SR 611 SAFETY STUDY

Ohio Department of Transportation

Prepared by:

BURGESS & NIPLE

Lanham
ENGINEERING LLC

May 2022

Table of Contents

List of Figures

List of Photos

List of Tables

Appendices

1.0 Executive Summary

The purpose of this study is to analyze the existing safety and capacity conditions and to determine potential countermeasures to reduce crash frequency along SR 611 between Colorado Avenue and Broadway in Lorain, Ohio. SR 611 is a two-way four-lane road with a speed limit of 35 mph located in a mainly commercial and industrial area. The bridge over the Black River located along SR 611 is an area of concern due to the curvature of the roadway, combined with the grade, narrow lanes, and lack of shoulders. These roadway characteristics create little room for driver error.

Crash data from January 1, 2018 through December 31, 2020 was obtained for the study area from ODOT's *GIS Crash Analysis Tool* (GCAT) and analyzed using the *Crash Analysis Module* (CAM) Tool. In the three-year period, 144 crashes occurred in the study area. There was one fatality reported in the study area and an additional 50 crashes (35 percent) resulted in injury. Two fatalities occurred outside the analysis period, in 2021. All three of these fatalities resulted from drivers traveling over the speed limit.

Based on the crash patterns and traffic operations in the study corridor, the following countermeasures are recommended:

Short-Term

- Stripe high visibility crosswalks at all the signalized intersections along the corridor ($26,000 – 2022 Dollars).
- Re-stripe stop bars and add lane use pavement markings and signage at all intersections along the corridor.
- Add speed radar feedback signs on the approaches of the Lofton Henderson Memorial Bridge ($8,000– 2022 Dollars).
- Reconfigure SR 611 from Colorado Avenue to Broadway to a two-lane roadway with a center two-way-left-turn lane (TWLTL) with bicycle lanes with a buffer on each side of the roadway ($299,600 – 2022 Dollars).
    - As part of the roadway reconfiguration, the eastbound and westbound left-turn lanes at SR 611 and Elyria Avenue could be realigned, thus providing better sight distance for the existing westbound left-turn movement and allowing the eastbound left-turn movement.
- Add rumble strips at certain locations in the TWLTL to prevent vehicles from using the TWLTL as a through lane ($2,000 per section – 2022 dollars).
- Add pedestrian signal heads and push buttons at the intersections of SR 611 with Colorado Avenue. Debris should also be cleared from sidewalks and curb ramps ($51,900 – 2022 Dollars).
- Continue with pedestrian signal head and push button improvements at the intersections of SR 611 with Elyria Avenue/21st Street and Broadway as part of the ODOT D12 pedestrian safety application submitted in January 2022.
- Enhance intersection lighting at SR 611/Kansas Avenue and Elyria Avenue/E 21st Street.
- Add "Intersection Ahead" sign with flashing lights for vehicles traveling southbound off the bridge north of Access Road ($2,000 –2022 dollars).

Medium-Term

- Improve existing sidewalk along the corridor ($525,900 – 2025 Dollars).
- Rebuild traffic signal at SR 611/Kansas Avenue and Colorado Avenue ($299,700 – 2025 Dollars).

Long-Term

- Remove the northbound right-turn slip lane at SR 611/Kansas and Colorado Avenue and bring the right-turn lane into the intersection ($215,500 – 2027 Dollars).
- Close the E 21st Street leg of SR 611 and Elyria Avenue/21st Street ($604,000 – 2027 Dollars).
- Add raised medians at certain locations in the TWLTL if vehicles are still using the TWLTL as a through lane, regardless of the rumble strips ($17,600 per median – 2022 Dollars).

2.0 Purpose and Location

The purpose of this study is to analyze the existing safety and capacity conditions and to determine potential countermeasures to reduce crash frequency along SR 611 from Colorado Avenue to Broadway in Lorain, Ohio. The study area is shown below in **Figure 1** with the speed limits of each roadway segment.

Figure 1: Study Area

3.0 Existing Conditions

Land use surrounding the study corridor is generally commercial and industrial with a few residences on the southern end of the corridor between Elyria Avenue and Broadway. There are several undeveloped or vacant lots along the corridor. SR 611 crosses over the Black River and goes underneath the Norfolk Southern railway line near Access Road.

Roadway Conditions

SR 611 between Colorado Avenue and Broadway is classified as a principal arterial. SR 611 is a two-way four-lane road with a speed limit of 35 mph between Colorado Avenue and Elyria Avenue and a two-way two-lane roadway with turn lanes between Elyria Avenue and Broadway. Continuous sidewalks are provided along the west side and discontinuous sidewalks exist in a few locations along the east side of the study corridor. In some locations, sidewalks were missing or in poor condition, cracked and overgrown by vegetation, or covered in debris, shown in **Photo 1** and **Photo 2**. The guardrail along the sidewalk along the west side of the bridge crossing the Black River had

several dents. Some of this damage is shown in **Photo 3**. On-street parking is not provided along SR 611. Pedestrian railings are provided on either side of the railroad underpass.

The Lofton Henderson Memorial Bridge over the Black River is an area of concern due to the curvature and grade on both of the bridge approaches, narrow 10-foot lanes, and lack of shoulders, shown in **Photo 4**. These roadway characteristics create little room for driver error. Pedestrians, bicyclists, and dirt bike drivers were observing using the sidewalk on the west side of the bridge to cross the river.

Photo 1: Sidewalk on South Side of SR 611

Photo 2: Sidewalk on North Side of SR 611

Photo 3: Guardrail on West Side of SR 611

Photo 4: Lofton Henderson Memorial Bridge

Intersections Conditions

SR 611 /Kansas Avenue and Colorado Avenue

The lane configuration for this signalized intersection is illustrated in **Figure 2**. The current signal is a four-sided box-span configuration. The northbound and westbound approaches have protected/permissive left-turn signal phasing, the eastbound approach has permissive left-turn signal phasing, and the southbound approach has protected left-turn signal phasing. The northbound and eastbound approaches have right-turn overlap phases. The lane use pavement markings are faded throughout the intersection, shown in **Photo 5.** Pedestrian signal heads and push buttons are not provided at the intersection. Crosswalks are striped on all approaches. The crosswalk striping across the northbound right-turn slip lane was very faded, shown in **Photo 6**. Pedestrians were observed traveling through the intersection, shown in **Photo 7**, especially after school release to travel to the fast-food establishments on the east side of SR 611. The Wendy's sign and utility pole on the northbound approach obstructs the pedestrian crossing location across the slip lane, shown in **Photo 8**. Pedestrians must be vigilant while crossing the slip lane as many vehicles are not slowing down or looking for pedestrians. During a site visit, traffic was observed queuing in the eastbound left-turn lane, shown in **Photo 9,** but all traffic was able to get through the intersection each cycle. Intersection lighting is provided at the intersection. A few of the traffic signal heads have some damage to the lens, creating signal visibility issues as shown in **Photo 10**.

Figure 2: Kansas Avenue/Colorado Avenue Intersection Lane Configuration

Photo 5: Faded Pavement Markings at Kansas Avenue /Colorado Avenue Intersection

Photo 6: Faded Crosswalk Markings at Kansas Avenue /Colorado Avenue Intersection

Photo 7: Pedestrians at Kansas Avenue /Colorado Avenue Intersection

Photo 8: Wendy's Sign Blocking Pedestrian Sight Distance at Kansas Avenue /Colorado Avenue Intersection

Photo 9: Queuing in Eastbound Left-Turn Lane at Kansas Avenue /Colorado Avenue Intersection

Photo 10: Damaged Eastbound Signal Heads at Kansas Avenue /Colorado Avenue Intersection

SR 611 and Elyria Avenue/E 21st Street

Figure 3 illustrates the lane configuration of the five-legged signalized intersection of SR 611 with Elyria Avenue and E 21st Street. The westbound and eastbound approaches to the intersection lack lane-use pavement markings and lane use signage. There are also several faded signs located on the span wires of the signal, shown in **Photo 11**. Some smaller nontraditional signal heads are provided, as shown in **Photo 12**. Per the City of Lorain, this signal head was installed to accommodate the high height truck traffic. A few of the traffic signal heads have some damage to the lenses, creating signal visibility issues as shown in **Photo 13**. A lack of pedestrian push buttons and signal heads, combined with all the different movements of the five-legged intersection, creates a stressful pedestrian crossing environment. The crosswalk on the westbound approach has a long crossing distance, shown in **Photo 14**, due to the eastbound slip lane. This signal is currently in design and will be rebuilt in the same configuration within the next few years.

