PREPARED FOR:

Montgomery County Department of Transportation
Planning

BRADLEY BOULEVARD (MD 191) BIKEWAY PROJECT

Traffic Study

Looking East toward Audubon Road

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I. Introduction

The Montgomery County Department of Transportation (MCDOT) initiated a Phase I Facility Planning Study to evaluate the construction of a dual bikeway along Bradley Boulevard (MD 191) between Wilson Lane (MD 188) and Goldsboro Road (MD 614). A dual bikeway includes on-road bike lanes (shoulders) as well as an off-road path to be shared by bicyclists and pedestrians.

This study reviewed the *1990 Approved and Adopted Bethesda-Chevy Chase Master Plan* and the *2005 Countywide Bikeways Functional Master Plan*. The study recommended providing a pedestrian connection between:

- existing sidewalk on Bradley Boulevard east of Goldsboro Road, and
- existing sidewalk on Wilson Lane.

The study area is located in a single-family residential community in Bethesda, Maryland, see the site map on Figure 1.

II. Existing Conditions

1. Existing Pedestrian Facilities: Signal, Crosswalk, and Sidewalk Locations

Note: *Throughout the study corridor, Bradley Boulevard is classified as an east-west roadway, and is labeled as such in this report, although it is aligned in the north-south direction in the vicinity of the Wilson Lane intersection.*

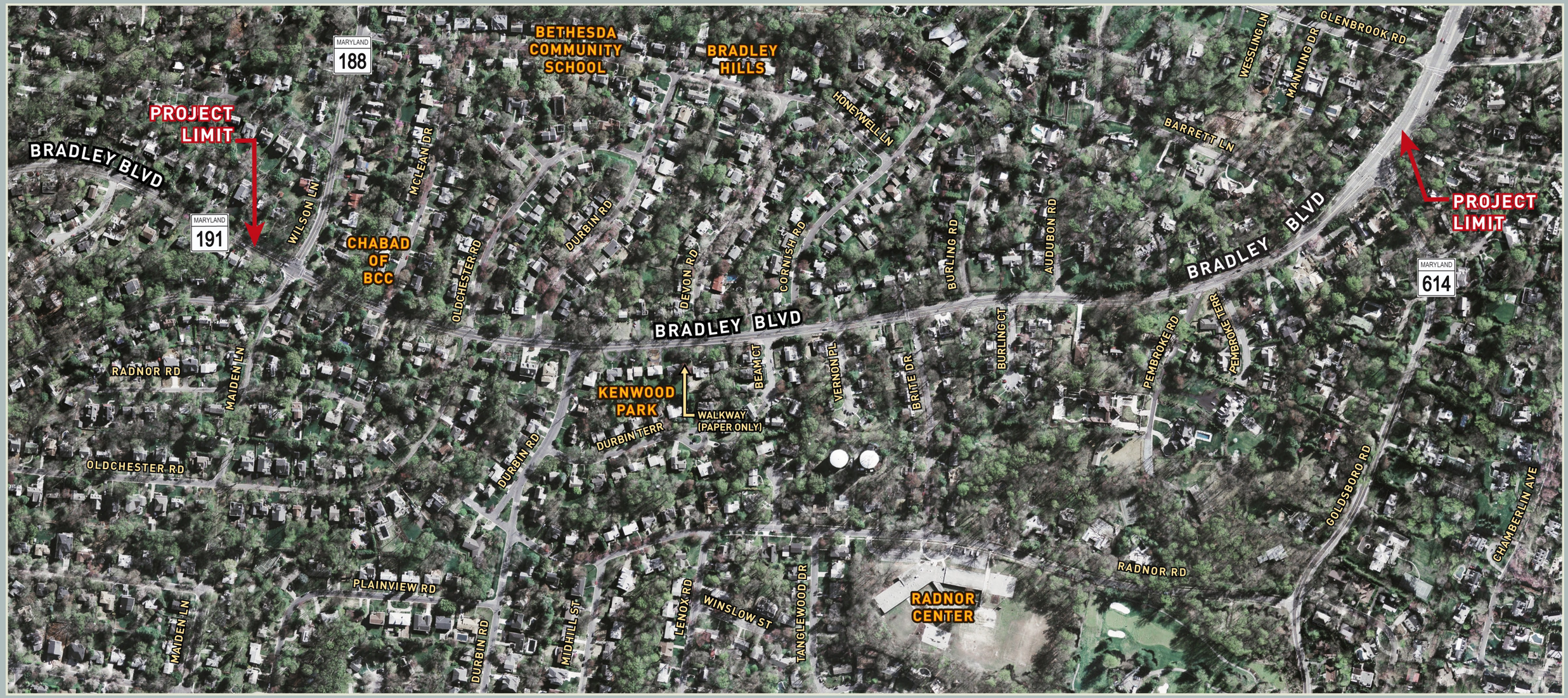
Two intersections in the study area are signal-controlled: ***Bradley Boulevard (MD 191) at Wilson Lane (MD 188)*** and ***Bradley Boulevard (MD 191) at Goldsboro Road (MD 614).*** The Bradley Boulevard at Wilson Lane intersection has crosswalks on two of the four approaches, one crossing the NB Wilson Lane approach, and one crossing the WB Bradley Boulevard approach. Within the study area is the ***Bradley Boulevard at Brite Drive*** intersection, which is stop-controlled along the Brite Drive approach. This intersection has a crosswalk on one of its three approaches, crossing the EB Bradley Boulevard approach. The Bradley Boulevard at Goldsboro Road intersection has no crosswalks along any of its three approaches. A summary of existing pedestrian facilities is shown in Table 1

TABLE 1 - Summary of Existing Pedestrian Facilities

Intersection/Roadway	Intersection	
	Existing Traffic Signal Control	Existing Marked Crosswalk
Bradley Boulevard at Wilson Lane	●	●
Bradley Boulevard between Wilson Lane and Brite Drive		
Bradley Boulevard at Brite Drive		●
Bradley Boulevard between Brite Drive and Goldsboro Road		
Bradley Boulevard at Goldsboro Road	●	

BRADLEY BOULEVARD (MD 191) BIKEWAY PROJECT

FIGURE 1: SITE MAP



There are intermittent sidewalk facilities throughout the study area as follows:

- Along the north side of Bradley Boulevard from the east limit of the study area to Barrett Lane – consisting of five to six foot wide sidewalks with a grass buffer of varying width.
- Bradley Boulevard at Wilson Lane – short segments of six to seven foot wide sidewalks on the northwest and southwest corners of the intersection.
- Bradley Boulevard at Durbin Road – short segment adjacent to EB Bradley Boulevard on the northwest corner of the intersection.
- Bradley Boulevard at Goldsboro Road – short segments adjacent to EB Bradley Boulevard on the southwest and southeast corners of the intersection.

