



# MD 924 Multi-Modal Corridor Study

## Volume II – Operational Analysis





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**MD 924 MULTI-MODAL CORRIDOR STUDY**  
**VOLUME II: OPERATIONAL ANALYSIS**

**I. INTRODUCTION**

**A. Overview**

As noted in *Volume I – Existing Conditions*, the operational analyses focused on the MD 924 and MD 24 corridors, and the roadways linking the two facilities. The study area is illustrated in Figure I.1. Currently, MD 924 serves local trips in addition to commuter traffic destined to I-95 and points east. The character of the MD 924 corridor should be less suburban and more characteristic of a livable and complete street that is inviting to multi-modal transportation, including non-motorized methods of travel, with joint use trails and transit. The MD 24 corridor, which parallels MD 924, was identified as the route to accommodate the major traffic flows to and from the I-95 interchange, diverting traffic from MD 924.

To facilitate access to MD 24, future design-year study area capacity upgrades focused on improved access to MD 24 with upgraded links from MD 924. Two design-years were selected for the future conditions analyses - a medium-term 2025, and a long-range 2040 Design-Year. Saturday analyses were not included for the future design-years since the weekday volumes controlled in the existing conditions analyses presented in *Volume I – Existing Conditions*.

The traffic projections for each target design-year were based on two factors – regional annual growth in traffic and trips generated by site specific developments in the study area. Once the volumes were determined, level of service and queue assessments were conducted with Synchro/SimTraffic, Critical Lane Analysis and SHA 95% Probability methodologies to determine areas of deficient operations. Mitigation measures were identified to provide acceptable intersection operations. Preliminary constructability reviews were performed to verify that the proposed roadway upgrades could be constructed with minimal impacts to adjacent properties.

The text that follows outlines the methodology employed in developing the design-year traffic volumes. Analyses are presented for upgrades that could be implemented prior to 2025, along with analysis results and upgrades for 2025 and 2040. Alternatives considered to address traffic demands, but not carried forward, are also noted. Similar to *Volume I – Existing Conditions*, the corridor has been divided into zones to facilitate the presentation of the analyses. The zones are:

- Zone 1 Woodsdale Road to Holly Wreath Road/Holly Wreath Court
- Zone 2 Holly Wreath Road/Holly Wreath Court to Patterson Mill Road/Barrington Place
- Zone 3 Patterson Mill Road/Barrington Place to MacPhail Road





**II. TRAFFIC VOLUME PROJECTIONS-BACKGROUND GROWTH**

**A. Annual Growth Rates**

Harford County policy regarding annual growth rates for Traffic Impact Studies is a 2.2% per year rate. Concern was expressed that the 2.2% growth rate for the typical three to five year horizon year of a Traffic Impact Study, would not be appropriate for a long-range study with 2025 and 2040 Design-Years. As an example, if a 2.2% annual growth rate was applied to the existing evening peak hour northbound through volume at the MD 24/Singer Road intersection, the volume would increase from 1,924 to 3,315 in 2040. To determine an alternative to the 2.2% annual growth, several sources were consulted including: historical traffic data from the SHA, planning studies from the Baltimore Metropolitan Council (BMC) and Harford County, in addition to work performed by the SHA’s Travel Forecasting and Analysis Division (TFAD).

**1. Historical Traffic Volumes:**

Typically, annual growth rates are derived through a review of historical traffic volume growth trends based on a year-to-year comparison. Traffic volume data along MD 924 and MD 24 were reviewed to determine an annual growth rate. Available traffic data is provided in Table II.1 for MD 924 and Table II.2 for MD 24. As noted, data was not available for all years. Review of the tables reveal that traffic volumes have generally been decreasing (blue) over the last several years. For instance, along MD 924, east of MD 24, volumes dropped from 32,089 in 2007 to 21,373 in 2011.

**Table II.1**

**Historical Traffic Volumes MD 924  
MD 924 Multi-Modal Corridor Study**

Location	MD 924 AADT-YEAR							
	2015	2012	2011	2010	2009	2008	2007	2006
East of MD 24	-	-	21373	-	-	-	32085	-
.10 Mi S of Wheel Rd	21328	20192	-	-	19046	-	-	19956
.20 Mi N of Ring Factory Rd	19545	20840	-	-	19729	-	-	22951

**Table II.2**

**Historical Traffic Volumes MD 24  
MD 924 Multi-Modal Corridor Study**

Location	MD 24 AADT-YEAR							
	2014	2013	2012	2010	2009	2008	2007	2006
.10 Mi N of Wheel Rd	-	40988	-	42901	-	-	43025	-
.20 Mi N of W. Ring Factory Rd	-	40212	-	46129	-	-	47554	-
.20 Mi S of Wheel Rd	-	43843	-	43346	-	-	48273	-
.40 Mi N of MD 924	43898	43904	44593	-	45891	45504	43634	43581



**2. Maximize 2040:**

Population growth data was included in the BMC Maximize 2040 final plan. The population forecast for Harford County assumes an 18.9% change from 2010 to 2040, correlating to an average 1.58% increase in the population yearly within 30 years. Based on the BMC’s Maximize 2040 final plan, from 2015 to 2040 the population will increase from 251,991 to 291,089 yielding a 1.56% annual growth rate. The employment forecast in Harford County was also considered in projecting traffic growth. From the Maximize 2040 plan, employment in Harford County from 2010 to 2040 will increase by 59.8%. The projected growth will yield an annual increase of 2.08% per year.

**3. Harford NEXT:**

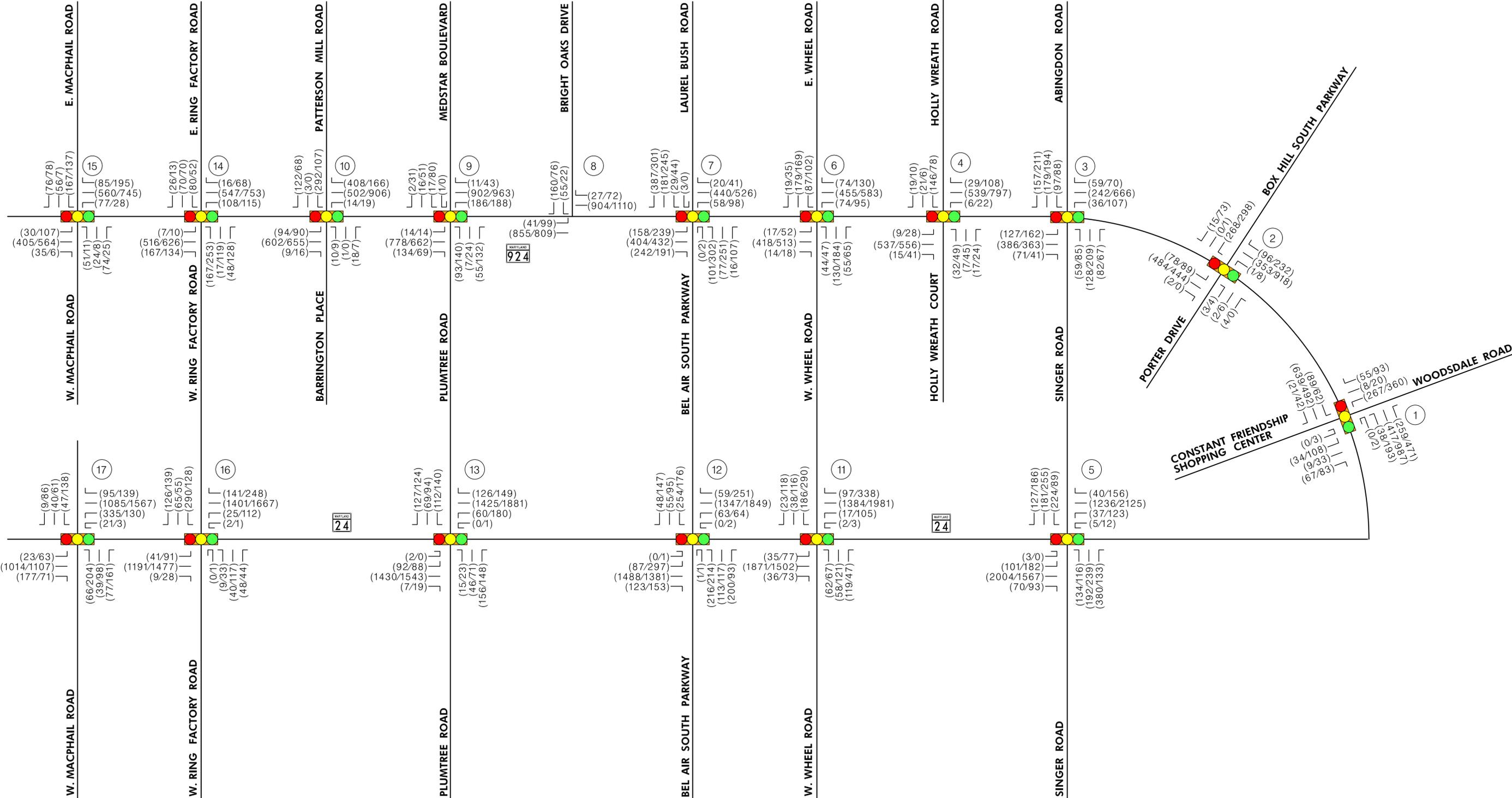
The comprehensive plan update Harford NEXT includes population growth assumptions similar to Maximize 2040. Harford County’s population was estimated to be 250,025 in 2015, and the data provided in the plan update predicted a population increase of 41,000 new residents by 2040. Based on the data presented by the County the annual percent increase would be 1.64%. The population is estimated to be 291,090 in 2040.

**4. SHA TFAD:**

The SHA TFAD is responsible for developing design-year traffic projections for all SHA design projects. SHA TFAD was contacted to determine if any recent studies were conducted regarding traffic growth along MD 924 and MD 24. The SHA has not performed formal planning studies along the MD 924 or MD 24 corridors in the past 10 years. However, several paving projects have been prepared that include a 20-year projection of traffic volumes, to develop the pavement section design. According to the recent SHA paving projects, a 20-year annual growth rate for MD 924 should be between 1.0% and 1.5%, and for MD 24, a 1.5% to 2% increase. It is important to note that the figures provided by the SHA represent total growth, which includes the trips generated from individual developments in the area, in addition to a regional annual growth rate. The SHA also noted that the growth rate for MD 24 is based on the facility being widened to six lanes by 2040.

**B. Resultant Annual Background Growth**

Given the variance in traffic volume growth trends, WBCM met with representatives of Harford County Planning and Zoning, SHA TFAD and BMC to discuss an appropriate traffic projection scenario. Based on the discussions, it was determined that a 1.0% annual growth rate would be applied to the through movements along MD 24 and a 0.5% annual growth rate be employed for the through movements along MD 924. The growth factors were applied to the mainline through movements as an initial calculation. The resultant volumes were then reviewed to verify that the numbers provided similar trends to the existing counts, related to increases or decreases in volumes between intersections. The additional reviews also included verification that volumes balanced between the intersections along MD 24 and MD 924 that had no intersecting roadways or driveways. If adjustments were required, volumes were adjusted by increasing the left or right turn volumes of the mainline and side road approaches. In all cases, volumes were increased as part of the adjustments to model a conservative approach. The resultant volumes are illustrated in Figure II.1 for the 2025 Design-Year and Figure II.2 for 2040.



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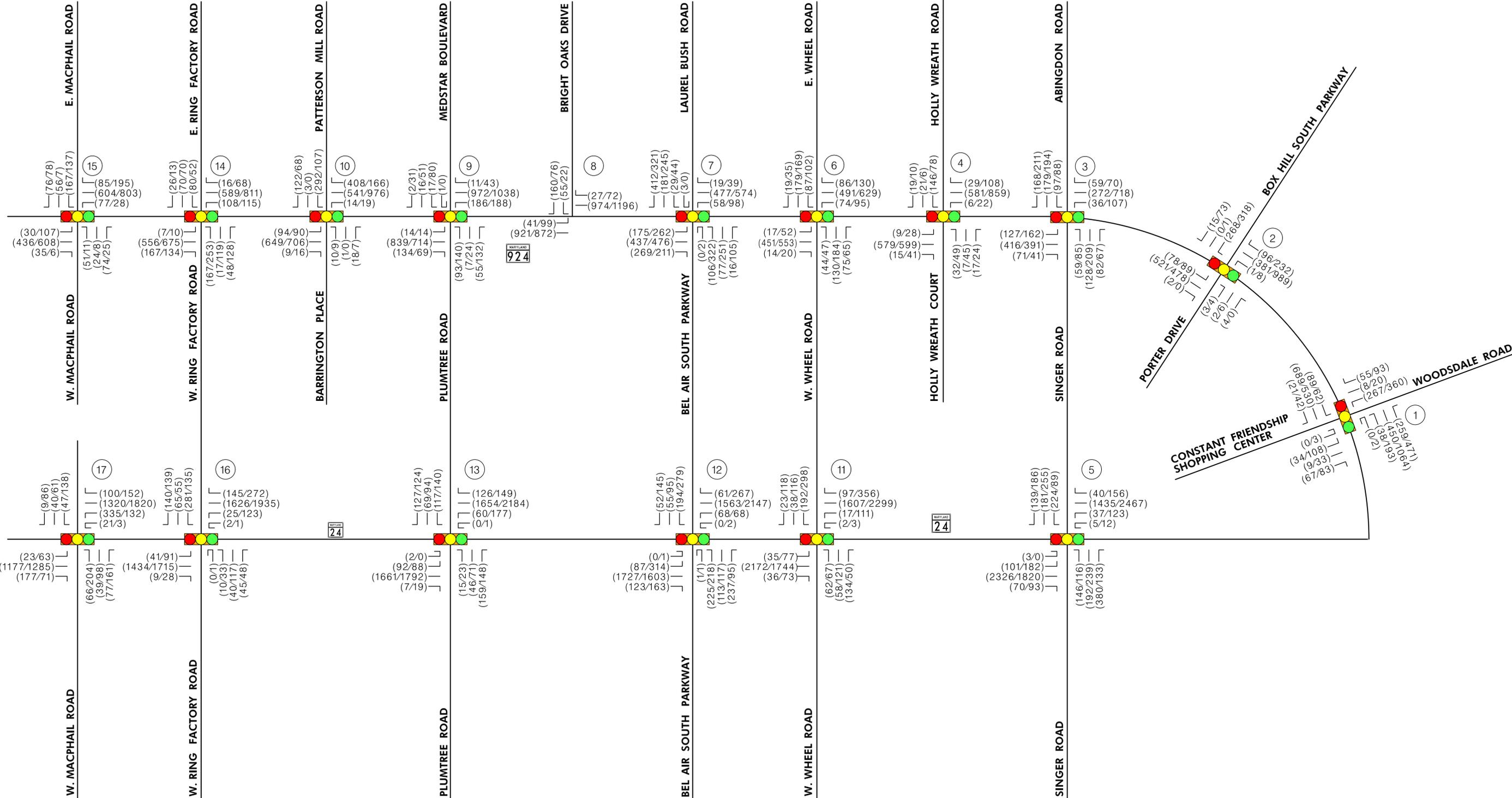
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**MARYLAND 924**

