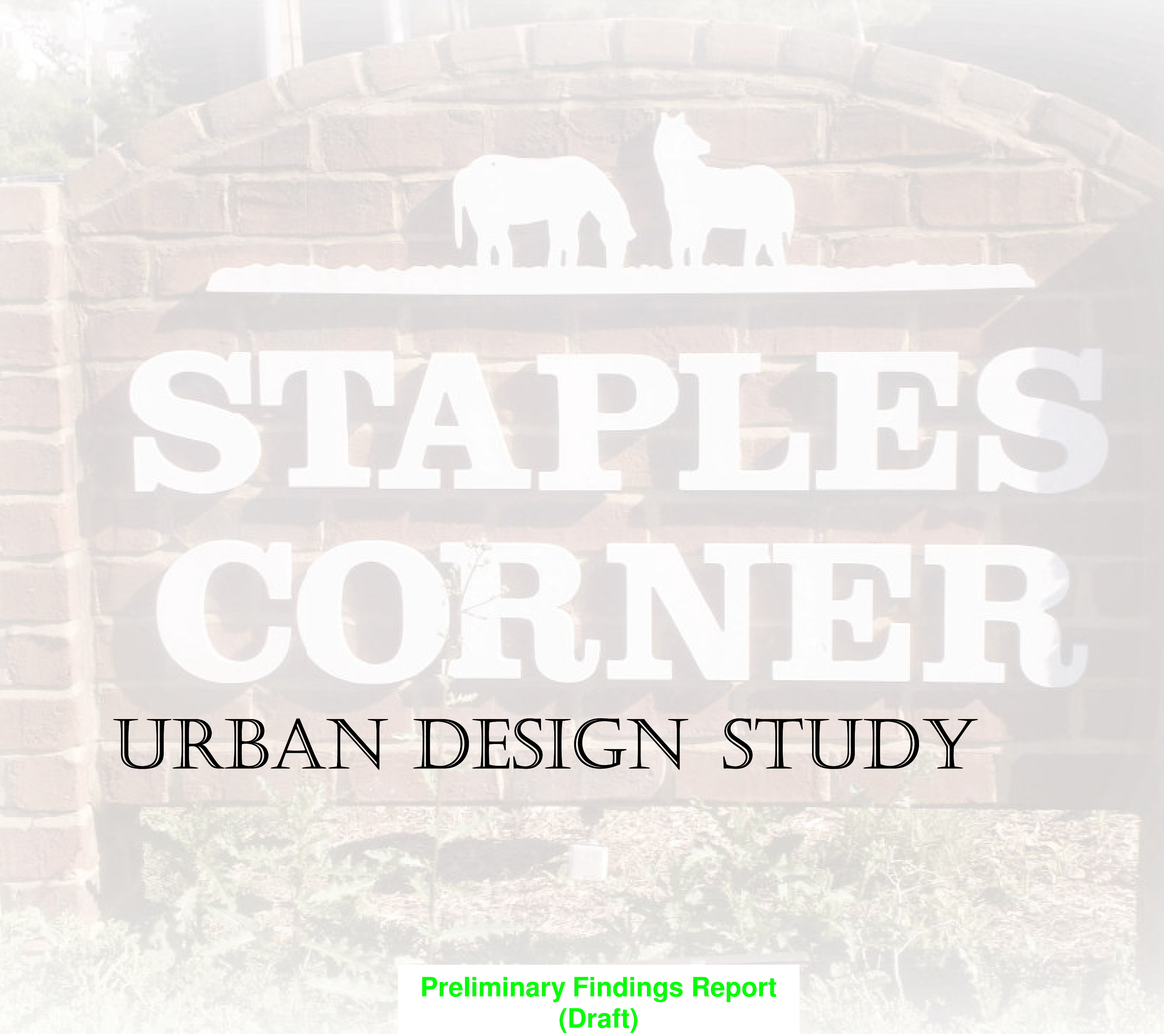

STAPLES CORNER

URBAN DESIGN STUDY

Preliminary Findings Report (Draft)

July 2008

Prepared for:
Anne Arundel County
Office of Planning and Zoning
777 N Capitol St, NW
Annapolis, MD 20002

Project No.: H539700
Contract No.: H539701

Prepared by:
Michael Baker Jr., Inc.
1304 Concourse Drive
Linthicum, MD 21090

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1. INTRODUCTION

The goal of this Staples Corner Urban Design Study is to create an Urban Design Concept Plan for the Staples Corner area in Anne Arundel County. The purpose of this plan is to provide a coherent framework for implementing the community's vision for the area. The concept plan will include design drawings as well as associated development design guidelines, recommended road and streetscape improvements, and economic development and/or revitalization strategies. This concept plan will be a product of public outreach involving property owners in the study area as well as representatives of local civic associations.

The study area (see Figure 1) surrounds a small commercial hub located at the intersection of Defense Highway (MD 450) and Davidsonville Road (MD 424) in the Crofton area of Anne Arundel County. The intersection is about 2.5 miles north of US 50/US 301, 1.7 miles east of RT 3, and 5 miles west of I-97. The study area includes approximately 70 acres of land zoned for local-scale commercial or small business uses. Existing commercial uses in the area include the Staples Corner Shopping Center and several small businesses as well as residences. Nearby community facilities include Crofton Park, Crofton Middle School, the Crofton Athletic Complex, and the Arundel Company 7 Fire Station.

Staples Corner is one of three "local centers" identified in the Crofton Small Area Plan that the County Council adopted in January 2001. The Crofton Small Area Plan (SAP), a community-based comprehensive land use plan for the Crofton Planning Area, recommends to

> "Expand existing commercial use at Staples Corner and achieve a unified plan for convenience retail and service uses with some professional offices serving the lower Crofton Triangle and nearby rural subdivisions to the south and east."

The SAP calls for revitalization and redevelopment at the Staples Corner, establishes the community vision for the Staples Corner, and develops general design guidelines to guide the revitalization. The SAP discusses the initial concept for development around Staples Corner with a traffic circle, expands the concept to increase the commercial zoning, and recommends a future development of a unified plan to guide development and redevelopments at the Staples Corner. Building on the groundwork of the SAP, this study is conducted to develop a conceptual unified plan to provide development guidance and design guidelines to achieve the shared community vision at the Staples Corner.

Figure 1. Staples Corner Urban Design Study Area

2. ANALYSIS OF THE DESIGN AND FUNCTION

Built on the preliminary analysis of the existing conditions, the public input from previous studies, and the feedback from the first public meeting, this task is undertaken to provide a better understanding of the study area, setting the stage for further analysis. Specifically, the work in this task is to

- assess the overall image, function and unique features of the study area;
- summarize key issues, opportunities, and constraints related to the image and function of the study area;
- provide case studies or models of well-designed local activity centers applicable to the study area.

2.1. Image, Function and Features

The image of Staples Corner is best described by local residents, business owners, visitors, and shoppers. It is “semi-rural” in nature, and it has a “small town feel”. People also like the “quirky” nature of businesses, when asked what they like most about the Staples Corner. The commercial nature of the Staples Corner dated back to original 1952 zoning. For the most part of the last century, Staples Corner was a convenient center for a rural community. The area is named after William Staples, who once owned a gas station and a small grocery store at the corner.

Figure 2. Staples Corner Shopping Center

The four quadrants surrounding the intersection of Davidsonville Road (MD 424), which runs north-south, and Defense Highway (MD450), which runs west-east, reflect varying stages of development. Most notably, the Staples Corner shopping plaza (Figure 2) is located at the northeast corner of the intersection; it is comprised of approximately 16,000 SF of commercial Gross Floor Area (GFA) and 83 parking spaces. It is set back from the road behind a BP service station and features streetscape elements such as sidewalks, street trees, lighting, signage, and some furnishings on the south side of the plaza. Tenants include convenience store and deli, a sit-down Mexican restaurant, a frame shop and art supply store, jewelry store, butcher, barber shop, florist, nail salon, and a liquor store. While its northern edge is defined by a wooded area and small creek, uses to the east include a motorcycle repair shop. A lack of screening between these uses and the service entrance and sidewalk are evident.

Figure 3. Northwest Quadrant (Left) and MD424 between MD 450 and Underwood (Right)

The commercial anchor within the northwest quadrant is Reno's Restaurant (Figure 3), a one-story structure built in the 1950s. The building is 40 feet from MD 450 and 50 feet from MD 424, with parking lots on both sides, with access provided from curb cuts located within 30-50 feet of the intersection. With the exception of a Verizon building at the northern end of the study area, there are no structures facing the road along MD 424 north of the intersection. The road leads over the creek into the intersection of MD 424 and Underwood Rd./Cardinal Crest Dr., to the residential neighborhoods at Crofton Country Club, and to Crofton Middle School and Crofton Park without visual or pedestrian linkages.

The southwest quadrant is marked by the open air display of the Garden Shop (Figure 4). While this long-standing business adds visual interest to area, it lacks sufficient parking, is isolated from pedestrian traffic, and lacks linkages to the surrounding parcels. The lot on the southeast corner is vacant with elevated topography and mature vegetation. Further south are low-density residential lots, most of which have incorporated businesses, such as a massage and acupuncture studio. The west side of Davidsonville Road south of Defense Highway has residential uses with businesses being operated out of many auxiliary structures. The southern end of the study area is marked by a large parcel that houses an abandoned building, a vast dilapidated parking lot with storage of trailers, boats, cars, and RVs, a cell phone tower, and the Arundel Company 7 Fire Station.

Figure 4. Southwest Quadrant (Left) and MD424 Looking North Near Fire Station

Figure 5. MD 450 Looking East to the Intersection (Left) and Looking West (Right)

More than half of the total 70 acres of the study area surrounds Defense Highway in the west part of the study area. The north side is characterized primarily by commercial and institutional uses such as the St. Paul's Lutheran Church, and few residential lots. The south side of the road has more residential parcels along with commercial and institutional uses, including a bar, small construction company, dentist office, and veterinary clinic. Several of the properties are newer with curb-cuts and turning areas while others have poorly defined ingress and egress. There is no uniform setback distance and some properties have installed tall fences for protection against street noise, view, and trespassing. They appear disconnected from the community and infer an unsafe environment. There are no sidewalks or other means of connectivity along Defense Highway (Figures 5 and 6).

Fences along Defense Highway

Traffic backup on MD 424 near Fire Station

Poorly defined ingress and egress

Lack of Sidewalk on MD 450 West

New curb cuts and shoulders

Lack of Designated Bicycle Facilities

Figure 6. Streetscape and Transportation Issues

2.2. Assets and Challenges

Staples Corner has both a great deal of assets and a number of challenges in transportation and streetscape. Figure 7 shows a summary of the assets and challenges in the study area. General observations of the study area include:

- Low densities for residential and commercial uses alike; majority of one-story structures.
- Varying architectural styles and streetscape designs.
- No sense of a “gateway” to the community or “entry” to the commercial center.
- General disconnect within the study area with surrounding communities and recreation assets.
- Lack of pedestrian walkways, bicycle lanes, and crosswalks.
- Lack of public open spaces and amenities, including furnishings, signage, landscaping, and public art.
- Large set backs of varying distance with residences and business being served by individual driveways, resulting in numerous curb cuts.
- Low visibility of business from the street due to lack of signage, setbacks, fences, and vegetation.
- Lots contain many small auxiliary and small storage structures.
- Aging building stock and infrastructure, including overhead utility lines.