2. Existing Bikeways: Shared-Use Paths, Shared Roadways and Bike Lanes

Bradley Boulevard currently does not have dedicated bicycle lanes. Bradley Boulevard intersects the Capital Crescent Trail and is in close proximity to the North Bethesda Trail (also known as the Bethesda Trolley Trail) near the study area. There are also on-road bike lanes on Fairfax Road and Little Falls Parkway just east of the study area.

According to the Montgomery County's *Countywide Bikeways Functional Master Plan*, dual bikeways (shared use path and signed shared roadway) are proposed on Bradley Boulevard from Persimmon Tree Road in the west to Wisconsin Avenue in the east, which includes the study area.

3. Geometric Configuration and Traffic Control

The existing travel lanes on Bradley Boulevard vary from 11' to 13', and average 11.5'. The existing shoulders on Bradley Boulevard vary from 2' to 12', and average 4'.

There are two signalized intersections within the study area on Bradley Boulevard. ***Bradley Boulevard at Wilson Lane*** is controlled by a two-phase traffic signal. At this intersection, Bradley Boulevard is a two-lane roadway. The WB lane is 13' wide east of Wilson Lane and 11.5' wide west of Wilson Lane. The EB lane is 11' wide west of Wilson Lane and 12' wide east of Wilson Lane. The posted speed limit on Bradley Boulevard is 30 mph. The nearest adjacent signalized intersections are located approximately 400 feet to the east of Goldsboro Road at Glenbrook Road, and approximately 0.5 miles to the west of Wilson Lane at Huntington Parkway. Adjacent land uses are primarily residential homes.

Bradley Boulevard at Goldsboro Road is controlled by a three-phase traffic signal, including exclusive/permissive left-turn phasing on the WB Bradley Boulevard approach. East of the intersection, Bradley Boulevard is a divided roadway with two 10' wide WB thru lanes, a separate 15' wide left-turn bay and three 11' wide EB lanes. Just west of the intersection, Bradley Boulevard has three 11' wide EB lanes, and one WB lane that is 18' wide, but narrows down to 12.5'approximately 330' west of the intersection.

At its intersection with Bradley Boulevard***, Wilson Lane*** is a two-lane roadway. The NB lane is 11' wide south of the intersection and 13' wide north of the intersection. The SB

lane is 11.5' wide north of the intersection and 11' wide south of the intersection. The posted speed limit on Wilson Lane is 30 mph. The nearest signalized intersections on Wilson Lane are located approximately 0.75 miles to the south at Whittier Boulevard and approximately 0.9 miles to the north at Old Georgetown Road (MD 187). Adjacent land uses are primarily residential homes.

At its intersection with Bradley Boulevard, ***Goldsboro Road*** is a two-lane roadway. The NB approach includes a separate left-turn lane and right-turn lane, both of which are 11' wide. The SB lane along this approach is 22' wide, which immediately narrows down to approximately 12'. There is no separate SB approach. The posted speed limit on Goldsboro Road is 30 mph. The nearest signalized intersection on Goldsboro Road is located approximately 0.9 miles to the south at River Road (MD 190). Adjacent land uses are primarily residential homes.

4. Travel Speeds

Vehicle travel speeds were measured along Bradley Boulevard between 10:45 AM and 1:00 PM on Thursday, April 23, 2009. Travel speeds were recorded at Wilson Lane, Brite Drive, and Goldsboro Road. Crosswalks across Bradley Boulevard are currently located at the Wilson Lane and Brite Drive intersections. Radar speed distributions are enclosed in Appendix A, and results are summarized in Table 2.

As indicated, Bradley Boulevard motorists are driving 4 to 9 mph above the posted 30-mph speed limit under free-flow conditions. During this period, vehicle speeds ranged from 24 to 53 mph.

TABLE 2 - Travel Speed Data Summary

Criteria	at Wilson Lane		at Brite Drive		at Goldsboro Road	
	WB	EB	WB	EB	WB	EB
Posted Speed Limit	30 mph	30 mph	30 mph	30 mph	30 mph	30 mph
85th Percentile Speed	36 mph	37 mph	37 mph	38 mph	39 mph	34 mph
% Exceeding Speed Limit	74%	78%	80%	84%	79%	58%
Mean Speed	32.9 mph	33.3 mph	33.8 mph	34.7 mph	34.5 mph	31.0 mph
High/Low Speed	43/27 mph	40/26 mph	52/27 mph	49/26 mph	53/27 mph	39/24 mph

5. Peak Hour Delays/Queues

During the majority of the day, motorists in queues were observed clearing the intersections during most cycles. Queuing analyses are included in Appendix B, and results are summarized in Table 3.

At the Bradley Boulevard at Wilson Lane intersection, the EB (AM) and WB (PM) queues on Bradley Boulevard were typically too long to be measured. During the AM peak period, EB left-turn queues of 4 or more vehicles in length would slow/completely block through traffic, not allowing through motorists to clear the intersection. During the PM peak period, slow-moving WB traffic west of Wilson Lane queued to, and periodically through the intersection, prohibiting WB traffic from clearing the intersection.

At the Bradley Boulevard at Goldsboro Road intersection, the longest turn queues form in the WB left-turn lane during the ***PM peak hour***. All of these lefts which are in queue at the beginning of the green interval clear during the exclusive left-turn arrow phase.

TABLE 3 - Peak Hour Queuing Summary along Bradley Boulevard

Peak Hour	Intersection Approach – Movement	Longest Queue[1]	Average Queue[1]	Vehicles Not Cleared[2]
7:45-8:45 AM	EB (All Vehicles) at Wilson Lane	20	20	*
	WB Lefts at Goldsboro Road	15	6.3	0 (1)
	EB Thrus at Goldsboro Road	10	6.2	0 (0)
5:30-6:30 PM	WB (All Vehicles) at Wilson Lane	20	20	*
	WB Lefts at Goldsboro Road	18	8.8	0 (0)
	EB Thrus at Goldsboro Road	8	4.4	0 (0)

[1] Per cycle
[2] Total vehicles during peak hour (vehicles in parentheses represent # vehicles clearing during yellow & all-red intervals)
* Vehicles not cleared cannot be determined because the excessive queue lengths are too long to be determined

6. Sight Distances

Stopping sight distances were measured at both signalized intersections as well as the crosswalk location at Brite Drive. Table 4 provides a summary of stopping sight distance criteria and available sight distances on the intersection approaches. Because the radar speed study shows 85th percentile speeds of 34 to 39 mph throughout the study area, a design speed of 40 mph was used for all approaches. As indicated, all available sight distances exceed criteria.