2025 ANNUAL GROWTH VOLUMES

SCALE: N.T.S.    FIGURE II. 1    JUNE 2017

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**MARYLAND 924**

2040 ANNUAL GROWTH VOLUMES

SCALE: N.T.S.    FIGURE II. 2    JUNE 2017

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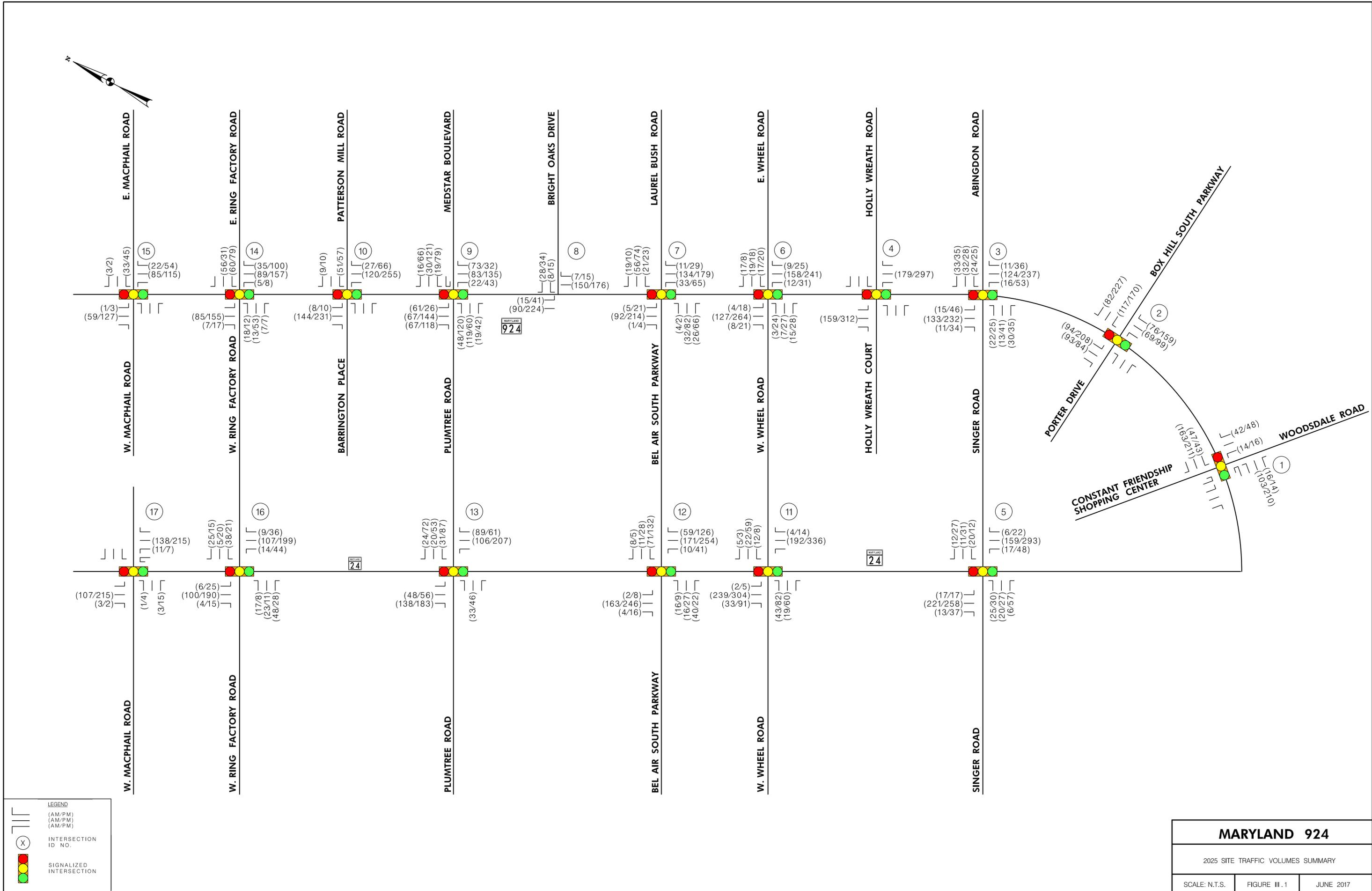
### **III. TRAFFIC VOLUME PROJECTIONS-LOCAL DEVELOPMENT**

Harford County Planning and Zoning was contacted to verify planned developments, potential parcel yields, and current counts of units yet to be constructed associated with approved developments located within the study area. Also, the Harford County web site was reviewed to determine if any other potential developments were pending in the study area.

Several factors were analyzed when developing the traffic volume projections based on local development:

- Harford County Development Data: Harford County data was used to account for development that could influence the MD 924 and MD 24 corridors.
- Study Area Development: Development Potential - Open parcels adjacent to the study area were analyzed to determine their likelihood of being developed by 2040.
- Trip Generation: ITE Trip Generation Manual (9<sup>th</sup> Edition) was used to quantify the highest volume generated by the development based on current zoning.
- Trip Distribution: Potential new trips were distributed to the roadway network based on distribution percentages included in a memo to Harford County on March 30, 2016 (included in Appendix II.A).

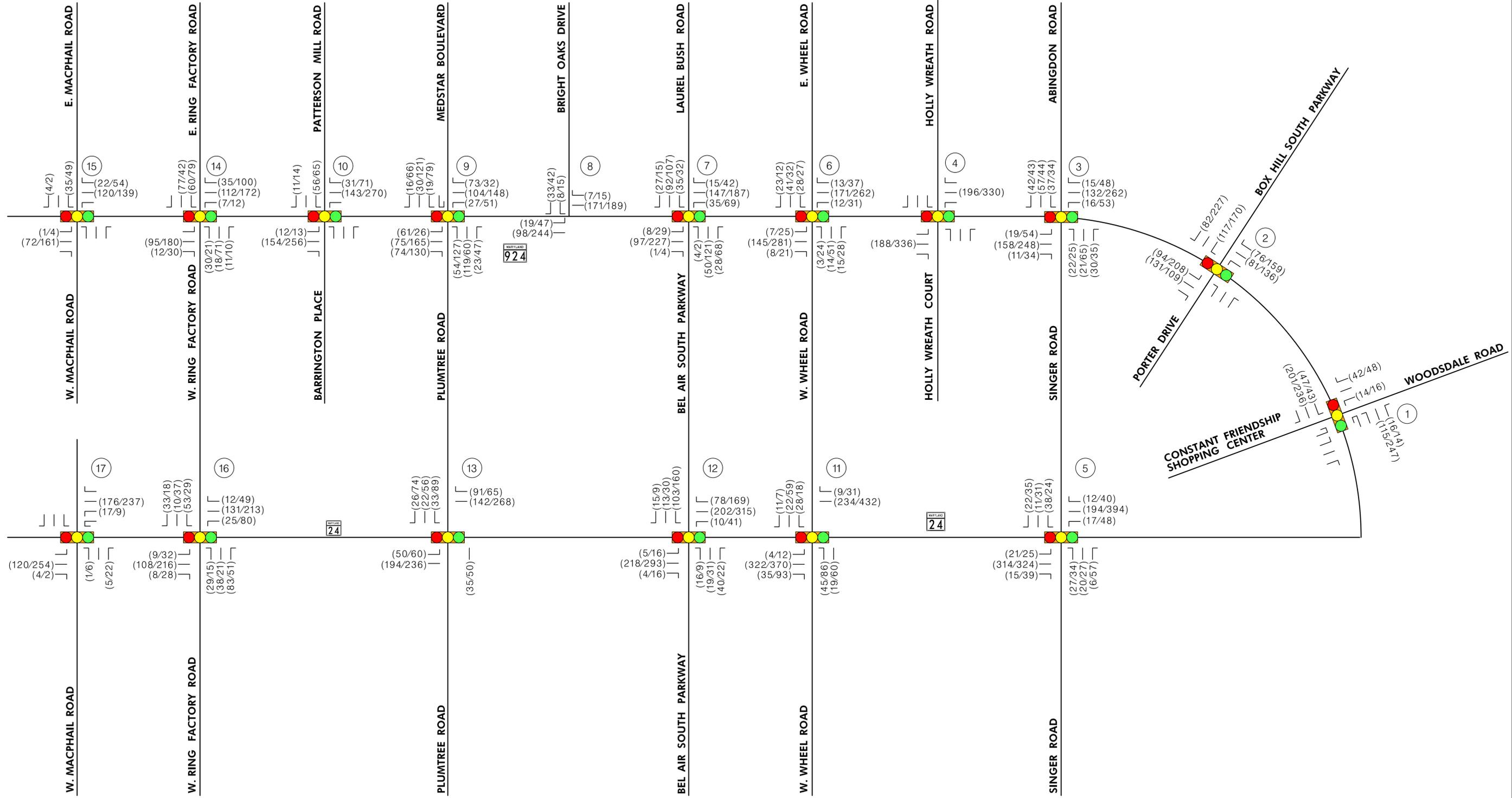
A detailed description of the local development data and calculated traffic projections is provided in Appendix II.A. Design-Year 2025 Site Traffic Volumes (Figure III.1) and the Design-Year 2040 Site Traffic Volumes (Figure III.2) were developed based on the traffic projections.



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<b>MARYLAND 924</b>		
2025 SITE TRAFFIC VOLUMES SUMMARY		
SCALE: N.T.S.	FIGURE III.1	JUNE 2017



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<b>MARYLAND 924</b>		
2040 SITE TRAFFIC VOLUMES SUMMARY		
SCALE: N.T.S.	FIGURE III. 2	JUNE 2017

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#### IV. PRIOR TO 2025

##### A. Road Safety Audit and Walkability Audit Overview

A Road Safety Audit (RSA) was performed to identify potential hazards along the roadway that could impact safety. The RSA focused on roadway elements (sight distance, alignment, shoulders, obstructions in clear zone, drainage, driveway access, etc.), traffic control devices (signing, pavement markings, signals), lighting and transit stops. The data was summarized in checklist format to facilitate standardization of responses and to clearly define the review elements. The reviews included both intersections and mid-block segments. Similar to the RSA, the Walkability Audit (WA) was based on a series of checklist items related to how well pedestrians and bicyclists can negotiate an area. The WA included elements such as path accessibility or obstructions, ease of crossing the street, pedestrian amenities (benches, shelters, etc.), appropriate warning signing, signals, driver behavior towards pedestrians and bicyclists, and identification of major generators. The WA is based on definitive roadway elements; however, the audit included a subjective element relating to the pedestrian or bicyclists' comfort level using the corridor. The RSA was conducted concurrently with the WA along MD 924. The audits were conducted by members of the WBCM/Jacobs Joint Venture, Harford County Planning and Harford County Department of Public Works.

##### B. Road Safety Audit Results

The crash data summarized in *Volume I – Existing Conditions* did not reveal any major safety issues along the corridor. The RSA did not identify any major corridor-wide safety deficiencies. The general results of the RSA are summarized below and are detailed in Appendix I.E:

- All crosswalk and stop line markings should be refreshed throughout Zone 2 and 3 and south of St. Clair Drive in Zone 1.
- By law, all access driveways to major shopping centers and businesses must have pavement markings and signing that conform to the Maryland Manual on Uniform Traffic Control Devices (MDMUTCD). Most of the access drives have pavement markings of the wrong color or missing/faded signs.
- Guardrail should be considered along northbound MD 924 at the Truth House Ministry Church driveway about 750 feet north of Box Hill South Parkway due to the existing drainage structures.
- Install advanced signal ahead warning sign with a street name plaque and near side pedestal mounted signal head for northbound traffic at Woodsdale Road.
- Revise advanced street name signs to provide upper and lower case lettering.
- Install lane-use control signs where missing at signalized intersections.
- Install “End School Zone” and “Fines Double” signs to delineate the school zone adjacent to Ring Factory Elementary School.

##### C. Walkability Audit Results

The Walkability Audit revealed that sections of MD 924 without sidewalk were still walkable based on the presence of wide shoulders. The photo log, sample field sheet, and suggested signing upgrades are provided in Appendix I.E. Major factors identified from the walk include:

- Sidewalks, in general, did not have any utility poles or signs providing obstacles.



- Many of the older sidewalks are experiencing weed growth in the construction joints.
- Most of the intersections in the northern portion of the study area do not have ADA compliant ramps.
- Several intersections lack Accessible Pedestrian Signals (APS), Countdown Pedestrian Signals (CPS) and crosswalks.
- Many of the older existing sidewalk widths north of Ring Factory Road are less than the required 5 feet to meet ADA requirements.
- In areas north of Bright Oaks Drive, the existing sidewalk is experiencing major base failures adjacent to inlets.
- A more direct diagonal route could be provided from Bel Air South Parkway to the sidewalk north of Laurel Bush Road.
- Connectivity is provided along the entire MD 924 corridor with either sidewalk on one side of the road or wide shoulders. The only exception is in Zone 1 from the end of the sidewalk north of Porter Drive to the start of the sidewalk south of Abingdon Road.
- Bike lane availability is limited to the two lane section between Holly Wreath Road and East/West Wheel Road.
- Shoulders have been marked along MD 924; however, some of the shoulders are less than 5 feet wide and are not bicycle compatible.
- None of the roadways linking MD 924 with MD 24 are bicycle compatible.

In an effort to pinpoint areas of focus, a Walkability Score ranging from 1 (poor walkability) to 5 (good walkability) was given to sections of MD 924. A further breakdown of the sections and their associated scores is located in **Volume I – Existing Conditions** - Figures VII.1, VII.2 and VII.3.

#### D. Immediate Actions

The following items were identified for immediate action, prior to the 2025 Design-Year:

- Initiate Travel Demand (TDM) and Transportation Systems (TSM) Management Solutions
  - Initiatives to produce a 5% reduction in through traffic along MD 24 and MD 924 due to telecommuting, shifting commute times, etc.
  - Modify signal timing and phasing
  - Revise lane assignments within the existing footprint
- Transit Improvements
  - General Improvements: Make bus stops more accessible and increase span and frequency of service
  - Bus stop and route alignment improvements for Harford Transit LINK
  - Bus stop improvements for MTA Commuter bus
  - Install Park & Ride facility
  - Initiatives to increase transit ridership
- Physical Improvements
  - Crosswalk and stop line pavement marking upgrades
  - Guardrail improvements
  - Sidewalk improvements to meet current SHA and ADA standards
  - Pavement marking and signing upgrades that conform to the MDMUTCD

**Volume I – Existing Conditions** provides additional details of the proposed upgrades prior to 2025.



## V. SHORT-TERM (2025)

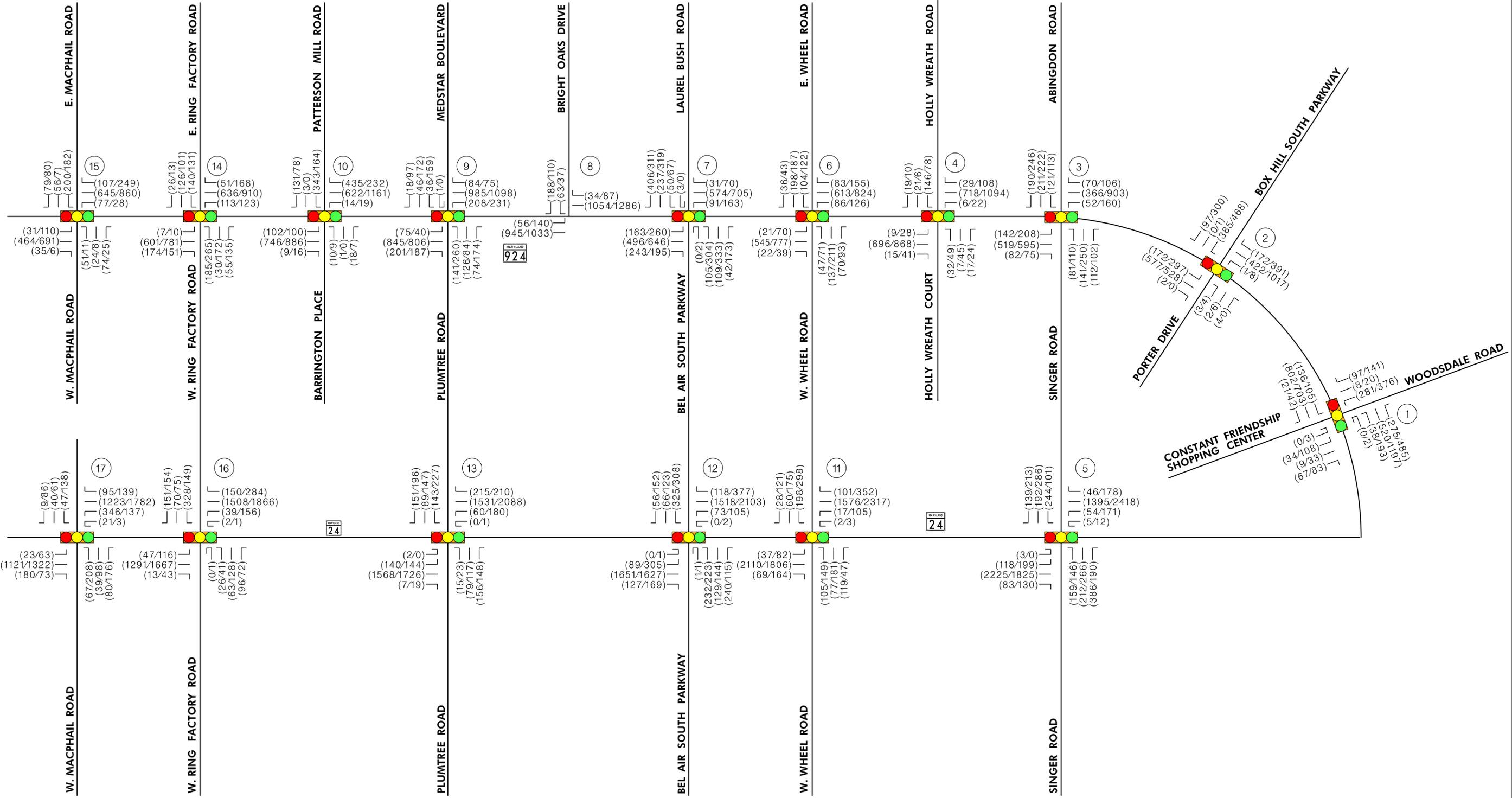
### A. Total Design-Year 2025 Traffic (No-Build) Volumes

