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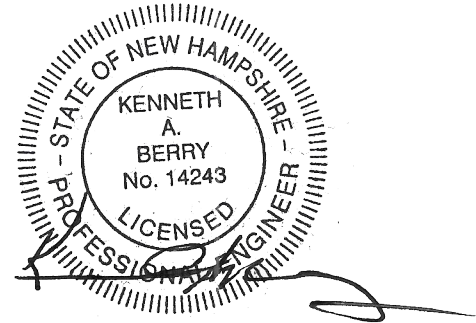
335 Second Crown Point Road
Barrington, NH 03825
Phone: (603) 332-2863
Fax: (603) 335-4623
www.BerrySurveying.Com

Town of Nottingham Planning Board
Attention: Chair Dirk Grotenhuis
139 Stage Road
P.O. Box 114
Nottingham, NH 03290

March 4th, 2019

RE: Traffic Impact Analysis & Distribution
Domus Developers Inc.
Old Turnpike Road / US Route 4
Nottingham, NH 03290

Mr. Grotenhuis,



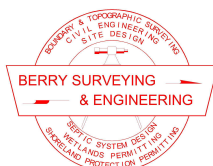
Pursuant to the Town of Nottingham Subdivision Regulations, Berry Surveying & Engineering (BS&E), on behalf of Domus Development, Inc., has prepared a Standard Traffic Impact Analysis for the development of twenty-two residential lots on Tax Map 6, Lot 22. The two points of analysis are the intersections of Sera Drive and US Route 4 and the intersection of Ada Drive and US Route 4.

The following conclusions were reached as a result Traffic Impact Analysis:

- A total of 7 vehicle trips (2 enter/5 exit) are predicted to occur at the AM peak hour and 9 vehicle trips (6 enter/3 exit) at the PM peak hour for Sera Drive.
- A total of 10 vehicle trips (3 enter/7 exit) are predicted to occur at the AM peak hour and 13 vehicle trips (8 enter/5 exit) at the PM peak hour for Ada Drive.
- The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a left-turn lane for Sera Drive.
- The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a right-turn lane for Sera Drive.
- The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a left -turn lane for Ada Drive.
- The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a right-turn lane for Ada Drive.
- It is recommended that the existing and surrounding infrastructure will be sufficient to handle the projected increase in vehicle trips and peak hour and all other hours.

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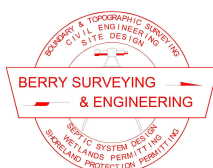


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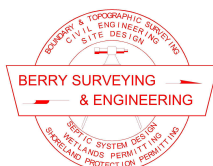


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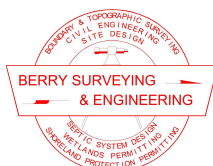
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Proposed Development & Introduction

The proposal is to develop Tax Map 6, Lot 22 to contain twenty-two total single-family detached housing lots with four non-building open space parcels. There are two proposed access roads, known as “Sera Drive” and “Ada Drive”. Sera Drive, located on the eastern portion of the parcel, provides access to nine lots and is approximately 1,060 linear feet in length. Ada Drive, located on the western portion of the parcel, provides access to thirteen lots and is approximately 1,285 linear feet in length. Both Sera and Ada Drive are proposed to have 24 foot pavement entrance radii for emergency vehicle turning, 10 foot paved travel lanes (20 foot total paved width), and 2 foot gravel shoulders on both sides of the roadway. Both Sera and Ada Drive utilize cul-de-sacs as a dead end treatment for vehicle turn around/circulation. Off-street parking will consist of individual driveways for each lot, no additional parking areas are proposed to be provided. The intersections of Sera Drive and Ada Drive with US Route 4 are located approximately 400 feet apart and are considered the points of analysis. The purpose of this analysis is to determine the maximum number of trips coming to and leaving Sera Drive and Ada Drive during certain peak periods of the day. This information is then used in determining the impact on safety as it relates to the existing roadway infrastructure. The following components of the analysis are typical for a project of this size pursuant to the Institute of Traffic Engineers (ITE) manual.

Existing Conditions

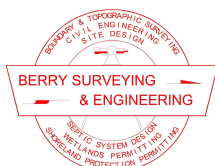
Existing Site Description

The existing site consists of Tax Map 6, Lot 22 containing 2,600,133 Sq. Ft. (59.69 Ac.) of land. Tax Map 6, Lot 22 is a vacant lot that is primarily wooded. The lot is proposed to be subdivided into twenty-two lots containing single-family detached homes and four non-building open space lots. Tax Map 6, Lot 22 is located in two zones, the Commercial/Industrial zone, which extends 1,000 feet from US Route 4, and the remainder of the lot is in the Residential/Agricultural zone. There is a residential driveway cut 275 feet to the west of the site in addition to five residential driveways across from the site and a vehicle pull off location towards the western side of the site.

Old Concord Turnpike / US Route 4 Description

US Route 4 is a two lane principal arterial road, according to the NHDOT MS2 Transportation Management System (NHDOT). This road provides access to NH Route 125/Lee to the east and NH Route 202/ Northwood to the west. It has an Average Annual Daily Traffic (AADT) of approximately 11,324 (2017) divided between east and west, also as shown by the NHDOT.

US Route 4 in the area of the project is composed of a forty two foot wide paved surface with twelve foot travel lanes and variable width gravel shoulders on the north and south side of the road. There is centerline delineation and fog / edge lines provided. The posted speed limit of the roadway is 50 miles per hour (MPH). The geometry of US Route 4 is relatively flat and straight



in the project location. There are no existing sidewalks, crosswalks, or other pedestrian amenities in the area of the project.

Approximately 0.5 miles to the east of the project site is the two-way stop controlled intersection of US Route 4 and Hall Road/Smoke Street. Hall Road and Smoke Street are local collector roads. Due to the minimal trip generation of the proposed site and the distance from the intersection, it is not likely that this intersection would be negatively affected by the proposed development.

Approximately 0.5 miles to the west of the project site is the two-way stop controlled intersection of US Route 4 and Sofia Way/Mendum's Landing Road. Sofia Way and Mendum's Landing Road are local collector roads. Due to the minimal trip generation of the proposed site and the distance from the intersection, it is also not likely that this intersection would be negatively affected by the proposed development.

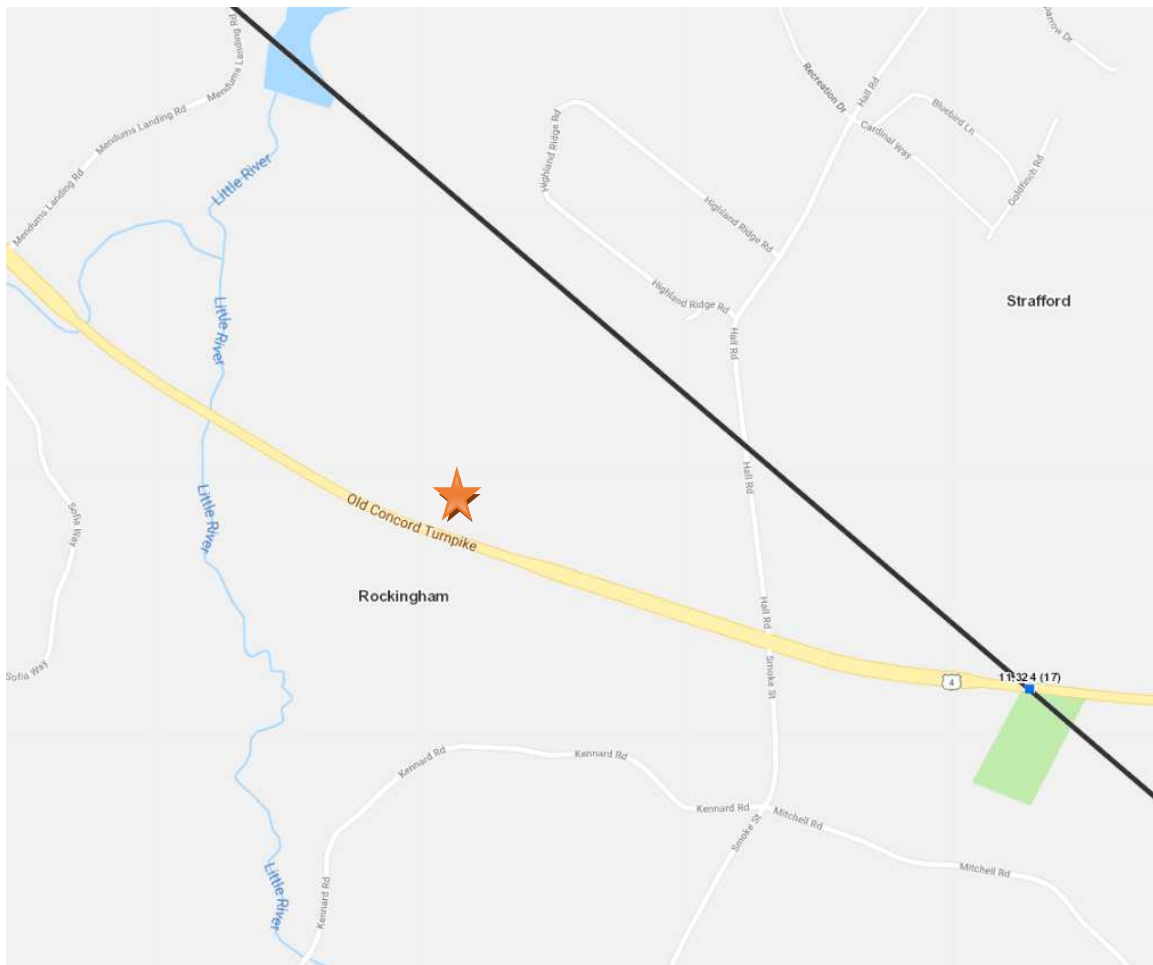
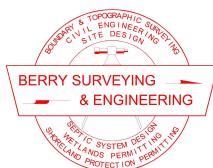


Figure 1: US Route 4 with surrounding roadways (NHDOT)



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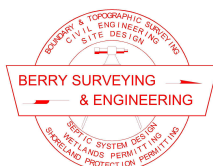
Existing Traffic Volumes

According to traffic counts recorded by the NHDOT for August 22nd - August 24th 2017, the US Route 4 AM and PM two-way peaks were 938 trips and 1,166 trips, respectively. It was found that US Route 4 has an AADT of 11,324 vehicles.

The highest peak hour traffic volume on this section of US Route 4 eastbound occurred from 7-8 AM with 640 vehicles and from 4-5 PM with 446 vehicles. Westbound highest peak hour traffic volume occurred from 7-8 AM with 305 vehicles and from 4-5 PM with 742 vehicles. Table #1 shows the traffic direction breakdown of US Route 4 and Figures #1-3 are graphical representations of the traffic variations occurring throughout the day. It can be seen from the directional percent distribution that the primary direction of travel during the AM peak hour is eastbound towards Lee and the Lee Traffic Circle. The primary direction of travel during the PM peak hour is westbound towards Northwood and NH Route 202. Traffic counts of US Route 4 are provided in Appendix A as Figures 7-16.

Traffic Distribution US Route 4						
Date		Eastbound		Westbound		Two-Way
8/22/2017	AM Peak	640	AM Peak	267	AM Peak	898
	PM Peak	446	PM Peak	705	PM Peak	1113
8/23/2017	AM Peak	633	AM Peak	305	AM Peak	938
	PM Peak	423	PM Peak	708	PM Peak	1120
8/24/2017	AM Peak	632	AM Peak	283	AM Peak	915
	PM Peak	424	PM Peak	742	PM Peak	1166
Average Peak Hour Traffic	AM Peak	635.0	AM Peak	285.0	AM Peak	917.0
	PM Peak	431.0	PM Peak	718.3	PM Peak	1133.0
% Distribution	AM Peak	69.0	AM Peak	31.0		
	PM Peak	37.5	PM Peak	62.5		

