

BUTTERMILK ROAD RESIDENTIAL DEVELOPMENT

KNOX COUNTY, TENNESSEE

TRAFFIC IMPACT STUDY

BUTTERMILK ROAD
KNOX COUNTY, TENNESSEE

CCI PROJECT NO. 00630-0002

REV 1

PREPARED FOR:

Eagle Bend
PO Box 11315
Knoxville, TN 37939

SUBMITTED BY:

Cannon & Cannon, Inc.
8550 Kingston Pike
Knoxville, TN 37919
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REVISED
JULY 6
2022

7-SC-22-C / 7-G-22-UR
TIS Version 2
7/6/2022

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REVISION I (07/06/22)

This report replaces the previous version of the traffic impact study dated 07/23/2021 prepared for this project in its entirety. The associated changes are related to comments received from the City of Knoxville and TDOT, which are located in Appendix F.

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TABLE OF CONTENTS

SECTION 1	EXECUTIVE SUMMARY	1
SECTION 2	INTRODUCTION & PURPOSE OF STUDY	2
SECTION 3	EXISTING CONDITIONS	4
SECTION 4	BACKGROUND CONDITIONS	8
SECTION 5	FUTURE CONDITIONS	10
SECTION 6	EVALUATIONS	15
SECTION 7	CONCLUSIONS & RECOMMENDATIONS	17
SECTION 8	APPENDIX	18

TABLE OF CONTENTS

FIGURES

FIGURE 1	LOCATION MAP	2
FIGURE 2	CONCEPTUAL SITE PLAN	3
FIGURE 3	EXISTING SITE CONDITIONS	5
FIGURE 4	2022 EXISTING TRAFFIC VOLUMES	7
FIGURE 5	2025 BACKGROUND TRAFFIC VOLUMES	9
FIGURE 6	TRIP DISTRIBUTION	12
FIGURE 7	TRIP ASSIGNMENT	13
FIGURE 8	2025 COMBINED TRAFFIC VOLUMES	14

TABLES

TABLE 1	ANNUAL AVERAGE DAILY TRAFFIC COUNT SUMMARY	5
TABLE 2	TRIP GENERATION SUMMARY	10
TABLE 3	CAPACITY ANALYSES SUMMARY	15

APPENDICES

APPENDIX A	TRAFFIC DATA	A-1
APPENDIX B	TRIP GENERATION INFORMATION	B-1
APPENDIX C	CAPACITY ANALYSES	C-1
APPENDIX D	TURN LANE WARRANT SHEETS	D-1
APPENDIX E	TIS COMMENT RESPONSE DOCUMENT	E-1

EXECUTIVE SUMMARY

This report provides a summary of a traffic impact study that was performed for a proposed single-family residential development on Buttermilk Road in Knox County, Tennessee. The project site is located on the south side of Buttermilk Road between the Graybeal Road intersections with Buttermilk Road. The development plan for this project consists of 102 single-family residential units. The proposed development will create a new full-movement access intersection onto Buttermilk Road.

The purpose of this study was the evaluation of the traffic operational and safety impacts of the proposed development upon roadways in the vicinity of the project site. Discussion with Knox County and Knoxville-Knox County Planning staff resulted in the proposed site access intersection at Buttermilk Road being identified for detailed study. Appropriate intersection evaluations such as capacity analyses, intersection sight distance analyses, and turn lane warrant evaluations were conducted at the study intersection for existing and future conditions, both with and without site generated traffic, in order to determine the anticipated impacts and to establish recommended measures to mitigate these impacts.

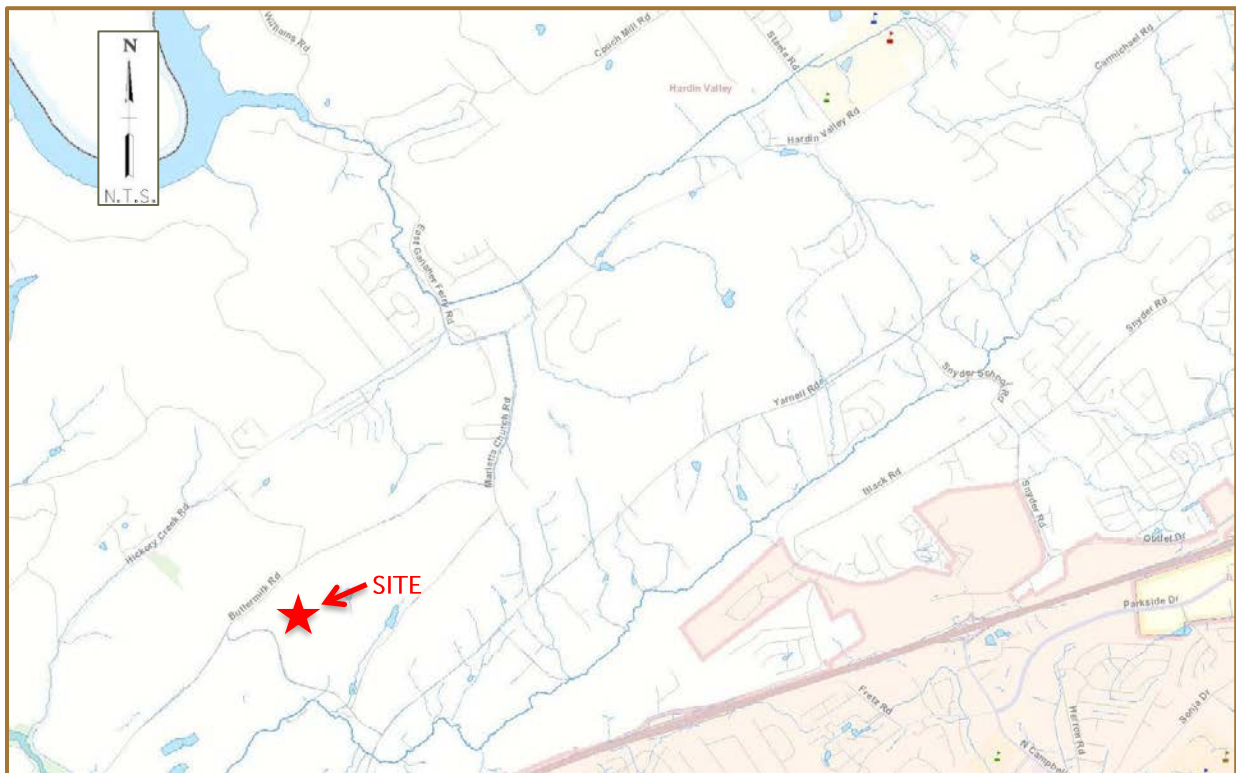
The primary conclusion of this study is that the traffic generated from the proposed development will not have a significant impact on the studied site access intersection at Buttermilk Road. Intersection levels-of-service are expected to be "A" during peak traffic periods for the site access intersection.

The following is a listing of recommendations that were developed to address traffic concerns in the vicinity of the project site:

1. Buttermilk Road at Proposed Site Access Point:
 - a. Install a northbound approach leg to create the intersection of Buttermilk Road at Proposed Site Access
2. Maintain intersection corner sight distances on the site access locations by ensuring that site grading, landscaping, signage, and other site features do not restrict intersection sight distance lines of sight.

INTRODUCTION & PURPOSE OF STUDY

This report provides a summary of a traffic impact study that was performed for a proposed single-family residential development on Buttermilk Road in Knox County, Tennessee. The project site is located on the south side of Buttermilk Road between the Graybeal Road intersections with Buttermilk Road. FIGURE 1 is a location map showing the major roadways in the project site vicinity.



**FIGURE 1
LOCATION MAP**

The development plan for this project consists of 102 single-family residential units. The proposed development will create a new full-movement access intersection onto Buttermilk Road. FIGURE 2 is a Conceptual Site Plan detailing the proposed site.

The purpose of this study was the evaluation of the traffic operational and safety impacts of the proposed development upon roadways in the vicinity of the project site. Discussion with Knox County and Knoxville-Knox County Planning staff resulted in the proposed site access intersection at Buttermilk Road being identified for detailed study. Appropriate intersection evaluations such as capacity analyses, intersection sight distance analyses, and turn lane warrant evaluations were conducted at the study intersection for existing and future conditions, both with and without site generated traffic, in order to determine the anticipated impacts and to establish recommended measures to mitigate these impacts.



EXISTING CONDITIONS

EXISTING ROADWAY CONDITIONS

Roadway conditions for the study roadways are summarized as follows:

- Buttermilk Road is a two-lane roadway with one lane in each direction within the vicinity of the proposed site. It is classified as a minor collector per the Knoxville-Knox County Planning Major Road Plan. Lane widths are 9 feet with open shoulders on both sides of Buttermilk Road and the posted speed limit is 30 mph.

Traffic control for the study intersection is as follows:

- Proposed Site Access Point at Buttermilk Road is proposed to be side-street STOP controlled.

EXISTING SITE CONDITIONS

The proposed development is located on the south side of Buttermilk Road between the Graybeal Road intersections with Buttermilk Road. The site will be adjacent to existing single family residential development along Buttermilk Road. Additionally, the proposed site slopes down from Buttermilk Road to a gentle rolling landscape. FIGURE 3 provides an aerial view of the project site and the surrounding area.



FIGURE 3
EXISTING SITE CONDITIONS

EXISTING TRAFFIC DATA

Existing traffic data was gathered for this study from Knoxville-Knox County Planning. Knoxville-Knox County Planning collects annual average daily traffic (AADT) data on roadways in the study area. One count station was found near the project site that was felt to have particular relevance for this study. The most currently available data from this station is contained in Table 1.

