

ROUNABOUT INTERSECTION ANALYSIS & CONCEPT DESIGN

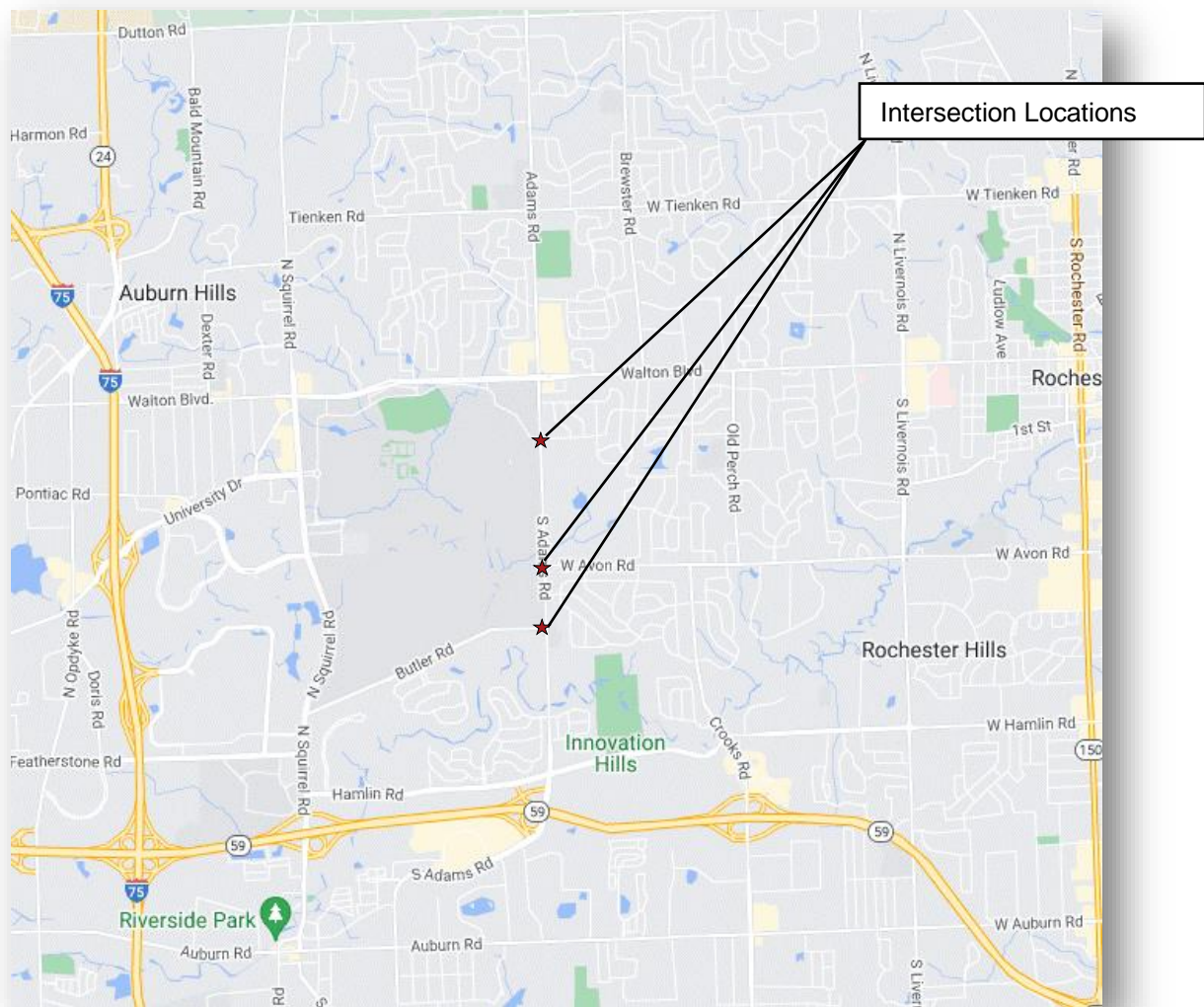
Adams Road Intersections:

BUTLER ROAD,

AVON ROAD &

HILLEDALE DRIVE/ MEADOW BROOK ROAD

Road Commission for Oakland County (RCOC), Michigan



April 30, 2024

April 30, 2024
(REVISED)

Lia Michaels, P.E., PTOE., Hubbell, Roth & Clark, Inc.

To:

From: Mark Lenters, Kimley-Horn and Associates, Inc.
Adam Gomez, Kimley-Horn and Associates, Inc.
Ali Donnes, E.I.T. Kimley-Horn and Associates, Inc.

Subject: Adams Road Corridor Roundabout Intersection Analysis and Concept Design
Memorandum:
1. Adams Road at Hillendale Drive/ Meadow Brook Road
2. Adams Road at Avon Road, and,
3. Adams Road at Butler Road,

INTRODUCTION

The three above-captioned intersections along the Adams Road Corridor are under review for conversion to roundabouts. The intersection of Adams Road at Butler Road is approximately 1,850 feet (0.35 miles) south of Avon Road, and the intersection of Adams Road at Hillendale Drive/ Meadow Brook Road is located approximately 3,790 feet (0.72 miles) north of Avon Road.

This memo focuses on the operational analysis and feasibility of roundabouts at the proposed locations. The analysis supports and refines the proposed conceptual designs by applying consistent design criteria with expected growth rates, to determine the required capacity for each location. This memo treats the combination of the three roundabouts as a system for consistency of speed, driver expectancy, operational capacity and collision risk.

Kimley-Horn evaluated the feasibility of both single lane and multilane roundabouts at each intersection. The operational analysis results presented in the following sections confirm the need for hybrid multilane roundabouts along the Adams Road corridor. All single lane roundabout analyses generated poor LOS for at least one of the peak hours for the design year forecasts (2045). The residual capacity reported in this memo indicates that one or more of the single lane roundabouts is expected to generated high delays or LOS E during the early years of operation, approximately year 2035.

METHOD AND RESULTS

Turning movement counts were collected by HRC on November 15 -17, 2022 for AM, Midday, and PM peak hours and provided to Kimley-Horn for use in this analysis. The peak hour turning movement counts are shown in Figure 1, Figure 2, and Figure 3. 2022 volumes were projected using a compound growth rate of 0.5% to the build year 2025, interim 2035 and the design year 2045 to assess future conditions of each roundabout. The interim year projections were used in single lane analyses, and the design year projections were used in the single lane and hybrid multilane analyses.

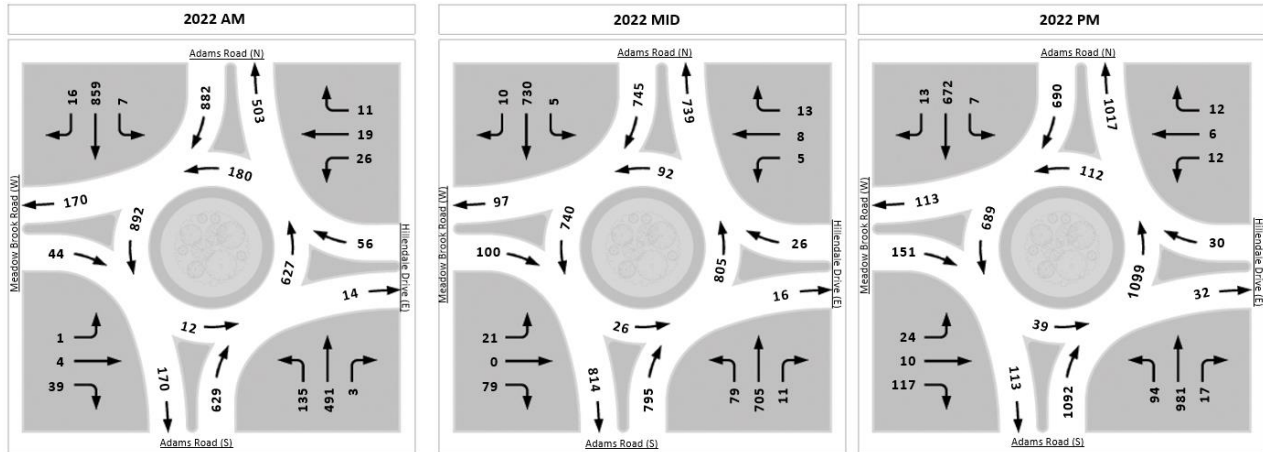


Figure 1: Adams Road at Meadow Brook Road/ Hillendale Drive – 2022 Turning Movement Patterns

