

final report

March 6, 2018

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DESIGN SERVICES

Traffic Impact Study

Oakland Hills
11333 Bardstown Creek Road
Louisville, KY

Prepared for

Louisville Metro Planning Commission
Kentucky Transportation Cabinet



17 Zone 1081

Table of Contents

INTRODUCTION	2
Figure 1. Site Map.....	2
EXISTING CONDITIONS	2
Figure 2. Existing Peak Hour Volumes	3
FUTURE CONDITIONS	3
Table 1. Peak Hour Trips Generated by Original Plan	3
Figure 3. No Build (Original Plan) Peak Hour Volumes	4
TRIP GENERATION	4
Table 2. Peak Hour Trips Generated by Site	5
Figure 4. Trip Distribution Percentages.....	5
Figure 5. Peak Hour Trips Generated by Site.....	6
Figure 6. Build Peak Hour Volumes	7
ANALYSIS	7
Table 3. Peak Hour Level of Service.....	8
CONCLUSIONS	8
APPENDIX	9

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PLANNING &
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Traffic Impact Study**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.

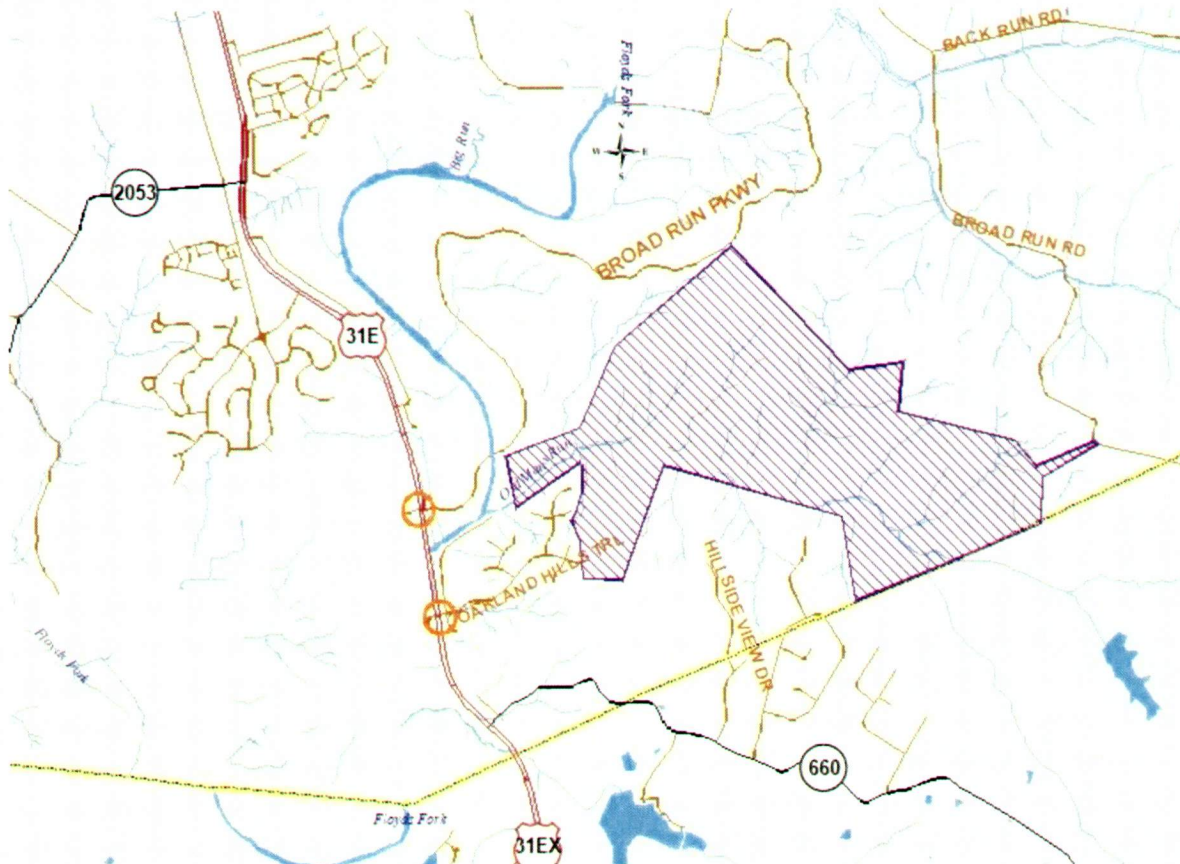


Figure 1. Site Map

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.

17 Zone 1081

Oakland Hills
Traffic Impact Study

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.