The Design-Year 2025 background traffic volumes (Figure II.1) were added to the 2025 site generated trips (Figure III.1) to yield the Design-Year 2025 total traffic volumes. The resultant total No-Build volumes are illustrated in Figure V.1. The No-Build volumes represent the raw design-year volumes with no adjustment due to mitigation measures. The existing conditions analyses indicated several intersections were operating at or near capacity with minimal reserve capacity to accommodate additional traffic demand. The required roadway capacity cannot be achieved through signal optimization or by adding a turn lane or two. Therefore, new or upgraded roadway connections were identified to provide alternate travel paths and reduce traffic demand. The measures considered are outlined in greater detail in the preliminary Highway Design plans located in Appendix II.B

### B. Total Design-Year 2025 Mitigation Measures Traffic Volumes

The associated traffic redistributions for 2025 Mitigation Measures are provided in Figure V.2. The trip redistribution associated with the roadway modifications are summarized below:

- MacPhail Road Connection: Several volume diversions were assumed with the anticipated connection of MacPhail Road between MD 924 and MD 24:
  - Approximately 10% of the MD 924 at MacPhail Road southbound through volumes were assumed to divert to MacPhail Road to access MD 24 versus utilizing W. Ring Factory Road.
  - Approximately 10% of the MD 924 at MacPhail Road westbound left turn volumes were assumed to continue west on MacPhail Road to access points west of MD 24 versus utilizing W. Ring Factory Road and MD 24.
  - Approximately 10% of the MD 24 at MacPhail Road eastbound right turn volumes were assumed to continue east on MacPhail Road to access points east of MD 924 versus utilizing W. Ring Factory Road and MD 924.
  - Approximately 48% of the MD 24 at W. Ring Factory Road northbound right turn volumes were assumed to divert to MacPhail Road to access MD 924 versus utilizing W. Ring Factory Road.
- MD 24 at Singer Road: Northbound U-turns at the MD 24 at Singer Road intersection were prohibited since a northbound left turn – eastbound right turn permissive/protected overlap signal was added to the eastbound right turn movement as part of the mitigation measures. Therefore, 100% of the U-turns were diverted to the MD 24 at Wheel Road intersection.



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INTERSECTION ID NO.

SIGNALIZED INTERSECTION

**MARYLAND 924**

2025 NO-BUILD VOLUMES

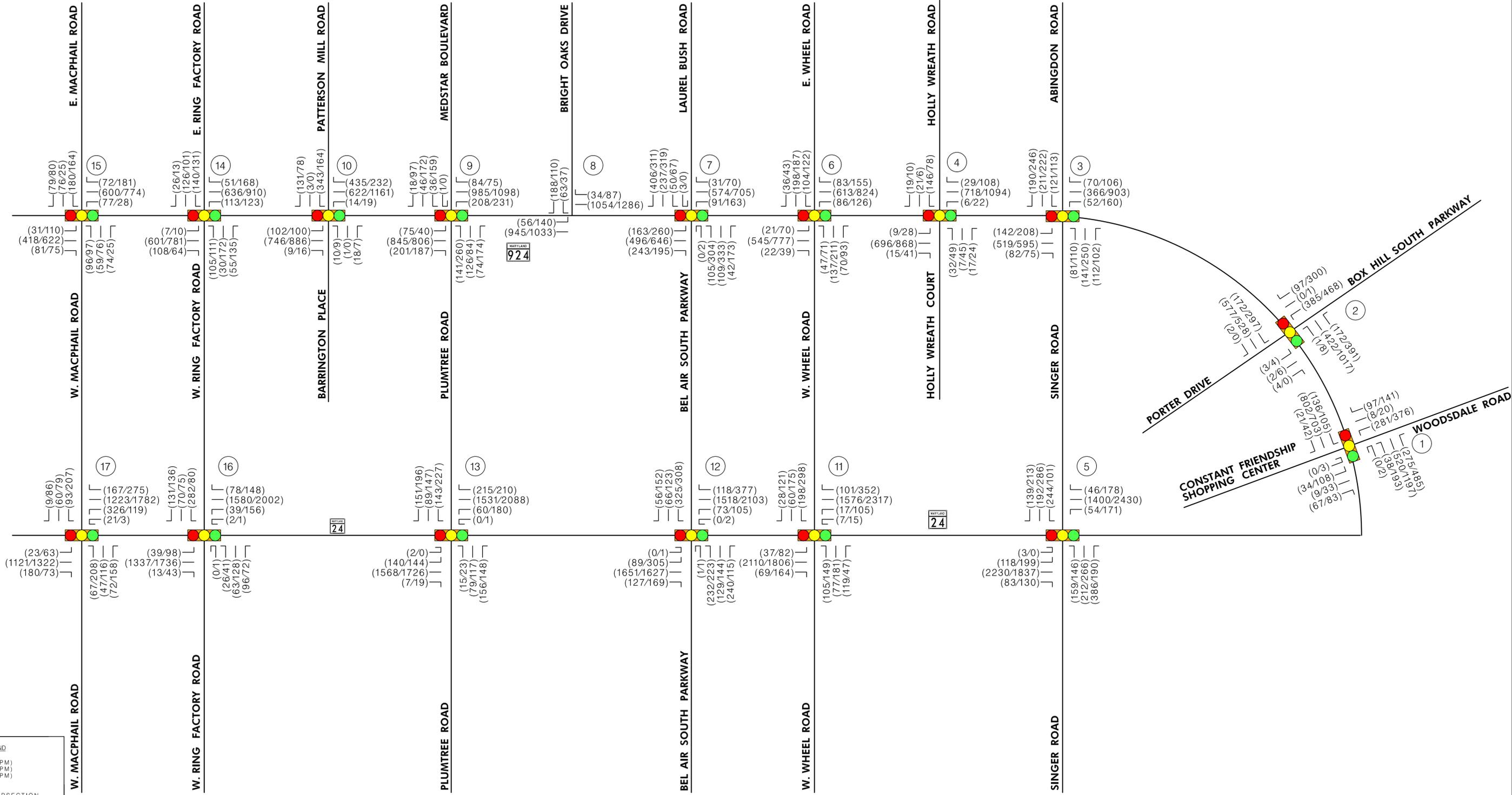
SCALE: N.T.S.	FIGURE V.1	JUNE 2017
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- INTERSECTION ID NO.
- EXISTING SIGNALIZED INTERSECTION
- GRADE SEPERATED INTERSECTION



<b>MARYLAND 924</b>		
2025 TOTAL (MITIGATION MEASURES) VOLUMES		
SCALE: N.T.S.	FIGURE V.2	JUNE 2017



### C. Operations Overview

The projected 2025 traffic volumes from Figure V.1 were analyzed with Synchro/Sim Traffic, the Critical Lane Analysis (CLA) and SHA 95% Probability methodologies to quantify level of service and queues. Harford County uses Synchro/Sim Traffic for capacity and queue analyses. The SHA’s methodologies of CLA for level of services and 95% Probability for queue analyses are provided as a reference. Queues are rounded up to the nearest 25-foot increment based on an average 25-foot vehicle length. An initial round of calculations were performed based on the existing lane geometry and signal phasing for a No-Build Scenario. Since many of the intersections currently operate at or near capacity, even with traffic signal optimization, roadway upgrades are required to address traffic demand. Subsequent analyses were conducted based on a six lane section along MD 24, moderate upgrades to the study area roadway network and the new roadway links previously noted. The analyses were recomputed with the volumes from Figure V.2. The major issue constraining operations are the high volume of turning movements paired with the high volume of conflicting through movements. As a result, typical upgrades included providing additional turn lanes while still limiting roadway improvements to maintain a two lane section (one lane in each direction) along MD 924 where feasible. The level of service and queue computation sheets and summary tables are provided in Appendix II.C for each Zone.

Level of Service (LOS) is a means of quantifying intersection operations by applying a letter grade A through F to the intersection. Free-flow conditions are represented by LOS A with little or no queues at signalized intersections, minimal delay and all vehicles clear during the green time allocated. The level of service gradually deteriorates with motorist delays and queues increasing from LOS B to LOS D. Levels of Service E and F indicate drivers are experiencing unacceptable delays and are queued for an extended period of time, often sitting through several signal cycles before finally clearing the intersection. Typically, LOS E and F are red flags that indicate upgrades to the intersection are required. Based on Synchro, delays in excess of 55 seconds per vehicle are considered LOS E. In developing the analyses, mitigation measures were developed in an effort to achieve a LOS D. However, given the constraints along the roadways, a delay within approximately 10 seconds of 55 second threshold was considered acceptable.

### D. Zone 1 – Design-Year 2025

**Level of Service** assessments under No-Build conditions are summarized in Table V.1 for Synchro and Table V.2 for CLA. The No-Build analyses assume traffic signal timing and phasing optimization and interconnect of signal groups to improve operations. As shown, for the No-Build condition, only the intersections of MD 924 with Woodsdale Road and Holly Wreath Court/Road would function at an overall acceptable level of service. However, individual minor street approaches of each intersection would function at a level of service E or F. The analyses were recomputed with minor upgrades to the intersections as illustrated in Figure V.3 and the trip diversion from Figure V.2. With the exception of MD 924 at Singer Road/Abingdon Road, the overall intersection levels of service improve to acceptable levels with the noted upgrades as shown in Table V.1 for Synchro and Table V.3 for CLA. MD 924 at Singer Road/Abingdon Road functions at a level of service ‘E’, but with a delay of less than 10 seconds above the level of service D/E threshold. A County approved mitigation measure to allow the MD 924 at Singer Road/Abingdon Road intersection to function at an acceptable level of service was not available since adding additional lanes along Signer Road is not environmentally feasible. Diverting traffic through prohibiting turning movements was not advanced due to anticipated public complaints.



**Table V.1**

**Synchro Summary for 2025 – Zone 1  
MD 924 Multi-Modal Corridor Study**

Zone 1					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
01	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	C 20.6	C 33.2	C 21.0	C 31.0
02	MD 924 at Porter Dr/Box Hill S. Parkway	B 18.7	F 124.4	C 26.8	C 31.3
03	MD 924 at Singer Rd/ Abingdon Rd	C 23.9	E 67.1	C 30.6	E 63.8
04	MD 924 at Holly Wreath Ct/Holly Wreath Rd	C 21.0	C 21.8	B 17.4	B 19.2
05	MD 24 at Singer Rd	F 144.1	F 139.0	C 30.5	D 42.6

**Table V.2**

**Critical Lane Analysis Summary for 2025 No-Build – Zone 1  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
01	ZONE 1	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	A (686)	0.43	B (1112)	0.70
02		MD 924 at Porter Dr/Box Hill S. Parkway	A (835)	0.52	F (1609)	1.01
03		MD 924 at Singer Rd/Abingdon Rd	A (863)	0.54	E (1474)	0.92
04		MD 924 at Holly Wreath Ct/Holly Wreath Rd	A (970)	0.61	D (1407)	0.88
05		MD 24 at Singer Rd	F (1859)	1.16	F (1961)	1.23





**Table V.3**

**Critical Lane Analysis Summary for 2025 Mitigation Measures– Zone 1  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
01	ZONE 1	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	A (686)	0.43	B (1112)	0.70
02		MD 924 at Porter Dr/ Box Hill S. Parkway	A (576)	0.36	B (1029)	0.64
03		MD 924 at Singer Rd/ Abingdon Rd	A (863)	0.54	E (1474)	0.92
04		MD 924 at Holly Wreath Ct/ Holly Wreath Rd	A (897)	0.56	C (1269)	0.79
05		MD 24 at Singer Rd	D (1307)	0.82	D (1394)	0.87

The following mitigation measures were utilized in Synchro to improve intersection levels of service:

01 – MD 924 at Constant Friendship Shopping Center/Woodsdale Road:

The signal cycle length was optimized to 130 seconds during the AM peak period and 120 seconds during the PM peak period (existing signal cycle length is 150 seconds in the AM and PM peak periods). It should be noted that the signal is interconnected to the MD 24/MD 924 interchange signals, which are located outside of the study limits. A full analysis of the coordinated system would need to be completed to verify that reducing the signal cycle length would benefit the system as a whole.

02 – MD 924 at Porter Drive/Box Hill South Parkway:

The installation of a second northbound through lane and a second southbound left turn lane are proposed to improve the intersection operations. The southbound left turn phasing will be modified from exclusive/permissive to exclusive. The signal cycle length is optimized to 130 seconds in the AM peak period (existing cycle length is 100 seconds) and 120 seconds in the PM peak period (existing cycle length is 130 seconds). Add pedestrian signals and crosswalks to the minor street approaches.

03 – MD 924 at Singer Road/Abingdon Road:

The signal cycle length is optimized to 130 seconds during the AM peak period and 150 seconds during the PM peak period (existing cycle length is 110 seconds during the AM and PM peak periods). Maintain existing exclusive/permissive phasing on all approaches.



04 – MD 924 at Holly Wreath Court/Road:

Modify the existing eastbound and westbound right and shared through/left lanes by restriping to a shared through/right lane and left turn lane with a storage length of 150 feet; maintain permissive phasing. Construct a 300-foot right turn lane on the northbound and southbound approaches to accommodate the queue jump. The signal cycle length is optimized to 130 seconds in the AM and PM peak periods (existing signal cycle length is 100 seconds). Add pedestrian signals and crosswalks for each minor street approach.

05 – MD 24 at Singer Road:

As part of SHA scheduled improvements, MD 24 will be widened to a six-lane section, which should occur prior to the 2025 Design-Year. Additional through lanes on all minor street approaches are required for improved traffic flow. A second eastbound right turn lane and right turn overlap phase is proposed, with the outermost right turn lane having a “No Turn on Red This Lane” (R3-5MOD) sign installed. An additional southbound left turn lane is also proposed. The signal cycle length is optimized to 130 seconds in the AM peak period (existing cycle length is 150 seconds) and 150 seconds in the PM peak period (existing cycle length is 180 seconds).

Singer Road Connection:

The link between MD 24 and MD 924 is to be improved to facilitate access to I-95 via MD 24, rather than MD 924. The 2025 analyses indicate that two approach lanes are required along Singer Road westbound and two receiving lanes eastbound from the MD 24 southbound double left turn lane. In addition, due to the intersecting streets, a center turn lane should be provided to accommodate left turn movements. A three lane section is required at the eastbound approach to MD 924. The existing right-of-way along Singer Road is 50 feet. In order to implement the required five-lane typical section, along with sidewalks, additional right-of-way will be required.

**Queue analyses** were performed for the Zone 1 intersections. Tables in Appendix II.C provide a summary of the SimTraffic and SHA 95% Probability methodology queue analyses results associated with the 2025 mitigation measures. Review of the table indicates that projected queues can be addressed.