Table 1: Directional breakdown of trips occurring on US Route 4



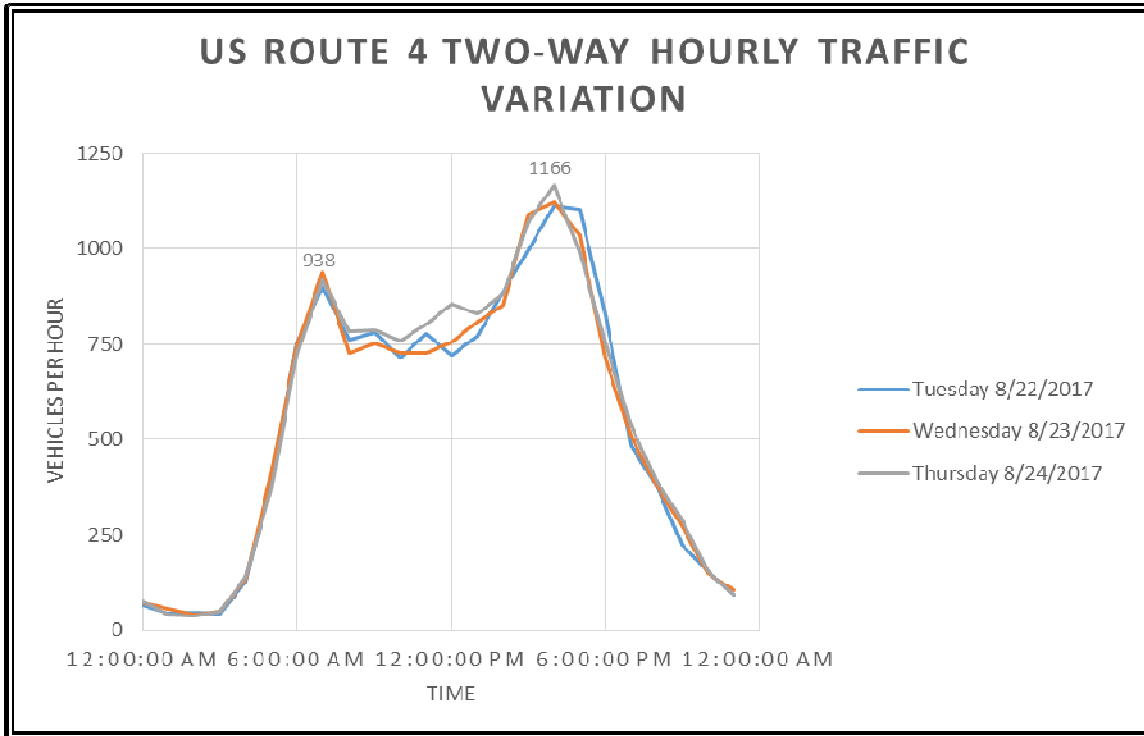


Figure 2: Graph of US Route 4 two-way hourly variation with peak values

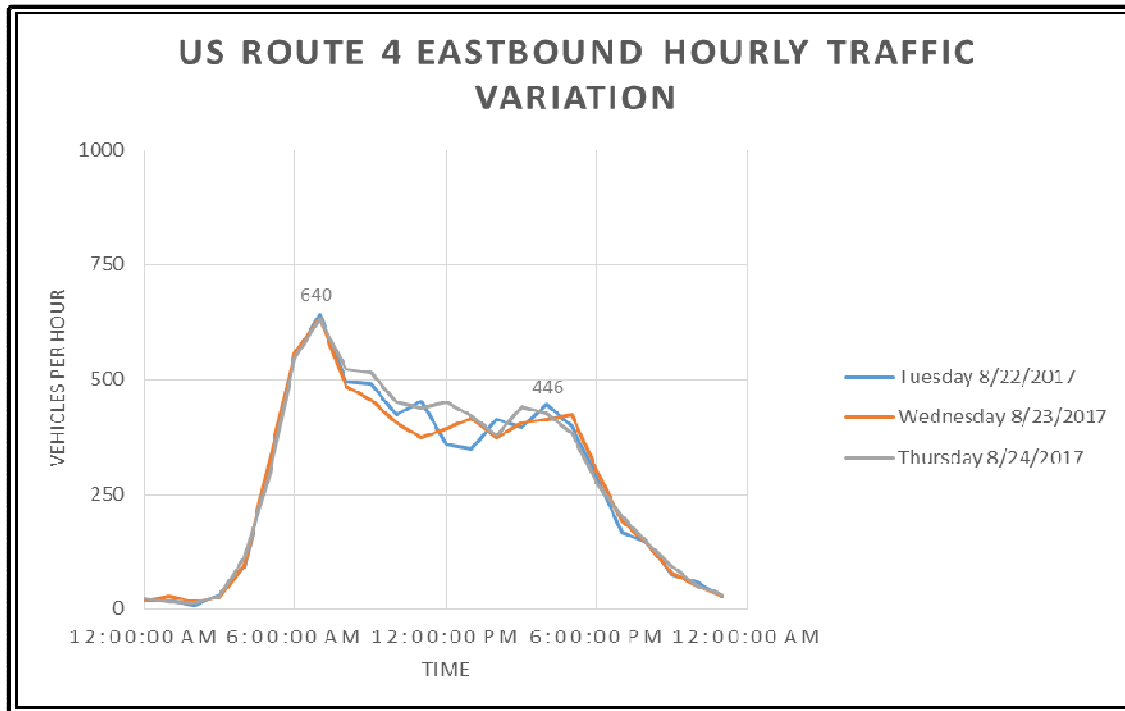


Figure 3: Graph of US Route 4 eastbound hourly variation with peak values



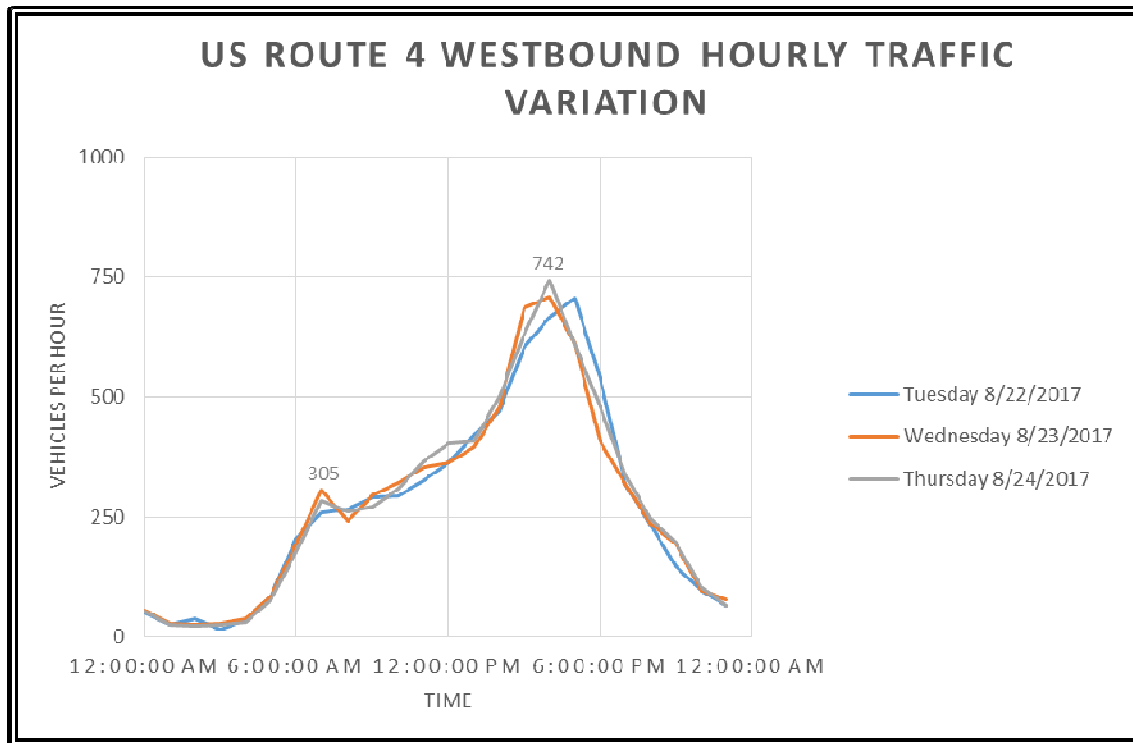


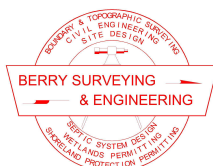
Figure 4: Graph of US Route 4 westbound hourly variation with peak values

Existing Vehicle Speeds

As previously mentioned, the posted speed limit of US Route 4 is 50 MPH. For the purposes of the safety analysis, the 85th percentile of speed is required. This particular section of US Route 4 was observed by Berry Surveying & Engineering to analyze the pass by traffic, reviewing speed. Excessive speeds were rare, and most operators obeyed the posted speed limits within a deviation of 5 MPH. This is consistent with speeds found on urban roads. The 85th percentile derived by observation and consistency with general practice is assumed to be 55 MPH. To be conservative, included for purposes of the turn-bay warrants analysis, 60 MPH is included in addition to 55 MPH. This is shown in Appendix E and does not change the results of the analyses.

Proposed Trip Generation

The 9th Edition ITE Trip Generation Manual was used to determine the proposed volume of trips, as well as the percentage of entrance-to-exit traffic experienced at the AM & PM peak hours between 7 and 9 AM and 4 and 6 PM, as well as the weekday total volume. Single-Family Detached Housing (210) was used in deriving the proposed trip generation for the Sera Drive and Ada Drive. Tables 2 and 3 provide average trip rate, total trips generated, enter to exit ratio, and the enter to exit distribution for Sera Drive and Ada Drive. Table 4 shows the combined



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proposed trip generation. As the use of the site will be single family residences, the primary vehicle trips generated will be two axel cars and trucks.

Single-Family Detached Housing Trip Generation Sera Drive:

Time Method	Weekday Total (Page 296) Dwelling Units			Time Method	AM Peak Adj. Street (Page 297) Dwelling Units			Time Method	PM Peak Adj. Street (Page 298) Dwelling Units		
# Units	9			# Units	9			# Units	9		
Avg. Rate	9.52			Avg. Rate	0.75			Avg. Rate	1.00		
Total Trips	85.7			Total Trips	6.8			Total Trips	9.0		
% Enter	50.0	Total Enter	42.8	% Enter	25.0	Total Enter	1.7	% Enter	63.0	Total Enter	5.7
% Exit	50.0	Total Exit	42.8	% Exit	75.0	Total Exit	5.1	% Exit	37.0	Total Exit	3.3

Table 2: (Single-Family Detached Housing) Peak hour of adjacent street traffic weekdays AM, PM, & weekday total for Sera Drive.

Single-Family Detached Housing Trip Generation Ada Drive:

Time Method	Weekday Total (Page 296) Dwelling Units			Time Method	AM Peak Adj. Street (Page 297) Dwelling Units			Time Method	PM Peak Adj. Street (Page 298) Dwelling Units		
# Units	13			# Units	13			# Units	13		
Avg. Rate	9.52			Avg. Rate	0.75			Avg. Rate	1.00		
Total Trips	123.8			Total Trips	9.8			Total Trips	13.0		
% Enter	50.0	Total Enter	61.9	% Enter	25.0	Total Enter	2.4	% Enter	63.0	Total Enter	8.2
% Exit	50.0	Total Exit	61.9	% Exit	75.0	Total Exit	7.3	% Exit	37.0	Total Exit	4.8

Table 3: (Single-Family Detached Housing) Peak hour of adjacent street traffic weekdays AM, PM, & weekday total for Ada Drive.

Total Proposed Trip Generation Sera Drive & Ada Drive

Time	Weekday Total Generation			Time	AM Peak Hour Total Generation			Time	PM Peak Hour Total Generation		
Total Trips	209.4			Total Trips	16.5			Total Trips	22.0		
% Enter	50	Total Enter	104.7	% Enter	25.0	Total Enter	4.1	% Enter	63.0	Total Enter	13.9
% Exit	50	Total Exit	104.7	% Exit	75.0	Total Exit	12.4	% Exit	37.0	Total Exit	8.1

Table 4: Total combined trip generation Sera Drive & Ada Drive

Build Traffic Projections and Turning Analysis

Traffic data obtained from the NHDOT’s Transportation Data Management System from 2017 has been projected to 2019 and ten years further to 2029. This has been done using an August peak seasonal adjustment factor of 1.03 (AM & PM) and using an annual growth rate of 1%, compounded annually. The derivation of the peak seasonal adjustment factor comes from an average series of values from other urban highways from across New Hampshire, which can be found as Table 17 in Appendix D. Figures 5 and 6 show the build turning movements to and from Sera Drive and Ada Drive during AM and PM peak hours. These figures also show the projected volume of traffic eastbound and westbound on US Route 4 in 2019 and the projected 2029 volumes. This data is then used to preform NCHRP 457 right-turn and left-turn bay warrant



analyses. It is important to note that there are enter and exit trips for Sera and Ada Drive that influence the pass-by traffic of each roadway. Appendix B shows the data that was used to conduct the analyses. In this data, the pass-by trips that influence the advancing and opposing volumes are accounted for in the total advancing volumes and total opposing volumes. These are denoted as Sera Drive Pass-by Generation (SBP) and Ada Drive Pass-by Generation (ABP).

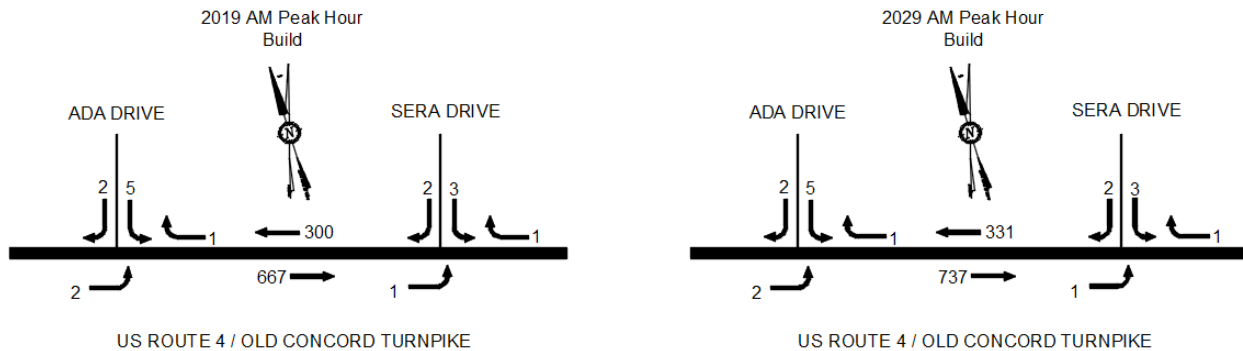


Figure 5: 2019 build projected traffic volumes and turning movements Ada Drive & Sera Drive

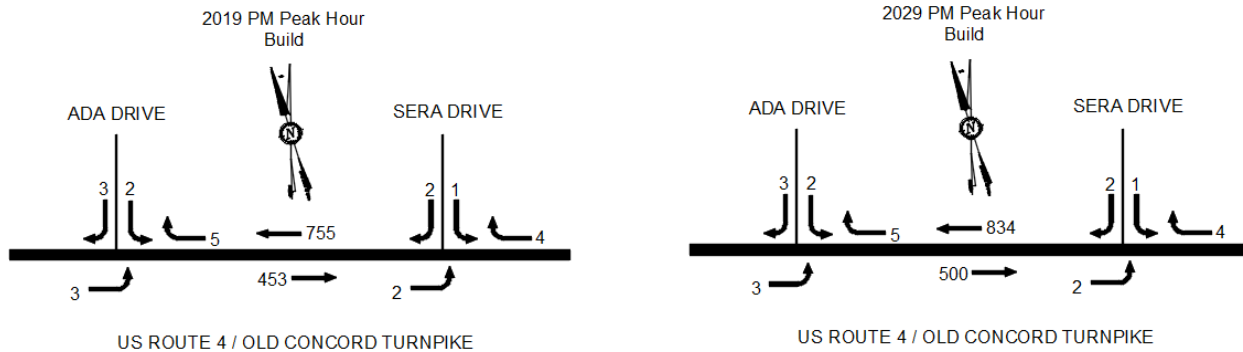


Figure 6: 2029 build projected traffic volumes and turning movements Ada Drive & Sera Drive

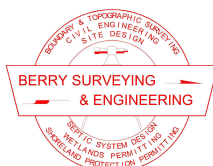
Tables 5-8 show in a tabular format the total trips that are calculated to occur to and from Sera Drive and Ada Drive are shown at AM and PM weekday peak hours in a build situation. These trips are further broken down into enter and exit to and from the site as well as percentage of left and right turns.

Time	AM Peak Hour Sera Drive	# Trips	Turn Type	% Distribution
Total Trips	6.8			
Trips Enter from US Route 4 Eastbound		1.2	Left	17.3
Trips Enter from US Route 4 Westbound		0.5	Right	7.7
Trips Exit to US Route 4 Eastbound		3.5	Left	51.8
Trips Exit to US Route 4 Westbound		1.6	Right	23.2

Table 5: Summary of AM build turning movements to and from Sera Drive

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Time	PM Peak Hour Sera Drive	# Trips	Turn Type	% Distribution
Total Trips	9.0			
	Trips Enter from US Route 4 Eastbound	2.1	Left	23.6
	Trips Enter from US Route 4 Westbound	3.5	Right	39.4
	Trips Exit to US Route 4 Eastbound	1.2	Left	13.9
	Trips Exit to US Route 4 Westbound	2.1	Right	23.1

Table 6: Summary of PM build turning movements to and from Sera Drive

Time	AM Peak Hour Ada Drive	# Trips	Turn Type	% Distribution
Total Trips	9.8			
	Trips Enter from US Route 4 Eastbound	1.7	Left	17.3
	Trips Enter from US Route 4 Westbound	0.8	Right	7.7
	Trips Exit to US Route 4 Eastbound	5.0	Left	51.8
	Trips Exit to US Route 4 Westbound	2.3	Right	23.2

Table 7: Summary of AM build turning movements to and from Ada Drive

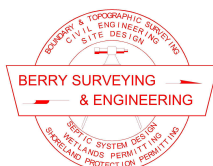
Time	PM Peak Hour Ada Drive	# Trips	Turn Type	% Distribution
Total Trips	13.0			
	Trips Enter from US Route 4 Eastbound	3.1	Left	23.6
	Trips Enter from US Route 4 Westbound	5.1	Right	39.4
	Trips Exit to US Route 4 Eastbound	1.8	Left	13.9
	Trips Exit to US Route 4 Westbound	3.0	Right	23.1

Table 8: Summary of AM build turning movements to and from Ada Drive

Left-Turn Warrants Analysis

Depending on vehicle speed, advancing vehicular volumes, opposing vehicular volumes, and the percent of left turns that vehicles are predicted to make, certain roadways may require special treatment for vehicles making left turning maneuvers. The determination of this special treatment is determined by the NCHRP 457 left-turn bay guidelines. Calibration constants of 3.0 seconds are used for average left turn time, 5.0 seconds for critical headway, and 1.9 seconds for vehicles to clear the advancing lane. If warranted, the left turn bay would allow for deceleration of vehicles and storage in the queue to wait safely for advancing traffic to pass.

The AM and PM peak traffic volumes from 2017 projected to 2019 and 2029 were used to determine if a left-turn bay is warranted to safely enter the site. For Sera Drive, it has been



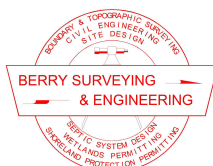
calculated that approximately 1 trip is to occur turning left into the site during the AM peak hour and 2 trips during the PM peak hour. For Ada Drive, it has been calculated that approximately 2 trips are to occur turning left into the site during the AM peak hour and 3 trips during the PM peak hour. The projection of the traffic volumes for AM and PM peak hours and data used to conduct the left-turn bay warrant analyses are included in Appendix B as Figures 18-21. The full warrant analyses can be found in Appendix B as Figures 22-29. Tables 9-12 are summaries of the left-turn bay warrant analyses for Sera Drive and Ada Drive. Using the 85th percentile speed of 55 MPH, it was determined that a left-turn bay is not warranted to safely enter Sera Drive or Ada Drive. It is important to note that the pass-by traffic generated by Sera Drive and Ada Drive influence the advancing and opposing volumes used in the analysis. These values are included in the advancing and opposing volumes shown in Tables 9-12. The results of the 60 MPH left-turn bay warrants analyses for Ada Drive and Sera Drive can be found in Appendix E as Figures 45-52.

Left-Turn Lane Warrants Analysis US Route 4 (Sera Drive)		
Factors	2019 AM Build Volume	2029 AM Build Volume
Left-Turn Volume (EB)	1	1
Advancing Volume (EB) (L+TR)	673	743
Opposing Volume (WB) (TR+R)	301	332
Percent Lefts	0%	0%
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	2,336	2,372
Left Turn Bay Warranted	NO	NO

Table 9: Summary of AM NCHRP 457 left-turn bay analysis Sera Drive

Left-Turn Lane Warrants Analysis US Route 4 (Sera Drive)		
Factors	2019 PM Build Volume	2029 PM Build Volume
Left-Turn Volume (EB)	2	2
Advancing Volume (EB) (L+TR)	457	504
Opposing Volume (WB) (TR+R)	763	842
Percent Lefts	0%	0%
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	885	860
Left Turn Bay Warranted	NO	NO

Table 10: Summary of PM NCHRP 457 left-turn bay analysis Sera Drive



Left-Turn Lane Warrants Analysis US Route 4 (Ada Drive)		
Factors	2019 AM Build Volume	2029 AM Build Volume
Left-Turn Volume (EB)	2	2
Advancing Volume (EB) (L+TR)	670	740
Opposing Volume (WB) (TR+R)	302	333
Percent Lefts	0%	0%
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	1,937	1,967
Left Turn Bay Warranted	NO	NO

Table 11: Summary of AM NCHRP 457 left-turn bay analysis Ada Drive

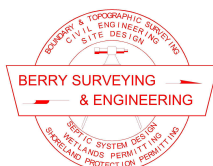
Left-Turn Lane Warrants Analysis US Route 4 (Ada Drive)		
Factors	2019 PM Build Volume	2029 PM Build Volume
Left-Turn Volume (EB)	3	3
Advancing Volume (EB) (L+TR)	458	505
Opposing Volume (WB) (TR+R)	762	841
Percent Lefts	1%	1%
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	739	684
Left Turn Bay Warranted	NO	NO

Table 12: Summary of PM NCHRP 457 left-turn bay analysis Ada Drive

Right-Turn Warrants Analysis

Depending on vehicle speed, advancing vehicular volumes, and the percent of right turns that vehicles are predicted to make, certain roadways may require special treatment for vehicles making right turning maneuvers. The determination of this special treatment is determined by the NCHRP 457 right turn bay guidelines. If warranted, the right-turn bay would allow for deceleration of vehicles and storage in the queue to wait safely for right turning traffic to clear.

