

final report

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DESIGN SERVICES

March 6, 2018

Traffic Impact Study

Oakland Hills
11333 Bardstown Creek Road
Louisville, KY

Prepared for

Louisville Metro Planning Commission
Kentucky Transportation Cabinet



17 Zone 1081

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INTRODUCTION

The subdivision plan for Oakland Hills on Bardstown Road in Louisville, KY shows 592 single family lots with a tract for multi-family of 348 units. Access to the subdivision will be from Bardstown Road and Broad Run Parkway. The original plan for this development had 736 single family lots with access only from Bardstown Road. **Figure 1** displays a map of the site. The purpose of this study is to examine the traffic impacts of the development upon the adjacent highway system. For this study, the impact area was defined to be the intersections of Bardstown Road with Oakland Hills Trail and Broad Run Parkway.

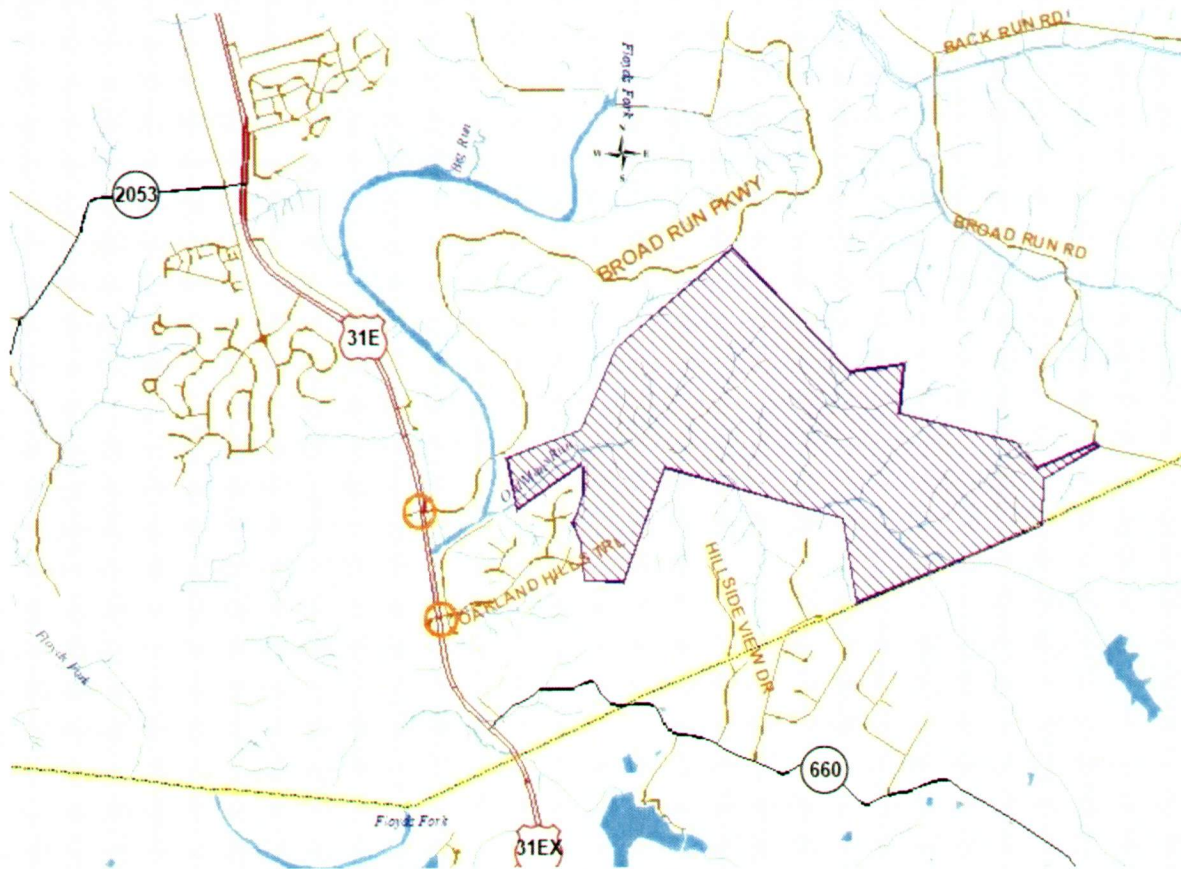


Figure 1. Site Map

EXISTING CONDITIONS

Bardstown Road, US 31E, is maintained by the Kentucky Transportation Cabinet (KYTC) with an estimated 2018 Average Daily Traffic (ADT) volume of 35,100 vehicles per day between the Bullitt County line and Thixton Lane (KY 2053), as estimated from the KYTC 2013 count at station 257. The road is a four-lane highway with twelve-foot lanes, a depressed 32 foot median and ten-foot paved shoulders. The speed limit is 55 mph. There are no sidewalks. The intersection with Oakland Hills Trail has dedicated left turn lanes and is controlled with a stop sign on Oakland Hills Trail. The intersection with Broad Run Parkway has dedicated left turn lanes on all approaches and is controlled with a traffic signal.

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A.m. and p.m. peak hour traffic counts were collected on January 10, and 31, 2018 (see Appendix A). The a.m. peak hour occurred between 7:00 and 8:00 a.m. and the p.m. peak hour occurred between 5:00 and 6:00 p.m. Figure 2 illustrates the existing a.m. and p.m. peak hour traffic volumes.

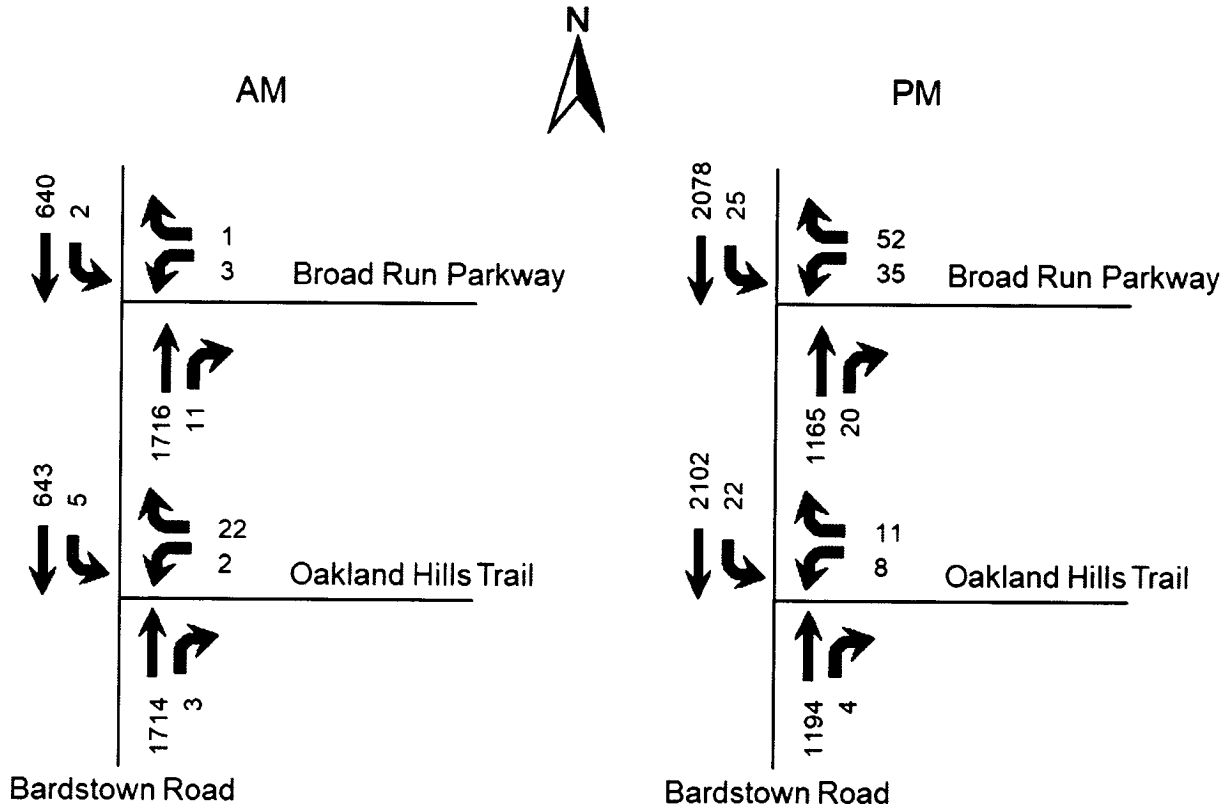


Figure 2. Existing Peak Hour Volumes

FUTURE CONDITIONS

The project completion date is 2030. An annual growth rate of 1.0 percent was applied to Bardstown Road and the park volumes. This is based upon historical growth at KYTC station C39 on US 31E in Bullitt County. The No Build volumes include full build-out of the original 736 lots. 57 lots currently have homes, so there are 679 remaining lots. The trip generation results are listed in Table 1. Figure 3 displays the 2030 No Build peak hour volumes.

