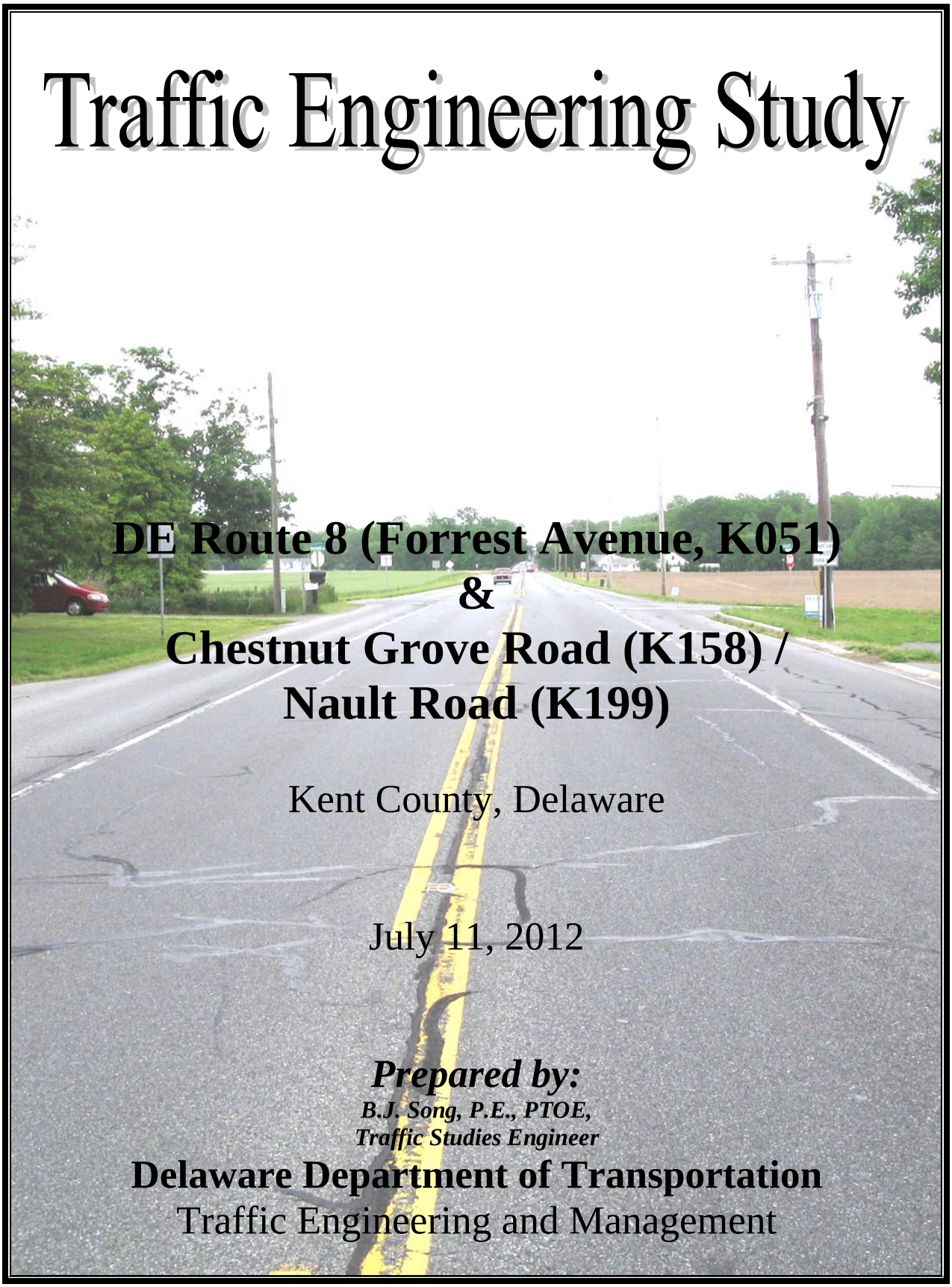
Traffic Engineering Study



DE Route 8 (Forrest Avenue, K051)
&
Chestnut Grove Road (K158) / Nault Road (K199)

Kent County, Delaware

July 11, 2012

Prepared by:

B.J. Song, P.E., PTOE,
Traffic Studies Engineer

Delaware Department of Transportation

Traffic Engineering and Management

EXECUTIVE SUMMARY

The Delaware Department of Transportation (DelDOT) has received a request to evaluate the intersection of DE Route 8 (Forrest Avenue, S051) and Chestnut Grove Road (K158) / Nault Road (K199), located west of the City of Dover in Kent County, Delaware. Senator David G. Lawson of Delaware Legislative District 15 forwarded concerns for safety at the intersection from his constituents. More specifically, he requested DelDOT to review the feasibility of installing a traffic signal at the intersection.

Accordingly, the purpose of this traffic engineering study is to evaluate safety and traffic operations at the above-mentioned intersection and determine the feasibility of installing a traffic signal, as well as any other roadway, signing and/or traffic control device improvements at this location. This study includes a 12-hour turning movement count, a site condition diagram with photographs; and evaluations of intersection sight distance, review of traffic control devices, intersection capacity, crash history and traffic signal warrant analysis. .

The significant findings of this traffic engineering study at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road are:

Intersection sight distance: From the Chestnut Grove Road approach and the Nault Road approach, the measured available intersection sight distance for vehicles looking left and right are greater than the distance recommended by AASHTO. The available intersection sight distances for vehicles turning left from the major street were also found to be greater than the minimums that are recommended by AASHTO.

Existing traffic volumes: The traffic count that was conducted for this study showed that the AM, Midday and PM peak hours of travel are 7:15 AM – 8:15 AM, 11:00 AM – 12:00 PM and 4:30 PM to 5:30 PM, respectively. The directional split of traffic indicates that the majority of traffic is traveling eastbound during the AM peak hour and evenly split during the Midday and PM peak hours on DE Route 8.

Existing intersection capacity: The results show that there are no delays (LOS A) for traffic turning left from both eastbound and westbound DE Route 8 during all three peak periods. The results also show that traffic approaching the intersection from the Nault Road approach operate with moderate delay (LOS C) during the Midday Peak period and heavy delay (LOS D & E) during the AM and the PM peak periods. The results also show that traffic approaching the intersection from the Chestnut Grove Road approach operate with minimal delay (LOS B) during the AM and the Midday peak periods and heavy delay (LOS D) during the PM peak period.

Speed Study Findings: The combined 85th percentile speed for both eastbound and westbound DE Route 8 was found to be 57 MPH for radar location 1, which indicates 85 percent of traffic is traveling at or below 57 MPH at location 1. Also, the combined 85th percentile speed for both eastbound and westbound DE Route 8 was found to be 56 MPH for radar location 2, which indicates 85 percent of traffic is traveling at or below 56 MPH at location 2. In addition, the data revealed that 68 percent of vehicles were traveling at speeds greater than the existing speed limit and 28 percent of vehicles were traveling at speeds 5 MPH or greater than the existing speed limit at radar location 1. Similarly, the data also revealed that 51 percent of vehicles were traveling at speeds greater than the existing speed limit and 20 percent of vehicles were traveling at speeds 5 MPH or greater than the existing speed limit at radar location 2.

Crash trend analysis: Crash data was obtained for this intersection covering the period from October 2008 to September 2011. The data showed that there were eleven (11) reported crashes occurring at this intersection. From January 2011 to December 2011, there were five (5) crashes that are susceptible to correction by the installation of a traffic signal.

Improvement Options:

- Based on the results of the traffic signal warrant analysis, a traffic signal is **warranted** at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.
- Based on observations of traffic operations at the intersection, upgrading the existing painted right-turn channelization islands to raised concrete islands should eliminate crashes involving vehicles using the right-turn lanes to pass stopped left-turning vehicles on DE Route 8.
- Field investigations revealed that the land use in the vicinity of the study intersection is predominantly residential. Installing rumble strips near a residential area could have a significant negative impact on the quality of life for nearby residents. Therefore, the installation of painted rumble strips is **not feasible** near the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

Based on the results of the traffic observations, data and analysis contained within this report, DelDOT presents the following improvement options to be considered for this location:

Option 1: *Install a traffic signal at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.*

Expected Benefits:
- Installing a traffic signal should reduce excessive delay experienced by vehicles approaching the intersection from the Chestnut Grove Road / Nault Road approaches.
- Installing a traffic signal should reduce the number of angle crashes and left-turn crashes at the intersection.
- Lane configuration change needed for the traffic signal installation should eliminate the crashes involving vehicles using the right-turn lanes to pass stopped left-turning vehicles on DE Route 8.

Possible Disadvantages:
- Increased delays to motorists on DE Route 8.
- Cost of operating and maintaining the traffic signal.
- Cost of possible additional land acquisition.
- Possible increase in number of rear-end crashes on DE Route 8.

Option 2: *Upgrade existing painted right-turn channelization islands on DE Route 8 to raised concrete right-turn channelization islands.*

Expected Benefits:
- Implementing raised concrete right-turn channelization islands should prohibit through vehicles on DE Route 8 from using the right-turn lanes to pass stopped left-turning vehicles.
- The provision of the raised right-turn channelization islands should eliminate angle crashes and left-turn crashes involving vehicles traveling through the intersection using the right-turn lanes.

Possible Disadvantages:
- Increased delays to motorists on DE Route 8.
- Cost of installing and maintaining the raised concrete channelization islands.

It should be noted that separate left-turn lanes will be added to the DE Route 8 approaches when the traffic signal is installed and right-turn channelization islands on DE Route 8 must be relocated. This means the proposed raised concrete right-turn channelization islands must be relocated at the time of the traffic signal installation; however, DelDOT recommends the raised concrete right-turn channelization islands to be installed as an interim improvement before the

traffic signal installation since the traffic signal installation will likely be a possible FY 2014 or FY2015 project.

DelDOT also considered installing Rumble Strips on the Chestnut Grove Road / Nault Road approaches. Field observations revealed that the land use in the vicinity of the study intersection is predominantly residential. Installing rumble strips near a residential area could have a significant negative impact on the quality of life for nearby residents. Therefore, DelDOT **does not recommend** installation of rumble strips at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

Based on the results from the radar study, it appears that many motorists traveling on DE Route 8 are not complying with the existing speed limit of 50 MPH. Lowering the speed limit on DE Route 8 is not advisable since the majority of motorists are currently not obeying the existing speed limit. In order for a lower speed limit to be warranted, the 85th percentile speed should be lower than the existing posted speed limit and there should be roadside features or other factors that cause motorists to select lower speed. The only effective measure that can reduce the travel speeds of motorists is police enforcement. Police enforcement can influence lower travel speeds on a roadway for a short period of time; however, the resulting lower travel speed could increase when the police enforcement is discontinued. This is due to drivers being accustomed to driving at the speed at which they feel safe and are comfortable. Therefore, it is recommended that the existing speed limit of 50 MPH remain in effect on DE Route 8. In addition, DelDOT also recommends additional speed enforcements to be conducted by the Delaware State Police (DSP) on DE Route 8 at the locations where the safety of the police officers conducting the speed enforcement will not be compromised.

Field observations conducted at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road have identified the need for minor traffic control device improvements. The proposed improvements are listed below:

- Remove existing Stop Ahead sign (W3-1) on southbound Chestnut Grove Road, located north of DE Route 8.
- Install new Stop Ahead sign (W3-1) and an Advance Street Name plaque (W16-8a-DE) for Forrest Avenue on southbound Chestnut Grove Road, approximately 250 feet north of DE Route 8.
- Remove existing Watch Children sign (W21-11-DE) and Advisory Speed 30 MPH sign (W13-1-30) on southbound Nault Road, located immediately south of DE Route 8.
- Remove existing Stop Ahead sign (W3-1) on northbound Nault Road, located south of DE Route 8.
- Install Stop Ahead sign (W3-1) and an Advance Street Name plaque (W16-8a-DE) for Forrest Avenue on northbound Nault Road, approximately 250 feet south of DE Route 8.

TABLE OF CONTENTS

Executive Summary i

I. Introduction 1

II. Previous Studies 1

III. Roadway and Site Characteristics 1

IV. Traffic Characteristics 3

V. Crash Trend Analysis 6

VI. Observation of Traffic Operations 7

VII. Improvement Options 7

VIII. Conclusions 12

IX. Recommendations 13

X. References 14

Appendix A: Existing Traffic Data / HCS Analysis Worksheets

Appendix B: Radar Data

Appendix C: Crash Data

Appendix D: Traffic Signal Warrant Worksheets

Appendix E: Site Photographs

Appendix F: Correspondence

Index of Tables

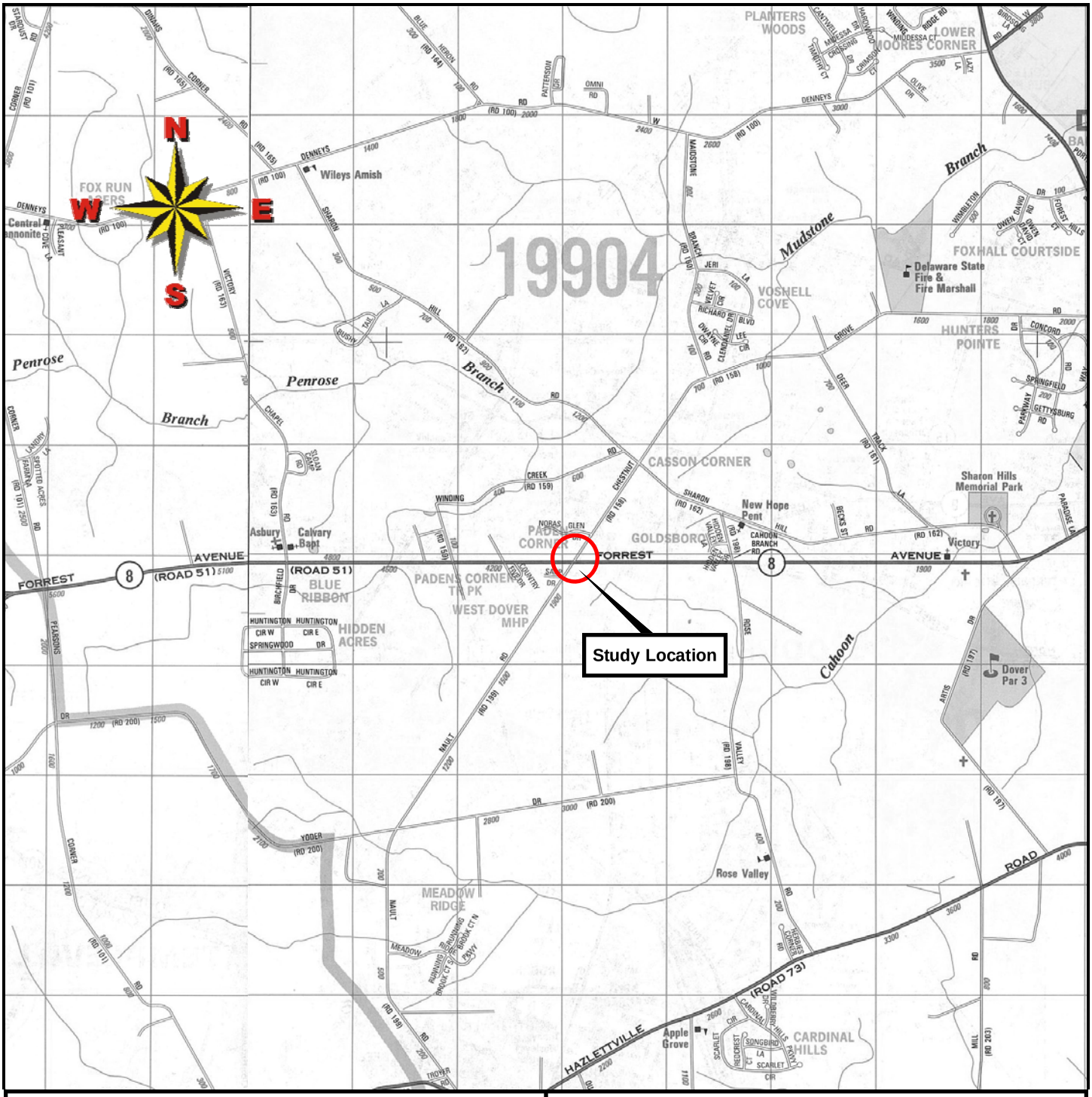
Table No. Page

1) Intersection Sight Distance Evaluation 3
2) 5/2/2012 & 5/3/2012 Peak Hour Turning Movement Volumes 4
3) Summary of HCS Unsignalized Intersection Analyses Results 5
4) Summary of 5/2/2012 Radar Data 5
5) Summary of Crash Data 7
6) Summary of Traffic Signal Warrants 10

