PENNSYLVANIA AVENUE NORTH AND SOUTH ROAD SAFETY AUDIT

Regional Intergovernmental Council

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1.0 Executive Summary

The goal of this study is to identify current transportation safety issues in the area of Pennsylvania Avenue North and Pennsylvania Avenue South from Virginia Street West to Washington Street in Charleston, West Virginia and explore potential countermeasures to improve safety by mitigating crashes and reducing traffic congestion. Both Pennsylvania Avenue North and Pennsylvania Avenue South are urban three-lane, one-way streets with a speed limit of 30 mph. I-64 runs parallel to both streets, elevated above the study area, with exit and entrance ramps located on Pennsylvania Avenue North and South. The following signalized intersections were studied along these corridors:

- Pennsylvania Avenue North & Virginia Street West
- Pennsylvania Avenue North & Randolph Street/Quarrier Street
- Pennsylvania Avenue North & Lee Street
- Pennsylvania Avenue North & Washington Street
- Pennsylvania Avenue South & Virginia Street
- Pennsylvania Avenue South & Randolph Street
- Pennsylvania Avenue South & Lee Street
- Pennsylvania Avenue South & Washington Street

Crash data from January 1, 2016 to December 31, 2018 was downloaded from the ReportBeam website. Each crash report was reviewed to determine potential factors contributing to crashes. In the three-year study period, there were 293 crashes with 75 (26 percent) resulting in injury. Angle collisions (58 percent) were the most common crash type. These collisions were attributed most often to red-light running at the signalized intersections. The intersection of Pennsylvania Avenue North and Randolph Street/Quarrier Street has the highest injury percentage (36 percent), while the intersection of Pennsylvania Avenue North and Lee Street has the highest overall crash frequency (78 crashes).

The following improvements and next steps are recommended to improve crashes within the study area.

- Recalculate and implement new clearance intervals at all signalized intersections.
- Evaluate the feasibility of installing backplates at all signalized intersections.
- Install LED signals at all signals (without LED indications) and programmable signal heads at least along Randolph Street and upgrade the signals that are currently programmable.
- Install advanced warning signs for the upcoming signals before Virginia Street West on Pennsylvania Avenue North and before Washington Street West on Pennsylvania Avenue South.
- Redesign and reconstruct signal for the I-64 Eastbound Off-Ramp at Lee Street to enhance signal head visibility for traffic on the off-ramp.
- Work with WVDOT to program a long-term project to widen the I-64 Eastbound Off-Ramp to Virginia Street West to provide a drop decision lane.

It is also suggested that traffic counts be collected at the intersections of Pennsylvania Avenue North with Virginia Street West and Lee Street. These traffic counts will be used to determine the number of vehicles using the each of these off-ramps as well as the impacts of the potential improvements to the ramp modifications.

2.0 Purpose

The goal of this study is to identify current transportation safety issues in the area of Pennsylvania Avenue North and Pennsylvania Avenue South from Virginia Street West to Washington Street in Charleston, West Virginia and explore potential countermeasures to improve safety by mitigating crashes and improving the traffic operations. The study area is shown in **Figure 1.**

Figure 1: Study Area

3.0 Existing Conditions

Roadway Conditions

The study area is located in the City of Charleston within Kanawha County in a primarily urban area. The land use in this study area is mainly commercial with some residential housing located to the west. The Charleston Coliseum and Convention Center is located east of the study area across the Elk River and the Women and Children's Hospital is located to the north on Pennsylvania Avenue North.

Both Pennsylvania Avenue North and Pennsylvania Avenue South are three-lane, one-way streets with a speed limit of 30 mph. Vehicles on Pennsylvania Avenue North travel northbound and vehicles on Pennsylvania Avenue South travel southbound. I-64 runs parallel to both streets, elevated above the study area. Two I-64 eastbound exit ramps and one I-64 eastbound entrance ramp are located along Pennsylvania Avenue North while Pennsylvania Avenue South provides access to two I-64 westbound entrance ramps. Street parking is not available on Pennsylvania Avenue North or Pennsylvania Avenue South, but parking lots are located between Pennsylvania Avenue North and Pennsylvania Avenue South underneath the I-64 Interstate bridge. Lighting is present along both roadways. Sidewalk is located along the west side of Pennsylvania Avenue South and the east side of Pennsylvania Avenue North.

Pennsylvania Avenue North and Pennsylvania Avenue South are both intersected by four one-way streets along the study area, Virginia Street West, Randolph/Quarrier Street, Lee Street and Washington Street. All the cross streets are all minor arterials and have sidewalks present on both sides of the street. The speed limit for all four side-streets in 30 mph. On-street parking is available west of Pennsylvania Avenue South on Randolph Street, Washington Street and Virginia Street West The direction of each of the cross streets and the number of lanes west and east of the study area is shown in **Table 1.**

Table 1: Cross Street Roadway Information

		# of Lanes	
	Travel Direction	West Leg	East Leg
Virginia Street West	Eastbound	3 lanes	2 lanes
Randolph Street	Westbound	2 lanes	4 lanes
Lee Street	Eastbound	4 lanes	3 lanes
Washington Street	Westbound	2 lanes	3 lanes

Intersections Conditions

The following signalized intersections are located in the study area. All traffic signals use video detection and are mounted on mast arms. A field visit of the study area was performed on Monday, June 8th, 2020. For the purposes of this report, Pennsylvania Avenue is described as the north/south roadway.