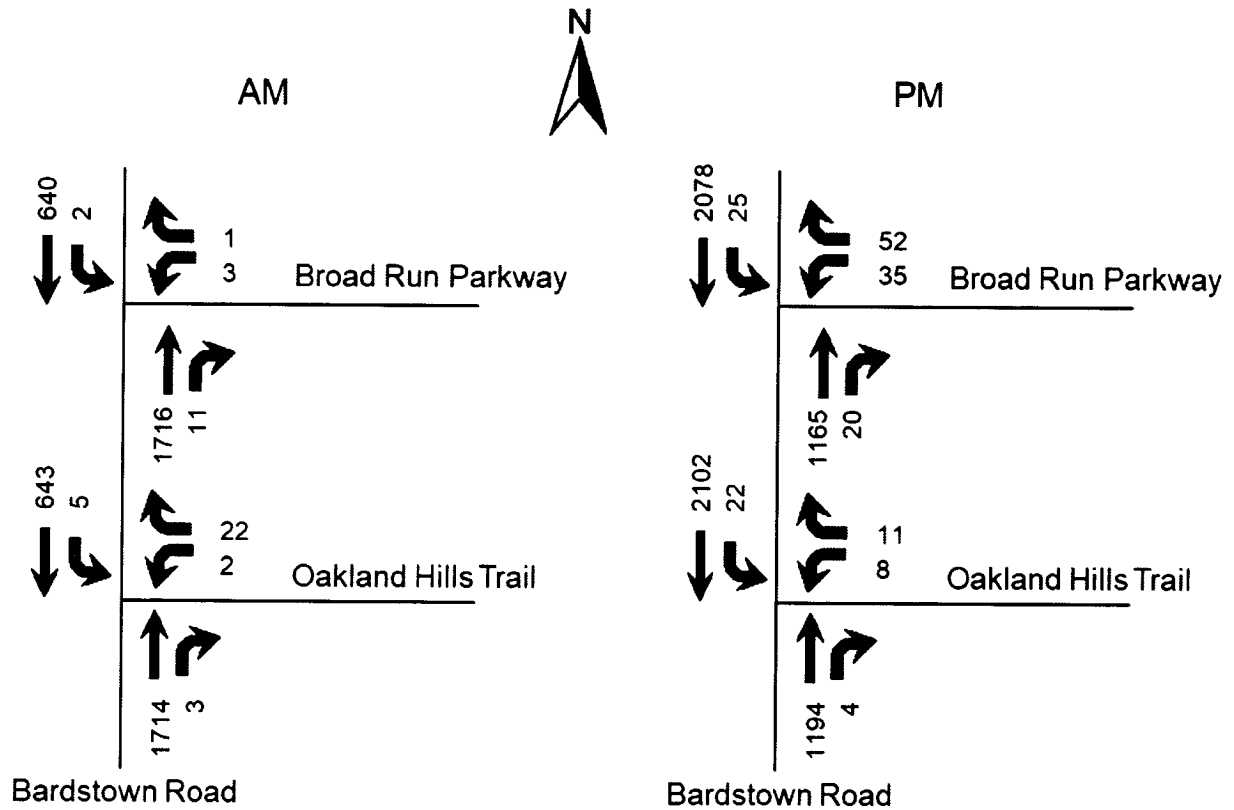


Figure 2. Existing Peak Hour Volumes

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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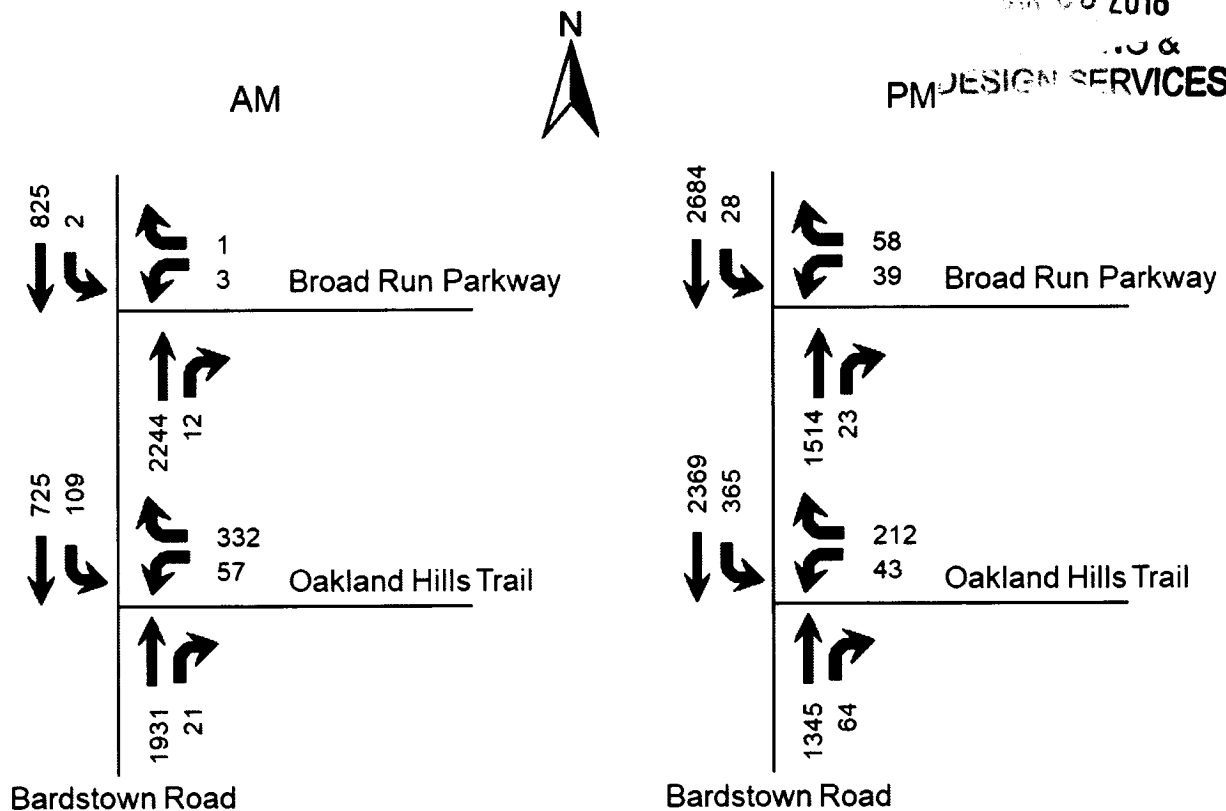


Figure 3. No Build (Original Plan) Peak Hour Volumes

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.

