

**Avery-Muirfield Drive
North Corridor Study**
☘ **City of Dublin, Ohio**

May 2012



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In 2005 the Avery-Muirfield Drive corridor between US 33 and Post Road was analyzed to determine the existing operational efficiency, future operational deficiencies and the best/most appropriate long-term operational solutions for the corridor. The analysis determined that the preferred solution for the intersections of Avery-Muirfield Drive with Perimeter Loop Road/Hospital Drive, Perimeter Drive, and Post Road was 3-lane roundabouts. At that time it was determined that two-lane roundabouts would initially be installed and expanded to 3-lanes in the future when needed.

The purpose of this report is to update the 2005 analysis with current traffic volumes and future year traffic projections and determine if the 2005 results need to be modified if they are not valid. The 2005 two-lane roundabout layout will be updated to reflect any modifications recommended in this report.

Study Area

The study area is Avery-Muirfield Drive from the WB US-33/SR 161 ramp intersection through the intersection of Post Road. In addition, the driveways to the east and west of Avery-Muirfield Drive on Perimeter Loop/Hospital Drive and Perimeter Drive were included in the analysis. These driveways are:

- SE Drive for Avery Road Retail Center/Walgreens on Hospital Drive
- McDonald's Access Road on Perimeter Loop
- McDonald's Access Road on Perimeter Drive
- Burger King Access Road on Perimeter Drive

The driveways are located very close to Avery-Muirfield Drive and have an operational and safety impacts to vehicles leaving the Avery-Muirfield Drive corridor. The biggest concern is with eastbound left turns into the McDonald's access road on Perimeter Loop and westbound left turns onto the Burger King access road on Perimeter Drive. As these left turning vehicles stop and wait for a gap in traffic, vehicles behind them are forced to stop unexpectedly, creating a rear-end crash potential. In addition, the left turns often have to be made through queued traffic from the Avery-Muirfield Drive signal, creating a left turn crash potential. The Burger King access road from Perimeter Drive has a left turn crash trend with 6 crashes in a three year period. The other three driveways do not currently have a crash problem; however, as volumes continue to increase in the study area, the potential for crashes at these driveways will increase. For these reasons, the following access restrictions will be made at these driveways:

- SE Drive for Avery Road Retail Center/Walgreens – The drive for the Avery Road Retail Center will be relocated to the south and will remain full access. The relocated drive will be a “T” intersection with Hospital Drive. The Walgreens drive will remain in its current location and be converted to a right-in-right-out.
- McDonald's Access on Perimeter Loop – This drive will be converted to a right-in-right-out.
- McDonald's Access on Perimeter Drive – This drive will remain a full access driveway.

- Burger King Access Road on Perimeter Drive – This drive will be converted to a right-in-right-out.

Figure 1 shows the preliminary layout for the access changes. When converting to a right-in-right-out, median islands were used to prevent the left turning movements. This is a more effective treatment to prevent the left turning movements than the traditional “pork chop” island on the driveway approaches. Cost estimates for the access changes can be found in the Cost Estimate section of this report.

Traffic Counts

Manual turning movement counts for the intersections along Avery-Muirfield Drive and the driveways on Perimeter Loop/Hospital Drive and Perimeter Drive were provided by the City of Dublin. These counts were conducted in late 2011 and early 2012. From the counts, the AM peak hour was determined to be 7:30AM-8:30AM. The PM peak was determined to be from 5:00PM to 6:00PM. The Peak Hour Factor was also determined from the traffic counts. The PHF is 0.93 and 0.96 for the AM and PM peaks respectively. Figure 2 shows the existing AM and PM traffic volumes for the study area. Copies of the traffic counts can be found in the Appendix.

The existing traffic counts were then hand adjusted based on the access restrictions at the drives east/west of Avery-Muirfield Drive. The existing “access changes” volumes are shown in Figure 3.

Figure 1 – Access Changes for Adjacent Driveways



Traffic Forecasts

2030 traffic forecasts were developed using two different methods. The first used the methodology established in the NCHRP Report 255. This methodology is an industry standard and is the same method used by ODOT to develop certified traffic. The second methodology used a sub-area of the 2030 City of Dublin VISSIM model combined with the land use assignments from the City of Dublin Travel Demand Model (TDM).

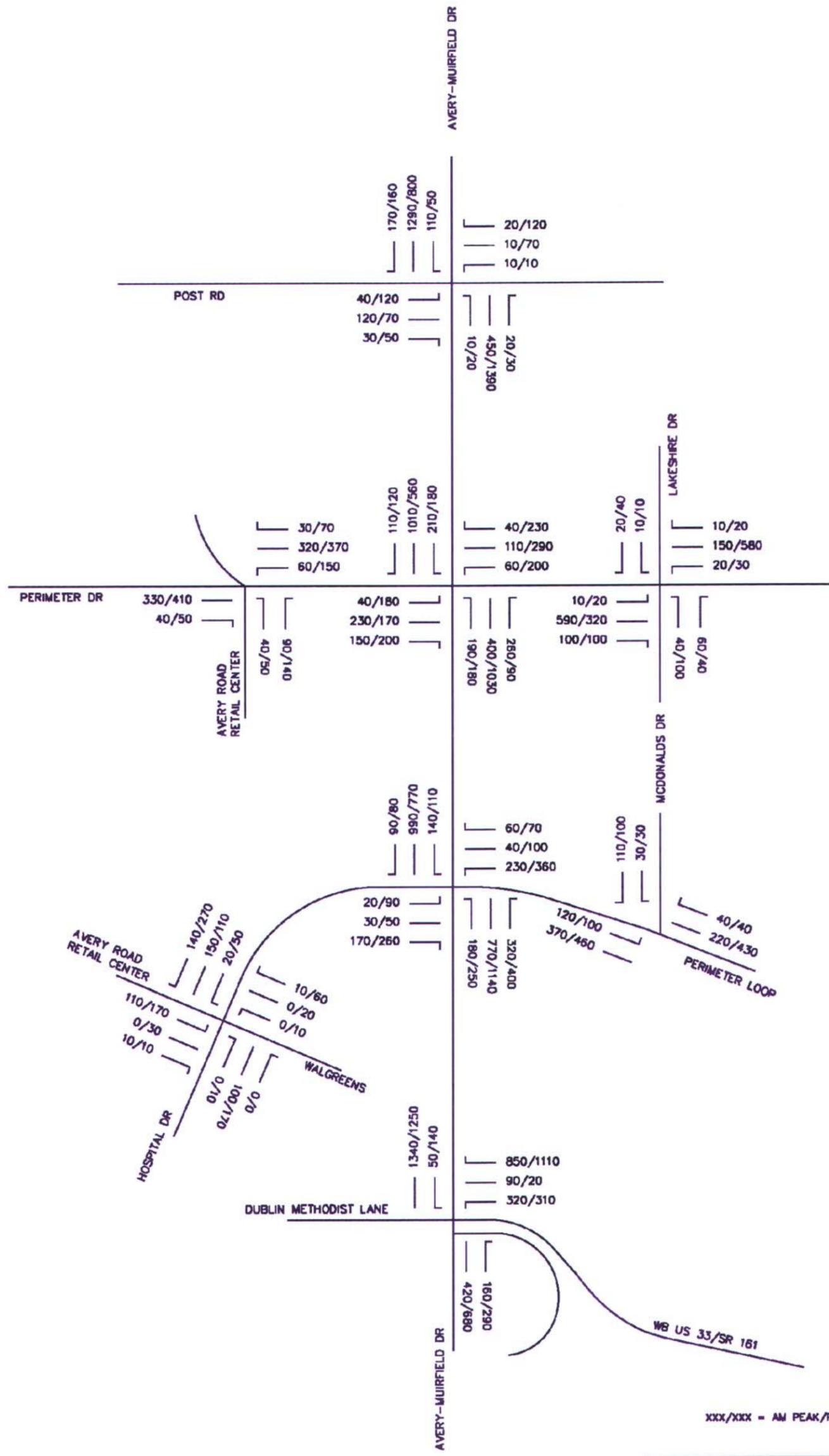
Both methods rely on the existing and future land use projections from the TDM. These projections show a very large growth between the existing and future years. A couple of links are shown to increase by more than 100%. In the AM peak, WB US 33 increases by approximately 129% west of Avery Road. A large portion of this traffic uses the US 42 exit while the rest continues farther west toward Marysville. The link between US 33 and Perimeter Loop/Hospital Drive increases by 128% NB and 82% SB. Most of this traffic increase is destined for the area between Perimeter Loop and Perimeter Drive, east of Avery-Muirfield Drive. Finally, the eastbound traffic on Perimeter Drive leaving the Avery-Muirfield Drive intersection is predicted to increase by 218%. In the PM similar traffic increases exist but are generally in the opposite direction as the AM peak hour.

The two methodologies were used to develop traffic assignments for the four intersections along Avery-Muirfield Drive. The turning volumes for the driveways east and west of Avery-Muirfield Drive were developed using manual assignment methods based on the estimated growth from the travel demand model. These turning volumes were developed as follows:

- McDonald's Access Road with Perimeter Loop and Perimeter Drive – These two driveway entrances are part of a Traffic Analysis Zone (TAZ) that encompasses everything east of Avery-Muirfield Drive, south of Perimeter Drive and north/west of Perimeter Loop. This is a very large area that generates a large amount of traffic. The portion of the TAZ traffic that would use the two McDonald's driveways is small. It was assumed that 10% of the total growth in the TAZ would use the two drives. Using this assumption, the 2030 in/out volumes at the driveways would have a 2% growth OUT and 47% growth IN during the AM peak and an 8% growth OUT and 24% growth IN during the PM peak over the existing traffic counts.
- The Avery Road Retail Center located west of Avery-Muirfield Drive between Perimeter Drive and Hospital Drive has two driveways in the study area. One is on Perimeter Drive, just west of Burger King. The second is on Hospital Drive, just west of Wendy's/Tim Horton's. The Avery Square Expansion Traffic Impact Study was used to obtain the total In/Out traffic volumes for the Avery Road Retail Center. The total TAZ growth from the travel demand model was applied to this count to determine the 2030 entering/exiting volume for all driveways. Based on the traffic counts and the portion of the parcel where development could occur, it is assumed that 75% of the total Avery Road Retail Center growth would use the two study drives in the AM peak and 65% in the PM peak. The final step

assumed that 70% of this growth will be at the Hospital Drive driveway and 30% at the Perimeter Drive driveway. This growth was applied to the existing counts.

The assignment from method one (NCHRP 255) was compared to the assignments produced by method two. Overall, the two methodologies compare fairly well. There are a couple locations where the two processes assumed different paths to get to the same TAZ but these could potentially be resolved by splitting the TAZ between Perimeter Drive and Perimeter Loop, east of Avery-Muirfield Drive, into two or three TAZs. There were a couple locations where the TDM showed a decrease on a link between the existing and future year. One of these locations was the TAZ for the hospital. Although the land use/employment data was the same for both years, the 2030 assignment showed a decrease. The other area that declined in the TDM was Avery-Muirfield Drive north of Perimeter Drive. This location dropped in the northbound direction during the AM peak and in the southbound direction during the PM peak. The NCHRP 255 methodology requires some manual adjustments to balance the future year link assignments. This also provides the opportunity to raise the assignments so there is not a decline in the future year. The VISSIM methodology is an automated process that does not include the manual adjustments. That being said, one location in the VISSIM assignment had to be manually adjusted to avoid getting a negative traffic assignment. The negative assignment was caused because the hand calculated volumes for the Avery Road Retail Center took more traffic off of Hospital Drive than was available. All in all, the two methodologies created comparable results. Ultimately, the NCHRP 255 assignments were used for the traffic analysis because the manual adjustment process was able to address some of the unexpected TDM results that the VISSIM model could not. The 2030 assignments for NCHRP 255 and VISSIM are shown in Figures 4 and 5.