Pennsylvania Avenue North and Virginia Street West

The lane configuration for this signalized intersection is summarized in **Figure 2.** The I-64 Eastbound Off-Ramp is a fifth leg of this intersection and is controlled by a separate traffic signal, shown in **Photo 1.** After vehicles exit the I-64 Eastbound Off-Ramp and continue through the traffic signal, they yield to traffic on Pennsylvania Avenue North using a short lane on the north leg of the intersection. Vehicles turning right onto Virginia Street West from the I-64 Eastbound Off-Ramp are channelized approximately 250 feet east of the intersection. Right turns on red are prohibited on the northbound approach per signing. Crosswalks are present on all legs except for the west leg. A pedestrian refugee island is provided for vehicles crossing the north leg with a pedestrian push button in the center island. Sidewalks are located on all legs. Pedestrian signal heads and push buttons with audible tones are present for crossing the west section of the north leg and the east leg of the intersection. On the eastbound approach a sign indicates that left-turning vehicles must yield to pedestrians. The pavement is in good condition, but the stop bar and lane use pavement markings were faded on the eastbound approach.

Figure 2: Pennsylvania Ave N and Virginia St W Lane Configuration

Photo 1: Pennsylvania Ave N and Virginia St W Off-Ramp Signal

Pennsylvania Avenue North and Randolph Street

The lane configuration for this signalized intersection is summarized in **Figure 3.** The westbound right-turn movement on Randolph Street is channelized and controlled by a yield sign. Crosswalks are present on all legs except for the west leg and a pedestrian refugee island is present on the north leg. The crosswalk is faded across the channelized right-turn lane, but a sign is present notifying vehicles to yield to pedestrians. Pedestrian signal heads are present for crossing all legs except the west leg. Pedestrian push buttons with audible tones are only present for crossing the north and south legs. A pedestal traffic signal is located on the left side of the westbound approach. Two other traffic signals on Randolph Street can be seen on the westbound approach, as seen in **Photo 2.** The pavement is cracked and rough through the center of the intersection and under the I-64 underpass as seen in **Photo 3.** The crosswalk and stop bar pavement markings are faded on the westbound approach. There are no lane use pavement markings on the westbound approach.

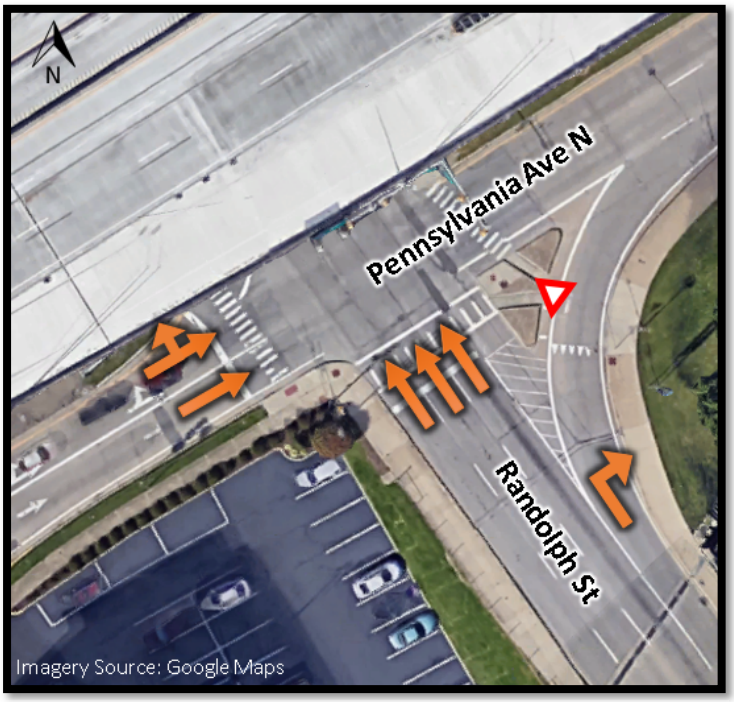

Figure 3: Pennsylvania Ave N and Randolph St Lane Configuration

Photo 2: Signals Westbound on Randolph Street

Photo 3: Damaged Pavement Under I-64 Interstate

Pennsylvania Avenue North and Lee Street

The lane configuration for this signalized intersection is summarized in **Figure 4.** Two traffic signals operating on separate phases are provided along the northbound direction, one for the I-64 Eastbound Off-Ramp and one for Pennsylvania Avenue North. Both traffic signals can be seen from the I-64 Eastbound Off-Ramp, shown in **Photo 4**. The signal directing traffic on the I-64 Eastbound Off-Ramp is approximately 50 feet behind the other traffic signal and has a 4-section and a 3-section signal head, both with right turn arrows. The LED signal heads at this intersection are programmable per WVDOH. However, the indications are still visible for both approaches. Crosswalks and pedestrian signal heads are provided for crossing the east and south legs of the intersection. Pedestrian push buttons with audible tones are only present for crossing the south leg. Signs are located on both signals indicating that vehicles are prohibited from turning on red. The pavement and pavement markings are in good condition. The grade difference between the two northbound approaches of the intersection is shown in **Photo 5.**

Figure 4: Pennsylvania Ave N and Lee St Lane Configuration

Photo 4: Northbound Signal Heads at Pennsylvania Ave North & Lee St

Photo 5: I-64 Ramp at Pennsylvania Ave North & Lee St

Pennsylvania Avenue North and Washington Street

The lane configuration for this signalized intersection is summarized in **Figure 5.** The I-64 Eastbound On-Ramp is located on the north leg of the intersection. A raised channelizing island is provided on the south leg between the through lanes and channelized left-turn lane. Crosswalks and pedestrian signal heads are provided for all legs of the intersection except for the west leg. Pedestrian push buttons with audible tones are only present on the north and south legs. Vehicles were observed accelerating through the intersection to enter the I-64 Eastbound On-Ramp, shown in **Photo 6.** There are no lane use pavement markings on the westbound approach. The sign for the I-64 Westbound On-Ramp is slightly obstructed by the traffic signal mast arm on the westbound approach, as seen in **Photo 7**.

