SR 48 AT OLD WILMINGTON ROAD
TRAFFIC SIGNAL WARRANT EVALUATION
JANUARY 30, 2019

Senate Resolution No. 10 (SR 10), sponsored by Senators Delcollo and Lavelle, was passed by the 149th General Assembly of the Delaware State Senate. SR 10 created a Special Committee to study and make recommendations regarding truck traffic along SR 41, SR 48, and SR 7 in New Castle County. Per SR 10, the Special Committee was directed to study and make recommendations regarding how to reduce the number of trucks traveling along these roadways and improvements in engineering, infrastructure, education, and enforcement that can improve the quality of life for those who live along these roadways. In a report published January 12, 2018, The Committee made recommendations to DelDOT and the General Assembly, which included recommendation #13: Conduct signal warrant studies for the following locations:

- SR 48 and Old Wilmington Road
- SR 48 and Courtney Road
- SR 48 and Hedgerow Place/Harlech Drive
- SR 48 and Old Hobson Farm

The following study presents the signal warrant analysis at SR 48 (Lancaster Pike) and Old Wilmington Road.

SITE DESCRIPTION

The intersection of SR 48 and Old Wilmington Road is located approximately 2.5 miles northwest of the City of Wilmington (see Figure 1). The intersection is located between the signalized SR 48 intersections with Loveville Road to the west and Hercules Road to the east. The eastbound approach contains a through lane and a left-turn lane. The westbound approach contains a through lane and a right-turn lane. SR 48 is an undivided roadway; however, there is a striped median in the vicinity of Old Wilmington Road. Old Wilmington Road is a two-lane, undivided roadway with a left-turn lane and a right-turn lane on the southbound approach. The speed limit is 50 mph on SR 48 and 40 mph on Old Wilmington Road. Southbound Old Wilmington Road is stop-controlled at SR 48, while SR 48 is free.

FIGURE 1
Site Location Map

CRASH SUMMARY

A total of 18 crashes were reported during the 6-year period between January 2013 and December 2018 at the intersection of SR 48 and Old Wilmington Road, including eight (44 percent) crashes resulting in personal injuries and one crash resulting in two fatalities. The following is a summary of the crashes by type:

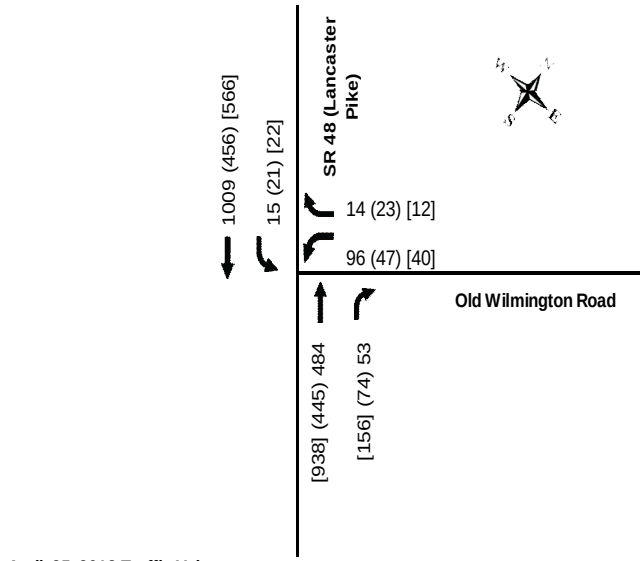
- 9 southbound left-turn/westbound through crashes (4 occurred in a 1-year period from January 2016 to December 2016)
- 2 crashes involving a northbound vehicle running off the road north of the intersection of SR 48 and Old Wilmington Rd
- 1 eastbound left-turn/southbound left-turn crash
- 1 eastbound rear end crash
- 1 eastbound sideswipe crash
- 1 crash involving a westbound right-turning vehicle that lost control and struck a southbound vehicle
- 1 crash involving a westbound vehicle that lost control and struck the guardrail
- 1 eastbound vehicle struck animal in roadway
- 1 eastbound sideswipe crash with westbound left-turn vehicle

The fatal crash occurred as a result of a southbound left-turning vehicle failing to remain stopped at the stop sign and hitting a westbound through vehicle. The crash resulted in two fatalities and three injuries.

TRAFFIC VOLUMES

Turning movement counts were conducted on Wednesday, April 25, 2018 from 6 AM to 7 PM and the results are depicted in Figure 2.