The AM and PM peak traffic volumes from 2017 projected to 2019 and 2029 were used to determine if a right-turn bay is warranted to safely enter the site. For Sera Drive, it has been calculated that approximately 1 trip is to occur turning right into the site during the AM peak hour and 4 trips during the PM peak hour. For Ada Drive, it has been calculated that approximately 1 trip is to occur turning right into the site during the AM peak hour and 5 trips during the PM peak hour. The projection of the traffic volumes for AM and PM peak hours and data used to conduct the right-turn bay warrant analyses are included in Appendix B as Figures 30-33. The full warrant analyses can be found in Appendix B as Figures 34-41. Tables 13-16 are summaries of the right-turn bay warrant analyses for Sera Drive and Ada Drive. Using the 85th percentile speed of 55 MPH, it was determined that a right-turn bay is not warranted to safely



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enter Sera Drive or Ada Drive. It is important to note that the pass-by traffic generated by Sera Drive and Ada Drive influence the advancing volumes used in the analysis. These values are included in the advancing and opposing volumes shown in Tables 13-16. The results of the 60 MPH right-turn bay warrants analyses for Ada Drive and Sera Drive can be found in Appendix E as Figures 53-60.

Right-Turn Lane Warrants Analysis US Route 4 (Sera Drive)		
Factors	2019 AM Build Volume	2029 AM Build Volume
Right-Turn Volume (WB)	1	1
Advancing Volume (WB) (TR+R)	301	332
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	23	22
Right-Turn Bay Warranted	NO	NO

Table 13: Summary of AM NCHRP 457 right-turn bay analysis Sera Drive

Right-Turn Lane Warrants Analysis US Route 4 (Sera Drive)		
Factors	2019 PM Build Volume	2029 PM Build Volume
Right-Turn Volume (WB)	4	4
Advancing Volume (WB) (TR+R)	308	339
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	23	21
Right-Turn Bay Warranted	NO	NO

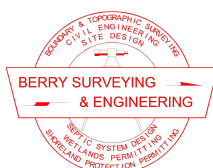
Table 14: Summary of PM NCHRP 457 right-turn bay analysis Sera Drive

Right-Turn Lane Warrants Analysis US Route 4 (Ada Drive)		
Factors	2019 AM Build Volume	2029 AM Build Volume
Right-Turn Volume (WB)	1	1
Advancing Volume (WB) (TR+R)	302	333
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	23	22
Right-Turn Bay Warranted	NO	NO

Table 15: Summary of AM NCHRP 457 right-turn bay analysis Ada Drive

Right-Turn Lane Warrants Analysis US Route 4 (Ada Drive)		
Factors	2019 PM Build Volume	2029 PM Build Volume
Right-Turn Volume (WB)	5	5
Advancing Volume (WB) (TR+R)	762	841
85th Percentile Speed (MPH)	55	55
Limiting Adv. Volume (veh/hr)	11	11
Right-Turn Bay Warranted	NO	NO

Table 16: Summary of PM NCHRP 457 right-turn bay analysis Ada Drive

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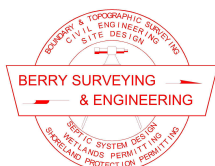
Sight Distance and Safety Analysis

Sight distance on US Route 4 to the east and west, as well as roadway alignment are the two determining factors of safety. For Sera Drive, sight distance to the east un-obstructed for well over 550 feet (measured), while sight distance to the west is un-obstructed for well over 500 feet (measured). Using Exhibit 3-1 (Stopping Sight Distance) (Figure 44) and Exhibit 3-2 (Stopping Sight Distance on Grades) (Figure 45) in the Geometric Design Manual, and a 55 mph 85th percentile speed, requires a stopping sight distance of 495 feet for eastbound traffic (0-3% upgrade) and 542 feet for westbound (5% downgrade (interpolation)). The standard sight distance required by NHDOT is 400 feet. In this instance both the easterly and westerly sight distances meet the design required warrant as well as the standard practice of NHDOT of 400 feet. There are no improvements required to obtain this sight distance.

For Ada Drive, sight distance to the east un-obstructed for well over 500 feet (measured), while sight distance to the west is un-obstructed for well over 500 feet (measured). Using Exhibit 3-1 (Stopping Sight Distance) (Figure 44) and Exhibit 3-2 (Stopping Sight Distance on Grades) (Figure 45) in the Geometric Design Manual, and a 55 mph 85th percentile speed, requires a stopping sight distance of 495 feet for eastbound traffic (0-3% upgrade) and 495 feet for westbound traffic ((0-3% downgrade)). The standard sight distance required by NHDOT is 400 feet. In this instance both the easterly and westerly sight distances meet the design required warrant as well as the standard practice of NHDOT of 400 feet. There are no improvements required to obtain this sight distance.

With respect to general safety of US Route 4 in relation to the peak hour trip generation and AADT, it is our assessment that the cross section of pavement and shoulder widths are appropriate.

*AASHTO Geometric Design of Highways and Streets (2011)



Conclusions and Recommendations

- 1.) A total of 7 vehicle trips (2 enter/5 exit) are predicted to occur at the AM peak hour and 9 vehicle trips (6 enter/3 exit) at the PM peak hour for Sera Drive.
- 2.) A total of 10 vehicle trips (3 enter/7 exit) are predicted to occur at the AM peak hour and 13 vehicle trips (8 enter/5 exit) at the PM peak hour for Ada Drive.
- 3.) The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a left-turn lane for Sera Drive.
- 4.) The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a right-turn lane for Sera Drive.
- 5.) The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a left-turn lane for Ada Drive.
- 6.) The 2019 and 2029 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a right-turn lane for Ada Drive.
- 7.) It is recommended that the existing and surrounding infrastructure will be sufficient to handle the projected increase in vehicle trips and peak hour and all other hours.

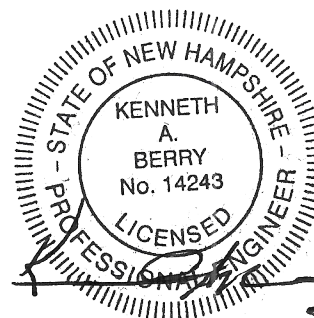
Respectfully Submitted,

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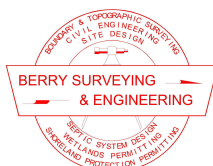


Christopher R. Berry, SIT
Principal, President

KRP/krp



Kenneth A. Berry, PE, LLS,
CPSWQ, CPESC, CESSWI
Principal, VP-Technical Operations



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Appendix A

US Route 4 Traffic Counts

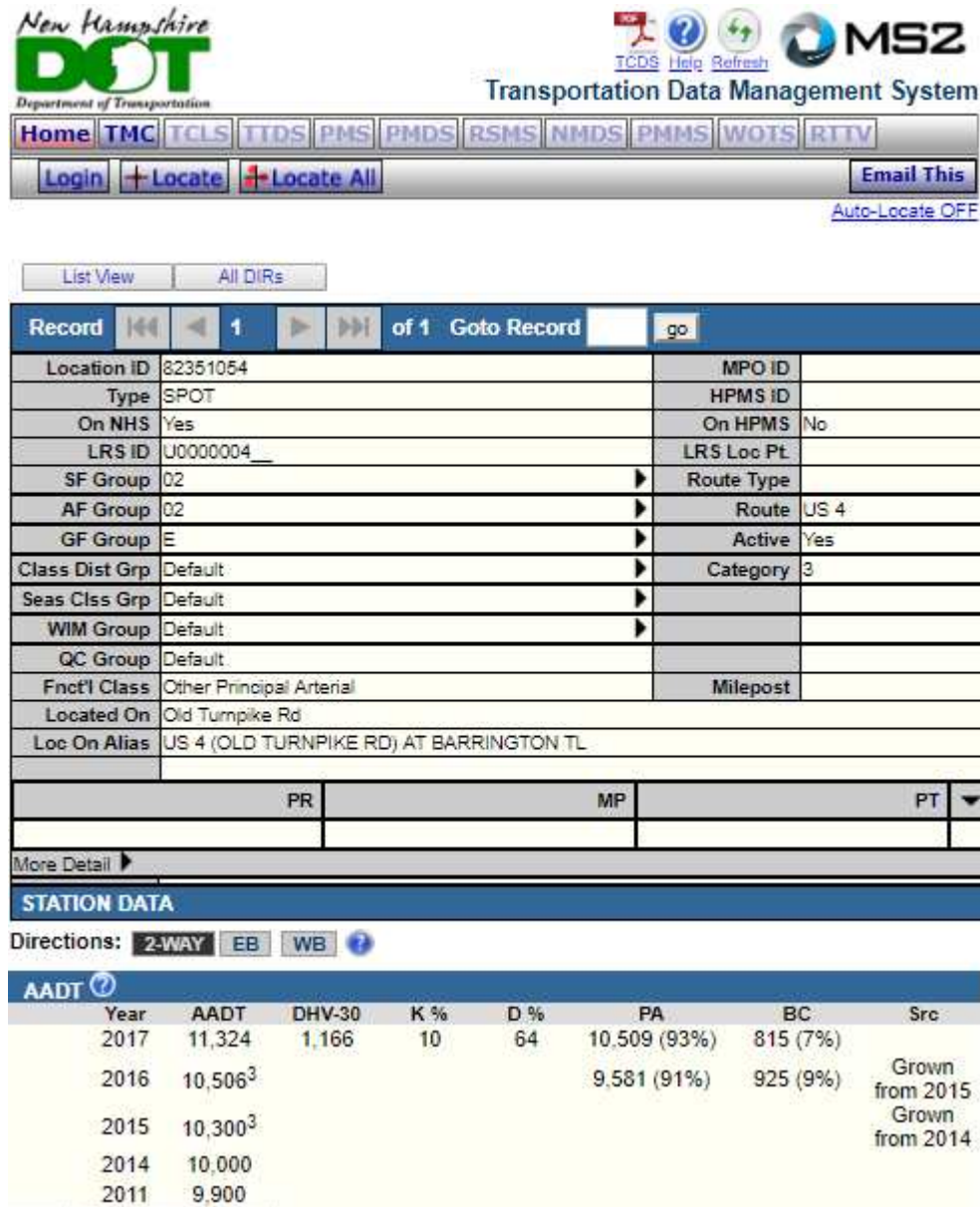
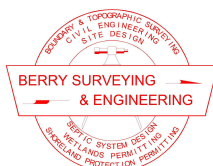


Figure 7: History of AADT values and classification for US Route 4



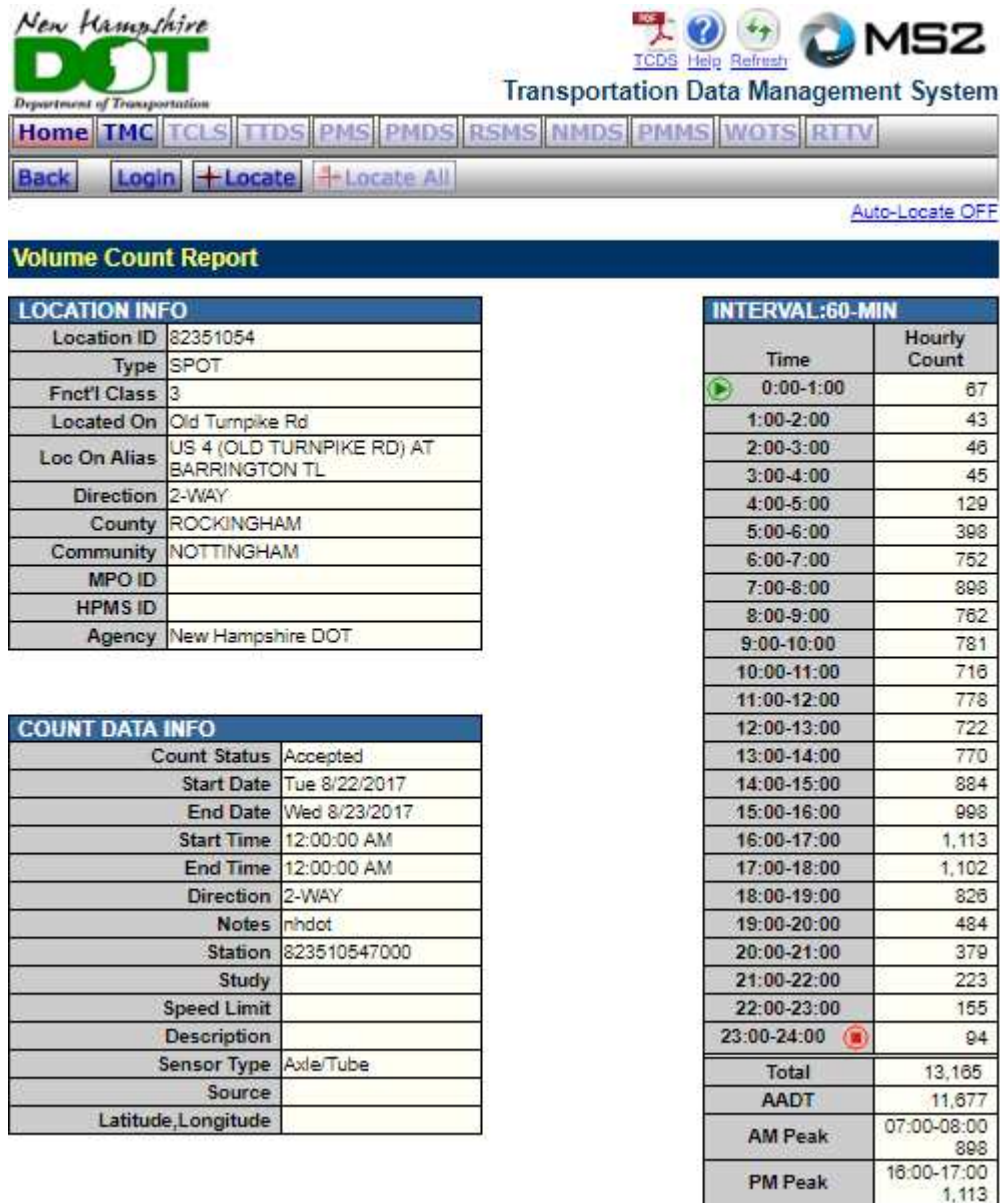
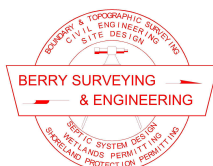


Figure 8: Tuesday August 22nd, 2017 US Route 4 two-way hourly traffic count



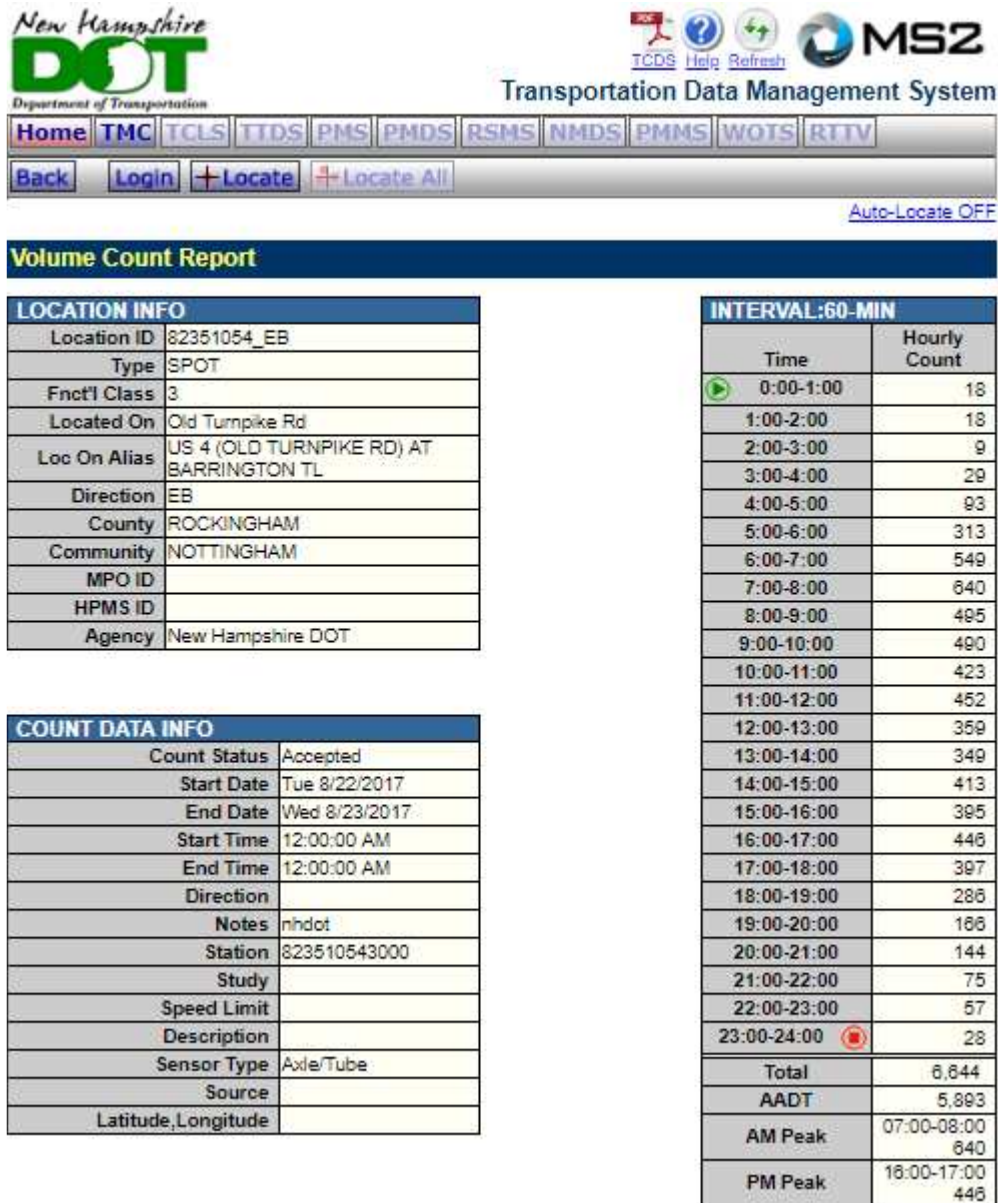
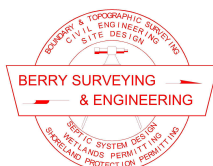