TABLE 4 - Stopping Sight Distances

Location	Approach	Criteria	Available Sight Distance	Criteria Met
Wilson Lane	WB	305'	535'	Yes
	EB	305'	850'	Yes
Brite Drive	WB	305'	710'	Yes
	EB	305'	725'	Yes
Goldsboro Road	WB	305'	440'*	Yes
	EB	305'	560'	Yes

* Sight distance extends past next intersection (Glenbrook Drive), which is 440' from Goldsboro Road

7. Traffic Volumes

A 13-hour turning movement count was conducted at the intersection of Bradley Boulevard at Goldsboro Road from 6:00 AM to 7:00 PM on Tuesday, April 21, 2009. A 13-hour turning movement count was conducted at the intersection of Bradley Boulevard at Wilson Lane from 6:00 AM to 7:00 PM on Thursday, April 23, 2009. A 5-hour turning movement count was performed at the intersection of Bradley Boulevard at Goldsboro Road from 7:00 AM to 12:00 Noon on Saturday, April 25, 2009. Peak hour traffic volumes are shown in Figures 1, 2, and 3. Appendix C contains the full count data. Peak hour vehicular volume characteristics are shown in Tables 5A and 5B. Peak hour pedestrian and bicycle volumes are shown in Tables 5C and 5D. As indicated, the predominant vehicular through movements along Bradley Boulevard are EB during the morning peak period and WB during the evening peak period. The predominant bicycle movements occur on the weekend from 7:00 AM to 8:00 AM.

FIGURE 2 - Existing Traffic Volumes (Weekday AM Peak Hour)

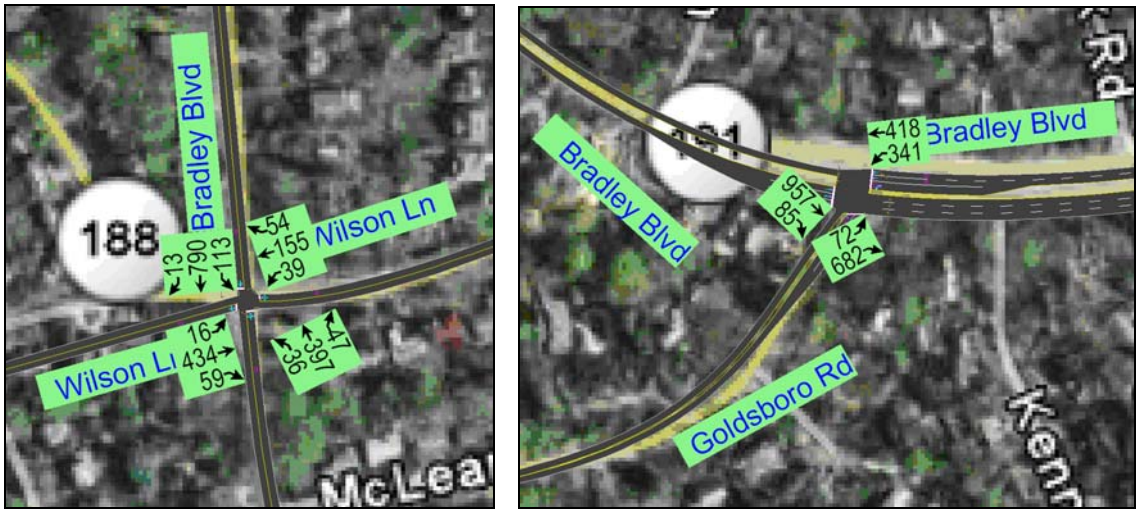


FIGURE 3 - Existing Traffic Volumes (Weekday PM Peak Hour)

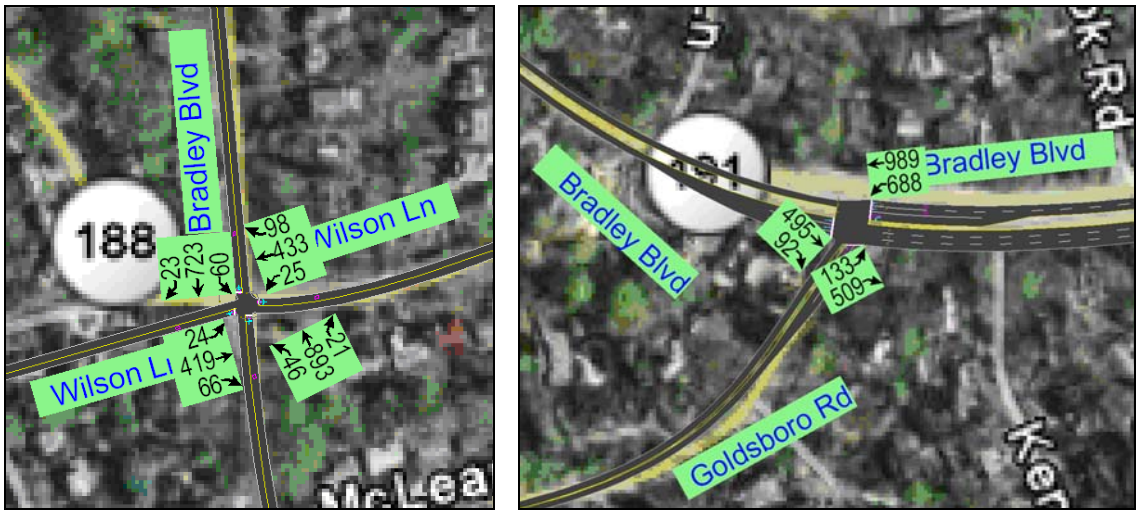


FIGURE 4 - Existing Traffic Volumes (Saturday Peak Hour)

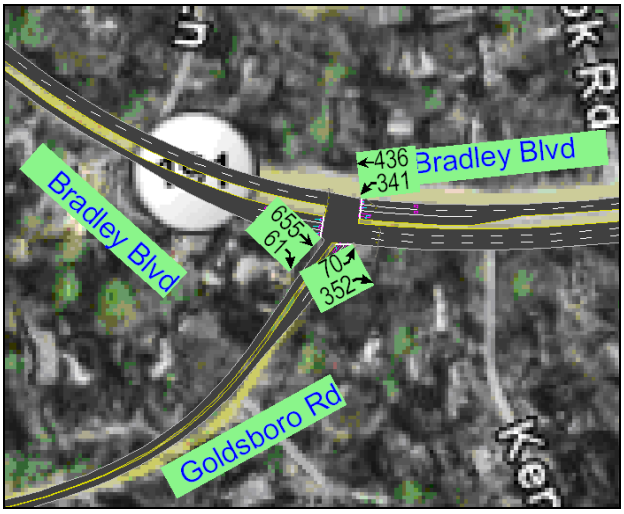


TABLE 5A - Peak Hour Vehicular Volume Characteristics – Bradley Boulevard at Wilson Lane

Peak Hour	Predominant Flow – Movement (vph)			
	Bradley Boulevard		Wilson Lane	
	Turns	Thru	Turns	Thru
Weekday 8:15 – 9:15 AM	EBL (113)	EB (790)	SBL (39) NBR (59)	NB (434)
Weekday 5:45 – 6:45 PM	EBL (60)	WB (893)	SBL (25) SBR (98)	NB (419) SB (433)

