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NHDOT
District VI – Attention Mr. Jim Hewitt, P.E.
PO Box 740
Durham, NH 03824

June 14, 2021

RE: Traffic Impact Analysis & Distribution
Dove Development Group, LLC
Community Lane
Tax Map 235, Lots 1-1 & 3
Barrington, NH 03825

Mr. Hewitt,

On behalf of the applicant, Dove Development Group, LLC, Berry Surveying & Engineering (BS&E) is submitting for your review a Traffic Impact Analysis for development of twenty-five multifamily mid-rise housing units, forty mid-rise residential (apartment) units with first floor commercial between two buildings, and 21,000 Sq. Ft. of general office space on the first floor between these two buildings. Of these two mixed-use buildings, one is proposed as part of this application and the second is conceptual for future development. The previously proposed bank use on Tax Map 239, Lot 2 is not currently being considered for construction and development. The point of analysis is the intersection of the existing site entrance, Community Lane, and N.H. Route 9 (Franklin Pierce Highway). Community Lane previously received approval from NHDOT as Christmas Lane in 2018, NHDOT permit #06-027-548.

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

- A total of 47 vehicle trips (27 enter/20 exit) are predicted to occur at the weekday AM peak hour and 83 vehicle trips (37 enter/46 exit) at the PM peak hour.
- A total of 90 vehicle trips (47 enter/43 exit) are predicted to occur at the Saturday peak.
- The 2021 and 2031 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a left-turn lane for all peak hours.
- The 2021 and 2031 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a right-turn lane for all peak hours.
- This is an increase of 45 weekday AM peak hour trips, 50 weekday PM peak hour trips, and 57 Saturday peak hour trips.

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Proposed Development & Introduction

The proposal is to develop Tax Map 235, Lots 1-1 & 3 to contain twenty-five multifamily mid-rise housing units, forty mid-rise residential (apartment) units with first floor commercial between two buildings, and 21,000 Sq. Ft. of general office space on the first floor between these two buildings. Each mixed use building will contain 10,500 Sq. Ft. within the first level, proposed to be general office space or other general uses and twenty apartment units above each. Of these two mixed-use buildings, one is proposed as part of this application and the second is conceptual for future development. In addition to the proposed trip generation, an existing specialty retail store (The Christmas Dove) and three single-family homes utilize Community Lane for access. Community Lane is a boulevard at the entrance, with enter and exit lanes separated by a median. An exit left and right turn lane are in place for safe vehicle turning and queue waiting time. The purpose of this analysis is to determine the maximum number of trips coming to and leaving the proposed project site 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 two lots, Tax Map 235, Lot 1-1 & 3. These parcels contain 7.42 Ac. and 17.07 Ac. of land, respectively. Lot 1-1 contains Community Lane and the remainder is wooded land. Lot 3 entirely consists of wooded land. As previously mentioned, the "Christmas Dove", a specialty retail store and three single family detached homes utilize Community Lane for access. These uses are located on Tax Map 235, Lots 1, 2, and 4, respectively. The site is located in the town center zone, and is surrounded by other commercial and residential lots. There is a commercial driveway approximately 250 feet to the east of the existing driveway cut, the "Village Barn", and a residential driveway across from the site.

NH Route 9 Road Description

NH Route 9 is a two lane major collector road, according to the NHDOT MS2 Transportation Management System (NHDOT). This road provides access to NH Route 125 and the Barrington town center to the east and more rural parts of Barrington to the west. It has an Average Annual Daily Traffic (AADT) of approximately 7,989 (2020) divided between east and west, also as shown by the NHDOT.

NH Route 9 in the area of the project is composed of a twenty-seven foot wide paved surface with a variable shoulder widths on the north and south side of the road. There is a centerline delineation and fog / edge lines provided. The posted speed limit of the roadway is 30 miles per hour (MPH). The geometry of NH Route 9 in the project area is situated on a curve, and is super

elevated to the south. The proposed driveway is on the apex of the curve to maximize sight distance. There are no existing sidewalks, crosswalks, or other pedestrian amenities in the area of the project.

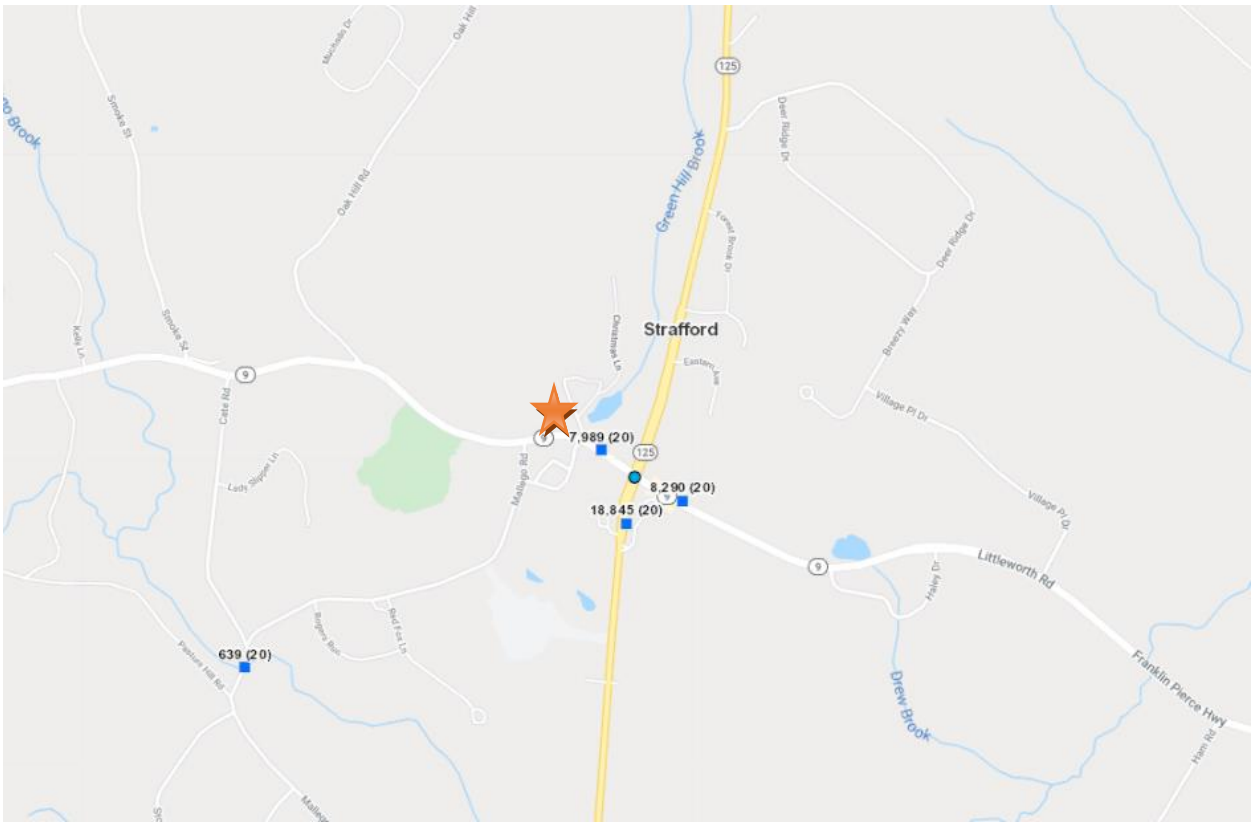


Figure 1: N.H. Route 9 with surrounding roadways (NHDOT)

Existing Traffic Volumes

According to traffic counts recorded the NHDOT for June 25th - 27th 2019, the N.H. Route 9 AM and PM weekday two-way peaks were 859 trips and 1,011 trips, respectively. It is shown by the NHDOT that this portion of N.H. Route 9 has an ADT of 7,989 vehicles (2020). The highest weekday peak hour traffic volume on this section of N.H. Route 9 eastbound occurred from 7-8 AM with 644 vehicles and from 4-5 PM with 359 vehicles. Westbound highest weekday peak hour traffic volume occurred from 8-9 AM with 217 vehicles and from 5-6 PM with 684 vehicles. Table #1 shows the traffic direction breakdown of N.H. Route 9 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 Weekday AM peak hour is eastbound towards Dover and NH Route 16. The primary direction of travel during the PM peak hour is westbound towards Barrington and Northwood. Traffic counts of N.H. Route 9 provided by the NHDOT are included in Appendix A as Figures 9-16.

Traffic Distribution N.H. Route 9						
Date	Eastbound		Westbound		Two-Way	
Tuesday 6/25/19	AM Peak	664	AM Peak	201	AM Peak	859
	PM Peak	298	PM Peak	581	PM Peak	864
Wednesday 6/26/19	AM Peak	596	AM Peak	216	AM Peak	812
	PM Peak	344	PM Peak	684	PM Peak	1011
Thursday 6/27/19	AM Peak	627	AM Peak	217	AM Peak	834
	PM Peak	359	PM Peak	645	PM Peak	1004
Average Peak Hour Traffic	AM Peak	629.0	AM Peak	211.3	AM Peak	835.5
	PM Peak	333.7	PM Peak	636.7	PM Peak	937.5
% Distribution	AM Peak	74.9	AM Peak	25.1		
	PM Peak	34.4	PM Peak	65.6		

Table 1: Directional breakdown of trips occurring on N.H. Route 9

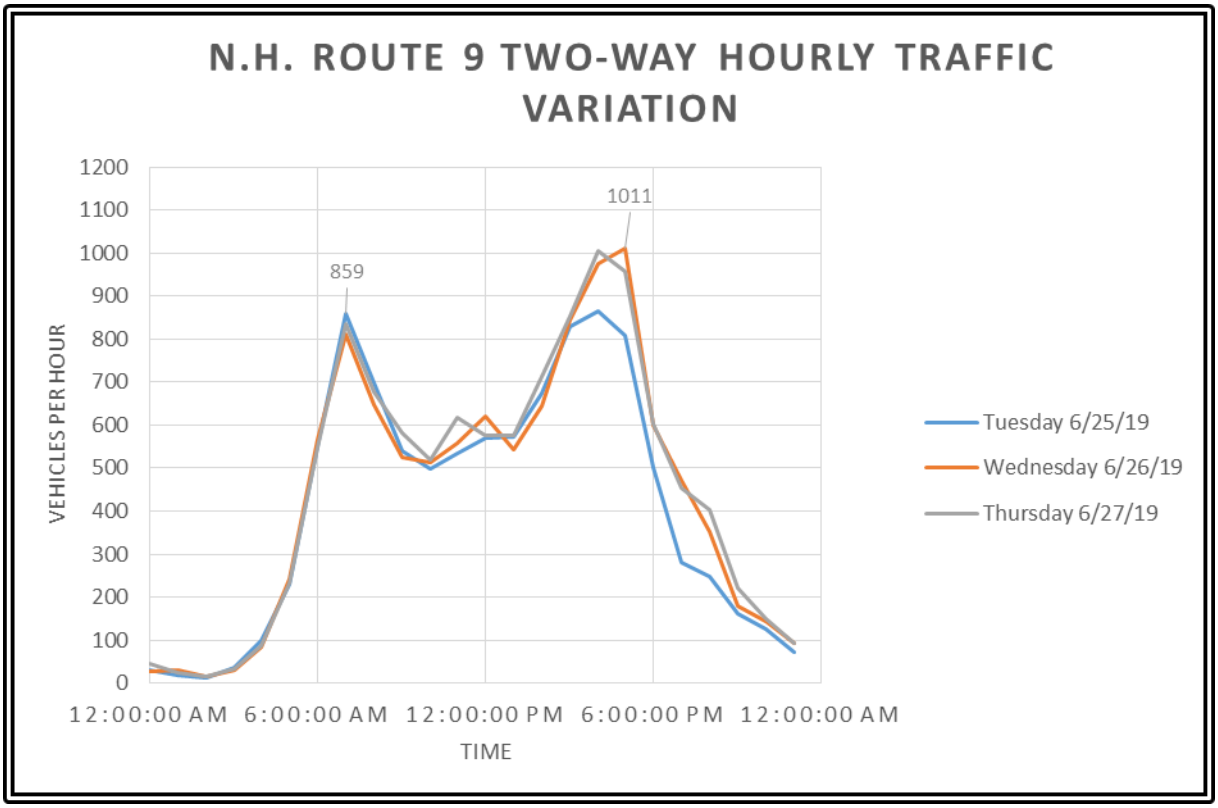


Figure 2: Graph of N.H. Route 9 two-way hourly variation

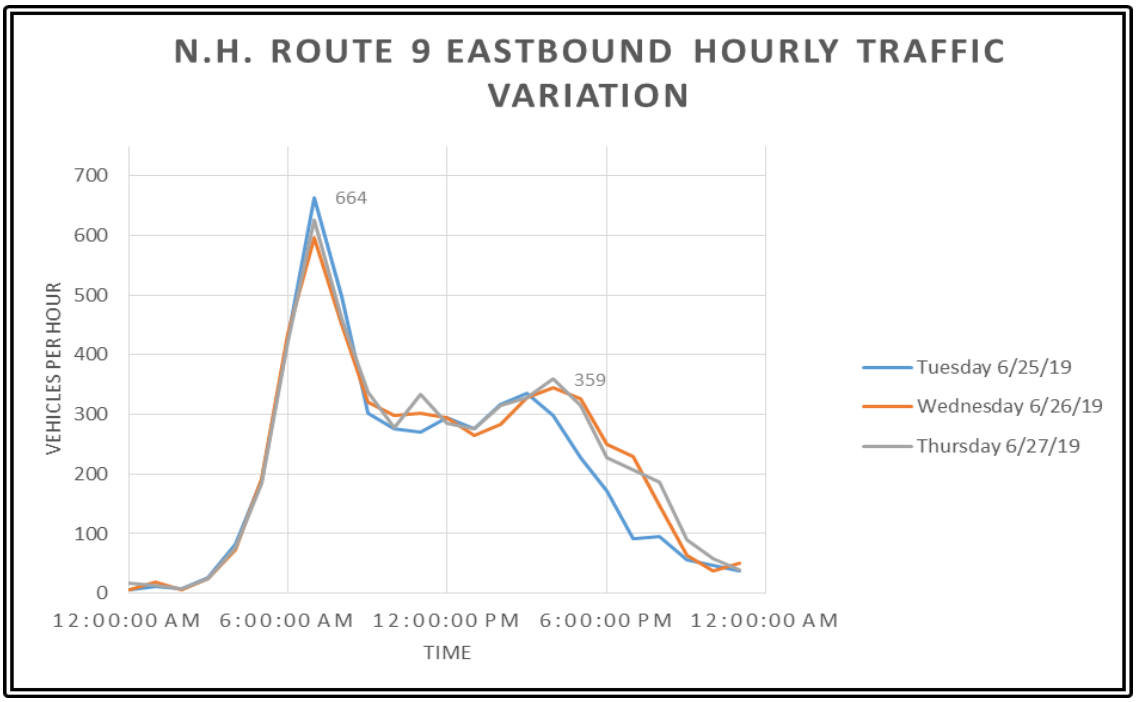


Figure 3: Graph of N.H. Route 9 eastbound hourly variation

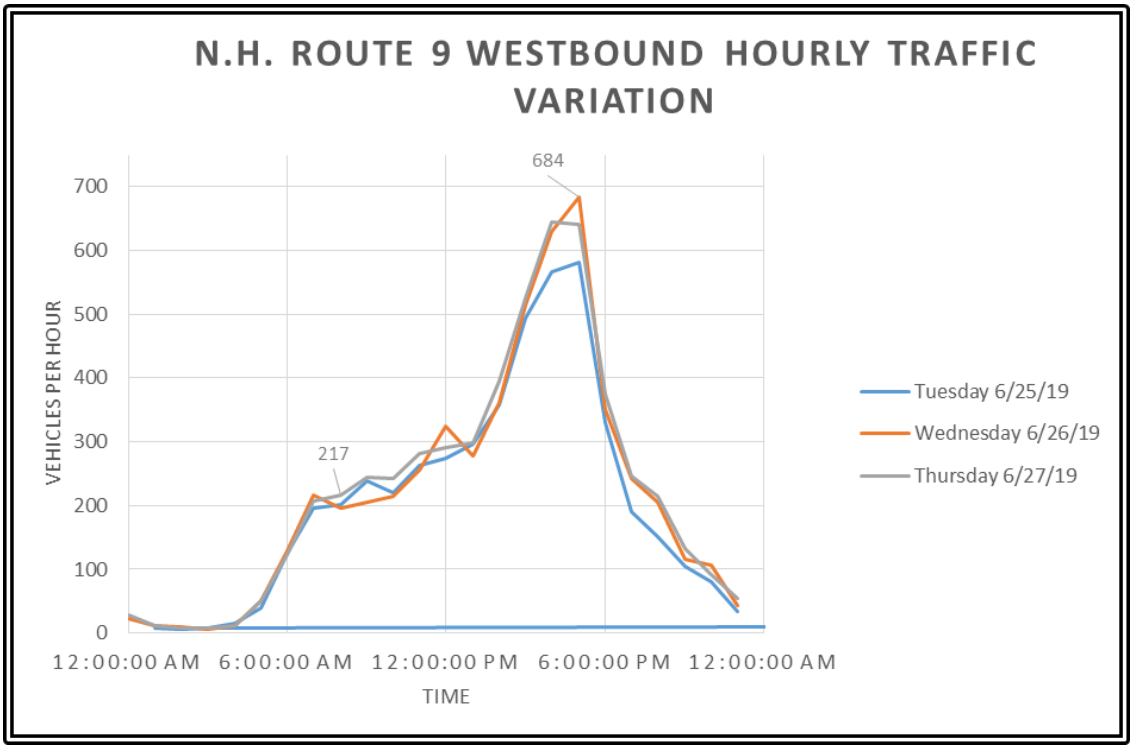


Figure 4: Graph of N.H. Route 9 westbound hourly variation with peak values

Existing Vehicle Speeds

As previously mentioned, the posted speed limit of NH Route 9 is 30 MPH. For the purposes of the safety analysis below, the 85th percentile of speed is required. This particular section of NH Route 9 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 35 MPH.