Table 1. Peak Hour Trips Generated by Original Plan

Land Use	A.M. Peak Hour			P.M. Peak Hour		
	Trips	In	Out	Trips	In	Out
Single-Family Detached (679 lots)	487	122	365	639	403	236

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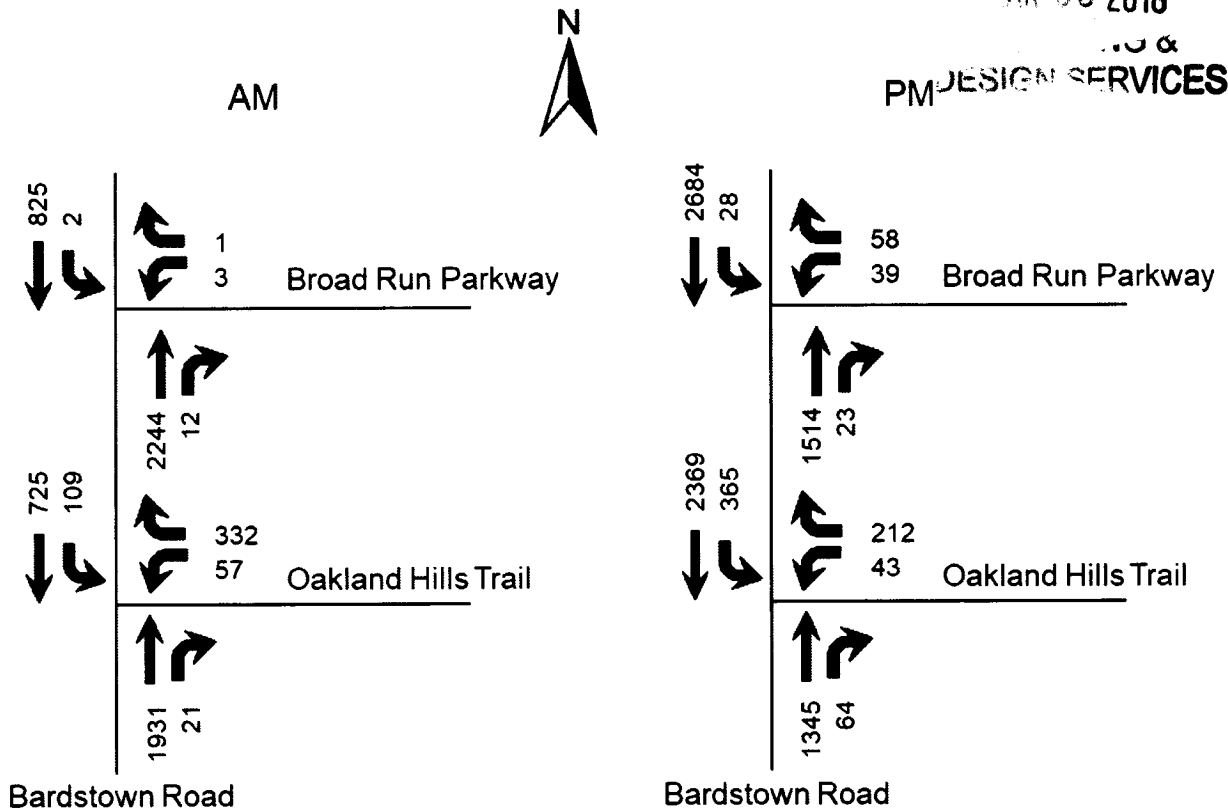


Figure 3. No Build (Original Plan) Peak Hour Volumes

TRIP GENERATION

The Institute of Transportation Engineers Trip Generation Manual, 10th Edition contains trip generation rates for a wide range of developments. The land uses of "Single-Family Detached (210)" and "Multifamily Housing (Mid-Rise) (221)" were reviewed and determined to be the best match. The trip generation results are listed in **Table 2**. The trips were assigned to the highway network with the percentages shown in **Figure 4**. **Figure 5** shows the trips generated by this development and distributed throughout the road network during the peak hours. **Figure 6** displays the individual turning movements for the peak hours when the development is completed.

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Table 2. Peak Hour Trips Generated by Site

Land Use	A.M. Peak Hour			P.M. Peak Hour		
	Trips	In	Out	Trips	In	Out
Single-Family Detached (592 lots)	425	106	319	560	353	207
Multifamily (Mid-Rise) (348 units)	116	30	86	147	89	58
TOTAL	541	136	405	707	442	265

