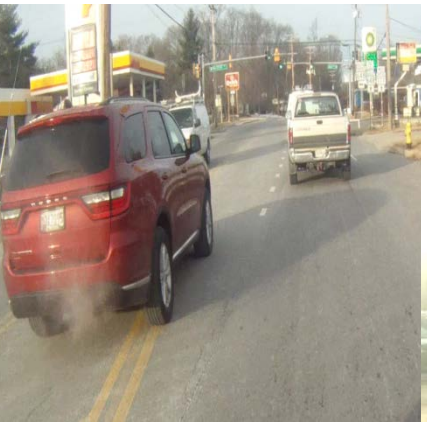
Arterial Congestion Management Studies

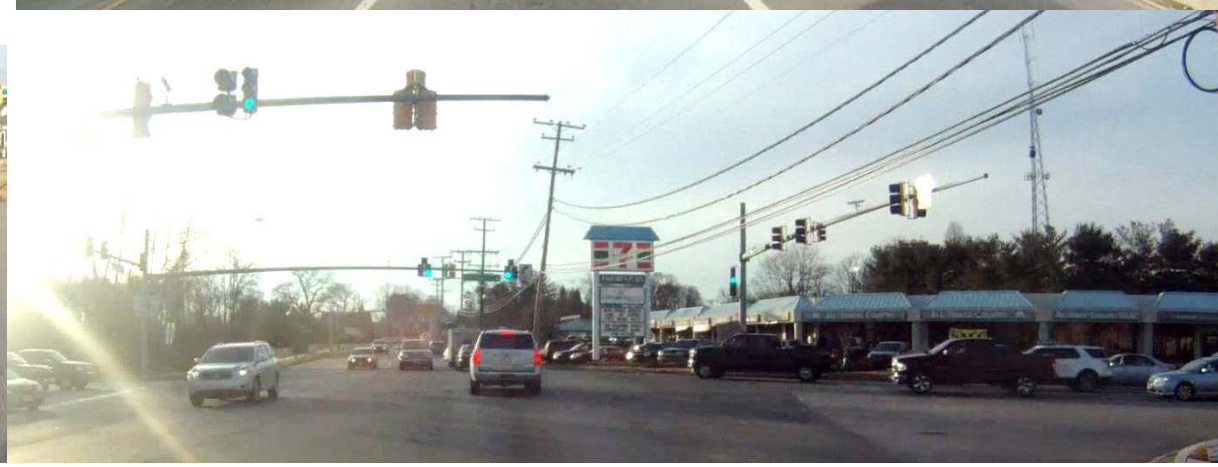
MD 177 Corridor

From Magothy Beach Road to MD 2
(SHA District 5)

Final Report

July 2015





Data Services Engineering Division
Travel Forecasting and Analysis
Office of Planning and Preliminary Engineering

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EXECUTIVE SUMMARY

The Arterial Congestion Management Baseline Report summarized major operational and safety findings, as well as proposed improvements to be considered for the next phase of the MD 177 study corridor (between Magothy Beach Road and MD 2). The approximately 4.5-mile corridor is primarily a two to four-lane undivided/divided section with posted speed limits of 35-40 MPH. Key congested intersections and bottleneck locations along the corridor were identified through field-measured travel times and speeds, evaluation of crash data, and intersection capacity and queuing analysis. Improvement concepts at these locations were suggested based on study findings and discussions with District 5.

Operational findings indicate the westbound direction of travel is approximately 2 mph slower during the PM peak hour than during the AM peak hour. In the eastbound direction, speeds are approximately 7 mph slower during the PM peak hour. The posted speed limit is 40 mph throughout most of the corridor and the average corridor speeds range between 17 and 25 mph depending on the peak hour and direction. Through volumes during the AM peak hour are generally around 500 vehicles per hour and can increase to about 800 vehicles per hour during the PM peak hour. Significant queueing in the eastbound direction during the PM peak hour was observed at the intersections of MD 177 at Solley Road/Waterford Road, MD 177 at Catherine Avenue/Outing Avenue, MD 177 at Magothy Bridge Road/Hog Neck Road, and MD 177 at Edwin Raynor Boulevard. Queue lengths ranged between 700 and 2,300 feet which resulted in cycle failure in some cases. The safety findings indicate that of the 306 police-reported crashes occurring between 2011-2013, 42% involved injuries (including one fatality). Rear end collisions were the most common type of crash (41%), which is consistent with congestion-related crash types. The highest number of crashes (30) occurred at both MD 648 (Baltimore Annapolis Boulevard) and the segment between Catherine Avenue and Tick Neck Road.

In consultation with District 5, the following proposed alternatives were chosen to be examined for congestion mitigation: (1) Widening to a 5-lane section between Solley Road and MD 100; (2) Intersection improvements at Solley Road, Catherine Avenue, Edwin Raynor Boulevard, and MD 607 on side streets.

Widening to a 5-lane section between Solley Road and MD 100 was designated as Alternative 1 and the intersection improvements were combined together into Alternative 2. Specifically, Alternative 2 was developed to include the following side street improvements: a 3rd

southbound lane providing exclusive through and left turn lanes from Solley Road, a 3rd northbound lane providing exclusive through and right turn lanes from Solley Road/Waterford Road, extending the 2nd northbound lane on Catherine Avenue to Schramms Crossing, restriping two northbound lanes running from just north of the MD 100 bridge to MD 177, converting the exclusive northbound right turn lane on Magothy Bridge Road to a shared through-right lane and providing a 2nd northbound receiving lane on Hog Neck Road, and converting the exclusive southbound right turn lane on Hog Neck Road to a shared through-right lane and extending the storage length.

The primary benefit of each alternative is operational. Operational issues addressed by Alternative 1 include eliminating all failing signalized intersections, improving PM peak average speeds by about 4 mph, reducing PM network delay by over 30%, and reducing PM travel time by over 15%. Alternative 2 was found to have very similar operational benefits to mainline widening. Operational issues addressed by Alternative 2 include eliminating all failing signalized intersections, improving PM peak average speeds by about 5 mph, reducing PM network delay by over 25%, and reducing PM travel time by over 15%.

Safety benefits of Alternative 1 are a reduction in rear-end and sideswipe collisions due to the reduced congestion experienced as a result of roadway widening. The safety benefits of Alternative 2 are less substantial with the addition of exclusive left and right turn lanes at Solley Road reducing crashes at that intersection. The other intersection improvements as part of Alternative 2 were assumed to have a negligible effect on crashes.

Concept plans and cost estimates using the major quantities estimates methodology were developed for each alternative. The total project cost for Alternative 1 is estimated to be $12.5 million and the total project cost for Alternative 2 is estimated to be $2.1 million. This gives Alternative 1 and Alternative 2 benefit to cost ratios of 3.4 and 16.8, respectively. The high benefit to cost ratio for Alternative 2 is high enough to rank it as one of the preferred alternatives.

I. BACKGROUND AND PURPOSE

The Arterial Congestion Management Program enables the Maryland State Highway Administration (SHA) to employ a data and performance driven approach in identifying potential low cost operational improvement projects along key, SHA maintained arterial corridors. This corridor based approach uses performance data from SHA's Annual Mobility Report, Highway Management Information System, Crash Database, as well as District and Traffic office input to identify short-term projects that address existing congestion and safety issues. Solutions include traditional geometric improvements, signal re-optimization, dynamic lane operations, ITS strategies, among others.

The Arterial Congestion Management Program evaluates alternatives through a benefit/cost and project life cycle analysis approach. System-wide operational results and qualitative measures of effectiveness are combined with safety and improvement costs to establish an annual list of corridors within the State of Maryland, based on the benefit return (often measured as delay savings) to implementation cost. The annual list of congestion mitigation strategies would be available for implementation through the appropriate State and/or local government agency. The goal of this Program is to enable roadway users of the chosen corridors to experience any operational and safety benefits derived from the improvement alternatives in the short-term, in contrast to more traditional long-term project planning studies.

From the 2015 Arterial Congestion Management Studies (ACMS), 12 corridors and their respective improvement alternatives were retained for further design through various funding sources, such as Fund 87. One of the retained corridors, MD 177 between Magothy Beach Road and MD 2 in Anne Arundel County, is detailed in this report. Information provided includes a summary of the existing conditions along the MD 177 corridor, such as traffic volumes, travel speeds, queues, intersection level of service, crash history, and potential congestion causes, as well as the development and evaluation of short-term improvement alternatives. This information will serve as a resource for the District office and others to carry the preferred improvement alternative forward through design, and eventually construction.

II. PREVIOUS STUDIES

All current and background projects for the corridor were obtained and reviewed. Sources for current and background projects included HNI, CLRP, developer improvements, OHD, CTP, DSED, Fund 77, Fund 76, Fund 87, CSIS/CSIL, local, and District studies. The projects found for the MD 177 between Magothy Beach Road and MD 2 are included in **Table 1** below.

Table 1: Previous Studies

Corridor	Limits	Type	Year	Description
MD 177	Solley Road to Edwin Raynor Boulevard	Local project	2015	Mountain Road Corridor Study, AA Co

A brief description of the project recommendation is provided below:

Mountain Road Corridor Study: Solley Road to Edwin Raynor Boulevard – Anne Arundel County is currently performing a MD 177 corridor study between Solley Road and Edwin Raynor Boulevard. The study is safety focused and exploring pedestrian and bike retrofits.

III. EXISTING CONDITIONS

A. MD 177 Study Area Corridor

The MD 177 study corridor is located in Pasadena, Maryland in northern Anne Arundel County. MD 177 runs in an east/west direction and is named Mountain Road through the length of the corridor. The corridor starts at MD 2, Governor Ritchie Highway and continues eastward, running parallel to MD 100 and ends just west of the merge of the MD 100 and MD 177 at Magothy Beach Rd.

MD 177 is a two- four lane undivided/divided urban minor arterial with two lanes in each direction near the western end of the corridor near MD 2 and MD 648 and three lanes with a two-way center left turn lane from east of the MD 10 to Edwin Raynor Blvd and two lane roadway for a majority of the study area.

Posted speed limits are 35-40 mph in each direction. **Figure 1** shows the corridor limits and study intersections. **Figures 2a and 2b** show the baseline maps.