17 Zone 1081

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

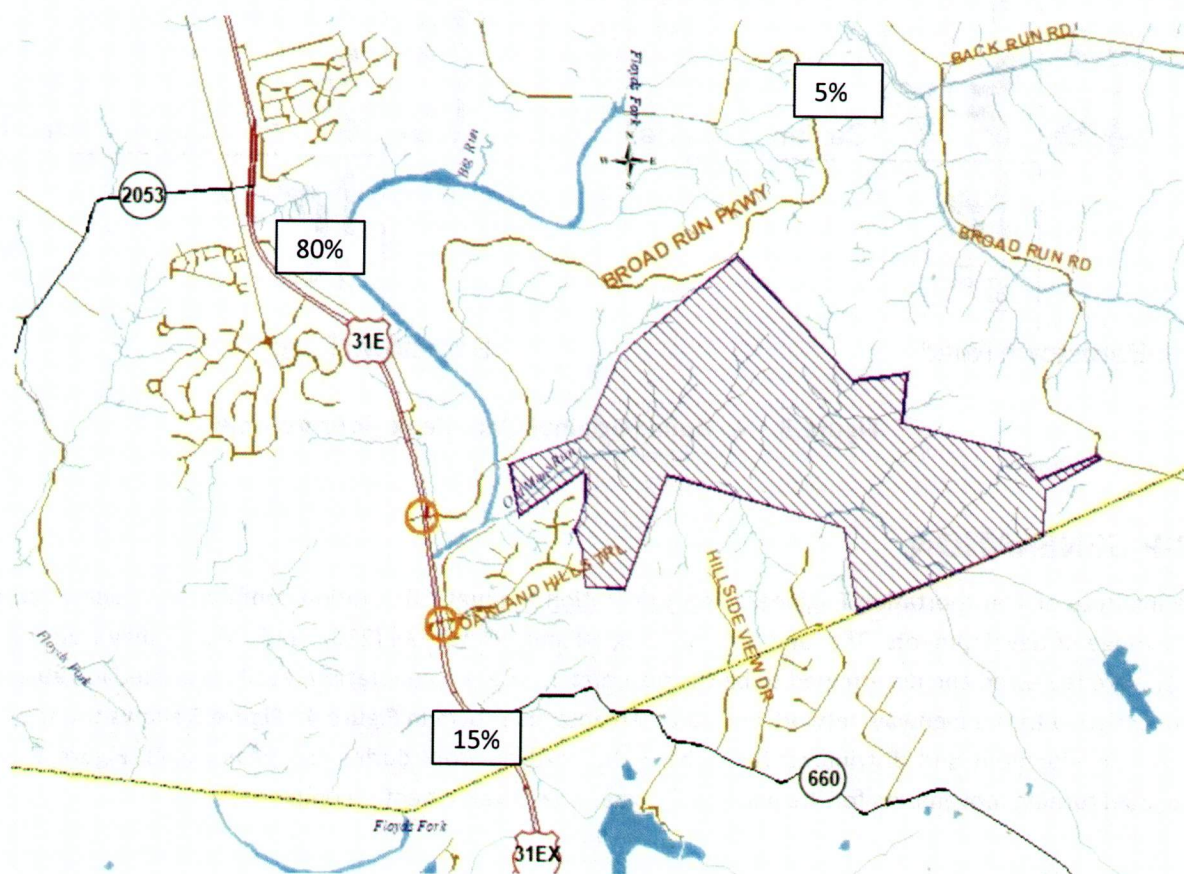


Figure 4. Trip Distribution Percentages

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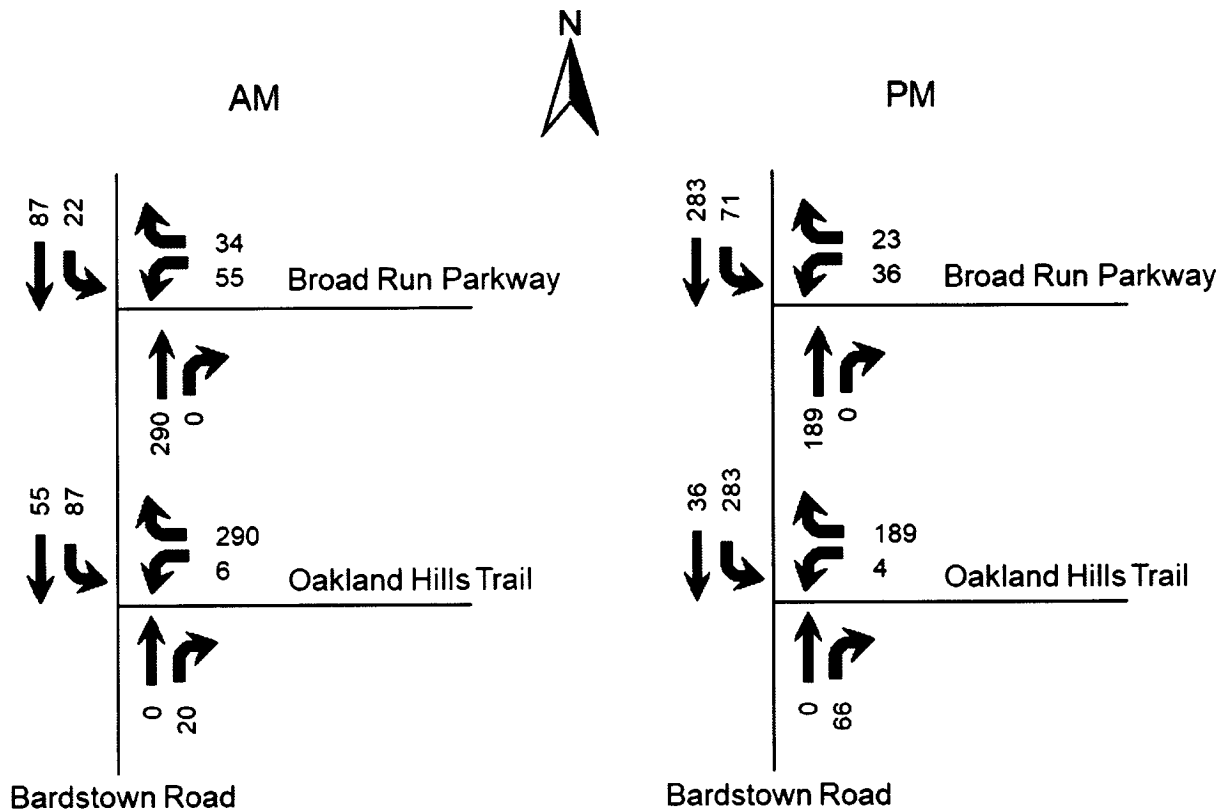