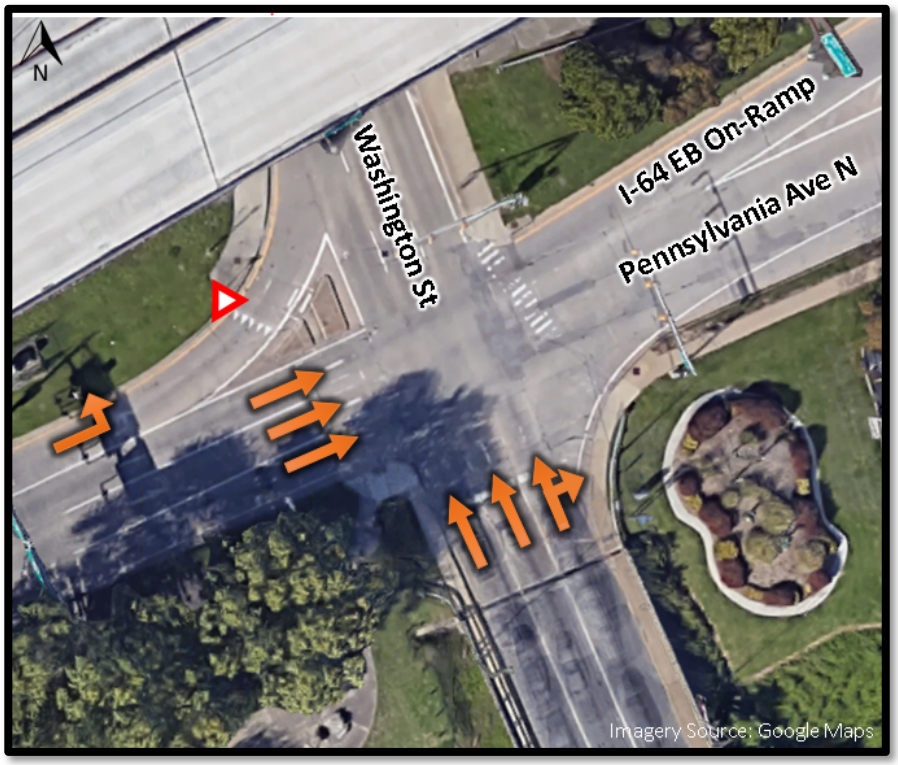

Figure 5: Pennsylvania Ave N and Washington St Configuration

Photo 6: I-64 Ramp at Pennsylvania Ave N and Washington St

Photo 7: Westbound Approach Pennsylvania Ave N and Washington St

Pennsylvania Avenue South and Washington Street

The lane configuration for this signalized intersection is summarized in **Figure 6**. Two driveways to a parking lot located under the I-64 bridge are on the north leg of the intersection. Crosswalks and pedestrian signal heads are provided on all legs of the intersection. Push buttons with audible tones are only provided to cross the north and south legs. A bus stop is located on Washington Street, approximately 50 feet east of the intersection, nearly under the I-64 overpass. The westbound left-turn lane is channelized by a raised concrete island. The yield sign for the westbound left-turn was obstructed by trees at the time of the field visit, shown in **Photo 8**. The lane use pavement markings are faded on the westbound approach. Sign clutter from overhead signs on the southbound approach is shown in **Photo 9**.

Figure 6: Pennsylvania Ave S and Washington Street Configuration

Photo 8: Obstructed Sign

Photo 9: Sign Clutter on Southbound approach

Pennsylvania Avenue South and Lee Street

Figure 7: Pennsylvania Ave S and Lee St Street Configuration

The lane configuration for this signalized intersection is summarized in **Figure 7.** The I-64 Westbound On-Ramp is located about 100 feet south of the intersection. Vehicles were observed accelerating quickly onto the I-64 Westbound On-Ramp when the signal turned green. Crosswalks and pedestrian signal heads are provided on all legs of the intersection and push buttons with audible tones are present to cross both the north and south legs. The pushbutton on the northwest corner the intersection did not work at the time of the field visit A bus stop is located on the southeast corner of the intersection on Lee Street. Right-turns on red are prohibited on the eastbound approach. The proximity of the buildings on the northwest corner of the intersection obstruct visibility for the both the eastbound and southbound approach, shown in **Photo 10**. The pavement and pavement markings are in good condition. Near misses were observed between vehicles turning in the two adjacent southbound left-turn lanes when their turning paths would overlap as drivers selected the receiving lane on Lee Street without regard to the vehicle in the adjacent lane. **Photo 11** shows the overhead lane use signs provided on the eastbound approach.

Photo 10: Building on Northwest Corner

Photo 11: Overhead Lane Use Signs

Pennsylvania Avenue South and Randolph Street

The lane configuration for this signalized intersection is summarized in **Figure 8.** Crosswalks and pedestrian signal heads are provided to cross both the north and west legs of the intersection. The LED signal heads on the mast arms are programmable per WVDOH. **Photo 12** shows the supplemental signal head present for the westbound approach on the left side of the street. The visors for the red and yellow signals were missing. Push buttons with audible tones are only provided to cross the north leg but were not functioning at the time of the field visit. The crosswalk on the west leg of the intersection is faded and mostly worn away, shown in **Photo 13**. The pavement is in overall good condition.

