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An Operational Performance and Safety Comparison of Roundabouts vs. Traditional Intersections

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Honors Thesis

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Abstract

As the modern roundabout becomes a more popular intersection alternative in the United States, the ability of the roundabout to effectively manage traffic and to do so safely is on the forefront of engineering concerns. Despite decades of international success and credibility, regions throughout the U.S. have been hesitant to implement roundabouts in place of more traditional intersections. This case study of a series of intersections in Dublin, OH assesses the operational performance of roundabouts as it compares to that of their stop-controlled and signalized counterparts and analyzes historical crash data to evaluate the safety of the various intersection types. Operationally, roundabouts proved to operate better than their alternatives up to a certain capacity. While the roundabouts did not show significantly fewer crashes than other intersections, injury rates for crashes were lower at roundabouts. With further data regarding traffic volumes, this research can help U.S. engineers understand the operational and safety benefits of modern roundabouts.

Dedication or Acknowledgements

I would like to acknowledge my advisor, Dr. Deogratias Eustace, with the Department of Civil & Environmental Engineering & Engineering Mechanics for his steady guidance and support. I would also like to thank Ms. Jeannie Willis with the City of Dublin, Ms. Letty Schamp with the City of Hilliard, and especially Mr. Steve Thieken with Burgess & Niple, Inc. for their invaluable input throughout the research process. I thank the University Honors Program and the Berry Summer Thesis Institute for the opportunity to pursue this study and for consistent support throughout. Finally, thank you to my friends and families who listened to me tirelessly advocate roundabouts for the past three years.

UNIVERSITY of DAYTON

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INTRODUCTION

Problem Statement

The modern roundabout is considered by many professional engineers a safer intersection alternative than a signalized or stop-controlled intersection. In Western Europe, where modern roundabouts were introduced in 1956, the roundabout is widely recognized for its superior in safety record to that of its alternatives. For a typical North American driver, however, the task of navigating a roundabout can be intimidating and nerve-racking. After drivers grow more accustomed to roundabouts in their everyday commute, they tend to actually prefer roundabouts to signalized intersections and stop signs. It is important that engineers can convince municipalities and driving populations of the safety and operational advantage that roundabouts offer before they are willing to introduce the new intersection into their own community.

Objective

This study assesses the safety and operational performance of four roundabouts as they compare to the performance of various types of traditional intersections within a relatively close proximity to the roundabouts. Studying intersections in the same geographical vicinity means that the data represents drivers with similar attitudes and purposes for navigating the roadway system. These similarities reduce some of the bias that occurs when comparing dissimilar or unfamiliar drivers in different geographical locations.

Typically the methods used to analyze road safety utilize historical information regarding the daily vehicular volume along a road segment or entering an intersection. Traffic volume data allows for some regression-to-the-mean in crash data and makes comparisons between intersections more relative. The intersections analyzed in this study are mostly on city roads, where such volumes are not recorded as thoroughly as they are

on state routes and interstates. Due to a lack of traffic volume data, a naïve comparison-group method was used to analyze the intersections in this study relative to one another.

LITERATURE REVIEW

Safety

The modern roundabout is widely considered to be a safer intersection type than traditional two-way stop controlled (TWSC) intersections and signal intersections. Three main roundabout characteristics contribute to their reputation as a safer intersection type: (1) roundabouts eliminate or alter conflict types, (2) they force drivers to reduce speeds to navigate the roundabout, and (3) they reduce crash severity (Rodegerdts et al. 2010). In terms of conflict types, roundabouts eliminate some of the most severe crash types by forcing all drivers to navigate their center island in the same direction. Left-turning vehicles turning in front of oncoming traffic and vehicles running red lights are especially injury producing crash types (Retting et al. 1995), neither of which occurs at a roundabout. In fact, the overall number of locations at which vehicle paths can potentially cross is reduced at a roundabout. This reduction is apparent from Figures 1 and 2, which depict the vehicle conflict points for 3-leg and 4-leg intersections with single-lane approaches (Rodegerdts et al. 2010). Conflict points denoted with the 'crossing' symbol are especially dangerous, as they represent those points where vehicles are susceptible to head-on or right angle collisions.

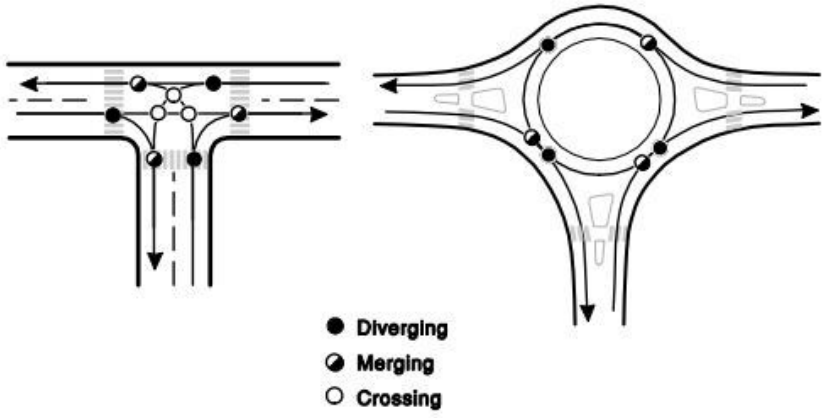


Figure 1 – Conflict Points, 3-Leg Intersections, Single Lane Approaches

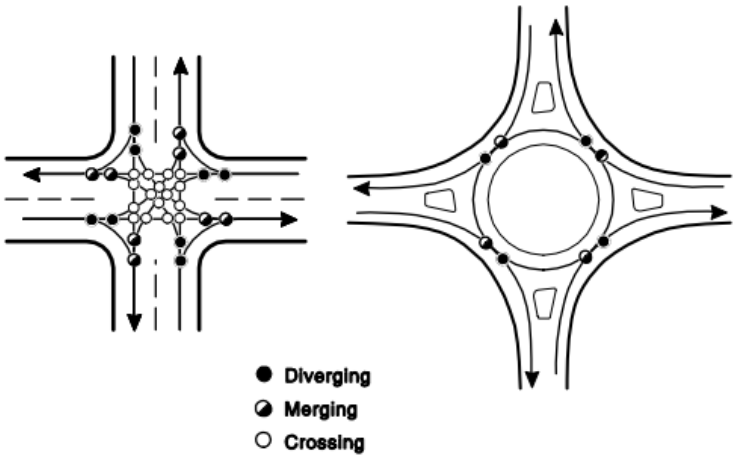


Figure 2 – Conflict Points, 4-Leg Intersections, Single Lane Approaches

Roundabouts also introduce safety benefits by reducing the speed of vehicles using the intersection. Obviously, drivers are forced to slow down more than they may have to at other intersections because of the raised center island in the middle of the roundabout. Modern roundabout entries are designed with flared entries that require drivers to slow down even more in order to navigate the entry. Proper geometric design, signing, and pavement markings are essential for making roundabouts safe for all users. Reducing the speed of navigating vehicles tends to also reduce the speed differential between vehicles, which can be a contributing factor in many injury accidents (Rodegerdts et al. 2010). Pedestrian safety is also generally improved at roundabouts, where pedestrians only have to cross one direction of traffic at a time because of splitter islands between roundabout entries and exits.

The reduction in crash severity can largely be attributed to those two previous characteristics. Roundabouts internationally have an excellent reputation for decreasing the rates of overall crashes and they are beginning to earn a similar reputation in the United States. A study conducted for the Insurance Institute for Highway Safety (IIHS) comments specifically on the large reduction of incapacitating injury and fatal accidents (Persuad et al. 2000).

In a study conducted by the Transportation Research Board (Rodegerdts et al. 2007), the number of crashes at a given location was reduced by 35% overall and 76% for injury crashes when it was converted from a stop control or signal intersection to a roundabout. The study does point out that intersections converted from all-way stop control (AWSC) to a roundabout saw statistically insignificant changes in crash rates. The study also indicated that single lane roundabouts performed better than multi-lane roundabouts in terms of reduced crash rates; this can be attributed to the increased number of conflict points in multi-lane roundabouts as vehicles entering or exiting the inner circulating lane cross two potential vehicle points instead of one.

Similarly, roundabouts in rural areas and on roads with lower traffic volumes have fewer crashes than their urban counterparts. Figure 3 shows the relationship between average annual daily traffic (AADT), number of lanes in the roundabout, and number of crashes reported. Clearly, single lane roundabouts have far fewer than multi-lane roundabouts. But more importantly, injury crashes represent a very low percentage, even for the multi-lane roundabout accidents.

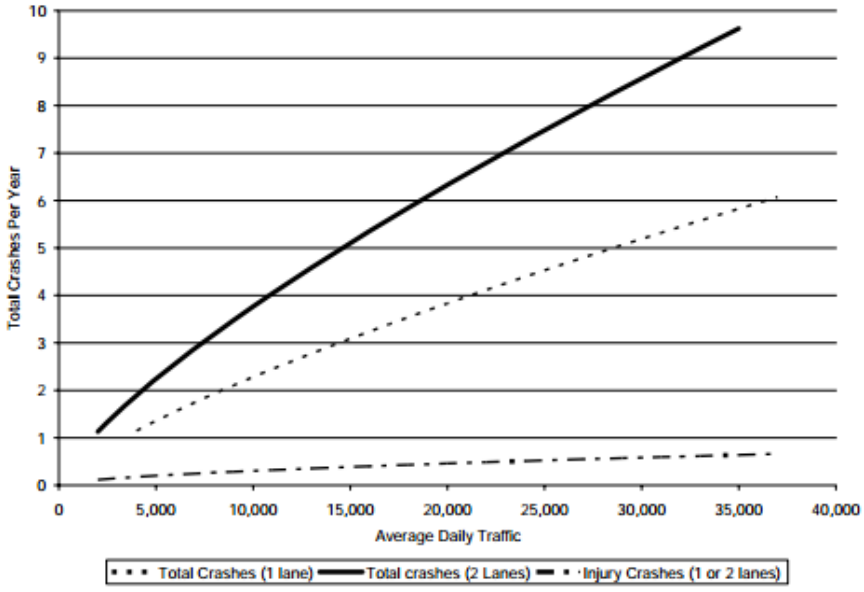


Figure 3 – Roundabout Crashes per Year by AADT

In other research conducted for this project, roundabouts in Ohio were examined for safety performance using the naïve before-and-after method. This method does not attribute all crash rate changes to roundabout conversion because it does not consider factors like traffic volume changes and other potential contributing factors, but the data is useful nonetheless. The study showed a decrease in total crashes by almost 30% when an intersection was converted from TWSC to a roundabout. More significantly, injury accidents at those locations were reduced by almost 80%. The study did not show similar results for the intersections converted from signals, where the total and injury crash quantities increased by more than double the expected quantities. However, these calculations were skewed by limited data in the after period used for the study; all of the intersections that were converted from signals to roundabouts provided less than a year of crash reports following the conversion. Still, the injury crash rate showed a slight decrease for those roundabouts, prompting the authors to suggest that roundabouts can contribute in a significant way in the public health perspective, because vehicle occupants, bicyclists, and pedestrians are all safer.

Operational Performance

Analyzing the operational performance of an intersection includes consideration of both the capacity of the intersection and the level of service (LOS) of the intersection, usually based on one or more measure of effectiveness. The Highway Capacity Manual (HCM) defines the capacity of a facility as "the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane or roadway during a given time period." The LOS is a more qualitative measure of an intersection that identifies its operational conditions and the perception that road users have of those conditions. Contributing to the LOS at intersections are the *control delay* – that incurred by signals, signs, and any other means of regulation at the intersection – and the *geometric delay* – that incurred by the necessary turning movements within an intersection (Rodegerdts et al. 2010).

Operational performance of roundabouts is directly influenced by traffic patterns, by gap acceptance characteristics of drivers, and by the geometric design of the roundabouts themselves. Generally, the capacity of a roundabout entry is greater when the conflicting volume, the flow in the circulating lanes at that entry, is lower. Researchers recognize that roundabout capacities in the United States increase over time as drivers become more accustomed to the intersections and as demands on the roundabouts force drivers to improve efficiency. The geometry of the roundabout effects the performance by reducing the speed of vehicles (thus contributing to the geometric delay), dictating the number of travel lanes (single lane vs. multi-lane), and by affecting the driver's perception of how to navigate the roundabout (their lane choice prior to entry). Generally, driver behaviors are attributed more for discrepancies in operational performance than geometric characteristics (Rodegerdts et al. 2010), assuming that no blatant design omissions occur.

METHODOLOGY

Study Area

This research focuses on a region of Dublin, Ohio that contains four roundabouts and five traditional intersections. When research began, the three-leg intersection of Brand Rd and Coffman Rd was stop-controlled on the Coffman Rd approach, but in 2013 the intersection was converted to a roundabout (Thus, for safety comparisons, the intersection is considered stop-controlled, because all crash data came from before the conversion. For operational measures, it will be analyzed as a roundabout). The city of Dublin has been on the forefront of roundabout implementation since installing the first modern roundabout in Ohio in 2004, so the study area offers a relatively dense series of intersections with many familiar drivers.

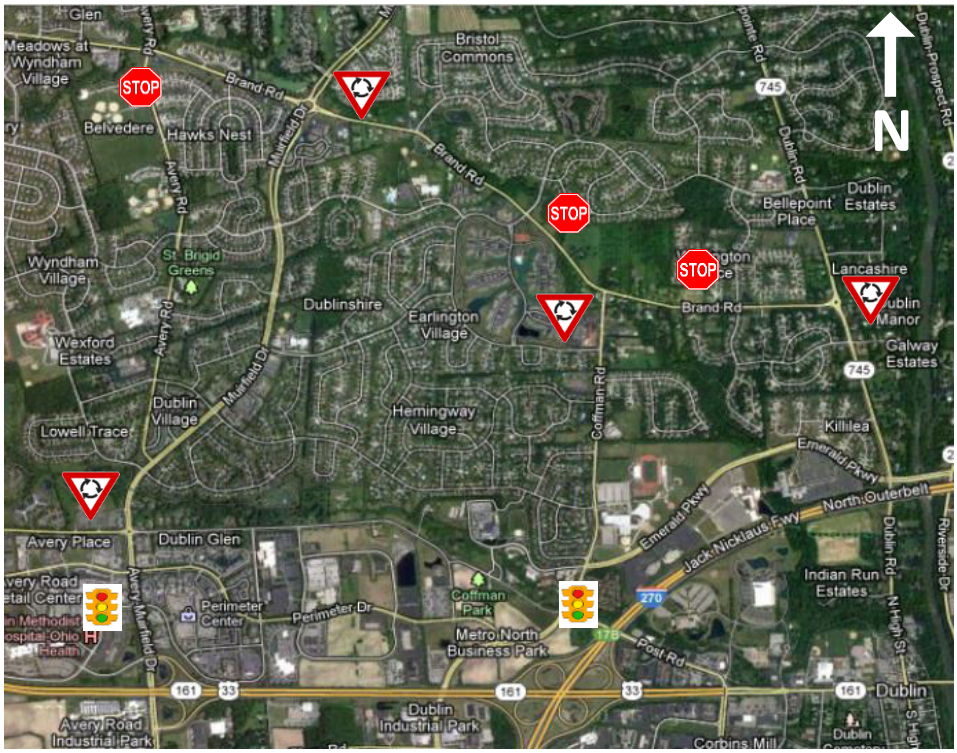


Figure 4 – A Map of the Study Area

Figure 5 – Brand Rd and Muirfield Dr Roundabout

The first roundabout implemented in Dublin (and in fact, in Ohio) was the intersection of Brand Rd and Muirfield Dr This roundabout was built in 2004 after a fatal accident occurred at the previously existing intersection and city officials sought a safer alternative.

Figure 6 – Brand Rd and Dublin Rd Roundabout

The roundabout at Brand Rd and Dublin Rd was the next to be converted in 2006.

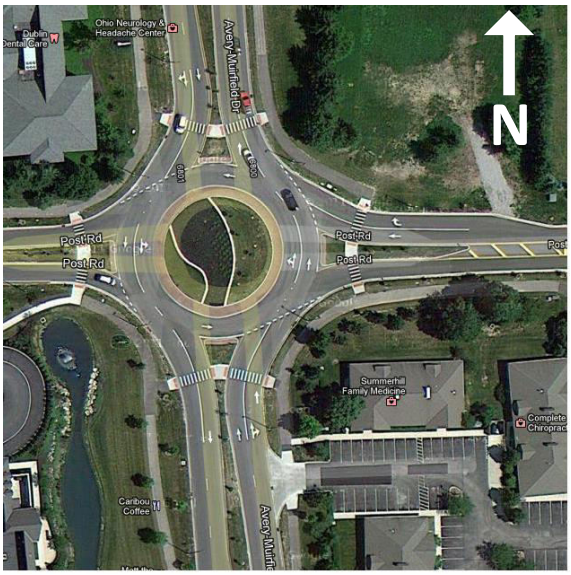


Figure 7 – Avery-Muirfield Dr and Post Rd Roundabout

In 2009, the intersection of Avery-Muirfield Dr and Post Rd was converted to a roundabout, making it by far the most heavily travelled of the three roundabouts. This roundabout is located just north of the signalized intersection of Avery-Muirfield Dr and Perimeter Dr.

Figure 8 – Brand Rd and Coffman Rd TWSC (2012)

Figure 9 – Brand Rd and Coffman Rd Roundabout (2014)

Finally, as previously mentioned, the three-leg intersection of Brand Rd and Coffman Rd was converted to a roundabout during the course of this research in 2013.

The intersections used for the study are listed in Table 1 along with their respective number of legs and existing traffic control. Intersections denoted as TWSC feature a freely moving main street intersected by a minor street where vehicles are controlled by stop signs. AWSC indicates that all directions are required to stop at stop signs.

Table 1 – Study Area Intersections

Site No.	Intersection	Approach Legs	Traffic Control
1	Avery-Muirfield Dr and Perimeter Dr	4	Signal
2	Avery-Muirfield Dr and Post Rd	4	Roundabout
3	Brand Rd and Avery Rd	4	AWSC
4	Brand Rd and Brandonway Dr	4	TWSC
5	Brand Rd and Coffman Rd	3	Roundabout*
6	Brand Rd and Coventry Woods Rd	4	TWSC
7	Brand Rd and Dublin Rd	3	Roundabout
8	Brand Rd and Muirfield Dr	4	Roundabout
9	Emerald Dr and Post Rd	3	Signal

* Site 5 was converted during the research period. All crash statistics are included in TWSC intersection quantities.

In order to fully assess roundabout performance in comparison with that of traditional stop-controlled and signalized intersections, this study compares the different intersections both in terms of safety and in terms of operations. In an effort to compare like intersections, three-leg intersections are compared to one another separately from four-leg intersections.

Data Collection

Safety

To obtain the crash reports for the intersections within the study area, the researchers used the Ohio Department of Transportation (ODOT)'s GIS Crash Analysis Tool (GCAT). This program allows the user to specify any location on the map of Ohio and a time frame and returns to the user all appropriate crash report numbers. GCAT is a relatively new software, and currently only returns crash information dating back to 2009. Thus, the crash data for this study date from 2009 to 2013. Not all crash reports in 2014 and 2015 have yet been uploaded to GCAT, so that data set was not included.

The Ohio Department of Public Safety keeps a database with all filed crash reports, so once the report numbers were obtained from ODOT, the researcher acquired the crash reports and filtered them by crash characteristics. For this study, the most significant details from the crash reports were the location of the crash, the date of the crash, the severity of the crash, the type of collision, and the weather and road conditions at the time of the crash.

Operational Performance

The traffic volumes that are used to evaluate the intersections in this study were obtained using MioVision traffic cameras during the summer of 2014. These cameras were set up within 100 feet of the intersections and recorded the turning movements of all vehicles entering and exiting the intersections during peak morning and afternoon hours.

The recordings were then processed to determine the total numbers of vehicles performing each movement (left, through, right, and U-turn) from each leg of the intersection and peak hour volumes were obtained.

At the roundabout intersection of Brand Rd and Muirfield Dr, no camera placement could successfully capture all movements without vehicles passing behind trees or out of the camera's view, therefore the MioVision processing was unable to successfully count the turning movements. The video recording of the intersection did, however, allow the researcher to manually count the movements. For this reason, the turning movement counts included in Appendix A for this intersection appear different than the other counts. Similarly, the mounted camera at Brand Rd and Dublin Rd was turned by the weather between the A.M. and P.M. traffic counts such that some vehicles exited the camera's view before completing their movement. MioVision automatic processing could not track those movements, so the researcher manually counted volumes through this intersection as well.

In addition to turning movement counts, the geometry of the intersections was obtained using Google Earth's measurement tools. Relevant measurements for all intersections include the number of approach legs, the number of approach lanes and their allowable movements, the lengths of any short lanes (turn lanes added only at the intersection), and median widths around the intersections. At roundabouts, other relevant aspects of the geometry include the number of circulating lanes around the roundabout, center island diameter, entry lane widths, and circulating lane widths.

Analysis

Safety

In addition to the GCAT tool, ODOT offers its Crash Analysis Module (CAM), a macro-enabled Excel workbook that extrapolates data from crash reports and can subsequently analyze the data. The data for each intersection was initially imported into the CAM tool. When the CAM tool imports data, it immediately pulls from the data all

information from a crash report that was included when it was uploaded to the GCAT system. The researcher sifted through the data to find and correct any mistakes in the crash report data pulled from GCAT. For instance, some crash types were listed as 'Unknown' in the CAM tool, but opening the crash report revealed that the crash was clearly an angle collision. In other cases the location of the crash was not actually at the intersection of interest; some crashes at nearby private drives were included in the initial data collection and had to be removed.

The crash reports included in the 2011 downloads were the most inconsistent in location. More than a dozen 2011 reports had to be removed because the coordinates associated with the reports were not consistent with the actual crash location. These reports were not included for the analysis, and the potential effect of this information discrepancy will be discussed later.

Operational Performance

To analyze the operations of each intersection, the turning movement counts and geometrical aspects of each intersection are input into Signalized and Unsignalized Intersection Design and Research Aid software (SIDRA Intersections 6.0). SIDRA calculates the capacity of each intersection using Highway Capacity Manual (HCM) formulas. For roundabouts, the HCM currently does not consider geometric details of the intersection like center island diameter and entry angle to significantly impact the capacity of the intersections, but other details of the intersection make capacities vary. SIDRA then analyzes each intersection based on the volumes travelling through them and outputs expected queue distances, approach delays, degree of saturation (volume/capacity), and an overall Level of Service (LOS) that is indicative of an intersections ability to adequately handle the traffic volumes.

SIDRA is especially useful for this study because it allows the comparison of alternative intersections in the place of existing ones. For instance, the researcher compared the three-leg intersection of Brand Rd and Coffman Rd that was converted in 2013 to a roundabout against its previous status as a TWSC intersection. Additionally, the software compares the AWSC intersection of Brand Rd and Avery Rd with a hypothetical alternative single lane roundabout.

RESULTS

Safety

From 2009 to 2013, there were a total of 97 crashes in the three roundabouts in the study area. The highest crash quantity was at the roundabout at Avery-Muirfield Dr and Post Rd, with 48, but only 6 resulted in injuries to one or more vehicle occupants (or a pedestrian). This roundabout also had the most vehicles navigate it during peak hours, as seen in Table 3. The other four-lane roundabout at the intersection of Brand Rd and Muirfield Dr had 26 crashes with seven resulting in injuries. Two of the 5 injuries at this roundabout involved bicyclists being hit by motor vehicles, one was a motorcycle that lost control, and the final 4 were the results of rear-end collisions.

At the three-leg roundabout at the intersection of Dublin Rd and Brand Rd, 23 crashes were recorded in the three years of the study. Six of the 23 resulted in injuries, 3 from rear-end collisions and 3 from vehicles that lost control (one suspected of operating while intoxicated).

Among the traditional stop-controlled and signalized intersections, there were 105 reported crashes from 2009 to 2013. While this quantity is higher than that of the roundabouts, it should be noted that there were twice as many intersections and almost twice as much total traffic during peak traffic times. At the four-leg signalized intersection of Avery-Muirfield Dr and Perimeter Dr, 46 crashes were recorded, 16 of them resulting in injuries. Eight of the 16 injuries happened in rear-end crashes, 5 in angle collisions when one vehicle was turning left, 2 in sideswipe crashes coming out of the intersection, and the last was a struck pedestrian.

At the four-way stop at Brand Rd and Avery Rd, 4 injury crashes and 5 PDO crashes were reported. Three of the injury accidents resulted from angle collisions when one vehicle turned in front of another and the fourth from a rear-end crash. At the 2 two-way stop controlled intersections of along Brand Rd where it intersects with Coventry

Woods Dr and Brandonway Dr, there were a total of 14 crashes with 4 reporting an injury; three from angle collisions and one from a rear-end collision. These three intersections had fewer than 4,000 vehicles counted in their turning movement counts recorded during either peak traffic hour.

The three-leg signal at the intersection of Emerald Dr and Post Rd had the highest recorded traffic volumes of any of the intersections during peak traffic hours. Still, just 28 crashes were reported from 2009 to 2013, and only 5 with injuries. The injuries resulted from 2 left turn angle collisions, 2 rear-end collisions, and one intoxicated driver that sideswiped several vehicles waiting at a red light at the intersection. The three-leg stop-controlled intersection of Brand Rd and Coffman Rd reported just 8 PDO crashes in the study's time frame. None of these were in 2013, probably due to the intersection being under construction as it was converted to a roundabout. Table 2 shows all of the crashes sorted by crash type and severity.

Table 2 – Crashes by Crash Type and Severity, 2009-2013

Location	Severity	Crash Type						Total	% Injury
		Rear-End	Side swipe	No Collision	Angle	Other	Peds/ Bikes		
Avery-Muirfield Dr & Post Rd	**PDO**	16	12	1	13	0	0	42	13%
	Injury	4	1	0	0	1	0	6	
Emerald Pkwy & Post Rd	**PDO**	12	6	1	3	1	0	23	18%
	Injury	2	1	0	2	0	0	5	
Muirfield Dr & Brand Rd	**PDO**	6	4	3	6	0	0	19	27%
	Injury	4	0	1	0	0	2	7	
Avery Rd & Brand Rd	**PDO**	0	1	1	3	0	0	5	44%
	Injury	1	0	0	3	0	0	4	
Coffman Rd & Brand Rd	**PDO**	1	0	1	6	0	0	8	0%
	Injury	0	0	0	0	0	0	0	
Dublin Rd & Brand Rd	**PDO**	8	3	2	3	1	0	17	26%
	Injury	3	0	3	0	0	0	6	
Brand Rd & Brandonway Dr	**PDO**	0	0	2	6	0	0	8	20%
	Injury	1	0	0	1	0	0	2	
Coventry Woods Dr & Brand Rd	**PDO**	1	0	0	1	0	0	2	50%
	Injury	0	0	0	2	0	0	2	
Avery-Muirfield Dr & Perimeter	**PDO**	17	4	0	8	1	0	30	35%
	Injury	8	2	0	5	0	1	16	
ROUNDABOUTS	**PDO**	**30**	**19**	**6**	**22**	**1**	**0**	**78**	**20%**
	Injury	**11**	**1**	**4**	**0**	**1**	**2**	**19**	
TRADITIONAL	**PDO**	**31**	**11**	**5**	**27**	**2**	**0**	**76**	28%
	Injury	**12**	**3**	**0**	**13**	**0**	**1**	**29**	

Overall, 20% of the crashes that occurred at these roundabouts from 2009 to 2013 resulted in injuries. At the traditional intersections in the study area, 28% of crashes resulted in injuries. While the overall quantities of crashes at the various intersections is perhaps even higher (relative to the traffic volume) at roundabouts than at traditional intersections, fewer crashes are severe enough to cause injury to those involved in the crash.

