Ohio Department of Transportation

Erie Avenue SW (SR 21) and Dolphin Street SW (SR 212)

Safety Study

March 31, 2026

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
Arcadis	Arcadis U.S., Inc.
AWSC	all-way stop control
CAM	Crash Analysis Module
ECAT	Economic Crash Analysis Tool
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
HSM	Highway Safety Manual
LOS	level of service
mph	miles per hour
$N_{expected}$	expected crash frequency
$N_{predicted}$	predicted crash frequency
ODOT	Ohio Department of Transportation
PCR	pavement condition rating
PDO	property damage only
SR	state route
SW	southwest
TFMS	Traffic Forecasting Management System
TIMS	Transportation Information Mapping System
v/c	volume to capacity

Executive Summary

The Ohio Department of Transportation (ODOT) retained Arcadis U.S., Inc. to study the overall safety and traffic operations of the two-way stop-controlled intersection of Erie Avenue SW (SR 21) and Dolphin Street SW (SR 212). The intersection is ranked #90 on the 2025 ODOT Highway Safety Improvement Program list for rural intersections and it is ranked #8 on ODOT Central Office's roundabout list for District 4. The purpose of this safety study is to analyze existing safety conditions, predict future safety conditions, and develop improvement alternatives for the intersection that will promote safe and efficient traffic operations now and in the future.

A crash analysis indicates that between 2020 and 2024, one fatal crash, nine injury crashes, and six property damage only crashes occurred at the intersection. Almost all of the crashes (15 of the 16 crashes) were angle crashes. The fatal crash and all nine injury crashes were angle crashes.

A capacity analysis indicates that vehicles waiting on Dolphin Street SW (SR 212) to turn onto Erie Avenue SW (SR 21) do not have difficulty finding a gap in traffic during the a.m. and p.m. peak hours.

Because 15 of the 16 crashes were angle crashes, including the fatal crash and nine injury crashes, the feasibility of converting the intersection to all-way stop control or to a single lane modern roundabout was evaluated for safety benefit, traffic operation, site impact, and construction cost.

Converting the intersection to all-way stop control, maintaining the existing overhead flashing red light for Dolphin Avenue SW (SR 212), and converting the existing overhead flashing yellow light for Erie Avenue SW (SR 21) to an overhead flashing red light is predicted to decrease crashes by one to two per year. It is predicted to reduce the delay experienced by vehicles waiting on Dolphin Street SW (SR 212) to turn onto Erie Avenue SW (SR 21). It will introduce minor delay to vehicles on Erie Avenue SW (SR 21), which is currently free flowing. The benefit-cost ratio is above one.

Converting the intersection to a single lane modern roundabout is predicted to decrease crashes by almost one per year. It is predicted to reduce the delay experienced by vehicles waiting on Dolphin Street SW (SR 212) to turn onto Erie Avenue SW (SR 21). It will introduce minor delays to vehicles on Erie Avenue SW (SR 21). The benefit-cost ratio is almost one.

It is recommended that the intersection be converted to AWSC now and converted to a single lane modern roundabout in the near future. According to TRB's NCHRP Report 672, a roundabout intersection is a preferred safety treatment at locations experiencing a high frequency of angle, rear-end, and left-turn crashes. The report indicates that roundabouts provide more time for drivers entering the intersection to adjust their speed and safely merge, and roundabouts reduce the potential for serious crashes within the intersection by reducing the number of conflict points compared to those associated with a traditional intersection. This improvement is predicted to decrease all crashes at the intersection while reducing delay for vehicles on Dolphin Street SW (SR 212) without degrading traffic operations on Erie Avenue SW (SR 21).

1 Introduction

The Ohio Department of Transportation (ODOT) retained Arcadis U.S., Inc. to study the overall safety and traffic operations of the two-way stop-controlled intersection of Erie Avenue SW (SR 21) and Dolphin Street SW (SR 212) on the southeast side of the Village of Beach City. A fatal crash occurred at the intersection in 2024. The intersection is ranked #90 on the 2025 ODOT Highway Safety Improvement Program list for rural intersections and it is ranked #8 on ODOT Central Office's roundabout list for District 4.

The safety study included an analysis of the existing safety performance of the intersection and identification of potential improvements to reduce crash frequency and improve overall safety. The study also included a traffic analysis to assess current intersection operations and to predict future intersection operations with and without implementing the proposed improvements. This report presents the results of the safety study.

2 Existing Conditions

The existing intersection geometry, safety, traffic volumes, and traffic operations are discussed below.

2.1 Intersection Geometry

Erie Avenue SW (SR 21) is a north-south principal arterial with a posted speed limit of 55 miles per hour (mph) and an average daily traffic (ADT) volume of 5,000 vehicles per day, of which 12 percent is truck traffic. There is one 12-foot-wide lane in each direction with 2-foot-wide asphalt shoulders. The road is striped with a double yellow centerline and edge lines south of the intersection and a northbound passing zone and edge lines north of the intersection. There are dual intersection ahead warning signs with reflective signposts on both approaches. Utility poles are present on both sides of the road. There is no roadway lighting. The pavement condition rating (PCR) is 98 according to the ODOT Transportation Information Mapping System (TIMS).

Dolphin Street SW (SR 212) is an east-west major collector with a posted speed limit of 55 mph and an ADT volume of 1,600 vehicles per day, of which 12 percent is truck traffic. There is one 12-foot-wide lane in each direction with 2-foot-wide asphalt shoulders. The road is striped with a double yellow centerline and edge lines east of the intersection and westbound passing zone and edge lines west of the intersection. There are dual stop ahead warning signs with reflective signposts on both approaches. Utility poles are present on both sides of the road. There is no roadway lighting. The PCR is 90 north of the intersection and 97 south of the intersection according to the ODOT TIMS website.

The intersection is unsignalized with an overhead flashing red light for Dolphin Avenue (SW 212) and an overhead flashing yellow light for Erie Avenue SW (SR 21). The approaches are all single lane with no turn lanes. The east and west approaches are stop controlled with dual stop signs with reflective signposts and signs indicating that cross traffic does not stop. The north and south approaches are free flowing. There are no pedestrian accommodations.