**E. Zone 2 – Design-Year 2025**

**Level of Service** analyses were performed for the 2025 Design-Year. The intersections in Zone 2 were analyzed with the 2025 projected traffic volumes from Figure V.1. The analysis results are summarized in Table V.4 for Synchro and Table V.5 for CLA. As shown, for the No-Build condition, all intersections would function at an unacceptable level of service during one or more of the peak hours, some with excessive delays. The exception is the intersection of MD 924 at Barrington Place/Patterson Mill Road (and Wheel Road based on CLA); however, although the overall level of service is acceptable, individual approaches would experience a level of service E or F. The No-Build analyses assume traffic signal timing and phasing optimization and interconnect of signal groups to improve operations. The analyses were recomputed with intersection upgrades as illustrated in Figure V.4 and the diverted traffic volumes from Figure V.2. As shown in Tables V.4 and V.6, the additional lanes and trip diversion does improve the levels of service to acceptable thresholds for all intersections except MD 924 at Plumtree Road. Although a level of service E, the calculated delays for the MD 924/Plumtree Road intersection were within 10 seconds of the level of service D/E threshold of 55 seconds.

**Table V.4**

**Synchro Summary for 2025 – Zone 2  
MD 924 Multi-Modal Corridor Study**

Zone 2					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
06	MD 924 at Wheel Rd	D 39.5	E 64.6	C 34.4	D 53.3
07	MD 924 at Bel Air S. Parkway/Laurel Bush Rd	D 35.6	F 87.9	C 28.5	D 42.5
08	MD 924 at Bright Oaks Dr	D	E	A	B
09	MD 924 at Plumtree Rd/ Medstar Boulevard	E 66.9	F 93.0	D 46.9	E 58.4
10	MD 924 at Barrington Pl/ Patterson Mill Rd	C 28.7	C 23.7	C 20.5	C 32.2
11	MD 24 at Wheel Rd	D 39.4	F 138.7	C 26.9	D 50.9
12	MD 24 at Bel Air S. Parkway	F 97.4	F 154.0	D 49.9	D 45.0
13	MD 24 at Plumtree Rd	D 40.0	E 67.4	C 23.8	C 23.6



**Table V.5**

**Critical Lane Analysis Summary for 2025 No-Build Conditions – Zone 2  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
06	ZONE 2	MD 924 at Wheel Rd	A (964)	0.60	D (1368)	0.86
07		MD 924 at Bel Air S. Parkway/Laurel Bush Rd	B (1120)	0.70	E (1530)	0.96
08		MD 924 at Bright Oaks Dr	C (1242)	0.78	E (1463)	0.91
09		MD 924 at Plumtree Rd/ Medstar Boulevard	C (1297)	0.81	E (1555)	0.97
10		MD 924 at Barrington Pl/ Patterson Mill Rd	B (1079)	0.67	D (1435)	0.90
11		MD 24 at Wheel Rd	E (1482)	0.93	E (1578)	0.99
12		MD 24 at Bel Air S. Parkway	D (1433)	0.90	F (1819)	1.14
13		MD 24 at Plumtree Rd	D (1223)	0.76	F (1636)	1.02

**Table V.6**

**Critical Lane Analysis Summary for 2025 Mitigation Measures – Zone 2  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
06	ZONE 2	MD 924 at Wheel Rd	A (934)	0.58	C (1275)	0.80
07		MD 924 at Bel Air S. Parkway/Laurel Bush Rd	A (835)	0.52	C (1168)	0.73
08		MD 924 at Bright Oaks Dr	A (768)	0.48	A (884)	0.55
09		MD 924 at Plumtree Rd/ Medstar Boulevard	B (1142)	0.71	C (1273)	0.80
10		MD 924 at Barrington Pl/ Patterson Mill Rd	A (942)	0.59	D (1370)	0.86
11		MD 24 at Wheel Rd	B (1092)	0.68	D (1337)	0.84
12		MD 24 at Bel Air S. Parkway	B (1076)	0.67	D (1363)	0.85
13		MD 24 at Plumtree Rd	A (993)	0.62	D (1323)	0.83





Intersection upgrades to accommodate the projected 2025 traffic volumes are summarized below:

06 – MD 924 at Wheel Road

An eastbound right turn lane with a 200 foot storage length is proposed; convert the existing shared through/right lane to a through lane. The signal cycle length is optimized to 130 seconds (existing cycle length is 120 seconds) in the AM peak period and 130 seconds (existing cycle length is 150 seconds) in the PM peak period. Install crosswalks and pedestrian signals for the southern and western approaches.

07 – MD 924 at Bel Air South Parkway/Laurel Bush Road:

Construct an additional eastbound left turn lane with a 225 foot storage length and an additional eastbound through lane. Install an additional westbound right turn lane with a 325-foot storage length and separate westbound left turn lane with a 125-foot storage length; convert the existing westbound shared through/left lane to a through lane. Install an additional southbound left turn lane with a 200-foot storage length and an additional northbound through lane. Convert southbound left turn phasing from exclusive/permissive to exclusive, as well as install a westbound right turn overlap phase; the outermost right turn lane would require a “No Turn on Red This Lane” (R3-5MOD) sign. The signal cycle length is optimized to 130 seconds (existing signal cycle length is 120 seconds) in the AM peak period and 150 seconds (existing signal cycle length is 150 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased.

08 – MD 924 at Bright Oaks Drive:

Construct an additional northbound and southbound through lane. Add a crosswalk to the Bright Oaks Drive approach.

09 – MD 924 at Plumtree Road/Medstar Boulevard:

Install an additional eastbound left turn lane with a storage length of 175 feet and a right turn lane with a storage length of 200 feet; convert the existing shared through-right lane to a through lane. Install an additional westbound left turn lane from Medstar Boulevard. Install an additional northbound left turn lane with a storage length of 150 feet and convert the northbound right turn lane to a shared through/right turn lane. The southbound left turn will continue to operate with exclusive/permissive phasing; the northbound left turn will operate with exclusive phasing. The eastbound and westbound approaches will operate as split phased. The signal cycle length is optimized to 130 seconds in the AM peak period (existing cycle length is 120 seconds) and 150 seconds in the PM peak period (existing cycle length is 150 seconds). Provide pedestrian signals and crosswalks on the minor street approaches.

10 – MD 924 at Barrington Place/Patterson Mill Road:

Construct an additional westbound left turn lane with a storage length of 400 feet and modify the left turn phasing from permissive to exclusive. Construct a southbound right turn lane with a storage length of 300 feet to accommodate the queue jump and convert the existing shared through-right lane to a through lane. The signal cycle length is optimized to 130 seconds (existing cycle length is 120 seconds) in the AM peak period and 150 seconds (existing cycle length is 150



seconds) in the PM peak period. Install pedestrian signals and a crosswalk for the Patterson Mill Road approach.

11 – MD 24 at Wheel Road:

Construct an additional northbound, southbound, eastbound and westbound through lane. Install an additional westbound left turn lane with a storage length of 350 feet and a westbound right turn lane with a storage length of 150 feet; convert the existing shared through-right lane to a through lane. Install an eastbound left turn lane with a storage length of 200 feet; convert the existing shared left-through lane to a through lane. The signal cycle length is optimized to 130 seconds (existing cycle length is 150 seconds) in the AM peak period and 150 seconds (existing cycle length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased.

12 – MD 24 at Bel Air South Parkway:

Construct an additional westbound left turn lane with a storage length of 200 feet and additional northbound and southbound through lanes. Install an additional eastbound left turn lane with a storage length of 125 feet and convert the existing eastbound shared left/through lane to a through lane. The signal cycle length is optimized to 150 seconds (existing cycle length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased.

13 – MD 24 at Plumtree Road:

Install an additional northbound and southbound through lane. The signal cycle length is optimized to 150 seconds (existing cycle length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate concurrently.

W. Wheel Road Connection:

The access to the Festival at Bel Air creates a major intersection along W. Wheel Road that must be accommodated. A seven lane section is required in 2025 at the east leg of the intersection with MD 24. The westbound W. Wheel Road approach at MD 24 would provide a right turn, two throughs and a double left turn lane with two eastbound receiving lanes. An eastbound left and westbound right turn lane would be maintained at the shopping center access and a left turn, right turn and through lane would be provided at the eastbound MD 924 approach with a shared through-right and left turn lane on the westbound approach. The parcel to the south of W. Wheel Road will be developed as a park by the County. Between MD 924 and MD 24, a five-lane section would be required; therefore, the necessary right-of-way to accommodate a minimum five-lane section along with sidewalks would be available from the County park property.

Bel Air South Parkway Connection:

Limited right-of-way is available to widen Bel Air South Parkway due to the dense development bordering the corridor. A minimum five-lane section is required with additional lanes necessary at the intersection with MD 924 to accommodate the seven-lane section and MD 24 to accommodate the six-lane section. Also, a six-foot median should be included in the typical section to accommodate pedestrian traffic.



Plumtree Road Connection:

A minimum three-lane section is required along Plumtree Road. Several commercial drives access Plumtree Road and would require a separate left turn lane. Dedication of right-of-way is recommended as part of the mitigation plan for development of the commercial parcel on the southwest side of Plumtree Road. The dedication will allow for the construction of the westbound left and right turn lanes at the intersection with MD 924, as well as two receiving lanes (six-lane section), and for providing continuous sidewalks along the south side of Plumtree Road. Right-of-way is available at the MD 24 intersection to accommodate widening for turn lanes.

**Queue analyses** were computed with the updated 2025 mitigation traffic volumes and lane assignments for Zone 2. Results of the SimTraffic and SHA 95% Probability analyses are summarized in tables located in Appendix II.C. Results provided in the tables indicate that projected queues can be addressed.

**F. Zone 3 – Design-Year 2025**

**Level of Service** analyses were computed with the 2025 projected traffic volumes for Zone 3 from Figure V.1. The analysis results are summarized in Table V.7 for Synchro and Table V.8 for CLA. As shown, for the No-Build condition the two Ring Factory Road intersections would function at unacceptable levels of service with excessive delays. Traffic signal timing and phasing optimization and interconnect of signal groups was not sufficient to provide acceptable operations. The analyses were recomputed with the intersection geometrics illustrated in Figure V.5 and the volumes from Figure V.2. As shown in Tables V.7 and V.9, the improved lane geometry does provide acceptable overall intersection operations; however, individual approaches at the two Ring Factory Road intersections would function at a level of service E. In an effort to maintain the two-lane section along MD 924, mitigation measures were limited related to providing double left turn lanes from the side streets to reduce delays.

**Table V.7**

**Synchro Summary for 2025 – Zone 3  
MD 924 Multi-Modal Corridor Study**

Zone 3					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
14	MD 924 at E. Ring Factory Rd/W. Ring Factory Rd.	D 50.9	F 82.0	C 34.0	D 52.4
15	MD 924 at W. MacPhail Rd/E. MacPhail Rd	D 35.6	D 53.2	C 31.4	C 27.2
16	MD 24 at W. Ring Factory Rd	F 89.8	E 66.5	D 50.6	C 33.1
17	MD 24 at W. MacPhail Rd	C 27.4	D 36.8	C 32.9	C 24.9



**Table V.8**

**Critical Lane Analysis Summary for 2025 No-Build Conditions – Zone 3  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
		LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
14	MD 924 at E. Ring Factory Rd/W. Ring Factory Rd	C (1165)	0.73	E (1459)	0.91
15	MD 924 at W. MacPhail Rd/E. MacPhail Rd	B (1128)	0.70	D (1447)	0.90
16	MD 24 at W. Ring Factory Rd	D (1363)	0.85	E (1536)	0.96
17	MD 24 at W. MacPhail Rd	A (901)	0.56	C (1279)	0.80

**Table V.9**

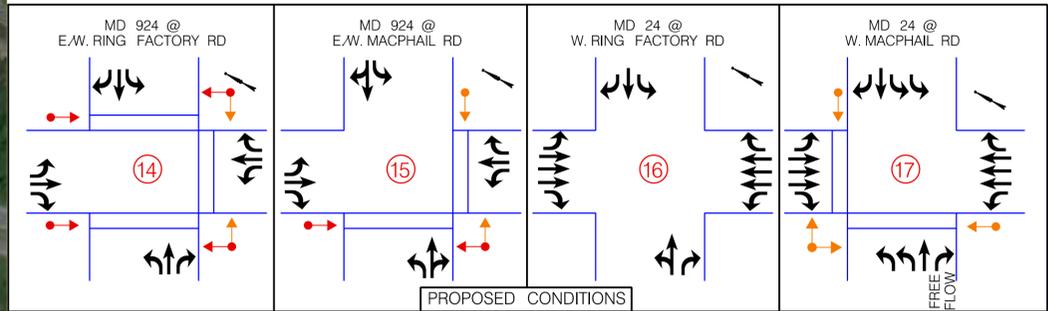
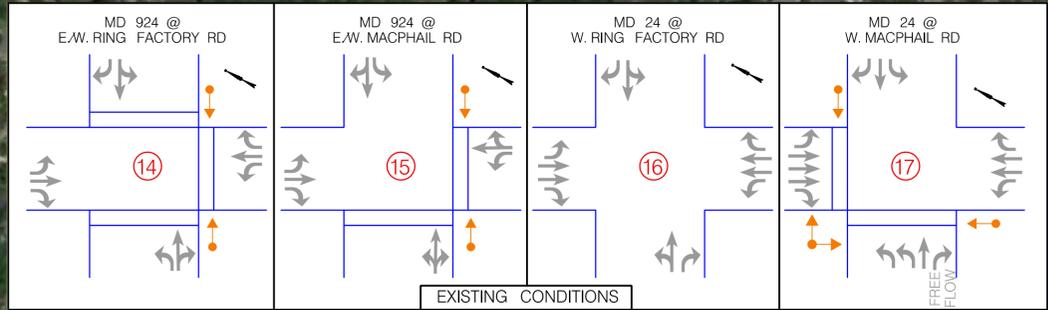
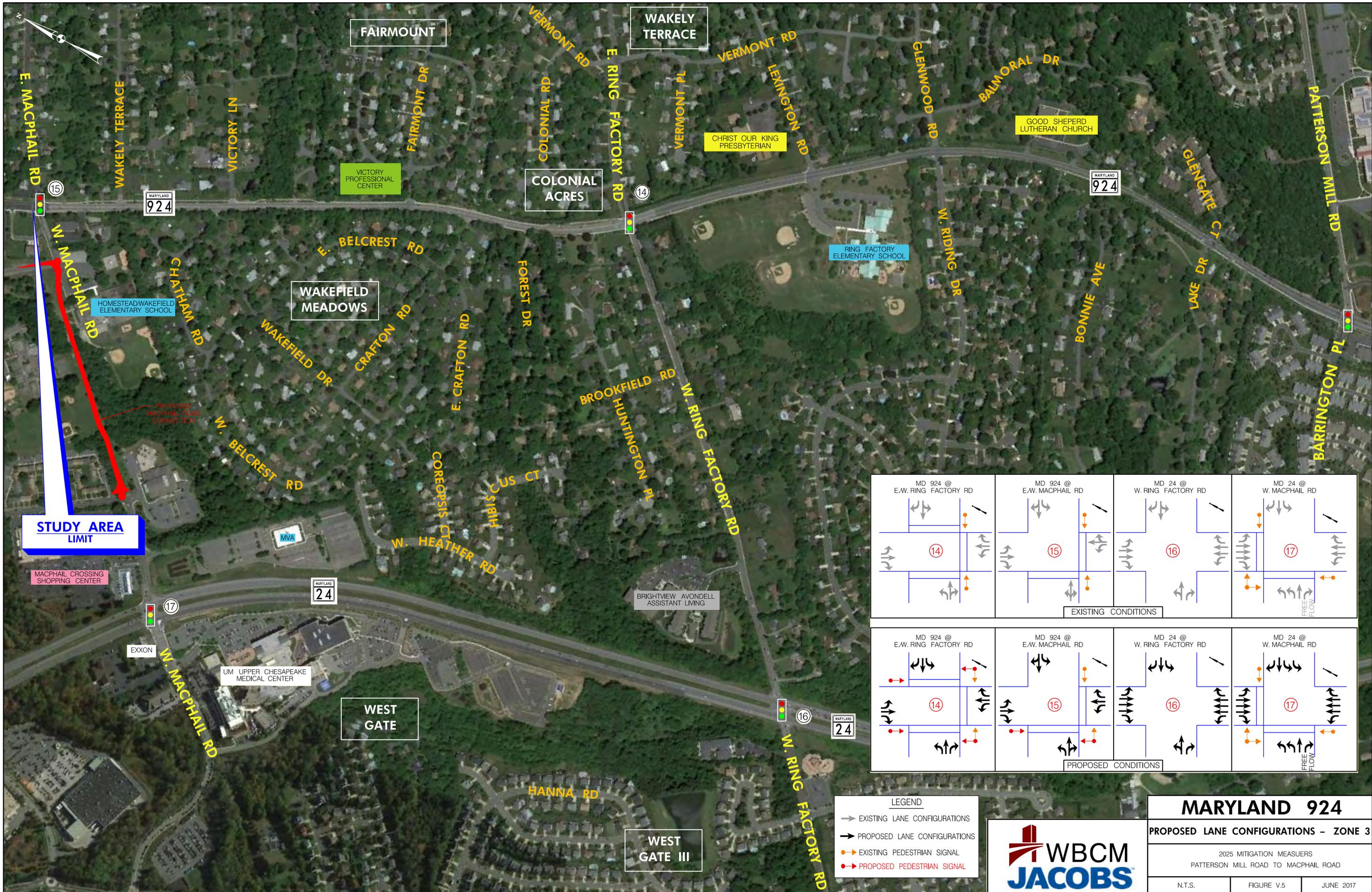
**Critical Lane Analysis Summary for 2025 Mitigation Measures – Zone 3  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
		LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
14	MD 924 at E. Ring Factory Rd/W. Ring Factory Rd.	A (959)	0.60	C (1223)	0.76
15	MD 924 at W. MacPhail Rd/E. MacPhail Rd	A (944)	0.59	B (1149)	0.72
16	MD 24 at W. Ring Factory Rd	B (1042)	0.65	B (1149)	0.72
17	MD 24 at W. MacPhail Rd	A (898)	0.56	B (1016)	0.64