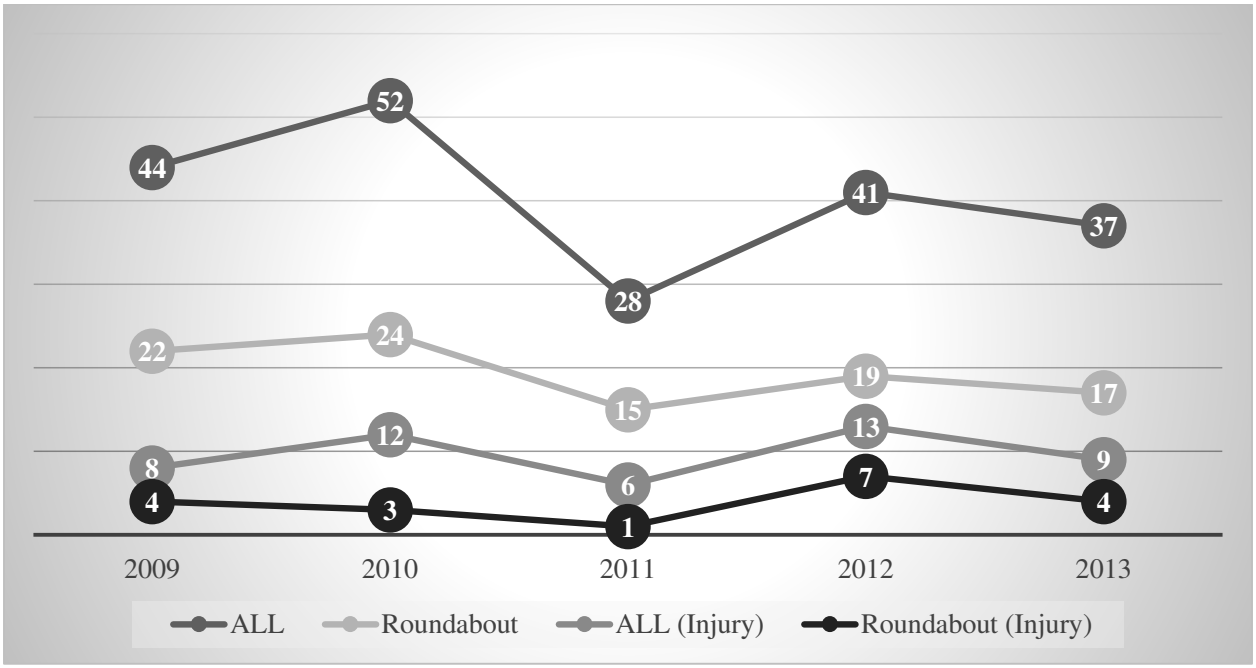


Figure 10 – Crashes per year, by intersection type and severity

To address the changing crash rates over time, Figure 10 shows the number of overall crashes, roundabout crashes, overall injury crashes, and roundabout injury crashes per year from 2009 to 2013. The data shows that roundabout crashes are generally trending downward, but does not show a decrease in roundabout injury crashes. In fact, the most roundabout injury crashes occurred in 2012.

Operational Performance

Tables 4 and 5 shows the results of the SIDRA analysis of the exiting intersections. The table shows the average delay per vehicle and the worst delay that a vehicle on the worst approach experiences. In the morning peak hour, none of the roundabouts experience a delay any larger than 22.9 seconds. In the evening, the Avery-Muirfield Dr and Post Rd roundabout does not perform as well because the volumes exceed the recommended capacity of the roundabout. The average delay at this roundabout is almost 40 seconds. It is of note, however, that the signalized intersection of Avery-Muirfield Dr and Perimeter Dr experiences similar delays in both the morning and evening peak hours. Above certain volumes, any form of traffic control will struggle to effectively maneuver all vehicles without causing some delays.

The Brand Rd and Muirfield Dr roundabout experiences heavier delays during the evening peak hour as well. This delay is a result of heavy volumes coming from the east leg. On this approach, the roundabout only has one lane, so the 577 vehicles approaching causes delays almost a minute long. All other approaches at Brand Rd and Muirfield Dr experience delays under 15 seconds in the evening peak hour.

The LOS column is the simplest way to assess the performance of these intersections, as it considers both the saturation of the intersection and the proportion of vehicles effected by the intersection delay. In the morning peak hour, the roundabouts are clearly effective, with LOS C and higher. As mentioned before, the Avery-Muirfield Dr and Post Rd roundabouts struggles to handle the capacity in the evening, but the LOS is still an E, which is acceptable. Queue lengths around these intersections are consistent with the delays.

Table 3 – Peak Hour Traffic Volumes

Site No.	Intersection	Peak Hour Volume (all approaches)	
		A.M.	P.M.
1	Avery-Muirfield Dr and Perimeter Dr	2979	3420
2	Avery-Muirfield Dr and Post Rd	2157	3108
3	Brand Rd and Avery Rd	877	1151
4	Brand Rd and Brandonway Dr	851	1268
5	Brand Rd and Coffman Rd	1029	1489
6	Brand Rd and Coventry Woods Rd	627	1073
7	Brand Rd and Dublin Rd	1354	1804
8	Brand Rd and Muirfield Dr	1401	1992
9	Emerald Dr and Post Rd	3099	3727

Table 4 – Existing Intersection Operational Analysis Results, AM

	Delay (sec)		Queue		Saturation	LOS
Location	Average	Worst	Proportion	Length (veh)	(v/c)	
Avery-Muirfield Dr & Post Rd	19	22.9	0.76	12	0.83	C
Muirfield Dr & Brand Rd	8.8	11.8	0.47	2	0.43	A
Brandonway Dr & Brand Rd	4.6	14.5	0.45	2	0.36	B
Coventry Woods Dr & Brand Rd	3.2	13.7	0.15	1	0.27	B
Avery-Muirfield Dr & Perimeter Dr	54.6	159.9	0.87	61	1.01	D
Avery Rd & Brand Rd	42	67.1	0.99	10	0.94	E
Emerald Pkwy. & Post Rd	13.7	21.4	0.73	25	0.82	B
Brand Rd & Coffman Rd	10.2	13.6	0.48	4	0.59	B
Dublin Rd & Brand Rd	13.4	19.6	0.53	7	0.73	B

Table 5 – Existing Intersection Operational Analysis Results, PM

	Delay (sec)		Queue		Saturation	LOS
Location	Average	Worst	Proportion	Length (veh)	(v/c)	
Avery-Muirfield Dr & Post Rd	39.6	61.1	0.88	33	1.03	E
Muirfield Dr & Brand Rd	24.1	51.3	0.73	13	0.97	C
Brandonway Dr & Brand Rd	9.6	43.4	0.74	6	0.68	D
Coventry Woods Dr & Brand Rd	3.1	27.2	0.12	2	0.33	D
Avery-Muirfield Dr & Perimeter Dr	44.9	81	0.91	36	0.87	D
Avery Rd & Brand Rd	48.7	71.6	0.99	11	0.97	E
Emerald Pkwy. & Post Rd	13.6	22.8	0.77	17	0.76	B
Brand Rd & Coffman Rd	17.8	24.7	0.72	11	0.83	C
Dublin Rd & Brand Rd	14.7	18.3	0.68	7	0.73	B

In addition to analyzing the existing intersections, this study also analyzed the intersection of Brand Rd and Coffman Rd as it existed before being converted to a roundabout in 2013. The results made clear the motivation for converting the intersection, despite it not having any injury accidents during the safety analysis. The three-leg intersection performed at a LOS D in the morning peak hour, but it had a saturation rate

of 1.59 in the evening and an LOS D. Vehicles queued for more than 5 minutes on the northbound stop-controlled approach. The queue length on that approach reached 53 vehicles.

Finally, the study analyzed a hypothetical alternative to the AWSC intersection of Brand Rd and Avery Rd. Using SIDRA, the researcher converted the intersection to a single circulating lane roundabout and the performance of the intersection improved dramatically. Instead of every vehicle being queued (by virtue of having stop control on all approaches), the queue proportion decreased to 0.49 in the morning and 0.60 in the evening peak hour. The LOS improved from an E to an A in the morning and from an E to a B in the evening. SIDRA results can be found in Appendix B.

DISCUSSION

Safety

Of note are the 13 injury crashes at traditional intersections that resulted from vehicles turning left in front of oncoming traffic. These sorts of collisions are eliminated with roundabouts, because dangerous left-turn movements are eliminated. All vehicles travel the same direction around the roundabout, so when they do collide at an angle, it is usually much less severe than the angle that cars incur with oncoming traffic at traditional intersections. About 40% of both groups' injuries reported came from rear-end collisions. While no intersection alternative can completely eliminate the possibility of rear-end collisions, roundabouts are designed to slow all traffic, so hopefully these collisions would be less severe. Four of the roundabout injury crashes resulted from vehicles that lost control navigating the roundabout, and one of those drivers was intoxicated. Over time, it is expected that drivers become more familiar with roundabouts and understand better the speeds required to safely navigate the roundabout.

Two of the roundabout injuries were incurred by struck bicyclists. Bicycle and pedestrian safety are always a concern for traffic engineers designing and implementing roundabouts. Bicyclists are allowed to use roundabouts just as vehicles are, but because of their limited stature, it may be easier for a driver to overlook a bicyclist navigating the roundabout and accidentally overtake him or her. In some cases, bicyclists choose to use the pedestrian crossings to navigate roundabouts. The challenge for pedestrians navigating roundabouts is two-fold. Because there is not a designated phase in which pedestrians are given the right-of-way, they are not as protected as they may be at a signal. Crossing the entry lanes is typically not very difficult because drivers can clearly see the approaching pedestrians as they prepare to cross. When pedestrians attempt to cross the exit lanes of roundabouts, however, the task becomes a bit more precarious. Drivers tend to focus on other vehicles in the roundabout when they are driving through it, so they sometimes do no notice pedestrians waiting at the exits to cross. Fortunately,

roundabout design has implemented some improvements to allow more room for drivers to allow pedestrians to cross without backing up traffic into the roundabout, increasing the safety of both the pedestrians and the vehicles.

The yearly data regarding all crashes shows a significant dip in 2011 from all other years of data. This may be a result of a flaw in the GCAT system that resulted in crash reports being filed at the wrong latitude and longitude. Because these crash reports are accumulated by specifying a region on the map of Ohio, if the latitude and longitude attached to the report are incorrect, not all relevant reports will not be downloaded. After the initial data was downloaded, several reports were removed from the data because they were not crashes that occurred at the study sites. Like those reports were filed in faulty locations, others that should have been located at the study sites may have been filed elsewhere.

Operational Performance

At volumes under 3,000 entering vehicles per hour, roundabouts proved to perform better than traditional intersections at reducing the average and worst delays of vehicles. While TWSC intersections allow main road through traffic to continue uninhibited by any sort of traffic control, the overall performance of these intersections suffer because of the delays incurred by the vehicles entering the intersections via the minor roads.

At volumes over 3,000 entering vehicles per hour, a 2-lane roundabout like the one at Avery-Muirfield Dr and Post Rd proved insufficient operationally. That many vehicles tends to overwhelm the roundabout and cause delays that may be more readily managed by a signalized intersection. The signalized intersection of Avery-Muirfield Dr and Perimeter Dr received a LOS better than that of the roundabout with similar volumes during the evening peak hour because it more equally distributed the delays to each approach.

The conversion of the TWSC intersection of Brand Rd and Coffman Rd was an exciting development during the course of this study. During the safety analysis, the study revealed no serious issues of crashes, injuries or otherwise. During the operational analysis, however, investigation of the previous conditions with the existing volumes revealed that the intersection was not adequate to control the northbound volume on the stop-controlled approach. The roundabout, while it does only operate at an LOS B in the morning and LOS C in the evening, more equally distributes the delays among all three approaches of the intersection such that the northbound vehicles are not waiting for several minutes for a gap in the through travel along Brand Rd.

The hypothetical roundabout at Brand Rd and Avery Rd revealed a similar improvement in operations. This observation is useful, because it proves that a single lane roundabout could effectively navigate the peak hour volumes at the existing AWSC intersection. However, this site reveals one of the limitations of roundabout installation; specifically, the topography surrounding the existing intersection does not allow for the construction of a roundabout. It would be more costly to obtain the right-of-way and adjust the grade around the intersection than can be reasonably expected for such a project. Some might argue that the intersection is nearing capacity (0.94 v/c A.M., 0.97 v/c P.M.), so some change may be necessary in the future, but a roundabout may not be feasible given the area directly around the intersection.

CONCLUSION AND RECOMMENDATIONS

Safety

This study analyzed three roundabouts in Dublin, Ohio for their safety by accumulating crash information at the roundabouts from 2009 to 2013. By comparing this data with that of more traditional intersections in the surrounding area, the study showed that the roundabouts do not drastically decrease the number of crashes that occur at an intersection. However, the ratio of crashes at roundabout intersections in which one or more person was injured was determined to be lower than the ratio at stop-controlled and signalized intersections. By assessing the data from crashes individually, it was clear that the tendency of roundabouts to eliminate more dangerous turning movements such as left turns contributed to their effectiveness in reducing injury crashes.

Rear-end collisions accounted for the highest percentage of injury crashes at roundabout and at traditional intersections alike. While rear-end collisions cannot be completely avoided by any intersection type, roundabouts require drivers to reduce speeds in order to effectively navigate the intersection regardless of other traffic. Though this speed reduction did not prove to significantly limit injury-causing rear-end collisions in this study, further research investigating such injury crashes may explain this trend and allow future design conditions to more effectively encourage speed reduction and therefore reduce overall crash severity.

In order to more closely assess the difference in crash quantities among the intersections in this study, further research should include measures of the daily traffic volume using the intersections and others like it. Much of the current roundabout safety research focuses on those on state roads and interstate exits where traffic volumes are measured yearly by government agencies. To assess the safety improvements of intersections in more suburban and rural areas, municipalities need to fund average daily traffic counts on these roadways. Doing so may encourage other smaller municipalities to see the roundabout as a viable option in intersection modification when safety is a factor in the desire to re-design.

Operational Performance

This study showed that a roundabout carrying a total traffic volume under about 3,000 vehicles during peak hours could not only effectively manage the traffic but could do so with much shorter delays than stop-controlled and signalized intersections. Though the comparisons are imperfect because of the different volumes using the intersections, roundabouts overall proved to operate at a higher Level of Service than their traditional counterparts in most situations.

The number of lanes available to each leg of a roundabout proved significant in each roundabout's ability to manage traffic volumes as well. While the Brand Rd and Muirfield Dr roundabout sufficiently carried all evening peak hour traffic on three of its legs, the westbound leg featured only one lane and could not quite adequately carry the volume travelling through. The roundabout at Avery-Muirfield Dr and Post Rd, to the contrary, carried many more vehicles on its southbound leg than any of the Brand Rd and Muirfield Dr roundabout, but because it featured two lanes that allow through movements. This detail is essential in roundabout construction and allows planners and traffic designers to ensure that each leg of a roundabout is adequately designed to carry the traffic passing through.

As with any analysis of the operational performance of roundabouts, it is difficult to state precisely a roundabout's ability to manage various traffic volumes explicitly. Researchers can use SIDRA tools to study approximate delays and queues, but only empirical observation of these intersections can provide an accurate assessment of the roundabout's performance. Further research must be done to assess modern roundabout performance in the United States as users become more familiar and the intersections become more common.

REFERENCES

Persuad, Bhagwant N., Richard A. Retting, Per E. Garder, and Dominique Lord. 2000. *Crash Reduction Following Installation of Roundabout in the United States.* Insurance Institute for Highway Safety. Arlington, VA.

Rodegerdts, Lee, Justin Bansen, Christopher Tiesler, Julia Knudsen, Edward Myers, Mark Johnson, Michael Moule, Bhagwant Persuad, Craig Lyon, Shauna Hallmark, Hillary Isebrands, R. Barry Corwn, and Andrew O'Brien. 2010. *NCHRP Report 672 Roundabouts: An Informational Guide.* Second Edition. Transportation Research Board. Washington, DC.

Rodegerdts, Lee, Miranda Blogg, Elizabeth Wemple, Edward Myers, Michael Kyte, Michael Dixon, George List, Aimee Flannery, Rod Troutbeck, Werner Brilon, Ning Wu, Bhagwant Persuad, Craig Lyon, David Harkey, and Daniel Carter. 2007. *NCHRP Report 572 Roundabout in the United States.* Transportation Research Board. Washington, DC.

APPENDIX A – CRASH SUMMARIES

ROW ID	CRASH DATE	HOUR	CRASH SEVERITY	TYPE OF CRASH
Avery-Muirfield Dr and Perimeter Dr	20090202	16	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20090430	8	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20090513	12	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20090710	17	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20090722	17	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20090820	20	Injury Crash	Pedestrian
Avery-Muirfield Dr and Perimeter Dr	20091016	23	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Perimeter Dr	20091222	21	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20100106	7	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20100427	16	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20100703	0	Injury Crash	Angle
Avery-Muirfield Dr and Perimeter Dr	20100718	21	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20100924	13	Injury Crash	Angle
Avery-Muirfield Dr and Perimeter Dr	20101106	17	Injury Crash	Angle
Avery-Muirfield Dr and Perimeter Dr	20101201	9	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20101118	9	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20101208	8	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20110105	7	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20110118	13	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20110204	8	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20110311	7	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20110421	19	Injury Crash	Sideswipe - Passing
Avery-Muirfield Dr and Perimeter Dr	20110512	15	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20110523	13	PDO	Backing
Avery-Muirfield Dr and Perimeter Dr	20111219	17	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Perimeter Dr	20120114	18	Injury Crash	Angle
Avery-Muirfield Dr and Perimeter Dr	20120116	14	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20120228	17	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20120403	17	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20120817	14	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20120907	19	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20120929	9	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20121020	18	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20121108	20	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Perimeter Dr	20121018	10	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Perimeter Dr	20121121	14	Injury Crash	Angle
Avery-Muirfield Dr and Perimeter Dr	20121203	15	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20121224	8	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20130102	18	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20130916	20	PDO	Angle
Avery-Muirfield Dr and Perimeter Dr	20131113	19	Injury Crash	Sideswipe - Passing
Avery-Muirfield Dr and Perimeter Dr	20130101	17	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20130509	15	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20130714	9	PDO	Rear End
Avery-Muirfield Dr and Perimeter Dr	20130816	9	Injury Crash	Rear End
Avery-Muirfield Dr and Perimeter Dr	20131223	14	PDO	Angle

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Avery-Muirfield Dr and Post Rd	20090106	9	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20090131	8	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20090130	15	Injury Crash	Rear End
Avery-Muirfield Dr and Post Rd	20090203	11	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20090220	15	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20090324	16	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20090706	17	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20091002	9	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20091124	21	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20091203	18	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20100124	10	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20100124	18	Injury Crash	Rear End
Avery-Muirfield Dr and Post Rd	20100203	7	PDO	Angle
Avery-Muirfield Dr and Post Rd	20100212	6	PDO	Angle
Avery-Muirfield Dr and Post Rd	20100226	18	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20100311	12	Injury Crash	Rear End
Avery-Muirfield Dr and Post Rd	20100514	15	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20100610	20	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20100619	9	PDO	Angle
Avery-Muirfield Dr and Post Rd	20100619	17	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20100720	13	Injury Crash	Overturning
Avery-Muirfield Dr and Post Rd	20101009	22	PDO	Angle
Avery-Muirfield Dr and Post Rd	20101105	17	PDO	Angle
Avery-Muirfield Dr and Post Rd	20101104	20	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20101203	10	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20110105	13	PDO	Angle
Avery-Muirfield Dr and Post Rd	20110117	18	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20110121	8	PDO	Angle
Avery-Muirfield Dr and Post Rd	20110419	13	PDO	Angle
Avery-Muirfield Dr and Post Rd	20110520	6	PDO	Angle
Avery-Muirfield Dr and Post Rd	20110530	16	PDO	Angle
Avery-Muirfield Dr and Post Rd	20110609	11	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20110908	18	Injury Crash	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20110919	18	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20120120	12	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20120224	8	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20120330	18	Injury Crash	Rear End
Avery-Muirfield Dr and Post Rd	20120430	12	Injury Crash	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20120819	17	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20121216	19	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20121025	17	PDO	Angle
Avery-Muirfield Dr and Post Rd	20130131	9	PDO	Sideswipe - Passing
Avery-Muirfield Dr and Post Rd	20130529	11	PDO	Angle
Avery-Muirfield Dr and Post Rd	20130712	12	PDO	Angle
Avery-Muirfield Dr and Post Rd	20130810	16	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20130302	22	PDO	Fixed Object
Avery-Muirfield Dr and Post Rd	20130612	12	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20130727	10	PDO	Rear End
Avery-Muirfield Dr and Post Rd	20131010	16	PDO	Sideswipe - Passing

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Brand Rd and Avery Rd	20090711	18	Injury Crash	Rear End
Brand Rd and Avery Rd	20090925	15	PDO	Angle
Brand Rd and Avery Rd	20101210	9	Injury Crash	Angle
Brand Rd and Avery Rd	20120610	18	PDO	Angle
Brand Rd and Avery Rd	20120508	8	Injury Crash	Angle
Brand Rd and Avery Rd	20121031	14	PDO	Fixed Object
Brand Rd and Avery Rd	20130206	18	PDO	Angle
Brand Rd and Avery Rd	20130319	8	PDO	Sideswipe - Passing
Brand Rd and Avery Rd	20130722	21	Injury Crash	Angle

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Brand Rd and Brandonway Dr	20100419	7	Injury Crash	Angle
Brand Rd and Brandonway Dr	20110815	12	Injury Crash	Rear End
Brand Rd and Brandonway Dr	20090427	17	PDO	Angle
Brand Rd and Brandonway Dr	20091121	22	PDO	Fixed Object
Brand Rd and Brandonway Dr	20100217	15	PDO	Angle
Brand Rd and Brandonway Dr	20100211	15	PDO	Angle
Brand Rd and Brandonway Dr	20100605	22	PDO	Angle
Brand Rd and Brandonway Dr	20101229	15	PDO	Angle
Brand Rd and Brandonway Dr	20110626	17	PDO	No Collision
Brand Rd and Brandonway Dr	20120517	18	PDO	Angle

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Brand Rd and Coffman Rd	20090630	16	PDO	Angle
Brand Rd and Coffman Rd	20091005	13	PDO	Angle
Brand Rd and Coffman Rd	20091118	10	PDO	Rear End
Brand Rd and Coffman Rd	20091228	17	PDO	Fixed Object
Brand Rd and Coffman Rd	20100729	19	PDO	Angle
Brand Rd and Coffman Rd	20101026	14	PDO	Angle
Brand Rd and Coffman Rd	20110102	18	PDO	Angle
Brand Rd and Coffman Rd	20120713	17	PDO	Angle

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Brand Rd and Coventry Woods Rd	20100402	7	Injury Crash	Angle
Brand Rd and Coventry Woods Rd	20100429	7	Injury Crash	Angle
Brand Rd and Coventry Woods Rd	20100328	22	PDO	Rear End
Brand Rd and Coventry Woods Rd	20130208	17	PDO	Angle

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Brand Rd and Dublin Rd	20090913	18	Injury Crash	No Collision
Brand Rd and Dublin Rd	20120601	14	Injury Crash	Rear End
Brand Rd and Dublin Rd	20131213	23	Injury Crash	Fixed Object
Brand Rd and Dublin Rd	20130225	8	Injury Crash	Rear End
Brand Rd and Dublin Rd	20130114	7	Injury Crash	Rear End
Brand Rd and Dublin Rd	20130614	0	Injury Crash	Fixed Object
Brand Rd and Dublin Rd	20090217	14	PDO	Sideswipe - Passing
Brand Rd and Dublin Rd	20090627	8	PDO	Sideswipe - Passing
Brand Rd and Dublin Rd	20091119	8	PDO	Rear End
Brand Rd and Dublin Rd	20091202	17	PDO	Unknown
Brand Rd and Dublin Rd	20091231	16	PDO	Rear End
Brand Rd and Dublin Rd	20100125	20	PDO	Angle
Brand Rd and Dublin Rd	20100329	11	PDO	Sideswipe - Passing
Brand Rd and Dublin Rd	20100410	18	PDO	Rear End
Brand Rd and Dublin Rd	20100827	15	PDO	Angle
Brand Rd and Dublin Rd	20101216	8	PDO	Rear End
Brand Rd and Dublin Rd	20110520	17	PDO	Angle
Brand Rd and Dublin Rd	20110604	23	PDO	Fixed Object
Brand Rd and Dublin Rd	20110921	16	PDO	Rear End
Brand Rd and Dublin Rd	20111019	12	PDO	Angle
Brand Rd and Dublin Rd	20111027	7	PDO	Rear End
Brand Rd and Dublin Rd	20120119	17	PDO	Rear End
Brand Rd and Dublin Rd	20131212	8	PDO	Rear End
Brand Rd and Dublin Rd	20131219	3	PDO	Fixed Object

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Brand Rd and Muirfield Dr	20090724	23	Injury Crash	Fixed Object
Brand Rd and Muirfield Dr	20091220	14	Injury Crash	Rear End
Brand Rd and Muirfield Dr	20111020	11	Injury Crash	Rear End
Brand Rd and Muirfield Dr	20120301	16	Injury Crash	Rear End
Brand Rd and Muirfield Dr	20120612	6	Injury Crash	Pedalcycles
Brand Rd and Muirfield Dr	20120807	6	Injury Crash	Pedalcycles
Brand Rd and Muirfield Dr	20120824	16	Injury Crash	Rear End
Brand Rd and Muirfield Dr	20090406	15	PDO	Angle
Brand Rd and Muirfield Dr	20090601	16	PDO	Sideswipe - Passing
Brand Rd and Muirfield Dr	20090824	12	PDO	Sideswipe - Passing
Brand Rd and Muirfield Dr	20090824	12	PDO	Sideswipe - Passing
Brand Rd and Muirfield Dr	20100501	14	PDO	Rear End
Brand Rd and Muirfield Dr	20100518	16	PDO	Fixed Object
Brand Rd and Muirfield Dr	20100520	6	PDO	Angle
Brand Rd and Muirfield Dr	20101220	17	PDO	Rear End
Brand Rd and Muirfield Dr	20110106	16	PDO	Angle
Brand Rd and Muirfield Dr	20110512	14	PDO	Sideswipe - Passing
Brand Rd and Muirfield Dr	20120103	17	PDO	Rear End
Brand Rd and Muirfield Dr	20120603	16	PDO	Angle
Brand Rd and Muirfield Dr	20120610	3	PDO	Fixed Object
Brand Rd and Muirfield Dr	20120822	9	PDO	Rear End
Brand Rd and Muirfield Dr	20120926	16	PDO	Fixed Object
Brand Rd and Muirfield Dr	20121206	17	PDO	Rear End
Brand Rd and Muirfield Dr	20130624	13	PDO	Angle
Brand Rd and Muirfield Dr	20130718	16	PDO	Angle
Brand Rd and Muirfield Dr	20131023	7	PDO	Rear End