The study area is illustrated on Figure 1.

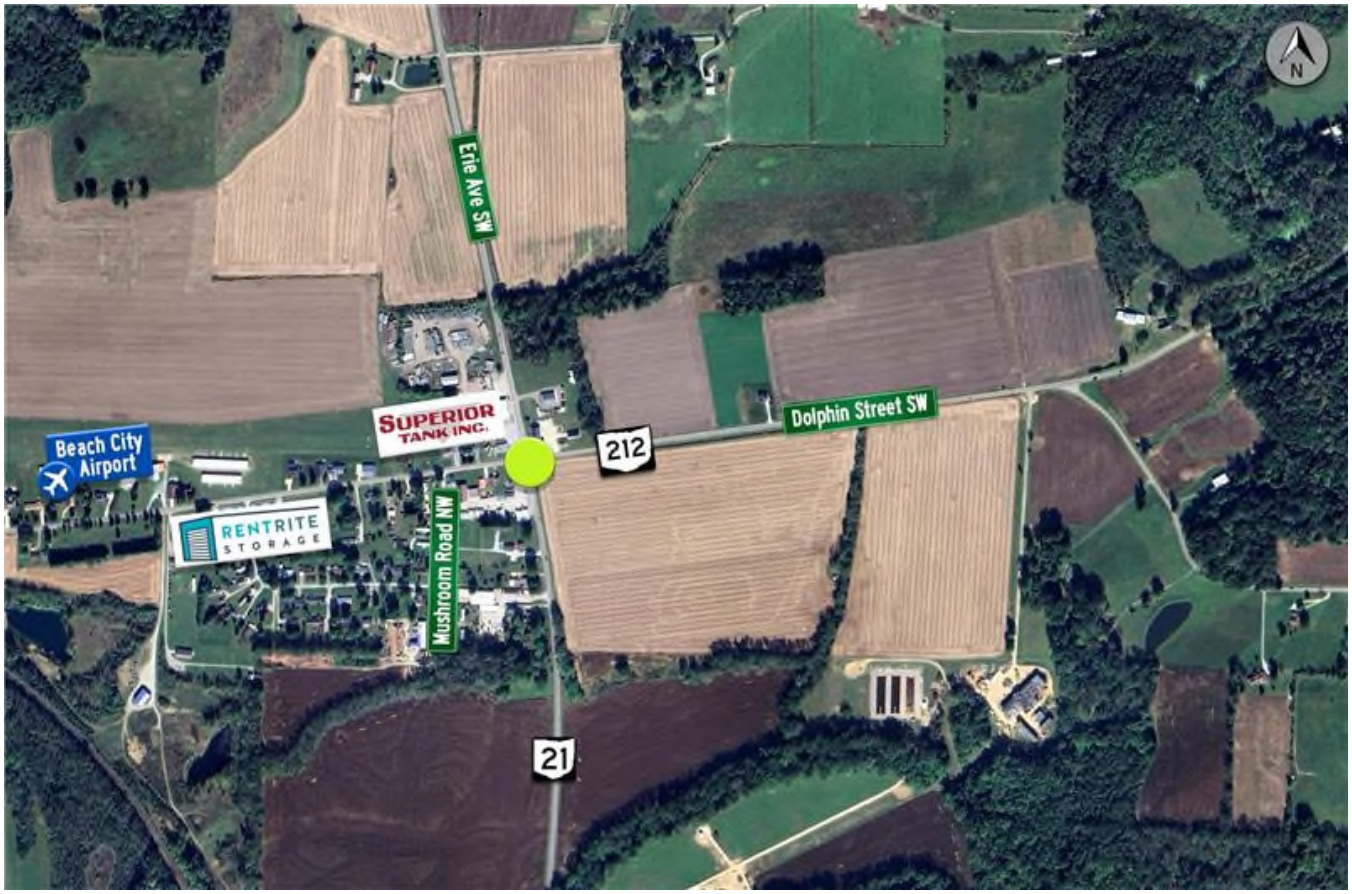


Figure 1 Study Area Map

A field review of the study area was conducted on September 4, 2025. Observations of the study area during the field review are summarized as follows:

- Passenger vehicles, trucks, and semi-trucks were observed during the field review. No pedestrians or bicycles were observed.
- Vehicle operating speeds appear to be close to the posted speed limit.
- Intersection sight distance is limited for drivers on Dolphin Street SW (SR 212) stopped at the stop bar. It is necessary to stop beyond the stop bar to adequately see traffic on Erie Avenue SW (SR 21).
- Traffic volumes on Dolphin Street SW (SR 212) are generally light to moderate. The longest queue observed at the stop sign was three cars during the p.m. peak hour.
- There are several commercial and residential access points in the northeast, northwest, and southwest quadrants of the intersection. The access points are large, wide driveways.
- The turn radius in the southeast quadrant is large.

2.2 Safety

Crash data from 2020 to 2024 were obtained from ODOT's TIMS. A total of 16 crashes occurred within the study area during the five-year period. Those crashes included one fatality, nine injuries, and 6 property damage only (PDO) crashes.

The crash data were analyzed using ODOT's Crash Analysis Module (CAM) Tool. Figure 2 shows a comparison of the crash data to statewide averages for urban intersections. As indicated on the figure, angle crashes and severe crashes occur more frequently compared to statewide averages.

A full printout from the ODOT CAM Tool is included in Appendix A. A crash diagram for the study area is included in Appendix B.