Figure 1: Study Area Corridor and Intersections

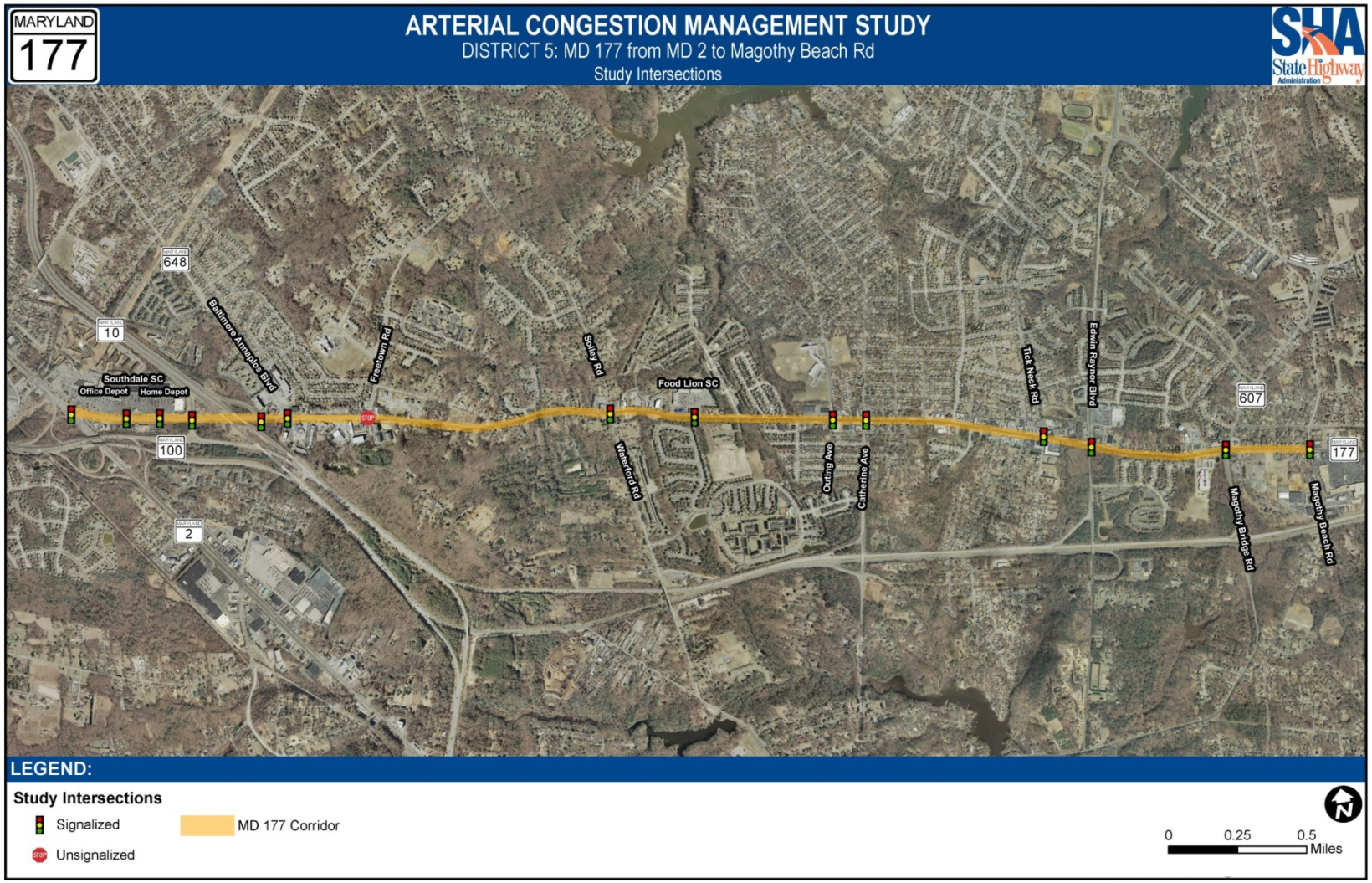


Figure 2a: Baseline Map

Figure 2b: Baseline Map

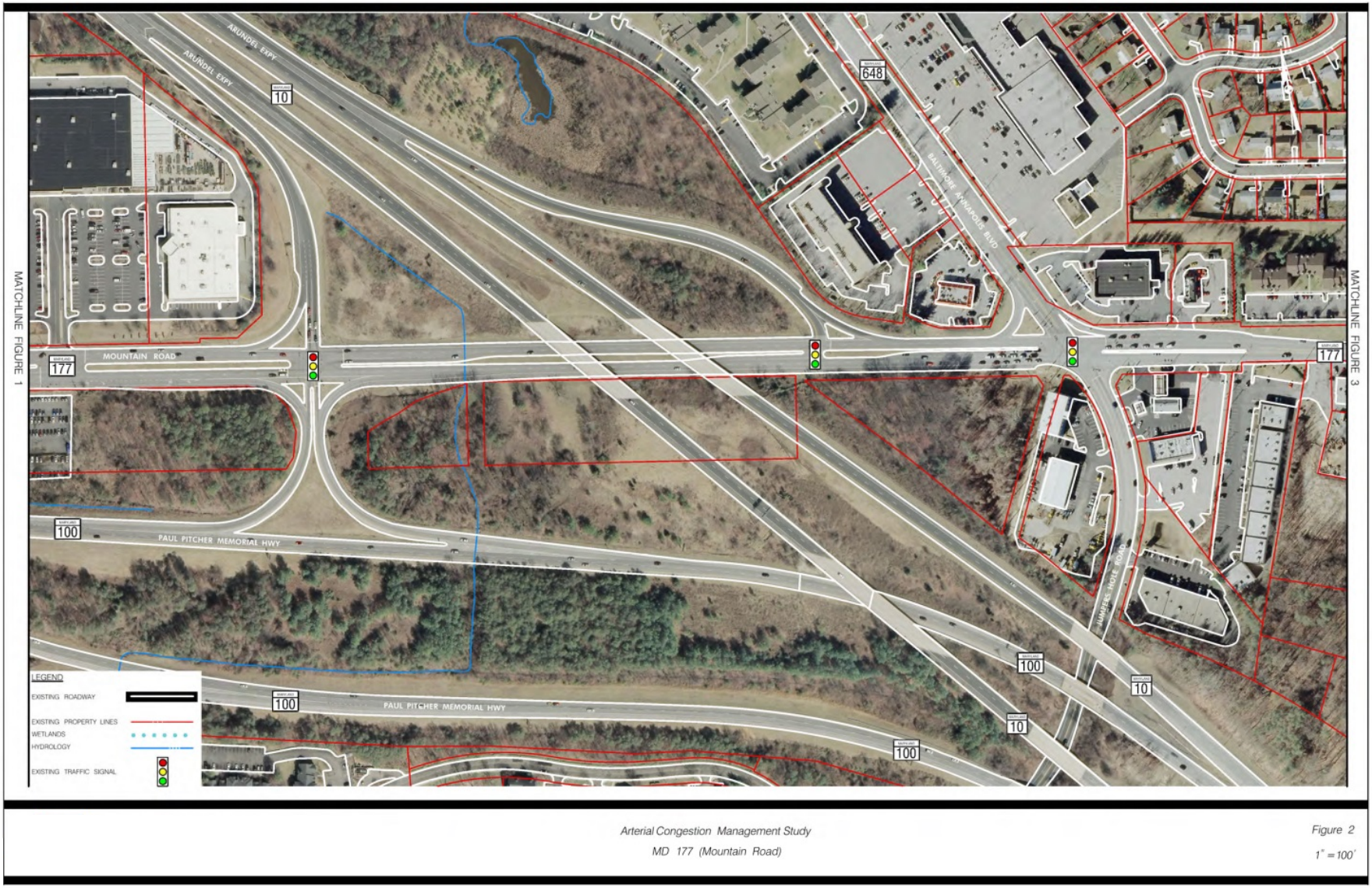


Figure 2c: Baseline Map

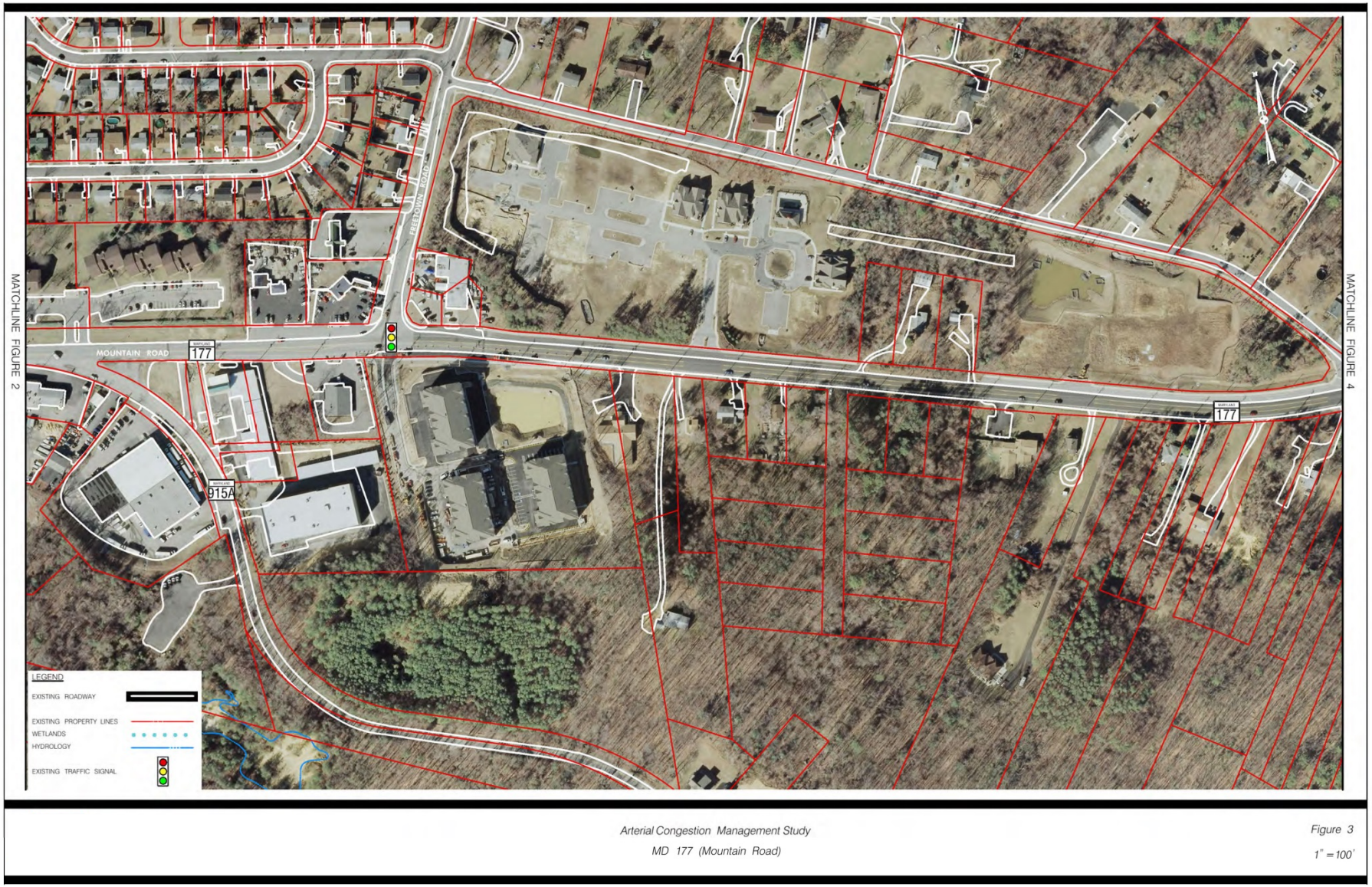


Figure 2d: Baseline Map

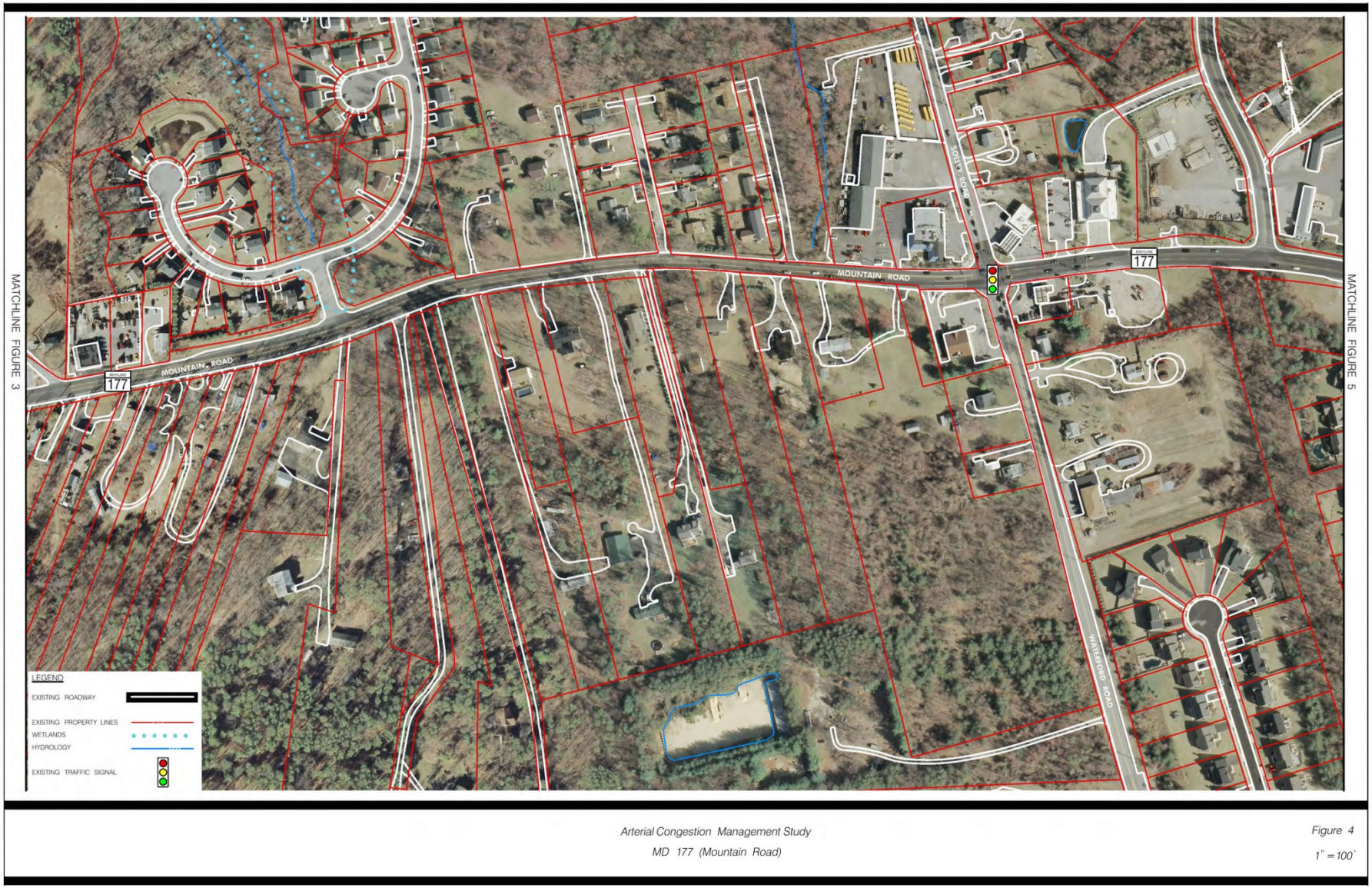


Figure 2e: Baseline Map

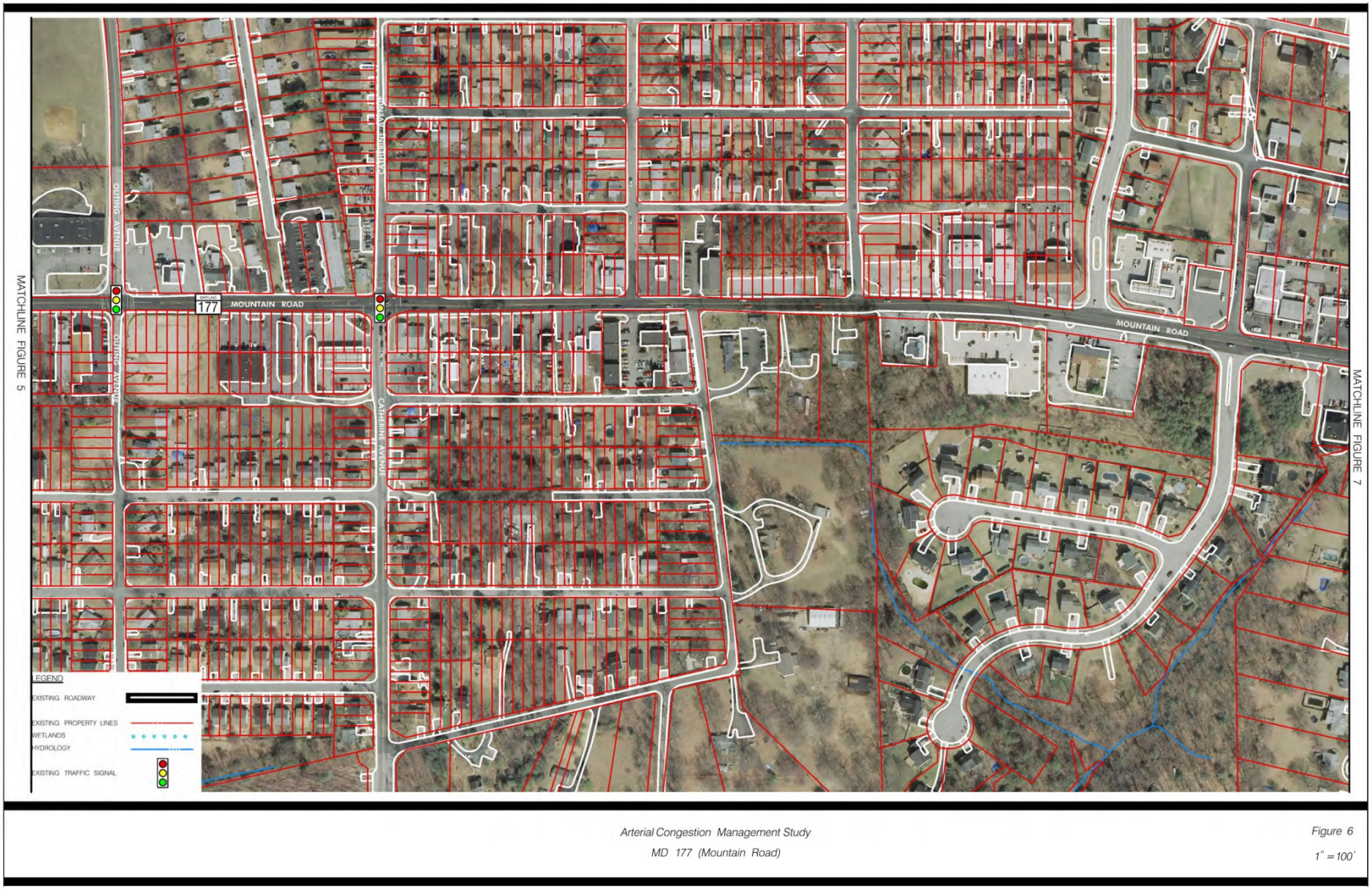


Figure 2f: Baseline Map

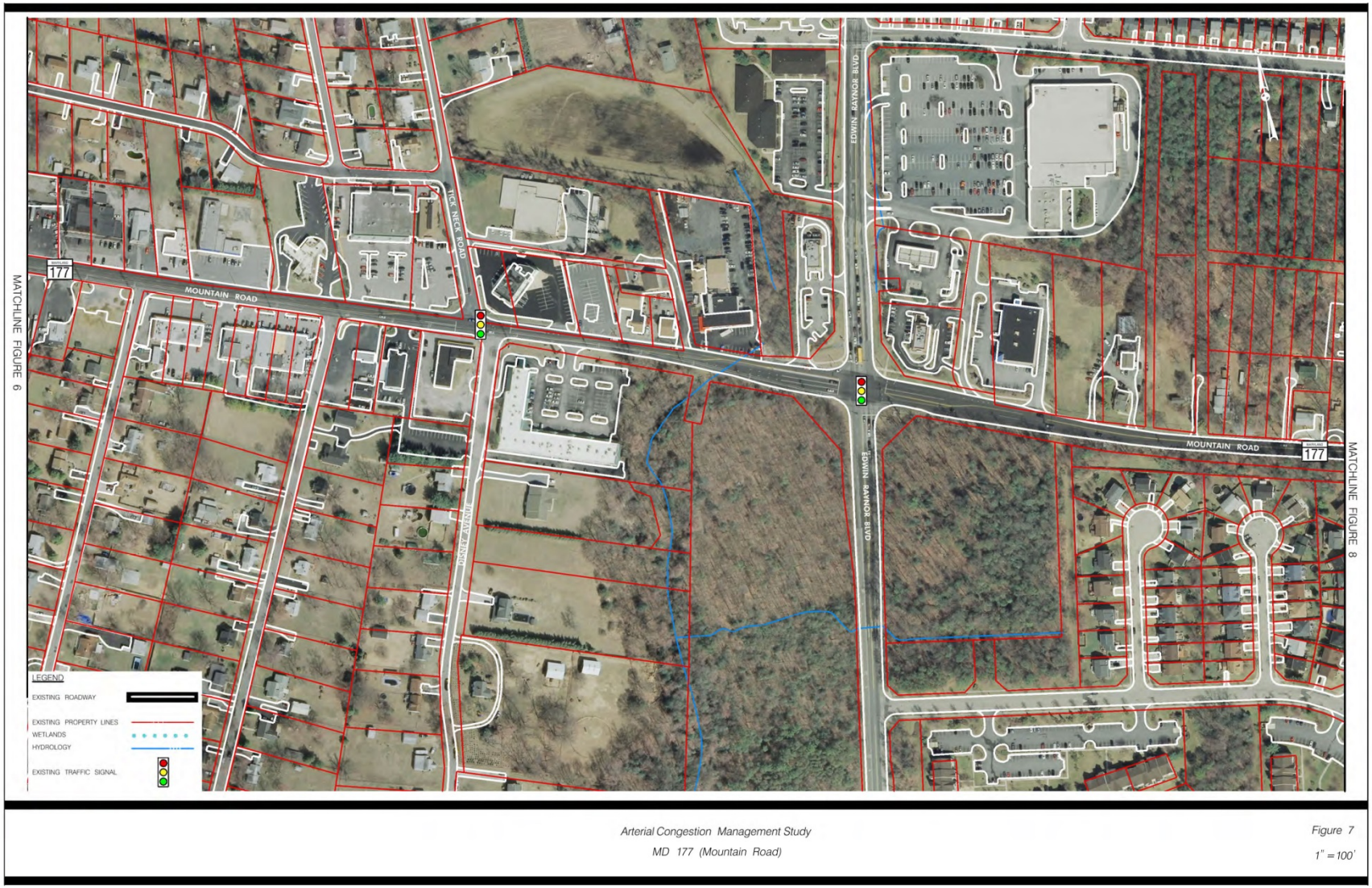
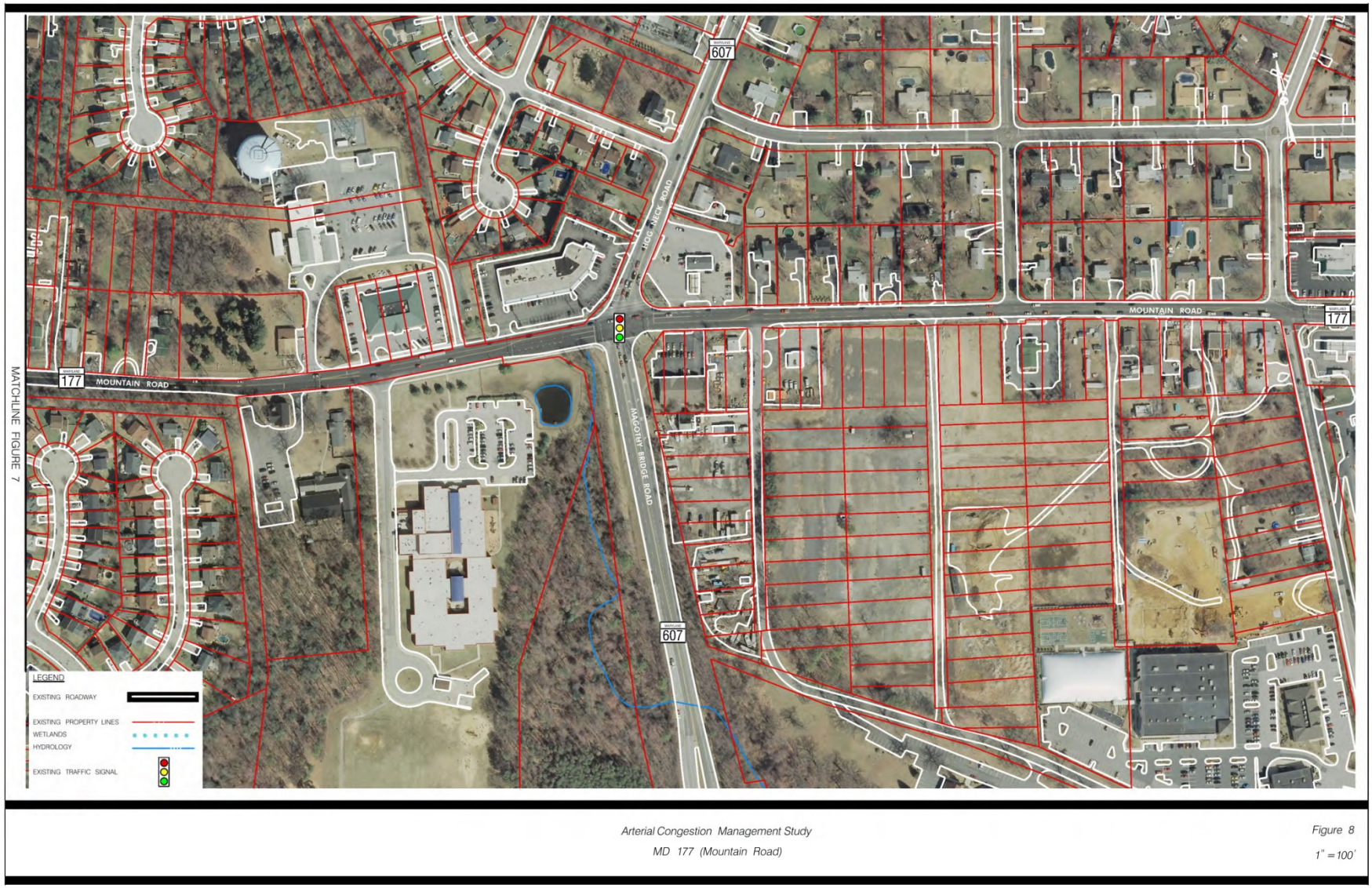


Figure 2g: Baseline Map



B. MD 177 Study Intersections

There are fifteen study intersections throughout the corridor including fourteen signalized intersections and one critical unsignalized intersection. Critical unsignalized intersections were included based on engineering judgement, although there are numerous other unsignalized intersections along the corridor. The study intersections are described below:

Signalized:

MD 177 at MD 2(Ritchie Hwy): MD 2 is a divided five-lane, two-way rural minor arterial that has two lanes southbound and three lanes going northbound. The intersection is 3-legged with MD 177 terminating at MD 2, and exclusive turn lanes are provided for all turning movements. Speed limit is 45 mph in both directions.

MD 177 at Southdale SC (Office Depot): Southdale is four-lane divided, two way local roadway connecting to an Office Depot and other local businesses north of MD 177 and a two-lane undivided driveway providing access to an auto dealership south of MD 177.

MD 177 at Southdale SC (Home Depot): This is a Tee-intersection with a three-lane undivided driveway north of the MD 177 that provides access to the Home Depot. Exclusive turn lanes are provided for all right turning movements

MD 177 at MD 100 ramps: The north approach at this intersection is the southbound MD 10 ramps and the south approach is the MD 100 westbound ramps. Exclusive turn lanes are provided for all right turning movements.

MD 177 at MD 10 ramps: This is a Tee-intersection with the north approach being the ramps to northbound MD 10. An exclusive turn lane is provided for the left turning movement.

MD 177 at MD 648 (Baltimore Annapolis Blvd): MD 648 is an undivided two-lane, two-way rural minor arterial. MD 648 is named Baltimore Annapolis Blvd north of MD 177 and Jumpers Hole Road south of MD 177.Turn lanes are provided for all turning movements. Speed limit is 30 mph in both directions.

MD 177 at Solley Rd: Solley Rd is two-lane undivided, two way local roadway providing access to residential communities north and south of MD 177. Turn lanes are provided for right turning movements southbound and left turning movements northbound. Speed limit is 40 mph in both directions.

MD 177 at Food Lion SC Entrance: This is a Tee-intersection with the north approach providing access to the Food Lion. Exclusive turn lanes are provided for both left and right turning movements.

MD 177 at Outing Ave: Outling Avenue is a two-lane undivided, two way local roadway providing access to residential communities north and south of MD 177. A turn lane is

provided for right turning southbound movement. Speed limit is 25 mph in both directions.

MD 177 at Catherine Ave: Catherine Avenue is a two-lane undivided, two way local roadway providing access to residential communities north and south of MD 177. A turn lane is provided for right turning northbound movement. Speed limit is 25 mph north of MD 177 and 35 mph south of MD 177.

MD 177 at Tick Neck Rd: Tick Neck Rd is a two-lane undivided, two way local roadway providing access to residential communities north and south of MD 177. South of MD 177 it is named Disney Avenue. A turn lane is provided for right turning southbound movement. Speed limit is 30 mph north of MD 177 and 25 mph south of MD 177.

MD 177 at Edwin Raynor Blvd: Edwin Raynor Drive is an undivided four-lane, two-way rural minor arterial. Turn lanes are provided for all left turning movements. Speed limit is 40 mph north of MD 177 and 45 mph south of MD 177.

MD 177 at MD 607 (Magothy Bridge Road/Hog Neck Road): MD 607 is an undivided two-lane, two-way urban other principal arterial. Turn lanes are provided for all left and right turning movements. Speed limit is 40 mph in each direction.

MD 177 at Magothy Beach Rd: Magothy Beach Road is an undivided two-lane, two-way local road connecting the shops in Lakeshore Plaza in the south and residential communities north of the intersection. Speed limit is 30 mph north and south of MD 177.

Unsignalized:

MD 177 at Freetown Road: Freetown Rd is a two-lane undivided, two way local roadway providing access to residential communities and Freetown Elementary north of MD 177. South of MD 177 it is named Cameryn Place and provides access to the residential community the Reserve at Stoney Creek. A turn lane is provided for right turning northbound movement. Speed limit is 30 mph north of MD 177.