XXX/XXX = AM PEAK/PM PEAK

AVERY ROAD CORRIDOR NORTH UPDATE	
EXISTING TRAFFIC VOLUMES	
BURGESS & NIPLÉ	
MARCH 2012	NOT TO SCALE

Figure 2 – Existing Traffic Volumes

Figure 3 – Existing Traffic Volumes with Access Changes

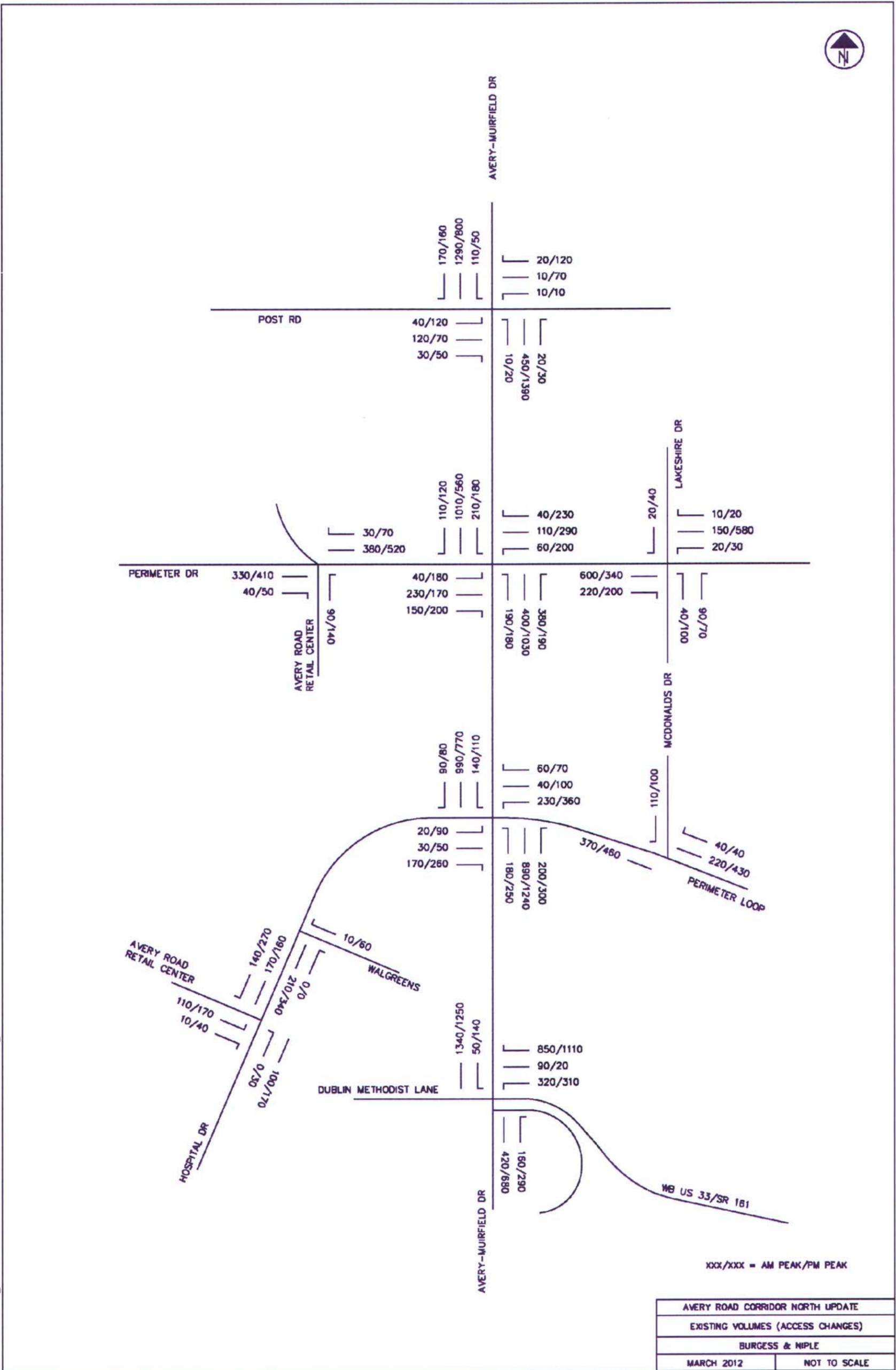


Figure 4 – 2030 Assignments – NCHRP 255 Methodology

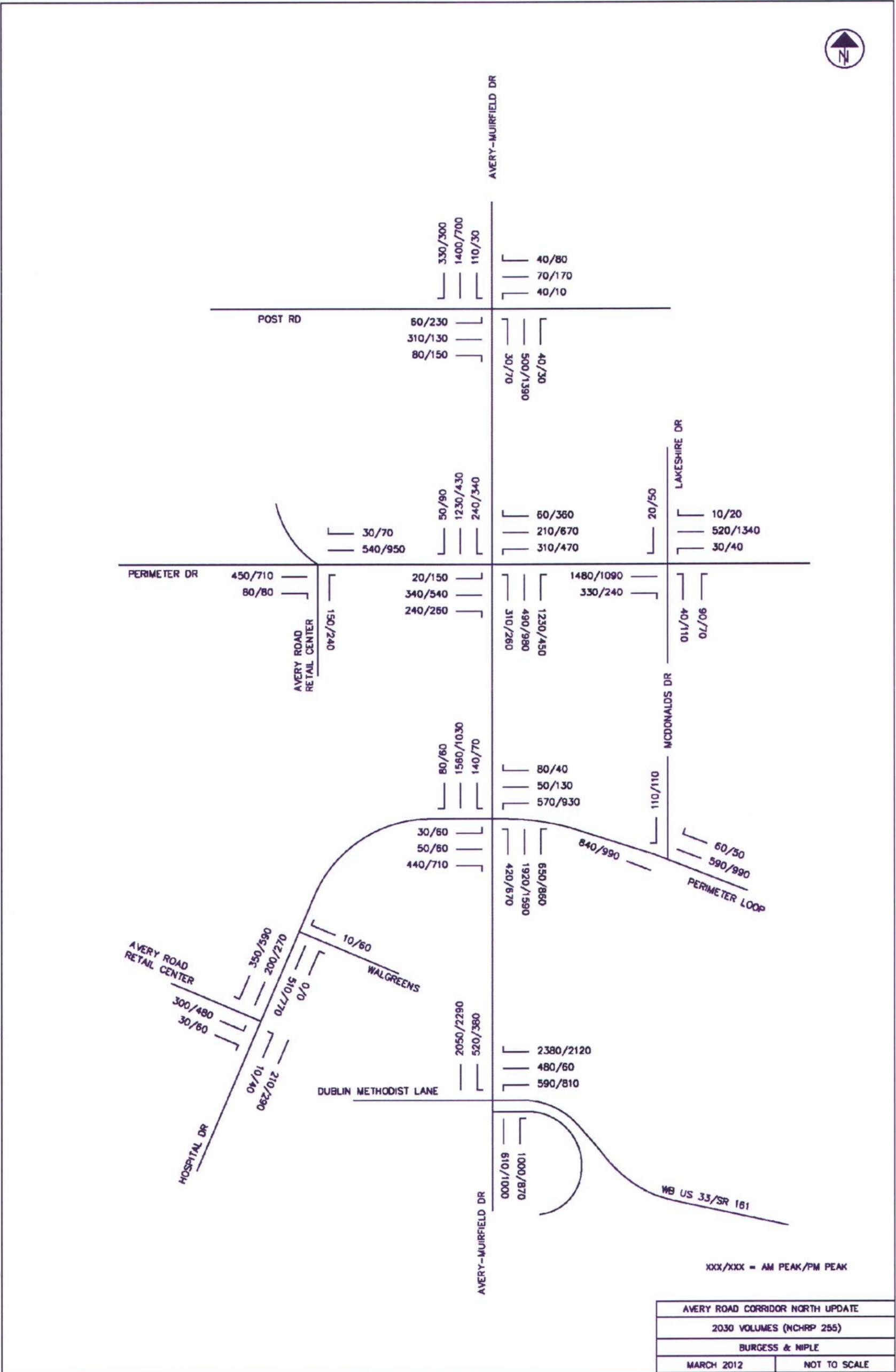
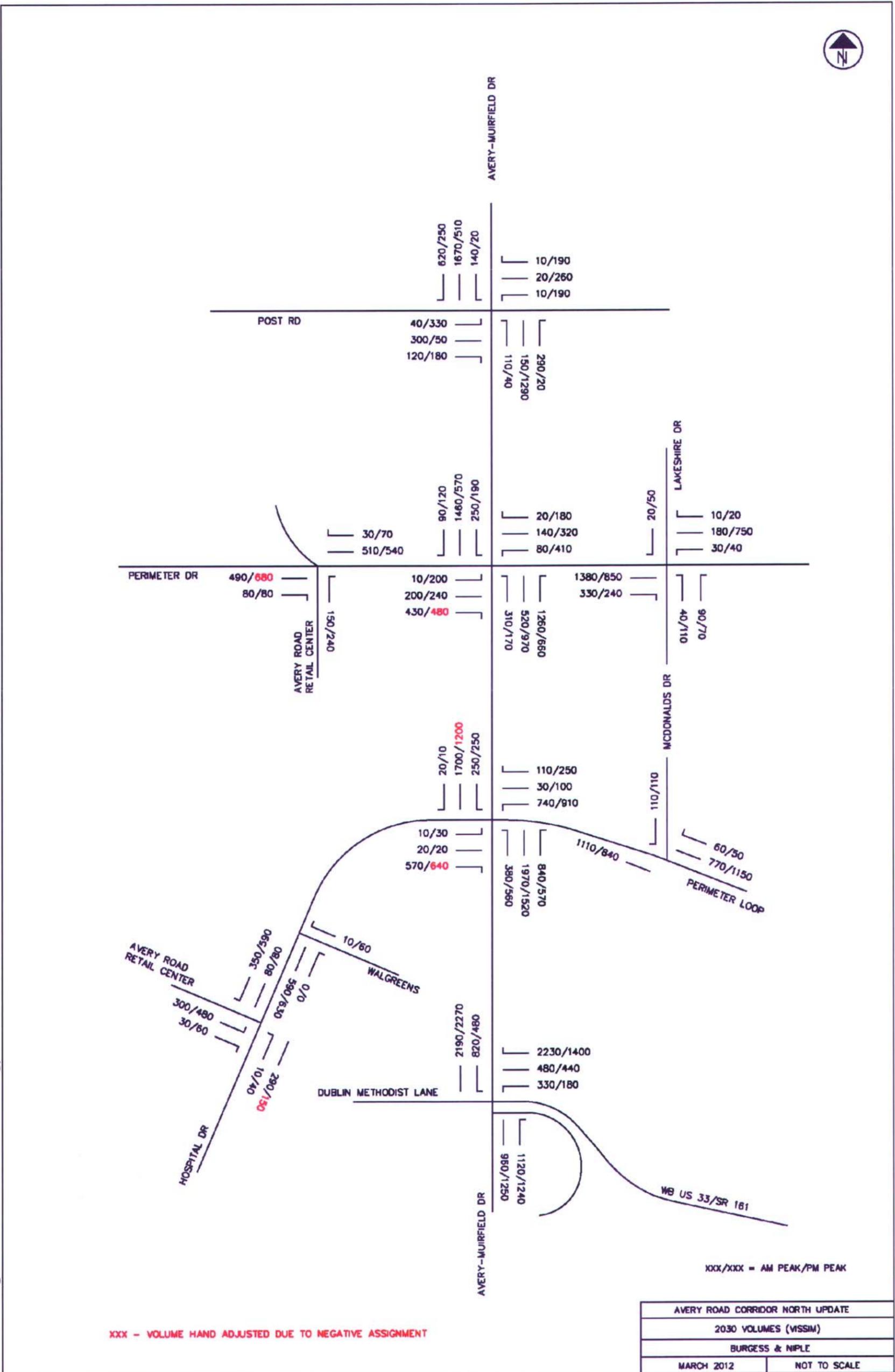