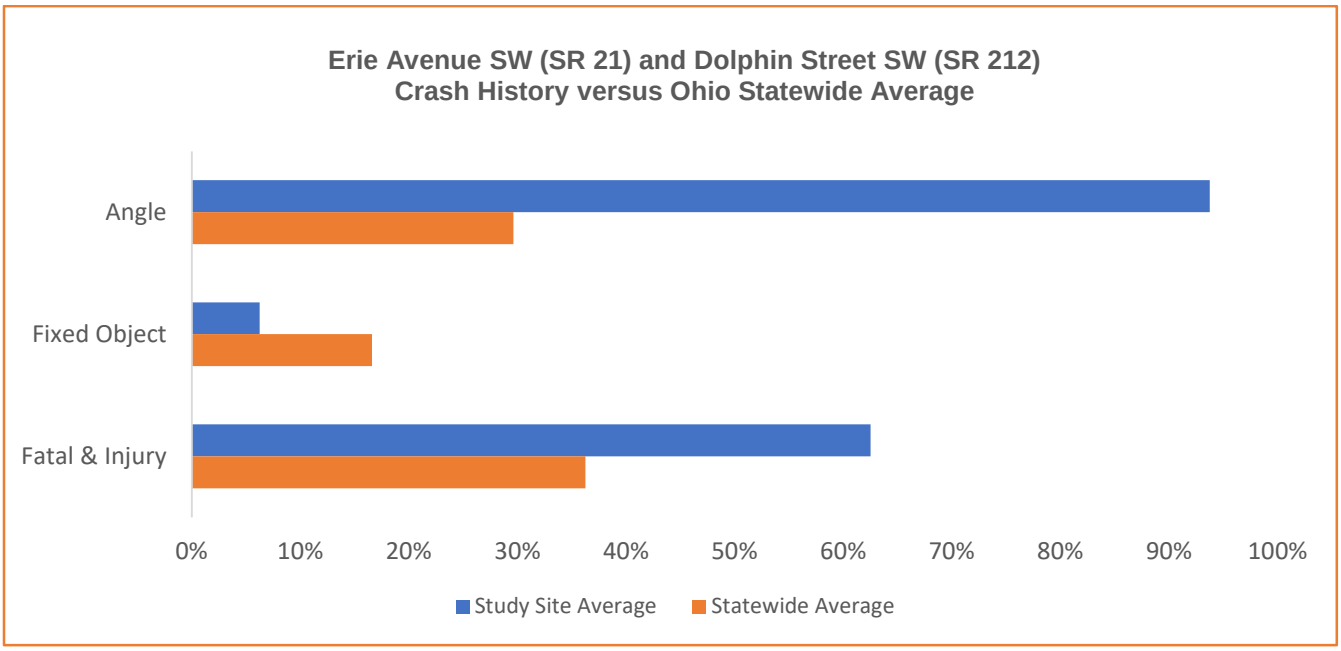


Figure 2 Crash History Compared to Statewide Averages

Additional statistics based on the crash data are summarized in Table 1. As indicated in the table, 15 of the 16 crashes were angle crashes and the remaining crash was a fixed object crash. The fatal crash and all nine injury crashes were angle crashes. All but two crashes occurred on dry pavement, indicating that weather may not be a contributing factor. Six injury crashes and one PDO crash occurred between 6 a.m. and 7 p.m. on weekdays. Detailed explanations of the common crash types are provided below:

- *Angle Crashes* – Angle crashes accounted for 94 percent of all crashes, all of the injuries, and the fatality:
  - The fatal crash and two injury crashes occurred when an eastbound vehicle was struck by a northbound vehicle.
  - One injury crash and one PDO crash occurred when an eastbound vehicle was struck by a southbound vehicle.

  - Four injury crashes and two PDO crashes occurred when a westbound vehicle was struck by a northbound vehicle.
  - Two injury crashes and two PDO crashes occurred when a westbound vehicle was struck by a southbound vehicle.
- *Fixed Object Crash* – The fixed object PDO crash involved a westbound vehicle that struck the stop sign in the northeast quadrant of the intersection and continued west through the intersection before stopping.

Table 1 Crash Statistics (2020 to 2024)

Severity	Fatal	Injury	PDO
Crashes	1	9	6
Weather Condition	**Fatal**	**Injury**	**PDO**
Dry	1	8	5
Wet	0	1	1
Snow and Ice	0	0	0
Crash Type	**Fatal**	**Injury**	**PDO**
Angle	1	9	5
Fixed Object	0	0	1
Month	**Fatal**	**Injury**	**PDO**
January	0	1	0
February	0	1	0
March	0	0	0
April	0	0	0
May	0	2	0
June	1	1	0
July	0	1	3
August	0	0	1
September	0	1	1
October	0	1	0
November	0	0	0
December	0	1	1

2.3 Traffic Volumes

MioVision cameras were used to collect vehicle, bicycle, and pedestrian traffic volume data. The MioVision data was collected on Wednesday, June 18, 2025 from 7:00 a.m. to 7:00 p.m. to capture the a.m. and p.m. peak period volumes. MioVision processing software was used to determine the a.m. and p.m. peak hours, the truck

percentages, and the bicycle and pedestrian volumes. The weekday a.m. peak hour begins at 7:00 a.m., and the weekday p.m. peak hour begins at 4:15 p.m.

District 11 input the MioVision data into ODOT's Traffic Forecast Modeling System (TFMS) to complete the traffic volume forecast. TFMS predicted a 1.8 percent growth rate for Erie Avenue SW (SR 21) north of the intersection, a 0.4 percent growth rate for Erie Avenue SW (SR 21) south of the intersection, a 2.1 percent growth rate for Dolphin Street SW (SR 212) west of the intersection, and a 3.1 percent growth rate for Dolphin Street SW (SR 212) east of the intersection. The TFMS growth rates exceed the one percent background linear growth rate typically recommended in northeast Ohio. However, the TFMS growth rates are not impacting the design of either safety improvement alternative so the growth rates were not reduced to one percent. The open year is 2030 and the design year is 2050. The output from TFMS is included in Appendix C.

2.4 Highway Capacity Software Analysis

A capacity analysis is the primary method for evaluating the efficiency of an intersection as it relates to vehicular traffic. The Highway Capacity Manual version 6 (HCM), published by the Transportation Research Board, outlines capacity analysis procedures and the level of service (LOS) criteria used as a qualitive measure to describe operational conditions. The HCM defines six levels of service, designated by the letters A through F. For signalized and unsignalized intersections, LOS is estimated by measuring the control delay per vehicle. The traffic density and vehicular delay conditions for each LOS are defined in Table 2.