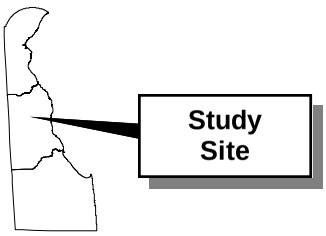
Index of Figures

Figure No. Follows Page

1) Map of the Study Area iv
2) Existing Site Diagram 1
3) Crash Diagram 6
4) Proposed Signing & Pavement Markings Diagram 14



Key Map of Delaware



Study Area Map

DE Route 8 (K051, Forrest Avenue)
@
Chestnut Grove Road (K158) / Nault Road (K199)

DelDOT Traffic	**May 2012**	**Figure 1**

I. Introduction

The Delaware Department of Transportation (DelDOT) has received a request to evaluate the intersection of DE Route 8 (Forrest Avenue, S051) and Chestnut Grove Road (K158) / Nault Road (K199), located west of the City of Dover in Kent County, Delaware. Senator David G. Lawson of Delaware Legislative District 15 forwarded concerns for safety at the intersection from his constituents. More specifically, he requested DelDOT to review the feasibility of installing a traffic signal at the intersection.

Accordingly, the purpose of this traffic engineering study is to evaluate safety and traffic operations at the above-mentioned intersection and determine the feasibility of installing a traffic signal, as well as any other roadway, signing and/or traffic control device improvements at this location. This study includes a 12-hour turning movement count, a site condition diagram with photographs; and evaluations of intersection sight distance, review of traffic control devices, intersection capacity, crash history and traffic signal warrant analysis.

All references to the American Association of State Highway and Transportation Officials (AASHTO) pertain to the 2011 edition of A Policy on Geometric Design of Highways and Streets. All references to the Delaware Manual on Uniform Traffic Control Devices (DEMUTCD) and to the Highway Capacity Manual (HCM) refer to the Year 2011 and the Year 2010 editions, respectively.

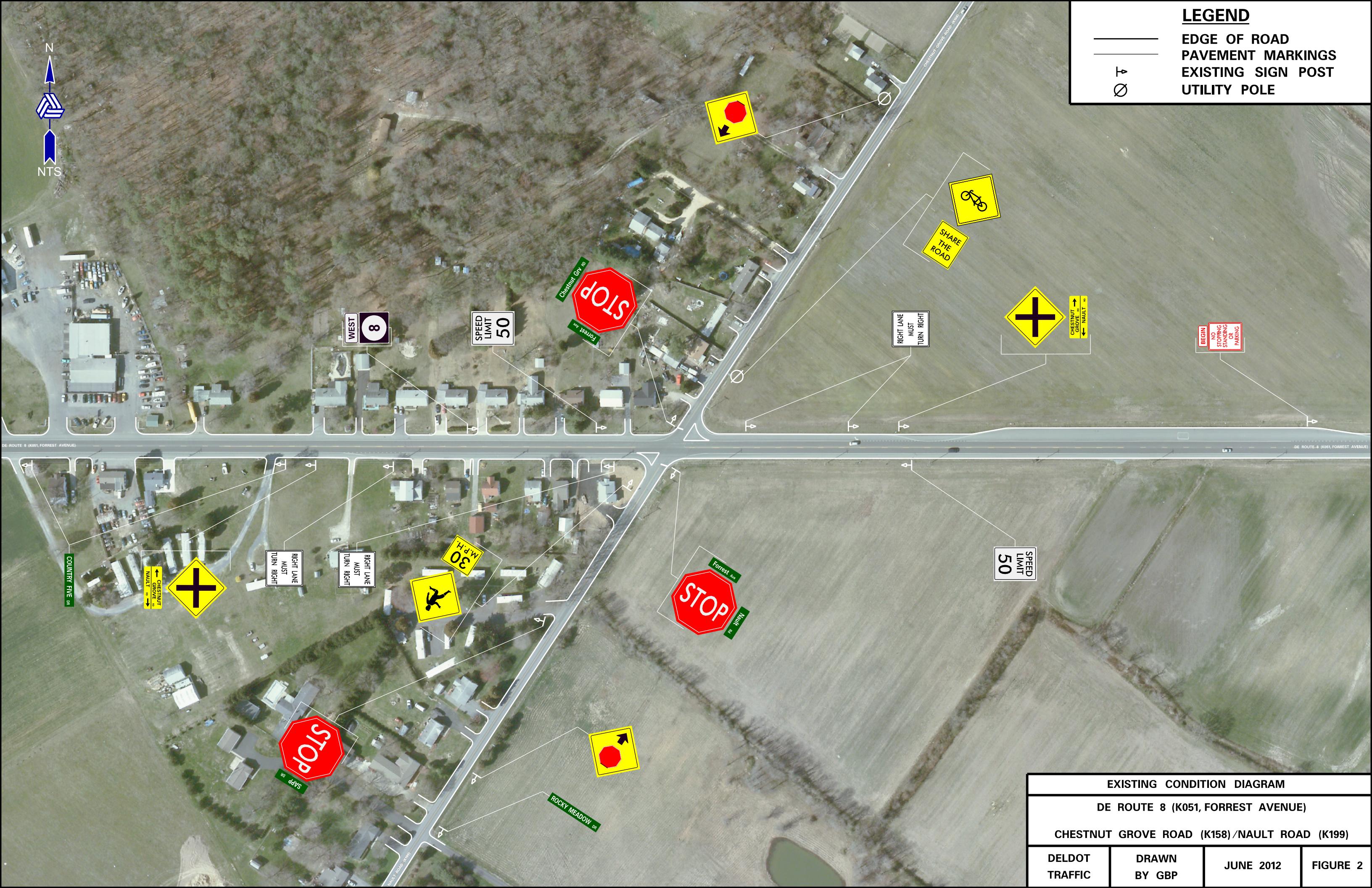
II. Previous Studies

Research of DelDOT archive revealed that the intersection of DE Route 8 and Chestnut Grove Road / Nault Road was previously studied in August 2006 and April 2009 for the consideration of a traffic signal. A traffic signal was not warranted based on the findings of both studies.

III. Roadway and Site Characteristics

The intersection of DE Route 8 and Chestnut Gove Road / Nault Road is located west of the City of Dover in Kent County (see Figure 1). DE Route 8 serves as the major roadway at the study intersection and the study segment of DE Route 8 is classified as a minor arterial according to DelDOT's 2005 Functional Classification Map for Kent County. According to DelDOT's Traffic Summary 2011, DE Route 8 has a 2011 Annual Average Daily Traffic (AADT) volume of 11,556 vehicles per day (vpd). DE Route 8 is a two-way roadway consisting of one lane in both the eastbound and westbound direction. DE Route 8 serves as one of the major east to west connectors in central Delaware connecting to the Delaware – Maryland state line to the west and to DE Route 9 (Bayside Drive, K017) to the east. DE Route 8 provides access to residential properties and agricultural properties in the vicinity of the study intersection. There are no separate left-turn lanes present on both the eastbound and the westbound DE Route 8; however, there are separate right-turn lanes present on both the eastbound and the westbound DE Route 8. The existing storage length for right-turn lanes are 500 feet and 350 feet for the eastbound and the westbound approach, respectively. A detailed sketch of the study intersection including lane widths, pavement markings and existing signing is shown in Figure 2.

Chestnut Grove Road / Nault Road serves as the minor roadway at the study intersection with Chestnut Grove Road referring to the portion of the roadway north of the DE Route 8 intersection and Nault Road referring to the portion of the roadway south of the DE Route 8 intersection. Both Chestnut Grove Road and Nault Road consist of one lane in both the northbound and southbound directions. The study segment of Chestnut Grove Road / Nault Road is classified as a local roadway according to DelDOT's 2005 Functional Classification Map for Kent County. According to DelDOT's Traffic Summary 2011, Chestnut Grove Road has AADT volume of 3,451 vehicles per day and Nault Road has AADT volume of 851 vehicles per day. Both Chestnut Grove Road / Nault Road provide access to residential and agricultural properties



EXISTING CONDITION DIAGRAM			
DE ROUTE 8 (K051, FORREST AVENUE)			
CHESTNUT GROVE ROAD (K158)/NAULT ROAD (K199)			
DELDOT TRAFFIC	DRAWN BY GBP	JUNE 2012	FIGURE 2

in the vicinity of the study intersection. There are no dedicated turning lanes present on the Chestnut Grove Road / Nault Road approaches.

- **Horizontal and Vertical Alignment**

The intersection of DE Route 8 and Chestnut Grove Road / Nault Road is located within a level terrain. The following geometric features were observed during the field study:

- There are no visible horizontal or vertical curves present on DE Route 8 in the vicinity of the study intersection.
- There are no visible horizontal curves present on Chestnut Grove Road / Nault Road; however, Chestnut Grove Road and Nault Road form a smooth vertical crest curve though the DE Route 8 intersection.
- Skew between DE Route 8 and Chestnut Grove Road / Nault Road is approximately 56 degrees.

- **Sidewalks and Shoulders**

There are 11 feet wide shoulder lanes present on eastbound and westbound DE Route 8. It should be noted that the shoulder lanes become right-turn lanes near the Chestnut Grove Road / Nault Road intersection. There are no shoulder lanes present on Chestnut Grove Road / Nault Road in the study area.

There are no sidewalks present on DE Route 8 or Chestnut Grove Road / Nault Road in the vicinity of the study intersection.

- **Signing and Pavement Markings**

The existing signing and pavement markings present on DE Route 8 and Chestnut Grove Road / Nault Road appear to be in compliance to the standards mandated by the DEMUTCD, however, the following observations were noted during the field investigation:

- Double yellow centerline markings, edge line marking and shoulder lane marking present on DE Route 8 appear to be worn out.
- There was no Advance Street Name plaque (W16-8a-DE) for Forrest Avenue (DE Route 8) present underneath the existing STOP Ahead signs on the Chestnut Grove Road / Nault Road approaches.
- There are painted right-turn channelization islands present on both the eastbound and the westbound DE Route 8.

- **Roadway Lighting**

There is no roadway or pedestrian lighting present along DE Route 8 or Chestnut Grove Road / Nault Road adjacent to the travel lane in the vicinity of the study intersection.

- **Adjacent Land Use**

The adjacent land use surrounding the intersection of DE Route 8 and Chestnut Grove Road / Nault Road predominantly consists of residential and agricultural. The northwest and southwest quadrants of the intersection appear to be used for residential purposes and the northeast and southeast quadrants of the intersection appears to be used for agricultural purposes. It should be noted that there is a new commercial building in the southwest quadrant; however the building appears to be vacant.

- **Sight Distance**

The available intersection sight distances were measured for the turning movements from the Chestnut Grove Road approach and the Nault Road approach onto DE Route 8. AASHTO recommends intersection sight distances that are a function of the design and/or operating speed of the major roadway. Table 1 includes the recommended minimum intersection sight distances for each movement calculated using the existing speed limit along DE Route 8 (50 MPH).

Table 1

Intersection Sight Distance Evaluation

		Measured Available ISD (feet)	AASHTO (2004) Recommended ISD (feet)
Northbound Nault Road	**Left-turn from Minor Road (AASHTO Case B1)**	> 1,000' (Looking Left) > 855' (Looking Right)	555' (50 mph Existing Speed Limit)
	Right-turn/Cross from Minor Road (AASHTO Cases B2 & B3)	> 1,000' (Looking Left) > 855' (Looking Right)	480' (50 mph Existing Speed Limit)
Southbound Chestnut Grove Road	**Left-turn from Minor Road (AASHTO Case B1)**	> 590' (Looking Left) > 1,000' (Looking Right)	555' (50 mph Existing Speed Limit)
	Right-turn/Cross from Minor Road (AASHTO Cases B2 & B3)	> 590' (Looking Left) > 1,000' (Looking Right)	480' (50 mph Existing Speed Limit)
Westbound DE Route 8	**Left-turn from Major Road (AASHTO Case F)**	> 1,000'	405' (50 mph Existing Speed Limit)
Eastbound DE Route 8	**Left-turn from Major Road (AASHTO Case F)**	> 1,000'	405' (50 mph Existing Speed Limit)

From the Chestnut Grove Road approach and the Nault Road approach, the measured available intersection sight distance for vehicles looking left and right are greater than the distance recommended by AASHTO.

AASHTO also provides recommended intersection sight distances for vehicles turning left from the major street. The available intersection sight distances for this case were also measured in the field and were found to be greater than the minimums that are recommended by AASHTO (see Table 1).

IV. Traffic Characteristics

- **Traffic Volumes**

An 8-hour turning movement count covering the AM, Middday and PM peak periods was performed at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road on Wednesday, May 2, 2012 and Thursday, May 3, 2012. Then a supplemental turning movement count covering the non-peak periods was performed on Wednesday May 23, 2012 and Tuesday, May 29, 2012 to complete a 12-hour count for the study intersection. The AM, Midday and PM peak hours of travel were identified as 7:15 AM – 8:15 AM, 11:00 AM – 12:00 PM and 4:30 PM – 5:30 PM, respectively. A summary of the peak hour turning movement volumes for the

intersection is shown in Table 2. The complete results from the turning movement count are provided in Appendix A.

The directional split of traffic on DE Route 8, the major street of the study intersection, for each of the peak hours identified above was found to be 23% westbound / 77% eastbound during the AM peak hour, 41% westbound / 59% eastbound during the Midday peak hour and 50% westbound / 50% eastbound during the PM peak hour. The directional split of traffic indicates that the majority of traffic is traveling eastbound during the AM peak hour and evenly split during the Midday and PM peak hours on DE route 8.