Figure 5 – 2030 Assignments – VISSIM Methodology



Crash Data

Figure 6 – Avery-Muirfield Drive & WB US 33/SR 161 Crash Diagram

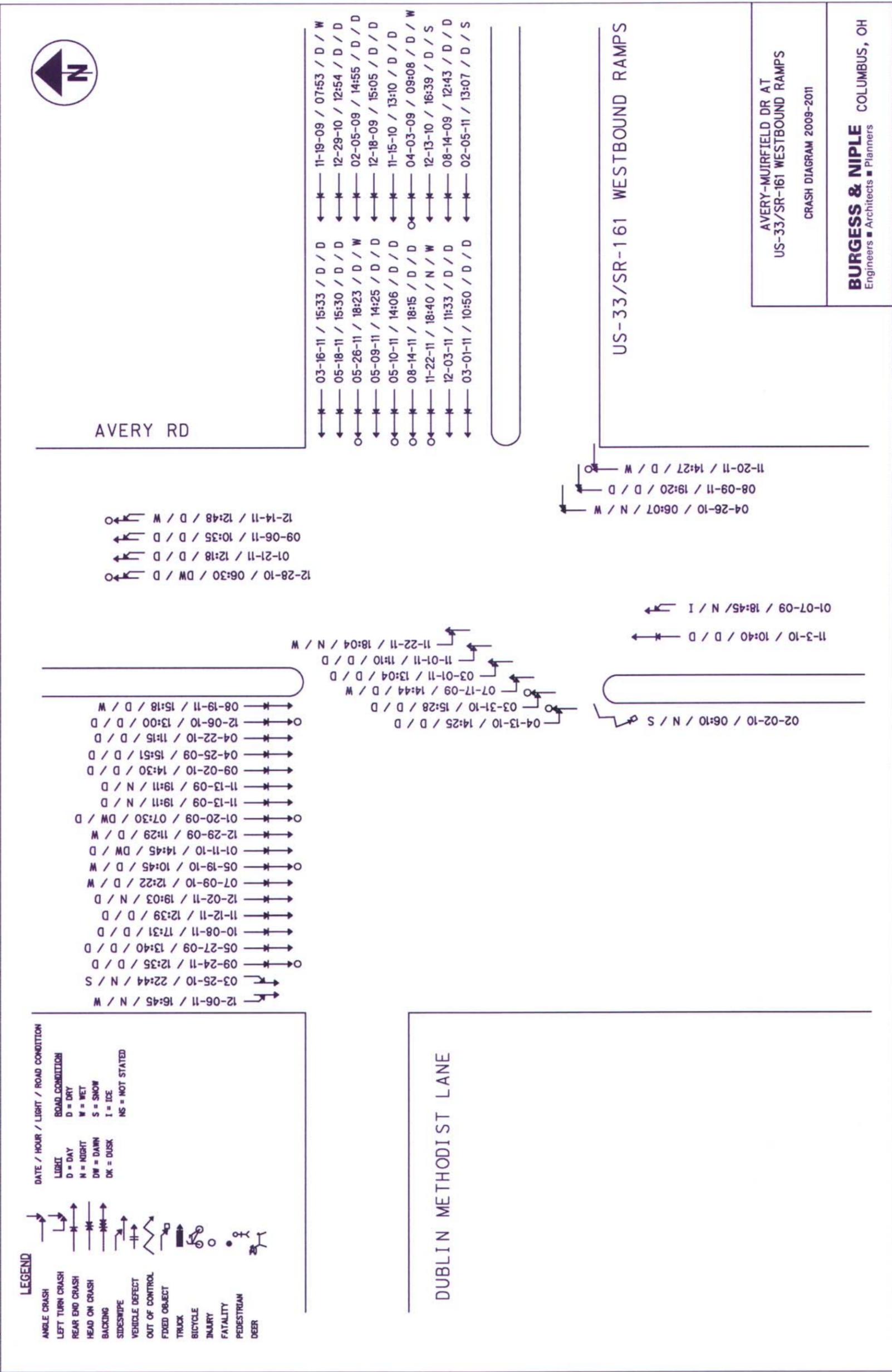


Figure 7 – Avery-Muirfield Drive & Perimeter Loop/Hospital Drive Crash Diagram

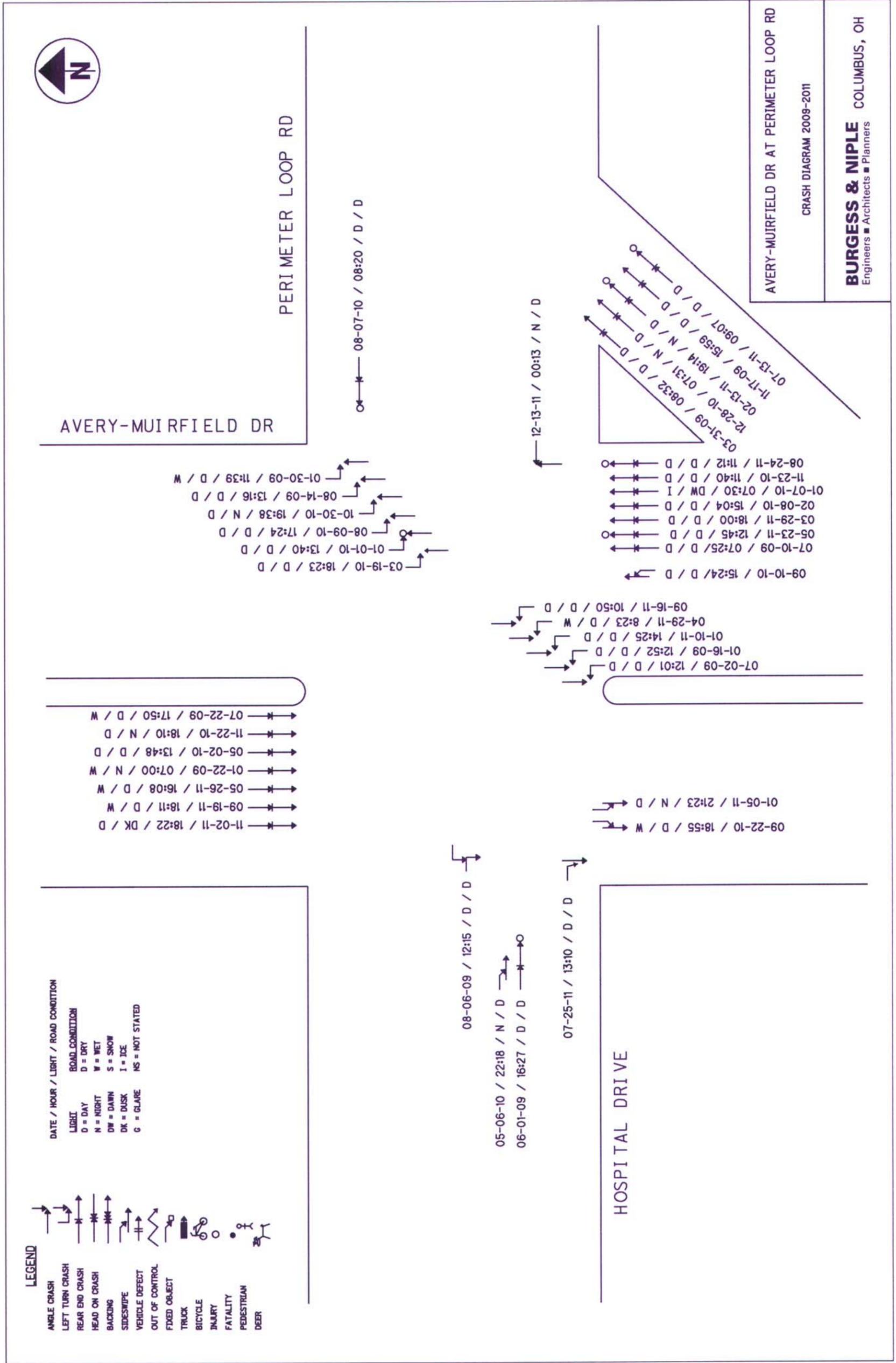


Figure 9– Avery-Muirfield Drive & Post Road Crash Diagram

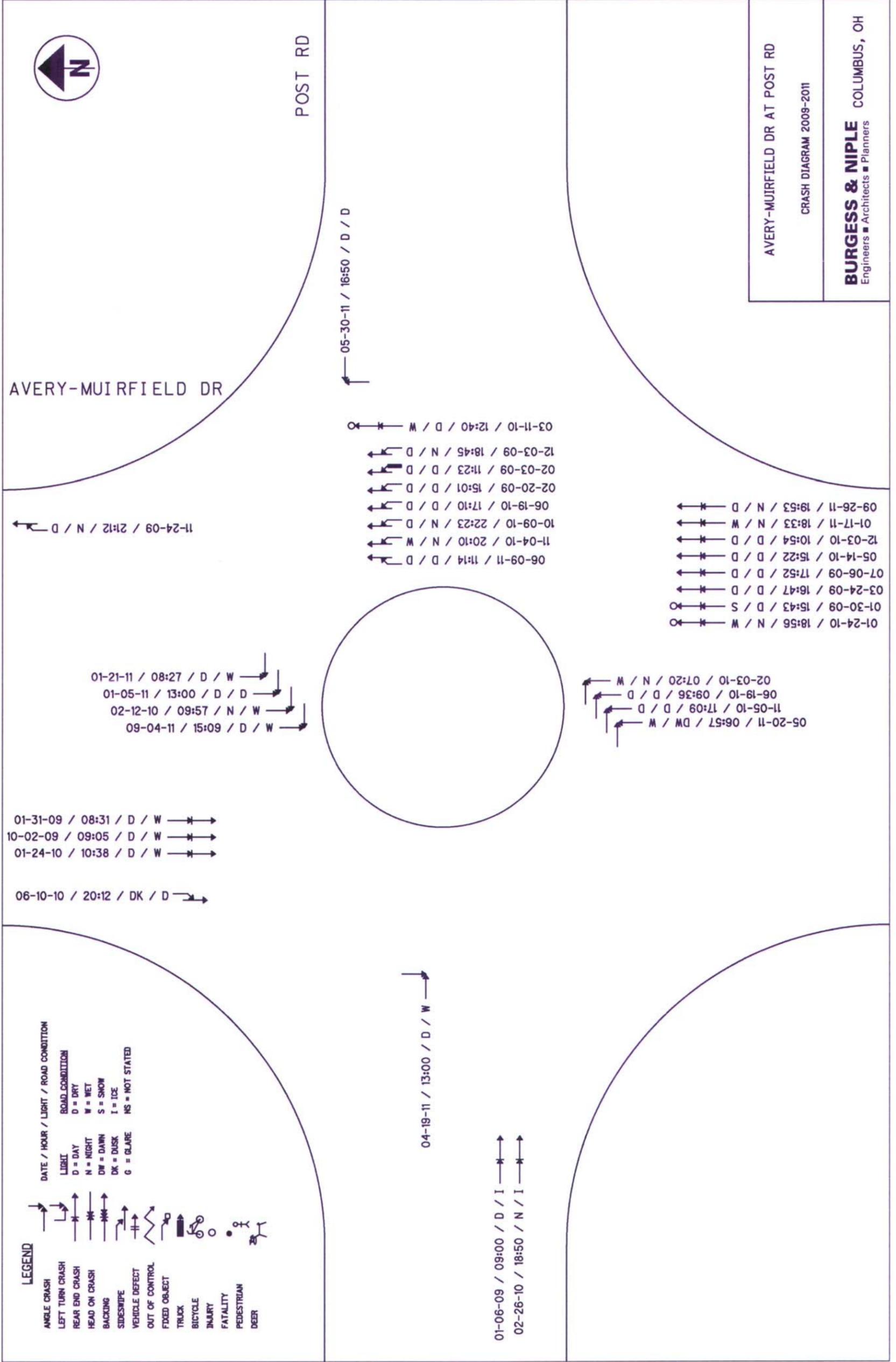


Figure 11 – Avery-Muirfield Drive & Perimeter Loop/Hospital Drive Crash Analysis Graphs and Table

TRAFFIC ACCIDENT ANALYSIS

County FRA Main Roadway Avery-Muirfield Dr
 Intersecting Roadway Perimeter Loop/Hospital Dr
 Prepared by JL Date 3/29/2012

Year	LIGHT CONDITION			ROADWAY CONDITION			CRASH TYPE						TOTAL		
	DAYLIGHT	DARK	TOTAL	DRY	WET	ICE	REAR-END	SIDESWIPE	LEFT TURN	RIGHT TURN	ANGLE	PDO	J/F	PDO	J/F
2009	9	1	10	7	3	0	5	0	5	0	0	0	0	10	1
2010	7	2	9	10	2	1	8	1	3	1	0	0	0	12	2
2011	7	3	10	7	4	0	4	1	3	0	1	0	0	10	4
Subtotal	23	6	29	24	7	1	15	2	11	1	1	0	0	32	7
Total	29	10	39	31	7	1	21	4	12	1	1	0	0	39	7

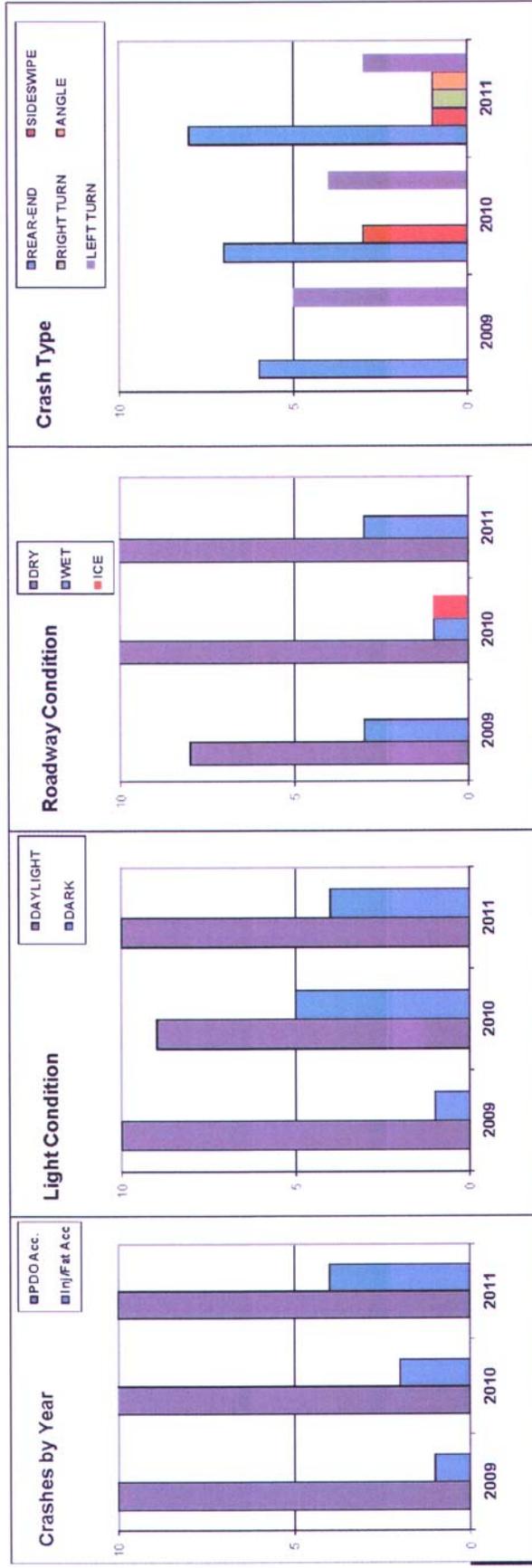


Figure 12 – Avery-Muirfield Drive & Perimeter Drive Crash Analysis Graphs and Table

TRAFFIC ACCIDENT ANALYSIS

County FRA Main Roadway Avery-Muirfield Dr
 Intersecting Roadway Perimeter Dr
 Prepared by JL Date 3/29/2012

Year	LIGHT CONDITION				ROADWAY CONDITION				REAR-END				SIDESWIPE				LEFT TURN				ANGLE				BACKING				PEDESTRIAN				TOTAL	
	DAYLIGHT	IF	PDO	IF	DAYLIGHT	IF	PDO	IF	IF	PDO	IF	PDO	IF	IF	PDO	IF	PDO	IF	IF	PDO	IF	PDO	IF	IF	PDO	IF	PDO	IF	PDO	IF				
2009	4	1	2	1	3	2	3	0	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	2	
2010	3	4	2	1	4	2	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	
2011	4	3	3	0	6	2	1	1	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	3		
Subtotal	11	8	7	2	13	8	6	1	11	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	19	9			
Total	19		9		21		7		15		3		3		5		3		3		1		3		1		1		28		28			