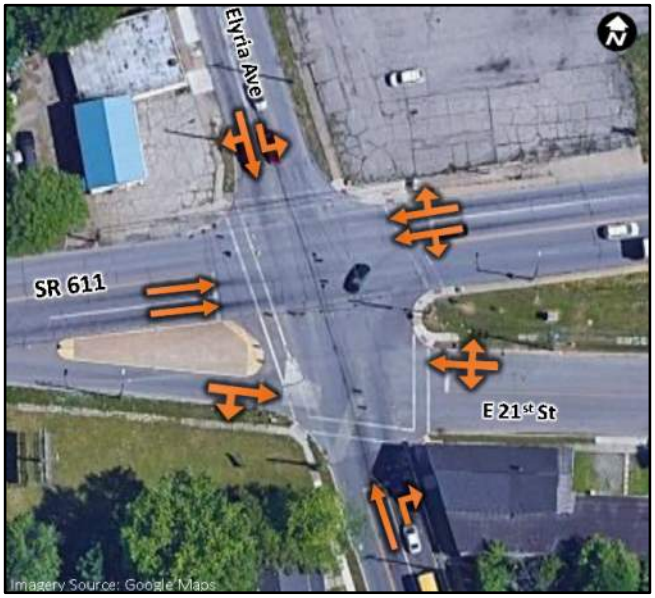


Figure 3: Elyria Avenue and E 21st Street Intersection Lane Configuration

Photo 11: Faded Turn Lane Signage at SR 611 and Elyria Avenue

Photo 12: Non-Traditional Signal Head at SR 611 Elyria Avenue

Photo 13: Damaged Signal Lens at SR 611 and Elyria Avenue

Photo 14: Southbound Approach to Intersection at SR 611 and Elyria Avenue

SR 611 and Broadway

The lane configuration for this signalized intersection is illustrated in **Figure 4**. All signal heads are mounted on mast arms, as shown in **Photo 15** Pedestrian signal heads, push buttons, curb ramps, and crosswalks are provided on all legs of the intersection. The crosswalk pavement markings are faded and difficult to see in some locations around the intersection, as shown in **Photo 16**. The tactile domes on the curb ramps on the northwest corner of the intersection was covered by asphalt, shown in **Photo 17**, due to a temporary repair by Columbia Gas. They are prioritizing a permanent repair.

Figure 4: Broadway Intersection Lane Configuration

Photo 15: SR 611 and Broadway Signal Heads

Photo 16: Faded Crosswalk Markings at SR 611 and Broadway

Photo 17: Northwest Corners Curb Ramps at SR 611 and Broadway

4.0 Data Collection

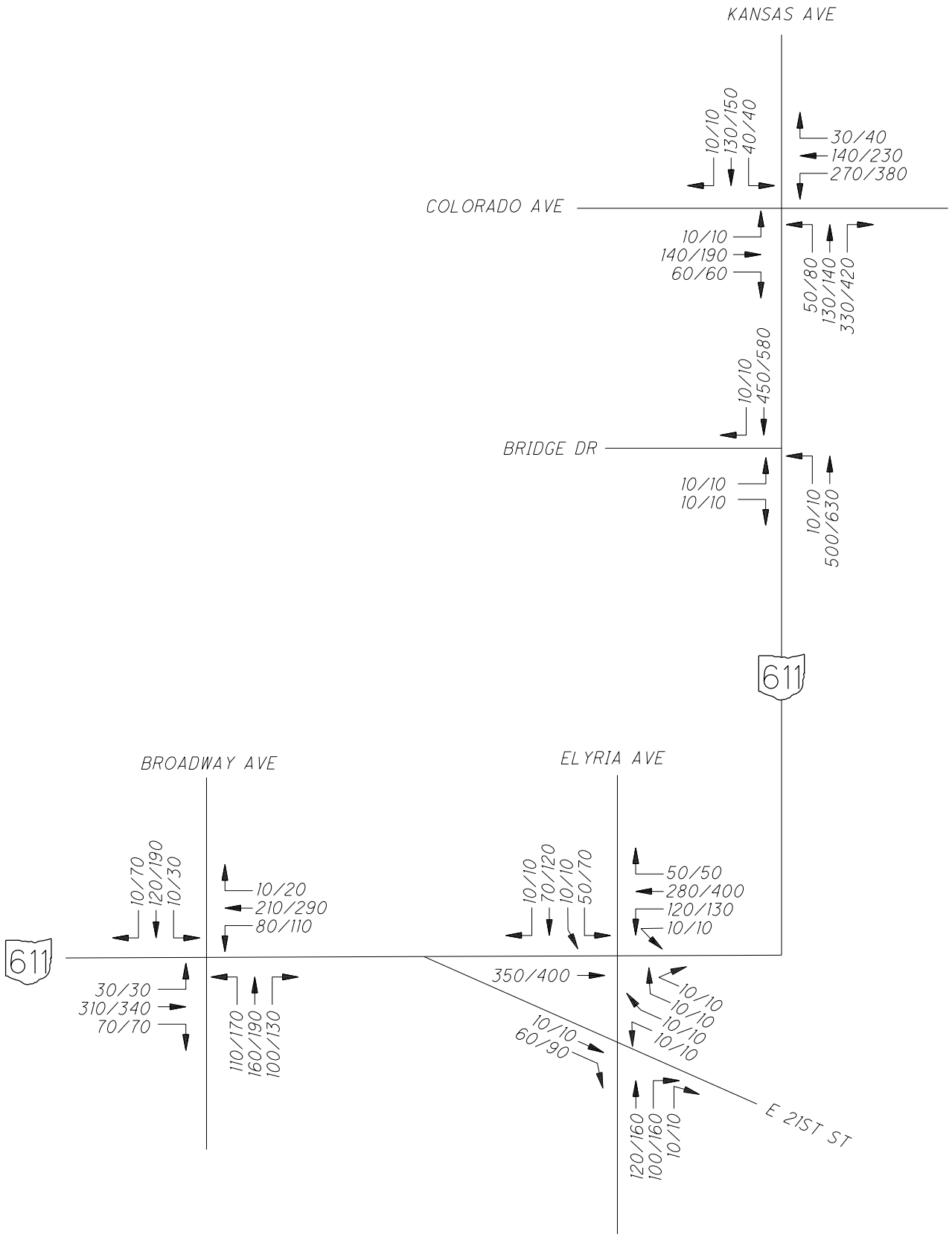
Turning movement counts for the following intersections were collected for 12 hours (7:00 AM to 7:00 PM) on Tuesday, February 8th, 2022.

- SR 611/Kansas Avenue and Colorado Avenue
- SR 611 and Elyria Avenue/E 21st Street
- SR 611 and Broadway

Turning movement counts for the intersection of SR 611 and Bridge Drive was collected for 24 hours between 12:00 AM and 12:00 AM on Tuesday, February 8th, 2022.

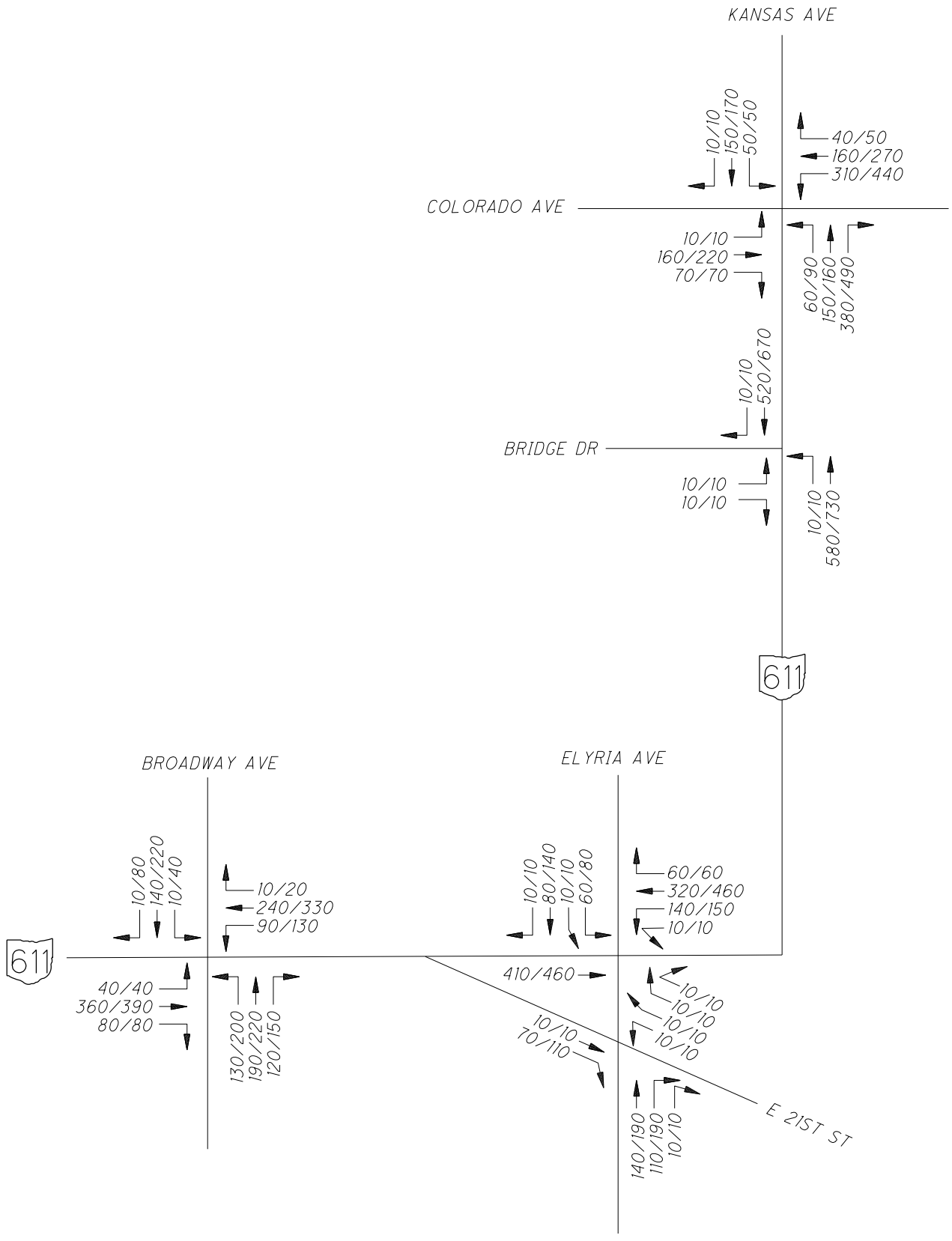
The AM peak hour was determined to be 7:30 AM to 8:30 AM while the PM peak hour was 3:30 PM to 4:30 PM. Note that the volumes were increased, balanced, and smoothed where appropriate. The 2022 peak hour volumes are illustrated in **Figure 5**. Raw traffic counts are provided in **Appendix A.**