Table 2 Level of Service and Delay Thresholds for Intersections

Level of Service	Signalized Intersection Delay (seconds)	Unsignalized Intersection and Roundabout Delay (seconds)
A	≤ 10	≤ 10
B	> 10 - 20	> 10 - 15
C	> 20 - 35	> 15 - 25
D	> 35 - 55	> 25 - 35
E	> 55 - 80	> 35 - 50
F	> 80 or V/C ratio > 1	> 50 or V/C ratio > 1

Note: v/c = volume to capacity

The no-build alternative and build alternative capacity analyses for the open year (2030) and the design year (2050) were conducted using Highway Capacity Software (HCS). The results of the no-build alternative capacity analysis are presented in Table 3 and Table 4.

Table 3 shows that in 2030, during the a.m. peak hour, the eastbound leg operates at LOS C with a 30-foot-long queue, and the westbound leg operates at LOS C with a 56-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with a 3-foot-long queue, and the southbound leg operates at LOS A with no queue. During the p.m. peak hour, the eastbound leg operates at LOS C with a 45-foot-long queue, and the westbound leg operates at LOS D with a 55-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW

(SR 212), the northbound leg operates at LOS A with a 3-foot-long queue, and the southbound leg operates at LOS A with no queue.

Table 3 No-Build (2030) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	A	1.6	2.5	A	1.4	2.5
Southbound	LTR	A	0.4	0.0	A	0.4	0.0
Eastbound	LTR	C	15.7	29.5	C	20.1	45.4
Westbound	LTR	C	23.0	55.6	D	28.8	54.9

Table 4 shows that in 2050, during the a.m. peak hour, the eastbound leg operates at LOS C with a 64-foot-long queue, and the westbound leg operates at LOS F with a 207-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with a 5-foot-long queue, and the southbound leg operates at LOS A with no queue. During the p.m. peak hour, the eastbound leg operates at LOS E with a 159-foot-long queue, and the westbound leg operates at LOS F with a 302-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with an 8-foot-long queue, and the southbound leg operates at LOS A with no queue.

Table 4 No-Build (2050) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	A	2.6	5.0	A	2.6	7.5
Southbound	LTR	A	0.4	0.0	A	0.4	0.0
Eastbound	LTR	C	21.4	64.3	E	49.2	158.8
Westbound	LTR	F	94.3	207.3	F	302.1	302.1

District 4 and District 11 noted that the TFMS growth rates discussed in Section 2.3 are higher than anticipated. The LOS predicted in Table 3 and Table 4 may be worse than real-world conditions. Outputs from HCS are included in Appendix D.

2.5 Traffic Signal Warrants and Multi-Way Stop Analysis

The traffic count data discussed in Section 2.3 were input into ODOT's Office of Traffic Operations' signal warrant spreadsheet to perform a traffic signal warrant analysis and to determine if the intersection meets the criteria for a traffic signal.

Traffic signal warrants 1a, 1b, 1c, 2, 3a, and 3b, which compare peak hour volumes to certain thresholds, were analyzed. The traffic signal warrant analysis results are summarized in Table 5 and indicate that the intersection does not meet the requirements for a traffic signal. Warrant 1a was met from 4:15 p.m. to 5:15 p.m. while warrant 1c was met from 1:15 p.m. to 5:15 p.m.

Table 5 Traffic Signal Warrant Analysis Results

Intersection	Criteria	Warrant 1 Eight-Hour Vehicular Volumes			Warrant 2	Warrant 3 Peak-Hour Volumes	
		1a	1b	1c		3a	3b
Erie Avenue SW (SR 21) and Dolphin Street SW (SR 212)	Number of Hours Met	1	0	5	0	0	0
	Warrant Met?	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met

The traffic count data discussed in Section 2.3 were input into ODOT's Office of Traffic Operations' signal warrant spreadsheet to determine if multi-way stop control is warranted. Table 6 shows the results of the AWSC analysis. The criteria to convert the intersection to a multi-way stop control are met.

Table 6 AWSC Criteria Analysis

AWSC Criteria	Criteria Met?	Remarks
Criteria A: Interim measure for a warranted traffic signal	No	Signal not warranted
Criteria B: 5 or more correctable crashes in a 12-month period	No	3.2 crashes per year
Criteria C1: 300 vehicles per hour on Major Street Approaches	Yes	None
Criteria C2: 200 or more vehicles/pedestrians/bicycles on Minor Street Approaches	No	0 of 8 hours met
Criteria C3: 70% Values of C1/C2 where 85th Percentile Speed is >40 mph	No	0 of 8 hours met
Criteria D: 80% threshold of volumes and crash experience	No	0 of 8 hours met

Outputs from the Office of Traffic Operations' signal warrant spreadsheet analysis are included in Appendix E.

2.6 Intersection Control Evaluation Tool

The ICE Tool was populated to evaluate a variety of intersection control types. Table 7 shows the results from the ICE tool. If the intersection is converted to AWSC the benefit-cost ratio is 0.72. If the intersection is converted to a roundabout the benefit-cost is 0.00. The ICE Tool is included in Appendix K.

Table 7 Intersection Control Evaluation Tool

Benefit Categories	AWSC	Roundabout
Net Present Value of Benefits	$388,932	$3,053,205
Net Present Value of Costs	$19,054	$3,296,796
Net Present Value of Improvement	$369,878	-$243,591
Benefit-Cost (B/C) Ratio	20.41	0.93
Delay B/C	19.69	0.92
Safety B/C	0.72	0.00

2.7 Turn Lane Warrants

The traffic volumes on the free-flow approaches of Erie Avenue SW (SR 21) were analyzed to determine if they meet the criteria to satisfy a turn lane warrant according to Figures 401-5b and 401-6b in ODOT's Location and Design Manual, Volume 1. The results are summarized in Table 8. As indicated in the table, a northbound left-turn lane and a northbound right-turn lane are warranted on Erie Avenue SW (SR 21). No southbound turn lanes on Erie Avenue SW (SR 21) are warranted.