FIGURE 2
Peak Hour Volumes



April 25, 2018 Traffic Volumes
00: AM Peak Hour (7:15 - 8:15 AM)
(00): Midday Peak Hour (11:30 AM - 12:30 PM)
[00]: PM Peak Hour (4:45 - 5:45 PM)

SIGHT DISTANCE

SR 48 has a 50-mph speed limit. The slope of eastbound SR 48 approaching the intersection of Old Wilmington Road is +3.7 percent, and the slope approaching Old Wilmington Road on westbound SR 48 is -4.2 percent. This data was used to determine the stopping and intersection sight distances from equations in the *AASHTO Policy on Geometric Design of Highways and Streets*.

As shown in Table 1, the southbound Old Wilmington Road corner sight distances looking left and right at SR 48 do not meet AASHTO criteria when vehicles are positioned at the stop line (view is obstructed by trees to the right and a vertical curve to the right; see Photos 1-2). Southbound Old Wilmington Road corner sight distances looking left meet AASHTO criteria when vehicles move beyond the stop line, but the corner sight distance is still not met looking right (see Photos 3-4). The stopping sight distances for eastbound SR 48 exceed AASHTO criteria; however, they are not met on westbound SR 48 due to the vertical curve.

Photo 1: Southbound Old Wilmington Rd corner sight distance looking left onto SR 48 (from stop line)

Photo 2: Southbound Old Wilmington Rd corner sight distance looking right onto SR 48 (from stop line)

Photo 3: Southbound Old Wilmington Rd corner sight distance looking left onto SR 48 (beyond stop line)

Photo 4: Southbound Old Wilmington Rd corner sight distance looking right onto SR 48 (beyond stop line)

TABLE 1
Sight Distance Measurements

Corner Sight Distance								
Approach	**Looking Left (688 ft required)**				**Looking Right (769 ft required)**			
	From stop line	**Criteria Met?**	**Beyond stop line**	**Criteria Met?**	**From stop line**	**Criteria Met?**	**Beyond stop line**	**Criteria Met?**
Southbound Old Wilmington Rd	508 ft	**No**	706 ft	Yes	725 ft	**No**	730 ft	**No**

Stopping Sight Distances			
Approach	**Measured**	**Criteria**	**Criteria Met?**
Westbound SR 48	345 ft	456 ft	**No**
Eastbound SR 48	525 ft	401 ft	Yes

SPEED STUDY

Free-flow vehicle speeds were measured along SR 48 between 9:40 AM and 11:15 AM on Thursday, January 11, 2018. The results are summarized in Table 2. As shown, the 85th-percentile speeds along SR 48 are 9 and 6 miles per hour above the 50-mph speed limit on eastbound and westbound SR 48, respectively.

TABLE 2
Speed Data Summary

Criteria	SR 48	
	Eastbound	**Westbound**
Posted Speed Limit	50 mph	50 mph
85th-Percentile Speed	59 mph	56 mph
% More Than 5 mph Over Speed Limit	28%	15%
Mean Speed	54 mph	53 mph
High/Low Speed	64/45 mph	64/39 mph
USLIMITS2 Recommendation	55 mph	55 mph

DELAY STUDY

Additional field studies were conducted to quantify the delay of vehicles on the southbound Old Wilmington Road approach to SR 48. Data was collected during the AM peak hour, which represents the peak side-street volume and delay, on Wednesday, January 24, 2018, from 6:45 AM to 7:45 AM. The results are summarized in Table 3.

TABLE 3
Delay Study Results Summary – Old Wilmington Road Southbound Left and Right Turns

	AM Peak Hour (6:45 AM – 7:45 AM)
Number of Vehicles Observed/Measured	82
Total Delay	0.74 vehicle-hours
Average Delay per Vehicle	32.6 sec
Average Delay per Stopped Vehicle	35.1 sec
Percent of Vehicles Stopped	92.7%

CAPACITY ANALYSIS

Additional analyses were conducted to compare the delay and queue lengths for the peak hours for the existing stop-controlled intersection and if a signal were installed at the intersection. *Synchro* and *SimTraffic* models were utilized to estimate the average intersection delay and the Old Wilmington Road southbound left-turn delay and queue length, as shown in Table 4 and Table 5. The proposed signal was modeled with a 150-second AM and 120-second PM cycle length to maintain coordination along the SR 48 corridor. The proposed signal was modeled with eastbound left-turn permissive phasing, and then with eastbound left-turn protective-permissive phasing based on the results from left-turn lane signal phasing flow chart, as seen in the Appendix.