Based on NOACA's Travel Demand Model (TDM), the traffic volumes in the area were not predicted to grow in the next 20 years, so an annual growth rate was not applied to existing volumes. ODOT's Peak Hour to Design Hour table for urban principal arterials was used to determine the design hour factor of 1.16. These tables are provided in **Appendix B.** These factors were multiplied by the existing volumes to get the 2022/2042 design hour volumes, summarized in **Figure 6**.



XX/XX - AM Existing Peak Hour Volumes/PM Existing Peak Hour Volumes

FIG 5	PID 115969	LOR-611 SAFETY STUDY 2022 EXISTING AM/PM VOLUMES	ANALYST KHC DATE 4/1/22	NOT TO SCALE	N



XX/XX - AM Design Hour Volumes/PM Design Hour Volumes

FIG 6	PID 115969	LOR-611 SAFETY STUDY FUTURE YEAR AM/PM VOLUMES	ANALYST KHC DATE 4/1/22	NOT TO SCALE	N

5.0 No Build Capacity Analysis

Intersection capacity was evaluated at the three signalized intersections using the design hour traffic volumes, existing lane configurations, and existing traffic control using Highway Capacity Software (HCS, Version 7). The signal times were optimized within HCS using the optimization process found in the ODOT Analysis and Traffic Simulation (OATS). Existing timing plans were unavailable. The No Build analysis is summarized in **Tables 1, Table 2** and **Table 3** with analysis output provided in **Appendix C.**

Table 1: Operational Analysis Results for No Build Conditions at SR 611 at Colorado Ave

SR 611 and Colorado Avenue												
	Overall Intersection	Eastbound Colorado Ave			Westbound Colorado Ave		Northbound SR 611			Southbound Kansas Ave		
		LT	TH	RT	LT	TH/RT	LT	TH	RT	LT	TH	TH/RT
Design AM Peak Hour												
LOS	C	C	C	B	C	B	B	C	C	D	C	C
Delay	24.7	22.7	25.1	19.6	31.2	15.3	18.0	22.9	26.3	38.1	22.1	22.1
v/c		0.03	0.40	0.16	0.78	0.31	0.14	0.34	0.75	0.52	0.18	0.18
95th % Queue		8'	131'	48'	160'	123'	40'	119'	314'	52'	61'	59'
		C – 23.4			C – 25.0		C – 24.6			C – 25.9		
Design PM Peak Hour												
LOS	C	C	C	C	D	B	C	C	C	D	C	C
Delay	31.4	28.4	34.3	24.6	49.3	15.9	22.8	28.1	27.9	44.7	27.5	27.5
v/c		0.04	0.61	0.17	0.94	0.42	0.24	0.38	0.80	0.57	0.22	0.22
95th % Queue		9'	229'	60'	445'	213'	76'	156'	433'	63'	86'	82'
		C – 31.9			D – 35.2		C – 27.3			C – 31.2		

Under No Build conditions, the intersection approaches and movements operate at LOS D or better during both peak hours. The westbound left-turn movement operates at a LOS D during the PM peak hour due to the high volume of left-turning vehicles during this time period. The volumes are approaching capacity for a single left-turn lane during the peak hour. The southbound left-turn movement, while not a large volume, is performing at LOS D in both the AM and PM as this movement is competing with the higher northbound right-turning volume for green time. The southbound left-turn movement is also protected-only which contributes to the increase in delay. While the delay is elevated for the southbound left-turn movement, the queue length is less than 65 feet in both peak periods.

Table 2: Operational Analysis Results for No Build Conditions at SR 611 and Elyria Ave

SR 611and Elyria Avenue											
	Overall Intersection	Eastbound SR 611			Westbound SR 611		Northbound Elyria Ave			Southbound Elyria Ave	
		LT	TH	RT	LT	TH/RT	LT	TH	RT	LT	TH/RT
Design AM Peak Hour											
LOS	C	-	B	-	C	C	-	B	B	C	A
Delay	20.4	-	19.7	-	28.6	21.9	-	15.2	16.2	31.7	8.1
v/c		-	0.45	-	0.82	0.69	-	0.26	0.41	0.54	0.12
95th % Queue		-	128'	-	201'	190'	-	90'	119'	52'	36'
		B – 19.7			C – 25.0		B – 15.7			B – 16.9	
Design PM Peak Hour											
LOS	C	-	B	-	C	C	-	B	B	C	A
Delay	21.2	-	19.9	-	31.0	23.2	-	16.1	16.5	31.6	8.4
v/c		-	0.49	-	0.92	0.79	-	0.32	0.38	0.59	0.18
95th % Queue		-	140'	-	240'	229'	-	113'	110'	64'	55'
		B – 19.9			C – 26.8		B – 16.3			B – 16.1	

East 21st Street and Elyria Avenue												
	Overall Intersection	Eastbound East 21st St			Westbound East 21st St		Northbound Elyria Ave			Southbound Elyria Ave		
		LT	TH	RT	LTR		LT	TH	RT	LT	TH	RT
Design AM Peak Hour												
LOS	B	-	B		B		-	B	B	B	A	-
Delay	10.5	-	11.1		10.5		-	13.5	10.5	16.6	6.4	-
v/c		-	0.26		0.07		-	0.73	0.04	0.33	0.31	-
95th % Queue		-	19'		6'		-	77'	3'	7'	35'	-
		B –11.1			B – 10.5		B – 13.4			A – 7.2		
Design PM Peak Hour												
LOS	B	-	B		B		-	B	A	B	A	-
Delay	11.0	-	14.1		13.0		-	13.5	9.4	18.5	5.9	-
v/c		-	0.47		0.12		-	0.81	0.03	0.33	0.37	-
95th % Queue		-	39'		13'		-	135'	3'	9'	50'	-
		B – 14.1			B – 13.0		B – 13.5			A – 6.8		

The intersection of SR 611 and Elyria Avenue/E 21st Street was analyzed as two intersections due to limitations of the analysis methodology. The intersection was split into the northern intersection of SR 611 at Elyria Avenue and a southern intersection of E 21st Street at Elyria Avenue. Both intersections operate at LOS C or better for both peak hours under No Build conditions.

Table 3: Operational Analysis Results for No Build Conditions at SR 611 and Broadway

SR 611 and Broadway											
	Overall Intersection	Eastbound SR 611		Westbound SR 611		Northbound Broadway			Southbound Broadway		
		LT	TH/RT	LT	TH/RT	LT	TH	RT	LT	TH	RT
Design AM Peak Hour											
LOS	B	B	C	B	A	C	B	B	C	C	C
Delay	18.6	15.4	22.5	13.9	9.2	20.3	17.1	17.2	25.5	27.1	27.1
v/c		0.10	0.90	0.32	0.31	0.40	0.32	0.34	0.05	0.45	0.46
95th % Queue		20'	278'	35'	89'	80'	90'	82'	7'	58'	54'
		C – 21.9		B – 10.5		B – 18.1			C – 27.0		
Design PM Peak Hour											
LOS	B	B	C	B	B	C	B	B	C	C	C
Delay	19.9	16.7	23.9	15.0	10.6	22.2	16.7	16.9	26.1	28.3	28.7
v/c		0.10	0.89	0.40	0.39	0.58	0.32	0.34	0.17	0.65	0.68
95th % Queue		19'	280'	48'	125'	120'	97'	88'	26'	107'	100'
		C – 23.3		B – 11.8		B – 18.7			C – 28.2		

The No Build operational analysis results at SR 611 and Broadway indicate that the intersection and all movements currently operate at LOS C or better during both peak periods.

6.0 Existing Safety Analysis

Crash Trends and Analysis

Crash data from January 1, 2018 through December 31, 2020 was obtained for the study area from ODOT's *GIS Crash Analysis Tool* (GCAT) and analyzed using the *Crash Analysis Module* (CAM) Tool. In the three-year period, 144 crashes occurred in the study area with 35 percent resulting in injury and one crash resulting in a fatality. **Figure 7** shows the frequency of crashes, by severity, per year. Property damage only collision crashes have continued to grow between 2018 and 2020 while injury collisions have remained consistent.