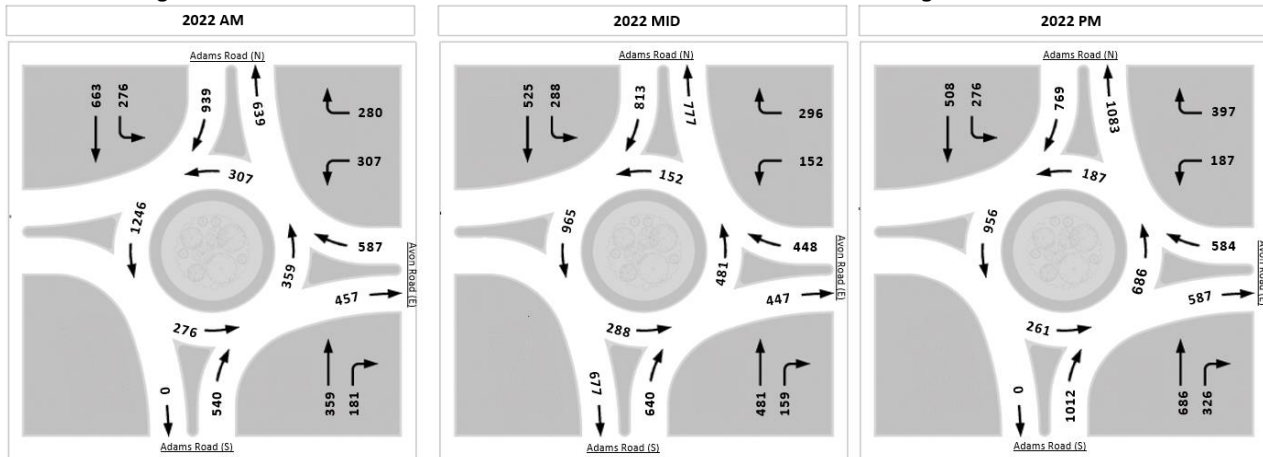


Figure 2: Adams Road at Avon Road – 2022 Turning Movement Patterns

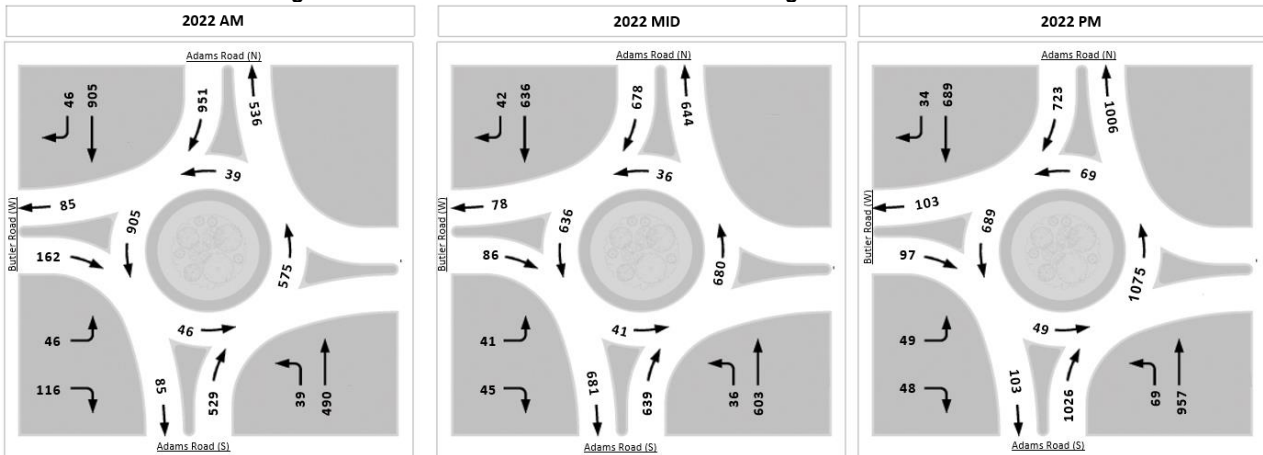


Figure 3: Adams Road at Butler Road – 2022 Turning Movement Patterns

Each of the roundabouts presented in this report were modeled using ARCADY10 (Assessment of Roundabout Capacity and Delay, Version 10) and HCM 6th Edition (*Highway Capacity Manual*) methodologies. ARCADY10 is a program based on U.K. empirical research into geometry-capacity relationships, adapted to U.S. conditions and drivers. The geometric parameters considered in the ARCADY capacity models are summarized in Table 1. HCM 6th Edition analysis results and ARCADY10 results often differ based on their various analysis parameters and model assumptions, but the true expected result is likely with the range of results.

Table 1: ARCADY Analysis Geometric Parameters

Parameter	Single-Lane Geometry	Multilane Geometry
Road Half-Width, ft	12	24
Entry Width, ft	14	24
Effective Flare Length, ft	50	0
Entry Radius, ft	65	65
Inscribed Circle Diameter (ICD), ft	120	150
Phi/ Entry Angle. deg	20	20

SINGLE LANE ROUNDABOUTS

Single lane roundabout analyses were conducted using ARCADY and HCM 6 methodologies for the interim year 2035 and design year 2045. Interim year analyses explore the feasibility of an expandable single lane roundabout where a multilane may not be required until year 2035 or later. Each lane configuration diagram represents the conceptual configurations used in each analysis and does not reflect a refined geometric design.

Adams Road at Meadow Brook Road and Hillendale Road

A single lane roundabout at Adams Road at Meadow Brook Road and Hillendale Road would be a simple, four-legged roundabout with no right-turn bypass lanes. Figure 4 below provides a conceptual lane configuration diagram of the single lane roundabout at Adams Road at Meadow Brook Road and Hillendale Road. The following tables present the results of the ARCADY and HCM 6 single lane roundabout analyses for the interim year 2035 and the design year 2045.

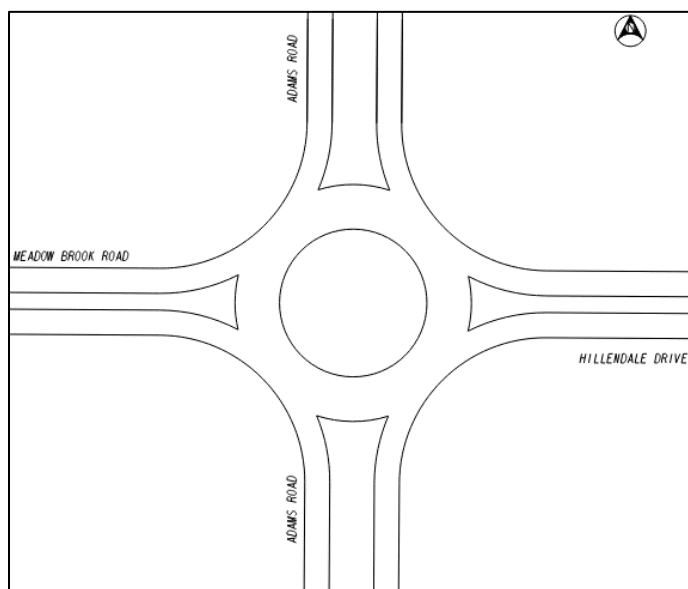


Figure 4: Single Lane Roundabout at Adams Road and Meadow Brook Road/ Hillendale Road (Not to Scale)

Table 2: Adams Road at Hillendale Road & Meadow Brook Road 2035 Single Lane ARCADY Roundabout Analysis

Adams Road at Hillendale Road and Meadow Brook Road 2035 Single Lane ARCADY Roundabout Analysis					
		East Leg Hillendale Road	North Leg Adams Road	West Leg Meadow Brook Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.5	28.2	0.5	1.7
	Delay (s)	4.33	18.6	5.35	6.33
	V/C Ratio	0.07	0.85	0.07	0.55
	LOS	A	C	A	A
	Intersection Delay (s)	12.96			
	Intersection LOS	B			
	Residual Capacity	11% - [North Leg Adams Road]			
MID PEAK	Queue (PCE)	0.5	5	0.5	6.4
	Delay (s)	4.81	9.32	5.18	9.52
	V/C Ratio	0.04	0.69	0.14	0.71
	LOS	A	A	A	A
	Intersection Delay (s)	9.1			
	Intersection LOS	A			
	Residual Capacity	35% - [South Leg Adams Road]			
PM PEAK	Queue (PCE)	0.5	2.7	1.1	86.1
	Delay (s)	6.59	8.46	5.36	64.18
	V/C Ratio	0.06	0.65	0.21	0.99
	LOS	A	A	A	F
	Intersection Delay (s)	39.21			
	Intersection LOS	E			
	Residual Capacity	-6% - [South Leg Adams Road]			