Intersection of NH Route 9 and NH Route 125

Approximately 0.1 miles to the east, NH Route 9 connects to NH Route 125 at an angle of 90 degrees, where a signalized intersection is used to control traffic movements. NH Route 125 has a posted speed limit of 35 MPH and is considered a principal arterial road according to the NHDOT. NH Route 125 consists of three north bound lanes (left, through, through + right) and three south bound lanes (left, through, through + right) in the area of the intersection of NH Route 9 and NH Route 125, with an Average Annual Daily Traffic (AADT) of 18,845 (2020) divided between north and south. The directional volume split is nearly 50/50, with a north bound AADT of 9,430 (2020) and south bound AADT of 9,415 (2020) and shows an increase in the PM peak hour traffic volumes proportional to what NH Route 9 experiences.

The directional breakdown of trips entering and exiting the site has taken into account the potential draw from NH Route 125. As NH Route 125 is a principal arterial road, this intersection will influence the trips to and from the site. Turn movements must be evaluated differently than the typical directional breakdown that would be derived strictly from the pass by traffic of NH Route 9. The ratio of AADT's from NH Route 9 and NH Route 125 was used to account for this. As trips enter and exit the project site to and from NH Route 125, entrance trips will influence the NH Route 9 west bound volume and exit trips will influence the NH Route 9 east bound volume. Table 2 shows a summary of AADT values for NH Route 9 and NH Route 125.

NH Route 125 AADT (2020):	18,845
NH Route 9 AADT (2020):	7,989
Combined AADT	26,834

Table 2: AADT values for NH Route 9 and NH Route 125

These AADT's where then applied to determine what percentage of vehicles would potentially enter or exit to the east or west of the site. It was determined that 70.2% of vehicles would enter from NH Route 9 westbound, coming from the intersection of NH Route 9 and NH Route 125, and 29.8% would enter from NH Route 9 eastbound. It was then determined that 70.2% of vehicles would exit to NH Route 9 eastbound, going to the intersection of NH Route 9 and NH Route 125, and 29.8% of vehicles would exit to NH Route 9 westbound. This directional break down is used later in the document in the determination of turning movements and turn bay

warrant analyses. In addition, Figure 5 shows the configuration of the intersection of NH Route 9 and NH Route 125 with surrounding roadways, including AADT values (NHDOT).

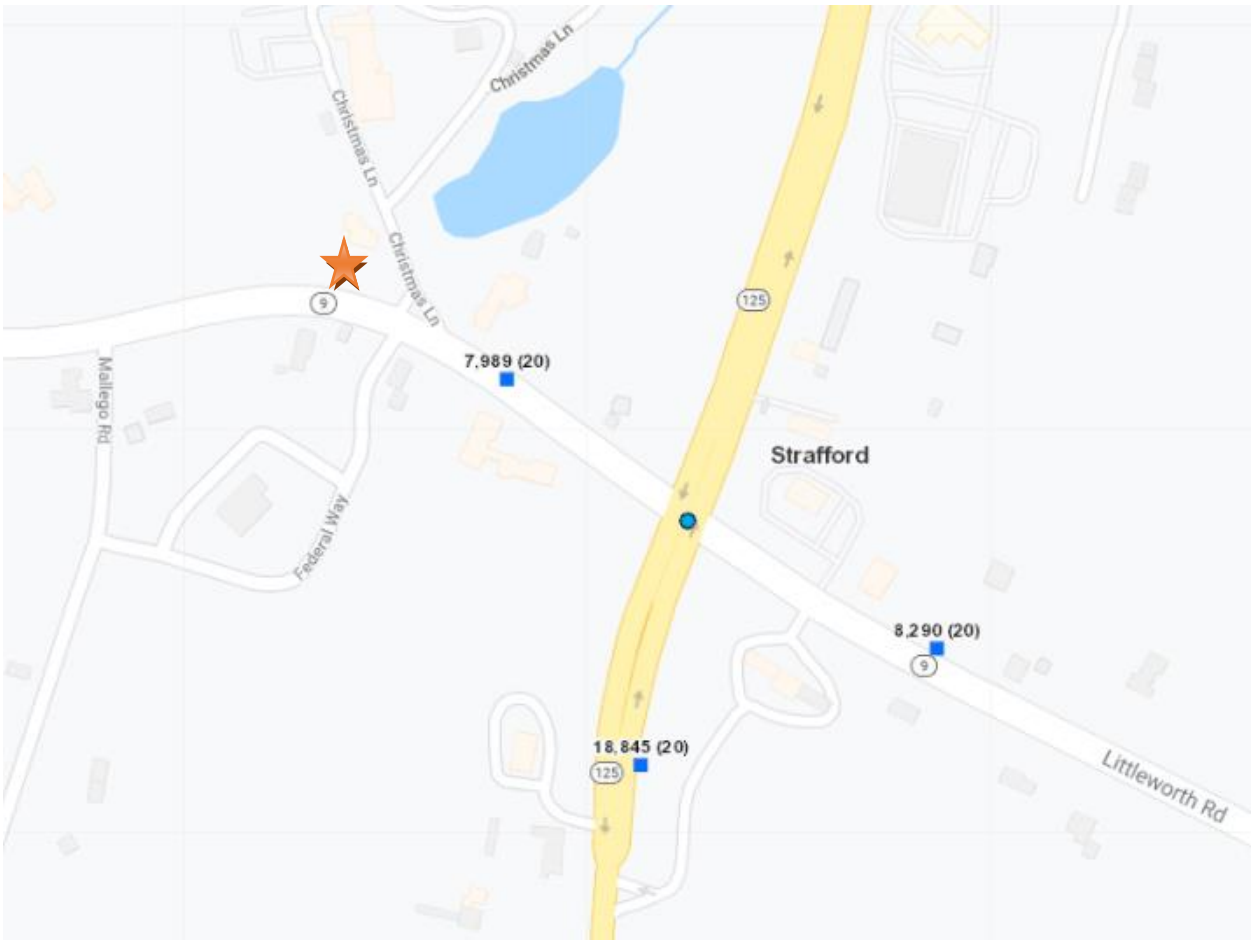


Figure 5: Figure of the intersection of NH Route 9 and NH Route 125 with AADT values (NHDOT)

Intersection of NH Route 9 and NH Route 125 Crash Data

Vehicle collision data obtained from the Barrington Police Department provided intersection crash information from 2011-2020. It was shown from this data that an average of seven vehicle collisions occur per year. Of these seven, an average of one occurs during the weekday AM peak hour, one during the PM Peak hour, and five occur off of weekday peak hours. A total of 65 document vehicle collisions occurred during the evaluation time frame with an average of one motor vehicle collision nearly every-other month. Table 3 demonstrates the breakdown of motor vehicle collisions at the intersection of NH Route 9 and NH Route 125:

Motor Vehicle Accidents Intersection of NH 9 & 125 Since 2011				
Year	AM Peak Hour	PM Peak Hour	Off Weekday Peak Hour	Total
2011	1	2	7	10
2012	0	0	4	4
2013	1	1	3	5
2014	0	3	10	13
2015	0	0	2	2
2016	0	1	2	3
2017	0	0	3	3
2018	0	1	3	4
2019	4	0	7	11
2020	5	1	4	10
Total	11	9	45	65
Average	1.1	0.9	4.5	6.5

Table 3: NH Route 9 & NH Route 125 motor vehicle collisions (Barrington PD)

Existing Trip Generation

The 9th and 10th Edition ITE Trip Generation Manual was used to determine the existing volume of trips, as well as the percentage of entrance-to-exit traffic experienced during the AM & PM peak hours between 7 and 9 AM and 4 and 6 PM and the Saturday peak hours between 11 AM and 1 PM. Land Use Codes Single Family Detached Housing (210 10th Edition) and Specialty Retail Center (826 9th Edition) were used in deriving the trip generation for the existing site. Tables 4-6 provide average trip rate, total trips generated, enter to exit ratio, and the enter to exit distribution. Given the extremely seasonal draw the Christmas Dove has, it is anticipated that the ITE generation rates given for this use, on this site, will generate a conservatively high volume of traffic for most times of the year. BS&E has witnessed far less traffic than stated below in the PM peak hour. Land Use Code 826 is not included in the 10th Edition, so the 9th Edition ITE Trip Generation Manual has been used to supplement the trip generation. This is also done to be consistent with the previously submitted TIA in 2018. Since the 9th Edition does not include a Saturday peak hour generation, the PM peak hour generation has been used for Saturday, generating a further conservative estimate.

Single Family Detached Housing Existing Trip Generation:

Time Method	AM Peak Adj. Street (Page 3) Dwelling Units			Time Method	PM Peak Adj. Street (Page 4) Dwelling Units			Time Method	Sat. Peak Generator (Page 8) Dwelling Units		
# Units	3			# Units	3			# Units	3		
Avg. Rate	0.74			Avg. Rate	0.99			Avg. Rate	0.93		
Total Trips	2.2			Total Trips	3.0			Total Trips	2.8		
% Enter	25.0	Total Enter	0.6	% Enter	63.0	Total Enter	1.9	% Enter	54.0	Total Enter	1.5
% Exit	75.0	Total Exit	1.7	% Exit	37.0	Total Exit	1.1	% Exit	46.0	Total Exit	1.3

Table 4: (Single Family Detached Housing) Peak hour of adjacent street traffic AM & PM

Specialty Retail Center Existing Trip Generation:

Time Method	AM Peak Adj. Street 1000 Sq. Ft Gross Leaseable Area			Time Method	PM Peak Adj. Street (Page 1580) 1000 Sq. Ft Gross Leaseable Area			Time Method	Sat. Peak Generator 1000 Sq. Ft Gross Leaseable Area		
GLA (Ft. Sq.)	11.45			GLA (Ft. Sq.)	11.45			GLA (Ft. Sq.)	11.45		
Avg. Rate	CLOSED			Avg. Rate	2.71			Avg. Rate	2.71		
Total Trips	0.0			Total Trips	31.0			Total Trips	31.0		
% Enter	0.0	Total Enter	0.0	% Enter	44.0	Total Enter	13.7	% Enter	50	Total Enter	15.5
% Exit	0.0	Total Exit	0.0	% Exit	56.0	Total Exit	17.4	% Exit	50	Total Exit	15.5

Table 5: (Specialty Retail Center) Peak hour of adjacent street traffic PM

Total Existing Trip Generation:

Time	AM Peak Adj. Street			Time	PM Peak Adj. Street			Time	Sat. Peak Generator		
Total Trips	2.2			Total Trips	34.0			Total Trips	33.8		
% Enter	25.0	Total Enter	0.6	% Enter	49.8	Total Enter	16.9	% Enter	54.0	Total Enter	18.3
% Exit	75.0	Total Exit	1.7	% Exit	50.2	Total Exit	17.1	% Exit	46.0	Total Exit	15.6

Table 6: Total existing trip generation peak hour of adjacent street traffic AM & PM

Proposed Trip Generation

The 10th Edition ITE Trip Generation Manual was used to determine the proposed volume of trips. Included is the percentage of entrance-to-exit traffic experienced during the weekday AM & PM peak hours between 7 and 9 AM and 4 and 6 PM and the Saturday peak hour between 11 AM and 1 PM. Land Use Codes Multifamily Housing (Mid-Rise) (221), Mid-Rise Residential with 1st Floor Commercial (231) and General Office Building (710) were used in deriving the proposed trip generation from the project site. Tables 7-9 provide average trip rate, total trips generated, enter to exit ratio, and the enter to exit distribution. Table 10 shows the total proposed trip generation during the weekday AM, PM peak hours, and Saturday peak hour. Table 11 shows the total trip generation of the existing plus the proposed. Table 12 shows the increase in proposed trips from the existing condition.

Multifamily Housing (Mid-rise):

Time Method	AM Peak Adj. Street (Page 273) Dwelling Units			Time Method	PM Peak Adj. Street (Page 274) Dwelling Units			Time Method	Sat. Peak Generator (Page 277) Dwelling Units		
# Units	40			# Units	40			# Units	40		
Avg. Rate	0.30			Avg. Rate	0.36			Avg. Rate	0.86		
Total Trips	12.0			Total Trips	14.4			Total Trips	34.4		
% Enter	28.0	Total Enter	3.4	% Enter	70.0	Total Enter	10.1	% Enter	50.0	Total Enter	17.2
% Exit	72.0	Total Exit	8.6	% Exit	30.0	Total Exit	4.3	% Exit	50.0	Total Exit	17.2

Table 7: (Multifamily Housing (Mid-rise)) Peak hr of adjacent street traffic AM, PM, & Saturday gen

Mid-Rise Residential w/ 1st Floor Commercial (Low Rise):

Time Method	Weekday Total (Page 31) Dwelling Units			Time Method	AM Peak Adj. Street (Page 32) Dwelling Units			Time Method	PM Peak Adj. Street (Page 33) Dwelling Units		
# Units	41			# Units	41			# Units	41		
Avg. Rate	9.44			Avg. Rate	0.46			Avg. Rate	0.56		
Total Trips	387.0			Total Trips	18.9			Total Trips	23.0		
% Enter	50.0	Total Enter	193.5	% Enter	23.0	Total Enter	4.3	% Enter	63.0	Total Enter	14.5
% Exit	50.0	Total Exit	193.5	% Exit	77.0	Total Exit	14.5	% Exit	37.0	Total Exit	8.5

Table 8: (Mid-Rise Res w/ 1st Fr Com) Peak hr of adjacent street traffic AM, PM, & Saturday gen

General Office Building:

Time Method	AM Peak Adj. Street (Page 4) 1000 Sq. Ft Gross Floor Area			Time Method	PM Peak Adj. Street (Page 5) 1000 Sq. Ft Gross Floor Area			Time Method	Sat. Peak Generator (Page 9) 1000 Sq. Ft Gross Floor Area		
GFA (Ft. Sq.)	21			GFA (Ft. Sq.)	21			GFA (Ft. Sq.)	21		
Avg. Rate	1.16			Avg. Rate	1.15			Avg. Rate	0.53		
Total Trips	24.4			Total Trips	24.2			Total Trips	11.1		
% Enter	86.0	Total Enter	20.9	% Enter	16.0	Total Enter	3.9	% Enter	54.0	Total Enter	6.0
% Exit	14.0	Total Exit	3.4	% Exit	84.0	Total Exit	20.3	% Exit	46.0	Total Exit	5.1

Table 9: (General Office Building) Peak hr of adjacent street traffic AM, PM, & Saturday gen

Total Proposed Trip Generation:

Time	AM Peak Adj. Street Traffic			Time	PM Peak Adj. Street Traffic			Time	Saturday Peak Generator		
Total Trips	45.4			Total Trips	49.6			Total Trips	56.5		
% Enter	58.8	Total Enter	26.6	% Enter	41.7	Total Enter	20.7	% Enter	50.6	Total Enter	28.6
% Exit	41.2	Total Exit	18.7	% Exit	58.3	Total Exit	28.9	% Exit	49.4	Total Exit	27.9

Table 10: Proposed trip generation from the project site during AM, PM, & Saturday gen

Total Existing & Proposed Trip Generation:

Time	AM Peak Adj. Street Traffic			Time	PM Peak Adj. Street Traffic			Time	Saturday Peak Generator		
Total Trips	47.6			Total Trips	83.5			Total Trips	90.3		
% Enter	57.2	Total Enter	27.2	% Enter	45.0	Total Enter	37.6	% Enter	51.9	Total Enter	46.9
% Exit	42.8	Total Exit	20.4	% Exit	55.0	Total Exit	46.0	% Exit	48.1	Total Exit	43.5

Table 11: Proposed trip generation from the project site Saturday & Sunday peak hour

Changes in Trip Generation:

Changes in Trip Generation	
Time	# Trips Increased
AM Peak	45.4
PM Peak	49.6
Saturday Peak	56.5

Table 12: Changes in trip generation

Build Traffic Projections and Turning Analysis

Traffic data obtained from the NHDOT in 2019 has been projected to 2021 and ten years further to 2031. This has been done using a June peak seasonal adjustment factor of 1.00 (AM, PM & Saturday) 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 22 in Appendix C. Figures 6 and 7 show the build turning movements to and from the proposed site during weekday AM and PM peak hours. Figure 8 shows the build turning movements to and from the proposed site during Saturday peak hour. These figures also show the projected volume of traffic eastbound and westbound on N.H. Route 9 for 2021 and 2031. This data is then used to preform NCHRP 457 left-turn and right-turn bay warrant analyses. Appendix B contains the data that was used to conduct the analyses as Figures 17-19 and 26-28. Since Saturday traffic counts for this area of NH Route 9 are not available, PM peak traffic volumes have been applied to Saturday turning movements as a conservative estimate or expected traffic. A visual of these turning movements is shown in the following figures.