TABLE 5B - Peak Hour Vehicular Volume Characteristics – Bradley Boulevard at Goldsboro Road

Peak Hour	Predominant Flow – Movement (vph)			
	Bradley Boulevard		Goldsboro Road	
	Turns	Thru	Lefts	Rights
Weekday 7:45 – 8:45 AM	WBL (341)	EB (957)	NBL (72)	NBR (682)
Weekday 5:30 – 6:30 PM	WBL (688)	WB (959)	NBL (133)	NBR (509)
Saturday 11:00 AM – 12:00 Noon	WBL (341)	EB (655)	NBL (70)	NBR (352)

TABLE 5C - Peak Hour Pedestrian/Bicycle Volume Characteristics – Bradley Boulevard at Wilson Lane

Peak Hour	Bradley Boulevard				Wilson Lane			
	Pedestrians		Bicycles		Pedestrians		Bicycles	
	EB	WB	EB	WB	NB	SB	NB	SB
Weekday 8:15 – 9:15 AM	0	6	0	9	0	0	7	3
Weekday 5:45 – 6:45 PM	2	16	4	3	2	6	1	5
Weekday 12:00 Noon– 1:00 PM Peak hour of bicycle traffic	8	0	0	25	0	0	3	2

TABLE 5D - Peak Hour Pedestrian/Bicycle Volume Characteristics – Bradley Boulevard at Goldsboro Road

Peak Hour	Bradley Boulevard				Goldsboro Road	
	Pedestrians		Bicycles		Pedestrians	Bicycles
	EB	WB	EB	WB	NB	NB
Weekday 7:45 – 8:45 AM Peak hour of vehicular and bicycle traffic	0	0	0	0	11	1
Weekday 5:30 – 6:30 PM	0	0	0	0	2	0
Saturday 11:00 AM – 12:00 Noon	0	1	9	9	1	1
Saturday 7:00 – 8:00 AM Peak hour of bicycle traffic	0	0	5	71	2	3

8. Existing Level of Service

Under MSHA's Critical Lane Volume (CLV) analysis, the Bradley Boulevard intersections with Wilson Lane and Goldsboro Road, respectively, operate at ***LOS F/B during the AM peak hour and LOS F/B during the PM peak hour.*** It was noted during peak hour observations that through/right-turning vehicles bypass left-turning vehicles at the Bradley Boulevard at Wilson Lane intersection along the Bradley Boulevard approaches and the SB Wilson Lane approach, creating effective left-turn/bypass lanes along these three approaches. This intersection was analyzed with left-turn lanes to more accurately reflect existing traffic conditions. With the effective left-turn lanes at the Bradley Boulevard at Wilson Lane intersection, the intersections operate at ***LOS D/B during the AM peak hour and LOS E/B during the PM peak hour (See Table 6).*** CLV worksheets can be found in Appendix D.

TABLE 6 – Existing Intersection CLV Summary

(With Effective Turn Lanes at the Bradley Boulevard at Wilson Lane Intersection)

Intersection	AM Peak Hour			PM Peak Hour		
	CLV	LOS	V/C Ratio	CLV	LOS	V/C Ratio
Bradley Boulevard at Wilson Lane	1403	D	0.88	1532	E	0.96
Bradley Boulevard at Goldsboro Road	1099	B	0.69	1056	B	0.66

Using Synchro/SimTraffic analysis with current lane configurations and observed green times, the Bradley Boulevard intersections with Wilson Lane and Goldsboro Road, respectively, operate at ***LOS F/C during the AM peak hour and LOS F/F during the PM peak hour.*** Because through/right-turning vehicles were observed bypassing left-turning vehicles at the Bradley Boulevard at Wilson Lane intersection along the Bradley Boulevard approaches and the SB Wilson Lane approach, the network was analyzed with left-turn lanes at those approaches to more accurately reflect existing traffic conditions. With the effective left-turn lanes at the Bradley Boulevard at Wilson Lane intersection, both intersections experience improved operations, which more closely represent actual conditions. The Bradley Boulevard at Goldsboro Road intersection experiences improvements due to reduced queues from the Bradley Boulevard at Wilson Lane intersection. With the effective left-turn lanes at the Bradley Boulevard at Wilson Lane intersection, the intersections operate at ***LOS D/C during the AM peak hour and LOS F/C during the PM peak hour (See Table 7).*** Detailed SimTraffic output can be found in Appendix E.

TABLE 7 – Existing Intersection SimTraffic Summary (With Effective Turn Lanes at the Bradley Boulevard at Wilson Lane Intersection)

Approach	AM Peak Hour			PM Peak Hour		
	Delay	LOS	95th % Queue (ft)	Delay	LOS	95th % Queue (ft)
Bradley Boulevard at Wilson Lane						
EB Bradley Boulevard	34.6	C	762	88.3	F	890
WB Bradley Boulevard	18.9	B	287	38.9	D	1064
NB Wilson Lane	99.7	F	1096	874.6	F	1884
SB Wilson Lane	37.5	D	211	108.2	F	1169
Intersection Summary	46.8	D	--	181.6	F	--
Bradley Boulevard at Goldsboro Road						
EB Bradley Boulevard	22.8	C	216	16.7	B	161
WB Bradley Boulevard	18.9	B	242	37.5	D	441
NB Goldsboro Road	26.8	C	233	19.6	B	132
Intersection Summary	22.9	C	--	28.6	C	--

9. Bus Ridership

Bus ridership volumes were provided by Montgomery County's Ride On Transit Services department. Bus route 36 travels both EB and WB through the study area.Bus ridership includes a total of 44 passengers entering and exiting the WB buses on an average weekday, and 44 entering and exiting the EB buses on an average weekday. This bus route does not operate on weekends. Table 8 provides a summary of bus ridership in this area. The bus stops along the EB route that experience the greatest usage are at Brite Drive (17 riders/day) and Durbin Road (9 riders/day). The Brite Drive bus stop is served by a crosswalk. The bus stops along the WB route that experience the greatest usage are at Audubon Road (15 riders/day), Durbin Road (9 riders/day), and Burling Court (7 riders/day). The most heavily-traveled time periods are during the AM period (19 riders/day in the area) and the mid-day period (17 riders/day) along the EB route, and during the PM period (18 riders/day) along the WB route.