SWOT is an evaluation method that evaluates the Strengths, Weaknesses, Opportunities, and Threats of a situation. The initial analysis of the study area resulted in a SWOT assessment summarized in Table 1.

Table 1. SWOT Analysis

Strengths	Weaknesses	Opportunities	Threats
Strong public involvement and sense of ownership; Long-standing existing local business community; Variety of services offered; Convenient location to metro areas; Urban and economic development potential; Mature trees; Charming semi-rural character. Small town feel	Traffic congestion; Long queuing; No pedestrian crossings or signals; Lack of sidewalks and connectivity to nearby parks and schools; Lack of designated bike lanes and facilities; Lack of public open spaces; Large/varying setbacks and fences infer disconnect from the street and community; Varying condition and design of curb-cuts and shoulders; Poor signage.	The intersection presents a focal point opportunity for enhancing the community identity; Development and redevelopment opportunities based on current zoning provisions; Traffic flow can be improved through signal timing, lane and intersection configuration; Bike lanes and sidewalks can be used to increase connectivity between residential and commercial areas, schools, and parks; Opportunities to incorporate innovative Low Impact Development (LID) stormwater management during revitalization; Better signage and traffic calming can be used to improve safety.	Disagreements on traffic improvement options; Through traffic; Seasonal large-scale events resulting in overflow traffic, Higher than average crash statistics; Narrow right-of-ways; Narrow shoulders, aboveground utilities; Reluctance to change.

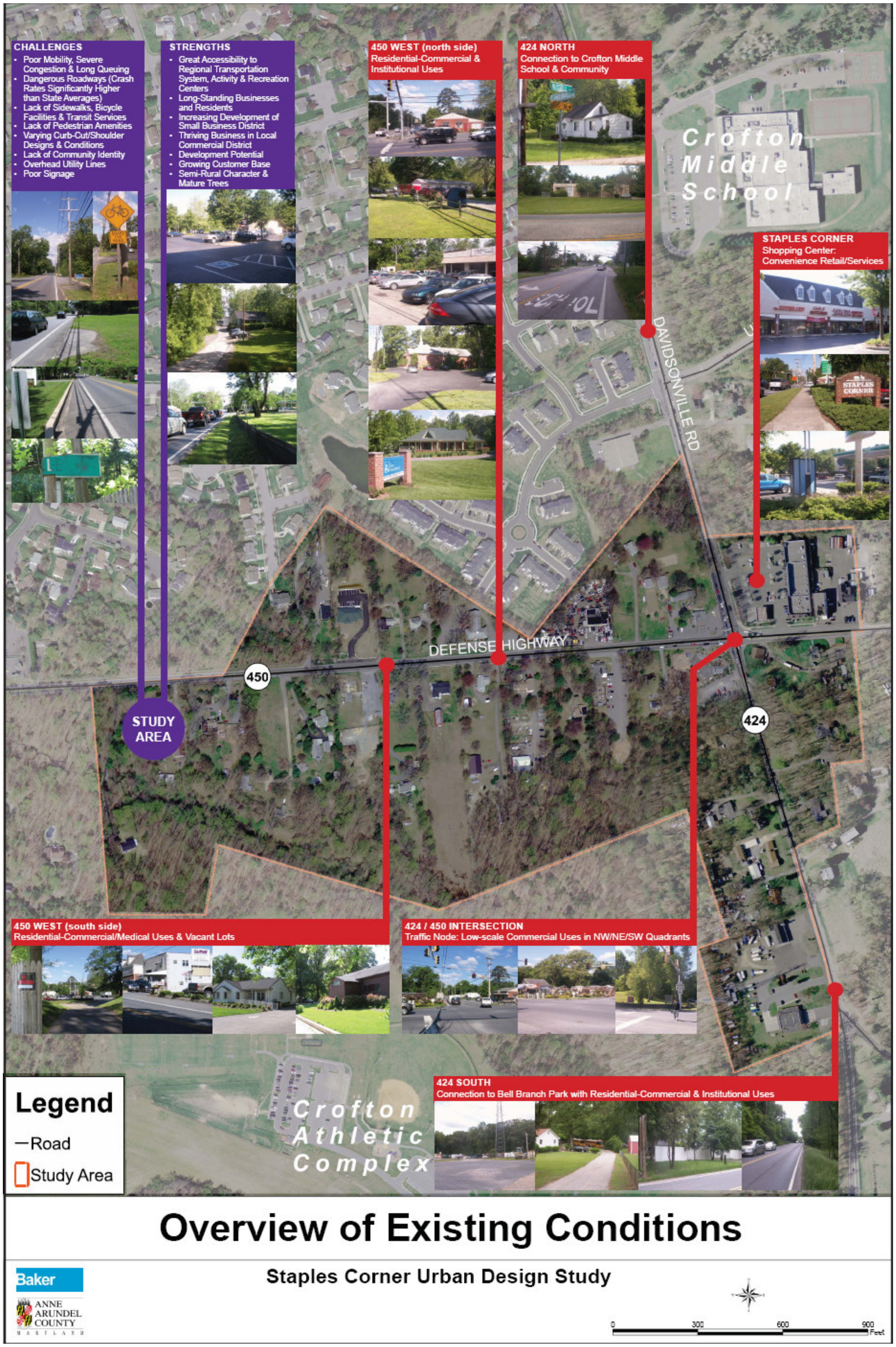

Figure 7. Existing Conditions

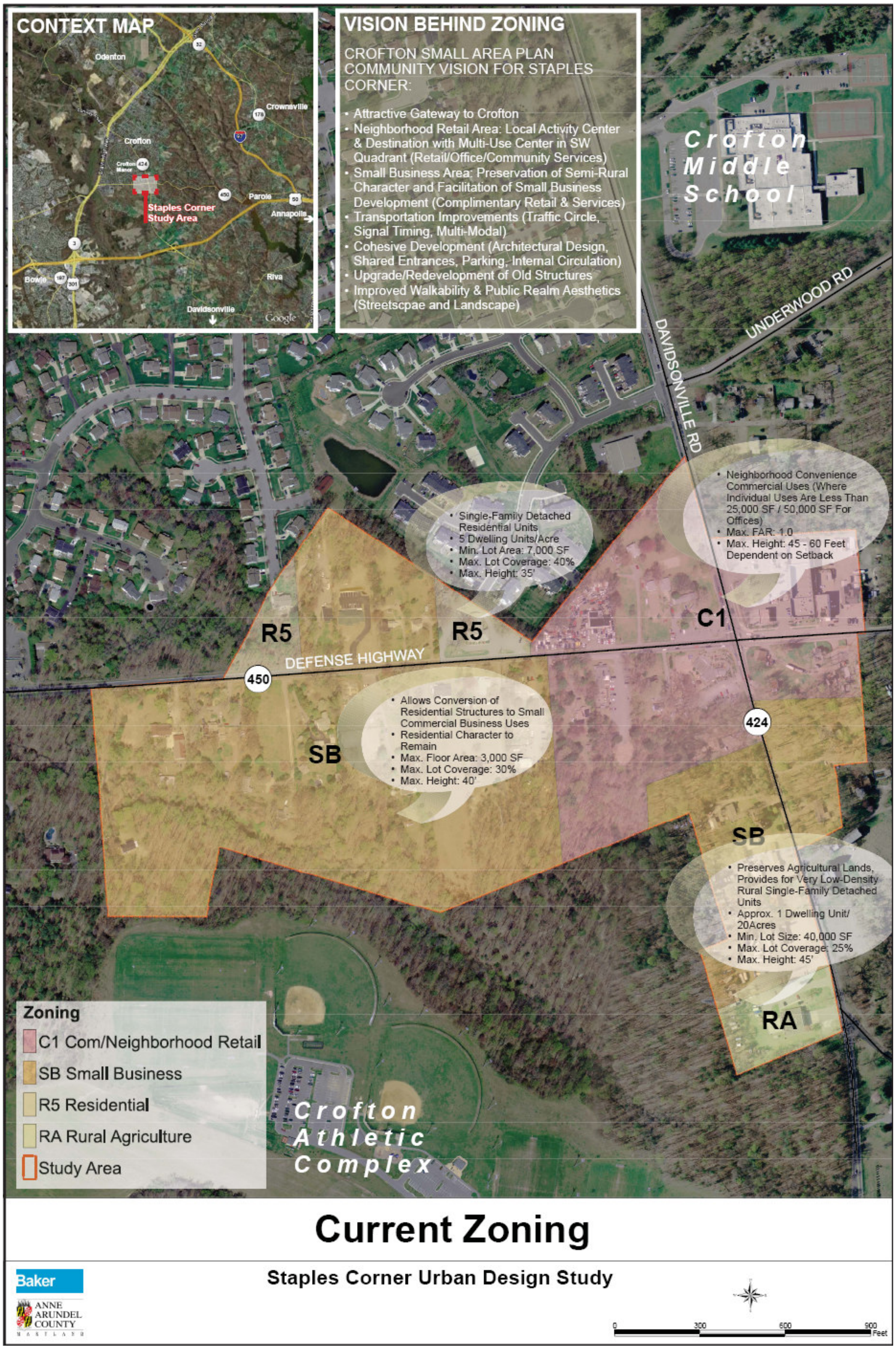

Figure 8. Current Zoning

2.3. Current Plan and Design

The Crofton Small Area Plan (SAP) establishes an urban design concept to "establish Staples Corner as a destination, serving as a local activity center, and creates an attractive gateway to Crofton." To achieve this vision, the SAP makes the following recommendations:

- Expand commercial zoning at Staples Corner from about 5 acres to some 17.5 acres, including all quadrants of the intersection.
- Establish Residential-Commercial/Small Business Area designation to provide complimentary retail and service uses closely related to the center and provide general development guidelines.
- Construct a traffic circle as a focal point for the community or conduct major intersection improvements for both aesthetic and traffic purposes.
- Develop a unified plan to coordinate architectural design and integrate site planning and to achieve a cohesive development consistent with the community vision.

As a result of the SAP recommendation, additional land in three quadrants of the MD 450/MD 424 intersection was rezoned to C1 (Local Commercial) and SBD (Small Business District) during the Comprehensive Zoning process in 2001, following adoption of the Small Area Plan. The current zoning for the study area is shown in Figure 8. The figure shows that four quadrants of the intersection are zoned as C1 to serve as a local activity center. Adjacent to the center is the transitional areas along MD 450 the west and MD 424 to the south, which are zoned as SBD (Small Business District). There are also a couple of small pieces at the edge of the study area, which are zoned for R5 (Residential) and RA (Rural Agriculture). As shown in Table 2, SBD zones occupy close to two thirds of the study area, the largest zoning category, followed by C1 with 30% of the total land.

Table 2. Zoning in the Study Area

Zoning	Description	Acres	% Total
C1	C1 Commercial - Neighborhood Retail	20.6	30%
SB	SB Small Business District	43.6	63%
RA	RA Rural Agricultural	2.2	3%
R5	R5 Residential	2.7	4%
TOTAL		69.2	100%

The SAP provides a conceptual sketch for the area (see Figure 9), with the following recommendations:

- Develop the southwest quadrant as a multiple-se center, including retail businesses and professional offices, as well as community services;

- Develop an internal loop roadway connecting to Davidsonville Road and Defense Highway some 300-600 feet away from the intersection.