Table 2
DE Route 8 @ Chestnut Grove Road / Nault Road
5/2/2012 and 5/3/2012 - Peak Hour Turning Movement Volumes

		AM Peak Hour (7:15 AM - 8:15 AM)				Midday Peak Hour (11:00 AM - 12:00 PM)				PM Peak Hour (4:30 PM - 5:30 PM)			
		L	**T**	**R**	***Total***	**L**	**T**	**R**	***Total***	**L**	**T**	**R**	***Total***
DE Route 8	WB	8	169	1	*178*	15	265	3	*283*	25	401	3	*429*
	EB	79	494	9	*582*	47	355	5	*407*	66	360	9	*435*
Chestnut Grove Road	SB	0	13	31	*44*	7	13	43	*63*	2	24	98	*125*
Nault Road	NB	2	34	29	*65*	8	12	27	*47*	6	19	16	*41*

- **Existing Capacity**

Capacity analyses were performed at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road using the traffic volumes shown in Table 3. These analyses were performed using the Highway Capacity Software 2010 v6.1 (HCS 2010) for unsignalized intersections. The HCS 2010 software is based on the capacity analysis theories and methodologies that are provided in the 2010 version of the Highway Capacity Manual. Unsignalized intersection capacity is measured in terms of Levels of Service (LOS) and delay, primarily for vehicles on the stop controlled approaches and vehicles turning left from the major street approaches. LOS A (delay ≤ 10 sec/veh) represents the best possible operating conditions or free flow operations, whereas LOS F (delay > 50 sec/veh) represents congested conditions, corresponding with traffic that has reached or exceeded available capacity, resulting in relatively high average delay per vehicle and a breakdown in the flow of traffic. The worksheets and software outputs for all of the capacity analyses are provided in Appendix A.

Table 3 shows the results of the capacity analyses for the intersection of DE Route 8 and Chestnut Grove Road / Nault Road using HCS 2010 for unsignalized intersections. The results show that there are no delays (LOS A) for traffic turning left from both eastbound and westbound DE Route 8 during all three peak periods. The results also show that traffic approaching the intersection from the Nault Road approach operate with moderate delay (LOS C) during the Midday Peak period and heavy delay (LOS D & E) during the AM and the PM peak periods. The results also show that traffic approaching the intersection from the Chestnut Grove Road approach operate with minimal delay (LOS B) during the AM and the Midday peak periods and heavy delay (LOS D) during the PM peak period.

Table 3
DE Route 8 @ Chestnut Grove Road / Nault Road
Summary of HCS 2010 Unsignalized Analyses Results

Approach	AM Peak Hour	Midday Peak Hour	PM Peak Hour
	Movement LOS (delay)	Movement LOS (delay)	Movement LOS (delay)
Eastbound DE Route 8 Left-Turn	A (7.8 seconds/vehicle)	A (8.0 seconds/vehicle)	A (8.7 seconds/vehicle)
Westbound DE Route 8 Left-Turn	A (9.0 seconds/vehicle)	A (8.1 seconds/vehicle)	A (8.4 seconds/vehicle)
Northbound Nault Road Left-Through-Right	D (25.9 seconds/vehicle)	C (16.1 seconds/vehicle)	E (39.0 seconds/vehicle)
Southbound Chestnut Grove Road Left-Through-Right	B (14.3 seconds/vehicle)	B (14.6 seconds/vehicle)	D (26.0 seconds/vehicle)

- **Speed Study Findings**

Speed study was performed using a conventional radar gun on DE Route 8 on Wednesday, May 2, 2012. In the speed study, vehicle travel speeds were measured at two locations on DE Route 8: approximately 800 feet east of the Chestnut Grove Road / Nault Road intersection (location 1) and approximately 1,200 feet west of the Chestnut Grove Road / Nault Road intersection (location 2). The speed data that was gathered was then used to determine the 85th percentile speed for DE Route 8. The 85th percentile speed is the speed at which 85 percent of the vehicles recorded are traveling at or below. This is based on the theory that most motorists select their speed based on roadway conditions and the surrounding environment. Setting artificial speed limits much lower or higher than the 85th percentile speed reduces the effectiveness of the speed limit and could lead to poor motorist compliance, which may increase the risk of being in a crash. The results of the speed study for DE Route 8 are provided in Table 4.

Table 4
DE Route 8 Radar Study Results

Site	Existing Speed Limit	Combined 85th Percentile Speed	% Vehicles Over Speed Limit	% Vehicles 5 MPH Over Speed Limit
Location 1	50 MPH	57 MPH	68%	28%
Location 2	50 MPH	56 MPH	51%	20%

The combined 85th percentile speed for both eastbound and westbound DE Route 8 was found to be 57 MPH for radar location 1, which indicates 85 percent of traffic is traveling at or below 57 MPH at location 1. Also, the combined 85th percentile speed for both eastbound and westbound DE Route 8 was found to be 56 MPH for radar location 2, which indicates 85 percent of traffic is traveling at or below 56 MPH at location 2. In addition, the data revealed that 68 percent of vehicles were traveling at speeds greater than the existing speed limit and 28 percent of vehicles were traveling at speeds 5 MPH or greater than the existing speed limit at radar location 1. Similarly, the data also revealed that 51 percent of vehicles were traveling at speeds greater than

the existing speed limit and 20 percent of vehicles were traveling at speeds 5 MPH or greater than the existing speed limit at radar location 2.

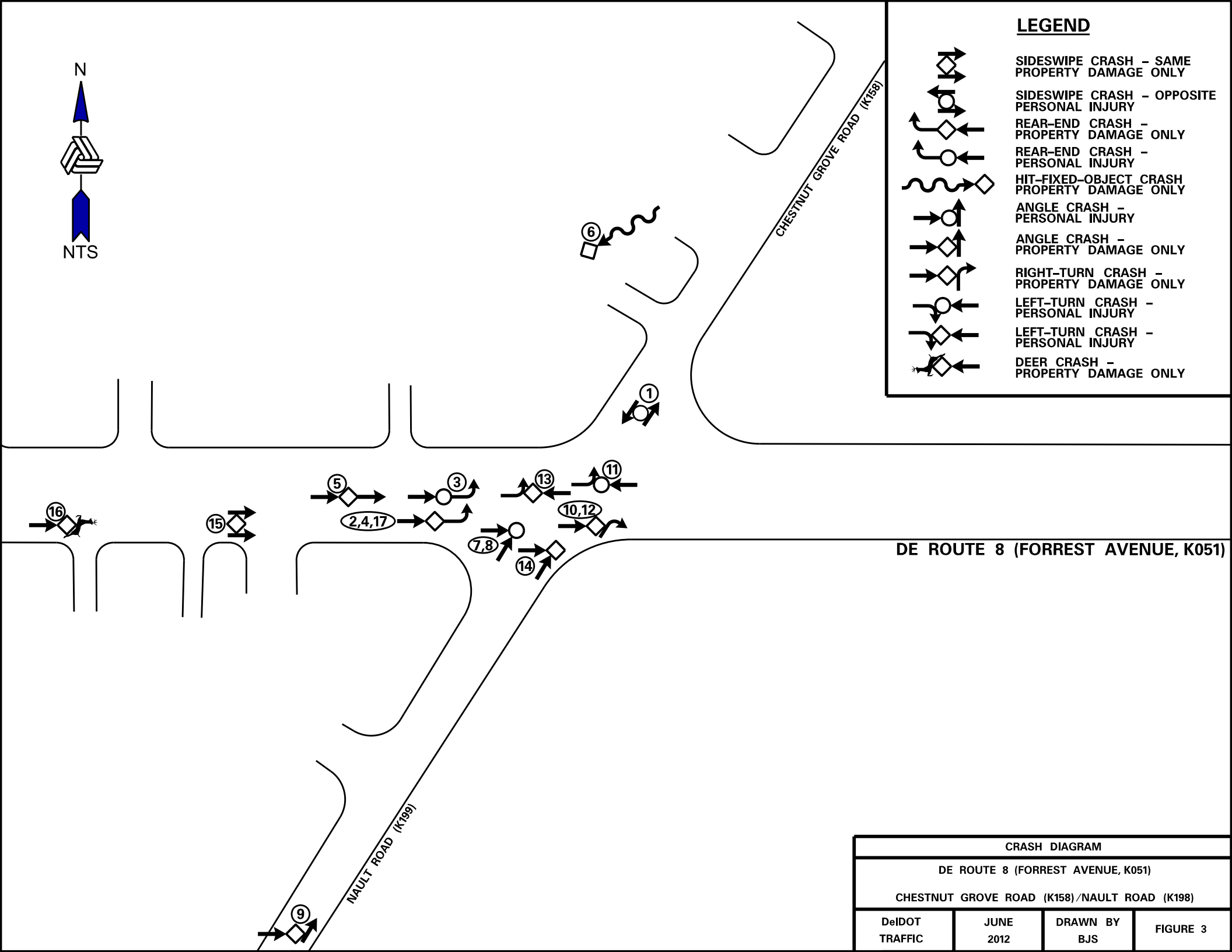
V. Crash Trend Analysis

The Planning Section of DelDOT provided the most recent crash data available for the study area, covering the period from April 2009 through April 2012. According to the available data, there were seventeen (17) reported crashes occurring at or near the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

The following trends were identifiable in the crash data set:

- There were five (5) crashes that resulted in personal injury at this location.
- Twelve (12) crashes occurred during daytime and five (5) crashes occurred during night time.
- There were eight (8) crashes susceptible to correction by the installation of a traffic signal. Crash data revealed that there were six (6) angle crashes and two (2) left-turn crashes; however, it should be mentioned one (1) of the reported angle crashes appears to have been occurred on Nault Road at a driveway immediately adjacent to the intersection. It appears angle crashes were attributable to motorists failing to remain stopped from the minor road approaches and left-turn crashes were attributable to motorists failing to yield right-of-way from eastbound DE Route 8 while attempting to make a left-turn on to Chestnut Grove Road.
- There were five (5) rear-end crashes reported and four (4) of the rear-end crashes were attributable to inattentive driving and one (1) rear-end crash was attributable to a motorist following another vehicle too closely.
- There was one (1) same-direction-sideswipe crash reported and the crash was attributable to a motorist performing an unsafe lane change on eastbound DE Route 8.
- There was one (1) opposite-direction-sideswipe crash reported and the crash was attributable to an eastbound motorist crossing into the westbound lane on DE Route 8.
- There was one (1) crash involving a motor vehicle and a deer in the roadway.

It should be noted that there were five (5) crashes susceptible to correction via the installation of a traffic signal within a 12-month period between January 2011 and December 2011.



CRASH DIAGRAM			
DE ROUTE 8 (FORREST AVENUE, K051)			
CHESTNUT GROVE ROAD (K158)/NAULT ROAD (K198)			
DelDOT TRAFFIC	JUNE 2012	DRAWN BY BJS	FIGURE 3

Table 5

DE Route 8 @ Chestnut Grove Road / Nault Road
Summary of Crash Data

	Date	Time	Day of Week	Weather	Lighting	Manner of Impact	Severity	Contributing Circumstances
1	6/24/2009	4:19 PM	Wednesday	Clear	Daylight	Sideswipe	Injury	Vehicle crossing centerline
2	5/21/2009	1:50 PM	Thursday	Clear	Daylight	Rear-end	PDO	Inattentive Driving
3	12/7/2009	2:40 PM	Monday	Clear	Daylight	Rear-end	Injury	Inattentive Driving
4	8/30/2009	5:49 PM	Sunday	Clear	Daylight	Rear-end	PDO	Inattentive Driving
5	9/19/2009	4:04 PM	Saturday	Clear	Daylight	Rear-end	PDO	Following too closely
6	5/22/2010	9:50 PM	Saturday	Rain	Dark/Unlit	ROR/HFO	PDO	Unknown / Hit & Run
7	8/16/2010	1:12 PM	Monday	Clear	Daylight	Angle	Injury	Failed to remain stopped
8	6/6/2010	2:15 PM	Sunday	Clear	Daylight	Angle	Injury	Failed to remain stopped
9	4/11/2011	12:00 AM	Monday	Cloudy	Daylight	Angle	PDO	Failed to remain stopped
10	8/16/2011	4:43 PM	Tuesday	Clear	Daylight	Angle	PDO	Failed to remain stopped
11	11/29/2011	8:45 AM	Tuesday	Rain	Daylight	Left-turn	Injury	Failed to yield ROW
12	5/9/2011	6:49 AM	Monday	Clear	Daylight	Angle	PDO	Failed to remain stopped
13	11/11/2011	5:37 PM	Friday	Clear	Dark/Unlit	Left-turn	PDO	Failed to yield ROW
14	1/25/2011	12:22 PM	Tuesday	Clear	Daylight	Angle	PDO	Failed to remain stopped
15	1/26/2012	6:33 AM	Thursday	Rain	Dark/Unlit	Sideswipe	PDO	Unsafe lane change
16	3/30/2012	8:59 PM	Friday	Clear	Dark/Unlit	Hit Deer	PDO	Animal in roadway
17	2/18/2012	5:40 PM	Saturday	Clear	Dark/Unlit	Rear-end	PDO	Inattentive Driving

PDO = Property Damage Only

ROR/HFO = Runoff-the-Road / Hit-Fixed-Object

VI. Observations of Traffic Operations

The following observations were recorded during visits to the study area during peak and off-peak periods:

- Vehicles traveling on the major street (DE Route 8) do not arrive at this intersection in platoons.
- There are painted right-turn channelization islands present on both eastbound and westbound DE Route 8 at the intersection; however, through vehicles were observed traversing over the painted right-turn channelization islands to pass stopped or slowing left-turning vehicles on both DE Route 8 approaches.
- Vehicles approaching the intersection from the southbound Chestnut Grove Road approach were observed stopping beyond the existing painted STOP bar due to shrubbery and mailbox present within the northwest quadrant of the intersection.

VII. Improvement Options

Based on the results of the traffic observations, data obtained and analyses contained within this report, DelDOT considered the following three (3) improvement options at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road: installation of a traffic signal, installation of concrete right-turn channelization islands on DE Route 8 and installation of painted rumble strips on the Chestnut Grove Road / Nault Road approaches.

Option 1 – Traffic Signal

The State of Delaware Manual on Uniform Traffic Control Devices (DEMUTCD)[3] specifies nine (9) warrants that may be used in the process of determining whether a traffic signal is justified at an intersection. These warrants were reviewed using traffic volume information from the turning movement counts and the three year crash data for the intersection of DE Route 8 and Chestnut Grove Road / Nault Road. Results of the signal warrant analyses are summarized in Table 6. The individual signal warrants are described in detail following the summary table.

Results of the signal warrant study showed that **two** of the nine signal warrants were met at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road. In addition, there were five (5) crashes susceptible to correction via the installation of traffic signal at the intersection within a 12-month period. The following is a detailed summary of the requirements for each of the warrants for traffic signal installation as specified by the DEMUTCD.

Warrant 1, Eight-Hour Vehicular Volumes

This warrant is divided into three parts. The first part, Condition A, minimum vehicular volume, is intended for use at locations where a large volume of intersecting traffic is the principal reason to consider signalization. The second part, Condition B, interruption of continuous traffic, is intended for use at locations where Condition A is not satisfied and where the traffic volume on the major street is so heavy that traffic on the minor intersecting street suffers excessive delay or conflict in entering or crossing the major street. The third part of this warrant is the combination of Conditions A and B, which is intended for use at locations where Condition A or Condition B is not satisfied. The combination of A and B should only be applied after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

- The traffic volumes on the DE Route 8 approaches must be at least 500 vph for Condition A and 750 vph for Condition B. The volume requirement for the combination of Condition A and Condition B is 80% of these values.

- The traffic volume on the most heavily traveled minor street approach (Chestnut Grove Road / Nault Road) must be at least 150 vph for Condition A and 75 vph for Condition B. The volume requirement for the combination of Condition A and Condition B is 80% of these values.