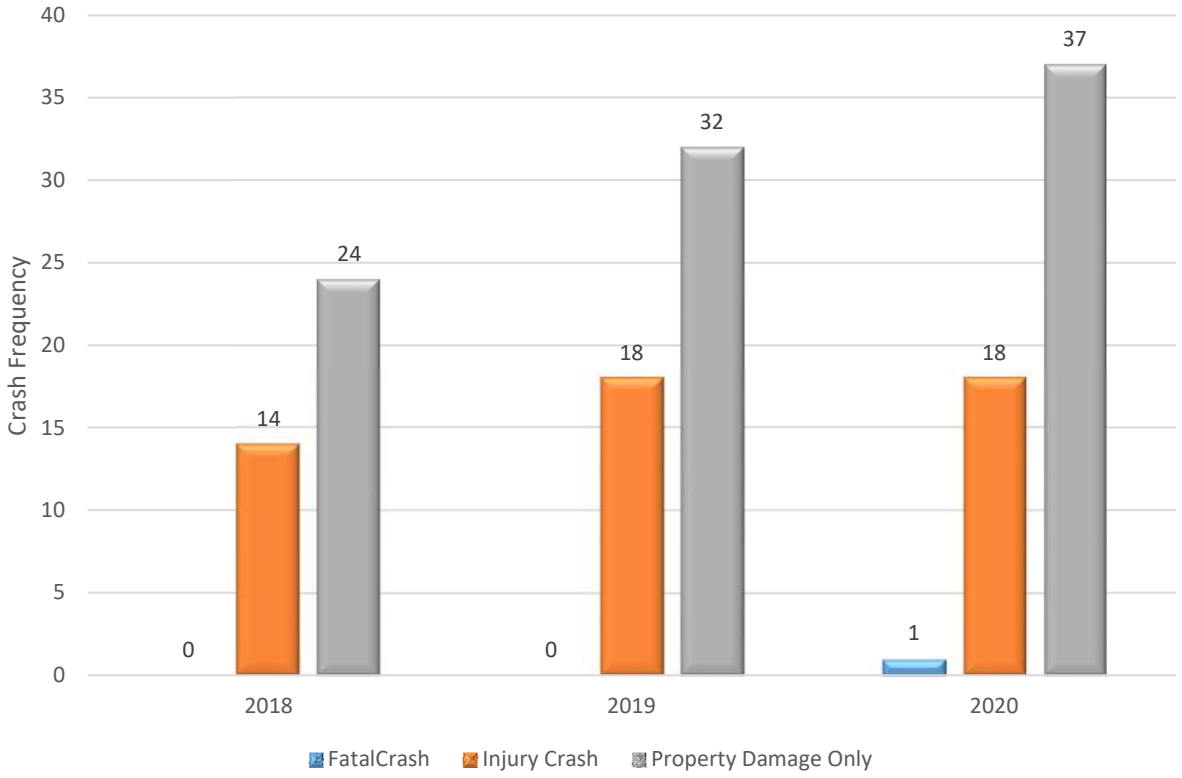


Figure 7: Frequency of Crashes by Year and Severity

Figure 8 displays the locations of the fatal and serious injury collisions along the study area. The main locations the fatal and serious injury collisions occurred were just south of the intersection of SR 611/Kansas Avenue and Colorado Avenue and on the Lofton Henderson Memorial Bridge.

While not included in the study period between 2018 and 2020, two additional fatal collisions occurred in the study area in 2021. A fatal crash occurred on January 23, 2021, at 1:11 PM, east of the intersection of SR 611 and Elyria Avenue at the railroad underpass. A vehicle was traveling eastbound at a high speed and failed to negotiate the curve at the underpass, striking the pedestrian handrail and concrete structure.

The other fatal crash occurred on August 21, 2021, at 8:53 PM when a vehicle was traveling northbound on the Lofton Henderson Memorial Bridge at an unsafe speed and attempted to change lanes to pass another vehicle on the bridge. The speeding vehicle lost control on the curve, hit the vehicle it was attempting to pass and hit another vehicle traveling the opposite directions in the southbound direction and then struck the guardrail. The driver of the speeding vehicle died after striking the guardrail.

While only nine percent of the collisions in the study area between 2018 and 2020 were speed related, drivers traveling at a high speed was a contributing factor in all three of the fatal collisions between 2020 and 2021.

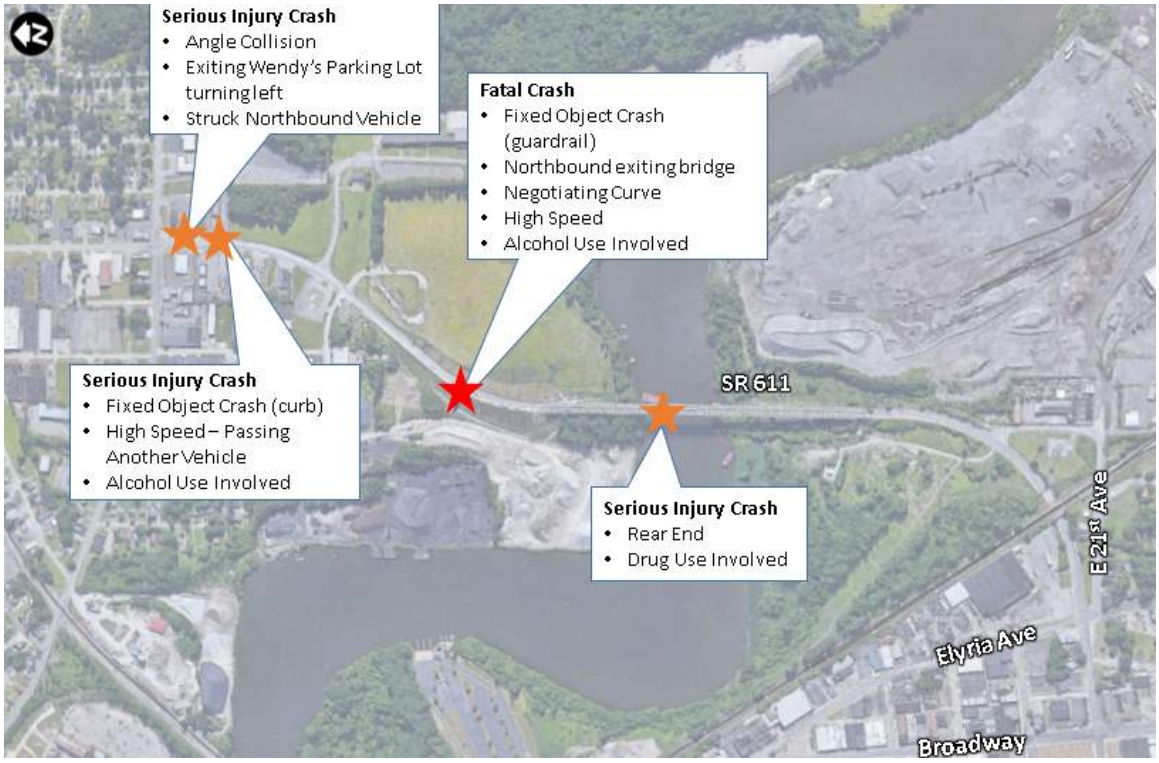


Figure 8: Fatal and Serious Injury Crashes (2018 to 2020)

Figure 9 shows the location of pedestrian and bicycle crashes. There were two crashes involving a bicycle and one crash involving a pedestrian. All three bicycle/pedestrian crashes occurred in intersection crosswalks, and all resulted in injury. The vehicle was at fault in the bicycle collision at SR 611 with Colorado Avenue and in the pedestrian collision at SR 611 and Broadway. The bicycle was at fault at the collision at SR 611 and Broadway, as it entered into the intersection during the "Do Not Walk" pedestrian phase. One crash occurred at the intersection of SR 611 and Colorado Avenue the other two occurred at SR 611 and Broadway.

Figure 9: Pedestrian and Bicycle Crashes

The majority (65 percent) of the collisions in the study area were intersection-related. Full analysis from the CAM Tool is provided in **Appendix D**. **Figure 10** shows the crash frequency in the study area by the crash type. The highest crash type in the study area was rear end collisions (33 percent).