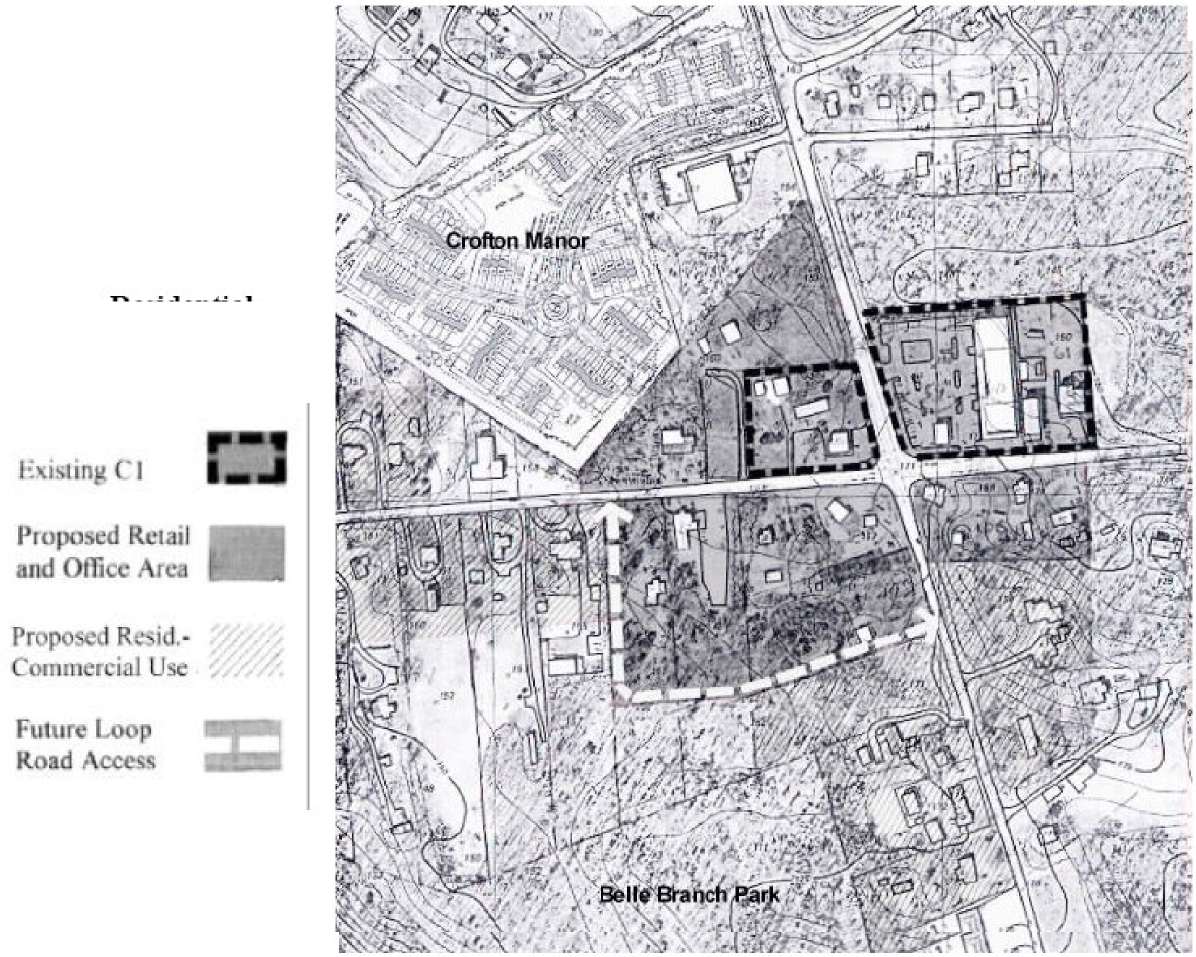

Figure 9. Conceptual Sketch of the Staples Corner

2.4. Public Involvement and Preferences

Public participation plays an important role in the planning process. This study plans to involve the stakeholders throughout the whole process, from identification of issues and concerns, to development of options for transportation and streetscape improvements, and to final recommendations. Three community meetings are envisioned throughout the study, with the first one being the project kick-off and identification of issues and challenges.

In the first public meeting, attendees were asked to provide their input and comments on a questionnaire. The questions cover the vision for the future of the Staples Corner, assets and challenges in the area, transportation and streetscape improvement priorities, as well as additional comments. Some of the major findings are summarized as follows:

- The attendees expressed their understanding of the Staples Corner's vision to local activity center and attractive gateway to Crofton. Respondents showed their strong preferences for road improvements as the most important component of the vision. Almost two thirds of the respondents chose road improvements that allow smooth traffic flow as their top priority for this vision. Pedestrian and bicycle improvements and streetscape amenities (sidewalk, lighting, landscaping, etc.) also received votes for the first priority in the vision, together accounting for almost thirty (30) percent.
- Respondents' preferences for roadway improvements also reflect their views on the most important challenges in the study area. Almost half of the responses placed traffic congestion as the most challenging issue in the study area. Traffic safety (vehicular & pedestrian) received almost one third of the votes for top challenges at Staples Corner.
- Top priority for transportation improvements is overwhelmingly vehicular traffic, receiving almost two thirds of the votes for top priority in the study area. Pedestrian facility improvements also received some attention, with nineteen (19) percent of the votes for top priority. A few responses (12%) chose transit improvements as their top priorities.
- Top priority for streetscape improvements is sidewalks and furnishings, receiving half of the votes for top priority in the study area. Signage received almost quarter of the votes for top priority, followed by landscaping (15%) and lighting (11%).
- Most of the respondents experience the Staples Corner area primarily as residents (42%), followed by motorists (24%), shoppers/visitors (16%), business owners or employees (13%).
- Respondents listed a number of assets that Staples Corner offers, including small town feel, rural character, unique and quirky nature of businesses, and accessibility to metro areas.
- Attendees also expresses a variety of concerns and comments, including pro and con of a roundabout, study area boundary, environmental issues, water and sewer, businesses, pedestrian and bicycle access, Renaissance Festival impacts, noise, enforcements. Attendees were almost even split in terms of their position on a roundabout as a traffic improvement option to the MD 450/MD424 intersection.

2.5. Urban Design Case Studies and Best Practice

Examining similar planning efforts and considering their approaches, outcomes, and lessons learned during the planning phase of the project at hand provides invaluable insight and inspiration for how this area may develop. After careful review of comparable projects, the planning team selected two case studies that may guide the overall vision and implementation of the Staples Corner Urban Design Study. Both examples are similar to Staples Corner in size, scope, and goal. The first, Hanover Square Redevelopment Project, describes how the community of small town Horseheads, NY created a streetscape plan to address traffic concerns and spur economic development. The second plan, East Main Street in Walla Walla, WA, developed streetscape improvements as a key part of the City's plan to revitalize its downtown. Concluding this section is a summary of best practices as they related to urban design and site development; they should be applied in the development of Staples Corner to achieve an appealing and economically and environmentally sustainable neighborhood center.

2.5.1. Case Study: Hanover Square Redevelopment Project, Horseheads, NY

Hanover Square is a historic five-legged intersection located in Horseheads, New York. The Square has served as the commercial and cultural centerpiece of the village for over 200 years.

In 1999, a study was conducted to examine ways to alleviate the traffic problems caused by the awkward intersection. The study revealed that uncontrolled traffic movements allowed motorists to enter the square creating congestion and a crash rate higher than the New York State average. The traffic patterns also created an unsafe environment for bicyclists and pedestrians.

The study identified six goals for the redevelopment of the Square: Improve safety for all users; Improve vehicular capacity; Retain as many on-street parking spaces as possible; Maintain and enhance the economic vitality of the businesses; Clarify and better define the traffic movements; Separate through traffic from local traffic. In order to meet these goals the study identified five possible options, including: Adding a traffic circle or roundabout; Converting some streets to one way; Creating a four-way signalized stop; Changing and enforcing truck routes; Making general improvements to the appearance and traffic movements of the Square.

Colored, textured treatments were used on driving surfaces to alert motorists as they enter a pedestrian setting.

The most feasible option for Hanover Square was to make general improvements to the appearance and traffic flow. To accomplish this many streetscape and traffic calming options were used to retrofit the Square without altering its historic character, such as high visibility crosswalks, pavement narrowing, landscaping, sidewalk extensions and curb line changes.

Changes were made to improve and tighten the intersection in a way that allowed for better driver, pedestrian and bicycle sight distance at each of the five approaches.

A small island was added as a way to better define the traffic lanes at the entrance of the intersection and provide a pedestrian safety zone

After the redevelopment, the crash rate for the intersection was significantly reduced. The revitalized Square became a catalyst for economic development, attracting new businesses, shoppers, and visitors. Many of the successes at Hanover Square have been adopted by Chemung County for use in other redevelopment projects.

Textured shoulders are a particularly good treatment for transition areas. Drivers see only travel lanes as available road space, so the road appears narrower than it is, helping to slow traffic and increasing the buffer between vehicles and pedestrians.

The reconstruction project improved the pedestrian environment by installing historically accurate lighting and street amenities. Other improvements to the Square included adding signage, designating 'pocket' parks, adding landscaping and creating public meeting places.

Like Staples Corner, Hanover Square is a small scale commercial center serving the surrounding neighborhood. The irregular traffic pattern of the Square created congestion and deterred pedestrians and bicyclists from the area. The redevelopment plan addressed traffic concerns as well as the needs of pedestrians and bicyclists and included open space and streetscape elements. The redevelopment plan was successful, and several elements can be applied to Staples Corner. Various traffic calming measures can be used to ease congestion and make the area friendlier to pedestrians and bicyclists. Open space, benches, sidewalks, pedestrian-scaled lighting, and signage can also help create a sense of community. Hanover Square is the gateway to Horseheads just as Staples Corner can be the gateway to Crofton.

2.5.2. East Main Street – Walla Walla, WA

Main Street is the primary axis through Walla Walla's historic downtown and the spine of the city's thriving downtown retail core. Main Street is characterized by its historically significant buildings and a wide right-of-way. Downtown Walla Walla experienced serious decline in its retail base during the 1980s.

To address the loss, a redevelopment plan was crafted to focus on economic development in the city's historic core. The plan outlined an urban design approach as a key means for luring new investment. The cornerstone of the design strategy was a catalyst streetscape improvement project along Main Street.

Crucial to the project was ensuring that streetscape improvements were compatible with the Downtown's existing historic structures.

New brick pavers were installed along the curb, and within key intersections. These unique paving treatments call out these intersections as special pedestrian zones while providing a degree of traffic calming.

Street trees and awnings shelter and provide shade for pedestrians creating a more pleasant walking environment.
Brick furnishing zones visually separate pedestrians from vehicles.
Bike racks provide for multi-modal transportation.
Public art was placed at key intersections.

A coordinated collection of new street furniture was installed that included benches, bike racks, trash receptacles, and traditional, pedestrian-scaled streetlights. Public art was placed on the sidewalks at key intersections. The broad-canopy trees that were selected and spaced at wide intervals now help to visually narrow Main Street's extensive right-of-way. The streetscape project also entailed installing new curbs and gutters and replacing underground utilities. The width of the right-of-way did not change as a result of the streetscape improvements.

Brick intersection paving and special crossing treatments calm traffic while distinguishing the intersections as special places within the district.

One challenge for the East Main Street corridor redevelopment was to incorporate existing structures into the streetscape plan. Staples Corner can use the same streetscape principles to help create a sense of community. The use of different pavement textures and curb features can alert motorists to the area and improve pedestrian safety. Street trees, pedestrian furniture, and public art can also help to create a sense of place. Staples Corner can use streetscape design similar to the way Walla Walla did to attract new development in the area.