*The requirements for this warrant were **satisfied** by the existing conditions at this intersection.*

Hours met: 2 of 8 hours for Condition A

9 of 8 hours for Condition B

Condition C is not applicable to this location

Warrant 2, Four-Hour Vehicular Volumes

This warrant is satisfied when, for each of any four hours on an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher volume minor street approach (one direction only) all fall above the curve in Figure 4C-1 of the DEMUTCD for the existing combination of approach lanes. Figure 4C-2 is used because the 70% criterion does apply to this location due to the speed limit on DE Route 8 being 50 MPH, which is greater than 40 MPH, as required by the warrant.

*The requirements for this warrant were **satisfied** by the existing conditions at this intersection.*

Hours Met: 4 of 4.

Warrant 3, Peak Hour

This warrant is intended for use at a location where traffic conditions are such that for a minimum of one hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street. The DEMUTCD specifically states, "This signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time. If the location meets these criteria, the peak hour warrant is satisfied when:

- The total stopped time delay experienced by the traffic on one minor street approach (Chestnut Grove Road / Nault Road) controlled by a stop sign equals or exceeds 4 vehicle-hours for a one-lane approach, and;
- The volume on the same minor street approach (Chestnut Grove Road / Nault Road) equals or exceeds 100 vehicles per hour for one moving lane of traffic, and;
- The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with 4 or more approaches.

The warrant can also be satisfied if the plotted point representing the vehicles per hour on the major (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-4 for the existing combination of approach lanes. Figure 4C-4 is used because the 70% criterion does apply to this location.

The intersection of DE Route 8 and Chestnut Grove Road / Nault Road cannot be considered an 'unusual case' since the intersection does not experience high volumes of vehicles entering and exiting this facility during short periods of time. Therefore, this warrant ***does not apply*** *to the intersection of DE Route and Chestnut Grove Road / Nault Road.*

Warrant 4, Pedestrian Volume

This warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

- The pedestrian volume crossing the major street at an intersection or midblock location during an average day is 100 or more for each of any 4 hours or 190 or more during 1 hour, and;
- There are fewer than 60 gaps per hour in the traffic stream of adequate length to allow pedestrians to cross during the same period when the pedestrian volume criterion is satisfied.

The requirements for this warrant were ***not satisfied*** *by the existing conditions at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.*

Warrant 5, School Crossing

A traffic control signal may be warranted at an established school crossing when a traffic engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at the school crossing shows that the number of adequate gaps in the traffic stream during the period when the children are using the crossing is less than the number of minutes in the same period.

This warrant does not apply to the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

Table 6
Summary of Signal Warrant Analysis

	MUTCD Requirement	Current Condition	Criteria Met?	Warrant Met?
Warrant 1 – Eight-Hour Vehicular Volume				
A. Minimum Vehicular Volume (Condition A)	8 Hours	2 Hours	No	**Yes**
B. Minimum Vehicular Volume (Condition B)	8 Hours	9 Hours	No	
C. Combination of A and B	8 Hours	0 Hours	No	
Warrant 2 – Four-Hour Vehicular Volume				
Figure 4C-2 of the DE MUTCD	4 Hours	4 Hours	No	**Yes**
Warrant 3 – Peak Hour				
Delay on minor street for unusual locations	N/A	N/A	No	**No**
Warrant 4 – Pedestrian Volume				
A. Figure 4C-5	4 Hours	0 Hours	No	**No**
B. Figure 4C-7	1 Hour	0 Hours	No	
Warrant 5- School Crossing				
Frequency and adequacy of gaps in vehicular traffic stream	N/A	N/A	No	**No**
Warrant 6- Coordinate Signal System				
Adequate platooning of vehicles within a coordinated signal system	N/A	N/A	No	**No**
Warrant 7- Crash History				
Number of Crashes	5 Crashes	5 Crashes	Yes	**No**
Minimum Vehicular Volume	8 Hours	6 Hours	No	
Warrant 8 – Roadway Network				
All Warrants Failed?			Yes	**No**
Warrant 9 – Intersection Near a Grade Crossing				
This intersection is not Near a Grade Crossing				

Warrant 6, Coordinated Signal System

The need for a traffic signal shall be considered if adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation on a two-way street. This warrant should not be applied if the resultant spacing of traffic control signals would be less than 1,000 ft.

This warrant does not apply to the intersection of DE Route 8 and Chestnut Grove Road / Nault Road since the intersection is not part of a coordinated signal system.

Warrant 7, Crash Experience

The following requirements must be met in order for this warrant to be satisfied:

- Other safety improvement alternatives have failed to produce adequate results, and;
- Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and

- There exists a volume of vehicular and pedestrian traffic not less than 80 percent of the requirements specified in warrant 1.

*The requirements for this warrant were **not satisfied** by the existing conditions at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road. Safety improvements such as right-turn channelization islands have been implemented at the intersection and there were **five (5)** crashes susceptible to correction by a traffic signal in a 12-month study period between January 2011 and December 2011; however, the 80% volume warrant was only satisfied 6 of 8 hours.*

Warrant 8, Roadway Network

The intent of this warrant is to encourage concentration and organization of traffic flow networks. For this reason, all elements of this warrant refer to intersections of two or more "major streets."

A major street as used in this warrant has one or more of the following characteristics:

- It is part of the street or highway system that serves as the principal network for through traffic flow;
- It includes rural or suburban highways outside, entering or traversing a city;
- It appears as a major route on an official plan such as a major street plan in a transportation study.

For this warrant to be met, the junction of two of more major streets must:

- Have a total entering volume of at least 1,000 vehicles during the peak hours of a typical weekday and have five year projected volumes which meet one or more requirements of Warrants 1, 2 and 3 during an average weekday.
- Have a total of existing or immediately projected entering volume of at least 1,000 vehicles for each of any five hours on a Saturday and/or Sunday.

This warrant does not apply to the intersection of DE Route 8 and Chestnut Grove Road / Nault Road, because the minor street (Chestnut Grove Road / Nault Road) approaches does not meet the requirements of a "major street."

Warrant 9, Intersection near a Grade Crossing

This warrant is applicable at locations where a grade crossing is located on an approach to an intersection and a traffic signal is needed in order to prevent vehicles from stopping on the tracks.

This warrant does not apply to the intersection of DE Route 8 and Chestnut Grove Road / Nault Road, since there are no grade crossings in the vicinity of the intersection.

Based on the results of the traffic signal warrant analysis, a traffic signal is **warranted** at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

Option 2 – Raised concrete right-turn channelization islands on DE Route 8

As mentioned in observations of traffic operations section, many vehicles were observed using the right-turn lane to pass vehicles stopped in the shared left-turn / through lane to make a left-turn. There are painted right-turn channelization islands present on both eastbound and westbound DE Route 8; however, vehicles using the right-turn lane to pass left-turning vehicles were observed traversing over the painted-right-turn channelization islands. In addition, vehicles making a right-turn from the minor street approaches (Chestnut Grove Road / Nault Road) were observed stopping beyond the existing painted stop line due to the skew at the intersection, which resulted in many near-miss crashes with vehicles passing on right-turn lanes at the intersection. Further review of the crash data at the intersection revealed that two (2) of the five (5) relevant angle crashes may have involved eastbound vehicles using the right-turn lane to pass left-turning vehicles. In addition, vehicles using the right-turn lane to pass left-turning vehicles created further

conflicts with other through vehicles stopped behind left-turning vehicles when they proceeded through the intersection. Upgrading the existing painted right-turn channelization islands to raised concrete right-turn channelization islands should eliminate angle crashes involving vehicles using the right-turn lanes as bypass lanes.

Option 3 – Rumble Strips

DelDOT also determined the feasibility of installing painted rumble strips on the Chestnut Grove Road / Nault Road approaches. Field observation revealed that the land use in the vicinity of the study intersection is predominantly residential. Installing rumble strips near a residential area could have a significant negative impact on the quality of life for nearby residents. Therefore, installation of rumble strips near the intersection of DE Route 8 and Chestnut Grove Road / Nault Road is **not feasible**.

VIII. Conclusions

The significant findings of this traffic engineering study at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road are:

Intersection sight distance: From the Chestnut Grove Road approach and the Nault Road approach, the measured available intersection sight distance for vehicles looking left and right are greater than the distance recommended by AASHTO. The available intersection sight distances for vehicles turning left from the major street were also found to be greater than the minimums that are recommended by AASHTO.

Existing traffic volumes: The traffic count that was conducted for this study showed that the AM, Midday and PM peak hours of travel are 7:15 AM – 8:15 AM, 11:00 AM – 12:00 PM and 4:30 PM to 5:30 PM, respectively. The directional split of traffic indicates that the majority of traffic is traveling eastbound during the AM peak hour and evenly split during the Midday and PM peak hours on DE Route 8.

Existing intersection capacity: The results show that there are no delays (LOS A) for traffic turning left from both eastbound and westbound DE Route 8 during all three peak periods. The results also show that traffic approaching the intersection from the Nault Road approach operate with moderate delay (LOS C) during the Midday Peak period and heavy delay (LOS D & E) during the AM and the PM peak periods. The results also show that traffic approaching the intersection from the Chestnut Grove Road approach operate with minimal delay (LOS B) during the AM and the Midday peak periods and heavy delay (LOS D) during the PM peak period.

Speed Study Findings: The combined 85th percentile speed for both eastbound and westbound DE Route 8 was found to be 57 MPH for radar location 1, which indicates 85 percent of traffic is traveling at or below 57 MPH at location 1. Also, the combined 85th percentile speed for both eastbound and westbound DE Route 8 was found to be 56 MPH for radar location 2, which indicates 85 percent of traffic is traveling at or below 56 MPH at location 2. In addition, the data revealed that 68 percent of vehicles were traveling at speeds greater than the existing speed limit and 28 percent of vehicles were traveling at speeds 5 MPH or greater than the existing speed limit at radar location 1. Similarly, the data also revealed that 51 percent of vehicles were traveling at speeds greater than the existing speed limit and 20 percent of vehicles were traveling at speeds 5 MPH or greater than the existing speed limit at radar location 2.

Crash trend analysis: Crash data was obtained for this intersection covering the period from October 2008 to September 2011. The data showed that there were eleven (11) reported crashes occurring at this intersection. From January 2011 to December 2011, there were five (5) crashes that are susceptible to correction by the installation of a traffic signal.

Improvement Options:

- Based on the results of the traffic signal warrant analysis, a traffic signal is **warranted** at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.
- Based on observations of traffic operations at the intersection, upgrading the existing painted right-turn channelization islands to raised concrete islands should eliminate crashes involving vehicles using the right-turn lanes to pass stopped left-turning vehicles on DE Route 8.
- Field investigations revealed that the land use in the vicinity of the study intersection is predominantly residential. Installing rumble strips near a residential area could have a significant negative impact on the quality of life for nearby residents. Therefore, the installation of painted rumble strips is **not feasible** near the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

IX. Recommendations

Based on the results of the traffic observations, data and analysis contained within this report, DelDOT presents the following improvement options to be considered for this location:

Option 1: *Install a traffic signal at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.*

Expected Benefits:

- Installing a traffic signal should reduce excessive delay experienced by vehicles approaching the intersection from the Chestnut Grove Road / Nault Road approaches.
- Installing a traffic signal should reduce the number of angle crashes and left-turn crashes at the intersection.
- Lane configuration change needed for the traffic signal installation should eliminate the crashes involving vehicles using the right-turn lanes to pass stopped left-turning vehicles on DE Route 8.

Possible Disadvantages:

- Increased delays to motorists on DE Route 8.
- Cost of operating and maintaining the traffic signal.
- Cost of possible additional land acquisition.
- Possible increase in number of rear-end crashes on DE Route 8.

Option 2: *Upgrade existing painted right-turn channelization islands on DE Route 8 to raised concrete right-turn channelization islands.*

Expected Benefits:

- Implementing raised concrete right-turn channelization islands should prohibit through vehicles on DE Route 8 from using the right-turn lanes to pass stopped left-turning vehicles.
- The provision of the raised right-turn channelization islands should eliminate angle crashes and left-turn crashes involving vehicles traveling through the intersection using the right-turn lanes.

Possible Disadvantages:

- Increased delays to motorists on DE Route 8.
- Cost of installing and maintaining the raised concrete channelization islands.

It should be noted that separate left-turn lanes will be added to the DE Route 8 approaches when the traffic signal is installed and right-turn channelization islands on DE Route 8 must be

relocated. This means the proposed raised concrete right-turn channelization islands must be relocated at the time of the traffic signal installation; however, DelDOT recommends the raised concrete right-turn channelization islands to be installed as an interim improvement before the traffic signal installation since the traffic signal installation will likely be a possible FY 2014 or FY2015 project.

DelDOT also considered installing Rumble Strips on the Chestnut Grove Road / Nault Road approaches. Field observations revealed that the land use in the vicinity of the study intersection is predominantly residential. Installing rumble strips near a residential area could have a significant negative impact on the quality of life for nearby residents. Therefore, DelDOT **does not recommend** installation of rumble strips at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road.

Based on the results from the radar study, it appears that many motorists traveling on DE Route 8 are not complying with the existing speed limit of 50 MPH. Lowering the speed limit on DE Route 8 is not advisable since the majority of motorists are currently not obeying the existing speed limit. In order for a lower speed limit to be warranted, the 85th percentile speed should be lower than the existing posted speed limit and there should be roadside features or other factors that cause motorists to select lower speed. The only effective measure that can reduce the travel speeds of motorists is police enforcement. Police enforcement can influence lower travel speeds on a roadway for a short period of time; however, the resulting lower travel speed could increase when the police enforcement is discontinued. This is due to drivers being accustomed to driving at the speed at which they feel safe and are comfortable. Therefore, it is recommended that the existing speed limit of 50 MPH remain in effect on DE Route 8. In addition, DelDOT also recommends additional speed enforcements to be conducted by the Delaware State Police (DSP) on DE Route 8 at the locations where the safety of the police officers conducting the speed enforcement will not be compromised.