Figure 9: Tuesday August 22nd, 2017 US Route 4 eastbound hourly traffic count



Volume Count Report

LOCATION INFO	
Location ID	82351054_WB
Type	SPOT
Funct'l Class	3
Located On	Old Turnpike Rd
Loc On Alias	US 4 (OLD TURNPIKE RD) AT BARRINGTON TL
Direction	WB
County	ROCKINGHAM
Community	NOTTINGHAM
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 8/22/2017
End Date	Wed 8/23/2017
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	823510547000
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	49
1:00-2:00	25
2:00-3:00	37
3:00-4:00	16
4:00-5:00	36
5:00-6:00	85
6:00-7:00	203
7:00-8:00	258
8:00-9:00	267
9:00-10:00	291
10:00-11:00	293
11:00-12:00	326
12:00-13:00	363
13:00-14:00	421
14:00-15:00	471
15:00-16:00	603
16:00-17:00	667
17:00-18:00	705
18:00-19:00	540
19:00-20:00	318
20:00-21:00	235
21:00-22:00	148
22:00-23:00	98
23:00-24:00	88
Total	6,521
AADT	5,784
AM Peak	11:00-12:00 326
PM Peak	17:00-18:00 705

Figure 10: Tuesday August 22nd, 2017 US Route 4 westbound hourly traffic count



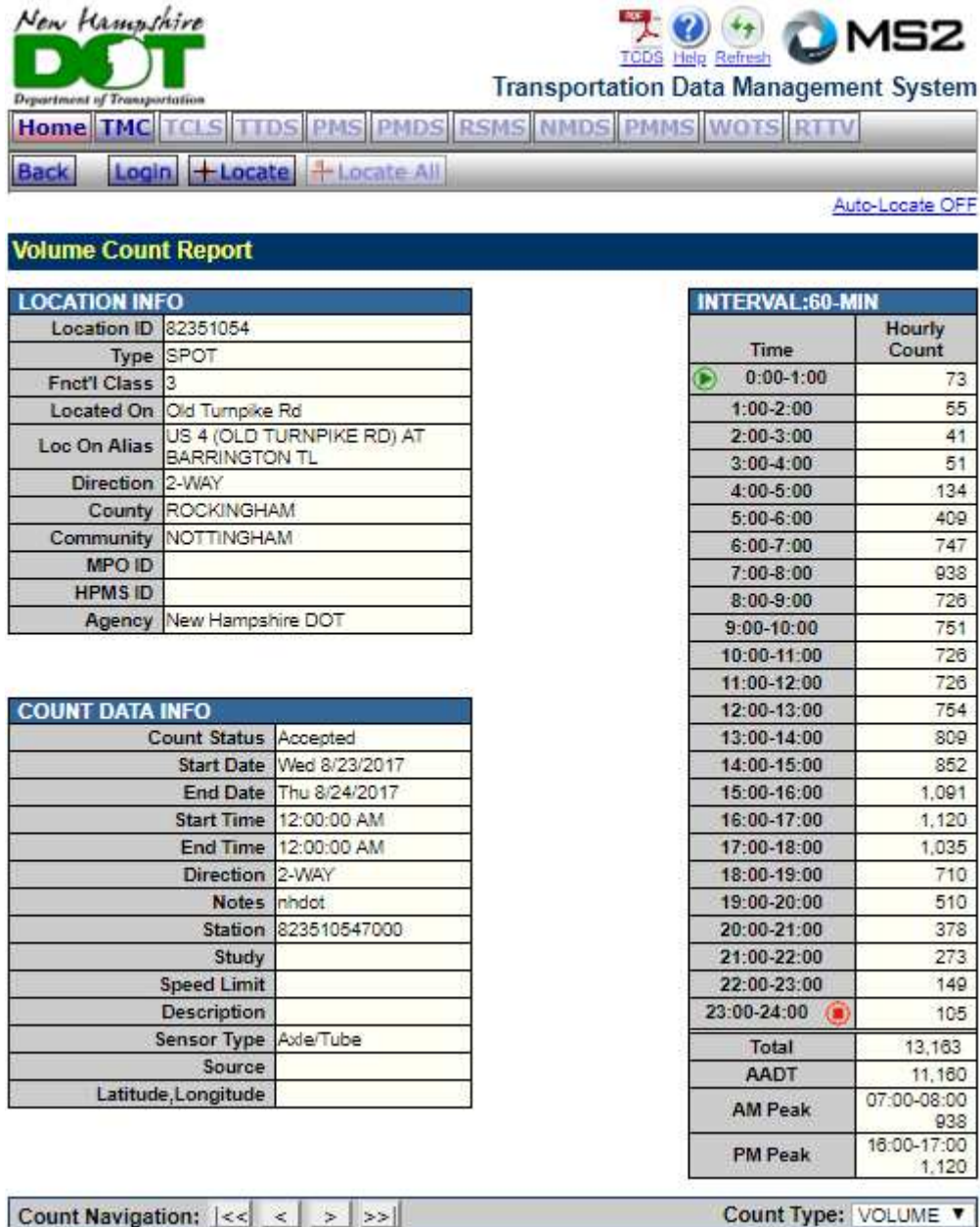
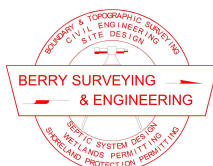


Figure 11: Wednesday August 23rd, 2017 US Route 4 two-way hourly traffic count



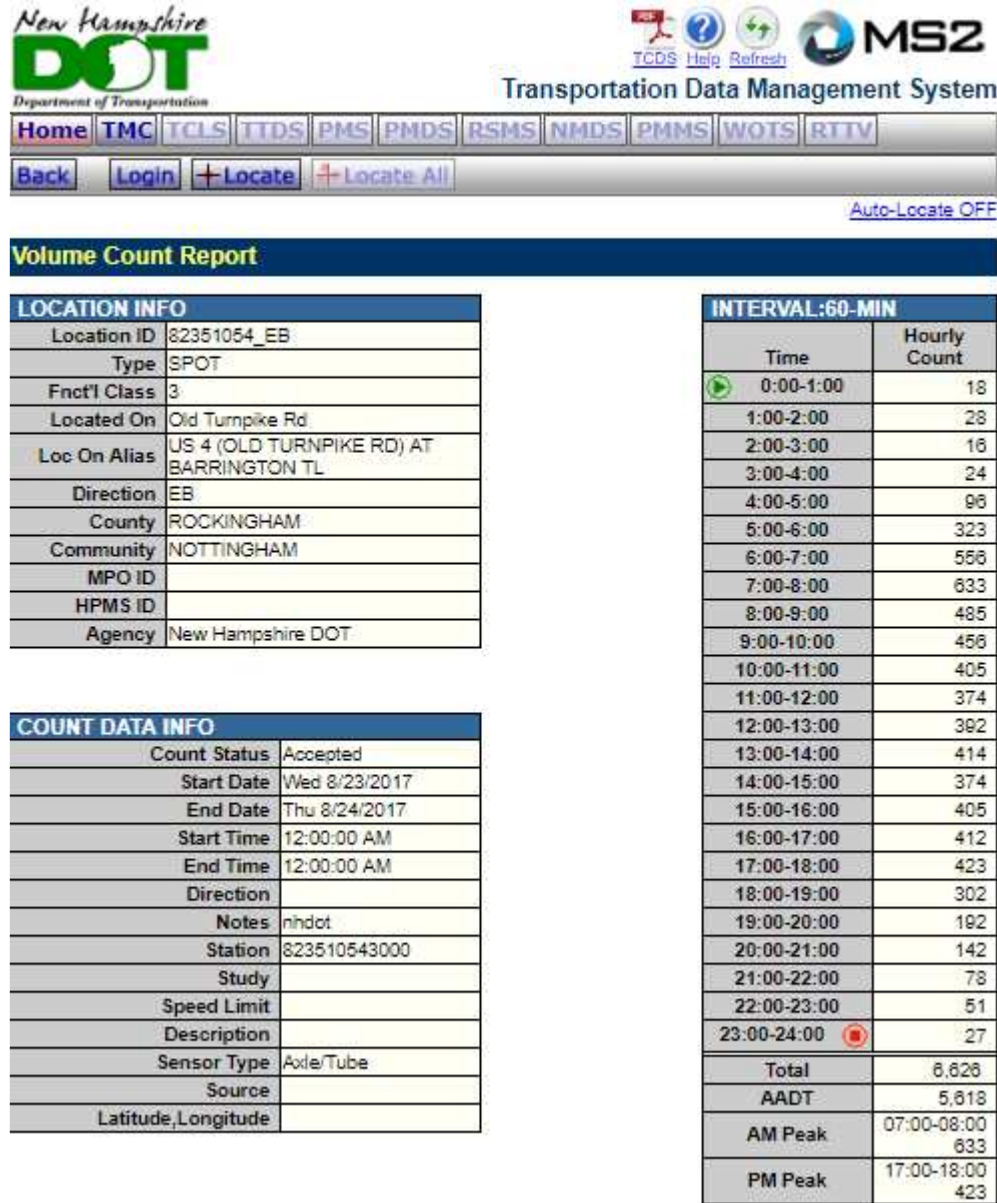
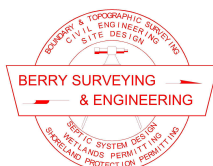


Figure 12: Wednesday August 23rd, 2017 US Route 4 eastbound hourly traffic count



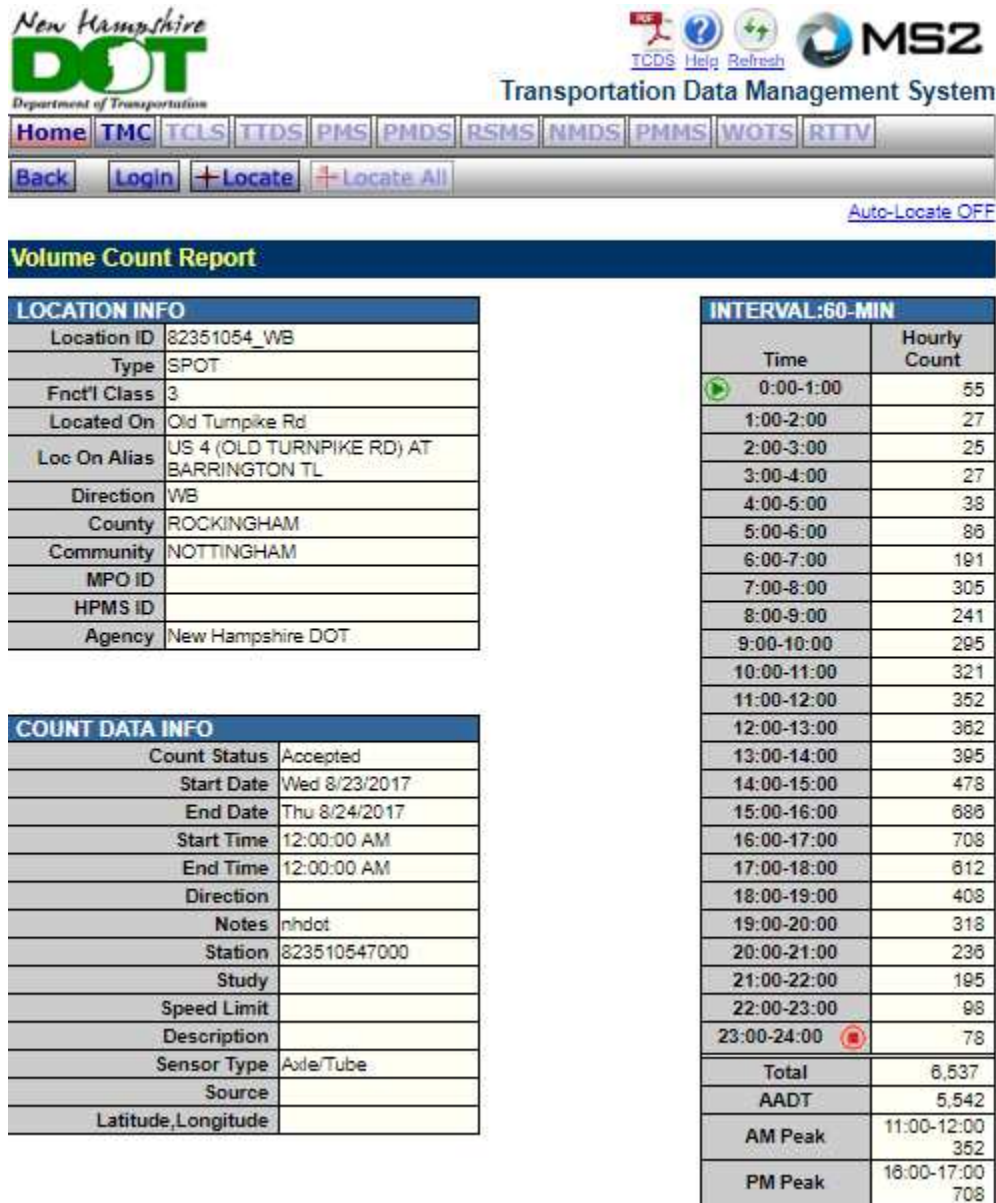
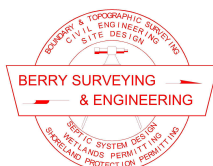


Figure 13: Wednesday August 23rd, 2017 US Route 4 westbound hourly traffic count



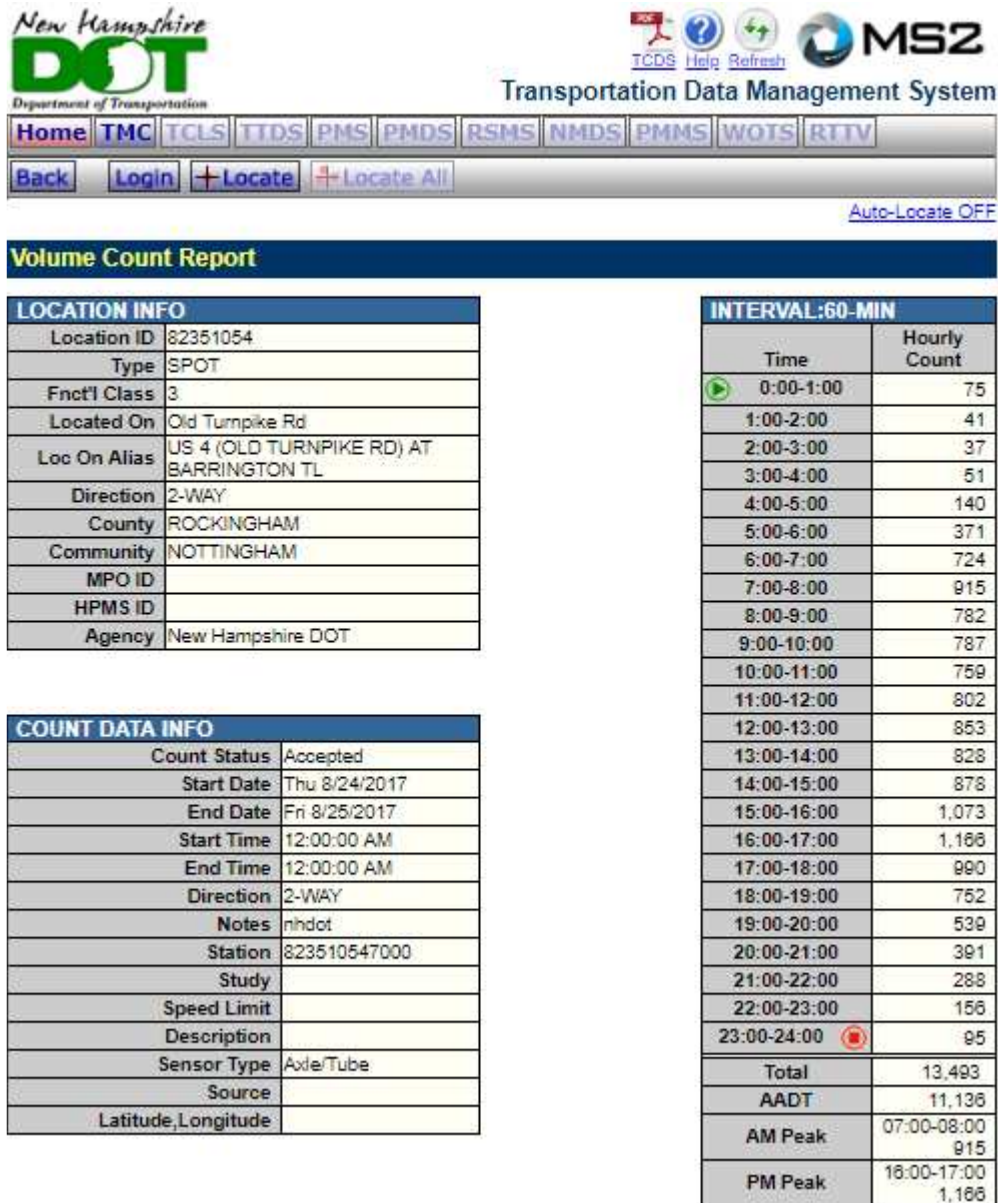
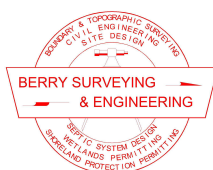