Table 3: Adams Road at Hillendale Road & Meadow Brook Road 2035 Single Lane HCM Roundabout Analysis

Adams Road at Hillendale Road and Meadow Brook Road 2035 Single Lane HCM Roundabout Analysis					
		East Leg Hillendale Road	North Leg Adams Road	West Leg Meadow Brook Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.3	14.5	0.3	3.4
	Delay (s)	5.55	29.7	7.06	8.44
	V/C Ratio	0.08	0.91	0.08	0.53
	LOS	A	D	A	A
	Intersection Delay (s)	19.95			
	Intersection LOS	C			
	Residual Capacity	3% - [North Leg Adams Rd]			
MID PEAK	Queue (PCE)	0.1	6.3	0.6	6
	Delay (s)	6.07	13.2	7.25	11.94
	V/C Ratio	0.05	0.7	0.17	0.68
	LOS	A	B	A	B
	Intersection Delay (s)	12.13			
	Intersection LOS	B			
	Residual Capacity	31% - [North Leg Adams Road]			
PM PEAK	Queue (PCE)	0.2	5.5	1.0	19.5
	Delay (s)	8.53	12.27	7.88	35.92
	V/C Ratio	0.07	0.67	0.25	0.97
	LOS	A	B	A	E
	Intersection Delay (s)	25.04			
	Intersection LOS	D			
	Residual Capacity	0% - [South Leg Adams Road]			

Table 4: Adams Road at Hillendale Road & Meadow Brook Road 2045 Single Lane ARCADY Roundabout Analysis

Adams Road at Hillendale Road and Meadow Brook Road 2045 Single Lane ARCADY Roundabout Analysis					
		East Leg Hillendale Road	North Leg Adams Road	West Leg Meadow Brook Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.5	37.9	0.5	2
	Delay (s)	4.46	24.66	5.61	6.78
	V/C Ratio	0.08	0.9	0.08	0.58
	LOS	A	C	A	A
	Intersection Delay (s)	16.46			
	Intersection LOS	C			
	Residual Capacity	5% - [North Leg Adams Road]			
MID PEAK	Queue (PCE)	0.5	8.8	0.5	10.5
	Delay (s)	5.02	10.57	5.43	10.81
	V/C Ratio	0.04	0.73	0.15	0.74
	LOS	A	B	A	B
	Intersection Delay (s)	10.29			
	Intersection LOS	B			
	Residual Capacity	29% - [South Leg Adams Road]			
PM PEAK	Queue (PCE)	0.5	5	1.3	108.1
	Delay (s)	6.78	9.43	5.65	109.19
	V/C Ratio	0.06	0.69	0.23	1.04
	LOS	A	A	A	F
	Intersection Delay (s)	64.57			
	Intersection LOS	F			
	Residual Capacity	-11% - [South Leg Adams Road]			

Table 5: Adams Road at Hillendale Road & Meadow Brook Road 2045 Single Lane HCM Roundabout Analysis

Adams Road at Hillendale Road and Meadow Brook Road 2045 Single Lane HCM Roundabout Analysis					
		East Leg Hillendale Road	North Leg Adams Road	West Leg Meadow Brook Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.3	18.3	0.3	3.8
	Delay (s)	5.78	40.06	7.49	8.96
	V/C Ratio	0.09	0.97	0.09	0.56
	LOS	A	E	A	A
	Intersection Delay (s)	25.85			
	Intersection LOS	D			
	Residual Capacity	-2% - [North Leg Adams Road]			
MID PEAK	Queue (PCE)	0.2	7.4	0.7	6.9
	Delay (s)	6.4	14.85	7.69	13.16
	V/C Ratio	0.05	0.74	0.18	0.72
	LOS	A	B	A	B
	Intersection Delay (s)	13.48			
	Intersection LOS	B			
	Residual Capacity	24% - [North Leg Adams Road]			
PM PEAK	Queue (PCE)	0.3	6.5	1.1	24.3
	Delay (s)	9.1	13.66	8.46	48.58
	V/C Ratio	0.08	0.71	0.27	1.02
	LOS	A	B	A	E
	Intersection Delay (s)	32.61			
	Intersection LOS	D			
	Residual Capacity	-5% - [South Leg Adams Road]			

Adams Road at Avon Road

A single lane roundabout at Adams Road at Avon Road would involve a three-leg roundabout with right-turn bypass lanes on the east leg and the south leg. Figure 5 below provides a conceptual lane configuration diagram of the single lane roundabout at Adams Road at Avon Road. The following tables present the results of the ARCADY and HCM6th single lane roundabout analyses for 2035 and 2045.

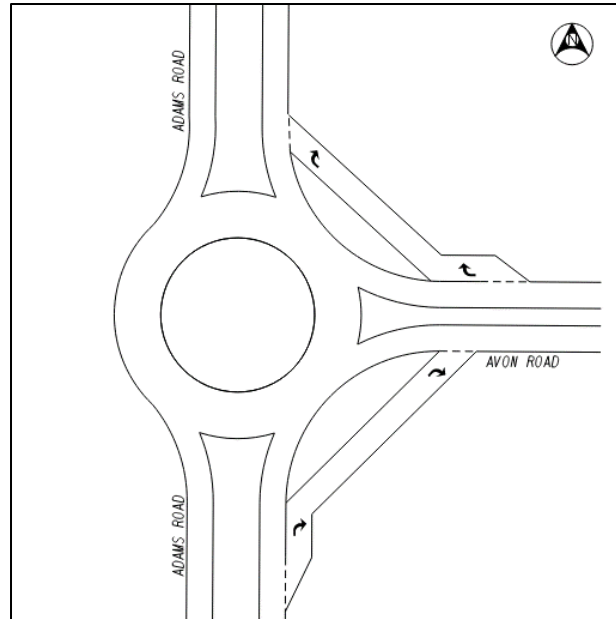


Figure 5: Single Lane Roundabout at Adams Road and Avon Road (Not to Scale)

Table 6: Adams Road at Avon Road 2035 Single Lane ARCADY Roundabout Analysis

Adams Road at Avon Road 2035 Single Lane ARCADY Roundabout Analysis				
		East Leg Avon Road	North Leg Adams Road	South Leg Adams Road
AM PEAK	Queue (PCE)	2.0	66.0	2.1
	Delay (s)	5.02	43.46	5.20
	V/C Ratio	0.33	0.98	0.36
	LOS	A	E	A
	Intersection Delay (s)	22.55		
	Intersection LOS	C		
	Residual Capacity	-3% - [North Leg Adams Road]		
MID PEAK	Queue (PCE)	0.5	15.0	1.5
	Delay (s)	4.4	12.89	6.53
	V/C Ratio	0.18	0.77	0.49
	LOS	A	B	A
	Intersection Delay (s)	8.75		
	Intersection LOS	A		
	Residual Capacity	21% - [North Leg Adams Road]		
PM PEAK	Queue (PCE)	1.4	11.2	6.00
	Delay (s)	5.61	11.67	10.15
	V/C Ratio	0.25	0.75	0.69
	LOS	A	B	B
	Intersection Delay (s)	9.52		
	Intersection LOS	A		
	Residual Capacity	25% - [North Leg Adams Road]		

Table 7: Adams Road at Avon Road 2035 Single Lane HCM Roundabout Analysis

Adams Road at Avon Road 2035 Single Lane HCM Roundabout Analysis				
		East Leg Avon Road	North Leg Adams Road	South Leg Adams Road
AM PEAK	Queue (PCE)	3.1	29.4	2.8
	Delay (s)	7.29	89.88	7.14
	V/C Ratio	0.35	1.13	0.4
	LOS	A	F	A
	Intersection Delay (s)	44.8		
	Intersection LOS	E		
	Residual Capacity	-13% - [North Leg Adams Road]		
MID PEAK	Queue (PCE)	2.6	9.8	4.5
	Delay (s)	7.77	19.39	9.94
	V/C Ratio	0.39	0.81	0.57
	LOS	A	C	A
	Intersection Delay (s)	13.47		
	Intersection LOS	B		
	Residual Capacity	14% - [North Leg Adams Road]		
PM PEAK	Queue (PCE)	5.8	9.2	10
	Delay (s)	13.79	19.02	15.15
	V/C Ratio	0.63	0.8	0.78
	LOS	B	C	C
	Intersection Delay (s)	16.07		
	Intersection LOS	C		
	Residual Capacity	14% - [North Leg Adams Road]		