ROW ID	CRASH DT	HOUR	CRASH SEVERITY	TYPE OF CRASH
Emerald Rd and Post Rd	20090422	10	PDO	Sideswipe - Passing
Emerald Rd and Post Rd	20090507	15	PDO	Angle
Emerald Rd and Post Rd	20090718	15	PDO	Rear End
Emerald Rd and Post Rd	20090805	11	PDO	Rear End
Emerald Rd and Post Rd	20090805	11	PDO	Rear End
Emerald Rd and Post Rd	20091015	21	Injury Crash	Angle
Emerald Rd and Post Rd	20100107	8	Injury Crash	Rear End
Emerald Rd and Post Rd	20100106	19	PDO	Rear End
Emerald Rd and Post Rd	20100503	7	PDO	Fixed Object
Emerald Rd and Post Rd	20100520	23	PDO	Sideswipe - Passing
Emerald Rd and Post Rd	20100719	17	PDO	Rear End
Emerald Rd and Post Rd	20100913	15	PDO	Sideswipe - Passing
Emerald Rd and Post Rd	20101128	11	PDO	Rear End
Emerald Rd and Post Rd	20101208	7	PDO	Sideswipe - Passing
Emerald Rd and Post Rd	20110503	16	Injury Crash	Rear End
Emerald Rd and Post Rd	20110512	8	PDO	Rear End
Emerald Rd and Post Rd	20120216	11	Injury Crash	Angle
Emerald Rd and Post Rd	20120613	7	PDO	Angle
Emerald Rd and Post Rd	20120830	11	PDO	Rear End
Emerald Rd and Post Rd	20120904	13	PDO	Rear End
Emerald Rd and Post Rd	20130418	13	Injury Crash	Sideswipe - Passing
Emerald Rd and Post Rd	20131025	11	PDO	Sideswipe - Passing
Emerald Rd and Post Rd	20131101	12	PDO	Angle
Emerald Rd and Post Rd	20130217	5	PDO	Backing
Emerald Rd and Post Rd	20130708	20	PDO	Rear End
Emerald Rd and Post Rd	20131021	15	PDO	Rear End
Emerald Rd and Post Rd	20131008	9	PDO	Rear End
Emerald Rd and Post Rd	20131203	12	PDO	Sideswipe - Passing

APPENDIX B – TURNING MOVEMENT COUNTS

Report Summary - Avery-Muirfield Dr and Perimeter Dr

		Southbound						Westbound						Northbound						Eastbound								Crosswalk	
Time Period	Class.	R	T	L	U	I	O	R	T	L	U	I	O	R	T	L	U	I	O	R	T	L	U	I	O	Total		destria	Total
Peak 1	Motorcycles	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	2	SB	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	112	959	169	0	1240	568	40	111	67	0	218	753	314	483	222	0	1019	1157	131	270	45	0	446	445	2923	WB	0	0
One Hour Peak	%	99%	99%	99%	0%	99%	96%	95%	97%	99%	0%	97%	98%	98%	96%	99%	0%	97%	99%	98%	99%	98%	0%	98%	98%	98%		0%	
7:45 AM - 8:45 AM	Other Vehicles	1	7	2	0	10	24	1	4	1	0	6	12	6	22	3	0	31	10	2	4	1	0	7	8	54	NB	0	0
	%	1%	1%	1%	0%	1%	4%	2%	3%	1%	0%	3%	2%	2%	4%	1%	0%	3%	1%	1%	1%	2%	0%	2%	2%	2%		0%	
	Total	**113**	**966**	**171**	**0**	**1250**	**593**	**42**	**115**	**68**	**0**	**225**	**765**	**320**	**505**	**225**	**0**	**1050**	**1168**	**134**	**274**	**46**	**0**	**454**	**453**	**2979**	EB	0	0
	PHF	0.88	0.78	0.84	0	0.81	0.94	0.58	0.82	0.63	0	0.84	0.92	0.87	0.91	0.72	0	0.88	0.81	0.86	0.9	0.72	0	0.9	0.78	0.91		0%	
	Approach %					42%	20%					8%	26%					35%	39%					15%	15%			**0**	**0**
Peak 2	Motorcycles	0	0	0	0	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2	SB	1	1
Specified Period	%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
4:00 PM - 6:00 PM	Cars & Light Goods	132	493	139	0	764	1367	192	337	181	1	711	453	96	1000	216	0	1312	886	212	217	175	0	604	685	3391	WB	3	3
One Hour Peak	%	99%	97%	100%	0%	98%	100%	99%	99%	99%	100%	99%	100%	99%	100%	99%	0%	100%	98%	100%	100%	99%	0%	100%	99%	99%		100%	
5:00 PM - 6:00 PM	Other Vehicles	1	15	0	0	16	3	0	2	2	0	4	1	1	2	3	0	6	17	0	0	1	0	1	6	27	NB	0	0
	%	1%	3%	0%	0%	2%	0%	0%	1%	1%	0%	1%	0%	1%	0%	1%	0%	0%	2%	0%	0%	1%	0%	0%	1%	1%		0%	
	Total	**133**	**508**	**139**	**0**	**780**	**1371**	**193**	**340**	**183**	**1**	**717**	**454**	**97**	**1002**	**219**	**0**	**1318**	**903**	**212**	**217**	**176**	**0**	**605**	**692**	**3420**	EB	2	2
	PHF	0.66	0.93	0.76	0	0.92	0.97	0.91	0.92	0.85	0.25	0.94	0.79	0.71	0.97	0.9	0	0.96	0.94	0.87	0.85	0.88	0	0.95	0.92	0.96		100%	
	Approach %					23%	40%					21%	13%					39%	26%					18%	20%			**6**	**6**

Report Summary - Avery Muirfield Dr and Post Rd

		Southbound						Westbound						Northbound						Eastbound								Crosswalk	
Time Period	**Class.**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	0	0	1	0	1	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	2	SB	0	0
Specified Period	%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	106	1083	121	6	1316	556	23	33	8	0	64	229	16	472	75	2	565	1130	37	92	55	0	184	214	2129	WB	1	1
One Hour Peak	%	100%	99%	99%	100%	99%	97%	100%	100%	100%	0%	100%	99%	100%	97%	99%	100%	97%	99%	97%	98%	98%	0%	98%	100%	99%		100%	
7:30 AM - 8:30 AM	Other Vehicles	0	7	0	0	7	15	0	0	0	0	0	2	0	14	1	0	15	8	1	2	1	0	4	1	26	NB	0	0
	%	0%	1%	0%	0%	1%	3%	0%	0%	0%	0%	0%	1%	0%	3%	1%	0%	3%	1%	3%	2%	2%	0%	2%	0%	1%		0%	
	Total	**106**	**1090**	**122**	**6**	**1324**	**572**	**23**	**33**	**8**	**0**	**64**	**232**	**16**	**487**	**76**	**2**	**581**	**1138**	**38**	**94**	**56**	**0**	**188**	**215**	**2157**	EB	0	0
	PHF	0.74	0.88	0.54	0.75	0.87	0.87	0.82	0.69	0.67	0	0.8	0.68	0.4	0.88	0.83	0.5	0.91	0.89	0.68	0.84	0.88	0	0.89	0.79	0.89		0%	
	Approach %					61%	27%					3%	11%					27%	53%					9%	10%			**1**	**1**
Peak 2	Motorcycles	0	6	0	0	6	7	0	0	0	0	0	0	0	6	0	0	6	6	0	0	1	0	1	0	13	SB	0	0
Specified Period	%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%	0%		0%	
4:00 PM - 6:00 PM	Cars & Light Goods	122	876	34	4	1036	1729	176	83	23	0	282	104	28	1397	78	9	1512	961	53	42	152	0	247	283	3077	WB	3	3
One Hour Peak	%	100%	98%	100%	100%	98%	99%	99%	100%	100%	0%	100%	99%	97%	99%	100%	100%	99%	98%	100%	100%	99%	0%	100%	100%	99%		100%	
5:00 PM - 6:00 PM	Other Vehicles	0	10	0	0	10	7	1	0	0	0	1	1	1	6	0	0	7	10	0	0	0	0	0	0	18	NB	0	0
	%	0%	1%	0%	0%	1%	0%	1%	0%	0%	0%	0%	1%	3%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%		0%	
	Total	**122**	**892**	**34**	**4**	**1052**	**1743**	**177**	**83**	**23**	**0**	**283**	**105**	**29**	**1409**	**78**	**9**	**1525**	**977**	**53**	**42**	**153**	**0**	**248**	**283**	**3108**	EB	4	4
	PHF	0.62	0.91	0.71	0.5	0.87	0.97	0.83	0.77	0.64	0	0.81	0.91	0.72	0.93	0.63	0.75	0.91	0.92	0.74	0.75	0.71	0	0.81	0.69	0.93		100%	
	Approach %					34%	56%					9%	3%					49%	31%					8%	9%			**7**	**7**

Report Summary - Brand Rd and Avery Rd

		Southbound						Westbound						Northbound						Eastbound								Crosswalk	
Time Period	**Class.**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	SB	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	59	195	81	0	335	127	24	157	13	0	194	228	8	70	32	0	110	255	47	139	33	0	219	248	858	WB	0	0
One Hour Peak	%	97%	98%	100%	0%	98%	93%	83%	99%	100%	0%	97%	99%	100%	93%	100%	0%	96%	98%	100%	99%	100%	0%	99%	99%	98%		0%	
7:30 AM - 8:30 AM	Other Vehicles	2	4	0	0	6	10	5	1	0	0	6	1	0	5	0	0	5	4	0	1	0	0	1	3	18	NB	4	4
	%	3%	2%	0%	0%	2%	7%	17%	1%	0%	0%	3%	0%	0%	7%	0%	0%	4%	2%	0%	1%	0%	0%	0%	1%	2%		100%	
	Total	**61**	**199**	**81**	**0**	**341**	**137**	**29**	**158**	**13**	**0**	**200**	**230**	**8**	**75**	**32**	**0**	**115**	**259**	**47**	**141**	**33**	**0**	**221**	**251**	**877**	EB	9	9
	PHF	0.76	0.94	0.75	0	0.92	0.73	0.72	0.68	0.54	0	0.81	0.93	0.67	0.72	0.57	0	0.78	0.98	0.65	0.9	0.69	0	0.97	0.71	0.91		100%	
	Approach %					39%	16%					23%	26%					13%	30%					25%	29%			**13**	**13**
Peak 2	Motorcycles	0	1	0	0	1	1	1	3	0	0	4	0	0	0	1	0	1	1	0	0	0	0	0	4	6	SB	0	0
Specified Period	%	0%	1%	0%	0%	0%	0%	1%	2%	0%	0%	1%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%		0%	
4:00 PM - 6:00 PM	Cars & Light Goods	86	142	58	0	286	399	108	130	26	0	264	219	23	227	80	0	330	222	54	138	64	0	256	296	1136	WB	0	0
One Hour Peak	%	100%	95%	100%	0%	98%	100%	99%	97%	100%	0%	98%	100%	100%	100%	99%	0%	99%	97%	100%	99%	100%	0%	100%	98%	99%		0%	
5:00 PM - 6:00 PM	Other Vehicles	0	6	0	0	6	1	0	1	0	0	1	1	0	1	0	0	1	6	0	1	0	0	1	1	9	NB	4	4
	%	0%	4%	0%	0%	2%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	1%	0%	0%	0%	0%	1%		100%	
	Total	**86**	**149**	**58**	**0**	**293**	**401**	**109**	**134**	**26**	**0**	**269**	**220**	**23**	**228**	**81**	**0**	**332**	**229**	**54**	**139**	**64**	**0**	**257**	**301**	**1151**	EB	1	1
	PHF	0.57	0.91	0.85	0	0.87	0.9	0.83	0.86	0.65	0	0.88	0.79	0.52	0.84	0.65	0	0.97	0.87	0.52	0.7	0.62	0	0.74	0.78	0.9		100%	
	Approach %					25%	35%					23%	19%					29%	20%					22%	26%			**5**	**5**

Report Summary - Brand Rd and Brandonway Dr

		Southwestbound						Northwestbound						Northeastbound						Southeastbound								Crosswalk	
Time Period	**Class.**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	SWB	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	1%	0%	0%	0%	0%	0%	0%	1%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	32	4	69	0	105	45	18	121	17	0	156	594	81	6	17	0	104	28	7	444	21	0	472	170	837	NWB	0	0
One Hour Peak	%	100%	100%	100%	0%	100%	100%	100%	95%	89%	0%	95%	99%	100%	100%	94%	0%	99%	93%	100%	99%	100%	0%	99%	96%	98%		0%	
7:30 AM - 8:30 AM	Other Vehicles	0	0	0	0	0	0	0	6	2	0	8	5	0	0	0	0	0	2	0	5	0	0	5	6	13	NEB	0	0
	%	0%	0%	0%	0%	0%	0%	0%	5%	11%	0%	5%	1%	0%	0%	0%	0%	0%	7%	0%	1%	0%	0%	1%	3%	2%		0%	
	Total	**32**	**4**	**69**	**0**	**105**	**45**	**18**	**127**	**19**	**0**	**164**	**599**	**81**	**6**	**18**	**0**	**105**	**30**	**7**	**449**	**21**	**0**	**477**	**177**	**851**	SEB	3	3
	PHF	0.8	0.5	0.75	0	0.85	0.87	0.64	0.93	0.68	0	0.89	0.91	0.84	0.75	0.5	0	0.77	0.75	0.44	0.94	0.75	0	0.91	0.9	0.98		100%	
	Approach %					12%	5%					19%	70%					12%	4%					56%	21%			**3**	**3**
Peak 2	Motorcycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SWB	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
4:00 PM - 6:00 PM	Cars & Light Goods	51	14	38	0	103	144	76	499	84	0	659	423	55	9	15	0	79	128	30	330	59	0	419	565	1260	NWB	0	0
One Hour Peak	%	100%	100%	100%	0%	100%	100%	100%	99%	99%	0%	99%	99%	98%	100%	100%	0%	99%	99%	100%	99%	100%	0%	99%	99%	99%		0%	
5:00 PM - 6:00 PM	Other Vehicles	0	0	0	0	0	0	0	3	1	0	4	4	1	0	0	0	1	1	0	3	0	0	3	3	8	NEB	1	1
	%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	1%	1%	2%	0%	0%	0%	1%	1%	0%	1%	0%	0%	1%	1%	1%		100%	
	Total	**51**	**14**	**38**	**0**	**103**	**144**	**76**	**502**	**85**	**0**	**663**	**427**	**56**	**9**	**15**	**0**	**80**	**129**	**30**	**333**	**59**	**0**	**422**	**568**	**1268**	SEB	1	1
	PHF	0.58	0.58	0.68	0	0.68	0.92	0.83	0.85	0.89	0	0.87	0.9	0.82	0.45	0.62	0	0.8	0.92	0.94	0.9	0.87	0	0.92	0.9	0.94		100%	
	Approach %					8%	11%					52%	34%					6%	10%					33%	45%			**2**	**2**

Report Summary - Brand Rd and Coffman Rd

		Westbound					Northbound					Eastbound							Crosswalk	
Time Period	**Class.**	**T**	**L**	**U**	**I**	**O**	**R**	**L**	**U**	**I**	**O**	**R**	**T**	**U**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	1	0	0	1	1	1	0	0	1	0	0	0	0	0	1	2	WB	0	0
Specified Period	%	1%	0%	0%	0%	0%	2%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	134	188	1	323	259	53	67	0	120	553	365	205	0	570	201	1013	NB	0	0
One Hour Peak	%	98%	100%	50%	99%	97%	98%	97%	0%	97%	100%	100%	97%	0%	99%	98%	98%		0%	
7:45 AM - 8:45 AM	Other Vehicles	2	0	1	3	8	0	2	1	3	2	1	7	0	8	4	14	EB	2	2
	%	1%	0%	50%	1%	3%	0%	3%	100%	2%	0%	0%	3%	0%	1%	2%	1%		100%	
	Total	**137**	**188**	**2**	**327**	**268**	**54**	**69**	**1**	**124**	**555**	**366**	**212**	**0**	**578**	**206**	**1029**		**2**	**2**
	PHF	0.74	0.6	0.5	0.73	0.88	0.79	0.75	0.25	0.84	0.69	0.75	0.84	0	0.78	0.9	0.77			
	Approach %				32%	26%				12%	54%				56%	20%				

	Brand From East			Coffman From South			Brand From West			TOTAL
Start Time	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	(veh)
4:00 PM		50	25	46		34	32	38		225
4:15 PM		65	19	43		59	23	61		270
4:30 PM		60	25	49		80	30	65		309
4:45 PM		77	29	64		61	39	63		333
5:00 PM		99	21	77		87	32	69		385
5:15 PM		80	23	86		81	35	71		376
5:30 PM		82	34	75		89	30	58		368
5:45 PM		92	30	60		75	42	61		360
										0
TOTAL		605	206	500		566	263	486		2626
Peak Hour		353	108	298		332	139	259		1489
5:00-6:00 PM										

Report Summary - Brand Rd and Coventry Woods Rd

		Southbound						Westbound						Northbound						Eastbound								Crosswalk	
Time Period	**Class.**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**R**	**T**	**L**	**U**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	SB	1	1
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
7:00 AM - 9:00 AM	Cars & Light Goods	65	1	39	1	106	32	16	176	0	0	192	322	5	0	15	0	20	7	6	278	15	0	299	256	617	WB	1	1
One Hour Peak	%	100%	100%	100%	100%	100%	97%	94%	98%	0%	0%	97%	99%	100%	0%	94%	0%	95%	78%	75%	99%	100%	0%	99%	98%	98%		100%	
7:30 AM - 8:30 AM	Other Vehicles	0	0	0	0	0	1	1	3	0	0	4	2	0	0	1	0	1	2	2	2	0	0	4	4	9	NB	0	0
	%	0%	0%	0%	0%	0%	3%	6%	2%	0%	0%	2%	1%	0%	0%	6%	0%	5%	22%	25%	1%	0%	0%	1%	2%	1%		0%	
	Total	**65**	**1**	**39**	**1**	**106**	**33**	**17**	**180**	**0**	**0**	**197**	**324**	**5**	**0**	**16**	**0**	**21**	**9**	**8**	**280**	**15**	**0**	**303**	**261**	**627**	EB	0	0
	PHF	0.68	0.25	0.7	0.25	0.83	0.75	0.53	0.9	0	0	0.93	0.9	0.62	0	0.67	0	0.75	0.56	0.5	0.83	0.62	0	0.86	0.83	0.95		0%	
	Approach %					17%	5%					31%	52%					3%	1%					48%	42%			**2**	**2**
Peak 2	Motorcycles	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	SB	5	5
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
4:00 PM - 6:00 PM	Cars & Light Goods	37	0	27	0	64	116	39	390	0	0	429	468	7	3	21	0	31	34	34	434	74	0	542	448	1066	WB	0	0
One Hour Peak	%	97%	0%	100%	0%	98%	100%	100%	99%	0%	0%	99%	100%	100%	100%	100%	0%	100%	97%	97%	100%	100%	0%	99%	99%	99%		0%	
4:45 PM - 5:45 PM	Other Vehicles	1	0	0	0	1	0	0	2	0	0	2	2	0	0	0	0	0	1	1	2	0	0	3	3	6	NB	0	0
	%	3%	0%	0%	0%	2%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	3%	0%	0%	0%	1%	1%	1%		0%	
	Total	**38**	**0**	**27**	**0**	**65**	**116**	**39**	**393**	**0**	**0**	**432**	**470**	**7**	**3**	**21**	**0**	**31**	**35**	**35**	**436**	**74**	**0**	**545**	**452**	**1073**	EB	3	3
	PHF	0.73	0	0.75	0	0.86	0.85	0.75	0.92	0	0	0.92	0.83	0.44	0.38	0.58	0	0.65	0.67	0.67	0.83	0.8	0	0.83	0.88	0.95		100%	
	Approach %					6%	11%					40%	44%					3%	3%					51%	42%			**8**	**8**

Report Summary - Brand Rd and Dublin Rd

		Southbound					Northbound					Eastbound							Crosswalk	
Time Period	Class.	R	T	U	I	O	T	L	U	I	O	R	L	U	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	1	1	0	2	0	0	0	0	0	2	1	0	0	1	1	3	SB	0	0
Specified Period	%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	128	647	0	775	211	165	104	1	270	893	245	46	1	292	233	1337	NB	0	0
One Hour Peak	%	98%	100%	0%	99%	96%	96%	97%	100%	96%	100%	100%	96%	100%	99%	98%	99%		0%	
7:30 AM - 8:30 AM	Other Vehicles	1	1	0	2	9	7	3	0	10	1	0	2	0	2	4	14	EB	0	0
	%	1%	0%	0%	0%	4%	4%	3%	0%	4%	0%	0%	4%	0%	1%	2%	1%		0%	
	Total	**130**	**649**	**0**	**779**	**220**	**172**	**107**	**1**	**280**	**896**	**246**	**48**	**1**	**295**	**238**	**1354**		**0**	**0**
	PHF	0.61	0.9	0	0.88	0.86	0.84	0.84	0.25	0.9	0.92	0.92	0.75	0.25	0.92	0.75	0.9			
	Approach %				58%	16%				21%	66%				22%	18%				
Peak 2	Motorcycles	0	4	0	4	3	2	2	0	4	6	2	1	0	3	2	11	SB	0	0
Specified Period	%	0%	1%	0%	1%	0%	0%	1%	0%	0%	1%	1%	0%	0%	1%	0%	1%		0%	
4:00 PM - 6:00 PM	Cars & Light Goods	68	291	0	359	811	585	367	1	953	539	247	226	2	475	437	1787	NB	0	0
One Hour Peak	%	100%	98%	0%	99%	100%	100%	99%	100%	99%	98%	98%	100%	100%	99%	99%	99%		0%	
5:00 PM - 6:00 PM	Other Vehicles	0	1	0	1	0	0	2	0	2	4	3	0	0	3	2	6	EB	7	7
	%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	1%	0%	0%	1%	0%	0%		100%	
	Total	**68**	**296**	**0**	**364**	**814**	**587**	**371**	**1**	**959**	**549**	**252**	**227**	**2**	**481**	**441**	**1804**		**7**	**7**
	PHF	0.85	0.92	0	0.92	0.93	0.95	0.95	0.25	0.95	0.91	0.89	0.8	0.25	0.92	0.94	0.97			
	Approach %				20%	45%				53%	30%				27%	24%				

File Name: Brand and Muirfield - AM
Start Date: 8/19/2014

	Muirfield From North			Brand From East			Muirfield From South			Brand From West			TOTAL
Start Time	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	(veh)
07:00 AM	4	86	33	4	25	7	15	23	1	6	38	4	246
07:15 AM	5	86	29	6	16	17	6	37	8	7	16	1	234
07:30 AM	8	117	35	9	26	10	17	40	4	11	53	6	336
07:45 AM	7	119	51	11	22	21	17	59	8	9	55	5	384
08:00 AM	6	81	52	21	30	19	14	59	5	8	47	2	344
08:15 AM	6	112	42	13	21	15	10	59	4	9	42	4	337
08:30 AM	11	78	36	13	10	17	10	45	6	11	40	4	281
08:45 AM	12	77	47	16	20	20	21	56	7	9	43	4	332
TOTAL	59	756	325	93	170	126	110	378	43	70	334	30	2494
Peak Hour	27	429	180	54	99	65	58	217	21	37	197	17	1401
PHF	0.84	0.90	0.87	0.64	0.83	0.77	0.85	0.92	0.66	0.84	0.90	0.71	

7:30-8:30 AM

File Name: Brand and Muirfield - PM
Start Date: 8/19/2014

	Muirfield From North			Brand From East			Muirfield From South			Brand From West			TOTAL
Start Time	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	(veh)
5:00 PM	7	79	49	51	61	18	34	111	15	7	44	11	487
5:15 PM	8	68	36	62	64	29	28	124	22	7	35	9	492
5:30 PM	8	68	38	67	62	18	31	122	19	6	60	3	502
5:45 PM	8	77	36	48	64	33	29	133	10	13	53	7	511
Peak Hour	31	292	159	228	251	98	122	490	66	33	192	30	1992
PHF	0.97	0.92	0.81	0.85	0.98	0.74	0.90	0.92	0.75	0.63	0.80	0.68	

5:00-6:00 PM

Report Summary - Emerald Rd and Post Rd

		Southbound					Westbound					Northbound						Crosswalk	
Time Period	Class.	T	L	U	I	O	R	L	U	I	O	R	T	U	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	0	1	0	1	2	2	0	0	2	1	0	0	0	0	0	3	SB	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars & Light Goods	686	701	0	1387	933	491	348	0	839	1107	406	442	0	848	1034	3074	WB	1	1
One Hour Peak	%	100%	99%	0%	100%	99%	99%	100%	0%	99%	99%	98%	100%	0%	99%	100%	99%		100%	
7:30 AM - 8:30 AM	Other Vehicles	2	3	0	5	7	5	1	0	6	12	9	2	0	11	3	22	NB	0	0
	%	0%	0%	0%	0%	1%	1%	0%	0%	1%	1%	2%	0%	0%	1%	0%	1%		0%	
	Total	**688**	**705**	**0**	**1393**	**942**	**498**	**349**	**0**	**847**	**1120**	**415**	**444**	**0**	**859**	**1037**	**3099**		**1**	**1**
	PHF	0.86	0.91	0	0.89	0.83	0.84	0.81	0	0.83	0.92	0.89	0.82	0	0.87	0.84	0.86			
	Approach %				45%	30%				27%	36%				28%	33%				

		Southbound					Westbound					Northbound						Crosswalk	
Time Period	Class.	T	L	U	I	O	R	L	U	I	O	R	T	U	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	0	2	0	2	0	0	1	0	1	2	0	0	0	0	1	3	N	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
4:00 PM - 6:00 PM	Cars & Light Goods	602	449	0	1051	1501	653	436	0	1089	1177	728	848	0	1576	1038	3716	E	0	0
One Hour Peak	%	100%	99%	0%	99%	100%	100%	100%	0%	100%	100%	100%	100%	0%	100%	100%	100%		0%	
4:45 PM - 5:45 PM	Other Vehicles	3	2	0	5	2	1	0	0	1	3	1	1	0	2	3	8	S	0	0
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
	Total	**605**	**453**	**0**	**1058**	**1503**	**654**	**437**	**0**	**1091**	**1182**	**729**	**849**	**0**	**1578**	**1042**	**3727**		**0**	**0**
	PHF	0.94	0.83	0	0.9	0.95	0.93	0.86	0	0.9	0.83	0.82	0.94	0	0.88	0.91	0.91			
	Approach %				28%	40%				29%	32%				42%	28%				