Table 8 Left- and Right-Turn Lane Warrant Analysis Results

Direction	Movement	Turn Lane Warranted
Northbound	L	Yes
	R	Yes
Southbound	L	No
	R	No

The complete results of the turn lane warrant analysis are included in Appendix F.

2.8 Turn Lane Lengths

The lengths of the warranted left- and right-turn lanes on Erie Avenue SW (SR 21) were calculated using guidelines outlined in the ODOT Location and Design Manual, Volume 1. This manual provides guidelines for calculating the length of each turn lane based on traffic demand.

The calculated length of each potential turn lane is summarized in Table 9. As shown in the table, both the northbound left-turn lane and the northbound right-turn lane should be 200 feet long.

Table 9 Calculated Left- and Right-Turn Lane Lengths

Direction	Movement	Calculated Storage (feet)		Proposed Turn Lane Length (feet)	Existing Turn Lane Length (feet)
		A.M.	P.M.		
Northbound	L	195	195	200	No Existing Turn Lane
	R	195	195	200	No Existing Turn Lane

The results of the turn lane warrant analysis are included in Appendix G.

2.9 Intersection Sight Distance

The Ohio Traffic Engineering Manual outlines the recommended process to check the intersection sight distance. The study area intersection sight distance was verified graphically based on ODOT Location and Design Manual Volume 1, Section 201.3 and Figures 201-4 and 201-5. The posted speed limit of 55 mph was used to check the sight distance. This speed limit requires a vehicle to have an intersection sight distance of 610 feet when completing a left turn and 530 feet when completing a right turn or crossing maneuver from a stopped condition. To ensure that no truck turning movements would be inhibited, the intersection was checked using the design stop bar location of 18 feet from the edge of the through lane pavement to the driver of the vehicle making the turning maneuver. The intersection sight distance for all movements for southbound Erie Avenue SW (SR 21) are acceptable. The intersection sight distance for the northbound maneuvers is obstructed by parked tankers (could be moved), a car port and a large tree. The available sight distance is only 35 to 75 feet since the car port and tankers are very close to the intersection. The intersection sight distance for both eastbound and westbound Dolphin Street.SW (SR 212) are acceptable. Diagrams documenting the intersection sight distance checks are included in Appendix H.

3 Safety Improvement Alternatives

Because 15 of the 16 crashes were angle crashes, including the fatal crash and nine injury crashes, safety improvement alternatives were selected to mitigate this crash type. Three alternatives were evaluated for safety benefit, traffic operation, site impact, and construction cost: all-way stop control (AWSC), northbound left- and right-turn lane, and roundabout alternatives.

3.1 All-Way Stop Alternative

To potentially reduce driver confusion and overlooking of stop signs, the feasibility of converting the intersection to AWSC, following ODOT SCD MT-125.00 for implementation, was examined.

3.1.1 Conceptual Schematic and Estimate of Probable Cost

A conceptual schematic of the AWSC alternative is included in Appendix I. The design vehicle is a WB-62. The schematic shows an AWSC intersection along with:

- Maintaining the existing overhead flashing red light for Dolphin Avenue SW (SR 212) and converting the existing overhead flashing yellow light for Erie Avenue SW (SR 21) to an overhead flashing red light.
- Removal of the existing signs that are below the dual stop signs with reflective posts on both approaches of Dolphin Street SW (SR 212) that indicate cross traffic does not stop.
- Removal of the existing dual intersection ahead warning signs with reflective signposts on both approaches of Erie Avenue SW (SR 21).
- Addition of dual stop ahead warning signs with reflective signposts on both approaches of Erie Avenue SW (SR 21).
- Addition of dual stop signs with reflective posts on both approaches of Erie Avenue SW (SR 21).
- Restriping of Erie Avenue SW (SR 21) to remove the northbound passing zone north of the intersection and restriping of Dolphin Street SW (SR 212) to remove the passing zone on both sides of the intersection.

A conceptual estimate of probable cost for the AWSC alternative was prepared using ODOT historical bid prices. Estimated construction costs were developed using estimated quantities for items that would be needed for or impacted by implementation of the AWSC alternative. The following assumptions were used in developing the conceptual estimate of probable cost:

- The rate of inflation was calculated using the ODOT Office of Estimating Calendar Year 26-30 Business Plan Inflation Calculator. Based on a construction midpoint of fall 2026, a 2.5 percent rate of inflation (to the assumed midpoint of construction) was assumed.
- Unit prices for all items were estimated based on ODOT Estimator libraries and/or ODOT's Item Price Search tool.
- A 25 percent design contingency was applied to each countermeasure.

The total 2026 conceptual estimate of probable cost (with inflation) is $19,053.78. A detailed cost estimate is included in Appendix J.

3.1.2 Safety Analysis

A predictive safety analysis uses the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) to determine how an intersection is performing compared to similar locations. The HSM is also used to assess the safety benefits of proposed alternatives. The HSM Part C discusses use of a predictive model for this type of analysis. The predictive method estimates the predicted crash frequency ($N_{predicted}$) together with observed crash frequency to estimate the expected crash frequency ($N_{expected}$). The difference between predicted and expected crash frequencies is explained below:

- $N_{predicted}$ is the anticipated (predicted) crash frequency, which describes how a location is expected to perform relative to similar sites. The calculation of $N_{predicted}$ uses Safety Performance Functions to determine a base condition and applies crash modification factors to account for site-specific features that are different from the base condition. The final value is multiplied by a calibration factor specific to Ohio to normalize the base condition.
- $N_{expected}$ is the estimated expected average crash frequency at a site for a given period. The calculation of $N_{expected}$ uses the Empirical Bayes method to combine actual crash frequency with $N_{predicted}$.

The difference between $N_{predicted}$ and $N_{expected}$ is the "expected excess crashes." If $N_{expected}$ is greater than $N_{predicted}$, the location may benefit from a safety improvement. If $N_{expected}$ is less than $N_{predicted}$, the site is experiencing fewer crashes than similar sites.