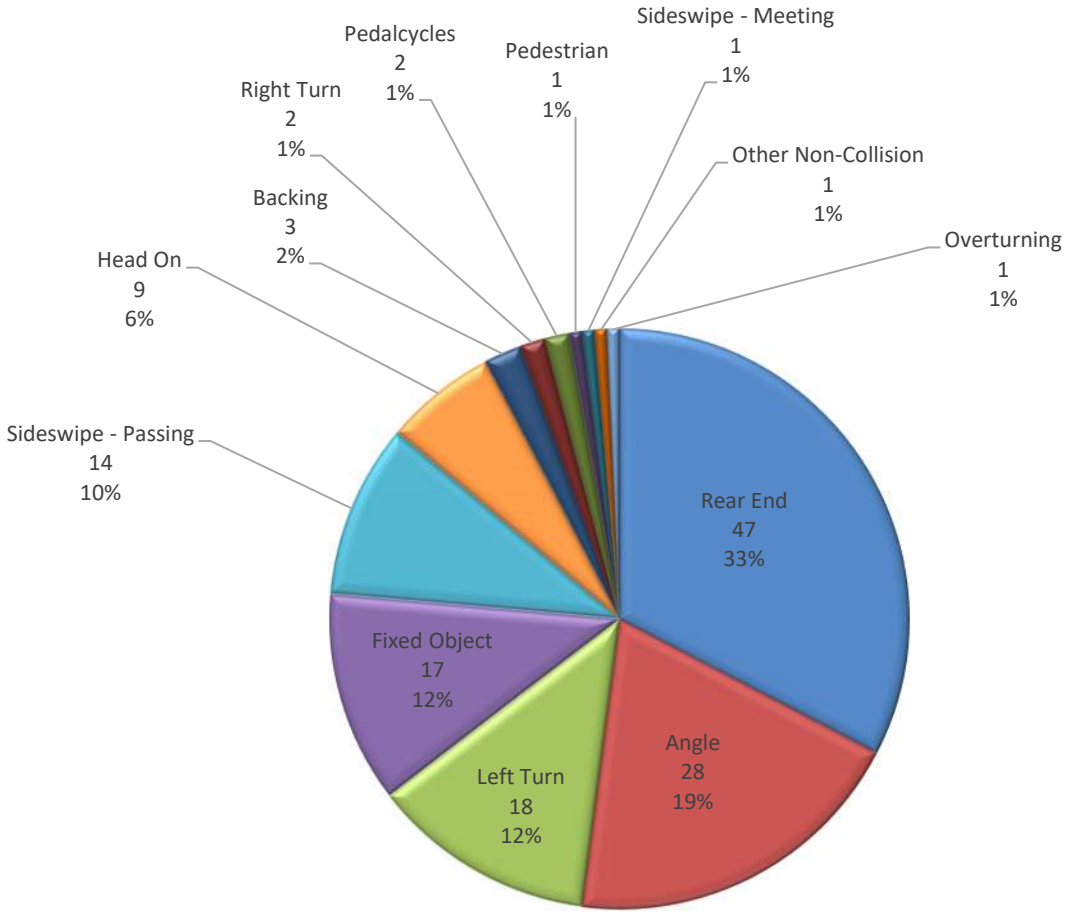


Figure 10: Crash Frequency by Crash Type

Figure 11 shows the crash frequency by hour of the day, with the highest peak occurring between 4:00 PM and 7:00 PM.

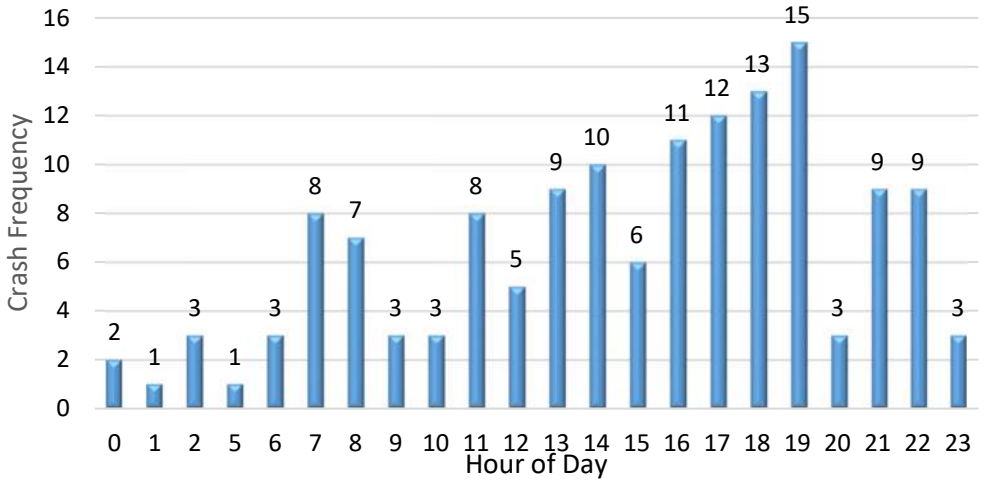


Figure 11: Crash Frequency by Hour of the Day

Table 4 shows the number of crashes and injury percentage at each intersection and segment along the corridor. The section of SR 611 between Colorado Avenue and Bridge Drive had the highest injury percentage with the majority of crashes being fixed object crashes from drivers losing control of their vehicle. The intersection of SR 611 /Kansas Avenue and Colorado Avenue had the highest number of crashes along the study area, with 41 crashes in the three-year period, but had the lowest injury percentage.

A collision diagram that shows crash patterns by illustrating the approximate location of each reported crash at the intersection of SR 611/Kansas Avenue and Colorado Avenue is provided in Appendix E.

Table 4. Crashes by Study Area Segment (2018-2020)

	Fatal	Injury	PDO	TOTAL	Injury Percentage
SR 611/Kansas Ave and Colorado Ave	0	11	30	41	27%
SR 611btw Colorado Ave and Bridge Dr	0	4	2	6	67%
SR 611and Bridge Dr	0	0	0	0	N/A
SR 611btw Bridge Dr and Access Rd	1	10	17	28	39%
SR 611 and Access Rd	0	2	3	5	40%
SR 611btw Access Rd and Elyria	0	1	1	2	50%
SR 611and Elyria	0	8	15	23	35%
SR 611and Broadway	0	14	25	39	36%
TOTAL	**1**	**50**	**93**	**144**	**35%**

SR 611 /Kansas Avenue and Colorado Avenue

The most common crash type at this intersection was rear end collisions. Out of the 24 rear end collisions, nine occurred on the northbound right-turn slip lane. This pattern of rear end crashes likely occurs when a right-turning vehicle begins to accelerate after finding a gap in traffic along Colorado Avenue. The driver then realizes that the gap is not adequate, abruptly brakes and is rear ended by the vehicle behind them. The second most common crash type at this intersection was angle crashes occurring throughout the intersection.

SR 611 and Elyria Avenue/E 21st Street

Left-turn collisions were the most common crash type at this intersection (48 percent). All of the left-turn collisions were between a westbound left-turning vehicle and eastbound vehicle. These left-turn collisions occurred due to westbound vehicles failing to yield to eastbound vehicles. This could be related to the two through lanes traveling eastbound at the intersection. The driver may think that the left through-lane is a left-turn lane and thus not know that they need to yield to that lane. Alternatively, the vehicle in the inside eastbound through lane may obstruct the view of vehicles in the outside eastbound through lane. As a result, the driver making a westbound left-turn may believe there is a clearance in traffic because they do not see the vehicle in the outside eastbound through lane. Out of the 11 left-turn collisions, four (36 percent) resulted in injury. Eight (73 percent) left-turn collisions occurred in nighttime conditions indicating that lighting could be an issue.

SR 611 and Broadway

The highest crash patterns as this intersection were angle collisions (36 percent) and rear end collisions (28 percent). The majority (57 percent) of the angle collisions occurred due to red light running. Out of the eight angle collisions that involved red light running, six crashes resulted from southbound vehicles running the red light. There was also one crash involving a bicycle and one crash involving a pedestrian at this intersection, both occurring in the crosswalks.

Highway Safety Manual Analysis

The Highway Safety Manual (HSM) is used to determine how an intersection is performing compared to similar intersections and to assess the safety benefit of countermeasures. ODOT's Economic Crash Analysis Tool (ECAT) was used to evaluate the intersection of SR 611/Kansas Avenue and Colorado Avenue and the proposed countermeasures. The following three factors are calculated from the HSM analysis:

- **Predicted Crash Frequency ($N_{predicted}$)** – How the site would be expected to perform relative to 1,000 similar sites with comparable volumes.
- **Expected Crash Frequency ($N_{expected}$)** – Average performance of the site over an extended period of time based on actual crash history.
- **Potential for Safety Improvement (PSI)** – Difference between expected crash frequency and predicted crash frequency. A positive PSI indicates that the location is performing poorly compared to similar locations and safety improvements would likely have a significant impact in reducing the crash frequency.

The intersection of SR 611/Kansas Avenue and Colorado Avenue was evaluated in ECAT. The results from the HSM Analysis are summarized in **Table 5.** Output from the ECAT analysis is included in **Appendix F**.

Table 5: SR 611 and Colorado Ave Existing Conditions HSM Analysis Results

	Fatal and Incapacitating Injury Crashes	Non-Incapacitating Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Total
$N_{predicted}$	0.15	0.70	0.98	4.96	6.79
$N_{expected}$	0.18	0.85	1.20	7.37	9.61
PSI	+0.03	+0.15	+0.23	+2.42	+2.82

This intersection is performing worse than other intersections with similar volumes and geometric characteristics in every severity, as indicated by the positive PSI. This intersection is performing worse than similar intersections by approximately three crashes per year. The severity with highest PSI was property damage only collisions.