Figure 14: Thursday August 24th, 2017 US Route 4 two-way hourly traffic count



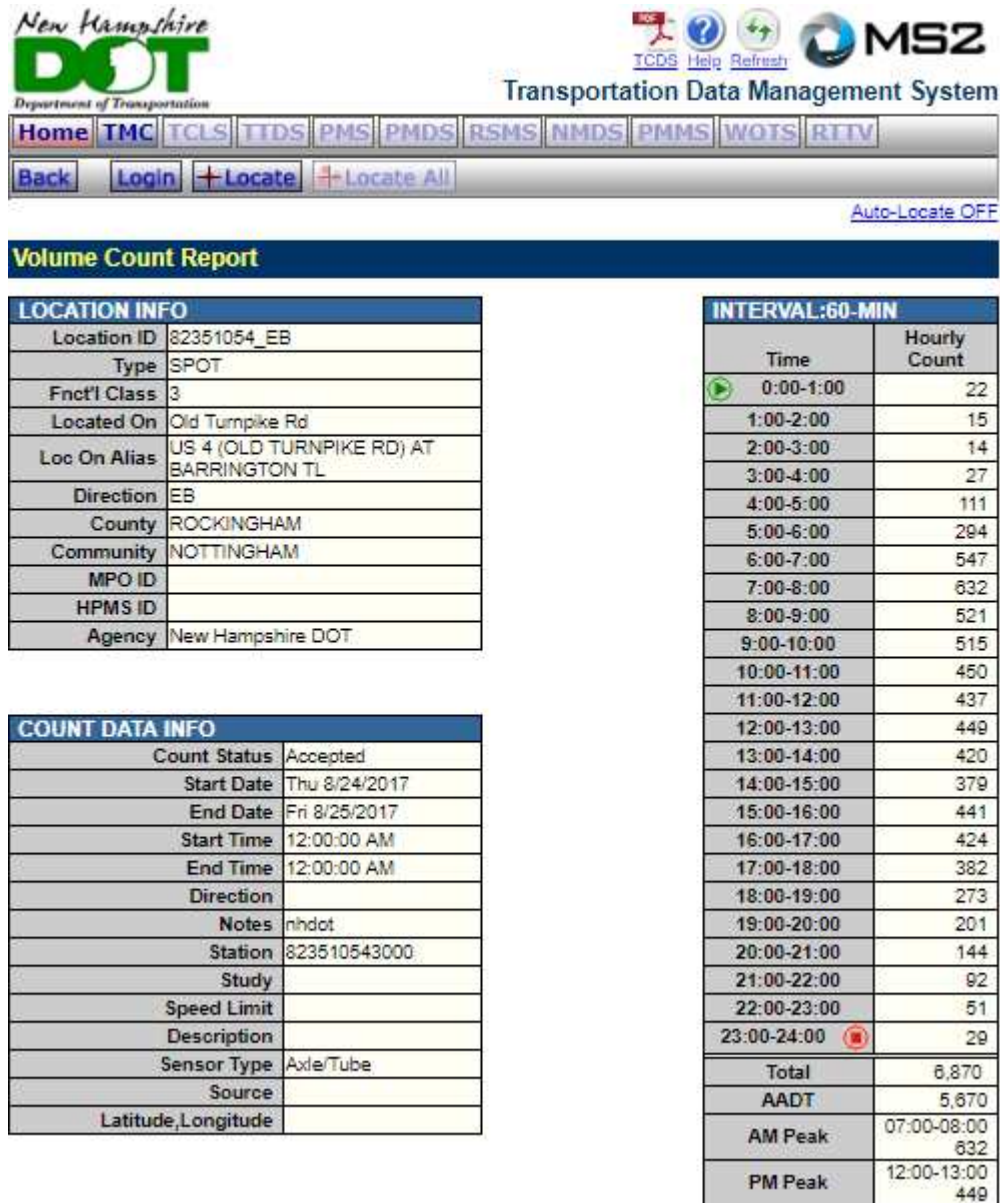
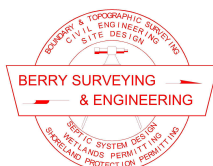


Figure 15: Thursday August 24th, 2017 US Route 4 eastbound hourly traffic count



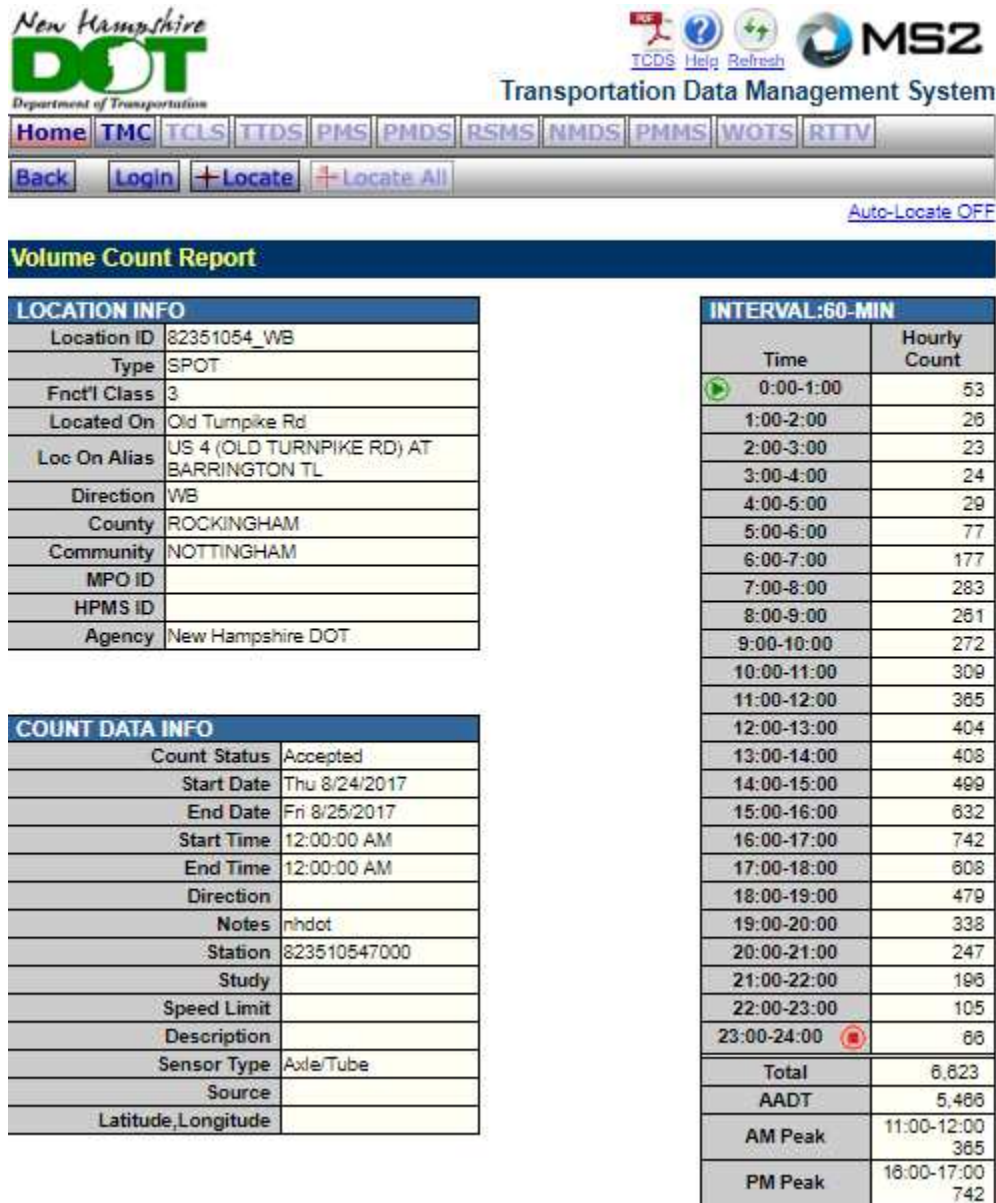
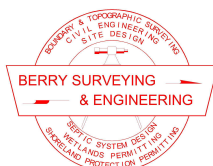


Figure 16: Thursday August 24th, 2017 US Route 4 westbound hourly traffic count



Appendix B

Data Used in Left-Turn Bay Warrants Analysis

Year	Advancing Volume	Advancing Volume Peaked	Ada Drive Exit Pass-by Generation (APB)	Left Turns	Total Advancing Volume (L+TR+APB)
2017	635	654.1	5.0	1.2	660.3
2018	641	660.6	5.0	1.2	666.8
2019	648	667.2	5.0	1.2	673.4
2020	654	673.9	5.0	1.2	680.1
2021	661	680.6	5.0	1.2	686.8
2022	667	687.4	5.0	1.2	693.6
2023	674	694.3	5.0	1.2	700.5
2024	681	701.2	5.0	1.2	707.4
2025	688	708.2	5.0	1.2	714.5
2026	694	715.3	5.0	1.2	721.5
2027	701	722.5	5.0	1.2	728.7
2028	708	729.7	5.0	1.2	735.9
2029	716	737.0	5.0	1.2	743.2
Year	Opposing Volume	Opposing Volume Peaked	Ada Drive Enter Pass-by Generation (APB)	Right Turns	Total Opposing Volume (TR+R+APB)
2017	285	293.6	0.8	0.5	294.8
2018	288	296.5	0.8	0.5	297.8
2019	291	299.5	0.8	0.5	300.7
2020	294	302.4	0.8	0.5	303.7
2021	297	305.5	0.8	0.5	306.7
2022	300	308.5	0.8	0.5	309.8
2023	303	311.6	0.8	0.5	312.9
2024	306	314.7	0.8	0.5	316.0
2025	309	317.9	0.8	0.5	319.2
2026	312	321.1	0.8	0.5	322.3
2027	315	324.3	0.8	0.5	325.5
2028	318	327.5	0.8	0.5	328.8
2029	321	330.8	0.8	0.5	332.1
Seasonal Peaking Factor (August)		1.03			

Figure 17: Data used for AM Peak hour left-turn warrant analyses Sera Drive

Year	Advancing Volume	Advancing Volume Peaked	Ada Drive Exit Pass-by Generation (APB)	Left Turns	Total Advancing Volume (L+TR+APB)
2017	431	443.9	1.8	2.1	447.9
2018	435	448.4	1.8	2.1	452.3
2019	440	452.9	1.8	2.1	456.8
2020	444	457.4	1.8	2.1	461.3
2021	449	462.0	1.8	2.1	465.9
2022	453	466.6	1.8	2.1	470.5
2023	458	471.2	1.8	2.1	475.2
2024	462	476.0	1.8	2.1	479.9
2025	467	480.7	1.8	2.1	484.6
2026	471	485.5	1.8	2.1	489.4
2027	476	490.4	1.8	2.1	494.3
2028	481	495.3	1.8	2.1	499.2
2029	486	500.2	1.8	2.1	504.2
Year	Opposing Volume	Opposing Volume Peaked	Ada Drive Enter Pass-by Generation (APB)	Right Turns	Total Opposing Volume (TR+R+APB)
2017	718	739.9	5.1	3.5	748.5
2018	726	747.3	5.1	3.5	755.9
2019	733	754.8	5.1	3.5	763.4
2020	740	762.3	5.1	3.5	771.0
2021	748	769.9	5.1	3.5	778.6
2022	755	777.6	5.1	3.5	786.3
2023	763	785.4	5.1	3.5	794.1
2024	770	793.3	5.1	3.5	801.9
2025	778	801.2	5.1	3.5	809.9
2026	786	809.2	5.1	3.5	817.9
2027	793	817.3	5.1	3.5	826.0
2028	801	825.5	5.1	3.5	834.1
2029	809	833.7	5.1	3.5	842.4
Seasonal Peaking Factor (August)		1.03			

Figure 18: Data used for PM Peak hour left-turn warrant analyses Sera Drive

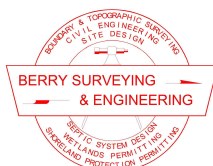


Year	Advancing Volume	Advancing Volume Peaked	Sera Drive Enter Pass-by Generation (SPB)	Left Turns	Total Advancing Volume (L+TR+SPB)
2017	635	654.1	1.2	1.7	656.9
2018	641	660.6	1.2	1.7	663.4
2019	648	667.2	1.2	1.7	670.0
2020	654	673.9	1.2	1.7	676.7
2021	661	680.6	1.2	1.7	683.5
2022	667	687.4	1.2	1.7	690.3
2023	674	694.3	1.2	1.7	697.1
2024	681	701.2	1.2	1.7	704.1
2025	688	708.2	1.2	1.7	711.1
2026	694	715.3	1.2	1.7	718.2
2027	701	722.5	1.2	1.7	725.3
2028	708	729.7	1.2	1.7	732.6
2029	716	737.0	1.2	1.7	739.8
Year	Opposing Volume	Opposing Volume Peaked	Sera Drive Exit Pass-by Generation (SPB)	Right Turns	Total Opposing Volume (TR+R+SPB)
2017	285	293.6	1.6	0.8	295.9
2018	288	296.5	1.6	0.8	298.8
2019	291	299.5	1.6	0.8	301.8
2020	294	302.4	1.6	0.8	304.8
2021	297	305.5	1.6	0.8	307.8
2022	300	308.5	1.6	0.8	310.8
2023	303	311.6	1.6	0.8	313.9
2024	306	314.7	1.6	0.8	317.0
2025	309	317.9	1.6	0.8	320.2
2026	312	321.1	1.6	0.8	323.4
2027	315	324.3	1.6	0.8	326.6
2028	318	327.5	1.6	0.8	329.8
2029	321	330.8	1.6	0.8	333.1
Seasonal Peaking Factor (August)		1.03			

Figure 19: Data used for AM Peak hour left-turn warrant analyses Ada Drive

Year	Advancing Volume	Advancing Volume Peaked	Sera Drive Enter Pass-by Generation (SPB)	Left Turns	Total Advancing Volume (L+TR+SPB)
2017	431	443.9	2.1	3.1	449.1
2018	435	448.4	2.1	3.1	453.6
2019	440	452.9	2.1	3.1	458.1
2020	444	457.4	2.1	3.1	462.6
2021	449	462.0	2.1	3.1	467.2
2022	453	466.6	2.1	3.1	471.8
2023	458	471.2	2.1	3.1	476.4
2024	462	476.0	2.1	3.1	481.2
2025	467	480.7	2.1	3.1	485.9
2026	471	485.5	2.1	3.1	490.7
2027	476	490.4	2.1	3.1	495.6
2028	481	495.3	2.1	3.1	500.5
2029	486	500.2	2.1	3.1	505.4
Year	Opposing Volume	Opposing Volume Peaked	Sera Drive Exit Pass-by Generation (SPB)	Right Turns	Total Opposing Volume (TR+R+SPB)
2017	718	739.9	2.1	5.1	747.1
2018	726	747.3	2.1	5.1	754.5
2019	733	754.8	2.1	5.1	762.0
2020	740	762.3	2.1	5.1	769.5
2021	748	769.9	2.1	5.1	777.1
2022	755	777.6	2.1	5.1	784.8
2023	763	785.4	2.1	5.1	792.6
2024	770	793.3	2.1	5.1	800.5
2025	778	801.2	2.1	5.1	808.4
2026	786	809.2	2.1	5.1	816.4
2027	793	817.3	2.1	5.1	824.5
2028	801	825.5	2.1	5.1	832.7
2029	809	833.7	2.1	5.1	840.9
Seasonal Peaking Factor (August)		1.03			

Figure 20: Data used for PM Peak hour left-turn warrant analyses Ada Drive



Left-Turn Bay Warrants Analysis (55 MPH)

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

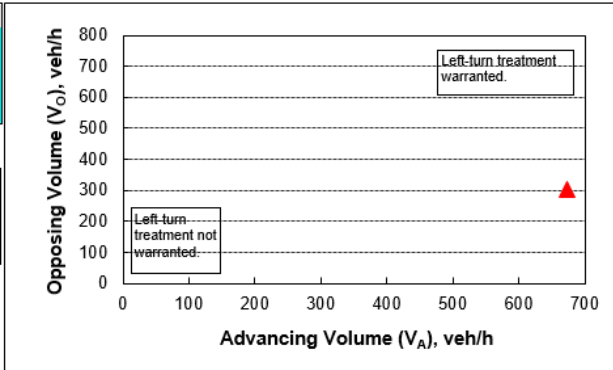
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	673
Opposing volume (V _O), veh/h:	301