C. Travel Times and Speeds

Existing “floating car” travel time studies were performed during the AM and PM periods (7-9 AM and 4-6 PM) along MD 177 in both directions between Magothy Beach Road and MD 2 on at least two different typical weekdays. AM travel time runs were performed on Thursday, January 29th and Thursday, February 5th and PM travel times were performed on Wednesday, February 4th and Thursday, February 5th. **Figure 3** displays the speeds that were collected based on the travel time runs. At least six runs in each direction were recorded.

INRIX gathers speed positions from real-world vehicles to determine the average speed for all significant roads and gathers and archives real-time traffic data at time periods down to one minute intervals. The University of Maryland and INRIX teamed together

as part of the I-95 Coalition Vehicle Probe Project to make this data available across 10 states through RITIS. The Regional Integrated Transportation Information System (RITIS) is an automated data sharing, dissemination, and archiving system that includes many performance measure, dashboard, and visual analytics tools that help agencies to gain situational awareness, measure performance, and communicate information between agencies and to the public.

Figure 4 displays the speeds from RITIS/INRIX that were collected for the time period between January 22 and February 22, 2015 on Tuesdays through Thursdays during the AM (7-9AM) and PM (4-6PM) peak hours. The INRIX data is comparable to the "floating car" travel times although only limited data between Baltimore Annapolis Boulevard and Solley Road was available.

The existing average measured travel times in the northbound and southbound direction for the AM and PM peak hour are shown in **Table 2**. The results show that travel times remain similar (11 minutes) in both directions during the AM peak hour and increase slightly (from 13 to 16 minutes) in the eastbound direction during the PM peak hour.

Table 2: Travel Times

MD 177 SEGMENTS		TRAVEL TIME (MINUTES:SECONDS) - AM (PM)	
LIMIT 1	**LIMIT 2**	**EB**	**WB**
Ritchie Highway	Southdale SC (Office Depot)	0:25 (0:31)	1:25 (1:30)
Southdale SC (Office Depot)	Southdale SC (Home Depot)	0:14 (0:15)	0:10 (0:11)
Southdale SC (Home Depot)	Ramps 9 & 10 to & fr MD 100 WB/Ramp 5 fr MD 10 SB	0:47 (0:30)	0:13 (0:12)
Ramps 9 & 10 to & fr MD 100 WB/Ramp 5 fr MD 10 SB	MD 10 NB Ramps	0:23 (0:24)	0:26 (0:42)
MD 10 NB Ramps	Baltimore Annapolis Blvd	0:35 (1:29)	0:13 (0:12)
Baltimore Annapolis Blvd	Freetown Rd	0:29 (0:33)	1:10 (1:20)
Freetown Rd	Waterford Rd	1:41 (3:02)	1:25 (1:26)
Waterford Rd	Food Lion SC Entrance	0:30 (0:40)	1:10 (0:52)
Food Lion SC Entrance	Outing Ave	1:01 (1:23)	0:44 (0:48)
Outing Ave	Catherine Ave	0:39 (0:55)	0:23 (0:18)
Catherine Ave	Tick Neck Rd	1:16 (1:36)	1:17 (1:37)
Tick Neck Rd	Edwin Raynor Blvd	0:26 (1:46)	0:26 (0:35)
Edwin Raynor Blvd	Hog Neck Rd	1:48 (1:58)	1:20 (1:18)
Hog Neck Rd	Magothy Beach Rd	0:58 (1:03)	1:27 (2:08)
Corridor total:		**11:11 (16:07)**	**11:49 (13:09)**

Table 3 shows observed travel speeds along the corridor. The overall corridor speeds show the westbound direction of travel is approximately 2 mph slower during the PM peak hour than during the AM peak hour. In the eastbound direction, speeds are approximately 7 mph slower during the PM peak hour. **Appendix A** contains detailed travel time data.

Table 3: Travel Speeds

MD 177 SEGMENTS		SPEED (MPH) AM (PM)		
		EB	WB	Posted Speed (EB & WB)
LIMIT 1	LIMIT 2			
Ritchie Hwy	Southdale SC (Office Depot)	28.4 (25.2)	11.9 (10.7)	40
Southdale SC (Office Depot)	Southdale SC (Home Depot)	34.9 (32.9)	42.9 (41.6)	
Southdale SC (Home Depot)	Ramps 9 & 10 to & fr MD 100 WB/Ramp 5 fr MD 10 SB	14.5 (21.4)	36.4 (36.5)	
Ramps 9 & 10 to & fr MD 100 WB/Ramp 5 fr MD 10 SB	MD 10 NB Ramps	37.2 (35.7)	35.3 (25.2)	
MD 10 NB Ramps	Baltimore Annapolis Blvd	22.4 (4.9)	33.0 (34.5)	
Baltimore Annapolis Blvd	Freetown Rd	36.7 (32.2)	18.5 (15.3)	
Freetown Rd	Waterford Rd	33.3 (18.5)	37.8 (37.1)	
Waterford Rd	Food Lion SC Entrance	37.3 (28.4)	20.1 (24.1)	
Food Lion SC Entrance	Outing Ave	32.6 (23.0)	40.7 (37.0)	
Outing Ave	Catherine Ave	15.3 (16.5)	22.8 (27.3)	35
Catherine Ave	Tick Neck Rd	31.0 (25.9)	30.7 (26.6)	40
Tick Neck Rd	Edwin Raynor Blvd	28.1 (7.0)	27.1 (19.8)	
Edwin Raynor Blvd	Hog Neck Rd	19.3 (18.3)	23.8 (25.4)	
Hog Neck Rd	Magothy Beach Rd	21.3 (20.3)	16.2 (9.7)	
Corridor Total:		**24.3 (17.1)**	**23.4 (21.0)**	35/40

Figure 3: Observed Peak AM/PM Vehicle Speed (Floating Car)