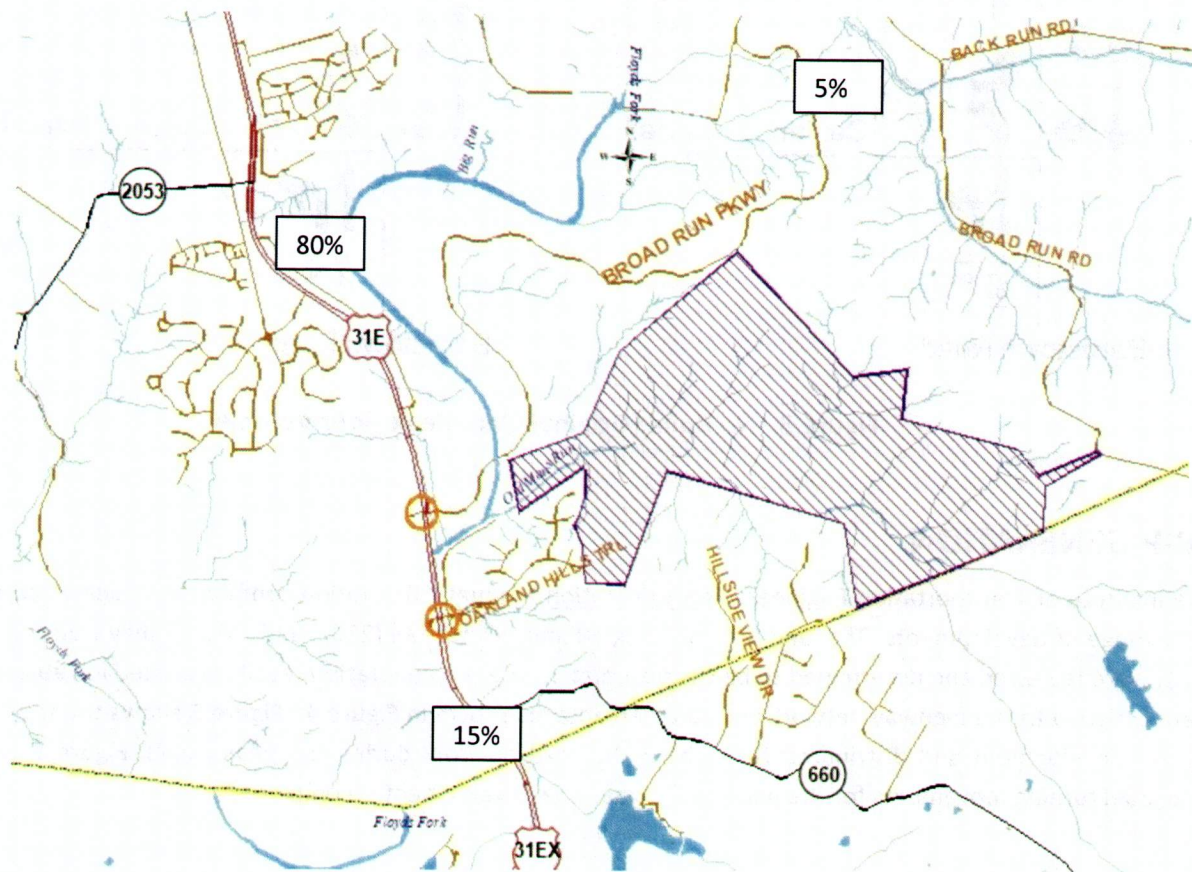


Figure 4. Trip Distribution Percentages

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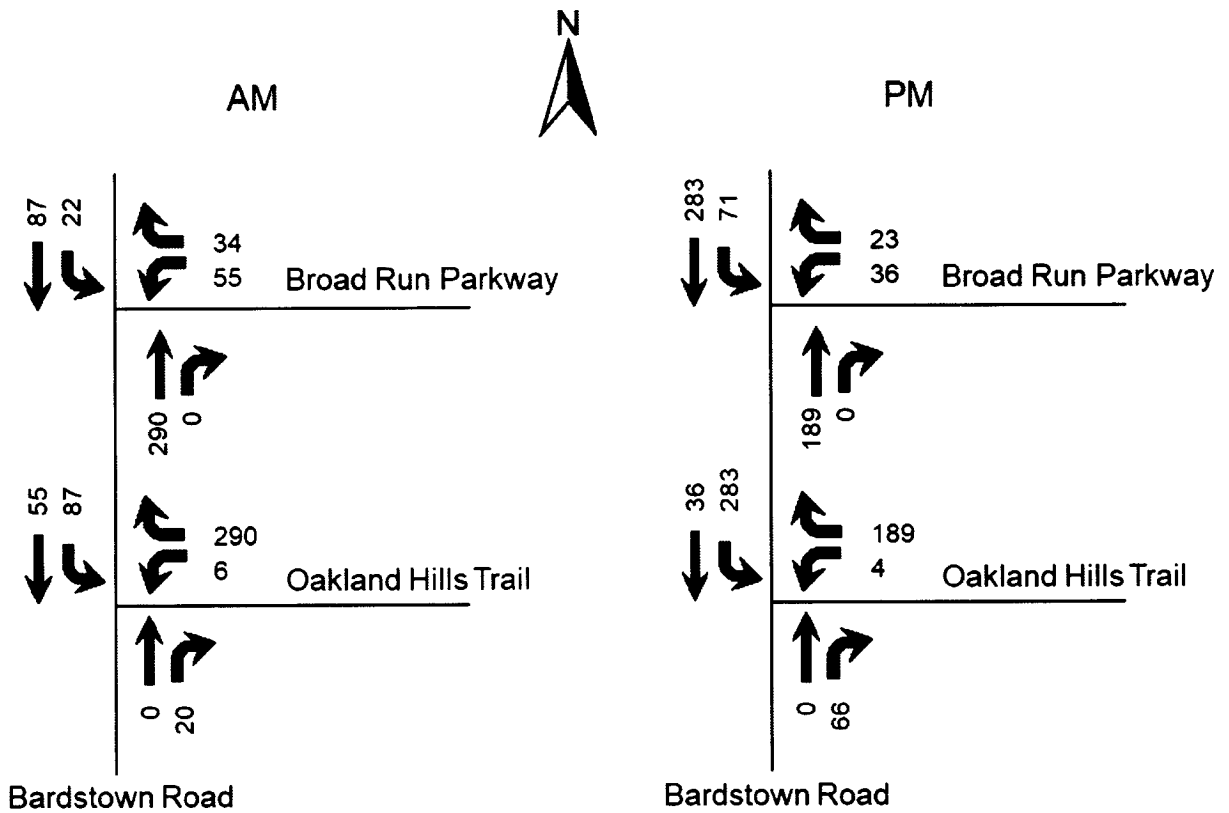


Figure 5. Peak Hour Trips Generated by Site

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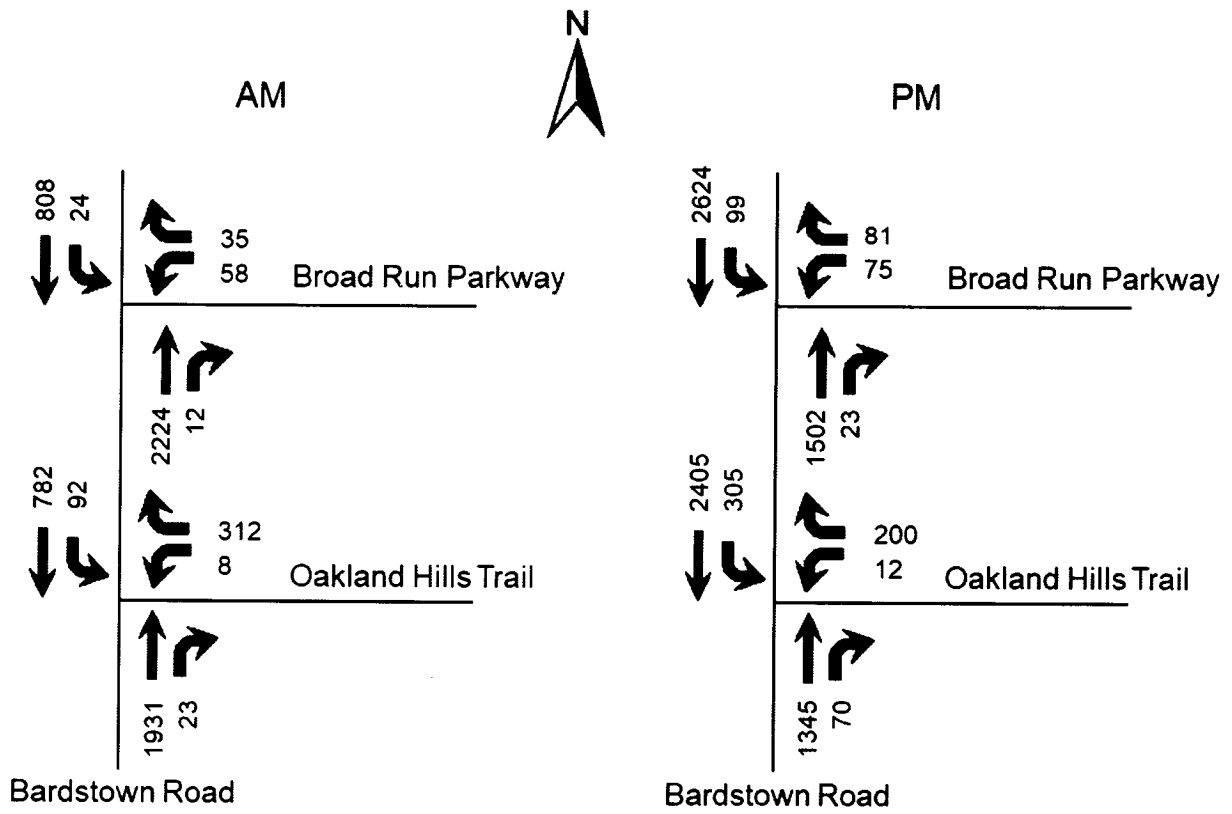


Figure 6. Build Peak Hour Volumes

ANALYSIS

The qualitative measure of operation for a roadway facility or intersection is evaluated by assigning a "Level of Service". Level of Service is a ranking scale from A through F, "A" is the best operating condition and "F" is the worst. Level of Service results depend upon the facility that is analyzed. In this case, the Level of Service is based upon the total delay experienced at an intersection.