Figure 6: 2021 & 2031 build projected traffic volumes and turning movements weekday AM peak hour

Figure 7: 2021 & 2031 build projected traffic volumes and turning movements weekday PM peak hour

Figure 8: 2021 & 2031 build projected traffic volumes and turning movements Saturday peak hour

Tables 13-15 show in a tabular format the total trips that are calculated to occur to and from the proposed site entrance are shown at the three peak hours analyzed 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	# Trips	Turn Type	% Distribution
Total Trips	47.6			
Trips Enter from Route 9 Eastbound		8.1	Left	17.0
Trips Enter from Route 9 Westbound		19.1	Right	40.2
Trips Exit to Route 9 Eastbound		14.3	Left	30.1
Trips Exit to Route 9 Westbound		6.1	Right	12.7

Table 13: Weekday AM peak hour build turning movements to and from the project site

Time	PM Peak Hour	# Trips	Turn Type	% Distribution
Total Trips	83.5			
Trips Enter from Route 9 Eastbound		11.2	Left	13.4
Trips Enter from Route 9 Westbound		26.4	Right	31.6
Trips Exit to Route 9 Eastbound		32.3	Left	38.6
Trips Exit to Route 9 Westbound		13.7	Right	16.4

Table 14: Weekday PM peak hour build turning movements to and from the project site

Time	Saturday Peak Hour	# Trips	Turn Type	% Distribution
Total Trips	90.3			
Trips Enter from Route 9 Eastbound		14.0	Left	15.4
Trips Enter from Route 9 Westbound		32.9	Right	36.4
Trips Exit to Route 9 Eastbound		30.5	Left	33.8
Trips Exit to Route 9 Westbound		12.9	Right	14.3

Table 15: Saturday peak hour build turning movements to and from the project site

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 traffic volumes obtained from the NHDOT from 2019 projected to 2021 and 2031 were used to determine if a left-turn bay is warranted to safely enter the site. It has been calculated that approximately 8 trips are to occur turning left into the site during the weekday AM peak hour and 11 trips during the PM peak hour. It has also been calculated that approximately 14 trips are to occur turning left into the site during the Saturday peak hour. The projection of the traffic volumes and data used to conduct the left-turn bay warrant analyses are included in Appendix B as Figures 17-19. The full warrant analyses can be found in Appendix B as Figures 20-25. Tables 16-18 are summaries of the left-turn bay warrant analyses for the proposed site entrance. Using the 85th percentile speed of 35 MPH, it was determined that a left-turn bay IS NOT warranted to safely enter the proposed site.

Left-Turn Lane Warrants Analysis N.H. Route 9		
Factors	2021 Weekday AM Build Volume	2031 Weekday AM Build Volume
Left-Turn Volume (EB)	8	8
Advancing Volume (EB) (L+TR+R)	669	736
Opposing Volume (WB) (TR+R)	235	257
Percent Lefts	1%	1%
85th Percentile Speed (MPH)	35	35
Limiting Adv. Volume (veh/hr)	1,275	1,243
Left-Turn Bay Warranted	NO	NO

Table 16: Summary of Weekday AM peak hour NCHRP 457 left-turn bay analysis

Left-Turn Lane Warrants Analysis N.H. Route 9		
Factors	2021 Weekday PM Build Volume	2031 Weekday PM Build Volume
Left-Turn Volume (EB)	11	11
Advancing Volume (EB) (L+TR+R)	378	414
Opposing Volume (WB) (TR+R)	676	744
Percent Lefts	3%	3%
85th Percentile Speed (MPH)	35	35
Limiting Adv. Volume (veh/hr)	518	484
Left-Turn Bay Warranted	NO	NO

Table 17: Summary of Weekday PM peak hour NCHRP 457 left-turn bay analysis

Left-Turn Lane Warrants Analysis N.H. Route 9		
Factors	2021 Weekday Sat. Build Volume	2031 Weekday Sat. Build Volume
Left-Turn Volume (EB)	14	14
Advancing Volume (EB) (L+TR+R)	387	423
Opposing Volume (WB) (TR+R)	682	750
Percent Lefts	4%	3%
85th Percentile Speed (MPH)	35	35
Limiting Adv. Volume (veh/hr)	468	432
Left-Turn Bay Warranted	NO	NO

Table 18: Summary of Saturday peak hour NCHRP 457 left-turn bay analysis

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 traffic volumes obtained from Accurate Counts from 2020 projected to 2021 and 2031 were used to determine if a right-turn bay is warranted to safely enter the site. It has been calculated that approximately 19 trips are to occur turning right into the site during the weekday AM peak hour and 26 trips during the PM peak hour. It has also been calculated that approximately 33 trips are to occur turning right into the site during the Saturday peak hour. The projection of the traffic volumes and data used to conduct the right-turn bay warrant analyses are included in Appendix B as Figures 26-28. The full warrant analyses can be found in Appendix B as Figures 29-34. Tables 19-21 are summaries of the right-turn bay warrant analyses for the proposed site entrance. Using the 85th percentile speed of 35 MPH, it was determined that a right-turn bay IS NOT warranted to safely enter the proposed site.

Right-Turn Lane Warrants Analysis N.H. Route 9		
Factors	2021 Weekday AM Build Volume	2031 Weekday AM Build Volume
Right-Turn Volume (WB)	19	19
Advancing Volume (WB) (FWL+TR+R)	243	265
85th Percentile Speed (MPH)	35	35
Limiting Right-Turn Volume (veh/hr)	2843	2058
Right-Turn Bay Warranted	NO	YES

Table 19: Summary of Weekday AM peak hour NCHRP 457 right-turn bay analysis

Right-Turn Lane Warrants Analysis N.H. Route 9		
Factors	2021 Weekday PM Build Volume	2031 Weekday PM Build Volume
Right-Turn Volume (WB)	26	26
Advancing Volume (WB) (L+TR+R)	687	755
85th Percentile Speed (MPH)	35	35
Limiting Right-Turn Volume (veh/hr)	65	46
Right-Turn Bay Warranted	NO	NO

Table 20: Summary of Weekday PM peak hour NCHRP 457 right-turn bay analysis

Right-Turn Lane Warrants Analysis N.H. Route 9		
Factors	2021 Weekday Sat. Build Volume	2031 Weekday Sat. Build Volume
Right-Turn Volume (WB)	33	33
Advancing Volume (WB) (L+TR+R)	696	764
85th Percentile Speed (MPH)	35	35
Limiting Right-Turn Volume (veh/hr)	62	44
Right-Turn Bay Warranted	NO	NO

Table 21: Summary of Saturday peak hour NCHRP 457 right-turn bay analysis

Sight Distance and Safety Analysis

The proposed driveway is located at the apex of the road curve to maximize sight distance. Sight distance to the east and west, as well as driveway alignment are the two determining factors of safety. Sight distance to the east is un-obstructed for well over 400 feet (measured) while sight distance to the west is un-obstructed for well over 400 feet (measured.) Using Exhibit 3-1 (Stopping Sight Distance) (Figure 35) in the Geometric Design Manual, a 35 mph 85th percentile speed requires the stopping sight distance be 250 feet from the both directions. The standard sight distance required by NHDOT is 400 feet in cases where the Geometric Design Manual would not require more. 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 maintain this site distance.

With respect to general safety of NH Route 9 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 47 vehicle trips (27 enter/20 exit) are predicted to occur at the weekday AM peak hour and 83 vehicle trips (37 enter/46 exit) at the PM peak hour.

2.) A total of 90 vehicle trips (47 enter/43 exit) are predicted to occur at the Saturday peak hour.

3.) The 2021 and 2031 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a left-turn lane for all peak hours.

4.) The 2021 and 2031 build traffic volumes DO NOT satisfy the NCHRP 457 guidelines for the implementation of a right-turn lane for all peak hours.

5.) This is an increase of 45 weekday AM peak hour trips, 50 weekday PM peak hour trips, and 57 Saturday peak hour trips.

Respectfully Submitted,

BERRY SURVEYING & ENGINEERING

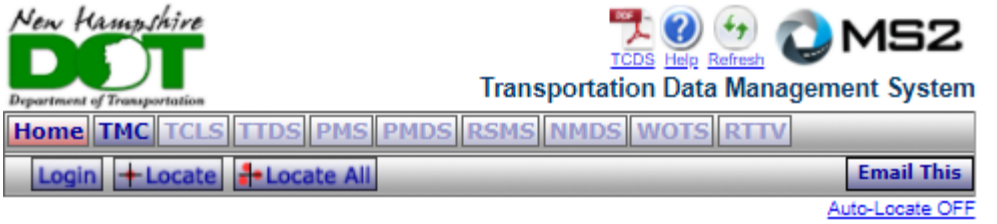
Christopher R. Berry, SIT
Principal, President

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

KRP/krp

Appendix A

Traffic Counts



List View | All DIRs

Record 1 of 1 Goto Record go

Location ID	82027056	MPO ID	
Type	SPOT	HPMS ID	
On NHS	No	On HPMS	No
LRS ID	S0000009__	LRS Loc Pt.	
SF Group	02	Route Type	
AF Group	02	Route	NH 9
GF Group	E	Active	Yes
Class Dist Grp	Default	Category	3
Seas Clss Grp	Default		
WIM Group	Default		
QC Group	Default		
Fnct'l Class	Major Collector	Milepost	
Located On	Franklin Pierce Hwy		
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)		

More Detail

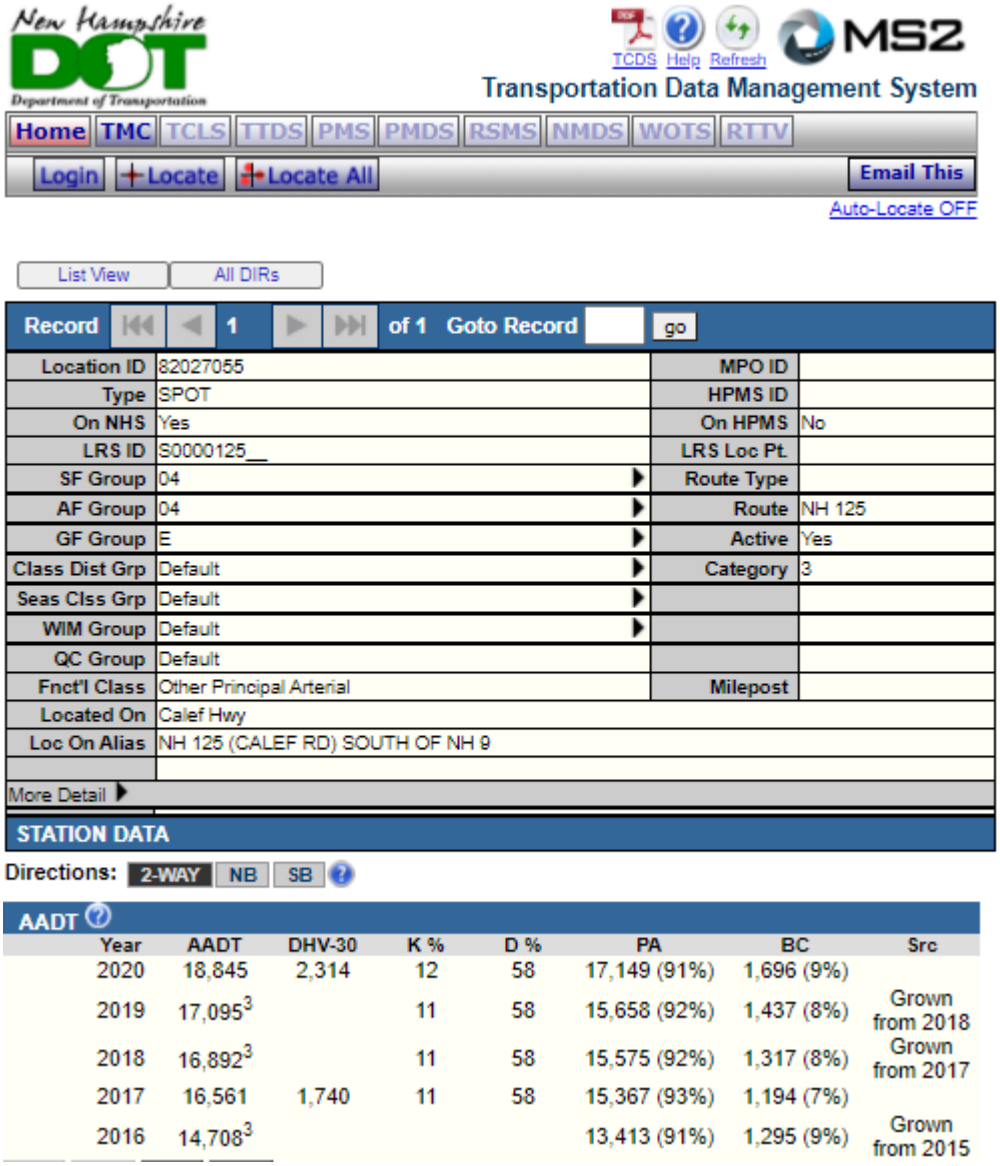
STATION DATA

Directions: 2-WAY EB WB

AADT

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2020	7,989[3]		11	68	7,270 (91%)	719 (9%)	Grown from 2019
2019	9,466	1,011	11	68	8,670 (92%)	796 (8%)	
2018	6,482[3]		13	71	5,977 (92%)	505 (8%)	Grown from 2017
2017	6,355[3]		13	71	5,899 (93%)	456 (7%)	Grown from 2016
2016	6,230	821	13	71	5,682 (91%)	548 (9%)	

Figure 9: History of AADT values and classification for N.H. Route 9



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Record 1 of 1 Goto Record go

Location ID	82027055	MPO ID	
Type	SPOT	HPMS ID	
On NHS	Yes	On HPMS	No
LRS ID	S0000125__	LRS Loc Pt.	
SF Group	04	Route Type	
AF Group	04	Route	NH 125
GF Group	E	Active	Yes
Class Dist Grp	Default	Category	3
Seas Clss Grp	Default		
WIM Group	Default		
QC Group	Default		
Fnct'l Class	Other Principal Arterial	Milepost	
Located On	Calef Hwy		
Loc On Alias	NH 125 (CALEF RD) SOUTH OF NH 9		

More Detail

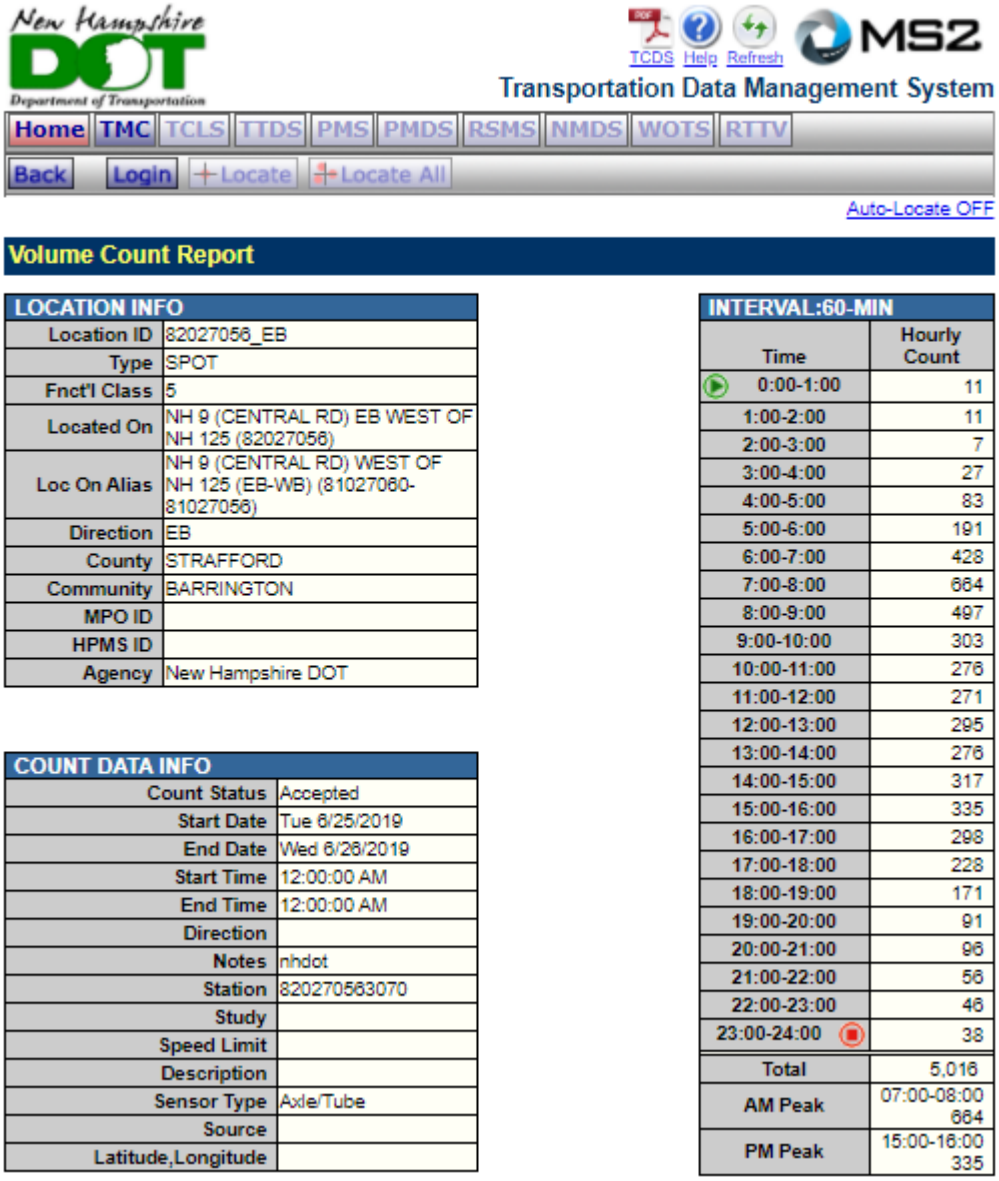
STATION DATA

Directions: 2-WAY | NB | SB

AADT

Year	AADT	DHV-30	K %	D %	PA	BC	Src
2020	18,845	2,314	12	58	17,149 (91%)	1,696 (9%)	
2019	17,095[3]		11	58	15,658 (92%)	1,437 (8%)	Grown from 2018
2018	16,892[3]		11	58	15,575 (92%)	1,317 (8%)	Grown from 2017
2017	16,561	1,740	11	58	15,367 (93%)	1,194 (7%)	
2016	14,708[3]				13,413 (91%)	1,295 (9%)	Grown from 2015