APPENDIX C – SIDRA INTERSECTION SUMMARIES

INTERSECTION SUMMARY

Site: Avery @ Perimeter AM

Avery Rd. and Perimeter Dr.
Signals - Pretimed Cycle Time = 140 seconds (Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Intersection Performance - Hourly Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Travel Speed (Average)	18.8	mph	0.0	mph	18.8	mph
Travel Distance (Total)	2259.9	veh-mi/h	0.0	ped-mi/h	2711.9	pers-mi/h
Travel Time (Total)	120.1	veh-h/h	0.0	ped-h/h	144.1	pers-h/h
Demand Flows (Total)	3650	veh/h	0	ped/h	4381	pers/h
Percent Heavy Vehicles (Demand)	1.8	%				
Degree of Saturation	0.960		0.000			
Practical Spare Capacity	-6.2	%				
Effective Intersection Capacity	3804	veh/h				
Control Delay (Total)	53.03	veh-h/h	0.00	ped-h/h	63.63	pers-h/h
Control Delay (Average)	52.3	sec	0.0	sec	52.3	sec
Control Delay (Worst Lane)	130.6	sec				
Control Delay (Worst Movement)	130.6	sec	0.0	sec	130.6	sec
Geometric Delay (Average)	0.0	sec				
Stop-Line Delay (Average)	52.3	sec				
Idling Time (Average)	47.3	sec				
Intersection Level of Service (LOS)	LOS D		NA			
95% Back of Queue - Vehicles (Worst Lane)	58.3	veh				
95% Back of Queue - Distance (Worst Lane)	1465.9	ft				
Queue Storage Ratio (Worst Lane)	1.84					
Total Effective Stops	3132	veh/h	0	ped/h	3759	pers/h
Effective Stop Rate	0.86	per veh	0.00	per ped	0.86	per pers
Proportion Queued	0.88		0.00		0.88	
Performance Index	411.4		0.0		411.4	
Cost (Total)	1685.05	$/h	0.00	$/h	1685.05	$/h
Fuel Consumption (Total)	99.0	gal/h				
Carbon Dioxide (Total)	884.8	kg/h				
Hydrocarbons (Total)	0.078	kg/h				
Carbon Monoxide (Total)	0.855	kg/h				
NOx (Total)	0.800	kg/h				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Demand Flows (Total)	1,752,213	veh/y	0	ped/y	2,102,656	pers/y
Delay	25,454	veh-h/y	0	ped-h/y	30,545	pers-h/y
Effective Stops	1,503,508	veh/y	0	ped/y	1,804,210	pers/y
Travel Distance	1,084,753	veh-mi/y	0	ped-mi/y	1,301,703	pers-mi/y
Travel Time	57,643	veh-h/y	0	ped-h/y	69,172	pers-h/y
Cost	808,824	$/y	0	$/y	808,824	$/y
Fuel Consumption	47,535	gal/y				
Carbon Dioxide	424,715	kg/y				
Hydrocarbons	38	kg/y				
Carbon Monoxide	410	kg/y				
NOx	384	kg/y				

INTERSECTION SUMMARY

Site: Avery @ Perimeter PM

Avery Rd. and Perimeter Dr.
Signals - Pretimed Cycle Time = 125 seconds (Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Intersection Performance - Hourly Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Travel Speed (Average)	20.1	mph	1.2	mph	20.0	mph
Travel Distance (Total)	2377.3	veh-mi/h	0.2	ped-mi/h	2852.9	pers-mi/h
Travel Time (Total)	118.5	veh-h/h	0.1	ped-h/h	142.3	pers-h/h
Demand Flows (Total)	3840	veh/h	7	ped/h	4607	pers/h
Percent Heavy Vehicles (Demand)	0.8	%				
Degree of Saturation	0.842		0.001			
Practical Spare Capacity	6.9	%				
Effective Intersection Capacity	4558	veh/h				
Control Delay (Total)	47.73	veh-h/h	0.07	ped-h/h	57.35	pers-h/h
Control Delay (Average)	44.8	sec	41.4	sec	44.8	sec
Control Delay (Worst Lane)	78.1	sec				
Control Delay (Worst Movement)	78.1	sec	51.1	sec	78.1	sec
Geometric Delay (Average)	0.0	sec				
Stop-Line Delay (Average)	44.8	sec				
Idling Time (Average)	40.0	sec				
Intersection Level of Service (LOS)	LOS D		LOS E			
95% Back of Queue - Vehicles (Worst Lane)	36.4	veh				
95% Back of Queue - Distance (Worst Lane)	912.4	ft				
Queue Storage Ratio (Worst Lane)	1.15					
Total Effective Stops	3206	veh/h	5	ped/h	3852	pers/h
Effective Stop Rate	0.83	per veh	0.81	per ped	0.84	per pers
Proportion Queued	0.91		0.81		0.91	
Performance Index	336.6		0.2		336.7	
Cost (Total)	1637.13	$/h	1.24	$/h	1638.37	$/h
Fuel Consumption (Total)	97.8	gal/h				
Carbon Dioxide (Total)	871.6	kg/h				
Hydrocarbons (Total)	0.076	kg/h				
Carbon Monoxide (Total)	0.855	kg/h				
NOx (Total)	0.506	kg/h				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Demand Flows (Total)	1,842,964	veh/y	3,130	ped/y	2,211,557	pers/y
Delay	22,911	veh-h/y	36	ped-h/y	27,529	pers-h/y
Effective Stops	1,538,844	veh/y	2,542	ped/y	1,849,155	pers/y
Travel Distance	1,141,087	veh-mi/y	76	ped-mi/y	1,369,381	pers-mi/y
Travel Time	56,883	veh-h/y	62	ped-h/y	68,322	pers-h/y
Cost	785,821	$/y	595	$/y	786,416	$/y
Fuel Consumption	46,932	gal/y				
Carbon Dioxide	418,365	kg/y				
Hydrocarbons	37	kg/y				
Carbon Monoxide	411	kg/y				
NOx	243	kg/y				

INTERSECTION SUMMARY

Site: Post @ Avery-Muirfield AM

Post Rd. at Avery-Muirfield Dr.

Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	26.9	mph	26.9	mph
Travel Distance (Total)	1660.2	veh-mi/h	1992.3	pers-mi/h
Travel Time (Total)	61.7	veh-h/h	74.1	pers-h/h
Demand Flows (Total)	2604	veh/h	3125	pers/h
Percent Heavy Vehicles (Demand)	1.2	%		
Degree of Saturation	0.828			
Practical Spare Capacity	2.7	%		
Effective Intersection Capacity	3146	veh/h		
Control Delay (Total)	13.73	veh-h/h	16.47	pers-h/h
Control Delay (Average)	19.0	sec	19.0	sec
Control Delay (Worst Lane)	22.9	sec		
Control Delay (Worst Movement)	22.9	sec	22.9	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	19.0	sec		
Idling Time (Average)	13.7	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	12.0	veh		
95% Back of Queue - Distance (Worst Lane)	301.4	ft		
Queue Storage Ratio (Worst Lane)	0.25			
Total Effective Stops	1721	veh/h	2066	pers/h
Effective Stop Rate	0.66	per veh	0.66	per pers
Proportion Queued	0.76		0.76	
Performance Index	99.3		99.3	
Cost (Total)	796.37	$/h	796.37	$/h
Fuel Consumption (Total)	61.1	gal/h		
Carbon Dioxide (Total)	545.7	kg/h		
Hydrocarbons (Total)	0.045	kg/h		
Carbon Monoxide (Total)	0.547	kg/h		
NOx (Total)	0.410	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	1,249,925	veh/y	1,499,911	pers/y
Delay	6,589	veh-h/y	7,907	pers-h/y
Effective Stops	826,292	veh/y	991,550	pers/y
Travel Distance	796,916	veh-mi/y	956,300	pers-mi/y
Travel Time	29,630	veh-h/y	35,556	pers-h/y
Cost	382,256	$/y	382,256	$/y
Fuel Consumption	29,349	gal/y		
Carbon Dioxide	261,939	kg/y		
Hydrocarbons	22	kg/y		
Carbon Monoxide	263	kg/y		
NOx	197	kg/y		

INTERSECTION SUMMARY

Site: Post @ Avery-Muirfield PM

Post Rd. at Avery-Muirfield Dr.

Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	21.7	mph	21.7	mph
Travel Distance (Total)	2295.5	veh-mi/h	2754.6	pers-mi/h
Travel Time (Total)	106.0	veh-h/h	127.2	pers-h/h
Demand Flows (Total)	3604	veh/h	4325	pers/h
Percent Heavy Vehicles (Demand)	0.6	%		
Degree of Saturation	1.027			
Practical Spare Capacity	-17.3	%		
Effective Intersection Capacity	3508	veh/h		
Control Delay (Total)	39.64	veh-h/h	47.57	pers-h/h
Control Delay (Average)	39.6	sec	39.6	sec
Control Delay (Worst Lane)	61.1	sec		
Control Delay (Worst Movement)	61.1	sec	61.1	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	39.6	sec		
Idling Time (Average)	27.8	sec		
Intersection Level of Service (LOS)	LOS E			
95% Back of Queue - Vehicles (Worst Lane)	32.7	veh		
95% Back of Queue - Distance (Worst Lane)	819.5	ft		
Queue Storage Ratio (Worst Lane)	0.68			
Total Effective Stops	4577	veh/h	5493	pers/h
Effective Stop Rate	1.27	per veh	1.27	per pers
Proportion Queued	0.88		0.88	
Performance Index	213.6		213.6	
Cost (Total)	1383.33	$/h	1383.33	$/h
Fuel Consumption (Total)	91.6	gal/h		
Carbon Dioxide (Total)	815.8	kg/h		
Hydrocarbons (Total)	0.071	kg/h		
Carbon Monoxide (Total)	0.796	kg/h		
NOx (Total)	0.412	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	1,729,977	veh/y	2,075,973	pers/y
Delay	19,026	veh-h/y	22,831	pers-h/y
Effective Stops	2,197,112	veh/y	2,636,535	pers/y
Travel Distance	1,101,824	veh-mi/y	1,322,189	pers-mi/y
Travel Time	50,886	veh-h/y	61,063	pers-h/y
Cost	663,998	$/y	663,998	$/y
Fuel Consumption	43,956	gal/y		
Carbon Dioxide	391,585	kg/y		
Hydrocarbons	34	kg/y		
Carbon Monoxide	382	kg/y		
NOx	198	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Avery AM

Brand Rd. @ Avery Rd.
Stop (All-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	19.7	mph	19.7	mph
Travel Distance (Total)	704.9	veh-mi/h	845.9	pers-mi/h
Travel Time (Total)	35.8	veh-h/h	43.0	pers-h/h
Demand Flows (Total)	1146	veh/h	1375	pers/h
Percent Heavy Vehicles (Demand)	2.0	%		
Degree of Saturation	0.941			
Practical Spare Capacity	-15.0	%		
Effective Intersection Capacity	1218	veh/h		
Control Delay (Total)	13.37	veh-h/h	16.05	pers-h/h
Control Delay (Average)	42.0	sec	42.0	sec
Control Delay (Worst Lane)	67.1	sec		
Control Delay (Worst Movement)	67.1	sec	67.1	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	42.0	sec		
Idling Time (Average)	24.9	sec		
Intersection Level of Service (LOS)	LOS E			
95% Back of Queue - Vehicles (Worst Lane)	10.1	veh		
95% Back of Queue - Distance (Worst Lane)	256.5	ft		
Queue Storage Ratio (Worst Lane)	0.31			
Total Effective Stops	2136	veh/h	2563	pers/h
Effective Stop Rate	1.86	per veh	1.86	per pers
Proportion Queued	0.99		0.99	
Performance Index	103.3		103.3	
Cost (Total)	472.53	$/h	472.53	$/h
Fuel Consumption (Total)	31.6	gal/h		
Carbon Dioxide (Total)	282.5	kg/h		
Hydrocarbons (Total)	0.025	kg/h		
Carbon Monoxide (Total)	0.277	kg/h		
NOx (Total)	0.305	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	549,945	veh/y	659,933	pers/y
Delay	6,420	veh-h/y	7,704	pers-h/y
Effective Stops	1,025,282	veh/y	1,230,339	pers/y
Travel Distance	338,365	veh-mi/y	406,037	pers-mi/y
Travel Time	17,186	veh-h/y	20,623	pers-h/y
Cost	226,814	$/y	226,814	$/y
Fuel Consumption	15,161	gal/y		
Carbon Dioxide	135,578	kg/y		
Hydrocarbons	12	kg/y		
Carbon Monoxide	133	kg/y		
NOx	146	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Avery AM - Conversion

Brand Rd. @ Avery Rd.
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	29.9	mph	29.9	mph
Travel Distance (Total)	726.4	veh-mi/h	871.7	pers-mi/h
Travel Time (Total)	24.3	veh-h/h	29.1	pers-h/h
Demand Flows (Total)	1146	veh/h	1375	pers/h
Percent Heavy Vehicles (Demand)	2.0	%		
Degree of Saturation	0.488			
Practical Spare Capacity	74.1	%		
Effective Intersection Capacity	2346	veh/h		
Control Delay (Total)	2.83	veh-h/h	3.39	pers-h/h
Control Delay (Average)	8.9	sec	8.9	sec
Control Delay (Worst Lane)	11.0	sec		
Control Delay (Worst Movement)	11.0	sec	11.0	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	8.9	sec		
Idling Time (Average)	6.1	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	2.6	veh		
95% Back of Queue - Distance (Worst Lane)	67.0	ft		
Queue Storage Ratio (Worst Lane)	0.06			
Total Effective Stops	499	veh/h	599	pers/h
Effective Stop Rate	0.44	per veh	0.44	per pers
Proportion Queued	0.49		0.49	
Performance Index	38.3		38.3	
Cost (Total)	312.80	$/h	312.80	$/h
Fuel Consumption (Total)	26.3	gal/h		
Carbon Dioxide (Total)	235.2	kg/h		
Hydrocarbons (Total)	0.019	kg/h		
Carbon Monoxide (Total)	0.236	kg/h		
NOx (Total)	0.249	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	549,945	veh/y	659,933	pers/y
Delay	1,357	veh-h/y	1,628	pers-h/y
Effective Stops	239,571	veh/y	287,486	pers/y
Travel Distance	348,687	veh-mi/y	418,425	pers-mi/y
Travel Time	11,648	veh-h/y	13,978	pers-h/y
Cost	150,144	$/y	150,144	$/y
Fuel Consumption	12,622	gal/y		
Carbon Dioxide	112,919	kg/y		
Hydrocarbons	9	kg/y		
Carbon Monoxide	113	kg/y		
NOx	120	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Avery PM

Brand Rd. @ Avery Rd.
Stop (All-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	18.6	mph	18.6	mph
Travel Distance (Total)	956.5	veh-mi/h	1147.8	pers-mi/h
Travel Time (Total)	51.4	veh-h/h	61.7	pers-h/h
Demand Flows (Total)	1554	veh/h	1865	pers/h
Percent Heavy Vehicles (Demand)	0.7	%		
Degree of Saturation	0.968			
Practical Spare Capacity	-17.4	%		
Effective Intersection Capacity	1605	veh/h		
Control Delay (Total)	21.02	veh-h/h	25.22	pers-h/h
Control Delay (Average)	48.7	sec	48.7	sec
Control Delay (Worst Lane)	71.6	sec		
Control Delay (Worst Movement)	71.6	sec	71.6	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	48.7	sec		
Idling Time (Average)	28.4	sec		
Intersection Level of Service (LOS)	LOS E			
95% Back of Queue - Vehicles (Worst Lane)	11.2	veh		
95% Back of Queue - Distance (Worst Lane)	285.5	ft		
Queue Storage Ratio (Worst Lane)	0.35			
Total Effective Stops	3177	veh/h	3813	pers/h
Effective Stop Rate	2.04	per veh	2.04	per pers
Proportion Queued	0.99		0.99	
Performance Index	135.3		135.3	
Cost (Total)	668.06	$/h	668.06	$/h
Fuel Consumption (Total)	41.6	gal/h		
Carbon Dioxide (Total)	370.9	kg/h		
Hydrocarbons (Total)	0.033	kg/h		
Carbon Monoxide (Total)	0.360	kg/h		
NOx (Total)	0.208	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	746,096	veh/y	895,316	pers/y
Delay	10,089	veh-h/y	12,107	pers-h/y
Effective Stops	1,525,022	veh/y	1,830,027	pers/y
Travel Distance	459,104	veh-mi/y	550,925	pers-mi/y
Travel Time	24,685	veh-h/y	29,622	pers-h/y
Cost	320,670	$/y	320,670	$/y
Fuel Consumption	19,976	gal/y		
Carbon Dioxide	178,013	kg/y		
Hydrocarbons	16	kg/y		
Carbon Monoxide	173	kg/y		
NOx	100	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Avery PM - Conversion

Brand Rd. @ Avery Rd.
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	28.8	mph	28.8	mph
Travel Distance (Total)	983.0	veh-mi/h	1179.7	pers-mi/h
Travel Time (Total)	34.1	veh-h/h	41.0	pers-h/h
Demand Flows (Total)	1554	veh/h	1865	pers/h
Percent Heavy Vehicles (Demand)	0.7	%		
Degree of Saturation	0.563			
Practical Spare Capacity	50.9	%		
Effective Intersection Capacity	2759	veh/h		
Control Delay (Total)	5.03	veh-h/h	6.03	pers-h/h
Control Delay (Average)	11.6	sec	11.6	sec
Control Delay (Worst Lane)	13.2	sec		
Control Delay (Worst Movement)	13.2	sec	13.2	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	11.6	sec		
Idling Time (Average)	8.1	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	3.5	veh		
95% Back of Queue - Distance (Worst Lane)	88.5	ft		
Queue Storage Ratio (Worst Lane)	0.07			
Total Effective Stops	922	veh/h	1107	pers/h
Effective Stop Rate	0.59	per veh	0.59	per pers
Proportion Queued	0.60		0.60	
Performance Index	55.8		55.8	
Cost (Total)	436.49	$/h	436.49	$/h
Fuel Consumption (Total)	34.6	gal/h		
Carbon Dioxide (Total)	308.5	kg/h		
Hydrocarbons (Total)	0.025	kg/h		
Carbon Monoxide (Total)	0.313	kg/h		
NOx (Total)	0.170	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	746,096	veh/y	895,316	pers/y
Delay	2,412	veh-h/y	2,895	pers-h/y
Effective Stops	442,617	veh/y	531,140	pers/y
Travel Distance	471,861	veh-mi/y	566,233	pers-mi/y
Travel Time	16,387	veh-h/y	19,664	pers-h/y
Cost	209,515	$/y	209,515	$/y
Fuel Consumption	16,612	gal/y		
Carbon Dioxide	148,060	kg/y		
Hydrocarbons	12	kg/y		
Carbon Monoxide	150	kg/y		
NOx	82	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Brandonway AM

Brand Rd. @ Earlington Pkwy / Brandonway Dr.
Stop (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	28.7	mph	28.7	mph
Travel Distance (Total)	610.2	veh-mi/h	732.2	pers-mi/h
Travel Time (Total)	21.3	veh-h/h	25.5	pers-h/h
Demand Flows (Total)	995	veh/h	1194	pers/h
Percent Heavy Vehicles (Demand)	1.5	%		
Degree of Saturation	0.364			
Practical Spare Capacity	120.0	%		
Effective Intersection Capacity	2735	veh/h		
Control Delay (Total)	1.27	veh-h/h	1.52	pers-h/h
Control Delay (Average)	4.6	sec	4.6	sec
Control Delay (Worst Lane)	14.5	sec		
Control Delay (Worst Movement)	14.5	sec	14.5	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	4.6	sec		
Idling Time (Average)	2.9	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	2.1	veh		
95% Back of Queue - Distance (Worst Lane)	51.8	ft		
Queue Storage Ratio (Worst Lane)	0.04			
Total Effective Stops	196	veh/h	235	pers/h
Effective Stop Rate	0.20	per veh	0.20	per pers
Proportion Queued	0.45		0.45	
Performance Index	25.7		25.7	
Cost (Total)	233.01	$/h	233.01	$/h
Fuel Consumption (Total)	19.6	gal/h		
Carbon Dioxide (Total)	175.4	kg/h		
Hydrocarbons (Total)	0.013	kg/h		
Carbon Monoxide (Total)	0.153	kg/h		
NOx (Total)	0.141	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	477,419	veh/y	572,903	pers/y
Delay	607	veh-h/y	729	pers-h/y
Effective Stops	94,006	veh/y	112,807	pers/y
Travel Distance	292,885	veh-mi/y	351,462	pers-mi/y
Travel Time	10,217	veh-h/y	12,261	pers-h/y
Cost	111,847	$/y	111,847	$/y
Fuel Consumption	9,424	gal/y		
Carbon Dioxide	84,213	kg/y		
Hydrocarbons	6	kg/y		
Carbon Monoxide	74	kg/y		
NOx	67	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Brandonway PM

Brand Rd. @ Earlington Pkwy / Brandonway Dr.
Stop (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	27.8	mph	27.8	mph
Travel Distance (Total)	940.4	veh-mi/h	1128.4	pers-mi/h
Travel Time (Total)	33.9	veh-h/h	40.6	pers-h/h
Demand Flows (Total)	1533	veh/h	1839	pers/h
Percent Heavy Vehicles (Demand)	0.6	%		
Degree of Saturation	0.683			
Practical Spare Capacity	17.2	%		
Effective Intersection Capacity	2246	veh/h		
Control Delay (Total)	4.10	veh-h/h	4.92	pers-h/h
Control Delay (Average)	9.6	sec	9.6	sec
Control Delay (Worst Lane)	43.4	sec		
Control Delay (Worst Movement)	43.4	sec	43.4	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	9.6	sec		
Idling Time (Average)	6.2	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	6.1	veh		
95% Back of Queue - Distance (Worst Lane)	153.0	ft		
Queue Storage Ratio (Worst Lane)	0.13			
Total Effective Stops	407	veh/h	488	pers/h
Effective Stop Rate	0.27	per veh	0.27	per pers
Proportion Queued	0.74		0.74	
Performance Index	43.2		43.2	
Cost (Total)	400.13	$/h	400.13	$/h
Fuel Consumption (Total)	31.9	gal/h		
Carbon Dioxide (Total)	284.6	kg/h		
Hydrocarbons (Total)	0.022	kg/h		
Carbon Monoxide (Total)	0.267	kg/h		
NOx (Total)	0.145	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	735,769	veh/y	882,923	pers/y
Delay	1,967	veh-h/y	2,360	pers-h/y
Effective Stops	195,170	veh/y	234,204	pers/y
Travel Distance	451,371	veh-mi/y	541,645	pers-mi/y
Travel Time	16,259	veh-h/y	19,510	pers-h/y
Cost	192,062	$/y	192,062	$/y
Fuel Consumption	15,330	gal/y		
Carbon Dioxide	136,610	kg/y		
Hydrocarbons	11	kg/y		
Carbon Monoxide	128	kg/y		
NOx	69	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Coffman AM (RDBT NOW)

Brand Rd. @ Coffman Rd.
Stop (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	30.6	mph	30.6	mph
Travel Distance (Total)	861.4	veh-mi/h	1033.7	pers-mi/h
Travel Time (Total)	28.2	veh-h/h	33.8	pers-h/h
Demand Flows (Total)	1399	veh/h	1679	pers/h
Percent Heavy Vehicles (Demand)	1.1	%		
Degree of Saturation	0.516			
Practical Spare Capacity	54.9	%		
Effective Intersection Capacity	2709	veh/h		
Control Delay (Total)	1.74	veh-h/h	2.09	pers-h/h
Control Delay (Average)	4.5	sec	4.5	sec
Control Delay (Worst Lane)	43.3	sec		
Control Delay (Worst Movement)	43.3	sec	43.3	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	4.5	sec		
Idling Time (Average)	3.3	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	2.5	veh		
95% Back of Queue - Distance (Worst Lane)	64.9	ft		
Queue Storage Ratio (Worst Lane)	0.05			
Total Effective Stops	353	veh/h	424	pers/h
Effective Stop Rate	0.25	per veh	0.25	per pers
Proportion Queued	0.23		0.23	
Performance Index	30.6		30.6	
Cost (Total)	324.93	$/h	324.93	$/h
Fuel Consumption (Total)	27.9	gal/h		
Carbon Dioxide (Total)	249.0	kg/h		
Hydrocarbons (Total)	0.019	kg/h		
Carbon Monoxide (Total)	0.259	kg/h		
NOx (Total)	0.151	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	671,618	veh/y	805,941	pers/y
Delay	836	veh-h/y	1,004	pers-h/y
Effective Stops	169,527	veh/y	203,433	pers/y
Travel Distance	413,485	veh-mi/y	496,181	pers-mi/y
Travel Time	13,519	veh-h/y	16,222	pers-h/y
Cost	155,964	$/y	155,964	$/y
Fuel Consumption	13,395	gal/y		
Carbon Dioxide	119,540	kg/y		
Hydrocarbons	9	kg/y		
Carbon Monoxide	124	kg/y		
NOx	73	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Coffman AM

Brand Rd. and Coffman Rd.
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	28.7	mph	28.7	mph
Travel Distance (Total)	879.5	veh-mi/h	1055.4	pers-mi/h
Travel Time (Total)	30.7	veh-h/h	36.8	pers-h/h
Demand Flows (Total)	1402	veh/h	1683	pers/h
Percent Heavy Vehicles (Demand)	1.1	%		
Degree of Saturation	0.595			
Practical Spare Capacity	42.9	%		
Effective Intersection Capacity	2358	veh/h		
Control Delay (Total)	3.99	veh-h/h	4.79	pers-h/h
Control Delay (Average)	10.2	sec	10.2	sec
Control Delay (Worst Lane)	13.6	sec		
Control Delay (Worst Movement)	13.6	sec	13.6	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	10.2	sec		
Idling Time (Average)	7.8	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	4.0	veh		
95% Back of Queue - Distance (Worst Lane)	101.4	ft		
Queue Storage Ratio (Worst Lane)	0.06			
Total Effective Stops	577	veh/h	692	pers/h
Effective Stop Rate	0.41	per veh	0.41	per pers
Proportion Queued	0.48		0.48	
Performance Index	45.0		45.0	
Cost (Total)	421.79	$/h	421.79	$/h
Fuel Consumption (Total)	31.5	gal/h		
Carbon Dioxide (Total)	281.4	kg/h		
Hydrocarbons (Total)	0.023	kg/h		
Carbon Monoxide (Total)	0.284	kg/h		
NOx (Total)	0.201	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	673,183	veh/y	807,820	pers/y
Delay	1,914	veh-h/y	2,297	pers-h/y
Effective Stops	276,965	veh/y	332,358	pers/y
Travel Distance	422,174	veh-mi/y	506,609	pers-mi/y
Travel Time	14,728	veh-h/y	17,674	pers-h/y
Cost	202,461	$/y	202,461	$/y
Fuel Consumption	15,138	gal/y		
Carbon Dioxide	135,075	kg/y		
Hydrocarbons	11	kg/y		
Carbon Monoxide	136	kg/y		
NOx	97	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Coffman PM (RDBT NOW)

Brand Rd. @ Coffman Rd.
Stop (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	16.0	mph	16.0	mph
Travel Distance (Total)	1063.7	veh-mi/h	1276.5	pers-mi/h
Travel Time (Total)	66.4	veh-h/h	79.7	pers-h/h
Demand Flows (Total)	1729	veh/h	2075	pers/h
Percent Heavy Vehicles (Demand)	0.0	%		
Degree of Saturation	1.589			
Practical Spare Capacity	-49.6	%		
Effective Intersection Capacity	1089	veh/h		
Control Delay (Total)	33.95	veh-h/h	40.75	pers-h/h
Control Delay (Average)	70.7	sec	70.7	sec
Control Delay (Worst Lane)	324.2	sec		
Control Delay (Worst Movement)	324.2	sec	324.2	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	70.7	sec		
Idling Time (Average)	61.4	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	52.8	veh		
95% Back of Queue - Distance (Worst Lane)	1319.4	ft		
Queue Storage Ratio (Worst Lane)	1.09			
Total Effective Stops	1537	veh/h	1844	pers/h
Effective Stop Rate	0.89	per veh	0.89	per pers
Proportion Queued	0.40		0.40	
Performance Index	96.2		96.2	
Cost (Total)	810.86	$/h	810.86	$/h
Fuel Consumption (Total)	43.4	gal/h		
Carbon Dioxide (Total)	386.2	kg/h		
Hydrocarbons (Total)	0.034	kg/h		
Carbon Monoxide (Total)	0.362	kg/h		
NOx (Total)	0.089	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	830,125	veh/y	996,150	pers/y
Delay	16,298	veh-h/y	19,558	pers-h/y
Effective Stops	737,792	veh/y	885,351	pers/y
Travel Distance	510,598	veh-mi/y	612,717	pers-mi/y
Travel Time	31,891	veh-h/y	38,270	pers-h/y
Cost	389,212	$/y	389,212	$/y
Fuel Consumption	20,841	gal/y		
Carbon Dioxide	185,396	kg/y		
Hydrocarbons	16	kg/y		
Carbon Monoxide	174	kg/y		
NOx	43	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Coffman PM