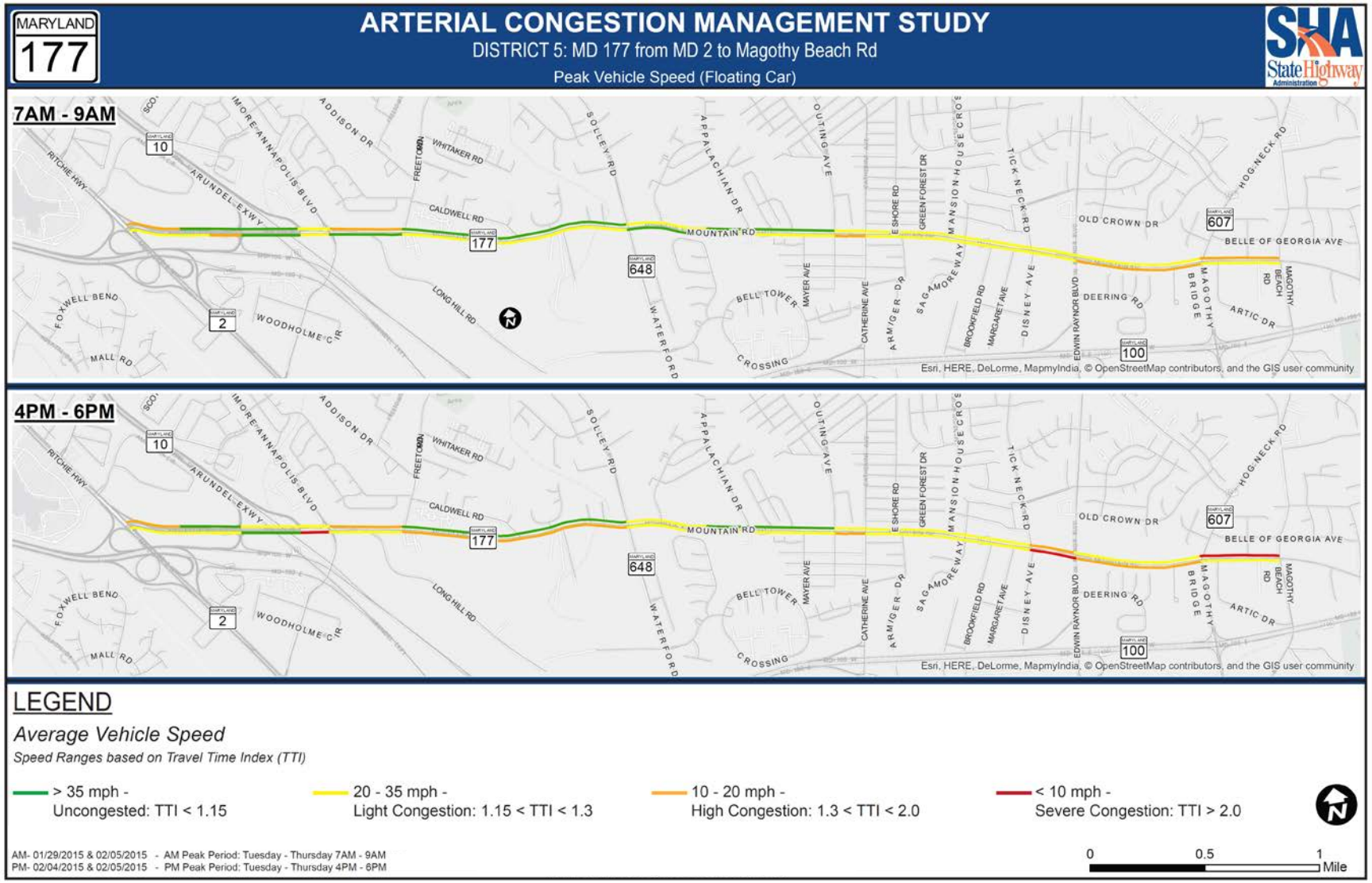
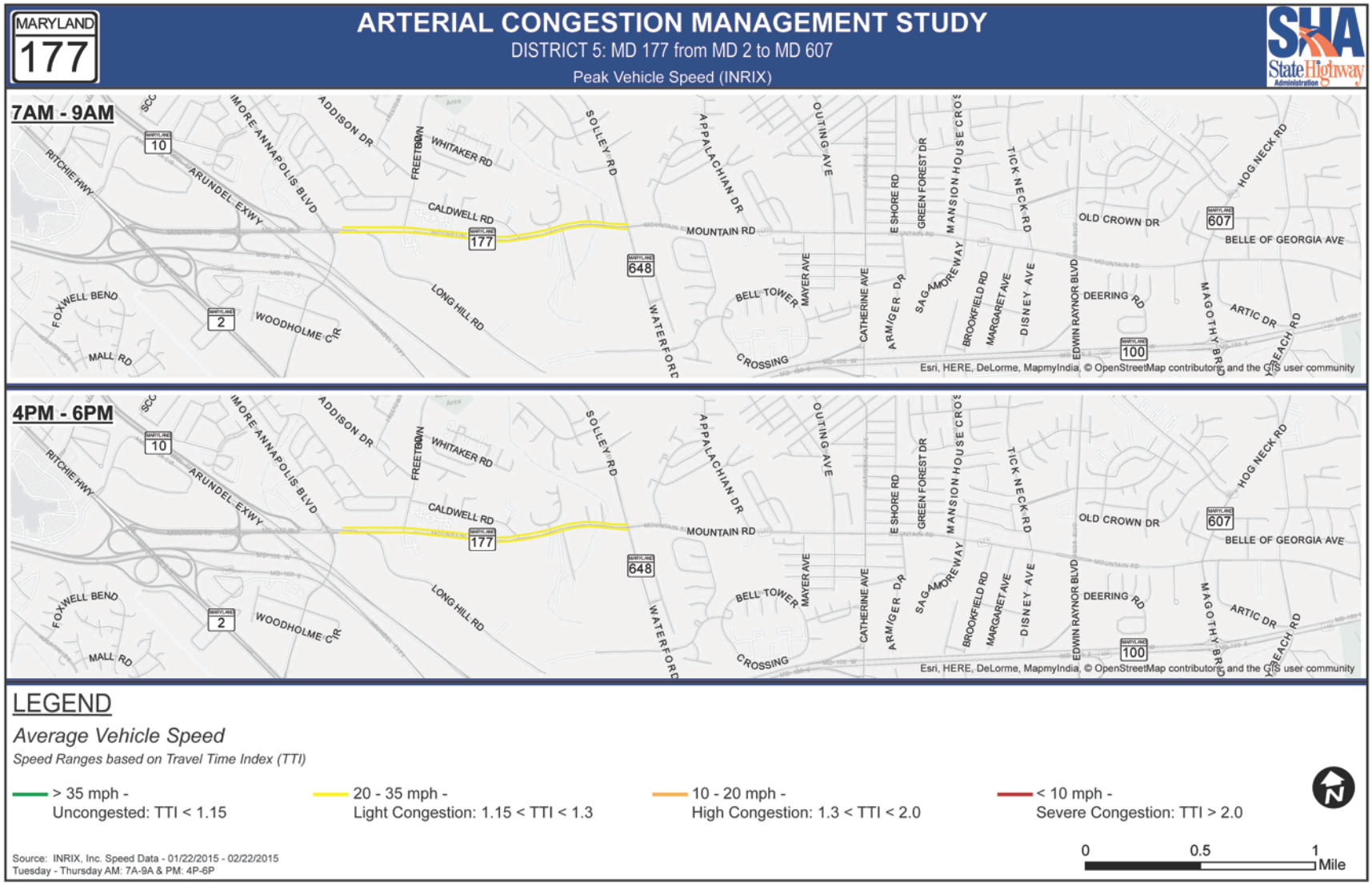


Figure 4: INRIX Peak AM/PM Vehicle Speed



IV. CRASH ANALYSIS SUMMARY

Crash data was requested for the entire study limits of MD 177 from MD 607 to MD 2 from the Maryland State Highway Administration's (SHA) Office of Traffic and Safety - Traffic Development and Support Division. Three years of crash data was provided for the period from January 01, 2011 to December 31, 2013. A total of 306 police-reported accidents occurred along this segment. The crashes are summarized below and in **Table 4**.

- One hundred and fourteen (114) crashes occurred in 2011, eighty-five (85) occurred in 2012, and one hundred and seven (107) occurred in 2013.
- One hundred and twenty eight crashes (42%) resulted in injury, and one hundred seventy seven crashes (58%) involved property damage only. ***One crash (1%) was fatal.***
- Rear end collisions were the most common type, with one hundred and twenty four collisions accounting for 41% of the crashes.
- Other crash types with a high frequency include forty-six (15%) angle collisions, forty-four (14%) left turn collisions, and twenty-six (8%) sideswipe collisions.
- Six crashes involved pedestrians. The fatal crash involved a pedestrian between MD 648 and Freetown Road. The remaining pedestrian crashes were spread throughout the corridor.
- Twenty-four crashes (8%) occurred between 6:00 AM and 9:00 AM; Eleven crashes (4%) occurred between 9:00 AM and 11:00 AM; Twenty-eight crashes (9%) occurred between 11:00 AM and 1:00 PM; Seventy crashes (23%) occurred between 1:00 PM and 4:00 PM; Eighty crashes (26%) occurred between 4:00 PM and 7:00 PM, and; Ninety-three crashes (30%) occurred between 7:00 PM and 6:00 AM.
- Thirty (30) crashes occurred on the segment between Catherine Avenue and Tick Neck Road. Fourteen of the thirty crashes were rear-end.
- Over the 2009-2011 period, thirty crashes (10%) occurred at MD 648, twenty-five crashes (8%) at Catherine Avenue, twenty-one crashes at Edwin Raynor Boulevard and the MD 100 Ramps (7% each), sixteen crashes (5%) at MD 2, and fifteen crashes (5%) at Solley Road/Waterford Road.

Crashes along the corridor have been displayed in **Figure 5,** crash data summary, and **Figure 6,** crash data by type. **Appendix B** contains detailed crash data provided by SHA.

Table 4: Crash Summary

Time of Day	# of Accidents
6:00 AM to 9:00 AM	24
9:00 AM to 11:00 PM	11
11:00 AM to 1:00 PM	28
1:00 PM to 4:00 PM	70
4:00 PM to 7:00 PM	80
7:00 PM to 6:00 AM	93
Total	**306**
Surface Condition	**# of Accidents**
Wet	59
Dry	244
Snow/Ice	3
Other	0
Total	**306**
Reported Year	**# of Accidents**
2011	114
2012	85
2013	107
Total	**306**
Illumination	**# of Accidents**
Day	193
Dawn / Dusk	15
Dark – Lights On	93
Dark – No Lights	4
Other	1
Total	**306**
Weather Condition	**# of Accidents**
Clear/Cloudy	262
Foggy	2
Raining	36
Snow/Sleet	5
Other	1
Total	**306**
Severity	**# of Accidents**
Fatal	1
Injury	128
Property Damage Only	177
Total	**306**
Signalized Study Intersection Crashes	**# of Accidents**
MD 2	16
Ent to Southdale SC (Office Depot)	1
Ent to Southdale SC (Home Depot)	0
MD 100 Ramps	21
MD 10 NB Ramp	2
MD 648E	30
Freetown Rd	8
Waterford Rd	15
Food Lion SC Ent	1
Outing Ave	7
Catherine Ave	25
Tick Neck Rd	8
Edwin Raynor Blvd	21
Magothy Bridge Rd	10

Accident Type	# of Accidents
Rear End	124
Angle	46
Left Turn	44
Sideswipe	26
Fixed Object: Other Pole	15
Opposite Direction	10
Parked Vehicle	8
Other	7
Pedestrian	6
Fixed Object: Curb	6
Fixed Object: Light Pole	5
Fixed Object: Tree/Shrubbery	4
Fixed Object: Sign Pole	2
Fixed Object: Fence	1
Fixed Object: Guardrail/Barrier	1
Other Fixed Object	1
Total	**306**
Contributing Factor	**# of Accidents**
Fail to give full attention	55
Fail to yield right-of-way	50
Other or unknown	50
Followed too closely	35
Too fast for conditions	32
Fail to obey traffic signal	12
Fail to obey other control	11
Fail to drive in single lane	10
Influence of alcohol	9
Improper turn	6
Fail to keep right of center	5
Physical or mental dificulty	4
Improper lane change	3
Fell asleep/fainted, etc.	3
Exceeded speed limit	2
Improper passing	2
Vehicle defect	2
License restriction, non-compliance	1
Influence of medication	1
Vision obstruction	1
Improper backing	1
Rain, snow	1
Icy or snow covered	1
Wet	1
Wrong way on one way	1
Operator using cell phone	1
Stopping in lane roadway	1
Passenger interfere/obstruction	1
Animal	1
Road under construction	1
Shoulders low, soft, or high	1
Improper right turn on red	1
Total	**306**

Figure 5: Crash Data By Summary

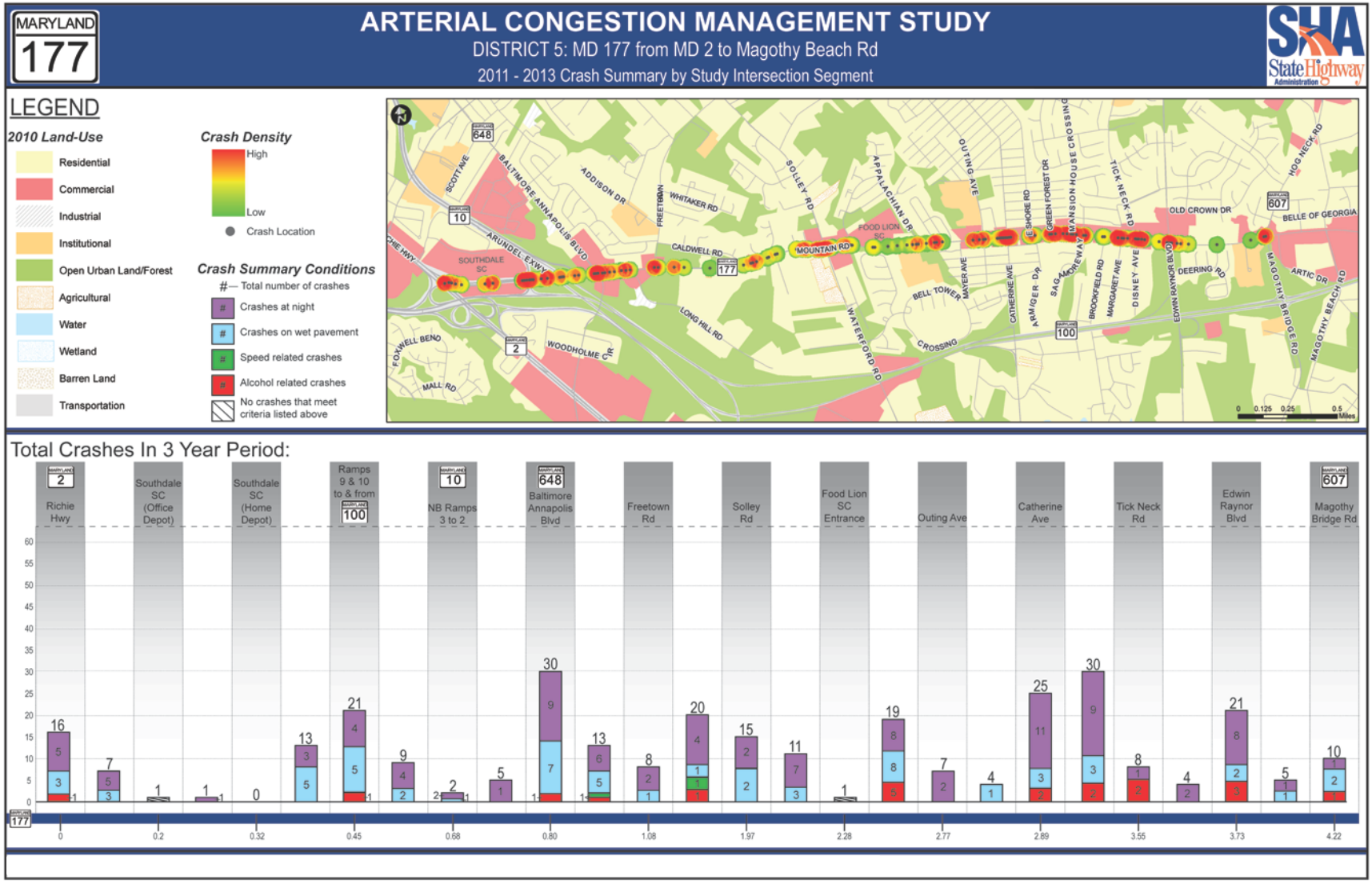
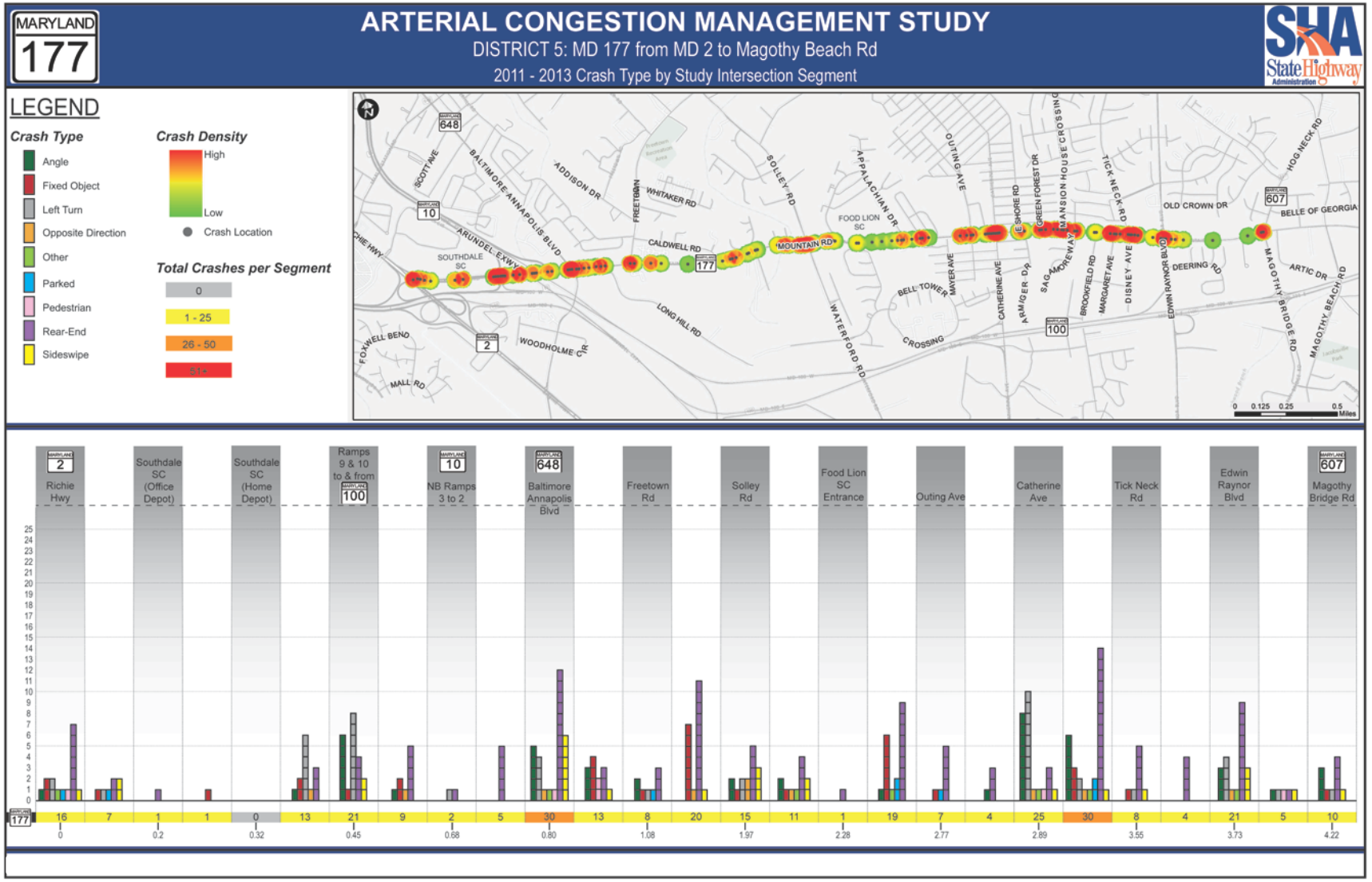