Figure 10: History of AADT values and classification for N.H. Route 125



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Volume Count Report

LOCATION INFO	
Location ID	82027056_EB
Type	SPOT
Fnct'l Class	5
Located On	NH 9 (CENTRAL RD) EB WEST OF NH 125 (82027056)
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)
Direction	EB
County	STRAFFORD
Community	BARRINGTON
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 6/25/2019
End Date	Wed 6/26/2019
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	820270563070
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	11
1:00-2:00	11
2:00-3:00	7
3:00-4:00	27
4:00-5:00	83
5:00-6:00	191
6:00-7:00	428
7:00-8:00	664
8:00-9:00	497
9:00-10:00	303
10:00-11:00	276
11:00-12:00	271
12:00-13:00	295
13:00-14:00	276
14:00-15:00	317
15:00-16:00	335
16:00-17:00	298
17:00-18:00	228
18:00-19:00	171
19:00-20:00	91
20:00-21:00	96
21:00-22:00	56
22:00-23:00	46
23:00-24:00	38
Total	5,016
AM Peak	07:00-08:00 664
PM Peak	15:00-16:00 335

Figure 11: Tuesday June 25, 2019 NH Route 9 eastbound hourly traffic count

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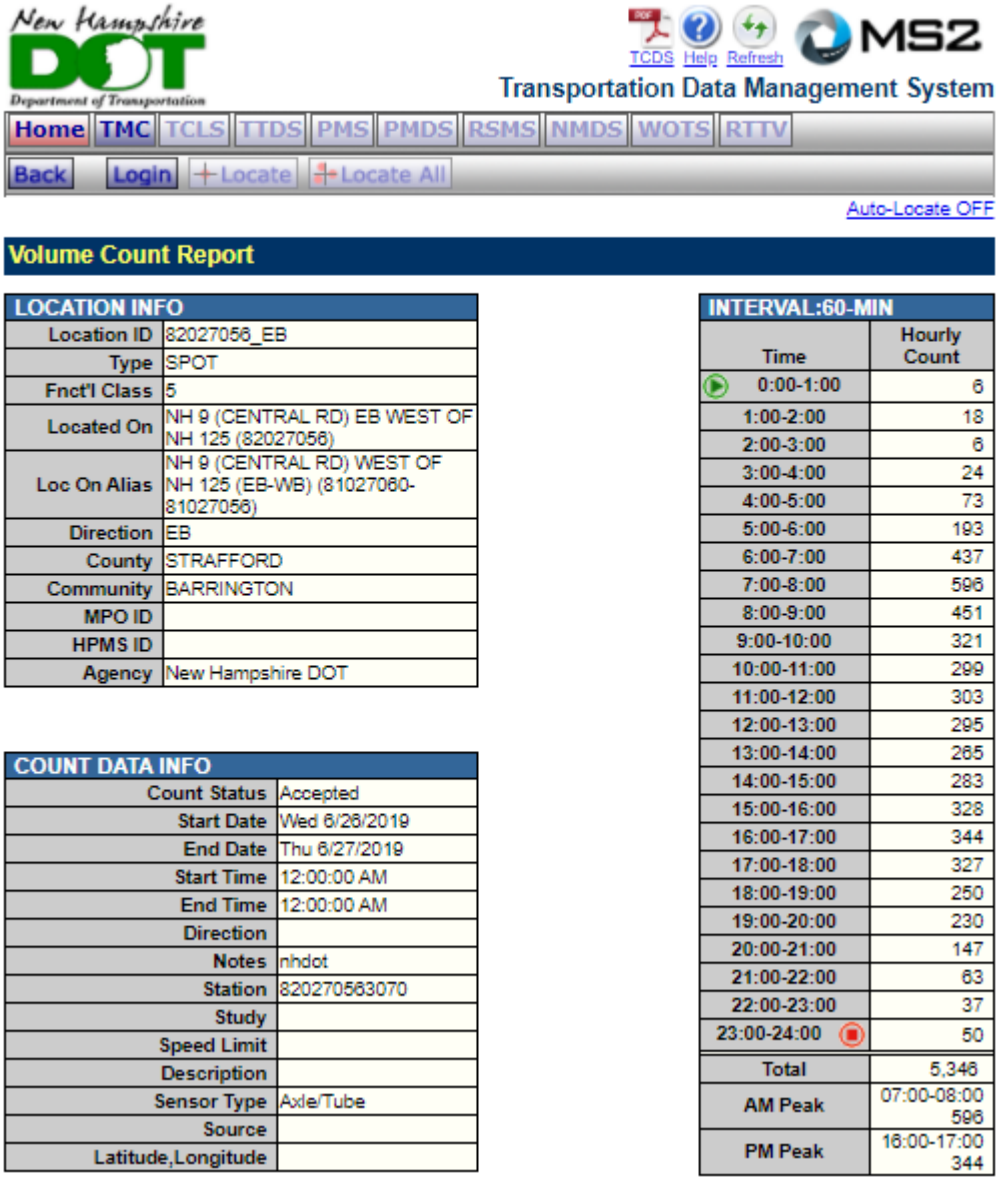
Volume Count Report

LOCATION INFO	
Location ID	82027056_WB
Type	SPOT
Fnct'l Class	5
Located On	NH 9 (CENTRAL RD) WB WEST OF NH 125 (82027056)
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)
Direction	WB
County	STRAFFORD
Community	BARRINGTON
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Tue 6/25/2019
End Date	Wed 6/26/2019
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	820270563070
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	24
1:00-2:00	8
2:00-3:00	6
3:00-4:00	8
4:00-5:00	15
5:00-6:00	40
6:00-7:00	125
7:00-8:00	195
8:00-9:00	201
9:00-10:00	238
10:00-11:00	221
11:00-12:00	263
12:00-13:00	274
13:00-14:00	296
14:00-15:00	358
15:00-16:00	494
16:00-17:00	566
17:00-18:00	581
18:00-19:00	330
19:00-20:00	190
20:00-21:00	151
21:00-22:00	104
22:00-23:00	80
23:00-24:00	34
Total	4,802
AM Peak	11:00-12:00 263
PM Peak	17:00-18:00 581

Figure 12: Tuesday June 25, 2019 NH Route 9 westbound hourly traffic count



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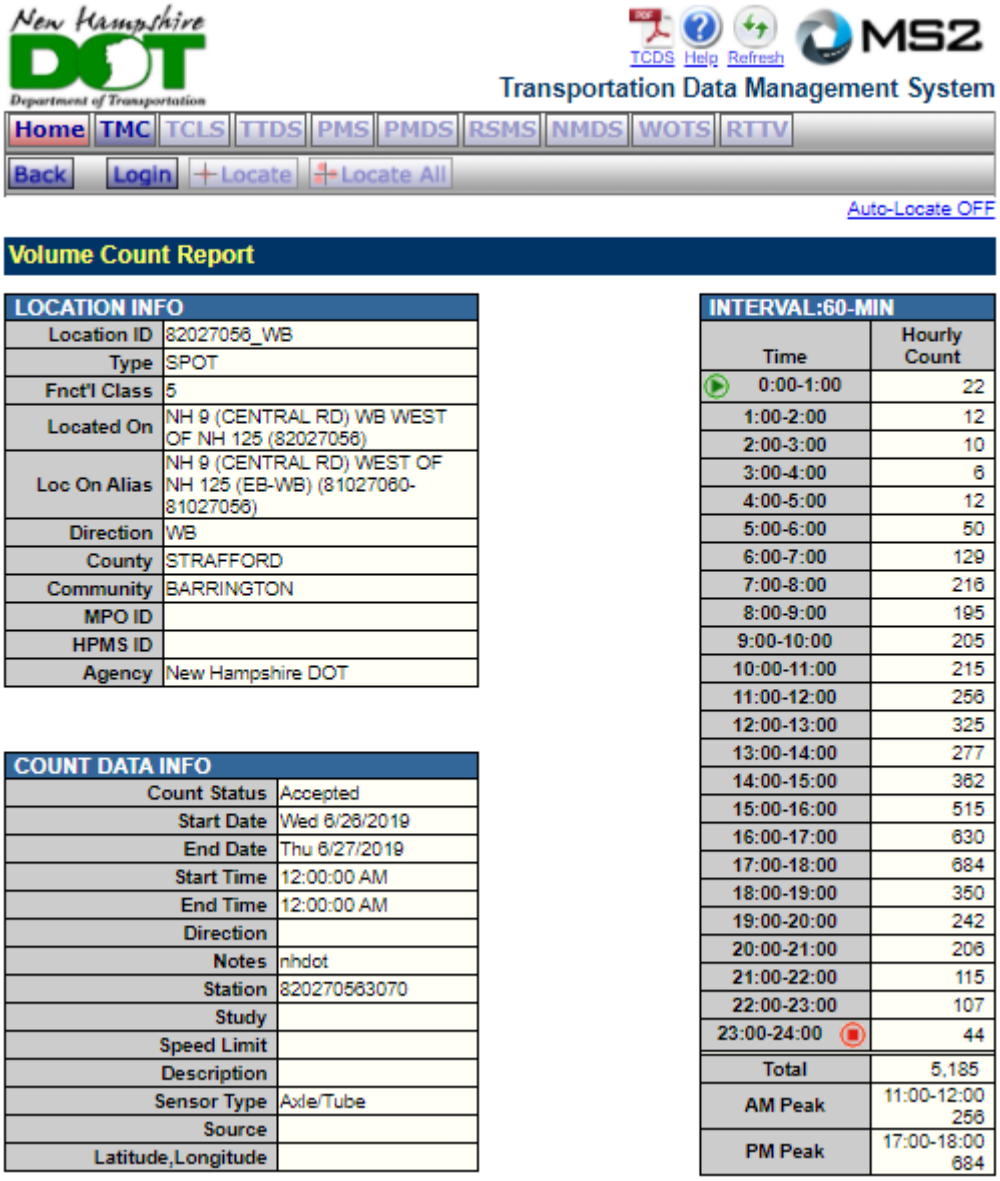
Volume Count Report

LOCATION INFO	
Location ID	82027056_EB
Type	SPOT
Fnct'l Class	5
Located On	NH 9 (CENTRAL RD) EB WEST OF NH 125 (82027056)
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)
Direction	EB
County	STRAFFORD
Community	BARRINGTON
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Wed 6/26/2019
End Date	Thu 6/27/2019
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	820270563070
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	6
1:00-2:00	18
2:00-3:00	6
3:00-4:00	24
4:00-5:00	73
5:00-6:00	193
6:00-7:00	437
7:00-8:00	596
8:00-9:00	451
9:00-10:00	321
10:00-11:00	299
11:00-12:00	303
12:00-13:00	295
13:00-14:00	265
14:00-15:00	283
15:00-16:00	328
16:00-17:00	344
17:00-18:00	327
18:00-19:00	250
19:00-20:00	230
20:00-21:00	147
21:00-22:00	63
22:00-23:00	37
23:00-24:00	50
Total	5,346
AM Peak	07:00-08:00 596
PM Peak	16:00-17:00 344

Figure 13: Wednesday June 26, 2019 NH Route 9 eastbound hourly traffic count



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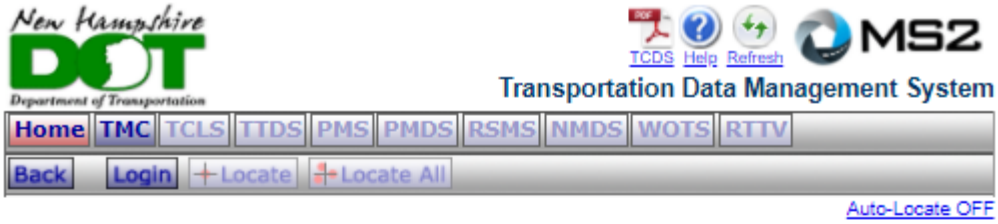
Volume Count Report

LOCATION INFO	
Location ID	82027056_WB
Type	SPOT
Fnct'l Class	5
Located On	NH 9 (CENTRAL RD) WB WEST OF NH 125 (82027056)
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)
Direction	WB
County	STRAFFORD
Community	BARRINGTON
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Wed 6/26/2019
End Date	Thu 6/27/2019
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	820270563070
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	22
1:00-2:00	12
2:00-3:00	10
3:00-4:00	6
4:00-5:00	12
5:00-6:00	50
6:00-7:00	129
7:00-8:00	216
8:00-9:00	195
9:00-10:00	205
10:00-11:00	215
11:00-12:00	256
12:00-13:00	325
13:00-14:00	277
14:00-15:00	362
15:00-16:00	515
16:00-17:00	630
17:00-18:00	684
18:00-19:00	350
19:00-20:00	242
20:00-21:00	206
21:00-22:00	115
22:00-23:00	107
23:00-24:00	44
Total	5,185
AM Peak	11:00-12:00 256
PM Peak	17:00-18:00 684

Figure 14: Wednesday June 26, 2019 NH Route 9 westbound hourly traffic count



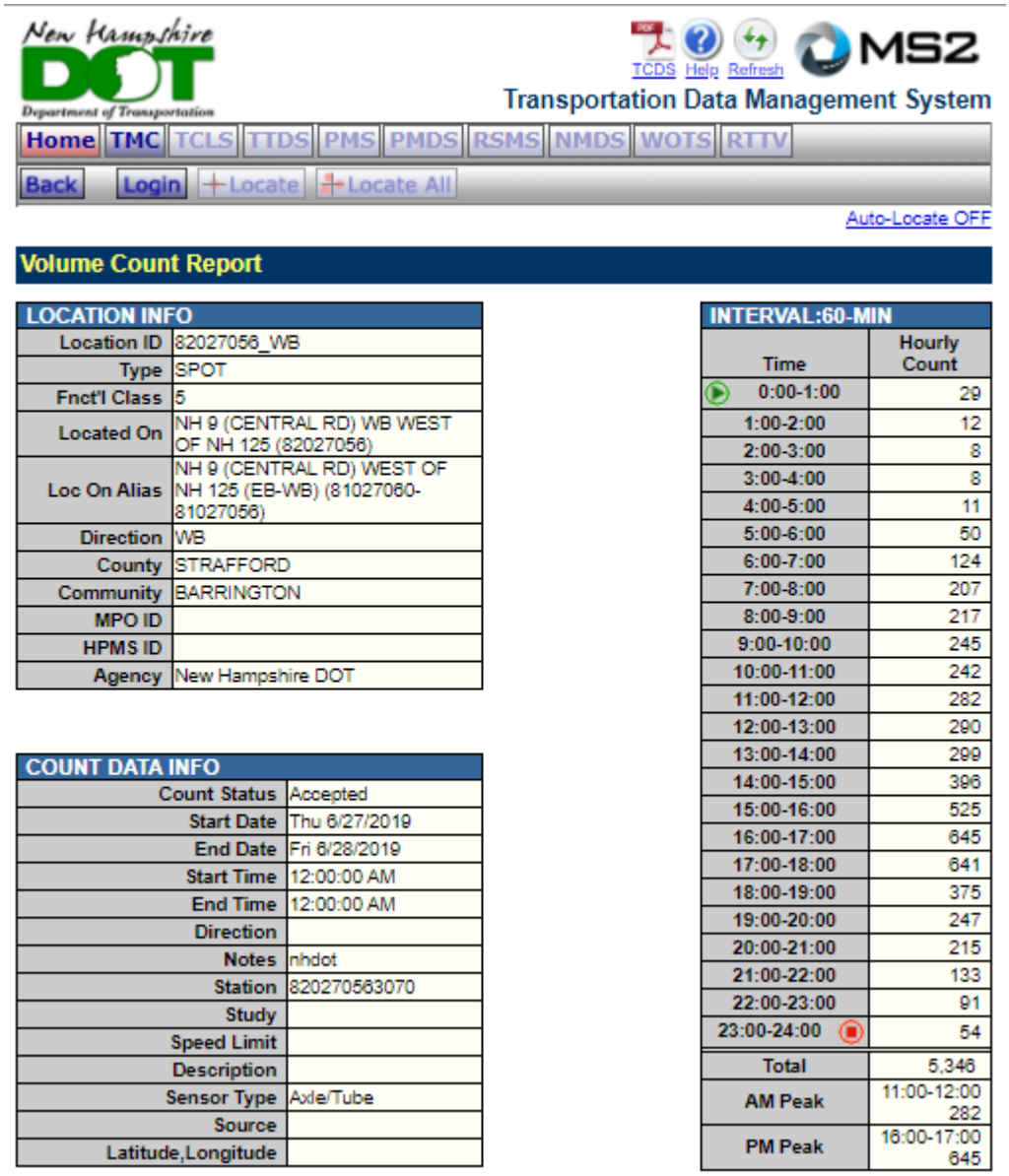
Volume Count Report

LOCATION INFO	
Location ID	82027056_EB
Type	SPOT
Fnct'l Class	5
Located On	NH 9 (CENTRAL RD) EB WEST OF NH 125 (82027056)
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)
Direction	EB
County	STRAFFORD
Community	BARRINGTON
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Thu 6/27/2019
End Date	Fri 6/28/2019
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	820270563070
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	17
1:00-2:00	13
2:00-3:00	7
3:00-4:00	24
4:00-5:00	76
5:00-6:00	184
6:00-7:00	424
7:00-8:00	627
8:00-9:00	461
9:00-10:00	338
10:00-11:00	278
11:00-12:00	334
12:00-13:00	285
13:00-14:00	276
14:00-15:00	316
15:00-16:00	329
16:00-17:00	359
17:00-18:00	315
18:00-19:00	228
19:00-20:00	207
20:00-21:00	187
21:00-22:00	89
22:00-23:00	58
23:00-24:00	40
Total	5,472
AM Peak	07:00-08:00 627
PM Peak	16:00-17:00 359

Figure 15: Thursday June 27, 2019 NH Route 9 eastbound hourly traffic count



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Volume Count Report

LOCATION INFO	
Location ID	82027056_WB
Type	SPOT
Fnct'l Class	5
Located On	NH 9 (CENTRAL RD) WB WEST OF NH 125 (82027056)
Loc On Alias	NH 9 (CENTRAL RD) WEST OF NH 125 (EB-WB) (81027060-81027056)
Direction	WB
County	STRAFFORD
Community	BARRINGTON
MPO ID	
HPMS ID	
Agency	New Hampshire DOT