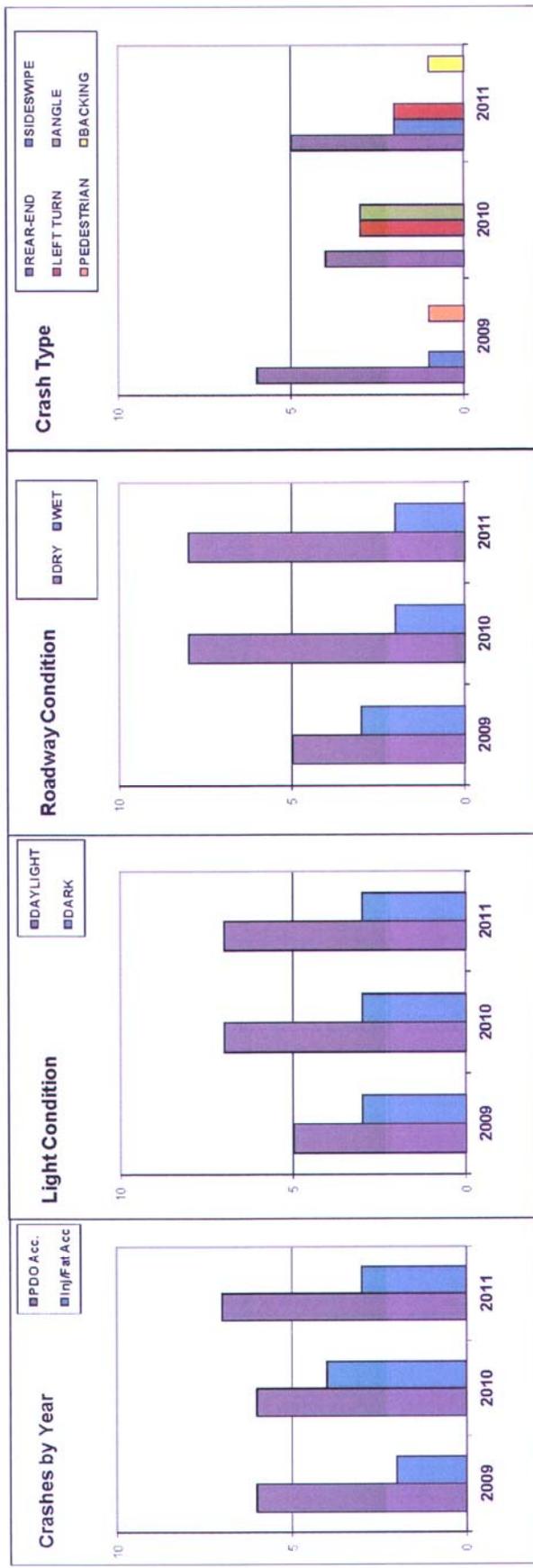
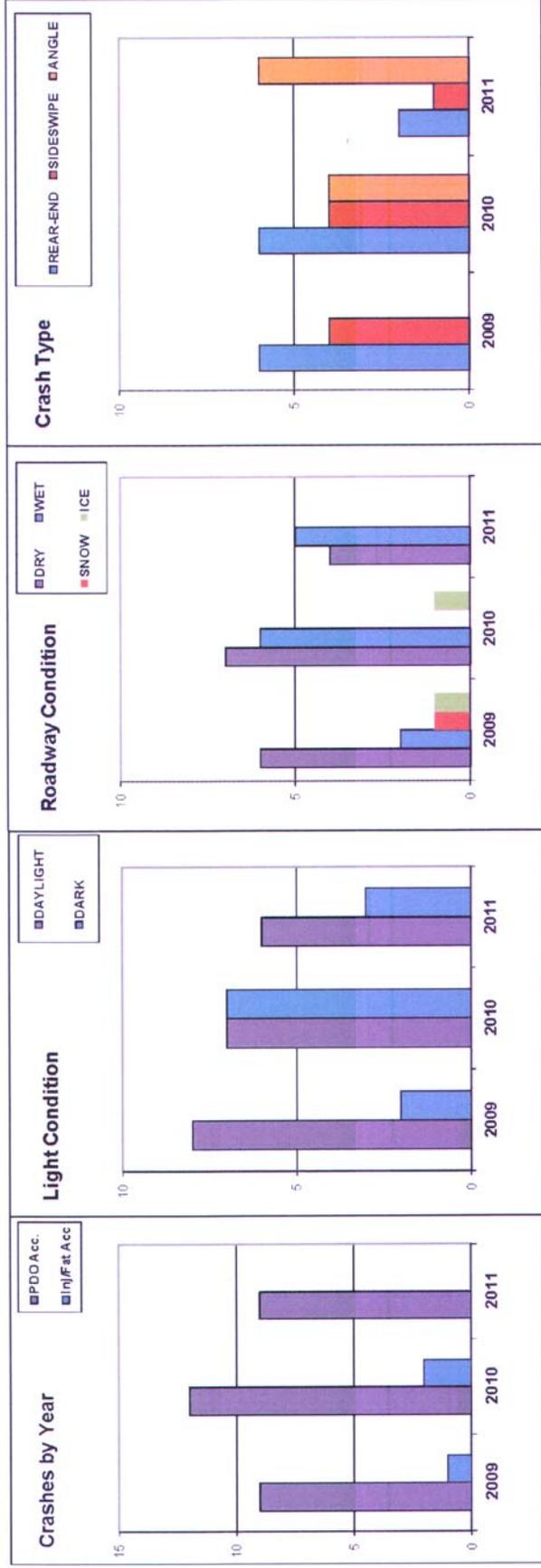


Figure 13 – Avery-Muirfield Drive & Post Road Crash Analysis Graphs and Table

TRAFFIC ACCIDENT ANALYSIS

County FRA Main Roadway Avery-Muirfield Dr
 Intersecting Roadway Post Rd
 Prepared by JL Date 3/29/2012

Year	LIGHT CONDITION				ROADWAY CONDITION				CRASH TYPE				TOTAL							
	DAYLIGHT	DARK		WET		SNOW		ICE		REAR-END		SIDESWIPE		ANGLE						
	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F	PDO	I/F				
2009	7	1	2	0	6	0	2	0	1	1	0	0	5	1	4	0	0	9	1	
2010	6	1	6	1	7	0	4	2	0	1	0	0	4	2	4	0	4	0	12	2
2011	6	0	3	0	4	0	5	0	0	0	0	0	2	0	1	0	6	0	9	0
Subtotal	19	2	11	1	17	0	11	2	0	1	2	0	11	3	9	0	10	0	30	3
Total	21		12		17		13		2		2		14		9		10		33	



Crash Analysis

Avery-Muirfield Drive at WB US 33/SR 161

The crash diagrams and data for this intersection are shown in Figures 6 and 10. From 2009 to 2011, there were 53 crashes at the intersection of Avery-Muirfield Drive and WB US 33/SR 161. Of those 53 crashes, 39 of them were property-damage only, 14 involved an injury and there were no fatalities at the intersection during these years. Daily traffic volumes at the intersection are 10,085 northbound, 20,000 southbound and 18,934 westbound. The crash rate at the intersection is 0.99 crashes per million entering vehicles.

The number of crashes at the intersection was 13 in 2009, 16 in 2010 and 24 in 2011.

Table 1 shows the percentage of each type of crash at this intersection compared to the statewide average percentage of crashes by type for urban intersections

Table 1 – Avery-Muirfield Drive at WB US 33/SR 161 crash types compared with statewide averages for urban intersections

Condition	# of crashes 2009-2011	% of crashes 2009-2011	% of Statewide Crashes (Urban Intersections) 2007-2009*
Nighttime	13	24.5	21.8
Wet pavement	14	26.4	22.1
Injury	14	26.4	26.2
Crash type			
Rear-end	36	67.9	31.3
Sideswipe	7	13.2	9.2
Left Turn	6	11.3	8.5
Angle	3	5.7	20.6
Fixed Object	1	1.9	7.4

*Statewide averages provided by Traffic Safety Analysis Systems and Services based on Ohio Department of Public Safety crash records.

The crash severity at this intersection is 26.4%. This is equivalent with the statewide rate of 26.2% and below the Dublin citywide rate of 29%.

The predominant crash type at this intersection is rear-end crashes, which account for almost 68% percent of the intersection crashes. All other crash types and conditions were near or below the statewide average.

Rear-end crashes – While rear-end crashes are typical of signalized intersections, the percentage of rear-end crashes at this intersection is high compared to the statewide

average for urban intersections. This is the most significant pattern of crashes at this intersection (36 of 53). Between 2009 and 2011, nine of these crashes resulted in an injury. The problem is especially distinct on the east and north approaches where 35 of the 37 crashes were rear-end. Since congestion is a common cause for rear-ends, capacity analysis was performed and is discussed in detail in the Capacity Analysis section. It is concluded that the intersection operates under congested conditions during both the morning and evening peak hours. Several crash reports state that vehicles were stopped in traffic.

Comparison to 2005 Study – The 2005 crash analysis for this intersection showed a three-year crash total of 56 crashes and a crash rate of 1.20 crashes per million entering vehicles. The crash severity was 18% and rear-end crashes accounted for 78% of the total intersection crashes. The crash analysis presented above documents very similar results. The crash rate (0.99 crashes per million entering vehicles), is a little lower, the crash severity (26%) is a little higher, and rear-end crashes are the predominant crash type.

Avery-Muirfield Drive at Perimeter Loop/Hospital Drive

The crash diagrams and data for this intersection are shown in Figures 7 and 11. From 2009 to 2011, there were 39 crashes at the intersection of Avery-Muirfield Drive and Perimeter Loop/Hospital Drive. Of those 39 crashes, 32 of them were property-damage only, seven involved an injury and there were no fatalities at the intersection during these years. Daily traffic volumes at the intersection are 18,226 northbound, 13,247 southbound, 4,814 eastbound and 5,955 westbound. The crash rate at the intersection is 0.84 crashes per million entering vehicles.

The number of crashes at the intersection was 11 in 2009, 14 in 2010 and 11 in 2011.

Table 2 shows the percentage of each type of crash at this intersection compared to the statewide average percentage of crashes by type for urban intersections.

Table 2 – Avery-Muirfield Drive at Perimeter Loop/Hospital Drive crash types compared with statewide averages for urban intersections

Condition	# of crashes 2009-2011	% of crashes 2009-2011	% of Statewide Crashes (Urban Intersections) 2007-2009*
Nighttime	10	25.6	21.8
Wet pavement	7	17.9	22.1
Injury	7	17.9	26.2
Crash type			
Rear-end	21	53.8	31.3
Left Turn	12	30.8	8.5
Sideswipe	4	10.3	9.2
Angle	1	2.6	20.6
Right Turn	1	2.6	0.3

*Statewide averages provided by Traffic Safety Analysis Systems and Services based on Ohio Department of Public Safety crash records.

The crash severity at this intersection is 17.9%. This is lower than the statewide rate of 26.2% and Dublin citywide rate of 29%. Installing a roundabout at this intersection would be expected to reduce the severity rate to well below the statewide and citywide rates.

The predominant crash types at this intersection are rear-end crashes and left turn, which together account for almost 85% percent of the intersection crashes. All other crash types and conditions were near or below the statewide average.

Rear-end crashes – While rear-end crashes are typical of signalized intersections, the percentage of rear-end crashes at this intersection is high compared to the statewide average for urban intersections. This is the most significant pattern of crashes at this intersection (21 of 39). Between 2009 and 2011, seven of these crashes resulted in an injury. The problem is especially distinct on the north and south approaches. Since congestion is a common cause for rear-ends, capacity analysis was performed and is discussed in detail in the Capacity Analysis section. It concluded that the intersection operates under congested conditions during both the morning and evening peak hours. Several crash reports state that vehicles were stopped in traffic.

Left turn crashes – This is the second most significant (12 of 39) type of crash at this intersection. Eleven of the left turning crashes involved northbound or southbound left turning vehicles failing to yield. This crash type can be eliminated with a roundabout.

Comparison to 2005 Study – The 2005 crash analysis for this intersection showed a three-year crash total of 29 crashes and a crash rate of 0.69 crashes per million entering vehicles. The crash severity was 21%. Left-turn/angle crashes accounted for 62% and

rear-end crashes accounted for 31% of the total intersection crashes. The crash analysis presented above shows slightly different results. The three-year crash total has increased to 39, crash rate has increased to 0.84 crashes per million entering vehicles, and the severity has slightly decreased to 18%. While left-turn/angle and rear-end are still the predominant crash types, rear-end crashes have become the most common, accounting for 54% of the total intersection crashes. Most of the differences from the 2005 study can be attributed to how the link crashes on the northbound approach were handled. In this study, we determined that the link crashes were caused by congestion related to the traffic signal and included them with the intersection crashes. In the 2005 study there were 13 northbound crashes that were analyzed as link crashes and not included with the intersection crashes. Had some of these been included with the intersection, the total crashes, crash rate and severity between the two studies would have been very similar.

Avery-Muirfield Drive at Perimeter Drive

The crash diagrams and data for this intersection are shown in Figures 8 and 12. From 2009 to 2011, there were 28 crashes at the intersection of Avery-Muirfield Drive and Perimeter Drive. Of those 28 crashes, 19 of them were property-damage only, nine involved an injury and there were no fatalities at the intersection during these years. Daily traffic volumes at the intersection are 12,732 northbound, 11,998 southbound, 6,715 eastbound and 5,574 westbound. The crash rate at the intersection is 0.69 crashes per million entering vehicles.

The number of crashes at the intersection was 8 in 2009, 10 in 2010 and 10 in 2011.

Table 3 shows the percentage of each type of crash at this intersection compared to the statewide average percentage of crashes by type for urban intersections.