To evaluate the impact of the proposed development, the vehicle delays at the intersections were determined using procedures detailed in the Highway Capacity Manual, 6th edition. Future delays and Level of Service were determined for the intersections using the HCS Streets (version 7.4) software. The delays and Level of Service are summarized in **Table 3**.

Table 3. Peak Hour Level of Service

Approach	A.M.			P.M.		
	2018 Existing	2030 No Build	2030 Build	2018 Existing	2030 No Build	2030 Build
Bardstown Road at Oakland Hills Trail						
Oakland Hills Trail Westbound	C 20.5	F 252.9	C 18.0	C 23.8	F 174.8	C 21.2
Bardstown Road Southbound (left)	C 18.1	D 37.2	D 30.6	B 11.9	D 26.9	C 21.5
Bardstown Road at Broad Run Parkway						
Broad Run Parkway Westbound	D 43.2	E 60.3	E 55.3	D 49.6	E 56.3	E 57.3
Bardstown Road Northbound	A 2.8	A 4.6	A 7.7	A 3.1	A 3.5	A 4.0
Bardstown Road Southbound	A 1.7	A 1.4	A 4.0	A 5.8	B 16.2	B 16.7

Key: Level of Service, Delay in seconds per vehicle

The Oakland Hills Trail intersection was evaluated for turn lanes using the Kentucky Transportation Cabinet Highway Design Guidance Manual dated March, 2017. Using the volumes in Figure 5, a northbound right turn lane will be required on Bardstown Road at the Oakland Hills Trail intersection.

CONCLUSIONS

Based upon the volume of traffic generated by the development and the amount of traffic forecasted for the year 2030, there will be a manageable impact to the existing highway network, with Levels of Service remaining within acceptable limits. A northbound right turn lane is required on Bardstown Road at the Oakland Hills Trail intersection. The proposed plan improves the traffic operations as compared to the existing plan for the site. The improvement is due to the access to the park road system, especially the signal at Broad Run Parkway intersection with Bardstown Road.

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APPENDIX

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Leg	Direction	Start Time	US 31E			Oakland Hills Trail			US 31E			Int Total
			Left	Thru	U-Turn	Left	Right	U-Turn	Left	Right	U-Turn	
	Southbound	7:00:00	0	118	0	0	0	8	0	1	0	618
		7:15:00	0	174	0	0	0	7	0	0	0	605
		7:30:00	3	178	0	0	1	2	0	0	0	606
		7:45:00	2	173	0	0	1	5	0	0	0	560
		8:00:00	2	147	0	0	1	7	0	4	0	566
		8:15:00	2	165	0	0	2	6	0	1	0	547
		8:30:00	0	139	0	0	5	5	0	1	0	519
		8:45:00	2	141	0	0	5	5	0	3	0	429
		16:00:00	4	439	0	0	2	2	0	2	0	713
		16:15:00	5	436	0	0	1	6	0	1	0	709
		16:30:00	8	514	0	0	1	2	0	1	0	807
		16:45:00	5	511	0	0	2	5	0	1	0	807
		17:00:00	3	549	0	0	5	3	0	1	0	901
		17:15:00	6	528	0	0	0	1	0	1	0	826
		17:30:00	2	510	0	0	3	3	0	2	0	766
		17:45:00	7	454	0	0	2	2	0	1	1	687
		Grand Total	51	5176	0	0	19	69	0	22	1	10666
	% Approach		1.0%	99.0%	0.0%	0.0%	21.6%	78.4%	0.0%	99.6%	0.4%	0.0%
	% Total		0.5%	48.5%	0.0%	0.2%	0.6%	50.0%	0.0%	50.0%	0.2%	0.0%
	Lights and M		50	5070	0	19	67	0	5237	21	1	10465
	% Lights and		98.0%	98.0%	0.0%	100%	97.1%	0.0%	98.3%	95.5%	100%	98.1%
	Heavy		1	106	0	0	2	0	91	1	0	201
	% Heavy		2.0%	2.0%	0.0%	0.0%	2.9%	0.0%	1.7%	4.5%	0.0%	1.9%
	AM TOTAL		5	643	0	2	22	0	1714	3	0	2389
	16:30:00		8	514	0	1	2	0	281	1	0	807
	16:45:00		5	511	0	2	5	0	283	1	0	807
	17:00:00		3	549	0	5	3	0	340	1	0	901
	17:15:00		6	528	0	0	1	0	290	1	0	826
	17:30:00		2	510	0	3	3	0	246	2	0	766
	17:45:00		7	454	0	2	2	0	220	1	1	687
	PM TOTAL		22	2102	0	8	11	0	1194	4	0	3341

Groundbreaking by Design



Traffic Counts
Bardstown Road (US 31E) at Oakland Hills Trail
1/10/2018

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Bardstown Road (US 31E) at Broad Run Parkway
1/31/2018



Groundbreaking by Design

Leg	Bardstown Rd			Broad Run Pkwy			Bardstown Rd		
	Southbound	Westbound	Northbound	Left	Right	U-Turn	Left	Right	U-Turn
Start Time	Left	Thru	U-Turn	Left	Right	U-Turn	Left	Right	U-Turn
7:00:00	0	100	0	1	0	0	0	468	3
7:15:00	0	160	0	0	0	0	0	451	2
7:30:00	1	172	0	0	1	0	0	392	6
7:45:00	1	208	0	2	0	0	0	405	0
8:00:00	0	172	0	0	1	0	0	337	2
8:15:00	2	158	0	1	0	0	0	349	0
8:30:00	1	149	0	1	0	0	0	358	1
8:45:00	0	156	0	0	0	0	0	306	0
16:00:00	12	404	1	6	10	0	0	257	8
16:15:00	8	447	0	5	9	0	0	243	6
16:30:00	10	526	0	9	8	0	0	274	8
16:45:00	4	510	0	2	5	0	0	252	3
17:00:00	6	511	0	11	11	0	0	308	2
17:15:00	10	511	0	5	13	0	0	344	7
17:30:00	3	519	0	10	15	0	0	286	5
17:45:00	6	537	0	9	13	0	0	227	6
Grand Total	64	5240	1	62	86	0	0	5257	59
% Approach	1.2%	98.8%	0.0%	41.9%	58.1%	0.0%	0.0%	98.9%	1.1%
% Total	0.6%	48.7%	0.0%	0.6%	0.8%	0.0%	0.0%	48.8%	0.5%
Lights and M	63	5151	1	61	86	0	0	5159	58
% Lights and	98.4%	98.3%	100%	98.4%	100%	0.0%	0.0%	98.1%	98.3%
Heavy	1	89	0	1	0	0	0	98	1
% Heavy	1.6%	1.7%	0.0%	1.6%	0.0%	0.0%	0.0%	1.9%	1.7%
Int Total									

7:00:00	7:15:00	7:30:00	7:45:00	AM TOTAL	17:00:00	17:15:00	17:30:00	17:45:00	PM TOTAL
0	0	1	1	2	6	10	3	6	25
100	160	172	208	640	511	511	519	537	2078
0	0	0	0	0	0	0	0	0	0
1	0	0	2	3	11	5	10	9	35
0	0	1	0	1	11	13	15	13	52
0	0	0	0	0	0	0	0	0	0
468	451	392	405	1716	308	344	286	227	1165
3	2	6	0	11	2	7	5	6	20
0	0	0	0	0	0	0	0	0	0
572	613	572	616	2373	849	890	838	798	3375

