Applicable when many collisions at unsignalized intersections are related to left-turn maneuvers. This countermeasure provides exclusive left-turn lanes, particularly on high-volume and high-speed major-road approaches to minimizing the collisions. This countermeasure applies to crashes occurring on the approaches /influence area of the new left- turn lanes, but is not eligible for use at existing all-way stop intersections.

### Benefit-Cost

- Implementation of this treatment reduces pedestrian crashes by 40% (WSDOT).
- 20 years of expected life
- Estimated $200,000 per intersection
- Cost variation based on how wide the new left lane.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

# Countermeasures for Roadway Segments

## R1. Add Segment Lighting

Applied to night-time crashes. In particular, patterns of rear-end, right-angle, turning or roadway departure collisions on the roadways may indicate that night-time drivers can be unaware of the roadway characteristics. This treatment addresses only to all night type crashes.

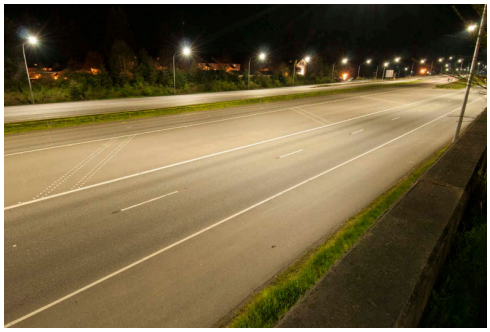
### Benefit-Cost

- Implementation of this treatment reduces injury crashes by 28% (HSM).
- 20 years of estimated life
- Estimated $8,000 per installation
- Cost variation depending if lighting connected to signal box.

Sources: CA-Local Roadway Safety Manual, Highway Safety Manual

EXISTING CONDITION

IMPLEMENTATION



## R2. Remove or Relocate Fixed Objects

Applicable to known locations or roadway segments prone to collisions with fixed objects such as utility poles, drainage structures, trees, and other fixed objects, such as the outside of a curve, end of lane drops, and in traffic islands. This treatment addresses fixed object crashes that occur within the current clear zone.

### Benefit-Cost

- Implementation on this treatment reduces run off road crashes by 38% (WSDOT).
- 20 years of expected life
- Varies. Up to estimated $50,000 per deployment
- Costs will generally be low, assuming that in most cases the objects to be removed are within the right-of-way.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## R3. Install Guardrail

Guardrail is installed to reduce the severity of lane departure crashes. This treatment addresses fixed object and run-off road crashes. Its value in reducing collisions should only be applied to locations where past crash data or engineering judgement suggests the guardrail may result in a few or less severe crashes because the guardrail itself is a fixed object.

### Benefit-Cost

- Implementation on this treatment reduces run off road crashes by 7-34% (ODOT).
- 20 years of expected life
- Estimated $50,000 per installation

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION

IMPLEMENTATION

## R4. Install Roadside Impact Attenuators

Impact attenuators are typically used to shield rigid roadside objects such as concrete barrier ends, steel guardrail ends and bridge pillars from oncoming automobiles. This treatment addresses fixed object and run-off road that occur with the limits of the new attenuators. This countermeasure and corresponding collision reduction benefits should only be applied to locations where past crash data or engineering judgement applied to existing conditions suggests the upgraded attenuators may result in a few or less severe crashes.

### Benefit-Cost

- Implementation of this treatment reduces crashes by 25%.
- 10 years of expected life
- Estimated $5,000 for steel railing, $2,500 for traffic barrels
- Costs depending on the scope of the project, type(s) used, and associated ongoing maintenance costs.

Sources: CA-Local Roadway Safety Manual

EXISTING CONDITION


IMPLEMENTATION

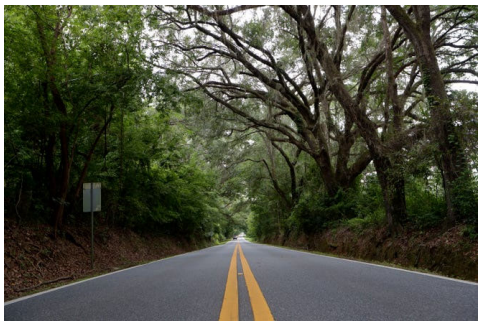
## R5. Add 2 ft Paved Shoulder

Installed in roadways that have a frequent incidence of vehicles leaving the travel lane resulting in an unsuccessful attempt to reenter the roadway. The probability of a safe recovery is increased if an errant vehicle is provided with an increased paved area in which to initiate such a recovery. This type of countermeasure addresses Fixed object, Run-off Road, and Sideswipe collisions.