Field observations conducted at the intersection of DE Route 8 and Chestnut Grove Road / Nault Road have identified the need for minor traffic control device improvements. The proposed improvements are listed below:

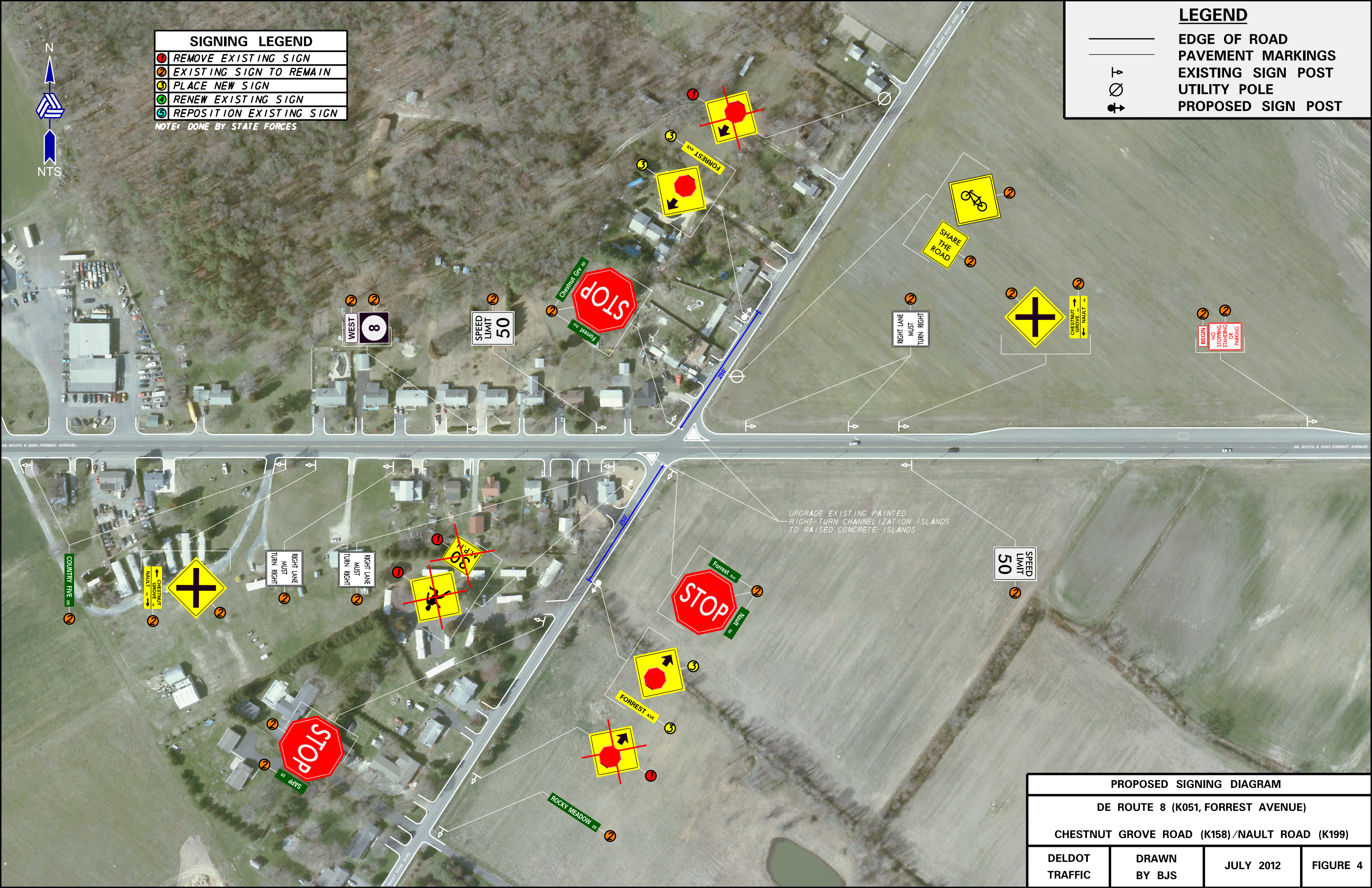
- Remove existing Stop Ahead sign (W3-1) on southbound Chestnut Grove Road, located north of DE Route 8.
- Install new Stop Ahead sign (W3-1) and an Advance Street Name plaque (W16-8a-DE) for Forrest Avenue on southbound Chestnut Grove Road, approximately 250 feet north of DE Route 8.
- Remove existing Watch Children sign (W21-11-DE) and Advisory Speed 30 MPH sign (W13-1-30) on southbound Nault Road, located immediately south of DE Route 8.
- Remove existing Stop Ahead sign (W3-1) on northbound Nault Road, located south of DE Route 8.
- Install Stop Ahead sign (W3-1) and an Advance Street Name plaque (W16-8a-DE) for Forrest Avenue on northbound Nault Road, approximately 250 feet south of DE Route 8.

X. Reference

i. AASHTO A Policy on Geometric Design of Highways and Streets. American Association of State Highway and Transportation Officials. Washington, D. C. 20001. 2004.

ii. Highway Capacity Manual. Transportation Research Board. Washington, D.C. 20001. 2010.

iii. State of Delaware Manual on Uniform Traffic Control Devices (DE MUTCD). Delaware Department of Transportation. Smyrna, DE 19977. 2011.



PROPOSED SIGNING DIAGRAM			
DE ROUTE 8 (K051, FORREST AVENUE)			
CHESTNUT GROVE ROAD (K158)/NAULT ROAD (K199)			
DELDOT TRAFFIC	DRAWN BY BJS	JULY 2012	FIGURE 4

APPENDIX A
Traffic Data

Existing Traffic Volume Data

HCS2010 Analysis Worksheets

Turning Movement Field Data

Requestor:	B.J. Song
Counter Name / Number:	Heather Mantz/ T-2923
County / City:	Kent County/ Dover
Road Number / Name:	Delaware Route 8-Forrest Avenue (K51) & Nault Road (K199)- Chestnut Grove Road (K158)
Signalized? **Yes** **No**	

Notes: This count was seperated to count in Bank 1 as Truck Traffic and Bank 2 as Bicycle Traffic. Horse and Buggies were counted as vehicles. Motorists were observed passing left turning vehicles in the right turn lane.

Pedestrian Count	
Bicycle Count	
Turning Movement Count	
Vehicle Separation	
Classification Count	
Intersection Delay Study	

Day 1	
Date	
05/02/12	
Wednesday	
Daylight, Clear, Dry	
Time	
7:00 - 9:00	
11:00 - 1:00	
2:00 - 6:00	
Day 2	
Date	
05/03/12	
Thursday	
Daylight, Clear, Dry	
Time	
7:00 - 9:00	
11:00 - 1:00	
2:00 - 6:00	

DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 1

Groups Printed- General Traffic - Truck Traffic - Bicycle Traffic

	Chestnut Grove Road (K158) Southbound					DE8-Forrest Avenue (K51) Westbound					Nault Road (K199) Northbound					DE8-Forrest Avenue (K51) Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	7	2	0	0	9	0	30	0	0	30	8	3	0	0	11	0	62	6	0	68	118
07:15 AM	6	3	0	0	9	0	32	3	0	35	10	8	0	0	18	1	122	22	0	145	207
07:30 AM	11	3	0	0	14	0	52	1	0	53	8	11	1	0	20	4	166	21	0	191	278
07:45 AM	8	4	0	0	12	1	53	3	0	57	8	6	1	0	15	2	133	14	0	149	233
Total	32	12	0	0	44	1	167	7	0	175	34	28	2	0	64	7	483	63	0	553	836
08:00 AM	6	3	0	0	9	0	32	1	0	33	3	9	0	0	12	2	73	22	0	97	151
08:15 AM	6	0	1	0	7	1	39	0	0	40	8	6	3	0	17	0	97	16	0	113	177
08:30 AM	6	2	2	0	10	0	31	1	0	32	2	2	3	0	7	2	103	21	0	126	175
08:45 AM	7	0	1	0	8	0	32	2	0	34	8	3	1	0	12	3	91	13	0	107	161
Total	25	5	4	0	34	1	134	4	0	139	21	20	7	0	48	7	364	72	0	443	664
*** BREAK ***																					
11:00 AM	8	2	2	0	12	0	65	5	0	70	3	2	1	0	6	1	94	12	0	107	195
11:15 AM	12	2	2	0	16	1	60	3	0	64	8	5	2	0	15	2	91	8	0	101	196
11:30 AM	15	5	1	0	21	0	67	4	0	71	4	1	2	0	7	1	84	17	0	102	201
11:45 AM	8	4	2	0	14	2	73	3	0	78	12	4	3	0	19	1	86	10	0	97	208
Total	43	13	7	0	63	3	265	15	0	283	27	12	8	0	47	5	355	47	0	407	800
12:00 PM	7	5	1	0	13	0	60	5	0	65	0	4	0	0	4	2	83	7	0	92	174
12:15 PM	13	3	0	0	16	0	68	8	0	76	3	2	3	0	8	0	77	10	0	87	187
12:30 PM	11	2	1	0	14	1	77	2	0	80	3	6	2	0	11	2	67	10	0	79	184
12:45 PM	9	2	0	0	11	1	69	3	0	73	1	3	2	0	6	0	83	14	0	97	187
Total	40	12	2	0	54	2	274	18	0	294	7	15	7	0	29	4	310	41	0	355	732
*** BREAK ***																					
02:00 PM	13	0	1	0	14	2	75	3	0	80	2	2	0	0	4	1	73	11	0	85	183
02:15 PM	13	4	0	0	17	0	72	5	0	77	4	1	3	0	8	1	69	11	1	82	184
02:30 PM	7	3	1	0	11	1	77	4	0	82	4	7	2	0	13	1	84	8	0	93	199
02:45 PM	22	4	2	0	28	0	75	1	0	76	3	7	4	0	14	4	60	19	0	83	201
Total	55	11	4	0	70	3	299	13	0	315	13	17	9	0	39	7	286	49	1	343	767
03:00 PM	19	2	0	0	21	3	89	3	0	95	6	4	2	0	12	3	71	9	0	83	211
03:15 PM	18	8	0	0	26	0	76	5	0	81	2	2	5	0	9	6	74	11	0	91	207
03:30 PM	15	10	5	0	30	0	93	5	0	98	1	5	2	0	8	1	90	3	0	94	230
03:45 PM	21	6	1	0	28	0	114	11	0	125	4	3	7	0	14	2	77	15	0	94	261
Total	73	26	6	0	105	3	372	24	0	399	13	14	16	0	43	12	312	38	0	362	909
04:00 PM	18	6	0	0	24	0	94	1	0	95	4	6	3	0	13	0	78	13	0	91	223

DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 2

Groups Printed- General Traffic - Truck Traffic - Bicycle Traffic

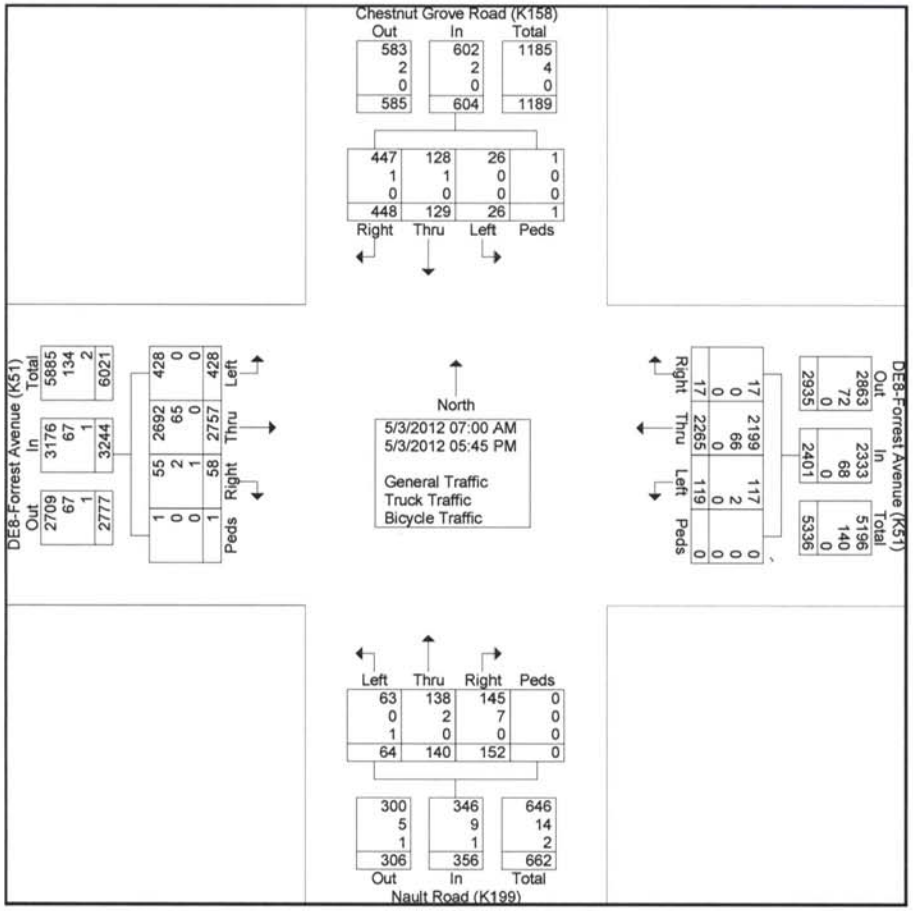
	Chestnut Grove Road (K158) Southbound					DE8-Forrest Avenue (K51) Westbound					Nault Road (K199) Northbound					DE8-Forrest Avenue (K51) Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:15 PM	28	8	0	0	36	0	92	6	0	98	4	3	1	0	8	4	47	9	0	60	202
04:30 PM	31	10	0	0	41	0	82	6	0	88	6	9	3	0	18	3	79	12	0	94	241
04:45 PM	28	8	1	0	37	0	127	9	0	136	2	4	1	0	7	1	84	16	0	101	281
Total	105	32	1	0	138	0	395	22	0	417	16	22	8	0	46	8	288	50	0	346	947
05:00 PM	21	2	1	1	25	2	100	3	0	105	3	5	1	0	9	3	84	18	0	105	244
05:15 PM	18	4	0	0	22	1	92	7	0	100	5	1	1	0	7	2	113	20	0	135	264
05:30 PM	20	3	0	0	23	1	85	3	0	89	7	3	2	0	12	3	79	19	0	101	225
05:45 PM	16	9	1	0	26	0	82	3	0	85	6	3	3	0	12	0	83	11	0	94	217
Total	75	18	2	1	96	4	359	16	0	379	21	12	7	0	40	8	359	68	0	435	950
Grand Total	448	129	26	1	604	17	2265	119	0	2401	152	140	64	0	356	58	2757	428	1	3244	6605
Apprch %	74.2	21.4	4.3	0.2		0.7	94.3	5	0		42.7	39.3	18	0		1.8	85	13.2	0		
Total %	6.8	2	0.4	0	9.1	0.3	34.3	1.8	0	36.4	2.3	2.1	1	0	5.4	0.9	41.7	6.5	0	49.1	
General Traffic	447	128	26	1	602	17	2199	117	0	2333	145	138	63	0	346	55	2692	428	1	3176	6457
% General Traffic	99.8	99.2	100	100	99.7	100	97.1	98.3	0	97.2	95.4	98.6	98.4	0	97.2	94.8	97.6	100	100	97.9	97.8
Truck Traffic	1	1	0	0	2	0	66	2	0	68	7	2	0	0	9	2	65	0	0	67	146
% Truck Traffic	0.2	0.8	0	0	0.3	0	2.9	1.7	0	2.8	4.6	1.4	0	0	2.5	3.4	2.4	0	0	2.1	2.2
Bicycle Traffic	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	2
% Bicycle Traffic	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0.3	1.7	0	0	0	0	0

DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 3



DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 4

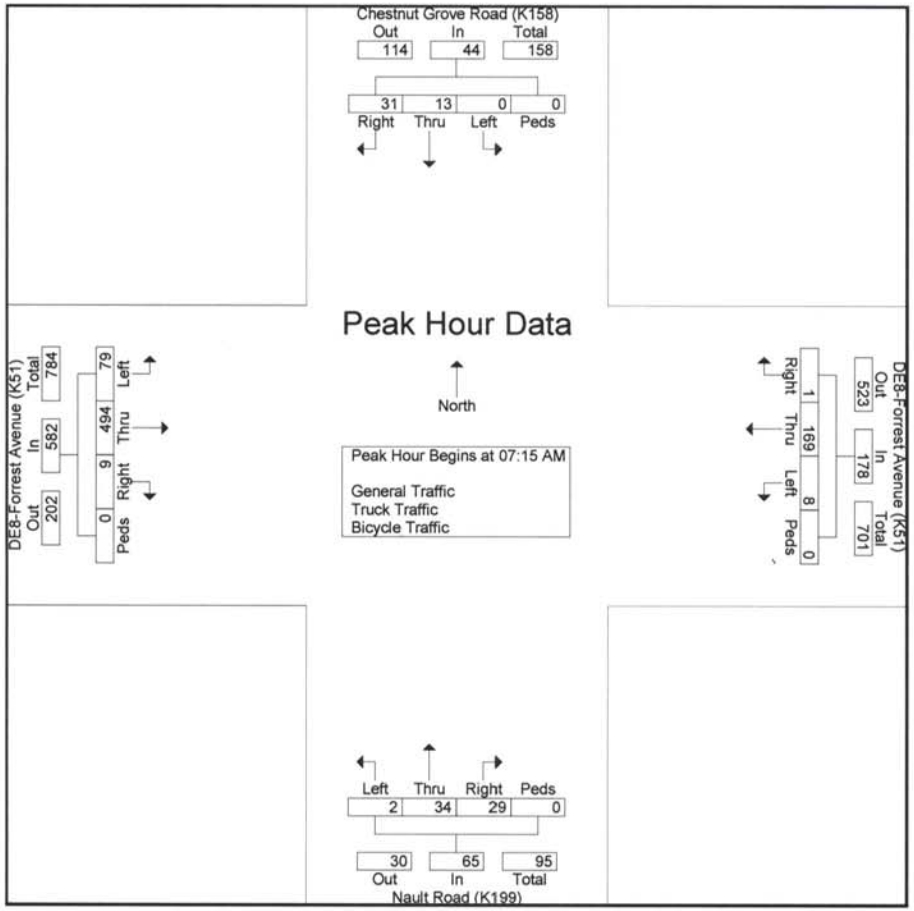
	Chestnut Grove Road (K158) Southbound					DE8-Forrest Avenue (K51) Westbound					Nault Road (K199) Northbound					DE8-Forrest Avenue (K51) Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:15 AM																					
07:15 AM	6	3	0	0	9	0	32	**3**	0	35	**10**	8	0	0	18	1	122	**22**	0	145	207
07:30 AM	**11**	3	0	0	**14**	0	52	1	0	53	8	**11**	**1**	0	**20**	**4**	**166**	21	0	**191**	**278**
07:45 AM	8	**4**	0	0	12	**1**	**53**	3	0	**57**	8	6	1	0	15	2	133	14	0	149	233
08:00 AM	6	3	0	0	9	0	32	1	0	33	3	9	0	0	12	2	73	22	0	97	151
Total Volume	31	13	0	0	44	1	169	8	0	178	29	34	2	0	65	9	494	79	0	582	869
% App. Total	70.5	29.5	0	0		0.6	94.9	4.5	0		44.6	52.3	3.1	0		1.5	84.9	13.6	0		
PHF	.705	.813	.000	.000	.786	.250	.797	.667	.000	.781	.725	.773	.500	.000	.813	.563	.744	.898	.000	.762	.781

DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 5



DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 6

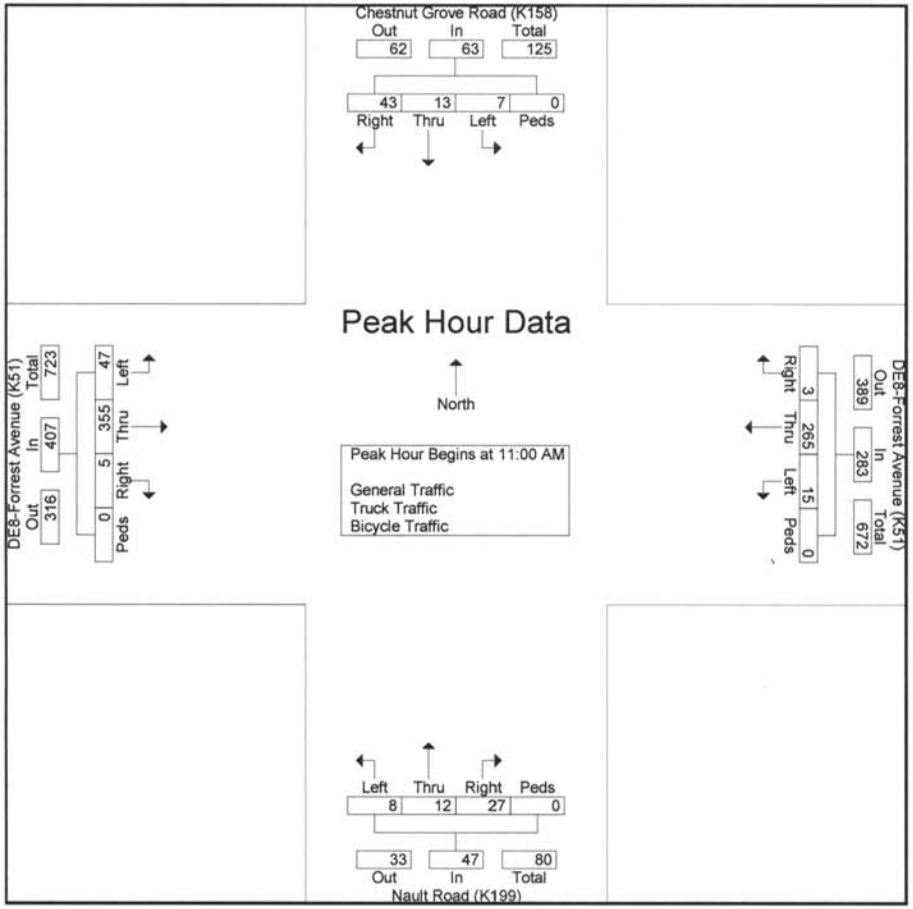
	Chestnut Grove Road (K158) Southbound					DE8-Forrest Avenue (K51) Westbound					Nault Road (K199) Northbound					DE8-Forrest Avenue (K51) Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:00 AM																					
11:00 AM	8	2	**2**	0	12	0	65	**5**	0	70	3	2	1	0	6	1	**94**	12	0	**107**	195
11:15 AM	12	2	2	0	16	1	60	3	0	64	8	**5**	2	0	15	**2**	91	8	0	101	196
11:30 AM	**15**	**5**	1	0	**21**	0	67	4	0	71	4	1	2	0	7	1	84	**17**	0	102	201
11:45 AM	8	4	2	0	14	**2**	**73**	3	0	**78**	**12**	4	**3**	0	**19**	1	86	10	0	97	**208**
Total Volume	43	13	7	0	63	3	265	15	0	283	27	12	8	0	47	5	355	47	0	407	800
% App. Total	68.3	20.6	11.1	0		1.1	93.6	5.3	0		57.4	25.5	17	0		1.2	87.2	11.5	0		
PHF	.717	.650	.875	.000	.750	.375	.908	.750	.000	.907	.563	.600	.667	.000	.618	.625	.944	.691	.000	.951	.962

DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 7



DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 8

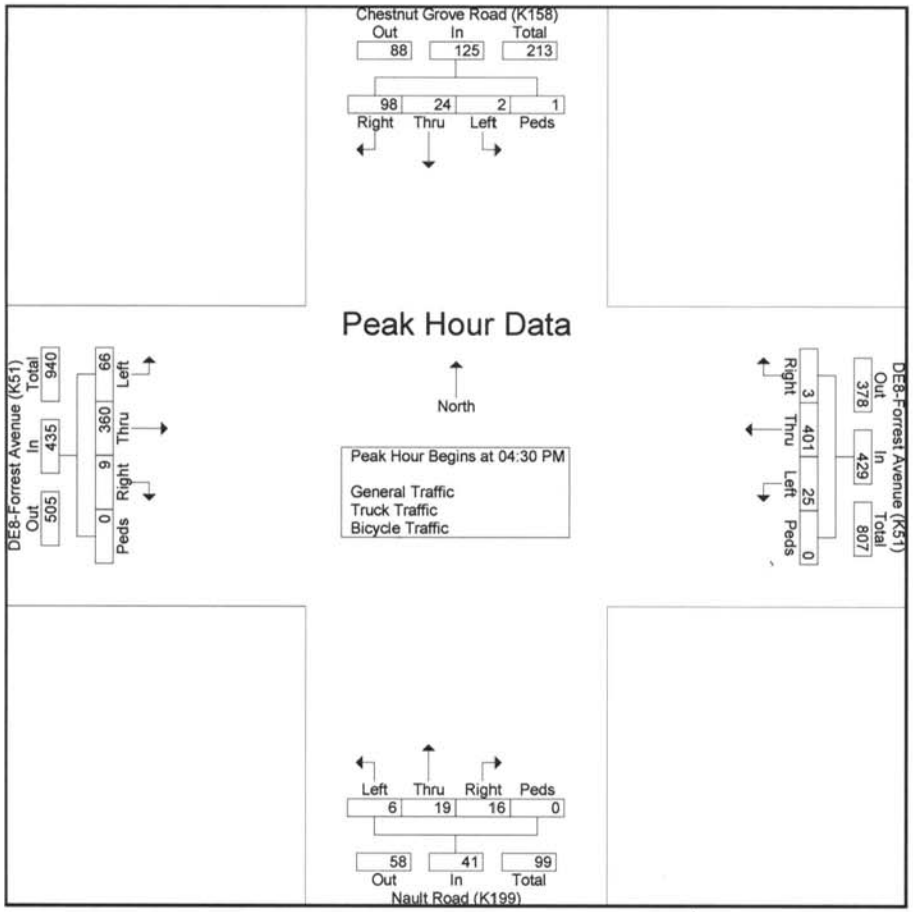
	Chestnut Grove Road (K158) Southbound					DE8-Forrest Avenue (K51) Westbound					Nault Road (K199) Northbound					DE8-Forrest Avenue (K51) Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 02:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:30 PM																					
04:30 PM	**31**	**10**	0	0	**41**	0	82	6	0	88	**6**	**9**	**3**	0	**18**	**3**	79	12	0	94	241
04:45 PM	28	8	**1**	0	37	0	**127**	**9**	0	**136**	2	4	1	0	7	1	84	16	0	101	**281**
05:00 PM	21	2	1	**1**	25	**2**	100	3	0	105	3	5	1	0	9	3	84	18	0	105	244
05:15 PM	18	4	0	0	22	1	92	7	0	100	5	1	1	0	7	2	**113**	**20**	0	**135**	264
Total Volume	98	24	2	1	125	3	401	25	0	429	16	19	6	0	41	9	360	66	0	435	1030
% App. Total	78.4	19.2	1.6	0.8		0.7	93.5	5.8	0		39	46.3	14.6	0		2.1	82.8	15.2	0		
PHF	.790	.600	.500	.250	.762	.375	.789	.694	.000	.789	.667	.528	.500	.000	.569	.750	.796	.825	.000	.806	.916

DelDOT- Traffic Management Center

169 Brick Store Landing Road
Smyrna, DE 19977
Telephone: 302-659-4066

Counter No.: T-2923
Counted By: Heather Mantz
Weather: Daylight/Clear/Dry
Day of Week: Wednesday

File Name : ForrestAve-NaultRd-Chestnut
Site Code : 00000000
Start Date : 5/3/2012
Page No : 9



TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*BJS*	Intersection	*DE 8 @ K158 / K199*
Agency/Co.	*DelDOT Traffic*	Jurisdiction	*Kent County*
Date Performed	*6/26/2012*	Analysis Year	*2012*
Analysis Time Period	*AM Peak(7:15AM-8:15AM)*		

Project Description *DE Route 8 @ K158/K199 - Signal Warrant Study*

East/West Street: *DE Route 8* | North/South Street: *Chestnut Grove / Nault Road*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)	*79*	*494*	*9*	*9*	*169*	*1*
Peak-Hour Factor, PHF	*0.90*	*0.74*	*0.56*	*0.67*	*0.80*	*0.25*
Hourly Flow Rate, HFR (veh/h)	*87*	*663*	*15*	*13*	*212*	*4*
Percent Heavy Vehicles	*0*	--	--	*2*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*0*	*1*	*1*
Configuration	*LT*		*R*	*LT*		*R*
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*2*	*34*	*29*	*0*	*13*	*31*
Peak-Hour Factor, PHF	*0.50*	*0.77*	*0.73*	*1.00*	*0.81*	*0.70*
Hourly Flow Rate, HFR (veh/h)	*4*	*43*	*39*	*0*	*15*	*44*
Percent Heavy Vehicles	*2*	*1*	*5*	*0*	*1*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*0*	*0*	*1*	*0*
Configuration		*LTR*			*LTR*	

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LT*	*LT*		*LTR*			*LTR*	
v (veh/h)	*87*	*13*		*86*			*59*	
C (m) (veh/h)	*1366*	*914*		*257*			*448*	
v/c	*0.06*	*0.01*		*0.33*			*0.13*	
95% queue length	*0.20*	*0.04*		*1.42*			*0.45*	
Control Delay (s/veh)	*7.8*	*9.0*		*25.9*			*14.3*	
LOS	*A*	*A*		*D*			*B*	
Approach Delay (s/veh)	--	--	*25.9*			*14.3*		
Approach LOS	--	--	*D*			*B*		

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 6/26/2012 3:04 PM

TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	*BJS*
Agency/Co.	*DelDOT Traffic*
Date Performed	*6/26/2012*
Analysis Time Period	*MD Peak(11:00AM-12:00PM)*

Site Information

Intersection	*DE 8 @ K158 / K199*
Jurisdiction	*Kent County*
Analysis Year	*2012*

Project Description *DE Route 8 @ K158/K199 - Signal Warrant Study*

East/West Street: *DE Route 8* | North/South Street: *Chestnut Grove / Nault Road*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)	*47*	*355*	*5*	*15*	*265*	*3*
Peak-Hour Factor, PHF	*0.69*	*0.94*	*0.63*	*0.75*	*0.91*	*0.38*
Hourly Flow Rate, HFR (veh/h)	*68*	*376*	*8*	*20*	*291*	*8*
Percent Heavy Vehicles	*0*	--	--	*2*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*0*	*1*	*1*
Configuration	*LT*		*R*	*LT*		*R*
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*8*	*12*	*27*	*7*	*13*	*43*
Peak-Hour Factor, PHF	*0.67*	*0.60*	*0.56*	*0.88*	*0.65*	*0.72*
Hourly Flow Rate, HFR (veh/h)	*11*	*19*	*47*	*8*	*20*	*59*
Percent Heavy Vehicles	*2*	*1*	*5*	*0*	*1*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*0*	*0*	*1*	*0*
Configuration		*LTR*			*LTR*	

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LT*	*LT*		*LTR*			*LTR*	
v (veh/h)	*68*	*20*		*77*			*87*	
C (m) (veh/h)	*1274*	*1174*		*401*			*463*	
v/c	*0.05*	*0.02*		*0.19*			*0.19*	
95% queue length	*0.17*	*0.05*		*0.70*			*0.68*	
Control Delay (s/veh)	*8.0*	*8.1*		*16.1*			*14.6*	
LOS	*A*	*A*		*C*			*B*	
Approach Delay (s/veh)	--	--	*16.1*			*14.6*		
Approach LOS	--	--	*C*			*B*		

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 6/26/2012 3:17 PM

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	*BJS*	Intersection	*DE 8 @ K158 / K199*
Agency/Co.	*DelDOT Traffic*	Jurisdiction	*Kent County*
Date Performed	*6/26/2012*	Analysis Year	*2012*
Analysis Time Period	*PM Peak(4:30PM-5:30PM)*		

Project Description *DE Route 8 @ K158/K199 - Signal Warrant Study*

East/West Street: *DE Route 8* | North/South Street: *Chestnut Grove / Nault Road*