COUNT DATA INFO	
Count Status	Accepted
Start Date	Thu 6/27/2019
End Date	Fri 6/28/2019
Start Time	12:00:00 AM
End Time	12:00:00 AM
Direction	
Notes	nhdot
Station	820270563070
Study	
Speed Limit	
Description	
Sensor Type	Axle/Tube
Source	
Latitude,Longitude	

INTERVAL:60-MIN	
Time	Hourly Count
0:00-1:00	29
1:00-2:00	12
2:00-3:00	8
3:00-4:00	8
4:00-5:00	11
5:00-6:00	50
6:00-7:00	124
7:00-8:00	207
8:00-9:00	217
9:00-10:00	245
10:00-11:00	242
11:00-12:00	282
12:00-13:00	290
13:00-14:00	299
14:00-15:00	396
15:00-16:00	525
16:00-17:00	645
17:00-18:00	641
18:00-19:00	375
19:00-20:00	247
20:00-21:00	215
21:00-22:00	133
22:00-23:00	91
23:00-24:00	54
Total	5,348
AM Peak	11:00-12:00 282
PM Peak	16:00-17:00 645

Figure 16: Thursday June 27, 2019 NH Route 9 westbound hourly traffic count

Appendix B

Data Used in Left-Turn Bay Warrants Analysis

Year	Advancing Volume	Advancing Volume Peaked (TR)	Left Turns (L)	Right Turns (R)	Total Advancing Volume (L+TR+R)
2019	629	629.0	8.1	19.1	656.2
2020	635	635.3	8.1	19.1	662.5
2021	642	641.6	8.1	19.1	668.8
2022	648	648.1	8.1	19.1	675.3
2023	655	654.5	8.1	19.1	681.7
2024	661	661.1	8.1	19.1	688.3
2025	668	667.7	8.1	19.1	694.9
2026	674	674.4	8.1	19.1	701.6
2027	681	681.1	8.1	19.1	708.3
2028	688	687.9	8.1	19.1	715.1
2029	695	694.8	8.1	19.1	722.0
2030	702	701.8	8.1	19.1	729.0
2031	709	708.8	8.1	19.1	736.0
Year	Opposing Volume	Opposing Volume Peaked (TR)	Right Turns (R)		Total Opposing Volume (TR+R)
2019	211	211.3	19.1		230.4
2020	213	213.4	19.1		232.6
2021	216	215.6	19.1		234.7
2022	218	217.7	19.1		236.8
2023	220	219.9	19.1		239.0
2024	222	222.1	19.1		241.2
2025	224	224.3	19.1		243.4
2026	227	226.6	19.1		245.7
2027	229	228.8	19.1		247.9
2028	231	231.1	19.1		250.2
2029	233	233.4	19.1		252.5
2030	236	235.8	19.1		254.9
2031	238	238.1	19.1		257.2
Seasonal Peaking Factor (June)		1.00			

Figure 17: Data used for Weekday AM peak hour left-turn warrant analyses

Year	Advancing Volume	Advancing Volume Peaked (TR)	Left Turns (L)	Right Turns (R)	Total Advancing Volume (L+TR+R)
2019	334	333.7	11.2	26.4	371.3
2020	337	337.0	11.2	26.4	374.6
2021	340	340.4	11.2	26.4	378.0
2022	344	343.8	11.2	26.4	381.4
2023	347	347.2	11.2	26.4	384.8
2024	351	350.7	11.2	26.4	388.3
2025	354	354.2	11.2	26.4	391.8
2026	358	357.7	11.2	26.4	395.3
2027	361	361.3	11.2	26.4	398.9
2028	365	364.9	11.2	26.4	402.5
2029	369	368.6	11.2	26.4	406.2
2030	372	372.3	11.2	26.4	409.8
2031	376	376.0	11.2	26.4	413.6
Year	Opposing Volume	Opposing Volume Peaked (TR)	Right Turns (R)		Total Opposing Volume (TR+R)
2019	637	636.7	26.4		663.1
2020	643	643.0	26.4		669.4
2021	649	649.5	26.4		675.9
2022	656	656.0	26.4		682.4
2023	663	662.5	26.4		688.9
2024	669	669.1	26.4		695.5
2025	676	675.8	26.4		702.2
2026	683	682.6	26.4		709.0
2027	689	689.4	26.4		715.8
2028	696	696.3	26.4		722.7
2029	703	703.3	26.4		729.7
2030	710	710.3	26.4		736.7
2031	717	717.4	26.4		743.8
Seasonal Peaking Factor (June)		1.00			

Figure 18: Data used for Weekday PM peak hour left-turn warrant analyses

Year	Advancing Volume	Advancing Volume Peaked (TR)	Left Turns (L)	Right Turns (R)	Total Advancing Volume (L+TR+R)
2019	334	333.7	14.0	32.9	380.5
2020	337	337.0	14.0	32.9	383.9
2021	340	340.4	14.0	32.9	387.2
2022	344	343.8	14.0	32.9	390.6
2023	347	347.2	14.0	32.9	394.1
2024	351	350.7	14.0	32.9	397.5
2025	354	354.2	14.0	32.9	401.1
2026	358	357.7	14.0	32.9	404.6
2027	361	361.3	14.0	32.9	408.2
2028	365	364.9	14.0	32.9	411.8
2029	369	368.6	14.0	32.9	415.4
2030	372	372.3	14.0	32.9	419.1
2031	376	376.0	14.0	32.9	422.8
Year	Opposing Volume	Opposing Volume Peaked (TR)	Right Turns (R)		Total Opposing Volume (TR+R)
2019	637	636.7	32.9		669.6
2020	643	643.0	32.9		675.9
2021	649	649.5	32.9		682.4
2022	656	656.0	32.9		688.9
2023	663	662.5	32.9		695.4
2024	669	669.1	32.9		702.1
2025	676	675.8	32.9		708.7
2026	683	682.6	32.9		715.5
2027	689	689.4	32.9		722.3
2028	696	696.3	32.9		729.2
2029	703	703.3	32.9		736.2
2030	710	710.3	32.9		743.2
2031	717	717.4	32.9		750.3
Seasonal Peaking Factor (June)		1.00			

Figure 19: Data used for Saturday peak hour left-turn warrant analyses

Left-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.

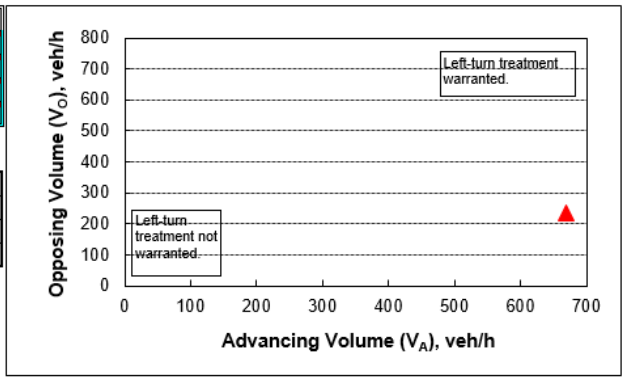
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	35
Percent of left-turns in advancing volume (V_A), %:	1%
Advancing volume (V_A), veh/h:	669
Opposing volume (V_O), veh/h:	235

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	1275
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 20: 2021 Weekday AM peak hour NCHRP 457 left-turn bay warrant analysis

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

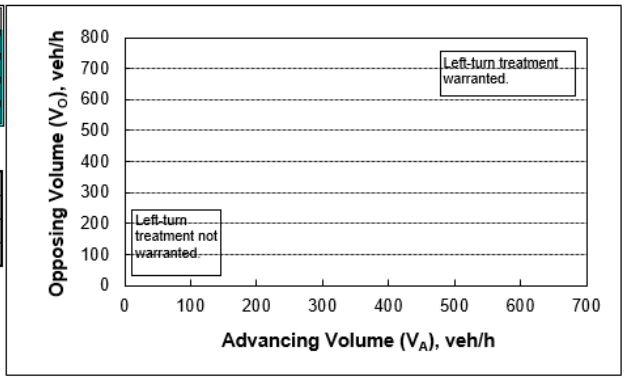
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	35
Percent of left-turns in advancing volume (V_A), %:	1%
Advancing volume (V_A), veh/h:	736
Opposing volume (V_O), veh/h:	257

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	1243
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: 2031 Weekday AM peak hour NCHRP 457 left-turn bay warrant analysis

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

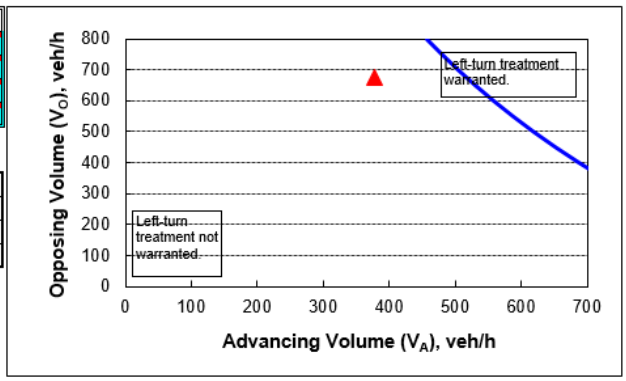
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	35
Percent of left-turns in advancing volume (V_A), %:	3%
Advancing volume (V_A), veh/h:	378
Opposing volume (V_O), veh/h:	676

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	518
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: 2021 Weekday PM peak hour NCHRP 457 left-turn bay warrant analysis

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

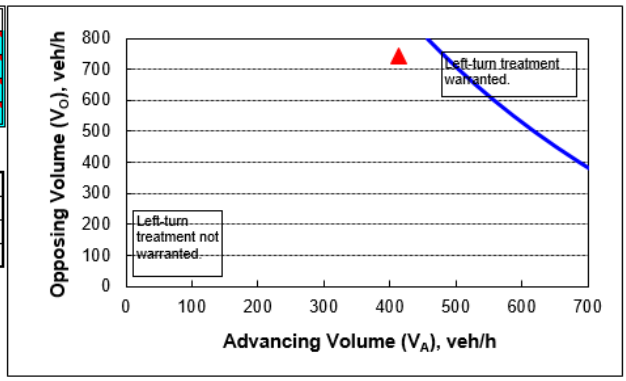
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	35
Percent of left-turns in advancing volume (V_A), %:	3%
Advancing volume (V_A), veh/h:	414
Opposing volume (V_O), veh/h:	744

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	484
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: 2031 Weekday PM peak hour NCHRP 457 left-turn bay warrant analysis

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

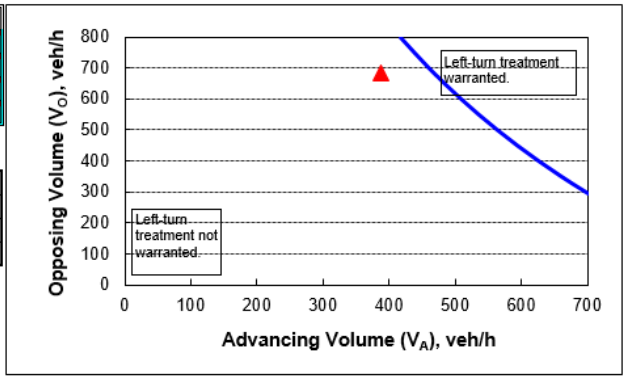
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	35
Percent of left-turns in advancing volume (V_A), %:	4%
Advancing volume (V_A), veh/h:	387
Opposing volume (V_O), veh/h:	682

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	468
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: 2021 Saturday peak hour NCHRP 457 left-turn bay warrant analysis

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

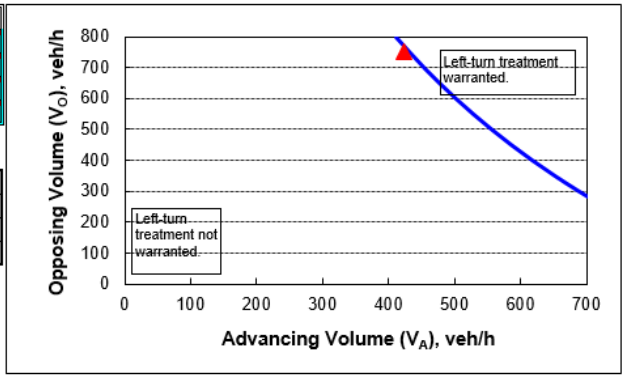
2-lane roadway (English)

INPUT

Variable	Value
85th percentile speed, mph:	40
Percent of left-turns in advancing volume (V_A), %:	3%
Advancing volume (V_A), veh/h:	423
Opposing volume (V_O), veh/h:	750

OUTPUT

Variable	Value
Limiting advancing volume (V_A), veh/h:	432
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: 2031 Saturday peak hour NCHRP 457 left-turn bay warrant analysis

Data Used in Right-Turn Bay Warrants Analysis

Year	Advancing Volume	Advancing Volume Peaked (TR)	Left Turns (L)	Right Turns (R)	Total Advancing Volume (L+TR+R)
2019	211	211.3	8.1	19.1	238.5
2020	213	213.4	8.1	19.1	240.7
2021	216	215.6	8.1	19.1	242.8
2022	218	217.7	8.1	19.1	244.9
2023	220	219.9	8.1	19.1	247.1
2024	222	222.1	8.1	19.1	249.3
2025	224	224.3	8.1	19.1	251.5
2026	227	226.6	8.1	19.1	253.8
2027	229	228.8	8.1	19.1	256.0
2028	231	231.1	8.1	19.1	258.3
2029	233	233.4	8.1	19.1	260.6
2030	236	235.8	8.1	19.1	263.0
2031	238	238.1	8.1	19.1	265.3
Seasonal Peaking Factor (June)		1.00			

Figure 26: Data used for Weekday AM peak hour right-turn warrant analyses

Year	Advancing Volume	Advancing Volume Peaked (TR)	Left Turns (L)	Right Turns (R)	Total Advancing Volume (L+TR+R)
2019	637	636.7	11.2	26.4	674.3
2020	643	643.0	11.2	26.4	680.6
2021	649	649.5	11.2	26.4	687.1
2022	656	656.0	11.2	26.4	693.5
2023	663	662.5	11.2	26.4	700.1
2024	669	669.1	11.2	26.4	706.7
2025	676	675.8	11.2	26.4	713.4
2026	683	682.6	11.2	26.4	720.2
2027	689	689.4	11.2	26.4	727.0
2028	696	696.3	11.2	26.4	733.9
2029	703	703.3	11.2	26.4	740.9
2030	710	710.3	11.2	26.4	747.9
2031	717	717.4	11.2	26.4	755.0
Seasonal Peaking Factor (June)		1.00			

Figure 27: Data used for Weekday PM peak hour right-turn warrant analyses

Year	Advancing Volume	Advancing Volume Peaked (TR)	Left Turns (L)	Right Turns (R)	Total Advancing Volume (L+TR+R)
2019	637	636.7	14.0	32.9	683.5
2020	643	643.0	14.0	32.9	689.9
2021	649	649.5	14.0	32.9	696.3
2022	656	656.0	14.0	32.9	702.8
2023	663	662.5	14.0	32.9	709.4
2024	669	669.1	14.0	32.9	716.0
2025	676	675.8	14.0	32.9	722.7
2026	683	682.6	14.0	32.9	729.5
2027	689	689.4	14.0	32.9	736.3
2028	696	696.3	14.0	32.9	743.2
2029	703	703.3	14.0	32.9	750.1
2030	710	710.3	14.0	32.9	757.2
2031	717	717.4	14.0	32.9	764.3
Seasonal Peaking Factor (June)		1.00			

Figure 28: Data used for Saturday peak hour right-turn warrant analyses

Right-Turn Bay Warrants Analysis

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:	35
Major-road volume (one direction), veh/h:	243
Right-turn volume, veh/h:	19

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	2843
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

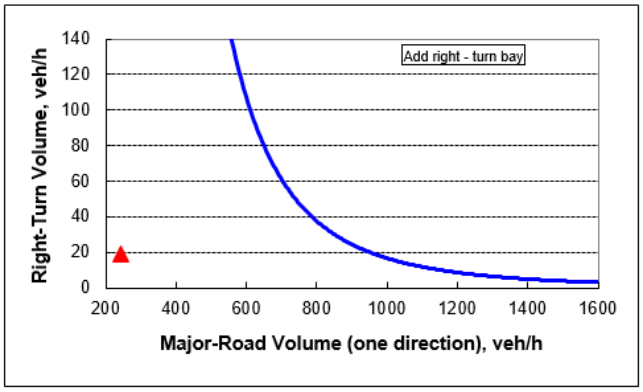


Figure 29: 2021 Weekday AM peak hour NCHRP 457 right-turn bay warrant analysis

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:	35
Major-road volume (one direction), veh/h:	265
Right-turn volume, veh/h:	19

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	2058
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

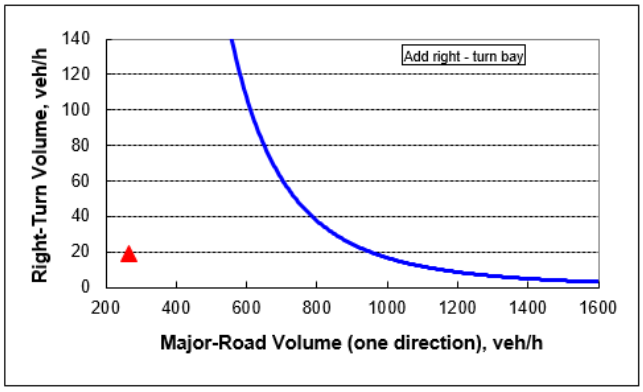


Figure 30: 2031 Weekday AM peak hour NCHRP 457 right-turn bay warrant analysis

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:	35
Major-road volume (one direction), veh/h:	687
Right-turn volume, veh/h:	26

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	65
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