Table 8: Adams Road at Avon Road 2045 Single Lane ARCADY Roundabout Analysis

Adams Road at Avon Road 2045 Single Lane ARCADY Roundabout Analysis				
		East Leg Avon Road	North Leg Adams Road	South Leg Adams Road
AM PEAK	Queue (PCE)	2.0	88.7	2.0
	Delay (s)	5.25	85.07	5.39
	V/C Ratio	0.35	1.04	0.38
	LOS	A	F	A
	Intersection Delay (s)	41.56		
	Intersection LOS	E		
	Residual Capacity	-7% - [North Leg Adams Road]		
MID PEAK	Queue (PCE)	0.8	22.0	1.5
	Delay (s)	4.54	15.56	6.98
	V/C Ratio	0.19	0.82	0.52
	LOS	A	C	A
	Intersection Delay (s)	10.07		
	Intersection LOS	B		
	Residual Capacity	15% - [North Leg Adams Road]		
PM PEAK	Queue (PCE)	1.2	17.000	10.3
	Delay (s)	5.93	13.83	11.73
	V/C Ratio	0.27	0.79	0.74
	LOS	A	B	B
	Intersection Delay (s)	10.98		
	Intersection LOS	B		
	Residual Capacity	18% - [North Leg Adams Road]		

Table 9: Adams Road at Avon Road 2045 HCM Single Lane Roundabout Analysis

Adams Road at Avon Road 2045 Single Lane HCM Roundabout Analysis				
		East Leg Avon Road	North Leg Adams Road	South Leg Adams Road
AM PEAK	Queue (PCE)	3.4	36.4	3.0
	Delay (s)	7.72	121.02	7.33
	V/C Ratio	0.38	1.21	0.42
	LOS	A	F	A
	Intersection Delay (s)	59.11		
	Intersection LOS	F		
	Residual Capacity	-18% - [North Leg Adams Road]		
MID PEAK	Queue (PCE)	2.9	12.0	5.1
	Delay (s)	8.31	23.64	10.85
	V/C Ratio	0.41	0.86	0.6
	LOS	A	C	B
	Intersection Delay (s)	15.72		
	Intersection LOS	C		
	Residual Capacity	8% - [North Leg Adams Road]		
PM PEAK	Queue (PCE)	6.9	11.2	12.1
	Delay (s)	15.99	23.11	18.05
	V/C Ratio	0.69	0.85	0.83
	LOS	C	C	C
	Intersection Delay (s)	19.18		
	Intersection LOS	C		
	Residual Capacity	8% - [North Leg Adams Road]		

Adams Road at Butler Road

A single lane roundabout at Adams Road at Butler Road would be a three-leg roundabout with no right-turn bypass lanes. Figure 6 below provides a conceptual lane configuration diagram of the single lane roundabout at Adams Road at Butler Road. The following tables present the results of the ARCADY and HCM6th single lane roundabout analyses for the interim year 2035 and the design year 2045.

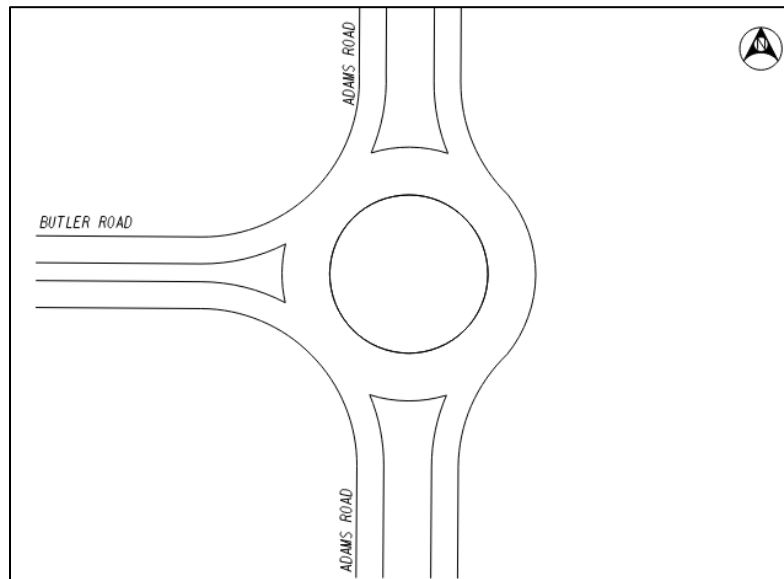


Figure 6: Single Lane Roundabout at Adams Road and Butler Road (Not to Scale)

Table 10: Adams Road at Butler Road 2035 ARCADY Single Lane Roundabout Analysis

Adams Road at Butler Road 2035 Single Lane ARCADY Roundabout Analysis				
		South Leg Adams Road	North Leg Adams Road	West Leg Butler Road
AM PEAK	95% Queue (PCE)	1.5	28.3	1.5
	Delay (s)	5.54	17.26	6.96
	V/C Ratio	0.47	0.85	0.26
	LOS	A	C	A
	Intersection Delay (s)	12.47		
	Intersection LOS	B		
	Residual Capacity	13% - [North Leg Adams Road]		
MID PEAK	95% Queue (PCE)	1.5	2.3	0.5
	Delay (s)	5.44	7.18	4.77
	V/C Ratio	0.47	0.61	0.11
	LOS	A	A	A
	Intersection Delay (s)	6.31		
	Intersection LOS	A		
	Residual Capacity	57% - [North Leg Adams Road]		
PM PEAK	95% Queue (PCE)	43.3	3.5	0.5
	Delay (s)	26.45	8.32	5.04
	V/C Ratio	0.92	0.66	0.13
	LOS	D	A	A
	Intersection Delay (s)	18.22		
	Intersection LOS	C		
	Residual Capacity	4% - [South Leg Adams Road]		

Table 11: Adams Road at Butler Road 2035 HCM Single Lane Roundabout Analysis

Adams Road at Butler Road 2035 Single Lane HCM Roundabout Analysis				
		South Leg Adams Road	North Leg Adams Road	West Leg Butler Road
AM PEAK	95% Queue (PCE)	2.7	10.9	1.4
	Delay (s)	7.68	18.82	10.8
	V/C Ratio	0.47	0.83	0.32
	LOS	A	C	B
	Intersection Delay (s)	14.45		
	Intersection LOS	B		
	Residual Capacity	15% - [North Leg Adams Road]		
MID PEAK	95% Queue (PCE)	2.6	4.2	0.5
	Delay (s)	7.53	9.68	6.35
	V/C Ratio	0.46	0.59	0.13
	LOS	A	A	A
	Intersection Delay (s)	8.58		
	Intersection LOS	A		
	Residual Capacity	59% - [North Leg Adams Road]		
PM PEAK	95% Queue (PCE)	15	5.3	0.6
	Delay (s)	26.25	11.46	6.9
	V/C Ratio	0.91	0.66	0.15
	LOS	D	B	A
	Intersection Delay (s)	19.44		
	Intersection LOS	C		
	Residual Capacity	6% - [South Leg Adams Road]		

Table 12: Adams Road at Butler Road 2045 ARCADY Roundabout Analysis

Adams Road at Butler Road 2045 Single Lane ARCADY Roundabout Analysis				
		South Leg Adams Road	North Leg Adams Road	West Leg Butler Road
AM PEAK	95% Queue (PCE)	1.5	37.5	1.5
	Delay (s)	5.82	22.28	7.47
	V/C Ratio	0.5	0.9	0.29
	LOS	A	C	A
	Intersection Delay (s)	15.51		
	Intersection LOS	C		
	Residual Capacity	7% - [North Leg Adams Road]		
MID PEAK	95% Queue (PCE)	1.5	3.0	0.5
	Delay (s)	5.71	7.80	4.93
	V/C Ratio	0.5	0.64	0.12
	LOS	A	A	A
	Intersection Delay (s)	6.76		
	Intersection LOS	A		
	Residual Capacity	49% - [North Leg Adams Road]		
PM PEAK	95% Queue (PCE)	67.1	5.1	1.4
	Delay (s)	37.42	9.25	5.99
	V/C Ratio	0.97	0.69	0.24
	LOS	E	A	A
	Intersection Delay (s)	24.1		
	Intersection LOS	C		
	Residual Capacity	-1% - [South Leg Adams Road]		