Brand Rd. and Coffman Rd.
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	26.3	mph	26.3	mph
Travel Distance (Total)	1088.6	veh-mi/h	1306.3	pers-mi/h
Travel Time (Total)	41.5	veh-h/h	49.8	pers-h/h
Demand Flows (Total)	1733	veh/h	2079	pers/h
Percent Heavy Vehicles (Demand)	0.0	%		
Degree of Saturation	0.826			
Practical Spare Capacity	2.9	%		
Effective Intersection Capacity	2098	veh/h		
Control Delay (Total)	8.55	veh-h/h	10.26	pers-h/h
Control Delay (Average)	17.8	sec	17.8	sec
Control Delay (Worst Lane)	24.7	sec		
Control Delay (Worst Movement)	24.7	sec	24.7	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	17.8	sec		
Idling Time (Average)	13.2	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	10.9	veh		
95% Back of Queue - Distance (Worst Lane)	272.7	ft		
Queue Storage Ratio (Worst Lane)	0.22			
Total Effective Stops	1290	veh/h	1548	pers/h
Effective Stop Rate	0.74	per veh	0.74	per pers
Proportion Queued	0.72		0.72	
Performance Index	76.1		76.1	
Cost (Total)	577.95	$/h	577.95	$/h
Fuel Consumption (Total)	39.6	gal/h		
Carbon Dioxide (Total)	352.2	kg/h		
Hydrocarbons (Total)	0.029	kg/h		
Carbon Monoxide (Total)	0.355	kg/h		
NOx (Total)	0.101	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	831,690	veh/y	998,029	pers/y
Delay	4,106	veh-h/y	4,927	pers-h/y
Effective Stops	619,080	veh/y	742,896	pers/y
Travel Distance	522,515	veh-mi/y	627,018	pers-mi/y
Travel Time	19,903	veh-h/y	23,884	pers-h/y
Cost	277,415	$/y	277,415	$/y
Fuel Consumption	19,004	gal/y		
Carbon Dioxide	169,052	kg/y		
Hydrocarbons	14	kg/y		
Carbon Monoxide	170	kg/y		
NOx	49	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Coventry Woods AM

Brand Rd. @ Coventry Dr.
Stop (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	29.8	mph	29.8	mph
Travel Distance (Total)	493.9	veh-mi/h	592.7	pers-mi/h
Travel Time (Total)	16.6	veh-h/h	19.9	pers-h/h
Demand Flows (Total)	805	veh/h	966	pers/h
Percent Heavy Vehicles (Demand)	1.6	%		
Degree of Saturation	0.274			
Practical Spare Capacity	191.9	%		
Effective Intersection Capacity	2937	veh/h		
Control Delay (Total)	0.71	veh-h/h	0.85	pers-h/h
Control Delay (Average)	3.2	sec	3.2	sec
Control Delay (Worst Lane)	13.7	sec		
Control Delay (Worst Movement)	13.7	sec	13.7	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	3.2	sec		
Idling Time (Average)	2.8	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	1.4	veh		
95% Back of Queue - Distance (Worst Lane)	34.0	ft		
Queue Storage Ratio (Worst Lane)	0.03			
Total Effective Stops	100	veh/h	120	pers/h
Effective Stop Rate	0.12	per veh	0.12	per pers
Proportion Queued	0.15		0.15	
Performance Index	19.0		19.0	
Cost (Total)	167.38	$/h	167.38	$/h
Fuel Consumption (Total)	14.5	gal/h		
Carbon Dioxide (Total)	129.9	kg/h		
Hydrocarbons (Total)	0.009	kg/h		
Carbon Monoxide (Total)	0.116	kg/h		
NOx (Total)	0.112	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	386,336	veh/y	463,603	pers/y
Delay	339	veh-h/y	407	pers-h/y
Effective Stops	48,152	veh/y	57,782	pers/y
Travel Distance	237,085	veh-mi/y	284,502	pers-mi/y
Travel Time	7,963	veh-h/y	9,556	pers-h/y
Cost	80,344	$/y	80,344	$/y
Fuel Consumption	6,972	gal/y		
Carbon Dioxide	62,345	kg/y		
Hydrocarbons	4	kg/y		
Carbon Monoxide	56	kg/y		
NOx	54	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Coventry Woods PM

Brand Rd. @ Coventry Dr.
Stop (Two-Way)

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	31.2	mph	31.2	mph
Travel Distance (Total)	800.7	veh-mi/h	960.8	pers-mi/h
Travel Time (Total)	25.7	veh-h/h	30.8	pers-h/h
Demand Flows (Total)	1305	veh/h	1566	pers/h
Percent Heavy Vehicles (Demand)	0.6	%		
Degree of Saturation	0.334			
Practical Spare Capacity	139.9	%		
Effective Intersection Capacity	3914	veh/h		
Control Delay (Total)	1.14	veh-h/h	1.37	pers-h/h
Control Delay (Average)	3.1	sec	3.1	sec
Control Delay (Worst Lane)	27.2	sec		
Control Delay (Worst Movement)	27.2	sec	27.2	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	3.1	sec		
Idling Time (Average)	2.7	sec		
Intersection Level of Service (LOS)	NA			
95% Back of Queue - Vehicles (Worst Lane)	1.6	veh		
95% Back of Queue - Distance (Worst Lane)	39.6	ft		
Queue Storage Ratio (Worst Lane)	0.03			
Total Effective Stops	162	veh/h	194	pers/h
Effective Stop Rate	0.12	per veh	0.12	per pers
Proportion Queued	0.12		0.12	
Performance Index	30.0		30.0	
Cost (Total)	255.41	$/h	255.41	$/h
Fuel Consumption (Total)	22.0	gal/h		
Carbon Dioxide (Total)	196.5	kg/h		
Hydrocarbons (Total)	0.014	kg/h		
Carbon Monoxide (Total)	0.194	kg/h		
NOx (Total)	0.084	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

NA: Intersection LOS for Vehicles is Not Applicable for two-way sign control since the average intersection delay is not a good LOS measure due to zero delays associated with major road movements.

HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	626,534	veh/y	751,841	pers/y
Delay	546	veh-h/y	656	pers-h/y
Effective Stops	77,523	veh/y	93,027	pers/y
Travel Distance	384,338	veh-mi/y	461,206	pers-mi/y
Travel Time	12,325	veh-h/y	14,790	pers-h/y
Cost	122,596	$/y	122,596	$/y
Fuel Consumption	10,583	gal/y		
Carbon Dioxide	94,329	kg/y		
Hydrocarbons	7	kg/y		
Carbon Monoxide	93	kg/y		
NOx	40	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Dublin AM

Brand Rd. at Dublin Rd.

Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	18.0	mph	18.0	mph
Travel Distance (Total)	1006.9	veh-mi/h	1208.3	pers-mi/h
Travel Time (Total)	55.9	veh-h/h	67.1	pers-h/h
Demand Flows (Total)	1601	veh/h	1921	pers/h
Percent Heavy Vehicles (Demand)	1.1	%		
Degree of Saturation	0.731			
Practical Spare Capacity	16.2	%		
Effective Intersection Capacity	2189	veh/h		
Control Delay (Total)	5.94	veh-h/h	7.13	pers-h/h
Control Delay (Average)	13.4	sec	13.4	sec
Control Delay (Worst Lane)	19.6	sec		
Control Delay (Worst Movement)	19.6	sec	19.6	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	13.4	sec		
Idling Time (Average)	10.3	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	7.3	veh		
95% Back of Queue - Distance (Worst Lane)	182.2	ft		
Queue Storage Ratio (Worst Lane)	0.15			
Total Effective Stops	717	veh/h	861	pers/h
Effective Stop Rate	0.45	per veh	0.45	per pers
Proportion Queued	0.53		0.53	
Performance Index	81.0		81.0	
Cost (Total)	529.72	$/h	529.72	$/h
Fuel Consumption (Total)	35.4	gal/h		
Carbon Dioxide (Total)	316.3	kg/h		
Hydrocarbons (Total)	0.023	kg/h		
Carbon Monoxide (Total)	0.132	kg/h		
NOx (Total)	0.168	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	768,490	veh/y	922,188	pers/y
Delay	2,852	veh-h/y	3,422	pers-h/y
Effective Stops	344,243	veh/y	413,091	pers/y
Travel Distance	483,317	veh-mi/y	579,981	pers-mi/y
Travel Time	26,853	veh-h/y	32,223	pers-h/y
Cost	254,263	$/y	254,263	$/y
Fuel Consumption	17,012	gal/y		
Carbon Dioxide	151,837	kg/y		
Hydrocarbons	11	kg/y		
Carbon Monoxide	63	kg/y		
NOx	81	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Dublin PM

Brand Rd. at Dublin Rd.

Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	17.9	mph	17.9	mph
Travel Distance (Total)	1256.5	veh-mi/h	1507.7	pers-mi/h
Travel Time (Total)	70.0	veh-h/h	84.1	pers-h/h
Demand Flows (Total)	1980	veh/h	2376	pers/h
Percent Heavy Vehicles (Demand)	0.3	%		
Degree of Saturation	0.728			
Practical Spare Capacity	16.8	%		
Effective Intersection Capacity	2721	veh/h		
Control Delay (Total)	8.09	veh-h/h	9.71	pers-h/h
Control Delay (Average)	14.7	sec	14.7	sec
Control Delay (Worst Lane)	18.3	sec		
Control Delay (Worst Movement)	18.3	sec	18.3	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	14.7	sec		
Idling Time (Average)	10.6	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	7.0	veh		
95% Back of Queue - Distance (Worst Lane)	174.6	ft		
Queue Storage Ratio (Worst Lane)	0.14			
Total Effective Stops	1420	veh/h	1704	pers/h
Effective Stop Rate	0.72	per veh	0.72	per pers
Proportion Queued	0.68		0.68	
Performance Index	101.0		101.0	
Cost (Total)	701.21	$/h	701.21	$/h
Fuel Consumption (Total)	45.4	gal/h		
Carbon Dioxide (Total)	404.0	kg/h		
Hydrocarbons (Total)	0.030	kg/h		
Carbon Monoxide (Total)	0.166	kg/h		
NOx (Total)	0.123	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	950,552	veh/y	1,140,663	pers/y
Delay	3,883	veh-h/y	4,659	pers-h/y
Effective Stops	681,546	veh/y	817,855	pers/y
Travel Distance	603,098	veh-mi/y	723,718	pers-mi/y
Travel Time	33,622	veh-h/y	40,346	pers-h/y
Cost	336,581	$/y	336,581	$/y
Fuel Consumption	21,775	gal/y		
Carbon Dioxide	193,905	kg/y		
Hydrocarbons	14	kg/y		
Carbon Monoxide	80	kg/y		
NOx	59	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Muirfield AM

Brand Rd. at Muirfield Dr.

Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	26.0	mph	26.0	mph
Travel Distance (Total)	1062.1	veh-mi/h	1274.5	pers-mi/h
Travel Time (Total)	40.9	veh-h/h	49.1	pers-h/h
Demand Flows (Total)	1627	veh/h	1952	pers/h
Percent Heavy Vehicles (Demand)	0.0	%		
Degree of Saturation	0.435			
Practical Spare Capacity	95.6	%		
Effective Intersection Capacity	3743	veh/h		
Control Delay (Total)	3.96	veh-h/h	4.75	pers-h/h
Control Delay (Average)	8.8	sec	8.8	sec
Control Delay (Worst Lane)	11.8	sec		
Control Delay (Worst Movement)	11.8	sec	11.8	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	8.8	sec		
Idling Time (Average)	5.8	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	1.9	veh		
95% Back of Queue - Distance (Worst Lane)	48.6	ft		
Queue Storage Ratio (Worst Lane)	0.04			
Total Effective Stops	694	veh/h	833	pers/h
Effective Stop Rate	0.43	per veh	0.43	per pers
Proportion Queued	0.47		0.47	
Performance Index	44.7		44.7	
Cost (Total)	411.23	$/h	411.23	$/h
Fuel Consumption (Total)	31.7	gal/h		
Carbon Dioxide (Total)	282.3	kg/h		
Hydrocarbons (Total)	0.020	kg/h		
Carbon Monoxide (Total)	0.193	kg/h		
NOx (Total)	0.060	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	780,757	veh/y	936,908	pers/y
Delay	1,902	veh-h/y	2,282	pers-h/y
Effective Stops	333,032	veh/y	399,638	pers/y
Travel Distance	509,809	veh-mi/y	611,770	pers-mi/y
Travel Time	19,636	veh-h/y	23,563	pers-h/y
Cost	197,391	$/y	197,391	$/y
Fuel Consumption	15,235	gal/y		
Carbon Dioxide	135,526	kg/y		
Hydrocarbons	10	kg/y		
Carbon Monoxide	93	kg/y		
NOx	29	kg/y		

INTERSECTION SUMMARY

Site: Brand @ Muirfield PM

Brand Rd. at Muirfield Dr.

Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	22.2	mph	22.2	mph
Travel Distance (Total)	1493.2	veh-mi/h	1791.9	pers-mi/h
Travel Time (Total)	67.3	veh-h/h	80.8	pers-h/h
Demand Flows (Total)	2295	veh/h	2754	pers/h
Percent Heavy Vehicles (Demand)	3.0	%		
Degree of Saturation	0.967			
Practical Spare Capacity	-12.1	%		
Effective Intersection Capacity	2374	veh/h		
Control Delay (Total)	15.34	veh-h/h	18.41	pers-h/h
Control Delay (Average)	24.1	sec	24.1	sec
Control Delay (Worst Lane)	51.3	sec		
Control Delay (Worst Movement)	51.3	sec	51.3	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	24.1	sec		
Idling Time (Average)	16.8	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	12.9	veh		
95% Back of Queue - Distance (Worst Lane)	330.5	ft		
Queue Storage Ratio (Worst Lane)	0.27			
Total Effective Stops	2096	veh/h	2516	pers/h
Effective Stop Rate	0.91	per veh	0.91	per pers
Proportion Queued	0.73		0.73	
Performance Index	117.5		117.5	
Cost (Total)	755.77	$/h	755.77	$/h
Fuel Consumption (Total)	56.0	gal/h		
Carbon Dioxide (Total)	502.3	kg/h		
Hydrocarbons (Total)	0.040	kg/h		
Carbon Monoxide (Total)	0.376	kg/h		
NOx (Total)	0.589	kg/h		

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	1,101,648	veh/y	1,321,977	pers/y
Delay	7,363	veh-h/y	8,835	pers-h/y
Effective Stops	1,006,211	veh/y	1,207,453	pers/y
Travel Distance	716,754	veh-mi/y	860,105	pers-mi/y
Travel Time	32,307	veh-h/y	38,768	pers-h/y
Cost	362,772	$/y	362,772	$/y
Fuel Consumption	26,879	gal/y		
Carbon Dioxide	241,102	kg/y		
Hydrocarbons	19	kg/y		
Carbon Monoxide	180	kg/y		
NOx	283	kg/y		

INTERSECTION SUMMARY

Site: Post @ Emerald AM

Post Rd. at Emerald Pkwy.
Signals - Pretimed Cycle Time = 70 seconds (Practical Cycle Time)

Intersection Performance - Hourly Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Travel Speed (Average)	27.4	mph	1.5	mph	27.4	mph
Travel Distance (Total)	2229.4	veh-mi/h	0.1	ped-mi/h	2675.4	pers-mi/h
Travel Time (Total)	81.4	veh-h/h	0.1	ped-h/h	97.8	pers-h/h
Demand Flows (Total)	3606	veh/h	3	ped/h	4327	pers/h
Percent Heavy Vehicles (Demand)	0.7	%				
Degree of Saturation	0.818		0.001			
Practical Spare Capacity	10.0	%				
Effective Intersection Capacity	4407	veh/h				
Control Delay (Total)	13.71	veh-h/h	0.02	ped-h/h	16.47	pers-h/h
Control Delay (Average)	13.7	sec	26.6	sec	13.7	sec
Control Delay (Worst Lane)	21.4	sec				
Control Delay (Worst Movement)	21.4	sec	26.6	sec	26.6	sec
Geometric Delay (Average)	0.0	sec				
Stop-Line Delay (Average)	13.7	sec				
Idling Time (Average)	10.0	sec				
Intersection Level of Service (LOS)	LOS B		LOS C			
95% Back of Queue - Vehicles (Worst Lane)	25.1	veh				
95% Back of Queue - Distance (Worst Lane)	629.6	ft				
Queue Storage Ratio (Worst Lane)	0.79					
Total Effective Stops	2403	veh/h	3	ped/h	2886	pers/h
Effective Stop Rate	0.67	per veh	0.87	per ped	0.67	per pers
Proportion Queued	0.73		0.87		0.73	
Performance Index	167.8		0.1		167.9	
Cost (Total)	1026.52	$/h	0.47	$/h	1026.99	$/h
Fuel Consumption (Total)	80.7	gal/h				
Carbon Dioxide (Total)	719.0	kg/h				
Hydrocarbons (Total)	0.059	kg/h				
Carbon Monoxide (Total)	0.735	kg/h				
NOx (Total)	0.417	kg/h				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Demand Flows (Total)	1,730,977	veh/y	1,565	ped/y	2,077,172	pers/y
Delay	6,579	veh-h/y	12	ped-h/y	7,906	pers-h/y
Effective Stops	1,153,317	veh/y	1,364	ped/y	1,385,344	pers/y
Travel Distance	1,070,124	veh-mi/y	38	ped-mi/y	1,284,186	pers-mi/y
Travel Time	39,080	veh-h/y	24	ped-h/y	46,920	pers-h/y
Cost	492,732	$/y	224	$/y	492,956	$/y
Fuel Consumption	38,720	gal/y				
Carbon Dioxide	345,123	kg/y				
Hydrocarbons	28	kg/y				
Carbon Monoxide	353	kg/y				
NOx	200	kg/y				

INTERSECTION SUMMARY

Site: Post @ Emerald PM

Post Rd. at Emerald Pkwy.
Signals - Pretimed Cycle Time = 70 seconds (Practical Cycle Time)

Intersection Performance - Hourly Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Travel Speed (Average)	27.4	mph	1.5	mph	26.8	mph
Travel Distance (Total)	2591.1	veh-mi/h	3.9	ped-mi/h	3113.3	pers-mi/h
Travel Time (Total)	94.5	veh-h/h	2.5	ped-h/h	116.0	pers-h/h
Demand Flows (Total)	4193	veh/h	163	ped/h	5032	pers/h
Percent Heavy Vehicles (Demand)	0.2	%				
Degree of Saturation	0.764		0.035			
Practical Spare Capacity	17.9	%				
Effective Intersection Capacity	5492	veh/h				
Control Delay (Total)	15.84	veh-h/h	1.21	ped-h/h	20.21	pers-h/h
Control Delay (Average)	13.6	sec	26.6	sec	14.5	sec
Control Delay (Worst Lane)	22.8	sec				
Control Delay (Worst Movement)	22.8	sec	26.6	sec	26.6	sec
Geometric Delay (Average)	0.0	sec				
Stop-Line Delay (Average)	13.6	sec				
Idling Time (Average)	9.8	sec				
Intersection Level of Service (LOS)	LOS B		LOS C			
95% Back of Queue - Vehicles (Worst Lane)	16.7	veh				
95% Back of Queue - Distance (Worst Lane)	420.3	ft				
Queue Storage Ratio (Worst Lane)	0.53					
Total Effective Stops	2925	veh/h	142	ped/h	3653	pers/h
Effective Stop Rate	0.70	per veh	0.87	per ped	0.73	per pers
Proportion Queued	0.77		0.87		0.80	
Performance Index	192.2		3.3		195.5	
Cost (Total)	1182.02	$/h	23.36	$/h	1205.39	$/h
Fuel Consumption (Total)	91.7	gal/h				
Carbon Dioxide (Total)	816.7	kg/h				
Hydrocarbons (Total)	0.067	kg/h				
Carbon Monoxide (Total)	0.841	kg/h				
NOx (Total)	0.306	kg/h				

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values						
Performance Measure	**Vehicles**		**Pedestrians**		**Persons**	
Demand Flows (Total)	2,012,631	veh/y	78,261	ped/y	2,415,157	pers/y
Delay	7,602	veh-h/y	579	ped-h/y	9,702	pers-h/y
Effective Stops	1,404,054	veh/y	68,354	ped/y	1,753,218	pers/y
Travel Distance	1,243,746	veh-mi/y	1,876	ped-mi/y	1,494,371	pers-mi/y
Travel Time	45,378	veh-h/y	1,219	ped-h/y	55,673	pers-h/y
Cost	567,371	$/y	11,214	$/y	578,585	$/y
Fuel Consumption	44,040	gal/y				
Carbon Dioxide	392,004	kg/y				
Hydrocarbons	32	kg/y				
Carbon Monoxide	404	kg/y				
NOx	147	kg/y				

APPENDIX D – LEVEL OF SERVICE SUMMARIES

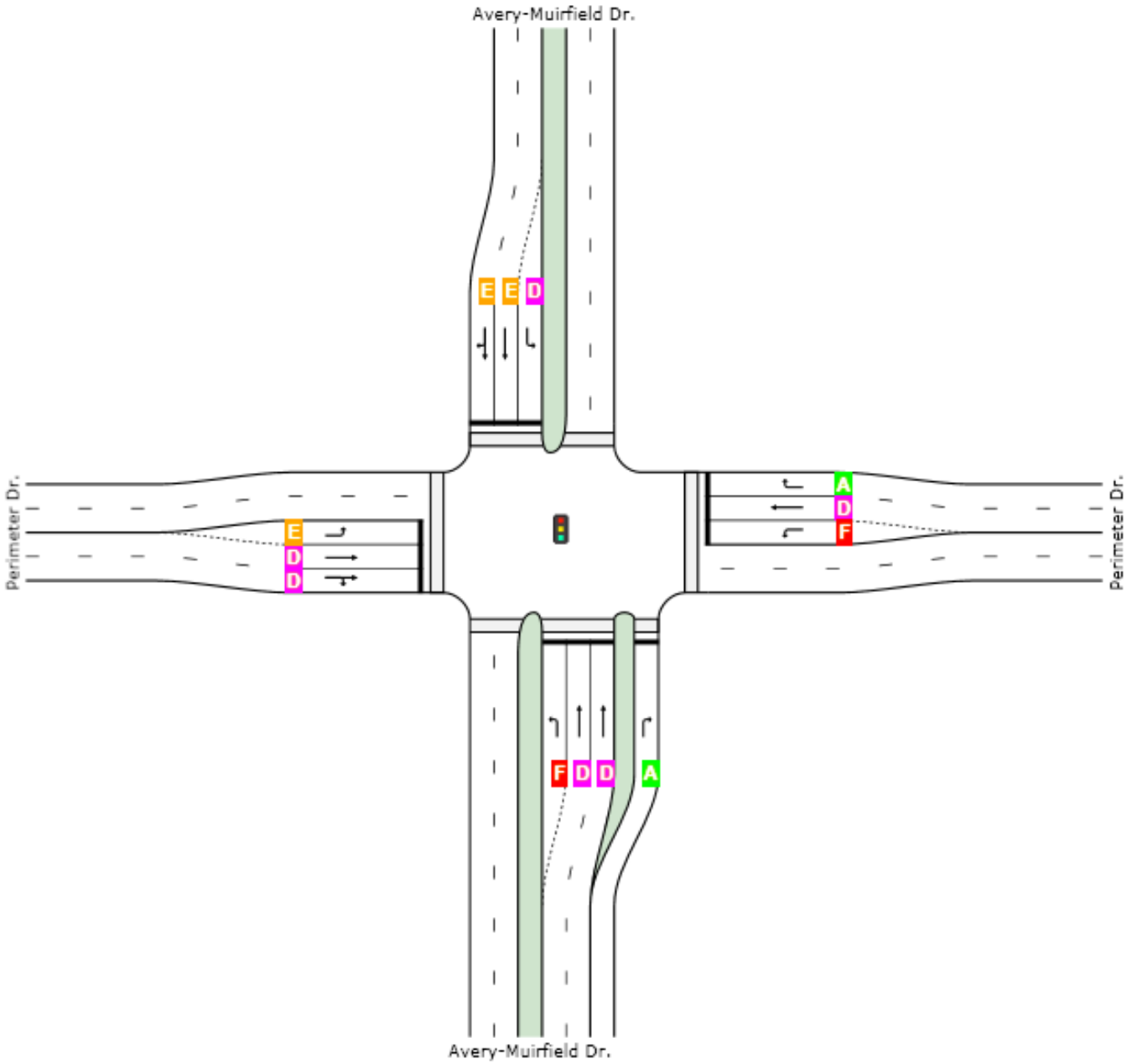
LEVEL OF SERVICE

Site: 1 Avery @ Perimeter AM

Avery Rd. and Perimeter Dr.
Signals - Pretimed Cycle Time = 140 seconds (Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