TABLE 1: ANNUAL AVERAGE DAILY TRAFFIC COUNT SUMMARY

COUNT YEAR	COUNT STATION 093M276 BUTTERMILK ROAD WEST OF PROPOSED SITE / EAST OF EVERETT ROAD
2013	450
2015	530
2017	520
2019	490
2022	518

The adjacent intersection traffic was utilized as the 2022 existing traffic volumes for this study since the study intersections do not currently exist. The existing ADT data is summarized in FIGURE 4 and the count summary sheets are contained in APPENDIX A.

EXISTING CAPACITY ANALYSES / LEVELS-OF-SERVICE

Capacity analyses employing the methods of the *Highway Capacity Manual* are typically conducted for the existing conditions at the study intersections. Since the studied intersection is currently proposed and does not exist, existing capacity analysis could not be performed. APPENDIX C contains a section entitled "Capacity and Level of Service Concepts", which provides a description of the utilized procedures.

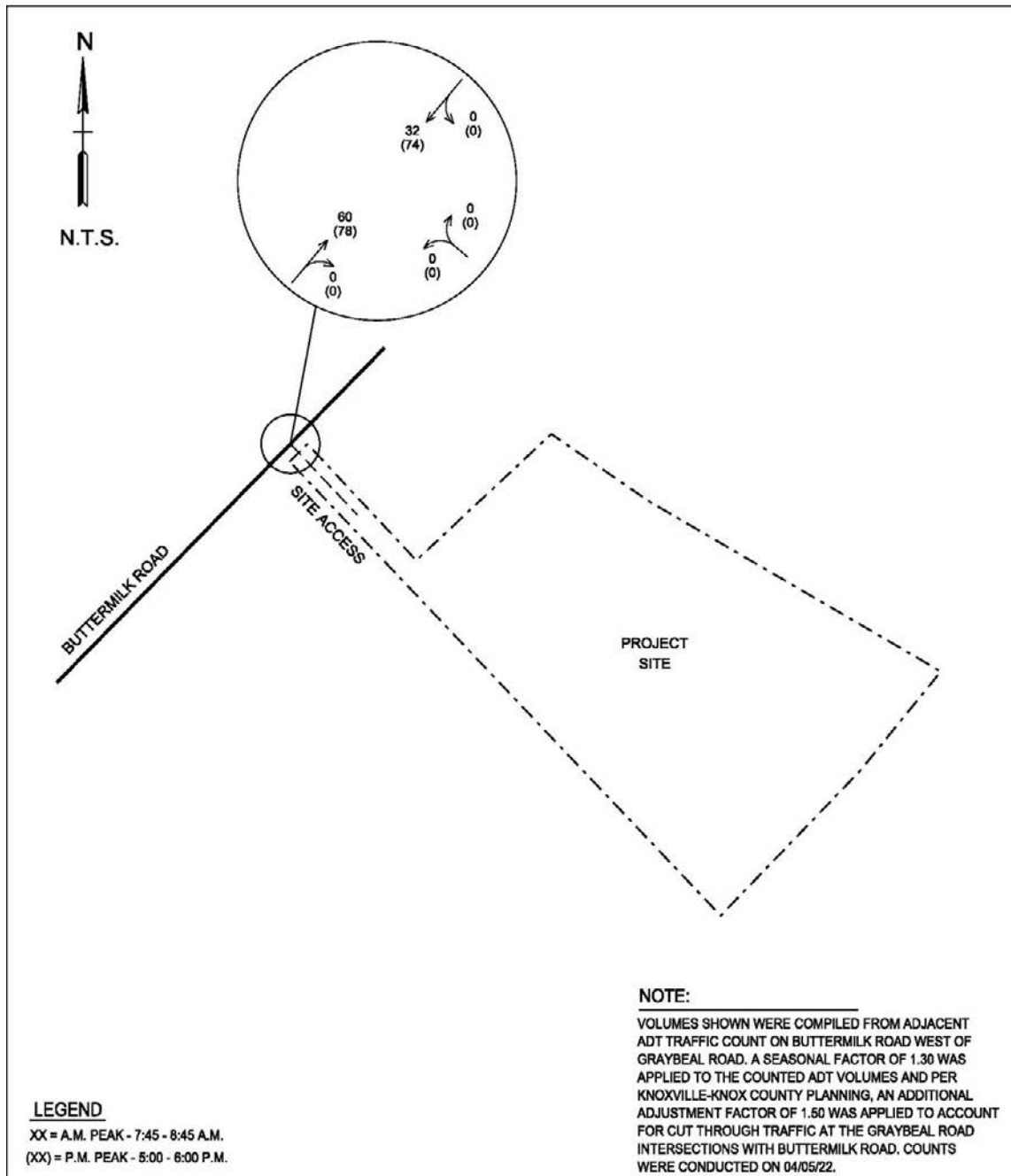


FIGURE 4
2022 EXISTING TRAFFIC VOLUMES

BACKGROUND CONDITIONS

BACKGROUND TRAFFIC GROWTH

The proposed development is anticipated to be constructed in one general phase with completion anticipated by 2025. Therefore, year 2025 was established as the appropriate design / analysis year for the study. In order to determine traffic volumes resulting solely from background traffic growth to year 2025, it was necessary to establish an annual growth rate for existing traffic. In addition to the AADT values previously discussed, knowledge of the surrounding area was used to determine an approximate annual growth rate. Based on the available data and anticipated growth in the area, a background annual growth rate of five percent was assumed. FIGURE 5 contains the background traffic volumes that would result from this annual growth rate from year 2022 to year 2025.

BACKGROUND CAPACITY ANALYSES / LEVELS-OF-SERVICE

Capacity analyses employing the methods of the *Highway Capacity Manual* are typically conducted for the background conditions at the study intersection to provide a baseline for comparing build and no-build traffic scenarios. Since the studied intersection is currently proposed and does not exist, background capacity analysis could not be performed.

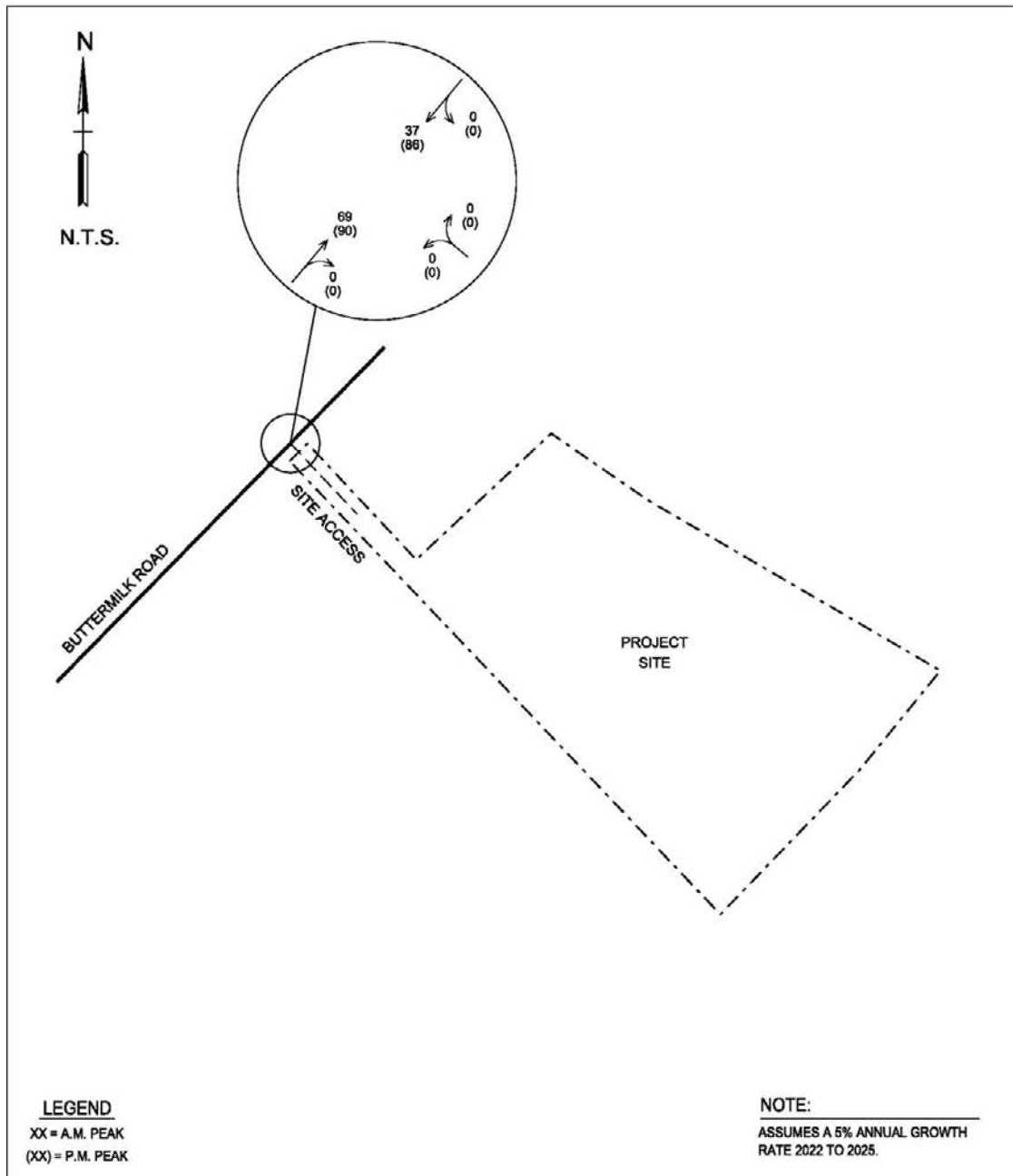


FIGURE 5
2025 BACKGROUND TRAFFIC VOLUMES

FUTURE CONDITIONS

TRIP GENERATION

In order to estimate the expected traffic volumes to be generated by the proposed development, the procedures of *Trip Generation, 11TH Edition* (Institute of Transportation Engineers-ITE) were utilized. The generated traffic volumes were determined based on the data for the peak hours of adjacent street traffic for Land Use Code 210 (Single Family Detached Housing). See TABLE 2 for a summary of the traffic generated for this project. More detailed information is contained in APPENDIX B.