Table 13: Adams Road at Butler Road 2045 HCM Roundabout Analysis

Adams Road at Butler Road 2045 Single Lane HCM Roundabout Analysis				
		South Leg Adams Road	North Leg Adams Road	West Leg Butler Road
AM PEAK	95% Queue (PCE)	2.9	13.2	1.6
	Delay (s)	8.09	22.69	11.81
	V/C Ratio	0.49	0.88	0.35
	LOS	A	C	B
	Intersection Delay (s)	16.91		
	Intersection LOS	C		
	Residual Capacity	9% - [North Leg Adams Road]		
MID PEAK	95% Queue (PCE)	2.8	4.7	0.5
	Delay (s)	7.92	10.40	6.66
	V/C Ratio	0.49	0.62	0.14
	LOS	A	B	A
	Intersection Delay (s)	9.14		
	Intersection LOS	A		
	Residual Capacity	51% - [North Leg Adams Road]		
PM PEAK	95% Queue (PCE)	18.3	6.1	1.2
	Delay (s)	33.29	12.60	8.97
	V/C Ratio	0.95	0.69	0.28
	LOS	D	B	A
	Intersection Delay (s)	23.41		
	Intersection LOS	C		
	Residual Capacity	1% - [South Leg Adams Road]		

All single lane roundabout analyses generated poor LOS for at least one of the peak hours for the design year forecasts (2045). The residual capacities reported in this memo indicates that one or more of the single lane roundabouts is expected to generated high delays or LOS E during the early years of operation, approximately year 2035. For this reason, single lane roundabouts are not recommended due to their inability to supply the near-term traffic demands.

HYBRID MULTILANE ROUNDABOUTS

In the following figures, Adams Road approaches are each shown with standard two-lane entries on the north and south approaches. Side street configurations vary based on entry and circulating volumes for each approach. Hybrid multilane roundabouts were analyzed using ARCADY and HCM 6 methodologies for the design year 2045. Each lane configuration diagram is a conceptual sketch and does not represent an accurate or refined geometric design. These sketches represent the schematic configurations used in each analysis.

Adams Road at Meadow Brook Road and Hillendale Road

A hybrid multilane roundabout at Adams Road at Meadow Brook Road and Hillendale Road would be a four-leg roundabout with no right-turn bypass lanes. The configuration features single lane entries on Meadow Brook Road and Hillendale Road with standard multilane entries along Adams Road. Figure 7 below provides a conceptual lane configuration diagram of the single lane roundabout at Adams Road at Meadow Brook Road and Hillendale Road. Table 14 and Table 15 present the results of the ARCADY and HCM 6 roundabout analyses for the design year 2045.

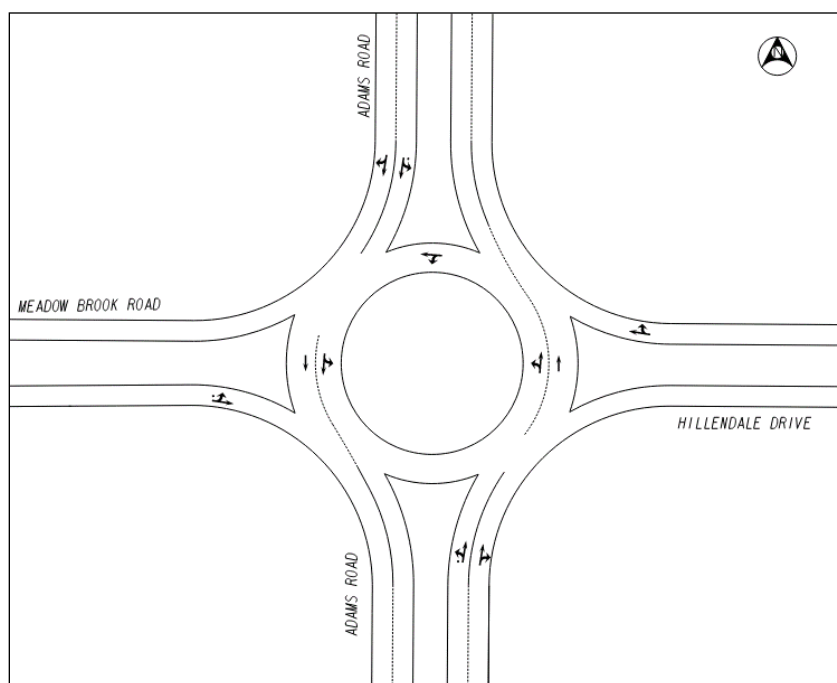


Figure 7: Hybrid Multilane Roundabout at Adams Road and Meadow Brook Road/ Hillendale Road (Not to Scale)

Table 14: Adams Road at Hillendale Road & Meadow Brook Road 2045 ARCADY Roundabout Analysis

Adams Road at Hillendale Road and Meadow Brook Road 2045 Hybrid Multilane ARCADY Roundabout Analysis					
		East Leg Hillendale Road	North Leg Adams Road	West Leg Meadow Brook Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.5	1.5	0.5	2.1
	Delay (s)	4.38	3.47	5.49	2.44
	V/C Ratio	0.08	0.5	0.08	0.33
	LOS	A	A	A	A
	Intersection Delay (s)	3.16			
	Intersection LOS	A			
	Residual Capacity	85% - [North Leg Adams Road]			
MID PEAK	Queue (PCE)	0.5	1.5	0.5	1.5
	Delay (s)	4.89	2.84	5.29	2.83
	V/C Ratio	0.04	0.41	0.15	0.42
	LOS	A	A	A	A
	Intersection Delay (s)	3.01			
	Intersection LOS	A			
	Residual Capacity	95% - [West Leg Meadow Brook Rd]			
PM PEAK	Queue (PCE)	0.5	2.8	1.2	2.3
	Delay (s)	6.9	2.75	5.5	3.96
	V/C Ratio	0.07	0.39	0.22	0.59
	LOS	A	A	A	A
	Intersection Delay (s)	3.69			
	Intersection LOS	A			
	Residual Capacity	53% - [East Leg Hillendale Rd]			

Table 15: Adams Road at Hillendale Road & Meadow Brook Road 2045 HCM Roundabout Analysis

Adams Road at Hillendale Road and Meadow Brook Road 2045 Hybrid Multilane HCM Roundabout Analysis					
		East Leg Hillendale Road	North Leg Adams Road	West Leg Meadow Brook Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.3	5.1	0.3	2.3
	Delay (s)	5.78	8.13	7.49	5.14
	V/C Ratio	0.09	0.46	0.09	0.33
	LOS	A	A	A	A
	Intersection Delay (s)	6.86			
	Intersection LOS	A			
	Residual Capacity	75% - [North Leg Adams Road]			
MID PEAK	Queue (PCE)	0.2	3.3	0.7	3.3
	Delay (s)	6.4	6.27	7.69	5.9
	V/C Ratio	0.05	0.36	0.18	0.38
	LOS	A	A	A	A
	Intersection Delay (s)	6.18			
	Intersection LOS	A			
	Residual Capacity	89% - [West Leg Meadow Brook Rd]			
PM PEAK	Queue (PCE)	0.3	3.1	1.1	5.7
	Delay (s)	9.1	6.13	8.46	7.76
	V/C Ratio	0.08	0.34	0.27	0.53
	LOS	A	A	A	A
	Intersection Delay (s)	7.26			
	Intersection LOS	A			
	Residual Capacity	71% - [West Leg Meadow Brook Rd]			

Adams Road at Avon Road

A hybrid multilane roundabout at Adams Road at Avon Road would be a three-leg roundabout with standard multilane entries along Adams Road and a single lane approach on Avon Road with a right turn bypass. Figure 8 below provides a conceptual lane configuration diagram of the hybrid multilane roundabout at Adams Road at Avon Road. Table 16 and Table 17 present the results of the ARCADY and HCM 6 roundabout analyses for the design year 2045.