Figure 8: Pennsylvania Ave S and Randolph Street Configuration

Photo 12: Supplemental Signal Head for Westbound Approach

Photo 13: Faded Crosswalk Markings

Pennsylvania Avenue South and Virginia Street West

The lane configuration for this signalized intersection is summarized in **Figure 9.** Crosswalks and pedestrian signal heads are provided to cross both the north and west legs of the intersection. Push buttons with audible tones are only provided to cross the north leg. The I-64 Westbound On-Ramp is located on the south leg of the intersection and is shown in **Photo 14.** The signal LED heads at this intersection are programmable per WVDOH. Traffic from Pennsylvania Avenue North must yield to the traffic coming from Pennsylvania Avenue South and Virginia Street West before merging onto the I-64 Westbound On-Ramp. Right-turns on red are prohibited on the eastbound approach. A bus stop is located on the southeast corner of the intersection on Virginia Street West. Similar to the previous intersection, the overhead sign for the I-64 Eastbound On-Ramp is obstructed by the mast arm along eastbound approach, shown in **Photo 15.**

Figure 9: Pennsylvania Ave S and Virginia St W Configuration

Photo 14: I-64 Ramp at Pennsylvania Ave S and Virginia St W

Photo 15: Eastbound Approach at Pennsylvania Ave S and Virginia St W

4.0 Crash Data

Crash data from January 1, 2016 to December 31, 2018 was downloaded from the ReportBeam website. Each crash report was reviewed to determine potential factors contributing to crashes. A collision diagram that shows crash patterns by illustrating the approximate location of each reported crash is provided in **Appendix A**. In the three-year study period, there were 293 crashes with 75 (26 percent) resulting in injury. There were no fatalities in the study area. **Figure 10** shows the crash frequency per year and by severity. The total crash frequency for each year spiked from 2017 to 2018, while the frequency of injury collisions has stayed relatively constant through the three-year study period.

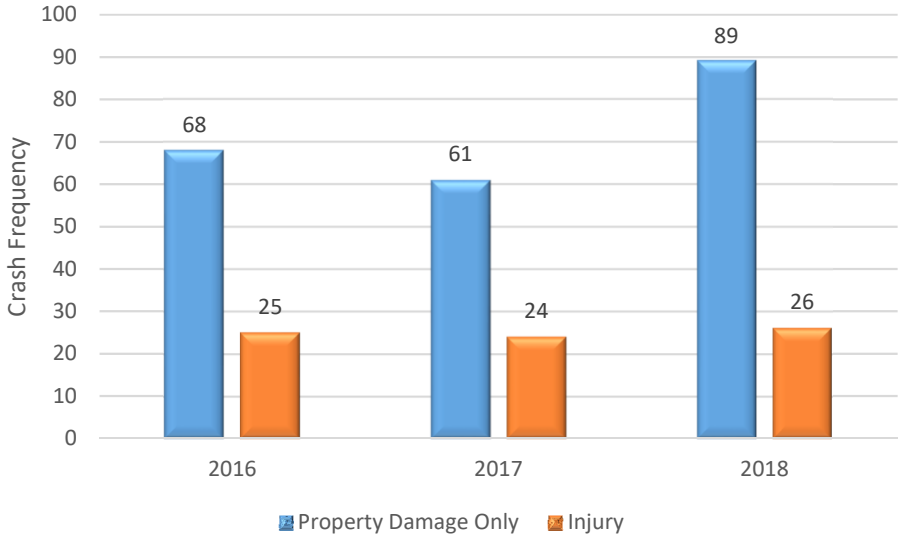

Figure 10: Frequency of Crashes by Year and Severity

Figure 11 illustrates the breakdown of crashes in the study area by crash type. Angle collisions (58 percent) were attributed most often to red-light running at the signalized intersections. The majority of collisions occurred in the daylight (83 percent) and on dry pavement (81 percent).

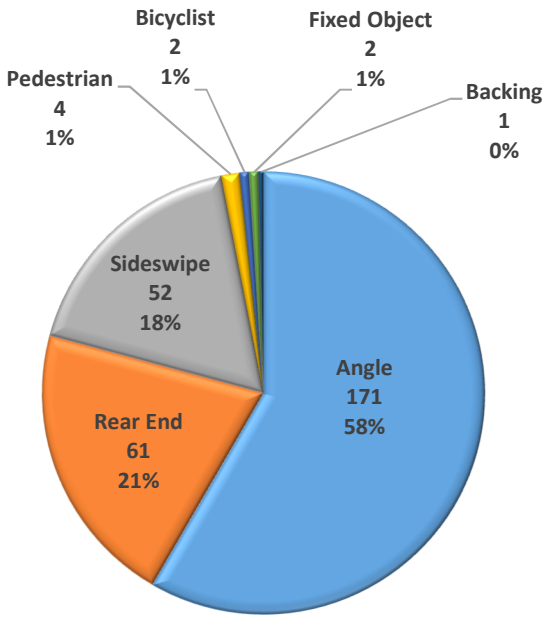

Figure 11: Crash Frequency by Crash Type

Figure 12 illustrates the breakdown of crashes in the study area by hour of the day, showing a fairly steady increase in crashes starting at 7:00 AM and peaking at 5:00 PM.