ODOT's Economic Crash Analysis Tool (ECAT) was used to calculate $N_{predicted}$ and $N_{expected}$ based on the existing conditions (traffic control, presence of a median, number of lanes, intersection control, lighting, presence of driveways). Crash modification factors were used in ECAT to calculate the reduction in crashes that can be expected if the AWSC, northbound left- and right-turn lane, and roundabout alternatives are implemented. ODOT's ECAT was also used to perform a benefit-cost analysis for the recommended alternatives.

Table 10 presents a comparison of the existing intersection ($N_{expected\ existing\ conditions}$) to similar intersections ($N_{predicted\ existing\ conditions}$) and to the intersection with implementation of the AWSC alternative ($N_{expected\ proposed\ alternative}$). The table shows that, overall, the intersection is functioning worse than similar intersections by 0.46 crashes per year. There is potential for improvement in fatal and incapacitating injury (KA) crashes (0.10), non-incapacitating injury (B) crashes (0.24), and possible injury (C) crashes (0.16). The table also shows that, if the AWSC alternative is implemented, the overall crash frequency is predicted to decrease by one to two crashes per year.

Table 10 All-Way Stop Control (AWSC) Alternative ECAT Results

Safety Performance Metric	KA	B	C	O	Total
$N_{predicted}$ (Existing Conditions)	0.18	0.43	0.28	1.41	2.29
$N_{expected}$ (Existing Conditions)	0.28	0.67	0.44	1.36	2.75
$N_{potential\ for\ improvement}$ (Existing Conditions)	0.10	0.24	0.16	-0.05	0.45
$N_{expected}$ (Proposed Alternative)	0.03	0.15	0.09	0.87	1.13

ODOT's ECAT was also used to compare the cost to construct the AWSC alternative to the anticipated safety benefit. The results of the benefit-cost analysis are shown in Table 11.

Table 11 All-Way Stop Control (AWSC) Alternative Benefit-Cost Summary

Value	Result
Expected Annual Crash Adjustment	-1.163
Net Present Value of the Build Alternative	$19,053.78
Net Present Value of Safety Benefit	$910,871.18
Benefit-Cost Ratio	47.81

The AWSC alternative has a benefit-cost ratio above one. The ECAT spreadsheet is included in Appendix K.

3.1.3 Highway Capacity Software Analysis

The results of the capacity analysis to model the AWSC alternative are presented in Table 11 and Table 12.

Table 12 shows that in 2030, overall, the AWSC intersection operates at LOS B during the a.m. peak hour and the p.m. peak hour. All movements operate at LOS C or better, and the longest queue is 103 feet on the northbound approach during the p.m. peak hour.

Table 12 All-Way Stop Control (AWSC) (2030) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	B	12.3	59.2	C	15.6	103.2
Southbound	LTR	B	12.0	53.6	B	13.0	63.8
Eastbound	LTR	A	10.0	18.8	B	10.7	22.7
Westbound	LTR	B	10.5	25.2	B	10.8	18.3
Overall		B	**11.5**		B	**13.5**	

Table 13 shows that in 2050, overall, the AWSC intersection operates at LOS C during the a.m. peak hour and LOS D during the p.m. peak hour. All movements operate at LOS C or better except for the northbound approach, which operates at LOS E with a 315-foot-long queue during the p.m. peak hour.

Table 13 All-Way Stop Control (AWSC) (2050) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	C	18.0	112.8	E	47.6	314.8
Southbound	LTR	C	15.2	79.0	C	20.1	114.4
Eastbound	LTR	B	12.4	37.5	C	15.8	60.5
Westbound	LTR	B	13.3	45.4	B	14.4	39.3
Overall		C	**15.3**		D	**30.3**	

District 4 and District 11 noted that the TFMS growth rates discussed in Section 2.3 are higher than anticipated. The LOS predicted in Table 3 and Table 4 may be worse than real-world conditions. Outputs from HCS are included in Appendix D.

3.2 Northbound Left-Turn Lane and Northbound Right-Turn Lane Alternative

Because traffic volumes satisfy warrants to construct a northbound left-turn lane and a northbound right-turn lane, the feasibility of adding these turn lanes was examined. However, adding turn lanes is not predicted to mitigate angle crashes.

3.2.1 Conceptual Schematic and Estimate of Probable Cost

A conceptual schematic and a conceptual estimate of probable cost for the alternative to construct a northbound left-turn lane and a northbound right-turn lane were not developed. This alternative is not predicted to address the angle crash trends.

3.2.2 Safety Analysis

Table 14 presents a comparison of the existing intersection ($N_{expected\ existing\ conditions}$) to similar intersections ($N_{predicted\ existing\ conditions}$) and to the intersection with implementation of the northbound left-turn lane and northbound right-turn lane alternative ($N_{expected\ proposed\ alternative}$). The table shows that, overall, the intersection is functioning better than similar intersections by 0.46 crashes per year. There is potential for improvement in fatal and incapacitating injury (KA) crashes (0.10), non-incapacitating injury (B) crashes (0.24), and possible injury (C) crashes (0.16). The table also shows that, if the northbound left-turn lane and northbound right-turn lane alternative is implemented, the overall crash frequency is predicted to decrease by almost one crash per year.

Table 14 Northbound Left-Turn Lane and Northbound Right-Turn Lane Alternative ECAT Results

Safety Performance Metric	KA	B	C	O	Total
$N_{predicted}$ (Existing Conditions)	0.18	0.43	0.28	1.41	2.29
$N_{expected}$ (Existing Conditions)	0.28	0.67	0.44	1.36	2.75
$N_{potential\ for\ improvement}$ (Existing Conditions)	0.10	0.24	0.16	-0.05	0.45
$N_{expected}$ (Proposed Alternative)	0.13	0.32	0.22	1.10	1.78

3.2.3 Highway Capacity Software Analysis

The results of the capacity analysis to model the northbound left-turn lane and northbound right-turn lane alternative are presented in Table 15 and Table 16.