For the 2025 Design-Year, intersection upgrades are proposed to accommodate traffic demand and provide acceptable overall intersection operations and queue storage as noted below:

**14 – MD 924 at E./W. Ring Factory Road:**

Construct an eastbound right turn lane with a storage length of 200 feet and convert the existing eastbound shared through/right lane to a through lane. Install a westbound left turn lane with a storage length of 200 feet and convert the existing westbound shared left/through lane to a through lane. The signal cycle length is optimized to 130 seconds (existing cycle length is 100 seconds) in the AM peak period and 140 seconds (existing cycle length is 110 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased. Pedestrian signals are proposed for the east and west approaches.



- LEGEND**
- EXISTING LANE CONFIGURATIONS
  - PROPOSED LANE CONFIGURATIONS
  - EXISTING PEDESTRIAN SIGNAL
  - PROPOSED PEDESTRIAN SIGNAL



<b>MARYLAND 924</b>		
<b>PROPOSED LANE CONFIGURATIONS - ZONE 3</b>		
2025 MITIGATION MEASURES PATTERSON MILL ROAD TO MACPHAIL ROAD		
N.T.S.	FIGURE V.5	JUNE 2017

SMALL FOOTNOTES: PLOTTED: Tuesday, June 13, 2017 AT 12:24 PM FILE: P:\2015\16025100\Drawings\06-Traffic\06n-4003\_md924\_25.dgn



15 – MD 924 at E./W. MacPhail Road:

Construct a northbound right turn lane with a storage length of 300 feet and convert the existing northbound shared through/right lane to a through lane. Install an eastbound left turn lane with a storage length of 225 feet and convert the existing westbound shared left/through/right to through/right. The signal cycle length is optimized to 140 seconds (existing cycle length is 100 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate concurrently. Provide pedestrian signals for the west leg of the intersection.

16 – MD 24 at W. Ring Factory Road:

Install an additional northbound and southbound through lane. Install a westbound left turn lane with a storage length of 250 feet and convert the westbound shared left/through lane to a through lane. The signal cycle length is optimized to 130 seconds (existing cycle length is 150 seconds) in the AM peak period and 150 seconds (existing cycle length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased.

17 – MD 24 at W. MacPhail Road:

Install an additional northbound through lane. Install an additional westbound left turn lane with a storage length of 150 feet. The signal cycle length is optimized to 130 seconds (existing cycle length is 150 seconds) in the AM peak period and 150 seconds (existing cycle length is 180 seconds) in the PM peak period.

W. Ring Factory Road Connection:

Right-of-way is limited to only 40 feet along W. Ring Factory Road. West Ring Factory Road serves single family dwelling units with direct access driveways. Property frontage would be required to provide a minimum three lane section with three 11 foot lanes, 5 foot bike lanes and sidewalks with a buffer from the roadway along both sides. The three lane section would allow for a center turn lane to serve the driveways.

W. MacPhail Road Connection:

A new section of roadway to connect W. MacPhail Road utilizing the Bel Air Schools Complex site is proposed. The roadway includes roundabouts at the S. Atwood Road and Bel Air Middle School/Homestead-Wakefield Elementary School intersections, in addition to a shared use path on the north side of the roadway.

**Queue analyses** were computed employing the SimTraffic and SHA 95% Probability methodologies for the key intersections in Zone 3. The analyses were based on the improved lane geometry and the mitigation volumes. Results of the analyses are summarized in tables located in Appendix II.C. The analyses reveal that the projected queues can be addressed.



## **VI. LONG-TERM (2040)**

### **A. Total Design-Year 2040 Traffic (No-Build) Volumes**

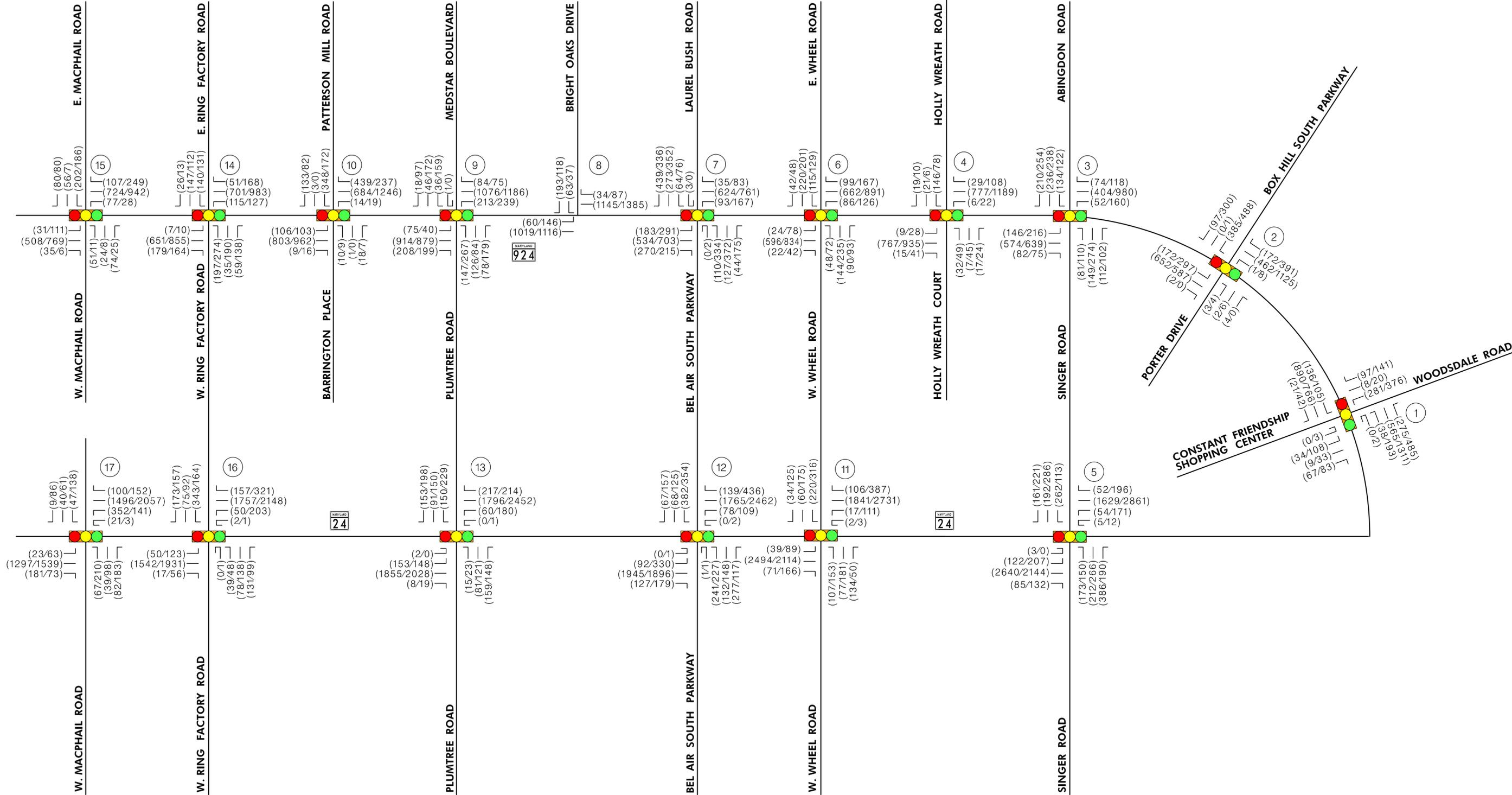
The total Design-Year 2040 No-Build volumes were derived by adding the background traffic volumes (Figure II.2) to the 2040 site generated trips (Figure III.2). Figure VI.1 provides the total No-Build 2040 volumes. As noted previously, No-Build volumes represent the raw design-year volumes with no diversion of traffic due to mitigation measures. Many of the intersections along the MD 924 and MD 24 corridors are currently operating at or near capacity, with minimal reserve capacity to accommodate additional traffic demand. Therefore, to provide acceptable intersection operations in 2040, major intersection upgrades are required, including grade-separation. In addition, new or upgraded roadway connections were identified to provide alternate travel paths and reduce traffic demand. The measures considered are outlined in greater detail in the preliminary Highway Design plans located in Appendix II.B.

### **B. Total Design-Year 2040 Mitigation Measures Traffic Volumes**

The volume diversions and upgrades proposed for 2025 were applied to the 2040 No-Build volumes and are provided as Figure VI.2. For 2040, additional roadway upgrades were considered to address traffic demand including grade-separated intersection movements and site access along MD 24. Figure VI.3 illustrates the associated 2040 redistributed traffic volumes.

The trip redistribution associated with the roadway modifications are summarized below:

- MacPhail Road Connection: Several volume diversions were assumed with the anticipated connection of MacPhail Road between MD 924 and MD 24:
  - Approximately 10% of the MD 924 at MacPhail Road southbound through volumes were assumed to divert to MacPhail Road to access MD 24 versus utilizing W. Ring Factory Road.
  - Approximately 10% of the MD 924 at MacPhail Road westbound left turn volumes were assumed to continue west on MacPhail Road to access points west of MD 24 versus utilizing W. Ring Factory Road and MD 24.
  - Approximately 10% of the MD 24 at MacPhail Road eastbound right turn volumes were assumed to continue east on MacPhail Road to access points east of MD 924 versus utilizing W. Ring Factory Road and MD 924.
  - Approximately 48% of the MD 24 at W. Ring Factory Road northbound right turn volumes were assumed to divert to MacPhail Road to access MD 924 versus utilizing W. Ring Factory Road.
  
- MD 24/Singer Road Grade-Separation: In order to provide free-flow operation along MD 24, conflicting movements could be grade-separated. The median grade-separated intersection would accommodate all left turn movements and Singer Road through movements. The through movement along MD 24 and all right turn movements would remain at-grade and free-flow.