7.0 Countermeasures for Consideration

The following short-term countermeasures were identified to mitigate crashes and improve safety within the study area:

- **Improve pavement markings:** Re-striping stop bars, adding lane use pavement markings and painting high visibility crosswalks are proposed along the corridor.
- **Add speed radar feedback signs on the approaches of the Lofton Henderson Memorial Bridge:** Several of the injury crashes and all the fatal crashes have been related to vehicles speeding along the corridor, especially on the Lofton Henderson Memorial Bridge. Speed radar feedback signs are proposed on the approaches of the Lofton Henderson Memorial Bridge to encourage drivers to slow down through the corridor.
- **Add "Intersection Ahead" sign with flashing lights for vehicles traveling southbound off the bridge north of Access Road:** Due to the curvature of SR 611 and the railroad overpass, sight distance to the Elyria Avenue intersection is obstructed. Additional advanced signage will help alert drivers to the upcoming intersection. Currently there is a "Be Prepared to Stop" sign that can be removed with the addition of this sign.
- **Roadway reconfiguration:** Reconfigure SR 611 from Colorado Avenue to Broadway to a two-lane roadway with a center two-way-left-turn lane (TWLTL). This infrastructure improvement is a proven safety countermeasure that has been shown to reduce vehicle speeds, crash frequency and increase mobility. The TWLTL typically reduces rear end collisions by eliminating unexpected slowing or stopped vehicles in the inside through lane when vehicles are waiting to turn left. Angle and left-turn collisions will also likely be reduced due to the shorter and simpler turning maneuvers with only one through lane in each direction. Sideswipe collisions will likely be reduced as vehicles will not be unexpectedly changing lanes to move around vehicles stopped on SR 611. The roadway configuration includes bicycle lanes on each side of the roadway with a buffer to improve bicycle mobility and safety in the corridor. A cycle track was also considered along the east side of the roadway but was eliminated due to the number of driveways, as well as the general unfamiliarity with this configuration.

  The cross section includes a 10-foot travel lane in the northbound and southbound direction, a 10-foot TWLTL, and a five-foot bike lane with a one-foot buffer on either side of the travel lanes. The roadway reconfiguration over the bridge does not need a TWLTL and can have a wider buffer between the bike lanes and the travel lanes. A painted median could be striped

Source:Streetmix

Figure 12: Typical Section of Bike Lanes

between the travel lanes. A typical section of this layout is shown in **Figure 12**. The pavement would need to be resurfaced and re-striped but very minimal pavement or curb work would be necessary.

Rumble strips are proposed in some locations within the TWLTL throughout the corridor to prevent vehicles from using the TWLTL as an additional through lane or using it to pass or speed around other vehicles. Small raised concrete median islands can be added to the TWLTL if the rumble strips are not effective in preventing vehicles from driving in the TWLTL.

Additionally, the following medium-term improvements are proposed:

- **Improve existing sidewalk along the corridor:** Some of the sidewalk is damaged, cracked, or missing along the corridor. Improving the existing sidewalk is proposed.

In addition to the road reconfiguration, the following improvements were identified at the study intersections:

SR 611/Kansas Avenue and Colorado Avenue

The following short-term improvements are proposed:

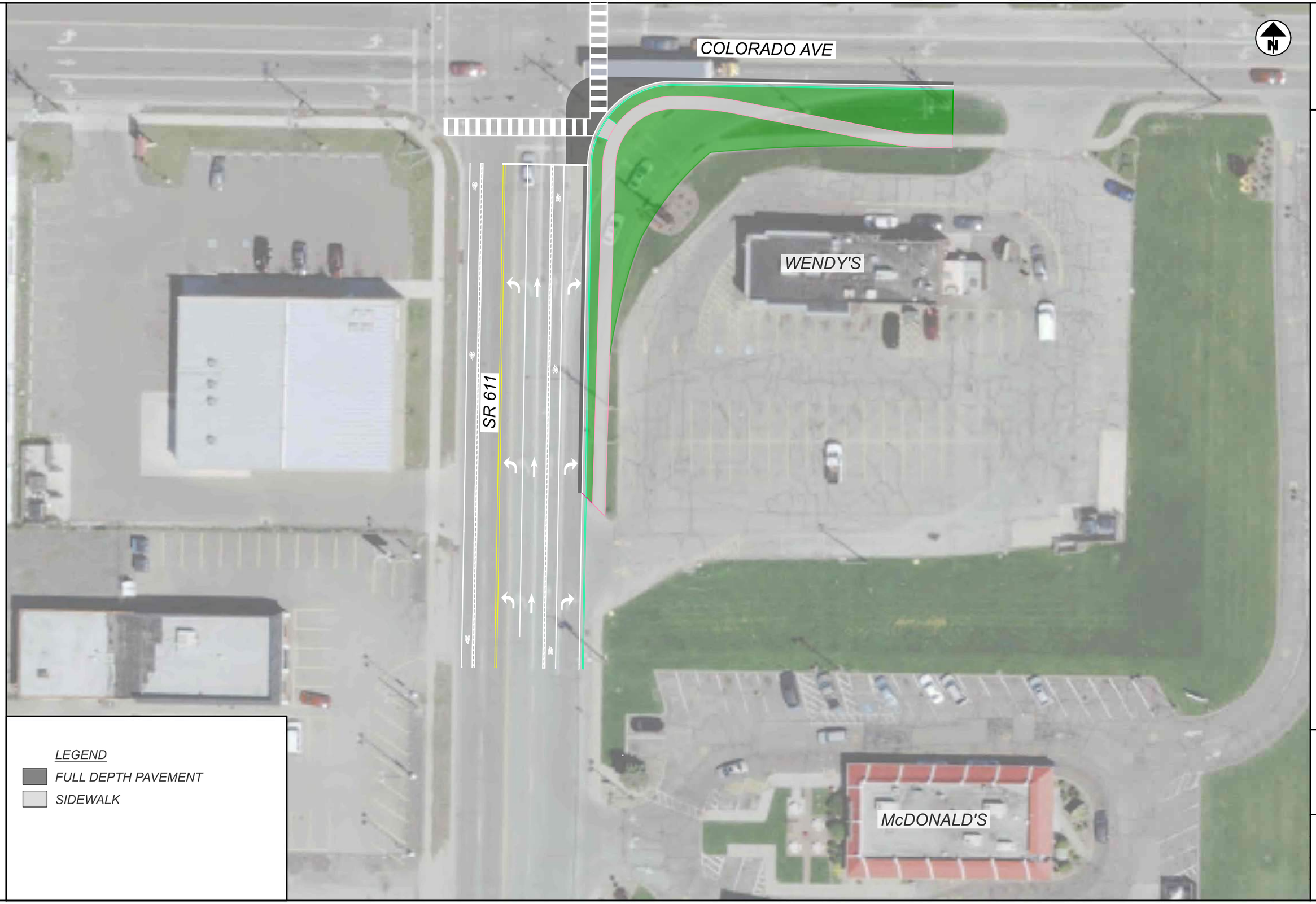
- **Improve pedestrian facilities:** Pedestrian improvements such as pedestrian signal heads, push buttons, and high visibility crosswalks are proposed to improve pedestrian safety.
- **Improve pavement markings:** Restriping the pavement markings is proposed due to the faded lane-use pavement markings throughout the intersection.

The following medium-term improvements are proposed:

- **Rebuild traffic signal:** Rebuilding the traffic signal is proposed to improve signal visibility. Retroreflective backplates are recommended on all signal heads in the rebuild of the traffic signal.

The following long-term improvements are proposed:

- **Remove the northbound right-turn slip lane:** Consider removing the right-turn slip lane at SR 611 and Colorado Avenue and creating a traditional right-turn lane at the intersection. Removing the slip lane is expected to help improve pedestrian safety and reduce rear end collisions at the intersection. The traffic signal would need to be rebuilt due to the pole located in the concrete island between the intersection and the slip lane. A layout of the right-turn lane removal is shown in **Figure 13**.



Northbound Right-Turn Slip Lane Removal

Figure 13

SR 611 and Elyria Avenue/E 21st Street

The following short-term improvements are proposed:

- **Improve pedestrian facilities:** Pedestrian improvements such as pedestrian signal heads, push buttons and high visibility crosswalks are proposed. Debris should also be cleared from sidewalks and curb ramps. This improvement will be funded through an ODOT D12 pedestrian safety project, awarded in May 2022.
- **Improve pavement markings:** Improving the lane-use pavement markings and signs is proposed. The layout of this intersection is non-traditional, so pavement markings and signs should help decrease driver confusion as they travel through this intersection.
- **Enhance intersection lighting:** Approximately half of the crashes at this intersection occurred in dark lighting conditions. Enhancing the intersection lighting at this intersection is proposed. Lighting poles are currently present on the east and north side of the intersection.
- **Westbound and eastbound left-turn lane realignment:** As part of the roadway reconfiguration, the eastbound and westbound left-turn lanes could be realigned, thus allowing the eastbound left-turn movement. **Figure 14** shows the left-turn lane realignment.

The following long-term improvements are proposed:

Close E 21st Street: Consider closing the E 21st Street leg of the intersection by constructing a cul-de-sac. This layout is shown in **Figure 15**. The E 21st Street leg of the intersection has several access points from Access Road and East Road. Based on the traffic counts, only approximately 100 vehicles traveled on this roadway in 12-hours. Removing this leg of the intersection would simplify the overall intersection movements and create a better environment for pedestrians crossing the intersection.

The E 21st Street leg currently allows trucks to bypass the railroad underpass. If this countermeasure is considered, more investigation would be required to determine alternative truck routes or necessary underpass reconstruction.