TABLE 2: TRIP GENERATION SUMMARY

LAND USE	ITE CODE	SIZE	WEEKDAY (TRIPS/DAY)	AM PEAK HOUR (TRIPS/HOUR)	PM PEAK HOUR (TRIPS/HOUR)
Single Family Detached Housing	210	102 Units	1,028	76	101
Entering Trips			514 (50%)	20 (26%)	64 (63%)
Exiting Trips			514 (50%)	56 (74%)	37 (37%)

TRIP DISTRIBUTION AND ASSIGNMENT

The proposed trip distribution for this development was determined through a review of existing travel patterns, local knowledge of the study area, proposed site location in relation to surrounding roadway network, and engineering judgment. FIGURE 6 provides a summary of how the above site generated trips would be assigned to the study intersections. FIGURE 7 provides the proposed trip assignment volumes to the studied intersections.

FUTURE TRAFFIC VOLUMES

Future projected traffic volumes for the study intersections were developed by adding the generated and assigned trips shown in FIGURE 7 to the 2025 background traffic volumes developed in the previous section and shown in FIGURE 5. These combined 2025 volumes reflect the existing traffic, the background traffic growth, and the generated traffic from the proposed development. These future volumes are shown on FIGURE 8 and are the combined volumes used in the analyses of future conditions with the proposed development.

FUTURE CAPACITY ANALYSES / LEVELS-OF-SERVICE

Capacity analyses were conducted for future conditions utilizing the traffic volumes shown in the build-out scenario. These analyses utilized proposed intersection traffic control and proposed lane configurations to determine if any mitigation is required to accommodate traffic generated by the proposed site. Tabular summaries of the analysis results and associated discussion are also contained in the EVALUATIONS section. In addition, detailed computer printout summaries of the analyses are contained in APPENDIX C.