All Movement Classes

	South	East	North	West	Intersection
LOS	D	E	E	D	D



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

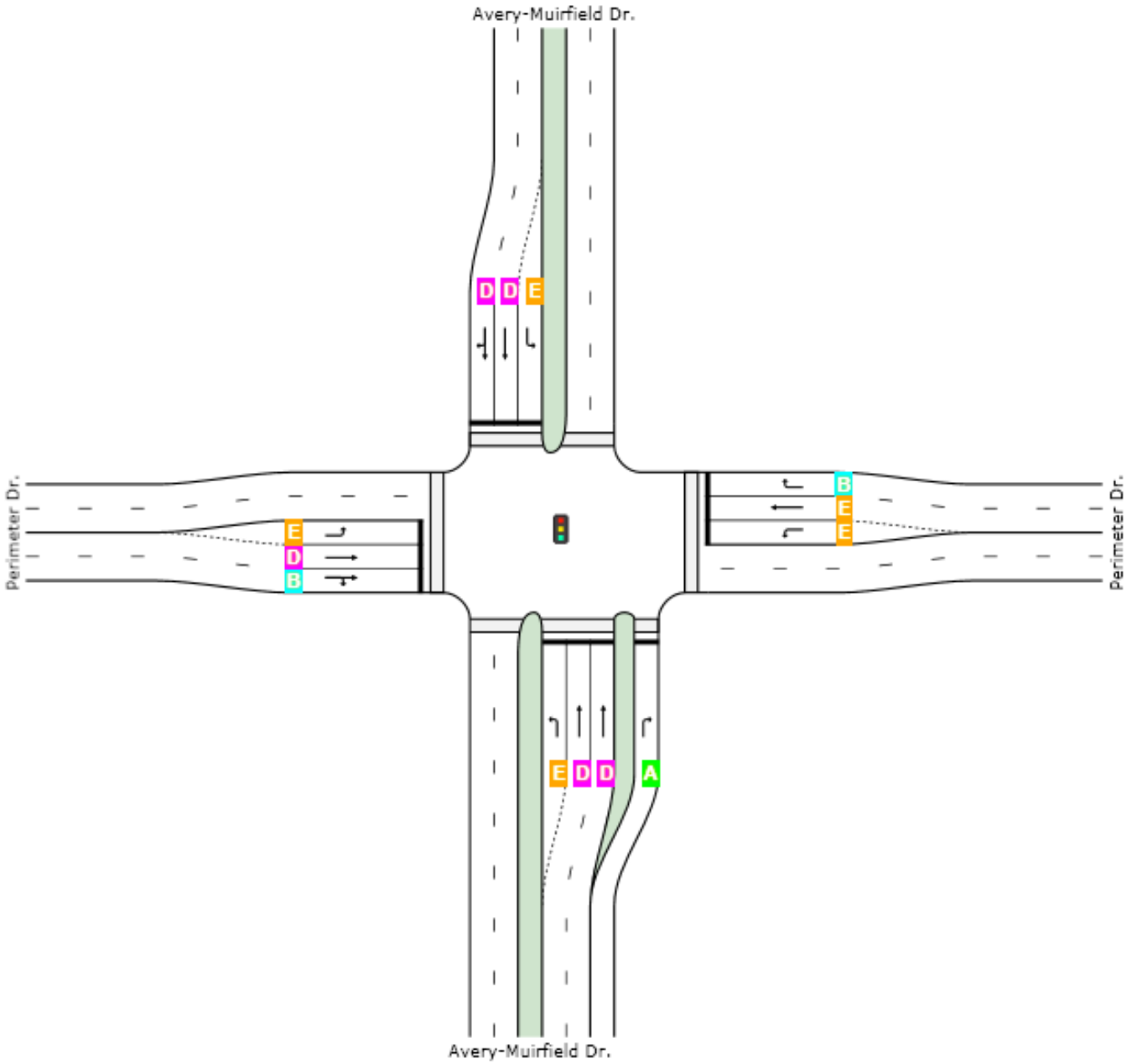
LEVEL OF SERVICE

Site: 1 Avery @ Perimeter PM

Avery Rd. and Perimeter Dr.
Signals - Pretimed Cycle Time = 125 seconds (Optimum Cycle Time - Minimum Delay)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

All Movement Classes

	South	East	North	West	Intersection
LOS	D	D	D	D	D



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

LEVEL OF SERVICE

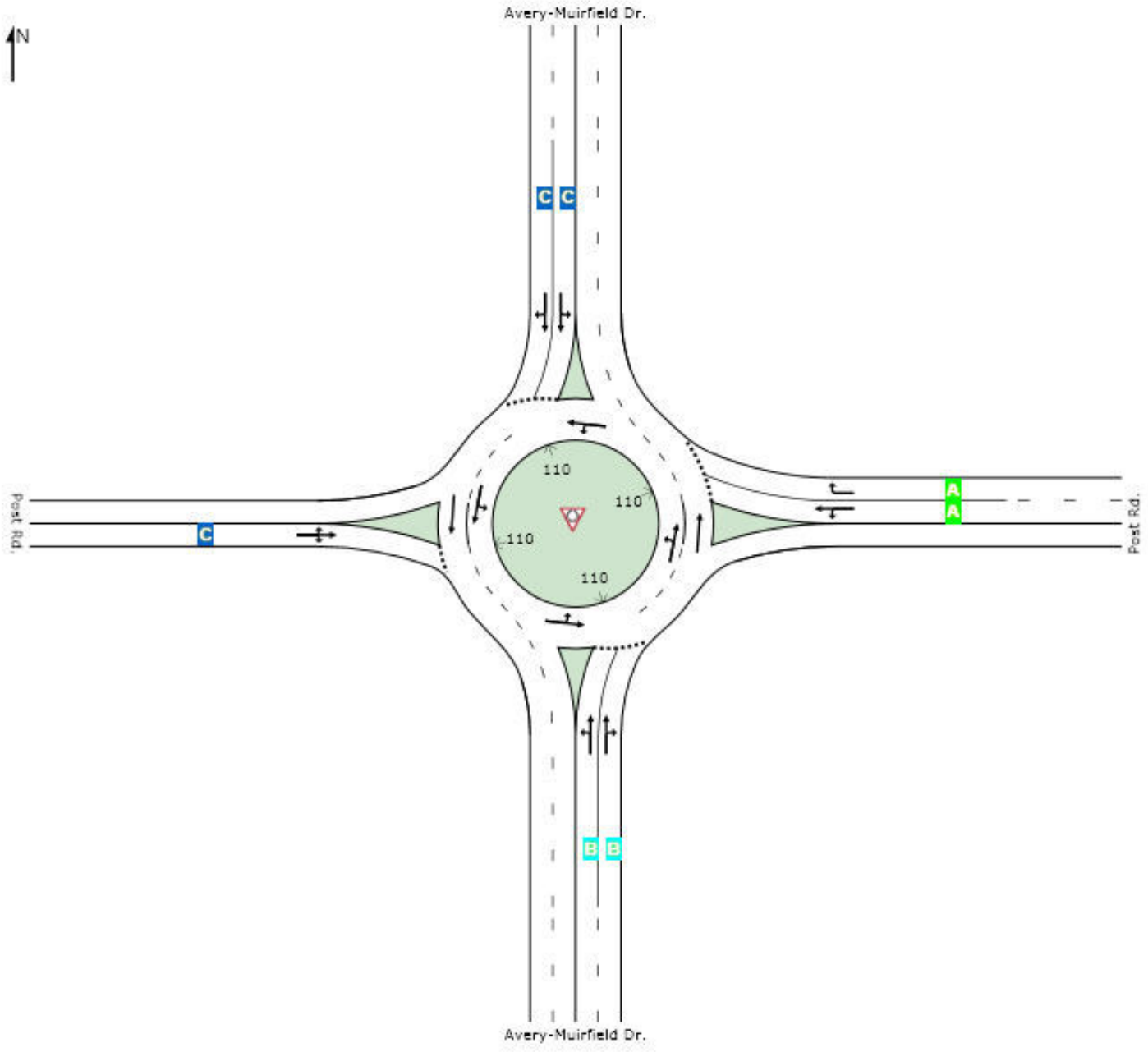
Site: 2 Post @ Avery-Muirfield AM

Post Rd. at Avery-Muirfield Dr.

Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	B	A	C	C	C



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

LEVEL OF SERVICE

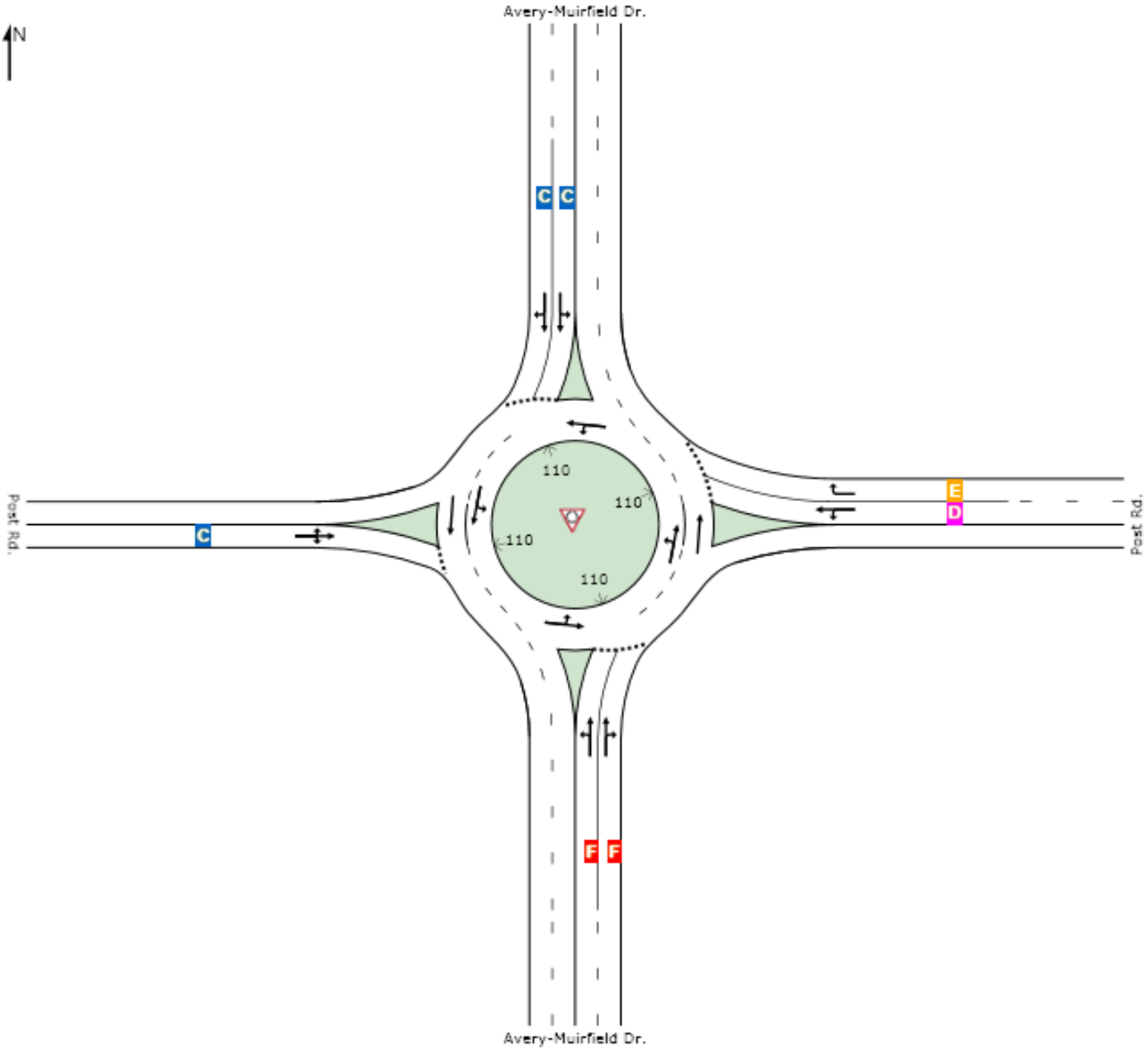
Site: 2 Post @ Avery-Muirfield PM

Post Rd. at Avery-Muirfield Dr.

Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	F	D	C	C	E



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

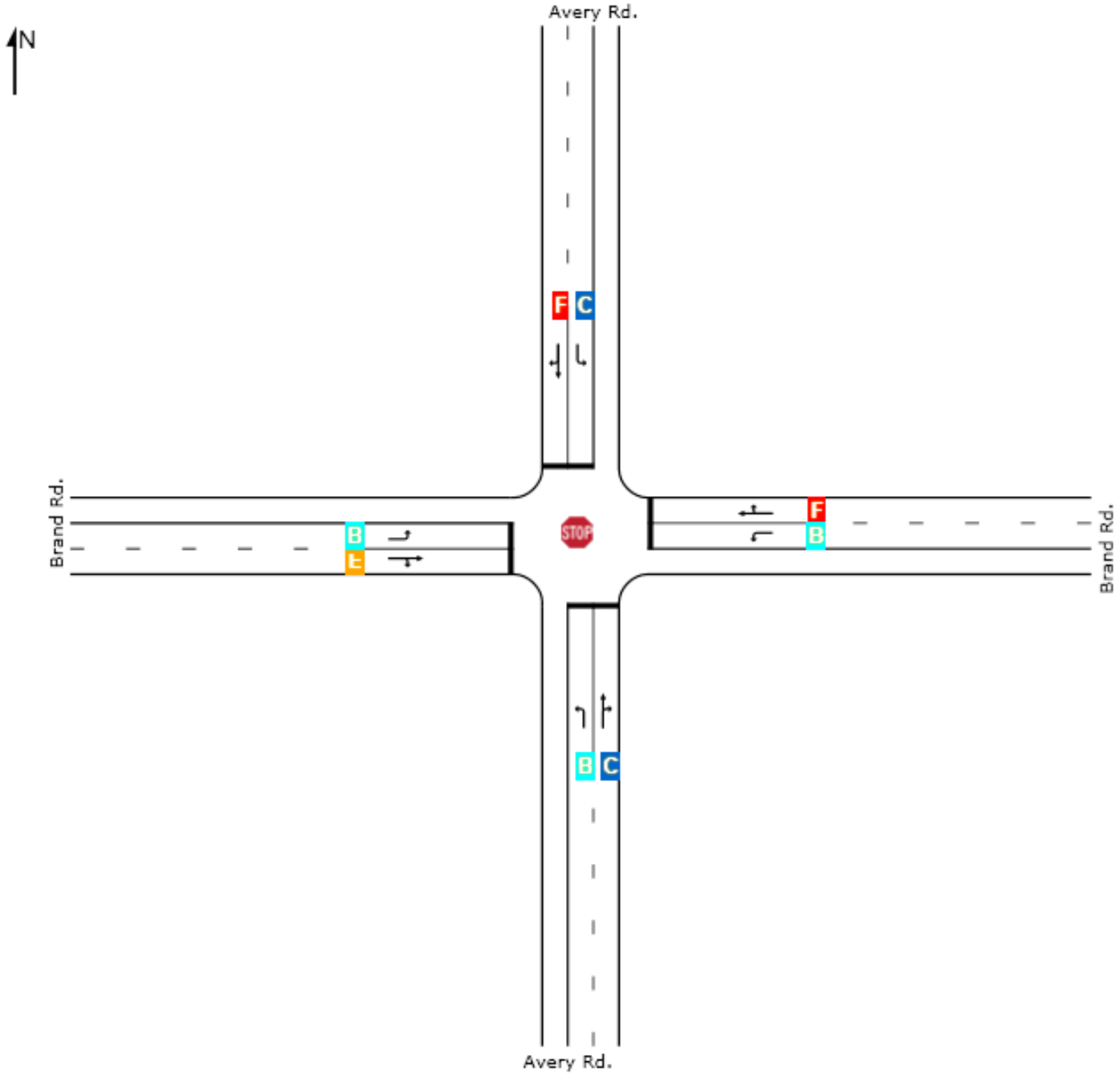
LEVEL OF SERVICE

Site: 3 Brand @ Avery AM

Brand Rd. @ Avery Rd.
Stop (All-Way)

All Movement Classes

	South	East	North	West	Intersection
LOS	C	F	F	D	E



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

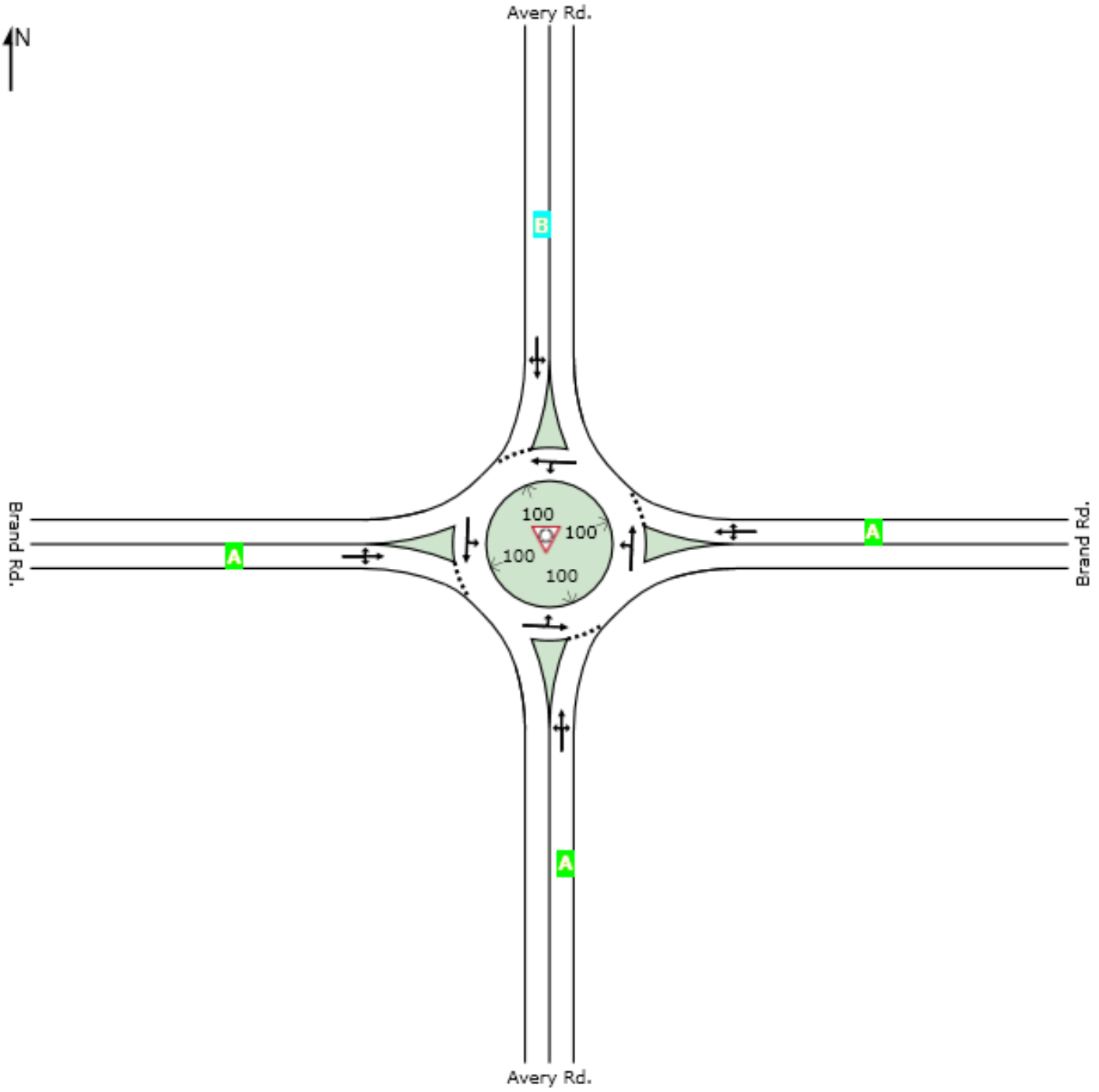
LEVEL OF SERVICE

Site: 3 Brand @ Avery AM - Conversion

Brand Rd. @ Avery Rd.
Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	A	A	B	A	A



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.

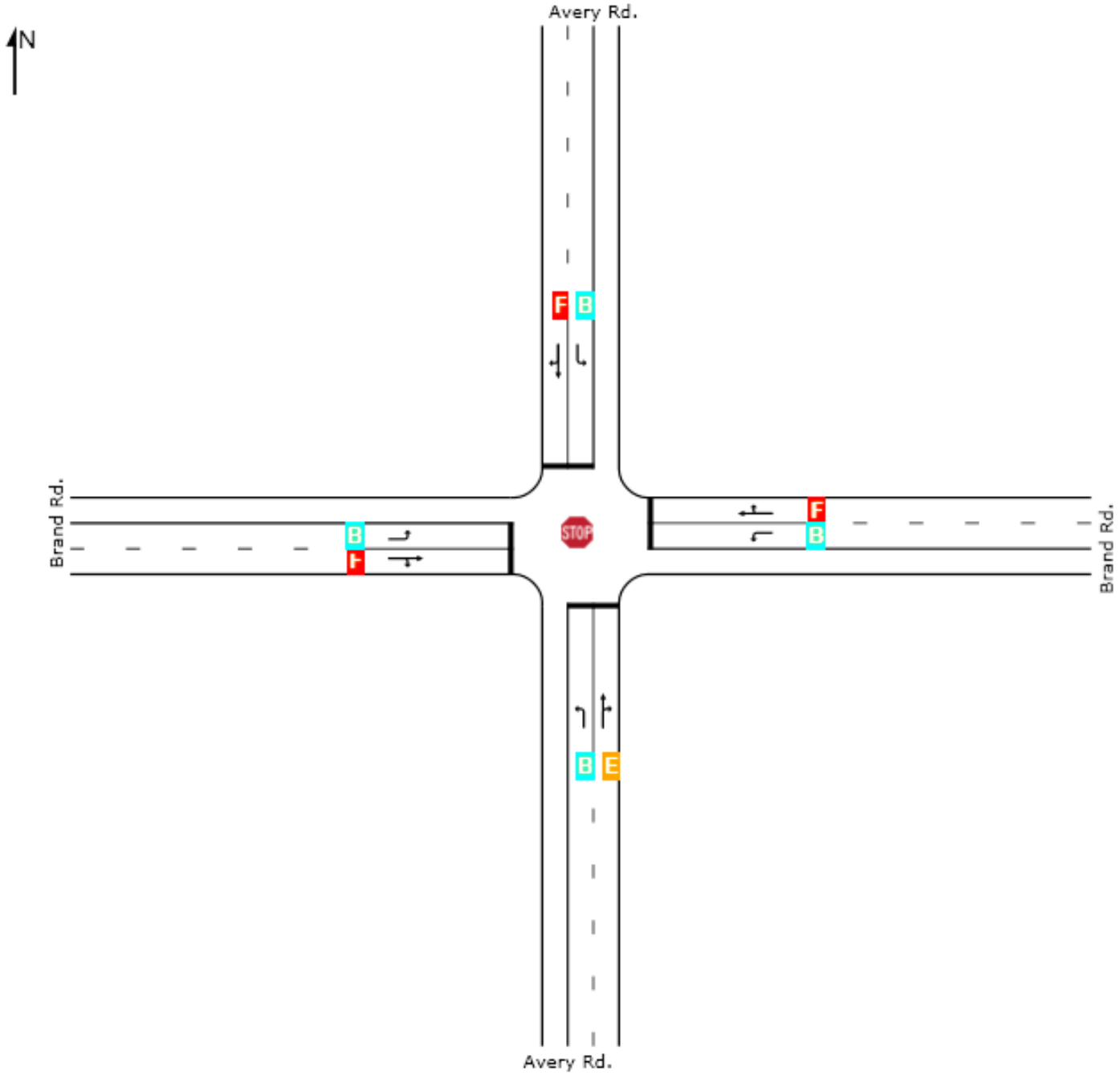
LEVEL OF SERVICE

Site: 3 Brand @ Avery PM

Brand Rd. @ Avery Rd.
Stop (All-Way)

All Movement Classes

	South	East	North	West	Intersection
LOS	D	F	F	E	E



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

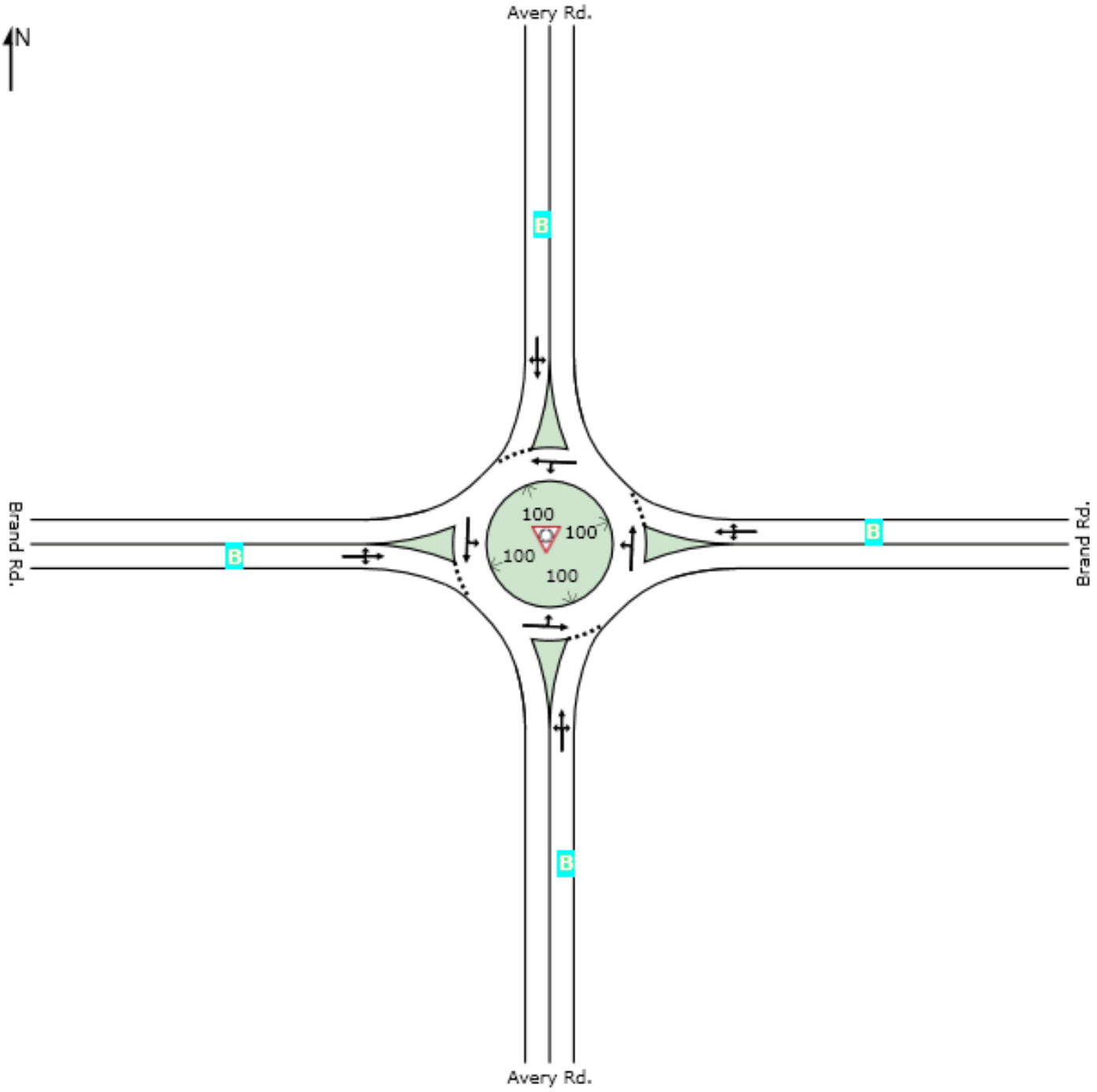
LEVEL OF SERVICE

Site: 3 Brand @ Avery PM - Conversion

Brand Rd. @ Avery Rd.
Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	B	B	B	B	B



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.