Figure 5. Peak Hour Trips Generated by Site

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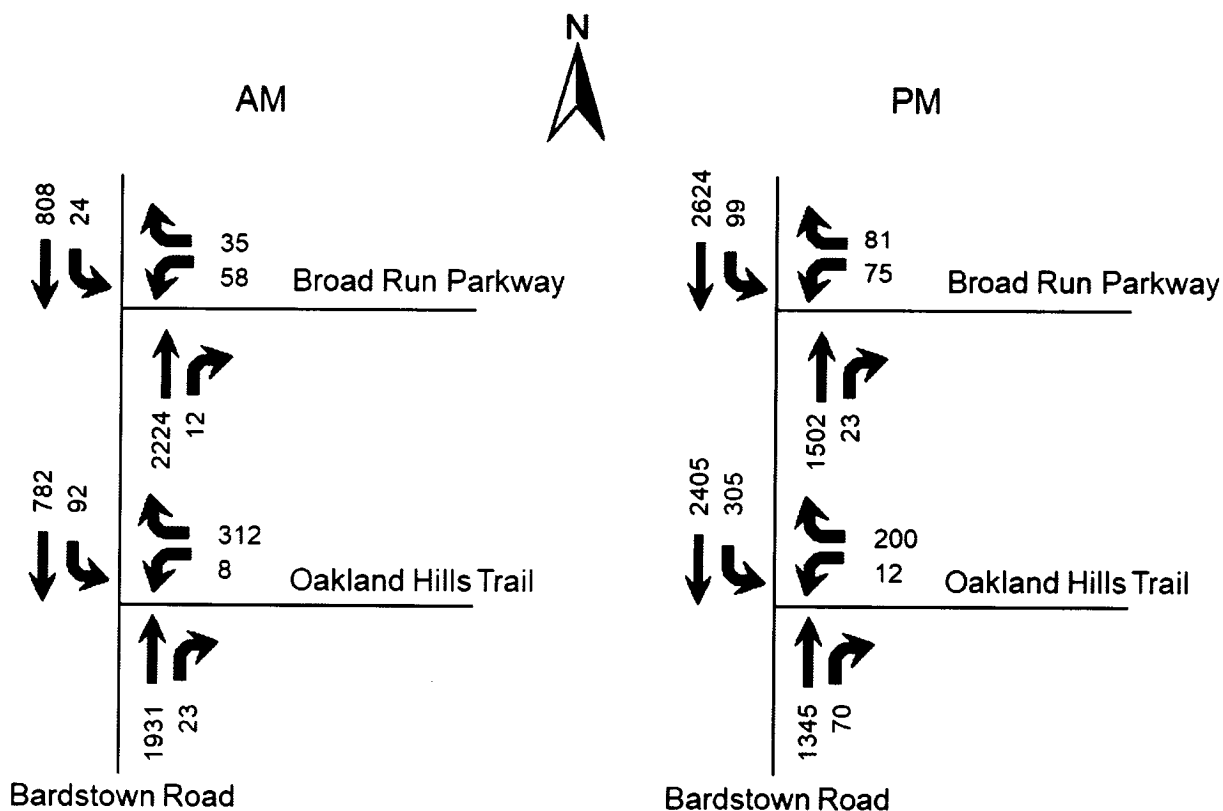


Figure 6. Build Peak Hour Volumes

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

	A.M.			P.M.		
Approach	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	A 2.5	A 3.8	A 8.1	A 6.0	B 12.6	B 13.8
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