TABLE 8 – Bus Route 36 Ridership Summary

Bus Stop	AM 4:59 AM - 8:56 AM		MID-DAY 8:57 AM – 3:56 PM		PM 3:57 PM – 6:56 PM		NIGHT After 6:57 PM		TOTAL	
	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Route 36 Eastbound FY09 Weekday										
Wilson Lane	0	0	0	3	0	0	0	0	0	3
Oldchester Road	1	0	1	0	0	0	0	0	2	0
Durbin Road	6	0	2	0	1	0	0	0	9	0
Beam Court	2	0	0	0	0	0	0	0	2	0
Brite Drive	6	0	6	1	4	0	0	0	16	1
Audubon Road	2	0	0	0	2	0	0	0	4	0
Pembroke Road	0	0	0	0	0	0	0	0	0	0
Goldsboro Road	0	0	1	1	0	0	0	0	1	1
Glenbrook Road	2	0	2	0	1	0	0	0	5	0
Total	19	0	12	5	8	0	0	0	39	5
Route 36 Westbound FY09 Weekday										
Goldsboro Road	0	0	0	0	0	0	0	0	0	0
Pembroke Road	0	0	0	1	0	0	0	0	0	1
Audubon Road	0	6	1	2	0	4	0	2	1	14
Burling Court	0	2	0	1	0	4	0	0	0	7
Cornish Road	0	0	0	0	0	4	0	0	0	4
Durbin Road	0	2	0	3	0	3	0	1	0	9
Oldchester Road	0	0	0	0	0	2	0	0	0	2
Wilson Lane	0	3	1	1	0	1	0	0	1	5
Total	0	13	2	8	0	18	0	3	2	42

10. Field Observations

Bradley Boulevard at Wilson Lane

- EB through vehicles bypass EB left-turning typically vehicles at a relatively high rate of speed, as long as the EB left-turn queue is three vehicles or less.
- The sight distance of EB lefts is blocked by WB lefts. WB through vehicles bypass waiting WB lefts, resulting in conflicts between EB lefts and WB through vehicles. At these times, WB through vehicles had to brake to avoid EB left-turning vehicles.
- EB and WB queues consistently extend to more than twenty vehicles during the AM and PM peak hours, respectively.

- On both Bradley Boulevard approaches and on the SB Wilson Lane approach, through vehicles use the shoulders to bypass left-turning vehicles, or right-turning vehicles use the shoulders to bypass left/through vehicles.

- At 5:38 PM, slow moving traffic west of this intersection queued through the intersection, making the intersection capacity-constrained. This scenario repeated three more times until 5:50 PM.

- During the PM peak hour, NB and SB queues of greater than ten vehicles frequently occurred.

- Throughout the PM peak hour, many EB left-turning vehicles were unable to turn during the green phase due to the heavy WB through movement and instead two to three vehicles would turn during the all-red phase, resulting in a potential safety issue.

Bradley Boulevard at Goldsboro Road

- During the AM peak hour, EB vehicles typically arrive in platoons at the start of their green phase and either do not come to a complete stop, or stop for two seconds or less.

- During the AM peak hour, NB rights form queues of seven to nineteen vehicles, and typically clear during the WB left-turn phase, which follows the NB phase. The NB phase always maxes out during this peak hour. An overlap phase would decrease delay for these NB right-turning motorists.

- During the PM peak hour, NB right-turning vehicles typically form short queues of three vehicles or less; there were two observed queues which were significantly longer (ten vehicles and twelve vehicles).

- WB queues developed west of this intersection from 5:50 to 6:10 PM; while these queues always cleared the intersection, they did cause increases in delay for WB through vehicles.

- During the PM peak hour, WB left-turning queues extended beyond the turn bay and spilled over into one of the through lanes, and extended as far as to the upstream signalized intersection of Bradley Boulevard at Glenbrook Road. Vehicles were blocked from entering the intersection at Glenbrook Road once during the PM peak hour.

- The two WB through lanes merge into one lane just as vehicles pass through the intersection, creating a potential safety issue. There are no pavement markings directing motorists to merge. During the AM peak hour, when WB through traffic is lighter, most vehicles use the left of the two through lanes to avoid merging in the intersection. During the PM peak hour, when traffic volumes are greater, vehicles slow down in the middle of the intersection to merge just as they clear the intersection. A local resident whose house is along this intersection remarked that the lack of a merging area represents a safety concern.

Pedestrian/Bicyclist Observations

- A group of approximately twenty bicyclists were observed traveling WB on Bradley Boulevard through the study area at 12:30 PM on Thursday, April 23, 2009.
- A group of approximately 60 bicyclists were observed making a left turn from WB Bradley Boulevard onto Goldsboro Road just before 7:30 AM on Saturday, April 25, 2009.
- Bicyclists at the Bradley Boulevard at Wilson Lane intersection were observed obeying the traffic signal when crossing the intersection.

11. Crash History

Crash data provided by the Montgomery County Traffic Engineering and Operations Section indicates that there were sixty-two (62) reported crashes in the study area for the five-year period between 2003 and 2007, including eighteen (18) reported crashes at the Wilson Lane intersection and nineteen (19) reported crashes at the Goldsboro Road intersection. Detailed crash data is included in Appendix F, summarized in Tables 9A, 9B, and 9C, and discussed below.

Crash data was compiled along all approaches to the two signalized intersections of Bradley Boulevard at Wilson Lane and Bradley Boulevard at Goldsboro Road. Crashes were also compiled along Bradley Boulevard between the two intersections. Of the sixty-two crashes, fifty-six (56) occurred along Bradley Boulevard, five (5) occurred along Wilson Lane, and one (1) occurred along Goldsboro Road.

Severity: No crash-related fatalities occurred during the five-year period. Thirty of the sixty-two (48 percent) involved crash-related injuries, including eleven at the Wilson Lane intersection and eight at the Goldsboro Road intersection.

Type: Twenty-three of the crashes involved left-turn collisions. Eighteen crashes involved rear-end collisions. There were seven angle collisions, all of which were at the Wilson Lane intersection. Nine collisions involved a fixed object. Three crashes involved a vehicle colliding with a bicyclist. Two of these crashes occurred at the intersection of Bradley Boulevard at Goldsboro Road, and one occurred near the intersection of Bradley Boulevard at Pembroke Terrace.

Cause: Fifteen of the sixty-two crashes (24 percent) occurred during darkness. Twenty (32 percent) occurred on a wet pavement surface. Two involved alcohol.

Crash Patterns: Four intersections have relatively high concentrations of crashes. These crash patterns and potential mitigation strategies are discussed below.

- ***Wilson Lane Intersection –*** This intersection had a total of eighteen crashes during the five-year study period. Eleven crashes resulted in personal injury. Four crashes were left-turn crashes, including three crashes involving WB left-turning motorists and one involving an EB left-turn. Five crashes were rear-end collisions, including one along WB Bradley Boulevard, three along EB Bradley Boulevard, and one along NB Wilson Lane.

This intersection has one lane along each approach, and during AM and PM peak hour observations, vehicles were seen bypassing left-turning vehicles along the shoulder. When vehicles make this maneuver, left-turning vehicles have difficulty seeing opposing through vehicles. Installation of left-turn bays along the Bradley Boulevard approaches would provide a safe storage location for left-turning vehicles and improve sight distance, thereby decreasing the likelihood of rear-end and left-turn crashes. There were eight right angle crashes, including three crashes involving WB Bradley Boulevard/NB Wilson Lane motorists, and two each involving WB/SB and EB/NB motorists. Restricting right turns on red along these approaches would potentially reduce the likelihood of right angle crashes. There was also a pedestrian collision involving a vehicle from WB Bradley Boulevard. A collision diagram of this intersection is provided in Figure 5.