Table 15 shows that in 2030, during the a.m. peak hour, the eastbound leg and the westbound leg operate at LOS C, with a 30-foot-long queue and a 53-foot-long queue, respectively. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with a 3-foot-long queue, and the southbound leg operates at LOS A with a 5-foot-long queue. During the p.m. peak hour, the eastbound leg operates at LOS C with a 43-foot-long queue, and the westbound leg operates at LOS D with a 52-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with a 3-foot-long queue, and the southbound leg operates at LOS A with a 5-foot-long queue.

Table 15 Northbound Left-Turn Lane and Northbound Right-Turn Lane (2030) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	L	A	8.0	2.8	A	8.0	2.6
	T	A	1.3	<5	A	1.0	<5
	R	A	1.3	<5	A	1.0	<5
Southbound	LTR	A	7.9	<5	A	8.1	<5
Eastbound	LTR	C	15.7	29.5	C	19.9	42.8
Westbound	LTR	C	22.6	53.1	D	26.9	52.2

Table 16 shows that in 2050, during the a.m. peak hour, the eastbound leg operates at LOS C with a 64-foot-long queue, and the westbound leg operates at LOS F with a 200-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with a 6-foot-long queue, and the southbound leg operates at LOS A with a 5-foot-long queue. During the p.m. peak hour, the eastbound leg operates at LOS E with a 149-foot-long queue, and the westbound leg operates at LOS F with a 259-foot-long queue. When vehicles are waiting on Erie Avenue SW (SR 21) to turn left onto Dolphin Street SW (SR 212), the northbound leg operates at LOS A with an 8-foot-long queue, and the southbound leg operates at LOS A with a 5-foot-long queue.

Table 16 Northbound Left-Turn Lane and Northbound Right-Turn Lane (2050) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	A	8.2	5.6	A	8.3	7.7
	T	A	2.1	<5	A	1.7	<5
	R	A	2.1	<5	A	1.7	<5
Southbound	LTR	A	8.0	<5	A	8.3	<5
Eastbound	LTR	C	21.1	64.3	E	45.2	148.7
Westbound	LTR	F	87.9	199.7	F	229.7	258.6

District 4 and District 11 noted that the TFMS growth rates discussed in Section 2.3 are higher than anticipated. The LOS predicted in Table 3 and Table 4 may be worse than real-world conditions. Outputs from HCS are included in Appendix D.

3.3 Single Lane Roundabout Alternative

To potentially reduce the frequency and severity of angle crashes, the feasibility of converting the intersection to a single lane modern roundabout was examined.

3.3.1 Conceptual Schematic and Estimate of Probable Cost

A conceptual schematic of the single lane roundabout alternative is included in Appendix I. The design vehicle is a WB-62. The schematic shows a single lane roundabout along with access management to reduce the width of the driveways in the northwest, northeast, and southwest quadrants of the intersection. The single lane modern roundabout will impact approximately 0.15 acres temporarily and 0.54 acres permanently.

A conceptual estimate of probable cost was prepared using ODOT historical bid prices. Estimated construction costs were developed using estimated quantities for items that would be needed for or impacted by implementation of the single lane roundabout alternative. The following assumptions were used in developing the conceptual estimate of probable cost:

- The rate of inflation was calculated using the ODOT Office of Estimating Calendar Year 26-60 Business Plan Inflation Calculator. Based on a construction midpoint of July 2031, a 19.7 percent rate of inflation (to the assumed midpoint of construction) was assumed.
- Unit prices for all items were estimated based on ODOT Estimator libraries and/or ODOT's Item Price Search tool.
- A 30 percent design contingency.
- A $84,000 cost for right-of-way acquisition

The total 2026 conceptual estimate of probable cost (with inflation) is $3,238,434.82. A detailed cost estimate is included in Appendix I.

3.3.2 Safety Analysis

Table 17 presents a comparison of the existing intersection ($N_{expected\ existing\ conditions}$) to similar intersections ($N_{predicted\ existing\ conditions}$) and to the intersection with implementation of the single lane roundabout alternative ($N_{expected\ proposed\ alternative}$). The table shows that, overall, the intersection is functioning worse than similar intersections by 0.46 crashes per year. There is potential for improvement in fatal and incapacitating injury (KA) crashes (0.10), non-incapacitating injury (B) crashes (0.24), and possible injury (C) crashes (0.16). The table also shows that, if the single lane roundabout alternative is implemented, the overall crash frequency is predicted to decrease by almost one crash per year.

Table 17 Single Lane Roundabout Alternative ECAT Results

Safety Performance Metric	KA	B	C	O	Total
$N_{predicted}$ (Existing Conditions)	0.18	0.43	0.28	1.41	2.29
$N_{expected}$ (Existing Conditions)	0.28	0.67	0.44	1.36	2.75
$N_{potential\ for\ improvement}$ (Existing Conditions)	0.10	0.24	0.16	-0.05	0.45
$N_{expected}$ (Proposed Alternative)	0.01	0.07	0.09	1.83	2.00

ODOT's ECAT was also used to compare the cost to construct the single lane roundabout alternative to the anticipated safety benefit. The results of the benefit-cost analysis are shown in Table 18.

Table 18 Single Lane Roundabout Alternative Benefit-Cost Summary

Value	Result
Expected Annual Crash Adjustment	-0.299
Net Present Value of the Build Alternative	$3,238,434.82
Net Present Value of Safety Benefit	$2,178,186.04
Benefit-Cost Ratio	0.67

The single lane roundabout alternative has a benefit-cost ratio that is almost one. The ECAT spreadsheet is included in Appendix K.

3.3.3 Highway Capacity Software Analysis

The results of the capacity analysis to model the single lane roundabout alternative are presented in Table 19 and Table 20.

Table 19 shows that in 2030, overall, the roundabout operates at LOS A during the a.m. peak hour and the p.m. peak hour. All movements operate at LOS A, and the longest queue is 41 feet on the northbound approach during the p.m. peak hour.