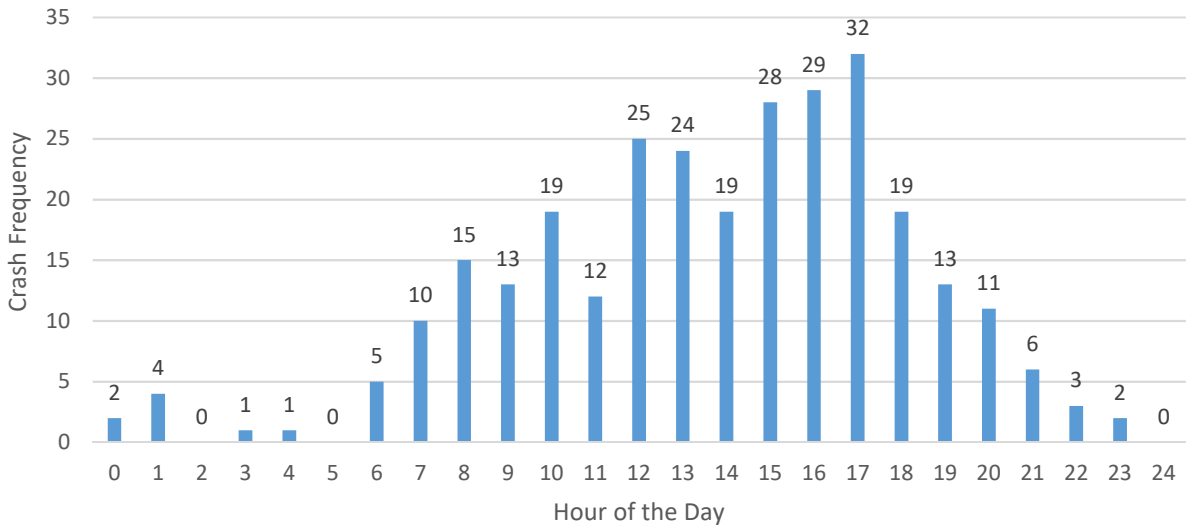

Figure 12: Crash Frequency by Hour of the Day

Table 2 summarizes the injury percentage for each of the signalized intersections in the study area with their respective crash frequencies. The intersection of Pennsylvania Avenue North and Randolph Street/Quarrier Street has the highest injury percentage (36 percent), while the intersection of Pennsylvania Avenue North and Lee Street has the highest overall crash frequency (78 crashes).

Table 2: Signalized Intersection Crash Statistics

	Injury Percentage	Crash Frequency
Pennsylvania Ave N & Virginia St	33%	9
Pennsylvania Ave N & Randolph St/Quarrier St	**36%**	45
Pennsylvania Ave N & Lee St	17%	**78**
Pennsylvania Ave N & Washington St	31%	36
Pennsylvania Ave S & Washington St	30%	44
Pennsylvania Ave S & Lee St	24%	49
Pennsylvania Ave S & Randolph St	29%	14
Pennsylvania Ave S & Virginia St	19%	16

The major crash patterns at each of the signalized intersections are summarized below:

Pennsylvania Avenue North & Virginia Street

There were no major crash patterns at this intersection.

Pennsylvania Avenue North & Randolph/Quarrier Street

The main crash pattern at this intersection was angle collisions due to westbound red-light running (27 crashes). These crashes could be caused by the amount of visual clutter along westbound Randolph Street/Quarrier Street. When traveling westbound down Quarrier Street, the driver could be focusing on one of the three signals visible from that approach. Additionally, this area is congested during peak hours of the day which may result in drivers growing impatient and clearing the intersection on the yellow or red clearance interval. Ten (37 percent) out of these 27 crashes resulted in injury. There was also some red-light running on the northbound approach resulting in angle collisions. The red-light running is likely the result of the overhead sign clutter and drivers confused by lane use, so the driver's focus is not on the signal.

Pennsylvania Avenue North & Lee Street

One crash pattern at this intersection involved vehicles in the right-turn only lane on the I-64 Eastbound Off-Ramp continuing straight instead of turning right (14 crashes). Right-turns onto Lee Street are allowed from both lanes on the I-64 Eastbound Off-Ramp. When vehicles in the right lane continue straight, they sideswipe a right-turning vehicle in the left lane. The geometric configuration of this intersection likely contributes to these crashes. Even though the signal is split-phased, providing the I-64 Eastbound Off-Ramp with its own signal phase, it is counter-intuitive for drivers to turn right in front of parallel traffic along Pennsylvania Avenue North.

Another main crash pattern at this intersection occurred when northbound vehicles on the I-64 Eastbound Off-Ramp turned right in front of northbound vehicles going straight through the intersection from Pennsylvania Avenue North (13 crashes). These crashes were usually the result of vehicles running the red signal for the I-64 Eastbound Off-Ramp which operates separately from the

signal on Pennsylvania Avenue North. Some of the red-light running occurred because both traffic signals can be seen from the I-64 Eastbound Off-Ramp, which resulted in some drivers looking at the incorrect traffic signal.

Several rear ends occurred on Pennsylvania Avenue North, with the most occurring in the far left-lane. While there were no clear causes to these crashes, vehicles in the far-left lane have a clear view of the signal for the I-64 Eastbound Off-Ramp. Additionally, the volumes were observed to be slightly higher in this lane than the others because this lane leads to eastbound I-64.

Pennsylvania Avenue North & Washington Street West

Out of the four pedestrian crashes in the study area, three occurred at this intersection and they all resulted in injury. The pedestrians were all in a crosswalk when they were hit but two of the pedestrians were crossing when vehicles had the right-of-way. The other report did not indicate if the pedestrian or the vehicle had the right-of-way. There were also several angle crashes resulting from red-light running in both the northbound and westbound directions. Sideswipe crashes on the northbound approach were also common due to vehicles turning or continuing straight from the intersection of Pennsylvania Avenue North and Lee Street and attempting to switch lanes before Washington Street.