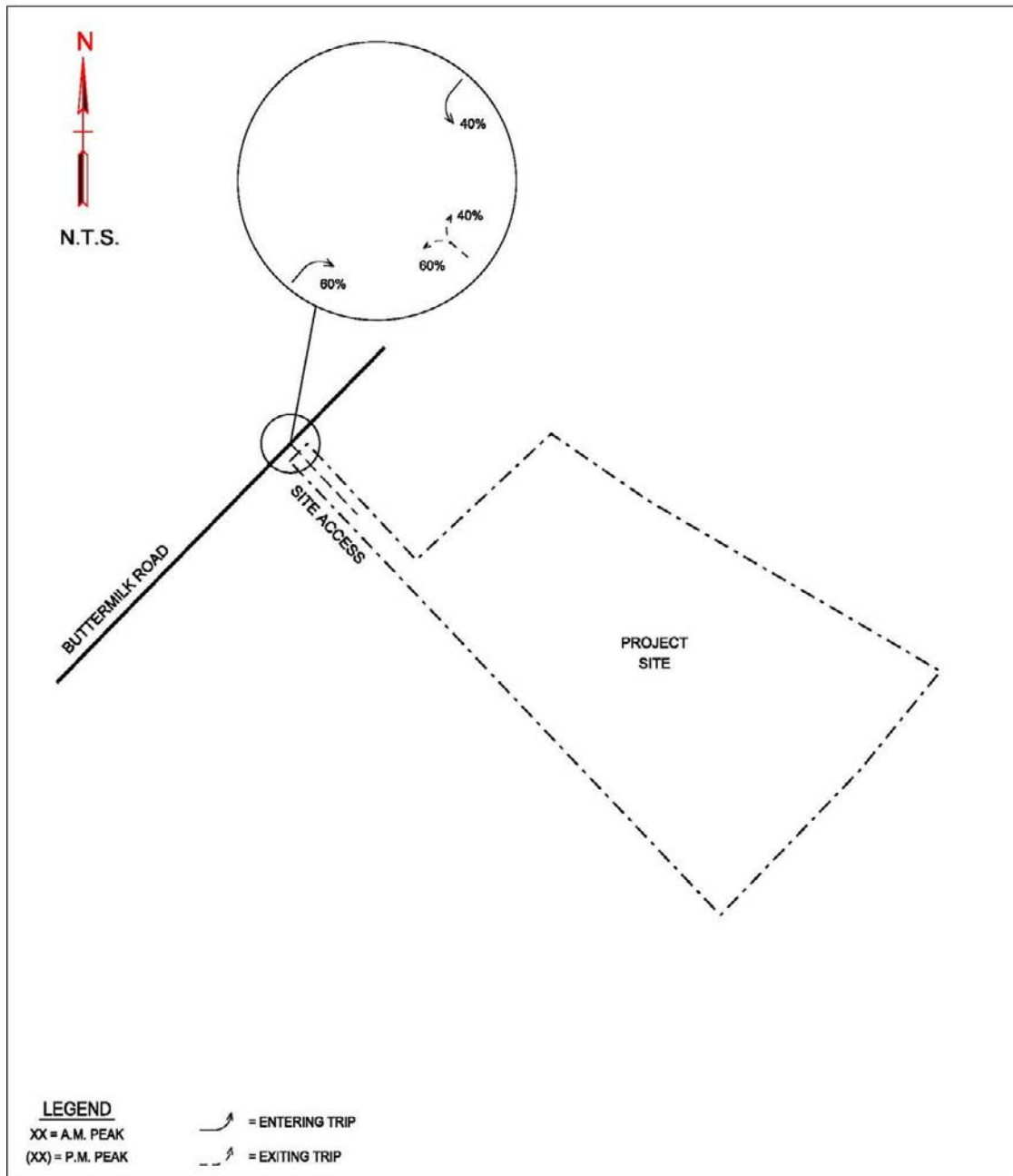


FIGURE 6
TRIP DISTRIBUTION

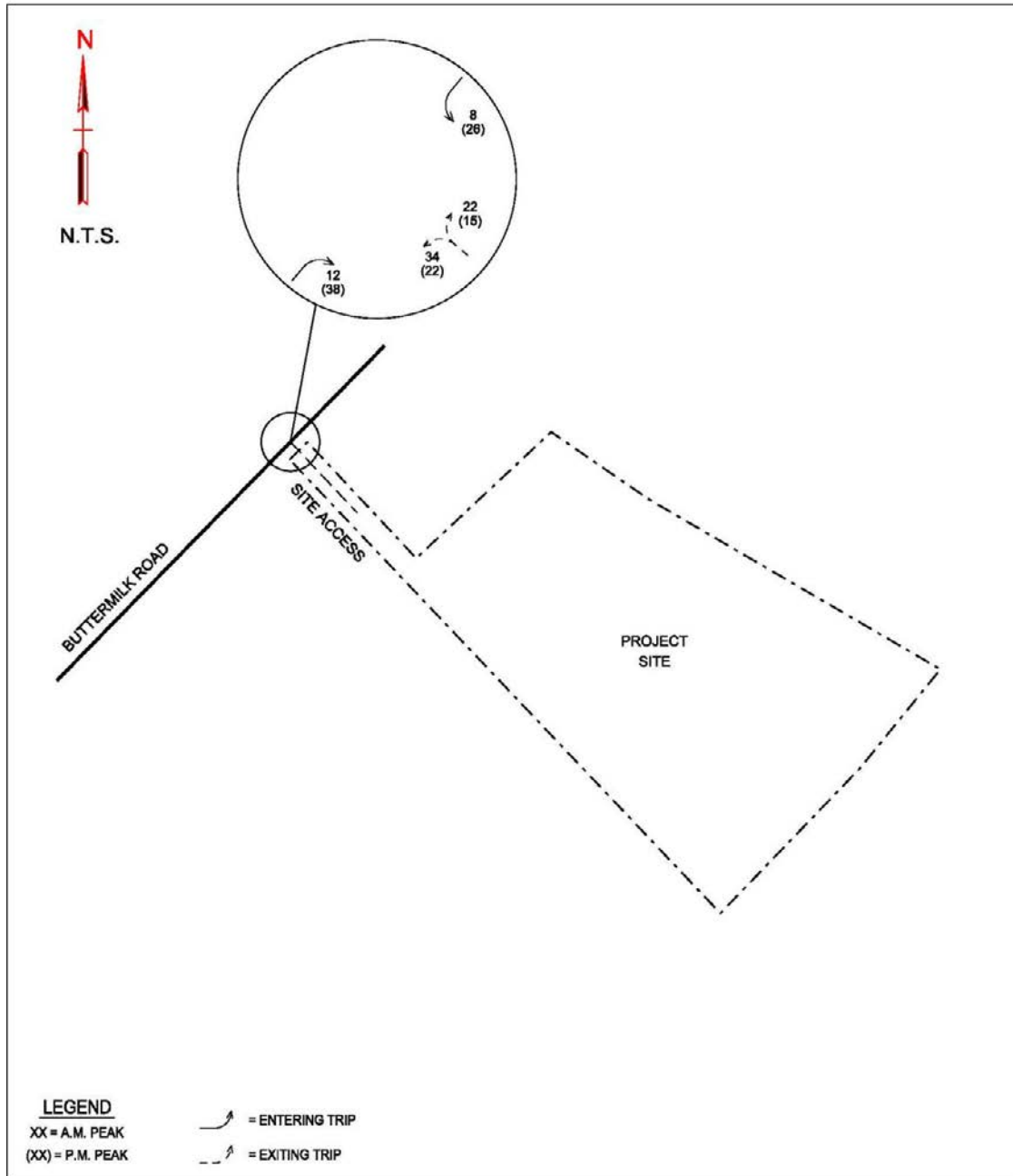


FIGURE 7
TRIP ASSIGNMENT

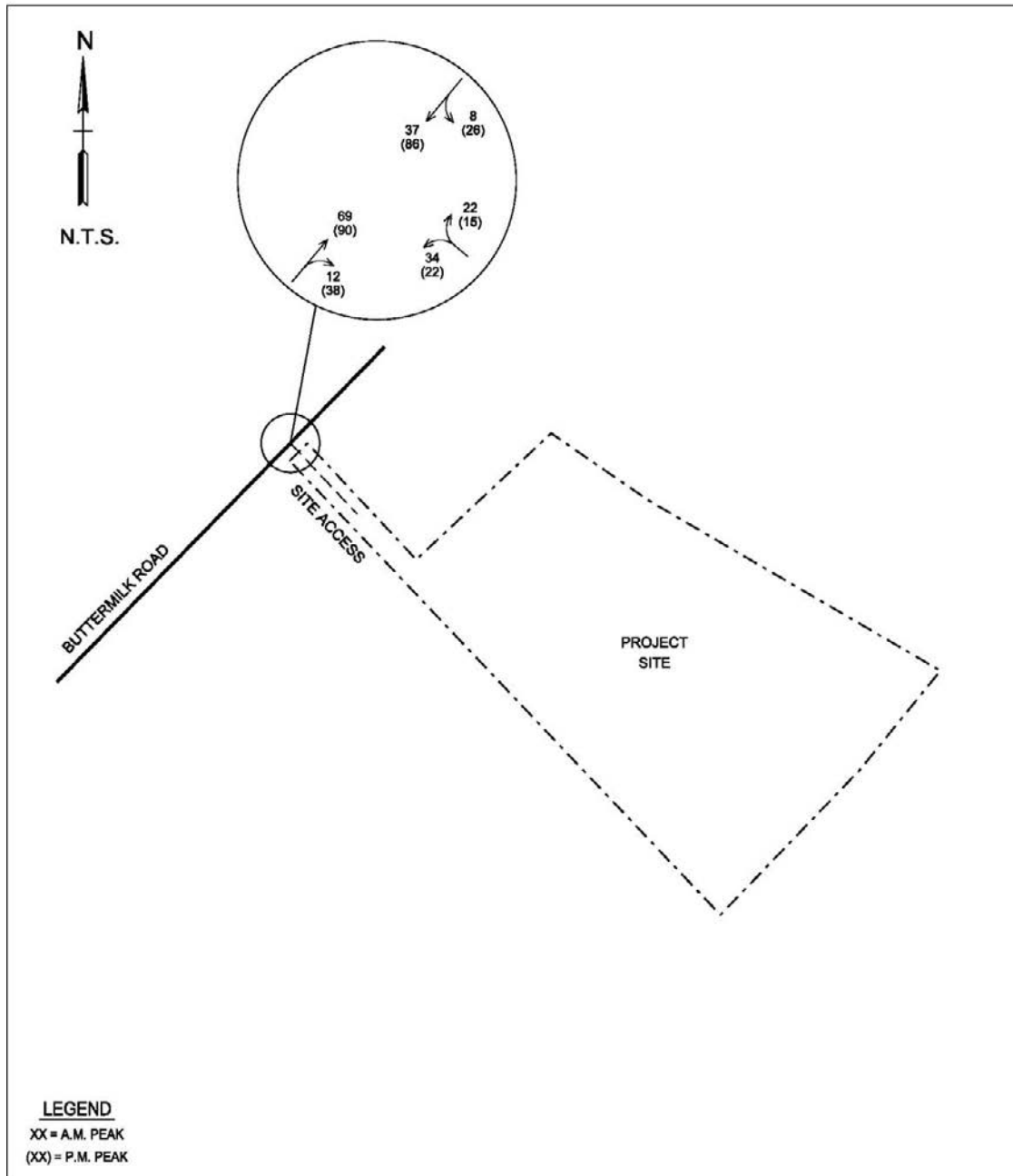


FIGURE 8
2025 COMBINED TRAFFIC VOLUMES

EVALUATIONS

INTERSECTION CAPACITY ANALYSES

As discussed in the preceding sections of this report, capacity analyses employing the methods of the Highway Capacity Manual (HCM 6th Edition) were conducted for the study intersections. These analyses were performed for the previously discussed development scenario. A summary of the capacity analyses results is shown in TABLE 3, while the resulting conclusions and recommendations are covered in the CONCLUSIONS and RECOMMENDATIONS section of this report. The complete capacity analysis reports are contained in APPENDIX C.

TABLE 3: CAPACITY ANALYSES SUMMARY

INTERSECTION	TIME PERIOD	YEAR 2022 EXISTING (LOS/DELAY)	YEAR 2025 BACKGROUND (LOS/DELAY)	YEAR 2025 COMBINED (LOS/DELAY)
Buttermilk Road at Access Point ¹ SIDE STREET STOP CONTROL – NB APPROACH	A.M. P.M.	-	-	A 9.3 A 9.9

¹SIDE STREET STOP CONTROL – Data shown are Level-of-Service and Average Vehicular Delay (seconds) for the critical side street approaches and major street left turn movements utilizing HCM methodology.

TURN LANE ASSESSMENTS

Turn lane warrant evaluations were conducted at the studied intersection of Buttermilk Road at Proposed Site Access. This evaluation found that neither a left-turn nor a right-turn lane were warranted during the studied peak hours at the studied intersection. The evaluations utilized Knox County left and right-turn lane volume thresholds. The spreadsheets summarizing these evaluations are contained in APPENDIX D.

SIGHT DISTANCE ASSESSMENT

Intersection sight distance was assessed looking both directions from the proposed site driveway intersection. Based on AASHTO sight distance requirements for 30 mph roadways, 335 feet of sight distance is required to make a left turn and 290 feet of sight distance is required to make a right turn from a side street stop-controlled scenario. Additionally, Knoxville-Knox County Subdivision Regulations state, "The minimum sight distance at an intersection (in both directions along the major street) shall be ten (10) times the posted speed limit, but in no case shall it be less than 250 feet."

Sight distance field measurements were ultimately inconclusive due to the excessive sight limiting vegetation surrounding the proposed site access. Field measurements indicate that 72 feet of sight distance is currently available when looking right and 79 feet of sight distance is currently available when looking left.

However, once the vegetation is cleared, it is believed sight distance requirements looking to the right from the proposed access can be achieved as the eastern intersection of Graybeal Road at Buttermilk Road (roughly 600 feet from the proposed access) was visible when stepping out beyond the sight limiting vegetation. Additionally, sight distance requirements looking left can likely be achieved if enough

sight limiting vegetation is cleared as sight distance was measured around 435 feet when stepping out beyond the sight limiting vegetation.

Care should be taken during the site development process to ensure that site features such as landscaping and signage to do not restrict the existing sight distances. Furthermore, clear sight triangles in both directions measured 15' back from the edge of traveled way along the proposed access point shall be provided. Coordination with the developer will be needed to ensure that the sight triangles can be achieved within the development's property limits, public right-of-way, or other easements as necessary.

CONCLUSIONS & RECOMMENDATIONS

The primary conclusion of this study is that the traffic generated from the proposed development will not have a significant impact on the studied site access intersection at Buttermilk Road. Intersection levels-of-service are expected to be "A" during peak traffic periods for the site access intersection.