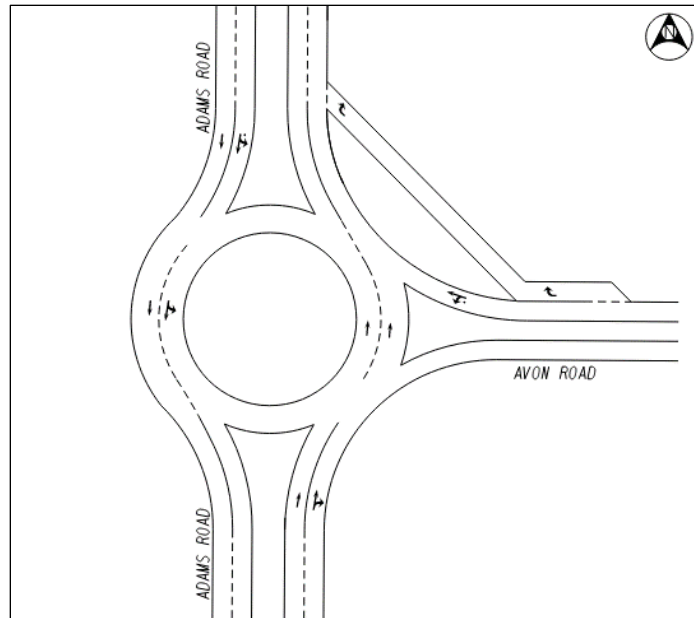


Figure 8: Hybrid Multilane Roundabout at Adams Road and Avon Road (Not to Scale)

Table 16: Adams Road at Avon Road 2045 ARCADY Hybrid Multilane Roundabout Analysis

Adams Road at Avon Road 2045 Hybrid Multilane ARCADY Roundabout Analysis				
		East Leg Avon Road	North Leg Adams Road	South Leg Adams Road
AM PEAK	Queue (PCE)	0.5	1.3	0.5
	Delay (s)	5.18	4.18	2.69
	V/C Ratio	0.35	0.57	0.32
	LOS	A	A	A
	Intersection Delay (s)	4.07		
	Intersection LOS	A		
	Residual Capacity	61% - [North Adams Rd]		
MID PEAK	Queue (PCE)	0.2	0.9	0.6
	Delay (s)	4.48	3.16	2.95
	V/C Ratio	0.19	0.46	0.38
	LOS	A	A	A
	Intersection Delay (s)	3.4		
	Intersection LOS	A		
	Residual Capacity	103% - [North Leg Adams Rd]		
PM PEAK	Queue (PCE)	0.4	0.8	1.5
	Delay (s)	5.78	3.06	4.36
	V/C Ratio	0.27	0.44	0.6
	LOS	A	A	A
	Intersection Delay (s)	4.29		
	Intersection LOS	A		
	Residual Capacity	56% - [South Leg Adams Rd]		

Table 17: Adams Road at Avon Road 2045 HCM6th Hybrid Multilane Roundabout Analysis

Adams Road at Avon Road 2045 Hybrid Multilane HCM Roundabout Analysis				
		East Leg Avon Road	North Leg Adams Road	South Leg Adams Road
AM PEAK	Queue (PCE)	3.4	8.8	3
	Delay (s)	7.72	13.37	7.31
	V/C Ratio	0.38	0.73	0.42
	LOS	A	B	A
	Intersection Delay (s)	10.18		
	Intersection LOS	B		
	Residual Capacity	25% - [North Leg Adams Road]		
MID PEAK	Queue (PCE)	2.9	4.8	3.8
	Delay (s)	8.31	8.31	8.06
	V/C Ratio	0.41	0.56	0.47
	LOS	A	A	A
	Intersection Delay (s)	8.23		
	Intersection LOS	A		
	Residual Capacity	62% - [North Leg Adams Road]		
PM PEAK	Queue (PCE)	6.9	4.5	9.7
	Delay (s)	15.99	8.22	13.91
	V/C Ratio	0.69	0.54	0.76
	LOS	C	A	B
	Intersection Delay (s)	12.58		
	Intersection LOS	B		
	Residual Capacity	18% - [East Leg Avon Rd]		

Adams Road at Butler Road

A hybrid multilane roundabout at Adams Road at Butler Road would be a three-leg roundabout with standard multilane entries along Adams Road and a single lane approach on Butler Road. Figure 9 below provides a conceptual lane configuration diagram of the hybrid multilane roundabout at Adams Road at Butler Road. Table 18 and Table 19 present the results of the ARCADY and HCM 6 roundabout analyses for the design year 2045.

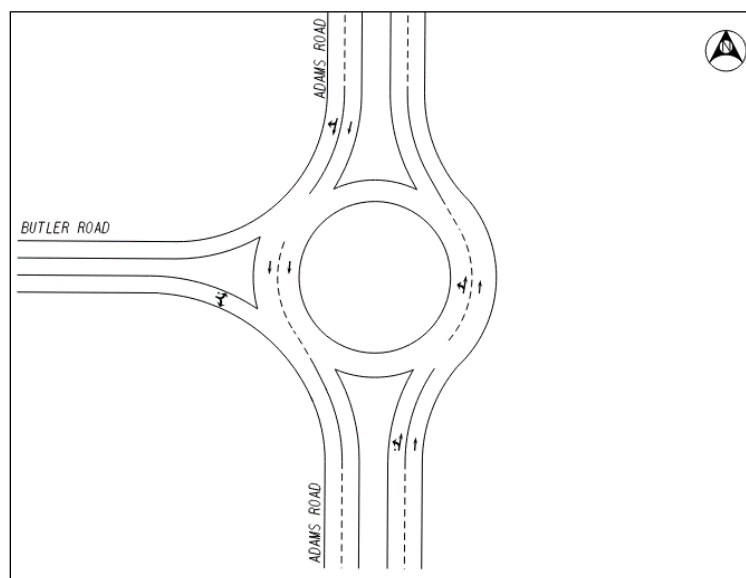


Figure 9: Hybrid Multilane Roundabout at Adams Road and Butler Road (Not to Scale)

Table 18: Adams Road at Butler Road 2045 Hybrid Multilane ARCADY Roundabout Analysis

Adams Road at Butler Road 2045 Hybrid Multilane ARCADY Roundabout Analysis				
		South Leg Adams Road	North Leg Adams Road	West Leg Butler Road
AM PEAK	95% Queue (PCE)	1.4	1.5	1.3
	Delay (s)	2.33	3.3	7.25
	V/C Ratio	0.29	0.51	0.28
	LOS	A	A	A
	Intersection Delay (s)	3.38		
	Intersection LOS	A		
	Residual Capacity	51% - [West Leg Butler Rd]		
MID PEAK	95% Queue (PCE)	1.3	2.1	0.5
	Delay (s)	2.3	2.56	4.83
	V/C Ratio	0.28	0.36	0.12
	LOS	A	A	A
	Intersection Delay (s)	2.6		
	Intersection LOS	A		
	Residual Capacity	128% - [West Leg Butler Rd]		
PM PEAK	95% Queue (PCE)	1.9	1.8	1.4
	Delay (s)	3.59	2.71	5.84
	V/C Ratio	0.55	0.39	0.23
	LOS	A	A	A
	Intersection Delay (s)	3.45		
	Intersection LOS	A		
	Residual Capacity	78% - [South Leg Adams Rd]		

Table 19: Adams Road at Butler Road 2045 Hybrid Multilane HCM Roundabout Analysis

Adams Road at Butler Road 2045 Hybrid Multilane HCM Roundabout Analysis				
		South Leg Adams Road	North Leg Adams Road	West Leg Butler Road
AM PEAK	95% Queue (PCE)	1.9	4.4	1.6
	Delay (s)	4.84	6.79	11.81
	V/C Ratio	0.26	0.44	0.35
	LOS	A	A	B
	Intersection Delay (s)	6.65		
	Intersection LOS	A		
	Residual Capacity	41% - [West Leg Butler Rd]		
MID PEAK	95% Queue (PCE)	1.9	2.6	0.5
	Delay (s)	4.76	5.38	6.66
	V/C Ratio	0.25	0.32	0.14
	LOS	A	A	A
	Intersection Delay (s)	5.21		
	Intersection LOS	A		
	Residual Capacity	120% - [West Leg Butler Rd]		
PM PEAK	95% Queue (PCE)	5.0	3.0	1.2
	Delay (s)	7.3	5.86	8.97
	V/C Ratio	0.49	0.35	0.28
	LOS	A	A	A
	Intersection Delay (s)	6.89		
	Intersection LOS	A		
	Residual Capacity	67% - [West Leg Butler Rd]		

RECOMMENDED LANE CONFIGURATIONS

Multilane roundabouts are recommended along the Adams Road corridor to accommodate capacity needs through the design year 2045. Figure 10 presents a combined schematic lane configuration of the Adams Road roundabouts. In the interest of conserving pavement and minimizing impacts, it is feasible to add flared entry lanes and drop lanes between roundabouts. The distance between each intersection is sufficient to justify the reduced cross-section in conjunction with hybrid multilane roundabouts.