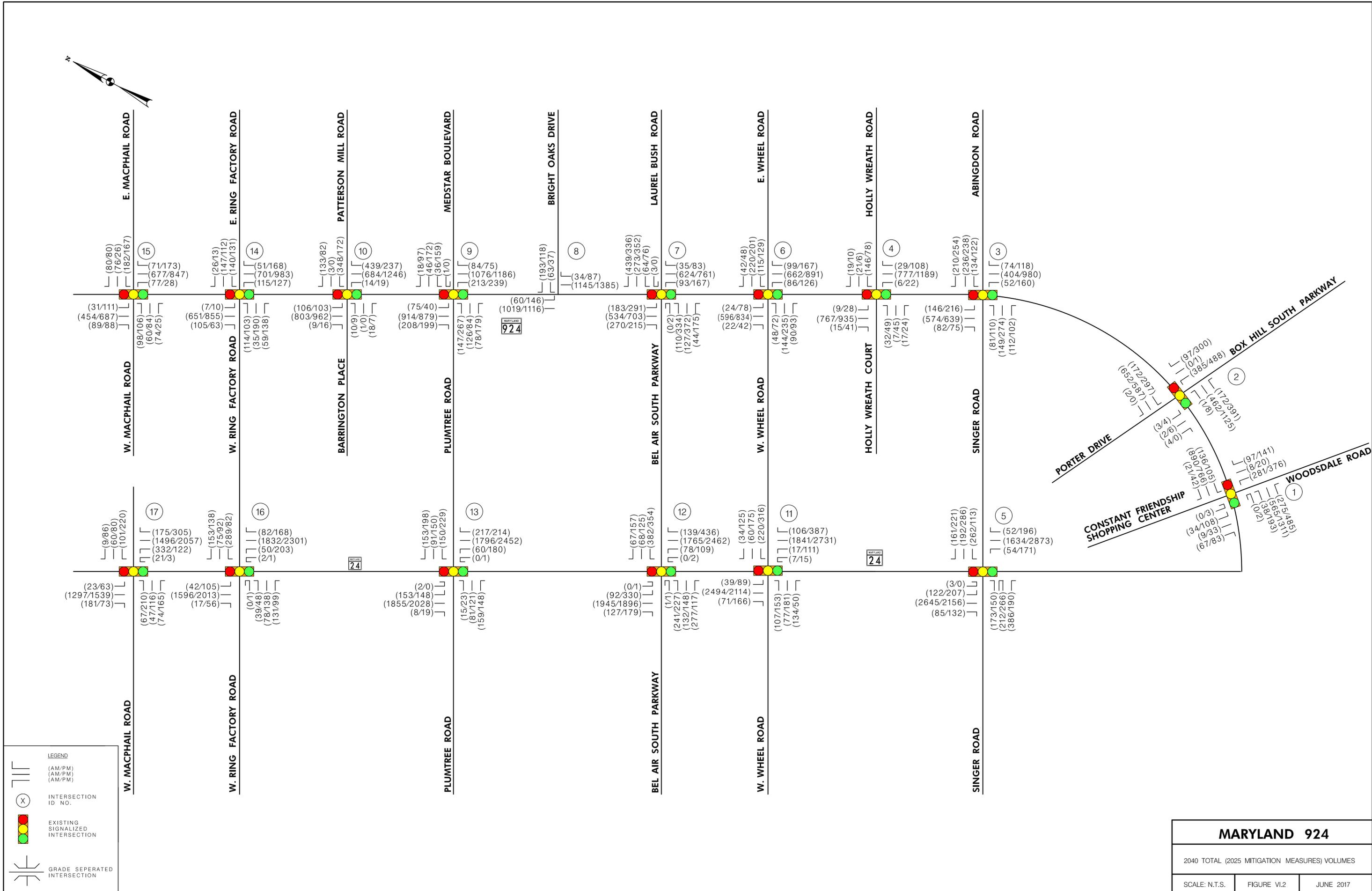
**LEGEND**

- (AM/PM)
- (AM/PM)
- (AM/PM)
- (AM/PM)
- INTERSECTION ID NO.
- SIGNALIZED INTERSECTION

**MARYLAND 924**

2040 NO-BUILD VOLUMES

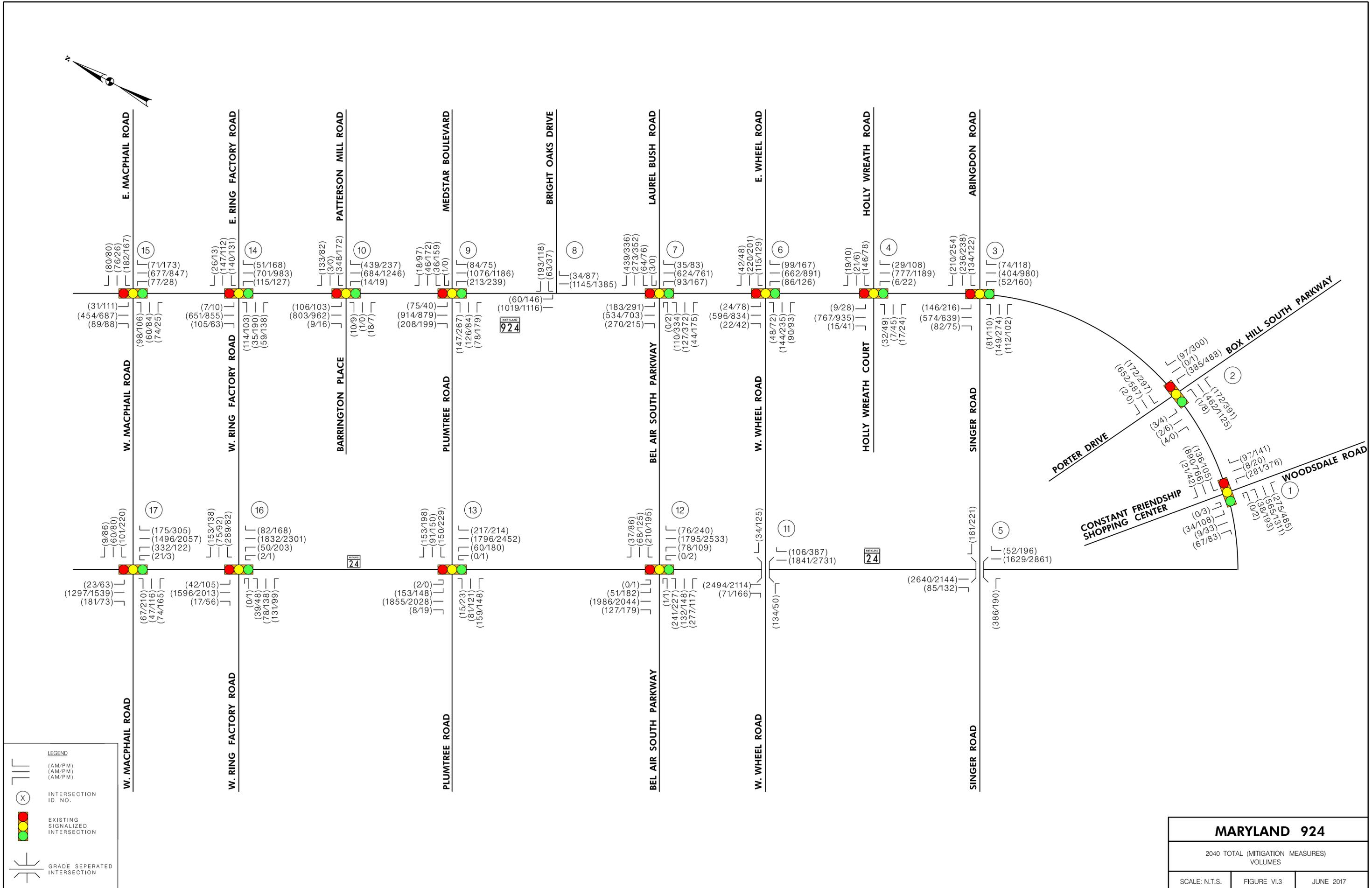
SCALE: N.T.S.    FIGURE VI.1    JUNE 2017



**LEGEND**

- (AM/PM)  
(AM/PM)  
(AM/PM)
- INTERSECTION ID NO.
- EXISTING SIGNALIZED INTERSECTION
- GRADE SEPERATED INTERSECTION

<b>MARYLAND 924</b>		
2040 TOTAL (2025 MITIGATION MEASURES) VOLUMES		
SCALE: N.T.S.	FIGURE VI.2	JUNE 2017



**LEGEND**

- (AM/PM)  
(AM/PM)  
(AM/PM)
- (X) INTERSECTION ID NO.
- EXISTING SIGNALIZED INTERSECTION
- GRADE SEPERATED INTERSECTION

<b>MARYLAND 924</b>		
2040 TOTAL (MITIGATION MEASURES) VOLUMES		
SCALE: N.T.S.	FIGURE VI.3	JUNE 2017



- MD 24 at W. Wheel Road Grade-Separation: Similar to the intersection of MD 24 and Singer Road, it is not feasible to widen the intersection to accommodate the anticipated traffic volumes. The grade-separation would bring all left turns into a median intersection along with the side road through and eastbound right turn volumes. Right turn traffic (excluding eastbound right turns) and MD 24 through volumes would remain at-grade and free-flow. The median ramps would also accommodate the traffic to and from the proposed grade-separated access at the Festival at Bel Air.
- MD 24/Festival at Bel Air Grade-separated Access: Volume diversions associated with the proposed MD 24 at Festival at Bel Air grade-separated access relate to the intersection at MD 24 and Bel Air South Parkway and include:
  - 45% of the Bel Air S. Parkway westbound left turn volumes were assumed to divert to the proposed Festival at Bel Air grade-separated intersection.
  - 45% of the Bel Air S. Parkway westbound right turn volumes were assumed to divert to the proposed Festival at Bel Air grade-separated intersection.
  - 45% of the MD 24 southbound left turns were assumed to divert to the proposed Festival at Bel Air grade-separated intersection.
  - 45% of the MD 24 northbound right turns were assumed to divert to the proposed Festival at Bel Air grade-separated intersection.
- MD 24 at Plumtree Road Directional Ramps: In an effort to relieve pressure on the existing intersections, a new access was considered along MD 24. The access would link to the internal roadway proposed as part of any development of the commercial parcel between MD 24 and MD 924. The link would provide directional access to and from the south to accommodate the major traffic distribution trends. The projected 2040 traffic volumes were not redistributed based on the directional access. The proposed access is included in the report for potential reservation of right-of-way.

### C. Operations Overview

Synchro/SimTraffic, Critical Lane Analysis (CLA), and SHA 95% Probability methodologies were used to conduct level of service and queue analyses for the Design-Year 2040 traffic projections from Figure VI.1. Since MD 924 and MD 24 are State routes, SHA’s CLA and 95% probability queue analyses are provided for reference. Queues are rounded up to the nearest 25-foot increment based on an average 25-foot vehicle length. The Design-Year 2040 analyses included No-Build analyses with two modified scenarios. The first scenario analyzed the upgraded Design-Year 2025 roadway network with the 2040 volumes. The second scenario included the Design-Year 2040 volumes with additional upgrades to meet anticipated traffic demand. The analyses were performed to identify additional roadway upgrades required to achieve a level of service D or a “high” level of service E. As noted in the previous section, “high” level of service E is considered a delay within 10 seconds of the level of service D/E threshold of 55 seconds.

Similar to the Design-Year 2025 conditions, the major issues impacting operations are the high volume of turning movements paired with the high volume of conflicting through movements. As a result, typical upgrades included providing additional turn lanes while maintaining a two lane section along MD 924 where feasible. The volumes at several intersections for the 2040 Design-



Year reached a level that could not reasonably be accommodated by at-grade intersections; therefore, the intersections were identified for potential grade-separation of major movements. The level of service and queue computation forms and summary tables are provided in Appendix II.D.

#### **D. Zone 1 – Design-Year 2040**

**Level of Service** assessments were performed for Zone 1. The results of the No-Build level of service analyses are summarized in Table VI.1 for Synchro and Table VI.2 for CLA. The No-Build analyses assume traffic signal timing and phasing optimization and interconnect of signal groups to improve operations. For 2040, under the No-Build condition, only the intersections of MD 924 with Woodsdale Road and Holly Wreath Road/Court would continue to function at an overall acceptable level of service. The analyses were recomputed with the mitigation measures from the 2025 analyses and the redistributed trips from Figure VI.2. As shown in Appendix II.D, based on Synchro, the 2025 capacity upgrades would not provide sufficient reserve capacity to accommodate the 2040 volumes. Employing the upgraded lane geometry from Figure VI.4 and the 2040 volumes from Figure VI.3 the analyses were recomputed. The additional through and turn lanes noted in Figure VI.4 do improve the level of service to acceptable levels as shown in Table VI.1 (Synchro) and Table VI.3 (CLA) along MD 924. Although a few minor street intersection approaches are shown as a level of service E with mitigation, the calculated delays are within 10 seconds of the level of service D/E threshold.

The 2025 mitigation measures at the MD 24/Singer Road intersection would not provide an acceptable level of service in the 2040 Design-Year; the intersection would require an eight-lane section on MD 24 to produce an acceptable level of service. A second southbound left turn lane would also be required. Additional lanes on all minor street approaches would be necessary in order to maintain acceptable intersection operations. A second eastbound left and through and second right turn lane with right turn overlap phase would be required. Also, an additional westbound left turn and through lane are required. The west leg of the intersection would require an eight lane section. The resultant level of service is summarized in Appendix II.D for the controlling evening peak hour. Even with the substantial widening, motorists would experience delays accessing MD 24 and traveling through the MD 24 corridor. In an effort to promote through traffic to use MD 24 rather than MD 924, grade-separation to eliminate signalized control of major movements should be considered at the MD 24/Singer Road intersection.

MD 24 was also analyzed using the HCM Basic Freeway Capacity methodology to determine the level of service and density adjacent to the proposed grade-separated roadway. The computation worksheets are provided in Appendix II.D. The level of service for MD 24 northbound, south of Singer Road under Design-Year 2040 conditions and in the controlling PM peak hour (assuming MD 24 is a six-lane section) is LOS ‘B’ with a density of 16.5 pc/mi/ln; the level of service drops to LOS ‘C’ with a density of 25.0 pc/mi/ln if only four lanes are available along MD 24. The level of service ‘C’ with four lanes along MD 24 indicates that if widened to an interim 6-lane section, the additional pavement could be used for MOT during construction of the grade-separation and for the widening required to accommodate the structure.



**Table VI.1**

**Synchro Summary for 2040 – Zone 1  
MD 924 Multi-Modal Corridor Study**

Zone 1					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
01	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	B 19.7	C 33.3	C 21.9	C 33.7
02	MD 924 at Porter Dr/Box Hill S. Parkway	B 18.8	F 147.9	C 24.0	D 41.2
03	MD 924 at Singer Rd/ Abingdon Rd	C 26.7	F 91.8	C 33.3	C 33.4
04	MD 924 at Holly Wreath Ct/Holly Wreath Rd	C 22.7	D 36.2	B 14.4	B 13.0
05	MD 24 at Singer Rd	F 200.1	F 204.9		

**Table VI.2**

**Critical Lane Analysis Summary for 2040 No-Build – Zone 1  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
01	ZONE 1	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	A (735)	0.46	C (1172)	0.73
02		MD 924 at Porter Dr/Box Hill S. Parkway	A (874)	0.55	F (1725)	1.08
03		MD 924 at Singer Rd/Abingdon Rd	A (943)	0.59	E (1543)	0.96
04		MD 924 at Holly Wreath Ct/Holly Wreath Rd	A (943)	0.59	B (1104)	0.69
05		MD 24 at Singer Rd	F (2105)	1.32	F (2217)	1.39





**Table VI.3**

**Critical Lane Analysis Summary for 2040 Mitigation Measures – Zone 1  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
01	ZONE 1	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	A (735)	0.46	C (1175)	0.73
02		MD 924 at Porter Dr/ Box Hill S. Parkway	A (597)	0.37	B (1100)	0.69
03		MD 924 at Singer Rd/ Abingdon Rd	A (943)	0.59	C (1216)	0.76
04		MD 924 at Holly Wreath Ct/ Holly Wreath Rd	A (943)	0.59	B (1104)	0.69

In addition to the 2025 mitigation measures, the following 2040 mitigation measures were utilized in Synchro to provide acceptable levels of service:

01 – MD 924 at Constant Friendship Shopping Center/Woodsdale Road:

The geometric upgrades from the Design-Year 2025 would be sufficient to accommodate Design-Year 2040 volumes. The signal cycle length was optimized to 120 seconds during the AM and PM peak periods (existing cycle length is 150 seconds in the AM and PM peak periods). It should be noted that the signal is interconnected to the MD 24/MD 924 interchange signals, which are located outside of the study limits. A full analysis of the coordinated system would need to be completed to verify that reducing the signal cycle length would benefit the system as a whole.

02 – MD 924 at Porter Drive/Box Hill South Parkway:

No additional geometric upgrades were required to accommodate Design-Year 2040 volumes. The signal cycle length is optimized to 120 seconds in the AM peak period (existing cycle length is 100 seconds) and 120 seconds in the PM peak period (existing cycle length is 130 seconds).

03 – MD 924 at Singer Road/Abingdon Road:

The signal cycle length is optimized to 120 seconds during the AM and PM peak periods (existing cycle length is 110 seconds during the AM and PM peak periods). A second northbound through lane (through/right turn) is required to accommodate the heavy northbound Design-Year 2040 PM peak volume. Maintain existing exclusive/permissive phasing on all approaches.

04 – MD 924 at Holly Wreath Court/Road:

The signal cycle length is optimized to 120 seconds in the AM and PM peak periods (existing cycle length is 100 seconds in the AM and PM peak periods). Install an additional through lane on the northbound approach to accommodate Design-Year 2040 volumes.



#### 05 – MD 24 at Singer Road:

The analyses indicate that the intersection will experience excessive delays. Major capacity upgrades would be required to provide acceptable levels of service and queues. Four through lanes in each direction along with double turn lanes southbound are required on MD 24. Widening of Singer Road would be required to provide an eight lane section with double right, through and left turn lanes on the west leg. In lieu of widening, the option of grade-separation was reviewed. A grade-separated median intersection could be provided to accommodate all left turn movements and Singer Road through movements. The MD 24 through movements and all right turn movements would remain at-grade and free-flow without signalized control. The grade-separation is discussed in further detail in the *Plan for the Corridor* companion document.

**Queue analyses** were computed based on the upgraded 2040 lane geometry from Figure VI.4 and the volumes from Figure VI.3. Results of the SimTraffic and 95% probability methodology analyses are summarized in tables located in Appendix II.D. Review of the tables indicates that the projected queues can be addressed.

#### **E. Zone 2 – Design-Year 2040**

**Level of Service** analyses were computed for the intersections in Zone 2 with the 2040 (Figure VI.1) projected No-Build traffic volumes. The analysis results are summarized in Table VI.4 (Synchro) and Table VI.5 (CLA). Due to the increased traffic demand, all intersections in Zone 2 would function at an unacceptable level of service, some with excessive delays. The exception is the intersection of MD 924 at Barrington Place/Patterson Mill Road; however, although the overall level of service is acceptable, individual approaches would experience a level of service E. As noted previously, the No-Build analyses assume only traffic signal timing and phasing optimization and interconnect of signal groups to improve operations. The 2025 Design-Year mitigation lane use (Figure V.3) and 2040 volumes applied to the 2025 mitigation measures (Figure VI.2) were analyzed. Results of the analyses are shown in tables located in Appendix II.D. Although the level of service improves for some intersections versus No-Build conditions, additional mitigation measures are warranted to provide acceptable operations. Review of the tables confirms the need for grade-separation along MD 24.

The analyses were recomputed to determine required intersection upgrades to achieve acceptable operations. The resultant lane configurations are illustrated in Figure VI.5, and the analysis summaries provided in Tables VI.4 for Synchro and Table VI.6 for CLA. As shown in the approach level of service and queuing tables located in Appendix II.D, the additional turn lanes improve the level of service and queues to acceptable levels along MD 924.