The following is a listing of recommendations that were developed to address traffic concerns in the vicinity of the project site:

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APPENDIX

APPENDIX ORDER:

A. TRAFFIC DATA

B. TRIP GENERATION INFORMATION

C. CAPACITY ANALYSES

D. TURN LANE WARRANT SHEETS

APPENDIX A – TRAFFIC DATA

VOLUME - RAW

Buttermilk Rd E/O Hickory Creek Rd (35.890518°,-84.243923°)

Day: Tuesday
Date: 4/5/2022City: Knoxville
Project #: TN22_190004_055

DAILY TOTALS					NB	SB						EB	WB						Total
					0	0						282	236						518
AM Period	NB	SB	EB	WB	TOTAL		PM Period	NB	SB	EB	WB	TOTAL							TOTAL
0:00			0	2	2		12:00			5	3	8							
0:15			0	0	0		12:15			2	5	7							
0:30			0	0	0		12:30			4	3	7							
0:45			0	0	0	2	12:45			6	17	0	11	6	28				
1:00			0	0	0		13:00			0	1	1							
1:15			0	0	0		13:15			0	3	3							
1:30			1	1	2		13:30			3	3	6							
1:45			0	1	0	1	13:45			5	8	5	12	10	20				
2:00			0	0	0		14:00			6	6	12							
2:15			0	0	0		14:15			2	1	3							
2:30			0	0	0		14:30			7	0	7							
2:45			0	0	0		14:45			4	19	2	9	6	28				
3:00			0	0	0		15:00			3	5	8							
3:15			0	1	1		15:15			3	3	6							
3:30			0	0	0		15:30			2	4	6							
3:45			0	0	0	1	15:45			2	10	4	16	6	26				
4:00			0	1	1		16:00			4	7	11							
4:15			0	1	1		16:15			12	5	17							
4:30			0	0	0		16:30			10	5	15							
4:45			1	1	0	2	16:45			4	30	5	22	9	52				
5:00			0	0	0		17:00			7	7	14							
5:15			1	1	2		17:15			11	9	20							
5:30			0	2	2		17:30			8	12	20							
5:45			0	1	3	6	17:45			14	40	10	38	24	78				
6:00			1	3	4		18:00			4	6	10							
6:15			4	1	5		18:15			3	4	7							
6:30			4	4	8		18:30			1	3	4							
6:45			5	14	3	11	18:45			3	11	1	14	4	25				
7:00			7	4	11		19:00			3	2	5							
7:15			3	6	9		19:15			3	1	4							
7:30			4	9	13		19:30			3	1	4							
7:45			7	21	3	22	19:45			1	10	1	5	2	15				
8:00			3	4	7		20:00			1	2	3							
8:15			9	3	12		20:15			2	4	6							
8:30			11	6	17		20:30			4	0	4							
8:45			4	27	3	16	20:45			1	8	1	7	2	15				
9:00			3	1	4		21:00			1	0	1							
9:15			4	7	11		21:15			3	1	4							
9:30			6	4	10		21:30			0	2	2							
9:45			7	20	3	15	21:45			0	4	0	3	0	7				
10:00			2	3	5		22:00			0	1	1							
10:15			3	2	5		22:15			2	0	2							
10:30			6	2	8		22:30			1	0	1							
10:45			1	12	3	9	22:45			1	4	0	1	1	5				
11:00			1	5	6		23:00			1	0	1							
11:15			7	2	9		23:15			0	0	0							
11:30			10	2	12		23:30			1	1	2							
11:45			3	21	5	11	23:45			1	3	1	2	2	5				
TOTALS			118	96	214		TOTALS			164	140	304							
SPLIT %			55.1%	44.9%	41.3%		SPLIT %			53.9%	46.1%	58.7%							

DAILY TOTALS			NB	SB							EB	WB	Total		
			0	0							282	236			
AM Peak Hour			7:45	6:45	7:45	PM Peak Hour					17:00	17:00	17:00		
AM Pk Volume			30	22	46	PM Pk Volume					40	38	78		
Pk Hr Factor			0.682	0.611	0.676	Pk Hr Factor					0.714	0.792	0.813		
7 - 9 Volume	0	0	48	38	86	4 - 6 Volume			0	0	70	60	130		
7 - 9 Peak Hour			7:45	7:00	7:45	4 - 6 Peak Hour					17:00	17:00	17:00		
7 - 9 Pk Volume	0	0	30	22	46	4 - 6 Pk Volume			0	0	40	38	78		
Pk Hr Factor	0.000	0.000	0.682	0.611	0.676	Pk Hr Factor			0.000	0.000	0.714	0.792	0.813		

VOLUME - SEASONAL FACTOR OF 1.30

Buttermilk Rd E/O Hickory Creek Rd (35.890518°,-84.243923°)

Day: Tuesday
Date: 4/5/2022City: Knoxville
Project #: TN22_190004_055

DAILY TOTALS					NB	SB	EB					WB	Total		
					0	0	368					308	675		
AM Period	NB	SB	EB	WB	TOTAL		PM Period	NB	SB	EB	WB	TOTAL			
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0:15			0	0	0		12:15			3	7	9			
0:30			0	0	0		12:30			5	4	9			
0:45			0	0	0	3	12:45			8	22	0	14	8	36
1:00			0	0	0		13:00			0	1	1			
1:15			0	0	0		13:15			0	4	4			
1:30			1	1	3		13:30			4	4	8			
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3:45			0	0	0	1	15:45			3	13	5	21	8	34
4:00			0	1	1		16:00			5	9	14			
4:15			0	1	1		16:15			16	7	22			
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4:45			1	1	0	3	16:45			5	39	7	29	12	68
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5:45			0	1	4	8	17:45			18	52	13	50	31	102
6:00			1	4	5		18:00			5	8	13			
6:15			5	1	7		18:15			4	5	9			
6:30			5	5	10		18:30			1	4	5			
6:45			7	18	10	33	18:45			4	14	1	18	5	33
7:00			9	5	14		19:00			4	3	7			
7:15			4	8	12		19:15			4	1	5			
7:30			5	12	17		19:30			4	1	5			
7:45			9	27	13	56	19:45			1	13	1	7	3	20
8:00			4	5	9		20:00			1	3	4			
8:15			12	4	16		20:15			3	5	8			
8:30			14	8	22		20:30			5	0	5			
8:45			5	35	9	56	20:45			1	10	1	9	3	20
9:00			4	1	5		21:00			1	0	1			
9:15			5	9	14		21:15			4	1	5			
9:30			8	5	13		21:30			0	3	3			
9:45			9	26	13	46	21:45			0	5	0	4	0	9
10:00			3	4	7		22:00			0	1	1			
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10:30			8	3	10		22:30			1	0	1			
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11:00			1	7	8		23:00			1	0	1			
11:15			9	3	12		23:15			0	0	0			
11:30			13	3	16		23:30			1	1	3			
11:45			4	27	7	42	23:45			1	4	1	3	3	7
TOTALS			154	125	279		TOTALS			214	182	396			
SPLIT %			55.1%	44.9%	41.3%		SPLIT %			53.9%	46.1%	58.7%			

DAILY TOTALS					NB	SB						EB	WB						Total
					0	0						368	308						675
AM Peak Hour			7:45	6:45	7:45		PM Peak Hour			17:00	17:00	17:00							
AM Pk Volume			39	29	60		PM Pk Volume			52	50	102							
Pk Hr Factor			0.682	0.611	0.676		Pk Hr Factor			0.714	0.792	0.813							
7 - 9 Volume	0	0	63	50	112		4 - 6 Volume	0	0	91	78	169							
7 - 9 Peak Hour			7:45	7:00	7:45		4 - 6 Peak Hour			17:00	17:00	17:00							
7 - 9 Pk Volume	0	0	39	29	60		4 - 6 Pk Volume	0	0	52	50	102							
Pk Hr Factor	0.000	0.000	0.682	0.611	0.676		Pk Hr Factor	0.000	0.000	0.714	0.792	0.813							

VOLUME - ADJUSTMENT FACTOR OF 1.50

Buttermilk Rd E/O Hickory Creek Rd (35.890518°,-84.243923°)

Day: Tuesday
Date: 4/5/2022City: Knoxville
Project #: TN22_190004_055

DAILY TOTALS					NB	SB	EB					WB	Total		
					0	0	551					461	1,013		
AM Period	NB	SB	EB	WB	TOTAL		PM Period	NB	SB	EB	WB	TOTAL			
0:00			0	4	4		12:00			10	6	16			
0:15			0	0	0		12:15			4	10	14			
0:30			0	0	0		12:30			8	6	14			
0:45			0	0	0	4	12:45			12	33	0	22	12	55
1:00			0	0	0		13:00			0	2	2			
1:15			0	0	0		13:15			0	6	6			
1:30			2	2	4		13:30			6	6	12			
1:45			0	2	0	2	13:45			10	16	10	23	20	39
2:00			0	0	0		14:00			12	12	23			
2:15			0	0	0		14:15			4	2	6			
2:30			0	0	0		14:30			14	0	14			
2:45			0	0	0		14:45			8	37	4	18	12	55
3:00			0	0	0		15:00			6	10	16			
3:15			0	2	2		15:15			6	6	12			
3:30			0	0	0		15:30			4	8	12			
3:45			0	0	0	2	15:45			4	20	8	31	12	51
4:00			0	2	2		16:00			8	14	22			
4:15			0	2	2		16:15			23	10	33			
4:30			0	0	0		16:30			20	10	29			
4:45			2	2	0	4	16:45			8	59	10	43	18	102
5:00			0	0	0		17:00			14	14	27			
5:15			2	2	4		17:15			22	18	39			
5:30			0	4	4		17:30			16	23	39			
5:45			0	2	6	12	17:45			27	78	20	74	47	152
6:00			2	6	8		18:00			8	12	20			
6:15			8	2	10		18:15			6	8	14			
6:30			8	8	16		18:30			2	6	8			
6:45			10	27	6	22	18:45			6	22	2	27	8	49
7:00			14	8	22		19:00			6	4	10			
7:15			6	12	18		19:15			6	2	8			
7:30			8	18	25		19:30			6	2	8			
7:45			14	41	6	43	19:45			2	20	2	10	4	29
8:00			6	8	14		20:00			2	4	6			
8:15			18	6	23		20:15			4	8	12			
8:30			22	12	33		20:30			8	0	8			
8:45			8	53	6	31	20:45			2	16	2	14	4	29
9:00			6	2	8		21:00			2	0	2			
9:15			8	14	22		21:15			6	2	8			
9:30			12	8	20		21:30			0	4	4			
9:45			14	39	6	29	21:45			0	8	0	6	0	14
10:00			4	6	10		22:00			0	2	2			
10:15			6	4	10		22:15			4	0	4			
10:30			12	4	16		22:30			2	0	2			
10:45			2	23	4	18	22:45			2	8	0	2	2	10
11:00			2	10	12		23:00			2	0	2			
11:15			14	4	18		23:15			0	0	0			
11:30			20	4	23		23:30			2	2	4			
11:45			6	41	4	22	23:45			2	6	2	4	4	10
TOTALS	231				188	418	TOTALS	321				274	594		
SPLIT %	55.1%				44.9%	41.3%	SPLIT %	53.9%				46.1%	58.7%		