The observed southbound left-turn average delay based on the delay study falls between the two models' estimates. Based on the analyses using *Synchro*, signalization of the intersection would decrease the average eastbound left-turn delay by approximately 3-9 seconds and increase the westbound right-turn delay minimally. The southbound left-turn delay would increase in the PM peak by approximately 6-11 seconds, but decrease significantly during the AM peak. Southbound left-turn delays and queues may experience slight increases; however, the minor increases are outweighed by the safety benefit of the expected angle crash reduction. All the 95th-percentile queue lengths are within the available storage lengths based on current lane configurations. The westbound 95th-Percentile queue length would not prevent access to vehicles leaving Westgate Drive.

TABLE 4
***Synchro* Capacity Analysis Summary**

	AM Peak Hour (7:15 AM – 8:15 AM)			PM Peak Hour (4:45 PM – 5:45 PM)		
Movement	**Stop-Controlled**	**Signalized: EBL Permissive**	**Signalized: EBL Protected-Permissive**	**Stop-Controlled**	**Signalized: EBL Permissive**	**Signalized: EBL Protected-Permissive**
Average Intersection Delay (LOS)	N/A	7.2 (A)	7.0 (A)	N/A	6.5 (A)	8.8 (A)
Southbound Left-Turn Average Delay (LOS) 95th-Percentile Queue (ft) (Storage = 165 ft)	88.9 (F) 140	68.5 (E) 160	68.5 (E) 160	49.5 (D) 59	56.0 (E) 64	60.9 (E) 65
Eastbound Left-Turn Average Delay (LOS) 95th-Percentile Queue (ft) (Storage = 100 ft)	8.9 (A) 2	0.6 (A) 1	1.7 (A) 2	11.5 (B) 5	2.6 (A) 10	8.7 (A) 9
Westbound Right-Turn Average Delay (LOS) 95th-Percentile Queue (ft) (Storage = 175 ft)	0 (A) 0	0.1 (A) 0	0.1 (A) 0	0 (A) 0	3.2 (A) 6	6.3 (A) 10
Eastbound Through 95th-Percentile Queue (ft)	-	410	85	-	277	377
Westbound Through 95th-Percentile Queue (ft)	-	16	23	-	337	440

TABLE 5
***SimTraffic* Capacity Analysis Summary**

Movement	AM Peak Hour (7:15 AM – 8:15 AM)			PM Peak Hour (4:45 PM – 5:45 PM)		
	Stop-Controlled	**Signalized: EBL Permissive**	**Signalized: EBL Protected-Permissive**	**Stop-Controlled**	**Signalized: EBL Permissive**	**Signalized: EBL Protected-Permissive**
Average Intersection Delay (LOS)	N/A	10.9 (B)	11.2 (B)	N/A	9.3 (A)	9.4 (A)
Southbound Left-Turn						
Average Delay (LOS)	20.0 (B)	66.4 (E)	69.2 (E)	25.2 (C)	58.4 (E)	62.7 (E)
95th-Percentile Queue (ft)	76	131	165	59	78	87
(Storage = 165 ft)						
Eastbound Left-Turn						
Average Delay (LOS)	9.9 (A)	17.1 (B)	13.1 (C)	15.9 (B)	16.7 (B)	26.1 (C)
95th-Percentile Queue (ft)	29	29	21	35	34	38
(Storage = 100 ft)						
Westbound Right-Turn						
Average Delay (LOS)	2.2 (A)	3.0 (A)	2.7 (A)	3.1 (A)	3.6 (A)	5.1 (A)
95th-Percentile Queue (ft)	-	22	16	7	30	32
(Storage = 175 ft)						
Eastbound Through						
95th-Percentile Queue (ft)	-	143	124	-	183	119
Westbound Through						
95th-Percentile Queue (ft)	-	145	80	-	139	174

TRAFFIC SIGNAL WARRANT ANALYSIS

A signal warrant analysis was conducted in accordance with the *2011 Delaware Manual on Uniform Traffic Control Devices (DE MUTCD)* for the SR 48 at Old Wilmington Road intersection. A summary of the warrant analysis is presented in Table 6. The 85th-percentile speeds on SR 48 exceed 40 miles per hour; therefore, the *2011 DE MUTCD's* reduced volume criteria were applied. One lane is provided for the major road (SR 48) approach, and two turn lanes are provided on the minor approach. Right turns from Old Wilmington Road were not included because they experience minimal delay. As shown in Table 6, Warrant 2 and Alternative Warrant 7 have been met.