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HCS Reports

HCS7 Two-Way Stop-Control Report																
General Information								Site Information								
Analyst	Diane Zimmerman							Intersection	Bardstown Rd at Oakland H							
Agency/Co.	Diane B Zimmerman Traffic Engineering							Jurisdiction								
Date Performed	2/8/2018							East/West Street	Oakland Hills							
Analysis Year	2018							North/South Street	Bardstown Road							
Time Analyzed	AM Peak							Peak Hour Factor	0.97							
Intersection Orientation	North-South							Analysis Time Period (hrs)	0.25							
Project Description	Oakland Hills															
Lanes																
Vehicle Volumes and Adjustments																
Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		1	0	1	0	0	2	0	0	1	2	0
Configuration						L		R			T	TR		L	T	
Volume, V (veh/h)						2		22			1714	3		5	643	
Percent Heavy Vehicles (%)						0		4						20		
Proportion Time Blocked																
Percent Grade (%)							0									
Right Turn Channelized		No				No				No				No		
Median Type/Storage		Left Only								1						
Critical and Follow-up Headways																
Base Critical Headway (sec)																
Critical Headway (sec)																
Base Follow-Up Headway (sec)																
Follow-Up Headway (sec)																
Delay, Queue Length, and Level of Service																
Flow Rate, v (veh/h)						2		23						5		
Capacity, c (veh/h)						106		284						280		
v/c Ratio						0.02		0.08						0.02		
95% Queue Length, Q ₉₅ (veh)						0.1		0.3						0.1		
Control Delay (s/veh)						39.8		18.8						18.1		
Level of Service, LOS						E		C						C		
Approach Delay (s/veh)						20.5								0.1		
Approach LOS						C										

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HCS7 Two-Way Stop-Control Report																	
General Information								Site Information									
Analyst	Diane Zimmerman							Intersection	Bardstown Rd at Oakland H								
Agency/Co.	Diane B Zimmerman Traffic Engineering							Jurisdiction									
Date Performed	3/6/18							East/West Street	Oakland Hills								
Analysis Year	2030							North/South Street	Bardstown Road								
Time Analyzed	AM Peak No Build							Peak Hour Factor	0.97								
Intersection Orientation	North-South							Analysis Time Period (hrs)	0.25								
Project Description	Oakland Hills																
Lanes																	
<p style="text-align: center;">Major Street: North-South</p>																	
Vehicle Volumes and Adjustments																	
Approach	Eastbound				Westbound				Northbound				Southbound				
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6	
Number of Lanes		0	0	0		1	0	1	0	0	2	0	0	1	2	0	
Configuration						L		R			T	TR		L	T		
Volume, V (veh/h)						57		332			1931	21		109	725		
Percent Heavy Vehicles (%)						0		4						20			
Proportion Time Blocked																	
Percent Grade (%)						0											
Right Turn Channelized		No				No				No				No			
Median Type/Storage		Left Only										1					
Critical and Follow-up Headways																	
Base Critical Headway (sec)																	
Critical Headway (sec)																	
Base Follow-Up Headway (sec)																	
Follow-Up Headway (sec)																	
Delay, Queue Length, and Level of Service																	
Flow Rate, v (veh/h)						59		342						112			
Capacity, c (veh/h)						66		236						220			
v/c Ratio						0.90		1.45						0.51			
95% Queue Length, Q ₉₅ (veh)						4.3		19.8						2.6			
Control Delay (s/veh)						186.9		264.2						37.2			
Level of Service, LOS						F		F						E			
Approach Delay (s/veh)						252.9								4.9			
Approach LOS						F											

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HCS7 Two-Way Stop-Control Report												
General Information						Site Information						
Analyst	Diane Zimmerman					Intersection	Bardstown Rd at Oakland H					
Agency/Co.	Diane B Zimmerman Traffic Engineering					Jurisdiction	Oakland Hills					
Date Performed	3/6/2018					East/West Street	Oakland Hills					
Analysis Year	2030					North/South Street	Bardstown Road					
Time Analyzed	AM Peak Build					Peak Hour Factor	0.97					
Intersection Orientation	North-South					Analysis Time Period (hrs)	0.25					
Project Description	Oakland Hills											
Lanes												
Vehicle Volumes and Adjustments												
Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	U	L	T	R	L	T	U	L	T	R	L	T
Priority	10	11	12	7	8	9	1U	1	2	3	4U	4
Number of Lanes	0	0	0	1	0	1	0	0	0	2	1	0
Configuration				L		R				T	R	L
Volume, V (veh/h)				8		312				1931	23	92
Percent Heavy Vehicles (%)				0		4						20
Proportion Time Blocked				0		0.300				0.000	0.300	0.000
Percent Grade (%)	0											
Right Turn Channelized	No											
Median Type/Storage	Left Only											
Base Critical Headway (sec)	1											
Critical and Follow-up Headways												
Base Critical Headway (sec)												
Critical Headway (sec)												
Base Follow-Up Headway (sec)												
Follow-Up Headway (sec)												
Delay, Queue Length, and Level of Service												
Flow Rate, v (veh/h)	8			322			617			233		
Capacity, c (veh/h)	80			617			617			233		
v/c Ratio	0.10			0.52			0.41			0.41		
95% Queue Length, Q ₉₅ (veh)	0.3			3.0			1.9			1.9		
Control Delay (s/veh)				55.2			17.0			30.6		
Level of Service, LOS				F			C			D		
Approach Delay (s/veh)	18.0			18.0			18.0			3.2		
Approach LOS	C			C			C			D		

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HCS7 Two-Way Stop-Control Report																
General Information								Site Information								
Analyst	Diane Zimmerman							Intersection	Bardstown Rd at Oakland H							
Agency/Co.	Diane B Zimmerman Traffic Engineering							Jurisdiction								
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Analysis Year	2018							North/South Street	Bardstown Road							
Time Analyzed	PM Peak							Peak Hour Factor	0.93							
Intersection Orientation	North-South							Analysis Time Period (hrs)	0.25							
Project Description	Oakland Hills															
Lanes																
<p>Major Street: North-South</p>																
Vehicle Volumes and Adjustments																
Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		1	0	1	0	0	2	0	0	1	2	0
Configuration						L		R			T	TR		L	T	
Volume, V (veh/h)						8		11			1194	4		22	2102	
Percent Heavy Vehicles (%)						0		0						0		
Proportion Time Blocked						0.000		0.000			0.000	0.000		0.000	0.000	
Percent Grade (%)							0									
Right Turn Channelized		No				No				No				No		
Median Type/Storage		Left Only								1						
Critical and Follow-up Headways																
Base Critical Headway (sec)																
Critical Headway (sec)																
Base Follow-Up Headway (sec)																
Follow-Up Headway (sec)																
Delay, Queue Length, and Level of Service																
Flow Rate, v (veh/h)						9		12							24	
Capacity, c (veh/h)						119		420							545	
v/c Ratio						0.07		0.03							0.04	
95% Queue Length, Q ₉₅ (veh)						0.2		0.1							0.1	
Control Delay (s/veh)						37.5		13.8							11.9	
Level of Service, LOS						E		B							B	
Approach Delay (s/veh)		23.8								0.1						
Approach LOS		C														

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Traffic Impact Study

HCS7 Two-Way Stop-Control Report																
General Information								Site Information								
Analyst	Diane Zimmerman							Intersection	Bardstown Rd at Oakland H							
Agency/Co.	Diane B Zimmerman Traffic Engineering							Jurisdiction								
Date Performed	3/6/18							East/West Street	Oakland Hills							
Analysis Year	2030							North/South Street	Bardstown Road							
Time Analyzed	PM Peak No Build							Peak Hour Factor	0.93							
Intersection Orientation	North-South							Analysis Time Period (hrs)	0.25							
Project Description	Oakland Hills Original															
Lanes																
<p>Major Street: North-South</p>																
Vehicle Volumes and Adjustments																
Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		1	0	1	0	0	2	1	0	1	2	0
Configuration						L		R			T	R		L	T	
Volume, V (veh/h)						43		212			1345	64		365	2369	
Percent Heavy Vehicles (%)						0		0						0		
Proportion Time Blocked						0.300		0.300			0.000	0.000		0.300	0.000	
Percent Grade (%)	0															
Right Turn Channelized	No				No				No				No			
Median Type/Storage	Left Only								1							
Critical and Follow-up Headways																
Base Critical Headway (sec)																
Critical Headway (sec)																
Base Follow-Up Headway (sec)																
Follow-Up Headway (sec)																
Delay, Queue Length, and Level of Service																
Flow Rate, v (veh/h)					46				228				392			
Capacity, c (veh/h)					20				764				544			
v/c Ratio					2.27				0.30				0.72			
95% Queue Length, Q ₉₅ (veh)					6.1				1.3				5.9			
Control Delay (s/veh)					978.8				11.7				26.9			
Level of Service, LOS					F				B				D			
Approach Delay (s/veh)					174.8								3.6			
Approach LOS					F											