Traffic Counts

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



Groundbreaking by Design

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Leg	Direction	Start Time	US 31E				Oakland Hills Trail				US 31E				Northbound				Int Total
			Left	Thru	U-Turn	Left	Right	U-Turn	Thru	Right	U-Turn	Right	U-Turn	Thru	Right	U-Turn	Left	Thru	
7:00:00			0	118	0	0	8	0	491	1	0	0	0	0	0	0	0	0	618
7:15:00			0	174	0	0	7	0	424	0	0	0	0	0	0	0	0	0	605
7:30:00			3	178	0	0	1	2	422	0	0	0	0	0	0	0	0	0	606
7:45:00			2	173	0	0	1	5	377	2	0	0	0	0	0	0	0	0	560
AM TOTAL			5	643	0	2	22	0	1714	3	0	0	0	0	0	0	0	0	2389
16:30:00			8	514	0	1	2	0	281	1	0	0	0	0	0	0	0	0	807
16:45:00			5	511	0	2	5	0	283	1	0	0	0	0	0	0	0	0	807
17:00:00			3	549	0	5	3	0	340	1	0	0	0	0	0	0	0	0	901
17:15:00			6	528	0	0	1	0	290	1	0	0	0	0	0	0	0	0	826
17:30:00			2	510	0	3	3	0	246	2	0	0	0	0	0	0	0	0	766
17:45:00			7	454	0	2	2	0	220	1	0	0	0	0	0	0	0	0	687
Grand Total			51	5176	0	19	69	0	5328	22	1	0	0	0	0	0	0	0	10666
% Approach			1.0%	99.0%	0.0%	21.6%	78.4%	0.0%	99.6%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
% Total			0.5%	48.5%	0.0%	0.2%	0.6%	0.0%	50.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Lights and M			50	5070	0	19	67	0	5237	21	1	0	0	0	0	0	0	0	10465
% Lights and			98.0%	98.0%	0.0%	100%	97.1%	0.0%	98.3%	95.5%	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	98.1%
Heavy			1	106	0	0	2	0	91	1	0	0	0	0	0	0	0	0	201
% Heavy			2.0%	2.0%	0.0%	0.0%	2.9%	0.0%	1.7%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%
PM TOTAL			22	2102	0	8	11	0	1194	4	0	0	0	0	0	0	0	0	3341

17 Zone 1081

Bardstown Road (US 31E) at Broad Run Parkway

1/31/2018



Groundbreaking by Design

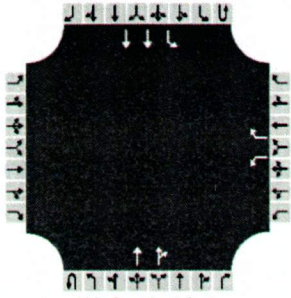
Leg	Direction	Bardstown Rd			Broad Run Pkwy			Bardstown Rd		
Start Time	Direction	Southbound			Westbound			Northbound		
		Left	Thru	U-Turn	Left	Right	U-Turn	Thru	Right	U-Turn
7:00:00		0	100	0	1	0	0	468	3	0
7:15:00		0	160	0	0	0	0	451	2	0
7:30:00		1	172	0	0	1	0	392	6	0
7:45:00		1	208	0	2	0	0	405	0	0
8:00:00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

7:00:00	0	100	0	1	0	0	0	468	3	0	572
7:15:00	0	160	0	0	0	0	0	451	2	0	613
7:30:00	1	172	0	0	0	1	0	392	6	0	572
7:45:00	1	208	0	2	0	0	0	405	0	0	616
8:00:00	0	172	0	0	0	1	0	337	2	0	512
8:15:00	2	158	0	1	0	0	0	349	0	0	510
8:30:00	1	149	0	1	0	0	0	358	1	0	510
8:45:00	0	156	0	0	0	0	0	306	0	0	462
16:00:00	12	404	1	6	10	0	0	257	8	0	698
16:15:00	8	447	0	5	9	0	0	243	6	0	718
16:30:00	10	526	0	9	8	0	0	274	8	0	835
16:45:00	4	510	0	2	5	0	0	252	3	0	776
17:00:00	6	511	0	11	11	0	0	308	2	0	849
17:15:00	10	511	0	5	13	0	0	344	7	0	890
17:30:00	3	519	0	10	15	0	0	286	5	0	838
17:45:00	6	537	0	9	13	0	0	227	6	0	798
Grand Total	64	5240	1	62	86	0	0	5257	59	0	10769
% Approach	1.2%	98.8%	0.0%	41.9%	58.1%	0.0%	0.0%	98.9%	1.1%	0.0%	
% Total	0.6%	48.7%	0.0%	0.6%	0.8%	0.0%	0.0%	48.8%	0.5%	0.0%	
Lights and M	63	5151	1	61	86	0	0	5159	58	0	10579
% Lights and	98.4%	98.3%	100%	98.4%	100%	0.0%	0.0%	98.1%	98.3%	0.0%	98.2%
Heavy	1	89	0	1	0	0	0	98	1	0	190
% Heavy	1.6%	1.7%	0.0%	1.6%	0.0%	0.0%	0.0%	1.9%	1.7%	0.0%	1.8%

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

17 Zone 1081

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																
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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 TWSC Version 7.4
Oakland Hills AM 17.xtw

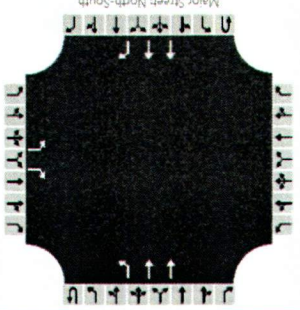
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HCS7 Two-Way Stop-Control Report																
General Information								Site Information								
Analyst	Diane Zimmerman							Intersection	Bardstown Rd at Oakland H							
Agency/Co.	Diane B Zimmerman Traffic Engineering							Jurisdiction								
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																
Major Street: North-South																
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											

17 Zone 1081

HCS7 Two-Way Stop-Control Report													
General Information							Site Information						
Analyst	Diane Zimmerman						Intersection	Bardstown Rd at Oakland Hills					
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	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	U	L	T	R	U	L	T	R	
Priority		10	11	12		7	8	9	1U	1	2	3	4U
Number of Lanes	0	0	0	0	1	0	1	0	0	0	1	1	2
Configuration					L		R					R	L
Volume, V (veh/h)					8		312					1931	23
Percent Heavy Vehicles (%)					0		4					20	
Proportion Time Blocked					0.300		0.300					0.300	0.000
Percent Grade (%)													
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)				8			322					95	
Capacity, c (veh/h)				80			617					233	
v/c Ratio				0.10			0.52					0.41	
95% Queue Length, Q ₉₅ (veh)				0.3			3.0					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						3.2			
Approach LOS				C									
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HCS7 TWC Version 7.4
Oakland Hills AM 30 B Oakxtw