- ***Goldsboro Road Intersection*** – This intersection had a total of nineteen crashes during the study period, eight of which resulted in personal injury. Twelve crashes were the result of vehicles making left turns. Six of these left-turn crashes resulted in personal injury, including the injuries of two bicyclists in separate incidents. During one of these crashes, the bicyclist was struck by a vehicle traveling EB turning left. During the other crash, the vehicle was traveling WB turning left. Nine of the left-turn crashes involved drivers turning left from WB Bradley Boulevard onto Goldsboro Road. Two of the WB left-turn crashes occurred during the AM peak period and two occurred during the PM peak period. Two of the three EB left-turn crashes occurred during the PM peak period. Installation of exclusive phasing for WB left-turns, which would comply with MSHA's Left-Turn Phasing Guidelines (see Table 10), would reduce the likelihood of left-turn crashes along this approach. Currently, WB Bradley Boulevard merges from two lanes to one west of the intersection, with no marked room to merge. The proposed merge area described in Section III, Potential Improvements, may mitigate safety issues here.

- ***Oldchester Road Intersection –*** This intersection had a total of five crashes during the study period. One crash, a head-on crash caused by a driver asleep at the wheel, involved injury. Two crashes were rear-end collisions, both in the WB direction. One of these crashes occurred during the AM peak and one occurred during the PM peak. Two crashes involved a fixed object.

- ***Durbin Road East Intersection –*** Bradley Boulevard has two intersections with Durbin Road. The easternmost of the two intersections had a total of four crashes during the study period. All four crashes were WB left-turn crashes, and three of these crashes occurred between 3:00 and 5:00 PM. The fourth crash occurred during the 10:00 PM hour. There is a vertical crest approximately 130 feet away at the west intersection, which may be restricting sight distance for WB left-turning vehicles.

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FIGURE 5: BRADLEY BOULEVARD AT WILSON LANE COLLISION DIAGRAM

TABLE 9A - Crash Data Summary – Bradley Boulevard at Wilson Lane

Crashes	2003	2004	2005	2006	2007	2003 – 2007	
						Total	Percent
Severity							
Fatal	0	0	0	0	0	0	0%
Injury	1	3	1	5	1	11	61%
Property Damage	3	0	1	3	0	7	39%
Total	4	3	2	8	1	18	100%
Type							
Left-Turn	0	0	2	2	0	4	22%
Rear-End	1	1	0	3	0	5	28%
Angle	3	2	0	2	1	8	44%
Fixed Object	0	0	0	0	0	0	0%
Sideswipe	0	0	0	0	0	0	0%
Pedestrian	0	0	0	1	0	1	6%
Case							
Wet Surface	3	0	1	3	0	7	39%
Darkness	2	0	1	2	0	5	28%
Alcohol Related	0	0	0	1	0	0	5%

TABLE 9B - Crash Data Summary – Bradley Boulevard at Goldsboro Road

Crashes	2003	2004	2005	2006	2007	2003 – 2007	
						Total	Percent
Severity							
Fatal	0	0	0	0	0	0	0%
Injury	0	0	4	2	2	8	42%
Property Damage	2	4	1	2	2	11	58%
Total	2	4	5	4	4	19	100%
Type							
Left-Turn	1	2	3	4*	2	12	63%
Rear-End	0	1	0	0	2	3	16%
Angle	0	0	0	0	0	0	0%
Fixed Object	1	0	1	0	0	2	11%
Sideswipe	0	0	1	0	0	1	5%
Head-On	0	1	0	0	0	1	5%
Case							
Wet Surface	0	1	2	0	0	3	16%
Darkness	0	0	2	0	0	2	11%
Alcohol Related	0	0	1	0	0	1	5%

**Two of these four crashes involve a vehicle colliding with a bicyclist.*

TABLE 9C - Crash Data Summary – Bradley Boulevard between Wilson Lane and Goldsboro Road

Crashes	2003	2004	2005	2006	2007	2003 – 2007 Total	2003 – 2007 Percent
Severity							
Fatal	0	0	0	0	0	0	0%
Injury	2	0	4	3	2	11	44%
Property Damage	3	3	2	4	2	14	56%
Total	**5**	**3**	**6**	**7**	**4**	**25**	**100%**
Type							
Left-Turn	1	1	1	1	2	6	24%
Rear-End	2	1	3	3	1	10	40%
Angle	0	0	0	0	0	0	0%
Fixed Object	2	1	2	2	0	7	28%
Sideswipe	0	0	0	0	0	0	0%
Head-On	0	0	0	1	0	1	4%
Collision with Bicyclist	0	0	0	0	1	1	4%
Case							
Wet Surface	4	1	3	3	0	11	44%
Darkness	1	2	0	3	3	9	36%
Alcohol Related	1	0	0	0	0	1	4%

III. Traffic Analyses

1. Left-Turn Bay Warrant Analysis

The Transportation Research Board's (TRB) *NCHRP Report 279, Intersection Channelization Design Guide (1985)*, states that the advantages of exclusive left-turn lanes at signalized intersections includes their proven safety effectiveness, effectiveness in improving intersection capacity, flexibility in improving intersection capacity, flexibility in possible signal phasing schemes, and understanding of operation by the driving public. *NCHRP Report 279* offers the following general "rules-of-thumb" for evaluating left-turn lane needs at signalized intersections, which were used to assess the four approaches of the Bradley Boulevard at Wilson Lane intersection.

- ***Left-Turn Volumes:*** *Separate left-turn lanes are required if 1) the left-turn volume exceeds 20 percent of total approach volumes; or 2) the left-turn volume exceeds 100 vph in peak periods.* No left-turn volumes meet the first criterion. The left-turn movement with the highest percentage is along SB Wilson Lane, which comprises 16% of the total approach volume during the AM peak hour. The only left-turn volume that exceeds 100 vph in a peak period is the EB Bradley Boulevard left-turn movement, which has an AM peak hour volume of 113 vph.

- ***Accidents:*** *Left-turn lanes should be considered on intersection approaches when a total of 4 or more left-turn accidents occur in 12 months, or 6 or more in 24 months*. There were 3 WB left-turn crashes, 1 EB left-turn crash, and 1 SB left-turn crash during the five-year study period; therefore, this criterion is not met.

Although criteria is only met along the EB Bradley Boulevard approach, observations indicated that separate left-turn lanes along the WB Bradley Boulevard approach would help to process through and right-turning traffic more safely and efficiently, especially during peak hours. Additionally, installation of a WB left-turn lane would match the proposed EB left-turn lane, and would improve sight distance for left turning vehicles.