### Benefit-Cost

- Implementation on this treatment reduces crashes by 5-13% (ODOT).
- 20 years of expected life.
- Estimated $150,000 (cost depends on need for right-of-way or if roadside modification isneeded).
- Shoulder widening costs would depend on whether new right-of-way is required and whether extensive roadside modification is needed. Since shoulder widening can be a relatively expensive treatment, one of the keys to creating a cost-effective project with at least a medium B/C ratio is targeting higher-hazard roadways.

EXISTING CONDITION



IMPLEMENTATION

Sources: CA-Local Roadway Safety Manual

## R6. Add Unpaved Shoulder

Appropriate to roadways with a frequent incidence of vehicles leaving the travel lane resulting inan unsuccessful attempt to reenter the roadway. This countermeasure addressed all types of crashes. Unless shoulder widening requires additional right-of-way and environmental impacts, these treatments can be implemented in a relatively short timeframe. This countermeasure only applies to crashes occurring within the limits of the new shoulder.

### Benefit-Cost

- Implementation on this treatment reduces crashes by 3-6% (ODOT).
- 20 years of expected life
- Estimated $50,000 (varies)
- The cost of adding a navigable non-paved shoulder would depend whether extensive roadside modification and shoulder stabilization are required.

IMPLEMENTATION

Sources: CA-Local Roadway Safety Manual

## R7. Install Chevron Signs on Horizontal Curves

IMPLEMENTATION

Set up on roadways that have an unacceptable level of crashes on relatively sharp curves during periods of light and darkness. Ideally this type of safety countermeasure would be combined with other sign evaluations and upgrades (install warning signs, delineators, markers, beacons, and relocation of existing signs per MUTCD standards). This treatment can address all types of crashes; but, specifically, run-offroad crashes occurring near curves. This treatment only applies to crashes occurring within the influence area of the new signs (i.e. only through the curve).

### Benefit-Cost:

- Implementation of this treatment reduces crashes by 64% (WSDOT).
- 10 years of expected life.
- Estimated $1,000 per curve
- Costs for implementing this strategy are nominal and depend on the number of signs. When considered at a single location, these low-cost improvements are usually funded through localfunding by local maintenance crews. However, this treatment can be effectively and efficientlyimplemented using a systematic approach with numerous locations, resulting in moderate cost projects that are more appropriate to seek state or federal funding.

Sources: CA-Local Roadway Safety Manual

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## R8. Add Speed Feedback Signs

IMPLEMENTATION


This type of treatment addresses all crashes caused by motorist traveling too fast, including horizontal curves. Before choosing this treatment, the agency needs to confirm the ability to provide power to the site (solar may be an option).

### Benefit-Cost

- Implementation on this treatment reduces crashes by 46% (WSDOT).
- 10 years of expected life
- Estimated $20,000-100,000
- Cost varies by type of implementation.

Sources: CA-Local Roadway Safety Manual

IMPLEMENTATION

## R9. Install Edge Line and Centerline Pavement Marking

Applicable on any road with a history of run-off-road right, head-on, opposite-direction-sideswipe, or run-off-road-left crashes is a candidate for this treatment. This treatment addresses all types, specifically impacts head-on and run-off road crashes. It only applies to crashes occurring within the limits of the new centerlines and/or edge lines. The treatment is not intended to be used for general maintenance activities (i.e. the replacement of existing striping) and must include upgraded safety features over the existing striping. For two lane roadways allowing passing, a striping audit must be done to ensure the passing limits meeting the MUTCD standards. Both the centerline and edge lines are expected to be upgraded.

### Benefit-Cost

» Implementation on this treatment reduces run off road, opposite direction and nighttime crashes by 21% (WSDOT).

» 10 years of expected life

» Estimated $4,000 (depends on number and length of segment, as well as striping material)

» Costs for implementing this strategy are nominal and depend on the number and length of segment as well as the striping material (paint, thermoplastic, etc.). This countermeasure can be effectively implemented using a systemic approach with numerous and long locations.