17 Zone 1081

Oakland Hills
Traffic Impact Study

HCS7 Two-Way Stop-Control Report																	
General Information								Site Information									
Analyst	Diane Zimmerman							Intersection	Bardstown Rd at Oakland H								
Agency/Co.	Diane B Zimmerman Traffic Engineering							Jurisdiction									
Date Performed	3/6/2018							East/West Street	Oakland Hills								
Analysis Year	2030							North/South Street	Bardstown Road								
Time Analyzed	PM Peak Build							Peak Hour Factor	0.93								
Intersection Orientation	North-South							Analysis Time Period (hrs)	0.25								
Project Description	Oakland Hills																
Lanes																	
<p style="text-align: center;">Major Street North-South</p>																	
Vehicle Volumes and Adjustments																	
Approach	Eastbound				Westbound				Northbound				Southbound				
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6	
Number of Lanes		0	0	0		1	0	1	0	0	2	1	0	1	2	0	
Configuration						L		R			T	R		L	T		
Volume, V (veh/h)						12		200			1345	70		305	2405		
Percent Heavy Vehicles (%)						0		0						0			
Proportion Time Blocked						0.300		0.300			0.000	0.000		0.300	0.000		
Percent Grade (%)						0											
Right Turn Channelized		No				No				No				No			
Median Type/Storage		Left Only										1					
Critical and Follow-up Headways																	
Base Critical Headway (sec)																	
Critical Headway (sec)																	
Base Follow-Up Headway (sec)																	
Follow-Up Headway (sec)																	
Delay, Queue Length, and Level of Service																	
Flow Rate, v (veh/h)						13		215						328			
Capacity, c (veh/h)						32		764						539			
v/c Ratio						0.41		0.28						0.61			
95% Queue Length, Q ₉₅ (veh)						1.3		1.2						4.0			
Control Delay (s/veh)						182.5		11.6						21.5			
Level of Service, LOS						F		B						C			
Approach Delay (s/veh)						21.2								2.4			
Approach LOS						C											

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HCS7 Signalized Intersection Results Summary

General Information															
Agency	Diane B. Zimmerman Traffic Engineering														
Analyst	DBZ														
Jurisdiction	AM Peak														
Urban Street	Bardstown Road														
Intersection	Bardstown Road														
Project Description	Oakland Hills														
Demand Information															
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R
Demand (v, veh/h)				3	0	1				1716	11	2			640
Signal Information															
Cycle, s	69.9														
Reference Phase	2														
Offset, s	0														
Reference Point	End														
Uncoordinated	Yes														
Simult. Gap E/W	On														
Force Mode	Fixed														
Simult. Gap N/S	On														
Green Extension Time (g _e), s	0.0														
Queue Clearance Time (g _s), s	2.1														
Max Allow Headway (MAH), s	5.0														
Change Period, (Y+R _c), s	6.6														
Phase Duration, s	7.2														
Case Number	11.0														
Assigned Phase	8														
Assigned Movement	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R
Adjusted Flow Rate (v, veh/h)	3	8	18	3	8	18	3	8	18	3	8	18	3	8	18
Adjusted Saturation Flow Rate (s, veh/h/s)	1810	1610	1900	1896	247	1809	1810	1610	1900	1896	247	1809	1810	1610	1900
Queue Service Time (g _s), s	0.1														
Cycle Queue Clearance Time (g _c), s	0.1														
Green Ratio (g/C)	0.01														
Capacity (c), veh/h	15														
Volume-to-Capacity Ratio (X)	0.222														
Back of Queue (Q), ft/ln (90 th percentile)	4.2														
Back of Queue (Q), veh/ln (90 th percentile)	0.2														
Queue Storage Ratio (RQ) (90 th percentile)	0.00														
Uniform Delay (d ₁), s/veh	34.4														
Incremental Delay (d ₂), s/veh	10.4														
Initial Queue Delay (d ₃), s/veh	0.0														
Control Delay (d), s/veh	44.9														
Level of Service (LOS)	D														
Approach Delay, s/veh / LOS	0.0	43.2			2.8			1.7			A				
Intersection Delay, s/veh / LOS	2.5														
Multimodal Results															
Bicycle LOS Score / LOS	EB			WB			NB			SB					
Pedestrian LOS Score / LOS	B			B			B			A					
Bicycle LOS Score / LOS	2.14			2.31			2.04			1.06					

172one 1081

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HCS7 Signalized Intersection Results Summary

General Information												
Agency	Diane B. Zimmerman Traffic Engineering											
Analyst	DBZ											
Analysis Date	Mar 6, 2018											
Area Type	Other											
Time Period	AM Peak											
Analysis Year	2030 No Build											
File Name	Broad Run AM 30 NB Org Plan.xus											
Project Description	Oakland Hills Original Plan											
Demand Information												
Approach Movement	EB			WB			NB			SB		
Demand (v), veh/h	L T R			L T R			L T R			L T R		
	3			1			2244			12 2 825		
Signal Information												
Cycle, s	103.8			Reference Phase			2					
Offset, s	0			Reference Point			End					
Uncoordinated	Yes			Simult. Gap E/W			On			Yellow 5.1		
Force Mode	Fixed			Simult. Gap N/S			On			Red 1.3		
Timer Results												
Assigned Phase	EBL			EBT			WBL			WBT		
Case Number	8			9.0			8.0			2		
Phase Duration, s	7.4			96.4			6.4			4.9		
Change Period (Y+Rc), s	6.6			6.4			6.4			4.9		
Max Allow Headway (MAH), s	5.0			5.0			4.9			4.9		
Queue Clearance Time (g _s), s	2.2			2.2			89.6			91.2		
Green Extension Time (g _e), s	0.0			0.0			0.4			0.0		
Phase Call Probability				0.12			1.00			1.00		
Max Out Probability				0.00			1.00			1.00		
Movement Group Results												
Approach Movement	L T R			L T R			L T R			L T R		
Assigned Movement	L			R			L			T		
Adjusted Flow Rate (V), veh/h	3			18			2			6		
Adjusted Saturation Flow Rate (s), veh/h/in	1810			1610			1900			1809		
Queue Service Time (g _s), s	0.2			0.1			87.6			4.6		
Cycle Queue Clearance Time (g _c), s	0.2			0.1			87.6			4.6		
Green Ratio (g/C)	0.01			0.01			0.87			0.87		
Capacity (c), veh/h	14			13			1647			3136		
Volume-to-Capacity Ratio (X)	0.226			0.085			0.744			0.286		
Back of Queue (Q), ft/in (90th percentile)	5.6			1.8			41.6			1.4		
Back of Queue (Q), veh/in (90th percentile)	0.2			0.1			1.7			0.1		
Queue Storage Ratio (RQ) (90th percentile)	0.00			0.00			0.00			0.00		
Uniform Delay (d ₁), s/veh	51.2			4.0			2.6			1.2		
Incremental Delay (d ₂), s/veh	10.9			4.0			2.0			0.1		
Initial Queue Delay (d ₃), s/veh	0.0			0.0			0.0			0.0		
Control Delay (d), s/veh	62.1			55.1			4.6			1.3		
Level of Service (LOS)	E			E			A			A		
Approach Delay, s/veh / LOS	0.0			60.3			4.6			1.4		
Intersection Delay, s/veh / LOS	3.8			A			A			A		
Multimodal Results												
EB	WB			NB			SB					
Pedestrian LOS Score / LOS	2.15 B			2.32 B			1.79 B			0.60 A		
Bicycle LOS Score / LOS				F			2.51 C			1.23 A		