Table 3 – Avery-Muirfield Drive at Perimeter Drive crash types compared with statewide averages for urban intersections

Condition	# of crashes 2009-2011	% of crashes 2009-2011	% of Statewide Crashes (Urban Intersections) 2007-2009*
Nighttime	9	32.1	21.8
Wet pavement	7	25.0	22.1
Injury	9	32.1	26.2
Crash type			
Rear-end	15	53.6	31.3
Left Turn	5	17.9	8.5
Sideswipe	3	10.7	9.2
Angle	3	10.7	20.6
Backing	1	3.6	4.6
Pedestrian	1	3.6	1.4

*Statewide averages provided by Traffic Safety Analysis Systems and Services based on Ohio Department of Public Safety crash records.

The percentage of nighttime crashes at this intersection is above the statewide average. Reviewing the crash reports reveals that the high percentage of nighttime crashes does not represent a crash problem. Three of the crashes occurred during the AM and PM peak periods and were congestion related. One involved alcohol and a couple occurred while the signal was in flash and the vehicles failed to yield.

The crash severity at this intersection is 32.1%. This is higher than the statewide rate of 26.2% and Dublin citywide rate of 29%. Installing a roundabout at this intersection would be expected to reduce the severity rate to well below the statewide and citywide rates.

The predominant crash types at this intersection are rear-end crashes and left turn, which together account for almost 72% percent of the intersection crashes. All other crash types and conditions were near or below the statewide average.

Rear-end crashes – While rear-end crashes are typical of signalized intersections, the percentage of rear-end crashes at this intersection is high compared to the statewide average for urban intersections. This is the most significant pattern of crashes at this intersection (15 of 28). Between 2009 and 2011, four of these crashes resulted in an injury. Since congestion is a common cause for rear-ends, capacity analysis was performed and is discussed in detail in the Capacity Analysis section. It concluded that the intersection operates under congested conditions during both the morning and evening peak hours. Several crash reports state that vehicles were stopped in traffic.

Left turn crashes – This is the second most significant (5 of 28) type of crash at this intersection. This crash type can be eliminated with a roundabout.

Comparison to 2005 Study – The 2005 crash analysis for this intersection showed a three-year crash total of 23 crashes and a crash rate of 0.56 crashes per million entering vehicles. The crash severity was 35%. Rear-end crashes accounted for 52% and left-turn/angle crashes accounted for 48% of the total intersection crashes. The crash analysis presented above documents very similar results. The three-year crash total (28) and the crash rate (0.69 crashes per million entering vehicles), are a little higher, the crash severity (32%) is a little lower, rear-end and left-turn/angle crashes are the predominant crash types.

Avery-Muirfield Drive at Post Road

The crash diagrams and data for this intersection are shown in Figures 9 and 13. From 2009 to 2011, there were 33 crashes at the intersection of Avery-Muirfield Drive and Post Road. Of those 33 crashes, 30 of them were property-damage only, three involved an injury and there were no fatalities at the intersection during these years. Daily traffic volumes at the intersection are 11,313 northbound, 14,598 southbound, 2,353 eastbound and 1,442 westbound. The crash rate at the intersection is 1.01 crashes per million entering vehicles. While this rate is the highest of the four corridor intersections, the injury crashes are significantly lower than the other three study intersections.

The number of crashes at the intersection was 10 in 2009, 14 in 2010 and 9 in 2011.

Table 4 shows the percentage of each type of crash at this intersection compared to the statewide average percentage of crashes by type for urban intersections.

Table 4 – Avery-Muirfield Drive at Post Road crash types compared with statewide averages for urban intersections

Condition	# of crashes 2009-2011	% of crashes 2009-2011	% of Statewide Crashes (Urban Intersections) 2007-2009*
Nighttime	12	36.4	21.8
Wet pavement	13	39.4	22.1
Injury	3	9.1	26.2
Crash type			
Rear-end	14	42.4	31.3
Angle	10	30.3	20.6
Sideswipe	9	27.3	9.2

*Statewide averages provided by Traffic Safety Analysis Systems and Services based on Ohio Department of Public Safety crash records.

The percentage of nighttime crashes at this intersection is above the statewide average. Reviewing the crash reports reveals that the high percentage of nighttime crashes does not represent a crash problem. Five of the crashes occurred during the AM and PM peak periods and were congestion related. One occurred on ice and one was related to a driver who was unfamiliar with the roundabout and drifted over the lane line within the roundabout.

The crash severity at this intersection is 9.1%. This is much lower than the statewide rate of 26.2% and Dublin citywide rate of 29%. The low crash severity at this intersection can be attributed to the roundabout at this location.

The predominant crash types at this intersection are rear-end crashes, angle crashes and sideswipe crashes, which together account for 100% percent of the intersection crashes. The geometric design of the roundabout was reviewed to determine if the roundabout design practices used in 2007 may be causing some of the high number of crashes seen at this intersection. Through this review it was determined that while the design of this roundabout meets the current design standards, the 170 foot diameter for the roundabout is on the lower end of the standards. A 180 foot diameter is preferred. The larger diameter roundabout may have a slight reduction in anticipated crashes, but this is not expected to be a significant reduction. Other possible causes for each crash type at this intersection will be addressed in the following discussion.

Rear-end crashes – Rear-end crashes accounted for almost half of the crashes at this intersection, and are the type most frequently seen at roundabouts. The only rear-end crash that involved an injury occurred within the circulating lanes, the rest were property-damage only. Rear end crashes are common at a roundabout as all vehicles entering the intersection are forced to slow and/or stop at the intersection. As the vehicles approach

the yield line, the driver is looking left to find an acceptable gap. Often times, a vehicle will start to enter the roundabout then determine that the gap is not acceptable and stop. This movement causes the vehicle behind them to move up thinking they have entered the roundabout, all while the driver is looking left, resulting in a rear-end crash. Through review of the crash reports, the driver statements typically included a comment similar to "I thought the vehicle was going and didn't see them stop." Further complicating this is that the intersection is approaching its capacity and with more traffic there is more opportunities for rear-end crashes. There is not a specific countermeasure to address this crash problem.

Angle crashes – The angle crashes at the intersection involved vehicles entering the roundabout without yielding to circulating traffic. Most of these crashes (8 of 10) involved northbound and southbound vehicles failing to yield. The likely cause of these crashes is simply the traffic patterns at the roundabout. Nearly all northbound and southbound vehicles travel through with very few turning left. This pattern has conditioned the drivers to anticipate the destination of the circulating vehicles and not expect the left turns. For example, a northbound vehicle will approach the roundabout, see a circulating vehicle and assume it is exiting to the south. The northbound vehicle will then enter the roundabout only to find that the circulating vehicle continued around to exit to the east. At this point the angle crash occurs. None of these crashes resulted in injury, unlike typical angle/left turn crashes at signalized intersections. 50% (4 of 8) at Perimeter Drive, 7.8% (1 of 13) at Perimeter Loop/Hospital Drive and 33% (3 of 9) of the angle/left turn crashes at WB US 33/SR 161 resulted in injuries.

Sideswipe crashes – All but two of the sideswipe crashes at the roundabout involved northbound vehicles in the circulating lanes changing lanes inside the roundabout, with the majority moving from the outside to the inside lane. Reviewing the crash reports did not provide a clear indication as to why vehicles were changing lanes within the roundabout other than the couple that stated they were not paying attention and drifted over the lane line. There is a possibility that this is related to the cause of the angle crashes. The northbound/southbound vehicle enters the roundabout, realizes that a vehicle is there and makes an evasive maneuver, resulting in a sideswipe instead of an angle crash. If this is the case, it is again a situation where the driver was not paying attention and there is not a specific countermeasure to address this.

Comparison to 2005 Study – The 2005 crash analysis for this intersection showed a three-year crash total of 10 crashes and a crash rate of 0.29 crashes per million entering vehicles. The crash severity was 20%. Rear-end crashes accounted for 60% and left-turn/angle crashes accounted for 30% of the total intersection crashes. The crash analysis presented above documents different results. The three-year crash total and crash rate has increased to 33 crashes and 1.01 crashes per million entering vehicles, respectively. The crash severity has been cut in half to 9%. Rear-end and angle crashes are still predominant types, however, sideswipe crashes have appeared as a crash trend. Because the intersection was signal controlled in the 2005 study and roundabout in the current study the results are not an apple-to-apple comparison. As discussed above, rear-end crashes are common at roundabouts. In addition, the unbalanced traffic flows at the intersection is likely a contributing factor to the number of angle and sideswipe crashes seen over the last three years.

Perimeter Loop/Hospital Drive & Perimeter Drive at Adjacent Driveways

The City of Dublin recorded 22 crashes from 2009 to 2011 along Perimeter Drive, Perimeter Loop, and Hospital Drive in the vicinity of Avery-Muirfield Drive. 11 of the 22 crashes were at the four driveways adjacent to Avery-Muirfield Drive that are part of this study. The remaining 11 crashes were at locations outside of the study area. Crashes at the four driveways are as follows:

- SE Drive for Avery Road Retail Center/Walgreens on Hospital Drive – One crash occurred in the three years of the study. There is not a crash problem at this drive.
- The McDonald's access drive at Perimeter Loop Drive – no crashes occurred at this driveway in the three years of the study. There is not a crash problem at this drive.
- The driveway on Perimeter Drive at the Burger King had six crashes, all of them left turn crashes, in the three years of the study. With the conversion of this drive to a right-in-right-out, all of these crashes can be eliminated.
- The McDonald's access drive on Perimeter Drive had four crashes, two of them left turn, in the three years of the study. Four crashes in three years does not indicate a crash problem at this drive.

Capacity Analysis

The operational analysis for signalized intersections was performed using *Synchro* traffic analysis software (*Highway Capacity Manual (HCM)* methods) to quantify the congestion problem at the intersections during morning and evening peak hours. Roundabout analysis was performed using the HCM Delay Model in *SIDRA*.

Level of Service (LOS) is evaluated on the basis of control delay per vehicle, in seconds per vehicle. The following tables define LOS for the different “grades” of service.

Table 5 - Level of Service at signalized and roundabout intersections

Level of Service	Control delay (sec)	Control delay (sec)	Description
	Signalized	Roundabout	
A	< 10	<10	Most vehicles do not stop.
B	10 – 20	10-15	Good progression; more vehicles stop than at LOS A.
C	20 – 35	15-25	The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.
D	35 – 55	25-35	Many vehicles stop, and the proportion of vehicles not stopping declines. Occasionally, all vehicles on an approach will not clear the intersection during the green.
E	55 – 80	35-50	Considered the limit of acceptable delay. Frequently, all vehicles on an approach will not clear the intersection during the green.
F	> 80	>50	Considered unacceptable to most drivers.

Capacity analysis was conducted at the intersections of Avery-Muirfield Drive to answer the following questions:

- What is the LOS at the intersections in the existing year?
- What year will the existing traffic signals reach capacity?
- What year will a two-lane roundabout reach capacity?

For the signalized intersections, the intersection will be assumed to have reached capacity when either the overall intersection LOS is E or F, OR when one of the approaches at the intersection reaches a volume-to-capacity (v/c) ratio of 1.0 or higher.

For the roundabouts, the intersection is assumed to have reached capacity when one of the approaches to the roundabout reaches a v/c ratio of 1.0 or higher.

Outputs from the capacity analysis can be found in the Appendix.

Avery-Muirfield Drive & Perimeter Loop/Hospital Drive

Signalized

Table 6 shows the capacity results for this intersection. The existing condition with full access driveways provides a slightly better operation than the existing condition with access restrictions to the adjacent driveways. Both conditions operate at an overall level of service of C. The reason for the minor differences in delays and v/c ratios is how the traffic was reassigned with the left turns prohibited. The McDonald’s driveway on Perimeter Loop has a high left in volume (120 vehicles in the AM and 100 vehicles in the

PM). It was assumed that this traffic came from the northbound right turn on Avery-Muirfield Drive. With the left in movement prohibited, the traffic was redirected on Avery-Muirfield Drive to Perimeter Drive where it would turn right and then right again on the McDonald's access road. Although the existing intersection operates acceptably overall, the intersection is approaching its capacity with high v/c ratios and relatively long calculated queue lengths for the northbound and southbound approaches.

By 2017, the signalized intersection is expected to reach capacity in the AM peak and be over capacity in the PM peak. Similar to the existing year, the operation of the intersection will be nearly the same with access restrictions to the adjacent driveways as without restrictions.