2.5.3. Best Practices

Per current zoning, the maximum built out within the four quadrants of Staples Corner would allow for 4-story structures accommodating a variety of uses. Higher densities allow for more businesses to locate in this neighborhood center; it also provides the opportunity to redesign the building alignment and façades, incorporate pockets of public open spaces, and create a unique identity. Challenges associated with increased densities include the increased traffic and parking demand. Below is a list of items to be considered for the development of Staples Corner. It highlights successful massing and placement of structures in comparable settings, suggests innovative techniques in stormwater management (i.e. Low Impact Development, LID), and outlines approaches for shared parking and circulation:

- **Context Sensitive Design/Solutions** – takes into consideration the communities and lands which streets, roads, and highways pass through. This practice can be implemented in Staples Corner by considering existing elements such as mature trees and rural character when developing an urban design plan.

- **Low Impact Development** – Includes structural and non-structural elements designed to decrease runoff and better manage stormwater. Several LID elements can be applied to Staples Corner; planting vegetation along reconstructed roadways and parking lots in addition to preserving existing mature trees can reduce the runoff of new development in the area.

- **New Urbanism** – Promotes the creation and restoration of diverse, walkable, compact, vibrant, mixed-use communities. There are currently many mixed uses in Staples Corner. Streetscape improvements can be used to create a friendly and vibrant center at the intersection of Davidsonville Road and Defense Highway. Extending sidewalks and paths to connect schools, parks, and neighborhoods will increase the walkability of the area.

- **Traditional Neighborhood Development** – A comprehensive planning system that includes a variety of housing types and land uses in a defined area. Similar to New Urbanism, several elements of Traditional Neighborhood Development are already being used in Staples Corner. The Crofton area is based on a comprehensive plan with a variety of housing types and mixed uses. Future urban design plans of Staples Corner will include existing elements of Traditional Neighborhood Design. New zoning such as the Small Business District can be used to create more mixed uses in the area including home based businesses and other offices in previously residential only areas.

- **Transfer of Development Rights** – Transfer of development rights programs are used to shift development from rural or agricultural areas to areas designated for development. Anne Arundel County could enact legislation to allow the sale of development rights. Development could be directed to areas inside the Crofton Triangle as a way to maintain the rural character of other parts of the county. The Staples Corner study area contains several large and deep lots. Transfer of development rights could direct higher density development at the intersection of Davidsonville Road and Defense Highway or could allow for development on only a small portion of a lot while leaving the rest unchanged.

- **Smart Growth** –that concentrates growth in the center of a city to avoid urban sprawl; and advocates compact, transit-oriented, walkable, and bicycle-friendly land use. Staples Corner is already using Smart Growth principles by directing growth around the intersection. Higher density and the massing of structures at the intersection of Davidsonville Road and Defense Highway will help to create a more walkable town center. Shared parking with a limited number of ingress and egress points will cause people to walk from shop to shop without driving. Increased sidewalks and bike lanes will also decrease driving and create healthier citizenry. The implementation of a regional bus service can cut down on congestion and help establish Staples Corner as a destination.

3. TRAVEL DEMAND ANALYSIS

The objectives of the travel demand analysis task are two folds:

- to better understand the existing and projected future traffic conditions in the study area,
- to evaluate the traffic improvement options for addressing the traffic issues in the study area.

To achieve these two objectives, the Consultant undertook a series of data collection and analysis efforts, including

- Traffic data collection and field inventory
- Existing condition level of service analysis for auto travel
- Existing condition level of service analysis for bicycle and pedestrian travel
- Crash data analysis
- Travel demand forecasts and future level of service analysis
- Feasibility analysis of a roundabout
- Analysis of transportation improvement options

3.1 Existing Traffic Conditions

Assessment of existing traffic conditions provides the background information about the current transportation system performances in the study area and establishes the need for evaluating transportation improvement options. To this end, a variety of traffic data was collected, and the level of service analysis was conducted:

- Gather signal timing and other related traffic data from the County and SHA;
- Conduct a field inventory of roadway conditions in the study area;
- Field observations of traffic conditions during AM, mid-day, and PM peaks.
- Collect turning movement count data at the MD 450/MD 424 intersection and the MD 424/Underwood Road intersection;
- Review and evaluate all existing conditions information (including field photos).
- Evaluate the existing levels of service.

The County provided turning movement count data at the intersections in and near the study area, that were collected in the previous traffic studies. Traffic signal plans and traffic signal timing for the signalized intersection(s) were obtained from the SHA, in the form of a Synchro file. Historical traffic counts were also downloaded from SHA's Traffic Monitoring System database.

The Consultant conducted a field survey of existing roadway conditions, including number, use and width of lanes, sidewalk dimensions and crosswalks, speed limits, pedestrian facilities, bicycle facilities , opportunities and constraints pertaining to access from intersecting side streets and driveways, field observations of traffic conditions during AM, mid-day, and PM peaks.

In April and May of 2008, the Consultant collected turning movements at the MD 450/MD 424 intersection and the MD 424/Underwood Road intersection. These counts were performed in the AM and PM peak periods (between 6:30 - 9:30 AM and 3:30 - 6:00 PM) on a weekday. The counts also included pedestrians and bicycles in the intersection. Daily traffic was also collected for continuous 24-hour vehicle volume counts on the four legs of the MD450 and MD 424 intersection and two legs of the MD 424/Underwood Road intersection. Data collection efforts follow the traffic monitoring standards established by the Federal Highway Administration and SHA.

The collected traffic data was used to evaluate the level of service of the MD450/MD424 intersection and the MD 424/Underwood Road intersection for the existing weekday A.M. and P.M. peak hours. The level of service evaluation was conducted for existing conditions, using Critical Lane Volume, HCM Method/SYNCHRO.

Synchro and SimTraffic program outputs provide a comprehensive list of Measures of Effectiveness. MOEs measure operational performance and reckoning, such as total delay, vehicle delay, stop delay, travel distance, travel time and average speed.

One of the best means of interpreting the performance of an entire arterial, as well as each of its intersections, is to analyze the level of service (LOS). LOS is a standardized measure of the operability of an intersection based upon the delay encountered by a vehicle using that intersection. Based on the Highway Capacity Manual, LOS is defined differently for freeways, signalized, and un-signalized intersections. LOS for signalized intersections, which is the typical type of intersections under study in this corridor, is defined based on average controlled delay time per vehicle (see Table 3). A letter grade A-F, defines an intersection's ability to pass traffic through the intersection. A LOS (A) represents excellent free flow conditions and LOS (F) represents failing conditions. Generally, LOS (D) is considered to be in acceptable traffic conditions and as a target to achieve at the intersections. LOS grades are calculated for each intersection during the a.m. and p.m. peak hours to analyze and compare intersection operations and traffic service levels.

Intersection LOS measures the operability of the whole intersection and each of its approach legs. At various locations, the overall intersection LOS may be better than that of its approach legs' LOS. That is, although one or several of the streets of an intersection are congested, the intersection as a whole may perform at an acceptable level.

Table 3. Level of Service Definitions

LOS	Description	Average Control Delay (Second)
A	Little or no delay, extremely favorable progression	<10
B	A few vehicles stop; Good progression / short cycle lengths,	10-20
C	Significant number of vehicles stop; Fair progression/longer cycle lengths.	20-35
D	Many vehicles stop; Noticeable influence of congestion, Noticeable cycle failures; Some unfavorable progression/longer cycle lengths.	35-55
E	Frequent cycle failures; Poor progression; Long cycle lengths; high volume/capacity (v/c) ratios.	55-80
F	Unacceptable to most drivers; Many cycle failures; Arrival flow rates exceed the capacity of the intersection; High v/c ratios; Poor progression.	>80

Source: Highway Capacity Manual.

Table 4. Existing Conditions Results – MD 450 @ MD 424

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
***EB** MD 450*	0.43	36	D		0.66	37.1	D	
***WB** MD 450*	0.37	36.5	D		0.31	50.3	D	
***NB** MD 424*	0.56	22.4	C		0.86	60.5	E	
***SB** MD 424*	0.73	25.9	C		0.72	36.8	D	
Overall Intersection:	0.53	27.7	C		0.74	45.1	D	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 5. Existing Conditions Results – MD 424 @ Underwood/Cardinal Crest

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
***EB** Cardinal Crest*	0.67	56.7	E		0.92	153.1	F	
***WB** Underwood*	1.1	113.4	F		0.94	101.4	F	
***NB** MD 424*	0.68	30.7	C		1.2	116.9	F	
***SB** MD 424*	0.84	38.2	D		2.05	88.1	F	
Overall Intersection:	0.89	55.6	E		1.72	108.4	F	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

As shown in Table 4 and 5, the intersection of MD424 at Underwood/Cardinal Crest performs poorly under the existing conditions for both AM and PM peak hours. During the PM peak hour, all four approach legs fail terribly at the intersection, and motorists experience substantial delays crossing the intersection. During the AM peak, two legs (Underwood and Cardinal Crest) fail to operate at the acceptable level, with substantial delays at Underwood. In comparison, the intersection of MD 450 and MD 424 achieves acceptable level of service as a whole for both AM and PM peak hours. However, MD 424 northbound approach fails to operate at the acceptable LOS during the PM peak, with a long queue as confirmed from field observations.

Intersection Critical Lane Volume and LOS Analysis was also conducted for both intersections during AM and PM peak hours, and the results are summarized in tables in the Appendix. Because of the differences in the methodology, critical lane volume analysis may generate the LOS results that are different from the HCM/Synchro analysis. The results show that the intersection of MD424 at Underwood/Cardinal Crest fails terribly under the existing conditions for PM peak hour, with the worst LOS of F. However, the intersections receive an acceptable LOS grade for the AM peak, inconsistent with the HCM/Synchro results. The intersection of MD 450 and MD 424 operates at an acceptable LOS for both AM and PM peak hours, consistent with the HCM/Synchro results. The HCM methodology has been an industry standard for evaluating roadway and intersection performances.

3.2 Bicycle and Pedestrian LOS

Similar to auto LOS measures, LOS measures for pedestrians, bicycles, and transits are established. The National Cooperative Highway Research Program (NCHRP) has just finished a five-year project, NCHRP 3-70 “Multimodal Level of Service Analysis for Urban Streets”, to “enhance methods to determine levels of service for automobile, transit, bicycle, and pedestrian modes on urban streets, with particular consideration to inter-modal interactions.”

The NCHRP 3-70 study proposes a multi-modal level of service framework for urban streets, which has the capability of comparing LOS measures across modes and taking into account the interactions among modes in an urban street setting. The NCHRP 3-70 multi-modal LOS methodology estimates the quality of services traveling on urban streets from the user satisfaction perspective—by four modes: bicycle, pedestrian, auto and transit. The traditional letter grade system is used to represent the modal level of services by converting the LOS model outputs. This methodology uses a uniform definition of LOS and provides a consistent basis for comparing levels of services across modes (Table 6).

Table 6. Bicycle and Pedestrian LOS Categories

LOS Model Outputs	LOS Letter Grade
Model <=2.00	A
2.00 < Model <= 2.75	B
2.75 < Model <= 3.50	C
3.50 < Model <= 4.25	D
4.25 < Model <= 5.00	E
Model > 5.00	F

Source: NCHRP 3-70 Final Report, February 2008, pages 100,113, 120,126.