Table 19 Single Lane Roundabout (2030) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	A	5.8	28.2	A	6.3	41.3
Southbound	LTR	A	6.5	31.0	A	6.1	31.9
Eastbound	LTR	A	5.5	13.4	A	5.2	12.6
Westbound	LTR	A	5.1	15.1	A	5.4	13.1
Overall		A	**5.8**		A	**6.0**	

Table 20 shows that in 2050, overall, the roundabout operates at LOS A during the a.m. peak hour and the p.m. peak hour. All movements operate at LOS A, and the longest queue is 67 feet on the northbound approach during the p.m. peak hour.

Table 20 Single Lane Roundabout (2050) Alternative HCS Capacity Analysis Results

Direction	Movement	A.M. Peak Hour			P.M. Peak Hour		
		LOS	Delay (seconds)	95th % Queue (feet)	LOS	Delay (seconds)	95th % Queue (feet)
Northbound	LTR	A	6.9	42.3	A	8.3	67.1
Southbound	LTR	A	7.8	42.3	A	7.5	42.6
Eastbound	LTR	A	6.9	24.1	A	6.9	27.7
Westbound	LTR	A	6.4	22.7	A	6.6	18.3
Overall		A	7.0		A	7.6	

District 4 and District 11 noted that the TFMS growth rates discussed in Section 2.3 are higher than anticipated. The LOS predicted in Table 3 and Table 4 may be worse than real-world conditions. Outputs from HCS are included in Appendix D.

4 Safety Improvement Alternatives Considered and Dismissed

As indicated in Table 5, traffic demand at the intersection of Erie Avenue SW (SR 21) and Dolphin Street SW (SR 212) does not satisfy the criteria to warrant a traffic signal. Nonetheless, the feasibility of constructing a new traffic signal at the intersection was evaluated to determine if it could potentially mitigate the frequency of crashes.

Table 21 presents a comparison of the existing intersection ($N_{expected\ existing\ conditions}$) to similar intersections ($N_{predicted\ existing\ conditions}$) and to the intersection with implementation of the proposed traffic signal ($N_{expected\ proposed\ alternative}$). The table shows that the overall crash frequency is predicted to increase by one to two crashes per year.

A traffic signal has the potential to mitigate left-turn and angle crashes. However, because the total number of crashes is predicted to increase, construction of a new traffic signal was not analyzed further to evaluate traffic operation, site impact, or construction cost.

Table 21 ECAT Results – Traffic Signal

Safety Performance Metric	KA	B	C	O	Total
$N_{predicted}$ (Existing Conditions)	0.18	0.43	0.28	1.41	2.29
$N_{expected}$ (Existing Conditions)	0.28	0.67	0.44	1.36	2.75
$N_{potential\ for\ improvement}$ (Existing Conditions)	0.10	0.24	0.16	-0.05	0.45
$N_{expected}$ (Proposed Alternative)	0.16	0.68	0.86	2.91	4.60

5 Conclusions and Recommendations

ODOT retained Arcadis to study the overall safety and traffic operations of the two-way stop-controlled intersection of Erie Avenue SW (SR 21) and Dolphin Street SW (SR 212).

The crash analysis indicates that between 2020 and 2024, one fatal crash, nine injury crashes, and six PDO only crashes occurred. Almost all of the crashes (15 of the 16 crashes) were angle crashes. The fatal crash and all nine injury crashes were angle crashes.

The capacity analysis indicates that vehicles waiting on Dolphin Street SW (SR 212) to turn onto Erie Avenue SW (SR 21) do not have difficulty finding a gap in traffic during the a.m. and p.m. peak hours.

Because 15 of the 16 crashes were angle crashes, including the fatal crash and nine injury crashes, the feasibility of converting the intersection to AWSC or to a single lane modern roundabout was evaluated for safety benefit, traffic operation, site impact, and construction cost. Table 22 presents a matrix comparing the AWSC alternative and the single lane modern roundabout alternative.

Table 22 Proposed Safety Countermeasure Comparison Matrix

Criteria	AWSC	Single Lane Modern Roundabout
Predicted Crash Reduction	1 to 2 crashes per year	Almost 1 crash per year
Mitigate Angle Crashes	No	Yes
HCS Capacity Analysis	**C** a.m. peak hour **D** p.m. peak hour	**A** a.m. peak hour **A** p.m. peak hour
Amish Buggy Safety	No Benefit	Mitigates Angle Crashes
Right-of-Way Impacts	None	< 1 acre permanent <1 acre temporary
Utility Impacts	None	Potential
Support Future Development	Does Not Address Angle Crashes Limited Traffic Capacity	Addresses Angle Crashes Excess Traffic Capacity
Construction Cost	$19,053.78	$3,238,434.82

Converting the intersection to AWSC, maintaining the existing overhead flashing red light for Dolphin Avenue SW (SR 212), and converting the existing yellow overhead flashing yellow light for Erie Avenue SW (SR 21) to an overhead flashing red light is predicted to decrease crashes by one to two per year. It is predicted to reduce the delay experienced by vehicles waiting on Dolphin Street SW (SR 212) to turn onto Erie Avenue SW (SR 21). It will introduce minor delay to vehicles on Erie Avenue SW (SR 21), which is currently free flowing. The benefit-cost ratio is above one. However, it does not mitigate angle crashes or manage access at the intersection.

Converting the intersection to a single lane modern roundabout is predicted to decrease crashes by almost one per year. It is predicted to reduce the delay experienced by vehicles waiting on Dolphin Street SW (SR 212) to turn onto the Erie Avenue SW (SR 21). It will introduce minor delays to vehicles on Erie Avenue SW (SR 21). The

benefit-cost ratio is almost one. The single lane modern roundabout will mitigate angle crashes which make up 15 of the 16 crashes, the fatal crash and nine injuries. It manages access and reduces speeds on all approaches. According to TRB's NCHRP Report 672, a roundabout intersection is a preferred safety treatment at locations experiencing a high frequency of angle, rear-end, and left-turn crashes. The report indicates that roundabouts provide more time for drivers entering the intersection to adjust their speed and safely merge, and roundabouts reduce the potential for serious crashes within the intersection by reducing the number of conflict points compared to those associated with a traditional intersection.

It is recommended that the intersection be converted to AWSC now and converted to a single lane modern roundabout in the near future.

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