Pennsylvania Avenue South & Washington Street

The most prevalent crash type at this location were angle crashes (21 crashes) resulting from southbound vehicles running the red light and colliding with a westbound vehicle. This intersection is the first signalized intersection on Pennsylvania Avenue South so drivers might not be expecting to stop at a traffic signal. There is also lot of overhead signage approaching the intersection which camouflages the traffic signal. Additionally, with the number of lanes at the intersection, drivers may be more focused on ensuring they are in the correct lane for downstream movements rather than focusing on the traffic signal.

Pennsylvania Avenue South & Lee Street

Angle crashes occurred in various different directions at this intersection, with the majority resulting from red-light running. The building on the northwest corner of the intersection blocks the view of oncoming traffic for both the southbound and eastbound traffic. When a vehicle is running the red indication, the driver on the opposing approach cannot see the oncoming vehicle until it is in the intersection which contributes to these angle crashes. On the eastbound approach there is also some overhead sign clutter which could be distracting drivers away from the traffic signal.

Sideswipe crashes also occurred when vehicles turning left in the adjacent southbound dual left-turn lanes did not stay in their respective lanes when turning. Additionally, sideswipe crashes also occurred when vehicles were in the far southbound left lane (that must turn onto Lee Street) and instead continued straight onto Pennsylvania Avenue South or onto the I-64 Westbound On-Ramp.

Pennsylvania Avenue South & Randolph Street

The main crash patterns at this intersection were angle crashes resulting from red-light running on both approaches. Five rear end collisions also occurred the southbound approach of the intersection.

Pennsylvania Avenue South & Virginia Street West

On the channelized left-turn lane on Virginia Street West that provides access to the I-64 Westbound On-Ramp, three rear ends collisions occurred. Vehicles would look north to merge onto the I-64 Westbound On-Ramp and not realize the car in front of them has stopped. Several angle crashes also occurred because of red-light running on both approaches.

5.0 Improvements for Consideration

The following improvements include countermeasures to mitigate the crash patterns at the eight intersections along Pennsylvania Avenue North and South.

Short-Term

- **Upgrade to LED signal heads:** Due to the prevalence of red-light running angle collisions in the study area, LED signals are proposed to improve signal visibility. LED signals are not only brighter and thus more visible to the driver, they also consume less electricity and have a longer lifespan than incandescent signals. While some signals are already LED indications, the signals throughout the study area should be evaluated and replaced as needed to improve visibility.

- **Add backplates to signal heads:** Backplates are proposed on all signal heads to improve signal visibility and help reduce red-light running. None of the intersections in the corridor currently have backplates on the signal heads. In some cases, the existing signal supports cannot accommodate the additional weight and wind load of backplates. Calculations would be required to determine if a new signal support would be required to make these improvements.

- **Add or upgrade optically programmed signal heads:** Optically programmed signals use special lenses to significantly restrict the angle and distance that a traffic signal can be seen. These are usually employed in situations where signals are placed closely together to improve signal visibility. While these signals can be applied at any signal in the study area, they would likely have the greatest safety benefit at the intersection of Pennsylvania Avenue North and Randolph Street/Quarrier Street, due to many traffic signals along Randolph Street. As previously mentioned, three of the intersections in the study area already have programmable signal heads. This technology was determined to be 12 to 14 years old, so it is recommended that newer technology be installed.

- **Check vehicular clearance intervals:** Clearance intervals that are too short can contribute to rear end collisions related to drivers stopping abruptly. Short clearance intervals can also lead to angle crashes because vehicles could still be clearing the intersection when a conflicting approach is given the green indication. Conversely, clearance intervals that are too long can encourage drivers to disrespect the interval thereby contributing to angle crashes when vehicles run the red light. In order to improve safety throughout the study area, it is recommended that clearance intervals be recalculated at all the signalized intersections.

- **Install "Signal Ahead" signs:** Since Pennsylvania Avenue South and Washington Street and Pennsylvania Avenue North and Virginia Street West are the first intersections vehicles arrive

at after entering Pennsylvania Avenue North and South, it recommended that "Signal Ahead" signs be installed on both the northbound and southbound approaches to alert traffic of the potential need to stop ahead.

- **Add lane-use pavement markings on all intersection approaches:** Clearly marked lane-use pavement markings will decrease driver confusion and distraction, thus reducing sideswipe and angle collisions. Additionally, where there are dual turn lanes, it is proposed that dotted lane line extensions be provided to indicate the turning paths for vehicles turning side-by-side.

Medium-Term

- **Modify the northbound signal at Pennsylvania Avenue North and Lee Street:** Several of the crashes at this intersection resulted from drivers looking at the incorrect signal along Pennsylvania Avenue North, since both traffic signals can be seen from the I-64 Eastbound Off-Ramp. The signal for the I-64 Eastbound Off-Ramp is also about 50 feet behind the Pennsylvania Avenue North signal which adds to the confusion. In order to decrease the possibility of drivers looking at the incorrect signal, it is proposed that the I-64 Eastbound Off-Ramp signal be moved south of the intersection on the I-64 Eastbound Off-Ramp approach. The stop bar on the I-64 Eastbound Off-Ramp would then also be moved south to meet the minimum requirements for distance between the signal heads and the stop bar. Given the curb radius on the northwest corner, the signal pole is already placed as far south as possible on the north side of the intersection. Furthermore, a near-side signal head is proposed to be mounted on the left side of the I-64 Eastbound Off-Ramp to enhance signal visibility for traffic exiting I-64. Additionally, it is proposed that the mast arm for the Pennsylvania Avenue North signal be extended and a "NO TURN ON RED" sign be added to the end of the mast arm.