The NCHRP 3-70 methodology was used to evaluate bicycle and pedestrian LOS for this study. The models and input variables are shown in the Appendix. The LOS models for four modes utilize a total of 37 input variables, which are categorized into four types: facility design, facility control/maintenance, transit service characteristics, and travel demand. Representing transportation system supply characteristics, the first three types of variables inform the planning process about how planning and design variables affect the traveler's experience on urban streets.

The results show that roadway segments in the study area have pedestrian and bicycle LOS below the acceptable LOS D.

3.3 Crash Analysis

This crash analysis examines historical accident records by incident locations to uncover spatial and temporal patterns, causes, severity, and frequency of accident occurrences. Several factors are quantified, such as day of the week, time of day, types of accidents and number of injuries. This data is cross-referenced with intersection geometrics to develop possible incident conclusions.

The Maryland State Highway Administration's Office of Traffic and Safety supplied crash data for the period of January 1, 2004 to July 31, 2007. Crash data, including crash summaries and a collision diagram, were prepared by the Crash Analysis Safety Team.

3.3.1. Intersection MD450 and MD 424

A review of the crash data at the intersection of MD450 and MD424 reveals the following:

- During the three and half year period, a total of twenty-one (21) crashes occurred at this intersection, four (4) of which were reported on MD 450 at MD 424 and seventeen (17) were reported on MD 424 at MD 450.

- None of the accidents at the intersection resulted in fatalities. Ten (10) injuries were reported as well as thirteen (13) instances of property damage.

- Nine (9) crashes were reported in 2004, six (6) in 2005, and three (3) each during 2006 and 2007.

- The most frequent crash types are rear end, left turn, and angle at the intersection. The crash types included one (1) rear end, and (1) left turn, and two (2) angle on MD 450. The crash types on MD 424 included five (5) rear end, five (5) left turn, three (3) angle, one (1) fixed object, two (2) other object, and one (1) animal.

- The probable causes of the twenty-one (21) crashes were 1) failure to provide full attention, 2) failure to yield right-of-way, 3) too fast for conditions, 4) failure to obey traffic signal, 5) follow too closely, 6) improper turn, 7) influence of alcohol/drugs, and 8) unknown.

- Of the twenty-one (21) reported crashes only three occurred when the pavement was wet. Six (6) of the crashes occurred at night while there were no pavement disturbances (wet, snowy, etc.) and one additional occurred at night on dry pavement with the presence of alcohol.

- There are also a notable number of crashes directly preceding/proceeding the MD 450/MD 424 intersection. On MD 450, additional eight (8) crashes occurred within four (4) miles east of the MD 424 intersection. Similarly, on MD 424 additional six (6) crashes occurred within four (4) miles north of the MD 450 intersection. Forty-one (41) percent of the total additional accidents were rear end collisions.

3.3.2. MD 450 (Defense Highway)

Accident data for the period of January 1, 2004 to July 31, 2007 are summarized in Tables 7 to 10 for Maryland 450 between Nancarles Drive to the West and Nob Hill Drive to the East.

Table 7. Crashes by Roadway Segment by Year (MD450)

MD 450 and	Between Nancarles Dr and MD 424	MD 424	Between MD 424 & Nob Hill Dr	Totals
2004	0	1	3	4
2005	2	3	5	10
2006	1	0	3	4
2007	2	0	2	4
Total	5	4	13	22

Note: 2007 data is partial, from January 1st to July 31st.

All Collisions

These tables indicate that between 2004 and 2007, the roadway segment with the highest number of incidents was located east of MD 424, between MD 424 and Nob Hill Drive, with 13 accidents and nine injuries. This is a roadway segment with curves, limited sight distance, and little developments adjacent to the roadway. There were much less crashes on MD 450 west of MD 424, but one accident resulted in a fatality between Nancarles Drive and MD 424. This collision occurred at night and alcohol was a factor. Of the accidents which occurred on MD 450, 59% involved injuries.

Table 8 shows an overall summary of the aforementioned segment of Maryland 450, with total accidents and total injuries by intersection as well as day of the week and time of day.

Weekdays accounted for 59% of the total number of accidents. Approximately 57% of all collisions occurred during the midday and 31% during the evening off peak periods. Only 12% of the total collisions occurred during the PM peak period with only one injury accident during that time frame. No collisions occurred during the AM peak period. Weekdays accounted for 59% of the total number of accidents.

Of all collisions reported, 50% occurred on a dry road surface with no extenuating factors such as nighttime driving, wet road conditions, or alcohol impairment. Of the additional collisions 22% occurred on a wet or snowy surface, 14% at night, and 14% involved a vehicle driven under the influence of alcohol.

Table 8. Accident Summary for all Collision Types (MD450)

MD 450 and	Between Nancarles Dr & MD 424	MD 424	Between MD 424 & Nob Hill Dr	Totals
Day of Week as % of Total Accidents				
Weekday	60%	25%	92%	**59%**
Weekend	40%	75%	8%	**41%**
Time of Day as % of Total Accidents				
AM Peak	0%	0%	0%	**0%**
Midday	60%	50%	62%	**57%**
PM Peak	20%	0%	15%	**12%**
Evening Off Peak	20%	50%	23%	**31%**
Total Accidents	5	4	13	**22**
Total Fatalities	1	0	0	**1**
Total Injuries	**7**	3	9	**19**

Vehicle-to-Vehicle Collisions

Table 9 summarizes the frequency of vehicle-to-vehicle accidents along Maryland 450. The table indicates where and how commonly the accidents involving only vehicular traffic occur along the corridor segment. The following are observations on the accident data included in Table 9:

- The majority of vehicle-to-vehicle collisions on this segment are categorized as rear-end crashes, comprising 41% of total accidents. The intersections located between MD 424 and Nob Hill Drive experienced a total of six rear end crashes. All of the rear end collisions on this segment occurred during midday hours with the exception of one which occurred during the PM peak period. Rear end accidents commonly result from driver distraction, sight distance, and sudden changes in speed or sudden stops by other vehicles.

- One of the most severe accidents is an angle or right-angle crash, when one vehicle is impacted on its side by an on-coming vehicle. The second highest number of incidents was angle crashes with the majority occurring at the intersection of MD 424. Right angles often stem from running red lights, limited visibility or the lack of a traffic control.
- One opposite direction collision occurred between Nancarles Drive and MD 424. Head on collisions are caused by driver distraction, driver impairment or traveling the wrong way down a one-way street.
- Two sideswipe collisions occurred in the segment area, one between MD 424 and Nob Hill Drive and one between Nancarles Drive and MD 424 which resulted in a fatality. Side swipes result from drivers trying to pass another vehicle or trying to avoid something in the road.
- Of all intersections along Maryland 450, the intersections between MD 424 and Nob Hill Drive recorded the maximum accidents, suggesting a safety review at this location. Rear end, sideswipe, overturn, and angle accidents occurred at this location. Over half of all collisions occurred during midday hours.

Table 9. Vehicle to Vehicle Type Collision Summary (MD450)

MD 450 and	Between Nancarles Dr and MD 424	MD 424	Between MD 424 & Nob Hill Dr	Totals
Angle	0	2	1	3
Left Turn	1	1	0	2
Right Turn	0	0	0	0
Rear End	2	1	6	9
Sideswipe	1	0	1	2
Opposite Direction	1	0	0	1
Overturn	0	0	2	2

Vehicle to Non-Vehicle Collisions

Table 10 summarizes all vehicle accidents involving either a pedestrian or a fixed object.

Information is divided into two types of accidents including pedestrian and "other." "Other" accidents refer to collisions with bicycles or fixed objects, running off the road, hitting a parked vehicle, and backing into something or any other incident that does not involve another vehicle. Few vehicle to non-vehicle collisions were recorded during the 2003-2007 period:

- There were no pedestrian accidents which occurred during the 2004-2007 period.
- Of incidents that comprised the "other" category 100% occurred at intersections between MD 424 and Nob Hill Drive. Poor road conditions were a factor (wet or snowy surface) in 67% of the vehicle to non-vehicle collisions at these intersections.
- "Other" accidents comprised 14% of total collisions.

Table 10. Vehicle to Non-Vehicle Type Collision Summary (MD450)

MD 450 and	Between Nancarles Dr and MD 424	MD 424	Between MD 424 & Nob Hill Dr	Totals
Pedestrian	**0**	**0**	**0**	**0**
Other	**0**	**0**	**3**	**3**
Total	0	0	3	3

3.3.3. MD 424 (Davidsonville Rd)

Accident data for the period of January 1, 2004 to July 31, 2007 are summarized in Tables 11 to 14 for Maryland 424 between Maryland 450 (Defense Highway) to the South and Underwood Road to the North. Table 12 shows an overall summary of the aforementioned segment of Maryland 424, with total accidents and total injuries by intersection as well as day of the week and time of day.

Table 11. Crashes by Roadway Segments by Year (MD424)

MD 424 and	MD 450	Between MD 450 & Russell Rd	Between Russell Rd & Underwood Rd	Totals
2004	8	3	2	13
2005	3	3	1	7
2006	3	2	2	6
2007*	3	1	1	6
Total	17	9	6	**32**

Note: 2007 data is partial, from January 1st to July 31st.

All Collisions

These tables indicate that between 2004 and 2007, the highest number of incidents occurred at the intersection of MD 424 and MD 450, with 17 accidents and seven injuries. The next highest number of incidents were recorded at the roadway segments between MD 450 up to and including Russell Road, with nine accidents and a total of five injuries.

Of the accidents which occurred on Maryland 424, 44% involved injuries. No fatal accidents occurred along this Maryland 424 roadway segment between 2004 and 2007.

Weekdays accounted for 75% of the total number of accidents. Approximately 44% of all collisions occurred during the midday and 29% during the evening off peak period. Only 6% of the total collisions occurred during the AM peak period, which did not involve injuries. The PM off peak period accounted for 21% of all collisions.

Of all collisions reported, 53% occurred on a dry road surface with no extenuating factors such as nighttime driving, wet road conditions, or alcohol impairment. Of the additional collisions 21% occurred on a wet or snowy surface, 13% at night, and 13% involved a vehicle driven under the influence of alcohol.

Table 12. Accident Summary for all Collision Types (MD424)

MD 424 and	MD 450	Between MD 450 & Russell Rd	Between Russell Rd & Underwood Rd	Total
Day of Week as % of Total Accidents				
Weekday	71%	88%	66%	**75%**
Weekend	29%	12%	34%	**25%**
Time of Day as % of Total Accidents				
AM Peak	6%	0%	0%	6%
Midday	35%	67%	34%	44%
PM Peak	12%	22%	33%	21%
Evening Off Peak	47%	11%	33%	29%
Total Accidents	17	9	6	32
Total Fatalities	0	0	0	0
Total Injuries	7	5	2	14

Vehicle-to-Vehicle Collisions

Table 13 summarizes the frequency of vehicle-to-vehicle accidents along Maryland 450. The table indicates where and how commonly the accidents involving only vehicular traffic occur along the corridor segment. The following are observations on the accident data included in Table 13:

- The majority of vehicle-to-vehicle collisions on this segment are categorized as rear-end crashes comprising 34% of total accidents. The intersection at MD 450 accounted for five of these types of crashes. Almost 45% of the rear end collisions on MD 424 occurred during midday hours and 37% occurred during the PM peak period.
- The second highest number of incidents were angle crashes (25%) with the majority occurring at the intersection of MD 450.
- Left turn accidents were the third highest to occur along Maryland 424, totaling 16% of total crashes. All of the left turn accidents occurred at the MD 450 intersection. Left turn accidents tend to occur most often when drivers proceed with turning movements during either the yellow or red traffic signal interval in front of oncoming traffic as well as in the absence of a left turn signal.
- Of all intersections along Maryland 424, the intersection at MD 450 recorded the maximum accidents, suggesting a safety review at this location. Rear end, left turn, and angle accidents occurred at this location. Almost half of all the collisions (47%) occurred during evening off peak hours while 36% occurred during midday hours. Only 17% occurred during AM and PM peak periods.