DAILY TOTALS			NB	SB				EB	WB				Total
			0	0				551	461				1013
AM Peak Hour			7:45	6:45	7:45			PM Peak Hour			17:00	17:00	17:00
AM Pk Volume			59	43	90			PM Pk Volume			78	74	152
Pk Hr Factor			0.682	0.611	0.676			Pk Hr Factor			0.714	0.792	0.813
7 - 9 Volume	0	0	94	74	168			4 - 6 Volume	0	0	137	117	254
7 - 9 Peak Hour			7:45	7:00	7:45			4 - 6 Peak Hour			17:00	17:00	17:00
7 - 9 Pk Volume	0	0	59	43	90			4 - 6 Pk Volume	0	0	78	74	152
Pk Hr Factor	0.000	0.000	0.682	0.611	0.676			Pk Hr Factor	0.000	0.000	0.714	0.792	0.813

APPENDIX B – TRIP GENERATION INFORMATION

Land Use: 210

Single-Family Detached Housing

Description

A single-family detached housing site includes any single-family detached home on an individual lot. A typical site surveyed is a suburban subdivision.

Specialized Land Use

Data have been submitted for several single-family detached housing developments with homes that are commonly referred to as patio homes. A patio home is a detached housing unit that is located on a small lot with little (or no) front or back yard. In some subdivisions, communal maintenance of outside grounds is provided for the patio homes. The three patio home sites total 299 dwelling units with overall weighted average trip generation rates of 5.35 vehicle trips per dwelling unit for weekday, 0.26 for the AM adjacent street peak hour, and 0.47 for the PM adjacent street peak hour. These patio home rates based on a small sample of sites are lower than those for single-family detached housing (Land Use 210), lower than those for single-family attached housing (Land Use 251), and higher than those for senior adult housing -- single-family (Land Use 251). Further analysis of this housing type will be conducted in a future edition of *Trip Generation Manual*.

Additional Data

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (<https://www.ite.org/technical-resources/topics/trip-and-parking-generation/>).

For 30 of the study sites, data on the number of residents and number of household vehicles are available. The overall averages for the 30 sites are 3.6 residents per dwelling unit and 1.5 vehicles per dwelling unit.

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Arizona, California, Connecticut, Delaware, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Minnesota, Montana, New Jersey, North Carolina, Ohio, Ontario (CAN), Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Vermont, Virginia, and West Virginia.

Source Numbers

100, 105, 114, 126, 157, 167, 177, 197, 207, 211, 217, 267, 275, 293, 300, 319, 320, 356, 357, 367, 384, 387, 407, 435, 522, 550, 552, 579, 598, 601, 603, 614, 637, 711, 716, 720, 728, 735, 868, 869, 903, 925, 936, 1005, 1007, 1008, 1010, 1033, 1066, 1077, 1078, 1079

Single-Family Detached Housing (210)

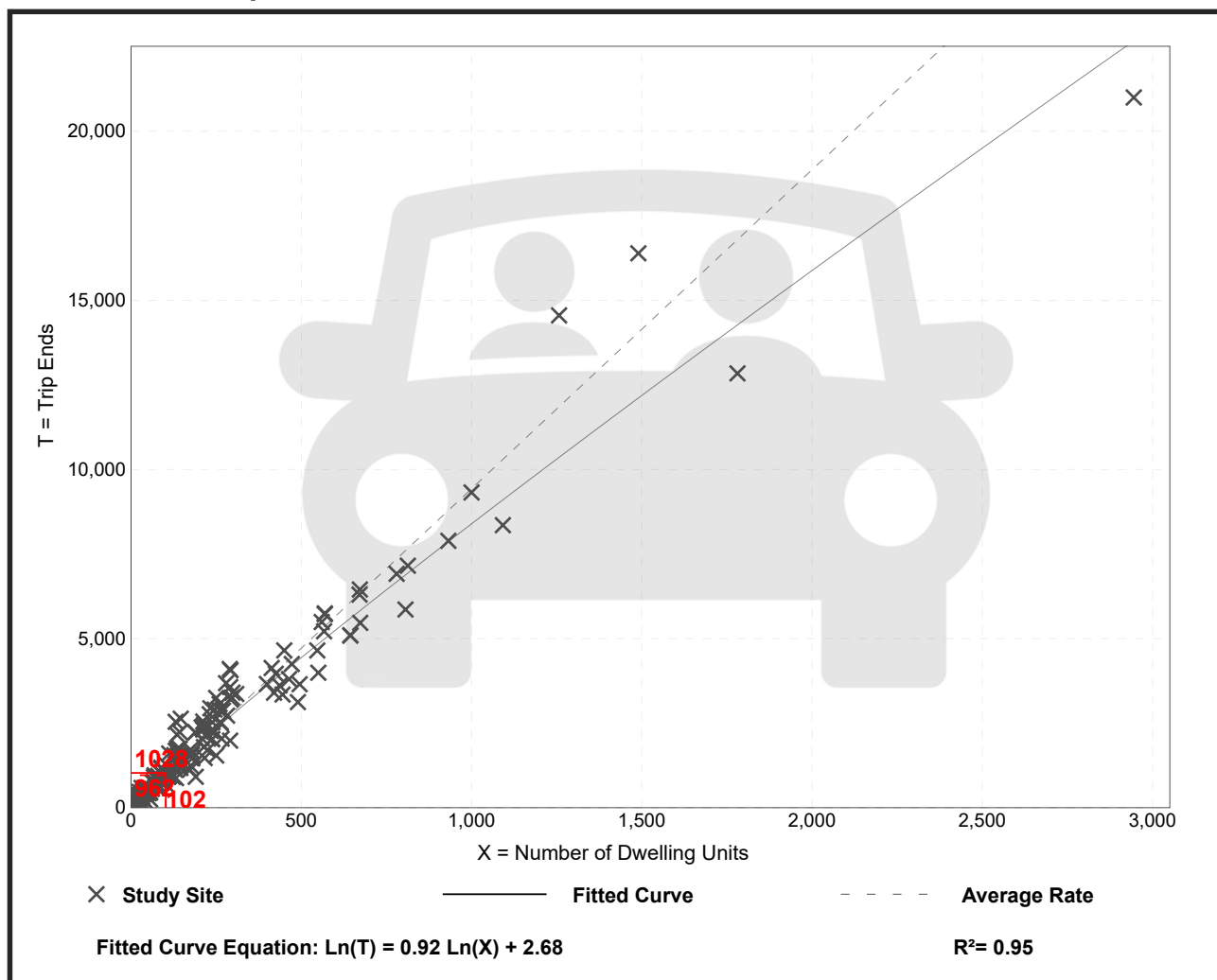
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 174
Avg. Num. of Dwelling Units: 246
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.43	4.45 - 22.61	2.13

Data Plot and Equation



Single-Family Detached Housing (210)

Vehicle Trip Ends vs: Dwelling Units

On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Setting/Location: General Urban/Suburban