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	2336
Guidance for determining the need for a major-road left-turn bay: Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 21: 2019 AM NCHRP 457 (55 MPH) left-turn bay warrant analysis Sera Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

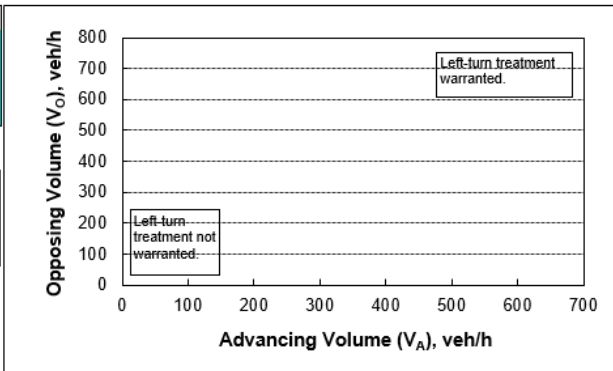
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	743
Opposing volume (V _O), veh/h:	332

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	2372
Guidance for determining the need for a major-road left-turn bay: Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 22: 2029 AM NCHRP 457 (55 MPH) left-turn bay warrant analysis Sera Drive

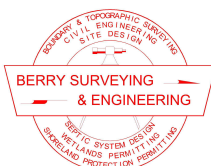


Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

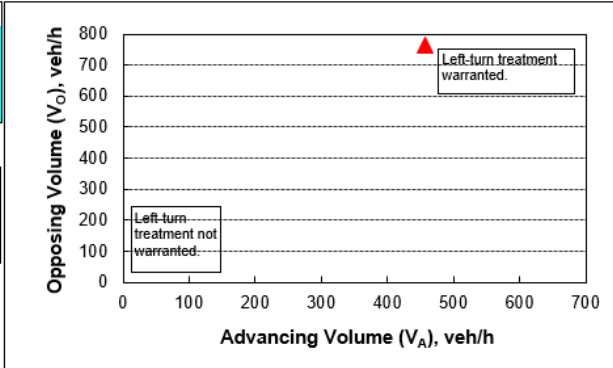
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	457
Opposing volume (V _O), veh/h:	763

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	885
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 23: 2019 PM NCHRP 457 (55 MPH) left-turn bay warrant analysis Sera Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

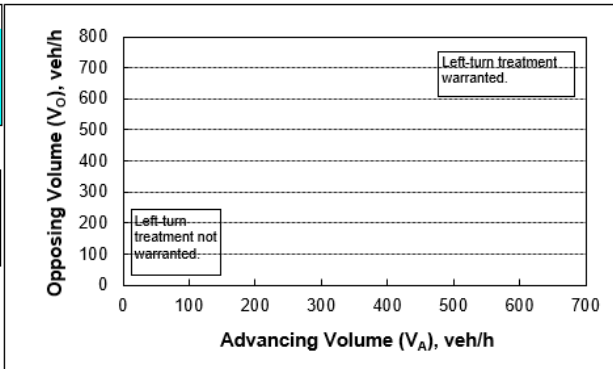
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	504
Opposing volume (V _O), veh/h:	842

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	860
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 24: 2029 PM NCHRP 457 (55 MPH) left-turn bay warrant analysis Sera Drive

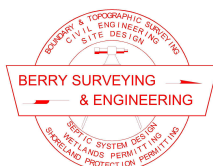


Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

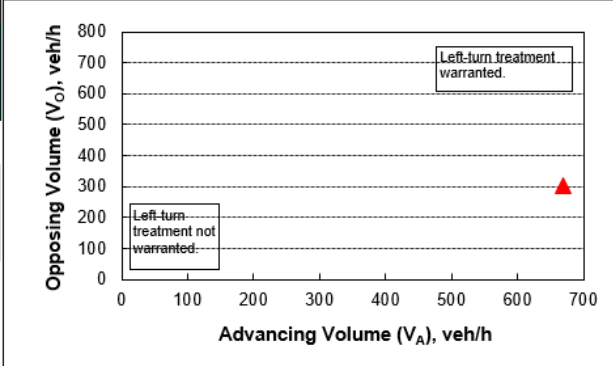
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	670
Opposing volume (V _O), veh/h:	302

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	1937
Guidance for determining the need for a major-road left-turn bay: Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 25: 2019 AM NCHRP 457 (55 MPH) left-turn bay warrant analysis Ada Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

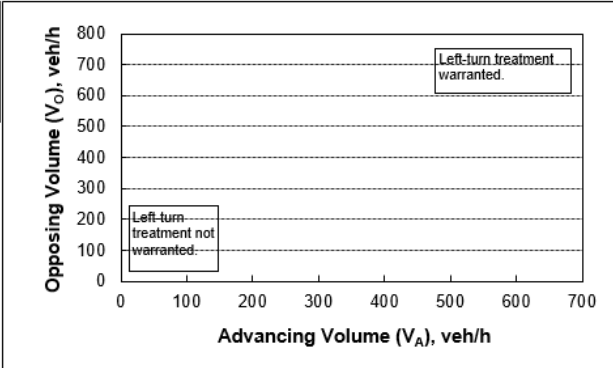
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	740
Opposing volume (V _O), veh/h:	333

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	1967
Guidance for determining the need for a major-road left-turn bay: Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 26: 2029 AM NCHRP 457 (55 MPH) left-turn bay warrant analysis Ada Drive

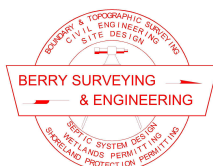


Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

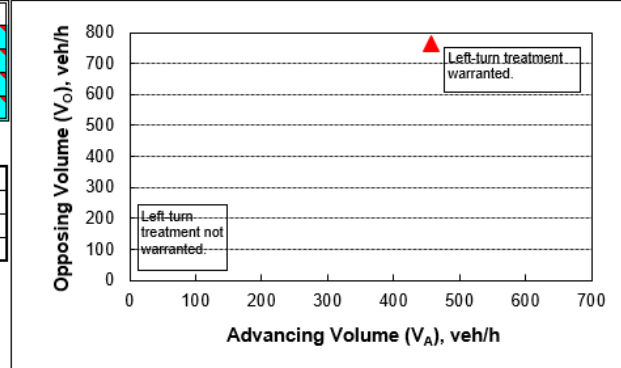
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	1%
Advancing volume (V _A), veh/h:	458
Opposing volume (V _O), veh/h:	762

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	739
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 27: 2019 PM NCHRP 457 (55 MPH) left-turn bay warrant analysis Ada Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

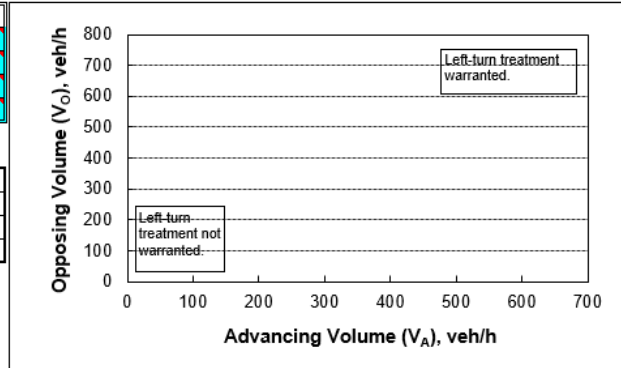
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	55
Percent of left-turns in advancing volume (V _A), %:	1%
Advancing volume (V _A), veh/h:	505
Opposing volume (V _O), veh/h:	841

OUTPUT

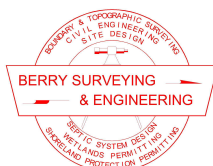
Variable	Value
Limiting advancing volume (V _A), veh/h:	684
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 28: 2029 PM NCHRP 457 (55 MPH) left-turn bay warrant analysis Ada Drive



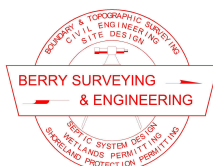
Data Used in Right-Turn Bay Warrants Analysis

Year	Advancing Volume	Advancing Volume Peaked	Right Turns	Ada Drive Enter Pass-by Generation (APB)	Total Advancing Volume (TR+R+APB)
2017	285	293.6	0.5	0.8	294.8
2018	288	296.5	0.5	0.8	297.8
2019	291	299.5	0.5	0.8	300.7
2020	294	302.4	0.5	0.8	303.7
2021	297	305.5	0.5	0.8	306.7
2022	300	308.5	0.5	0.8	309.8
2023	303	311.6	0.5	0.8	312.9
2024	306	314.7	0.5	0.8	316.0
2025	309	317.9	0.5	0.8	319.2
2026	312	321.1	0.5	0.8	322.3
2027	315	324.3	0.5	0.8	325.5
2028	318	327.5	0.5	0.8	328.8
2029	321	330.8	0.5	0.8	332.1
Seasonal Peaking Factor (August)		1.03			

Figure 29: Data used for AM Peak hour right-turn warrant analyses Sera Drive

Year	Advancing Volume	Advancing Volume Peaked	Right Turns	Ada Drive Enter Pass-by Generation (APB)	Total Advancing Volume (TR+R+APB)
2017	285	293.6	3.5	5.1	302.2
2018	288	296.5	3.5	5.1	305.1
2019	291	299.5	3.5	5.1	308.1
2020	294	302.4	3.5	5.1	311.1
2021	297	305.5	3.5	5.1	314.1
2022	300	308.5	3.5	5.1	317.2
2023	303	311.6	3.5	5.1	320.3
2024	306	314.7	3.5	5.1	323.4
2025	309	317.9	3.5	5.1	326.5
2026	312	321.1	3.5	5.1	329.7
2027	315	324.3	3.5	5.1	332.9
2028	318	327.5	3.5	5.1	336.2
2029	321	330.8	3.5	5.1	339.4
Seasonal Peaking Factor (August)		1.03			

Figure 30: Data used for PM Peak hour right-turn warrant analyses Sera Drive

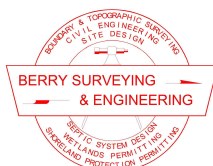


Year	Advancing Volume	Advancing Volume Peaked	Right Turns	Sera Drive Exit Pass-by Generation (SPB)	Total Advancing Volume (TR+R+SBP)
2017	285	293.6	0.8	1.6	295.9
2018	288	296.5	0.8	1.6	298.8
2019	291	299.5	0.8	1.6	301.8
2020	294	302.4	0.8	1.6	304.8
2021	297	305.5	0.8	1.6	307.8
2022	300	308.5	0.8	1.6	310.8
2023	303	311.6	0.8	1.6	313.9
2024	306	314.7	0.8	1.6	317.0
2025	309	317.9	0.8	1.6	320.2
2026	312	321.1	0.8	1.6	323.4
2027	315	324.3	0.8	1.6	326.6
2028	318	327.5	0.8	1.6	329.8
2029	321	330.8	0.8	1.6	333.1
Seasonal Peaking Factor (August)		1.03			

Figure 31: Data used for AM Peak hour right-turn warrant analyses Ada Drive

Year	Advancing Volume	Advancing Volume Peaked	Right Turns	Sera Drive Exit Pass-by Generation (SPB)	Total Advancing Volume (TR+R+SBP)
2017	718	739.9	5.1	2.1	747.1
2018	726	747.3	5.1	2.1	754.5
2019	733	754.8	5.1	2.1	762.0
2020	740	762.3	5.1	2.1	769.5
2021	748	769.9	5.1	2.1	777.1
2022	755	777.6	5.1	2.1	784.8
2023	763	785.4	5.1	2.1	792.6
2024	770	793.3	5.1	2.1	800.5
2025	778	801.2	5.1	2.1	808.4
2026	786	809.2	5.1	2.1	816.4
2027	793	817.3	5.1	2.1	824.5
2028	801	825.5	5.1	2.1	832.7
2029	809	833.7	5.1	2.1	840.9
Seasonal Peaking Factor (August)		1.03			

Figure 32: Data used for PM Peak hour right-turn warrant analyses Ada Drive



Right-Turn Bay Warrants Analysis (55 MPH)

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	301
Right-turn volume, veh/h:	1

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	23
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

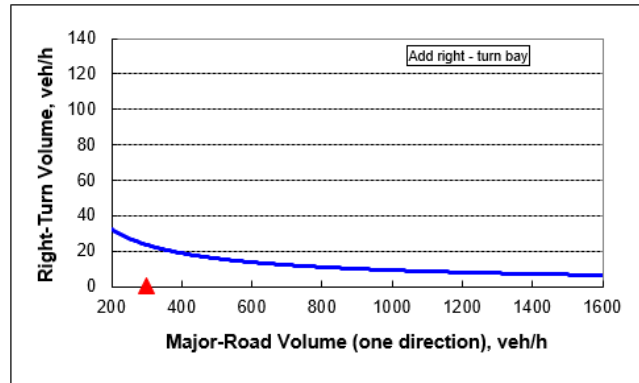


Figure 33: 2019 AM NCHRP 457 (55 MPH) right-turn bay warrant analysis Sera Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	332
Right-turn volume, veh/h:	1

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	22
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

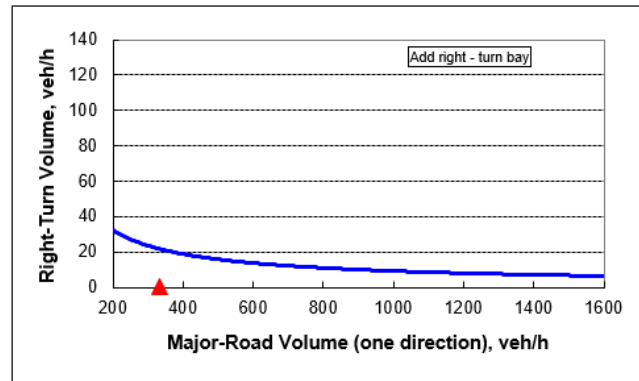


Figure 34: 2029 AM NCHRP 457 (55 MPH) right-turn bay warrant analysis Sera Drive

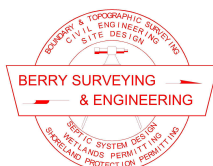


Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	308
Right-turn volume, veh/h:	4

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	23
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

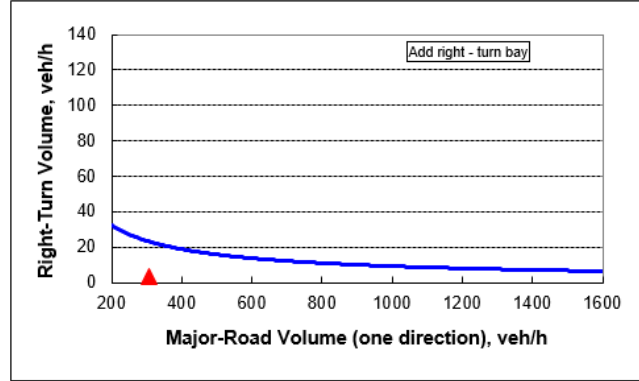


Figure 35: 2019 PM NCHRP 457 (55 MPH) right-turn bay warrant analysis Sera Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	339
Right-turn volume, veh/h:	4

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	21
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

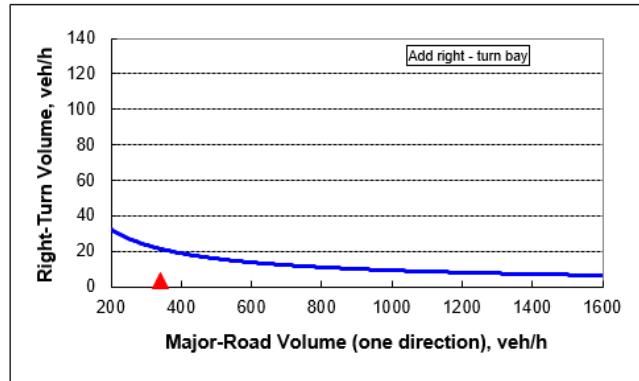


Figure 36: 2029 PM NCHRP 457 (55 MPH) right-turn bay warrant analysis Sera Drive

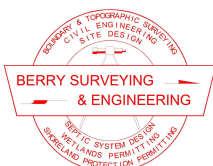


Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	302
Right-turn volume, veh/h:	1
OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	23
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

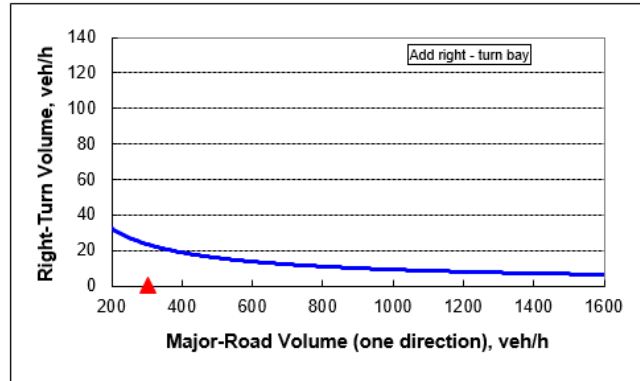


Figure 37: 2019 AM NCHRP 457 (55 MPH) right-turn bay warrant analysis Ada Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	333
Right-turn volume, veh/h:	1
OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	22
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