Sources: CA-Local Roadway Safety Manual

IMPLEMENTATION

## R10. Install No Passing Zone

Installed on roadways that have a high percentage of head-on crashes suggesting that many head-on crashes may relate to failed passing maneuvers. No Passing Zones should be installed where drivers' "passing sight distance" is not available due to horizontal or vertical obstructions. This treatmentaddresses all types of crashes that occur when drivers cannot differentiate the centerline markings between passing and no-passing area. This treatment only applies to crashes occurring within the limits of the new or extended no-passing zones.

### Benefit-Cost

» Implementation of this treatment reduces crashes by 45%.

» 10 years of expected life

» Estimated $2,000 (varies)

» When considered at a single location, these low cost improvements are usually funded through local funding by local maintenance crews. However, This treatment can be effectivelyand efficiently implemented using a systematic approach with numerous and long locations, resulting in low to moderate cost projects that are more appropriate to seek state or federalfunding.

## R11. Install Centerline Rumble Strips/Stripes

IMPLEMENTATION

Center Line rumble strips/stripes should be used on segments with a history of head-on crashes. This treatment addresses head-on and opposite-direction side-swipe crashes by alerting drivers who travel into the oncoming travel lane.

### Benefit-Cost

- » Implementation of this treatment reduces crashes by 20%.
- » 10 years of expected life
- » Estimated $3,000 per mile
- » Costs for implementing this strategy are nominal and depend on the number and length oflocations.

Sources: CA-Local Roadway Safety Manual

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## R12. Install Edge Line Rumble Strips/Stripes

IMPLEMENTATION

Shoulder and edge line milled rumble strips/stripes should be used on roads with a history of roadway departure crashes. This treatment addresses run-off road crashes by providing an auditory and tactile warning when driven on, alerting drivers drifting outside their travel lanes.

### Benefit-Cost

- » Implementation of this treatment reduces opposite direction crashes by 40% and fatal/injury crashes by 8%.
- » 10 years of expected life
- » Estimated $3,000 per mile
- » Costs for implementing this strategy are nominal and depend on the number and length oflocations.

Sources: CA-Local Roadway Safety Manual

## R13. Rail Crossing Treatments

IMPLEMENTATION

**Four Quadrant Gates** extend across all roadway lanes on both the approach and the departure side of the crossing. Unlike two-quadrant gate systems, four-quadrant gates provide additional visual constraints and inhibit most traffic movements over the crossing after the gates have been lowered. Safe guards are put in place to ensure vehicles are not trapped on the tracks.

Four Quadrant Gate

**Wayside Horns** can be used as an adjunct to train-activated crossing warning systems to provide audible warning of an approaching train for traffic on each approach to the highway-rail crossing. A wayside horn system consists of a horn or series of horns located at a public highway-rail crossing and directed at oncoming motorists. The wayside horn system simulates a train horn and sounds at a minimum of 15 seconds prior to the train's arrival at the highway-rail crossing, until the lead locomotive has traversed the crossing. It is typically used at locations where the train horn is not sounded.

Wayside Horn

### Benefit-Cost

- Quantified benefits unknown.
- 10 Years of expected life
- Estimated $700,000 for four quadrant gate system
- Estimated $500,000 for wayside horn system

Sources: FHWA, FRA

## R14. No Passing Zone Signs

IMPLEMENTATION

A No Passing Zone, indicated by a solid yellow line on the left side of the driver's direction of travel, indicates a zone through which sight distance is restricted or where other conditions make overtaking and passing inappropriate. No Passing Zones are regulatory and legally enforceable.


In situations where head-on collision history is observed, a NO PASSING ZONE pennant can provide additional information to drivers at the beginning of the No Passing Zone, discouraging passing maneuvers. The NO PASSING ZONE sign is installed on the left side of the roadway.


Additionally, DO NOT PASS signs can be added as a supplement to No Passing Zone pavement markings to emphasize the restriction on passing. It can be installed at the beginning of, and at intervals within, the No Passing Zone.