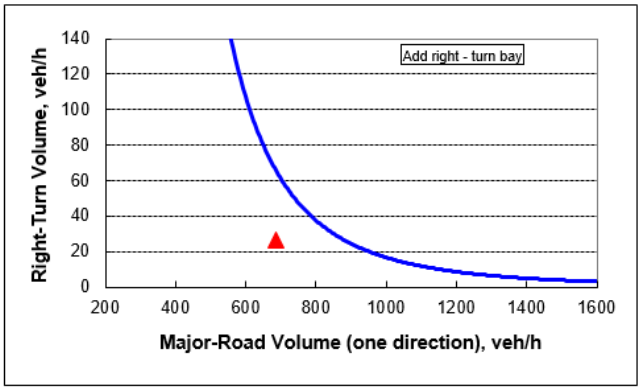


Figure 31: 2021 Weekday PM peak hour NCHRP 457 right-turn bay warrant analysis

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:	35
Major-road volume (one direction), veh/h:	755
Right-turn volume, veh/h:	26

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	46
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

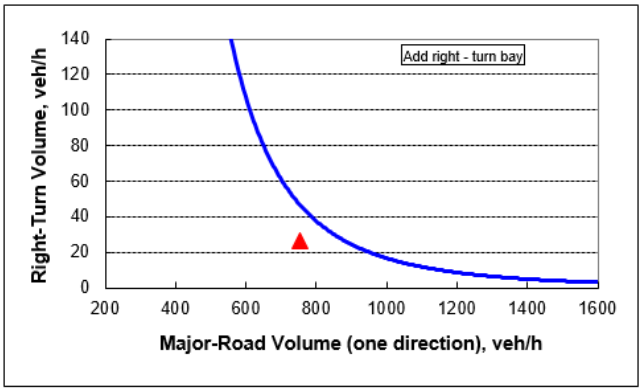


Figure 32: 2031 Weekday PM peak hour NCHRP 457 right-turn bay warrant analysis

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:	35
Major-road volume (one direction), veh/h:	696
Right-turn volume, veh/h:	33

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	62
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

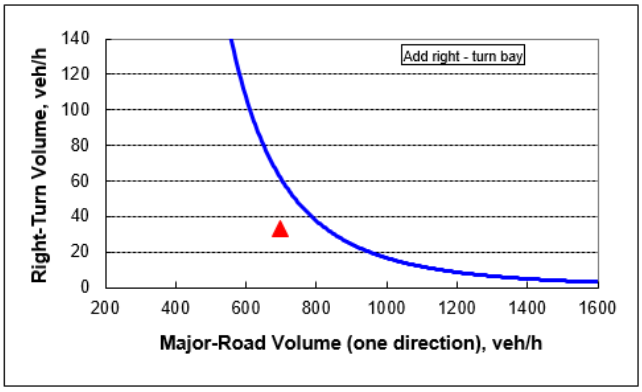


Figure 33: 2021 Saturday peak hour NCHRP 457 right-turn bay warrant analysis

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:	35
Major-road volume (one direction), veh/h:	764
Right-turn volume, veh/h:	33

OUTPUT

Variable	Value
Limiting right-turn volume, veh/h:	44
Guidance for determining the need for a major-road right-turn bay for a 2-lane roadway:	
Do NOT add right-turn bay.	

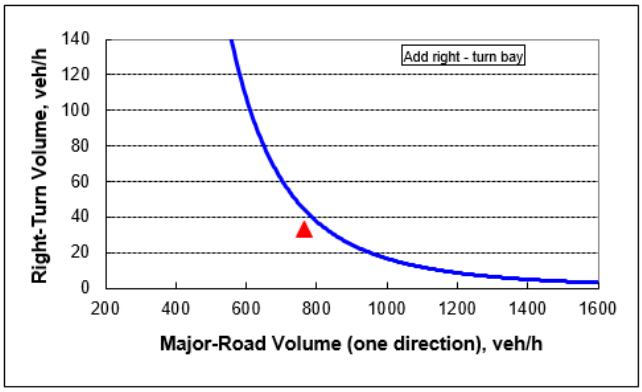


Figure 34: 2031 Saturday peak hour NCHRP 457 right-turn bay warrant analysis

Appendix C

Miscellaneous

Group 4 Averages:		Year 2018 Monthly Data Urban Highways	
		Adjustment to	
Month	ADT	Average	Peak
January	11282	1.13	1.24
February	11848	1.08	1.18
March	11828	1.08	1.18
April	12491	1.02	1.12
May	13587	0.94	1.03
June	13911	0.92	1.00
July	13765	0.93	1.01
August	13945	0.92	1.00
September	13168	0.97	1.06
October	13367	0.96	1.04
November	12215	1.05	1.14
December	11963	1.07	1.17
Average ADT:	12781		
Peak ADT:	13945		

Table 22: Derivation of the seasonal peaking factor

Table 3-1. Stopping Sight Distance on Level Roadways

U.S. Customary					Metric				
Design Speed (mph)	Brake Reaction Distance (ft)	Braking Distance on Level (ft)	Stopping Sight Distance		Design Speed (km/h)	Brake Reaction Distance (m)	Braking Distance on Level (m)	Stopping Sight Distance	
			Calculated (ft)	Design (ft)				Calculated (m)	Design (m)
15	55.1	21.6	76.7	80	20	13.9	4.6	18.5	20
20	73.5	38.4	111.9	115	30	20.9	10.3	31.2	35
25	91.9	60.0	151.9	155	40	27.8	18.4	46.2	50
30	110.3	86.4	196.7	200	50	34.8	28.7	63.5	65
35	128.6	117.6	246.2	250	60	41.7	41.3	83.0	85
40	147.0	153.6	300.6	305	70	48.7	56.2	104.9	105
45	165.4	194.4	359.8	360	80	55.6	73.4	129.0	130
50	183.8	240.0	423.8	425	90	62.6	92.9	155.5	160
55	202.1	290.3	492.4	495	100	69.5	114.7	184.2	185
60	220.5	345.5	566.0	570	110	76.5	138.8	215.3	220
65	238.9	405.5	644.4	645	120	83.4	165.2	248.6	250
70	257.3	470.3	727.6	730	130	90.4	193.8	284.2	285
75	275.6	539.9	815.5	820	140	97.3	224.8	322.1	325
80	294.0	614.3	908.3	910					
85	313.5	693.5	1007.0	1010					

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

Figure 35: Derivation of stopping sight distance requirements

Appendix D

Trip Generation Derivation

Specialty Retail Center
(826)

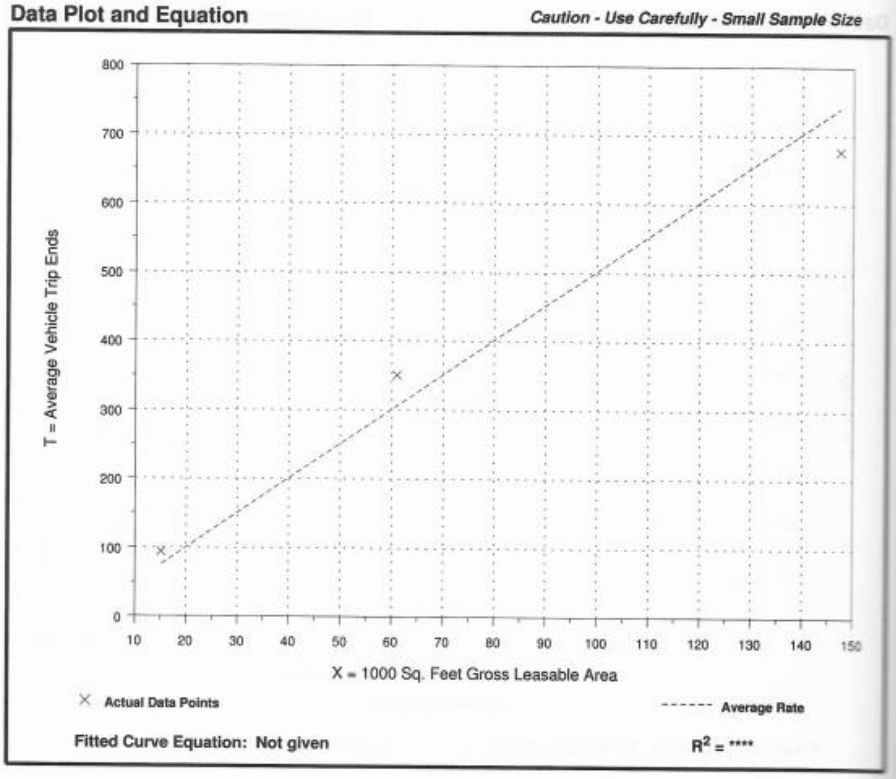
Average Vehicle Trip Ends vs: **1000 Sq. Feet Gross Leasable Area**
On a: **Weekday,**
P.M. Peak Hour of Generator

Number of Studies: 3
Average 1000 Sq. Feet GLA: 75
Directional Distribution: 56% entering, 44% exiting

Trip Generation per 1000 Sq. Feet Gross Leasable Area

Average Rate	Range of Rates	Standard Deviation
5.02	4.59 - 6.18	2.31

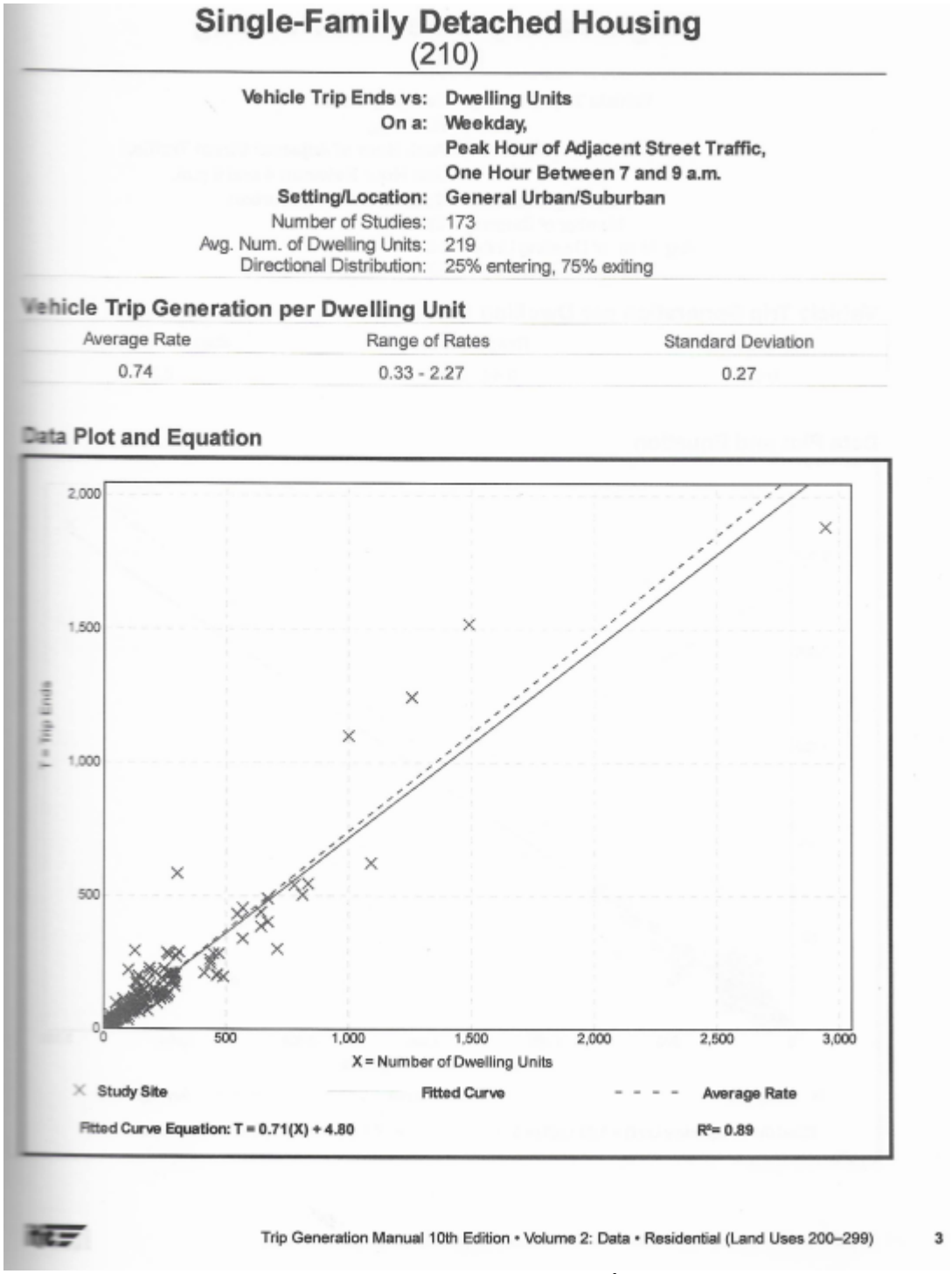
Data Plot and Equation *Caution - Use Carefully - Small Sample Size*



Fitted Curve Equation: Not given R^2 = ****

1582 *Trip Generation*, 9th Edition • Institute of Transportation Engineers

Figure 36: ITE Trip Generation, 9th Edition



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: 173
Avg. Num. of Dwelling Units: 219
Directional Distribution: 25% entering, 75% exiting

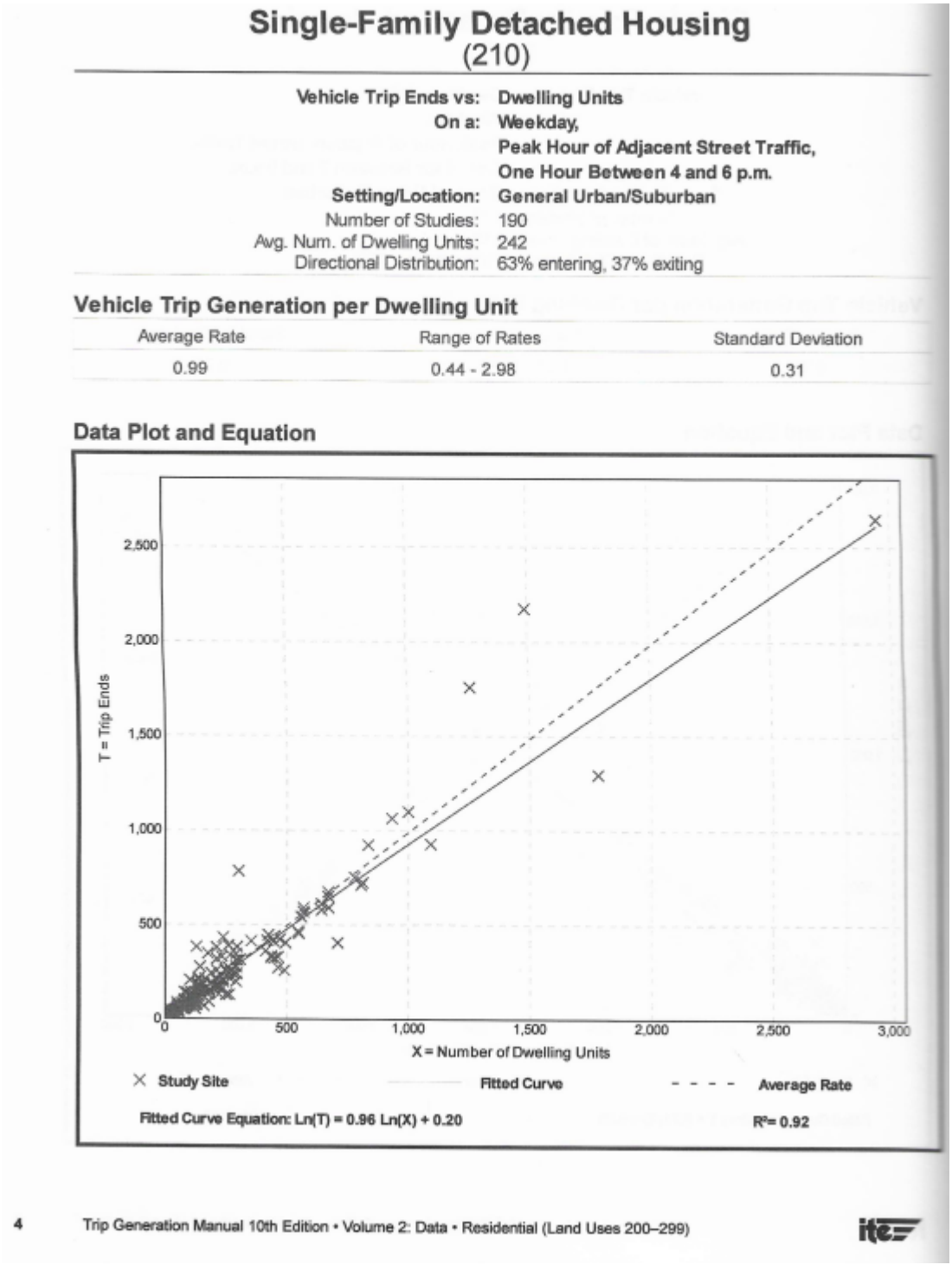
Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.74	0.33 - 2.27	0.27

Data Plot and Equation

Trip Generation Manual 10th Edition • Volume 2: Data • Residential (Land Uses 200–299) 3

Figure 37: ITE Trip Generation, 10th Edition



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: 190
Avg. Num. of Dwelling Units: 242
Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.99	0.44 - 2.98	0.31

Data Plot and Equation

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Figure 38: ITE Trip Generation, 10th Edition

Single-Family Detached Housing
(210)