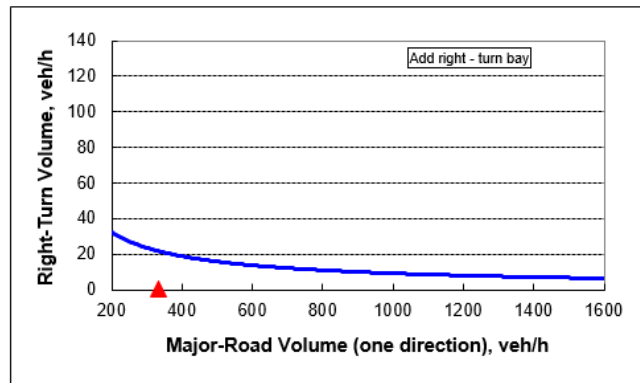


Figure 38: 2029 AM NCHRP 457 (55 MPH) right-turn bay warrant analysis Ada Drive

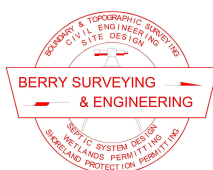


Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	762
Right-turn volume, veh/h:	5

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	11
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

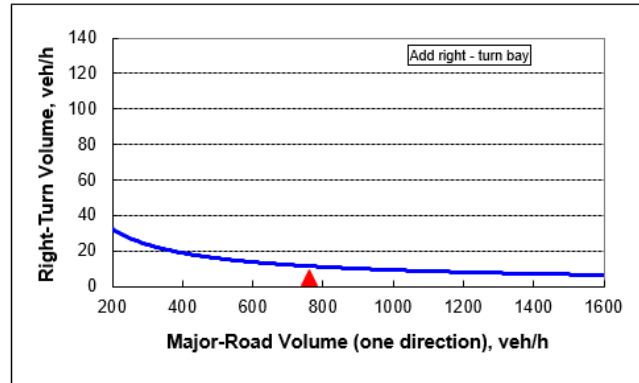


Figure 39: 2019 PM NCHRP 457 (55 MPH) right-turn bay warrant analysis Ada Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	55
Major-road volume (one direction), veh/h:	841
Right-turn volume, veh/h:	5

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	11
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

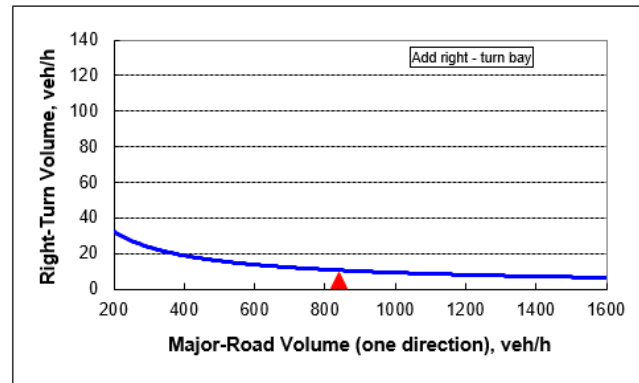
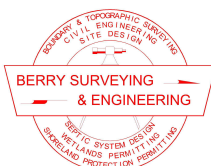


Figure 40: 2029 PM NCHRP 457 (55 MPH) right-turn bay warrant analysis Ada Drive



Appendix C

Trip Generation Derivation

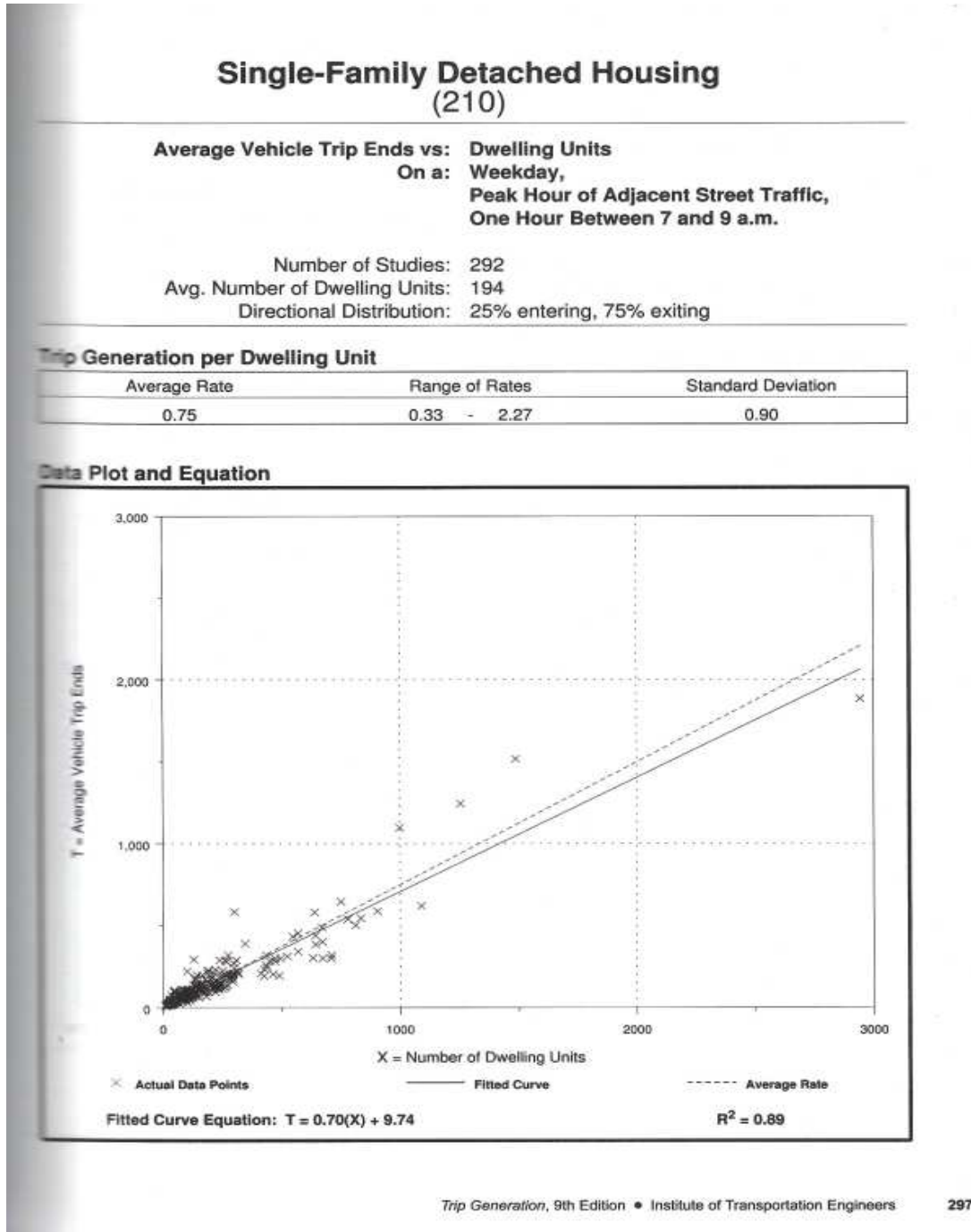
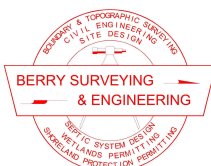


Figure 41: ITE Trip Generation, 9th Edition

BERRY SURVEYING & ENGINEERING
 335 Second Crown Pt. Rd., Barrington, NH 03825
 (603) 332-2863 / (603) 335-4623 FAX
 www.BerrySurveying.Com



Single-Family Detached Housing (210)

Average Vehicle Trip Ends vs: Dwelling Units
 On a: Weekday,
 Peak Hour of Adjacent Street Traffic,
 One Hour Between 4 and 6 p.m.

Number of Studies: 321
 Avg. Number of Dwelling Units: 207
 Directional Distribution: 63% entering, 37% exiting

Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
1.00	0.42 - 2.98	1.05

Data Plot and Equation

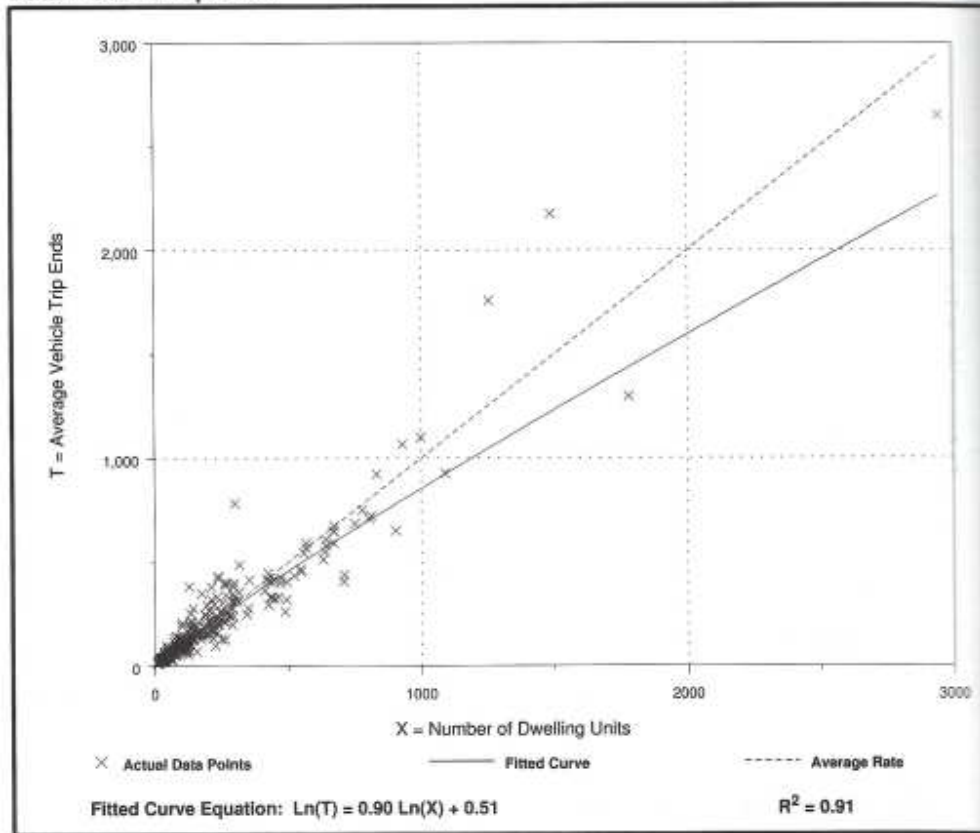
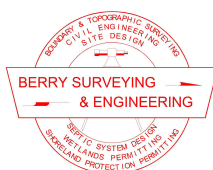


Figure 42: ITE Trip Generation, 9th Edition

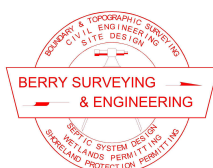


Appendix D

Miscellaneous

Year 2016 Monthly Data			
Group 4 Averages:		Urban Highways	
Month	ADT	Adjustment to	
		Average	Peak
January	13,573	1.16	1.25
February	14,038	1.12	1.21
March	15,731	1.00	1.08
April	16,139	0.97	1.05
May	15,705	1.00	1.08
June	16,766	0.94	1.01
July	15,752	1.00	1.08
August	16,529	0.95	1.03
September	17,007	0.92	1.00
October	16,598	0.94	1.02
November	15,649	1.00	1.09
December	14,638	1.07	1.16
Average ADT:	15,677		
Peak ADT:	17,007		

Table 17: Derivation of the seasonal peaking factor



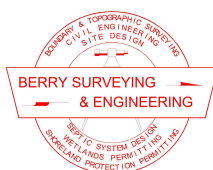
AASHTO—Geometric Design of Highways and Streets

Metric						US Customary					
Design speed (km/h)	Brake reaction distance (m)	Braking distance on level (m)	Stopping sight distance (m)		Design (m)	Design speed (mph)	Brake reaction distance (ft)	Braking distance on level (ft)	Stopping sight distance (ft)		Design (ft)
			Calculated	Design					Calculated	Design	
20	13.9	4.6	18.5	20	20	15	55.1	21.6	76.7	80	80
30	20.9	10.3	31.2	35	35	20	73.5	38.4	111.9	115	115
40	27.8	18.4	46.2	50	50	25	91.9	60.0	151.9	155	155
50	34.8	28.7	63.5	65	65	30	110.3	86.4	196.7	200	200
60	41.7	41.3	83.0	85	85	35	128.6	117.6	246.2	250	250
70	48.7	56.2	104.9	105	105	40	147.0	153.6	300.6	305	305
80	55.6	73.4	129.0	130	130	45	165.4	194.4	359.8	360	360
90	62.6	92.9	155.5	160	160	50	183.8	240.0	423.8	425	425
100	69.5	114.7	184.2	185	185	55	202.1	290.3	492.4	495	495
110	76.5	138.8	215.3	220	220	60	220.5	345.5	566.0	570	570
120	83.4	165.2	248.6	250	250	65	238.9	405.5	644.4	645	645
130	90.4	193.8	284.2	285	285	70	257.3	470.3	727.6	730	730
						75	275.6	539.9	815.5	820	820
						80	294.0	614.3	908.3	910	910

Note: Brake reaction distance predicated on a time of 2.5 s; deceleration rate of 3.4 m/s² [11.2 ft/s²] used to determine calculated sight distance.

Exhibit 3-1. Stopping Sight Distance

Figure 43: Derivation of stopping sight distance requirements

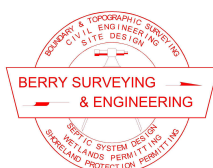


Elements of Design

Metric							US Customary						
Design speed (km/h)	Stopping sight distance (m)						Design speed (mph)	Stopping sight distance (ft)					
	Downgrades			Upgrades				Downgrades			Upgrades		
	3 %	6 %	9 %	3 %	6 %	9 %		3 %	6 %	9 %	3 %	6 %	9 %
20	20	20	20	19	18	18	15	80	82	85	75	74	73
30	32	35	35	31	30	29	20	116	120	126	109	107	104
40	50	50	53	45	44	43	25	158	165	173	147	143	140
50	66	70	74	61	59	58	30	205	215	227	200	184	179
60	87	92	97	80	77	75	35	257	271	287	237	229	222
70	110	116	124	100	97	93	40	315	333	354	289	278	269
80	136	144	154	123	118	114	45	378	400	427	344	331	320
90	164	174	187	148	141	136	50	446	474	507	405	388	375
100	194	207	223	174	167	160	55	520	553	593	469	450	433
110	227	243	262	203	194	186	60	598	638	686	538	515	495
120	263	281	304	234	223	214	65	682	728	785	612	584	561
130	302	323	350	267	254	243	70	771	825	891	690	658	631
							75	866	927	1003	772	736	704
							80	965	1035	1121	859	817	782

Exhibit 3-2. Stopping Sight Distance on Grades

Figure 44: Derivation of stopping sight distance requirements at grades



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Appendix E

Left-Turn Bay Warrants Analysis (60 MPH)

The data used for the 55 MPH left and right-turn bay warrants analysis (shown in Appendix B), has been utilized for the 60 MPH left and right-turn bay warrants analysis.