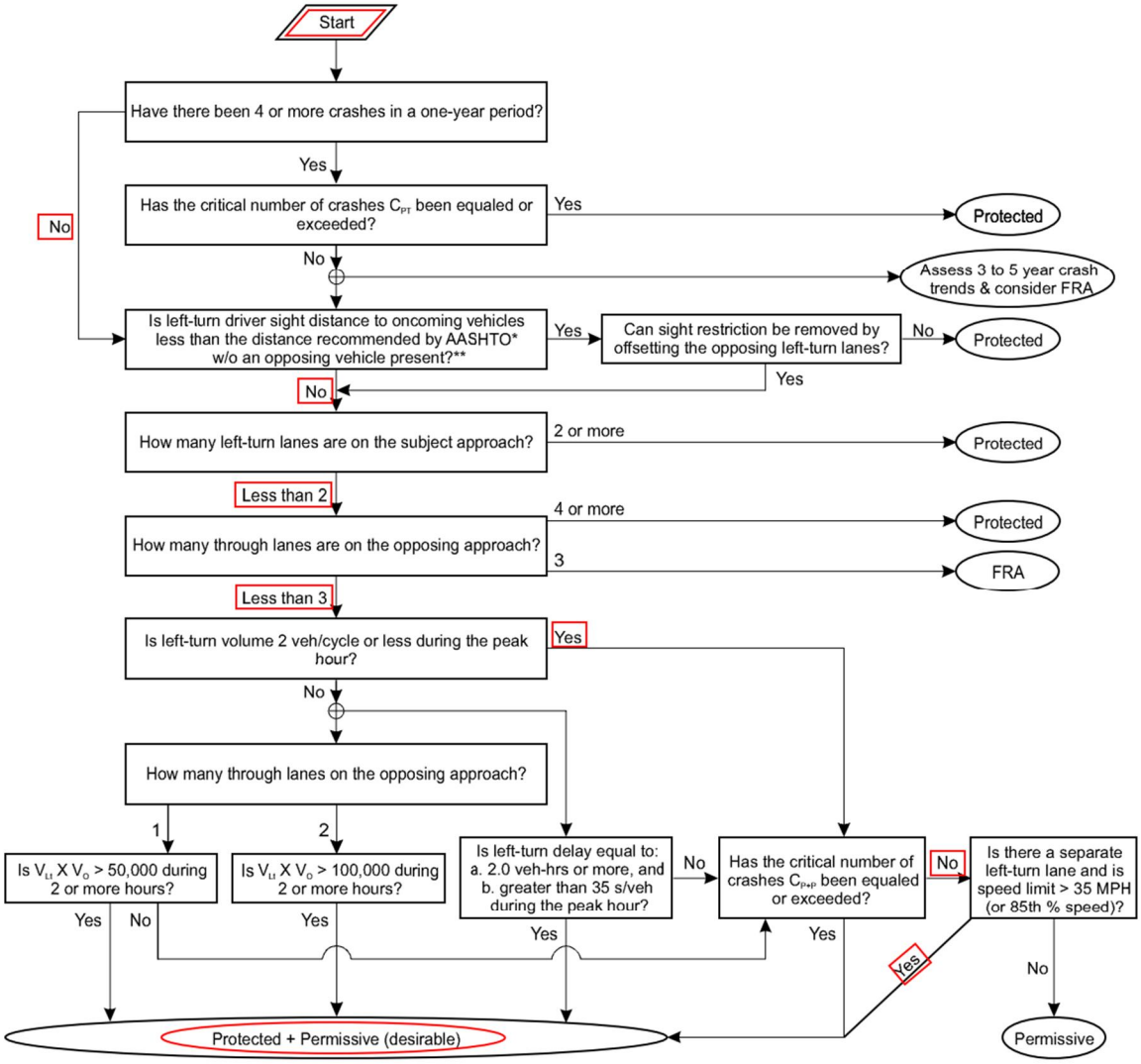
TABLE 6
Traffic Signal Warrant Analysis Summary