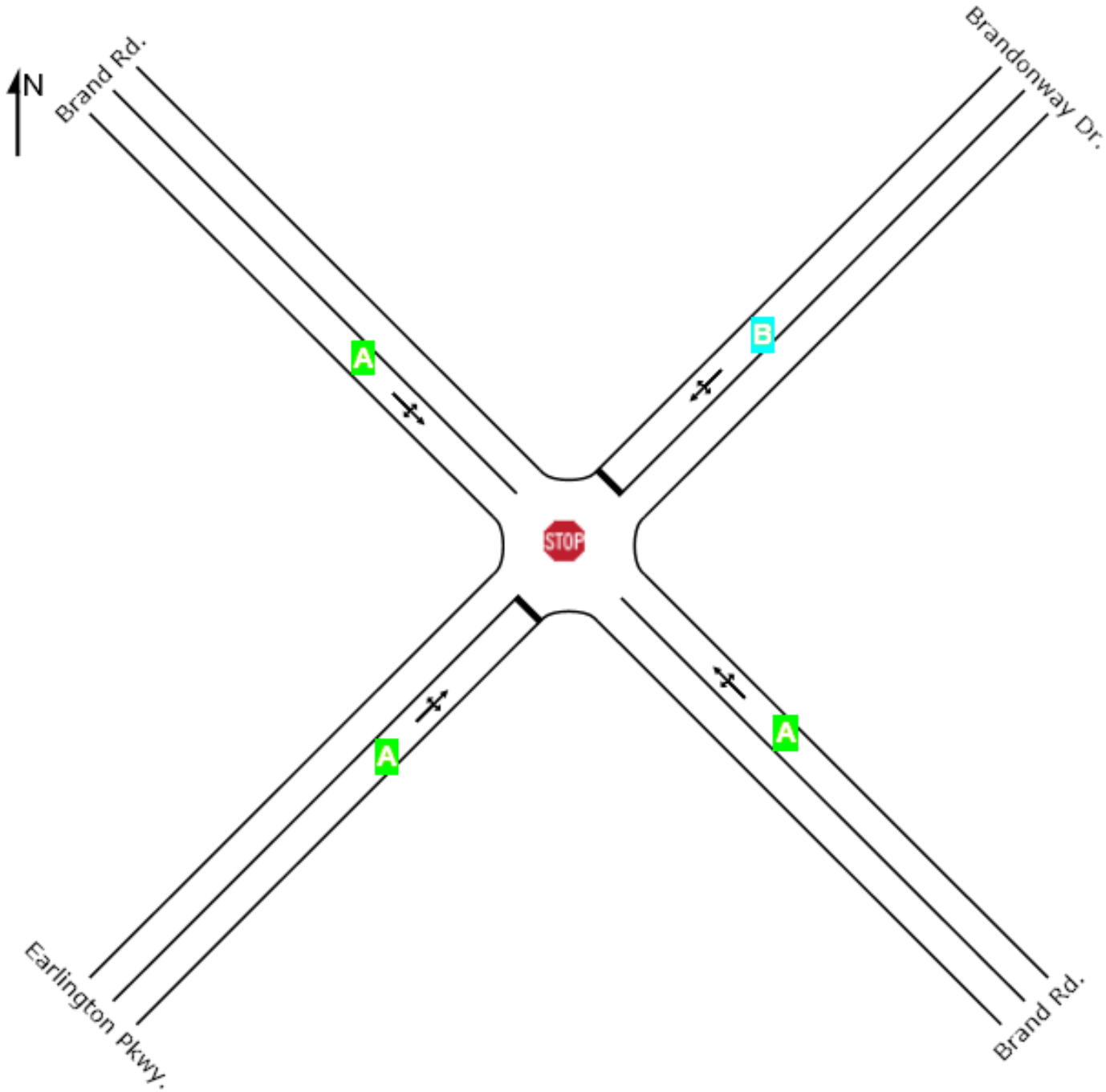
LEVEL OF SERVICE

Site: 4 Brand @ Brandonway AM

Brand Rd. @ Earlington Pkwy / Brandonway Dr.
Stop (Two-Way)

All Movement Classes

	Southeast	Northeast	Northwest	Southwest	Intersection
LOS	NA	B	NA	A	NA



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Minor Road Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).

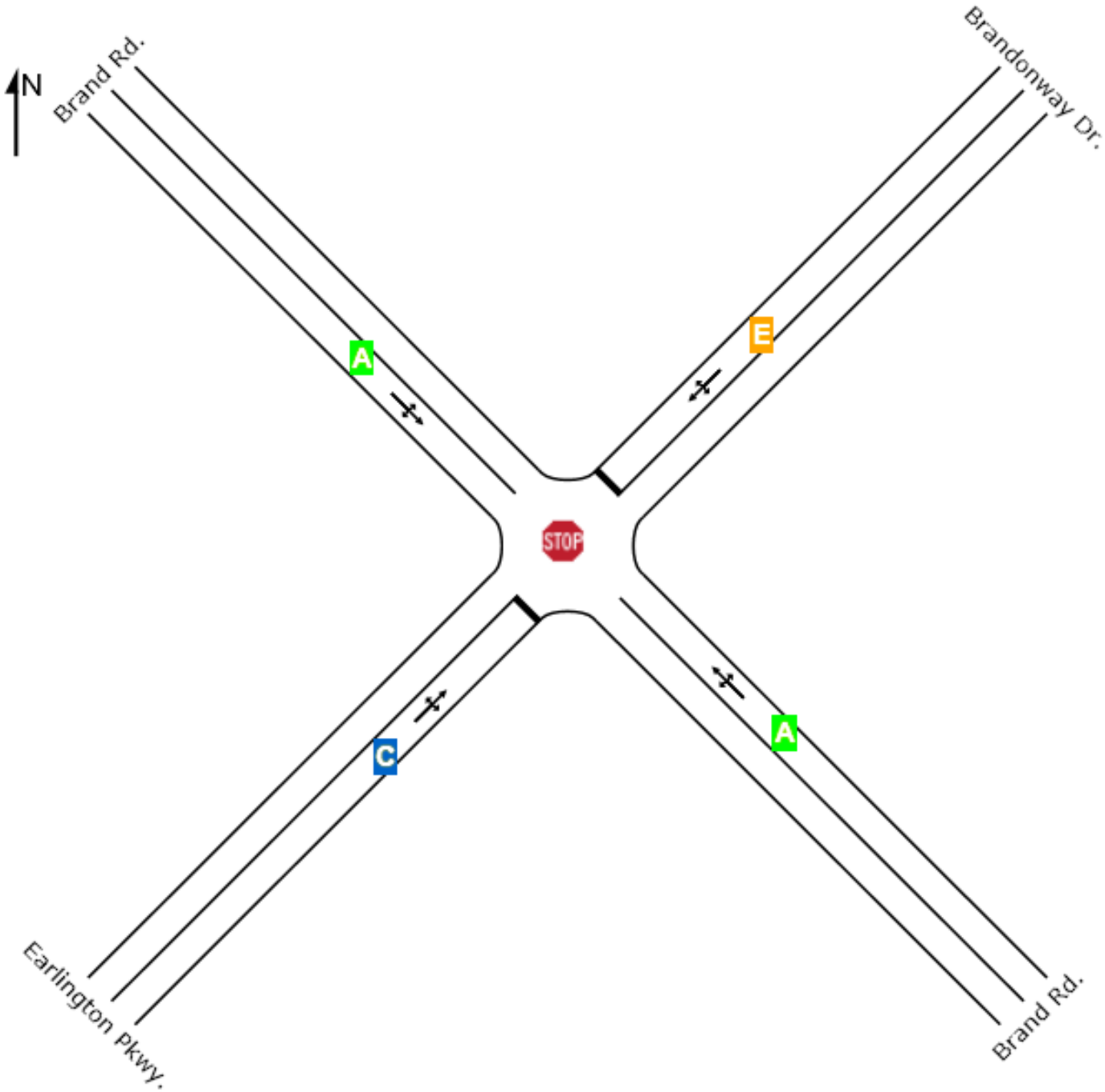
LEVEL OF SERVICE

Site: 4 Brand @ Brandonway PM

Brand Rd. @ Earlington Pkwy / Brandonway Dr.
Stop (Two-Way)

All Movement Classes

	Southeast	Northeast	Northwest	Southwest	Intersection
LOS	NA	E	NA	C	NA



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Minor Road Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).

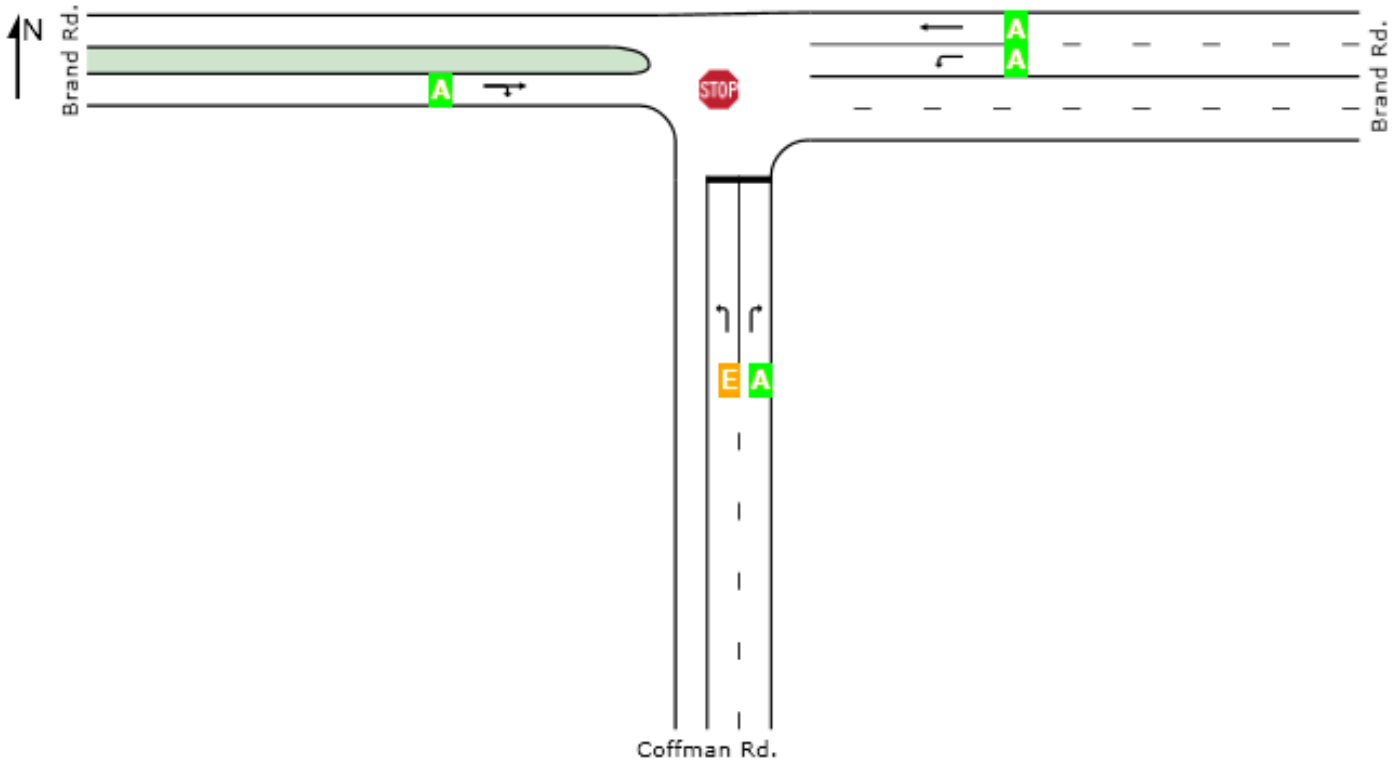
LEVEL OF SERVICE

Site: 5 Brand @ Coffman AM (RDBT NOW)

Brand Rd. @ Coffman Rd.
Stop (Two-Way)

All Movement Classes

	South	East	West	Intersection
LOS	D	NA	NA	NA



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Minor Road Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

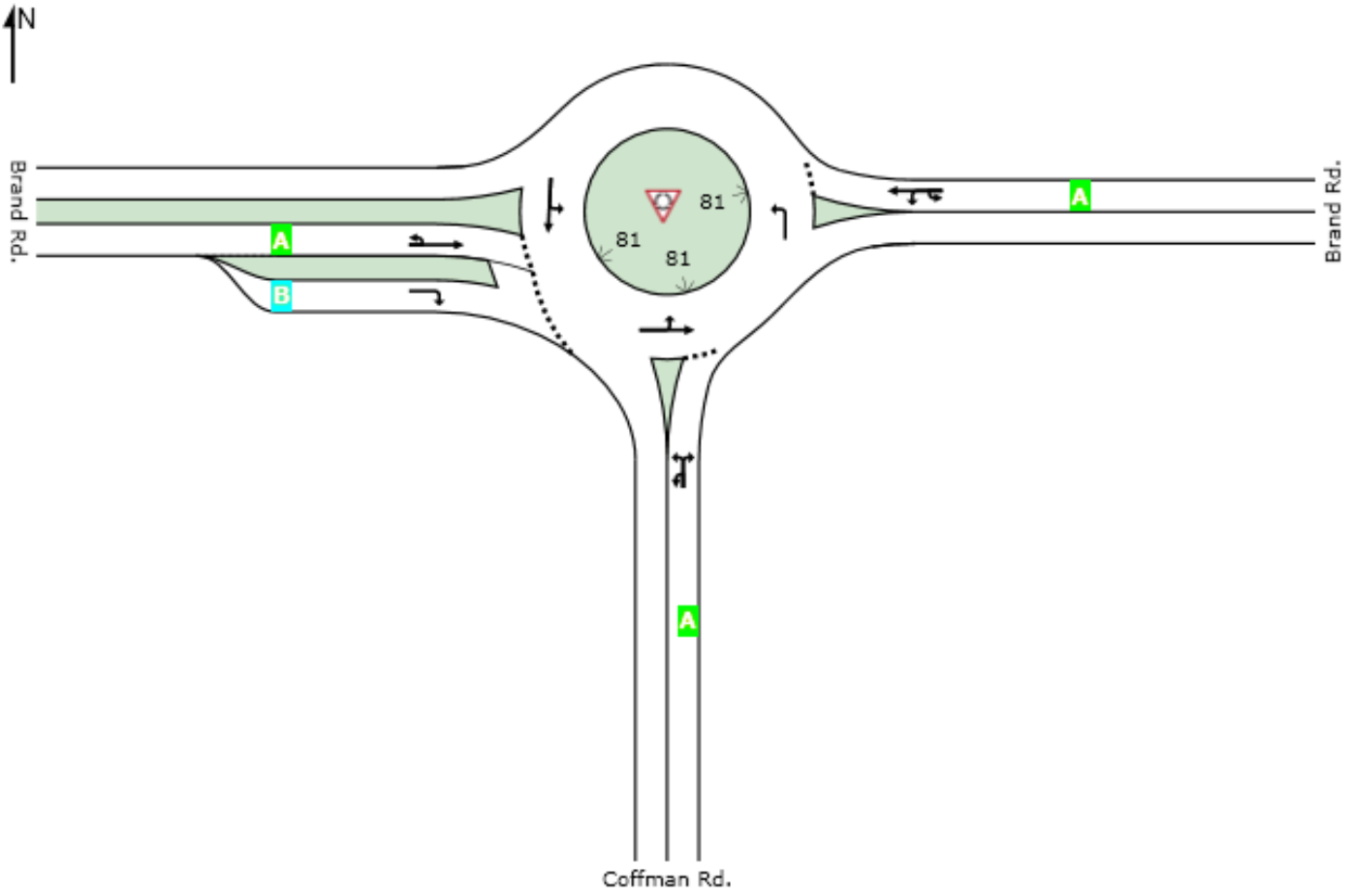
LEVEL OF SERVICE

Site: 5 Brand @ Coffman AM

Brand Rd. and Coffman Rd.
Roundabout

All Movement Classes

	South	East	West	Intersection
LOS	A	A	B	B



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

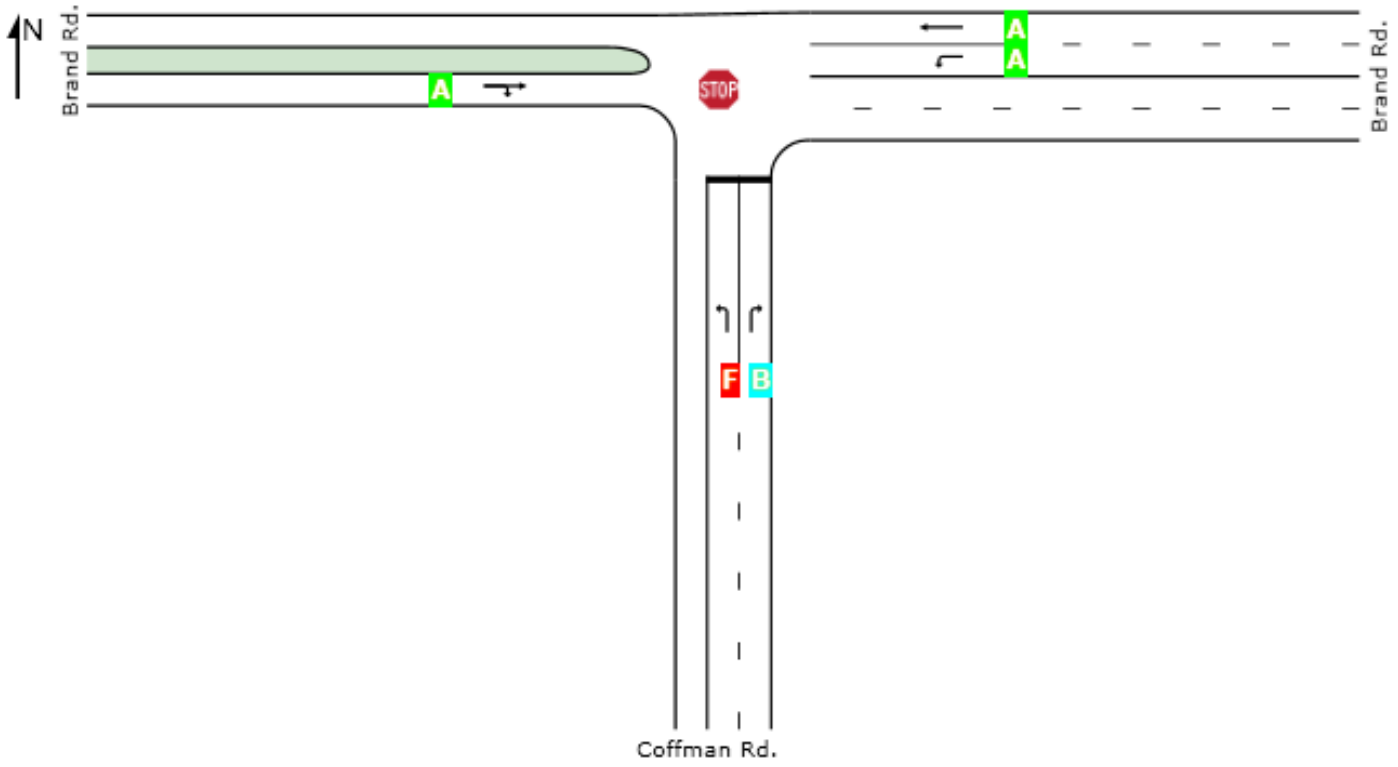
LEVEL OF SERVICE

Site: 5 Brand @ Coffman PM (RDBT NOW)

Brand Rd. @ Coffman Rd.
Stop (Two-Way)

All Movement Classes

	South	East	West	Intersection
LOS	F	NA	NA	NA



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Minor Road Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

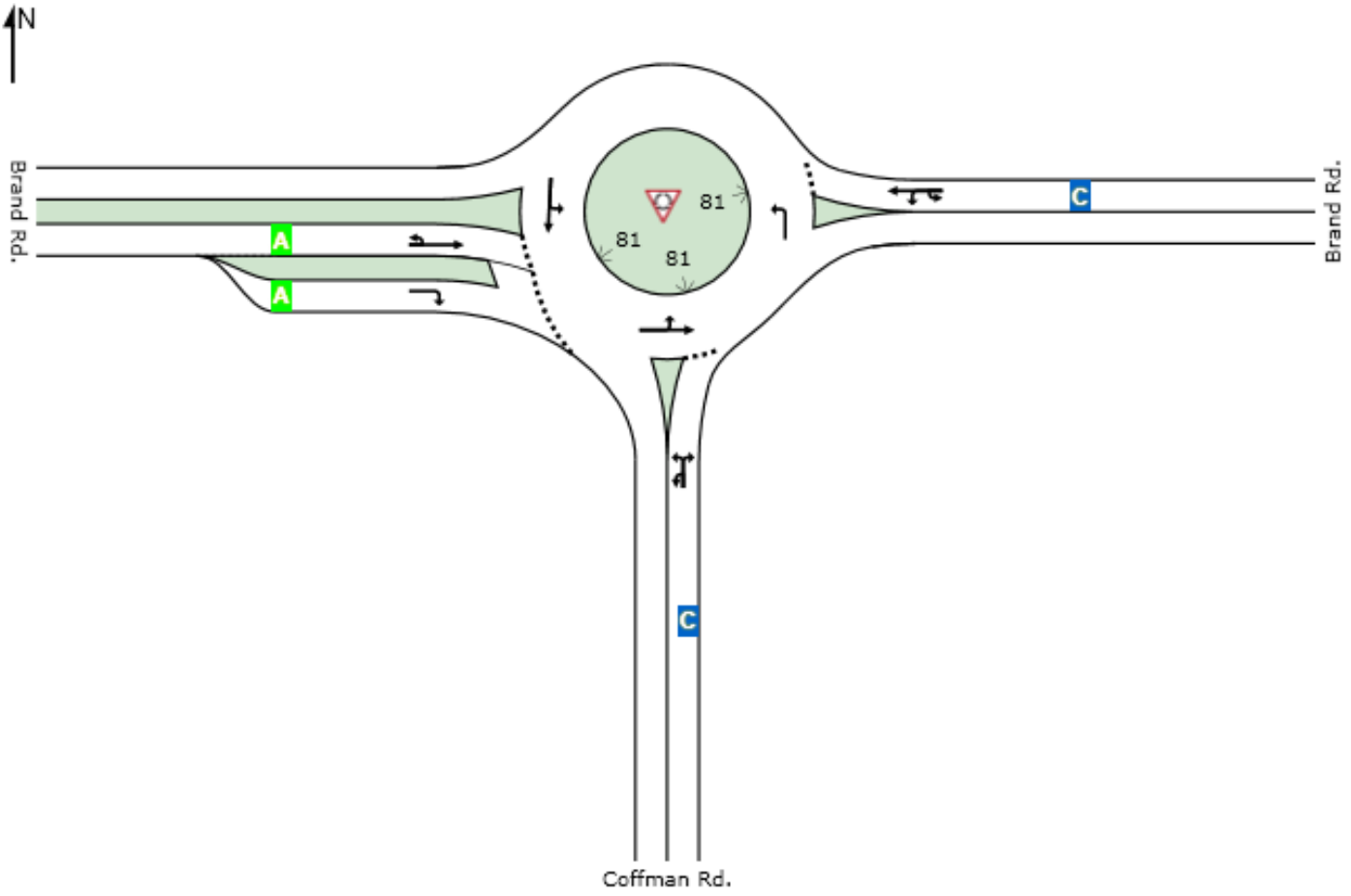
LEVEL OF SERVICE

Site: 5 Brand @ Coffman PM

Brand Rd. and Coffman Rd.
Roundabout

All Movement Classes

	South	East	West	Intersection
LOS	C	C	A	C



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

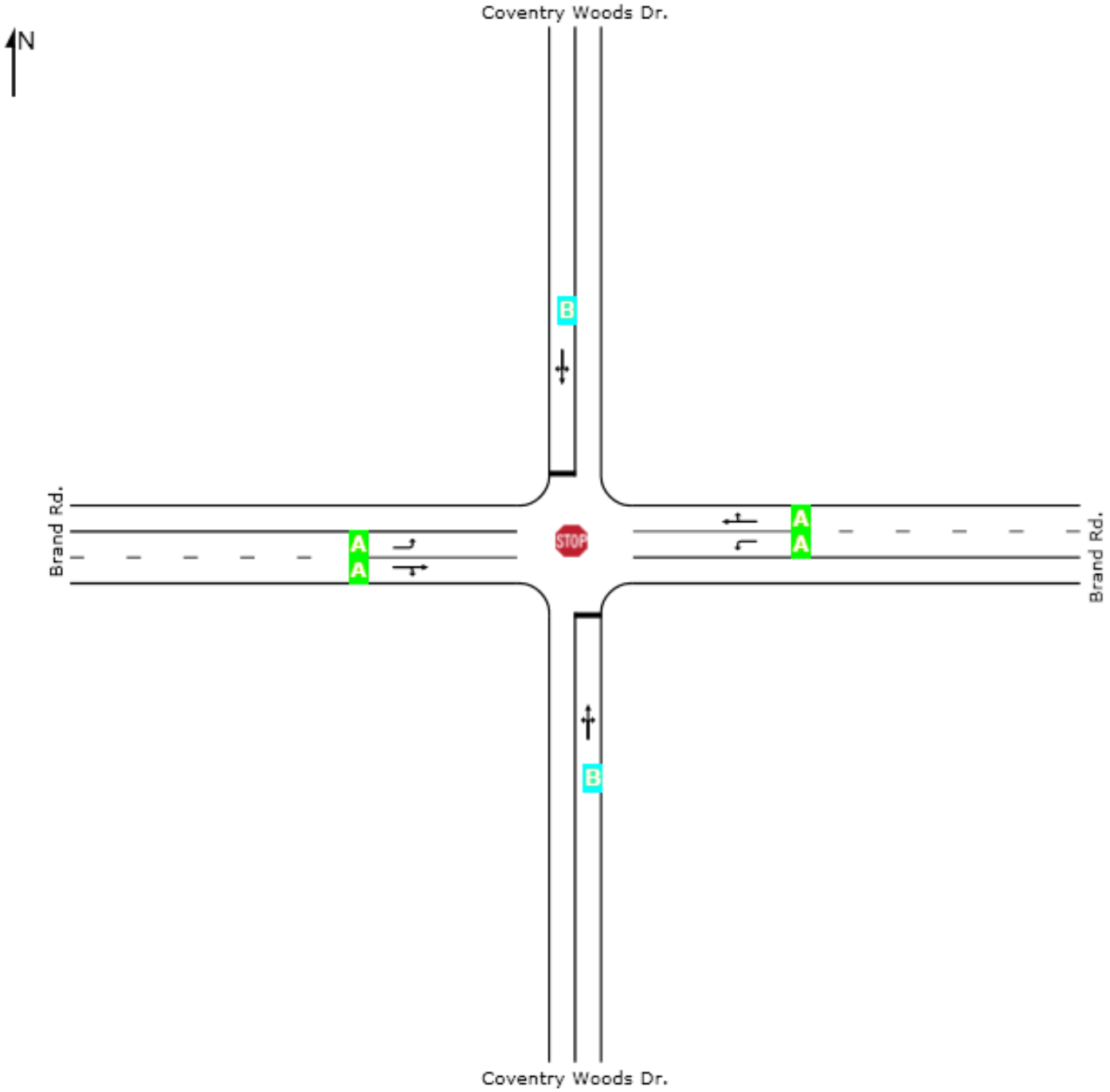
LEVEL OF SERVICE

Site: 6 Brand @ Coventry Woods AM

Brand Rd. @ Coventry Dr.
Stop (Two-Way)

All Movement Classes

	South	East	North	West	Intersection
LOS	B	NA	B	NA	NA



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Minor Road Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).