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

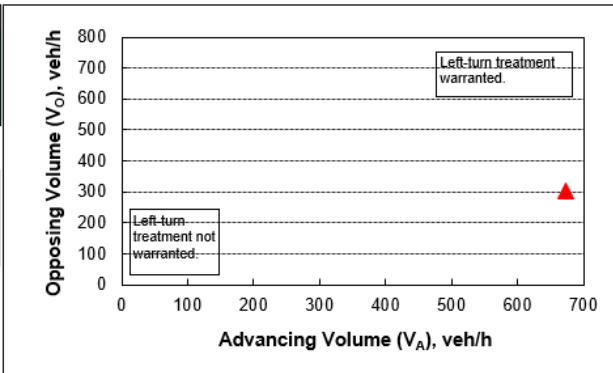
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	673
Opposing volume (V _O), veh/h:	301

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	2089
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 45: 2019 AM NCHRP 457 (60 MPH) left-turn bay warrant analysis Sera Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

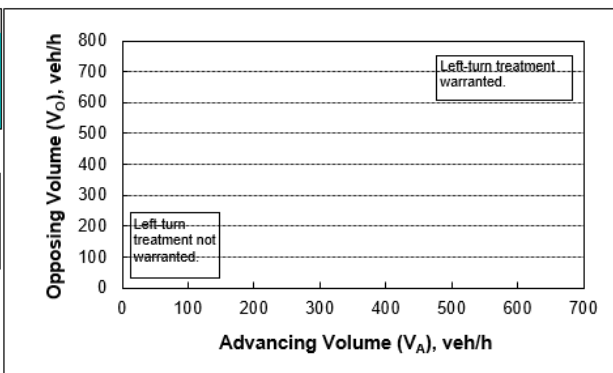
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	743
Opposing volume (V _O), veh/h:	332

OUTPUT

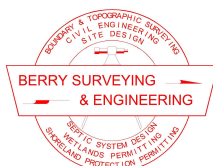
Variable	Value
Limiting advancing volume (V _A), veh/h:	2121
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 46: 2029 AM NCHRP 457 (60 MPH) left-turn bay warrant analysis Sera Drive



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Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

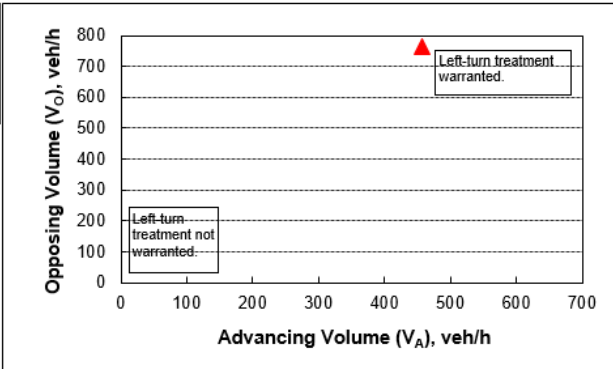
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	457
Opposing volume (V _O), veh/h:	763

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	792
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 47: 2019 PM NCHRP 457 (60 MPH) left-turn bay warrant analysis Sera Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

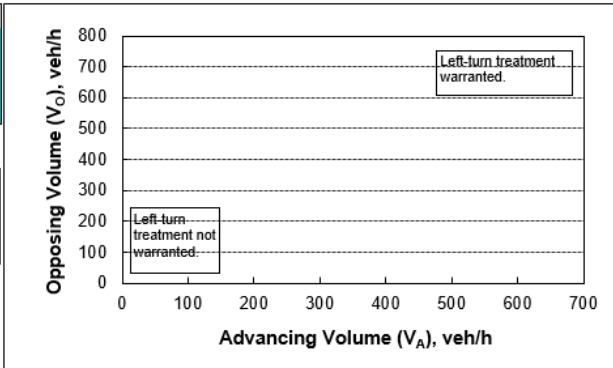
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	504
Opposing volume (V _O), veh/h:	842

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	770
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 48: 2029 PM NCHRP 457 (60 MPH) left-turn bay warrant analysis Sera Drive

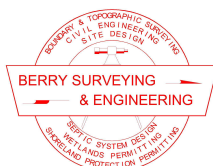


Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

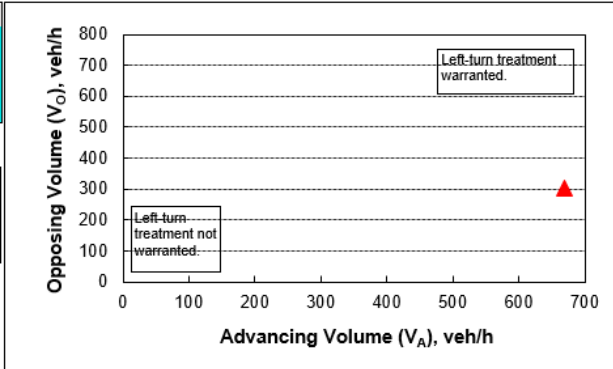
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	670
Opposing volume (V _O), veh/h:	302

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	1733
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 49: 2019 AM NCHRP 457 (60 MPH) left-turn bay warrant analysis Ada Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

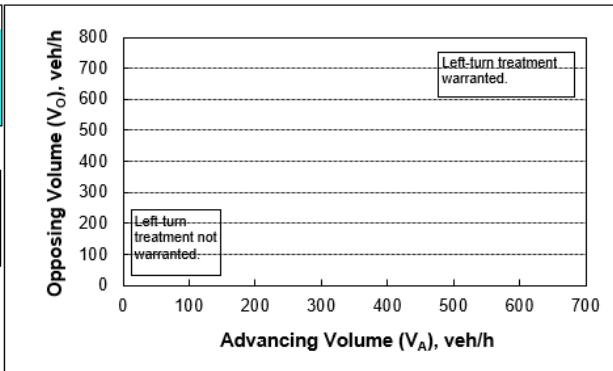
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	0%
Advancing volume (V _A), veh/h:	740
Opposing volume (V _O), veh/h:	333

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	1760
Guidance for determining the need for a major-road left-turn bay:	
Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 50: 2029 AM NCHRP 457 (60 MPH) left-turn bay warrant analysis Ada Drive

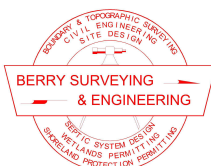


Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

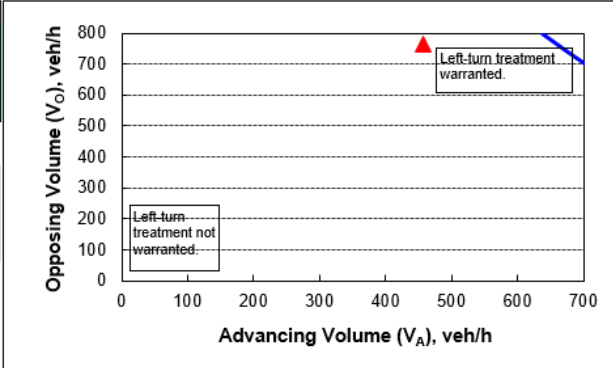
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	1%
Advancing volume (V _A), veh/h:	458
Opposing volume (V _O), veh/h:	762

OUTPUT

Variable	Value
Limiting advancing volume (V _A), veh/h:	661
Guidance for determining the need for a major-road left-turn bay: Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 51: 2019 PM NCHRP 457 (60 MPH) left-turn bay warrant analysis Ada Drive

Figure 2 - 5. Guideline for determining the need for a major-road left-turn bay at a two-way stop-controlled intersection.

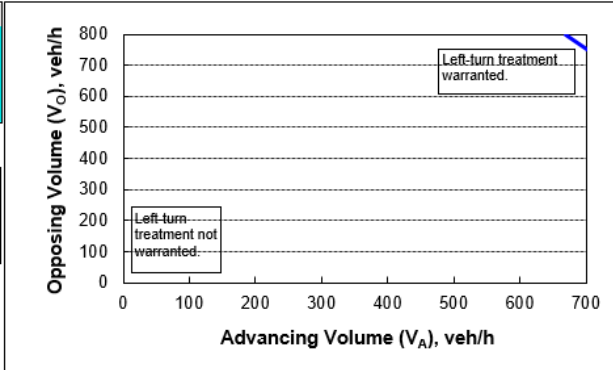
2-lane roadway (English)

INPUT

Variable	Value
85 th percentile speed, mph:	60
Percent of left-turns in advancing volume (V _A), %:	1%
Advancing volume (V _A), veh/h:	505
Opposing volume (V _O), veh/h:	841

OUTPUT

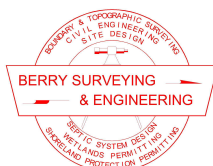
Variable	Value
Limiting advancing volume (V _A), veh/h:	643
Guidance for determining the need for a major-road left-turn bay: Left-turn treatment NOT warranted.	



CALIBRATION CONSTANTS

Variable	Value
Average time for making left-turn, s:	3.0
Critical headway, s:	5.0
Average time for left-turn vehicle to clear the advancing lane, s:	1.9

Figure 52: 2029 PM NCHRP 457 (60 MPH) left-turn bay warrant analysis Ada Drive



Right-Turn Bay Warrants Analysis (60 MPH)

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	60
Major-road volume (one direction), veh/h:	301
Right-turn volume, veh/h:	1
OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	15
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

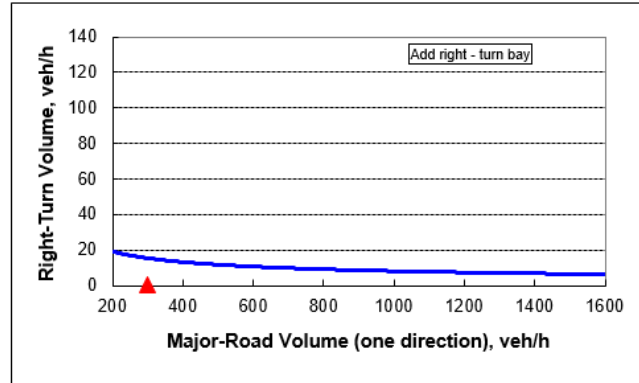


Figure 53: 2019 AM NCHRP 457 (60 MPH) right-turn bay warrant analysis Sera Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	60
Major-road volume (one direction), veh/h:	332
Right-turn volume, veh/h:	1
OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	15
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

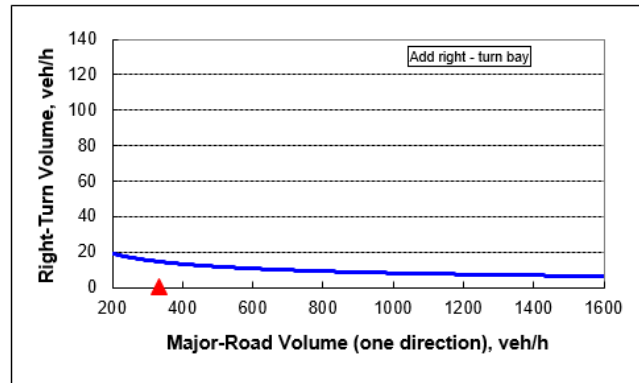


Figure 54: 2029 AM NCHRP 457 (60 MPH) right-turn bay warrant analysis Sera Drive

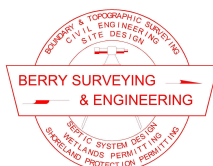


Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	60
Major-road volume (one direction), veh/h:	308
Right-turn volume, veh/h:	4
OUTPUT	
Limiting right-turn volume, veh/h:	15
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

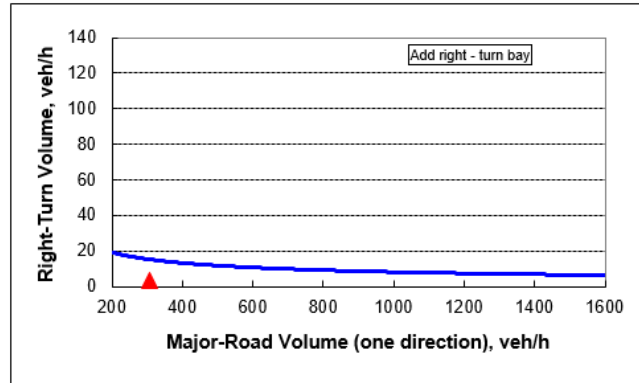


Figure 55: 2019 PM NCHRP 457 (60 MPH) right-turn bay warrant analysis Sera Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	60
Major-road volume (one direction), veh/h:	339
Right-turn volume, veh/h:	4
OUTPUT	
Limiting right-turn volume, veh/h:	14
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

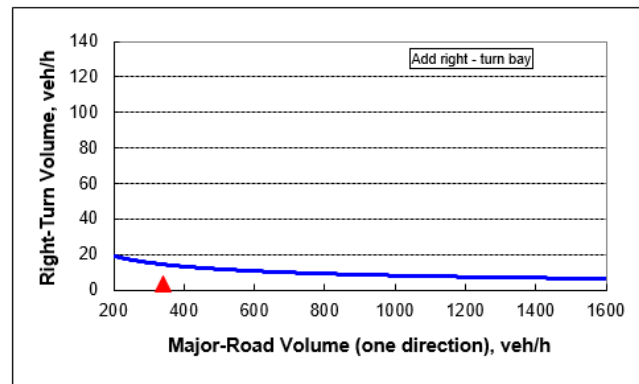


Figure 56: 2029 PM NCHRP 457 (60 MPH) right-turn bay warrant analysis Sera Drive

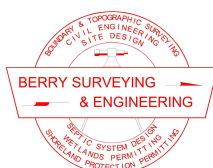


Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

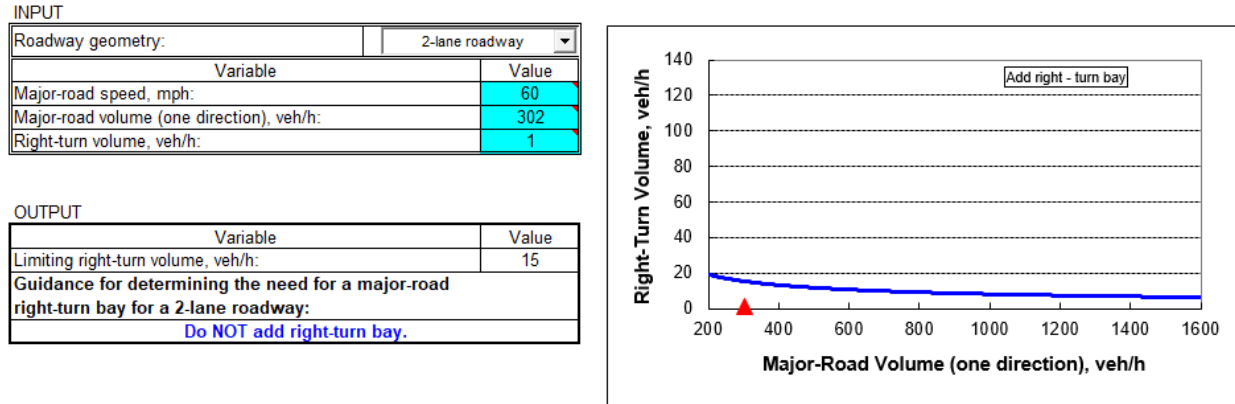


Figure 57: 2019 AM NCHRP 457 (60 MPH) right-turn bay warrant analysis Ada Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

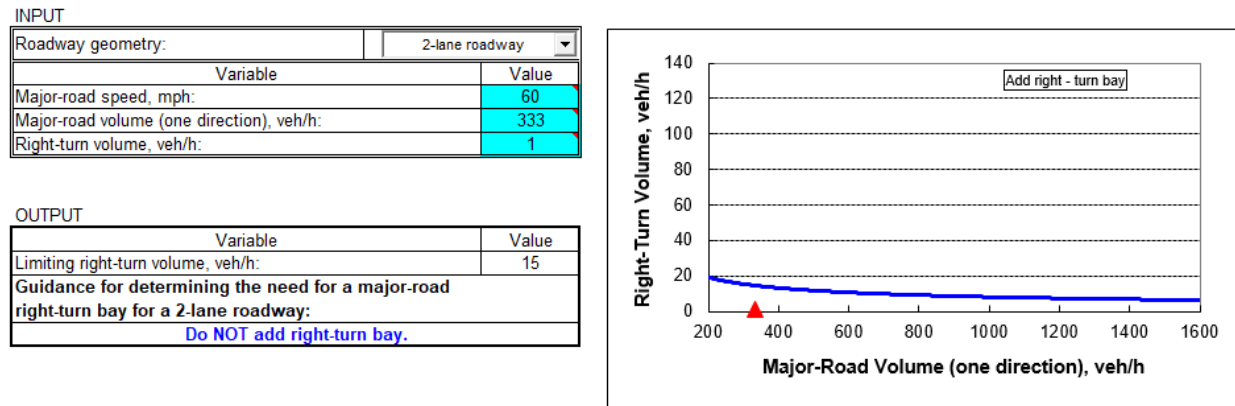


Figure 58: 2029 AM NCHRP 457 (60 MPH) right-turn bay warrant analysis Ada Drive

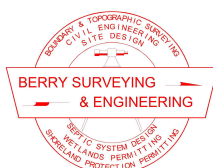


Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	60
Major-road volume (one direction), veh/h:	762
Right-turn volume, veh/h:	5

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	9
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

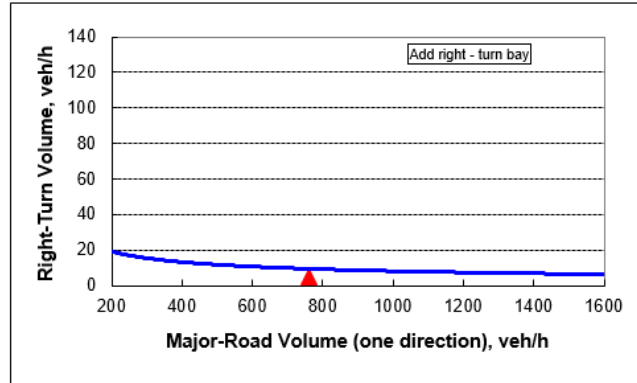


Figure 59: 2019 PM NCHRP 457 (60 MPH) right-turn bay warrant analysis Ada Drive

Figure 2 - 6. Guideline for determining the need for a major-road right-turn bay at a two-way stop-controlled intersection.

INPUT	
Roadway geometry:	2-lane roadway
Variable	Value
Major-road speed, mph:	60
Major-road volume (one direction), veh/h:	841
Right-turn volume, veh/h:	5

OUTPUT	
Variable	Value
Limiting right-turn volume, veh/h:	9
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

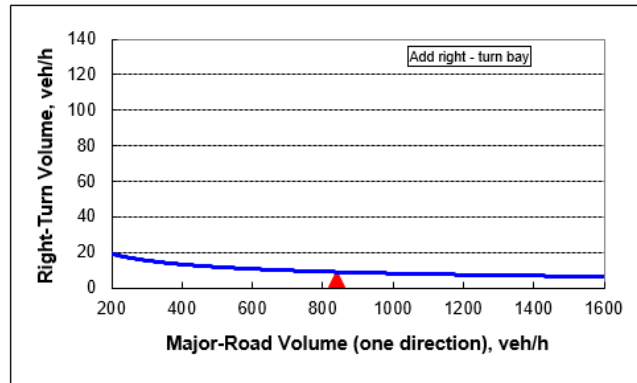


Figure 60: 2029 PM NCHRP 457 (60 MPH) right-turn bay warrant analysis Ada Drive