**Table VI.4**

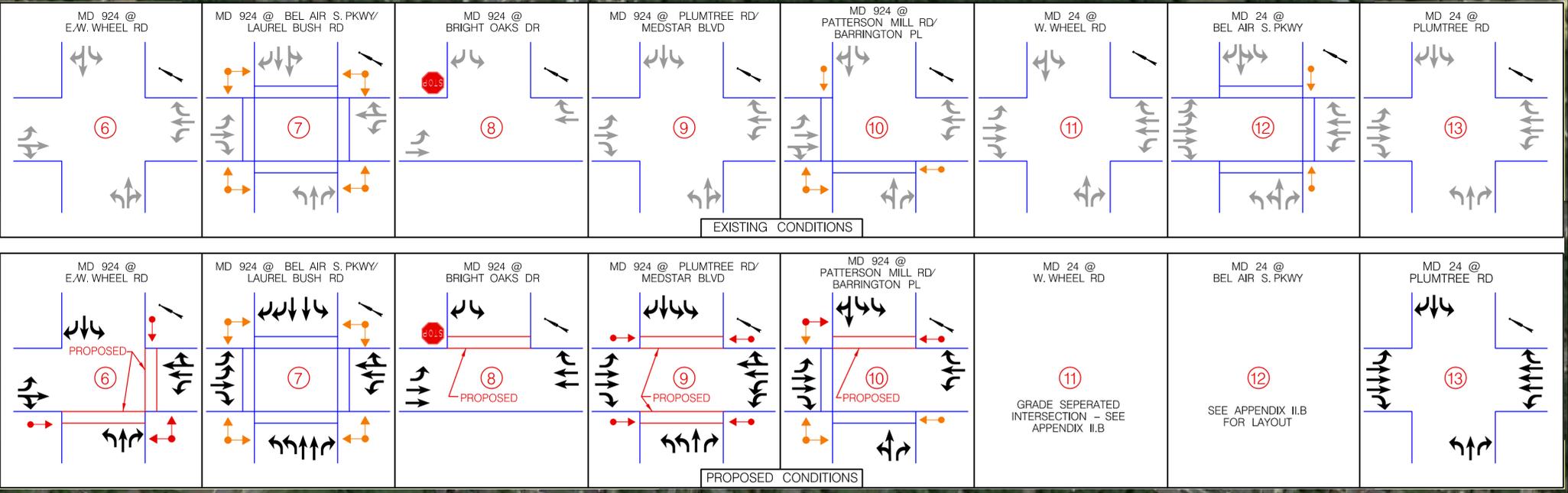
**Synchro Summary for 2040 – Zone 2  
MD 924 Multi-Modal Corridor Study**

ZONE 2					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
06	MD 924 at Wheel Rd	D 43.3	E 73.8	C 29.1	D 42.8
07	MD 924 at Bel Air S. Parkway/Laurel Bush Rd	D 42.7	F 115.4	C 31.7	D 52.7
08	MD 924 at Bright Oaks Dr	D	F	A	B
09	MD 924 at Plumtree Rd/ Medstar Boulevard	F 85.5	F 110.9	D 35.7	D 37.9
10	MD 924 at Barrington Pl/ Patterson Mill Rd	C 30.3	D 36.7	C 23.0	D 36.1
11	MD 24 at Wheel Rd	F 85.2	F 207.7		
12	MD 24 at Bel Air S. Parkway	F 138.5	F 225.3	E 56.7	E 67.5
13	MD 24 at Plumtree Rd	C 33.6	F 107.2	C 26.3	D 43.4

**Table VI.5**

**Critical Lane Analysis Summary for 2040 No-Build Conditions – Zone 2  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
06	ZONE 2	MD 924 at E./W. Wheel Rd	B (1053)	0.66	E (1456)	0.91
07		MD 924 at Bel Air S. Parkway/Laurel Bush Rd	C (1224)	0.77	F (1622)	1.01
08		MD 924 at Bright Oaks Dr	D (1338)	0.84	F (1567)	0.98
09		MD 924 at Plumtree Rd/ Medstar Boulevard	D (1392)	0.87	F (1665)	1.04
10		MD 924 at Barrington Pl/ Patterson Mill Rd	B (1138)	0.71	E (1466)	0.92
11		MD 24 at E. Wheel Rd	F (1625)	1.02	F (2076)	0.91
12		MD 24 at Bel Air S. Parkway	F (1663)	1.04	F (2193)	1.37
13		MD 24 at Plumtree Rd	D (1381)	0.86	F (1847)	1.15



**LEGEND**

- EXISTING LANE CONFIGURATIONS
- PROPOSED LANE CONFIGURATIONS
- EXISTING PEDESTRIAN SIGNAL
- PROPOSED PEDESTRIAN SIGNAL

**MARYLAND 924**

**PROPOSED LANE CONFIGURATIONS - ZONE 2**

2040 MITIGATION MEASURES  
HOLLY WREATH ROAD TO PATTERSON MILL ROAD

N.T.S.	FIGURE VI.5	JUNE 2017
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**Table VI.6**

**Critical Lane Analysis Summary for 2040 Mitigation Measures – Zone 2  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
06	ZONE 2	MD 924 at E./W. Wheel Rd	A (972)	0.61	D (1366)	0.85
07		MD 924 at Bel Air S. Parkway/Laurel Bush Rd	A (894)	0.56	C (1269)	0.79
08		MD 924 at Bright Oaks Dr	A (823)	0.51	A (945)	0.59
09		MD 924 at Plumtree Rd/ Medstar Boulevard	A (885)	0.55	B (1066)	0.67
10		MD 924 at Barrington Pl/ Patterson Mill Rd	B (1011)	0.63	E (1462)	0.91
11		MD 24 at E. Wheel Rd (Grade-separated)				
12		MD 24 at Bel Air S. Parkway	C (1196)	0.75	D (1415)	0.88
13		MD 24 at Plumtree Rd	B (1122)	0.70	E (1479)	0.92

The mitigation measures at the MD 24 at Bel Air South Parkway intersection substantially improve the level of service and delay in both the AM and PM peak hours. However, the AM and PM peak hour overall level of service remain at a level of service E, though the delay is only 12.5 seconds above the level of service D/E threshold. The MD 24/E. Wheel Road intersection would require an eight lane section along MD 24 and a seven lane section along E. Wheel Road, in addition to double left turn lanes to provide an acceptable level of service. Grade-separation was considered to provide improved operations and facilitate access to and from MD 24.

MD 24 was also analyzed using the HCM Basic Freeway Capacity methodology to determine the level of service and density adjacent to the proposed grade-separated roadway. The computation worksheets are provided in Appendix II.D. The level of service for MD 24 northbound, south of Wheel Road under the Design-Year 2040 and in the controlling PM peak hour (assuming MD 24 is a six lane section) is LOS ‘B’ with a density of 16.3 pc/mi/ln; the level of service drops to LOS ‘C’ with a density of 24.6 pc/mi/ln if only four lanes are available along MD 24. The level of service ‘C’ with four lanes along MD 24 indicates that if widened to an interim 6-lane section, the additional pavement could be used for MOT during construction of the grade-separation and for the widening required to accommodate the structure.

In order to accommodate the projected increased traffic demand for the 2040 Design-Year, the following intersection upgrades were included in the analyses:



06 – MD 924 at Wheel Road:

A westbound right turn lane with a 175 foot storage length is proposed; convert the existing westbound shared through/right turn lane to a through lane. Install an additional northbound (through/right turn) lane. The signal cycle length is optimized to 140 seconds (existing cycle length is 150 seconds) in the PM peak period.

07 – MD 924 at Bel Air South Parkway/Laurel Bush Road:

Extend the southbound double left turn lane storage length from 200 feet to 400 feet. The signal cycle length is optimized to 130 seconds (existing signal cycle length is 120 seconds) in the AM peak period and 140 seconds (existing signal cycle length is 150 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased.

08 – MD 924 at Bright Oaks Drive:

No additional upgrades beyond 2025 mitigation measures are required.

09 – MD 924 at Plumtree Road/Medstar Boulevard:

Install an additional southbound through lane. The southbound left turn will continue to operate with exclusive/permissive phasing and the northbound left turn will operate with Exclusive phasing. The eastbound and westbound approaches will operate as split phased. The signal cycle length is optimized to 130 seconds in the AM peak period (existing cycle length is 120 seconds) and 140 seconds in the PM peak period (existing cycle length is 150 seconds).

10 – MD 924 at Barrington Place/Patterson Mill Road:

The signal cycle length is optimized to 130 seconds (existing cycle length is 120 seconds) in the AM peak period and 140 seconds (existing cycle length is 150 seconds) in the PM peak period. No additional geometric upgrades are required.

11 – MD 24 at E. Wheel Road:

Given the high through movements and opposing turning movements, major roadway widening would be required to accommodate the projected traffic. An eight-lane section would be required along MD 24, and a seven-lane section with double left turn lanes would be required along E. Wheel Road.

As an alternate to the at-grade intersection, grade-separation was reviewed. A grade-separated intersection with median ramps to accommodate left turns, side street through movements and eastbound right turns could be constructed. The at-grade lanes would have free-flow right turns at all approaches (excluding eastbound right turns) and free-flow mainline through movements. The grade-separated intersection at E. Wheel Road would provide a link to the grade-separated access to and from the Festival at Bel Air. The design elements of the interchange are reviewed in further detail in the **Plan for the Corridor** companion document.

12 – MD 24 at Bel Air South Parkway:

Install additional lanes related to the Festival at Bel Air and Plumtree development ramps along the northbound and southbound approaches. The signal cycle length is optimized to 160 seconds (existing cycle length is 150 seconds) in the AM peak period and 170 seconds (existing cycle



length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased. The analysis volumes for MD 24 at Bel Air South Parkway include a substantial reduction in turning movements due to anticipated diversion to the Festival at Bel Air grade-separated access. Without the alternate access, the MD 24 at Bel Air South Parkway would perform at a level of service F with severe congestion and excessive queues.

#### 13 – MD 24 at Plumtree Road:

Adjust the northbound and southbound lane alignment to accommodate the Plumtree Road directional ramps and Festival at Bel Air grade-separated access. The signal cycle length is optimized to 160 seconds (existing cycle length is 150 seconds) in the AM peak period and 170 seconds (existing cycle length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate concurrently.

**Queue analyses** were performed. Tables in Appendix II.D provide a summary of the SimTraffic and SHA 95% Probability methodology queue analyses results associated with the 2040 mitigation measures. Review of the tables indicate that queues will be accommodated by the upgraded lane geometry.

#### **F. Zone 3 – Design-Year 2040**

**Level of Service** computations for the intersections in Zone 3 were completed employing the 2040 projected No-Build traffic volumes (Figure VI.1). The analysis results are summarized in Table VI.7 for the morning and evening peak hour Synchro results, with the CLA analyses summarized in Table VI.8. As shown, for the No-Build condition, all intersections would function at an unacceptable level of service, some with excessive delays. The No-Build analyses assume only traffic signal timing and phasing optimization and interconnect of signal groups to improve operations. The 2025 Design-Year mitigation measures (Figures VI.2 and V.5) would not be sufficient to accommodate the 2040 projected traffic as shown in the tables located in Appendix II.D. The results of the analyses were reviewed to determine lane geometry required to address failing intersection approaches; the proposed lane use modifications are illustrated in Figure VI.6. The increase in lane capacity was limited on the minor street approaches of MD 924 to single turn lanes in an effort to maintain the two lane section along MD 924. As shown in Tables VI.7 for Synchro and Table VI.9 for CLA, the additional lanes do improve the level of service to acceptable levels. The MD 924/E./W. Ring Factory Road intersection is projected to function at a level of service E; however, the delay is less than 10 seconds over the level of service D/E threshold.



**Table VI.7**

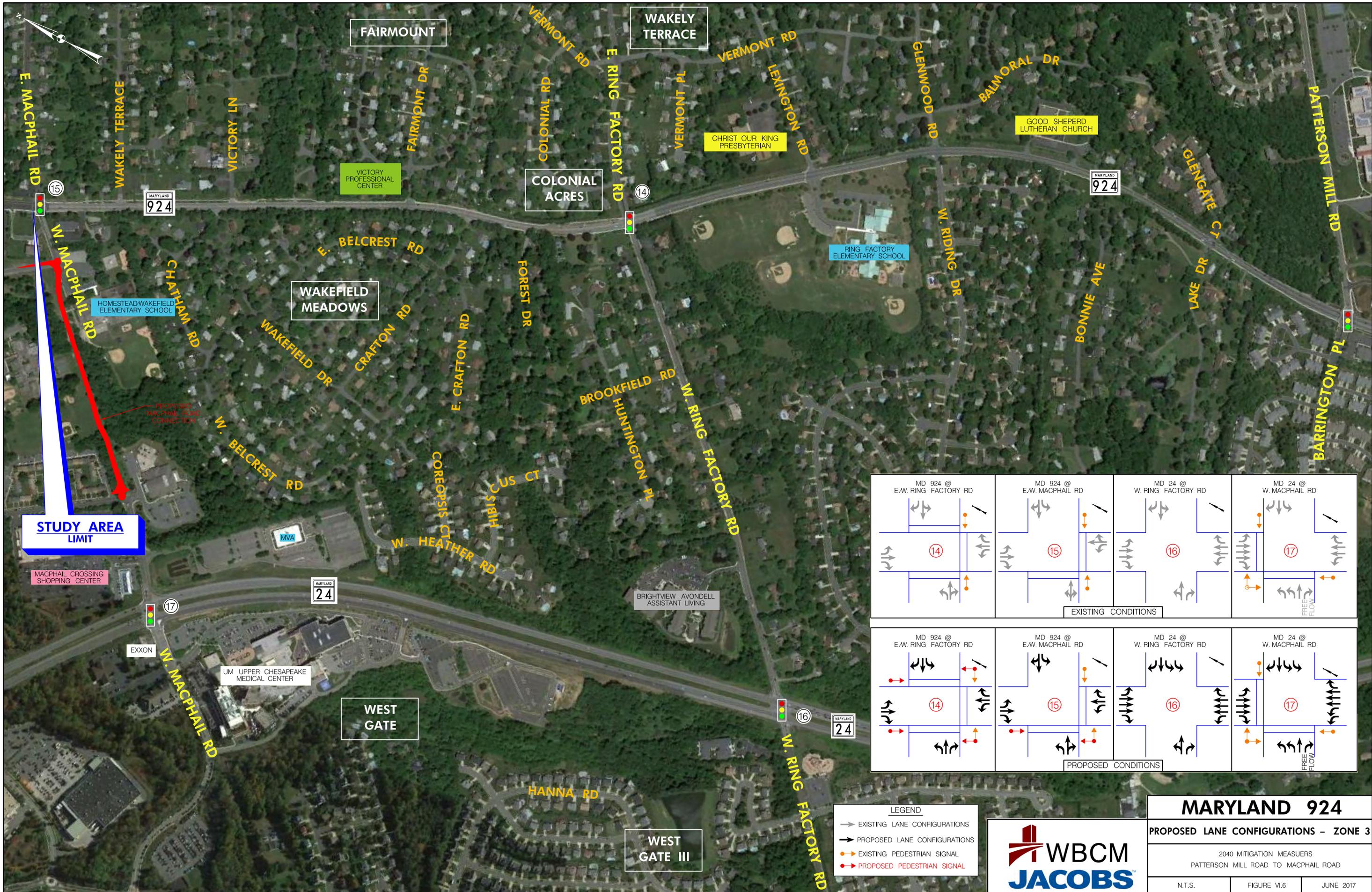
**Synchro Summary for 2040 – Zone 3  
MD 924 Multi-Modal Corridor Study**

Zone 3					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
14	MD 924 at E. Ring Factory Rd/W. Ring Factory Rd.	C 34.3	F 95.4	D 45.9	E 56.8
15	MD 924 at W. MacPhail Rd/E. MacPhail Rd	D 51.5	E 67.0	D 37.9	D 41.1
16	MD 24 at W. Ring Factory Rd	F 112.9	F 129.1	D 47.6	D 49.2
17	MD 24 at W. MacPhail Rd	C 31.2	E 57.2	C 33.0	C 28.8

**Table VI.8**

**Critical Lane Analysis Summary for 2040 No-Build Conditions – Zone 3  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
		LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
14	MD 924 at E. Ring Factory Rd/ W. Ring Factory Rd	C (1173)	0.73	E (1492)	0.93
15	MD 924 at E. MacPhail Rd/ W. MacPhail Rd	C (1217)	0.76	E (1524)	0.95
16	MD 24 at W. Ring Factory Rd	E (1541)	0.96	F (1747)	1.09
17	MD 24 at W. MacPhail Rd	A (979)	0.61	D (1430)	0.89



MD 924 @ E.W. RING FACTORY RD	MD 924 @ E.W. MACPHAIL RD	MD 24 @ W. RING FACTORY RD	MD 24 @ W. MACPHAIL RD
EXISTING CONDITIONS			

MD 924 @ E.W. RING FACTORY RD	MD 924 @ E.W. MACPHAIL RD	MD 24 @ W. RING FACTORY RD	MD 24 @ W. MACPHAIL RD
PROPOSED CONDITIONS			

- LEGEND**
- EXISTING LANE CONFIGURATIONS
  - PROPOSED LANE CONFIGURATIONS
  - EXISTING PEDESTRIAN SIGNAL
  - PROPOSED PEDESTRIAN SIGNAL



MARYLAND 924		
PROPOSED LANE CONFIGURATIONS - ZONE 3		
2040 MITIGATION MEASURES PATTERSON MILL ROAD TO MACPHAIL ROAD		
N.T.S.	FIGURE V1.6	JUNE 2017

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**Table VI.9**

**Critical Lane Analysis Summary for 2040 Mitigation Measures – Zone 3  
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
		LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
14	MD 924 at E. Ring Factory Rd/ W. Ring Factory Rd	B (1027)	0.64	D (1314)	0.82
15	MD 924 at E. MacPhail Rd/ W. MacPhail Rd	B (1024)	0.64	C (1234)	0.77
16	MD 24 at W. Ring Factory Rd	B (1065)	0.67	D (1304)	0.82
17	MD 24 at W. MacPhail Rd	A (839)	0.52	B (1134)	0.71

The additional mitigation measures for 2040 for Zone 3 are summarized below:

14 – MD 924 at W./E. Ring Factory Road:

The signal cycle length is optimized to 140 seconds (existing cycle length is 100 seconds) in the AM peak period and 140 seconds (existing cycle length is 110 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased. The 2025 geometric mitigation measures are sufficient for 2040 volumes; no additional geometric upgrades are required.