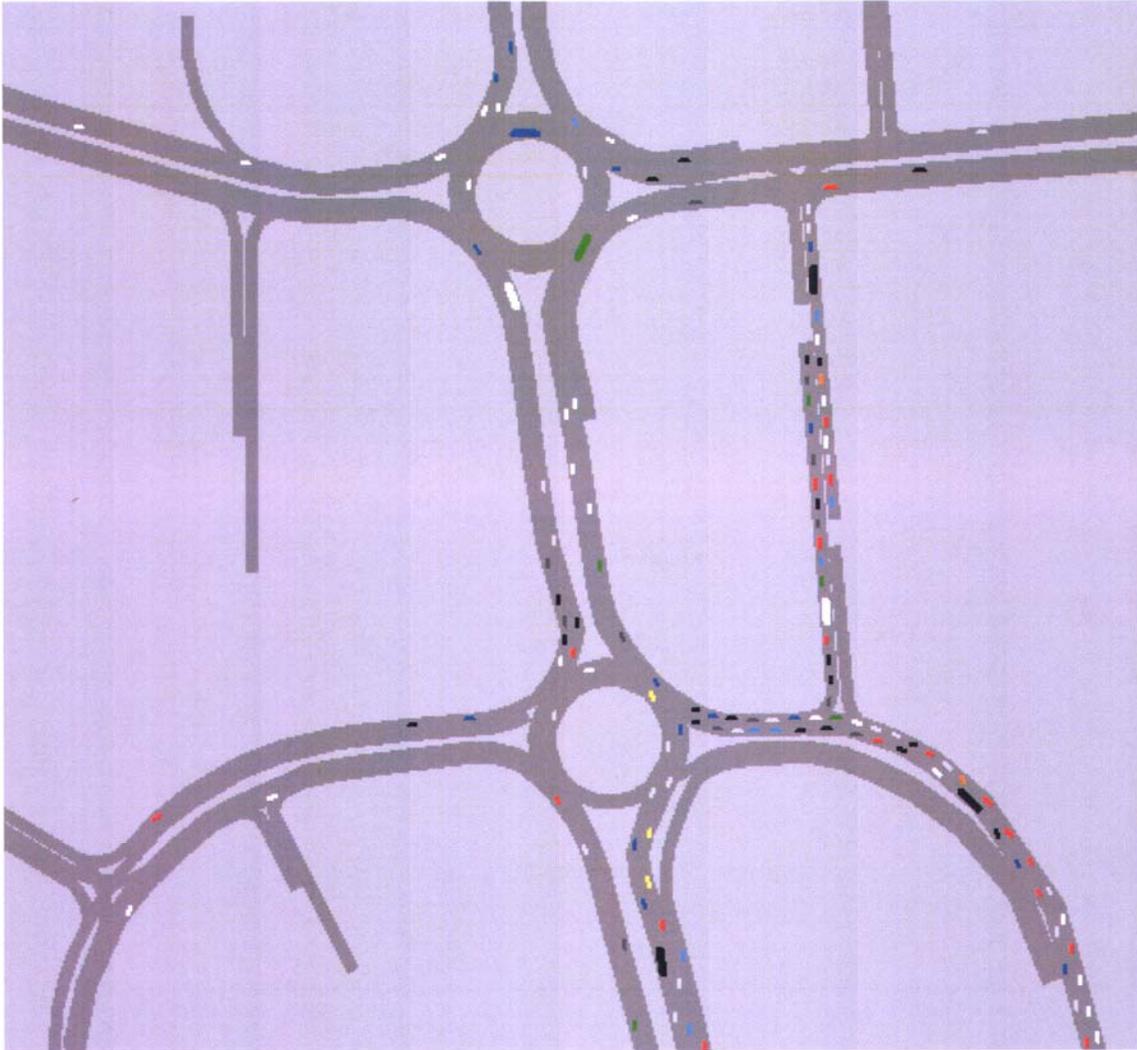
Roundabout

The analysis of the two-lane roundabout at this intersection resulted in a couple changes to the lane use shown in the 2005 study. These changes are:

- The eastbound approach at the Perimeter Loop/Hospital Drive roundabout has been changed from through/left and through/right lanes to through/left and right only. Changing the eastbound approach to a single through lane means that there is only one eastbound departure lane instead of the two in the original 2005 layout. This provides the pavement and receiving lane necessary to allow the northbound right turn to become a free movement. The free movement creates the second departure lane.
- The westbound approach at the Perimeter Loop/Hospital Drive roundabout has been changed from through/left and through/right lanes to left only and left/through/right.

The two-lane roundabout is expected to reach capacity in the PM peak in 2014. At that point, traffic on the northbound approach will arrive at the roundabout in a fairly consistent stream. Traffic entering the roundabout from the east will have to yield to the northbound traffic. Due to the steady northbound traffic, there will not be enough gaps to allow all of the westbound traffic demand to enter the roundabout. This will cause a v/c ratio greater than 1.0 for the westbound approach. This observation was confirmed using VISSIM. The VISSIM model, which is much more sensitive and realistic for traffic operations on overcapacity links, shows that the roundabout will be significantly over capacity and only 77% of the westbound traffic in the PM peak will be able to find an acceptable gap and enter the roundabout. As the westbound traffic spills back, it quickly blocks the McDonald's access drive and causes significant queuing on this drive. This condition is shown in Figure 14. The two-lane roundabout at this intersection will be at failing conditions on opening day. Current City policy is to maintain two through lanes along the Avery-Muirfield corridor, which limits the roundabouts to two-lanes. As a comparison with the two-lane roundabout at Post Road, the existing traffic counts for the Perimeter Loop/Hospital Drive intersection has approximately 30% more entering traffic in the peak hours than the Post Road roundabout. By 2030, the Perimeter Loop/Hospital Drive intersection will have approximately 90% more traffic than the Post Road intersection.

Figure 14 – VISSIM screenshot in 2014 PM Peak



Avery-Muirfield Drive & Perimeter Drive

Signal

Table 7 shows the capacity results for this intersection. The existing condition with full access driveways provides a slightly better operation than the existing condition with access restrictions to the adjacent driveways. Both conditions operate at an overall level of service of C. As with the Perimeter Loop/Hospital Drive intersection, the minor differences in delays and v/c ratios is how the traffic was reassigned with the left turns prohibited. Although the intersection operates acceptably overall, the intersection is approaching its capacity and produces relatively long calculated queue lengths for the northbound and southbound approaches.

By the 2021 PM peak hour, the westbound and southbound approach v/c ratios are expected to be greater than 1.0. Also, the queue lengths are expected to be over 600 feet. The signalized intersection will no longer be able to process the expected traffic demand.

This operation is expected to occur with and without access changes to the adjacent driveways.

Roundabout

The two-lane roundabout from the 2005 study is expected to operate over capacity in the 2013 peak. The northbound and westbound approaches will have v/c ratios greater than 1.0. The northbound right and westbound right volumes are relatively high. Separating these volumes from the through volumes would add additional capacity for these failing approaches. If northbound and westbound right turn lanes were added to the roundabout, the intersection would not reach capacity until 2018. This roundabout was also evaluated in VISSIM for 2014. Unfortunately, as traffic at the Perimeter Loop/Hospital Drive roundabout begins to break down, it limits the amount of traffic that arrives at the Perimeter Drive roundabout. This reduced traffic flow produces LOS, delays, v/c ratios and queue lengths that are better than what would be present if all of the traffic that wanted to travel through the roundabout could get there. Because of this, VISSIM analysis past 2014 is unreliable and cannot be compared to *SIDRA*.

Avery-Muirfield Drive & Post Road

Table 8 shows the capacity results for this intersection. No changes to the existing roundabout were assumed. Under current traffic conditions, the roundabout operates with an overall LOS of C in both the AM and PM peak. One v/c ratio (northbound in PM peak) is approaching 0.90 and queue lengths are over 300 feet in length, but the intersection is operating fairly well. By 2022, the roundabout is expected to reach capacity in the AM peak hour. At this point, the eastbound approach will have a v/c ratio greater than 1.0 and expected queue lengths will be over 500 feet on the southbound approach and 400 feet on the northbound approach.

Queuing

Queue lengths were examined to determine what effect they would have on upstream intersections and driveways. In the existing year, queues along Avery-Muirfield Drive do not reach upstream intersections. However, by the time the intersections reach their service life, queues will become an issue. The longest southbound queues at the intersection with Perimeter Loop/Hospital Drive will just reach the 600 foot spacing between the Perimeter Drive intersection in the service life year for both the signalized intersection and the roundabout. At the intersection of Perimeter Drive, the southbound queue is expected to extend past the 600 foot distance to the Post Road roundabout by the 2021 service life of the traffic signal and be near Post Road by the 2018 service life of the two-lane roundabout.

Queuing at the adjacent driveways was also evaluated. At the McDonald's access road on Perimeter Loop, the existing queue routinely extends past the driveway, particularly in the PM peak. By 2015, both the AM and PM peaks will experience routine queuing past the driveway. The Burger King drive on Perimeter Drive does not have a queuing issue in the existing condition. By the service life of the Avery-Muirfield intersection, queues will begin to reach the driveway. Queues on Perimeter Drive currently extend past the McDonald's access road. This condition will worsen as the Avery-Muirfield Drive intersection approaches its service life. As queues worsen and the driveways become

blocked more frequently, the operation and safety at the driveways will deteriorate. It will become increasingly difficult to make a left turn into or out of the driveway and the number of left turn crashes would be expected to increase. In addition, there is very little left turn storage on Perimeter Loop and Perimeter Drive for the driveways. As left turning vehicles are forced to wait longer to make the turn, the possibility that queues could develop that affect the intersections on Avery-Muirfield Drive increases. With the roundabout designs, the close proximity of the drives to the roundabouts will make it very difficult to fit in a left turn lane for the drive without affecting the design of the approach and splitter island to the roundabout. For these operational, geometric and safety reasons, the access changes proposed at these driveways should be implemented.

Table 6 – Avery-Muirfield Drive & Perimeter Loop/Hospital Drive Capacity Analysis

Perimeter Loop Rd/Hospital Dr	Approach	AM Peak Hour				PM Peak Hour			
		LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)	LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)
Existing with Full Access Driveways (Signalized)	Eastbound	D	36.8	0.35	87	D	38.6	0.50	117
	Westbound	D	48.5	0.57	174	E	55.1	0.77	297
	Northbound	C	23.4	0.72	238	C	28.2	0.85	393
	Southbound	B	19.3	0.87	292	C	33.4	0.83	230
	Overall	C	25.4			C	34.5		
Existing with Driveway Access Changes (Signalized)	Eastbound	D	36.7	0.35	88	D	39.3	0.51	123
	Westbound	D	48.9	0.58	174	E	59.6	0.80	310
	Northbound	C	26.8	0.71	326	C	27.4	0.87	405
	Southbound	B	19.1	0.87	285	C	32.1	0.79	211
	Overall	C	26.8			C	34.5		
2017 with Full Access Driveways (Signalized)	Eastbound	D	42.3	0.60	151	D	44.2	0.76	197
	Westbound	E	60.4	0.78	265	F	86.3	0.99	437
	Northbound	C	32.8	1.00	377	C	33.7	1.01	490
	Southbound	D	31.8	0.99	595	D	52.7	0.98	473
	Overall	D	36.3			D	47.6		
2017 with Driveway Access Changes (Signalized)	Eastbound	D	42.3	0.60	152	D	44.0	0.76	195
	Westbound	E	61.5	0.79	267	F	85.5	0.99	435
	Northbound	C	34.8	1.00	441	D	38.1	1.01	546
	Southbound	D	35.2	0.98	580	D	54.3	0.99	475
	Overall	D	38.6			D	50.0		
2014 (Roundabout) SIDRA HCM	Eastbound	C	24.1	0.60	54	D	30.8	0.78	94
	Westbound	C	19.3	0.49	42	F	96.9	1.03	267
	Northbound	B	14.9	0.73	180	E	37.3	0.97	603
	Southbound	E	43.8	0.94	313	E	37.9	0.87	171
	Overall	D	27.1			E	45.6		

Table 6 (continued) – Avery-Muirfield Drive & Perimeter Loop/Hospital Drive Capacity Analysis

Perimeter Loop Rd/Hospital Dr	Approach	AM Peak Hour				PM Peak Hour			
		LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)	LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)
2014 With Full Access Driveways (Roundabout) VISSIM	Eastbound	D	34.0		260.00	D	28.9		361.5
	Westbound	B	14.2		214.10	F	54.8		992.9
	Northbound	A	3.7		145.80	A	7.4		299.4
	Southbound	A	8.9		349.40	A	9.4		208.9
	Overall	A	9.0			C	17.4		
2014 With Driveway Access Changes (Roundabout) VISSIM	Eastbound	D	34.0		251.80	D	25.8		350.9
	Westbound	C	20.3		257.00	F	71.0		955
	Northbound	A	4.3		190.40	A	8.2		348.8
	Southbound	A	8.4		334.70	A	8.4		221.1
	Overall	A	9.8			C	18.5		

Table 7 – Avery-Muirfield Drive & Perimeter Drive Capacity Analysis

Perimeter Dr	Approach	AM Peak Hour				PM Peak Hour			
		LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)	LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)
Existing with Full Access Driveways (Signalized)	Eastbound	D	49.4	0.64	159	D	43.9	0.68	162
	Westbound	D	39.1	0.37	131	D	41.7	0.77	329
	Northbound	B	16.2	0.64	192	B	12.0	0.81	83
	Southbound	C	27.0	0.77	452	C	30.2	0.70	256
	Overall	C	28.0			C	27.9		
Existing with Driveway Access Changes (Signalized)	Eastbound	D	49.4	0.64	159	D	44.5	0.68	162
	Westbound	C	33.9	0.30	125	D	41.5	0.77	329
	Northbound	B	17.6	0.72	196	B	11.8	0.81	167
	Southbound	C	30.7	0.82	477	C	30.2	0.54	256
	Overall	C	29.3			C	27.4		
2021 with Full Access Driveways (Signalized)	Eastbound	E	60.3	0.84	235	E	79.4	0.97	322
	Westbound	C	32.1	0.57	161	E	71.1	1.04	618
	Northbound	C	29.2	0.99	219	C	20.0	0.98	198
	Southbound	D	53.1	1.00	635	D	51.3	1.01	336
	Overall	D	43.0			D	50.9		
2021 with Driveway Access Changes (Signalized)	Eastbound	E	60.3	0.84	325	E	75.4	0.97	317
	Westbound	C	33.9	0.61	165	E	73.0	1.04	618
	Northbound	C	31.2	0.95	178	B	14.4	0.98	154
	Southbound	D	49.2	0.98	626	D	51.3	1.01	336
	Overall	D	42.0			D	47.8		
2013 (Roundabout w/o NB and WB right turn lanes) SIDRA HCM	Eastbound	C	24.1	0.59	55	C	17.7	0.56	57
	Westbound	A	7.7	0.19	14	F	82.1	1.01	298
	Northbound	C	21.0	0.74	125	F	59.9	1.01	515
	Southbound	D	31.4	0.88	250	C	20.9	0.70	97
	Overall	D	25.0			E	48.6		