Figure 6: Crash Data By Type



V. FIELD OBSERVATIONS

Field observations were taken on Thursday, January 29th during the AM peak hour and on Wednesday, February 4th during the PM peak hour. Observations focused on congestion, queues, conflicts, and safety. The primary purposes for collecting the field observations were: 1) to document the level of congestion and 2) to serve as a validation measure for the microscopic simulation model. General field observations are presented below:

AM Peak Hour (January 29th, 2015)

- Most of the Shopping Center Signals are on flash at the beginning of the peak period.
- Turn bay overflow multiple times for westbound left turn lane from MD 177 onto MD 100 westbound (Ramp 9). This was likely due to a cycle failure.
- Eastbound right turn lane overflow on MD 177 at Catherine Avenue blocks through lane.
- Westbound left turn lane overflow on MD 177 was observed at Catherine Avenue.

PM Peak Hour (February 4th, 2015)

- Eastbound queuing on MD 177 from Magothy Beach Road extended to Sandy Spring Bank consistently and approached Magothy Bridge Rd/Hog Neck Rd during maximum queues.
- Eastbound queues on MD 177 from Catherine Avenue spill back through Outing Avenue throughout the peak hour. Signal was green at Outing Avenue but vehicles were not able to proceed due to queues from Catherine Avenue.
- Eastbound queues on MD 177 from Solley Road/Waterford Road were observed to extend back to Mountain View Way multiple times throughout the peak hour causing cycle failure on some occasions. The long queue lengths cause turn bay blockage at Solley Road/Waterford Road.
- There are two firehouses with flashing signals that may be preempted when emergency vehicles are present. One is located just 275' east of Solley Road/Waterford Road. The other is located approximately 750' west of Magothy Bridge Rd/Hog Neck Rd.
- Eastbound MD 177 cycle failure was experienced once at Magothy Bridge Rd/Hog Neck Rd.
- Eastbound left turn lane overflow was observed at Jumpers Hole Road.
- Eastbound queues on MD 177 at Edwin Raynor Boulevard spilled back through Tick Neck Road/Disney Ave and cycle failure occurred (~5:14 PM)

- EB queuing from Jumpers Hole Road/Baltimore Annapolis Blvd extended through the MD 10 Ramp flashing signal consistently during the PM peak hour.
- The NB approach on Catherine Avenue at MD 177 had significant queueing.

VI. DATA COLLECTION AND TRAFFIC VOLUMES

A. Existing Conditions (2015) Traffic Volumes

Fifteen (15) hour turning movement counts were obtained from the State Highway Administration (SHA) for all study intersections along the corridor. Previous existing traffic counts from SHA were used if collected recently. If counts were determined to be outdated or no previous counts existed, new counts were performed during late January and early February 2015.

The raw intersection counts were then balanced between intersections and interchanges using DSED's zero-balancing approach. This method disregards minor driveway volumes between intersections and assumes a zero difference between intersections. Peak hour volumes were rounded to the nearest 5 vehicles.

Figure 7 displays balanced peak hour turning movement counts and lane configurations for the study intersections. Detailed raw traffic count data is included in **Appendix C**.

VII. TRAFFIC OPERATIONS ANALYSIS – EXISTING CONDITIONS

The operations analysis was performed using Synchro™ and SimTraffic™ software. Synchro is a macroscopic and deterministic traffic signal timing and analysis software program which implements the methodology of the Highway Capacity Manual. SimTraffic is a microscopic simulation and animation software program.

To develop a base model in Synchro, the following data is necessary:

- Field inventories of roadway geometry
- Traffic counts for all signalized intersections and key unsignalized intersections
- Existing signal timings, phasing and operational settings
- Travel time studies including delays, stops and queues
- Field observations of existing conditions

For each corridor, a thorough field review was performed. The review recorded roadway characteristics such as number of lanes, lane configuration, and turn restrictions. Lane widths, tapers, storage lengths, and distances between intersections were spot-checked for consistency with Google Earth. Additionally, traffic regulations such as parking restrictions, turn restrictions, crosswalk locations, and bus stop locations were also noted.

Existing signal timing and phasing data was obtained from SHA's Office of Traffic and Safety via signal timing sheets or provided Synchro files. Phasing was subsequently verified in the field. During the AM peak hour, all intersections run "free" except MD 2 at MD 177 which is coordinated with a 120 second cycle length along MD 2. During the PM peak hour, all intersections east of and including MD 648 run "free". The signals between the Southdale Shopping Center/Car Dealership intersection and Ramp 10 to MD 10 NB intersection are actuated-coordinated with cycle lengths of 120 seconds. MD 2 at MD 177 remains coordinated along MD 2 with a 150 second cycle length.

Volume and timing data for all study intersections was then coded into a Synchro network to perform capacity analysis. The base Synchro models for the existing conditions were developed for the AM and PM peak periods.

A. Model Calibration

After coding the base Synchro models, they were calibrated to ensure that actual existing field conditions were reflected (i.e. matching "floating car" travel times and observed queue lengths). The calibration process consists of inputting field measured values (speeds, saturated flow rates, etc.) to override default values, and then comparing field measurements of arterial travel time with the output from the Synchro/SimTraffic models. SimTraffic can output queue lengths and arterial travel times.

The Synchro modeling SOP guidance from SHA's DSED – Travel Forecasting suggests using travel times or speeds over short segments (e.g. signalized intersection to signalized intersection) to calibrate the network. A maximum ±10 percent variation in arterial travel time for small segments no more than 1 mile long and an overall ±5 percent corridor variation is required. It should be noted due to the heavily congested conditions at some signals during the PM peak hour some exceptions were made. For this study, calibration was verified using "floating car" arterial travel times vs. SimTraffic arterial travel times as shown in **Table 5**. All SimTraffic results are based off of at least a minimum of five 60-minute runs and 15 minute seeding interval.

Figure 7: Existing Volumes Diagram

MD 177 Traffic Volume Diagram

Figure 1

N.T.S.

Table 5: "Floating Car" vs Model-Derived Arterial Travel Time Comparison

MD 177 Segments	Travel Time (min:sec) - AM (PM)											
	Eastbound						Westbound					
	"Floating Car"		SimTraffic		% Difference		"Floating Car"		SimTraffic		% Difference	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
MD 2 to Waterford Road/Solley Road	4:34	6:44	4:30	6:20	-1%	-(6%)	5:02	5:33	4:31	5:32	-10%	(0%)
Waterford Road/Solley Road to Edwin Raynor Boulevard	3:52	6:20	3:54	7:07	1%	(12%)	4:00	4:10	4:15	4:53	6%	(17%)
Edwin Raynor Boulevard to Magothy Beach Rd	2:46	3:01	2:24	2:43	-13%	-(10%)	2:47	3:26	2:30	3:07	-10%	-(9%)
Corridor total:	**11:12**	**(16:05)**	**10:48**	**(16:10)**	**-4%**	**(1%)**	**11:49**	**(13:09)**	**11:16**	**(13:32)**	**-5%**	**(3%)**

B. Intersection Capacity Analysis

Synchro implements Highway Capacity Manual (HCM) 2000 methods of analysis which were used for the intersection capacity analyses of all study intersections. Performance measures of effectiveness include level of service (LOS), volume-to-capacity (v/c) ratio, and average vehicle delay. The existing AM and PM peak hour LOS results are displayed in **Figure 8** and **Figure 9**, respectively. **Table 6** summarizes the results of the existing capacity analysis and detailed reports are contained in **Appendix D**.

The results show that MD 177 at Outing Avenue and MD 177 at Magothy Bridge Rd/Hog Neck Road both fail during the PM peak hour. The intersections of Edwin Raynor Boulevard at MD 177 and Magothy Beach Road/Park Ave operate with LOS E during the PM peak hour. The intersection of MD 177 at Jumpers Hole Road operates with a LOS E during the AM peak hour. The unsignalized intersection of MD 177 at Freetown Road operates with a failing southbound approach during both the AM and PM peak hours and a failing northbound approach during the AM peak hour.