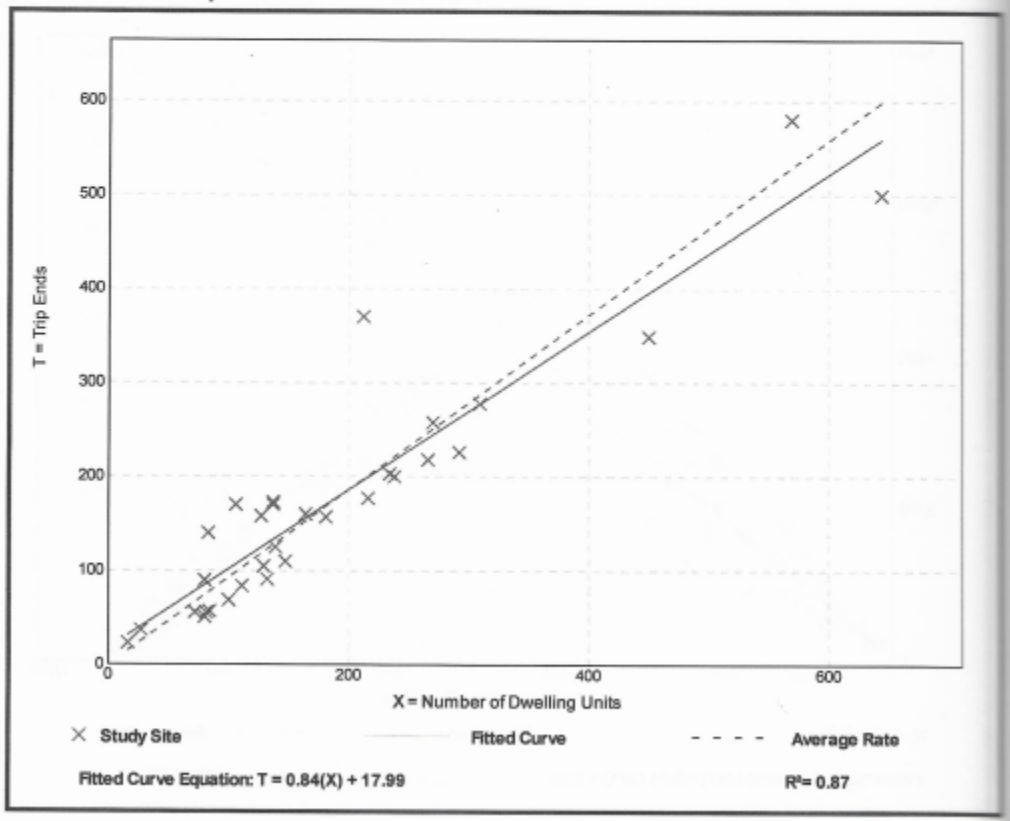
Vehicle Trip Ends vs: **Dwelling Units**
On a: **Saturday, Peak Hour of Generator**

Setting/Location: **General Urban/Suburban**
Number of Studies: 31
Avg. Num. of Dwelling Units: 188
Directional Distribution: 54% entering, 46% exiting

Vehicle Trip Generation per Dwelling Unit

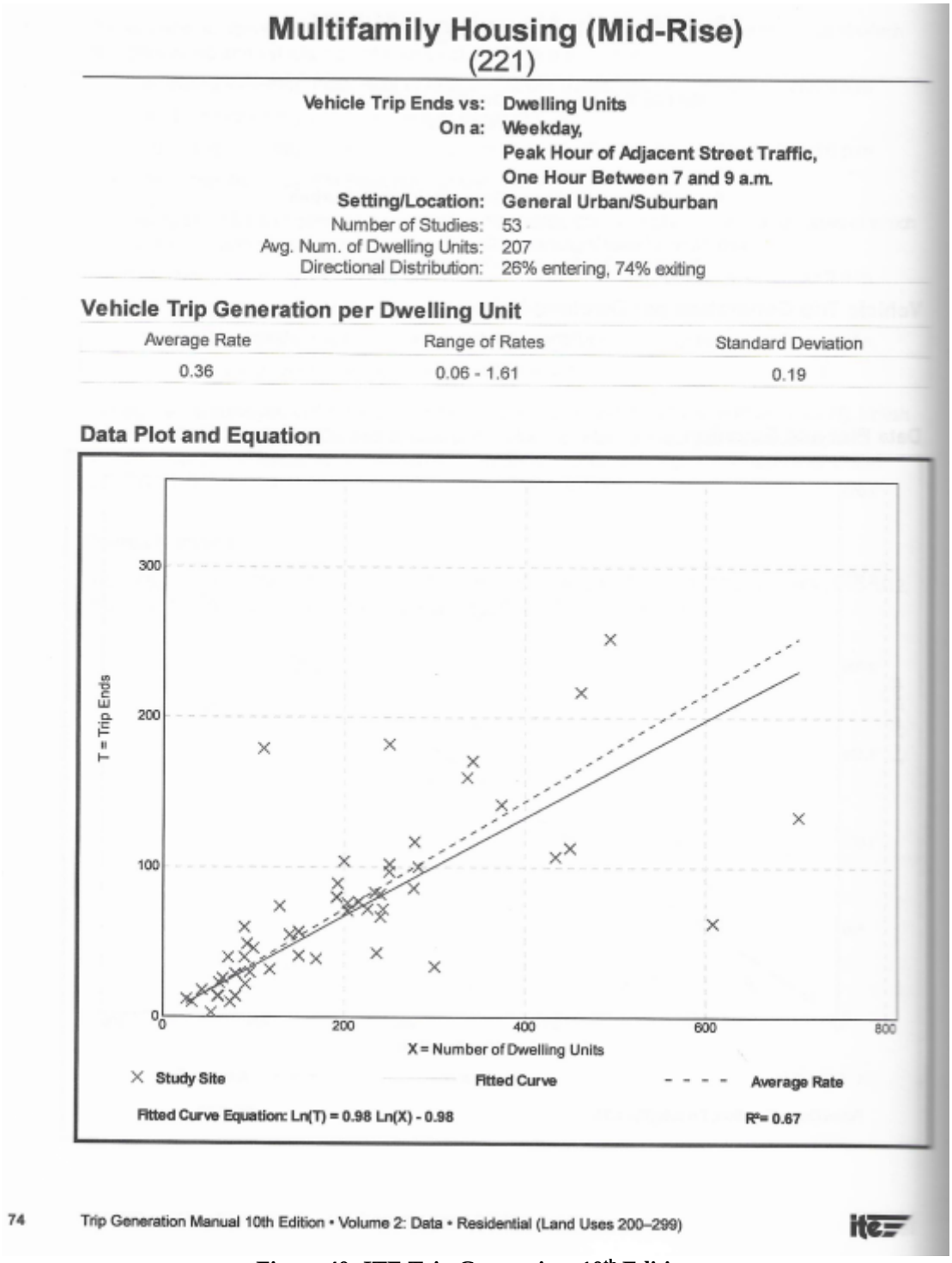
Average Rate	Range of Rates	Standard Deviation
0.93	0.64 - 1.75	0.26

Data Plot and Equation



8 Trip Generation Manual 10th Edition • Volume 2: Data • Residential (Land Uses 200–299)

Figure 39: ITE Trip Generation, 10th Edition



Multifamily Housing (Mid-Rise)
(221)

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: 53
Avg. Num. of Dwelling Units: 207
Directional Distribution: 26% entering, 74% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.36	0.06 - 1.61	0.19

Data Plot and Equation

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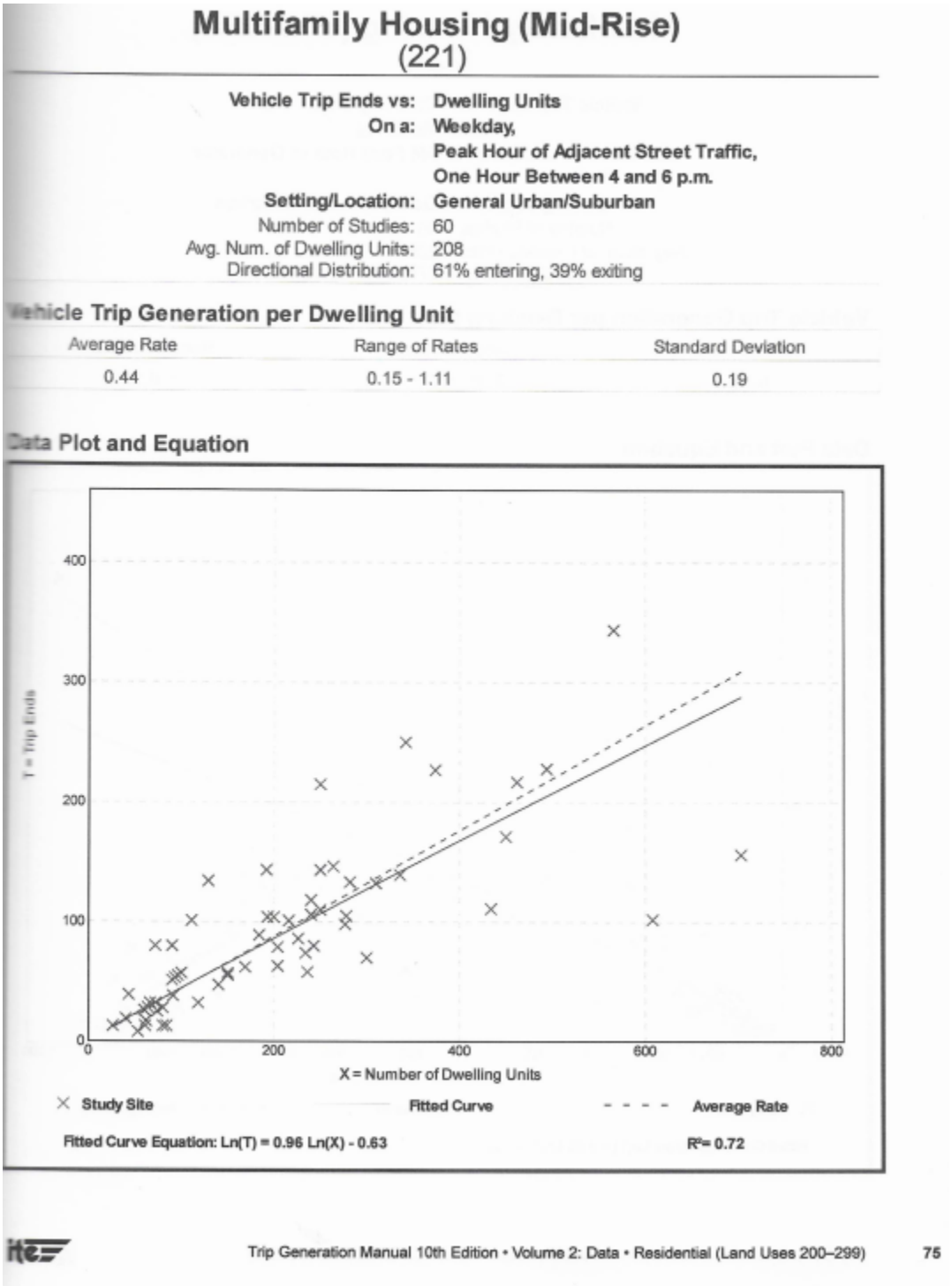
Figure 40: ITE Trip Generation, 10th Edition



Multifamily Housing (Mid-Rise)
(221)

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: 60
Avg. Num. of Dwelling Units: 208
Directional Distribution: 61% entering, 39% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.44	0.15 - 1.11	0.19

Data Plot and Equation

Figure 41: ITE Trip Generation, 10th Edition

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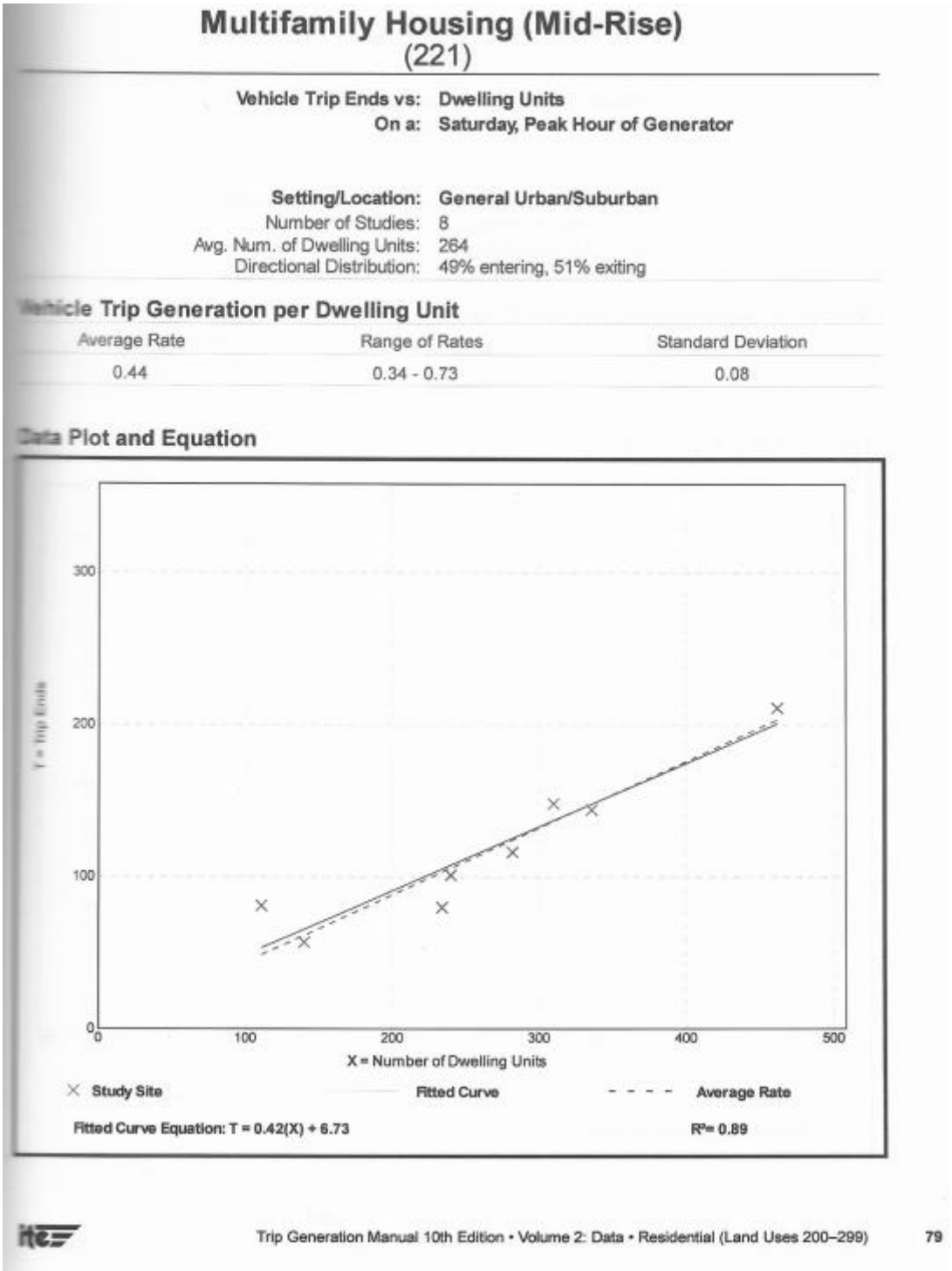

Multifamily Housing (Mid-Rise)
(221)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Saturday, Peak Hour of Generator**

Setting/Location: **General Urban/Suburban**
Number of Studies: 8
Avg. Num. of Dwelling Units: 264
Directional Distribution: 49% entering, 51% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.44	0.34 - 0.73	0.08

Data Plot and Equation

Fitted Curve Equation: T = 0.42(X) + 6.73 R^2= 0.89

Figure 42: ITE Trip Generation, 10th Edition

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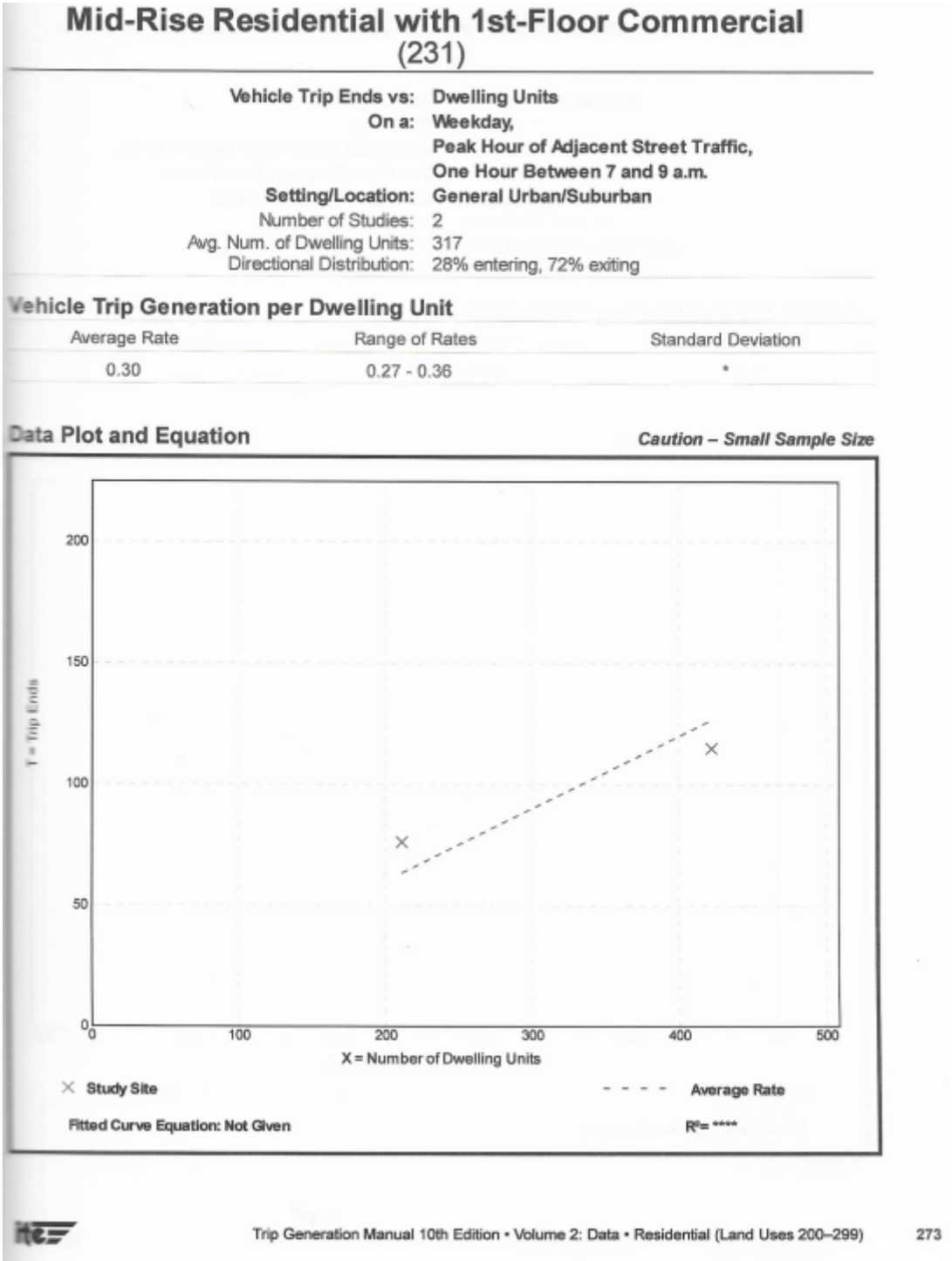