### Benefit-Cost

- Quantified benefits unknown.
- 10 Years of expected life
- Estimated $200 per sign

Sources: FHWA

## Figure Links

S1a https://www.aaroads.com/california/ca-238.html S1b https://www.aaroads.com/california/ca-262.html
S2a https://safety.fhwa.dot.gov/provencountermeasures/lighting.cfm
S2b http://wishtv.com/2016/02/16/new-traffic-signals-aim-to-reduce-crashes/
S3a http://www.k-state.edu/roundabouts/ada/news/USNews.htm
S3b https://parade.com/19072/marilynvossavant/what-would-traffic-light-synchronization-cost/
S4a https://www.fhwa.dot.gov/publications/research/safety/09036/index.cfm
S4b http://www.madriverunion.com/samoa-boulevard-traffic-light-system-changed-up/
S5a https://dohanews.co/qatars-civil-defense-junction-is-now-a-proper-intersection/
S5b http://www.gulf-times.com/story/461946/Ashghal-opens-signal-controlled-intersection-on-New-Rayyan-Road
S6a http://www.cochraneeagle.com/article/Cochrane-familes-celebrate-cultural-diversity-20170803
S6b https://rspcb.safety.fhwa.dot.gov/noteworthy/html/edccasestudy_ky.aspx
S7a https://bouldercolorado.gov/transportation/median-maintenance
S7b Unknown
S8a Google Streetview
S8b https://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/through-bike-lanes/
S9a Google Streetview
S9b Google Streetview
S10 https://www.sacbee.com/news/local/article239121918.html
S11 https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int.cfm

NS1a Google Streetview
NS1b Google Streetview
NS2a Google Streetview
NS2b http://www.ite.org/uiig/types.asp
NS3a https://www.flickr.com/photos/repowers/2933707788/
NS3b Google Streetview
NS4a https://alchemistsdiary.wordpress.com/2017/07/22/
NS4b https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa09020/fhwasa09020.pdf
NS5a http://www.cleveland.com/berea/index.ssf/2012/11/berea_changes_stop_sign_parkin.html
NS5b https://radiobintangsembilan.com/2016/03/07/hindari-kecelakaan-anak-sekolah-warga-minta-garis-kejut/
NS6a http://www.jurist.org/hotline/2014/03/zachary-heiden-maine-panhandling.php
NS6b https://www.edmonton.ca/transportation/on_your_streets/neighbourhood-traffic-concerns.aspx
NS7a Google Streetview
NS7b https://ux.stackexchange.com/questions/42867/how-does-the-projection-angle-of-road-arrows-change-drivers-expectations-of-the
NS8a https://en.wikipedia.org/wiki/Uncontrolled_intersection
NS8b https://safety.fhwa.dot.gov/provencountermeasures/crosswalk-visibility.cfm
NS9a Google Streetview
NS9b https://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/major-street-crossing/

R1a https://www.shutterstock.com/nb/video/clip-9830723-4k-driving-car-on-highway-roadway-night
R1b https://www.wsdot.wa.gov/research/reports/fullreports/847.1.pdf
R2a Google Streetview
R2b Google Streetview
R3a Google Streetview
R3b https://www.reddit.com/r/funny/comments/4zcplq/a_local_plumbers_truck_decal/
R4a Unknown
R4b http://lslee.com/attenuators/Impact-Attenuators
R5a Unknown
R5b https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa11018/
R6b https://www.fhwa.dot.gov/publications/research/safety/15030/009.cfm

R7b https://safety.fhwa.dot.gov/provencountermeasures/enhanced_delineation.cfm
R8b https://www.fhwa.dot.gov/publications/research/safety/15030/009.cfm
R9b https://www.fhwa.dot.gov/publications/research/safety/15030/009.cfm
R10b https://www.shutterstock.com/nb/search/double+yellow+lines
R11b https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/bike_ig/
R12b https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/bike_ig/
R13a https://cms.cityoftacoma.org/PublicWorks/RR_Crossing/Dome_OldTown/Option4_S_C_St_Poster_1of2.pdf
R13b https://safety.fhwa.dot.gov/hsip/xings/com_roaduser/fhwasa18040/
R14a https://safety.fhwa.dot.gov/older_users/fhwasa15088/ch4.cfm
R14b https://driving-tests.org/road-signs/do-not-pass-sign/