Table 13. Vehicle to Vehicle Type Collision Summary (MD424)

MD 424 and	MD 450	Between MD 450 Up to & Including Russell Rd	Between Russell Rd & Underwood Rd	Totals
Angle	3	3	2	8
Left Turn	5	0	0	5
Right Turn	0	0	0	0
Rear End	5	3	3	11
Sideswipe	0	1	0	1
Opposite Direction	0	0	0	0
Overturn	0	0	0	0

Vehicle to Non-Vehicle Collisions

Table 14 summarizes all vehicle accidents involving either a pedestrian or a fixed object:

- There were no pedestrian accidents which occurred during the 2004-2007 period.
- Of incidents that comprised the "other" category 57% occurred at the MD 450 intersection. Poor road conditions were a factor (wet or snowy surface) in only one collision at this intersection. Two collisions involved fixed/other objects and one involved an animal.
- "Other" accidents comprised 22% of total collisions.

Table 14. Vehicle to Non-Vehicle Type Collision Summary (MD424)

MD 450 and	Between Nancarles Dr and MD 424	MD 424	Between MD 424 & Nob Hill Dr	Totals
Pedestrian	0	0	0	**0**
Other	4	2	1	**7**
Total	4	2	1	**7**

3.4 Traffic Condition Forecasts

The Consultant conducted traffic growth forecasts on the roadway in the study area, using two data sources. SHA's Traffic Monitoring System database provides historical annual average daily traffic (AADT) data for traffic count stations throughout the state. The latest data tabulate AADT for years 2001 through 2007, with four stations located inside and near the study area. Table 15 shows traffic growth for these four stations, with growth in traffic on MD 424 and decline in traffic on MD 450.

Table 15. Historical Traffic Growth (AADT)

Route	Location	2001	2007	%Growth
MD 424	0.1 Mi N of MD 450	16,675	18,710	12%
MD 424	0.3 MI N OF US50	13,175	14,430	10%
MD 450	0.1 MI E OF MD424	7,225	6,512	-10%
MD 450	0.2 MI E OF MD3	21,500	19,972	-7%

* MD450 AADT values are estimates.

The second data source is from the West County Model. After refining highway links, the 2000 and 2030 models were run, and the traffic demand was examined for roadways, and growth was calculated.

Two growth scenarios are established for roadways in the study area (see Table 16), based on the two data sources. These two scenarios are used to grow the 2008 peak turning movement volumes to evaluate the future intersection performances.

Table 16. Traffic Growth Assumptions for 2008-2030

Road	Low Growth	High Growth
MD 424	35%	45%
MD 450	0%	10%
Underwood	10%	15%

Tables 17 through 20 show the intersection performance values under both scenarios. The MD424/Underwood intersection will fail under both scenarios. The intersection of MD 450 and MD 424 will operate below the acceptable level of service for PM peak.

Table 17. 2030 Forecast Results Under Existing Timing – MD 450 @ MD 424 (Low Growth Scenario)

Existing Conditions	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
EB *MD 450*	0.62	69.0	E		0.77	49.5	D	
WB *MD 450*	0.54	67.8	E		0.44	64.0	E	
NB *MD 424*	0.65	22.8	C		0.98	73.1	E	
SB *MD 424*	0.79	30.0	C		1.05	51.9	D	
Overall Intersection	0.71	35.8	D		0.91	59.0	E	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 18. 2030 Forecast Results Under Existing Timing–MD 424 @ Underwood/Cardinal Crest (Low Growth Scenario)

Existing Conditions	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
EB *Cardinal Crest*	1.28	175.2	F		0.96	162.5	F	
WB *Underwood*	1.54	292.7	F		1.08	126.9	F	
NB *MD 424*	0.73	29.6	C		1.63	301.7	F	
SB *MD 424*	0.90	41.4	D		2.76	130.8	F	
Overall Intersection	1.11	98.1	F		2.25	235.3	F	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 19. 2030 Forecast Results Under Existing Timing–MD 450 @ MD 424 (High Growth Scenario)

Existing Conditions	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
EB *MD 450*	0.65	69.8	E		0.86	55.0	D	
WB *MD 450*	0.56	67.9	E		0.53	68.8	E	
NB *MD 424*	0.82	34.9	C		1.06	91.7	F	
SB *MD 424*	0.86	35.1	D		1.13	64.1	E	
Overall Intersection:	0.79	42.0	D		0.98	70.3	E	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 20. 2030 Forecast Results Under Existing Timing— MD 424 @ Underwood/Cardinal Crest (High Growth Scenario)

Existing Conditions	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
EB *Cardinal Crest*	1.56	236.7	F		1.02	177.7	F	
WB *Underwood*	1.71	361.4	F		1.15	143.2	F	
NB *MD 424*	0.76	29.8	C		1.75	356.0	F	
SB *MD 424*	0.93	44.3	D		2.98	144.9	F	
Overall Intersection:	1.20	115.3	F		2.42	274.4	F	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

3.5 Traffic Improvement Options

Both intersections needs traffic improvements to operate at the favorable conditions. First, the Consultant evaluates the options to optimize the signal timing and lane configuration under both the existing and forecast conditions.

Signal Optimization Under Existing Condition

- Restripe the approaching lanes of the intersection MD 424 @ Underwood/Cardinal Crest, making one left-turn only lane and through lane shared with right-turn for both westbound and eastbound direction.
- Get rid of the split phasing at the intersection of MD 424 @ Underwood/Cardinal Crest
- Optimize the cycle length, splits and offsets for two intersections.
- The cycle length for both intersections is 70 seconds for AM peak and 90 seconds for the PM peak.

Table 21. Signal Optimization– MD 450 @ MD 424

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
EB *MD 450*	0.27	19.6	B		0.77	27.2	C	
WB *MD 450*	0.29	20.7	C		0.40	30.6	C	
NB *MD 424*	0.76	21.0	C		0.87	36.4	D	
SB *MD 424*	0.88	25.5	C		0.70	20.3	C	
Overall Intersection	0.61	23.0	C		0.83	28.1	C	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 22. Signal Optimization – MD 424 @ Underwood/Cardinal Crest

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
EB *Cardinal Crest*	0.09	15.5	B		0.14	34.1	C	
WB *Underwood*	0.87	35.7	D		0.91	61.2	E	
NB *MD 424*	0.56	10.3	B		1.04	38.9	D	
SB *MD 424*	0.70	15.6	B		1.01	18.3	B	
Overall Intersection	0.77	18.9	B		1.02	36.1	D	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Tables 21 and 22 show intersection performances under signal optimization for existing conditions. Through signal optimization, both intersections can perform satisfactorily. The level of services for both AM and PM peak hours are D or better.

The same signal optimization is also applied to future conditions, and the results are shown in Tables 23 through 26. The intersection of MD 424 and Underwood/Cardinal Crest will fail for

PM peak hours under both growth scenarios. Under the high growth scenario, the intersection of MD 450 and MD 424 will operate at LOS E for PM peak, below the acceptable LOS D. MD 424 northbound and MD 450 east bound approaches to the MD450/MD424 intersection will operate at LOS E for PM peak hour, under both scenarios.

Table 23. 2030 Forecast Results Under Signal Optimization – MD 450 @ MD 424 (Low Growth Scenario)

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
***EB** MD 450*	0.36	29.4	C		1.11	72.8	E	
***WB** MD 450*	0.34	29.2	C		0.46	34.3	C	
***NB** MD 424*	1.01	42.3	D		1.05	67.5	E	
***SB** MD 424*	0.96	30.6	C		0.95	33.2	C	
Intersection	0.74	33.6	C		1.02	52.8	D	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 24. 2030 Forecast Results Under Signal Optimization–MD 424 @ Underwood/Cardinal Crest (Low Growth Scenario)

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
***EB** Cardinal Crest*	0.09	19.4	B		0.14	36.2	D	
***WB** Underwood*	0.94	51.2	D		1.2	117.7	F	
***NB** MD 424*	0.74	26.4	C		1.37	176.4	F	
***SB** MD 424*	0.91	30.6	C		1.36	34	C	
Intersection	0.93	33.1	C		1.35	129.5	F	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 25. 2030 Forecast Results Under Signal Optimization–MD 450 @ MD 424 (High Growth Scenario)

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
***EB** MD 450*	0.43	31.1	C		1.06	68.3	E	
***WB** MD 450*	0.39	30.6	C		0.53	38.5	D	
***NB** MD 424*	1.09	57.2	E		1.05	69.3	E	
***SB** MD 424*	1.00	35.3	D		1.04	40.5	D	
Intersection	0.81	40.4	D		1.03	55.2	E	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

Table 26. 2030 Forecast Results Under Signal Optimization— MD 424 @ Underwood/Cardinal Crest (High Growth Scenario)

Existing Conditions:	AM Peak Hour				PM Peak Hour			
	V/C	Delay	LOS		V/C	Delay	LOS	
***EB** Cardinal Crest*	0.10	19.4	B		0.17	39.5	D	
***WB** Underwood*	0.99	60.6	E		1.18	116.9	F	
***NB** MD 424*	0.80	17.7	B		0.98	218.8	F	
***SB** MD 424*	0.98	41.8	D		1.00	50.7	D	
Intersection:	0.98	36.8	D		1.58	159.9	F	

Notes: V/C=Volume/Capacity, Delay=Control Delay in seconds.

6. REFERENCES

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APPENDIX LEVEL OF SERVICES

Pedestrian Segment LOS

The segment pedestrian LOS is calculated as follows:

$$\textbf{Ped Seg LOS}_S = -1.2276 \ln (W_{ol} + W_l + f_p \times \%OSP + f_b \times W_b + f_{sw} \times Ws) + 0.0091(Vol_{15}/L) + 0.0004\, SPD^2 + 6.0468$$

Where

Ped SegLOS	= Pedestrian level of service score for a segment
Ln	= Natural log
W_{ol}	= Width of outside lane
W_l	= Width of shoulder or bicycle lane
f_p	= On-street parking effect coefficient (= 0.20)
%OSP	= Percent of segment with on-street parking
f_b	= Buffer area coefficient = 5.37 for any continuous barrier at least 3 feet high separating walkway from motor vehicle traffic. A discontinuous barrier (e.g. trees, bollards, etc.) can be considered a continuous barrier if they are at least 3 feet high and are spaced 20 feet on center or less.
W_b	= Buffer width (distance between edge of pavement and sidewalk, in feet)
f_{sw}	= Sidewalk presence coefficient (= 6 – 0.3W_s)
W_s	= Width of sidewalk. For widths greater than 10 feet, use 10 feet.
V	= Directional volume of motorized vehicles in the direction closest to the pedestrian. (vph)
PHF	= Peak hour factor
L	= Total number of through lanes for direction of traffic closest to pedestrians.
SPD	= Average running speed of motorized vehicle traffic (mi/h)

Pedestrian Intersection LOS

The intersection LOS for pedestrians is computed only for signalized intersections:

$$\textbf{Ped Int LOS (Signal)} = 0.00569(RTOR+PermLefts) + 0.00013(PerpTrafVol*PerpTrafSpeed) + 0.0681(LanesCrossed^{0.514}) + 0.0401\ln(PedDelay) - RTCI(0.0027PerpTrafVol - 0.1946) + 1.7806$$

where

RTOR+PermLefts	= Sum of the number of right-turn-on-red vehicles and the number of motorists making a permitted left turn in a 15 minute period
PerpTrafVol*PerpTrafSpeed	= Product of the traffic in the outside through lane of the street being crossed and the midblock 85th percentile speed of traffic on the street being crossed in a 15 minute period
LanesCrossed	= The number of lanes being crossed by the pedestrian

PedDelay	= Average number of seconds the pedestrian is delayed before being able to cross the intersection. If delay = zero, use 1.00 seconds.
RTCI	= Number of right turn channelization islands on the crossing. Can take on only the following values: 0, 1, or 2.