Intersection Orientation: *East-West* | Study Period (hrs): *0.25*

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume (veh/h)	*66*	*360*	*9*	*25*	*401*	*3*
Peak-Hour Factor, PHF	*0.83*	*0.80*	*0.75*	*0.69*	*0.79*	*0.38*
Hourly Flow Rate, HFR (veh/h)	*79*	*451*	*12*	*36*	*508*	*8*
Percent Heavy Vehicles	*0*	--	--	*2*	--	--
Median Type	*Undivided*					
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*1*	*0*	*1*	*1*
Configuration	*LT*		*R*	*LT*		*R*
Upstream Signal		*0*			*0*	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume (veh/h)	*6*	*19*	*16*	*2*	*24*	*98*
Peak-Hour Factor, PHF	*0.50*	*0.53*	*0.67*	*0.50*	*0.60*	*0.79*
Hourly Flow Rate, HFR (veh/h)	*12*	*35*	*23*	*4*	*39*	*124*
Percent Heavy Vehicles	*2*	*1*	*5*	*0*	*1*	*0*
Percent Grade (%)		*0*			*0*	
Flared Approach		*N*			*N*	
Storage		*0*			*0*	
RT Channelized			*0*			*0*
Lanes	*0*	*1*	*0*	*0*	*1*	*0*
Configuration		*LTR*			*LTR*	

Delay, Queue Length, and Level of Service

Approach	Eastbound	Westbound	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LT*	*LT*		*LTR*			*LTR*	
v (veh/h)	*79*	*36*		*70*			*167*	
C (m) (veh/h)	*1060*	*1098*		*174*			*335*	
v/c	*0.07*	*0.03*		*0.40*			*0.50*	
95% queue length	*0.24*	*0.10*		*1.78*			*2.65*	
Control Delay (s/veh)	*8.7*	*8.4*		*39.0*			*26.0*	
LOS	*A*	*A*		*E*			*D*	
Approach Delay (s/veh)	--	--	*39.0*			*26.0*		
Approach LOS	--	--	*E*			*D*		

Copyright © 2010 University of Florida, All Rights Reserved *HCS+*™ Version 5.6 Generated: 6/26/2012 3:20 PM

APPENDIX B

Radar Data

RADAR COLLECTION DATA

REQUESTED BY:	**B.J. Song**	SHEET NO.:	**One of Two**
COUNTY:	**Kent County**	DATE:	**5/2/2012**
ROAD NO.:	**K51**	BY:	**Heather Mantz**
ROAD NAME:	**Forrest Avenue**		

SPEED	EASTBOUND		WESTBOUND		TOTAL	SECONDS
65	I	1	I	1	2	0.93
64	I	1	I	1	2	
63			I	1	1	
62			II	2	2	
61			I	1	1	
60	II	2	II	2	4	1.0
59	III	3	I	1	4	
58	IIIII II	7	IIII	4	11	
57	IIII	4	IIII	4	8	
56	IIIII	5	IIII	4	9	
55	IIIII II	7	IIIII	5	12	
54	IIIII IIIII IIIII I	16	IIIII IIIII	10	26	1.1
53	IIIII II	7	IIIII IIIII II	12	19	
52	IIIII	5	IIIII IIII	9	14	
51	IIIII IIIII II	12	IIIII III	8	20	
50	IIIII IIIII IIIII	15	IIIII IIIII	10	25	1.2
49	IIIII	5	IIIII I	6	11	
48	IIII	4	IIIII	5	9	
47	I	1	IIII	4	5	
46	III	3	II	2	5	1.3
45	II	2	I	1	3	
44			II	2	2	
43			II	2	2	1.4
42			III	3	3	
41					0	
40					0	1.5
39					0	
38					0	
37					0	1.6
36					0	
35					0	1.7
34					0	
33					0	1.8
32					0	
31					0	1.9
30					0	2.0
29					0	2.1
28					0	
27					0	2.2
26					0	2.3
25					0	2.4
24					0	2.5
23					0	2.6
22					0	
21					0	2.8
20					0	3.0
TOTALS:		**100**		**100**	**200**	

POSTED SPEED: **50** MPH

WEATHER: **Daylight/Cloudy/Dry**

OBSERVATION POINT: On Forrest Avenue approximately 800' east of Nault Road (K199)

PERCENTILE SPEEDS:

	50%	85%	TIME:
EASTBOUND	53 MPH	57 MPH	**1:15 pm - 1:55 pm**
WESTBOUND	52 MPH	57 MPH	**1:15 pm - 1:55 pm**
COMBINED	53 MPH	57 MPH	**1:15 pm - 1:55 pm**

Field Notes:

RADAR COLLECTION DATA

REQUESTED BY:	**B.J. Song**	SHEET NO.:	**Two of Two**
COUNTY:	**Kent County**	DATE:	**5/2/2012**
ROAD NO.:	**K51**	BY:	**Heather Mantz**
ROAD NAME:	**Forrest Avenue**		

SPEED	EASTBOUND		WESTBOUND		TOTAL	SECONDS
65			I	1	1	0.93
64					0	
63			I	1	1	
62					0	
61	I	1	I	1	2	
60	II	2	I	1	3	1.0
59			II	2	2	
58	II	2	IIII	4	6	
57	IIIII	5	IIIII I	6	11	
56	IIII	4	III	3	7	
55	III	3	IIII	4	7	
54	IIIII II	7	IIIII II	7	14	1.1
53	IIIII III	8	IIIII I	6	14	
52	IIIII II	7	IIIII IIII	9	16	
51	IIIII IIIII I	11	IIIII II	7	18	
50	IIIII I	6	IIIII IIIII III	13	19	1.2
49	IIIII IIIII III	13	IIIII III	8	21	
48	IIIII IIII	9	IIIII	5	14	
47	IIII	4	IIII	4	8	
46	IIIII III	8	IIIII I	6	14	1.3
45	IIII	4	IIII	4	8	
44			IIIII I	6	6	
43	III	3	I	1	4	1.4
42	I	1	I	1	2	
41					0	
40	I	1			1	1.5
39					0	
38					0	
37	I	1			1	1.6
36					0	
35					0	1.7
34					0	
33					0	1.8
32					0	
31					0	1.9
30					0	2.0
29					0	2.1
28					0	
27					0	2.2
26					0	2.3
25					0	2.4
24					0	2.5
23					0	2.6
22					0	
21					0	2.8
20					0	3.0
TOTALS:		**100**		**100**	**200**	

POSTED SPEED: **50** MPH

WEATHER: **Daylight/Cloudy/Dry**

OBSERVATION POINT: On Forrest Avenue approximately 1200' west of Nault Road (K199)

PERCENTILE SPEEDS:

	50%	85%	TIME:
EASTBOUND	51 MPH	55 MPH	**1:55 pm - 2:30 pm**
WESTBOUND	51 MPH	57 MPH	**1:55 pm - 2:30 pm**
COMBINED	51 MPH	56 MPH	**1:55 pm - 2:30 pm**

Field Notes:

APPENDIX C

Crash Data

Delaware Crash Analysis Reporting System (CARS)

Crash Study Time Period: *Study Period from 04-27-2009 to 04-27-2012*
Query Type: *singlePoint*
Description: *reports - DE Rt 8 @ Chestnut Grove Road/Nault Road*

Study Requested By:
Study Generated By: TDTSDLR
Number of Crashes: 17
Includes Non-Reportable Crashes: N
Study Code:

Disclaimer for CARS: Crash data and associated police reports are intended for DelDOT use only and shall not be transmitted, copied, distributed or provided to any entity other than DelDOT unless written approval is received from the DelDOT Legal Section. Police reports are the property of the Delaware State Police.

DE Route 8 (K051, Forrest Avenue) @
Chestnut Grove Road (K158) / Nault Road (K199)

Crash History Table
(April 2009 - April 2012)

12/11/2012
DelDOT Traffic

	Date	Time	Weather	Lighting	Surface	Manner of Impact	Severity	Milepoint	Contributing Circumstances	Orientation	Location
1	6/24/2009	4:19 PM	Clear	Daylight	Dry	Siedswipe-opposite	Injury	2.08	Vehicle crossed centerline	WB/EB	At intersection
2	5/21/2009	1:50 PM	Clear	Daylight	Dry	Rear-end	PDO	2.08	Innatentive driving	EBLT/EB	At intersection
3	12/7/2009	2:40 PM	Clear	Daylight	Dry	Rear-end	Injury	2.08	Innatentive driving	EBLT/EB	At intersection
4	8/30/2009	5:49 PM	Clear	Daylight	Dry	Rear-end	PDO	2.08	Innatentive driving	EBLT/EB	At intersection
5	9/19/2009	4:04 PM	Clear	Daylight	Dry	Rear-end	PDO	2.08	Following too closely	EB/EB	At intersection
6	5/22/2010	9:50 PM	Rain	Dark-unlit	Wet	ROR/HFO	PDO	0.01	Unknown / Hit-and-run	SB	Chestnut Grove Road
7	8/16/2010	1:12 PM	Clear	Daylight	Dry	Angle	Injury	0.00	Failure to remain stopped at a STOP sign	EB/SB	At intersection
8	6/6/2010	2:15 PM	Clear	Daylight	Dry	Angle	Injury	2.08	Failure to remain stopped at a STOP sign	EB/SB	At intersection
9	4/11/2011	12:00 AM	Cloudy	Daylight	Dry	Angle	PDO	2.01	Failure to remain stopped at a STOP sign	NB/EB	Nault Road at Sapp Drive
10	8/16/2011	4:43 PM	Clear	Daylight	Dry	Angle	PDO	2.08	Failure to remain stopped at a STOP sign	EB/NBRT	At intersection
11	11/29/2011	8:45 AM	Rain	Daylight	Wet	Left-turn	Injury	0.00	Failure to yield right of way	WB/EBLT	At intersection
12	5/9/2011	6:49 AM	Clear	Daylight	Dry	Angle	PDO	2.08	Failure to remain stopped at a STOP sign	EB/NBRT	At intersection
13	11/11/2011	5:37 PM	Clear	Dark-unlit	Dry	Left-turn	PDO	0.00	Failure to yield right of way	WB/EBLT	At intersection
14	1/25/2011	12:22 PM	Clear	Daylight	Dry	Angle	PDO	1.86	Failure to remain stopped at a STOP sign	EB/NB	At intersection
15	1/26/2012	6:33 AM	Rain	Dark-unlit	Wet	Sideswipe-same	PDO	0.00	Unsafe lane change	EB/EB	At intersection
16	3/30/2012	8:59 PM	Clear	Dark-unlit	Dry	Hit deer	PDO	1.91	Animal in roadway	EB	165' W/O Nault Road
17	2/18/2012	5:40 PM	Clear	Dark-unlit	Dry	Rear-end	PDO	0.00	Innatentive driving	EBLT/EB	At intersection

ROR: Run-off the Road

PDO: Property Damage Only

APPENDIX D

Traffic Signal Warrant Worksheets

DELAWARE DEPARTMENT OF TRANSPORTATION

TRAFFIC ENGINEERING AND MANAGEMENT

SUPPLEMENTAL TRAFFIC SIGNAL EVALUATION FORM

This form is based on the Traffic Signal Warrants from the 2003 Edition of the Manual on Uniform Traffic Control Devices published by the Federal Highway Administration

Location:	DE Roue 8 @ Chestnut Grove Road / Nault Road	**Date:**	June 4, 2012
County:	Kent	**Analyst:**	BJS

FORM NAVIGATION

Click on the links below to navigate to a particular location in this form

Intersection Characteristics
Volume Input
Warrant 1 *Eight-Hour Vehicular Volume*
Warrant 2 *Four-Hour Vehicular Volume*
Warrant 3 *Peak Hour*
Warrant 4 *Pedestrian Volume*
Warrant 5 *School Crossing*
Warrant 6 *Coordinated Signal System*
Warrant 7 *Crash Experience*
Warrant 8 *Roadway Network*

INTERSECTION CHARACTERISTICS

Major Road Name:	DE Route 8	**Orientation:**	East/West
Minor Road Name:	Chestnut Grove Road / Nault Road	**Orientation:**	North/South

Choose the number of travel lanes on the MAJOR road and MINOR road, respectively.

Major Street Approach	Minor Street Approach
1 Lane	1 Lane

Does the 85th percentile speed of major street traffic or the speed limit exceed 40 MPH?
Please enter the major street 85th-percentile speed or roadway speed limit in the box at right. 50 MPH — YES

Does the intersection lie within the built up area of an isolated community, having a population of less than 10,000? No

INPUT HOURLY AND PEDESTRIAN VOLUMES

Hours	Major Street Volumes: DE Route 8			Peds Crossing Major Street	Minor Street Volumes: Chestnut Grove Road / Nault Road		
	Eastbound	Westbound	Approach Total		Northbound	Southbound	Maximum Volume
7 - 8 AM	553	175	***728***	0	69	44	***69***
8 - 9 AM	443	139	***582***	0	48	34	***48***
9 - 10 AM	383	185	***568***	0	41	41	***41***
10 - 11 AM	352	214	***566***	0	35	33	***35***
11 AM - 12 PM	407	283	***690***	0	47	63	***63***
12 - 1 PM	355	294	***649***	0	29	54	***54***
1 - 2 PM	370	258	***628***	0	38	54	***54***
2 - 3 PM	343	315	***658***	1	39	70	***70***
3 - 4 PM	362	399	***761***	0	43	105	***105***
4 - 5 PM	346	417	***763***	0	46	138	***138***
5 - 6 PM	435	379	***814***	0	40	96	***96***
6 - 7 PM	297	289	***586***	0	27	55	***55***

WARRANT 1 - EIGHT HOUR VEHICULAR VOLUME

The need for a traffic control signal shall be considered if an engineering study finds that Condition A or Condition B is met for each of any 8 hours of an average day.

Condition A
A minimum of **350** vehicles per hour required on the major road and a minimum of **105** vehicles per hour required on the higher volume minor road approach.
A total of **2** hours meet Condition A.

WARRANT 1 IS NOT SATISFIED BY CONDITION A - PROCEED TO CONDITION B

Condition B
A minimum of **525** vehicles per hour required on the major road and a minimum of **53** vehicles per hour required on the higher volume minor road approach.
A total of **9** hours meet Condition B.

WARRANT IS SATISFIED BY CONDITION B

The combination of Conditions A and B is intended for application at locations where Condition A and Condition B are not satisified.
The combination of Conditions A and B should be applied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.
The need for a traffic control signal shall be considered if an engineering study finds that both of the following conditions are met for each of any 8 hours of an average day.

Question 1a: Have other alternatives that could cause less delay and inconvenience to traffic been tried at this location? **No**
Question 1b: If the answer to question 1a is yes, have those alternatives failed to correct the traffic problems?

Condition A
A minimum of **280** vehicles per hour required on the major road and a minimum of **84** vehicles per hour required on the higher volume minor road approach.
A total of **N/A** hours meet Condition A.

Condition B
A minimum of **420** vehicles per hour required on the major road and a minimum of **42** vehicles per hour required on the higher volume minor road approach.
A total of **N/A** hours meet Condition B.

A total of **N/A** hours meet the Combination of Condition A and Condition B.