2. Left-Turn Signal Phasing Evaluation

MSHA's Left-Turn Phasing Guidelines flowchart and the October 5, 1982 memorandum from Montgomery County's Traffic Operations Section entitled "Guidelines for Selection of Left Turn Phase Type" (see Appendix G) were followed to evaluate left-turn phasing needs on the four approaches of the Bradley Boulevard at Wilson Lane intersection, and the WB approach of the Bradley Boulevard at Goldsboro Road intersection. Table 10 summarizes the results. As indicated, the existing permissive signal phasing is recommended for all approaches at the Bradley Boulevard at Wilson Lane intersection. At the Bradley Boulevard at Goldsboro Road intersection, it is recommended that exclusive phasing be implemented. This movement currently operates under exclusive/permissive phasing.

In order to specifically quantify that which represents a "***severe left-turn accident problem*** that could be corrected by exclusive phasing" and "a pattern of left turning accidents" (see Appendix G), several recognized traffic engineering sources were researched. Sample left-turn accident criteria indicating a need for exclusive left-turn phasing are as follows:

- ***Institute of Transportation Engineers' (ITE) Manual of Traffic Signal Design*** – Chapter 4 suggested guidelines. *Consider left-turn phasing if a critical number of left-turn accidents have occurred; that is, for one approach, four left-turn accidents in one year or six in two years are critical; or for both approaches, six left-turn accidents in one year or ten in two years are critical.*

- ***Federal Highway Administration's (FHWA) Manual on Uniform Traffic Control Devices (MUTCD 2000)*** – Traffic Signal Warrant 6 criterion B (Section 4C.08) can be applied to left-turn phasing needs. *Five or more reported crashes of types susceptible to correction by a*n exclusive left-turn *traffic control signal* phase, *have occurred within a 12-month period* (per approach), *each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash.*

- ***Transportation Research Board's Transportation Research Record 1069, Guidelines for Selecting Type of Left-Turn Phasing*** – Data provided to determine *"whether the number of left-turn accidents is unusually high" includes an average annual left-turn accident rate for exclusive/ permissive phasing of 3.38*. If a rate exceeds this number, then exclusive phasing is deemed necessary for that approach.

Each approach of the Bradley Boulevard at Wilson Lane intersection experienced a maximum of three left-turn accidents in a two-year period; therefore, left-turn phasing criteria from *ITE's Manual of Traffic Signal Design* is not met at this intersection. Exclusive left-turn phasing along WB Bradley Boulevard at Goldsboro Road is recommended based on the high-volume cross product. Additionally, there were six (6) left-turn crashes along this movement during the two-year period of 2006 to 2007; therefore, installation of exclusive phasing for this movement would also be recommended based on left-turn phasing criteria from *ITE's Manual of Traffic Signal Design*. This approach currently operates under exclusive/permissive phasing, and during the AM peak hour, a total of nineteen (19) vehicles which were in queue at the beginning of the exclusive phase were observed turning left during the permissive phase. During the PM peak hour, while all queues clear during the exclusive phase, some vehicles which arrive after the start of the exclusive phase clear during the permissive phase. Installation of exclusive phasing only as opposed to exclusive/permissive phasing will result in more delay and queuing for WB left-turning vehicles and will increase the likelihood of WB queues blocking the Bradley Boulevard at Glenbrook Road intersection; however, it is still recommended considering the high number of left-turn crashes along this approach.

TABLE 10 - Left-Turn Signal Phasing Evaluation Summary

Approach – Direction	Step #	MSHA Criteria	Response/Conditions	Result/Next Step
Bradley Boulevard at Wilson Lane				
Bradley Boulevard – EB at Wilson Lane	**I**	Is left-turn demand → 2 per cycle (average in highest hour)?	YES: 113 lefts/30 cycles per hour = 3.8 lefts/cycle (8:15 – 9:15 AM)	II
	II	How many opposing lanes?	ONE	III
	III	Is volume cross product →70,000 (in highest hour)?	NO: 60 x 893 = 53,580	IV
	IV	Is the opposing speed → 45 mph	NO: 85th percentile speed on WB Bradley Boulevard is 36 mph	V
	V	Is sight distance restricted?	NO	VI
	VI	Is there a severe left-turn accident problem that could be corrected by exclusive phasing?	NO: One (1) EB Bradley Boulevard left-turn accident in 2006.	**Permissive Phasing (Existing)**
Bradley Boulevard – WB at Wilson Lane	**I**	Is left-turn demand → 2 per cycle (average in highest hour)?	NO: 46 lefts/30 cycles per hour = 1.5 lefts/cycle (5:45 – 6:45 PM)	VI
	VI	Is there a severe left-turn accident problem that could be corrected by exclusive phasing?	NO: One (1) WB Bradley Boulevard left-turn accident in 2005 and two (2) in 2006.	**Permissive Phasing (Existing)**
Wilson Lane – NB at Bradley Boulevard	**I**	Is left-turn demand → 2 per cycle (average in highest hour)?	NO: 24 lefts/30 cycles per hour = 0.8 lefts/cycle (5:15 – 6:15 PM)	VI
	VI	Is there a severe left-turn accident problem that could be corrected by exclusive phasing?	NO: Zero (0) NB Wilson Lane left-turn accidents from 2005 to 2007	**Permissive Phasing (Existing)**
Wilson Lane – SB at Bradley Boulevard	**I**	Is left-turn demand → 2 per cycle (average in highest hour)?	NO: 39 lefts/30 cycles per hour = 2.1 lefts/cycle (8:15 – 9:15 AM)	VI
	VI	Is there a severe left-turn accident problem that could be corrected by exclusive phasing?	NO: One (1) SB Wilson Lane left-turn accident from 2005 to 2007	**Permissive Phasing (Existing)**
Bradley Boulevard at Goldsboro Road				
Bradley Boulevard – WB at Goldsboro Road	**I**	Is left-turn demand → 2 per cycle (average in highest hour)?	YES: 688 lefts/36 cycles per hour = 19.1 lefts/cycle (5:30 – 6:30 PM)	II
	II	How many opposing lanes?	THREE	III
	III	Is volume cross product →144,000 (in highest hour)?	YES: 688 x 495 = 340,560	**Exclusive Phasing**

3. Queuing Analyses

MSHA's *Poisson* method was used to evaluate left-turn bay storage lengths on all approaches to the intersections of Bradley Boulevard at Wilson Lane and Bradley Boulevard at Goldsboro Road. Computation worksheets are included in Appendix H and results are summarized in Table 11.