DE MUTCD Warrant	Criteria			No. of Hours Meets Criteria (Warrants 1, 2, 4) Actual Conditions (Warrant 3)		Warrant Criteria Met?
	Major Street Volume (VPH)	**Minor Street Volume (VPH)**	**No. of Hours Required**			
1 – Eight-Hour Vehicular Volume	*(**Any** of the three conditions must be met)*					
Cond. A – Min. Vehicular Volume	420	105	8	0	No	No
Cond. B – Interruption of Cont. Traffic	630	53	8	6	No	
Cond. C – Combination of Conditions • 80% of Condition A • 80% of Condition B	336 504	84 42	8 8	0 1	No	
2 – Four-Hour Vehicular Volume	(See Figure 4C-1 or 4C-2)		4	4		**Yes**
3 – Peak Hour	*(**Either** of the two conditions must be met)*					
Condition A	Delay ≥ 4 Veh.-Hrs. Approach Volume ≥ 100 vph Entering Volume ≥ 800 vph		1	0	No	N/A
Condition B	(See Figure 4C-3 or 4C-4)		1	1	**Yes**	
4 – Pedestrian Volume	*(**Both** of the two conditions must be met)*					
Condition A	(See Figure 4C-5 or 4C-6)		4	0	No	No
Condition B	(See Figure 4C-7 or 4C-8)		1	0	No	
5 – School Crossing	(Refer to *DE MUTCD* Section 4C.06 for Criteria)			-		N/A
6 – Coordinated Signal System	(Refer to *DE MUTCD* Section 4C.07 for Criteria)			-		N/A
7 – Crash Experience	(Refer to *DE MUTCD* Section 4C.08 for Criteria)			-		No
Alternative 7 – Crash Experience	(Refer to *MUTCD* Interim Approval, IA-19 for Criteria)			-		**Yes**
8 – Roadway Network	(Refer to *DE MUTCD* Section 4C.09 for Criteria)			-		N/A
9 – Intersection Near a Grade Crossing	(Refer to *DE MUTCD* Section 4C.10 for Criteria)			-		N/A

RECOMMENDATIONS

Based on existing traffic volumes, Warrant 2–Four-Hour Vehicular Volume is met based on the April 2018 counts. Warrant 1–Eight-Hour Vehicular Volume was three side-street cars short of meeting the minimum warrant requirements. Warrant 7–Crash Experience was one peak-year crash short of meeting the minimum warrant requirements for the crash history portion of the warrant but did meet the minimum volume warrant requirements. The Alternative Warrant 7–Crash Experience, as described in IA-19, is met with 4 angle crashes (3 required) in a one-year period, as well as having 7 angle crashes (5 required) in a three-year period. Signalization of the intersection is recommended at this time based on meeting Warrant 2 and Alternative Warrant 7, as well as safety concerns regarding the crash history. Based on the Crash Modification Factors (CMFs) provided in the *The Highway Safety Manual* for a three-way stop-controlled intersection being converted to a signalized intersection, there would be 1.6 left-turn crashes per year compared to the current 4 left-turn crashes per year. According to an ongoing "before/after" study of locations in Delaware where a signal was installed at an intersection that met the crash history warrant, the amount of angle crashes may decrease by 53 percent and personal injury crashes may reduce by 14 percent after signalization. Additionally, a Red Signal Ahead When Flashing (W3-3-DE) assembly on the westbound approach is recommended as a result of the insufficient stopping sight distance for westbound SR 48 traffic.

APPENDIX



*AASHTO, A Policy on Geometric Design of Highways and Streets, 2011 (or current), Chapter 9, 9.5.3 Intersection Control, Case F - Left Turn From the Major Road. Calculated based on Equation 9-1 and Table 9-13, adjusted for number of lanes, as needed.

Variables:
V_{LT} = left-turn volume on the subject approach, veh/h
V_O = through plus right-turn volume on the appoach opposing the subject left-turn movement, veh/h

**If left-turn driver sight distance is temporarily obstructed by an opposing left-turning vehicle and consequently temporarily less than AASHTO recommendations, consideration should be given to the obstruction's frequency and the potential for and severity of crashes (e.g., consider opposing left turn phasing, opposing through speeds and volumes).

Source:
Adapted from FHWA's Signal Timing Manual

Number of Left-turn Movements on Subject Road	Period During Which Crashes are Considered (years)	Critical Left-Turn-Related Crash Count When Considering Protected-only, C_{pt} (crashes/period)	When Considering Prot.+Perm., C_{p+p} (crashes/period)
One	1	6	4
One	2	11	6
One	3	14	7
Both	1	11	6
Both	2	18	9
Both	3	26	13

Guidelines for determining left-turn lane signal phasing treatment