Bicycle Segment LOS

$$BSeg = 0.507\ Ln\ (V/(4{*}PHF{*}L)) + 0.199Fs{*}(1+10.38HV)^2 + 7.066(1/PC)^2 - 0.005(We)^2 + 0.760$$

where

BSeg	= Bicycle score for directional segment of street.
Ln	= Natural log
PHF	= Peak Hour Factor (see Chapter 10 for default values)
L	= Total number of directional through lanes
V	= Directional motorized vehicle volume (vph). (Note: V > 4 *PHF * L)
Fs	= Effective speed factor = 1.1199 In(S - 20) + 0.8103
S	= Average running speed of motorized vehicles (mph) (Note: S >= 21)
HV	= Proportion of heavy vehicles in motorized vehicle volume. Note: if the auto volume is < 200 vph, the %HV used in this equation must be <= 50% to avoid unrealistically poor LOS results for low volume and high percent HV conditions.
PC	= FHWA's five point pavement surface condition rating (5=Excellent, 1=Poor) (A default of 3 may be used for good to excellent pavement)
We	= Average effective width of outside through lane (ft) = Wv - (10ft x %OSP) (ft) ** If W1 < 4 = Wv + W1 - 2 (10 x %OSP) (ft) ** Otherwise
%OSP	= Percentage of segment with occupied on-street parking
W1	= width of paving between the outside lane stripe and the edge of pavement (ft)
Wv	= Effective width as a function of traffic volume (ft) = Wt (ft) ** If V > 160 vph or street is divided = Wt*(2-(0.005 x V)) (ft) ** Otherwise
Wt	= Width of outside through lane plus paved shoulder (including bike lane where present) (ft) Note: parking lane can be counted as shoulder only if 0% occupied.

Bicycle Intersection LOS

$$Bint = -0.2144Wt + 0.0153\mathit{CD} + 0.0066\ (V/(4{*}PHF{*}\mathit{L})) + 4.1324$$

Where
Bint = bicycle intersection LOS score
Wt = total width of outside through lane and bike lane (if present) on study direction of street (ft).
CD = The curb-to-curb width of the cross-street at the intersection (ft).
V = Volume of directional traffic (vph)
L = Total number of through lanes on the subject approach to the intersection.

HCM Signalized Intersection Capacity Analysis
3: MD 450 & MD 424 — 6/16/2008

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	86	81	85	63	130	65	179	307	25	126	539	313
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	1.00	0.98	1.00	1.00		1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt	1.00	0.92		1.00	1.00	0.85	1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1770	1720		1770	1863	1544	1770	1842		1770	1863	1583
Flt Permitted	0.53	1.00		0.51	1.00	1.00	0.20	1.00		0.39	1.00	1.00
Satd. Flow (perm)	985	1720		958	1863	1544	365	1842		731	1863	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	93	88	92	68	141	71	195	334	27	137	586	340
RTOR Reduction (vph)	0	19	0	0	0	41	0	1	0	0	0	24
Lane Group Flow (vph)	93	161	0	68	141	30	195	360	0	137	586	316
Confl. Peds. (#/hr)						2						
Turn Type	pm+pt			pm+pt		Perm	pm+pt			pm+pt		Perm
Protected Phases	1	6		5	2		3	8		7	4	
Permitted Phases	6			2		2	8			4		4
Actuated Green, G (s)	33.8	22.6		31.2	21.3	21.3	57.1	45.5		59.1	46.5	46.5
Effective Green, g (s)	35.8	24.6		33.2	23.3	23.3	59.1	47.5		61.1	48.5	48.5
Actuated g/C Ratio	0.32	0.22		0.29	0.21	0.21	0.52	0.42		0.54	0.43	0.43
Clearance Time (s)	5.0	6.0		5.0	6.0	6.0	5.0	6.0		5.0	6.0	6.0
Vehicle Extension (s)	2.5	6.0		2.5	6.0	6.0	2.5	3.5		2.5	3.5	3.5
Lane Grp Cap (vph)	398	376		361	386	319	349	777		522	802	682
v/s Ratio Prot	c0.03	c0.09		0.02	0.08		c0.06	0.20		0.03	c0.31	
v/s Ratio Perm	0.05			0.04		0.02	0.23			0.11		0.20
v/c Ratio	0.23	0.43		0.19	0.37	0.09	0.56	0.46		0.26	0.73	0.46
Uniform Delay, d1	27.8	37.9		29.2	38.3	36.1	18.2	23.4		13.7	26.6	22.8
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	0.2	2.2		0.2	1.7	0.4	1.6	0.5		0.2	3.6	0.6
Delay (s)	28.0	40.2		29.4	40.0	36.5	19.8	23.9		13.9	30.2	23.4
Level of Service	C	D		C	D	D	B	C		B	C	C
Approach Delay (s)		36.0			36.5			22.4			25.9	
Approach LOS		D			D			C			C	

Intersection Summary			
HCM Average Control Delay	27.7	HCM Level of Service	C
HCM Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	112.6	Sum of lost time (s)	8.0
Intersection Capacity Utilization	68.9%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
3: MD 450 & MD 424

6/16/2008

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	364	185	147	48	149	205	70	505	26	142	402	154
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frpb, ped/bikes	1.00	1.00		1.00	1.00	0.98	1.00	1.00		1.00	1.00	1.00
Flpb, ped/bikes	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt	1.00	0.93		1.00	1.00	0.85	1.00	0.99		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1770	1739		1770	1863	1546	1770	1849		1770	1863	1583
Flt Permitted	0.50	1.00		0.55	1.00	1.00	0.30	1.00		0.09	1.00	1.00
Satd. Flow (perm)	932	1739		1016	1863	1546	558	1849		173	1863	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	396	201	160	52	162	223	76	549	28	154	437	167
RTOR Reduction (vph)	0	13	0	0	0	117	0	1	0	0	0	24
Lane Group Flow (vph)	396	348	0	52	162	106	76	576	0	154	437	143
Confl. Peds. (#/hr)						2						
Turn Type	pm+pt			pm+pt		Perm	pm+pt			pm+pt		Perm
Protected Phases	1	6		5	2		3	8		7	4	
Permitted Phases	6			2		2	8			4		4
Actuated Green, G (s)	85.5	73.6		56.0	49.1	49.1	72.7	63.3		82.3	68.1	68.1
Effective Green, g (s)	86.5	75.6		58.0	51.1	51.1	74.7	65.3		83.5	70.1	70.1
Actuated g/C Ratio	0.48	0.42		0.32	0.28	0.28	0.42	0.36		0.46	0.39	0.39
Clearance Time (s)	5.0	6.0		5.0	6.0	6.0	5.0	6.0		5.0	6.0	6.0
Vehicle Extension (s)	2.5	6.0		2.5	6.0	6.0	2.5	3.5		2.5	3.5	3.5
Lane Grp Cap (vph)	599	730		360	529	439	302	671		215	726	616
v/s Ratio Prot	c0.12	0.20		0.01	0.09		0.01	c0.31		c0.06	0.23	
v/s Ratio Perm	c0.20			0.04		0.07	0.09			0.27		0.09
v/c Ratio	0.66	0.48		0.14	0.31	0.24	0.25	0.86		0.72	0.60	0.23
Uniform Delay, d1	32.0	37.8		42.6	50.5	49.5	34.3	53.1		38.3	43.8	36.9
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00		1.33	0.73	0.65
Incremental Delay, d2	2.5	2.2		0.1	1.5	1.3	0.3	10.8		9.4	1.4	0.2
Delay (s)	34.4	40.1		42.7	52.0	50.8	34.6	63.9		60.3	33.3	24.3
Level of Service	C	D		D	D	D	C	E		E	C	C
Approach Delay (s)		37.1			50.3			60.5			36.8	
Approach LOS		D			D			E			D	

Intersection Summary			
HCM Average Control Delay	45.1	HCM Level of Service	D
HCM Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	180.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	82.9%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

HCM Signalized Intersection Capacity Analysis
8: Cardinal Crest Dr & MD 424

6/16/2008

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	21	28	53	363	16	48	8	448	68	26	644	7
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	0.85		1.00	0.85	1.00	0.98		1.00	1.00	0.85
Flt Protected		0.98	1.00		0.95	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)		1823	1583		1778	1583	1770	1826		1770	1863	1583
Flt Permitted		0.25	1.00		0.70	1.00	0.12	1.00		0.23	1.00	1.00
Satd. Flow (perm)		469	1583		1297	1583	216	1826		436	1863	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	23	30	58	395	17	52	9	487	74	28	700	8
RTOR Reduction (vph)	0	0	48	0	0	24	0	4	0	0	0	1
Lane Group Flow (vph)	0	53	10	0	412	28	9	557	0	28	700	7
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		Perm
Protected Phases		3			4			2			6	
Permitted Phases	3		3	4		4	2			6		6
Actuated Green, G (s)		20.2	20.2		35.3	35.3	55.6	55.6		55.6	55.6	55.6
Effective Green, g (s)		21.7	21.7		36.8	36.8	57.6	57.6		57.6	57.6	57.6
Actuated g/C Ratio		0.17	0.17		0.29	0.29	0.45	0.45		0.45	0.45	0.45
Clearance Time (s)		5.5	5.5		5.5	5.5	6.0	6.0		6.0	6.0	6.0
Vehicle Extension (s)		3.0	3.0		5.0	5.0	5.0	5.0		5.0	5.0	5.0
Lane Grp Cap (vph)		79	268		373	455	97	821		196	838	712
v/s Ratio Prot								0.30			c0.38	
v/s Ratio Perm		c0.11	0.01		c0.32	0.02	0.04			0.06		0.00
v/c Ratio		0.67	0.04		1.10	0.06	0.09	0.68		0.14	0.84	0.01
Uniform Delay, d1		49.9	44.5		45.6	33.1	20.2	27.9		20.7	31.1	19.5
Progression Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		20.1	0.1		77.9	0.1	0.9	2.9		0.7	8.0	0.0
Delay (s)		70.0	44.5		123.5	33.2	21.1	30.8		21.4	39.1	19.5
Level of Service		E	D		F	C	C	C		C	D	B
Approach Delay (s)		56.7			113.4			30.7			38.2	
Approach LOS		E			F			C			D	

Intersection Summary			
HCM Average Control Delay	55.6	HCM Level of Service	E
HCM Volume to Capacity ratio	0.89		
Actuated Cycle Length (s)	128.1	Sum of lost time (s)	12.0
Intersection Capacity Utilization	89.3%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
8: Cardinal Crest Dr & MD 424