Figure 8: Existing Intersection LOS AM

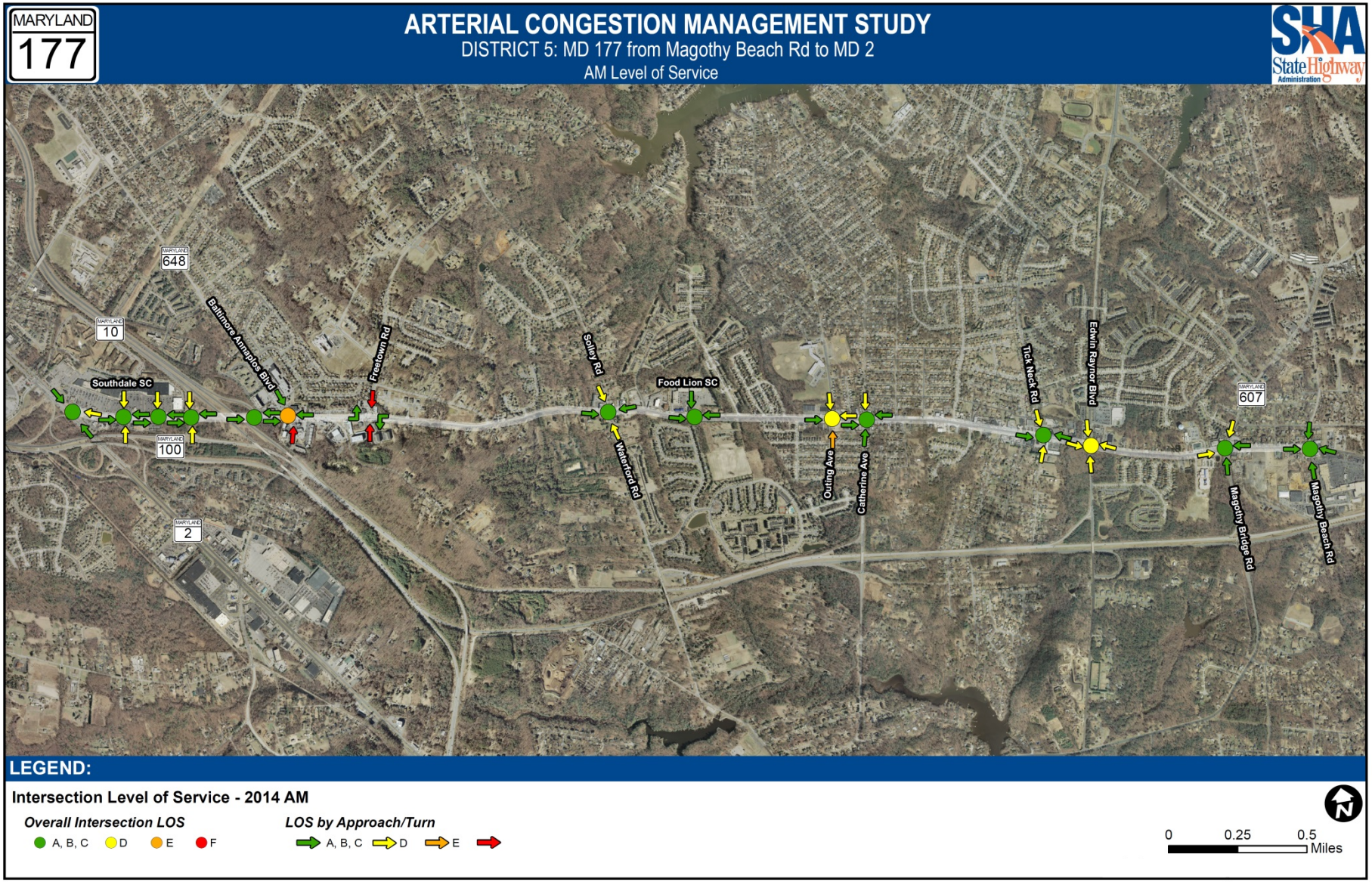


Figure 9: Existing Intersection LOS PM

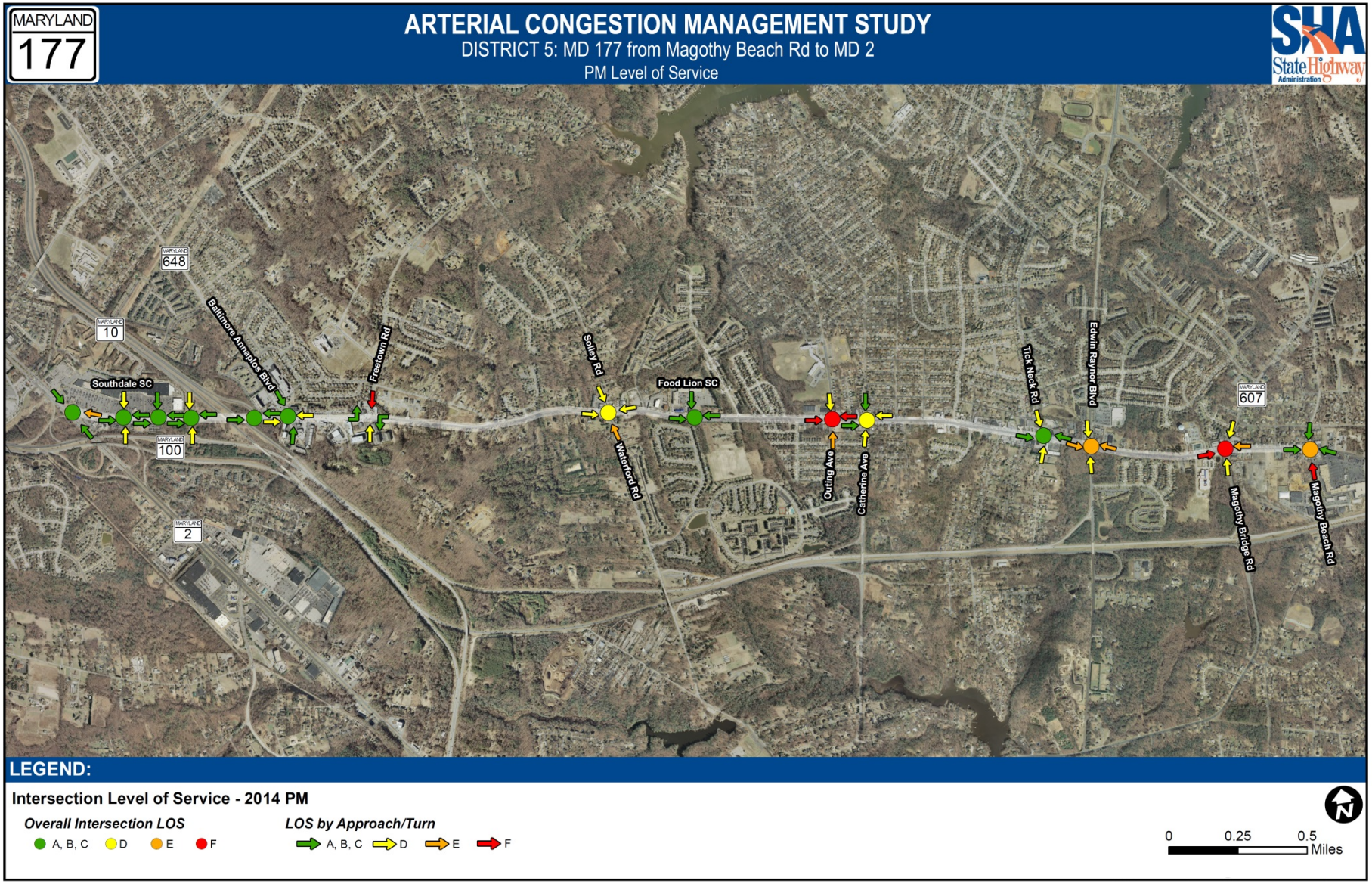


Table 6: Existing Capacity Analysis Results

#	Intersection	Approach	Existing - AM (PM)		
			LOS	Delay / Veh (sec)	V/C
1	MD 2 & Ramp from MD 100/MD 177	**Overall**	C (C)	20.6 (26.5)	0.29 (0.46)
		E	A (A)	0.1 (0.0)	0.6 (0.0)
		W	D (E)	51.4 (68.6)	0.36 (0.68)
		N	A (B)	4.7 (14.2)	0.23 (0.38)
		S	B (C)	17.3 (21.1)	0.59 (0.70)
2	Car Dealership/Southdale SC & MD 177	**Overall**	A (B)	6.7 (15.3)	0.17 (0.29)
		E	A (B)	4.8 (16.4)	0.14 (0.26)
		W	A (A)	3.8 (7.2)	0.14 (0.33)
		N	D (D)	51.7 (53.4)	0.17 (0.06)
		S	D (D)	49.6 (40.1)	0.47 (0.21)
3	MD 177 & Home Depot	**Overall**	A (B)	7.9 (16.1)	0.16 (0.26)
		E	A (A)	1.6 (5.3)	0.13 (0.24)
		W	A (C)	7.6 (24.0)	0.15 (0.31)
		N	-(-)	-(-)	-(-)
		S	D (C)	42.5 (35.0)	0.26 (0.17)
4	MD 100 WB Ramp/MD 10 SB Ramp & MD 177	**Overall**	C (C)	20.4 (33.9)	0.65 (0.76)
		E	B (C)	19.9 (33.3)	0.34 (0.80)
		W	A (C)	10 (22.2)	0.67 (0.70)
		N	D (D)	43.8 (50.6)	0.52 (0.75)
		S	D (D)	44 (42.1)	0.56 (0.77)
5	MD 177 & Ramp to MD 10 NB	**Overall**	A (A)	2.0 (0.7)	0.45 (0.34)
		E	A (A)	0.12 (0.10)	0.17 (0.32)
		W	A (A)	3 (1.5)	0.47 (3.2)
		N	-(-)	-(-)	-(-)
		S	A (A)	0.0 (0.0)	0.0 (0.0)
6	Jumper's Hole Rd/MD 648 & MD 177	**Overall**	E (C)	59.7 (31.4)	0.76 (0.47)
		E	C (D)	27.8 (37.1)	0.46 (0.57)
		W	C (D)	25.8 (39.5)	0.31 (0.61)
		N	F (C)	110.8 (24.0)	1.23 (0.30)
		S	C (C)	24.8 (21.6)	0.44 (0.37)
7	Cameryn Pl/Freetown Rd & MD 177	**Overall**	-(-)	-(-)	-(-)
		E	B (B)	11.3 (10.3)	0.37 (0.54)
		W	A (A)	8.8 (9.9)	0.52 (0.40)
		N	F (F)	> 600 (317.5)	> 4.00 (0.71)
		S	F (D)	76.1 (30.4)	0.97 (0.44)
8	Waterford Road/Solley Rd & MD 177	**Overall**	C (D)	34.7 (45.3)	0.72 (0.75)
		E	C (D)	22.5 (35.1)	0.39 (0.74)
		W	C (D)	34.9 (42.9)	0.82 (0.77)
		N	D (E)	50.5 (63.8)	0.59 (0.77)
		S	D (D)	37.2 (55.0)	0.68 (0.75)
9	MD 177 & Mountain Marketplace Primary	**Overall**	A (B)	8.9 (12.4)	0.57 (0.73)
		E	A (A)	3.9 (9.8)	0.33 (0.71)
		W	A (B)	9.4 (12.9)	0.62 (0.65)
		N	-(-)	-(-)	-(-)
		S	C (C)	22.8 (21.7)	0.28 (0.44)

#	Intersection	Approach	Existing - AM (PM)		
			LOS	Delay / Veh (sec)	V/C
10	Outing Avenue & MD 177	**Overall**	D (F)	44.3 (206.4)	0.65 (0.66)
		E	C (F)	27.1 (313.4)	0.55 (1.55)
		W	D (F)	50.9 (140.2)	0.90 (1.17)
		N	E (E)	56.2 (72.1)	0.11 (0.17)
		S	D (D)	52.4 (35.5)	0.81 (0.24)
11	Catherine Ave & MD 177	**Overall**	C (D)	24.2 (41.2)	0.58 (0.95)
		E	C (C)	28.7 (31.8)	0.53 (0.97)
		W	B (D)	15.4 (51.3)	0.62 (0.87)
		N	C (D)	32.9 (44.3)	0.38 (0.88)
		S	D (C)	42.5 (34.4)	0.19 (0.10)
12	Disney Ave/Tick Neck Road & MD 177	**Overall**	B (B)	14.8 (17.7)	0.35 (0.69)
		E	A (B)	6.9 (14.6)	0.3 (0.76)
		W	A (B)	7.1 (13.1)	0.29 (0.65)
		N	D (D)	45.1 (43.5)	0.01 (0.03)
		S	D (D)	38.9 (39.8)	0.59 (0.57)
13	Edwin Raynor Boulevard & MD 177	**Overall**	D (E)	40.2 (57.6)	0.59 (0.86)
		E	D (E)	36.4 (74.5)	0.47 (0.91)
		W	D (E)	35.6 (68.1)	0.61 (0.77)
		N	D (D)	40 (50.3)	0.38 (0.85)
		S	D (D)	44.0 (39.5)	0.76 (0.63)
14	Magothy Bridge Rd/Hog Neck Road & MD 177	**Overall**	C (F)	34.4 (82.6)	0.71 (0.98)
		E	D (F)	35.5 (170.1)	0.69 (1.27)
		W	C (E)	27 (59.5)	0.42 (0.84)
		N	C (D)	33.7 (52.2)	0.39 (0.91)
		S	D (D)	38.5 (35.7)	0.85 (0.67)
15	Magothy Beach Rd/Park Ave & MD 177	**Overall**	C (E)	22.2 (73.4)	0.66 (0.94)
		E	C (C)	21.8 (28.1)	0.75 (0.88)
		W	B (B)	14.9 (13.4)	0.44 (0.44)
		N	C (F)	33.5 (273.0)	0.45 (1.46)
		S	C (C)	33.1 (47.4)	0.57 (0.58)

C. Queuing Analysis

Queuing for the existing conditions was assessed using SimTraffic. Five 60 minute simulations with a 15 minute seeding intervals were run for each peak hour. **Table 7** shows the AM and PM peak hour 95th percentile queues for the study intersections. Detailed queuing reports are contained in **Appendix E**.

The results show the most significant queuing occurs through the one lane portions of MD 177 during the PM peak hour. The eastbound queues of MD 177 at Waterford Road/Solley Road and MD 177 at Outing Avenue extend over 2,000 feet during the PM peak hour. The eastbound queue at the intersection of Edwin Raynor Boulevard also extends to approximately 1,000 feet during the PM peak hour. Queue lengths exceeding the available turn bay storage length or extending through an adjacent intersection are highlighted in red.

Table 7: Existing 95th Percentile Queue Lengths

#	Intersection	Approach	Distance to Next Intersection (ft)	Intersecting Road Name at Nearest Intersection	Existing 95th Percentile Queue Length (ft) - AM (PM)
					Existing
1	MD 177 at MD 2 Ramp from MD 100	EBT	Free	N/A	N/A
		WBL	1010	Entrance to Southdate SC (Office Depot)	62 (139)
		WBR	1000	Right Turn Bay	0 (23)
		NBTR	2,550	Ashberry Ln	103 (259)
		SBL	650	Left Turn Bay	147 (231)
		SBT	810	American Cir	56 (80)
2	MD 177 at Entrance to Southdate SC (Office Depot)	EBL	250	Left Turn Bay	15 (9)
		EBTR	975	MD 2	44 (140)
		WBL	100	Left Turn Bay	34 (91)
		WBTR	585	Entrance to Southdate SC (Home Depot)	80 (117)
		NBLTR	175	N/A	37 (49)
		SBL	175	N/A	65 (94)
		SBTR	275	N/A	18 (62)
		SBR	275	N/A	29 (65)
3	MD 177 at Entrance to Southdate SC (Home Depot)	EBL	375	Left Turn Bay	45 (60)
		EBT	585	Entrance to Southdate SC (Office Depot)	60 (137)
		WBTR	545	Ramps MD 100	188 (237)
		SBL	210	Left Turn Bay	56 (77)
		SBLR	330	N/A	91 (156)
4	MD 177 at MD 100 WB Ramp & MD 10 SB Ramp	EBTR	536	Entrance to Southdate SC (Home Depot)	199 (315)
		WBL	275	Left Turn Bay	190 (188)
		WBT	1150	MD 10 NB Ramps	150 (163)
		NBL	960	MD 100	123 (206)
		NBR	120	Right Turn Bay	22 (66)
		SBL	300	Left Turn Bay	116 (234)
		SBLT	1910	MD 10	158 (293)
		SBR	330	Right Turn Bay	0 (53)
5	MD 177 at MD 10 NB Ramps (3 to Ramp 2)	EBL	240	Left Turn Bay	76 (59)
		WBTR	560	Baltimore Annapolis Blvd	74 (108)
6	MD 177 at Baltimore Annapolis Blvd/ MD 648E	EBL	340	Left Turn Bay	91 (174)
		EBTR	1745	Ramps MD 100	195 (164)
		WBL	320	Left Turn Bay	99 (151)
		WBT	710	Long Hill Rd	79 (250)
		WBR	400	Right Turn Bay	128 (37)
		NBL	250	Left Turn Bay	392 (157)
		NBT	1,525	Evening Star Dr	897 (199)
		NBR	250	Right Turn Bay	422 (0)
		SBL	320	Left Turn Bay	102 (167)
		SBT	260	Albert Dr	173 (183)
		SBR	320	Right Turn Bay	19 (22)
7	MD 177 at Freetown Road	EBL	100	Left Turn Bay	75 (86)
		EBTR	700	Long Hill Rd	0 (32)
		WBL	150	Left Turn Bay	12 (16)
		WBT	700	Pearman's West	3 (11)
		WBR	125	Right Turn Bay	13 (4)
		NBLT	300	Dead End	37 (30)
		SBLT	595	Caldwell Rd	20 (38)
		SBR	250	Right Turn Bay	118 (77)
8	MD 177 at Waterford Road/ Solley Road	EBL	175	Left Turn Bay	90 (248)
		EBT	417	Carnene Rd	187 (2204)
		EBR	150	Right Turn Bay	72 (215)
		WBL	200	Left Turn Bay	218 (168)
		WBTR	625	Mountain Eastate Dr	499 (672)
		NBL	175	Left Turn Bay	145 (229)
		NBTR	1,580	Champion Ln	156 (473)
		SBLT	1220	Sangria Ct	229 (292)
		SBR	250	Right Turn Bay	132 (167)

#	Intersection	Approach	Distance to Next Intersection (ft)	Intersecting Road Name at Nearest Intersection	Existing 95th Percentile Queue Length (ft) - AM (PM)
					Existing
9	MD 177 at Food Lion Sc Entrance	EBL	200	Left Turn Bay	37 (71)
		EBT	916	Mountain Eastate Dr	114 (237)
		WBT	793	Appalachian Dr/Schramms Rd	225 (325)
		WBR	115	Right Turn Bay	77 (103)
		NBT	No Approach	N/A	N/A
		SBL	185	Left Turn Bay	65 (111)
		SBR	185	NA	77 (77)
10	MD 177 at Outing Avenue	EBL	150	Left Turn Bay	55 (131)
		EBTR	580	Mayer Ave	301 (2127)
		WBTR	580	Chaterine Avenue	304 (467)
		NBLTR	421	228th St	51 (93)
		SBLT	710	Cuba Dr	323 (179)
		SBR	225	Right Turn Bay	226 (123)
11	MD 177 at Catherine Avenue	EBL	275	Left Turn Bay	109 (283)
		EBT	577	Outing Avenue	363 (529)
		EBR	250	Right Turn Bay	231 (250)
		WBL	175	Left Turn Bay	215 (229)
		WBTR	563	E Shore Rd	393 (757)
		NBLT	190	227th St	126 (673)
		NBR	325	Right Turn Bay	82 (429)
		SBLTR	190	225th St	98 (126)
12	MD 177 at Tick Neck Road	EBL	150	Left Turn Bay	10 (150)
		EBTR	295	Margaret Ave	126 (783)
		WBL	160	Left Turn Bay	36 (35)
		WBTR	850	Edwin Raynor Blvd	143 (333)
		NBLTR	1300	Mildred Ave	35 (73)
		SBLT	290	Gladnor Rd	130 (112)
		SBR	300	Right Turn Bay	63 (70)
13	MD 177 at Edwin Raynor Blvd.	EBL	300	Left Turn Bay	84 (388)
		EBT	825	Disney Ave	276 (979)
		EBR	200	Right Turn Bay	136 (264)
		WBL	175	Left Turn Bay	132 (181)
		WBT	2550	Magothy Bridge Rd /Hog Neck Rd	218 (497)
		WBR	375	Right Turn Bay	45 (253)
		NBL	175	Left Turn Bay	99 (257)
		NBT	700	Deering Rd	194 (728)
		NBTR	460	Right Turn Bay	160 (542)
		SBL	200	Left Turn Bay	243 (200)
		SBTR	790	Old Crown Dr/Littleton Way	405 (264)
14	MD 177 at Hog Neck Road / Magothy Bridge Road	EBL	200	Left Turn Bay	120 (183)
		EBT	2,555	Edwin Raynor Blvd	327 (756)
		EBR	200	Right Turn Bay	142 (127)
		WBL	250	Left Turn Bay	97 (83)
		WBT	860	Roys Drive	214 (384)
		WBR	250	Right Turn Bay	102 (292)
		NBL	375	Left Turn Bay	47 (331)
		NBTR	1,695	Paul Pitcher Memorial Hwy	179 (579)
		SBL	375	Left Turn Bay	174 (155)
		SBT	410	Westwood Manor Way	387 (208)
		SBR	150	Right Turn Bay	132 (54)
15	MD 177 at Magothy Beach Road	EBL	100	Left Turn Bay	42 (71)
		EBTR	612	Broadway/Roys Dr	249 (656)
		WBL	125	Left Turn Bay	27 (58)
		WBTR	1060	Postal Ct	147 (184)
		NBLTR	214	Postal Court	112 (419)
		SBLTR	380	Belle of Georgia Ave.	151 (139)

VIII. SUMMARY OF EXISTING CONDITIONS

The following is a summary of findings based on the existing analyses and field observations:

Travel Time/Speed

- From the "floating car" travel time runs, the overall corridor speeds show the westbound direction of travel is approximately 2 mph slower during the PM peak hour than during the AM peak hour. In the eastbound direction, speeds are approximately 7 mph slower during the PM peak hour.

Crash Analysis

- For the period from January 01, 2011 to December 31, 2013, a total of 306 police-reported accidents occurred along this segment.
- Rear end collisions were the most common type of crash in the corridor which is consistent with congestion related crash types.

Intersection Analysis

MD 177 at Solley Road/Waterford

- Eastbound queues on MD 177 from Solley Road/Waterford Road were observed to extend back to Mountain View Way multiple times throughout the peak hour causing cycle failure on some occasions. The long queue lengths cause turn bay blockage at Solley Road/Waterford Road. Queue lengths in SimTraffic exceed 2,000 feet.