Table 7 (continued) – Avery-Muirfield Drive & Perimeter Drive Capacity Analysis

Perimeter Dr	Approach	AM Peak Hour				PM Peak Hour			
		LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)	LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)
2018 (Roundabout with NB and WB right turn lanes) SIDRA HCM	Eastbound	E	35.5	0.72	76	D	26.5	0.71	87
	Westbound	A	8.5	0.25	19	F	58.8	0.95	193
	Northbound	D	30.4	0.97	358	E	45.3	0.97	336
	Southbound	F	60.0	1.01	531	D	33.9	0.82	132
	Overall	E	40.7			E	43.0		
2014 With Full Access Driveways (Roundabout) VISSIM	Eastbound	C	20.3		203.5	B	11.8		233.2
	Westbound	A	5.1		55.3	D	31.4		467.2
	Northbound	A	4.3		146	A	9.2		361.8
	Southbound	A	8.3		409.6	A	6.8		192.9
	Overall	A	8.5			B	14.3		
2014 With Driveway Access Changes (Roundabout) VISSIM	Eastbound	D	27.1		289.3	B	13.9		273.9
	Westbound	A	5.2		61.2	D	32.3		501.6
	Northbound	A	5.6		283.2	A	9.7		451.8
	Southbound	A	8.4		400	A	6.1		154
	Overall	A	9.8			C	14.6		

Table 8 – Avery-Muirfield Drive & Post Road Capacity Analysis

Post Road	Approach	AM Peak Hour				PM Peak Hour			
		LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)	LOS	Average Vehicle Delay (sec)	Maximum Approach V/C	95th Percentile Queue Length (ft)
2012 (SIDRA HCM)	Eastbound	C	22.7	0.54	46	B	12.9	0.43	37
	Westbound	A	5.4	0.03	2	C	16.3	0.35	25
	Northbound	A	8.3	0.33	34	D	28.4	0.86	331
	Southbound	C	17.9	0.78	259	B	10.6	0.54	84
	Overall	C	16.1			C	20.0		
2022 (SIDRA HCM)	Eastbound	F	84.7	1.01	263	C	15.8	0.56	58
	Westbound	A	6.3	0.11	7	C	18.2	0.40	30
	Northbound	B	10.7	0.41	46	D	33.6	0.90	395
	Southbound	D	32.1	0.92	527	B	12.7	0.59	98
	Overall	D	33.5			C	23.5		

Comparison to 2005 Study

Methodology

The methodology and assumptions used to conduct the study in 2005 was slightly different than the methodology and assumptions used for this revised study. Most of the differences were in regards to the development of the 2030 traffic forecasts. The other difference was the analysis parameters for the roundabouts. These changes are described below.

- **Reduced Traffic Counts** – The traffic counts obtained for the 2005 study were up to 10% higher than the counts taken in 2012. This reduction in traffic volumes along the corridor has an effect on the 2030 design assignments between the two studies. Table 9 shows the comparison of the existing traffic counts between the two studies.
- **Revised Land Use** – While both studies used a 2030 design year, the land use used in each study was very different. In the 2005 study, the traffic assignments were developed during the I-270/US 33 Northwest Freeway Major Investment Study. This study used the MORPC regional travel demand model and its associated land use. This revised study used the land use contained in the City of Dublin Travel Demand Model. Each of these models makes different assumptions on the amount of development that will occur within the City of Dublin. These different assumptions create different 2030 assignments in the travel demand model, which in turn creates different design traffic assignments. Table 9 shows the comparison of the 2030 traffic assignments between the two studies.
- **Roundabout Analysis** – When the 2005 study was conducted, *Sidra* was the standard roundabout analysis tool for capacity analysis. The developers of *Sidra* created their own formulas and methodologies to conduct the analysis. Since 2005, the Highway Capacity Manual (HCM) has added a roundabout analysis methodology based on new research on American roundabouts. The HCM methodology is now the industry standard for roundabout analysis. The *Sidra* and HCM methodologies are different and will produce some differences in the results.

Table 9 – Comparison of Traffic Volumes to 2005 Study

Location	Original 2005		2012 Revised	
	AM	PM	AM	PM
Existing Traffic Counts				
WB US 33/SR 161 Intersection	3360	3620	3230	3800
Perimeter Loop Intersection	3520	4080	3040	3680
Perimeter Drive Intersection	3010	3955	2810	3530
Post Road Intersection	2370	3140	2280	2890
2030 Traffic Assignments				
WB US 33/SR 161 Intersection	5235	5605	7630	7530
Perimeter Loop Intersection	4335	5395	5990	6270
Perimeter Drive Intersection	4540	5030	4730	5000
Post Road Intersection	3665	4140	3010	3290
Perimeter Loop, West of Avery-Muirfield	710	1235	1070	1690
Perimeter Loop, East of Avery-Muirfield	925	1310	1540	2090
Perimeter Drive, West of Avery-Muirfield	1065	1330	1170	1970
Perimeter Drive, East of Avery-Muirfield	1740	1720	2390	2830
Post Road, West of Avery-Muirfield	355	690	880	1050
Post Road, East of Avery-Muirfield	440	550	610	450
Avery-Muirfield, South of Perimeter Loop	3930	4660	4140	5790
Avery-Muirfield, South of Perimeter Drive	3175	3585	3810	2850
Avery-Muirfield, South of Post Road	3105	3425	2090	2350
Avery-Muirfield, North of Post Road	3430	3615	2440	2730

Existing Counts and 2030 Assignments

As shown in Table 9, the traffic counts conducted in 2012 were lower than the counts conducted for the 2005 study. It should be pointed out that the 2005 study did not have the Dublin Methodist Lane connection at the WB US 3/SR 161 intersection. Traffic using this connection in 2005 would have traveled through the Perimeter Loop Drive intersection. By removing that volume from the 2005 existing counts the Perimeter Loop intersection counts would be closer to the 2012 counts, but still slightly higher.

The 2030 assignments have several differences between the 2005 and 2012 studies. The total intersection assignments in the 2012 study are higher at the WB US 33/SR 161 and Perimeter Loop/Hospital Drive intersections, equal at the Perimeter Drive intersection and lower at the Post Road intersection than the 2005 study. Also, the link assignments on Perimeter Loop, Hospital Drive, and Perimeter Drive are higher in the 2012 study. The higher side street assignments are caused by the different land use assumptions between the two studies. In addition, the higher side street assignments pulled some of the traffic off of Avery-Muirfield Drive. North of Perimeter Loop Drive, the Avery-Muirfield Drive corridor assignments are lower in the 2012 study than the 2005 study.

Service Life

The service life determined by the capacity analysis has been compared to what was determined in the 2005 study. At the Post Road and Perimeter Drive intersections, the calculated service life in this revised study is longer than what was calculated in 2005. The Post Road roundabout will operate acceptably until 2022, instead of 2014 determined in the previous study. Perimeter Drive will operate acceptably as a signal until 2021 and 2018 as a roundabout. This is in comparison to the 2010 and 2015 years determined in the previous study. The intersection with Perimeter Loop/Hospital Drive had very similar service life results compared to the 2005 study. Table 10 shows the service life comparison for the intersections.

Table 10 – Comparison of Service Life at Intersections to 2005 Study

Intersection	Original 2005 Study		2012 Revised Study	
	Signal	Roundabout	Signal	Roundabout
Perimeter Loop/Hospital Dr	2016	2015	2017	2014
Perimeter Drive	2010	2015	2021	2018
Post Road	N/A	2014	N/A	2022

Avery-Muirfield & Post Road – At the Post Road intersection, the 2030 traffic assignments in this study are 15-20% lower than the 2030 assignments in the 2005 study. In fact, the 2030 assignments in the PM peak hour are only slightly higher than the traffic counts taken for the 2005 study. This significant reduction in traffic assignments, combined with the changes in roundabout analysis methodology are the reasons there is an eight year increase in the service life of the roundabout.

Avery-Muirfield & Perimeter Drive – At the Perimeter Drive intersection, the service life of the traffic signal has increased by 11 years compared to the 2005 study. There are a couple factors that contribute to this increase. The biggest factor is the reduction in intersection traffic counts between 2005 and 2012. In the PM peak, which is the first peak hour at this intersection to reach capacity, the total intersection traffic count was 3,955 and 3,530 vehicles in 2005 and 2012 respectively. The total 2030 PM peak intersection traffic assignments are 5,030 and 5,000 in the 2005 and 2012 studies respectively. The interim year traffic assignments were developed using a straight line growth between the existing count and the 2030 assignment. For the 2005 study, the signal was projected to reach capacity in 2010. Using the straight line growth, the total intersection traffic in 2010 would be **4,165 vehicles**. In the 2012 study, the signal was projected to reach capacity in 2021. Using straight line growth, the total intersection traffic in 2021 would be **4,270 vehicles**. This shows that the intersection is reaching capacity at essentially the same volume. The change in traffic counts and land use assignments have combined to create the 11 year increase in service life.

For a roundabout at the Perimeter Drive intersection, a comparison of the 2030 traffic assignments shows that while the total entering volume of this intersection in this study is the same as in the 2005 study, there have been some significant changes to how this traffic is traveling through the intersection. The traffic assigned to/from Perimeter Loop Drive has increased from the 2005 study. At the same time, the two highest traffic movements in the intersection, NB and SB through, have decreased by over 30% in this

study. These changes in traffic patterns, combined with the changes in roundabout methodology are the reasons there is a three year increase in the service life of the roundabout.

Roundabout Layout

In 2010, Burgess & Niple developed an exhibit showing the layout for two-lane roundabouts at Perimeter Loop/Hospital Drive and Perimeter Drive. This layout was based on the analysis in the 2005 study. This original layout is shown in Figure 15. With this revised study, the updated traffic volumes and revised capacity analysis has resulted in a couple modifications to this layout. These modifications at Perimeter Loop/Hospital Drive include lane use changes to the eastbound and westbound approaches and the conversion of the northbound right turn lane to a free right movement. Figure 16 shows the modified two-lane roundabout layout, including the changes at Perimeter Loop/Hospital Drive.

The capacity analysis of the Perimeter Drive roundabout revealed that additional capacity could be obtained by adding northbound and westbound right turn lanes at the roundabout. These right turn lanes would provide an additional 5 years of operation for the roundabout. This layout is shown in Figure 17.

Figure 15 – Original Two-Lane Roundabout Layout from 2005 Study

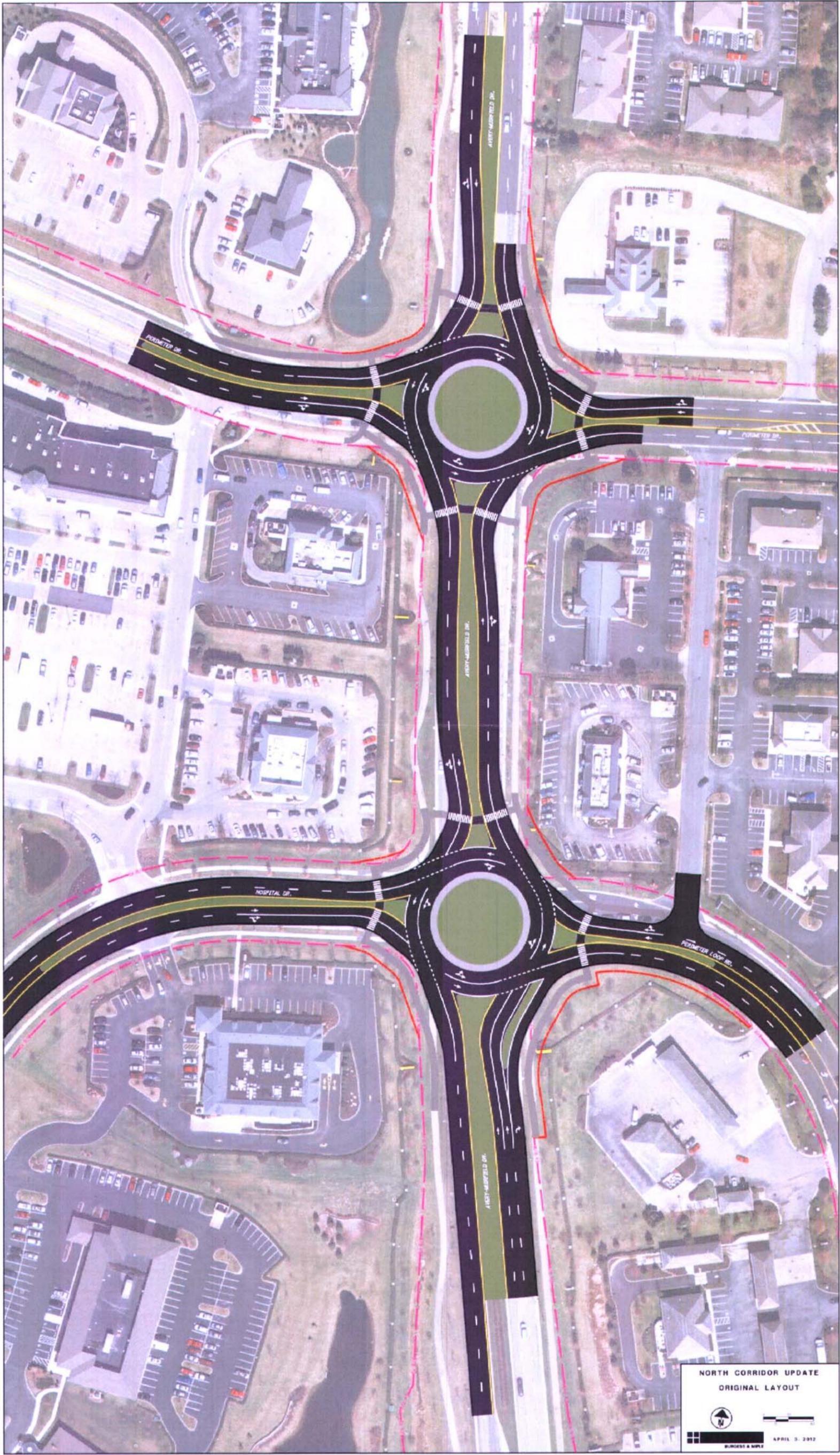


Figure 16— Modified Two-Lane Roundabout Layout with Changes to Perimeter Loop/Hospital Drive