Mid-Rise Residential with 1st-Floor Commercial
(231)

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:	2
Avg. Num. of Dwelling Units:	317
Directional Distribution:	28% entering, 72% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.30	0.27 - 0.36	*

Data Plot and Equation

Caution – Small Sample Size

Figure 43: ITE Trip Generation, 10th Edition

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Mid-Rise Residential with 1st-Floor Commercial
(231)

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:	2
Avg. Num. of Dwelling Units:	317
Directional Distribution:	70% entering, 30% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.36	0.30 - 0.46	*

Data Plot and Equation

Caution – Small Sample Size

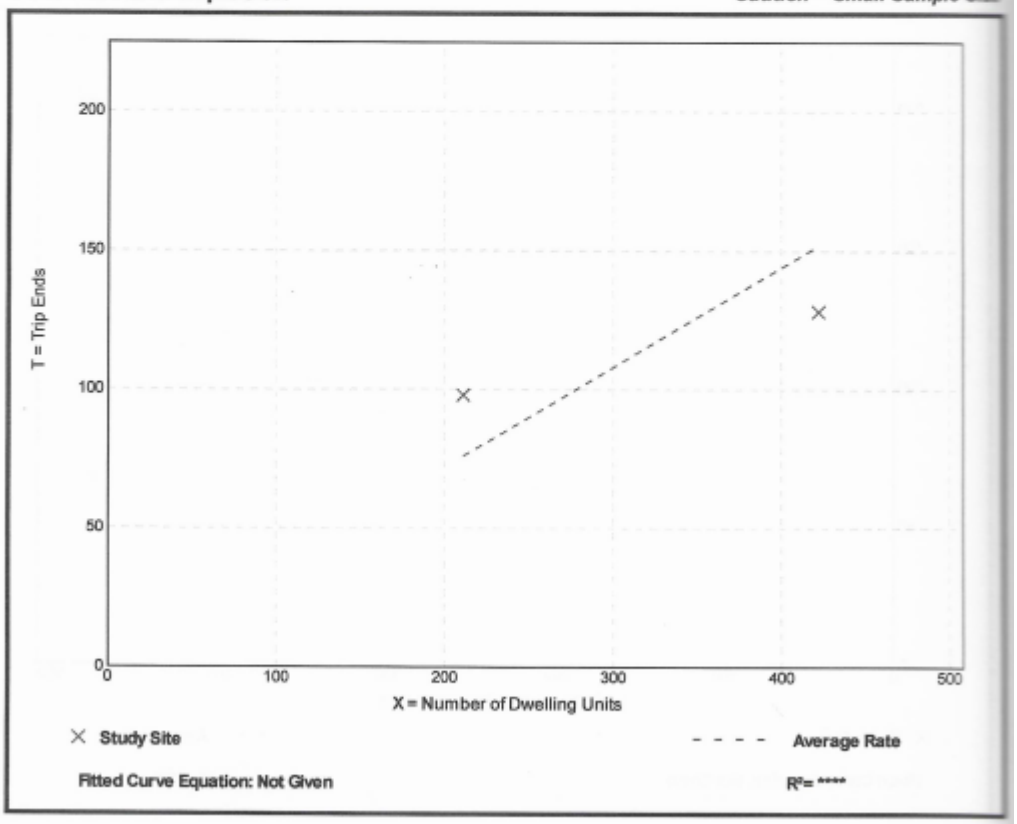

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Figure 44: ITE Trip Generation, 10th Edition

Mid-Rise Residential with 1st-Floor Commercial
(231)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Saturday, Peak Hour of Generator**

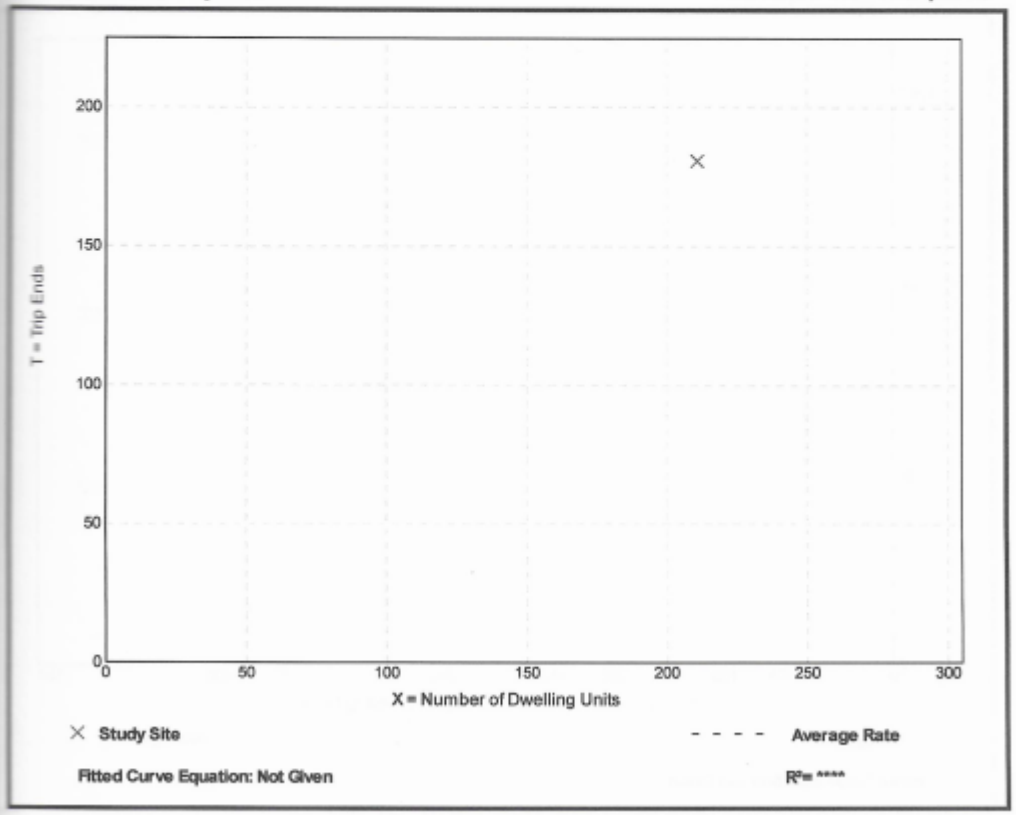
Setting/Location: **General Urban/Suburban**
Number of Studies: 1
Avg. Num. of Dwelling Units: 211
Directional Distribution: Not Available

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.86	0.86 - 0.86	*

Data Plot and Equation

Caution – Small Sample Size



Fitted Curve Equation: Not Given R^2= ****

Figure 45: ITE Trip Generation, 10th Edition

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General Office Building
(710)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
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: 35
1000 Sq. Ft. GFA: 117
Directional Distribution: 86% entering, 14% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.16	0.37 - 4.23	0.47

Data Plot and Equation

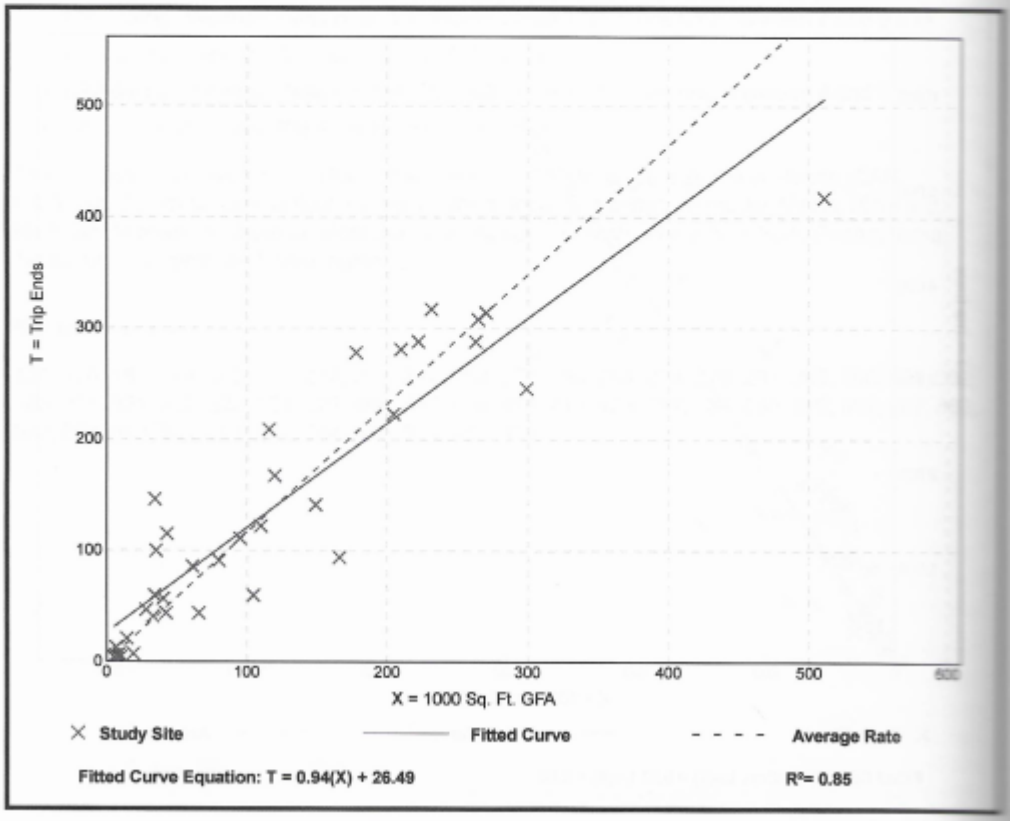

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Figure 46: ITE Trip Generation, 10th Edition

General Office Building
(710)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
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: 32
1000 Sq. Ft. GFA: 114
Directional Distribution: 16% entering, 84% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.15	0.47 - 3.23	0.42

Data Plot and Equation

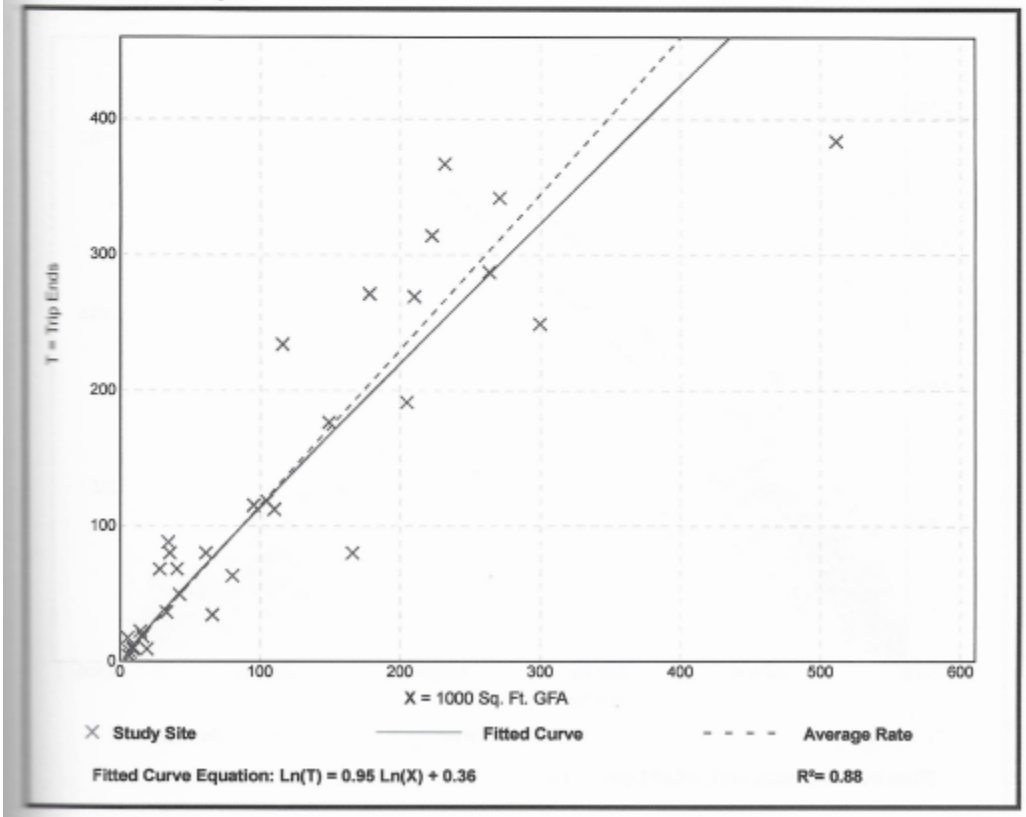

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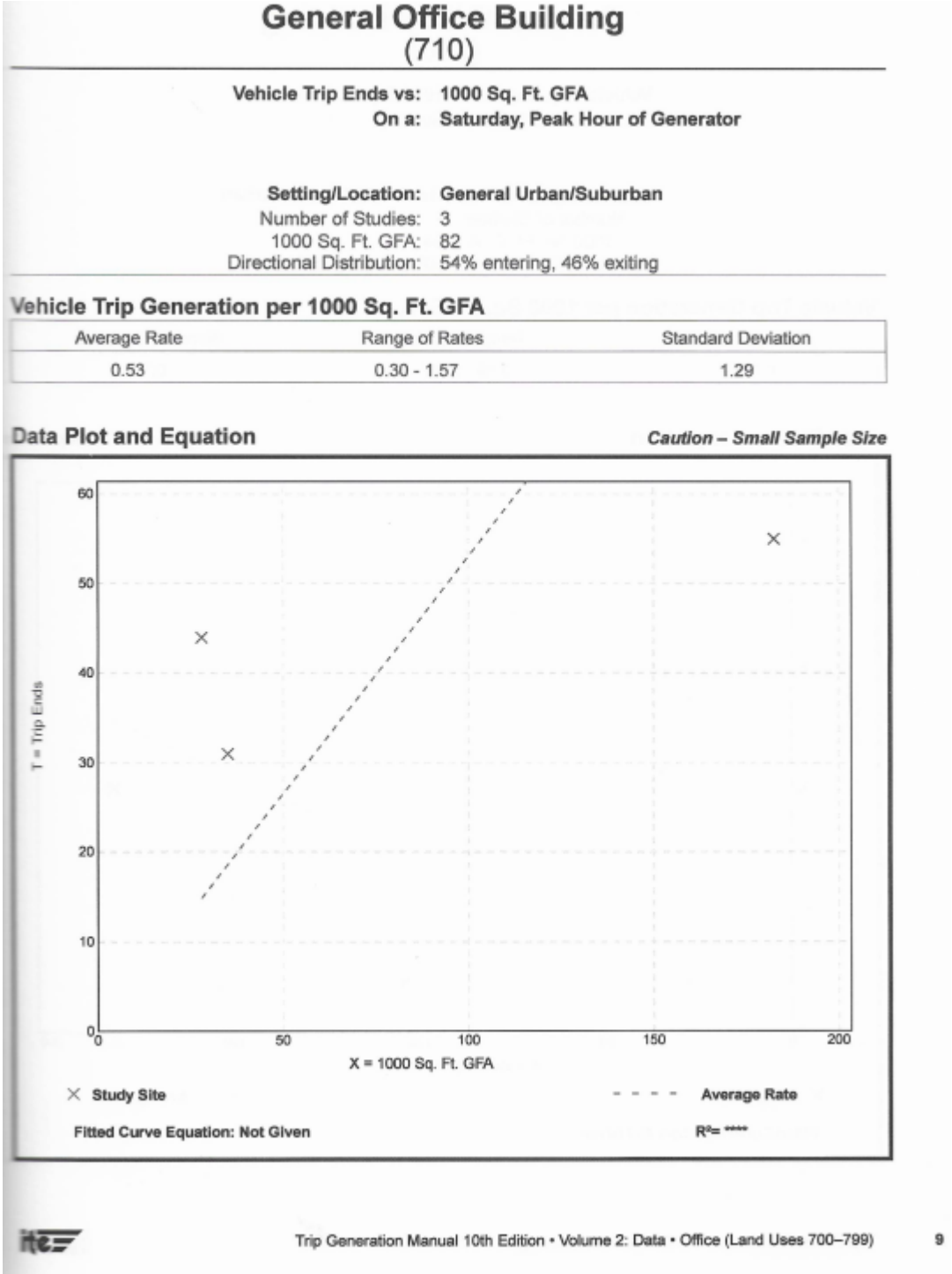
Figure 47: ITE Trip Generation, 10th Edition



General Office Building
(710)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Saturday, Peak Hour of Generator**

Setting/Location: **General Urban/Suburban**
Number of Studies: 3
1000 Sq. Ft. GFA: 82
Directional Distribution: 54% entering, 46% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.53	0.30 - 1.57	1.29

Data Plot and Equation

Caution – Small Sample Size

Figure 48: ITE Trip Generation, 10th Edition

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