Number of Studies: 192

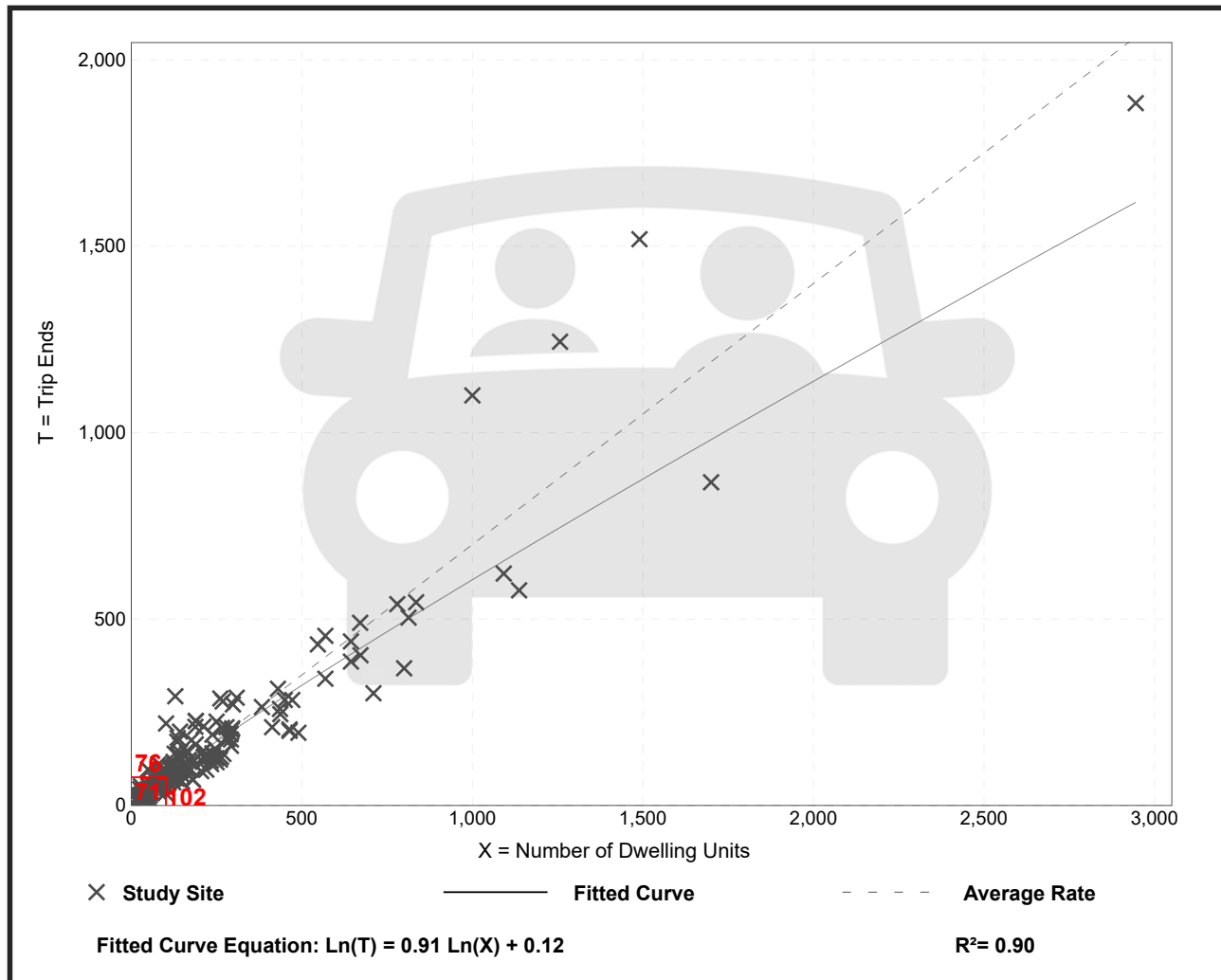
Avg. Num. of Dwelling Units: 226

Directional Distribution: 26% entering, 74% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.70	0.27 - 2.27	0.24

Data Plot and Equation



Single-Family Detached Housing (210)

Vehicle Trip Ends vs: Dwelling Units

On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Setting/Location: General Urban/Suburban

Number of Studies: 208

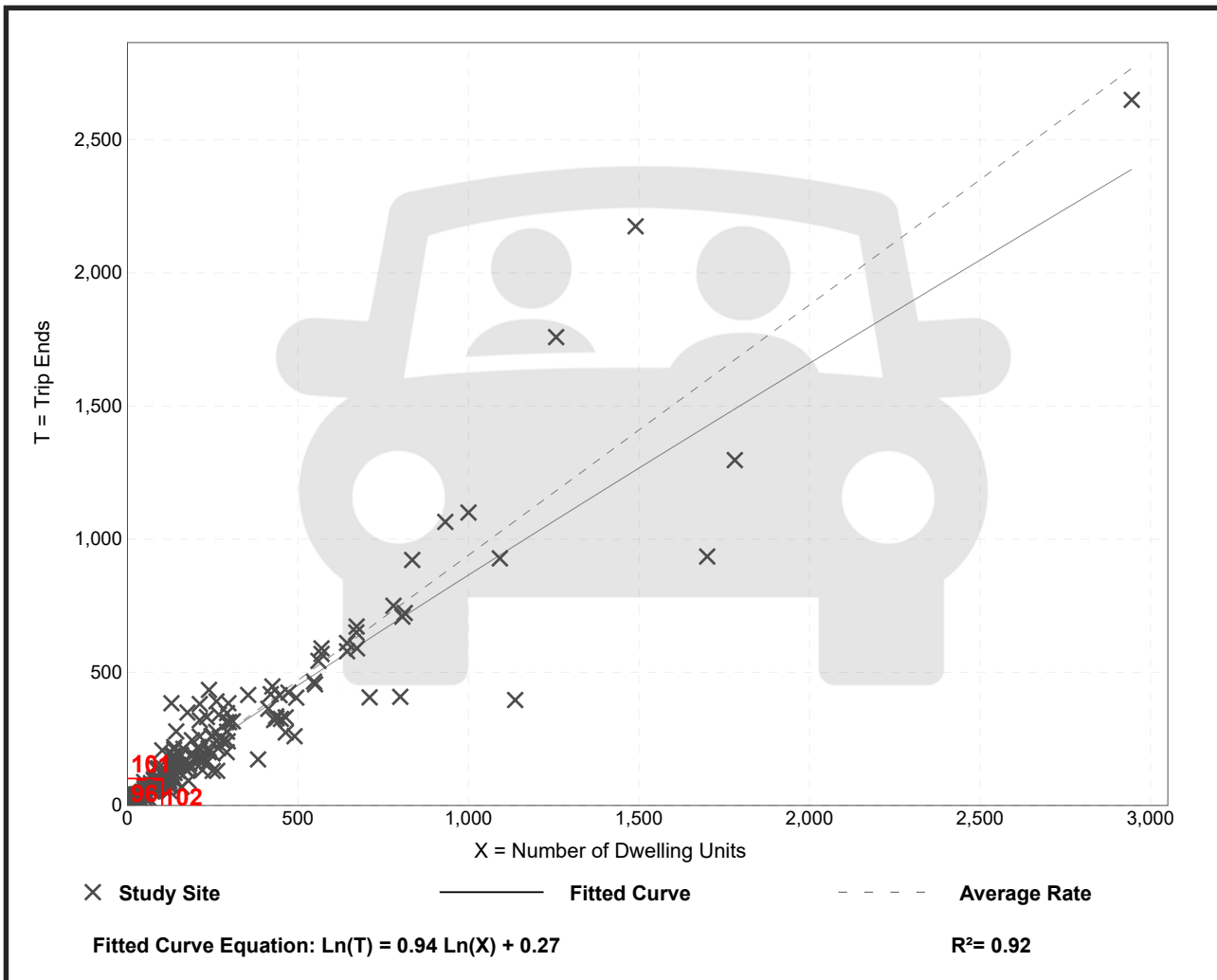
Avg. Num. of Dwelling Units: 248

Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.94	0.35 - 2.98	0.31

Data Plot and Equation



APPENDIX C – CAPACITY ANALYSES

CAPACITY AND LEVEL-OF-SERVICE CONCEPTS

In a general sense, a roadway is similar to a pipeline or other material carrying conduit in that it has a certain capacity for the amount of material (vehicles) that it can efficiently carry. As the number of vehicles in a given time period gradually increases, the quality of traffic flow gradually decreases. On roadway sections this results in increasing turbulence in the traffic stream, and at intersections it results in increasing stops and delay. As the volumes begin to approach the capacity of the facility, these problems rapidly magnify, with resulting serious levels of congestion, stops, delay, excess fuel consumption, pollutant emissions, etc.

The Transportation Research Board has published the Year 2010 Highway Capacity Manual (HCM2010), which establishes theoretical techniques to quantify the capacity conditions on all types of roadways, intersections, ramps, pedestrian facilities, etc. A basic concept that is applicable to most of these techniques is the idea of level of service (LOS). This concept establishes a rating system that quantifies the quality of traffic flow, as perceived by motorists and/or passengers. The general system is similar to a school grade scale, and is outlined as follows:

Level of Service (LOS)	General Quality of Traffic Flow	Description of Corresponding Conditions
A	Excellent	Roadways – Free flow, high maneuverability Intersections – Very few stops, very low delay
B	Very Good	Roadways – Free flow, slightly lower maneuverability Intersections – Minor stops, low delay
C	Good	Roadways – Stable flow, restricted maneuverability Intersections – Significant stops, significant delay
D	Fair	Roadways – Marginally stable flow, congestion seriously restricts maneuverability Intersections – High stops, long but tolerable delay
E	Poor	Roadways – Unstable flow*, lower operating speeds, congestion severely restricts maneuverability Intersections – All vehicles stop, very long queues and very long intolerable delay
F	Very Poor	Roadways – Forced flow, stoppages may be lengthy, congestion severely restricts maneuverability Intersections – All vehicles stop, extensive queues and extremely long intolerable delay

*Unstable flow is such that minor fluctuations or disruptions can result in rapid degradation to LOS F.

LOS CRITERIA: SIGNALIZED & UNSIGNALIZED INTERSECTIONS

LOS	CONTROL DELAY (S/VEH)		
	SIGNALIZED	UNSIGNALIZED	ROUNDBABOUT
A	≤10	≤10	≤10
B	>10-20	>10-15	>10-15
C	>20-35	>15-25	>15-25
D	>35-55	>25-35	>25-35
E	>55-80	>35-50	>35-50
F	>80	>50	>50

Another measure of intersection capacity that is often used in the evaluation of intersection operations is the volume to capacity (V/C) ratio. This ratio is defined as “the ratio of flow rate to capacity”, and is a good measure of how much of an intersection’s available capacity has been used up by the analysis volumes. Conversely, it also provides an indication of the reserve capacity available for future growth in traffic volumes.

The Intersection Capacity Utilization (ICU) is another measure that expresses a value similar to the V/C ratio. Specifically, the ICU method “sums the amount of the time required to serve all movements at saturation for a given cycle length and divides by that reference cycle length.” The ICU is considered a more accurate measure of volume to capacity conditions for a signalized intersection, primarily because it accounts for the effects of the signal timing on intersection capacity.