Generated: 3/6/2018 11:25:40 AM

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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	2/8/2018							East/West Street	Oakland Hills							
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																
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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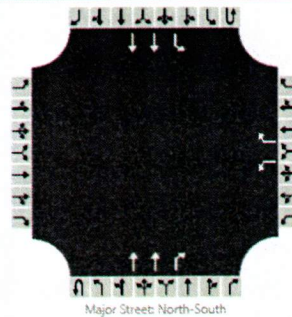
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PLANNING &
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HCS7 Two-Way Stop-Control Report

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	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



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											

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																
Major Street: North-South																
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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Oakland Hills
Traffic Impact Study

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HCS7 Signalized Intersection Results Summary

General Information			
Agency	Diane B. Zimmerman Traffic Engineering		
Analyst	DBZ		
Jurisdiction	Time Period	Analysis Date	Area Type
Urban Street	AM Peak	2/8/2018	Other
Intersection	File Name	Analysis Year	PHF
Broad Run Parkway	Broad Run AM 18.xus	2018	0.92
Project Description	Oakland Hills		

Demand Information			
Approach Movement	L	T	R
EB	L	T	R
WB	L	T	R
NB	L	T	R
SB	L	T	R

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	Yellow	5.1
Queue Clearance Time (g _s), s	2.1	Red	1.3
Max Allow Headway (MAH), s	5.0	Green	56.4
Change Period, (Y+R _c), s	6.6		0.6
Phase Duration, s	7.2		0.0
Case Number	11.0		0.0
Assigned Phase	8		0.0
EBL	EBT	WBL	WBT
NBL	NBT	SBL	SBT

Timer Results			
Assigned Phase	EBL	EBT	WBL
Case Number	11.0	8	18
Phase Duration, s	7.2	6.6	5.0
Change Period, (Y+R _c), s	6.6	6.4	2.8
Max Allow Headway (MAH), s	5.0	2.1	49.0
Queue Clearance Time (g _s), s	2.1	0.0	6.8
Green Extension Time (g _e), s	0.0	0.08	1.00
Max Out Probability			0.02

Movement Group Results			
Approach Movement	L	T	R
EB	L	T	R
WB	L	T	R
NB	L	T	R
SB	L	T	R
Assigned Movement	L	T	R
Adjusted Flow Rate (v), veh/h	3	8	18
Adjusted Saturation Flow Rate (s), veh/h	1810	1610	1900
Queue Service Time (g _s), s	0.1	0.0	47.0
Cycle Queue Clearance Time (g _c), s	0.1	0.0	47.0
Green Ratio (g/C)	0.01	0.01	0.81
Capacity (c), veh/h	15	13	1531
Volume-to-Capacity Ratio (X)	0.222	0.083	0.613
Back of Queue (Q), ft/in (90 th percentile)	4.2	1.4	2.9
Back of Queue (Q), veh/in (90 th percentile)	0.2	0.1	0.1
Queue Storage Ratio (RQ) (90 th percentile)	0.00	0.00	0.00
Uniform Delay (d ₁), s/veh	34.4	34.4	2.6
Incremental Delay (d ₂), s/veh	10.4	3.8	0.1
Initial Queue Delay (d ₃), s/veh	0.0	0.0	0.0
Control Delay (d), s/veh	44.9	38.2	2.8
Level of Service (LOS)	D	D	A
Approach Delay, s/veh / LOS	43.2	2.8	1.7
Intersection Delay, s/veh / LOS	0.0	2.5	A
Multimodal Results			
EB	WB	NB	SB
Pedestrian LOS Score / LOS	2.31	1.81	1.29
Bicycle LOS Score / LOS	0.49	2.04	1.06

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HCS7 Signalized Intersection Results Summary