MD 177 at Catherine Avenue/Outing Avenue

- Eastbound queues on MD 177 from Catherine Avenue spill back through Outing Avenue throughout the peak hour. Signal was green at Outing Avenue but vehicles were not able to proceed due to queues from Catherine Avenue. SimTraffic queues at Outing Avenue were over 2,000 feet.

MD 177 at Magothy Bridge Rd/Hog Neck Rd

- Eastbound MD 177 cycle failure was experienced once at Magothy Bridge Rd/Hog Neck Rd which is consistent with the LOS F in the PM peak hour.

MD 177 at Edwin Raynor Boulevard

- Eastbound queues on MD 177 at Edwin Raynor Boulevard spilled back through Tick Neck Road/Disney Ave and cycle failure was observed.

The next section identifies and evaluates several short-term improvement concepts that will address the findings above, tests expected traffic and safety operational benefits, and estimates construction costs and project benefit-to-cost ratios and life cycles.

IX. ALTERNATIVES DEVELOPMENT

Per previous consultation with District 5, the following proposed alternatives were chosen to be examined for congestion mitigation: (1) Widening to a 5-lane section between Solley Road and MD 100; (2) Intersection improvements at Solley Road, Catherine Avenue, Edwin Raynor Boulevard, and MD 607 on side streets.

A. Description

Alternative 1

Alternative 1 recommends widening MD 177 to a 5-lane section between Solley Road and MD 100. The cross section will consist of 2 lanes in each direction and a two-way left turn lane. Exclusive turn lanes will be maintained where already present. The additional through lanes on MD 177 will improve capacity and speeds throughout the corridor.

Alternative 2

Alternative 2 recommends intersection improvements along the MD 177 corridor at Solley Road, Catherine Avenue, Edwin Raynor Boulevard, and MD 607. Capacity improvements on the side streets allow for longer mainline phases, improving capacity and speeds on MD 177. Alternative 2 will include the following improvements:

<u>Solley Road/Waterford Road</u>

- 3rd southbound lane providing exclusive through and left turn lanes from Solley Road.
- 3rd northbound lane providing exclusive through and right turn lanes from Solley Road/Waterford Road

<u>Catherine Avenue</u>

- Extend 2nd northbound lane on Catherine Avenue to Schramms Crossing. Schrams Crossing is the entrance to Farmington Village located approximately 1500’ south of MD 177.

<u>Edwin Raynor Boulevard</u>

- Two northbound lanes on Edwin Raynor Boulevard are currently striped from just north of Deering Road to MD 177. However, the roadway width remains constant south of Deering Road allowing for restriping of the shoulder as a second northbound lane on Edwin Raynor Boulevard. The two northbound lanes would run from just north of the MD 100 bridge to MD 177.

MD 607 (Magothy Bridge Road/Hog Neck Road)

- Convert exclusive northbound right turn lane on Magothy Bridge Road to a shared through-right lane and provide 2nd northbound receiving lane on Hog Neck Road
- Convert exclusive southbound right turn lane on Hog Neck Road to a shared through-right lane and extend storage length.

B. Problems Addressed

Alternative 1

Operational issues addressed by Alternative 1 include eliminating all failing signalized intersections, improving PM peak average speeds by about 4 mph, reducing PM network delay by over 30%, and reducing PM travel time by over 15%.

The primary benefit of this Alternative is operational; however, roadway widening is expected to have a substantial safety benefit as well. The safety benefit of widening is a reduction in rear-end and sideswipe collisions due to the reduced congestion expected from additional lanes.

Alternative 2

Alternative 2 was found to have very similar operational benefits to mainline widening. Operational issues addressed by Alternative 2 include eliminating all failing signalized intersections, improving PM peak average speeds by about 5 mph, reducing PM network delay by over 25%, and reducing PM travel time by over 15%.

It should be noted although the intersection improvements in Alternative 2 did not directly modify the intersection of MD 177 at Outing Avenue, MD 177 at Catherine Avenue and MD 177 at Outing Avenue are tied together with relays. Catherine Avenue runs free and the signal at Outing Avenue is dependent upon what occurrs at Catherine Avenue.

The primary benefit of Alternative 2 is operational as well. There is a minor reduction of crashes at the intersection of Solley Road due to the addition of exclusive left and right turn lanes. The other intersection improvements as part of Alternative 2 were assumed to have a negligible effect on crashes.

X. CONCEPT PLAN

Concept plans were developed for all proposed alternatives in order to come up with cost estimates and better estimate necessary right-of-way acquisitions and environmental impacts.

A. Geometric Assumptions / Cross-sections

Some geometric assumptions were necessary in coming up with the standard cross-sections for each alternative. The assumptions for each alternative are described below.

Alternative 1
For Alternative 1, a full mill and overlay with widening is assumed. The two-way left turn lane would remain and an additional through lane in each direction would be included in the proposed 5-lane section along with sidewalks and shoulders. Exclusive turn lanes were assumed to be maintained where already present. **Figure 10** shows the concept plan.

Alternative 2
For Alternative 2, all work is assumed to be on the side streets only and no mainline resurfacing, sidewalk construction, etc. is assumed. Along Catherine Avenue and Edwin Raynor Boulevard, the Alternative involves removing shoulder areas that can currently be used by bicycles in order to add capacity. Although not included in the cost estimate, it appears utilities would be a large cost incurred on this project. There are numerous runs of overhead lines that would need to be relocated. **Figure 11** shows the concept plan.

XI. PROJECT COST ESTIMATE

Construction cost estimates were developed for each alternative using SHA's Major Quantities Estimates methodology. The total project cost for Alternative 1 and Alternative 2 were estimated to be $12.5 million and $2.1 million, respectively. A detailed cost estimate break down is provided in **Appendix F**.

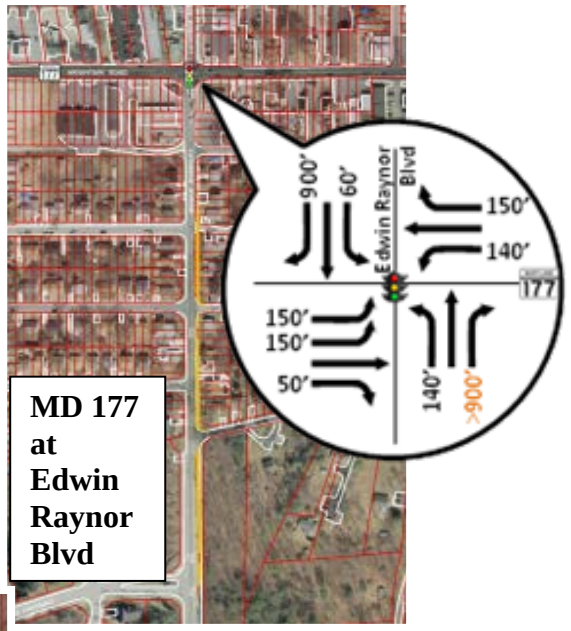
A. Major Quantities Estimates Methodology

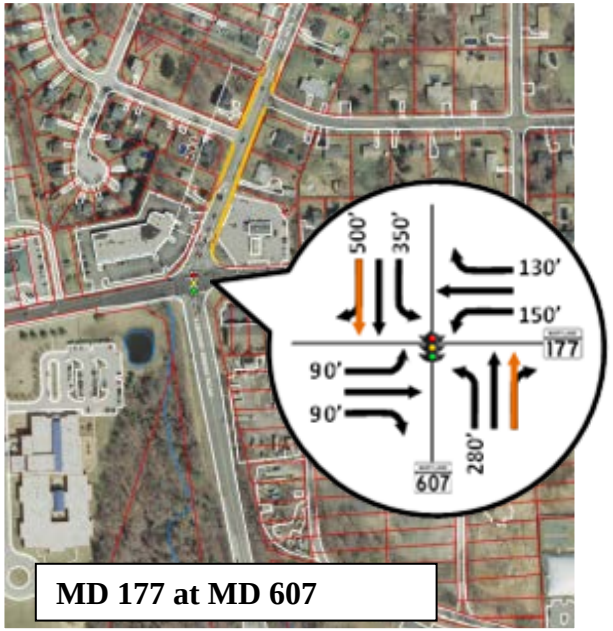
Major Quantities Estimates are used to estimate construction costs during the planning stage and early in the preliminary engineering stage. The idea is to estimate as accurately as possible those categories that can be estimated in the very early stages such as Grading, Paving, Structures and Shoulders items and compute the remaining categories as percentages of those categories. A total of ten categories were used for estimates.

It should be noted that the cost estimates provided for each alternative do not include right of way and underground utility costs although they may be covered in %-based items/contingencies.

Figure 10: Alternative 1 Concept Plans

Figure 21: Alternative 2 Concept Plans





B. Key Risks

A key risk was considered any type of complication that may negatively affect the success of the proposed alternative improvements. The risk categories identified for this study were environmental, permitting, and structural. The alternatives would have structural risks including utility impacts for both alternatives and bicycle impacts (removal of shoulder in certain areas) for Alternative 2. Both alternatives would also have permitting risks with the need to impact additional right-of-way.

C. "Alternative" Funding Opportunities

Alternative 1
There are no identified private or local funding opportunities at this time.

Alternative 2
Since Alternative 2 involves improvements to some County roads, there may be an opportunity for County funding.

XII. TRAFFIC SAFETY BENEFITS

A. CMF Methodology

Crash Modification Factors (CMFs) represent the relative change in crash frequency due to a change in one specific condition (when all other conditions and site characteristics remain constant). CMFs are the ratio of the crash frequency of a site under two different conditions. Therefore, a CMF may serve as an estimate of the effect of a particular geometric design or traffic control feature on the effectiveness of a particular treatment or condition. CMFs can be multiplied together to estimate the combined effects of the respective elements or treatments.

Most CMFs used are provided directly in the Highway Safety Manual (HSM) or on the Crash Modification Factors Clearinghouse website by FHWA. Some treatments are not listed in either source so factors were intuitively come up with that would be useful for analysis but are not from empirical data. Therefore, results should be used only for comparative analysis of the alternatives assuming the CMFs are applied consistently.

Alternative 1
Roadway widening was assumed to improve congestions and reduce rear-end and sideswipe crashes throughout the widened segment.

Alternative 2
The addition of an exclusive turn lanes is assumed to reduce crashes at the intersection of Solley Road. Although the other improvements of Alternative 2 provide operational benefit, no safety benefit was assumed.

B. CMF Calculation

CMFs were calculated by multiplying the applicable CMF(s) for each alternative by the number of crashes occurring on each segment or intersection that is affected by the improvement. The sum of the total number of crashes reduced by the improved segment(s)/intersection(s) was turned into a reduction percentage for all the crashes occurring along the study corridor. The number of crashes by type (i.e. fatal, injury, property damage only, pedestrian crashes) over a 3 year period were averaged and reduced by the overall percentage to develop the safety savings over the 20 year project life span.

For Alternative 1 a 3% reduction in crashes was assumed and for Alternative 2 a 1% reduction in crashes was assumed.

XIII. ECONOMIC DEVELOPMENTS

A. Land Use Forecasts

There are no known economic development projects under progress along the corridor.

B. Traffic Forecasts

Forecasts volumes were not necessary since there were no known economic development projects and expected project completion is less than 2 years.

XIV. TRAFFIC OPERATIONS ANALYSIS - ALTERNATIVES

The previously calibrated existing conditions models, described in the "Existing Conditions" section, were modified to reflect each alternative.

An Alternative 1 and Alternative 2 scenario were modeled to reflect the improvements discussed in the "Alternatives Development" section.

A. Methodology

The operations analysis was performed using Synchro™ and SimTraffic™ software. Synchro is a macroscopic and deterministic traffic signal timing and analysis software program which implements the methodology of the Highway Capacity Manual. SimTraffic is a microscopic simulation and animation software program.

Synchro implements Highway Capacity Manual (HCM) 2000 methods of analysis which were used for the intersection capacity analyses of all study intersections. Performance measures of effectiveness include level of service (LOS), volume-to-capacity (v/c) ratio, and average vehicle delay. In SimTraffic, five 60 minute simulations with a 15 minute seeding intervals were run for each peak hour which can report network performance measures and 95th percentile queue lengths.

B. Intersection Capacity Analysis

The AM peak hour No Build, Alternative 1, and Alternative 2 LOS results are displayed in **Figure 12**. The PM peak hour No Build, Alternative 1, and Alternative 2 LOS results are displayed in **Figure 13**. **Table 8** summarizes the comparison of the No Build, Alternative 1, and Alternative 2 capacity analysis.

Detailed HCM reports for all alternatives are contained in **Appendix G**.

During the PM peak hour, the LOS for MD 177 at Outing Avenue improves from a LOS F to LOS C in Alternative 1 and LOS E in Alternative 2. The intersection of MD 177 at Magothy Bridge Road/Hog Neck Road also improves from LOS F to LOS C in both alternatives during the PM peak hour.

C. Queuing Analysis

Queuing was assessed using the 95th percentile queues reported from five 60 minute SimTraffic simulations with 15 minute seeding intervals for each peak hour.

Since Alternative 1 was not advanced as a preferred alternative, a detailed queuing analysis was not performed.

A brief summary of the differences between critical queues in the No Build and Alternative 2 are shown below:

- During the PM peak hour, turn bay spillover for the right turn lane from westbound MD 177 onto Hog Neck Road is eliminated as 95th percentile queues are reduced from 292’ to 117’.
- The eastbound through queue on MD 177 at Edwin Raynor Boulevard is reduced from 979’ to 476’ during the PM peak hour.
- The eastbound through queue on MD 177 at Outing Avenue (signal cluster with Catherine Avenue) is reduced from 2,127’ to 510’ during the PM peak hour.
- The eastbound through queue on MD 177 at Waterford Road/Solley Road is reduced from 2,204’ to 617’ during the PM peak hour.

Queues for the four intersections with proposed improvements are shown in **Table 9**. Queuing reports are included in **Appendix H**.