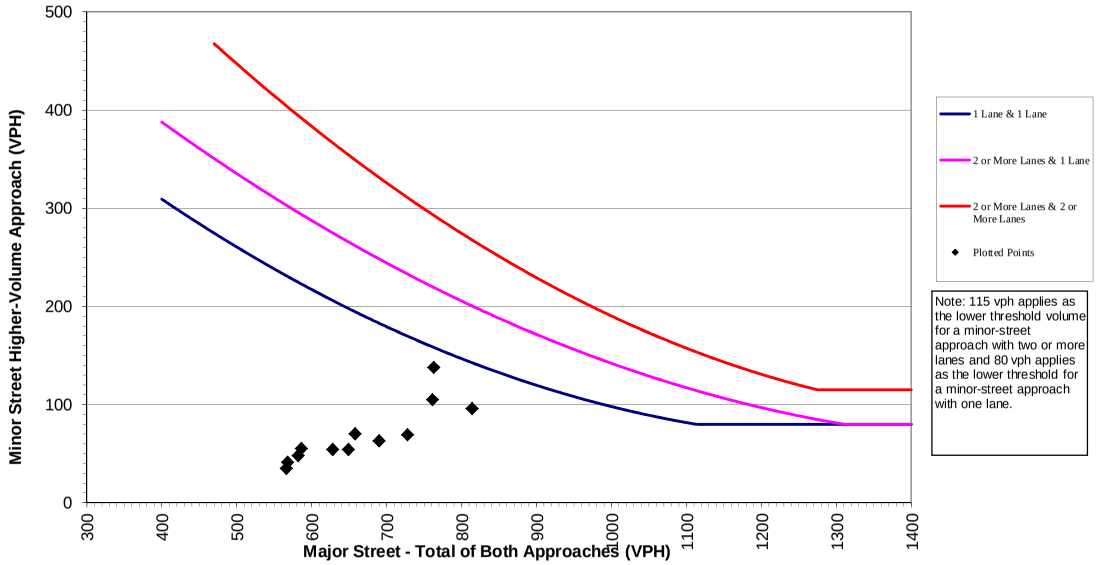
THE COMBINATION OF CONDITIONS A & B IS NOT APPLICABLE TO THIS LOCATION

WARRANT 2 - FOUR HOUR VEHICULAR VOLUME

The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied whre the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major-street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in the figures below for the existing combination of approach lanes.

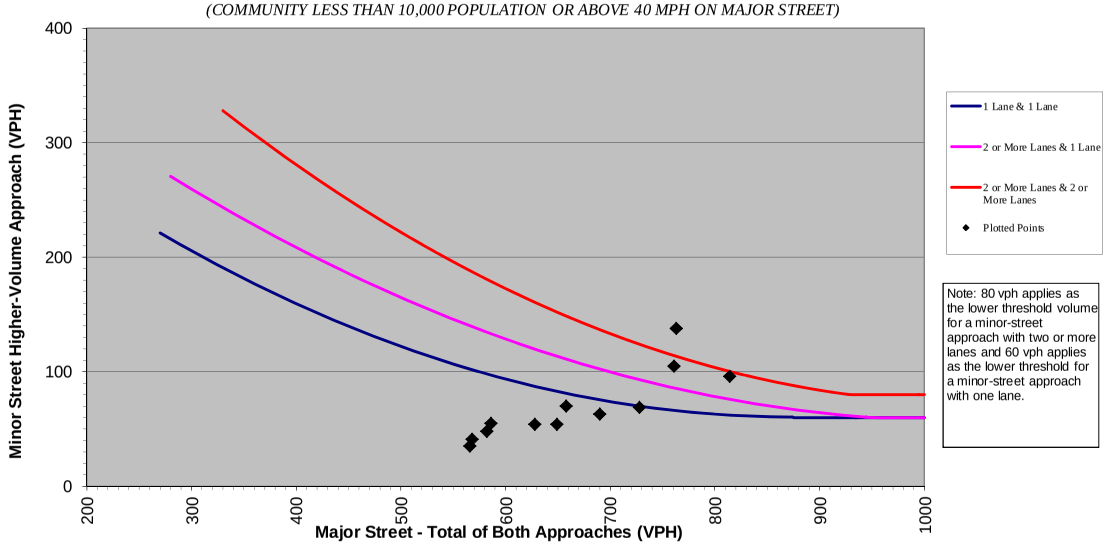
Figure 4C-1 - Warrant 2, Four-Hour Vehicular Volume



Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold for a minor-street approach with one lane.

Figure 4C-2 - Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold for a minor-street approach with one lane.

Enter the number of points that lie above the applicable curve in either Figure 4C-1 or Figure 4C-2 | **4**

WARRANT 2 IS SATISFIED - PROCEED TO WARRANT 3

WARRANT 3 - PEAK HOUR

The Peak Hour signal warrant ins intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

This signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

Is this location an "unusual case" such as an office complex, manufacturing plant, industrial complex or high-occupancy vehicle facility that attracts or discharges large numbers of vehicles over a short time?	NO

Warrant 3 is not applicable to this intersection - Proceed to Warrant 4

The need for a traffic control signal shall be considered if an engineering study finds that the criteria in either of the following two categories are met:

Category A:	If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:	
Question 1:	Does the total stopped time delay experienced by the traffic on one minor-street approach (one direction only) that is controlled by a STOP sign equal or exceed: 4 vehicle-hours for a one-lane approach; or 5 vehicle-hours for a two-lane approach?	

NOTE: Delay must be determined from the completion of a STOP sign delay study performed in the field. Delay values from typical capacity analyses are not acceptable.

Question 2:	Does the volume on the same minor-street approach (one direction only) equal or exceed 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes?	
Question 3:	Does the total entering volume serviced during the hour equal or exceed 650 vehicles per hour for an intersection with three approaches or 800 vehicles per hour for intersections with four or more approaches?	
Category B:	Does the plotted point representing the vehicles per hour on the major-street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day fall above the applicable curve in Figure 4C-3 or Figure 4C-4, below, for the existing combination of approach lanes?	YES

Figure 4C-3 - Warrant 3, Peak Hour

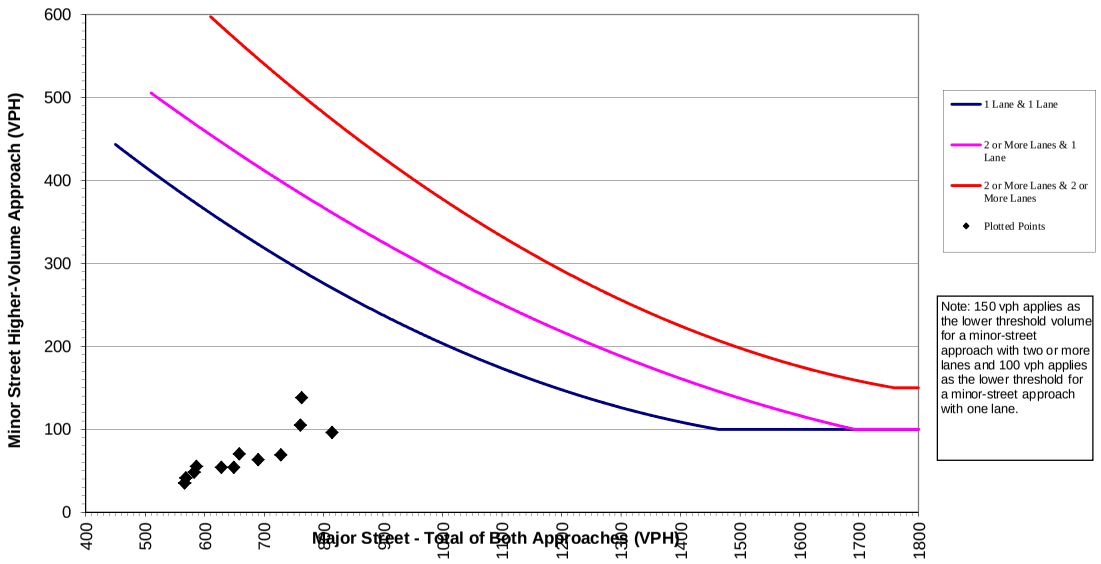
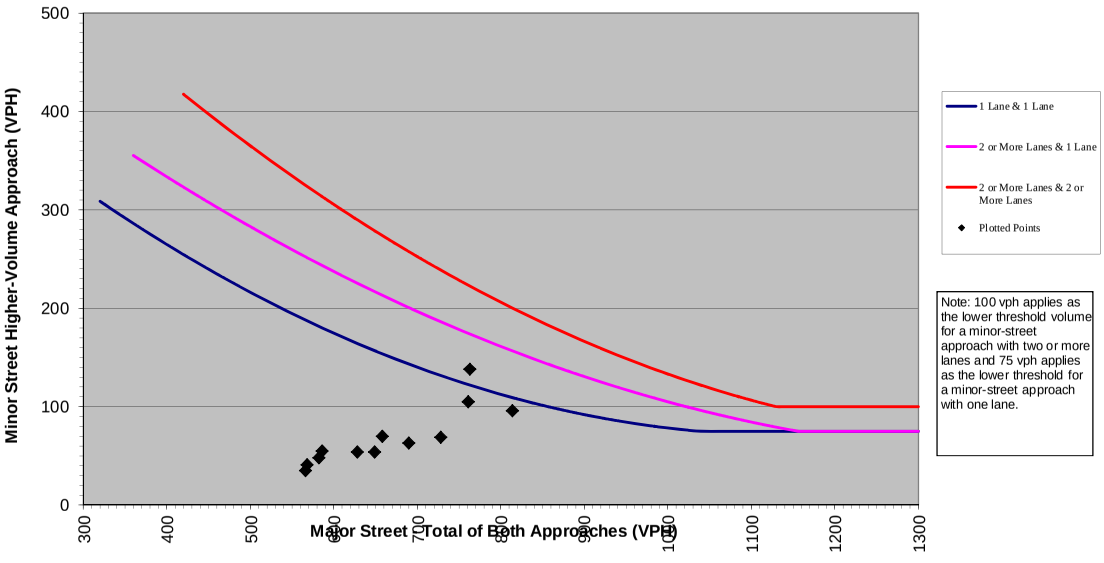


Figure 4C-4 - Warrant 3, Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



Enter the number of points that lie above the applicable curve in either Figure 4C-3 or Figure 4C-4	1

WARRANT 3 IS NOT APPLICABLE TO THIS INTERSECTION - PROCEED TO WARRANT 4

WARRANT 4 - PEDESTRIAN VOLUME

The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

The Pedestrian Volume signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 300 ft (90 m), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

Question 1a:	What is the distance to the nearest traffic control signal along the major street?	10000
Question 1b:	If the proposed signal is less than 300 feet from the nearest existing signal on the major street, will the proposed signal restrict the progressive movement of traffic?	NO

Proceed to next step

The need for a traffic control signal at an intersection or midblock crossing shall be considered if an engineering study finds that both of the following criteria are met:

Criteria A:	Does the pedestrian volume crossing the major street at an intersection or midblock location during an average day equal 100 or more for each of any 4 hours or 190 or more during any 1 hour?	NO
Criteria B:	Are there fewer than 60 gaps per hour in the traffic stream of adequate length to allow pedestrians to cross during the same period when the pedestrian volume criterion is satisfied? *Where there is a divided street having a median of sufficient width for pedestrians to wait, the requirement applies separately to each direction of vehicular traffic*.	gaps/hour

NOTE: Gaps in vehicular traffic must be determined by performing a gap study in the field.

WARRANT 4 IS NOT SATISFIED - PROCEED TO WARRANT 5

WARRANT 5 - SCHOOL CROSSING

The School Crossing signal warrant is intended for applications where the fact that school children cross the major street is the principal reason to consider installing a traffic control signal.

Question 1:	Is the study intersection within an established school zone?	NO

Warrant 5 is not applicable to this location - Proceed to Warrant 6

The School Crossing signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 300 ft (90 m), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

Question 2a:	What is the distance to the nearest traffic control signal along the major street?	
Question 2b:	If the proposed signal is less than 300 feet from the nearest existing signal on the major street, will the proposed signal restrict the progressive movement of traffic?	

The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the children are using the crossing is less than the number of minutes in the same period (see Section 7A.03 of the MUTCD) and there are a minimum of 20 students during the highest crossing hour.

Question 3a:	What is the number of adequate gaps in the traffic stream during the period when the children are using the crossing?	
Question 3b:	What is the number of minutes during the same period when the children are using the crossing?	
Question 3c:	What is the number of students during the highest crossing hour?	

WARRANT 5 IS NOT APPLICABLE TO THIS LOCATION - PROCEED TO WARRANT 6

WARRANT 6 - COORDINATED SIGNAL SYSTEM

Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections where they would not otherwise be needed in order to maintain proper platooning of vehicles.

Question 1:	Is this unsignalized intersection within a corrdior of signals that operate on a coordinated signal system?	NO

Proceed to Warrant 7

Question 2:	If a signal was installed at this intersection, would the resultant spacing of traffic control signals be less than 1000 feet apart?	

The need for a traffic control signal shall be considered if an engineering study finds that one of the following criteria is met:

Criteria A:	On a one-way street or a street that has traffic predominantly in one direction, are the adjacent traffic control signals so far apart that they do not provide the necessary degree of vehicular platooning?	
Criteria B:	On a two-way street, do the adjacent traffic control signals provide the necessary degree of platooning?	
Question 3:	Will the proposed and adjacent traffic control signals collectively provide a progressive operation?	

WARRANT 6 IS NOT APPLICABLE TO THIS INTERSECTION - PROCEED TO WARRANT 7

WARRANT 7 - CRASH EXPERIENCE

The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:

Criteria A:	Has an adequate trial of alternatives with satisfactory observance and enforcement failed to reduce the crash frequency?	No
	If answer to Criteria A is YES, please list the failed alternatives below:	
Criteria B:	Has five (5) or more crashes, of types susceptible to correction by a traffic control signal, occurred within a 12-month period? Each crash must involve personal injury or property damage exceeding the applicable requirements for a reportable crash.	YES
	Number of crashes of types susceptible to correction by a traffic control signal occurring within a 12-month period.	5
Criteria C:	Are 80% of the requirements of Warrant 1 or Warrant 4 met?	YES

WARRANT 7 IS NOT SATISFIED - PROCEED TO WARRANT 8

WARRANT 8 - ROADWAY NETWORK

Installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network.

Question 1:	**In order for this warrant to be applicable to the study intersection, the study intersection must be the junction of two (2) or more major routes. A major route as used in this signal warrant shall have one or more of the following characteristics:**	
Criteria A:	Is each route part of the street or highway system tat serves as the principal roadway network for through traffic flow?	No
Criteria B:	Does each route include rural or suburban highways outside, entering or traversing a City?	
Criteria C:	Does each route appear as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study?	No

The study intersection is not the junction of two or more major routes - Warrant 8 is not applicable to this intersection, Proceed to the end of the worksheet

The need for a traffic control signal shall be considered if an engineering study finds that the common intersection of two or more major routes meets one or both of the following criteria:

Criteria A:	Does the intersection have a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and have a 5-year preojcted traffic volume, based on an engineering study, that meets one or more of Warrants 1, 2, and 3 during an average weekday?	No
Criteria B:	Does the intersection have a total existing, or immediately projected entering volume of at least 1,000 vehicles per hour for each of any 5 hours of a nonnormal business day (Saturday or Sunday)?	No

WARRANT 8 IS NOT APPLICABLE

APPENDIX E

Site Photographs

1) DE Route 8 looking West toward Chestnut Grove Road / Nault Road

2) DE Route 8 looking East toward Chestnut Grove Road / Nault Road

3) Chestnut Grove Road Looking South Toward DE Route 8

4) Nault Road Looking North Toward DE Route 8

5) Southbound Chestnut Grove Road Looking Left (East)

6) Southbound Chestnut Grove Road Looking Right (West)

7) Northbound Nault Road Looking Left (West)

8) Northbound Nault Road Looking Right (East)