HCS7 Signalized Intersection Results Summary											
General Information				Intersection Information							
Agency	Diane B. Zimmerman Traffic Engineering			Analysis Date		Mar 6, 2018		Area Type		Other	
Analyst	DBZ			Time Period		AM Peak		PHF		0.92	
Urban Street	Bardstown Road			Analysis Year		2030 No Build		Analysis Period		1 > 7:00	
Intersection	Broad Run Parkway			File Name		Broad Run AM 30 NB Org Plan.xus					
Project Description				Oakland Hills Original Plan							
Demand Information				Signal Information							
Approach Movement				L	T	R	L	T	R	L	T
Demand (v , veh/h							3			1	
										2244	12
										2	825
Timer Results				Phase Duration, s							
Assigned Phase				EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Case Number							8		2		6
Change Period, (Y+R), s							7.4		96.4		96.4
Max Allow Headway (MAH), s							6.6		6.4		6.4
Queue Clearance Time (g s), s							5.0		4.9		4.9
Green Extension Time (g s), s							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							
Assigned Movement				L	T	R	L	T	R	L	T
Adjusted Flow Rate (v , veh/h				3		1	18		2	12	2
Adjusted Saturation Flow Rate (s , veh/h/in				1810		1610		1900	1896	140	1809
Queue Service Time (g s), s				0.2		0.1		87.6	25.3	1.6	4.6
Cycle Queue Clearance Time (g c), s				0.2		0.1		87.6	25.3	89.2	4.6
Green Ratio (g/C)				0.01		0.01		0.87	0.87	0.87	0.87
Capacity (c) , veh/h				14		13		1647	1644	73	3136
Volume-to-Capacity Ratio (X)				0.226		0.085		0.744	0.746	0.030	0.286
Back of Queue (Q) , ft/in (90 th percentile)				5.6		1.8		41.6	42.1	2.6	1.4
Back of Queue (Q) , veh/in (90 th percentile)				0.2		0.1		1.7	1.7	0.1	0.1
Queue Storage Ratio (RQ) (90 th percentile)				0.00		0.00		0.00	0.00	0.00	0.00
Uniform Delay (d s), s/veh				51.2		51.1		2.6	2.6	50.3	1.2
Incremental Delay (d i), s/veh				10.9		4.0		2.0	2.0	0.2	0.1
Initial Queue Delay (d s), s/veh				0.0		0.0		0.0	0.0	0.0	0.0
Control Delay (d), s/veh				62.1		55.1		4.6	4.7	50.5	1.3
Level of Service (LOS)				E		E		A	A	D	A
Approach Delay, s/veh / LOS				60.3		60.3		4.6	A	1.4	A
Intersection Delay, s/veh / LOS				3.8		3.8		A	A	1.4	A
Multimodal Results											
Pedestrian LOS Score / LOS				2.15	B	2.32	B	1.79	B	0.60	A
Bicycle LOS Score / LOS								2.51	C	1.23	A

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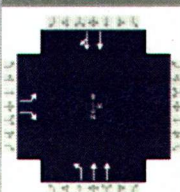
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Oakland Hills
Traffic Impact Study

HCS7 Signalized Intersection Results Summary

General Information									
Agency		Diane B. Zimmerman Traffic Engineering							
Analyst		DBZ							
Jurisdiction		Mar 6, 2018							
Urban Street		AM Peak							
Intersection		2030 Build							
Project Description		Broad Run AM 30 B Oak.xus							
Oakland Hills									
Demand Information									
Approach Movement		L	T	R	L	T	R	L	T
Demand (v, veh/h					58		35		2224
								12	24
								808	
Signal Information									
Cycle, s		109.7	Reference Phase	2					
Offset, s		0	Reference Point	End					
Uncoordinated		Yes	Simult. Gap E/W	On					
Force Mode		Fixed	Simult. Gap N/S	On					
		Red	1.3	3.0	0.0	0.0	0.0	0.0	0.0
		Yellow	5.1	3.6	0.0	0.0	0.0	0.0	0.0
		Green	90.0	6.7	0.0	0.0	0.0	0.0	0.0
									

Timer Results									
Assigned Phase		EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Case Number					9.0	8.0			6.0
Phase Duration, s					13.3	96.4			96.4
Change Period, (Y+R), s					6.6	6.4			6.4
Max Allow Headway (MAH), s					5.0	5.0			5.0
Queue Clearance Time (g), s					5.7	87.4			92.0
Green Extension Time (g + s), s					0.5	2.6			0.0
Phase Call Probability					0.95	1.00			1.00
Max Out Probability					0.00				1.00
Movement Group Results									
Approach Movement		L	T	R	L	T	R	L	T
Assigned Movement					3	18	2	1	6
Adjusted Flow Rate (v, veh/h)					63	38	1215	26	878
Adjusted Saturation Flow Rate (s, veh/h/s)					1810	1610	1900	1896	1809
Queue Service Time (g + s), s					3.7	2.5	85.4	35.1	6.3
Cycle Queue Clearance Time (g + s), s					3.7	2.5	85.4	35.1	6.3
Green Ratio (g/C)					0.06	0.06	0.82	0.82	0.82
Capacity (c), veh/h					110	98	1559	1556	2968
Volume-to-Capacity Ratio (X)					0.572	0.388	0.779	0.781	0.364
Back of Queue (Q), ft/in (90 th percentile)					81.3	47.5	232.3	34.9	38.8
Back of Queue (Q), veh/in (90 th percentile)					3.3	1.9	9.3	1.4	1.6
Queue Storage Ratio (RQ) (90 th percentile)					0.00	0.00	0.00	0.00	0.00
Uniform Delay (d), s/veh					50.1	49.5	4.9	54.3	2.3
Incremental Delay (d2), s/veh					6.5	3.5	2.8	4.4	0.1
Initial Queue Delay (d3), s/veh					0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh					56.6	53.1	7.7	58.7	2.4
Level of Service (LOS)					E	D	A	E	A
Approach Delay, s/veh / LOS					55.3	55.3	7.7	58.7	2.4
Intersection Delay, s/veh / LOS					8.1	8.1	7.7	7.7	2.4
Multimodal Results									
Bicycle LOS Score / LOS									
Pedestrian LOS Score / LOS		2.15	B	2.32	B	1.82	B	0.62	A
Bicycle LOS Score / LOS									

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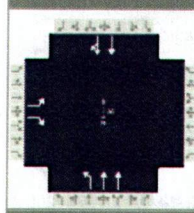
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HCS7 Signalized Intersection Results Summary