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Oakland Hills Traffic Impact Study

HCS7 Signalized Intersection Results Summary

General Information		Agency: Diane B. Zimmerman Traffic Engineering	Duration, h: 0.25
Analyst: DBZ	Analysis Date: Mar 6, 2018	Area Type: Other	
Jurisdiction:	Time Period: AM Peak	PHF: 0.92	
Urban Street: Bardstown Road	Analysis Year: 2030 Build	Analysis Period: 1 > 7:00	
Intersection: Broad Run Parkway	File Name: Broad Run AM 30 B Oak.xus		
Project Description: Oakland Hills			

Demand Information		Approach Movement: L T R	Demand (v, veh/h): L 58 T 35 R 24
Signal Information		Cycle, s: 109.7	Reference Phase: 2
Offset, s: 0	Reference Point: End	Green: 90.0	Yellow: 5.1
Uncoordinated: Yes	Simult. Gap E/W: On	Red: 1.3	3.0
Force Mode: Fixed	Simult. Gap N/S: On		

Timer Results		EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase: 6	Case Number: 8.0	9.0	13.3	96.4	6.4	6.4	92.0	1.00	1.00
Phase Duration, s: 6.0	Change Period, (Y+R+c), s: 6.4	5.0	5.0	5.0	5.0	5.0	5.0	6.3	6.3
Max Allow Headway (MAH), s: 6.4	Queue Clearance Time (g+s), s: 92.0	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Green Extension Time (g+e), s: 0.0	Phase Call Probability: 1.00	0.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Max Out Probability: 1.00									

Movement Group Results		EB	WB	NB	SB
Approach Movement: L T R	Assigned Movement: 3	1810	1610	1215	1215
Adjusted Flow Rate (v), veh/h: 1810	Adjusted Saturation Flow Rate (s), veh/h/in: 1809	63	38	26	878
Queue Service Time (g+s), s: 3.7	Cycle Queue Clearance Time (g+c), s: 6.3	2.5	2.5	2.5	2.5
Green Ratio (g/c): 0.06	Capacity (c), veh/h: 110	0.06	0.06	0.06	0.06
Volume-to-Capacity Ratio (X): 0.572	Back of Queue (Q), ft/in (90th percentile): 81.3	0.388	0.388	0.388	0.388
Back of Queue (Q), ft/in (90th percentile): 81.3	Back of Queue (Q), veh/in (90th percentile): 3.3	47.5	47.5	47.5	47.5
Queue Storage Ratio (Rq) (90th percentile): 0.00	Uniform Delay (d), s/veh: 50.1	1.9	1.9	1.9	1.9
Incremental Delay (d2), s/veh: 6.5	Initial Queue Delay (d3), s/veh: 0.0	3.5	3.5	3.5	3.5
Control Delay (d), s/veh: 56.6	Level of Service (LOS): E	53.1	53.1	53.1	53.1
Approach Delay, s/veh / LOS: 55.3 / E	Intersection Delay, s/veh / LOS: 8.1 / A	7.7	7.7	7.7	7.7
Multimodal Results		EB	WB	NB	SB
Pedestrian LOS Score / LOS: 2.15 / B	Bicycle LOS Score / LOS: 1.23 / A	2.32	2.32	2.32	2.32

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HCS7 Signalized Intersection Results Summary

General Information																								
Agency	Diane B. Zimmerman Traffic Engineering																							
Analyst	DBZ																							
Jurisdiction	2/8/2018																							
Urban Street	Bardstown Road																							
Intersection	Broad Run Parkway																							
Project Description	Oakland Hills																							
Intersection Information																								
Duration, h	0.25																							
Area Type	Other																							
PHF	0.95																							
Analysis Period	1 > 5:00																							
Analysis Year	2018																							
File Name	Broad Run PM 18.xus																							
Demand Information																								
Approach Movement	EB			WB			NB			SB														
Demand (v), veh/h	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R									
			35			52			1165			20			25 2078									
Signal Information																								
Cycle, s	100.3			2																				
Reference Phase	2			1			1			2			3											
Reference Point	End			Green			80.9			6.5			0.0											
Offset, s	0			0.0			0.0			0.0			0.0											
Uncoordinated	Yes			Simult. Gap E/W			On			Yellow			5.1											
Force Mode	Fixed			Simult. Gap N/S			On			Red			1.3											
Timer Results																								
Assigned Phase	EBL			EBT			WBL			WBT			NBL			NBT			SBL			SBT		
Case Number	9.0			9.0			9.0			8.0			8.0			2			6					
Phase Duration, s	13.1			13.1			8.3			8.3			8.3			8.3			8.3					
Change Period, (Y+Rc), s	6.6			6.6			6.6			6.4			6.4			6.4								
Max Allow Headway (MAH), s	5.1			5.1			4.9			4.9			4.9			4.9								
Queue Clearance Time (g _s), s	5.3			5.3			25.6			25.6			25.6			25.6								
Green Extension Time (g _e), s	0.4			0.4			53.4			53.4			53.4			53.4								
Phase Call Probability	0.92			0.92			1.00			1.00			1.00			1.00								
Max Out Probability	0.00			0.00			0.77			0.77			0.77			0.77								
Movement Group Results																								
Approach Movement	EB			WB			NB			SB														
Assigned Movement	L	T	R	L	T	R	L	T	R	L	T	R	L	T	R									
Adjusted Flow Rate (v), veh/h	37	55	55	625	622	26	2187	1809	29.8	2.0	2.0	2.0	2.0	2.0	2.0									
Adjusted Saturation Flow Rate (s), veh/h/in	1810	1610	1900	1888	453	1809	29.8	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06									
Queue Service Time (g _s), s	2.0	3.3	23.6	9.6	2.7	29.8	29.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0									
Cycle Queue Clearance Time (g _c), s	2.0	3.3	23.6	9.6	2.7	29.8	29.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0									
Green Ratio (g/c)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06									
Capacity (c), veh/h	116	104	1532	1522	331	2916	2916	116	116	116	116	116	116	116	116									
Volume-to-Capacity Ratio (X)	0.316	0.528	0.408	0.409	0.080	0.750	0.750	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316									
Back of Queue (Q), ft/in (90 th percentile)	40.5	63.7	63.4	63.1	10.5	173.8	173.8	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5									
Back of Queue (Q), veh/in (90 th percentile)	1.6	2.5	2.5	2.5	0.4	7.0	7.0	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6									
Queue Storage Ratio (R _Q) (90 th percentile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
Uniform Delay (d _i), s/veh	44.8	45.5	2.8	2.8	9.8	4.8	4.8	44.8	44.8	44.8	44.8	44.8	44.8	44.8	44.8									
Incremental Delay (d ₂), s/veh	2.2	5.8	0.2	0.3	0.1	1.0	1.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2									
Initial Queue Delay (d ₃), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
Control Delay (d _i), s/veh	47.0	51.3	3.1	3.1	9.9	5.8	5.8	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0									
Level of Service (LOS)	D	D	A	A	A	A	A	D	D	D	D	D	D	D	D									
Approach Delay, s/veh / LOS	0.0			49.6			3.1			5.8			A											
Intersection Delay, s/veh / LOS	6.0			6.0			6.0			6.0			A											
Multimodal Results																								
Bicycle LOS Score / LOS	2.15			B			2.32			B			1.82			B								
Pedestrian LOS Score / LOS	2.15			B			2.32			B			1.82			B								
Bicycle LOS Score / LOS	2.15			B			2.32			B			1.82			B								

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Oakland Hills Traffic Impact Study

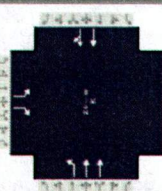
HCS7 Signalized Intersection Results Summary