TABLE 11 – Turn Bay Storage Length Summary

Approach – Direction		Available Storage	AM Peak Hour		PM Peak Hour		Recommended Storage Length
			Volume (vph)	Queue Length	Volume (vph)	Queue Length	
Bradley Boulevard at Wilson Lane							
Bradley Boulevard	**EB Left**	0'	113	75'	60	100'	**100'**
	WB Left	0'	396	175'	46	125'	**175'**
Wilson Lane	**NB Left**	0'	16	50'	24	50'	**50'**
	SB Left	0'	39	75'	25	50'	**75'**
Bradley Boulevard at Goldsboro Road							
Bradley Boulevard	**WB Left**	195'	341	375'	688	675'	**675'**
Goldsboro Road	**NB Left**	101'	72	125'	133	175'	**175'**

As indicated, the approaches at the Bradley Boulevard at Wilson Lane intersection would require turn bays of 50 to 175 feet if turn bays are installed. The existing turn bays at the Bradley Boulevard at Goldsboro Road intersection fall short of the computed length required on both approaches. As the longest observed queue along WB Bradley Boulevard was eighteen vehicles, only 450 feet of storage length (18 vehicles x 25 feet per vehicle) would be required to serve this approach; however, the intersection of Bradley Boulevard at Glenbrook Road, which is a signalized intersection, is approximately 400 feet from the Goldsboro Road intersection. When the eighteen vehicle length queue occurred, the queue temporarily extended into the Glenbrook Road intersection. As the 195 foot WB left-turn bay at Goldsboro Road is restricted by the 90 foot left-turn bay at Glenbrook Road, major reconstruction would be necessary to increase WB left-turn storage. Signal timing

modifications may result in improved operations and shorter WB left-turn queues at Goldsboro Road.

4. Crosswalk Evaluation

Currently, there are two crosswalks across Bradley Boulevard within the study area: at the Wilson Lane (WB approach) and Brite Drive (EB approach) intersections. The AASHTO Green Book recommends a minimum no-parking zone of 20 feet from all crosswalks on both the near and far sides of the intersection on all intersection legs for urban streets with 20 to 30 mph speed limits. While 20 feet is the minimum, 50 feet is desirable. A no-parking zone of 30 feet in advance of each signal, stop sign, and yield sign should also be provided. Currently, there is no parking adjacent to either of the existing crosswalks crossing Bradley Boulevard in this study area.

The existing crosswalks should remain in their current locations. Furthermore, a crosswalk at the Bradley Boulevard at Goldsboro Road intersection should be considered along the WB Bradley Boulevard approach. There is an existing sidewalk on the south side of Bradley Boulevard which extends from Goldsboro Road to Wisconsin Avenue and one on the north side which extends to Connecticut Avenue (along Bradley Boulevard and Bradley Lane). A crosswalk crossing Bradley Boulevard on the east leg of its intersection with Goldsboro Road would provide pedestrian access from east of the study area to Wilson Lane via the proposed off-road shared use path, although it may create a conflict with the high volume of NB right-turns from Goldsboro Road. With potential sidewalk construction along the south side of Bradley Boulevard through the study area, a crosswalk would be necessary across the NB Goldsboro Road approach.

IV. Potential Improvements

Several potential improvement options could reduce delay and improve overall traffic operations at the study intersections. The following improvements are subject to review and approval by the Division of Traffic Engineering and Operations. Proposed improvements include the following:

- Bradley Boulevard at Wilson Lane:
    - Install turn bays along both Bradley Boulevard approaches to allow thru and right-turning vehicles to bypass left-turning vehicles safely, and to provide adequate sight distance for left-turning vehicles. These turn bays would reduce delay and queuing for thru and right-turning vehicles, as well as improve overall safety at the intersection. Turn bay storage length analysis was performed for each of the approaches to determine what storage length would be adequate. A summary of this analysis is shown in Table 11, along with recommended turn bay lengths. Turn bay storage computations can be found in Appendix G.
    - Restrict right turns on red along the Bradley Boulevard approaches to reduce the likelihood of right angle crashes.
    - The shared-use path that will run along the north side of Bradley Boulevard will tie into the roadway bike lane, just east of Wilson Lane. Bicyclists who wish to continue on Bradley Boulevard will do so with this connection. The path will also tie into the Wilson Lane sidewalk/path for pedestrians and bicyclists who wish to connect to Wilson Lane.

Bradley Boulevard will prevent vehicles that are bypassing left-turning vehicles from interfering with the bicyclists in this area. If the right turn on red restriction is implemented, then bicyclists and pedestrians that are approaching Wilson Lane while Bradley Boulevard sees a red light can turn on to Wilson Lane without any interference from right-turning vehicles.

- Bradley Boulevard at Goldsboro Road:
  - To allow WB traffic to safely merge, widen or restripe WB Bradley Boulevard west of the intersection and remove/relocate lane reduction warning signs along WB Bradley Boulevard per MD MUTCD requirements.
    - Lower-cost option (as designed and approved by SHA)
      - ❖ Restripe WB Bradley Boulevard west of the intersection, to provide two WB lanes for 45 ft west of the intersection, followed by a 170 foot taper.
      - ❖ Install "SINGLE LANE" sign with W5-3(1) "BEYOND SIGNAL" plate, W4-2mod "ALTERNATE MERGE (SYMBOL) sign with W9-2(3)mod "ALTERNATE MERGE" plate and R4-9(1) "FORM SINGLE LANE" sign. Remove existing lane reduction signing.
    - Higher-cost option
      - ❖ Widen or restripe WB Bradley Boulevard west of the intersection, to provide two WB lanes for 400 feet west of the intersection, followed by a 100 foot taper.
      - ❖ Relocate W9-2(2)L "LANE ENDS" and W9-2(3)L "MERGE LEFT" signs approximately 275 feet to the west.
      - ❖ Relocate W4-2R sign approximately 200 feet to the west.
      - ❖ Relocate W9-2(4) "LANE ENDS MERGE LEFT" sign to far-side span.
  - Install a crosswalk at the Bradley Boulevard at Goldsboro Road intersection across the east leg of Bradley Boulevard.
  - Install overlap phasing for NB right-turning vehicles along Goldsboro Road. Several of these vehicles turn during the WB left-turn phase, and are currently required to stop first. Installation of overlap phasing would reduce delay and queuing for these vehicles.
  - Install exclusive phasing for the WB left-turn movement per MSHA requirements. Doing so would reduce the likelihood of left-turn crashes for this movement, although it will increase the likelihood of WB queues blocking the Bradley Boulevard at Glenbrook Road intersection.
  - Extend NB left-turn lane along Goldsboro Road to 175 feet (See Table 11).
  - The Bradley Boulevard WB improvements will consider bicyclists during design. A minimum 5' bike lane will be maintained through the intersection as well as the existing curb and sidewalk. Somewhere just west of the intersection the shared use path will

develop. The existing sidewalk will tie into the shared use path. WB on road bicyclists will have the option at this location of staying on road in a bike lane or diverting to the shared use path.

- Just west of Goldsboro Road, the EB bike lane that will run along the south side of Bradley Boulevard will tie into and begin sharing the right lane of Bradley Boulevard which is the outer of three through lanes on Bradley Boulevard from this location to the east.