- **Prohibit right-turns from the Lee Street I-64 Eastbound Off-Ramp:** The two main crash patterns at this intersection were related to vehicles turning right off of the I-64 Eastbound Off-Ramp onto Lee Street. This improvement prohibits right-turns from the I-64 Eastbound Off-Ramp and reroutes this movement to Washington Street as illustrated in **Figure 13**. This improvement would also include signing modification to encourage right-turning traffic to use the I-64 Eastbound Off-Ramp at Virginia Street West, thus reducing the right-turn volume that will be rerouted. Evaluations would need to be performed to determine the

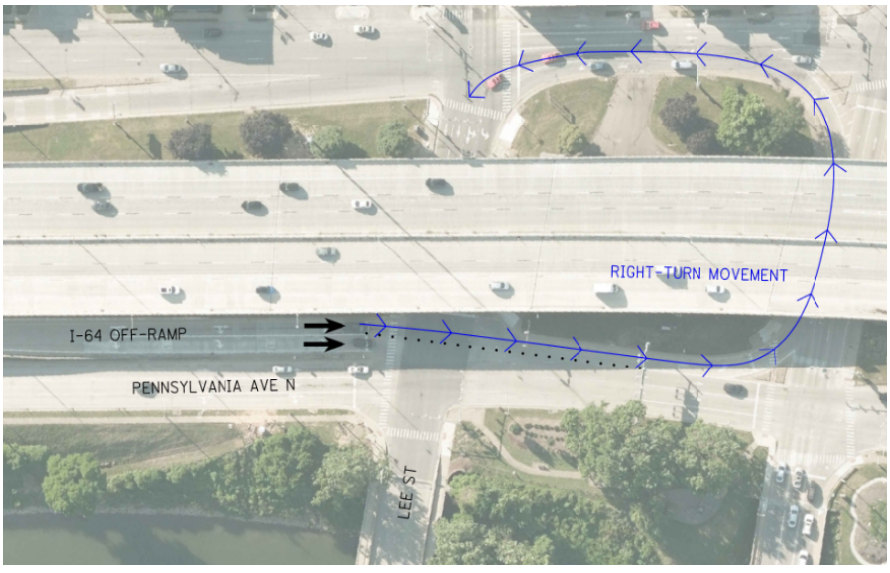

Figure 13: Re-Route Right-Turns for I-64 Lee Street Ramp

operational impacts of this improvement, especially for the AM peak when this volume is reportedly the highest. Furthermore, enforcing right-turn prohibitions may be difficult, especially if the drivers are familiar with the area and are used to turning right from the ramp. Additionally, this improvement would still require the I-64 Eastbound Off-Ramp and Pennsylvania Avenue North to be split-phased, thus there could still be confusion surrounding the multiple signal heads on different phases. For these reasons, this improvement is not recommended for implementation.

- **Close the I-64 Off-Ramp at Lee Street (without modifying the I-64 Off-Ramp at Virginia Street West):** To eliminate the I-64 Eastbound Off-Ramp at this intersection altogether, it is proposed that the ramp be closed, forcing all eastbound I-64 traffic accessing Pennsylvania Avenue North to use the I-64 Eastbound Off-Ramp at Virginia Street West. However, the weave along I-64 eastbound between US 119 and Virginia Street West causes significant congestion and slow-downs. By closing the Lee Street ramp, more traffic will be re-routed to the Virginia Street West ramp which will exacerbate the existing congestion issues on I-64. For this improvement to be successful, the I-64 bridge over the Kanawha River would need to be widened to improve, if not mitigate, the weave along eastbound I-64.

Long-Term

- **Modify the I-64 Eastbound Off-Ramp at Lee Street**: In an effort to remove the split phasing at the Lee Street intersection, the possibility of modifying the I-64 Eastbound Off-Ramp so that traffic from the ramp could position in the correct lane prior to the signal (as illustrated in **Figure 14**). In order to meet the clearance required over Quarrier Street, this modification would only provide 300 feet of distance between where the ramp meets the grade of Pennsylvania Avenue North, thus providing a very short weaving distance. This improvement would likely create additional crashes as a result of the short weaving distance and therefore is not recommended.

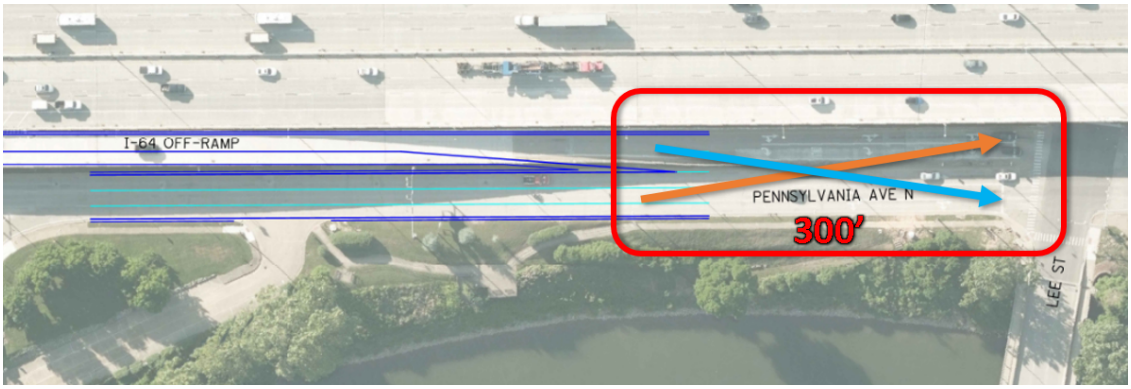

Figure 14: Modify Lee Street Ramp

- **Relocate the I-64 Eastbound Off-Ramp at Lee Street (and close Quarrier Street):** This alternative is similar to the previous alternative, except the section of Quarrier Street under the I-64 bridge would be closed so that more separation can be provided between where the I-64 Eastbound Off-Ramp meets the grade of Pennsylvania Avenue North and the Lee Street signal (as illustrated in **Figure 15**). This modification provides approximately 600 feet between the ramp and the signal which is still not preferred with the amount of traffic required to weave in this distance. Furthermore, the closure of Quarrier Street under I-64

would require traffic northbound on Randolph Street to travel approximately a half mile out of the way to continue traveling on northbound Quarrier Street. This traffic would be added to those required to weave in the short distance provided between the I-64 Eastbound Off-Ramp and Lee Street. For these reasons, this improvement is not recommended at this location.