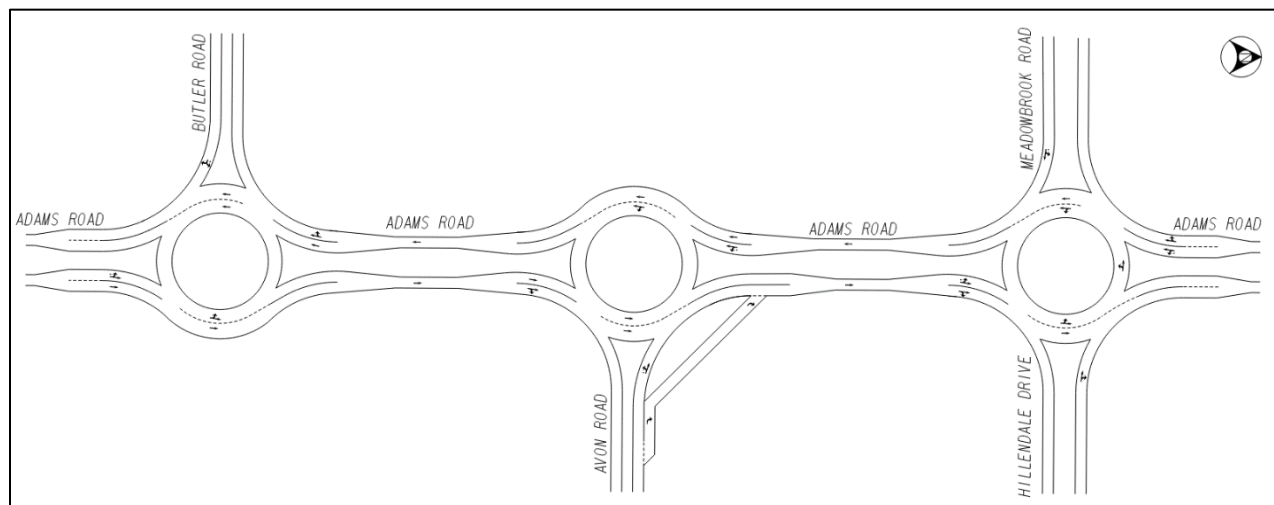


Figure 10: Adams Road Recommended Hybrid Multilane Roundabout Configurations (Not to Scale)

GEOMETRIC DESIGN

Kimley-Horn developed horizontal designs for the intersections of Adams Road at Butler Road, Adams Road at Avon Road, and Adams Road at Hillendale Drive/ Meadow Brook Road based on the preferred lane configurations presented in Figure 10. A summary of the design criteria is presented below in Table 20. An overview of all three roundabouts is presented in Exhibit 1.4.

The proposed roundabout designs include hybrid multilane roundabouts with ICDs ranging from 130-ft to 140-ft. Roundabout entry speeds along Adams Road (north/south) range from 26-29mph. Entry speeds on single lane approaches (east/west) range from 23-25mph. Each roundabout accommodates a WB-67 making through movements by straddling lanes on Adams Road. The designs accommodate a WB-40 making all other turning movements. Busses and Fire trucks were also checked for each design to ensure they do not mount the central island for any of their turning movements.

Table 20: Adams Road Corridor Hybrid Multilane Design Criteria

Geometric Design Element	Hybrid Multilane
Inscribed Circle Diameter	130-140 ft
Circular ROW Footprint	178 – 210 ft
Design and Accommodation Vehicle	WB-40 (Typical); WB-67 (North/South Thru); Straddling Lanes Fire Truck/BUS-45 No Truck Apron Use
Fastest Path Entry Speed, V1 (method: NCHRP 1043, 9.4)	23-25 mph (single lane); 26-29 (multilane)
Splitter Island Length	200 ft. minimum (45+mph); 29 ft. minimum (25mph)
Entry Radius	40 - 105 ft
Exit Taper	Based on design speed of 35mph
Exit Radius	NA (tangential exits)
Entry Angle	20 – 40 degrees
Entry Width, F-F	19 – 28 ft.
Circulatory Roadway Width, F-F	22 – 28 ft. (12ft. lanes on multilane)
Exit Width, F-F	21 – 28 ft.
Truck Apron Width	15 ft.
Minimum Tangent between Approach Curves	50 ft.

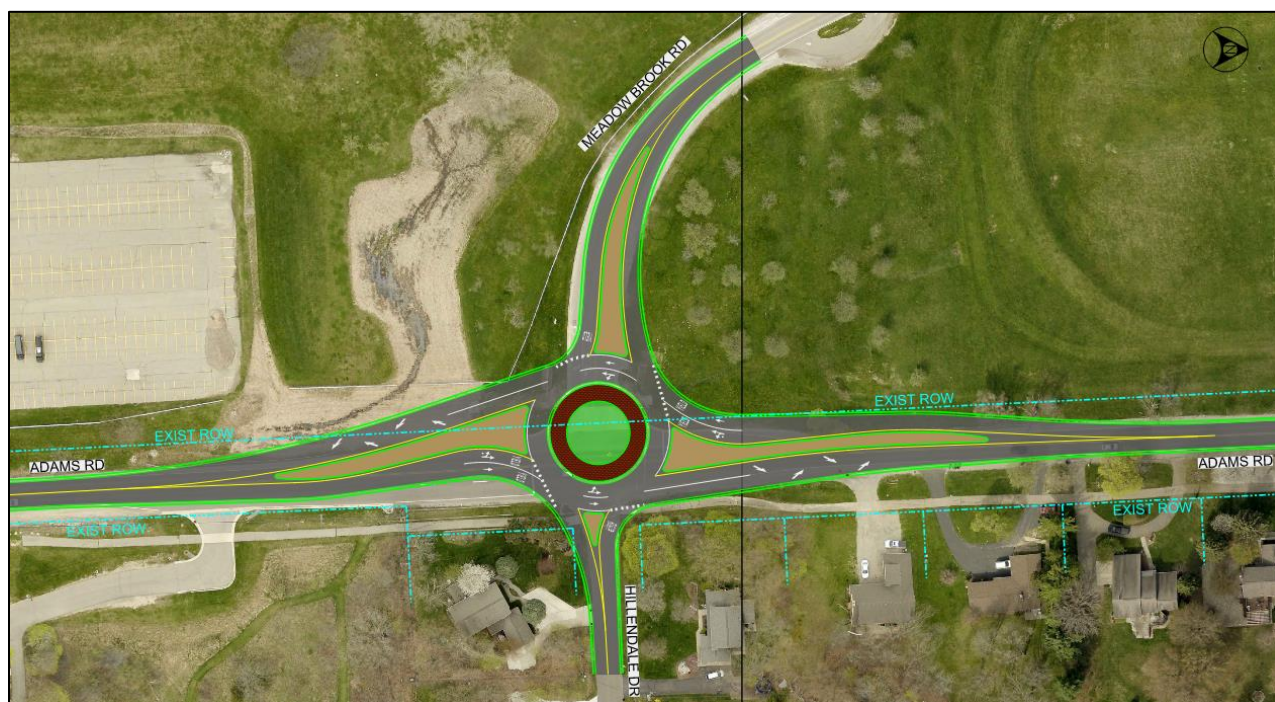


Figure 11: Adams Road at Meadow Brook Road and Hillendale Road

The proposed hybrid multilane roundabout for the intersection of Adams Road at Meadow Brook Road and Hillendale Road (Figure 11) has an ICD of 140-ft. Multilane approaches include two 12-ft lanes, and single lane approaches have entry lane widths of approximately 16-ft. See Exhibit 1.1.0 and Exhibit 1.1.1.