HCS7 Two-Way Stop-Control Report

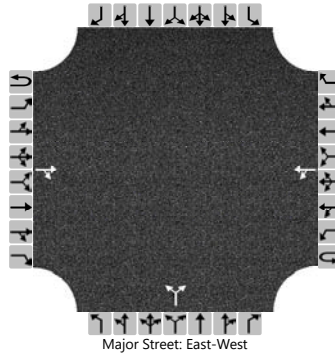
General Information

Analyst	Wesley Stokes
Agency/Co.	Cannon & Cannon, Inc.
Date Performed	5/26/2022
Analysis Year	2022
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	2025 Combined

Site Information

Intersection	Buttermilk at Site Access
Jurisdiction	Knox County
East/West Street	Buttermilk Road
North/South Street	Site Access
Peak Hour Factor	0.92
Analysis Time Period (hrs)	0.25

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	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	1	0		0	0	0
Configuration				TR		LT					LR					
Volume (veh/h)			69	12		8	37			34		22				
Percent Heavy Vehicles (%)						3				3		3				
Proportion Time Blocked																
Percent Grade (%)									0							
Right Turn Channelized																
Median Type Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)						4.1				7.1		6.2				
Critical Headway (sec)						4.13				6.43		6.23				
Base Follow-Up Headway (sec)						2.2				3.5		3.3				
Follow-Up Headway (sec)						2.23				3.53		3.33				

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)					9					61						
Capacity, c (veh/h)					1501					893						
v/c Ratio					0.01					0.07						
95% Queue Length, Q ₉₅ (veh)					0.0					0.2						
Control Delay (s/veh)					7.4					9.3						
Level of Service (LOS)					A					A						
Approach Delay (s/veh)					1.4				9.3							
Approach LOS									A							

HCS7 Two-Way Stop-Control Report

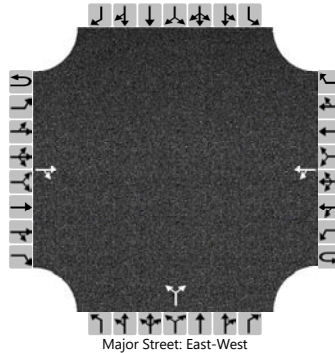
General Information

Analyst	Wesley Stokes
Agency/Co.	Cannon & Cannon, Inc.
Date Performed	5/26/2022
Analysis Year	2022
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	2025 Combined

Site Information

Intersection	Buttermilk at Site Access
Jurisdiction	Knox County
East/West Street	Buttermilk Road
North/South Street	Site Access
Peak Hour Factor	0.92
Analysis Time Period (hrs)	0.25

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	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	1	0		0	0	0
Configuration				TR		LT					LR					
Volume (veh/h)			90	38		26	86			22		15				
Percent Heavy Vehicles (%)						3				3		3				
Proportion Time Blocked																
Percent Grade (%)									0							
Right Turn Channelized																
Median Type Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)						4.1				7.1		6.2				
Critical Headway (sec)						4.13				6.43		6.23				
Base Follow-Up Headway (sec)						2.2				3.5		3.3				
Follow-Up Headway (sec)						2.23				3.53		3.33				

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						28					40					
Capacity, c (veh/h)						1438					781					
v/c Ratio						0.02					0.05					
95% Queue Length, Q ₉₅ (veh)						0.1					0.2					
Control Delay (s/veh)						7.6					9.9					
Level of Service (LOS)						A					A					
Approach Delay (s/veh)					1.9				9.9							
Approach LOS									A							

APPENDIX D – TURN LANE WARRANT SHEETS

TABLE 4A
KNOX COUNTY LEFT-TURN LANE VOLUME THRESHOLDS
FOR 2-LANE ROADWAYS WITH A PREVAILING SPEED OF 0 TO 35 MPH

Project No: 00630-0002
 Project Name: Buttermilk Rd Single Family
 Notes:

(If the left-turn volume exceeds the table value a left-turn lane is needed)

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	100 - 149	150 - 199	200 - 249	250 - 299	300 - 349	350 - 399
100 - 149	300	235	185	145	120	100
150 - 199	245	200	160	130	110	90
200 - 249	205	170	140	115	100	80
250 - 299	175	150	125	105	90	70
300 - 349	155	135	110	95	80	65
350 - 399	135	120	100	85	70	60
400 - 449	120	105	90	75	65	55
450 - 499	105	90	80	70	60	50
500 - 549	95	80	70	65	55	50
550 - 599	85	70	65	60	50	45
600 - 649	75	65	60	55	45	40
650 - 699	70	60	55	50	40	35
700 - 749	65	55	50	45	35	30
750 or More	60	50	45	40	35	30

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	= / > 600
100 - 149	100	80	70	60	55	50
150 - 199	90	75	65	55	50	45
200 - 249	80	72	60	55	50	45
250 - 299	70	65	55	50	45	40
300 - 349	65	60	50	50	45	40
350 - 399	60	55	50	45	40	40
400 - 449	55	50	45	45	40	35
450 - 499	50	45	45	40	35	35
500 - 549	50	45	40	40	35	35
550 - 599	45	40	40	35	35	35
600 - 649	40	35	35	35	35	30
650 - 699	35	35	35	30	30	30
700 - 749	30	30	30	30	30	30
750 or More	30	30	30	30	30	30

* Or through volume only if a right-turn lane exists

Intersection	Time Period	Opposing Volume	Through Volume	Left-Turn Volume	Warrant Threshold	Left-Turn Lane Warranted (Yes / No)
Site @ Buttermilk	AM Peak	81	37	8	N/A	NO
Site @ Buttermilk	PM Peak	128	86	26	300	NO

TABLE 4B
KNOX COUNTY RIGHT-TURN LANE VOLUME THRESHOLDS
FOR 2-LANE ROADWAYS WITH A PREVAILING SPEED OF 0 TO 35 MPH

Project No: 00630-0002
Project Name: Buttermilk Rd Single Family
Notes:

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	< 100	100 - 199	200 - 249	250 - 299	300 - 349	350 - 399
Fewer Than 25						
25 - 49						
50 - 99						
100 - 149						
150 - 199						
200 - 249						
250 - 299						Yes
300 - 349					Yes	Yes
350 - 399				Yes	Yes	Yes
400 - 449			Yes	Yes	Yes	Yes
450 - 499			Yes	Yes	Yes	Yes
500 - 549		Yes	Yes	Yes	Yes	Yes
550 - 599		Yes	Yes	Yes	Yes	Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	= / > 600
Fewer Than 25						
25 - 49						Yes
50 - 99					Yes	Yes
100 - 149				Yes	Yes	Yes
150 - 199			Yes	Yes	Yes	Yes
200 - 249		Yes	Yes	Yes	Yes	Yes
250 - 299	Yes	Yes	Yes	Yes	Yes	Yes
300 - 349	Yes	Yes	Yes	Yes	Yes	Yes
350 - 399	Yes	Yes	Yes	Yes	Yes	Yes
400 - 449	Yes	Yes	Yes	Yes	Yes	Yes
450 - 499	Yes	Yes	Yes	Yes	Yes	Yes
500 - 549	Yes	Yes	Yes	Yes	Yes	Yes
550 - 599	Yes	Yes	Yes	Yes	Yes	Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

* Or through volume only if a left-turn lane exists

Intersection	Time Period	Through Volume	Right-Turn Volume	Right-Turn Lane Warranted (Yes / No)
Site @ Buttermilk	AM Peak	69	12	NO
Site @ Buttermilk	PM Peak	90	38	NO

APPENDIX E – TIS COMMENT RESPONSE DOCUMENT

Date: July 6, 2022

Project Name: Buttermilk Road Residential Development

To: Knox County Engineering and Public Works (EPW) and Knoxville-Knox County Planning

Subject: TIS Comment Response Document for Buttermilk Road Residential Development

Dear Knox County EPW and Knoxville-Knox County Planning Staff,

The following comment response document is submitted to address comments dated June 9, 2022 that were sent to Cannon & Cannon, Inc. on July 5, 2022:

1. **Reviewer Comment:** Please review the AM peak period volume reported for the eastbound direction as it appears to be too low (we derived 59 vehicles instead of the 41 shown) based on the count data and revise all analyses as appropriate.

Response: Comment addressed and analysis throughout the Revised TIS has been updated.

2. **Reviewer Comment:** In the second column of Table 3 please move the 'NB' abbreviation to the Intersection column in order to avoid confusion.

Response: Comment addressed in Table 3 on page 15 of the Revised TIS.

3. **Reviewer Comment:** The sight distance assessment needs to cite the controlling standard for minimum sight distance requirements in Knox County which are documented in the Knoxville-Knox County Subdivision Regulations as being 10 times the posted speed limit.

Response: Comment addressed on page 15 in the "Sight Distance Assessment" section of the Revised TIS.

4. **Reviewer Comment:** Include additional detail regarding the sight distance standards and the need to provide clear sight triangles in both directions measured from 15' back from the edge of the traveled way. Due to the narrowness of the development's access right-of-way there will need to be coordination with the site engineer to ensure that sight triangles can be achieved within this development's property limits, public right-of-way or other easements as necessary that will need to be shown on the site plan.

Response: Comment addressed on page 16 in the "Sight Distance Assessment" section of the Revised TIS.

5. **Reviewer Comment:** Please include a header or some other method of identifying the difference between the count data shown on Pages A-2 and A-4 as it is not immediately clear whether it is

just a duplication. We understand that the second count includes the seasonal factor of 1.3 but this should be clearly noted and additionally a third count sheet could be provided showing the application of the 1.5 factor that was applied.

Response: Comment addressed in Appendix A of the Revised TIS.

Sincerely,



Wesley Stokes, P.E.