General Information										
Agency	Diane B. Zimmerman Traffic Engineering									
Analyst	DBZ									
Jurisdiction										
Urban Street	Bardstown Road									
Intersection	Broad Run Parkway									
Project Description	Oakland Hills									
Intersection Information										
Analysis Date	2/8/2018		Area Type	Other		Time Period	PM Peak		Analysis Period	1 > 5:00
Duration, h	0.25									
Analysis Results										
Analysis Year	2018		Analysis Period	1 > 5:00						
File Name	Broad Run PM 18.xus									
Signal Information										
Cycle, s	100.3	Reference Phase	2	End	Green	80.9	6.5	0.0	0.0	0.0
Offset, s	0	Reference Point	End	Yellow	5.1	3.6	0.0	0.0	0.0	0.0
Uncoordinated	Yes	Simult. Gap E/W	On	Red	1.3	3.0	0.0	0.0	0.0	0.0
Force Mode	Fixed	Simult. Gap N/S	On							
Demand Information										
Approach Movement	L		T	R	L	T	R	L	T	R
Demand (v), veh/h						35		52		1165
						20		25		2078
							</			

Timer Results										Movement Group Results										Multimodal Results																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
Assigned Phase		Case Number		Phase Duration, s		Max Allow Headway (MAH), s		Queue Clearance Time (g s), s		Green Extension Time (g e), s		Phase Call Probability		Max Out Probability		EB		WB		NB		SB		Assigned Phase		Case Number		Phase Duration, s		Max Allow Headway (MAH), s		Queue Clearance Time (g s), s		Green Extension Time (g e), s		Phase Call Probability		Max Out Probability																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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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	Time Period	PM Peak													
	PHF	0.95													
Intersection	Analysis Year	2030 No Build													
	Analysis Period	1 > 5:00													
File Name		Broad Run PM 30 NB Org Plan.xus													
Oakland Hills Original Plan															
Demand Information															
Approach Movement		L	T	R	L	T	R	L	T						
Demand (V), veh/h		39		58		1514		28							
		SB		WB		NB		SB							
Signal Information															
Cycle, s	Reference Phase	2													
	End	Green	89.8	6.7	0.0	0.0	0.0	0.0	0.0						
Offset, s	Reference Point	On	Yellow	5.1	3.6	0.0	0.0	0.0	0.0						
	End	On	Red	1.3	3.0	0.0	0.0	0.0	0.0						
Force Mode		Fixed													
Uncoordinated		Yes													
Simult. Gap N/S		On													
Signal Diagram															

Timer Results									
Assigned Phase				8		2			
Case Number				9.0		8.0			6
Phase Duration, s				13.3		96.2			96.2
Change Period, (Y+R), s				6.6		6.4			6.4
Max Allow Headway (MAH), s				5.1		4.9			4.9
Queue Clearance Time (g s), s				6.1		37.8			72.2
Green Extension Time (g s), s				0.5		50.9			17.6
Phase Call Probability				0.96		1.00			1.00
Max Out Probability				0.00		0.97			0.99
Movement Group Results									
	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT	
Assigned Phase				8		2			6
Case Number				9.0		8.0			6.0
Phase Duration, s				13.3		96.2			96.2
Change Period, (Y+R), s				6.6		6.4			6.4
Max Allow Headway (MAH), s				5.1		4.9			4.9
Queue Clearance Time (g s), s				6.1		37.8			72.2
Green Extension Time (g s), s				0.5		50.9			17.6
Phase Call Probability				0.96		1.00			1.00
Max Out Probability				0.00		0.97			0.99
Movement Group Results									
	EB		WB		NB		SB		
Approach Movement	L	T	R	L	T	R	L	T	R
Assigned Movement				18	2	12	1	6	
Adjusted Flow Rate (v), veh/h				61	810	808	29	2825	
Adjusted Saturation Flow Rate (s), veh/h/in				1610	1900	1890	317	1809	
Queue Service Time (g s), s				2.4	4.1	35.8	14.7	5.7	70.2
Cycle Queue Clearance Time (g c), s				2.4	4.1	35.8	14.7	41.4	70.2
Green Ratio (g/C)				0.06	0.82	0.82	0.82	0.82	
Capacity (c), veh/h				111	98	1558	1550	222	2967
Volume-to-Capacity Ratio (X)				0.371	0.621	0.520	0.521	0.133	0.952
Back of Queue (Q), ft/in (90 th percentile)				50.4	80.8	100.3	100.1	17.7	433.8
Back of Queue (Q), veh/in (90 th percentile)				2.0	3.2	4.0	4.0	0.7	17.4
Queue Storage Ratio (RQ) (90 th percentile)				0.00	0.00	0.00	0.00	0.00	0.00
Uniform Delay (d +), s/veh				49.4	50.2	3.1	3.1	15.5	8.1
Incremental Delay (d 2), s/veh				2.9	8.8	0.4	0.4	0.4	8.2
Initial Queue Delay (d 3), s/veh				0.0	0.0	0.0	0.0	0.0	0.0
Control Delay (d), s/veh				52.3	59.0	3.5	3.5	15.8	16.2
Level of Service (LOS)				D	E	A	A	B	B
Approach Delay, s/veh / LOS	0.0			56.3		3.5		16.2	B
Intersection Delay, s/veh / LOS			12.6				B		C
Multimodal Results									
	EB		WB		NB		SB		
Pedestrian LOS Score / LOS	2.15	B	2.32	B	1.82	B	0.62	A	
Bicycle LOS Score / LOS				F		B	2.84	C	

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Diane B. Zimmerman
Traffic Engineering, LLC

[illegible]



MEMO

To: Lee Hasken

Date: 7 March 2018

From: Mark O'Hara, HOK

Copies To: Gus Drosos/Brian Ashworth/Rashed Singaby/Steven Holt, HOK

Client: LCFC

Bart Miller/Erin Kueht, WPM

Project: LCFC Stadium

Dan Almond, MST

Project #: 17.70079.00

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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