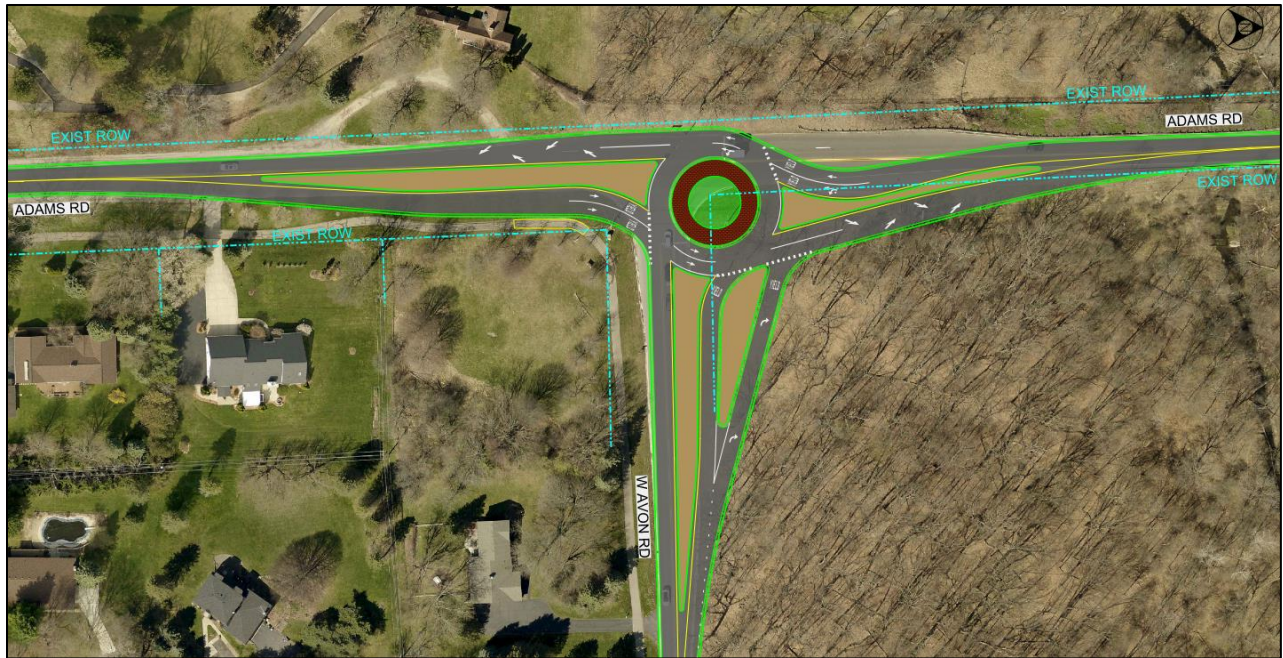


Figure 12: Adams Road at West Avon Road

The proposed hybrid multilane roundabout for the intersection of Adams Road at West Avon Road (Figure 12) has an ICD of 130-ft. Multilane approaches include two 12-ft lanes, and the single lane approach has an entry lane width of 16-ft. Operational analyses for the roundabout justify the need for a westbound right turn bypass lane on West Avon Road. See Exhibit 1.2.0 and Exhibit 1.2.1.

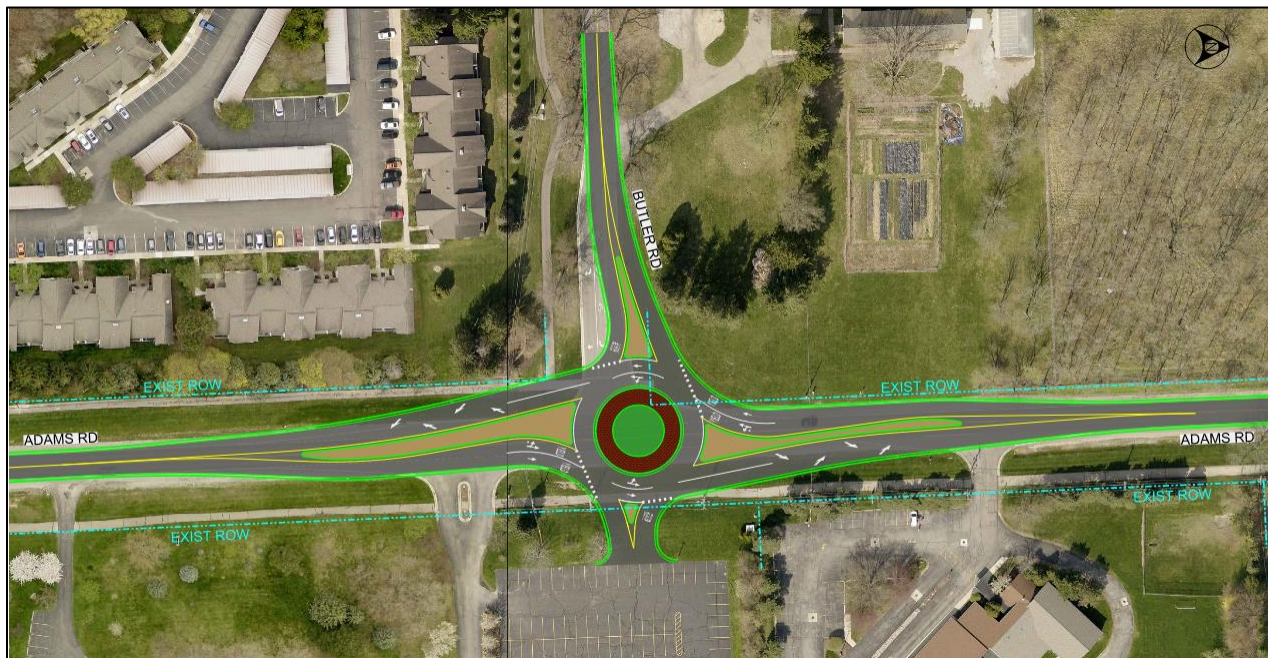


Figure 13: Adams Road at Butler Road

The proposed hybrid multilane roundabout for the intersection of Adams Road at Butler Road (Figure 13) has an ICD of 130-ft. Multilane approaches include two 12-ft lanes, and the single lane approach has an entry lane width of 16-ft. The Somerset School driveway, which is currently located just south of the intersection, will be relocated to the circle to ensure full access for those entering and exiting the roundabout. See Exhibit 1.3.0 and Exhibit 1.3.1.

PEDESTRIAN RECOMMENDATIONS

Kimley-Horn did not provide pedestrian accommodations in the recommended geometry, but crossings will be included in the final design. Kimley-Horn recommends the following parameters for pedestrian crossings to meet ADA/ PROWAG requirements and provide the safest route for pedestrians at the proposed roundabouts.

- Pedestrian crossings should be located 20 to 25-ft from the entry yield line.
- Where at least 6-ft of refuge area is present, crosswalks should be angled perpendicular to the traveled way on the entry and exits and have a deflection at the center of the splitter island. Where 6-ft is not present, the crossing may continue through without a deflection or detectable warning surfaces through the splitter island.
- A maximum longitudinal grade of 5% should be considered at the crosswalk location.

GEOMETRIC SENSITIVITY AND CAPACITY CONSIDERATIONS

The proposed roundabouts are more compact than traditional hybrid or multilane roundabouts. The compact circles reduce right-of-way impacts, maintain appropriate geometric speed control, and promote safety for pedestrians by reducing crossing distances through splitter islands.

More compact hybrid multilane circle diameters of 130-ft to 140-ft are expected to experience slightly higher delays than what is projected by traditional two-lane entry and two-lane exit roundabouts. Flared entries and lane drops on exits are likely to contribute to uneven lane utilization at the roundabout, which will reduce yield line capacities. The proposed circle diameters in conjunction with flared entries and lane drops are expected to have some negative impact on roundabout capacity. Fortunately, the results given in this report suggest that this expected loss of capacity will not substantially impact the performance of the roundabout through the year 2045.

Each multilane entry includes two 12-ft lanes. Kimley-Horn also explored the potential to reduce multilane lane entries to two 11-ft lanes. These lane reductions would still allow the design and check vehicles to maneuver the roundabout without over-tracking mounting splitter islands or landscaped areas. When reducing lane widths, it is recommended that the change originate from the splitter island side of any entry versus the curb side or speed controlling outside entry radius. On this basis, the lane width reductions would not affect geometric speed control (fastest path speeds) or cause path overlap for two vehicles entering the roundabout.

The designs shown in Figure 10, Figure 11, and Figure 12 include symmetrical zipper merges on the exits. This implies that both lanes merge simultaneously to maximize the capacity of a multilane roundabout. As discussed in our recent meeting, the roundabouts will not need to maximize roundabout capacity. Thus, asymmetrical exits with the right lane of a two-lane exit dropping, will not substantially affect roundabout performance through 2045. Therefore, the proposed two-lane roundabout exits may be designed to promote the outside lane to merge into the inside lane.