SR 611 and Broadway

The following short-term countermeasures are proposed:

- **Stripe high visibility crosswalks:** High visibility crosswalks should be striped on all legs of the intersection. This improvement will be funded through an ODOT D12 pedestrian safety project, awarded in May 2022.
- **Modify stop bar placement:** Truck turns were run at the intersection, and it was found that to accommodate a semi-truck through the intersection, the stop bar on the west leg should be shifted to the west 30 feet.
- **Improve pavement markings:** Restriping the pavement markings is proposed due to the faded lane-use pavement markings throughout the intersection.

The traffic signals at the intersections of SR 611 with Elyria Avenue/E 21st Street and Broadway are both in the process of being redesigned and rebuilt.

ELYRIA AVE

SR 611

E 21st STREET

HORIZONTAL SCALE IN FEET

0 10 20 40

LEGEND

RESURFACING

Left-Turn Realignment at Elyria Avenue and E 21st Street

Figure 14

HORIZONTAL SCALE IN FEET
0 10 20 40

ELYRIA AVE

℄ SR 611

SR 611

PC 105+76.97

101 102 103 104 105 106

E 21st STREET

LEGEND

FULL DEPTH PAVEMENT OR RESURFACING

SIDEWALK

Closure and Cul-De-Sac at E 21st Street

Figure 15

8.0 Countermeasure Evaluation

8.1 Signal Warrant Analysis

Signal warrants were performed for the intersections SR 611 at Colorado Avenue, SR 611 at Elyria Avenue, and SR 611 at Broadway. The signal warrants were performed with the lane configurations for the roadway reconfiguration. The three intersections are currently signalized, but a warrant analysis was performed at each location to determine if the signal is still needed. Unwarranted signals can result in increased delay, congestion, and crashes. When a signal is not warranted and vehicles have excessive delay, it may encourage drivers to disregard the signal. Additionally, vehicles may cut through side streets to avoid the unwarranted signal. Based on the signal warrant analysis, all three intersections currently meet the criteria to warrant a signal. The detailed signal warrants are provided in **Appendix G.** The following signal warrants were met for each signalized intersection:

- Warrant 1, Eight-Hour Vehicular Volume
- Warrant 2, Four-Hour Vehicular Volume

An additional signal warrant analysis was completed at the existing unsignalized intersection of SR 611 and Bridge Drive to determine if a signal is warranted after the roadway reconfiguration. The warrant analysis indicated that this intersection does not meet warrants and should remain unsignalized.

8.2 Operational Evaluation

Roadway Reconfiguration

Operational analysis was conducted for the countermeasures discussed in **Section 7.0** of this report. The analysis was conducted with HCS for the 2022/2042 design year volumes. The goal of this analysis is to confirm that the safety recommendations at the intersections can operate at acceptable levels of service.

The operational analysis was completed for a roadway reconfiguration at SR 611 and Colorado Avenue. This reconfiguration is accomplished by modifying the north approach to convert the southbound shared through/right-turn lane to a dedicated right-turn lane. The lane use of this intersection modification is shown in **Figure 16**.

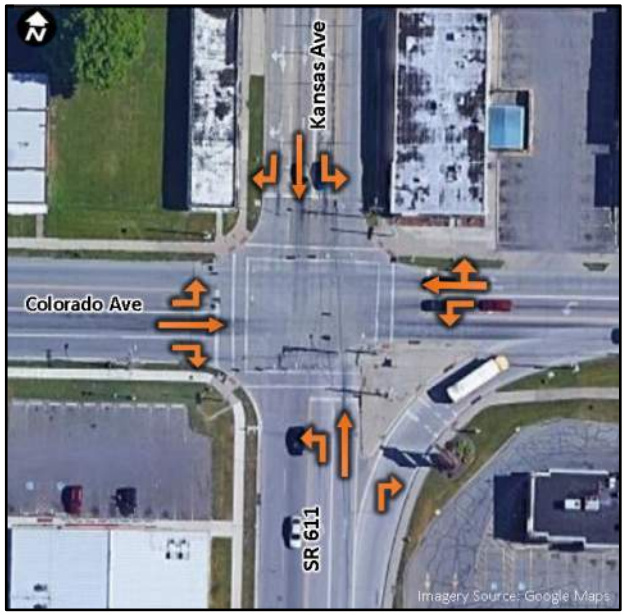


Figure 16: SR 611 and Colorado Avenue Roadway Reconfiguration Lane Configuration

The analysis results are shown in **Table 6**. Detailed results can be found in **Appendix H**.

Table 6: SR 611 at Colorado Avenue Road Reconfiguration Analysis Results (Design Year)

SR 611 and Colorado Avenue												
	Overall Intersection	Eastbound Colorado Ave			Westbound Colorado Ave		Northbound SR 611			Southbound Kansas Ave		
		LT	TH	RT	LT	TH/RT	LT	TH	RT	LT	TH	TH/RT
Design AM Peak Hour												
LOS	C	C	C	B	D	B	B	B	C	C	B	B
Delay	25.6	20.2	34.3	17.3	37.5	11.9	14.5	18.8	28.6	24.2	19.1	17.2
v/c		0.04	0.76	0.24	0.88	0.35	0.17	0.47	0.85	0.43	0.47	0.04
95th % Queue		5’	130’	34’	239’	77’	26’	80’	260’	31’	82’	5’
		C – 28.8			C – 27.5		C – 24.7			C – 20.2		
Design PM Peak Hour												
LOS	C	C	D	C	D	B	C	C	C	D	C	C
Delay	32.2	30.1	37.2	26.2	52.1	16.3	23.6	28.6	25.7	46.0	29.6	26.5
v/c		0.04	0.65	0.19	0.96	0.431	0.27	0.38	0.78	0.57	0.41	0.03
95th % Queue		10’	244’	64’	479’	226’	79’	161’	426’	64’	173’	9’
		C – 34.4			D – 37.0		C – 26.1			C – 33.0		

The analysis shown above indicates that all movements and approaches at the intersection will operate at LOS D or better with the proposed roadway configuration. Comparable to the No Build conditions analysis, the westbound left-turn movement is approaching capacity in the design year during the PM peak, but the queueing remains within the existing storage.

At the intersection of SR 611 and Elyria Avenue, the proposed road reconfiguration was analyzed by removing an eastbound and westbound through lane. The lane configuration of the intersection modification is shown in **Figure 17**. The analysis only focused on the northern intersection of SR 611 and Elyria Avenue as no changes were recommended for the E 21st Street approaches. The analysis results are shown in **Table 7**.

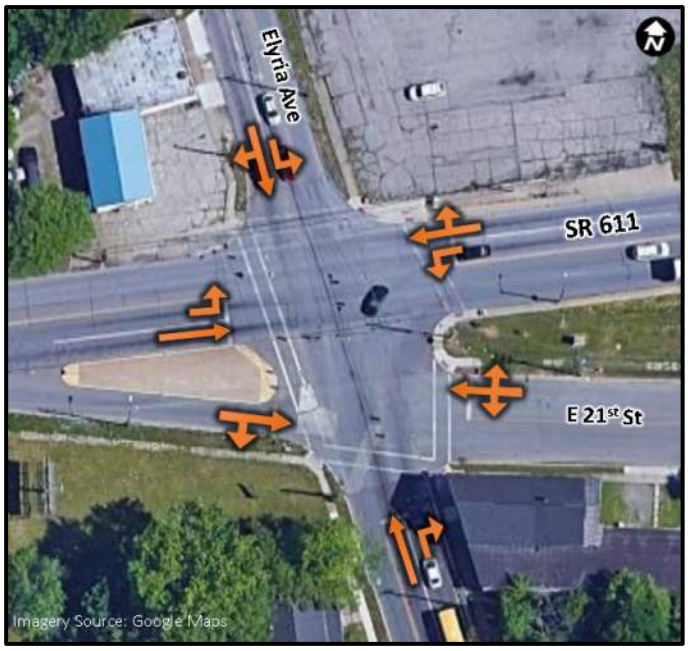


Figure 17: SR 611 and Elyria Avenue Roadway Reconfiguration Lane Configuration

Table 7: SR 611 at Elyria Avenue Road Reconfiguration Analysis Results (Design Year)

SR 611 and Elyria Avenue											
	Overall Intersection	Eastbound SR 611			Westbound SR 611		Northbound Elyria Ave			Southbound Elyria Ave	
		LT	TH	RT	LT	TH/RT	LT	TH	RT	LT	TH/RT
Design AM Peak Hour											
LOS	C	-	C	-	C	B	-	C	C	D	B
Delay	25.0	-	31.3	-	24.9	18.1	-	24.3	26.1	40.9	15.3
v/c		-	0.89	-	0.63	0.55	-	0.33	0.52	0.61	0.15
95th % Queue		-	357’	-	112’	254’	-	138’	183’	69’	64’
		C – 31.3			C – 20.0		C – 25.2			C – 24.9	
Design PM Peak Hour											
LOS	C	-	C	-	C	C	-	C	C	D	B
Delay	25.8	-	32.4	-	22.2	20.3	-	26.7	27.3	42.5	16.9
v/c		-	0.91	-	0.63	0.66	-	0.41	0.50	0.69	0.23
95th % Queue		-	395’	-	100’	333’	-	180’	175’	87’	103’
		C – 32.4			C – 20.7		C – 27.0			C – 25.4	

The analysis results show that all movements operate at LOS D or better and all approaches are LOS C. The eastbound through movement has queues that are approximately 250 feet and 330 feet long during the peak hours but would not back into the intersection of SR 611 and Broadway.