15 – MD 924 at W./E. MacPhail Road:

Optimize cycle length to 140 seconds (existing is 100 seconds) in the AM peak period and 140 seconds (existing cycle length is 100 seconds) in the PM peak period. Modify the eastbound and westbound left-turn phasing from permissive to exclusive/permissive. No additional geometric upgrades are required for 2040.

16 – MD 24 at W. Ring Factory Road:

Install a second westbound left turn lane with a storage length of 250 feet. The signal cycle length is optimized to 140 seconds (existing cycle length is 150 seconds) in the AM peak period and 170 seconds (existing cycle length is 180 seconds) in the PM peak period. The eastbound and westbound approaches will continue to operate as split phased.

17 – MD 24 at W. MacPhail Road:

Install an additional northbound left turn lane with a storage length of 650 feet. Install additional west leg receiving lane to accommodate traffic from the added northbound left turn lane. The signal cycle length is optimized to 120 seconds (existing is 150 seconds) in the AM peak period and 170 seconds (existing is 180 seconds) in the PM peak period.

**Queue analyses** employing the 2040 mitigation volumes (Figure VI.3) and the 2040 lane geometry upgrades for Zone 3 (Figure VI.6) were calculated. Queue analyses were performed



with SimTraffic and SHA 95% Probability methodology. Results of the analyses are summarized in tables located in Appendix II.D. As illustrated in the tables, projected queues can be accommodated.

## **VII. ENVIRONMENTAL CONSIDERATIONS**

### **A. Stormwater Management/Drainage/Erosion and Sediment Control**

Stormwater management (SWM) will be required for the new pavement and the redevelopment pavement areas. The section of the roadway that is milled and resurfaced will not need to be managed. The proposed typical section of MD 924 will have curb and gutter for the entire length; therefore, stormwater runoff will need to be collected by storm drain inlets along the curb line and be conveyed by the storm drain pipes to the SWM facility locations. It is anticipated that MD 24 will remain an open section with sheet flow to roadside ditches then conveyed to SWM facilities. The facilities must be designed for both Quality and Quantity Management. Quality Management can be provided by Environmental Site Design (ESD) facilities such as Grassed Swales, Bio-Retention or Micro-Bioretenion facilities, submerged Gravel Wetlands, or infiltration facilities. Quantity management may require a pond to manage the 10-year flow at a minimum, and possibly the 100-year storm in flood prone areas.

Variances and waivers may be required to meet water quantity management due to various hardships such as proximity to developed area and steep slopes. The potential for variances would be most acute in the densely developed areas along MD 924 and MD 24 in Zone 2 between Wheel Road and Plumtree Road. The proposed park south of Wheel Road and school sites could provide space for stormwater management ponds. Joint use ponds could be pursued as major parcels are developed or for existing facilities. Impacts to existing stormwater management facilities will need to be determined and mitigated. Micro-practices for SWM such as filtering inlets, tree boxes, porous pavement sidewalks, impervious area removal/reductions and Micro-bioretenions may be needed to meet water quality treatment criteria. As part of drainage final design, all roadway cross culverts within the limit of work must be analyzed for the 100 year functional storm and the existing condition evaluated. The culverts will be analyzed to check the functional storm is contained within the road edge elevation. Depending upon the condition of the culvert and capacity, the culverts either may need lining or replacement. All outfalls within the project limit will be analyzed for stable and adequate conveyance and retrofitted, if necessary.

For Erosion and Sediment Control (ESC), the project will be divided into multi-phases of construction. Inlet protection, silt fence, super silt fence, Temporary Gabion Outlet Structures and stabilized construction entrances will be employed as ESC measures. Project wide, areas with runoff not directed toward an ESC device shall be same day stabilized.

### **B. Landscape, Wetlands, and Historic Preservation**

Roadside Tree Removal Permits will be completed for roadside tree impacts associated with the roadway improvements. Landscape plans would be included to provide aesthetics and mitigation for the tree removals in accordance with Department of Natural Resources and Maryland Department of the Environment requirements. A Joint Permit Application will be completed for any possible wetland and/or water of US impacts. A search of Maryland's Environmental Resources and Land Information Network mapping did not reveal any wetlands adjacent to the



roadway (Appendix II.E). The northeast quadrant of the MD 24/Wheel Road intersection is in the 100 year flood plain.

Historic properties listed on the Maryland Inventory and National Registry of Historic Properties are present on the south side of the MD 924/St. Mary’s Church Road intersection (St. Mary’s Church), along Wheel Road at Old Emmorton Road (Mt. Carmel Methodist Church), and along Singer Road east of Silver Spring Lane (Dale Terrace Tennant House). Although anticipated impacts are minimal, appropriate permits will be required for construction activities adjacent to the historic properties.

## **VIII. OTHER ALTERNATIVES CONSIDERED BUT NOT CARRIED FORWARD**

Several alternatives were considered but dropped from the final report due to reasons such as level of service thresholds not being met and the alternative not being approved by Harford County.

### **A. MD 924 at St. Clair Drive/Entrance to Giant**

Field observations revealed that the alley that serves the Giant Food store south of Abingdon Road is employed as a local detour to bypass congestion at the MD 924/Abingdon Road intersection. If upgraded to accommodate additional traffic volumes, the alley could provide a convenient means of eliminating several movements at the MD 924/Abingdon Road intersection, thus improving system operations. The alley could be upgraded to local road standards and serve the left turn movements from Abingdon Road and southbound left turns from MD 924. In addition to the movements served by the upgraded alley connection, St. Clair Drive could also serve to accommodate movements from the MD 924/Abingdon Road/Singer Road intersection. St. Clair Drive links Singer Road with MD 924 and could provide an alternate route for the right turn traffic from Singer Road and northbound left turn movements from MD 924. St. Clair Drive would be suitable to accommodate the diverted trips given the pavement width and lack of direct access residential driveways. Therefore, upgrading the connection between MD 924 and Abingdon Road through the Giant parking lot was considered.

By prohibiting turning movements at the MD 924 at Singer Road/Abingdon Road intersection, the intersection operations improved at MD 924/Singer Road/Abingdon Road which allowed the two-lane section to be maintained along MD 924 (north of Porter Drive/Box Hill S. Parkway to south of Wheel Road) through 2040. The diverted volumes were added to the existing volumes at the MD 924 at St. Clair Drive/Entrance to Giant-Connection to Abingdon Road intersection. Existing traffic volumes for the MD 924/St. Clair Drive intersection were developed by performing trip generation for the land uses served by the Giant driveway and St. Clair Drive. The following are volume diversions from the MD 924 at Singer Road/Abingdon Road intersection to the MD 924 at St. Clair Drive/Entrance to Giant-Connection to Abingdon Road intersection:

- 100% of the northbound left and right turn volumes.
- 100% of the southbound left turn volume.
- 100% of the westbound left and right turn volumes.
- 100% of the eastbound right turn volume.

The results of the Synchro analyses are provided in Appendix II.F for the 2040 Design-Year and summarized in Table VIII.1.



**Table VIII.1**

**Synchro Summary for 2040 (St. Clair Drive/Entrance to Giant Connection) – Zone 1  
MD 924 Multi-Modal Corridor Study**

Zone 1					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
01	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	B 19.7	C 33.3	C 21.3	C 33.3
02	MD 924 at Porter Dr/Box Hill S. Parkway	B 18.8	F 147.9	C 20.1	D 43.5
02A	MD 924 at St. Clair Dr/Giant Entrance			B 15.3	D 54.6
03	MD 924 at Singer Rd/Abingdon Rd	C 26.7	F 91.8	B 19.9	C 27.3
04	MD 924 at Holly Wreath Ct/Holly Wreath Rd	C 22.7	D 36.2	B 15.9	C 25.2

Table VIII.1 shows that the alternative would provide an acceptable level of service at the study intersections. However, the alternative was not used since it did not receive the County’s concurrence.

**B. Elimination of Westbound Right Turn - MD 924 at Singer Road/Abingdon Road**

The traffic projections indicate a significant volume increase for the westbound right turn movement along Abingdon Road at MD 924. The heavy right turn volumes carry through to the intersection at Holly Wreath Drive requiring two northbound lanes to provide an acceptable level of service. The right turn traffic from Abingdon Road is destined for points north that are served by Laurel Bush Road and Wheel Road. If the right turn movement from Abingdon Road is eliminated, the displaced vehicles can be accommodated by the Wheel Road intersection. The northeast quadrant of the MD 924 at Singer Road/Abingdon Road intersection would be modified to discourage right turn traffic.

All MD 924 at Singer Road/Abingdon Road westbound right turn volumes were diverted north to access MD 924 via Holly Wreath Road and Wheel Road. Approximately 30% of the right turn volumes were assumed to utilize Holly Wreath Road and 70% would use Wheel Road. The results of the Synchro analyses are provided in Appendix II.F for the 2040 Design-Year and summarized in Table VIII.2.

The results of the Synchro analyses are provided in Appendix II.F for the 2040 Design-Year and summarized in Table VIII.2.



**Table VIII.2**

**Synchro Summary for 2040 (Elimination of Westbound Right Turn - MD 924  
at Singer Road/Abingdon Road) – Zone 2  
MD 924 Multi-Modal Corridor Study**

Zone 2					
Int. ID No.	Intersection	NO-BUILD LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
06	MD 924 at Wheel Rd	D 43.3	E 73.8	C 25.7	D 37.0
07	MD 924 at Bel Air S. Parkway/ Laurel Bush Road	D 42.7	F 115.4	C 31.5	D 54.9

Table VIII.2 shows that the alternative would provide an acceptable level of service at the study intersections. However, the concept was not used since it did not receive the County’s concurrence.

**C. Directional Interchange along I-95 at MD 136**

As previously stated, approximately 65% of the study area traffic is oriented to the I-95 corridor or south along MD 24. An alternate means of access to I-95 would help to alleviate some of the congestion along MD 24, MD 924 and MD 543. An existing grade-separation is provided for MD 136 over I-95. Directional ramps to and from the south along I-95 at MD 136 could be provided that would serve traffic in the eastern portion of the study area. The ramps could tie into managed lanes that are proposed along the I-95 corridor. The concept was not carried forward as it is understood that the MDTA will not entertain any proposals for a new interchange along I-95.

**D. MD 24 at Singer Road At-Grade 2040 Mitigation Measures**

Maintaining MD 24 at Singer Road as an at-grade intersection was considered as another alternative to grade-separated median ramps in the 2040 Design-Year. Synchro analyses were conducted on the intersection using the volumes in Figure VI.2 to determine the required upgrades to produce an acceptable level of service.

As part of SHA scheduled improvements, MD 24 will be widened to a six-lane section prior to the 2025 Design-Year. However, to produce an acceptable level of service, MD 24 requires widening to an eight-lane section at the intersection. A second southbound left turn lane would also be required. Additional lanes on all minor street approaches would be necessary in order to improve traffic flow. A second eastbound left and through lane and second right turn lane with right turn overlap phase are required, with the outermost right turn lane having a “No Turn on Red This Lane” (R3-5MOD) sign installed. An additional westbound left turn and through lane are also necessary. The west leg of the intersection would require an eight-lane section due to the additional approach and receiving lanes. The Synchro analyses results are provided in Appendix II.F for the 2040 Design-Year. Results of the analyses show that the intersection can be maintained at a level of service D (38.0 sec/veh delay) with the proposed at-grade mitigation measures during the PM peak hour. The concept was dropped from consideration since the



required widening along MD 24 and the side streets is cost prohibitive and not environmentally practical.

#### **E. MD 24 at Wheel Road At-Grade 2040 Mitigation Measures**

In lieu of the proposed grade-separation, upgrades to provide acceptable at-grade intersection operations were identified. Synchro analyses were conducted on the intersection using the volumes in Figure VI.2.

A six-lane section is proposed on MD 24 as part of SHA scheduled improvements prior to the 2025 Design-Year. Widening of MD 24 to an eight-lane section at the intersection would be required to provide an acceptable level of service in the 2040 Design-Year. In addition, all minor street approaches would require additional lanes to improve traffic flow. The eastbound and westbound approaches would consist of two left turn, two through and one right turn lane. The Wheel Road approaches would consist of a seven-lane section to accommodate the added approach and receiving lanes. The Synchro analyses results are provided in Appendix II.F for the 2040 Design-Year. Results of the analyses show that the intersection can be maintained at a level of service C (32.5 sec/veh delay) with the proposed at-grade mitigation measures. The concept was dropped from consideration since the required widening along MD 24 and the side streets is not practical.

#### **F. Bus Rapid Transit**

Bus rapid transit (BRT) has gained popularity in the United States in recent years. BRT can move a large number of people in congested corridors at lower cost than rail transit. Attributes of bus rapid transit include dedicated right-of-way, off-board fare collection, signal priority at intersections, and platform-level boarding.

The MD 924 corridor is currently not well-suited for bus rapid transit. Bus rapid transit systems with ridership levels below 1,000 passengers per hour per direction (pphpd) during the peak hour carry fewer passengers than a normal mixed-traffic lane.<sup>1</sup> New BRT lines should therefore be able to achieve passenger ridership of at least 1,000 pphpd. Current and projected land uses and densities in the MD 924 corridor are not able to generate transit trips in sufficient number to justify the dedicated bus lanes that characterize BRT. Instead, queue jumps are proposed at selected intersections in order to improve running time and schedule adherence.

The MD 924 right-of-way is also restricted. Because the proposed design of the roadway includes sections with only one through lane in each direction, it is not possible to convert a travel lane for bus-only use. Therefore, BRT would require widening the roadway which would result in impacts to adjacent properties and limit the ability to provide enhanced pedestrian and bicycle facilities.

In order to shift vehicle trips in the corridor to transit, Harford Transit should instead increase frequency of existing transit routes operating in mixed traffic. Realigning routes to better suit travel patterns, as studied in the 2008 Transit Development Plan, also deserve further consideration.

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<sup>1</sup> Institute for Transportation Development and Policy. “The Scorecard,” accessed June 27, 2016.  
<https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/the-scorecard/>.



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# MD 924 Multi-Modal Corridor Study

## Volume II – Operational Analysis



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