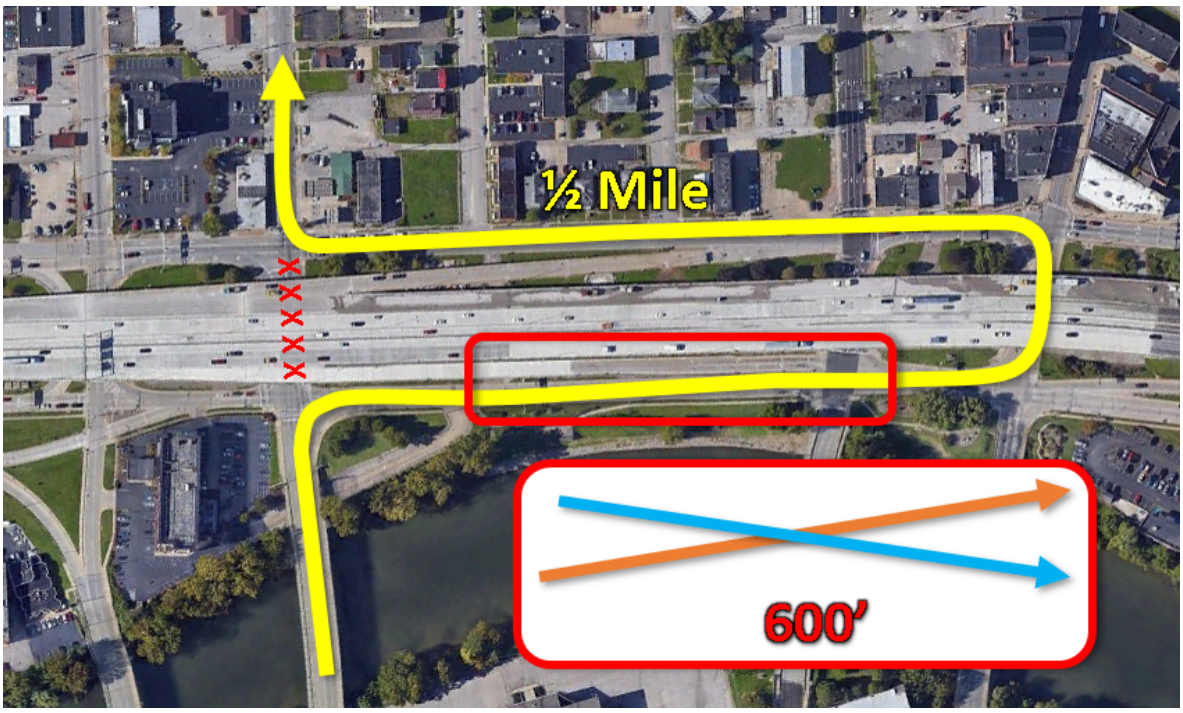

Figure 15: Relocate Lee Street Ramp and Close Quarrier Street

- **Add a drop decision lane at the Virginia Street West Ramp:** As previously discussed, closing the I-64 Eastbound Off-Ramp to Lee Street is not preferred because of the impacts to traffic along eastbound I-64 at the Virginia Street West ramp. To lessen the impacts, a drop decision lane could be implemented (as illustrated in **Figure 16**). This improvement requires that only traffic entering I-64 from US 119 to change lanes. Traffic on eastbound I-64 does not need to change lanes to exit to Virginia Street West.
  This improvement requires the I-64 Eastbound Off-Ramp at Virginia Street West be widened from one lane to two lanes. This alternative would not completely remove the conflicts created on I-64 eastbound due to weave, but it would reduce the current number of vehicles weaving to exit onto Virginia Street West. As stated previously, the I-64 bridge over the Kanawha River would need to be widened to significantly improve the weave along eastbound I-64.

Figure 16: Drop Decision Lane at Virginia Street West Ramp

6.0 Recommendations and Next Steps

The following improvements and next steps are recommended to improve crashes within the study area.

- Recalculate and implement new clearance intervals at all signalized intersections.
- Evaluate the feasibility of installing backplates at all signalized intersections.
- Install LED signals at all signals (without LED indications) and programmable signal heads at least along Randolph Street and upgrade the signals that are currently programmable.
- Install advanced warning signs for the upcoming signals before Virginia Street West on Pennsylvania Avenue North and before Washington Street West on Pennsylvania Avenue South.
- Redesign and reconstruct the signal for the I-64 Eastbound Off-Ramp at Lee Street to enhance signal head visibility for traffic on the off-ramp.
- Work with WVDOT to program a long-term project to widen the I-64 Eastbound Off-Ramp to Virginia Street West to provide a drop decision lane.

It is also suggested that traffic counts be collected at the intersections of Pennsylvania Avenue North with Virginia Street West and Lee Street. These traffic counts will be used to determine the number of vehicles using the each of these off-ramps as well as the impacts of the potential improvements to the ramp modifications.