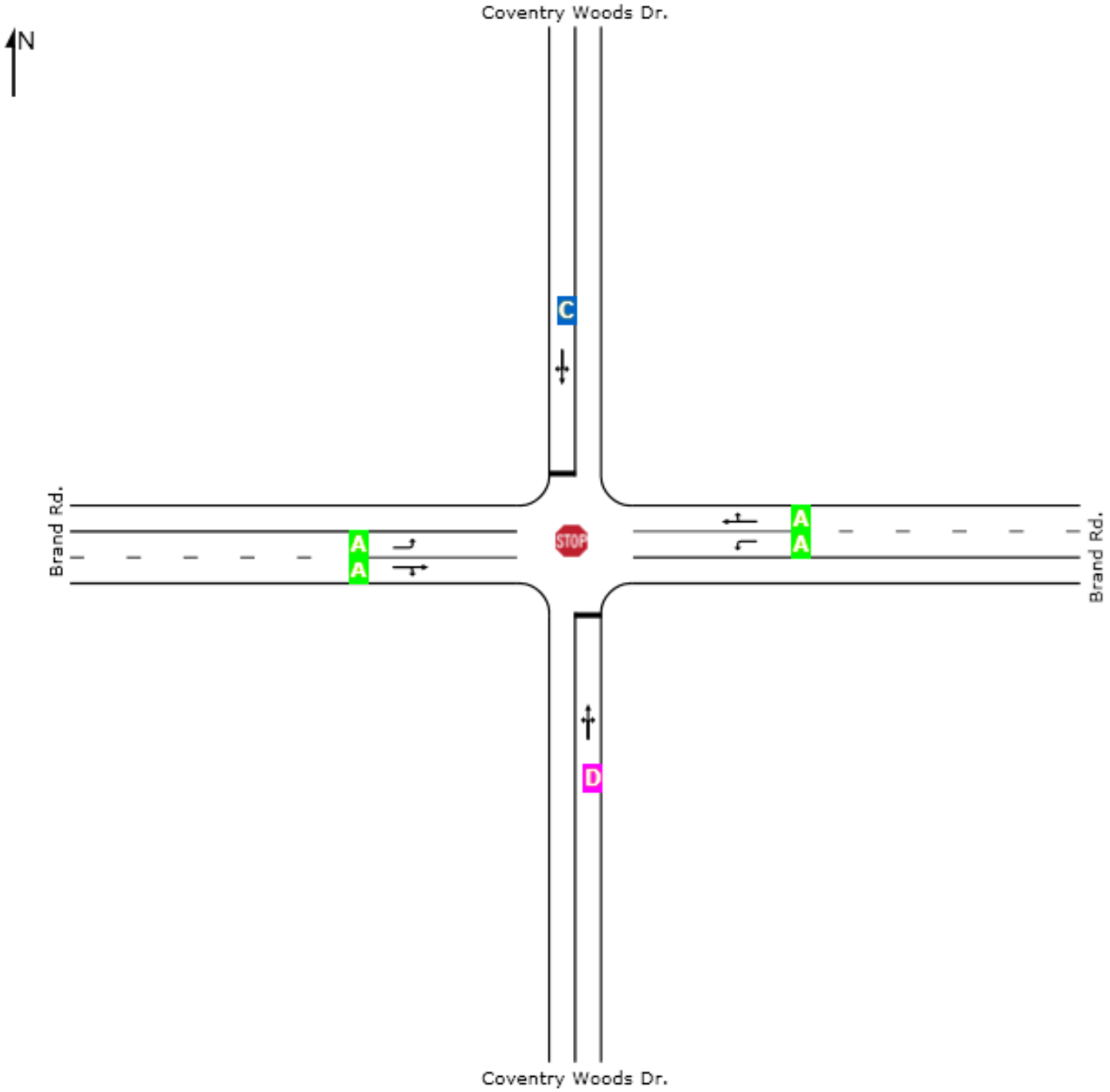
LEVEL OF SERVICE

Site: 6 Brand @ Coventry Woods PM

Brand Rd. @ Coventry Dr.
Stop (Two-Way)

All Movement Classes

	South	East	North	West	Intersection
LOS	D	NA	C	NA	NA



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Minor Road Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).

LEVEL OF SERVICE

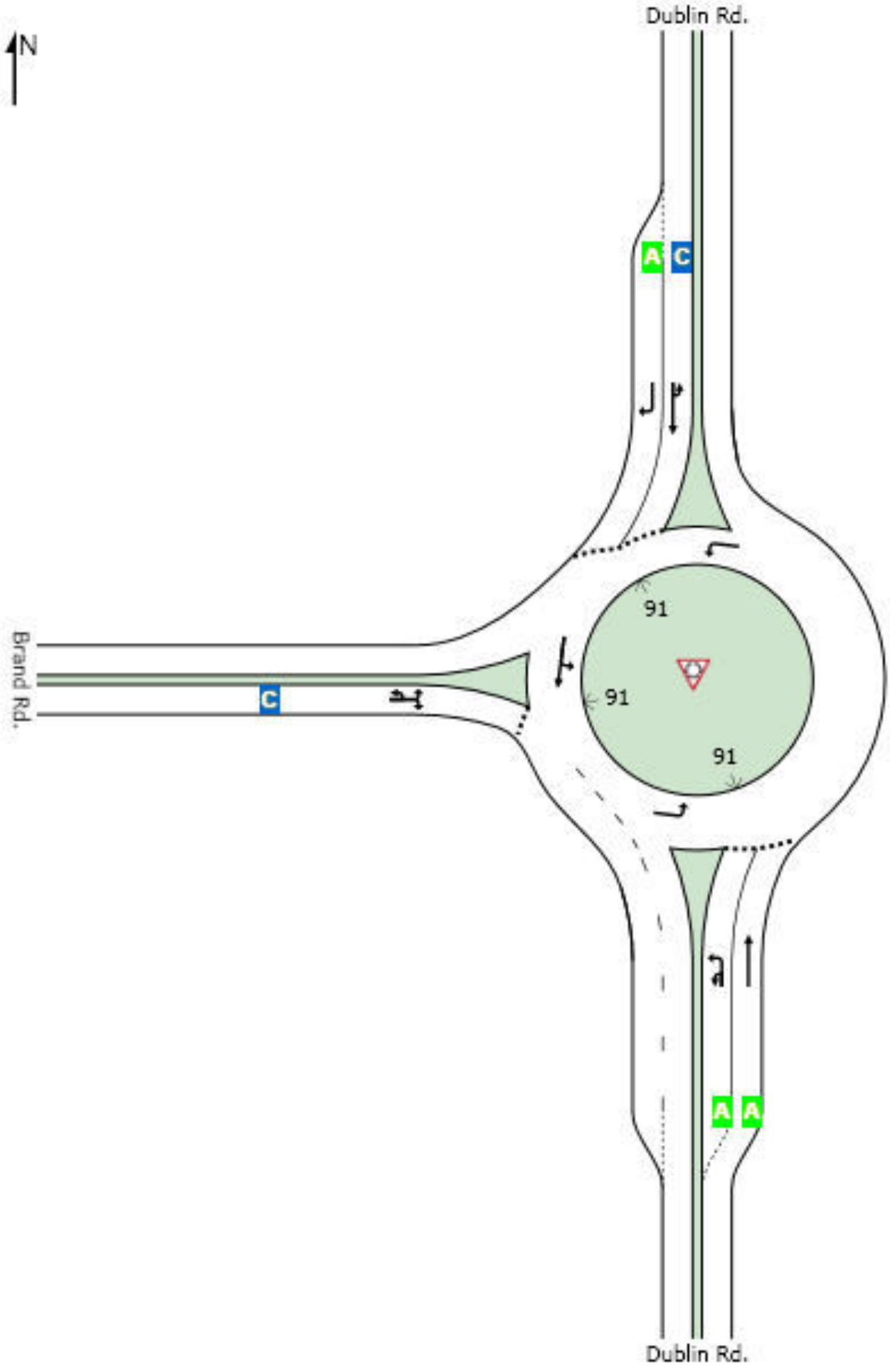
Site: 7 Brand @ Dublin AM

Brand Rd. at Dublin Rd.

Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	A	B	C	B


N
Dublin Rd.
A
C
91
91
91
Brand Rd.
C
A
A
Dublin Rd.

LEVEL OF SERVICE

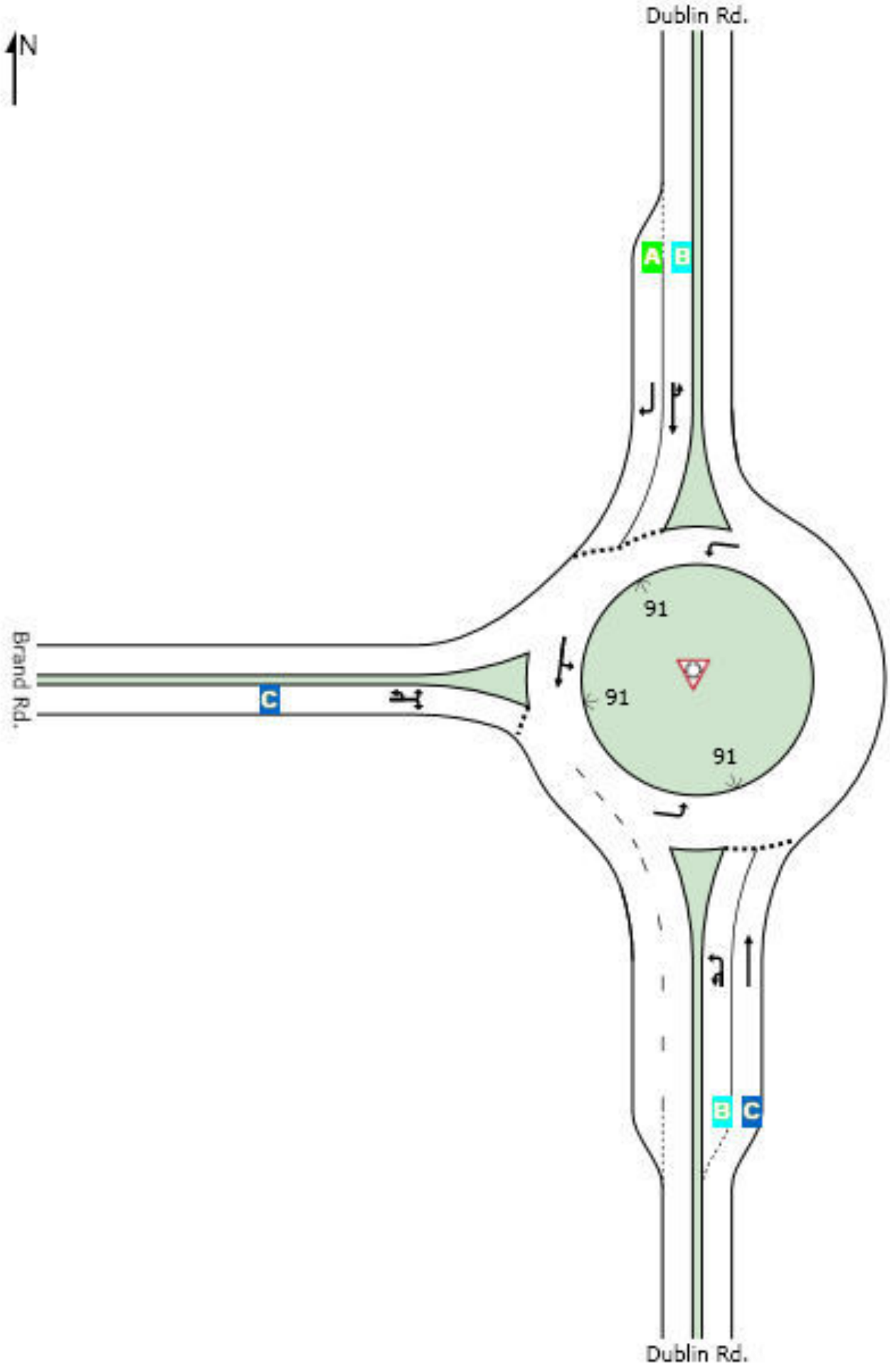
Site: 7 Brand @ Dublin PM

Brand Rd. at Dublin Rd.

Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	C	A	C	B


N
Dublin Rd.
A
B
91
91
91
Brand Rd.
C
B
C
Dublin Rd.

LEVEL OF SERVICE

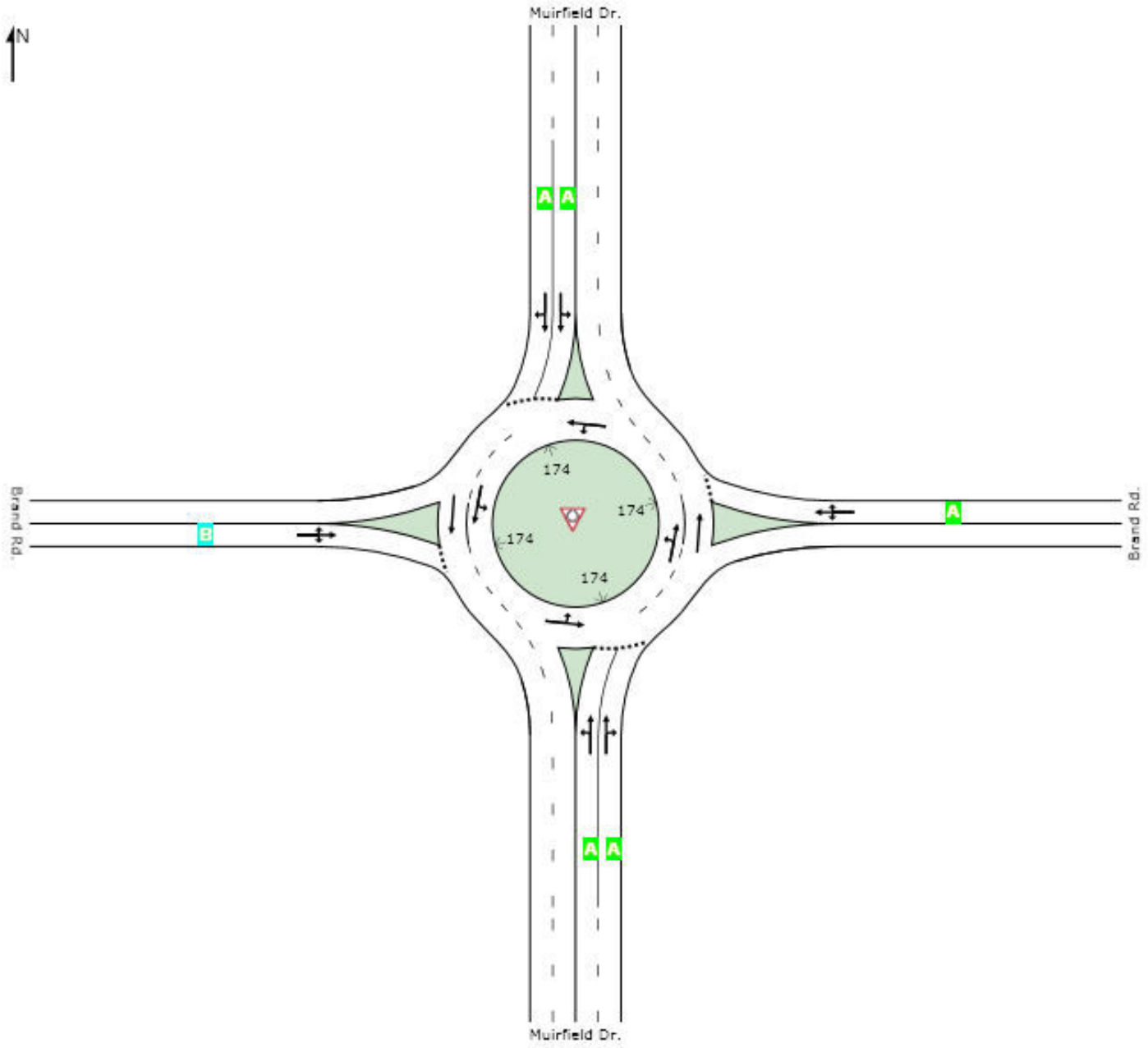
Site: 8 Brand @ Muirfield AM

Brand Rd. at Muirfield Dr.

Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	A	A	A	B	A



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

LEVEL OF SERVICE

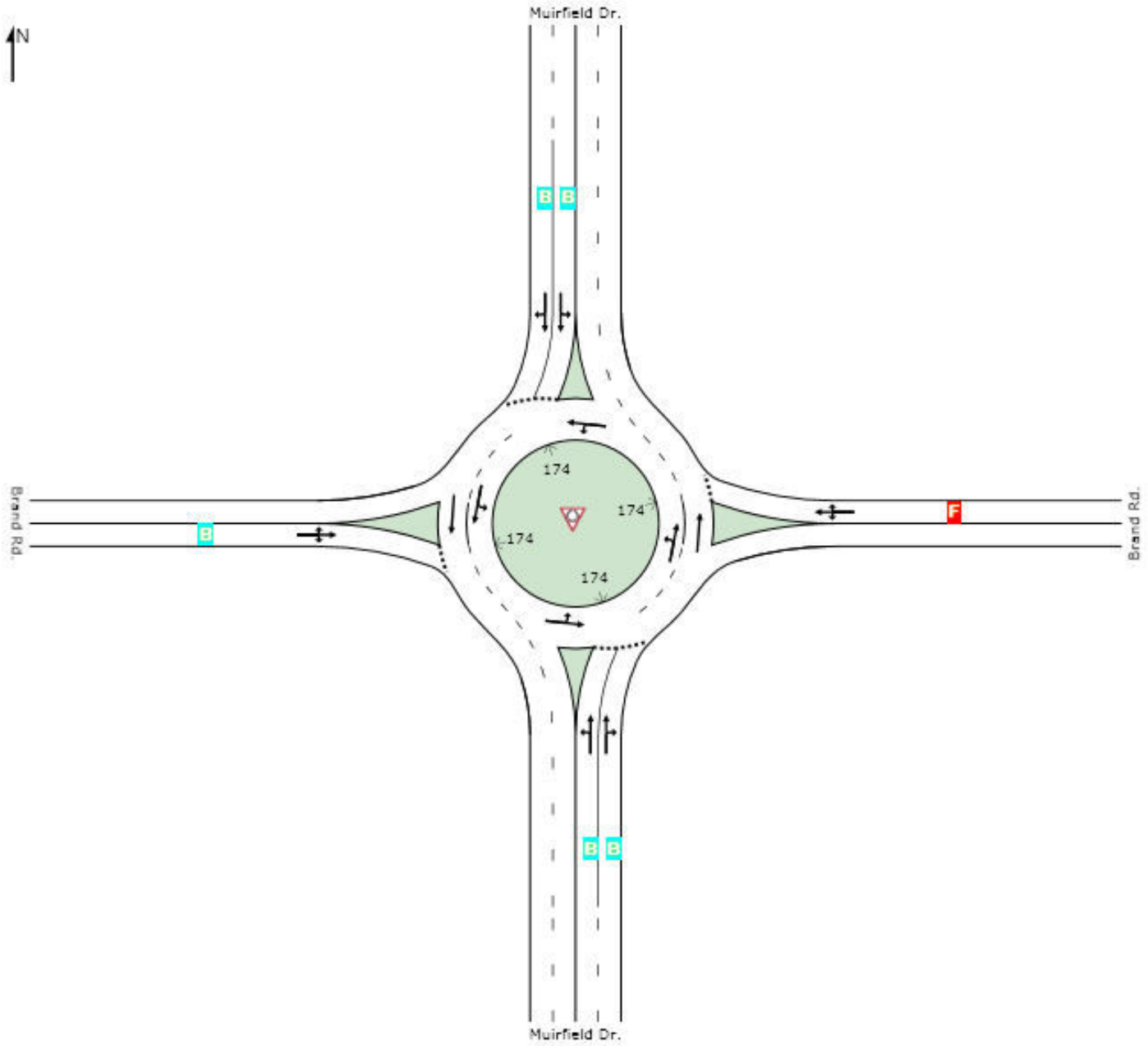
Site: 8 Brand @ Muirfield PM

Brand Rd. at Muirfield Dr.

Roundabout

All Movement Classes

	South	East	North	West	Intersection
LOS	B	F	B	B	C



Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 2010).
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

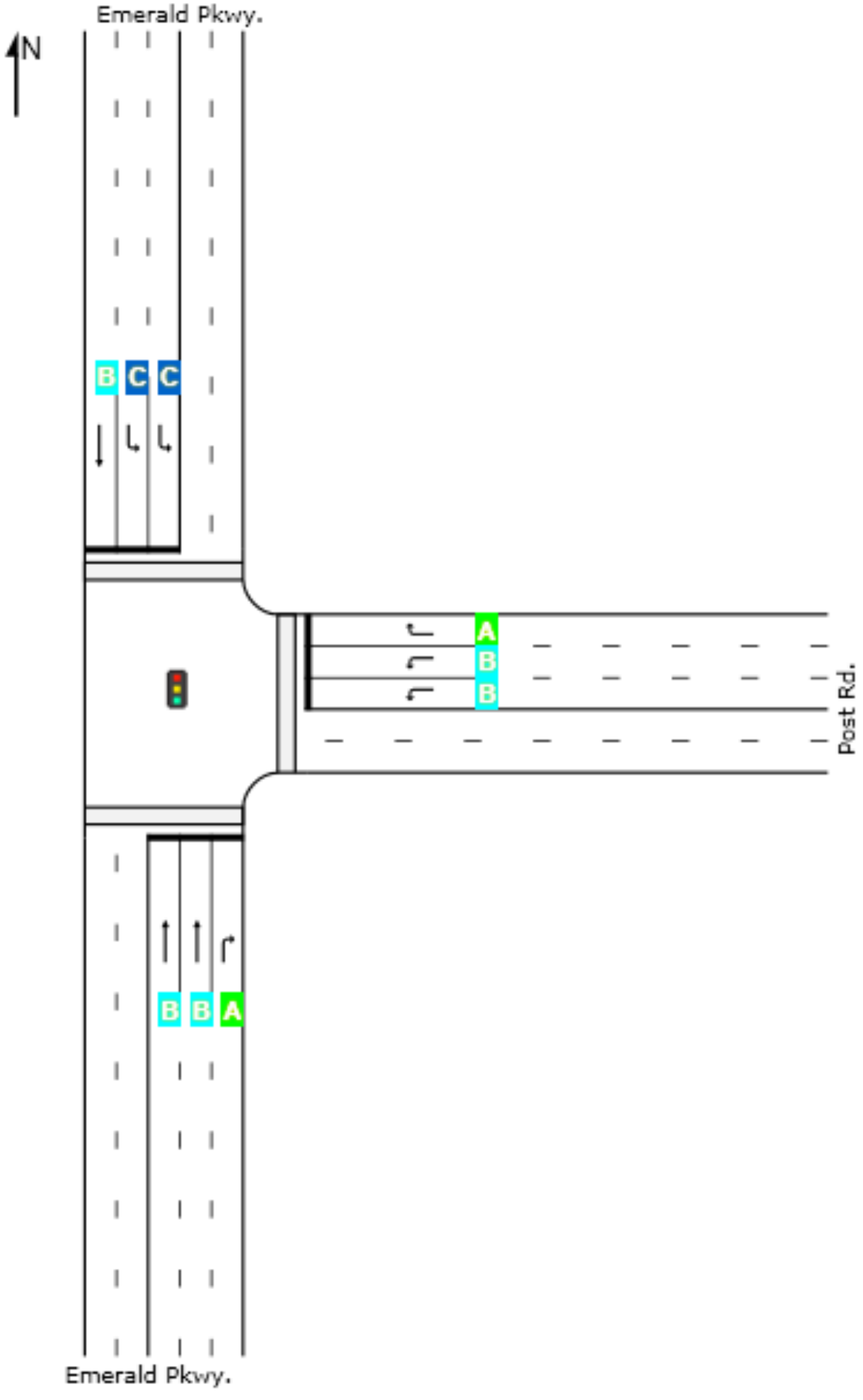
LEVEL OF SERVICE

Site: 9 Post @ Emerald AM

Post Rd. at Emerald Pkwy.
Signals - Pretimed Cycle Time = 70 seconds (Practical Cycle Time)

All Movement Classes

	South	East	North	Intersection
LOS	B	A	B	B


Emerald Pkwy.
N
B
C
C
A
B
B
Post Rd.
B
B
A
Emerald Pkwy.

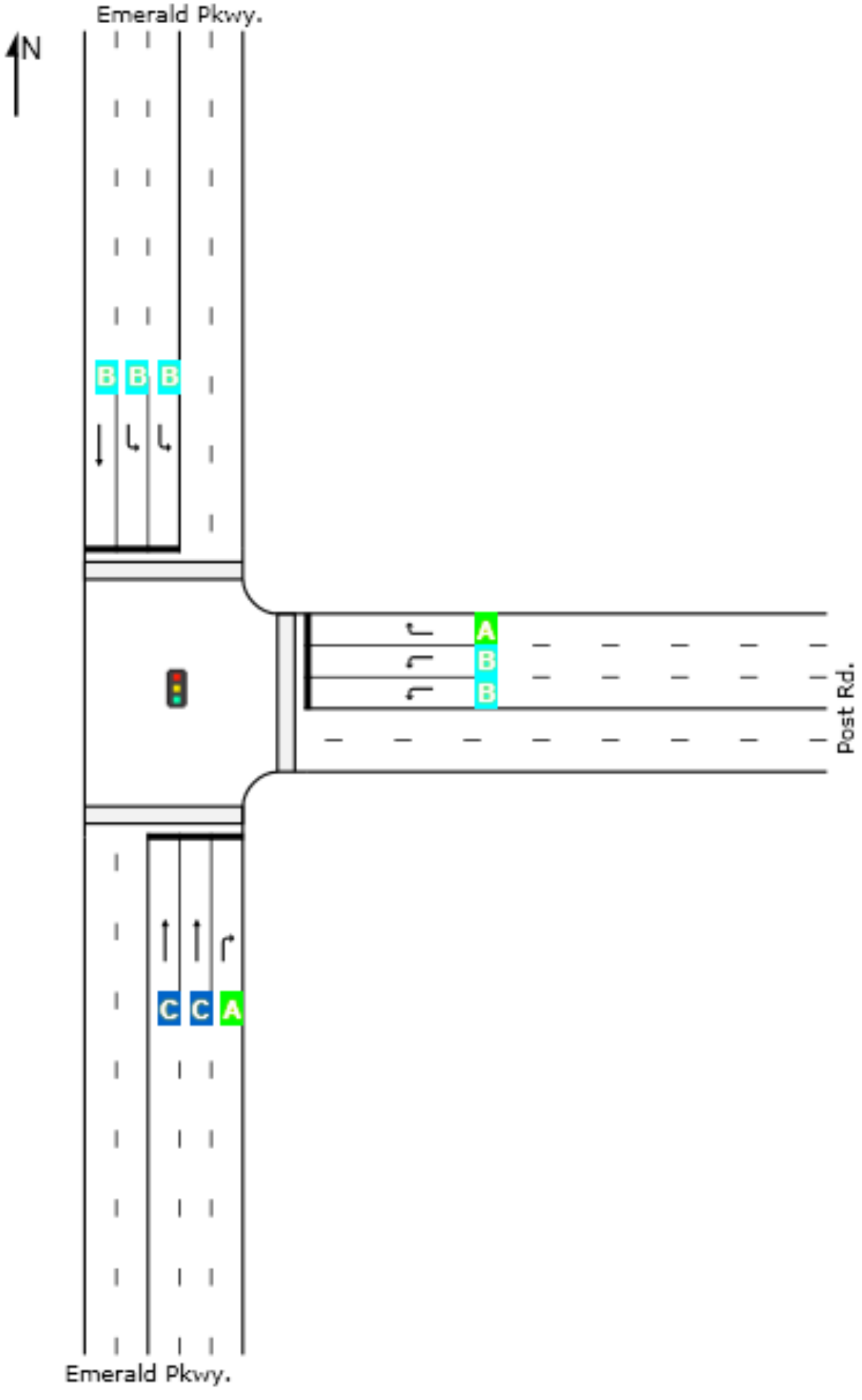
LEVEL OF SERVICE

Site: 9 Post @ Emerald PM

Post Rd. at Emerald Pkwy.
Signals - Pretimed Cycle Time = 70 seconds (Practical Cycle Time)

All Movement Classes

	South	East	North	Intersection
LOS	B	B	B	B


Emerald Pkwy.
N
B
B
B
A
B
B
Post Rd.
C
C
A
Emerald Pkwy.