6/16/2008

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	14	30	12	165	11	104	25	972	354	77	495	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0		4.0	4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		1.00	1.00		1.00	1.00	1.00	1.00		1.00	1.00	1.00
Frt		1.00	0.85		1.00	0.85	1.00	0.96		1.00	1.00	0.85
Flt Protected		0.98	1.00		0.96	1.00	0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)		1834	1583		1779	1583	1770	1788		1770	1863	1583
Flt Permitted		0.25	1.00		0.70	1.00	0.38	1.00		0.03	1.00	1.00
Satd. Flow (perm)		466	1583		1312	1583	709	1788		62	1863	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	15	33	13	179	12	113	27	1057	385	84	538	22
RTOR Reduction (vph)	0	0	12	0	0	95	0	7	0	0	0	2
Lane Group Flow (vph)	0	48	1	0	191	18	27	1435	0	84	538	20
Turn Type	Perm		Perm	Perm		Perm	Perm			Perm		Perm
Protected Phases		3			4			2			6	
Permitted Phases	3		3	4		4	2			6		6
Actuated Green, G (s)		18.4	18.4		26.4	26.4	118.2	118.2		118.2	118.2	118.2
Effective Green, g (s)		19.9	19.9		27.9	27.9	120.2	120.2		120.2	120.2	120.2
Actuated g/C Ratio		0.11	0.11		0.16	0.16	0.67	0.67		0.67	0.67	0.67
Clearance Time (s)		5.5	5.5		5.5	5.5	6.0	6.0		6.0	6.0	6.0
Vehicle Extension (s)		3.0	3.0		5.0	5.0	5.0	5.0		5.0	5.0	5.0
Lane Grp Cap (vph)		52	175		203	245	473	1194		41	1244	1057
v/s Ratio Prot								0.80			0.29	
v/s Ratio Perm		c0.10	0.00		c0.15	0.01	0.04			c1.36		0.01
v/c Ratio		0.92	0.01		0.94	0.07	0.06	1.20		2.05	0.43	0.02
Uniform Delay, d1		79.3	71.3		75.2	65.0	10.3	29.9		29.9	14.0	10.1
Progression Factor		1.00	1.00		1.00	1.00	0.97	0.70		1.00	1.00	1.00
Incremental Delay, d2		96.0	0.0		47.6	0.3	0.2	98.0		546.1	1.1	0.0
Delay (s)		175.3	71.3		122.8	65.2	10.2	118.9		576.0	15.1	10.1
Level of Service		F	E		F	E	B	F		F	B	B
Approach Delay (s)		153.1			101.4			116.9			88.1	
Approach LOS		F			F			F			F	

Intersection Summary			
HCM Average Control Delay	108.4	HCM Level of Service	F
HCM Volume to Capacity ratio	1.72		
Actuated Cycle Length (s)	180.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	95.8%	ICU Level of Service	F
Analysis Period (min)	15		
c Critical Lane Group			

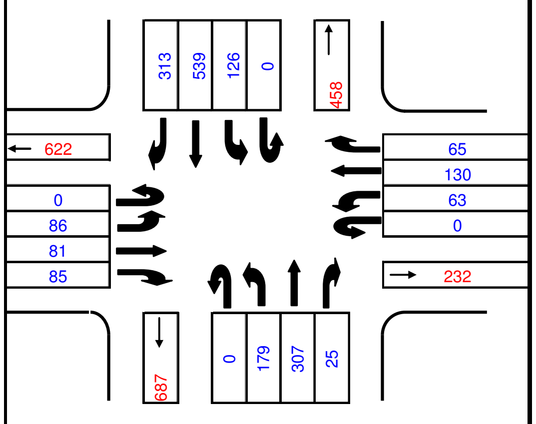
Critical Lane Analysis (Existing Condition for MD450 at MD424)

Maryland State Highway Administration
Intersection Critical Lane Volume and Level of Service Analysis

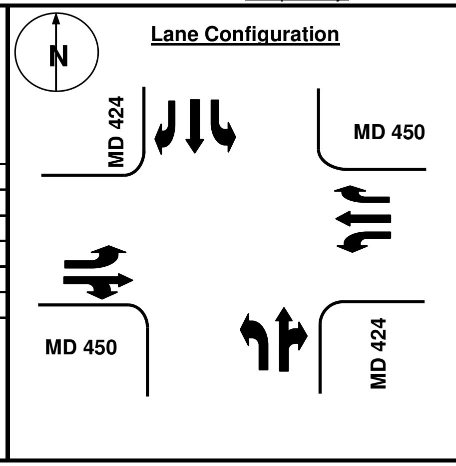
Prepared by: **Michael Baker Jr**

Count Date: 5/7/2008 | Location: MD 450 @ MD 424
Conditions: Existing Weekday
Design Year: | Computed by: JLI | Date 7/21/2008

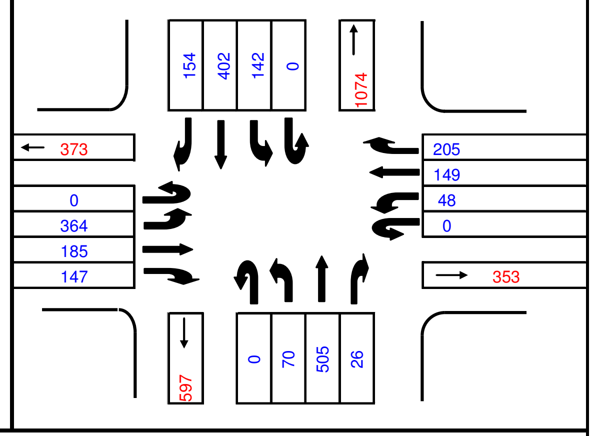
Morning Peak Hour: **7:30-8:30 AM**



Lane Configuration



Evening Peak Hour: **5:00-6:00 PM**



Number of Lanes	Lane Use Factor	Service Level	Critical Lane Vol	Opposing Volume (VPH)	PCE
1	= 1.00	A	<= 1000	<= 199	1.1
2	= 0.55	B	<= 1150	<= 599	2.0
3	= 0.40	C	<= 1300	<= 799	3.0
4	= 0.30	D	<= 1450	<= 999	4.0
Dbl-Lt	= 0.60	E	<= 1600	> 1000	5.0
		F	> 1600		

Phasing

RTOR/Overlap: ☐ Northbound ☐ Southbound ☐ Eastbound ☐ Westbound

Split Phasing: ○ East/West ○ North/South ◉ None

Inx. Control: ◉ Signal ○ Stop

Phase	Movement	Volume 1	Lane Use Factor - 2	Lane volume 1 X 2	Opposing Movement	Critical ln. volume	*
	NB	332	1.00	332	126	458	
	SB	539	1.00	539	179	718	*
	EB	166	1.00	166	63	229	*
	WB	130	1.00	130	86	216	
Remarks:		* Critical volume			Total	947	
					Level of service (V/C)	0.59	A

Phase	Movement	Volume 1	Lane Use Factor - 2	Lane volume 1 X 2	Opposing Movement	Critical ln. Volume	*
	NB	531	1.00	531	142	673	*
	SB	402	1.00	402	70	472	
	EB	332	1.00	332	48	380	
	WB	149	1.00	149	364	513	*
Remarks:		* Critical volume			Total	1186	
					Level of service (V/C)	0.74	C

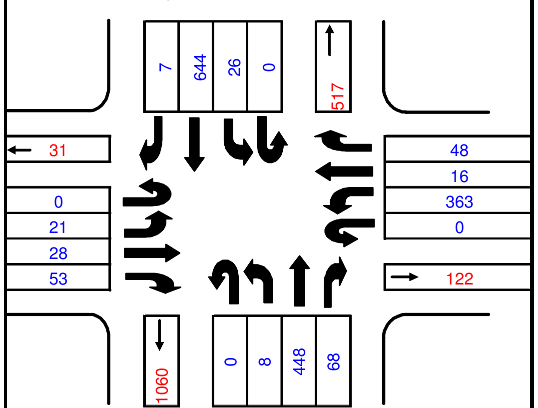
Critical Lane Analysis (Existing Condition for MD424 at Underwood)

Maryland State Highway Administration
Intersection Critical Lane Volume and Level of Service Analysis

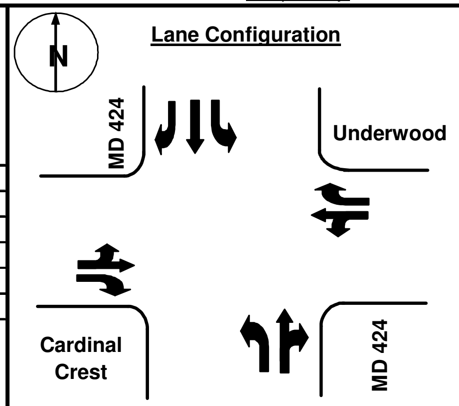
Prepared by: **Michael Baker Jr**

Count Date: 5/7/2008 Location: MD 424 @ Underwood
Conditions: Existing Weekday
Design Year: Computed by: JLI Date 7/21/2008

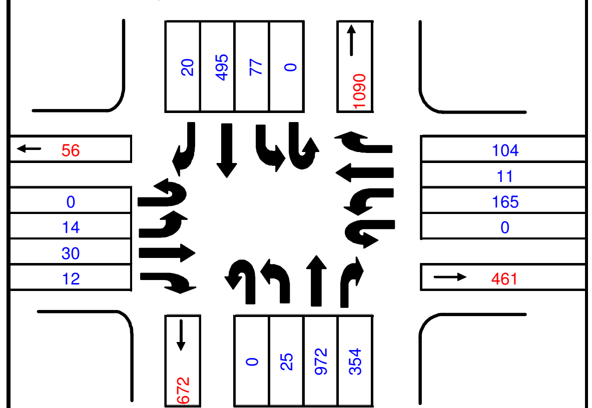
Morning Peak Hour: **7:30-8:30 AM**



Lane Configuration



Evening Peak Hour: **5:00-6:00 PM**



Number of Lanes	Lane Use Factor	Service Level	Critical Lane Vol	Opposing Volume (VPH)	PCE
1	= 1.00	A <= 1000		<= 199	1.1
2	= 0.55	B <= 1150		<= 599	2.0
3	= 0.40	C <= 1300		<= 799	3.0
4	= 0.30	D <= 1450		<= 999	4.0
Dbl-Lt	= 0.60	E <= 1600		> 1000	5.0
		F > 1600			

Phasing

RTOR/Overlap: ☐ Northbound ☐ Southbound ☐ Eastbound ☐ Westbound

Split Phasing: ◉ East/West ○ North/South ○ None

Inx. Control: ◉ Signal ○ Stop

Phase	Movement	Volume 1	Lane Use Factor - 2	Lane volume 1 X 2	Opposing Movement	Critical ln. volume	*	Phase	Movement	Volume 1	Lane Use Factor - 2	Lane volume 1 X 2	Opposing Movement	Critical ln. Volume	*
	NB	516	1.00	516	26	542			NB	1326	1.00	1326	77	1403	*
	SB	644	1.00	644	8	652	*		SB	495	1.00	495	25	520	
	EB	53	1.00	53	0	53	*		EB	44	1.00	44	0	44	*
	WB	379	1.00	379	0	379	*		WB	176	1.00	176	0	176	*
Remarks:		* Critical volume			Total	1084		Remarks:			* Critical volume		Total	1623	
					Level of service (V/C)	0.68	B						Level of service (V/C)	1.01	F