Figure 12: AM Peak Hour LOS Comparison

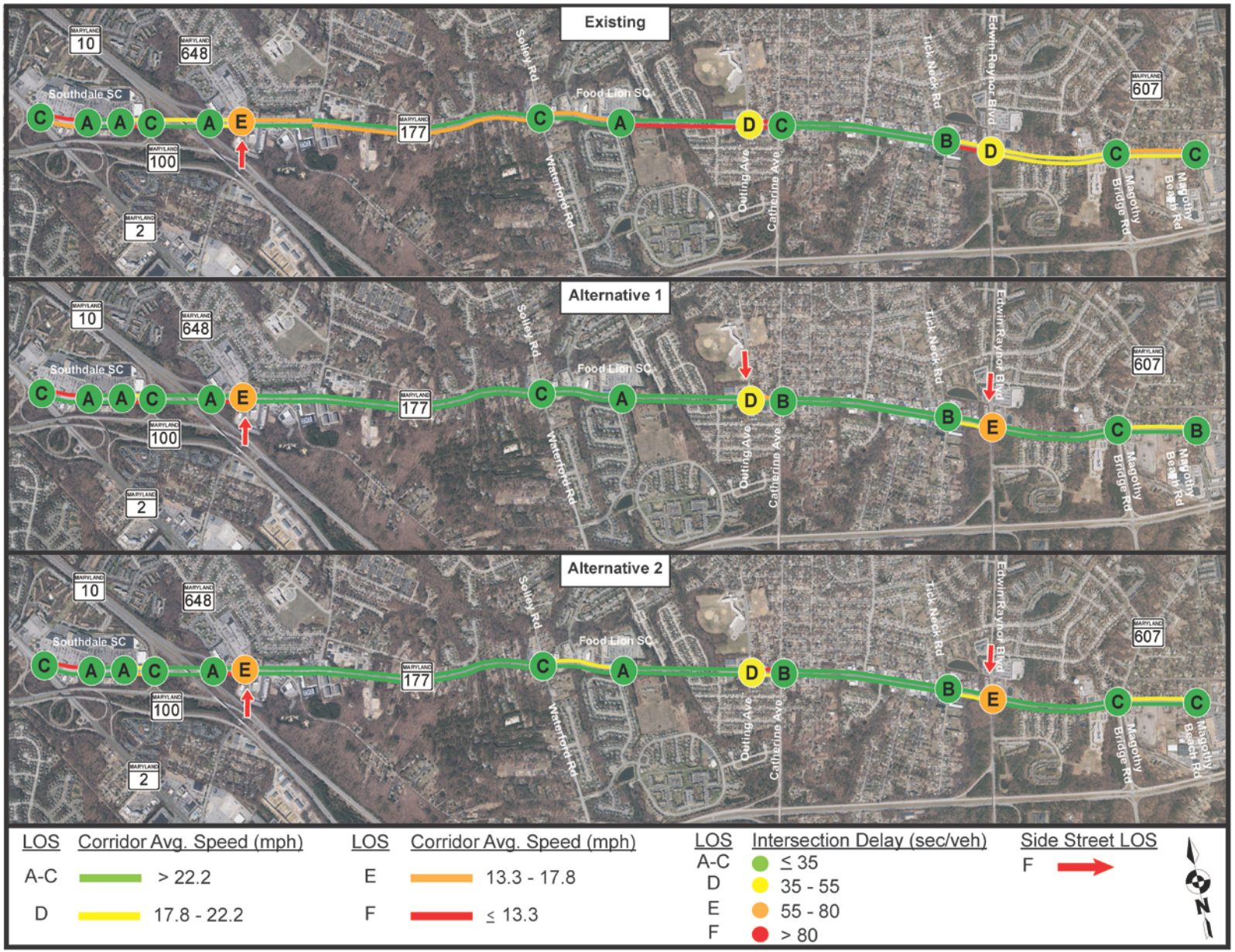


Figure 13: PM Peak Hour LOS Comparison

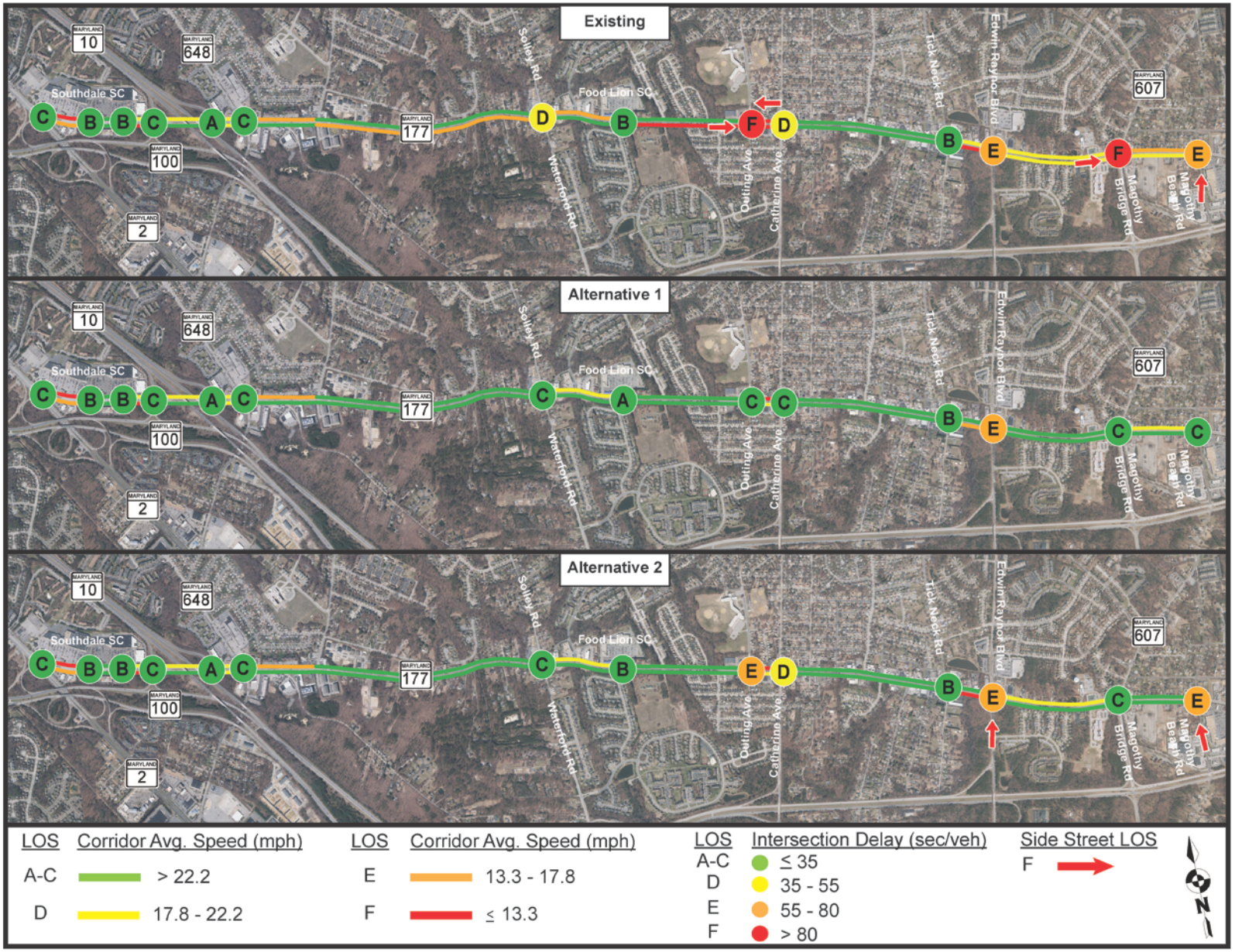


Table 8: LOS Comparison

Intersection	Approach	Existing - AM (PM)			Alternative 1 - Widening			Alternative 2 - Intersection Improvements		
		LOS	Delay / Veh (sec)	V/C	LOS	Delay / Veh (sec)	V/C	LOS	Delay / Veh (sec)	V/C
MD 2 & Ramp from MD 100/MD 177	**Overall**	C (C)	20.6 (26.5)	0.29 (0.46)	No Change			No Change		
Car Dealership/Southdale SC & MD 177	**Overall**	A (B)	6.7 (15.3)	0.17 (0.29)	No Change			No Change		
MD 177 & Home Depot	**Overall**	A (B)	7.9 (16.1)	0.16 (0.26)	No Change			No Change		
MD 100 WB Ramp/MD 10 SB Ramp & MD 177	**Overall**	C (C)	20.4 (33.9)	0.65 (0.76)	No Change			No Change		
MD 177 & Ramp to MD 10 NB	**Overall**	A (A)	2.0 (0.7)	0.45 (0.34)	No Change			No Change		
Jumper's Hole Rd/MD 648 & MD 177	**Overall**	E (C)	59.7 (31.4)	0.76 (0.47)	No Change			No Change		
Cameryn Pl/Freetown Rd & MD 177	**Overall**	F (F)	76.1 (317.5)	0.97 (0.71)	No Change			No Change		
Waterford Road/Solley Rd & MD 177	**Overall**	C (D)	34.7 (45.3)	0.72 (0.75)	C (C)	26.0 (28.2)	0.59 (0.65)	C (C)	25 (25.3)	0.78 (0.76)
MD 177 & Mountain Marketplace Primary	**Overall**	A (B)	8.9 (12.4)	0.57 (0.73)	A (A)	6.3 (8.0)	0.34 (0.45)	A (B)	8.9 (12.4)	0.57 (0.73)
Outing Avenue & MD 177	**Overall**	D (F)	44.3 (206.4)	0.65 (0.66)	D (C)	44.6 (30.2)	0.50 (0.38)	D (E)	35.1 (62.8)	0.64 (0.58)
Catherine Ave & MD 177	**Overall**	C (D)	24.2 (41.2)	0.58 (0.95)	B (C)	13.3 (32.9)	0.73 (0.86)	B (D)	18.2 (43.3)	0.71 (1.04)
Disney Ave/Tick Neck Road & MD 177	**Overall**	B (B)	14.8 (17.7)	0.35 (0.69)	B (B)	13.4 (12.7)	0.28 (0.47)	B (B)	14.8 (17.7)	0.35 (0.69)
Edwin Raynor Boulevard & MD 177	**Overall**	D (E)	40.2 (57.6)	0.59 (0.86)	E (E)	65.9 (55.7)	0.59 (0.86)	E (E)	66.7 (61.2)	0.71 (1.04)
Magothy Bridge Rd/Hog Neck Road & MD 177	**Overall**	C (F)	34.4 (82.6)	0.71 (0.98)	C (C)	22.1 (34.3)	0.69 (0.88)	C (C)	23.6 (34.1)	0.65 (0.89)
Magothy Beach Rd/Park Ave & MD 177	**Overall**	C (E)	22.2 (73.4)	0.66 (0.94)	B (C)	14.7 (23.1)	0.46 (0.69)	C (E)	22.2 (73.4)	0.66 (0.94)

Table 9: 95th Percentile Queue Lengths Comparison

Intersection	Approach	Distance to Next Intersection (ft)	Intersecting Road Name at Nearest Intersection	No Build 95th Percentile Queue Length (ft) - AM (PM)	Alternative 2 95th Percentile Queue Length (ft) - AM (PM)
				Existing	Alternative 2
MD 177 at Hog Neck Road / Magothy Bridge Road	EBL	200	Left Turn Bay	120 (183)	97 (156)
	EBT	2,555	Edwin Raynor Blvd	327 (756)	241 (453)
	EBR	200	Right Turn Bay	142 (127)	113 (131)
	WBL	250	Left Turn Bay	97 (83)	76 (30)
	WBT	860	Roys Drive	214 (384)	176 (200)
	WBR	250	Right Turn Bay	102 (292)	81 (117)
	NBL	375	Left Turn Bay	47 (331)	46 (120)
	NBTR	1,695	Paul Pitcher Memorial Hwy	179 (579)	139 (224)
	SBL	375	Left Turn Bay	174 (155)	95 (122)
	SBT	410	Westwood Manor Way	387 (208)	149 (98)
	SBR	150	Right Turn Bay	132 (54)	-
MD 177 at Edwin Raynor Blvd.	EBL	300	Left Turn Bay	84 (388)	57 (329)
	EBT	825	Disney Ave	276 (979)	181 (476)
	EBR	200	Right Turn Bay	136 (264)	70 (254)
	WBL	175	Left Turn Bay	132 (181)	82 (212)
	WBT	2550	Magothy Bridge Rd /Hog Neck Rd	218 (497)	150 (362)
	WBR	375	Right Turn Bay	45 (253)	41 (137)
	NBL	175	Left Turn Bay	99 (257)	73 (256)
	NBT	700	Deering Rd	194 (728)	123 (746)
	NBTR	460	Right Turn Bay	160 (542)	92 (712)
	SBL	200	Left Turn Bay	243 (200)	261 (177)
	SBTR	790	Old Crown Dr/Littleton Way	405 (264)	445 (238)
MD 177 at Catherine Avenue	EBL	275	Left Turn Bay	109 (283)	66 (184)
	EBT	577	Outing Avenue	363 (529)	167 (235)
	EBR	250	Right Turn Bay	231 (250)	108 (120)
	WBL	175	Left Turn Bay	215 (229)	211 (214)
	WBTR	563	E Shore Rd	393 (757)	338 (330)
	NBLT	190	227th St	126 (673)	114 (726)
	NBR	325	Right Turn Bay	82 (429)	90 (601)
	SBLTR	190	225th St	98 (126)	95 (120)
MD 177 at Outing Avenue	EBL	150	Left Turn Bay	55 (131)	38 (126)
	EBTR	580	Mayer Ave	301 (2127)	278 (510)
	WBTR	580	Chaterine Avenue	304 (467)	226 (319)
	NBLTR	421	228th St	51 (93)	45 (65)
	SBLT	710	Cuba Dr	323 (179)	301 (167)
	SBR	225	Right Turn Bay	226 (123)	203 (122)
MD 177 at Waterford Road/ Solley Road	EBL	175	Left Turn Bay	90 (248)	72 (232)
	EBT	417	Carnene Rd	187 (2204)	161 (617)
	EBR	150	Right Turn Bay	72 (215)	64 (215)
	WBL	200	Left Turn Bay	218 (168)	179 (131)
	WBTR	625	Mountain Eastate Dr	499 (672)	428 (386)
	NBL	175	Left Turn Bay	145 (229)	112 (115)
	NBTR	1,580	Champion Ln	156 (473)	117 (154)
	SBLT	1220	Sangria Ct	229 (292)	125 (129)
	SBR	250	Right Turn Bay	132 (167)	95 (73)

D. Network Performance

Network performance measures such as average speeds, travel time, and delay can be output from SimTraffic. Some of the critical outputs are shown in the **Table 10** below. SimTraffic performance reports are included in **Appendix I**.

Table 10: Network Performance Comparison

Performance Measures	Existing - AM (PM)		Alternative 1 - Widening		Alternative 2 - Intersection Improvements	
	AM	PM	AM	PM	AM	PM
Average Network Speed (mph)	19	16	21	20	20	19
Average Delay (seconds)	54.2	90.4	47.5	60.2	51.2	66.2
Total Delay (hours)	156.5	342.7	137.4	227.8	148.3	250.5
Travel Time (hours)	565.7	653.0	527.8	543.0	536.0	552.2

XV. BENEFIT TO COST RATIO

SHA has a standard Benefit-Cost Analysis Tool that was used for the benefit to cost ratio calculation. The Benefit-Cost analysis spreadsheet tool is designed for computing and comparing benefits and costs of a project.

A. Key Assumptions

Several key assumptions were necessary in order to compute the Benefit to cost ratio. These assumptions include the following:

- Project Life Span – 20 years
- Hours of AM and PM peak – 2 hours each peak
- Heavy Vehicle Percentage – Corridor specific from I-TMS
- Annual Traffic Growth Factor – Corridor specific from I-TMS
- Annual Growth in Heavy Vehicle Percentage – Assumed to be same as auto growth
- Working Days Per Year – 250
- Average Vehicle Occupancy – 1.2
- Auto Congestion Cost Per Hour - $25.68
- Truck Congestion Cost Per Hour - $66.08
- Reliability Ratio – Heavy Vehicles – 2.0
- Annual Depreciation in Travel Time Reliability (%) – 3
- Fuel Savings Per Hour of Delay Savings – $0.72
- Salvage Value – 10%
- Annual Inflation Rate – 2.30%
- Annual Discount Rate – 2.32%
- Accident Cost Data
    - Fatal - $1,453,861
    - Injury - $81,355
    - Property Damage Only - $9,177
    - Pedestrian Crashes - $64,139
- No-Build Operations and Maintenance Cost – 15%
- Operation Cost (Project Life Span) – 10%

B. Calculation

The Benefit Cost spreadsheet sums the safety and operational benefits together to get the total benefit and divides the total benefit by the sum of the project cost plus operations and maintenance cost over 20 years.

In order to calculate the benefit to cost ratio, the spreadsheet also needs several corridor and alternative specific inputs. These inputs include crash data and a CMF or percentage reduction in crashes to calculate the safety benefit. To calculate the operational costs network delay and travel time data from the 5 SimTraffic runs are necessary. Also, alternative construction cost is necessary to calculate the total cost.

The benefit to cost ratio for Alternative 1 was 3.4 and for Alternative 2 was 16.8. A detailed summary is included in **Appendix J**.

XVI. PREFERRED ALTERNATIVE

Based on the results of the Traffic Operations Analysis, Alternative 2 (intersection improvements on side streets of Solley Road, Catherine Avenue, Edwin Raynor Boulevard, and MD 607) has been identified as the Preferred Alternative for the MD 177 study corridor. Alternative 2 resulted in a significant improvement in operational delays and LOS from both an intersection level and roadway network perspective. From a safety standpoint, improvements from Alternative 2 are shown to reduce the expected number of crashes in the corridor by approximately 1%, contributing to an overall Benefit/Cost Ratio estimated at 16.8. A Benefit/Cost Summary is provided in **Table 11** below.

Table 11: Preferred Alternative Benefit/Cost Summary

Safety Savings (millions)	Operational Savings (millions)	Benefit/Cost	Cost Estimate (millions)	ROW Impacts (acres)
$0.5	$38.8	16.8	$2.1*	0.7

*ROW costs not included

The Preferred Alternative has been retained for more detailed design after consideration and input provided from Senior Management, District Offices, the Office of Traffic and Safety, and the Office of Planning and Preliminary Engineering.

XVII. NEXT STEPS

Upon submittal of this Arterial Congestion Management Study Final Report to SHA's District 5 – Traffic Office, all alternatives analyzed in this report will be reviewed, as well as the proposed improvements associated with the Preferred Alternative. With concept approval of the Preferred Alternative, the following process will take place:

- Approval of Concept by the Office of Traffic and Safety
- Concept design development by District 5 Engineering Systems Team
- Concept design review and approval by the Chief Engineers/Senior Management
- Final design
- Advertisement of project
- Construction of project

It is anticipated that construction completion would occur in the Fall of 2017 or Spring of 2018 timeframe.