General Information													
Agency	Diane B. Zimmerman Traffic Engineering												
Analyst	DBZ												
Jurisdiction	Mar 6, 2018												
Urban Street	Bardstown Road												
Intersection	Broad Run Parkway												
Project Description	Oakland Hills Original Plan												
Demand Information													
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R	
Demand (v), veh/h				39			58			1514	23	28	2684
Signal Information													
Cycle, s	109.5												
Reference Phase	2												
Reference Point	End												
Green	89.8												
Yellow	5.1												
Red	1.3												
Simult. Gap N/S	On												
Simult. Gap E/W	On												
Uncoordinated	Yes												
Force Mode	Fixed												
Timer Results													
Assigned Phase	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT					
Case Number	9.0												
Phase Duration, s	13.3												
Change Period, (Y+Rc), s	6.6												
Max Allow Headway (MAH), s	5.1												
Queue Clearance Time (g*), s	6.1												
Green Extension Time (g*), s	50.9												
Phase Call Probability	1.00												
Max Out Probability	0.99												
Movement Group Results													
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R	
Assigned Flow Rate (v), veh/h	41	61	18	18	61	1810	1610	1900	1890	317	29	2825	
Adjusted Saturation Flow Rate (s), veh/h	1810	1610	1810	1610	1900	1890	317	29	2825				
Queue Service Time (g*), s	2.4	4.1	4.1	4.1	35.8	14.7	5.7	70.2	70.2				
Cycle Queue Clearance Time (g*), s	2.4	4.1	4.1	4.1	35.8	14.7	41.4	70.2	70.2				
Green Ratio (g/C)	0.06	0.06	0.06	0.06	0.82	0.82	0.82	0.82	0.82				
Capacity (c), veh/h	111	98	98	98	1558	1550	222	2967	2967				
Volume-to-Capacity Ratio (X)	0.371	0.621	0.621	0.621	0.520	0.521	0.133	0.962	0.962				
Back of Queue (Q), ft/h (90th percentile)	50.4	80.8	80.8	80.8	100.3	100.1	17.7	433.8	433.8				
Back of Queue (Q), veh/h (90th percentile)	2.0	3.2	3.2	3.2	4.0	4.0	0.7	17.4	17.4				
Queue Storage Ratio (RQ) (90th percentile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
Uniform Delay (d), s/veh	49.4	50.2	50.2	50.2	3.1	3.1	15.5	8.1	8.1				
Incremental Delay (d2), s/veh	2.9	8.8	8.8	8.8	0.4	0.4	0.4	8.2	8.2				
Initial Queue Delay (d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Control Delay (d), s/veh	52.3	59.0	59.0	59.0	3.5	3.5	15.8	16.2	16.2				
Level of Service (LOS)	D												
Approach Delay, s/veh / LOS	0.0			56.3			3.5			16.2			
Intersection Delay, s/veh / LOS	12.6												
Multimodal Results													
EB	WB	NB	SB										
Pedestrian LOS Score / LOS	2.32	B	1.82	B	0.62	A							
Bicycle LOS Score / LOS						2.84	C						

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HCS7 Signalized Intersection Results Summary

General Information		Intersection Information	
Agency	Diane B. Zimmerman Traffic Engineering	Duration, h	0.25
Analyst	DBZ	Analysis Date	Mar 6, 2018
Jurisdiction	PM Peak	Area Type	Other
Urban Street	Bardstown Road	PHF	0.95
Intersection	Broad Run Parkway	Analysis Year	2030 Build
Project Description	Oakland Hills	Analysis Period	1 > 5:00
		File Name	Broad Run PM 30 B Oak.xls
			
Demand Information			
Approach Movement	L	T	R
	EB	WB	NB
	L	T	R
Demand (V), veh/h	75	81	1502
			23
			99
			2624
Signal Information			
Cycle, s	111.3	Reference Phase	2
Offset, s	0	Reference Point	End
Green	89.8	8.5	0.0
Yellow	5.1	3.6	0.0
Red	1.3	3.0	0.0
Force Mode	Fixed	Simult. Gap N/S	On
Uncoordinated	Yes	Simult. Gap E/W	On
Phase Call Probability			
Max Out Probability			
Green Extension Time (g _e), s		0.8	51.5
Queue Clearance Time (g _c), s		7.7	37.3
Max Allow Headway (MAH), s		5.1	5.0
Change Period, (Y+R _c), s		6.6	6.4
Phase Duration, s		15.1	96.2
Case Number		9.0	8.0
Assigned Phase	EBL	EBT	WBL
			WBT
			NBL
			NBT
			SBL
Timer Results			
Assigned Flow Rate (V), veh/h	79	85	804
Adjusted Saturation Flow Rate (s), veh/h/in	1810	1610	1900
Queue Service Time (g _s), s	4.7	5.7	35.3
Cycle Queue Clearance Time (g _c), s	4.7	5.7	35.3
Green Ratio (g/C)	0.08	0.08	0.81
Capacity (c), veh/h	138	123	1533
Volume-to-Capacity Ratio (X)	0.570	0.692	0.524
Back of Queue (Q), ft/in (90th percentile)	100.1	114	128.2
Back of Queue (Q), veh/in (90th percentile)	4.0	4.6	5.1
Queue Storage Ratio (R _q) (90th percentile)	0.00	0.00	0.00
Uniform Delay (d ₁), s/veh	49.7	50.1	3.6
Incremental Delay (d ₂), s/veh	5.2	9.5	0.4
Initial Queue Delay (d ₃), s/veh	0.0	0.0	0.0
Control Delay (d), s/veh	54.8	59.6	4.0
Level of Service (LOS)	D	E	A
Approach Delay, s/veh / LOS	0.0	57.3	4.0
Intersection Delay, s/veh / LOS	13.8		
Multimodal Results			
Pedestrian LOS Score / LOS	2.15	B	2.32
Bicycle LOS Score / LOS			
	EB	WB	NB
			SB
			A
			B
			C
			2.85

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17 Zone 1081



MEMO

To: Lee Hasken
From: Mark O'Hara, HOK
Client: LCFC
Project: LCFC Stadium
Project #: 17.70079.00

Date: 7 March 2018
Copies To: Gus Drosos/Brian Ashworth/Rashed Singaby/Steven Holt, HOK
Bart Miller/Erin Kueht, WPM
Dan Almond, MST
Mark Sites/Kent Gootee, Mindel Scott

RE: Pitch and Concourse Elevation Investigation

As requested, HOK is providing this memo to investigate lowering the pitch and concourse elevations to aid in understanding the potential savings in fill material.

The design team arrived at the current pitch (444.0') and concourse (453.0') elevations with the knowledge of the 100-year floodplain (449.8') and using Slugger Field (approximately 443.5') as a local precedent. It is HOK's understanding that Slugger Field has not been adversely affected by flood waters since its construction.

The relationship between the pitch and concourse elevations are a result of the seating bowl capacity and sight lines, among others. The pitch, concourse and seating bowl should be thought of as a system. This system can move as a whole.

With the pitch elevation at 444.0' the subsurface drainage invert elevation is assumed to be 438.50'. The invert shown on the field subdrainage plan (see sheet PF 1-2) that ties into the storm sewer manhole (see MSD plans) is well above the high water table elevation of 420'. We suggest installing a back water valve at this location in the event that water table does exceed 420'. The fields' subdrainage piping system can also intercept rising water table, and hold for a time in the piping and gravel layer until the water recedes.

With this knowledge, HOK does not oppose investigating the saving to be had in fill material with lowering the pitch and concourse elevations.

The options, in 6" increments are the following:

Option A: Lower by 0.5'

Pitch - 443.5'
Concourse - 452.5'

Option B: Lower by 1.0'

Pitch - 443.0'
Concourse - 452.0'

Option C: Lower by 1.5'

Pitch - 442.5'
Concourse - 451.5'

All options keep the concourse above the 100-year floodplain elevation.

While the field tunnel, dock and service yard are lower than the 100-year flood elevation, this areas is protected by elevations above the 100-year flood elevation.

At this time, these options do not appear to require any significant structural modifications.

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