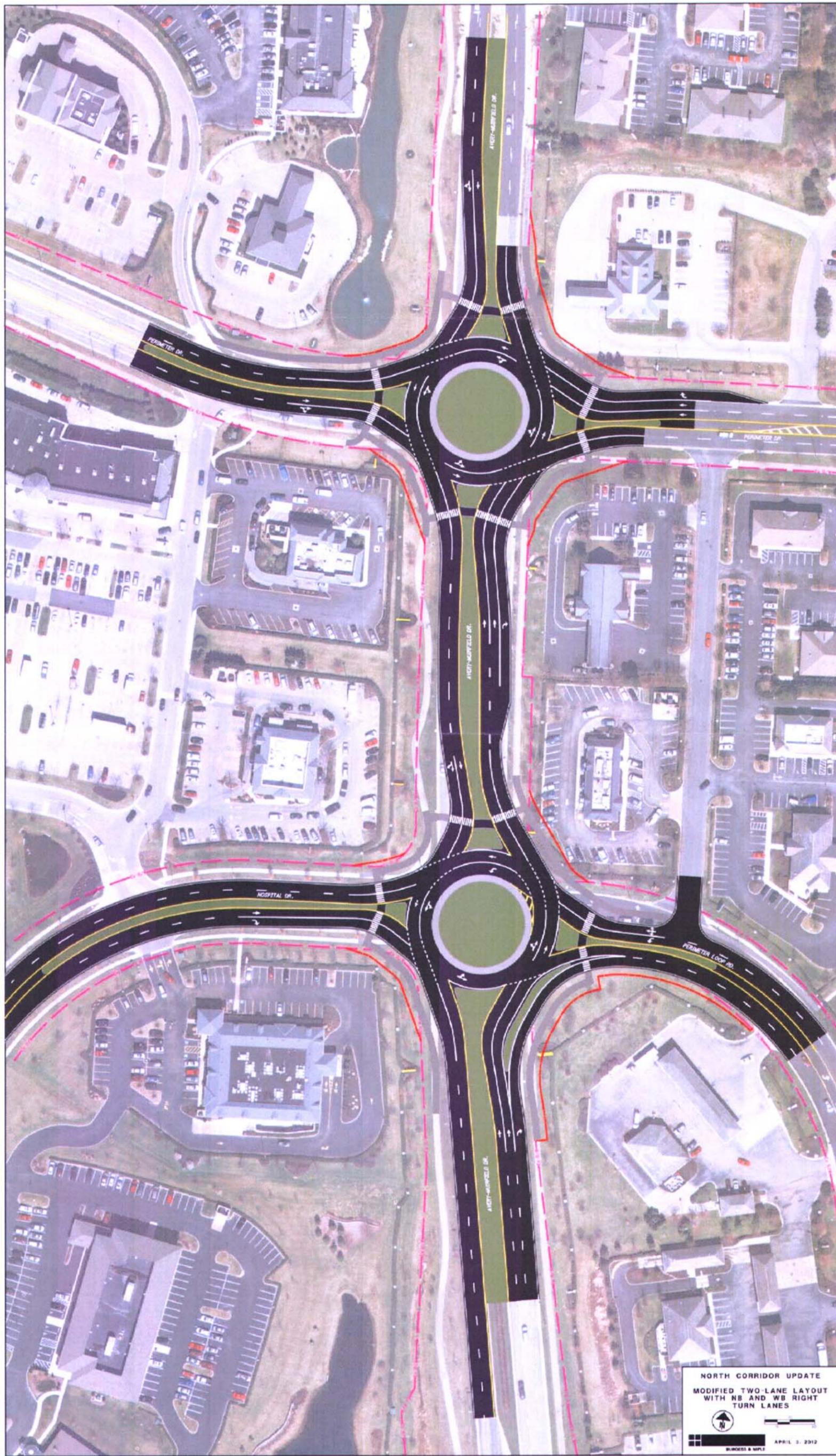
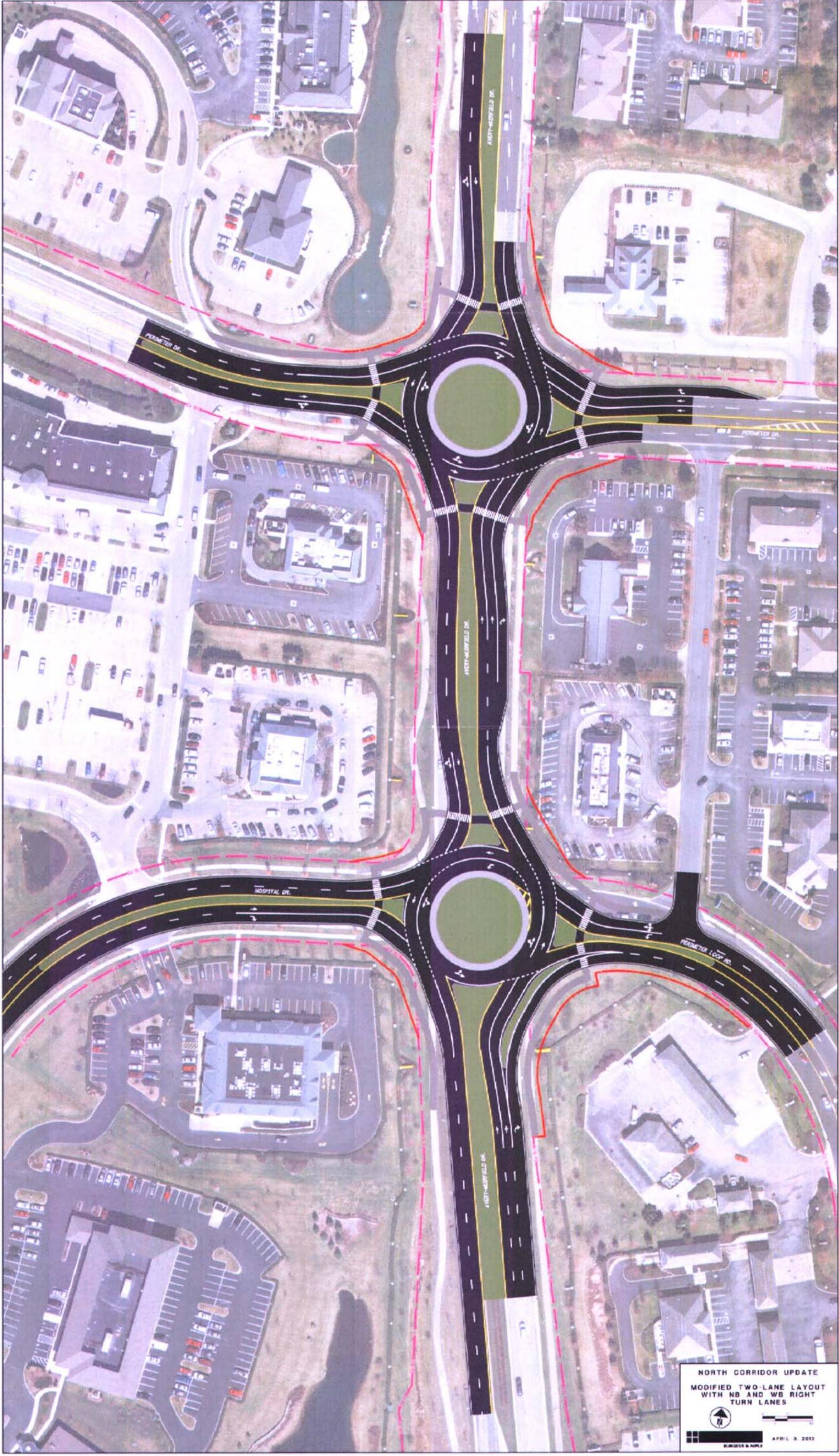


Figure 17— Modified Two-Lane Roundabout Layout with Changes to Perimeter Loop/Hospital Drive and Perimeter Drive Right Turn Lanes



Cost Estimates

Cost estimates for the original two-lane roundabout layout were developed by B&N in 2010. Based on the unit prices from recent construction projects, the unit prices have remained unchanged in the 18 months since the original estimates were prepared. The only unit price that has shown some increase is the cost of asphalt. For this reason, all unit prices from the 2010 estimate have remained the same except for a slight increase in asphalt cost. Table 11 shows the cost estimate for the intersections of Avery-Muirfield Drive & Perimeter Loop/Hospital Drive and Avery-Muirfield Drive & Perimeter Drive.

Table 12 shows the cost estimate for the access modifications to the adjacent driveways on Perimeter Loop/Hospital Drive and Perimeter Drive. Two options for these changes were developed. The first option assumed the median islands would have grass inside and the second option assumed the median islands would have brick pavers inside. The cost for the relocated Avery Road Retail Center driveway is in addition to the cost for the roundabouts. The cost for the other driveway changes is only applicable if the roundabouts are NOT constructed. The median island changes necessary at these driveways are part of the roundabout layouts and included in their cost. Detailed construction cost breakdowns can be found in the Appendix.

Table 11 – Roundabout Cost Estimates

Intersection	2010 Estimate	Modified Two-Lane Layout	Modified Two-Lane Layout with Right Turn Lanes at Perimeter Drive
Perimeter Loop/Hospital Drive	\$2,066,871	\$2,097,812	\$2,097,812
Perimeter Drive	\$1,909,606	\$1,923,866	\$1,947,191
Total	\$3,976,477	4,021,678	\$4,045,003

Table 12 – Access Modifications to Adjacent Driveways Cost Estimates

Location	Grass Median	Brick Paver Median
Relocated Avery Road Retail Center Drive	\$257,117	\$305,675
McDonald's Access Road @ Perimeter Loop	\$116,764	\$116,764
Burger King Access Road @ Perimeter Drive	\$85,407	\$125,464
Total	\$459,288	\$547,902

Conclusions

The Avery-Muirfield Drive corridor north of US-33/SR-161 was originally studied in 2005 to determine best/most appropriate long-term operational solutions for the corridor. The purpose of this current study is to update the 2005 analysis and determine if the 2005 results need to be modified. In addition, closely spaced commercial driveways on either side of Avery-Muirfield Drive along Perimeter Loop, Hospital Drive and Perimeter Drive were evaluated to determine what access changes are necessary.

Revised 2030 traffic forecasts were developed for this study. Compared to the 2030 assignments from the 2005 study, traffic forecasts at the Perimeter Loop/Hospital Drive intersection went up, traffic forecasts at the Perimeter Drive intersection remained about the same and traffic forecasts at the Post Road intersection went down.

Current City policy is to maintain two through lanes along the Avery-Muirfield corridor, which limits the roundabouts to two-lanes. Using the revised traffic assignments, the intersections were analyzed to determine what year the existing traffic signals and proposed two-lane roundabouts would reach capacity. These results were then compared to the results of the 2005 study. The following table shows the service life comparison between the two studies.

Intersection	Original 2005 Study		2012 Revised Study	
	Signal	Roundabout	Signal	Roundabout
Perimeter Loop/Hospital Dr	2016	2015	2017	2014
Perimeter Drive	2010	2015	2021	2018
Post Road	N/A	2014	N/A	2022

As shown in the table, the Perimeter Loop/Hospital Drive intersection is expected to exceed capacity in a similar time frame as the 2005 study. The Perimeter Drive and Post Road intersection service life has been extended from the 2005 study results.

Traffic analysis for this revised study identified a few changes to the two-lane roundabout layouts originally proposed in the 2005 study. These changes are:

- Eastbound approach at the Perimeter Loop/Hospital Drive roundabout changed from through/left and through/right lanes to a through/left and right only. Changing the eastbound approach to a single through lane means that there is only one eastbound departure lane instead of the two in the original 2005 layout. This provides the pavement and receiving lane necessary to allow the northbound right turn to become a free movement
- The westbound approach at the Perimeter Loop/Hospital Drive roundabout has been changed from through/left and through/right lanes to left only and left/through/right.
- Right turn lanes have been added to the northbound and westbound approaches at the Perimeter Drive roundabout.

Analysis of the commercial driveways east and west of Avery-Muirfield Drive revealed a few concerns and some recommended access changes. First, existing queues from the Avery-Muirfield Drive intersections extend past these drives today. This will only worsen as traffic volumes in the corridor increase. As the length of time that the driveways are blocked increases, it will be more difficult to make a left turn into or out of the driveway. The result will be an increase in the number of left turn crashes. In addition, it will be difficult to provide a left turn lane into these driveways in the two-lane roundabout design without negatively affecting the design of the approaches and splitter islands to the roundabouts. For these reasons, the following changes are recommended at the commercial drives:

- SE Drive for Avery Road Retail Center/Walgreens – Relocate the drive for the Avery Road Retail Center to the south as a “T” intersection with Hospital Drive. The driveway will remain full access. Convert the Walgreens drive to right-in-right-out using a raised median island.
- McDonald’s Access on Perimeter Loop – Convert this drive to right-in-right-out using a raised median island.
- Burger King Access Road on Perimeter Drive – Convert this drive to right-in-right-out using a raised median island.