Long-Term Improvements

Next, an analysis was completed for a modification to the existing SR 611 and Colorado Avenue intersection. The modification addresses the channelized northbound right-turn slip lane. Replacing the channelized right-turn lane with a signal-controlled right-turn slip lane at the intersection is proposed. The analysis results are shown in **Table 8.**

Table 8: SR 611 at Colorado Avenue Remove Channelized Right-Turn Lane (Design Year)

SR 611 and Colorado Avenue												
	Overall Intersection	Eastbound Colorado Ave			Westbound Colorado Ave		Northbound SR 611			Southbound Kansas Ave		
		LT	TH	RT	LT	TH/RT	LT	TH	RT	LT	TH	RT
Design AM Peak Hour												
LOS	C	C	C	B	C	B	B	C	C	B	C	C
Delay	23.2	23.2	25.8	19.0	29.3	15.1	18.6	23.1	23.3	19.5	23.3	23.4
v/c		0.03	0.41	0.16	0.76	0.31	0.14	0.34	0.73	0.14	0.19	0.20
95th % Queue		8’	133’	47’	127’	121’	44’	119’	295’	34’	63’	62’
		C – 23.7			C – 23.7		C – 22.8			C – 22.4		
Design PM Peak Hour												
LOS	C	C	D	C	D	B	C	C	C	C	C	C
Delay	31.0	28.6	35.5	24.8	49.8	15.3	23.3	28.3	27.0	23.4	29.3	26.2
v/c		0.04	0.65	0.18	0.95	0.43	0.28	0.40	0.80	0.16	0.43	0.03
95th % Queue		9’	234’	60’	457’	214’	76’	156’	424’	41’	167’	9’
		C – 32.8			D – 35.3		C – 26.8			C – 27.9		

With the channelized right-turn slip lane removal, all movements and approaches operate at LOS D or better. The westbound left volumes are approaching the capacity of a single left-turn lane during the PM peak.

Another modification analyzed was to close the E 21st Street legs of the intersection to create a four-leg intersection to simplify signal timings and reduce the width of the intersection. This alternative did not include the road reconfiguration on SR 611. The analysis results are shown in **Table 9**.

Table 9: SR 611 at Elyria Avenue Closing E 21st Street (Design Year)

SR 611 and Elyria Avenue											
	Overall Intersection	Eastbound SR 611			Westbound SR 611		Northbound Elyria Ave			Southbound Elyria Ave	
		LT	TH	RT	LT	TH/RT	LT	TH	RT	LT	TH/RT
Design AM Peak Hour											
LOS	B	-	B	B	B	B	-	B	B	B	B
Delay	13.8	-	11.5	10.5	15.4	12.7	-	19.2	19.1	13.4	10.4
v/c		-	0.35	0.13	0.55	0.51	-	0.47	0.43	0.17	0.15
95th % Queue		-	73'	23'	114'	105'	-	77'	60'	25'	32'
		B – 11.4			B – 14.0		B – 19.2			B – 11.6	
Design PM Peak Hour											
LOS	B	-	B	B	B	B	-	C	C	B	B
Delay	15.2	-	12.1	11.2	17.9	14.5	-	20.2	21.1	13.5	10.6
v/c		-	0.38	0.20	0.65	0.61	-	0.58	0.69	0.21	0.22
95th % Queue		-	83'	37'	152'	144'	-	101'	104'	31'	51'
		B – 11.9			B – 16.1		C – 20.6			B – 11.6	

The analysis results show that the simplified intersection at Elyria Avenue operates more efficiently by removing the additional legs of East 21st Street and creating a smaller intersection. All movements operate at LOS C and the overall intersection operates at LOS B for both peak periods.

8.3 Safety Performance Analysis

Safety analysis was performed for the roadway reconfiguration intersection of SR 611/Kansas Avenue and Colorado Avenue. The results of the HSM analysis are summarized in **Table 10.** Detailed results can be found in **Appendix I.**

Table 10: SR 611 and Colorado Ave Roadway Reconfiguration HSM Analysis Results

	Fatal and Incapacitating Injury Crashes	Non-Incapacitating Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Total
$N_{expected}$ - Existing	0.18	0.85	1.20	7.37	9.61
$N_{expected}$ - Proposed	0.18	0.81	1.15	7.05	9.20
Changed in Crashes	-0.01	-0.04	-0.05	-0.32	-0.42

The roadway reconfiguration would modify the southbound approach at the intersection from a shared through/right-turn lane to an exclusive right-turn lane. The addition of this exclusive right-turn lane on the southbound approach is estimated to reduce crashes by approximately 0.5 crashes per year.

8.4 Cost Considerations

The cost estimate for the short-term, medium-term and long-term improvements are summarized in **Table 11, Table 12 and Table 13.** A detailed breakdown of the construction cost estimates is provided in **Appendix J**.

The roadway reconfiguration and raised concrete median island cost estimates include the costs of mobilization and layout/staking, along with a 30 percent contingency and 20 percent design cost. The roadway configuration cost includes the cost for resurfacing. A resurfacing project is planned for FY 2024. The pedestrian upgrades include the 20 percent design cost and mobilization. Costs were not included for the pedestrian signal heads at the intersections of SR 611 with Elyria Avenue and Broadway because the City of Lorain has applied for grant funding for these improvements. Only one section of transverse rumble strips and one raised concrete median island was included in the cost estimates. The cost of the rumble strips and median islands will be increased if more are needed.

Table 11: Short Term Improvements

	Cost Estimate (2022)
Roadway Reconfiguration (Striping and Resurfacing)	$299,600
Rumble Strips (per section)	$2,000
Pedestrian Upgrades to SR 611 and Colorado Ave	$51,900
Radar Feedback Signs	$8,000
High Visibility Crosswalk Striping (13 crosswalks at signalized intersections)	$26,000
“Intersection Ahead” Warning Sign with flashers	$2,000

The medium-term cost estimates included costs for mobilization, layout/ staking and are inflated to 2025 costs. A 30 percent contingency and 20 percent design were also included.

Table 12: Medium Term Improvements

	Cost Estimate (2025)
Sidewalk Replacement	$525,900
Re-Build Signal at SR 611 and Colorado Avenue	$299,700

The long-term cost estimates included costs for mobilization, layout/ staking and are inflated to 2027 costs. A 30 percent contingency and 20 percent design were also included. The cost estimates do not include right-of-way costs or utility relocation which may be required.

Table 13: Long Term Improvements

	Cost Estimate (2027)
Elyria Avenue – Removing 21st Street	$604,000
Colorado Ave – Remove Right-Turn Slip Lane	$215,500
Raised Concrete Median Island	$17,600

9.0 Conclusions and Recommendations

Based on the crash patterns and traffic operations in the study corridor, the following countermeasures are recommended:

Short-Term

- Stripe high visibility crosswalks at all the signalized intersections along the corridor ($26,000 – 2022 Dollars).
- Re-stripe stop bars and add lane use pavement markings and signage at all intersections along the corridor.
- Add speed radar feedback signs on the approaches of the Lofton Henderson Memorial Bridge ($8,000– 2022 Dollars).
- Reconfigure SR 611 from Colorado Avenue to Broadway to a two-lane roadway with a center two-way-left-turn lane (TWLTL) with bicycle lanes with a buffer on each side of the roadway ($299,600 – 2022 Dollars).
    - As part of the roadway reconfiguration, the eastbound and westbound left-turn lanes at SR 611 and Elyria Avenue could be realigned, thus providing better sight distance for the existing westbound left-turn movement and allowing the eastbound left-turn movement.
- Add rumble strips at certain locations in the TWLTL to prevent vehicles from using the TWLTL as an add lane ($2,000 per section – 2022 dollars).
- Add pedestrian signal heads and push buttons at the intersections of SR 611 with Colorado Avenue. Debris should also be cleared from sidewalks and curb ramps ($51,900 – 2022 Dollars).
- Continue with pedestrian signal head and push button improvements at the intersections of SR 611 with Elyria Avenue/21st Street and Broadway as part of the ODOT D12 pedestrian safety application submitted in January 2022.
- Enhance intersection lighting at SR 611/Kansas Avenue and Elyria Avenue/E 21st Street.
- Add “Intersection Ahead” sign with flashing lights for vehicles traveling southbound off the bridge north of Access Road ($2,000 – 2022 dollars).

Medium-Term

- Improve existing sidewalk along the corridor ($525,900 – 2025 Dollars).
- Rebuild traffic signal at SR 611/Kansas Avenue and Colorado Avenue ($299,700 – 2025 Dollars).

Long-Term

- Remove the northbound right-turn slip lane at SR 611/Kansas and Colorado Avenue and bring the right-turn lane into the intersection ($215,500 – 2027 Dollars).
- Close the E 21st Street leg of SR 611 and Elyria Avenue/21st Street ($604,000 – 2027 Dollars).
- Add raised medians at certain locations in the TWLTL if vehicles are still using the TWLTL as an additional through lane, regardless of the rumble strips ($17,600 per median – 2022 Dollars).